The Nature Conservancy

Fishing *for* Solutions

A Fisheries Management Guidebook for Non-Fisheries Managers

Jeremy Rude

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—Jeremy Rude, Fisheries Specialist, Global Marine Team

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Emily Matthews
Editing

Arnaud Ghelfi
Design and Layout

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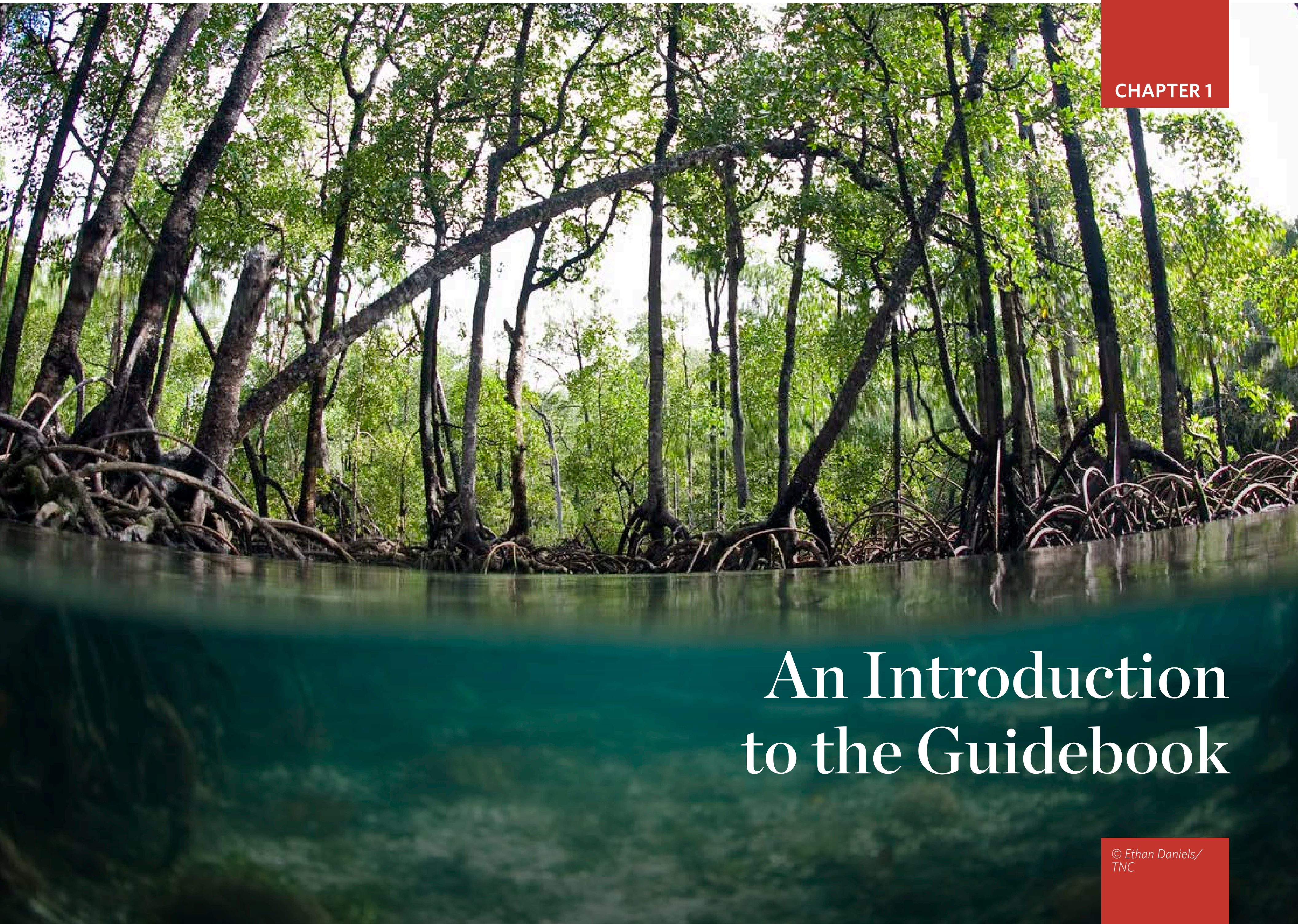

CHAPTER 1

An Introduction to the Guidebook

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CHAPTER 1

An Introduction to the Guidebook

Managers of coastal ecosystems and fisheries have not always seen eye to eye. From the point of view of the marine conservationist, the fishing industry may sometimes seem like an unwelcome giant vacuum cleaner in the ocean. To the fisheries manager, the conservationist's urge to protect a particular species of fish or coral may seem like an exasperating and naïve objection in the face of vital economic and social interests. But the interests of conservation and fisheries managers are overlapping and merging in ways that would have seemed impossible only a few decades ago.

The goal of fisheries management is to provide immediate benefits to society without compromising the long-term health of fish stocks. This goal has proven increasingly difficult to achieve for a number of different reasons. Above all, there is the inherent conflict between short-term social and economic needs for food and income, and the need for long-term sustainability. This conflict has grown over time, with rising demand for fish and fish products, and technological advances that increase pressure on fisheries and ecosystems. Attempts to overcome this conflict are hampered by scientific uncertainty, poor management practices, failure to include stakeholders in the management process, insufficient capacity within management agencies, and poor coordination between fishery managers and conservation practitioners, among others.[1]

The goal of marine conservation is somewhat broader: to protect the long-term health of all marine species and ecosystems by limiting human-caused damage and restoring degraded marine ecosystems. To achieve this goal, marine conservationists rely on a combination of scientific principles derived from marine biology, oceanography, and fisheries science, as well as the tools of economics and marine policy. The challenge of bridging multiple disciplines and applying policy or practices to

1. Cochrane and Garcia, 2009

wide geographic areas can be daunting. The challenge is made still harder by an ocean that has little regard for geopolitical boundaries, where the impacts generated by one country are often felt by many others.

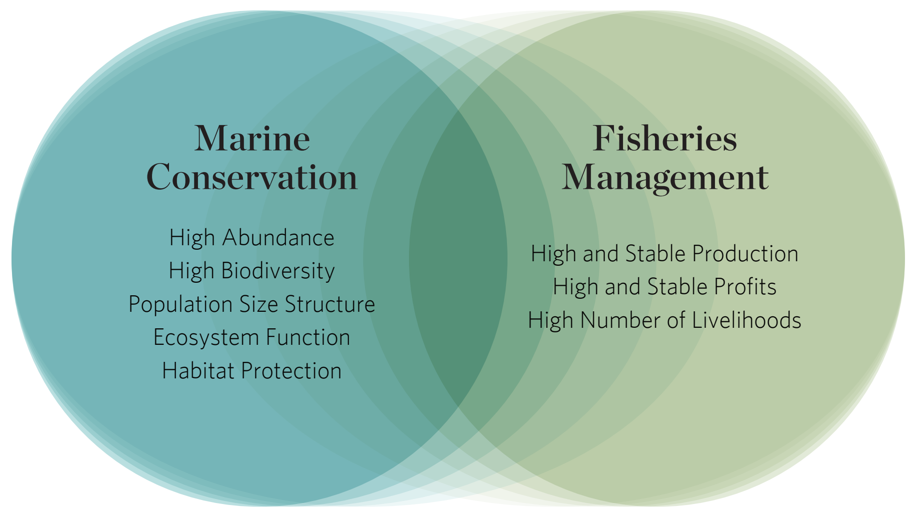
While fishery managers and marine conservationists may seem at odds with one another, biodiversity and food production objectives can be reconciled by using a combination of diverse management and conservation policies tailored to local social and ecological contexts. Marine conservation practitioners are increasingly realizing the importance of conserving seascapes that are sources of livelihoods and food security, while fisheries managers are recognizing the role of biodiversity and ecosystem dynamics in achieving economically and ecologically sustainable fisheries[2] (Figure 1).

This guidebook is designed to help conservationists improve the management of marine resources by providing a broad overview of the different components that collectively make up fisheries management. It offers insights into how fisheries management can assist marine conservation practitioners in achieving their objectives, and illustrates how conservation practitioners can integrate fisheries management into marine conservation strategies. Additionally, the guide provides suggestions on how to overcome some of the particular issues that can make the alignment of marine conservation and fisheries management goals so problematic.

There is rarely a single person who performs the functions of a "fisheries manager." Rather, the tasks of data gathering, analysis and synthesis, formulating advice, and making and implementing decisions are delegated to specialists within sub-departments of government. But fisheries managers are not only government specialists—the responsibilities of fisheries management are often formally shared between government and other stakeholders.[3] This division of responsibility can represent an opportunity for inclusive decision-making and shared benefits. In the absence of a strong governance capacity, individuals from related marine conservation disciplines, such as marine spatial planners, coral reef managers, and marine protected area (MPA) managers, often play key roles in fisheries management.

The guidebook is therefore aimed at a broad audience of environmental managers and is intended to be a practical guide to those wishing to integrate elements of fisheries management into their work. While much of the information and guidance presented in this guidebook is appropriate to fisheries around the world, its focus is on subsistence, artisanal, and industrial fisheries in the developing world, where resources and capacity in fisheries management are often lacking. We have focused on marine capture fisheries, although much of the information is also relevant to freshwater capture fisheries.

FIGURE 1. Fishery and Marine Conservation Objectives: Traditionally Different but Increasingly Overlapping

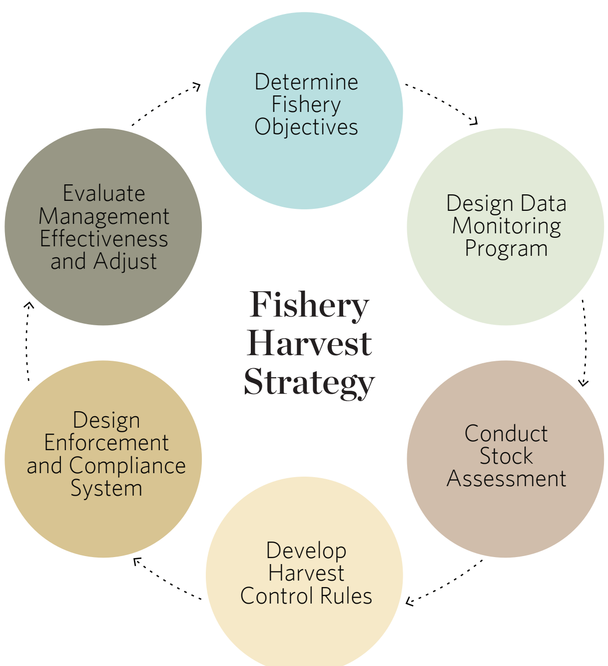


Source: Adapted from Salomon et al., 2011.

2. *Salomon et al., 2011*
3. *Cochrane and Garcia, 2009*

We present a broad overview of the different components that collectively make up a fishery harvest strategy, illustrate how conservation practitioners can integrate each of these components into their marine conservation strategies, offer suggestions on how to overcome some of the challenges in fisheries management, and point individuals in the right direction to find more detailed information. This guidebook is not designed to go into great technical and operational detail on specific management functions or tasks, which often involve formal training or, at the very least, would require a larger set of handbooks. Instead, we are trying to provide an introductory view of topics that need to be considered when engaging in fisheries management, and suggest how they can be integrated into broader marine conservation.

FIGURE 2. The Components and Iterative Process of a Fishery Harvest Strategy



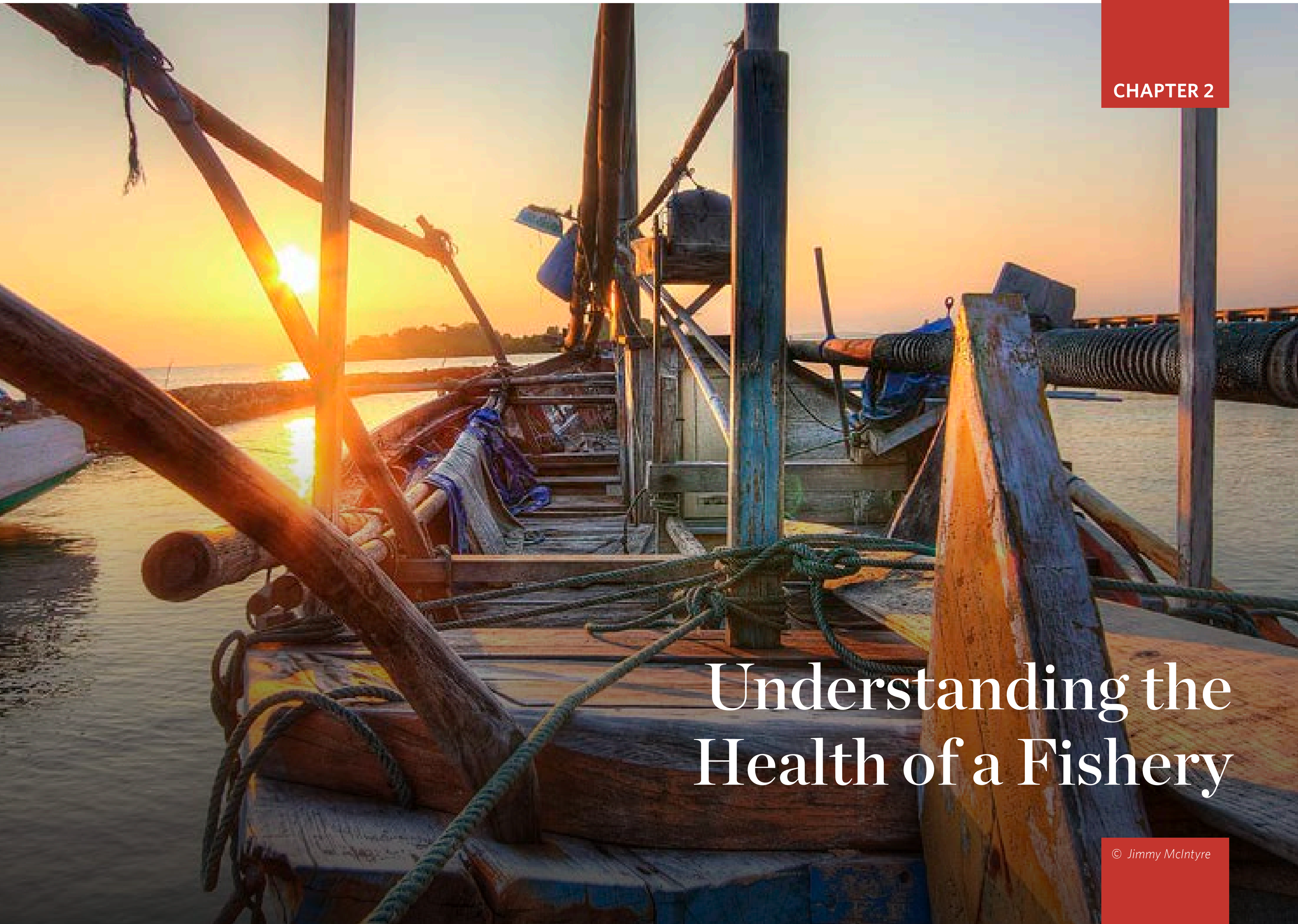
Fishing boats in Ancon, Peru.

© William Chilton/ TNC

Different organizations and agencies around the world may describe the concepts of fisheries management using different terminology and language, so it's best to clarify what we mean by a harvest strategy. We define a harvest strategy as the combination of data monitoring, stock assessment, harvest control rules, and enforcement and compliance mechanisms that work together to achieve the biological, ecological, economic, and social objectives of the fishery (Figure 2).

