GUIDELINES FOR CREATING EFFECTIVE MARINE RESERVES

SYSTEMATIZING THE STEPS NEEDED FOR SUCCESS

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OVERVIEW

Oceans bring value to people by providing food, oxygen, recreation, fishing, and other ecosystem services. These systems, however, are constantly threatened by human impacts. Faced with climate change, overfishing, pollution, nutrient imbalances, and other declines in the health of marine ecosystems, tropical seas can suffer and deteriorate without protective actions.

For these reasons, marine resource managers and environmental stakeholders increasingly turn towards ecosystem-based approaches to management, including the implementation of marine reserves. In this manual, marine reserves are defined as designated expanses of the sea where species are fully protected from fishing to enhance the management or conservation of marine resources. Marine reserves can help exploited populations increase in abundance, biomass, and size by decreasing fishing mortality. They can also protect habitat and enhance biodiversity.

Marine reserves can help support not only the protection of marine resources, but studies have also found that successful and robust marine reserves may provide ecosystem resilience to climate change and other environmental threats (McLeod *et al*., 2009; Bernhardt & Leslie, 2013). Nevertheless, to receive the full array of benefits a marine reserve can provide, the marine reserve must have a scientifically-based design, strong compliance from all users, and enforcement by governing bodies.

A marine reserve's implementation process may differ depending on many factors, including: its objectives, the ecological and social context, the involvement of stakeholders, target species, and the effectiveness of management and enforcement (Pendleton *et al.*, 2017). This report outlines what protections marine reserves can provide and compiles the steps and actions needed to properly design and implement them based on best scientific practices. It assesses all ecological, social, and economic components necessary to consider when implementing marine reserves including necessary steps, tools, outcomes, and limitations of using marine reserves to achieve conservation, financial, and social benefits (Selig and Bruno, 2010; Edgar *et al.*, 2014; Gill *et al.*, 2017).

SUMMARY

This report provides guidelines to the process of creating and implementing marine reserves that are efficient and effective. Marine reserves are designated expanses of ocean that fully protect species/habitat from extractive activities and are more globally known as marine reserves (PISCO, 2007). If designed correctly, studies have shown marine reserves can increase density; biomass; species size; preserve biodiversity and genetic diversity; conserve ecosystems and maintain ecological processes; create sustainability; protect commercially valuable species; replenish depleted stocks; enhance education and research; and provide recreation, tourism, social and economic benefits (Clark, 1996; Salm *et al.*, 2000; Halpern, 2003; Sala & Giakoumi 2017).

For these reasons, marine reserves are gaining global popularity as a management tool. And with thousands of examples around the world, there are a wide-variety of design and implementation strategies for marine reserves (Pendleton *et al.*, 2017). Since different reserves were designed and implemented using different approaches, there is a rich opportunity to learn from the experiences of others and systematize the best practices and design principles.

To this end, we compiled relevant scientific literature, reports, guidelines, and available tools to synthesize these experiences. We also assessed this process in Quintana Roo, Mexico where an alliance of stakeholders has formed to better organize themselves and enhance the process of marine reserve formation. This report is the physical copy of an online, interactive website that a facilitator (i.e. non-governmental organizations, foundations or other institutions that assist or facilitate the process of creating a marine reserve) can reference to create and implement more effective marine reserves.

We designed our report to include the following:

> *Decision Tree.* The facilitator will answer a series of questions to evaluate if marine reserves are the proper management strategy based on challenges to be solved, the species involved, and the objectives to be met. The decision tree has three possible management outcomes: No Marine reserve, Single Marine reserve, or a Network of Marine reserves.
>
> *No Marine Reserve***.** In many cases, marine reserves are not the best solution for the challenges that are faced. This section outlines other management controls that can help improve the sustainability of the target species when marine reserves are not viable or appropriate.
>
> *Single Marine Reserve Process.* This section describes the necessary approach to develop one marine reserve.

*Network of Marine Reserves Process***.** Describes the necessary approach to develop a network of marine reserves. This involves knowing connectivity patterns and protection of different habitats relevant for the target species.

*Compilation of Tools***.** Support tools have been developed for most of the key steps in the process of creating, implementing, and evaluating marine reserves. These tools have been created in multiple efforts around the world, but they have never been previously assembled into a comprehensive toolbox.

Marine Reserve Creation Process

We divide this process into four phases:

1. Engagement

Approaching and engaging resource-users and local communities to understand their needs, aspirations, organization/structure, and well-being of the community. Establishing a trusting relationship with the community and developing a clear view of the opportunities and challenges they face. If the resource-users and communities show strong social structure, their participation and involvement in the marine reserve planning and decision-making process can increase the likelihood of its success (Dyer and McGoodwin, 1994; FAO, 2011; Grantham, 2013; Halpern *et al*., 2013).

2. Creation

Creating the design and legal foundation for the marine reserve through engagement with stakeholders and community members/resource users. The scientific design process may be complemented by user local knowledge of the area and productive habitats.

3. Implementation

Applying the new marine management strategy. This phase requires monitoring and enforcement of marine reserves as well as periodic evaluation of target species/habitat. If there are short term costs before benefits arise, this phase would be enhanced by financial strategies to offset costs.

4. Learning and Enhancement

Ongoing adaptation of the management strategy using lessons learned in the above phases to enhance benefits or address gaps. The benefits from learning grow if they are shared with other communities to highlight what is working and what is not.

The phases are further divided to address the social, biological, governmental, and economic components necessary for implementing effective and successful marine reserves.

Ecological component – Addresses the biology and ecology of the target species and the biophysical parameters of the marine reserve.

Social component – Addresses the social structure, needs, and motivations of resource-users and communities directly affected by a marine reserve.

Governance component – Addresses the rules, regulations, institutions, and power relationships among actors involved in the process of creating a marine reserve.

Economic component – Addresses the economic strategies that can serve as incentives for resource-users and host communities.

While the report flows linearly, and each stage has a set of defined recommendations and steps, many of the ideas and steps happen concurrently; meaning, they are not static and can interact throughout the process (i.e. when facing challenges during implementation, engagement strategies need to be strengthened).

HISTORICAL CONTEXT

Mexico has adopted a series of strategies to protect marine and terrestrial ecosystems, including the creation of natural protected areas (in Spanish: Areas Naturales Protegidas – ANP). ANPs are supported by the General Law of Ecological Equilibrium and Environmental Protection (in Spanish: Ley General del Equilibrio Ecológico y la Protección al Ambiente) (LGEEPA) and have been used to create biosphere reserves, national parks, and areas for protection of flora and fauna (CONANP, 2016).

In early 1990s the United Nations Educational, Scientific and Cultural Organization (UNESCO), advocated for biosphere reserves. These are multi-zone areas used to achieve conservation, sustainable development, and to conduct research and education (Hoffman, 2014). In the Quintana Roo region, the Sian Ka'an Biosphere Reserve and Banco Chinchorro Biosphere Reserve were declared in 1986 and 1996, respectively (UNESCO, 2018). The goals of these reserves are to protect coral reefs and marine biodiversity while maintaining the livelihood of fishing co-operative members. To do this, areas of no-take and no extraction were coupled with areas of resource use and tourism-related activities (Hoffman, 2014).

Within these two biosphere reserves, the fisheries are co-managed by the National Commission of Protected Areas (CONANP) and the National Commission for Fisheries and Aquaculture (CONAPESCA) (Ley-Cooper *et al.,* 2013). CONANP, an arm of Secretariat of the Environment and Natural Resources (SEMARNAT), is in charge of the environment (CONANP, 2012). CONAPESCA, an arm of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), has responsibility to develop mechanisms and implement policies and programs for the sustainable development of aquatic and fisheries resources (SAGARPA, 2015). CONAPESCA grants fishers fishing concessions and permits to exploit fishery resources in areas that can include biosphere reserves. Despite these management and conservation efforts, Mexico has seen a decrease in biological diversity and marine ecosystem health (CONANP, 2016).

In 2014, the Government of Mexico, via SAGARPA, enacted a new law for fishery management called NOM-049-SAG / PESC-2014 that formally allows the establishment of refuge zone (Zonas de Refugio in Spanish) (SAGARPA, 2014). The fish refuge zones as a Mexican legal instrument have the principal objectives of:

- Recover species of commercial interest
- Improve fishery production in adjacent waters
- Prevent overexploitation
- Recover overexploited species
- Preserve habitat of fishing species
- Maintain biological process (reproduction, recruitment, growth, feeding)

According to law, SAGARPA, through CONAPESCA, and based on the technical opinion of the National Fisheries Institute (INAPESCA), may establish fish refuge zones. This tool is meant to improve the status of exploited species where a user or interested party can apply to establish refuge zones inside or outside natural protected areas. Thus, making a legal distinction between this new fishery management law under SAGARPA's jurisdiction and the traditional natural protected areas under CONANP's jurisdiction. Currently, no-take marine reserves can take the following forms in Mexico: fish refuge zones in natural protected areas, fish refuge zones within a concession, fish refuge zones outside protected areas, and nucleus zones in natural protected areas. In this manual, we focus on fish refuge zones (no-take marine reserves) that are within a concession and/or a natural protected area.

INTRODUCTION

Marine reserves versus marine protected areas:

A vast array of terminology exists when defining a protected area of an ocean. For this reason, it is important to distinguish what these set of guidelines refer to when naming a protected area, a marine reserve. Marine reserves are designated expanses of ocean that *fully* protect species/habitat from extractive activities and harm (PISCO, 2007). Marine reserves are also known as no-take marine protected areas. Marine reserves differ from the more general marine protected areas (MPAs) as MPAs are designed as "[a]ny area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN, 1998). In essence, a MPA may protect some coastal land in addition to the marine environment and has *some* form and degree of protection (not always the same throughout the MPA).

For the purposes of these guidelines, we explore how to create marine reserves (no-take marine protected areas) to achieve conservation and fishery goals.

What can marine reserves achieve?

Marine reserves are promoted as an effective tool for protecting biodiversity and achieving sustainable use of marine resources (Worm *et al.* 2006; Lester *et al.* 2009). For these reasons, marine reserves are used to protect and/or replenish the abundance and diversity of marine life and habitat (OECD, 2017). This includes maintaining essential ecological processes and life support systems and ensuring the sustainable uses of marine species and ecosystems. Studies show that successful marine reserves can achieve several positive outcomes such as:

- Increase and/or protect fish biomass, density, and species diversity (Halpern, 2003; Lester and Halpern, 2008; Edgar *et al*., 2014; Gill *et al.*, 2017),
- Promote the dispersal of more larvae (Harrison *et al*., 2012) and adults to benefit both fisheries and biodiversity outside the marine reserve (Gaines *et al.* 2010; Di Lorenzo *et al.*, 2016),
- Enhance education and research,
- Provide recreation and tourism,
- And may make marine ecosystems more resilient to climate change (Roberts *et al.*, 2017).

For fisheries that are multi-species, sedentary stocks, or for which broader ecological impacts of fishing are an issue, marine reserves have many potential advantages. Nevertheless, marine reserves are not a panacea and cannot address all fishery and/or conservation challenges. Their potential for improving fisheries management will be limited if the roots of the *fisheries* failures are not addressed (Hilborn *et al.*, 2004). For example, if the fishery has a spatial distribution of effort, and the governance favors individual rather than collective decision-making structures, other fishery management tools (i.e. Individual Transferable Quotas) can provide better results (Cancino *et al.*, 2007).

Furthermore, whenever a fishery is already well-managed by the application of other fishery management tools or is performed mainly with the use of low-impact highly-selective methods (e.g. hand-capture of lobster while freediving), it is likely that a marine reserve will not have a positive impact or could even reduce the fishery's efficiency. Hilborn *et al.* (2004), describe that marine reserve facilitators will see fewer benefits if the marine reserve targets a highly mobile single species fishery with little to no bycatch or habitat impact.

What do effective marine reserves have in common?

The success of marine reserves relies heavily on the existence of legal frameworks, acceptance by local communities, an effective and supported management system, attainable and measurable objectives, and the delineation of clear boundaries (Wells *et al.*, 2016). The central principles for a well-supported management system are: representativeness of habitats according to the established objective, the need to develop wider management tools beyond the marine reserve, and the crucial role of local communities and stakeholders in all phases and long-term monitoring with serious evaluation to provide the necessary information for co-management (Wells *et al.*, 2016).

Planning, monitoring, and evaluating the process and outcomes are also necessary to learn about what has worked and why (Hilborn, 2004). Some co-planned and co-managed examples of marine reserves show positive impacts to the community and surrounding marine ecosystem with objectives established by a consensus (Day, 2008). However, objectives for a marine reserve must be specific, explicit, realistic and measurable throughout an extended period of time (Day, 2008; Agardy *et al.*, 2011; Pendleton *et al.*, 2017).

Other key elements that increase success of a marine reserve include (Di Franco *et al.*, 2016; Karr *et al.*, 2017):

- The use of a participatory implementation process that empowers fishers to increase compliance and surveillance;
- Integration of local knowledge with scientific evidence;
- The existence of a management plan with specific goals and objectives that can be assessed and adapted, if necessary;
- Fishers constant engagement and involvement in management plan adaptations;
- Increased or added benefits to the local community or user-groups;
- And high social capital that enhances partnerships among different sectors and stakeholders.

Through our extensive literature analysis, we found that an effective marine reserve creation and implementation process should be supported and motivated by four major components: ecological, social, economic, and governance structure. Below is a brief summary of each.

Ecological Component

Scientific analysis on the status and biology of the target ecosystem and/or species will help determine the size, location, duration, and connectivity of marine reserves that are critical to their effectiveness. Target species for marine reserve conservation include key fisheries species, species with important ecological functions such as herbivores and indicator species, and rare and threatened species (King & Beazley, 2005). Dependent upon how far these focal species move or which life history stage will be protected, facilitators must determine how big a marine reserve should be, how many, or if marine reserves can provide adequate protection for conservation at all.

Social Component

Marine reserves can directly and indirectly impact coastal resource users and/or associated fishing communities (Christie *et al.*, 2003). Each community is different, and their leadership and organization structures will influence the success of a marine reserve (FAO, 2011). There are several key social science frameworks that help identify these characteristics and inform how best to utilize them for marine reserve success.

If these user-groups and communities show strong social structure, their participation and involvement in the marine reserve planning and decision-making process can increase the likelihood of its success (Dyer and McGoodwin, 1994; FAO, 2011; Grantham, 2013; Halpern *et al*., 2013). Conversely, if the social structure is weak there will be a need to implement capacity building to have effective stakeholder participation and increase the probability of success (FAO, 2011).