Chapters 2 through 4 describe the core components of fisheries management: data collection, stock assessment, harvest control rules, and enforcement. Chapter 5 covers approaches to improving fisheries management through engagement with seafood supply chains. We conclude, in Chapter 6, by highlighting a few promising trends in fisheries management that may help conservation managers to bridge the divide between fisheries and marine conservation and achieve complementary objectives.

CHAPTER 2



Understanding the Health of a Fishery

© *Jimmy McIntyre*

CHAPTER 2

Understanding the Health of a Fishery

Background

Data collection and stock assessments are the foundation of fisheries management and the hard work of undertaking them is a critical step in ensuring the long-term health of a fishery. Why are they so important? Consider for a moment that a fishery is like a bank account that provides no information on the current balance, or on the interest rate it pays. The woman who owns this account gives everyone in her large family an ATM card; each family member then rushes to the ATM to make withdrawals without ever getting a balance overview. The account holder tries to record how much her relatives are withdrawing, but this isn't easy because the ATM is far away, the bank sends her no statements, and her relatives don't inform her when they make their withdrawals. Without information on how much money is being withdrawn from her account, it's impossible for her to keep track of her balance.

Is your fishery like this woman's bank account; does it lack data collection and a stock assessment? You're not alone. Unfortunately, the majority of the world's fisheries lack the information that is needed to determine the health of the stock. This situation leads to poor management and in many cases allows overfishing to continue. Indeed, the business management adage, "you can't manage what you don't measure" is particularly appropriate to fisheries. Traditional stock assessment methods developed with temperate fisheries in mind are complex, expensive, and require large amounts of data and capacity. Fortunately, fisheries scientists have come a long way in developing and applying simpler and cheaper ways to assess the health of a stock. This chapter covers the basics of:

- Data collection and data-limited stock assessment techniques and their usefulness to conservation practitioners
- Selecting an appropriate data collection program and stock assessment method
- Challenges in data collection and stock assessments
- Emerging strategies for progress

Data collection

Collecting and accurately interpreting fishery data is fundamentally important to our understanding of the dynamics and status of fished species. The data we use to assess the health of the stock can be categorized as either fishery-dependent or fishery-independent. Both types of data are needed to gain an understanding of changes occurring in a fishery.

Fishery-dependent data are obtained from the fishing process itself and are collected through market surveys, interviews, port surveys, vessel-monitoring systems, onboard observers, and other methods. These data may include information on the composition of the catch (the targeted species as well as bycatch), the weight of fish caught, the fishing effort used (e.g., number of trips, engine size, hours with nets in water, etc.), the length of the individual fish caught, and life history attributes of the species. Fishery-independent data are derived from research surveys and are separate from fishing activities. Research surveys employ scientists to take samples of the targeted species throughout their potential range using traps, nets, acoustics, and video to get an unbiased view of the condition of the fishery. Other fishery-independent data are gathered through visual census surveys done with SCUBA and snorkel gear. Survey data may provide an index of fish abundance, information about size, age, and maturity of the fish in the stock, and information on habitat.[4]

Each of the monitoring methods described above can yield a range of data and information, from a basic understanding of how the fishery operates to biological information and data that lead to an understanding of the stock status (Table 1).

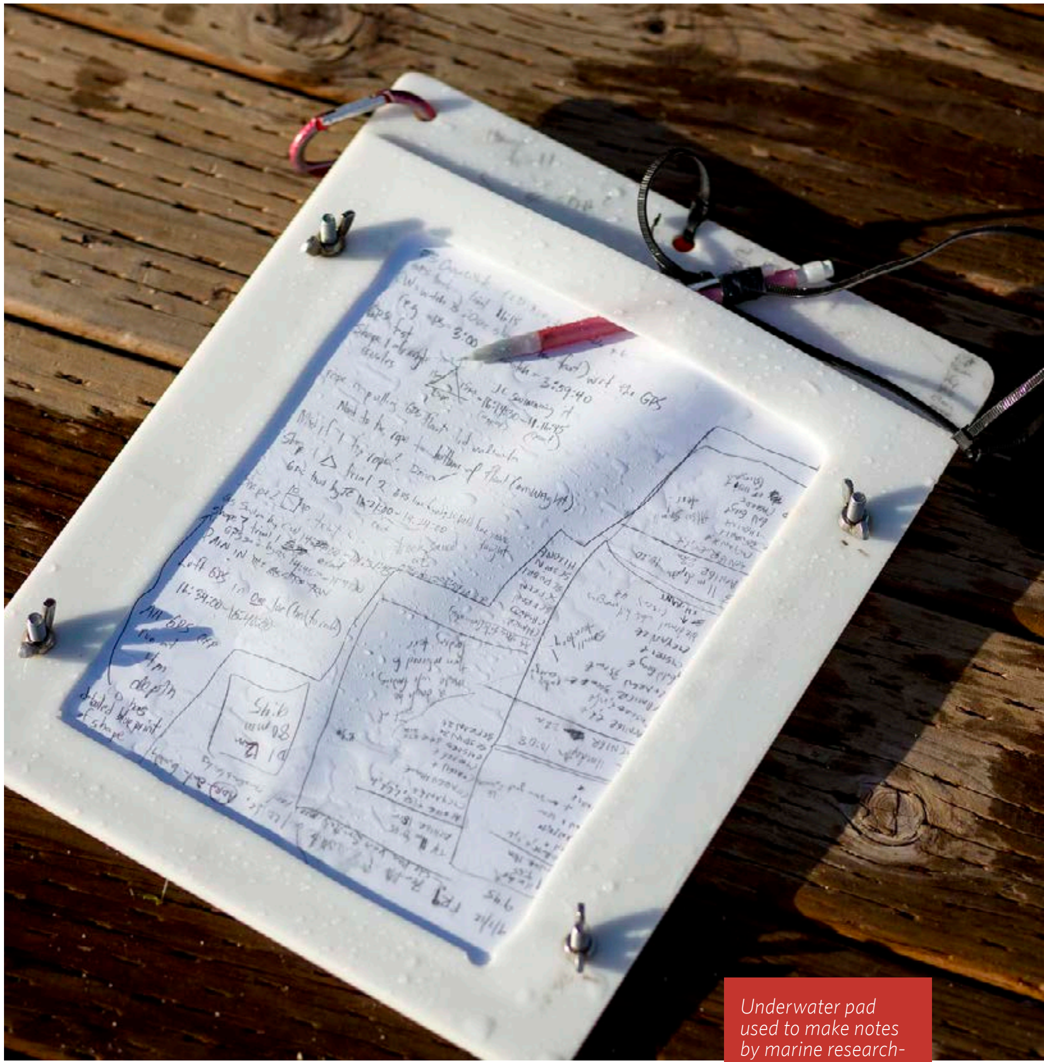
Stock assessments

A stock assessment uses fishery-dependent and fishery-independent data to detect changes in the condition of fish stocks over time. Such changes may trigger a management response, aimed at meeting one or more target objectives of the fishery.

4. *Cooper, 2006*

For example, if managers assess a stock and detect that too many juvenile fish are being harvested, leaving the stock with a low reproductive potential, managers can use this information to set limits on the size of the fish being caught.

To assess the status of a fishery, we use fishery-dependent and -independent data to create performance indicators and



Underwater pad used to make notes by marine researchers at Palmyra Atoll.

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TABLE 1. Types and Characteristics of Data Monitoring Methods

Monitoring Method	Description	Potential Data	Limitations	Cost	Required Capacity
Market Surveys	An individual travels to relevant fisheries markets to make note of characteristics of the catch	Species composition, size data, maturity/reproductive state, sex ratios, temporal changes in catch characteristics	• May be difficult if markets are numerous and spatially disaggregated • Data may not be representative of the stock	Low	Low
Interviews	An individual interviews fishers/traders wherever appropriate (e.g., docks, beach, restaurants, home) about fishery characteristics and trends	Nature of operations, target/key species, key habitat/fishing grounds, drivers behind historical changes, size composition, information sharing/competition, behavioral drivers, location, supply chain	• Usually provides only anecdotal information, not quantitative • Usually only broad level of detail	Low	Low
Port Monitoring	Trained enumerators (fishers, traders, or government officials) spend their days at the dock to observe and record key information on the catch	Landed catch, species composition, size data, maturity/reproductive state, sex ratios, temporal changes in catch characteristics, effort in terms of trip duration, fishing location	• May be difficult if ports are numerous and spatially disaggregated • Data may not be representative of the stock • Potential for misreporting	Low-Medium	Low-Medium
Fishery-independent Surveys	Practitioners or fishers are trained to regularly or irregularly conduct surveys within the fishery boundaries. Information on stock status is obtained. Usually requires a boat and/or underwater survey gear	Biomass estimates by time and space, size data, maturity/reproductive state, sex ratios, density ratio within and outside of reserves	• Provides no fishery-dependent data • May be difficult to obtain representative coverage	Medium	Medium
Automated Information Gathering	Electronic monitoring units (e.g., VMS,[a] AIS,[b] cameras) are placed on all boats in the fleet to track fishers' location. Information is received at a control center via satellite and stored in a server. Can be linked to enforcement and surveillance efforts	Distance traveled, processing and handling time, discarding, validation and verification, selective size harvesting	• High amount of post-processing time with cameras • Equipment can be very expensive • Requires database infrastructure and capability	Medium-High	High
Logbooks	Fishers/companies record information on catch via electronic or paper logbooks, which are aggregated into a single database	Across-fleet catch by species, by time and space, across-fleet effort by time and space, size data, discarding, gear type	• Requires database infrastructure and capability • Potential for misreporting	Medium-High	High
Observers	Trained observers accompany the fleet on trips to record information on catch and fishing behavior	Catch, effort, spatial information, size data, maturity/reproductive state, sex ratios, discarding, distance traveled, species composition, processing and handling time, validation and verification, selective size harvesting	• Usually very expensive • Potential for operator error • Likely only partial coverage of fleet	High	High

a. Vessel Monitoring Systems: a satellite-based monitoring system that provides authorities with the location, course, and speed of vessels around the world
b. Automatic Identification Systems: a Very High Frequency (VHF) radio broadcasting system that enables AIS-equipped vessels and shore-based stations to send and receive identifying information
Source: Adapted from Dowling et al. (In press)

reference points that tell us how well the fishery is doing relative to a target (see Figure 3). Performance indicators are measures of some attribute of the fishery, including:

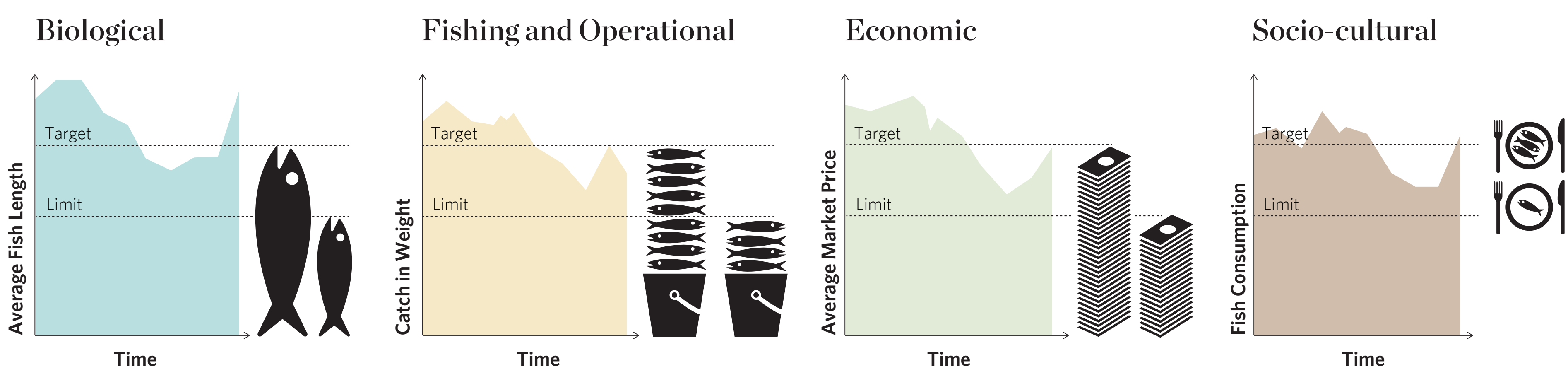
- Proxy indicators for biomass (e.g., catch-per-unit-effort or density estimates) and fishing mortality (e.g., length composition of the catch)
- Quantitative and qualitative empirical indicators (e.g., mean size of fish in the catch) and
- Statistically derived indicators using a model (e.g., biomass estimated from catch history using a stock assessment model)

Reference points are predetermined levels that are established for each performance indicator. They allow us to analyze the relationship between the indicators and the objectives of the fishery. There are typically two types of reference points: (1) a target reference point, where the value of the indicator corresponds to a *desirable* condition of the fishery and (2) a limit reference point, where falling below the value of the indicator corresponds to an *undesirable* condition of the fishery (e.g., overfished).

Biological reference points are frequently founded in the concept of maximum sustainable yield (MSY)—a concept traditionally used by fisheries managers to set fishery targets. MSY is the largest average yield (catch) that can be taken from a species' stock for an indefinite period of time under constant environmental conditions. In fisheries science, the letter B is used to denote biomass, the total weight of the fish in a given stock. The term B_{MSY} is used to indicate the stock size that can produce the maximum sustainable yield. Similarly, the letter F denotes the fishing mortality rate, while F_{MSY} indicates the fishing mortality rate that would maintain the maximum sustainable yield.

Fisheries managers usually aim to maintain biomass near MSY, therefore F_{MSY} and B_{MSY} have been used often in conventional fisheries management as limit reference points. These reference points can be used to help determine whether a stock is

FIGURE 3. Fisheries Performance Indicators and Reference Points



Note: There are many ways to measure the social, biological, economic, and operational performance of a fishery. Fishery managers often use harvest control rules to indicate when and how much to adjust management when indicators change (for better or for worse). Managers aim to keep indicators at or above the Target Points. Harvest control rules typically become more restrictive if certain thresholds, such as Limit Reference Points, are reached.

overfished and/or whether overfishing is occurring. A good rule of thumb is to consider a stock overfished when its biomass is below 50 percent of B_{MSY}, however this may vary depending on the biology of the species. Overfishing occurs when more than the sustainable share is taken out of a given fish stock, that is, when the fishing rate is above F_{MSY}. Though it may seem a little counter-intuitive at first, overfishing can occur whether a stock's biomass is above B_{MSY} or not, and a stock can be overfished whether or not the fishing rate is below F_{MSY}. The matrix shown in Table 2 explains the general relationship between biomass of a stock and fishing mortality in determining the status of the stock.