Governance Component

Governance is the process by which laws, systems, and institutions surrounding marine reserves are developed and enforced to attain marine resource management across all scales of government, organizations, and users (Jones *et al.*, 2013; Gallacher *et al.*, 2016). In the context of small-scale fisheries, governance has many forms, and has evolved from state control, to co-management, to community-based management, to property rights and more recently, to an integrated approach to governance (Basurto *et al.*, 2017).

Growing forces like the dependence of locals on marine resources and increase demand in the global fish market lead users to develop a wide range of incentive mechanisms to govern the resources. According to Jones *et al.* (2013), these incentives include better communication and knowledge sharing, economic, and participative and legal incentives including political will, surveillance, and enforcement.

Economic Component

Economic incentives drive important behavioral changes in the fisheries sector and including incentives in the marine reserve process is crucial for marine reserves to succeed in achieving conservation and fishery management goals (Hilborn *et al.*, 2005; Gonzalez *et al.*, 2006; Costello *et al.*, 2010; Kaplan *et al.*, 2015). Marine reserve facilitators should provide these incentives to communities to create and implement successful marine reserves. Incentivizing the process include: (1) financing the creation of the marine reserve, (2) reducing costs attributable to marine reserves, and (3) enhancing the benefits they provide – in the short and long term. By incorporating a financial plan, facilitators improve fisher livelihoods, effectively reduce the risk of low to no enforcement and surveillance by local communities/cooperatives and help create effective marine reserves (Gelcich & Donlan, 2015; Hamel *et al.*, 2017).

Challenges

Compliance is a crucial and challenging step to achieve desirable outcomes as enforcement is difficult and generally costly (Mora *et al.*, 2006; Cinner *et al.*, 2014; Edgar *et al.*, 2014; Kaplan *et al.*, 2015; Gill *et al.*, 2017; Bergseth *et al.*, 2017). The loss of fishing area and the increased competition for fish in the remaining areas create an incentive for poaching inside the marine reserve. One way to enhance compliance is to align incentives with communities' needs (McClanahan *et al.*, 2006). Identifying the proper incentives will increase probability of compliance.

There must be clear incentives to increase compliance when enforcement is weak. Marine reserves combined with financial strategies to overcome short-term fishery losses fosters a strong and sustainable system that will achieve desirable conservation outcome (Gill *et al.*, 2017). If marine reserve regulations are followed, the improvement of the stocks will also produce an economic benefit (Figure 1).

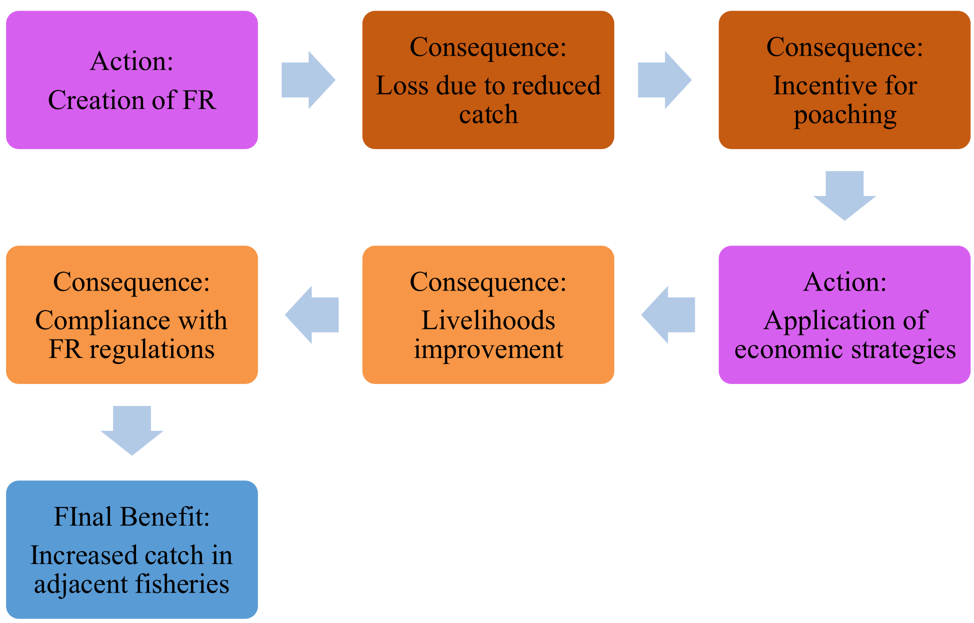

Figure 1. Cycle of actions and consequences from the creation of a FR to the retrieval of benefits through increased catch in adjacent fisheries.

Success Stories

Given the diversity in objectives, goals, and people involved, there are a wide variety of outcomes in the design and implementation of marine reserves. Below, we explore two case studies that were particularly successful in this process. These studies provide insight on what marine reserves can achieve and best practices to attain favorable outcomes.

Punta Coyote – Baja California, Mexico

El Corredor San Cosme-Punta Coyote región in Baja California Sur, Mexico, is a multispecies finfish fishery. A NGO, Niparaja, worked with the local community to elucidate the potential threats of increasing fishing effort on the fishery stock and the consequences this could have on their livelihoods and food security. NGOs and communities from the region shared their knowledge and efforts to develop solutions for the depleted stocks. Through participatory action, fishers approached the government to establish a network of marine reserves. In this case study, some key drivers of success were:

- A common understanding of the problem.
- An agreed upon vision of how to overcome the problem.
- A methodology to collect information (scientific and local knowledge) needed for design and implementation.
- Conducting data-limited stock assessments to evaluate the current state of the fishery.
- Enhancing social capital and building trust among fishers, government, and Niparaja to overcome generally poor governance and lack of capacities for enforcement and management actions.
- Enabling participation at the different levels of local production, which enhanced economic incentives.

Source: Kaar *et al.*, 2017.

Belize – Government-led initiative

The lobster and conch fisheries in Belize are the most valuable fisheries in the country. Increases in fishing effort threatened resource abundances so the government of Belize took action to improve fisheries governance. To do this, the government established two pilot initiatives to study the effect of Territorial Use Right for Fishing (TURF; i.e. area-based fishing rights) in two multi-zone marine reserves in 2011 and 2012. These TURF areas, locally called Managed Access Areas, consisted of no-take zones and general use zones. This new system would reduce fishing effort via access restrictions and allow for species recovery in the no-take zones.

Babcock *et al.* (2015) observed improvements to lobster and conch population status in these pilot sites. These positive results prompted the government to scale up the management plan to a national level. This is an example of a stakeholder-centered solution to integrate fisheries governance and science-based management.

The participatory process engaged government officials, NGOs, and 75% of Belize' fishers in the design of a national Managed Access System. Currently, the government is developing an adaptive management framework to integrate fisheries governance, scientific assessment, and science-based fishing mortality control to avoid the stock from collapsing. This process relies on collecting data annually to assess fishery performance and conservation outcomes. In some cases, the data are fishery dependent (catch) surveys. In others, the surveys are fishery independent (underwater assessment).

Belize also developed training and education programs for marine reserve facilitators and fishers. This contributed to capacity building and improved data collection for future analysis. Combining scientific-based assessment into fishers' management decisions makes the Belize fisheries management system robust, thereby enhancing fishery benefits.

Source: Kaar *et al.*, 2017.

Summary

Marine reserves are a tool used to achieve conservation and fisheries goals. They can increase biomass and biodiversity, promote larval dispersal, benefit surrounding fisheries, enhance education, and make the ecosystem more resilient to climate change. But, marine reserves can provide little to no benefits if they are poorly designed or if they do not directly address a fishery problem.

Key elements for effective marine reserve are: existence of a legal framework, a participatory approach that integrates the local community, integration of local and scientific knowledge, measurable goals, scientific analysis, assurance of added value from the marine reserve, increase or added benefits to the resource users, and the creation of an adaptive management plan.

Some of the challenges associated with marine reserves are: good data collection to evaluate the marine reserve and cope with uncertainty, identifying proper incentives for resource-users, and establishing a sustainable financial strategy to overcome short-term costs.

HOW TO USE THIS GUIDE

This manual is intended for use by parties interested in creating a marine reserve as a management strategy, or the facilitator of the process. The "user" of this guide (i.e. facilitator of the marine reserve creation, implementation, and enforcement process) should have knowledge on biological characteristics and access to data of target species or habitat. Typically, facilitators might include representatives from scientific organizations, non-governmental organizations (NGOs), marine planners, environmental or conservation organizations, and/or private agencies, to name a few.

The facilitators will initially identify the best management strategy to employ based on target species/habitat biology and status through a simple decision tree. Then, the facilitators will move forward to the design sections most applicable to their challenge.

Steps Include:

1. Decision Tree

Outcomes: (a) No Marine Reserve; (b) Single Marine Reserve; (c) Network of Marine Reserves

2. Go to most appropriate management strategy section
   (a) → No Marine Reserve Section
   (b) → Single Marine Reserve Section
   (c) → Go through Single Marine Reserve Section then complement each of the phases with the information found within the same phase within the Network of Marine Reserves Section

Marine reserves cannot solve all marine conservation and fisheries challenges. The No Marine Reserve section outlines other management strategies that may serve as more suitable options when marine reserves are not appropriate. These options can be explored separately.

Within the marine reserve sections, facilitators will be introduced to the structured phases and components to address in a successful marine reserve creation process.

DECISION TREE

As a first step to these guidelines, we developed a decision tree to guide users to the most appropriate management strategy to attain their conservation and/or fisheries objectives. Based on an assessment of the scientific literature, the decision tree focuses on the problems that exist and the objectives that are not being met to classify potential solutions three categories: (1) not implementing a marine reserve but using other management strategies, (2) a single marine reserve that can produce local benefits or (3) a network of marine reserves for regional or ecosystem benefits (Figure 2).

Considerations:

When using the marine reserve decision tree, facilitators should have clearly articulated conservation and/or fishery objectives and sufficient or expert knowledge of the biological characteristics of the species and habitats in need of protection. Some key characteristics include home range of target species, feasibility to encompass entire species home range in a marine reserve, key habitat needs, species status, and vulnerable life history stages of species.

The objectives of marine reserves influence their design – size, location, and spacing. Marine reserve benefits fundamentally rely on their size being substantially larger than the normal home range sizes of species in need of protection (figure 3). For fisheries benefits, marine reserves must provide spillover of adults and/or larval export (Gaines *et al.*, 2010). For conservation benefits, marine reserves rely on optimal location and size to protect threatened species and habitats (Viana *et al.*, 2017).

To provide significant large-scale or regional conservation or fisheries benefits for target species, networks of multiple reserves are key (Gaines *et al.* 2010). Although single marine reserves can provide local fisheries benefits, solving broader species or ecosystem level challenges requires networks of marine reserves across regional scales (Gleason *et al.*, 2013).

A key element for creating marine reserves, either singly or in a network, is to motivate actions using the breadth of potential social, economic, and biological benefits. A single marine reserve can be motivated by increased economic gains and by improved social dynamics (how users organize themselves). A network of marine reserves can augment these locally generated benefits through connections among sites that create broader regional social, economic and biological benefits.

How to Use the Marine Reserve Decision Tree:

The decision tree is comprised of questions that have binary responses. Facilitators must answer each question before advancing to the subsequent question. If facilitators are uncertain how to answer a question within the tree, we recommend choosing the most conservative path.

For example, the first question in the decision tree relies on knowing the stock status of the species. Well-managed marine species, particularly fisheries, have fewer potential benefits from creating a no-take area for that species (Lester *et al*., 2009; Viana *et al.*, 2017). If no sound science-based stock status evaluation exists, facilitators can perhaps seek qualitative and descriptive trend analyses based on local knowledge. In the face of large uncertainty on the status of species, a conservative decision may be warranted.

Once an outcome is chosen, facilitators can address the economic, social, and ecological impacts of different marine reserve designs. The size of the marine reserve and number of marine reserves within a network are intentionally undefined, because they are habitat, species, and objective specific. Decision-making tools such as the Fish Forever TURF-Reserve Design Tool (Oyanedel *et al.*, 2017) can help to determine size and placement of marine reserves while other literature informs the necessary spatial planning for an effective network of marine reserves (Gaines *et al.* 2010).

Step 1. Decision Tree

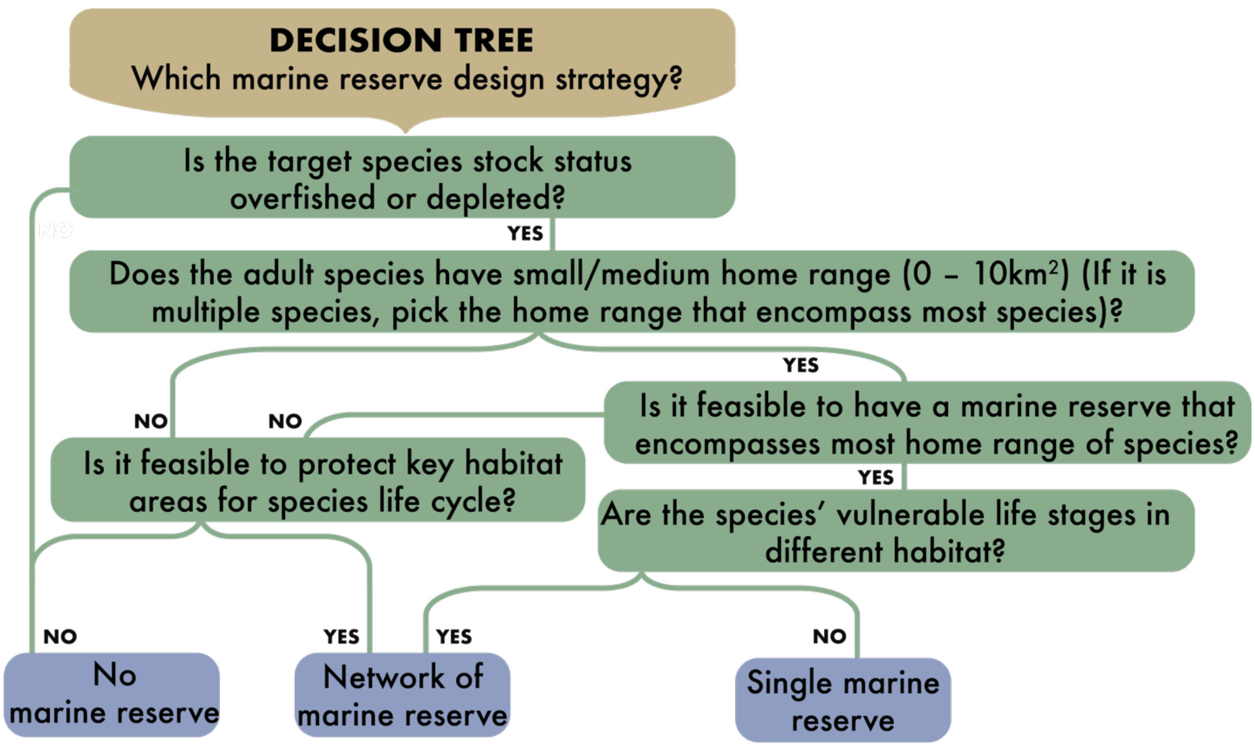

Figure 2. Decision tree asking pivotal questions to determine the most viable management option to meet primary objectives.