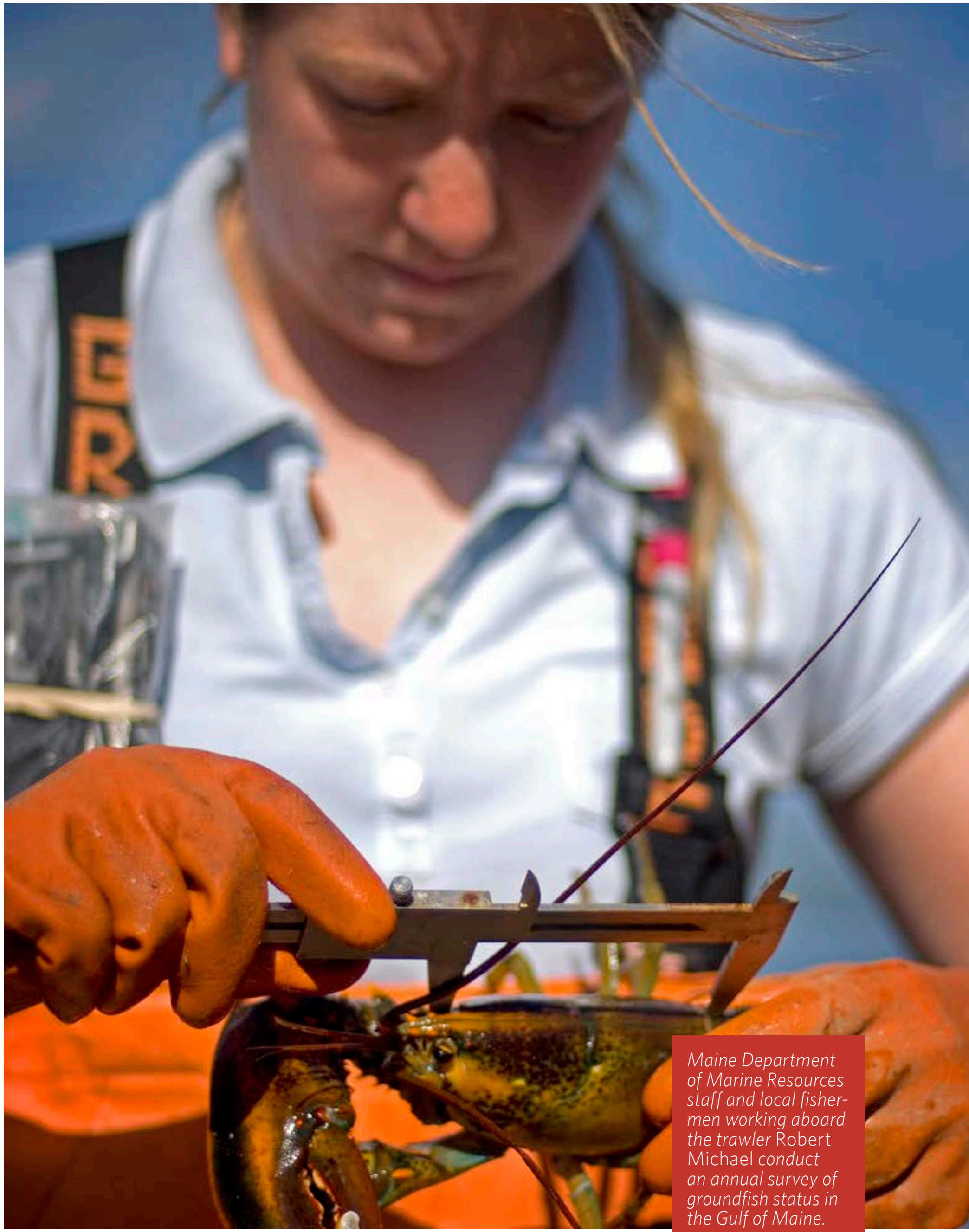
TABLE 2.

Overfished, Overfishing, or Both?

	$B/B_{MSY} \leq 0.5$	$0.5 < B/B_{MSY} < 1.5$	$B/B_{MSY} \geq 1.5$
$F/F_{MSY} \geq 1$	Stock is overfished and Overfishing is occurring	Stock is fully fished and Overfishing is occurring	Stock is under fished but Overfishing is occurring
$F/F_{MSY} < 1$	Stock is overfished but Overfishing is not occurring	Stock is fully fished and Overfishing is not occurring	Stock is under fished and Overfishing is not occurring

MSY is not without its limitations. It assumes that the environment is constant—anything that affects the birth, growth, or death rates of a fish, from water temperature and habitat composition to predator and prey abundance, is assumed not to change. Additionally, calculating MSY requires datasets that many fisheries do not have.

Resource constraints on data monitoring have encouraged the development of less costly and more innovative monitoring solutions. Several assessment methods have been developed recently that do not require long data records and may not require calculating MSY (Table 3).



Maine Department of Marine Resources staff and local fishermen working aboard the trawler Robert Michael conduct an annual survey of groundfish status in the Gulf of Maine.

© Bridget Besaw/ TNC

TABLE 3. Examples of Data-Limited Stock Assessment Methods

Assessment Method "Family"	Description	Assessment Examples	Limitations	Required Technical Expertise	Required Data
No Reference Points	Assesses the vulnerability of stocks or ecosystems to overfishing and other threats using a qualitative scoring system or expert judgment	• Productivity Susceptibility Assessment (PSA) • Comprehensive Assessment Risk to Ecosystems (CARE) • Ecological Risk Analysis (ERA) • Changes in fishery characteristics	• May not allow for optimizing fishery at a target objective • May be difficult to design harvest control rules • Doesn't quantify stock status	Low	Low
Proxy Reference Points	Estimates proxy reference points using time series of indicators that are assumed to relate to stock status	• Standardized CPUE[a] • Depletion analysis • Ratio of density inside/outside MPAs • Catch curves • Catch, CPUE by size indicators	• Not biomass-based reference points • Reference points based on historical data may be subjective or biased	Low-Medium	Low-Medium
Framework-based Assessments	Uses multiple indicators to estimate proxy reference points for stock status. Useful where multiple reliable, independent indicators are available. "Proxy reference points" may be incorporated into framework-based assessments	• Hierarchical decision trees • Sequential trigger systems • Traffic lights • CUSUM[b] control charts • RAPFISH[c]	• Not biomass-based reference points • Use of multiple indicators may be needed for robustness	Medium	Medium
Stock Status-based Reference Points	Estimates reference points for stock status (biomass (B) or fishing mortality (F)) through modeling and indicates whether or not catches are sustainable	• Only Reliable Catch Series (ORCS) • Depletion-based Stock Reduction Analysis (DB-SRA) • Production models • Length-based SPR[d] assessment • Catch MSY[e]	• Time-consuming and data-intensive • Some methods may be relatively costly • Requires high expertise	High	High

a. Catch-per-unit-effort – an indirect measurement of fish abundance
b. Cumulative sum (control chart) – a sequential analysis technique typically used for monitoring change detection
c. Rapid Appraisal for Fisheries – a multidisciplinary rapid appraisal technique for fisheries status evaluation
d. Spawning potential ratio – a measure of current egg production relative to egg production when stock is unfished
e. Maximum sustainable yield – the maximum level at which a natural resource can be routinely exploited without long-term depletion

Why Understanding the Health of a Fish Stock can Help your Conservation Work

Collecting information and data within a fishery and understanding the health of the stock have several applications for advancing marine conservation and can be an important way to measure the success of conservation efforts (Box 1). Collecting fisheries data and undertaking a stock assessment may:

- Inform marine spatial planning
- Identify threatened and vulnerable species and habitats
- Improve the capacity for marine management

Data from fishery-independent surveys can be used to help design a network of marine reserves, identify which coastal areas may be vulnerable to land-based impacts, and prioritize conservation efforts spatially. Fishery-independent surveys can help determine the home ranges, spawning migrations, and ontogenetic shifts in habitats for important species. This type of movement data is a critical component in the design of effective marine reserves that seek to maximize benefits not only to fisheries management, but also to biodiversity conservation and climate change adaptation.[5] Other fisheries data, such as fishing locations and fish-dependent habitats, may also be useful for prioritizing land conservation investments that reduce coastal runoff.[6] When local fisheries data are not available to inform marine spatial planning, global tools may be helpful in prioritizing conservation efforts. The *Mapping Ocean Wealth* project, a spatial tool that quantitatively calculates many of the ecosystem services provided by the ocean, estimates the fish production (in terms of biomass) produced by coral reefs, mangroves, and oyster reefs around the world.

Fisheries data can contribute to understanding the impacts of fishing on non-targeted species and habitats. Recording data on fisheries bycatch—the incidental catch of non-targeted species including other fish, turtles, and seabirds—can provide critical information on the status of vulnerable and sensitive species. Fisheries data about the characteristics of the fishery may also reveal the types and locations of fishing methods employed and the impacts they have on different habitats. Information about the impacts of fishing activities on sensitive species and habitats allows conservation managers to minimize or compensate for those impacts.

BOX 1. The Path to Sustainable Fisheries is Paved with Data

In 2012, The Nature Conservancy established a pilot project in the Northern Reefs to assess stock status using data-limited stock assessment techniques and to rebuild fish stocks. Trained fishers helped scientists collect data on species, size, and maturity for about 2,800 fish caught in Palau's waters by measuring their own catch as well as fish for sale at a fish market.

The simple technique relies on sample size ratios to assess how much spawning is occurring and how much is enough. At its most basic, the technique uses two pieces of local data, size of fish and maturity of fish, combined with existing biological information, to produce a ratio of spawning potential. As a general rule, if fish can achieve at least 20 percent of their natural lifetime spawning, a fishery can sustain itself. Less than that and the fishery will decline. While 20 percent is the minimum number, scientists hope to see fisheries achieving 30–50 percent of natural spawning. The findings in Palau were worrisome, showing that 60 percent of fish caught were juvenile, achieving just 3–5 percent of their lifetime spawning. The consequences of this were clear: if most fish are not reproducing, in a short time there will be no more fish.

Fishery managers used the results to implement appropriate fishery management tools, such as minimum and maximum size limits, protection of key spawning aggregations, and improvements in the design of the nationwide network of protected areas. *You can learn more here*.

5. Green et al., 2014a, 2014b
6. Klein et al., 2010; Alvarez-Romero et al., 2011

The design and successful implementation of a monitoring program for fisheries data may increase the capacity for marine management and conservation outside of fisheries. Simply by establishing a system to collect fisheries data, marine conservationists might find that fishery stakeholders are more likely to get involved with, or support, other aspects of marine conservation. In Kenya, government officials created Beach Management Units (BMUs), a co-management approach to fisheries that involves fishers, fish traders, boat owners, fish processors, and other beach stakeholders who traditionally depend on fishing activities for their livelihoods. BMUs collect and compile data and then discuss a management plan for the area, which includes the management of fisheries, important habitats (such as mangroves, coral reefs, and seagrasses), and threatened and endangered species. The program has increased fishers' sense of stewardship over marine resources and the capacity of governance in marine conservation.

Applied Guidance

Innovations in fisheries science have produced new data collection methodologies and stock assessment techniques for a diverse range of fishery characteristics, opening the door to sustainable management for thousands of fisheries around the world (Box 2). Referencing the tables above, consider the following questions to help guide you in designing the most appropriate data collection program and stock assessment methodology for your fishery.

What types of fisheries data are currently available?
Different stock assessment techniques rely on different types and combinations of data. Identifying the types of available data (e.g., size, catch, CPUE, effort) and information on biological life history traits (e.g., natural mortality, growth rate, size at maturity), as well as the quality (reliability and representativeness) and duration of collection, will help you target the stock assessment options that are available to determine the health of the stock in your fishery.

What is the governance context of your fishery?
Governance systems range from centralized, top-down, government-run to decentralized, bottom-up, community-based approaches. Understanding the governance structure, and identifying where management capacities are strongest, may help you identify an appropriate data-monitoring system. Some data monitoring systems are inherently more appropriate for fisheries with strong governance and institutional capacity (e.g., onboard observer coverage programs) while other systems can be implemented more easily with a community-based approach (e.g., voluntary data collection from fishers). It is also important to consider the existing regulatory requirements—some regulations require specific types of data collection or a particular set of stock assessment outputs.

Diego Ochoa (left) of The Nature Conservancy talks with Rosendo Gonzalez, local fisherman for 40 years.

© Mark Godfrey/ TNC

Who are the stakeholders in the fishery and how are they involved in the management process?
Mapping the stakeholders in a fishery allows you to better identify the capacities of different institutions and may assist in assigning roles and responsibilities when designing a data monitoring system. Determining the technical expertise of various stakeholders may also help to narrow the choice of available stock assessment options or identify the need to bring in outside expertise.

What is the nature of the fishery?
Fisheries often have unique characteristics that limit the feasibility of a particular data collection system or stock assessment method. Determining the range of vessels, scale of harvest, number and location of ports, and destined markets of a fishery may help you identify inappropriate data monitoring techniques and thus help narrow the selection of systems. Characterizing a fishery as subsistence-based, artisanal (local versus commercial), or large-scale industrial may also help determine the institutional capacity available for data collection.

What is the value of the fishery?
The total value of a fishery at first sale can help determine an appropriate budget for monitoring and help narrow the choice of available options. Costs for research and data monitoring at the national level typically range from 1–5 percent of the total value of production.[7] At the individual fishery level, it might not be necessary to calculate the monetary value, and assigning a relative value to the fishery (low, medium, high) may be enough to specify available options.

Challenges and Strategies for Progress

The high levels of heterogeneity and uncertainty in fisheries, combined with limited resources and capacity for collecting and analyzing data, can lead to substantial challenges in assessing the health of fishery stocks. However, regardless of region or fishery type, these challenges can be categorized into a number of core issues that impede our efforts to promote greater sustainability. These core issues are outlined below and, while overcoming such barriers can seem a daunting task, advancements in fisheries management are providing some solutions.

High costs
Traditional fishery stock assessments require extensive data inputs that often cost hundreds of thousands of dollars per species to collect. These costs can be prohibitive when they are close to, or even exceed, the revenues generated by small-scale fisheries.[8] Fortunately, more and more stock assessment methods are emerging that require far fewer data inputs, and can be collected in very resource-limited fisheries (see Table 3). In co-managed fisheries where fishers, industry, and NGOs

7. OECD, 2003

8. Apel et al., 2013

BOX 2. Managing for Sustainability with FishPath

There is a clear need for cheaper, easier ways of measuring and managing data-limited fisheries but it has proven hard to get these techniques to the fishery managers who need them, and even harder for people to choose among the hundreds of possible combinations of methods that exist.

The Nature Conservancy has responded by developing the FishPath tool. FishPath is a process-oriented decision-making software application developed by a group of renowned fishery scientists and conservation practitioners from around the world under the auspices of the Science for Nature and People Partnership (SNAPP). It provides a step-by-step guide to identifying options for selecting data monitoring programs, stock assessment methods, and management actions for data- and capacity-limited fisheries. It is designed to be tailored to a specific fishery, taking into account not only characteristics of the target fishery and local marine environment but also the relevant socio-economic and governance context in which the fishery operates, as well as political and economic information. *You can learn more here*.

are involved in the management process, it might be possible to share the responsibility for data collection and reduce the overall costs.

Lack of technical expertise
Most fishery stock assessments require at least moderate levels of technical skill to complete, while some methodologies require high levels of expertise to develop and run. Technical skills range from database management to computer coding skills and knowledge of population biology and fisheries science. Additionally, many emerging markets lack the institutional resources to support the collection and management of fisheries data. Even if information is collected, there is literally nowhere for it to go. Database management is a heavy lift, requiring maintenance, storage capacity, and strategic development of access rights and security. The latter, especially, requires careful planning and dialogue with all stakeholders to ensure legality and effective use of the database in ways that benefit both industry and fisheries. Clearly defining objectives upfront can help determine the level of uncertainty that is acceptable in a fishery, the technical expertise that will be required, and whether it can be found within the stakeholder group or will need to be sourced externally.

Lack of social capacity
Many data monitoring programs are created but not sustained due to a lack of resources or a lack of commitment from data collectors. Problems are more likely to arise when the people responsible for collecting data are not involved in designing the system or in the management decisions that are made after the data have been collected. Leadership within a fishing community plays a strong role in winning support and buy-in from peers. When strong management capacity is absent, good community leaders may prove critical to the success of data monitoring programs, so it is important to identify such leaders, invest in their development, and support their efforts.

More Information

Technical guidance on how to design data monitoring programs and run a stock assessment can be found in the following publications and manuals.

A Guide to Fisheries Stock Assessment: From Data to Recommendations – An introductory guide to fisheries stock assessment science that includes concepts and terminology.

Guide to Fisheries Science and Stock Assessments - An introductory guide to fisheries stock assessment science that includes concepts and terminology.

Manual for Assessing Fish Stocks on Pacific Coral Reefs - Training manual for data collection techniques, assessment and statistical methods, and data management for multispecies reef fisheries.

Introduction to Tropical Fish Stock Assessment – Manual of stock assessment principles, statistical methods, and data management for multispecies reef fisheries.

Manual on Sample-based Data Collection for Fisheries Assessment – Training manual for data collection techniques and data management for fisheries.

CHAPTER 3

Designing Harvest Control Rules to Meet Fishery Objectives

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CHAPTER 3

Designing Harvest Control Rules to Meet Fishery Objectives

Background

As we described in the last chapter, data collected from a monitoring program feed into a stock assessment, which evaluates how the fishery is doing by using indicators that track change toward or away from established reference points. The results are used to design harvest control rules, which involve a set of well-defined management actions implemented in the fishery (e.g., season closures) and the rules that dictate the magnitude of the action (e.g., length of season closure). Harvest control rules provide frameworks for making fisheries management decisions, such as restricting certain gear types, establishing a marine reserve, and setting catch quotas, and are driven by the objectives of a fishery. Fishery objectives can include a range of stakeholder interests, including maximizing employment opportunities, long-term fishery profits or yields, and habitat/environment protection, among others.

In this chapter you will find information on:

- Different management actions used to maintain a healthy fish stock
- How a well-designed set of fisheries harvest control rules can improve marine conservation
- How to determine which management actions might be most appropriate in the context of your fishery
- Common challenges to designing and implementing harvest control rules and strategies for progress

Harvest control rules are implemented in response to changes in indicators of stock status with respect to reference points. For example, a management action may first be triggered when a performance indicator falls below a target reference point.

Harvest control rules typically become more stringent as an indicator continues to drop below the target reference point, and demand severe adjustments if the limit reference point is exceeded. Good harvest control rules will incorporate a variety of biological, socio-economic, and governance indicators, and are often most effective when all stakeholders in the fishery are involved in the selection process.

The fisheries management cycle begins anew with the data monitoring program recording the effects of the management action(s) taken, a stock assessment evaluating these effects, and so on. Management actions fall into two broad categories: controls on inputs to the fishery (e.g., types of fishing gear allowed in the fishery), and controls on the outputs of the fishery (e.g., setting a total allowable catch for the fishery). Table 4 describes some of the more common management actions that fall under these categories, along with their principal benefits and limitations.

Small-scale coastal fisheries in the developing world have been demonstrated to benefit most from management strategies that are built around community-based co-management. Territorial Use Rights in Fisheries (TURFs), a spatial form of property rights in which individuals or a collective group of fishers are granted exclusive access to harvest resources within a geographically defined area, hold particular promise if there is supporting legislation and governance structures. A TURF system does not replace the harvest strategy process, but transfers the primary responsibility for managing, harvesting, and sustaining fishery resources to the fisher.[9]

9. *Moreno and Revenga, 2012*

TABLE 4: Management Actions: Benefits and Limitations

Management Category	Management Action	Benefits	Limitations
Input Controls	Gear restrictions	• Useful in multispecies fisheries to minimize targeting of vulnerable species • Effective at reducing bycatch • Useful where there is little capacity for monitoring and enforcement • Tend to favor maximum employment objectives	• May be susceptible to effort creep • Focus more on avoiding limit reference points rather than achieving targets • Can still lead to losses in critical ecosystem services • Enforcement requires presence of officers at ports and inspection at sea
Input Controls	Minimum and maximum size limits	• Useful for protecting juveniles or mega-spawners • Useful for protecting slow-growing, long-lived species with variable recruitment • Useful where there is little capacity for monitoring and enforcement	• Not effective for rejected fish with poor survivorship • Not effective for species with complex life history/growth rates • Enforcement requires presence of officers at ports and inspection at sea
Input Controls	Seasonal closures	• Can be daily, seasonal, or trigger-based • Useful if there are temporal spawning grounds • Useful if there are seasonal concentrations of effort	• Unlikely to be effective at reducing effort unless coupled with other tools like catch limits or gear restrictions • Require an effective communication and awareness-raising campaign, particularly if trigger-based • Enforcement requires presence of officers at ports and inspection at sea

Table continued on next page

TABLE 4: Management Actions: Benefits and Limitations (Cont'd)

Management Category	Management Action	Benefits	Limitations
Input Controls	Marine Protected Areas (multiuse areas, no-take reserves)	• Can be rotational, seasonal, permanent, or trigger-based • Most effective for sedentary species • Useful if there are spatial spawning grounds or habitats vulnerable to fishing • Useful if there are spatial concentrations of effort • May maximize benefits to tourism markets • May provide benefits to fishers from spillover and recruitment • Nearshore MPAs may be managed from a distance (via radar, cameras, and vigilance posts) and do not require constant physical presence unless a vessel enters the area	• Not effective for highly migratory species • May have high management costs that can result in conflict and displacement • May lead to concentration of effort in other areas • A single illegal entry could decimate the population/habitat being protected
Input Controls	Fishing licenses or permits	• Can be daily, seasonal, or annual • Common control for restricting number of boats or fishers in a fishery	• Difficult if there are many fleets
Input Controls	Limits on dive hours or trips, number of lines/hooks, net setting time	• Can be daily, seasonal, or annual	• May be problematic in multi-species fisheries if they include species at risk of overfishing • Enforcement may require presence of inspectors at sea and/or ports
Output Controls	Total allowable catch (TAC) or catch limits	• Can be daily, seasonal, or annual	• Difficult if there are many fleets
Rights-based Output Controls	Catch shares (transferable and non-transferable quotas, community and individual)	• Can be daily, seasonal, or annual • Enforcement and data collection may be performed together	• Difficult if there are many fleets • May not be easy to regulate in a multispecies context • Can be difficult to allocate quotas equitably • Enforcement requires presence of inspectors at ports or commercialization centers
Rights-based Output Controls	Territorial Use Rights in Fisheries (TURFs)	• Useful for multispecies fisheries • Align incentives for stewardship • Require minimal scientific input and external enforcement	• Can be difficult to assign access rights equitably • Proper design, enforcement, and operational capacity require strong leadership and co-management capacity • May not be effective for highly migratory species • Require a national policy framework that permits communities to own and allocate use rights for fisheries • Not effective in highly populated areas

Developed countries commonly use output controls that focus on setting a total allowable catch. This can be implemented through catch shares and quota systems that allocate a specified amount of a fishery's total allowable catch to an individual or group. Output controls typically require good data and strong governance to be successful. Basic input controls, such as closed areas, effort limits, and gear restrictions are integral components of management strategies across all governance structures and fishery scales.[10]

Why Harvest Control Rules can Help your Conservation Work

Designing and implementing effective harvest control rules may:

- Increase fish biomass
- Raise the economic value of the fishery
- Build local leadership capacity
- Feed vulnerable people
- Protect biologically diverse ecosystems

Unmanaged stocks are typically overexploited and have a biomass level below that which would produce the maximum sustainable yield.[11] Well-designed harvest control rules that result in stock recovery are likely to increase fish productivity, fish biomass, and yields, and sustain the resource in the long term.

Better management of fisheries that are fully exploited, combined with actions to aid the recovery of overexploited fisheries, could also generate increased revenues over time.[12]

10. CEA, 2012
11. Costello et al., 2016
12. Arnason et al., 2009; Sumaila et al., 2012; Hilborn and Ovando, 2014; Costello et al., 2016

Crab pots in Greenbackville, Virginia

© Jason Houston/ TNC

Maximum economic yield (MEY) is a concept that represents the level of fishing effort and catch that maximizes economic profits in the fishery over time. At the same time, it can help to conserve fish stocks. Setting target reference points that correspond to the MEY rather than the maximum sustainable yield (MSY) typically results in lower yields. However, because fishers are using less fishing effort, they reduce their associated costs and maximize their profits (Figure 4). MEY catch levels can also reduce the risk of accidental overfishing and improve ecosystem health. Increased revenues, in turn, may be used to help sustain management systems that provide benefits to other industries and communities. In Australia, the commercial fishing industry contributes toward management costs that are directly related to fishing, which may benefit the broader community in addition to the industry.[13]

Communities may find that harvest control rules contribute to social cohesion as well as more profitable fisheries. A study looking at the outcomes of co-management arrangements found that 85 percent of co-managed fisheries also demonstrated enhanced unity—improved community cohesion,

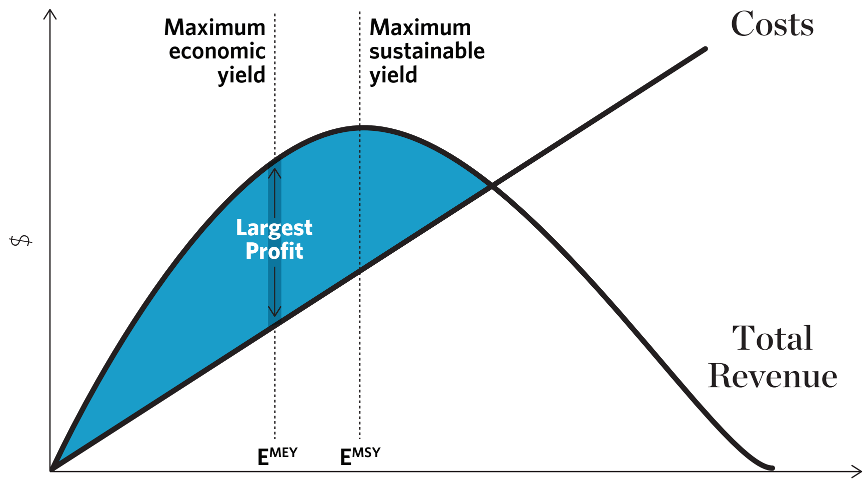
13. Cox, 2001

Locals discuss the future of Nahtik Marine Protected Area while looking over a nautical map of the island of Pohnpei.

© Nick Hall/TNC

FIGURE 4. MEY Catch Levels are More Precautionary and Profitable than MSY Catch Levels

Let's suppose that current fishing effort is at the point of E^{MSY}. Here, long-term fishing yields are maximized, resulting in maximized total revenues. By reducing fishing effort to E^{MEY} and letting the stock biomass recover, slightly lower revenues can be made but at a much lower fishing cost, which maximizes profits.



communication among fishers, information sharing, and economic trade.[14] When fishers become engaged in the management process, they are likely to be more empowered to play an important role as marine stewards—combating threats such as pollution, oil and gas extraction, mining, and illegal, unreported, and unregulated (IUU) fishing.

Perhaps most importantly, harvest control rules are essential if fisheries are to continue to employ tens of millions of people and produce healthy food for billions. Currently, most fisheries are underperforming—it is estimated that 68 percent of the world's fisheries are overfished, resulting in suboptimal food production compared to fisheries managed at MSY.[15]

14. Gutierrez et al., 2011
15. Costello et al., 2016

Additionally, fisheries that are underexploited could be producing a great deal more food if they were managed with harvest control rules that corresponded to MSY.

Harvest control rules, like MPAs and gear restrictions, may also help to maintain high levels of biodiversity in marine ecosystems such as coral reefs. They can protect critical habitats—including migration routes, places of refuge against predators, spawning grounds and nursery areas—and control harvests of keystone species.[16]

Applied Guidance

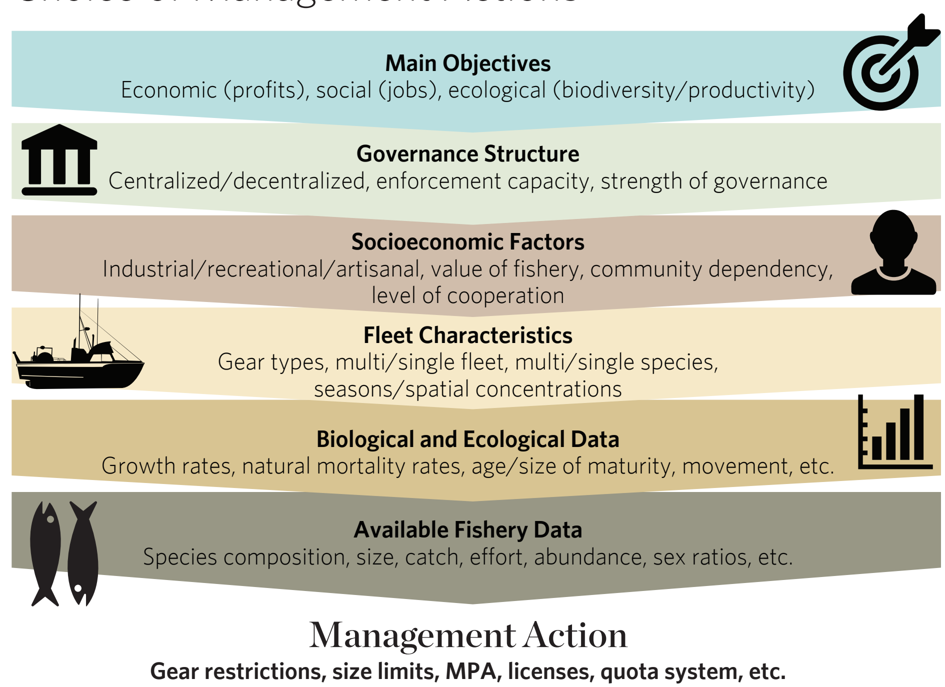
Well-documented management solutions exist for nearly every type of fishery. Determining the most appropriate management actions for a particular fishery requires identifying its specific characteristics (Figure 5). Walking through the following questions may help you determine the right course of action:

What are the main objectives of the fishery?
The relative strength of economic, social, and ecological objectives will influence the mixture of management actions chosen for a particular fishery. For example, if one objective is to maximize livelihood opportunities, introducing a permitting system that limits fishing effort is likely not the best option. Alternatively, maximizing biodiversity may require an ecosystem-based management approach and use of a network of marine reserves. Objectives are sometimes compatible (MSY maximizes biological production and often meets high-employment objectives) but sometimes in conflict (MSY does not maximize ecosystem preservation or economic profitability). Setting objectives and choosing solutions therefore requires the mutual agreement of stakeholders.[17]

What is the strength and structure of governance?
Understanding how governance is structured and where management capacities are strongest may help you identify an appropriate management action. Some management actions are inherently more appropriate in limited entry fisheries with strong governance and enforcement capacity (e.g., catch and effort limits) while other management actions may be more appropriate in open access fisheries governed by institutions that have limited capacity (e.g., gear restrictions, size limits).

What is the socioeconomic context of the fishery?
A perceptive study of the socioeconomic conditions of fishers goes a long way in the design and successful implementation of effective harvest control rules. Gaining an understanding of cultural preferences regarding management can help increase compliance. Estimating the dependency of the local community on the fishery for food or income may eliminate some

FIGURE 5: Fishery Characteristics Will Determine the Choice of Management Actions



16. Roberts and Hawkins, 2000
17. Hilborn, 2007

management options or highlight others. A fishery with a very low value may not be able to afford to implement and enforce catch and effort limits.

What are the characteristics of the fleet?
Determining the range of vessels, scale of harvest, gears used, environmental conditions, destined markets, and other operational characteristics of a fishery that describe the local environment and behavior of fishers may help you identify and rule out inappropriate management actions. For example, if there are multiple fleets (small boats for subsistence catch as well as industrial boats for commercial catch), catch quotas may be difficult to institute without allocation disputes, whereas effort restrictions by area or time may be better options. Likewise, if your fishery is likely to experience effort creep (a slow increase in fishing effort as fishers become more efficient through new technology or fishing methods), management actions that limit effort may not be an effective strategy.