Below, we provide a justification for the overarching elements of the decision tree and direct users to the next appropriate step.

Primary Objective

To determine whether a marine reserve is a good solution, facilitators and stakeholders must have a marine conservation and/or fisheries management objective. A marine reserve could help populations increase biomass, abundance, and size of individual species (Lester *et al.*, 2009). Marine reserves can also provide ecological benefits to local fisheries and eventual economic benefits that increase their bottom line and local tourism (Sala *et al.*, 2013).

Scale of Biology

Focusing on biological aspects and processes of single or multiple target species (e.g. life history cycle and movement) will help determine if a marine reserve can provide protection. Species grow and mature at different rates and move varying distances across varying habitats as adults and juveniles. For example, damselfishes move approximately 0.1 to 0.5 km, large parrotfishes move 3 to 10 km, and some snappers can move 10 to 100 km (Green *et al.*, 2015). Marine reserves can only provide protection for adults and juveniles while they are within the confines of their ranges. Thus, effective marine reserves should encompass the entire movement of individuals of key species (Gaines *et al.*, 2010; Green *et al.*, 2017). In the decision tree, a small to medium home range is defined to be between 0 to 10 km, and a large home range is defined as greater than 10 km^2 (PISCO, 2016).

Single and multiple target species require consideration of not only the scale of movement but also the multiple habitat types that need protection, local larval production, and recruitment sites. This is important for spillover of adult organisms and dispersal of larvae from marine reserves (Sala *et al.*, 2013). Due to the varying scale of movement of different species, for a reserve to provide protection for all species in the target group, it needs to meet the requirements of the most mobile species.

- ❖ Protecting Key Habitat

Some species have vulnerable life stages that live in different habitats. If the key habitats are separated spatially, then implementing a network of marine reserves may be a more viable option than trying to find create a reserve that encompasses all the key habitats. As species move throughout their life cycle, they may use different habitats (PISCO, 2016). For example, Caribbean spiny lobsters settle as larvae in nearshore areas with hard bottom, seagrass or mangroves and then move to the fore reef after reaching a certain age (Green *et al.*, 2017). If there are threats to survival in these different habitats that could be lessened by a marine reserve, the design of effective marine reserves for such species may depend on adequate habitat representation and replication through the placement of reserves in all key habitats (Gaines *et al.* 2010). In cases where the threats to life stages involve factors that may not benefit from a marine reserve (e.g., polluted runoff from land), other management strategies will be key to a comprehensive solution.

Many studies have shown that species that rely on critical habitat during part of their life cycle can receive positive results from marine reserves (Sadovy & Domeier, 2005; Jones *et al.*, 2007; IUCN-WCPA, 2008; Sale *et al.*, 2010). Critical habitats may include feeding, mating, overwintering grounds and other aggregations sites, as well as corridors between these sites such as migration routes (Green *et al.*, 2013). Assessing the status and distribution of key habitats is an important step to identifying current challenges and potential solutions through marine reserves.

- ❖ Larval Production and Movement

For many species, the most mobile stage of the life cycle is the microscopic larvae that are released into the plankton by spawning females. The scales of larval movements depend on the length of time in the plankton, the behavior of the larvae and the patterns of ocean currents. They can range from hundreds of meters to many hundreds of kilometers for different species. Because larvae are microscopic, they are often not affected by fishing activities as they move across the ocean seascape. Therefore, their movement can provide pathways of connectivity among multiple FRs in a network (Gaines *et al.*, 2010). In addition, even if adults do not move from within a marine reserve, but larvae disperse outside, the marine reserve can seed fished populations beyond its borders (conch reference). Therefore, one goal for the design of a network of marine reserves is vibrant connectivity among reserves and valuable fished sites.

Step 2.

After traversing the decision tree, if facilitators received a management strategy of No Marine Reserve, please continue on to the No Marine Reserve section. If facilitators received the management strategy of a single marine reserve, please refer to that section for next steps. Finally, if the goal is a network of marine reserves, please read through the Single Marine Reserve section first and complement it with the additional Network of Marine Reserves section. A Network of Marine Reserves still relies on well-designed components.

NO MARINE RESERVE

While many marine resource managers turn to implementing marine reserves for conservation and fisheries management, there are limits to the threats that marine reserves can adequately address. Many conservation and fishery management problems need other regulations and policies for effective protection, whether in parallel with marine reserves or as a better alternative to them.

Examples of other fishery management control options as outlined by McDonald *et al*. (2018) are mentioned below. To better grasp how to put these controls in place, what target limits to set, what they protect, and their effectiveness in meeting socioeconomic objectives please visit the Adaptive Fisheries Assessment and Management (AFAM) Toolkit Guidance document.

Catch limit. Sets an upper limit on how many fish can be removed by a fishery over a certain period of time. This can be for an entire fishery or can be allocated as catch shares to individuals or groups of individuals (such as a fisher association).

Bag/trip limit. Limits the number and/or weight of a species that an individual fisher or vessel can take in a single day.

Size limit. Sets minimum and/or maximum bounds on the size of the fish that can be legally caught.

Gear / Vessel Restrictions. Restricts the type, amount, or techniques allowed for a given type of fishing gear used by fishers in a particular fishery (including banning destructive fishing gear such as dynamite, cyanide, and fine mesh nets)

Deployment Limits. Places a cap on the number of gear each fisher can use (such as the number of hooks on a line or fixed traps).

Sex specific controls. Protect reproductively important individuals by setting sex-specific regulations on fishing activity.

Seasonal Closures. The banning of fishing activity during certain seasons to protect vulnerable life history stages.

Protection of ecologically important species. Restrict fishing of specific species to protect key ecological functions.

SINGLE MARINE RESERVE

In the case where a single reserve may meet marine resource management and/or conservation primary objectives, managers, scientists, and/or stakeholders (i.e. marine reserve facilitators) one of the key decisions is the location of the marine reserve. The location will affect the biophysical characteristics of the reserve that affect its expected conservation/fishery benefits. The location also determines how resource-users will be affected by the marine reserve. The intersections between these biological and social variables are key to the impacts, both positive and negative, of the marine reserve. Once designed, motivating marine reserve creation and implementation requires ensuring the proper governance, social, and economic incentives and capacities are in place.

At-a-Glance

This four-phase single marine reserve creation and implementation process utilizes economic, ecological, social, and governance components to facilitate an effective marine reserve creation and implementation process. This process is summarized in the following five steps:

1. Determine best location and size of marine reserve and when it will provide benefits using provided tools.
2. **Phase I**. Engage with the local community and assess their social and leadership structure, determine needs and financial burdens, create trusted relationships, and gather any necessary baseline data needed to determine marine reserve design.
3. **Phase II**. Create the marine reserve through a participatory approach using local knowledge and scientific analyses (using provided tools).
4. **Phase III.** Implement the marine reserve; monitor, surveil, and evaluate it; and apply appropriate financial strategies to overcome short-term costs.
5. **Phase IV**. Provide opportunities to exchange information among communities to determine what worked best. Use adaptive management strategies to overcome governance, economic, social, and ecological gaps or barriers to better address community and scientific needs.

Before approaching communities, facilitators should determine approximate marine reserve location, size, and benefits to effectively meet objectives. This depends upon available and sufficient baseline data on target species or habitats. Valuable baseline data depend on initial objectives, but some examples are abundance, catch, size, effort, density, status of fish stock assessment, and data concerning the health of the target species/habitat. The baseline data will help determine later if the marine reserve is positively influencing the outlined objectives. If a facilitator has ample baseline data, there are a variety of valuable toolkits to inform effective marine reserve designs (see: Tools section pp.45). Then they may proceed with phase I.

If facilitators are data limited, they might use information from similar ecosystems and incorporate local fisher knowledge to protect an area for which little baseline information are available (Johannes, 1998). Local knowledge provides a holistic understanding of the resources. In this case, facilitators should proceed to the engagement phase to gather more baseline data to ensure scientifically-backed benefit predictions. The collection of data should begin as close to the onset of the engagement phase as possible (and permit-able). Then facilitators may use the provided tools to inform a beneficial marine reserve design.

Several studies propose guidelines on how to tailor a marine reserve to meet objective goals (e.g. Kelleher, 1999; PISCO 2016; Uribe *et al.*, 2010; Green *et al.*, 2013). Biophysical design criteria for marine reserves likely to maximize protection and benefits include:

Location

Dependent upon conservation and management goals, marine reserves should be placed in critical habitats, such as spawning and mating grounds, nurseries, feeding areas, areas of high biodiversity, source areas that support species distribution, and/or essential habitats for species protection. To protect or conserve species, the location of the marine reserve should cover an area that provides optimal conditions for the species. When creating marine reserves, facilitators should consider the appropriate habitats for protection of target species (Green *et al*., 2017). When inputting data into marine reserve creation tools, habitat characterization is key for obtaining accurate results (pp. 45). Studies on different target species may better inform facilitators the appropriate habitats to protect for certain species.

Dependent upon where these habitats are and areas where the marine reserve is implemented, this could have varied costs for resource users and enforcement teams. Reserves that are closer to shore may be easier to manage as monitoring and enforcement teams do not have to travel far to protect them or can possibly monitor from shore. Contrastingly, reserves that are far from shore or plain sight, may be more expensive and burdensome to monitor and enforce. When a marine reserve area is determined (phase II) these costs should be considered when strategizing an economic plan for those who may incur the costs.

Additionally, should facilitators find the area for a marine reserve is located in prime fishing grounds, costs to the fishers should be incorporated when suggesting and executing alternate economic strategies (more on this in phase I and phase II).

Size

To achieve objective success, the marine reserve should be large enough to protect target species and considers the effectiveness of other management tools outside of the reserve (NRC, 2001). The optimal marine reserve size for a species depends on what target species/habitat is protected and the size of its home range. Because the survival of species cannot usually be linked to a specific site, a marine reserve should encompass, sustain, and protect a viable number of target species within their boundaries but also allow for spillover outside the marine reserve (Goñi *et al*., 2010; Green *et al.*, 2013). It also must maximize protection for ecologically critical areas and processes (Agardy, 2000). For this reason, the size is influenced by the mobility patterns of the adult target species (Figure 3). Another key aspect is to determine size based upon larval duration in the water column. Species with longer larval dispersal require larger fractions of coastlines (Botsford *et al.* 2001).

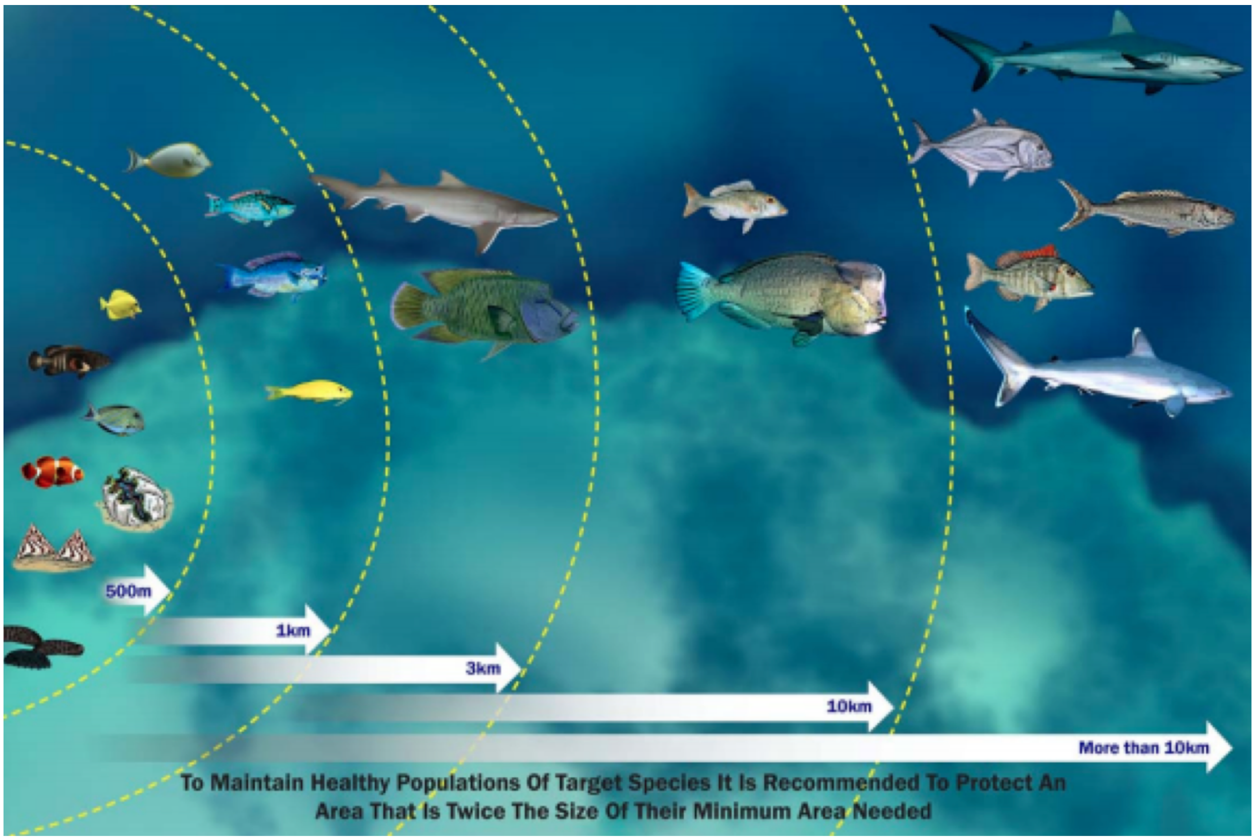

Figure 3. Different species have smaller or larger home ranges and therefore need appropriately sized marine reserves. Source: Green *et al.*, 2013.

Typically, marine reserves are placed within marine protected areas (MPAs) that cover at least 10-20 km^2 (20-40% of habitat) for conservation purposes or enough area to protect critical habitat (Green *et al.* 2013). MPAs are another management tool used to protect natural areas and species through a variety of management measures. Larger marine reserves will enhance ecosystem benefits but may have consequences for fisheries yield as this may reduce spillover (Kramer & Chapman, 1999; Chapman & Kramer, 2000).