What are the life history traits of the targeted species?
The consideration of certain biological and ecological traits of the main target species, such as the growth and movement patterns throughout their life cycle and information on their associated habitats, may be helpful in identifying robust management actions. For example, sedentary species (those that don't move much or don't have large ranges) stand to benefit from marine reserves much more than migratory species. Highly productive and short-lived (boom and bust) species might be appropriately managed with seasonal closures, while minimum and maximum size limits are unlikely to be very useful.

What kinds of fishery data are available?
Certain types of data naturally lend themselves to certain types of management action. For example, if all you have is data on fish length, then size limits may be a preferred management option. Management actions like catch and effort limits usually require more extensive data inputs with lower levels of uncertainty than some other actions, while gear restrictions, marine reserves, seasonal closures, and size limits may be more appropriate in data-limited scenarios.

These questions are a good start when thinking about what types of management actions are most appropriate in your fishery. If you would like to take the next step in designing harvest control rules, consider using the Nature Conservancy's FishPath tool described at the end of Chapter 2.
You can learn more here.

Challenges and Strategies for Progress

Upfront burden of restricted fishing
Many communities rely heavily on the harvests of artisanal and subsistence fisheries for food and as a source of income. Setting up harvest control rules that reduce the amount of catch in the short term may significantly impact individual fishers or members of a community, who must accept reduced levels of food and income. Many small-scale fisheries

BOX 3. Alternative Livelihoods and Conservation through Eco-tourism

The Misool Eco Resort in Raja Ampat, Indonesia is an example of a marine conservation, tourism, and community engagement program. In 2005, the resort entered into a 25-year lease agreement with a local community to establish a no-take zone surrounding Batbitim, the island where the resort was built, and many neighboring islands. In return for rights to the islands and the surrounding marine area, the resort agreed to act as a steward of the area and pay a lease fee to the neighboring community every five years. In addition to making rental payments, the resort also employs around 120 local villagers, who are entirely removed from the extraction of marine resources, and provides them with health insurance for themselves and their families, job training, and English lessons. Under the agreement, the resort regularly patrols the area for illegal fishing and shark finning and manages the area for conservation, including observance of the no-take area.

consist of just a few kilometers of coastline and setting up a marine reserve as part of a fisheries harvest strategy is likely to represent a real cost to the community. In the longer term, the community might benefit from increased spillover of fish from the reserve to fished areas and increased production of larvae from the more numerous and larger fish living inside the reserve,[18] but the immediate impacts may be difficult to overcome. Flexible reserve designs, philanthropic loans, and increases in prices paid for fish may help to offset the short-term economic losses of establishing a marine reserve. However, even optimally designed reserves may struggle to provide economic benefits within a decade.[19] In the short term, alternative livelihood programs such as craft production, small-scale tourism, teaching, aquaculture, crop farming, agro-processing, and apiculture may be solutions that can supplement a community's reduced income from fisheries by providing other employment options until the benefits of increased fish production are realized (Box 3).

Upfront costs and lack of financing

Developing and implementing fishery-specific harvest control rules often involves upfront costs for design, monitoring, and enforcement that are prohibitive for many low-revenue fisheries or in cases where fishery management institutions are weak. Governing agencies typically have deficient budgets, and a low-margin seafood industry is understandably unwilling to contribute to fishery reform costs.[20] Due to the lack of sufficient public sources of money, the transition to more sustainable, profitable fisheries so far has been funded largely by philanthropic loans. Low interest (<1–3%) philanthropic loans or social equity investments may be options for fisheries where an investable business proposition is associated with improving the fishery. However, to date, few investment-ready fishery projects have proven sufficiently attractive to bring in investors interested in an environmental, social, and financial return. The investment case for philanthropic and private money financing the transition to sustainability is clearest when the potential for creating value is high and risk is minimized.

Lack of effective governance

The capacity, sophistication, and authority of the institutions responsible for fishery management vary hugely among nations. A lack of effective governance is often compounded by too little data, money, and infrastructure to create and enforce the system.[21] Vessel licensing and permit limits, closed seasons, gear restrictions, and large closed areas are potential management options for industrial fisheries in most parts of the world. However, in countries with weak governing institutions, output controls like TACs and catch shares rarely work—even when these controls are required by law, they can be undermined by poor enforcement and excessive costs.[22] Small-scale, data- and capacity-deficient fisheries require a very different approach, particularly in coastal areas of the developing world that lack an effective centralized government. If the legal right of fishers to assert tenure over their coastal marine resources is supported by law, co-management and cooperative approaches may be ideal options—for example, limits on access, gear restrictions, closed areas, and seasonal limits—because they effectively close the fishery to outsiders and incentivize local fishers to manage their stocks for long-term health.[23] Policymakers may be reluctant to pass legislation due the perceived negative impacts of fisheries management on fishers' livelihoods, incomes, and food security, or fear of political backlash. Engaging in outreach programs, collaborative research, and supporting the devolution of management rights and responsibilities to local entities with more governance capacity are all ways to

"Low interest philanthropic loans or social equity investments may be options for fisheries where an investable business proposition is associated with improving the fishery."

18. Almany et al., 2015
19. Ovando et al., 2016
20. CEA, 2012
21. CEA, 2012
22. CEA, 2012
23. Worm et al., 2009; CEA, 2012

overcome this barrier.

Lack of social capacity

In the absence of a strong centralized government, co-management and cooperatives approaches to implementing fisheries harvest control rules have shown success. However, without social capacity at the local level, the success of co-management and cooperatives may be low. A study on the attributes of successful approaches to co-management in fisheries documented the "critical importance of prominent community leaders and robust social capital for successfully managing aquatic resources and securing the livelihoods of communities depending on them."[24] Identifying community leaders and building social capital may prove more successful in developing effective local management than simply imposing harvest control rules without the involvement of all local stakeholders.

24. Gutierrez et al., 2011

More Information

Detailed guidance on how to develop harvest control rules can be found in the following publications and guides.

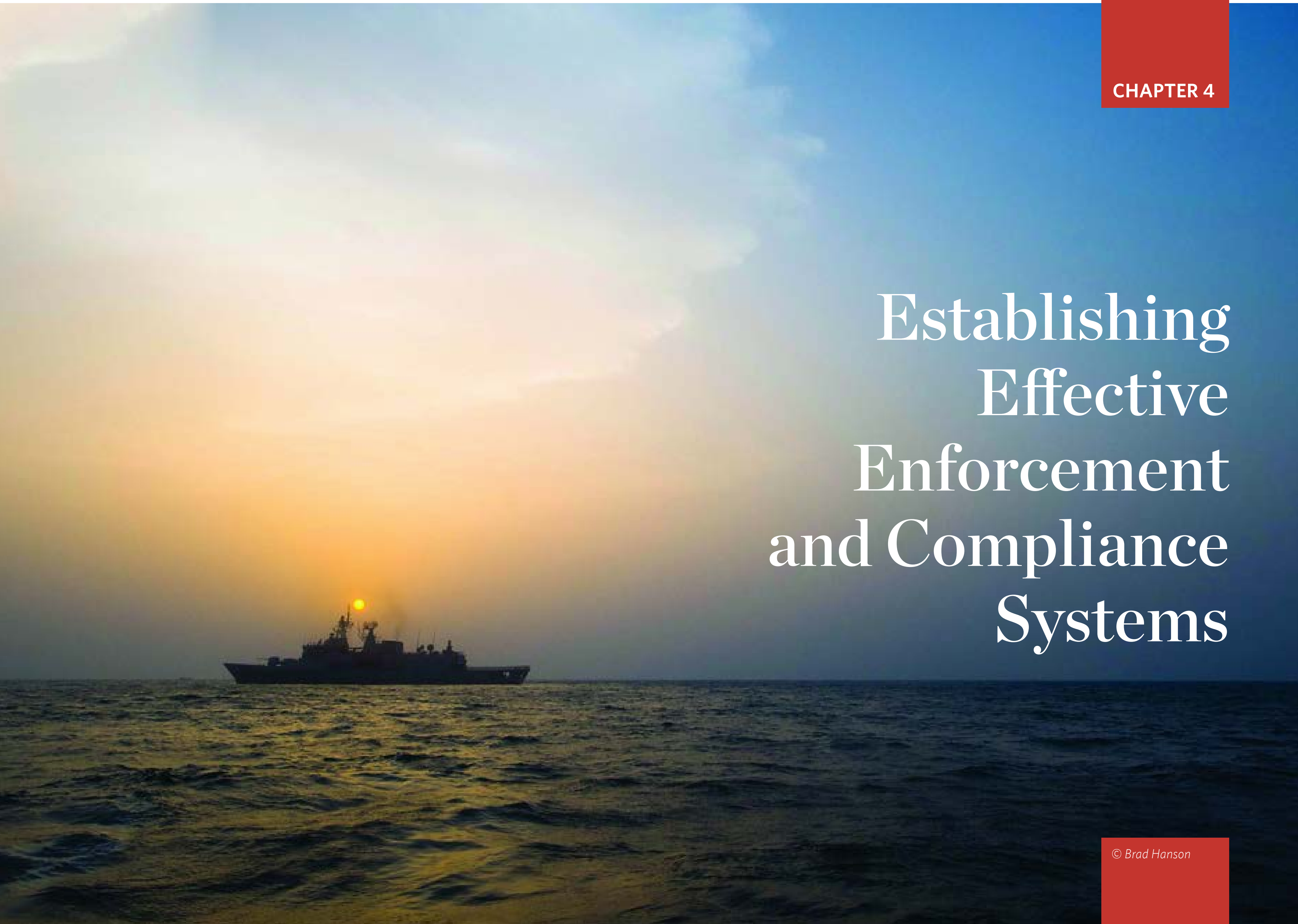
A Fishery Manager's Guidebook – A practical guide for those actively engaged in fisheries management containing information on the broad and often complex task of fisheries management.

FIP Handbook: Guidelines for Developing Fishery Improvement Projects – The FIP Handbook presents a set of guidelines and a toolkit to help simplify the approach to establishing FIPs and improving sustainability.

National Guidelines to Develop Fishery Harvest Strategies – A framework to support a consistent approach to developing a fisheries harvest strategy, with a focus on Australian fisheries.

CHAPTER 4

Establishing Effective Enforcement and Compliance Systems



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CHAPTER 4

Establishing Effective Enforcement and Compliance Systems

Background

Fish stocks around the world are under growing pressure and the need to find innovative and practical resource management strategies is more important than ever. Disregard for fishery laws is common; global estimates suggest that a minimum of 20 percent of seafood worldwide is caught illegally, representing 11 to 25 million metric tons of fish with an economic value of between $10 billion and $23 billion.[25] It often takes only a few law-breakers to impact the whole fleet significantly.[26]

To successfully eliminate illegal fishing, we must not only draft relevant regulations, but also design and fund effective enforcement systems and foster a culture of compliance. Historically, naval and coast guard authorities have been responsible for marine law enforcement; however, many fishery and park agencies that lack training and equipment are also tasked with fisheries enforcement. Most of these agencies are understaffed, lack budgetary resources, and have limited authority to ensure compliance within their fishery zones. That is, they lack power of arrest and the ability to use force.

A fishery enforcement system is most effective in deterring fishers from committing illegal activities when the consequences of getting caught outweigh the potential economic gains. There are two components of fisheries enforcement: the methods and technologies of monitoring, control, and surveillance (MCS) used to identify violators and enforce regulations, and the mechanisms and approaches used to achieve compliance. In this chapter you will find information on:

- Different surveillance tools used in fisheries enforcement systems
- How an effective enforcement system can benefit marine conservation

*This chapter was developed using information adapted from Enforcement Guide: Near-Shore Artisanal Fisheries by WildAid and The Nature Conservancy. For more information, see the **full report.***

25. Agnew et al., 2009
26. Stiles et al., 2013

- Useful guidelines to consider when designing and implementing an MCS system and how to achieve acceptable levels of compliance
- Common challenges that managers face when engaging in fisheries enforcement and strategies for progress

No single technology provides a "silver bullet" where enforcement is concerned, so surveillance systems are often designed using multiple technologies and methods. For example, radars or high-power cameras can be used in combination with Vessel Monitoring Systems (VMS) and Automatic Identification Systems (AIS). Both are vessel-tracking systems that depend on equipment installed on each boat. Radars or cameras placed near productive fishing grounds, passageways, or ports can detect vessels that have deactivated their AIS transceivers and are fishing in a prohibited area, even when they are many nautical miles (nm) out to sea (Figure 6).

In Table 5, we evaluate different surveillance technologies and patrol assets by providing a brief description of each technology or method and the benefits and limitations of its application.