Smaller marine reserves (≃0.4km or larger), allow for export of more adults and larvae into fished areas, and are more likely to be implemented by fishery managers (Alcala & Russ, 2006; Jones *et al.*, 2007; Lester *et al.*, 2009) and accepted by host communities. While small reserves do show positive effects, they should not solely be relied upon for conservation and fishery management objectives.

Marine reserves are most useful for fish that characteristically remain in certain areas of the sea and typically restrict themselves to reefs, kelp forests, or other such areas which makes it suitable for protection. Species with home ranges between 0 and 10 km^2 need small to large marine reserves. A small network of reserves will not protect stocks with very high home range (>10km^2). Rather, regulations on catch or size and better management outside a marine reserve is a suitable strategy to attain conservation benefits (PISCO, 2016).

Dependent upon objectives and outside fishery management the size and complexity of a marine reserve will be different.

Time

When creating marine reserves for fisheries it is imperative to note that recovery efforts will span over an extended period of time and fishers should consider alternate sources of income. For over-exploited and rebuilding populations, marine reserves should be in enforced for 20-40 years to have lasting effects and benefits (Green *et al.*, 2013).

It is also important to determine when marine reserves will benefit the target species to implement appropriate, time-efficient financial strategies and provide approximate time-scales to motivate communities and gain their trust.

> To help determine location, size, and time it would take to see benefits, we have included a TOOLS section (pp. 45) that lists several replicable and user-friendly tools that facilitators can use to design these spaces.

While designing the marine reserve prior to engaging the communities may seem top-down, this step is necessary to determine beneficial outcomes from marine reserve implementation. Scientific predictions of conservation or fisheries benefit will help facilitators promote marine reserves to local communities. Then, local communities and facilitators work together in phase II to co-create and finalize designs.

Phase I: Engagement

The engagement phase is a strong driving force in the success of marine reserves. It aims to build relationships and understanding of the social, political, economic, and ecological dynamics surrounding the development of a marine reserve (Suarez-Castillo *et al.*, 2016). In this phase, facilitators will determine and address the needs of the community and provide capacity building and learning opportunities, to gain trust within the communities to better motivate the implementation of marine reserves. Many of the steps and processes in this phase, as in each of the phases, may happen concurrently and components are outlined for readability. Please read through the entire section to better determine the order needed for a specific location.

Governance Component

Acknowledging the need to understand the local and large-scale social, legal, political, and governing context of an area or region is key in the development of any governance approach (Bennet and Dearden, 2014). The process involved in developing, approving, and following informal and formal rules to attain conservation/fishery goals translates into transparency, responsiveness, inclusiveness, and participation among involved parties (Basurto *et al.* 2017; United Nations Educational, Scientific and Cultural Organization, 2017).

Identifying motivations and finding solutions for how resources are used or accessed have resulted in varying institutional and management systems (Carlsson and Berkes, 2005). In this phase, the facilitating organizations and/or government agencies along with fishers and community members should conduct a scoping of existing laws, policies, institutions, and systems, both formal and informal, that govern the target marine resources (Borrini-Feryerabend *et al.*, 2013). This initial acknowledgement of authority (or authorities) who have power and/or responsibilities, and the feedback from participants influences governance approaches (OECD, 2017). This allows for consistency between the development of overarching objectives for marine reserves and expected governance approach used to attain objectives.

If no form of governance system exists, then it is in the interest of all participants to initiate dialogue with respective authorities, users and/or groups, both at a local and national level. Suarez-Castillo *et al.* (2016) recommend representative and participative engagement of stakeholders in the management of fishery resources via a **community committee**. This is to ensure collective and active participation in decision-making to support a good governance structure for marine reserves. While a community committee can be specific to an area, facilitators can help drive and support marine reserve governance based on cross-sectional assessment of local community's formal, informal, and customary laws, processes, and practices. Understanding the legal environment and jurisdictional power of government agencies can help foster an enabling environment for legal and policy mandates (Bennet and Dearden, 2014) that support effective marine reserves.

Social Component

It is important to recognize that not all stakeholders have the same stake or interest in the creation of marine reserve. Therefore, the impact of a marine reserve may vary based on the interaction the stakeholder has with the resource and how closely it impacts their livelihood. For example, the investment and interest of direct resource users such as a fisher will differ from that of indirect resource users, such as an investor (FAO, 2011). This means facilitators should identify key actors to the process. Some questions that help identify who should be included in the design process of a marine reserve are:

1. Who are the various stakeholders related to the fishery resource and marine area?
2. What group/coalition do they belong or can reasonably be associated with?
3. What level of interest (and concerns) do they have in the fishery resource and the marine area?
4. What is the importance and influence that each stakeholder has on the target resources or its management?
5. What are stakeholders' positions towards the conservation of target resources and marine habitats?

Once relevant stakeholders are identified, an assessment of community social structure should be conducted. This should focus on the community's relationship with the target resource to better understand how a marine reserve will impact the local economy and society (FAO, 2011). Below are key characteristics that inform this assessment:

Location. Physical place where the fishers are in relation to the resource and market. Is it a rural or an urban association? This distinction impacts the engagement approach (Ostrom, 2009).

Community History/ Past Experiences. Understanding how people' livelihoods have evolved (FAO, 2011). Past interactions that affect current members' behavior and fishing dynamics (e.g. crisis within the organization or natural disasters) (Ostrom, 2009).

Relevant Actors / Change Agents. Number of members in the community that affect the decision-making process related to the fishers (Ostrom, 2009). Recognition that people within the community can be powerful change agents (Gutiérrez *et al.*, 2010).

Community Needs. Recognizing the different needs of diverse stakeholder groups; recognizing the importance of context (FAO, 2011).

Importance of the Resource. Economic and cultural dependence on the resource to sustain their livelihoods.

Trust and Reciprocity. Trust is a measure of the extent to which members of a community feel confident that other members will live up to their agreements even if doing so may not be in their immediate interest. Reciprocity is a symmetrical response to a previous co-operative or defective action by a member of the community. It also measures trust in the political system and leaders (Ostrom, 2009).

By understanding the above characteristics within the context of fishing communities, it allows for integration of viewpoints and needs when creating a management plan (phase II). This serves as the foundation when approaching communities and formalizing their contribution to the creation process. This is especially helpful when delegating monitoring and management responsibilities. Identifying the communities' capacity for enforcement during the initial phase of engagement can identify the best management plans for a marine reserve (FAO, 2011).

After defining community ties to the target resource, facilitators should then incorporate opportunities for achieving a shared vision for how the target resource and community can benefit from a marine reserve. This requires identifying local power relationships and partnerships and developing relationships with stakeholders (FAO, 2011). Facilitators must establish strong relationships with the community for high participation in community decision making (PISCO, 2016). Below are a few tools to help facilitators establish and engage in relationships with the host communities:

Rapid/participatory rural appraisals (RRA/PRA). RRA or PRA entails gaining local knowledge, information, and insight from local people using a range of interactive tools and methods. These tools and methods are broad, varied and may include secondary data review, workshops, interviews, participatory mapping techniques, diagrams and graphics (FAO, 2011).

Social Mapping. A visualization technique illustrating community relationships and their interrelationships with the natural resources and other features of a particular location. The social map reflects perceptions, attitudes, beliefs, and values among community members. This information can serve as the basis for discussions and future decision-making (FAO, 2011).

Rules-in-Use. Does the association have access to any funding; from whom, when and for what (Ostrom, 2009).

Asset mapping. Mapping information acquisition and dissemination process of a community's important assets. Mapping highlights the interconnections among assets and how to access them. This information can guide planning and decision-making on the location and boundaries of the marine reserve, as well as on issues of access. It could also be used to devise strategies for building assets to sustain and enhance community development (FAO, 2011).

In addition to the methods and tools listed above, Coral Reefs and Livelihood Initiative created capacity building techniques that could be applied to build trusted relationships (FAO, 2011):

Build shared leadership and partnership	Cater to a diversity of skill levels
Understand and match needs of the community	Raise awareness in government and NGOs, and facilitating support
Build innovative capacity and continuing livelihood development	Build the capacity of service providers and create an enabling environment;
Build on existing diversity	Work through local institutions
Build on people's strengths	Cluster support
Enhance existing livelihoods where possible	Build entrepreneurial capacity early target service provision
Develop an adaptive plan for the future	

Such technique should be used to help address equity issues that will inevitably arrive from the implementation of a marine reserve. This is due to several reasons, including the immediate loss of resources and the need for alternative incomes. Capacity building and support will insure the communities' engagement and empowerment (FAO, 2011).

Marine Reserves in the Philippines

The establishment of marine reserves in the Philippines is an example of a successful community-based approach. The process begins with environmental specialists or non-profit organizations understanding fishing community structure by either living with the locals or consistently visiting the community and establishing a presence. Through this process, participatory and scientific surveys of the environment and social conditions are conducted. Formal and informal educational workshops created awareness about the importance of the marine resource. The workshops not only address fishery management tools but also help to establish working relationships to collect baseline data of the fishery and ecological conditions. This participatory scientific method helped to determine best marine reserve location and led to its formal declaration. Figure 4 shows the principles that were used to engage with fishery communities.

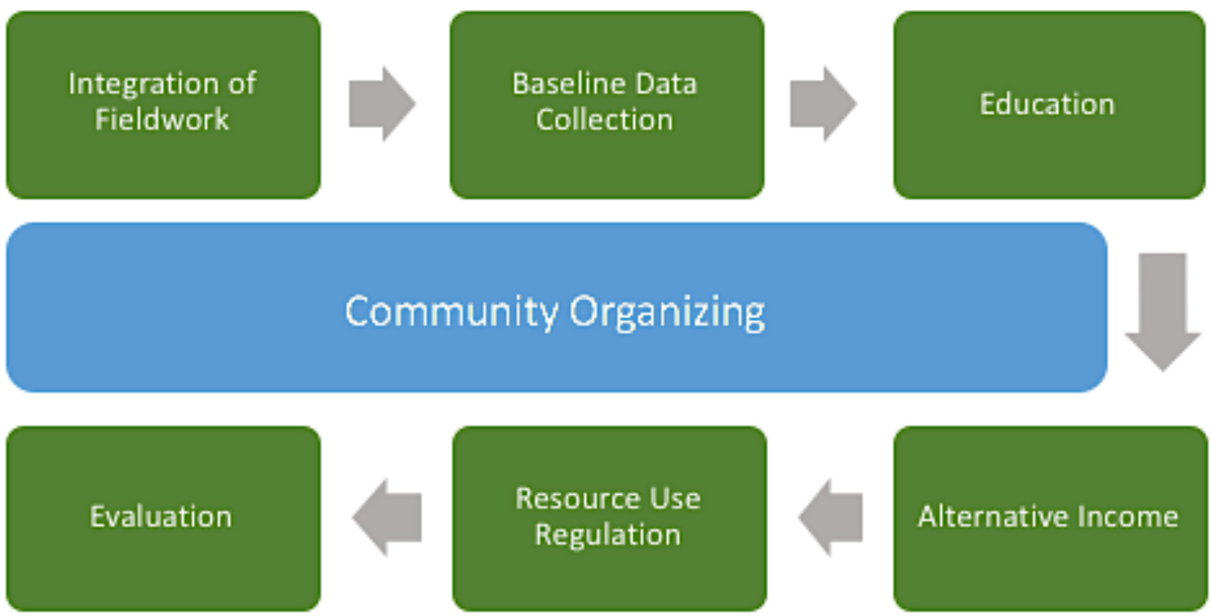

Figure 4. Steps needed for community engagement exemplified in Apo Islands, Philippines.

Sources: White *et al.*, 2002; Christie & White 2007; FAO 2011

Economic Component

During the engagement phase, it is also important to concurrently develop a base understanding of the potential opportunities and challenges for the economic sustainability of a marine reserve within the community that will harbor one. This helps to determine what financial strategies may be most opportune to employ.

Some information needed to build this comprehension requires the collection of certain data that may or may not be available at the beginning of the process, and a qualitative analysis of the structures and systems in place, which can include the value chain of the product (especially the commercial and power relationships between each link) and the sources of income within the community. Below is a summary of key economic determinants important for a facilitator to know about the host community and the target resource.

Fishery Economic Status. Understand the economic status of the fishery. Is catch at the maximum economic yield or near? Is the fishery open access? Knowing the economic status of the fishery will help create a baseline for projections of fishery costs and benefits from a marine reserve. It will also help define fishery objectives and identify handicaps in management (Anderson, 1975; Dichmond *et al*., 2010; Peirson *et al*., 2001). Data and tools: a specific description on data and tools to perform this activity is included in the Tools section (pp.45).

State of Value. Know the value of the product and trade system. How much are fishers getting for the product and why? Knowing the current conditions of quality and sustainability of the product and the local fish trade system can help understanding the price fishers are getting and the opportunities for better prices ahead (Gordon & Cook, 2004; Hadjimichael & Hegland, 2016; Roth & Rosenthal, 2006). Data and tools: (a) conceptual maps of the value chain for the fishery, including the distribution of income (i.e. price at dock, price at wholesaler, retail price, final price in restaurants), and (b) a benchmarking analysis of the sustainability and quality characteristics of the product.

Income and labor. Understand all sources of income for the community. Does this income heavily depend on fishing, or are there alternative and complementary activities? How is labor and revenue distributed across age and gender? Identifying the main sources of income, such as the patterns of labor and revenue distribution, will help identify opportunities and challenges for a more equitable distribution of benefits and costs, and to further propose alternative sources of income (included in the economic strategies, at Chapter III: Creation, page AA) (Allison & Ellis, 2001; Allison & Horemans, 2006; Bennet, 2005; Frocklin *et al*., 2013). Data and tools: (a) information on employment by gender and age, and (b) information on income for the different economic activities, and (c) conceptual maps on labor and income distribution.

Fishing Efficiency. Understand opportunities for costs reduction in the fishery. Is fishing effort too high (i.e. are trips or distance covered too long? Are sites fished too recurrently)? Reducing costs in fishing activities can help buffer the economic loss implied by the creation of marine reserves. Having a collectively organized fishery could help it reach the highest efficiency (Berkes *et al*., 2000; Mantjoro, 1996; Valderrama & Anderson, 2007). Data and tools: (1) mapping of the fishing grounds, (2) data on fishing trips (longitude and time, grounds aimed, catch), and (3) data on costs, especially in fuel.

Ecological Component

If facilitators do not have the appropriate or necessary baseline data to properly assess ideal marine reserve size and location, it is during this phase that they should attain those data as best as possible. Facilitators should engage and involve the local community to participate throughout this process and follow local rules or governance structures when gathering data.

As we move toward the creation phase, some management plans suggest to first form a **core group** of elected representatives from each of the facilitators, stakeholders, managers, decision-makers, fishers, and host communities involved to make this phase as streamline and efficient as possible (Kelleher & Phillips, 1999; Salm *et al.*, 2000; Agardy, 2000; Roberts *et al.,* 2003; White *et al.*, 2006). This core group can then work together to develop a management plan (phase II) for the marine reserve process. Throughout this report, we will refer to this core group to facilitate certain aspects in the phases involved in establishing a marine reserve.

Phase II: Creation

After assessing community dynamics and establishing proper communication and engagement with the host community, the facilitator together with the core group can then shift into the creation phase. The creation phase consists of the on-the-ground creation of the marine reserve using tools (see: tools section), local knowledge, and legislation legalizing its implementation through collaboration among all the participating groups.

Governance Component

The authorities who have power and/or responsibilities within the governing system as well as non-governmental, private sector, and community-based organizations will help shape the governance approach in the creation process. To do this requires knowing and understanding the level of interactions that occur among groups that influence marine reserve effectiveness (Bennet and Dearden, 2014) and improving the existing governance system or transitioning to a more adequate approach.

Interactions can be vertical or horizontal. Vertical interactions occur among individuals or groups within different hierarchical organizational levels (i.e. local, state, national). While horizontal interactions occur among groups within similar organizational levels. The recognition of these interactions will help shape cooperation and coordination among stakeholder groups, particularly as roles and responsibilities are defined according to adopted governance approach. This includes duties in monitoring, enforcement, and surveillance.

The creation of a governance approach is highly dependent on the context and characteristics of the communities and stakeholder groups. Although the top-down, centralized state control approach was once the norm (Basurto *et al.*, 2017), decentralization, shared authority, and co-governance has gained popularity (Kooiman *et al.*, 2008). Below we share governance approaches for managed marine areas around the world.

Governance Approaches from Around the World

Five broad governance approaches from 20 marine protected areas (MPAs) were developed based on how responsibilities and authority were distributed among entities involved in governing the MPA and the incentives used to guide the governance processes (Jones *et al.*, 2013). The approaches are:

1. Management primarily by the government with a clear legal incentive where governance is steered by a well-established legal framework.
2. Management by government with significant decentralization and/or influences from private organizations. This involves power sharing or responsibilities divided between

central government and lower forms of government or government agencies and non-governmental organizations (NGOs).
3. Management primarily by the local communities under collective management arrangements. Community groups have power to self-governance and develop rules for MPA management.
4. Management primarily by the private sector and/or NGOs granted with property/management rights.
5. No clearly recognizable effective governance framework in place.

Each governance approach has implications for marine reserve management and involvement of stakeholders. Jones *et al.* (2013) suggest the integration of institutional diversity and the combination of governance approaches for more effective marine protected areas, which can be applied to marine reserves. In creating a locally or regionally appropriate governance approach, key groups will develop roles and responsibilities and governing rules, monitoring, and surveillance strategies. This phase will create the foundation to conduct diligence with key actors within the state, non-governmental or private sector, and local communities to maintain an effective governance structure for marine reserves.

Ecological and Social Components

When creating a marine reserve and using a bottom up approach, many times initial scientific specifications may not be met because communities may not be willing to set aside such an expansive space (as seen in the Quintana Roo case study pp. 46). However, it is important to note that initial movements towards marine protective actions are starting points to the greater goal and often take time. It is important to nurture the process along without compromising too much of the scientific basis, so resource users feel a tie to the project. If the community, including all user groups, do not feel connected, responsible for, and in need of the marine reserve, the marine reserve will be ineffective (more on this in the implementation phase) (FAO, 2011).

Therefore, through a collective and participatory decision to implement a marine reserve, stakeholders, resource users, host communities, and facilitators must explicitly state and agree upon goals and objectives during the creation phase. By making inclusion a formal objective, it may lead to compromises in marine reserve design but ultimately provide a more sustainable conservation plan (Halpern et al., 2013). Through the integration of knowledge and science, the core group can decide on marine reserve size and location.

Disagreements and conflict will arise in most, if not all, marine reserve creation processes due to several factors including reallocation of resource, divergent views on management practices, access to both ‘inside’ and ‘outside’ of marine reserves, and several other factors (FAO, 2011). Conflicts between stakeholders often lead to marine reserve failure, and cause loss of trust within communities (White *et al.*, 2002). Understanding the source of conflict is important and developing, documenting, and sharing a conflict resolution plan that incorporates both formal and informal cultural processes can reduce intensity of disputes. Conflict resolution plans should be developed with community members and can be written into official marine reserve documentation and formal agreements. If communities do not address social issues, biological goals will likely suffer (FAO, 2011). Public consultation process is one way of bringing all parties to the table to resolve conflicts in an open and comprehensive way (FAO, 2011).

Economic Component

The greatest long-term economic benefits created by a marine reserve arises from the expected improvement of the stocks (Russ *et al.*, 2004; Roberts *et al.*, 2001). A diversity of tools are available to calculate the future benefits from improved stocks near marine reserves (some listed in Tools section pp.45). Depending on the life history characteristics of the focal species (i.e. age at first maturity, fecundity) and the marine reserve design (i.e. size, location), these benefits may take a shorter or longer time to impact the local economy. Accounting for the time-lag in economic benefits will inform a general model that proposes a business case for fishers directly affected by the marine reserve (Sala *et al.*, 2013). In the Tools section of this manual, we incorporate a tool to measure costs and benefits of a marine reserve.

The predicted time it would take to receive direct benefits from a marine reserve should be transparently shared with the host community to better manage expectations. The arrival of these benefits will depend on compliance with marine reserve regulations, which will largely rely on the successfulness of the other economic strategies also described in this phase (incentivizing a marine reserve can also be used in the engagement phase, however, we list it under this phase as the creation of a marine reserve and community assessments will help determine what financial packaging will be best).

Establishing a marine reserve necessitates funding to (1) fill the income gap created by the reduced fishing grounds, (2) develop technical studies necessary to support the creation of the marine reserve, and (3) perform the monitoring and surveillance activities. In Quintana Roo, surveyed fishers stated that this loss, along with logistical expenses for monitoring and surveillance, were the biggest costs of implementing a marine reserve (See Surveys in Appendix). Below we elaborate on five main strategies that can finance a marine reserve, reduce its costs, and enhance benefits (Figure 5). Table 1 lists some economic instruments that could be considered to overcome costs.

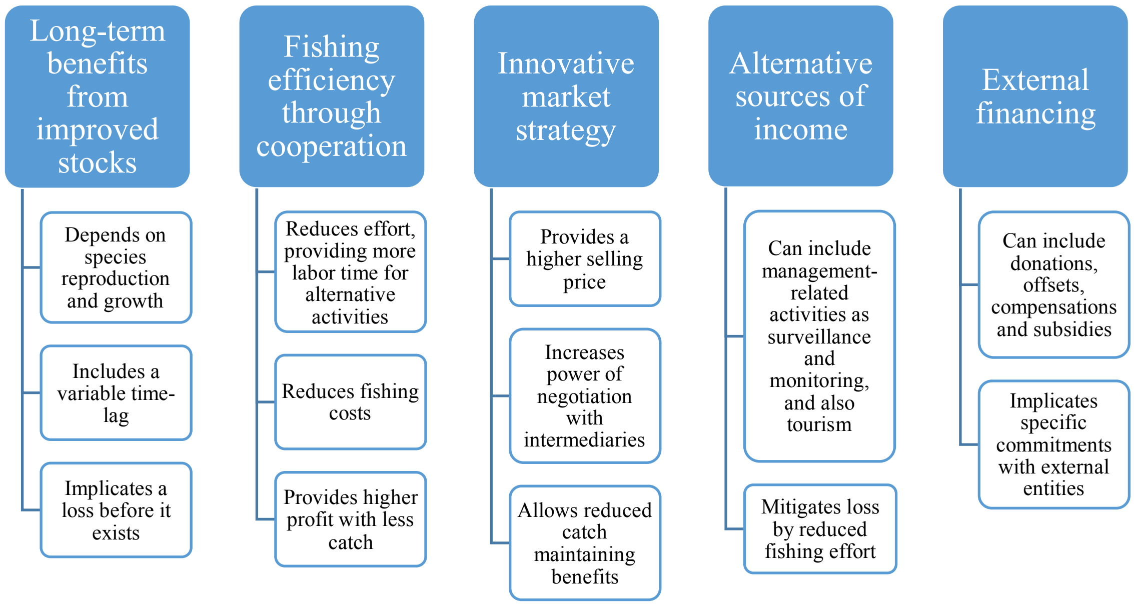

Figure 5. Five main strategies to finance a marine reserve, reduce the costs and losses they create, and enhance the benefits they provide (constructed based on literature cited in text).

Table 1: Description of possible economic instruments for financing marine reserves (adapted from OECD, 2017)

Economic Instrument	Reasoning
Taxes	Generate a tax policy that addresses conservation issues e.g. finance a marine reserve.
User fees (e.g. entrance fees)	Set fee according to the willingness to pay from visitors/recreational users.
Subsidies	To overcome the burden of closures, marine reserves, or gear restriction.
Payment for Ecosystem Services (PES)	Generate a payment system that considers the added value of conservation.
Biodiversity offset	Compensate for significant residual adverse biodiversity impacts arising from project development.
Non-compliance penalties	Facilities (e.g. aquaculture) and fishers that do not comply with regulations should pay penalties that could be used for financing marine reserves.

Fines on damages	According to environmental impact assessments or strategic environmental assessments.
Voluntary agreements (partnerships)	Philanthropy or other partnership that directly pays for the cost of the reserve.

In general, effectively financing conservation in coastal and marine areas is a challenge (OECD, 2017). In fact, the financial burden of achieving targets of conservation is generally overlooked (i.e. conserve 10% of the ocean by 2020 under Conservation on Biology Diversity and Sustainable Development Goals). The Organization for Economic Cooperation and Development's book (2017) on marine protected areas emphasizes the need for more comprehensive and diverse financing portfolios. Below are three other ways facilitators can approach incentivizing the creation and implementation of a marine reserve.

Tourism

Tourism can financially support a marine reserve host-community but can also negatively impact conservation and fishing (Fabinyi, 2008; Lopes *et al.*, 2015). While an increase of recreational activity has been shown to improve communities' economies, it can also create social division and tension (Brondo & Bown, 2011). Before implementing or even proposing tourism as an alternative source of income, it should be assessed for feasibility and desirability. Although our guide does not delve into how to develop touristic activities we gathered some components that should be considered (Hiwasaki, 2006; Reed, 1997; Zapata et al., 2010):

Identifying attractions. Identify which characteristics or elements of the area may attract tourists and characterize where the value lies. Investigate how the touristic market values those attractions. Learn about the attraction itself and compose a body of interpretation about it.

Leveraging existing attractions. Understand the current touristic attractions by learning about the types of tourism active around the area, their benefits and possible impacts. Would they be easy to reach and attract to the area? Is that the type of tourism the local community wishes to attract? Can the local community compete in this market?

Infrastructure, logistics, and capacity. Tourism activities imply basic infrastructure, logistic and technical capacity, including communication, safety, and group handling. While these depend on the type of tourism and activity proposed, it is important to review them, as some activities require specific standards to be met to become a legal service provider.

Increased Efficiency

Fisheries that work within concessions are capable of coordinating and organizing the fishing activity inside their jurisdiction (Deacon *et al.*, 2008). Fishers can increase fishing efficiency by reducing gas consumption by fishing closer to shore, rotating fishing grounds, and concentrating the effort on the most effective fishers (Daw, 2008; FAO, 2002). This last tactic, however, must be analyzed carefully, as it can cause equity issues and oppose collective objectives of organized fishing communities. We detailed these strategies below (Berkes *et al.*, 2000; Deacon *et al.*, 2008; Daw, 2008; FAO, 2002; Mantjoro, 1996; Valderrama & Anderson, 2007):

> *Register catch and share information.* Recording, systematizing, and sharing information about catch, per fishing site, can help the community map the fishing area to identify productive fishing grounds and design a collaborative fishing strategy. It can provide information about variability in abundance and composition of fishing spots, which can help to select the proper gear. Additionally, it can reveal specific features of each site, such as recurrence of juvenile catch during certain times of the year or high probability of gear loss.
>
> *Fishing ground rotation.* Using the information from registered catch, fishers can apply fishing ground rotations. This can include the closure of certain sites when they are least productive or when they show a high occurrence of juvenile catch—directing the effort to the more productive spots.
>
> *Reduce fishing effort through communication and coordination.* Designing a collaborative fishing plan can help the community to avoid excessive pressure on certain fishing spots (i.e. preventing two vessels from deploying gear in them, the same day), which could lead to an increase in efficiency (i.e. higher catch per unit of effort).

The feasibility and applicability of these collective actions will largely depend on the governance and social characteristics of the community involved.

Market Strategy

The creation of a marine reserve is often associated with the idea that they create unique opportunities and conditions for certification in sustainable practices and increase the value of the product. Although it has been argued and tested that eco-labeling and certification can create price premiums for seafood, the distribution and value chain setting for the fishery sector constrains the benefits of the application of sustainable prices mostly to retailers and intermediates (Gudmunsson *et al.*, 2006; Roheim *et al.*, 2011; Hadjimichael & Hegland, 2016).

Strong market strategies must accompany the increased value of the seafood to increase benefits for the fishers. A basic market strategy for small-scale fisheries should at least focus on two points: the adaptation of the product to new market needs, and the management of the distribution chain as a way to enhance negotiation power and reclaim a higher percentage of the final selling price of products (Gordon & Cook, 2004; Jacinto, 2004). The strategy should include these components:

Local system analysis. Characterize and understand the current economic and commercial setting of the local fishing industry. Different settings as co-operatives or patron-client relations pose distinct opportunities and challenges (Basurto *et al.*, 2013). Who owns the fleet and the gear? How are the fishing journeys funded (who pays for gasoline, oil and ice when required) and when (before or after)?

Value chain analysis. Analyzing the components of the distribution chain for the selected product, and how investment and revenue is distributed can help identify opportunities and challenges to get more benefits from fishing (Kitts

& Edwards, 2003; Sapkota *et al.*, 2015). For example, with a couple or only one buyer, long distances from urban areas, and weak logistic capacity, fishers are commonly obligated to sell at a low price. Having a higher and more diverse demand at docks will rely on the product matching the demands of the market. Seafood caught, killed, stored, and handled in an environmentally-friendly way may create opportunities to attract buyers willing to pay a higher price. In some cases, co-operatives have managed to reduce intermediaries and trade its own products collectively, as the case of Tárcoles, in the Central Pacific of Costa Rica (Cofré & Estrada, 2017). However, this strategy requires higher investment, logistic capacity, and knowledge. Recently, some small entrepreneurships have recognized this gap and started working closer to fishing co-operatives and communities, offering better prices for high quality products (Smartfish in Mexico, www.smartfish.com).