FIGURE 6. Surveillance Technologies and their Range of Coverage

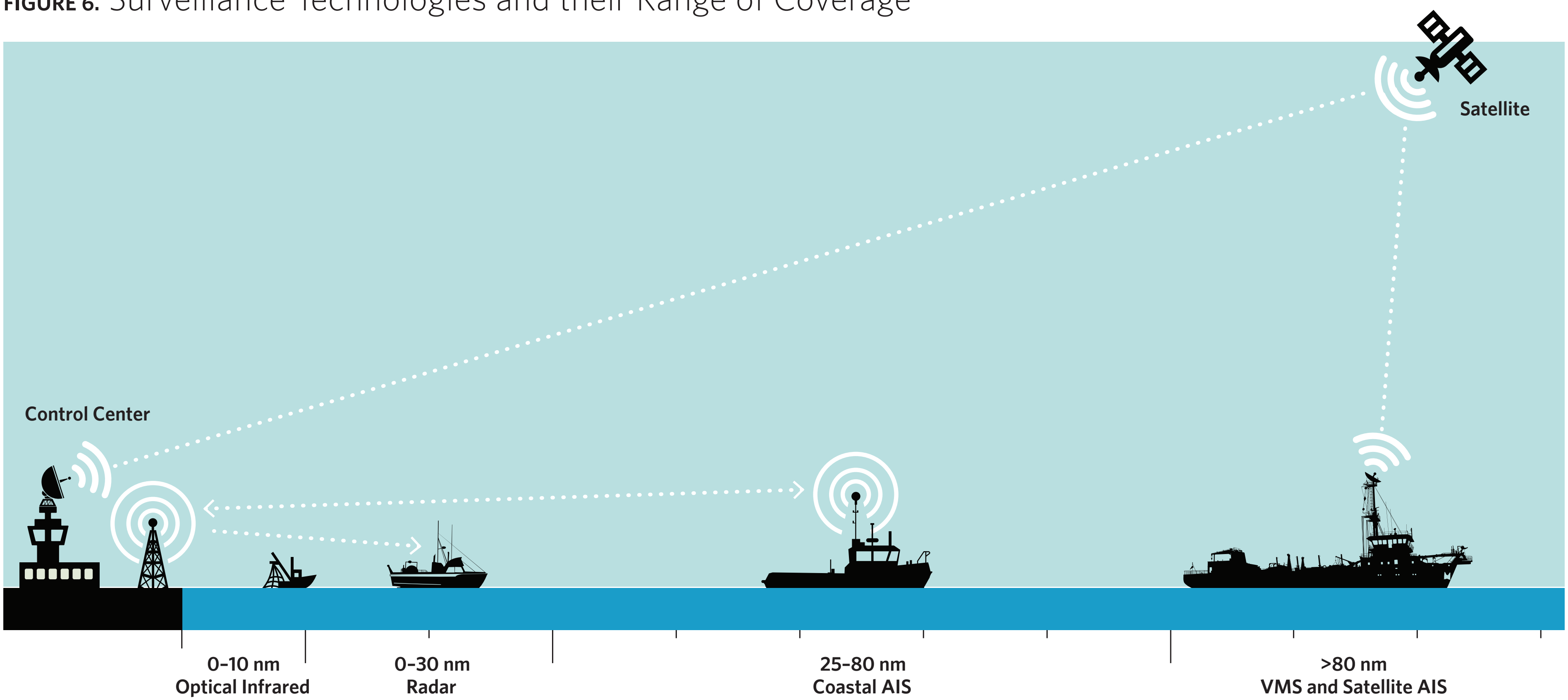

TABLE 5. Surveillance Technologies and their Application

Surveillance Technologies and Methods	Description	Benefits	Limitations
Port Monitoring	Officers patrol ports to check for violations of management regulations. May include the inspection of the catch composition and volume, size, vessel licenses, gear	• Cost effective • Can monitor a large number of management regulations	• Cannot monitor at-sea activity
Vessel Patrols	A team patrols the fishery area in a vessel to check for violations of management regulations, or to intervene when a violation is identified	• Physical presence of an authority on the water remains one of the best deterrents to illegal activity • Can monitor a large number of management regulations	• Difficult to cover large fishery areas • Fishers may be able to anticipate patrols or at-sea boardings
VHF Radio Communications	A group of public or private frequencies that the International Telecommunications Union, as well as national authorities, assign for establishing communications among vessels and between coastal stations and vessels at sea. Radio networks comprise repeaters (optional), base stations, and handhelds	• Low-cost tool for enforcement planning and coordination • Primary tool used for search and rescue and general safety at sea • Useful for community-based enforcement	• Useful for communication only; not a method of detection
Radar Towers	Radars employ radio pulsed signals to detect obstructions in their line of sight. Radars require qualified staff for operation and maintenance	• Radars are a very mature and stable technology with easy-to-obtain technical support • Ideal for detection of medium to large vessels at distances up to 30 nm	• The site must possess a clear arc of vision with no geographical obstructions • The site requires an elevation of >100 meters for best coverage • Radars require a steady supply of energy including an emergency backup source
Vigilance Posts	Vigilance posts with the use of binoculars and/or telescopes are strategically placed from a 12 to 15-meter-high lookout, providing a visual horizon of about 9–12 nm	• Cost-effective • Good option for monitoring near-shore fishing grounds and access ways	• May not be effective at night
Video Cameras	Digital video recorders are placed in various locations on a fishing vessel, usually the areas where gear is deployed and retrieved, and where fish are brought on board and/or processed; multiple cameras can cover the same area for more thorough observation	• Good option when staffing is limited • Effective way of monitoring key access ways, ports, and specific geographic areas	• May not be effective at night

Table continued on next page

TABLE 5. Surveillance Technologies and their Application (Cont'd)

Surveillance Technologies and Methods	Description	Benefits	Limitations
Vessel Monitoring Systems (VMS)	VMS is a satellite-based monitoring system that provides vessel positions around the world, typically with location intervals from 1-6 hours	• VMS is more appropriate for larger vessels and where large oceanic expanses need to be monitored • VMS is a closed source system: transmitted information is coded and seen only by ship owner and the respective authority unless operated by a Regional Fisheries Management Organization (RFMO) or data-sharing agreements exist between countries	• Not suitable for small, near-shore vessels that tend to move too quickly to be monitored over 1-6 hour intervals • Monthly costs to the user may be too expensive for small-scale fishers
Automatic Identification Systems (AIS)	AIS is a “focalized” system that initially worked over VHF frequencies and required shore-based stations to receive vessel positions. The use of shore-based stations limited the coverage to the “radio horizon” (usually between 15 and 80 nm). Recent developments have succeeded in placing AIS-based stations on satellites, allowing them to overcome range limitations while still using the same VHF spectrum	• Shore-based AIS service has no cost to the user and provides vessel positions every 3-30 seconds depending on the type of beacon on board: Class A - merchant ships, and Class B - small vessels	• AIS is an open source system: information is public and all AIS-equipped vessels can view one another • Requires a regulatory framework that mandates use, including penalties • Requires a reliable vessel registry • Can be turned off by fishers at any time
Aircraft Patrols	A pilot and observer in a small single- or twin-engined aircraft patrol a large area. Planes require a support crew, mechanics, a hangar with fuel tanks, maintained runway, spare part and tools, and aircraft insurance	• Useful when working in coordination with patrol vessels for interdiction or search and rescue	• High operational and maintenance costs may be prohibitive • Not suitable for small-scale vessels or small-area fisheries
Unmanned Aerial Vehicles (UAV)	A UAV is controlled remotely (e.g., flown by a pilot at a ground control station) or pre-programmed to fly autonomously, based on flight plans or more complex dynamic automation systems	• Operators do not typically require the same degree of training, certification and experience as maritime patrol pilots • UAVs do not require large ground crews, costly maintenance and certifications, and are less weather-dependent • Well suited to overfly planned patrol lanes (i.e., closed-area boundaries)	• High operational and maintenance costs may be prohibitive • Not suitable for small-scale vessels or small-area fisheries

Source: Adapted from WildAid (2015).

Why Fisheries Enforcement can Help your Conservation Work

Designing and implementing fisheries enforcement systems may:

- Improve compliance with coastal marine and fishing regulations
- Improve maritime safety and emergency response
- Build local leadership capacity

It may seem obvious that designing and implementing an effective fisheries enforcement system will increase compliance with harvest control rules enacted by fisheries management bodies. However, enforcement systems can also contribute to marine conservation by identifying and responding to local stressors on coastal habitats, including land-based and marine-based pollution, illegal near-shore logging activities and coastal development, and other harmful impacts from tourism and recreational activities. Additionally, they may help deter other illegal activities such as human and drug trafficking.

A fisheries enforcement system that incorporates marine vessels may also improve maritime safety and the capacity to respond to environmental emergencies, providing benefits for fishing, tourism, shipping, and offshore industries. Marine incidents, such as vessel collisions and groundings, missing vessels/persons, and fires, among others, may be resolved more easily with regular vessel patrols and/or standby vessels. Additionally, the impacts of environmental emergencies like hurricanes and oil spills may be dealt with more rapidly.

At the community level, in particular, developing an enforcement system inclusively with fishers may engage them in the management process, empowering them to help combat threats, such as pollution and IUU fishing, that impact their own livelihood. In Barbuda, an enforcement system was developed collaboratively between representatives of the coast guard, police, fishers, and NGOs through the Blue Halo Initiative. The design of the enforcement system followed the establishment of local regulations for coastal zoning and fisheries in 2014. Communication and collaboration were the central themes of the development process, building a foundation of community engagement and voluntary compliance rooted in mutual respect.

Local rangers on patrol.

© Jürgen Freund/ Misool Eco Resort

Applied Guidance

The core components of monitoring, control, and surveillance (MCS) are a control center and patrol staff. In most cases, however, the design and implementation of an MCS system and the surveillance technologies and methods used for a particular area will depend on the specific characteristics of the fishery. The following questions may help you determine the type of system and tools most appropriate for your particular context.

What is the geographical context?
The size of a fishing area and its coastal topography will help you determine the characteristics of patrol vessels, surveillance technologies, communications equipment, and minimum personnel needs. We have classified fishing areas into three sizes; however, these are guidelines only and are not appropriate in all circumstances (Table 6).

What are the characteristics of the fleet?
Defining the characteristics of a fishery by developing a "fishing operations profile" will help you determine the most appropriate types of surveillance technologies and methods, as well as when and where to coordinate patrol operations. The following questions can help develop a fishing operations profile:

- How many fishers are there and what is their level of organization?
- Where are the primary ports and fishing routes?
- What kinds of vessels and motors are used?
- What are the target species and gears used?

TABLE 6. Classification of Fishing Areas by Size

Small < 41 km^2 (< 12 nm^2)	**Medium** 41 km^2 - 150 km^2 (12 nm^2 to 44 nm^2)	**Large** > 150 km^2 (> 44 nm^2)
A small area is less than 41 km^2 and can be monitored via simple technologies in combination with patrol vessels. Typically, there is little need for either technological sophistication or extensive communication systems: vigilance posts equipped with binoculars and a VHF handheld radio can often cover the area	A medium area ranges from 41 km^2 to 150 km^2 and will typically require a series of investments including: • **Patrol Assets:** Vessels with greater endurance and larger outboard motors • **Surveillance:** Location and establishment of vigilance posts with a minimum height of 30–60 meters for the installation of radars, video cameras, and/or other technology • **Communications:** A robust VHF network including base radios, handhelds, and perhaps the placement of repeaters • **Personnel:** Additional personnel and increased specialization	A large area is greater than 150 km^2 and will require additional investments including: • **Patrol Assets:** High endurance semi-oceanic vessels, larger outboard motors, and possibly aircraft or UAVs • **Surveillance:** A combination of non-collaborative sensors (radars and high power cameras) and collaborative monitoring systems (AIS or VMS) may become cost-effective options for reducing operational expenses • **Communications:** A more robust VHF/HF network including base radios, handhelds, and perhaps the placement of repeaters • **Personnel:** Additional personnel and increased specialization (offshore navigation)

Source: Adapted from WildAid (2015).

- When and where does fishing occur?
- What is the role of traditions and customs?

What kind of legal framework is in place?
A good understanding of the legal framework is critical because it specifies competencies and jurisdictions of agencies as well as the regulations that govern maritime activities. Reviewing the legal framework can help you determine the most appropriate type of surveillance technologies and methods to be used. The scope and drafting quality of the legal framework has huge implications for the ultimate success or failure of an enforcement system. The following three key elements should be analyzed as part of designing an enforcement system:

1. **Vessel registry:** An up-to-date fishing vessel registry provides critical information to enforcement authorities about the vessel and its owner, and is essential for levying sanctions, especially when considering the use of VMS and AIS technology. Determining whether a registry exists and the extent to which it is representative of the fleet is an essential step.

2. **Zonification:** Mapping and zoning specific activities (i.e., fishing, tourism, transportation) and areas with higher ecosystem value can help facilitate better surveillance within a given area. Use or access areas should be clearly delineated and classified. Simpler is better, especially in the early stages of zonification schemes because too many different areas within a protected area may confuse stakeholders, generate conflict, or complicate the task of enforcement by officers.

3. **Regulations:** A firm understanding of all existing regulations is necessary to set up a system to enforce those laws, and will help you determine the most appropriate surveillance technologies and methods when designing and implementing an MCS system. In 2015, Palau's Northern Reef States passed legislation mandating the establishment of a joint enforcement force between Ngarchelong and Kayangel States, including a three-year ban on fishing several vulnerable species. This type of information is critical when designing an enforcement system.

If there are deficiencies in the legal framework, for example, weak regulations or no vessel registry, collaborative technology such as VMS or AIS may not be an option, or further work might be required on legal reforms in order to correct structural issues or fill gaps. In this scenario, you must do the best you can and focus efforts on establishing presence, using simple surveillance equipment, and carrying out education and outreach efforts. When a clear legal framework exists, collaborative technology can also be considered if the size of the area warrants the use of a more sophisticated technology.

Challenges and Strategies for Progress

The most robust enforcement systems containing state-of-the-art technology and regular monitoring will still fail if mechanisms are not in place that deter illegal activities and achieve acceptable levels of compliance. Simply put: if there are no consequences, fishers and industry will continue to violate laws. Compliance can be achieved through prosecution and sanction (the hard approach) and education and outreach programs (the soft approach).

Compliance challenges (hard approach)

Inadequate judiciary system
An efficient judiciary system is essential if fishery laws and regulations are to be effective. If there is no real prospect of prosecution, compliance with regulations is likely to be poor, which in turn lowers respect for regulations and negatively impacts the morale of the enforcement agencies.

Unfortunately, environmental crimes don't tend to be a high priority for most elected officials and are difficult to prosecute because multiple agencies are involved in the process. In addition, environmental law is a rapidly expanding field and many judges and attorneys are not trained or regularly updated on environmental policies or the technical and scientific advancements in fisheries. This situation contributes to case error and incorrect application of the regulations. Indeed, a recent report on fisheries management in Chile concluded that training and increased awareness among judges and district attorneys was needed and a stricter application of the law would be required to substantially reduce illegal fishing.[27] International organizations, such as TRAFFIC and Wildlife Alliance, are building capacity in this space by providing technical assistance to government agencies through workshops that bring together representatives of the judicial sector and train them on administering sanctions, prosecution, investigation, and environmental laws.

Some countries have addressed the problem by creating special environmental court systems. South Africa established the Environmental Court in 2003 to prosecute abalone-related offences. Abalone cases previously had a low priority in the judiciary system—the conviction rate was 10 percent and sanctions were generally lenient. The court completed 166 cases with a conviction rate of 75 percent in the first 18 months of its creation.[28]

Inadequate application of sanctions

Generally speaking, sanctions are either administered under criminal or civil law, requiring lawyers and courts, but they may also be carried out by an administrative agency. While the legal framework is unique in each country, building capacity of other personnel authorized to administer sanctions, in order to support an effective judiciary system, may be accomplished in a variety of ways. For example, establishing a standardized format for vessel boarding reports and training officers in their use can improve the efficiency of the sanctioning process. Facilitating communication between the legal team that prosecutes cases and the enforcement team that collects the evidence and enforces the law can help build stronger cases. Identifying and assigning additional lawyers from NGOs or supporting institutions to follow up on environmental marine violations or crimes can also help build capacity. Finally, the use of administrative sanctions such as detaining vessels, seizing fishing gear, and suspending or revoking ship permits/licenses, may help to prevent future violations.

Limited material resources

In many locations, the navy, police, and judiciary may lack the necessary material resources for effective enforcement efforts. Designing a strategy that limits capital costs (fixed, one-time expenses) by leveraging existing infrastructure and keeping the number of vigilance posts and equipment costs to the minimum can help reduce the cost of an enforcement system. All new acquisitions of vessels, equipment, or other assets should take into account the full costs of lifetime maintenance and operations and be free of donor influence. For example, many agencies have received patrol vessels and other assets from donors who had the best of intentions; however, their maintenance proved too costly and now they lie around unused and deteriorating. It's not always the best technology that should be used, but the most appropriate technology given the context. The most valuable component of every effective program is a trained group of rangers/officers who are actively engaged in their enforcement mission.

"Leveraging existing infrastructure and keeping the number of vigilance posts and equipment costs to the minimum can help reduce the cost of an enforcement system"

Operating costs (recurring expenses) can be minimized by strategically placing vigilance posts, moorings, and vessels near concentrated fishing areas or high-traffic maritime routes, using appropriately sized and fuel-efficient outboard motors, deploying a VHF marine radio network, and using

27. Moreno and Revenga, 2012
28. Hauck and Kroese, 2006

cost-effective electronic sensors when feasible. The incorporation of fishers, tourism operators, and traditional leaders into the design and operation of an enforcement system can also help reduce operating costs and can bolster compliance.

Compliance challenges (soft approach)

Lack of community buy-in

Compliance can be a particular challenge in cases where fisheries management is based on laws that have been formulated with little or no stakeholder consultation. For example, in Ghana, many fishers are illiterate, which limits their ability to know what the law actually requires or prohibits, and leads to frequent violations. Even those fishers who can read do not have easy access to the regulations and may be unable to interpret the legal language correctly.[29]

Education and outreach is critical to foster community buy-in as well as to inform stakeholders of rules and regulations. If fishers see that the sanctions are working, they will be more willing to report violations. But if they report them and nothing happens, they tend to lose faith in the system and are not encouraged either to report others' violations or follow the regulations themselves. Once fishery regulations are in effect, agency enforcement teams should consider developing a simple education and outreach plan directed toward local fishers, foreign fishers, and the community alike. Distributing information to all stakeholders on zoning, regulations, restrictions, and fines through the most appropriate forum, whether simple fact sheets, town meetings, or webinars, can increase compliance. Engaging enforcement officers in outreach activities can help foster positive relationships between fishers and law enforcement. Bulletin boards can be placed near key ports and fishing cooperatives to broadcast regulations, and pamphlets can be provided at airports and tourism kiosks. Outreach can also be targeted to local primary and secondary schools with exhibits, videos, and informal discussions. Branded merchandise such as T-shirts, ball caps, and bracelets is often popular and, embellished with appropriate messages, can be distributed to increase awareness.