Market strategy design. Much of the added value of sustainable fishing practices is not translated into a higher price for the fishers. The origin of this situation can include (1) a deficient communication of the value itself, (2) low quality of the product due to bad handling and storage, and (3) lack of trading opportunities (Ardjosoediro & Neven, 2008; Jacinto & Pomeroy, 2011; Kitts & Edwards, 2003; Roth & Rosenthal, 2006) (Figure 6).

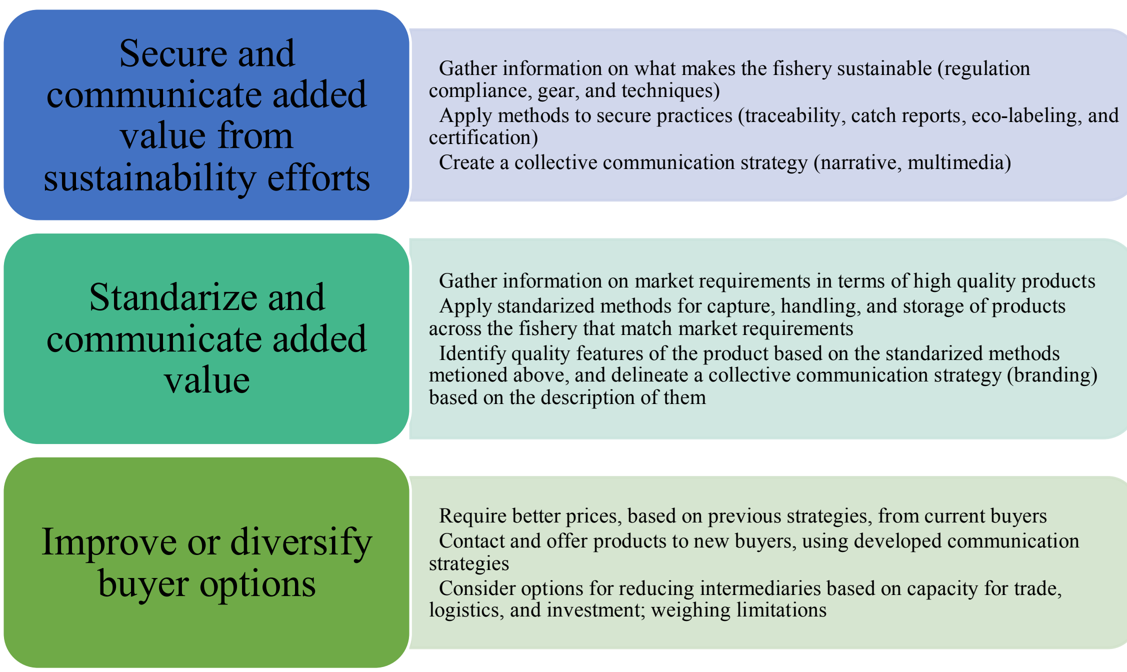

Figure 6. Basic elements of a market strategy design for communities to obtain higher benefits from fishing, based on sustainable practices. The creation of a marine reserve can encourage good practices in fishing, which can be used to gain more benefits from fishing. These strategies should be selected and developed based on their feasibility and fit. Constructed based on literature cited in text.

Phase III: Implementation

Implementation, monitoring, enforcement, evaluation, and management are key to effective marine reserves (Day, 2008).

Governance Component

Well-established governance systems rely on strong legal incentives to facilitate the implementation, enforcement, and ultimate recovery of the marine resources (Jones *et al.*, 2013). Existing principal legislation or policy either can shape the governance system chosen or can be developed and legislated because of the chosen governance approach. This phase is highly dependent on the groups involved in the creation of marine reserve and the established rules surrounding it. As seen in Mexico's case study (pp. 46), successful designation of marine reserves in 2012 links strongly to the identification of local-users and stakeholders and their participation in both the engagement and creation phases. Their participation and ownership of the marine reserve process contributes to good governance.

Diligent monitoring, enforcement, and surveillance of marine reserves will ensure compliance of regulations. This phase heavily relies on coordination among key agencies who have legal mandate (Suarez-Castillo *et al.*, 2016) and stakeholder groups to conduct effective enforcement of marine reserves.

Ecological Component

Continual monitoring and evaluation of the area are necessary to determine the success or failure of the marine reserve as suggested by other management guides (Kelleher and Phillips, 1999; Salm *et al.*, 2000; White *et al*., 2006). The core group can designate certain entities responsible for continual data collection and analysis of target species. For this step, the facilitator will need to implement a schedule of when data collection will take place and at what frequency. Involving nearby institutions or relevant government entities is useful throughout this process.

Kelleher and Phillips (1999) suggest facilitators and scientists (or an evaluation team) sustain a productive relationship through common support for the initial goals and objectives of the project, mutual understanding of respective pressures, long-term commitment to the process, and communication on information and progress reports on the monitoring and research status. Once reports and analysis are available, the core group can adapt management strategies to ensure continual success of the marine reserve. Adaptive management is covered further in the learning and enhancement phase.

Social and Economic Component

The implementation phase also consists of designing enforcement methods with community input to facilitate compliance. One example is creating identifiable boundaries for a marine reserve, such as landmarks both on and off shore, or lines of latitude and longitude that are within range of enforcement bodies (PISCO, 2016). This makes the marine reserve boundaries easily understood by user-groups. If there are private, state, or federal funds to ensure the compliance of a marine reserve, co-operative members can be trained, participate, and get paid for in monitoring activities (Velez *et al.*, 2014). Where government support lacks, communities can create village watch groups in conjunction with local police to regularly surveil the area and penalize offenders (specific to each country and dependent on capacity). Again, incentivizing marine reserves motivates self-surveillance, which may be the most likely option in many cases.

Additionally, the effectiveness of a marine reserve is increased when resource user rights are developed with respect to existing formal and informal community rules (Fiske, 1992). Rules should be tailored to specific local, social, and environmental norms. Capacity building that promotes self-governance among communities can reinforce higher level institutions and shared leadership of management interventions (Christie *et al.*, 2003; Cudney-Bueno & Basurto 2009; Gutierrez *et al.*, 2010) Below are elements that have a positive effect on marine reserve implementation:

Monitoring. Monitor the environmental performance of the marine reserve. Make research and monitoring participatory and share results (Ostrom, 2009).

Rules and Regulations. Help implement objectives and management decisions and should be established within the overall legal framework. The developing and interpreting of rules and regulations generally requires legal professionals and should involve stakeholders as well. Reinforced by governance. (FAO,2011)

Compliance & Enforcement. Enforcement will support compliance with marine reserve rules and regulations. Enforcement includes a variety of measures ranging from self-enforcement to more technical solutions (FAO, 2011).

Available Technology. What means do resource users have to regulate and enforce marine reserves. Identify infrastructure and fisher gear availability (Ostrom, 2009).

Sanctions. Are there sanctions for those who do not comply? Who enforces sanctions? Sanctions should fit the offense to reinforce marine reserve protection (Ostrom, 2009).

Access to Support Funding. Degree by which fishers use the same harvesting technology (Ostrom, 2009).

We include here a series proposed indicators and type of data to be gathered during this phase. It is crucial that the information is recorded at the very beginning of the implementation process.

Economic Strategy	**Objective**	**Indicators**
Fishing Efficiency Through Cooperation	Evaluate the increase in the fishery's efficiency	Fishing effort, catch, seasonality and fishing cost, per fishing spot

Innovative Marketing Strategy	Evaluate the increase in the product's value and revenue	Number and diversity of buyers, number and diversity of commercial channels, selling price
Alternative Sources of Income	Evaluate the increase in alternative income sources and labor opportunities	Number and diversity of jobs in the community, mean salary per activity, number and diversity of local businesses
External Financing	Evaluate the increase in financing sources and the successful coverage of the Marine Reserve's implementation costs	Total budget, budget per financing source, implementation costs covered by activity

Phase IV: Learning and Enhancement

The learning and enhancement phase is comprised of additional capacity building practices that can reinforce the success of a marine reserve. Stakeholders and groups involved in marine reserve creation must come together via collaborative learning platforms to share lessons learned and successes. This includes introducing and providing conflict resolution mechanics, adaptive management strategies, ensuring economic practices offset losses, and deriving a mechanism to improve the governance approach (FAO, 2011). This is important particularly as systems evolve — shaping the decision-making processes (Borrini-Feyerabend and Hill, 2015) and ultimately the laws, systems, and institutions surrounding marine reserves.

Ecological component

During this phase, facilitators should enlist the support of the evaluation team to adapt management strategies to mirror environmental needs. Adaptive management promotes a cyclical management system through the testing of previous assumptions made during the initial marine reserve design — it is learning by doing (Borrini-Feryerabend *et al.*, 2013).

Through the assessment of results, the evaluation team can work with the core group to revise and improve current management practices. One way to do this is using the MAREA tool to assess marine reserve progress (pp.45). This includes analyzing all ecological, economic, and social goals and objectives and adapting to political, social, governance, and economic shifts within the country.

Governance and Social Components

The ongoing review of governance systems will help make adjustments where needed and create a space for learning. However, this is dependent on an ongoing participatory process and creating a learning attitude for all involved (Young, 2010).

An adaptive management plan also includes appropriately responding to climate change and further resource degradation (FAO, 2003). Below is a list of additional learning and enhancement elements that can aid in the sustainability of a marine reserve.

Co-Management. Provide a way to share the management burden between government and local communities or users. *Effective adaptive management.* Using past experiences and adapting decisions and practices accordingly, marine reserve management can be improved (FAO, 2011).
Social Capital. Degree by which one or several individuals can draw upon or rely on others for support or assistance in times of need (Ostrom, 2009).
Conflict-resolution mechanisms. Conflicts between stakeholders may arise, and mechanisms must be in place from the beginning to deal with this eventuality. Appropriate solutions are context-specific and should be culturally relevant (FAO, 2011).

Marine Reserves in the Philippines
Implementation and Learning and Enhancement Phase: Once the marine reserve is passed by governmental institutions, the marine reserve is usually enforced by the community members who were part of the engagement and creation processes. These groups are governmentally supported and known as bantay dagat (sea guardian) groups. As the marine reserve is implemented, the development of alternative livelihood activities is created. This includes workshops such as consumer co-operatives, livestock-rearing, and ecotourism development. Additionally, some of the marine reserves are monitored by scientists and community members alike; this oversight has been used to validate what is achievable by marine reserves. This process has been replicated throughout the Philippines, in over a hundred locations. Sources: White *et al.*, 2002; Christie & White, 2007; FAO 2011

Economic Component

Finally, economic strategies should be updated and reviewed to determine the success of the implemented economic strategies.

- Who is bearing the costs?
- Are fishers perceiving or gaining benefits, and from where?
- Which economic strategies were more successful and why?

The review of the host community finances might give light to the benefits that the community has received during the process. An analysis of the profit per unit of fishing effort could be a simple way to assess the success of strategies focused on efficiency and market strategies. And perception-based surveys can help shed light on model accomplishments and challenges.

Here is a review of some suggested questions to be addressed during the evaluation process, in regard to implemented economic strategies.

Economic Strategy	**Questions**
Fishing Efficiency Through Cooperation	Has the fishery's efficiency (profit-cost relation) increased? Have fishing grounds been characterized? Is the proper information being recorded and shared? Are sensitive grounds and species being protected seasonally? Are fishing grounds being taken advantage of when most productive? Is fishing being performed coordinately?
Innovative Marketing Strategy	Has the selling price of the product increased? Are there more and more diverse buyers and commercial channels for the product? Has the value of the product increased? Is the value from quality and sustainability being properly communicated through the value chain?
Alternative Sources of Income	Has mean income increased? Has diversity of sources of income increased in the community? Have new and different businesses arisen?
External Financing	What is the general budget for the implementation of the Marine Reserve? Are all implementation activities being financed properly? Have sources of financing increased or diversified?

NETWORK OF MARINE RESERVES

When creating a network of marine reserves, facilitators must treat each individual reserve as a single reserve throughout the process. Meaning, each identified reserve placement will require facilitators to engage with different user-groups of that specific area and perhaps even different legal framework. Please refer to the Single Marine reserve section for the bulk of the four-phase process. The main differences in approaching the creation of a network as opposed to a single marine reserve are detailed in the phases below. Our intention is that you add these steps to the phase and components above.

First facilitators need to determine placement of each of the marine reserves (Alvarez-Romero *et al*., 2018). This requires determining ideal biophysical parameters of the marine reserves (also mentioned in single marine reserve) and mapping connectivity. The tools (in TOOL section) may also help the facilitator determine these parameters. Effective marine reserves will need a case by case evaluation and proper monitoring programs to avoid creating false expectations of what can be a potentially valuable management tool.

Location

For species that require multiple marine reserves, or a network, marine reserves should be located in critical habitat in the different life history stages of the species. For example, one marine reserve protects spawning grounds while another protects nursery areas, and another provides protection for feeding or habitat grounds for that (those) species. Friedlander *et al.* (2003) find that "ecologically relevant habitats include leeward forereefs (associated with banks and islands), patch reefs (banks and islands), gorgonian beds (banks and islands), shallow sea grass (<3 m depth) ..., deep sea grass, mangroves, reef crest (banks and islands), windward forereefs (banks and islands), and other lagoonal basin formations (banks and islands). "

Connectivity

Networks of marine reserves have the greatest chance of including all species, life stages, and ecological linkages if they encompass representative portions of all ecologically relevant habitat types (Ballantine, 1997; Friedlander & Parish, 1998; Murray *et al.*, 1999).

Connectivity refers to the transfer of individuals among reserves. It influences the degree to which adult, juvenile, and larval movements are connected and requires spatial planning of suitable marine reserve locations that will harbor and protect focal species life history stages (Margules and Pressey, 2000). By protecting multiple life history stages, facilitators ensure the birth of a new generation of target species. Should the movement of individuals into another marine reserve be negatively influenced by fishing efforts, facilitators should consider creating a seasonal closure for migrating species. Moreover, networks should ensure that sufficient larvae are being exchanged between reserves to ensure that those populations will persist into the future (Hastings & Botsford, 2003; Almany *et al.*, 2009).

If connectivity patterns are unknown but currents are known, strong, and consistent, then a greater number of protected areas should be place on the upstream end of the management area (IUCN, 2008; McLeod *et al.*, 2009; Shanks, 2009).

After determining where and how many marine reserves to implement, facilitators should internally assess their capacity and ability to reach out to each of the communities or resource-users. If the facilitator does not have the capacity to implement all of the marine reserves, the facilitator should seek the support and funding from other agencies/organizations to ensure success of the entire process. Then proceed to phase I.