A member of the Ghanaian maritime police looks at a suspected illicit fishing vessel prior to boarding.

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Economic incentives to break rules

It can sometimes be the case that tighter fishing restrictions are imposed but fish stocks continue to decline. These situations might be due to "routine" noncompliance, where the income from illegally obtained fish simply increases the economic incentive for fishers to violate fishing regulations. Rights-based output controls such as catch shares and TURFs that close the fishery to outsiders and incentivize fishers to be stewards of their stocks may be ideal options if there is a supporting legal structure.

29. *Boachie-Yiadom, 2013*

Where rights-based management is not feasible, increasing surveillance or establishing more meaningful penalties may be enough to deter illegal fishing. Phased approaches to the enforcement of regulations can also be helpful: for example, violators are first warned about infractions for a 6–12 month trial period but, over time, enforcement officers gradually impose tougher sanctions.

Ultimately, engaging fishers in all processes of fisheries management from data monitoring to the development of harvest control rules, and investing in education and outreach, is the most promising route to achieving voluntary compliance.

More Information

Technical guidance on how to design an enforcement system can be found in the following publications and manuals.

Near-Shore Artisanal Fisheries Enforcement Guide – An overview of the different enforcement systems used to monitor and manage near-shore fisheries.

Palau Northern Reef Assessment – An analysis of the legal framework, competencies, and jurisdictions of all marine enforcement agencies in the Northern Reefs (Palau) undertaken prior to designing an enforcement system that is practical, affordable, and feasible to implement.

Barbuda Blue Halo Enforcement Blueprint – An analysis of the legal framework, competencies, and jurisdictions of all marine enforcement agencies is undertaken prior to designing an enforcement system that is practical, affordable, and feasible to implement.

Stolen Seafood: The Impacts of Pirate Fishing on Our Oceans – A report summarizing the global extent of illegal fishing, its impact on people, the environment, and economy, the motivations behind illegal fishing, and recommendations for eliminating illegal fishing.

CHAPTER 5

Using Market Incentives to Reform Supply Chains and Achieve Fisheries Objectives

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CHAPTER 5

Using Market Incentives to Reform Supply Chains and Achieve Fisheries Objectives

Background

The term supply "chain" might be misleading because, in our global economy, there are few products that move along a simple, linear track from production to consumption. In reality, today's supply chains of goods like clothing, cars, and cod resemble complex networks that produce, transform, aggregate, separate, package, transport, store, ship, trade, sell, and serve goods. And few supply chains are more complex and obscure than those involving seafood.

In this chapter we focus on seafood supply chains and their role in complementing sustainable fisheries management and marine conservation. You will find information about:

- The characteristics of seafood and its supply chains
- How reform efforts in seafood supply chains can benefit marine conservation
- Guidance on identifying supply chain attributes and developing a strategy to effectively promote and incentivize more responsible fishing practices
- Common challenges in seafood supply chains and strategies to overcome them

On a global scale, the seafood industry handles approximately 158 million metric tons of product (over 91 million tons wild caught) every year. However, these estimates may significantly omit and underreport catch data for recreational and small-scale fisheries, as well as untargeted bycatch.[30] Tens of millions of people worldwide who fish for a living collectively harvest thousands of different species; they fish in every ocean on the planet, they range from independent artisanal fishers in small

30. FAO, 2014; Pauly and Zeller, 2016

*This chapter was developed using information adapted from Making Sense of Wild Seafood Supply Chains by Future of Fish and The Nature Conservancy. For more information, see the **full report**.*

communities to crews aboard industrial factory trawlers that spend months at sea. In addition to the diversity of producers, certain characteristics of seafood and the practices of supply chain actors make seafood a wholly unique industry (Table 7).

A characteristic shared by all wild seafood supply chains is that they originate with a producer (the fisher) and terminate with an end buyer, who sells to a consumer. End buyers can include marketplaces, supermarket chains, restaurants, hotels, schools, and other food service establishments. Sometimes fishers may sell their catch directly to consumers. However, where seafood is sold into more formal markets, the number and combination of mid-chain actors (e.g., aggregators, primary processors, traders, wholesalers, dealers, secondary processors,

TABLE 7. The Unique Characteristics of Seafood and the Consequences for Seafood Supply Chains

Characteristic	Consequences
Unpredictable	Wild catch fisheries are highly variable by nature, which in turn creates risk for the entire supply chain. Unlike farming or aquaculture, where productivity can be managed and maximized, wild fisheries are at the mercy of constantly changing environmental and biological conditions. This unpredictability carries over into the markets, where buyers may favor some fishers over others because of the composition of their catch and fluctuating market demands.
Highly perishable product	Fishers often have few options when it comes to finding buyers for their catch and rarely have the luxury of holding out for better prices. Once sold into the chain, mid-chain players must work rapidly to move fresh inventory, which limits their bargaining power, unless they have capacity to preserve (freeze, cure, or can) acquired fresh product before it spoils. Post-harvest, over 20% of seafood worldwide goes to waste within the supply chain before it reaches the consumer.
Low margins	With the exception of a few high-end products, most seafood companies are working on paper-thin margins. This is a result of the race to sell, as well as the disconnect between the cost of fishing and the price of fish, with prices paid to fishers often not enough even to cover their costs. Government subsidies that compensate fishers further contribute to overcapacity and mask the true cost of fishing from the consumer. These conditions often force mid-chain players to focus on quantity, not quality, in order to survive.
Disassembly and aggregation	Most seafood is processed in a manner that makes it particularly challenging to tie product-origin data to a finished product. For example, some forms of processing, such as canning, involve the mixing of multiple fish that may have been caught in different regions by different vessels on different days. Other processing methods involve partitioning a single fish into loins that are each sold to a different buyer and even processed in different ways, depending on the quality of the fish.
Minimal product tracking	Putting a serial number on a filet is difficult, expensive, and time-consuming. While advances have been made in tagging individual high-value fish, product tracking is usually done at a much larger scale (if at all), which opens up the possibility of substitution, mislabeling, and lost information.
Global market, global demand	Seafood (from wild and farmed sources) is the largest globally traded food commodity by value in the world ($130 billion in 2013).[a] Advances in freezer and transportation technology have enabled access to seafood from any region in the world, at any time of year. This availability (along with subsidies) has fueled growing demand for seafood on a global scale. In particular, growth of the middle and upper classes in China will continue to increase demand for seafood.

a. FAO 2014.
Source: Adapted from FoF (2015).

distributors, transporters) can vary drastically. While seafood supply chains themselves are not components of fisheries management, engagement with supply chains can result in social, economic, and environmental benefits in similar ways to management improvements.

Why Engaging in Seafood Supply Chains can Help your Conservation Work

While many seafood supply chains currently contribute to the problem of overfishing and illegal, unreported, and unregulated (IUU) fishing, it is also the case that the network of seafood supply chains around the globe can become part of the solution. Engaging key actors and supporting shifts in business practices may:

- Secure better data that inform marine management
- Influence responsible fishing practices and reduce IUU
- Reduce risk and bottom-line costs and increase revenues and market opportunities

Seafood supply chains can serve as a source of data that support more robust stock assessment models and management actions for targeted species, inform marine spatial planning, and provide information on threatened and vulnerable species and habitats. Information on what is being caught and how, its size and weight, and harvesting location, for example, helps environmental managers better manage marine resources and their habitats.

Supporting changes in seafood supply chains may result in powerful behavioral shifts that can translate to marine conservation benefits. Particularly in the absence of political will and/or capacity to pass fishery management regulations, engaging key supply chain actors and supporting shifts in business practices can be a powerful way to incentivize change on the water. For example, the data limitations in Indonesia's deepwater snapper and grouper fishery would normally make sound management almost impossible. However, with a clearer understanding of stock health through industry-led data collection, that is changing. In the absence of effective management regulations (and based on the collected data described in Box 4), some export companies have agreed to purchase only sexually mature fish (of a certain size) to help contribute to the long-term health of the fishery. The Conservancy and its partners in Indonesia are building a database with information collected by this system that could someday inform harvest control rules in the deepwater snapper/grouper fishery.

Integrating traceability technology and data collection into the operations of supply chain actors may accomplish numerous business goals, by reducing bottom-line costs and risks and

BOX 4. Using Technology to Change the Way Fisheries are Managed

In Indonesia, The Nature Conservancy is working with a seafood company and a number of fish traders to improve data collection in the deepwater snapper and grouper fishery in the Timor Sea. The Conservancy created identification guides for the more than 120 species in this fishery, and routinely trains personnel at the processing plant as well as fish traders in species identification. Fish IDs for each species are then assigned specific barcodes that can be scanned, enabling the quality-control personnel and graders at the processing plant to attach the correct name to each fish as it is being processed. When fish enter the plant they are identified and sorted, weighed on a digital scale, and passed on to the system's unique measuring board where a different set of barcodes associated with a specific length are scanned and data are uploaded to a digital database. Tracking information taken from a GPS device on the fishing boat is also linked to the database, allowing us to understand which fish are being caught and where fish are being caught. The fish length and harvest location data collected by this system allow scientists to monitor trends in stock health over time for each species. By increasing the accuracy, efficiency, and traceability of the processing line, the system also brings business wins by reducing overall costs. *You can learn more here*.

increasing revenues and market share opportunities. Improved product traceability may enable quicker and less costly product recalls, reduce inefficiencies and improve operations, facilitate inventory management, and help to reduce product spoilage and waste.[31] Data collection that starts at the point of harvest or with the first receiver may allow for product differentiation that helps leverage different markets and price premiums, preserve accurate product information as demanded by the market, and establish stable partnerships with buyers looking for long-term supply.[32] Product differentiation frequently occurs through "storied fish"—seafood sold with accurate information about its journey from water to plate, including where, when, and how it was caught, who caught it, and any compelling facts about the people or communities involved in the fishery.[33] Such market-based arguments can be persuasive when you are seeking to engage with representatives of the seafood supply chain in your fishery.

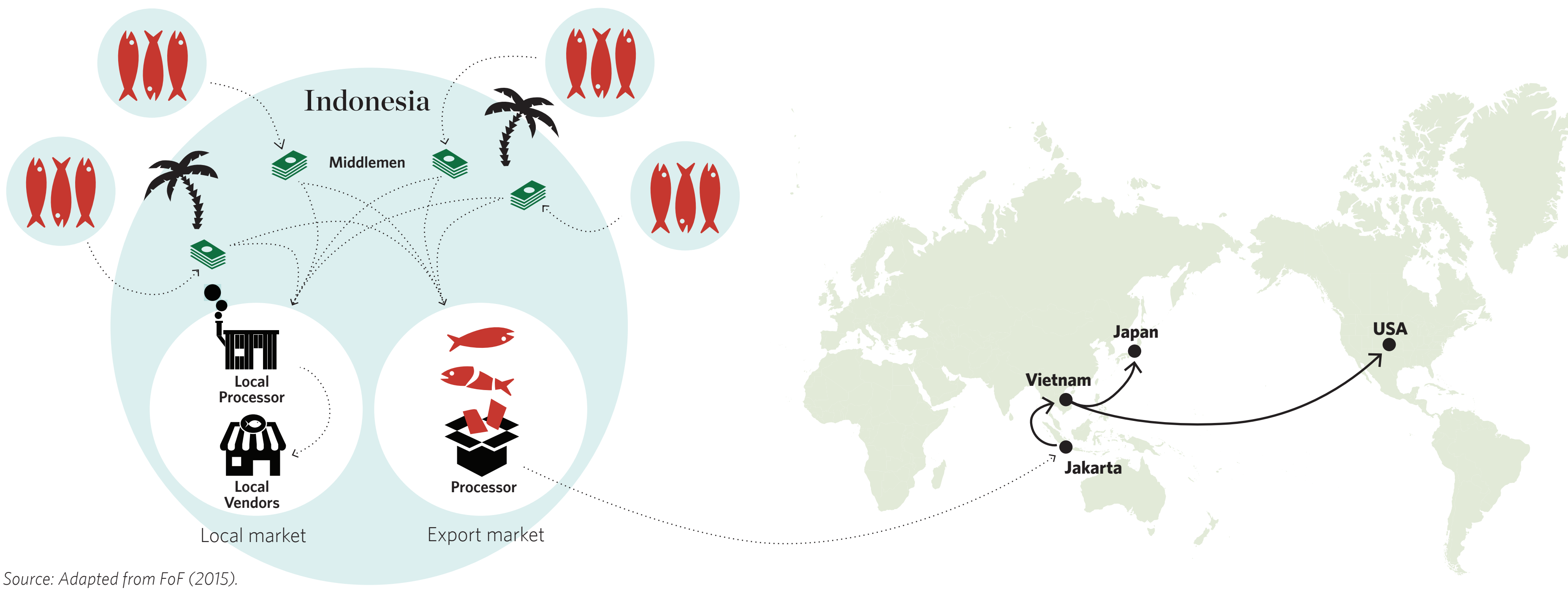
31. FoF, 2016
32. FoF, 2016

Applied Guidance

As a general rule, as the number of mid-chain actors in a supply chain increases, so do the complexity of relationships, the risk of losing traceability data and "story," and the possibility of fraud. But shorter supply chains don't always correspond with more trustworthy and reliable data. In a very short supply chain, where one processor aggregates catch from dozens of fishers and then sells to two retailers, the process of tracing

33. FoF, 2016

FIGURE 7. A Map of Supply Chain Actors in the Indonesia Deepwater Snapper and Grouper Fishery



Source: Adapted from FoF (2015).

each product back to the source is impossible without a system for segregating and labeling product from every producer. In Figure 7, we show a supply chain map of the Indonesia deepwater snapper and grouper fishery. This example illustrates how mapping the structure and actors in a seafood supply chain can identify barriers and help guide resource managers looking to engage with supply chains as a mechanism for improving local resource management.

In this section, we ask questions that can help you to identify common supply chain attributes present in your fishery, and which relate to the way seafood products and information flow, the roles of mid-chain actors within certain supply chains, and the motivations that drive particular business practices. Identifying the presence of specific attributes in a supply chain can help shape strategies for how to effectively promote and incentivize more responsible fishing practices, better data capture and tracking, and better storytelling around the product origin.

Is the seafood product differentiated?
At one end of the product spectrum are commodities, which lack differentiation between products. These are usually high-volume products aggregated from many sources and are considered identical, regardless of how, where, when, or by whom they were produced or harvested. At the other end of the spectrum are differentiated products, which are distinguishable from one another based on specific information, including harvest location, fishing method, fisher or fishing community, certification status, and brand name. Purchasing decisions by buyers of differentiated products may be driven more by quality than price, or at least equally by these two features, as opposed to the price-driven decision-making that occurs with commodity products. A differentiated product may be more open to tracking information about product origin.