Phase I: Engagement

Once the network of marine reserves is mapped out, facilitators should try to implement all marine reserves at the same time, if possible, to ensure connectivity, benefits, and success of the network.

Social Component

Ultimately, the social components of a single and network of marine reserves are similar, with the exception of scaling up the number of stakeholders involved (FAO, 2011). This also means creating economic incentives to each of the communities directly affected by the implementation of a marine reserve within a network. This is especially true when marine reserves are not directly tied to fisheries benefits but are used for conserving regional ecosystems (i.e. protecting spawning grounds that are not a part of the fishery).

Economic Component

While the primary inherent benefit of a network of marine reserves depends on the success of the network as a whole, most of the efforts to overcome costs and enhance benefits of the marine reserves fall under local competences. There are some special features that networks provide that could help enhance these local processes.

> *Collective sustainability efforts.* Sustainability efforts can be shared between fishing communities (co-operatives) to save money and time. An example could be a fishery that applies for MSC certification that shares costs and efforts among participating co-operatives throughout the process. This, however, depends on how similarly the co-operatives work (fish), and their ability to cooperate (Basurto *et al*., 2013; Foley & McCay, 2014; Perez-Ramirez *et al*., 2012a; Velez *et al*., 2014).
>
> *Collective market strategies.* Different co-operatives can join in collective market strategies to sell their products at a higher price and can create a strong brand for their products. This strategy better markets their product to gain more profit (Cofre & Estrada, 2017; Kitts & Edwards, 2003).
>
> *Access to funding and technical assistance*. In the same way, organized co-operatives can build stronger projects and proposals to seek funding and get technical assistance (Moreno *et al*., 2016). When communities work together to multiply their impact, they have stronger institutional influence to push the processes needed to accomplish their goals.

Phase II: Creation

Economic Component

Most of the content in this section is already outline in the *Phase II: Creation Single Marine Reserve* section. All financial strategies analyzed are applicable to a network of marine reserves, as each individual marine reserve within a network is developed needing individualistic packaging. While the benefits of the network of marine reserves are healthier fisheries or regional ecosystems, this depends on the success of the network as a whole. Most of the efforts to overcome costs and enhance benefits of the network fall under local competences.

Ecological Component

In this particular phase, if too much of the science is compromised in each marine reserve creation process, then the network function can begin to fall apart. Facilitators should ensure that the network will still provide regional benefits by measuring the benefits of the agreed upon location and size for each of the marine reserves and ensure regional benefits.

Phase III: Implementation

Economic Component

For a network of marine reserves, implementation remains one of the most challenging parts because if an individual marine reserve is not monitored and/or surveilled properly then other communities will be affected due to the connectivity of the marine reserves. For this reason, it is important that individual reserves can provide local benefits to its users, so the users remain engaged throughout the process.

For the marine reserves that do not provide local benefits (i.e. spawning grounds of fish stocks not relevant for the local fishery), the financial packaging or quid pro quo options become paramount to offer to those communities. If communities receive benefits and compensation for their efforts, it may enhance the likelihood the marine reserve will be successfully managed.

Phase IV: Learning and Enhancement

A network of marine reserves requires a slightly different application of the implementation phase as the success of the parts will affect the success of the whole. Workshops, conferences, and assemblies serve to create connection and form relationships. Educating the resource-users about the importance of a network and how each marine reserve impacts one another is a key for success.

Efficient communication between evaluation teams allows for quick changes or adaptations to management plans to ensure the success of the network.

MARINE RESERVES IN QUINTANA ROO, MEXICO

Mexican laws govern use, management, and protection of marine resources. These laws include the General Law of Ecological Equilibrium and Environmental Protection (Ley General del Equilibrio Ecologico y la Proteccion al Ambiente, LGEEPA), General Law for Sustainable Fisheries and Aquaculture (Ley General de Pesca y Acuacultura Sustentable, LGPAS), and General Law of Wildlife (Ley General de Vida Silvestre, LGVS). Under the listed legislations falls the "normas" which are regulations detailing fishery laws (Gobierno Mexico, 2017). In 2012, the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (Secretaria de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, SAGARPA) enacted the NOM-049-SAG / PESC-2014 which determines the procedure to establish refuge zones for fishery resources in waters of federal jurisdiction of the United Mexican States (Raziel Villegas, pers. comm.). Through the NOM 049, local cooperatives gained legal authority from the Mexican government to propose, designate, and implement marine reserves as a fisheries management tool.

In the Quintana Roo State of Mexico, fishing co-operatives are holders of fishing concessions along the barrier reef and within protected areas and are integral to the development of the fishing industry (Velez *et al.* 2014; Sosa-Cordero, 2011). Most co-operatives in Mexico adhere to similar rules and limited-entry mechanisms (Velez *et al.* 2014).

Civil society organizations (CSO), government agencies, and non-governmental organizations invest in capacity building and science-based monitoring to provide support the co-operatives (Espinosa-Romero *et al.,* 2017). In fact, in 2011, the Kanan Kay Alliance (Alliance) was created to systemize and coordinate regional efforts in Quintana Roo, Mexico to establish marine reserves. The Alliance unifies fishing co-operatives, non-governmental organizations, governmental agencies, and funders. Their ultimate goal is to establish an effective network of marine reserves to protect 20% of the territorial waters of the State of Quintana Roo for the recovery of artisanal fisheries and the conservation of the Mesoamerican Reef. Most of the marine reserves established in the region are within concession areas. But this is not always the case in other parts of Mexico.

The Alliance serves as a strong example of a multi-stakeholder approach to designing a marine reserve. Its structure, functions, and operating principles can be drawn upon for other initiatives that aim to create marine reserves through a bottom-up approach (Moreno *et al.*, 2016). The Alliance made resource-users an integral part of the marine reserve design process because human-environmental interaction is a key part of ecosystem management (Fulton *et al.*, 2013).

The Alliance has served as a platform to access the funds needed to perform various tasks during the creation and implementation of marine reserves. Surveyed funding institutions stated that the amount of resources being directed to the Quintana Roo area have significantly increased because of the implementation of marine reserves and the work of the Alliance. Funds have been used to develop the technical studies that support the creation of the marine reserves for governmental paperwork. Some funding are used to run capacity building workshops that train the fishers on scientific methods for biological monitoring, and also to finance the monitoring activities, paying involved fishers a stipend to compensate for the lost hours of fishing, and covering logistics.

Within the Alliance, stakeholders interact in several ways including a bi-annual general assembly meetings and intermittent capacity workshops. Throughout the year representatives from each stakeholder group meet to discuss these five main lines of strategy:

1. Design and **establish marine reserves**.
2. Advocate for a **legal framework** that controls and conducts surveillance of marine reserves.
3. Develop **socio-economic** solutions that support coastal communities.
4. Provide **capacity building** workshops to increase the livelihoods of coastal communities.
5. Promote **communication** through consolidation of the network of marine reserves and other tools to implement sustainable fisheries management.

- Concrete initial objectives
- Clear function and purpose
- Open and flexible model with continuous inclusion of new participants
- Transparent communication
- Open, friendly, direct, and constructive communication
- Continuous follow-up on agreements made during assemblies
- Professional facilitation for the assembly
- Gradual redefining of
- goals
- Shared leadership; path and rhythm dictated by the fishers
- Ownership of the initiative by the fishers
- Committed fishers and strong leaders
- Capable institutions willing to help the fishing communities

Through participatory meetings with the members of the cooperatives, areas of concessions were suggested by fishers as potential marine reserves. These areas were assessed for their suitability and counterproposals were suggested if necessary. The areas were then marked by GPS and reviewed within technical studies to present to the government agencies for review (Fulton *et al*., 2013). The Alliance has identified key factors that lead to a successful network of marine reserves (Moreno *et al.*, 2016).

<u>Identified Gaps</u>

In the summer of 2017, we conducted field-work in some of the Quintana Roo fishing communities (Castagnino *et al.*, 2018 in prep). To assess the impacts of marine reserves in the hosting communities and their concessions, we interviewed 38 fishers from six cooperatives, including SCPP Banco Chinchorro, SCPP Langosteros del Caribe, SCPP Andres Quintana Roo, SCPP Cozumel, SCPP Jose Maria Ascorra and SCPP Vigia Chico. Using a scale from -10 (extremely negative) to 10 (extremely positive), zero being neutral. We asked for perceived ecological, social/governance, and economic impacts of the marine reserves. The results showed that marine reserves had significant positive ecological impacts across all the cooperatives. However, regarding social/governance and economic impacts, there was less consistency in the impacts, with higher variability across cooperatives (the average answers ranged from close to zero, to highly positive, but there were negative answers in both components).

We also applied a web-based survey to 14 NGOs and 4 Funders, to assess their perceived impacts of marine reserves, using the same scale. Again, there was consistency across all organizations regarding the highly positive impacts of marine reserves on the ecosystem. However, there was inconsistency regarding the social and economic impacts of marine reserves on their organizations, with answers ranging from neutral to extremely positive.

These surveys were developed and conducted to better understand how the different stakeholders of the Alliance perceive the process, costs, and benefits of marine reserves. The possible reasons for some inconsistencies are based on the level of success in the application of some of the strategies described throughout the present manual, the enabling characteristics of each cooperative, and/or the specific experience and historical background of the communities. Some of the most important gaps in financing sources have been identified around surveillance activities, which in most of the cases have to be performed by fishers (based on survey results). This effect is particularly important in the case of the larger and farther marine reserves.

Through personal communication with Mexican Caribbean lobster fishermen, we learned that the six cooperatives from Banco Chinchorro and Sian Ka'an Biosphere Reserves gathered in a federation to get their lobster fisheries certified by the Marine Stewardship Council (MSC) (with financial support from the World Wildlife Fund). However, fishers could not gain a higher price for their newly certified product as new market opportunities were not explored. So, after the cycle of certification concluded, the cooperatives decided not to renew because the certification maintenance is too costly.

While often considered as a strong competitive advantage, MSC certification requires a high investment for small-scale fisheries and does not automatically produce benefits for the local economy (Pérez-Ramirez *et al.*, 2012b). To capitalize the environmental value secured through the certification, additional marketing strategies should be applied, allowing access to markets that are willing to pay a higher price for the certification.

Finally, some alternative sources of income are present in communities of the area, mainly related with tourism. However, they are not related to the marine reserves and are only present in the ones that already had a developed industry before their creation. The feasibility and desirability of tourism should be assessed in the different communities before engaging in the activity.

Another identified gap was the costs and benefits were not projected, nor the time frame in which they would arrive has been described (Moreno *et al.,* 2016; Velez *et al*., 2014). This is primarily because of a lack in the data required to perform such analyses. Some of the tools compiled in this report, for example the TURF Reserve Toolkit, could help perform this task and provide a profit curve over time. With that information, economic constraints and needs could be more easily identified by the hosting communities, and more appropriate and effective strategies could be designed and implemented.

Another tool developed for this manual, was a bio-economic model to assess cost and benefits associated to the creation of marine reserve. The model is simple but requires minimum information about the local fishery. Data such as length data of landings of the target species (in this case lobster) are needed to determine the status of the fishery and fishing mortality rates. Additionally, density data will show how lobster are distributed in the area of interest. And finally, specific parameters such as movement rate for the species and intrinsic growth rate of the specie in the region. Using these tools could improve the design of the marine reserve in Quintana Roo by maximizing ecological and economic benefits and also understanding what are going to be the cost and when is it expected to see benefits, in order to develop a financial plan accordingly.

In this area of study, some of the fishing co-operatives are more than four decades old, and already work in coordination, sharing information and applying internal systems to motivate and secure compliance with current regulations. These collaborative systems, supported by strong governance, create huge opportunities for fishing efficiency (Basurto *et al.*, 2013; Berkes *et al.,* 2000; Mantjoro, 2008; Perez-Ramirez, 2012a). However, more data on the distribution of catch and effort have to be systematized and used for the development of collaborative fishing strategies if cooperatives are to take advantage of this feature.

TOOLS

For almost any combination of marine reserve phases and components, there are existing tools developed by fisheries management and marine conservation experts to achieve optimal marine reserve goals. These tools encompass various inputs and outcomes. For example, the Adaptive Fisheries Assessment and Management (AFAM) Toolkit evaluates target species stock status, uses scientific criterion to create a marine reserve, and can be used during the engagement and/or creation phases, depending on availability of data and reception of resource-users.

Table #. List of available tools to use throughout this process. We outline what the tools are, how they are useful, and the data they require.

Tool	Developer	Website	Applicable Phase
1. Adaptive Fisheries Assessment and Management (AFAM) Toolkit	Sustainable Fisheries Group	https://sfg-csb.shinyapps.io/afam-dashboard/	Engagement, Creation
2. TURFReserve Toolkit	Sustainable Fisheries Group/Fish Forever	http://sfg.msi.ucsb.edu/share/tools	Engagement, Creation, Implementation
3. Marine Reserve Evaluation Application (MAREA-TurfEffect Tool)	Villasenor *et al.* 2018	https://github.com/turfeffect/MAREA	Implementation, Learning & Enhancement
4. MPA Management Effectiveness Assessment Tool (MPA MEAT)	National Coral Triangle Initiative Coordinating Committee. 2011	http://www.coraltriangleinitiative.org	Engagement, Creation, Learning & Enhancement
5. Integrated Valuation of Ecosystem Services and Tradeoffs (INVEST)	Natural Capital	https://www.naturalcapitalproject.org/invest/	Engagement, Creation, Implementation, Learning & Enhancement
6. MARXAN	MARXAN Conservation Solutions	Marxan.org	Engagement, Creation, Implementation, Learning & Enhancement

7. Socio-economic Assessment Tool	Rosales, 2018		Creation, Implementation, Learning & Enhancement
8. Sea Sketch	Marine Science Institute, University of California	https://www.seasketch.org/about/	Engagement, Creation, Implementation, Learning & Enhancement

Adaptive Fisheries Assessment and Management (AFAM) Toolkit

The AFAM tool estimates the status of a fishery, helps implement fisheries management strategies, evaluates those strategies, and makes adjustment accordingly (McDonald *et al.* 2018). It uses an eight (8)-step process:

Step 1 - Determine Assessment and Management Tier. A data inventory is done using a tier system based on what are available. Tier 1 is < 1 year of data, Tier 2 =1 year of data; Tier 3 is 2 or more years of data.

Step 2 - Determine appropriate fisheries management controls. Managers have the option to choose from a list of existing Fisheries Management Controls (FMC).

Step 3 - Select performance indicators, reference points, and assessment methods. Each Tiers have options for indicators. It is recommended to use multiple indicators for each data stream. For each indicator, select a target reference point and a limit reference point. For each performance indicators, choose appropriate assessment method.

Step 4 - Define harvest control rules. These HCR are used to adjust the Fisheries Management Controls based on where fishery performance indicators fall relative to their reference points.

Step 5 - Perform assessment methods. AFAM has a HTML based dashboard that allows users to upload data and conduct performance assessment.

Step 6 - Interpret assessment results.

Step 7 - Adjust fisheries management controls using defined harvest control rules.

Step 8 - Complete your fishery management plan.

<u>Why is it useful?</u>

Although the AFAM Toolkit focuses on assessing and managing fisheries, certain steps in the process can help facilitators determine the status of the fisheries of interest. Step 3 of the AFAM process, can be used to choose an appropriate method to assess status of stock. This step provides a variety of models to estimate fishing mortality, spawning potential ratio, trends over time, biomass ratio and density ratio. Include models: catch curve model, mean length, bounded mean length mortality estimator, length-based spawning potential ratio, Froese sustainability indicators, trend analyses, mean weight, coral-reef thresholds, fished: unfished density ratio, and no-take zone catch curve. By obtaining the fishing mortality output of these models, facilitators can determine status of fish stock.

<u>Data Needed</u>

To use Step 3 and corresponding models, minimum data required include qualitative characterization of the fishery (including local history, gear types, target species, fishing locations, fishing seasons), TURF and Reserve size and location (if applicable), list of prioritized species for management, list of prioritized goals for management, and estimated vulnerability of prioritized target species. Recommended data include landings, effort, and CPUE of key target species; length composition data of key target species; fished: unfished density ratio and coral reef thresholds; household survey data on community knowledge, attitude, interpersonal communication, and practices relating to fisheries management; household survey data on the impact fisheries management is having on the community; information on violations to the no-take zone and violations of TURF regulations; and qualitative information on the community's preparedness for implementing fisheries management and associated barriers.

TurfReserve Toolkit

This toolkit is comprised of the following tools:

Fisheries Landscape Assessment and Global Setting

TurfReserve Design Survey

Marine Reserve Evaluation Tool (MaRET)

TurfReserve Tool (Oyanedel *et al.*, 2015)

Fisheries Landscape Assessment and Global Setting

This tool sets objectives for reserves, assesses risk to the ecosystem, and prioritizes species and habitat for protection and management. Although this tool targets establishing Turf-Reserves, it can help facilitators of marine reserves choose target species and goals.

<u>Why is it useful?</u>

FLAGS is useful if facilitators do not have enough background information on the communities and resource-users. It provides an opportunity to engage the community in setting goals for target species taking into consideration the reality on the ground.

<u>Data Needed</u>

Data needed for this tool includes stakeholder participation for local knowledge on species, habitat, and threats.

TurfReserve Design Survey

This tool is a research- and survey-based resource assessment from the perspective of local users It integrates local knowledge with scientific technical expertise to provide guidance in designing the TURF-Reserve. It gathers information on coastal environment, resources, and people via interviews, community-drawn maps, diagrams, habitat assessments, and secondary data. Thus, providing site-specific data that feed directly into the TURF-Reserve design process.

<u>Why is it useful?</u>

This survey design is useful in obtaining more defined information of the site – including people and marine resources, particularly when data is not readily available.

<u>Data Needed</u>

The data needed include stakeholders' knowledge; on-site visual surveys (coral, seagrass, mangroves) for coastal habitat health, condition, and structure, and secondary data (previously collected, reported, published). Specific templates of surveys are available at the tool's website.

Marine Reserve Evaluation Tool (MARET)

This tool is used to evaluate the reserve side of TURF-reserves. It gathers information on existing marine reserve(s) to assist and promote informed decision-making for TURF-Reserve design at a Fish Forever site. It uses a scoring system to evaluate the biophysical, governance, non-fishing impacts, and performance attributes for a thriving and successful marine reserve. The outputs of MARET serve as inputs for the TURF-Reserve Design Tool.

<u>Why is it useful?</u>

This is a quick and systematic way to obtain a snapshot status of an existing marine reserve that will be combined with a TURF design. Even if that is not the case, MARET can easily be used by technical staff of facilitating organizations to obtain a preliminary evaluation of the status of the marine reserve.

<u>Data Needed</u>

Since this is specific to existing marine reserves that will be part of a TurfReserve design, data includes the FLAGS and TurfReserve Design Survey results, existing zoning maps, management plans, and secondary data.

TurfReserve Tool

This tool is a decision support tool that incorporates species and habitat information to create TURF-Reserve design options. It uses an excel-based model that analyzes and weighs tradeoffs among reserve designs – comparing fishery abundance, harvest, and fisher profits. This tool uses biological, economic, and spatial information that comes primarily from the TURF-Reserve Design Survey and the TURF-Reserve species selection, as well as secondary sources where needed. This design tool provides explicit and transparent technical guidance on some of the key biological and socio-economic tradeoffs associated with proposed TURF-Reserve design options. The more accurate and specific the data, the more representative of the community conditions the trade-off analysis will be.

<u>Why is it useful?</u>

This tool is adequate for data limited areas where there is interest to manage marine resources. It heavily relies on habitat characterization of the areas, target species life history parameters and other fishery specific information.

<u>Data Needed</u>

Data for this tool are obtained from TURF-Reserve design survey, FLAGS Toolkit, existing zoning maps and/or management plans, and any other secondary data readily available. The community maps featuring habitat characterization or the same ones in FLAGS or MARET, will be transposed into a 10 by 10 grid to further develop a spatial habitat characterization and highlight areas of interest such as fishing and spawning grounds, among others. Other data required is the list of target species for the TURF; biological data such as home range, intrinsic growth rate, and species preferred habitat type; economic data such as price of target species and cost of fishing for target species; qualitative status of the fish population in important habitats; primary gear; illegal fishing; and qualitative trend estimates. Other recommended data includes life history data collected from local studies and scientific literature.

Marine Reserve Evaluation Application (MAREA-TurfEffect Tool)

This tool uses a framework that evaluates effectiveness of no-take reserves by considering biophysical, socioeconomic, and governance indicators (Villasenor-Derbez *et al*., 2018). It uses an online application that automates the necessary analyses to evaluate the no-take reserves. The outputs are easy-to-interpret, color-coded scores for each indicator as well as an overall score of the reserve. It also generates a technical report that includes graphs and regression tables containing coefficients of the fitted models.

Why is it useful?

This tool is useful to evaluate existing marine reserves. The biological underwater data needed to run this tool are mainly richness and abundance data and does not require more specific data collection information (for example, species morphometric data).

Data Needed

Biophysical data include an underwater visual survey, species, size, size class, counts, including richness and abundance. Species-specific allometric growth parameters, trophic levels, and size at maturity can be obtained from literature. Socioeconomic data includes regional landings and average annual price per kilo for each species. Governance data can be obtained from perception-based survey data administered to fishers and community leaders.

MPA Management Effectiveness Assessment Tool (MPA MEAT)

This tool was developed for the Philippines marine protected areas to assess governance in terms of enforcement, implementation, and maintenance (National Coral Triangle Initiative Coordinating Committee, 2011). It measures MPA effectiveness using an objective evaluation-based tool. It uses scoring and certain threshold governance processes that help evaluate management effectiveness outputs and outcome. This tool uses a sequential level system where each level of the MPA MEAT have criteria and activities that needs to be satisfied. For each level, there are governance thresholds such as management plan, patrol and surveillance, funding, and ecological and socioeconomic impact assessments. In each level, a score or governance level is given. The minimum threshold scores should be satisfied to pass the level.

Why is it useful?

This tool is practical and can be done by assisted self-evaluation or by using key informant interviews. The scoring system can be used to identify overall effort placed in to MPA management as well as identify and incorporate activities that will help in effective management. Although this tool is specific to MPA, its scoring and indicator system can be adapted to marine reserves.

Data Needed

Data to input into the tools are collected via community perception surveys and the MPA Management Effectiveness Assessment Tool survey form.

Integrated Valuation of Ecosystem Services and Tradeoffs (INVEST)

Natural Capital developed INVEST using iterative engagement with stakeholders to aid in decision-making (Sharp *et al.*, 2016). INVEST is an open-source software model used to map and value ecosystems goods and services. The model assesses tradeoffs with alternative management choices and identify areas where investment in natural environment can enhance human development and conservation. It explores how changes in ecosystems can translate to changes in benefits to people by quantifying and valuing ecosystem services. INVEST incorporates various models that can quantify, map and value the benefits provided by marine systems.

Why is it useful?

In this tool, the decision-making is completed via consultations that include policy makers, communities, and conservation groups. Stakeholders may query about services provided by the seascape and how new programs, policies, or laws will affect the services in the future. Additionally, stakeholders have the opportunity to develop “management scenarios” and explore changes in marine resources and ecosystem service values by using biophysical and economic models that produce several outputs. InVEST can estimate the amount and value of ecosystem services that are provided on the current landscape or under future scenarios.

Data Needed

The data used by InVEST includes maps, biophysical data (species, landscape, region), monetary estimates based on existing literature, and population size.

MARXAN

MARXAN is a decision-support tool for systematic conservation planning (Ardron *et al.*, 2010). It is widely used in designing marine and terrestrial reserves as well as evaluating the performance of existing reserve systems. This tool has been used globally to identify areas that achieve conservation goals at minimal costs and meet spatial requirements while including data on ecological processes, threats, and conditions. MARXAN is able to produce various options to meet socio-economic and conservation objectives.

Why is it useful?

MARXAN uses an integrated and systematic approach in reserve design and conservation planning. Reserve designs in MARXAN are based on specific goals, current and future threats and priorities, and alternative management options to make adequate decisions. This tool relies on accurate scientific information to project costs and benefits of alternative decision options.

Data Needed

Data includes maps of human uses; threats; land tenure; and best available ecological, socio-economic, and cultural data. The data type includes fishing areas, developed areas, leases or tenure areas, habitat types, and distribution of biodiversity. Data acquisition, quality, preparation, and management is the responsibility of the user.

SOCIO-ECONOMIC ASSESSMENT TOOL (SEAT)

SEAT was developed for the Philippines' MPA's and to compliment MPA Effectiveness Assessment Tool (MEAT). It assesses the socio-economic benefits MPA's provide to communities surrounding it by use of indicators. SEAT methods are simple and user-friendly, and entails a survey implemented among MPA managers. SEAT uses two sets of indicators, the input indicators refers to financial inputs provided by government units for MPA and the output indicators refers to socio-economic indicators that enhance financial, human and social capital.

Why is it useful?

The indicators were developed based on data available in the Philippines, thus does not require robust in-depth data-intensive surveys. The financial inputs by governing authority includes various interventions such as budgets allocated for MPA management, revenues generate by MPA, MPA trust fund, business plans, incentive and disincentive schemes. The outputs indicators rely on human-wellbeing and includes income, employment, health status, knowledge, cultural values, social groups, funding for social groups, social interactions, and community leaders.

Data Needed

The data gathering is done by key informant interviews with MPA managers for input indicators and survey instruments to MPA users and wider community to obtain information for output indicators. Based on responses, a score is given for each indicator and thus, the MPA is evaluated for socio-economic impacts (Rosales, 2018).

SEA SKETCH

Sea Sketch is a marine spatial planning tool developed by the McClintock Lab at the Marine Science Institute at University of California Santa Barbara. This tool provides analytics and reporting based on sketch attributes, including data layers for area of importance and/or use. Sea Sketch can provide tradeoff analysis of designs based on ecological and fishing values and can incorporate other models like MARXAN and Invest (https://www.seasketch.org/about/).

Why is it useful?

Sea Sketch uses an iterative process, based on stakeholder input, to make science-based decision-making. Provide reports, spatial maps, tradeoff graphs, and cumulative impact analysis.

Data Needed

This tool uses spatial data, community mapping, stakeholder local knowledge, species abundance data, fishing areas and/or other social, economic or scientific data. Sea Sketch team tailors their services based on project goals and objectives of stakeholders.

CLIMATE CHANGE IMPACTS

In the face of climate change, marine reserve placement and location is a critical factor for species recovery. Climate change will likely impact species by decreasing their populations; pushing them deeper and/or more poleward; and change their physiology, development rates, reproduction, behavior and survival (Brander, 2010; Nye *et al.*, 2009; Cheung *et al.*, 2010; Alvarez-Romero *et al.*, 2018). While changes will not be dramatic for some species, facilitators should keep future migrations in mind when creating stationary protected areas. Additionally, climate change may inflate the time lag between when the marine reserves are established and when facilitators/fisheries will see benefits. For this reason, the economic component necessary for fisheries must not solely rely on the marine reserve but also other business measures that will enhance their bottom line.

Studies have shown, however, that areas with high biodiversity show more resilience against climate change (McLeod *et al.*, 2009; Bernhardt & Leslie, 2013; Roberts *et al.*, 2017). Therefore, implementing marine reserves that enhance local ecosystems can offer support to the reef as the environment changes, dependent on the size and success of the reserve(s). Marine protected areas that are no-take, well-enforced, well established (> 10 years old), large (>100km), and isolated have shown the greatest conservation benefits and their effectiveness in mitigating climate change impacts will be highly contingent on these factors (Edgar *et al.*, 2014). When larger reserves are not possible or necessary, a smaller network of reserves, in addition to other management tools may help against climate change influences (Roberts *et al.*, 2017).

CONCLUDING REMARKS

In all, marine reserves have the potential to be beneficial for both conservation and fisheries management. Facilitators should first employ the correct conservation tool for a specific conservation/fishery objective, whether that be no marine reserve, a single marine reserve, a network of marine reserves, or any of the above with added outside regulations. To make this decision, facilitators must have knowledge of the biological characteristics of the species in need of protection including their home range and critical habitat. Next, facilitators must protect areas of critical habitat proportional to the species home range and percentage of the total habitat. Adequate protection ensures success and benefits from the marine reserve.

Once the location of the marine reserve(s) are determined, facilitators must engage resource-users in the area needed. Their participation and engagement throughout the creation process helps to ensure proper enforcement and surveillance throughout the implementation phase. Important components to address are the strength of the governance and social system within the community or among the resource-users and the creation of an economic incentives that buffer the temporary losses experienced in the first few years from a new marine reserve.

Each of these steps and components are equally important in the implementation of marine reserves. While many facilitators tend to focus on the biological and biophysical parameters required for creation of marine reserves, neglecting the people directly affected and economically impacted by the marine reserves will result in an unsuccessful marine reserve.

Lastly, keeping communication lines open between facilitators and resource-users throughout the process and beyond is imperative to maintain trust and keep resource-users engaged. After the implementation process, facilitators must follow through with economic plans and check that resource-users are being compensated for their willingness to participate and comply with marine reserve regulations. They must also ensure the management plan is adapted to address gaps, design changes, enforcement mechanisms, and social stability.

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