Is there a strong brand associated with the product?
Influential product brands can drive practices in some supply chains by dictating product specifications and other protocols that producers, processors, distributors, and end buyers must follow. The influence is frequently top-down, coming from an end buyer (e.g., Walmart), a value-added processor, a broker, or a certification standards setter, such as the Marine Stewardship Council. Brands are also created by or in collaboration with fishers in a bottom-up approach that influences supply chains, as seen with some traceability companies (e.g., ThisFish), NGOs (e.g., Gulf Wild), or even fishing cooperatives (e.g., Alaska Gold). The specifications required by the brand may be based on location, quality, sustainability criteria, or other attributes that distinguish the brand in the marketplace. In this way, brand products are similar to differentiated products, in that both are trying to distinguish themselves as being different or better than the rest. The difference is that differentiated products differentiate a product from other products,

Atlantic Red Crabs, caught in 2,000 feet of water 60-80 miles off the coast of the Mid and North Atlantic are the only certified crabs in North America.

© Jason Houston/ TNC

whereas brands differentiate a customer from other customers. Depending on the mission of the brand and ability to access key decision-makers, it is possible to influence an entire supply chain by working with a brand to incorporate sustainability criteria into its product specifications.

Are there healthy relationship dynamics within the supply chain?

Relationships within the seafood industry are often long-lasting and built on trust, especially relationships between fishers and their buyers, which are often both business and personal in nature. For example, a fisherman may rely on the middleman to whom he sells his catch for loans to pay for fuel and ice, or even financing for his fishing boat. Often, the middleman is a member of the fisher's family. However, the power dynamics of the seller-buyer relationship can skew quite easily, especially if the buyer begins to exploit the seller's vulnerable position (holding spoiling inventory) or limited market access. Supply chains with equal power dynamics between actors and healthy relationships might be among the most flexible and potentially open to implementing changes that could benefit the long-term sustainability of a fishery—both in terms of the resource and the people and businesses involved. In situations where trading-partner relationships are weak or heavily one-sided, the supply chain will be very difficult to influence directly.

Is the supply chain vertically integrated?

Many seafood supply chains are vertically integrated, where all supply chain functions fall under a single company that controls most of the major steps—from fishing activities to the end buyer, or even to the consumer. Vertical integration provides a company with guaranteed access to product landed by its vessels, protects the company from unpredictable changes in selling price, and allows for close quality and inventory control. On the other end of the spectrum are dispersed supply chains in which every operation in the chain is performed by an independent actor, each one working to make a profit. As a supply chain gets longer, shrinking margins incentivize actors to do whatever they can to lower their costs (including committing fraud), because the next actor along the chain is always looking to pay the lowest price possible. Vertical integration can greatly accelerate the implementation of more responsible management and fishing practices for sustainably minded companies—all that is needed is a top-down directive. However, vertical integration can create a barrier to change for companies that are motivated only by profits or that do not value the idea of sustainable management.

Is there a bottleneck in market access?

Fisheries often involve a large number of fishers selling to a few middlemen who control the supply-chain relationships. These middlemen are essentially gatekeepers who create a bottleneck for fishers, restricting access to the market. There may be a series of middlemen-aggregators who collect product for a single processor/distributor that supplies a domestic or international market. Conversely, there may be a single middleman/processor/exporter who buys product from all the local fishers and is the gateway for foreign companies to gain access to local product. In bottleneck supply chains, positive changes in fisher behavior may be influenced by middlemen who believe that sustainable practices align with their business needs. In the case of fishery improvement projects (FIPs), sustainable practices are often introduced in partnership with a major domestic or foreign buyer that can promise better market share or premium prices in return for better management or fishing practices.

"Vertical integration can greatly accelerate the implementation of more responsible management and fishing practices for sustainably minded companies"

Reef fish on display at one of the fish market stalls in Kolonia, the capital city of Pohnpei, Federated States of Micronesia.

© Nick Hall/TNC

Challenges and Strategies for Progress

Mapping a seafood supply chain and describing its key characteristics can play an important role in overcoming a number of challenges to reforming seafood supply chains in line with sustainable fisheries goals.

Lack of vessel-level data capture

Without paper or electronic records of what was caught, where, when, and how, by each vessel for each trip, it is not possible to determine the sustainability or legality of a product. Fishery-dependent data are often the only available data for determining stock health, especially in countries where government resources are too limited to run fishery-independent data collection. Mapping and describing a seafood supply chain may help to locate the biggest barriers to data collection and identify the stakeholders with the most leverage to influence the collection of vessel-level data.

Product transformation prior to data recording

When a product or group of products is processed or transformed prior to the first instance of data collection, it becomes much more difficult to determine the sustainability or legality of a product. Product transformation can include 1) grading of product to selectively deliver certain species or sizes to a processor (recorded catch at this stage does not account for the original catch composition), 2) removing flesh from the shell before sizing, maturity, or sex is determined, and 3) skinning and fileting a fish before species identification has occurred. Mapping and describing the seafood supply chain may help to identify the stakeholders with the most leverage to influence how (in what form) vessel-level data are collected. Identifying or creating a market for product waste (shells, scraps) may also be an option to incentivize fishers to land the product whole.

Aggregation of supply

The mixing of products from different fishing events into a single product makes it difficult, if not impossible, to accurately track catch origin, catch method, date of harvest, size composition, or any other data related to the fishing activity. Product mixing may occur at sea (i.e., during transshipment), at a landing port, or at a processing center. Mapping and describing a seafood supply chain may help to identify the stakeholders with the most leverage to influence the collection of vessel-level data, separated by fishing events, which can be used to promote storied fish.

Fishers typically are not businesspeople

Fishers are experts at fishing, but fishers in a particular supply chain might not have the knowledge or experience necessary to engage more productively and sustainably in the seafood industry. Helping fishers get more value for their products often requires developing their skills in processing, marketing, price negotiations, logistics (e.g., transport, product handling), management and administration (e.g., inventory management, purchase orders, invoices), and even community organizing (e.g., co-ops, associations). A realistic strategy for sustainable management must provide fishers with the necessary business-related support services so that they can focus instead on changing their fishing practices, for example, swapping out fishing gear. For lasting and self-sustaining change, consider offering training to fishers who are natural entrepreneurs and interested in doing more than just fishing.

Cultural preferences

The ingrained expectations, assumptions, and perceptions of a particular culture shape everything from which species are favored to the way fishers view their roles in the community, and can explain a lot about the root motivations or causes for certain behaviors. Cultural norms are often tied to deeply held values and are extremely difficult to shift. However, understanding the beliefs and expectations that directly influence fisher behavior is critical to crafting strategies that align—and perhaps even leverage—those values, rather than fighting against them.

Lack of monitoring and enforcement

Government agencies are often limited in terms of the resources and capacity they can provide to monitor actors in the supply chain who may be breaking the rules. A significant lack of enforcement—both on the water and inside processing facilities—quickly erodes the confidence of fishers and buyers who are being asked to make sacrifices in order to fish or source seafood responsibly. As part of the exercise to map your seafood supply chain, you could examine the key elements required to establish and sustain an effective law enforcement system that is grounded in existing constitutional law. Consider designing a blueprint for a training program and engaging in systematic training of enforcement institutions. For guidance on how to improve enforcement systems, see Chapter 4.

More Information

Information and guidance on how to improve supply chain management and increase traceability can be found in the following publications and manuals.

Making Sense of Wild Seafood Supply Chains – A primer for resource managers, scientists, fishers, and other industry players seeking to harness the power of supply chains to ignite sustainable management in artisanal fisheries.

Without a Trace II – A summary of traceability efforts in the seafood industry, governance bodies, non-profit organizations, and certification bodies around the world.

Getting There From Here – A guide for companies implementing seafood supply chain traceability technology.

Traceability Principles for Wild-Caught Fish Products – A set of principles that summarize the essential characteristics of effective wild-caught fish traceability systems.

CHAPTER 6

Looking Ahead

CHAPTER 6

Looking Ahead

The objectives of fisheries management and marine conservation often overlap but the strategies to achieve these objectives are frequently misaligned, leading to conflict and missed opportunities for collaboration. As with the management of any public resource, driving positive change requires a deep understanding of the social and political factors affecting the communities that depend on resource use; factors that often become barriers to reform, and to designing compatible solutions that can work for the majority of stakeholders over time.

The *emerging strategies for progress* sections throughout this guidebook offered some starting points for exploration. In addition, we briefly highlight in this chapter several trends occurring in fisheries management that show great promise for moving fisheries toward sustainability.

Promising Trends in Fisheries Management

Governance moving toward co-management and rights-based management systems

Over the past 50 years, significant changes have been taking place in fisheries governance systems, with implications for the roles of the institutions involved in fisheries management. In many countries, fishery objectives have shifted away from simply maximizing catches and employment to prioritizing the sustainable harvest of stocks and managing for ecosystem health. Policies are shifting from the use of traditional command-and-control regulations to access rights and more participatory management approaches.[34] With this shift have followed changes in the structure of governance systems, from top-down hierarchical governance toward co-governance and self-governance structures that emphasize fisher participation and decentralization of management authority and responsibility to lower levels of government and institutions. This shift, although far from complete, is seen as a positive evolution in management, especially when it comes to small-scale fisheries.

In the case of many small-scale fisheries, the failure of top-down, command-and-control systems has led to the application of more devolved and locally accountable management structures and the development of co-management and community-based management arrangements.[35] If well designed and implemented, the advantages of co-management include

34. *MRAG, 2006*
35. *MRAG, 2006*

decision-making that is better informed, more flexibility in management approaches, and the incorporation of traditional ecological knowledge from fishers and other local stakeholders.[36] For example, in the Choiseul Province of the Solomon Islands, the Lauru Land Conference of Tribal Community (LLCTC) developed a community-driven conservation plan, which led to a political commitment from the government to support and legitimize provincial Locally Managed Marine Areas (LMMAs). The success of the community-led LMMAs led the provincial government to develop and ratify the Choiseul Province Fishery and Marine Environment ordinance in 2011, which legally binds fishery management plans developed by communities and further supports the traditional laws that are practiced.[37] The LLCTC has since been overwhelmed with requests for help in setting up LMMAs in other areas, and the process is being used as a model for other areas in Melanesia.

Management shifting to include multiple sectors at ecosystem level

We now have a much greater appreciation of how the oceans support and sustain human life by providing goods and services such as seafood, medicine, nutrient cycling, water purification, protection of shores from erosion and storm damage, regulation of climate and weather, recreation, and spiritual, religious, and other cultural benefits.[38] Ecosystem-based management (EBM) has been advocated for decades as an integrated approach to ocean management that considers the entire ecosystem, including humans, in order to maintain an ecosystem in a healthy, productive, and resilient condition that is capable of providing the services humans want and need.[39]

With specific regard to fisheries management, our understanding of predator-prey interactions and the transfer of energy between trophic levels has taken on new importance. These insights are resulting in improved accounting for variations in recruitment, for example, by factoring in natural predation, and better management of reserve prey for dependent predators. An example would be the management of capelin and krill stocks to support predators like squid, fish, seabirds, seals, and baleen whales. Moreover, increased sensitivity within the marine conservation community concerning the social and economic impacts of conservation measures on fisheries and other marine resource sectors has led to efforts to minimize

Local villager, Kirino Olpet, spearfishing in the lagoon waters of Ant Atoll, Pohnpei, Federated States of Micronesia.

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36. McLeod et al., 2005
37. Kereseka, 2014
38. McLeod et al., 2005
39. McLeod et al., 2005

adverse impacts. For example, optimization processes can be used to design small MPAs that meet conservation objectives, develop catch shares that achieve greater profitability, and balance other requirements.[40] However, the application of comprehensive EBM plans is still not practiced regularly, most likely due to miscommunication between academic scientists and management agencies, and institutional structures that favor the management of individual sectors.[41]

For EBM to be effective, human activities should be managed in a fashion that considers the impacts of each sector on the entire ecosystem as well as on other sectors. The long-term, integrated, cumulative impacts of all relevant sectors (i.e., fisheries, conservation, tourism, coastal development, energy, marine transportation, recreation) on an ecosystem must be evaluated, with a mechanism for adjusting impacts of individual sectors. Tackling all sectors together is at times impractical; however, incremental management improvements that address the management of interacting groups of species as well as sectors can lead not only to a reduction of user conflict but to long-term sustainability.

Sustainable financing and impact investment

Under the right enabling conditions, investment in fisheries management can yield positive returns, especially in fisheries with strong governance in place. A 2015 study concluded that the recovery of overexploited fisheries globally could increase global fish stocks by 36 percent.[42] A study by Encourage Capital has identified fisheries investment blueprints that generate potential equity returns of 5–35 percent.[43]

In addition to providing better yields, fisheries management interventions, such as the implementation of territorial use rights, quotas, catch shares, or the use of technology to improve access to markets and operational efficiencies, can improve fishers' profits. At times, sustainably harvested fish can command a market premium or, more often, ensure access to markets.

However, there are very few "investable" fisheries projects in the developing world, mostly because the risk is still very high. For likely investor groups, such as small equity investors and impact investors, the greatest challenge to accelerating fisheries investment remains the uncertainty and risk of returns. The investment case for the use of philanthropic and private capital to finance the transition to sustainability is made most clearly when key enabling conditions are present that create value and minimize risk:

"The greatest challenge to accelerating fisheries investment remains the uncertainty and risk of returns."

- A regulatory framework exists that enables tenure rights over the fishing resource, aligns incentives, and empowers the fishers to pursue sustainable use of a marine resource
- A harvest strategy has been developed that is based on solid understanding of the condition of stocks and establishes harvest control rules that effectively manage fishery harvests at sustainable levels
- Enforcement and compliance mechanisms operate to provide assurance that fishers comply with fishery regulations and that illegal activities will be contained

With these enabling conditions in place, investment can be channeled toward the three key drivers of increased fisheries value:[44]

1. Improving stock health leads to a more abundant resource that supports higher long-term yields and makes fish less costly to find and catch.
2. Increasing operational efficiency can reduce the cost of

40. Salomon et al., 2011
41. Arkema et al., 2006
42. Costello et al., 2015
43. Wachowicz et al., 2016
44. Holmes et al., 2014

fishing, reduce spoilage, and improve fish delivery through the supply chain, thereby improving profit margins and the returns from the fishing industry as a whole.

3. Increasing market value through improved market access, certification, product branding, and long-term partnerships returns more value to fishers.

Eco-certification and storied seafood

Eco-certification in the seafood sector has evolved considerably from its roots in dolphin-safe tuna labels created in the late 1970s. Since then, the use of eco-certification and other market tools such as storied fish, when properly designed and implemented, have been constructive factors in increasing the sustainability of fisheries. Between 2003 and 2015, certified sustainable seafood (both aquaculture and wild catch) grew from 500,000 metric tons, or 0.5 percent of global production, to 23 million metric tons, or 14 percent of total global production.[45]

As consumers have become more aware of sustainability issues, retailers and manufacturers supplying developed country markets have increasingly recognized the value of affiliation with sustainability certifications. Early adopters were motivated to pursue certification mostly by their interest in demonstrating leadership and seeking product differentiation. However, as eco-labeling has transitioned into mainstream markets, the primary value of eco-certifications has arguably shifted from providing brand enhancement to providing reputational risk management.[46]

Eco-certification increasingly focuses not only on biological objectives associated with the targeted species, but also on incorporating principles of ecosystem-based management and good governance. For example, the Marine Stewardship Council (MSC), probably the most widely recognized fisheries certification body, uses ***standards*** that include seven criteria concerning the status and exploitation of the target species assessed, 15 criteria concerning the ecosystem effects of the fishery, and nine criteria related to the governance of the fishery.

Fishermen prepare their nets before setting them at night in the waters between Ile a Vache and Les Cayes, Haiti.

© Tim Calver/TNC

While eco-certifications show great promise for transforming fisheries, significant challenges remain. Certification growth has for the most part been restricted to limited segments of the market—primarily to fisheries with strong management capacity and species groups with high visibility in

45. Potts et al., 2016
46. Potts et al., 2016

developed-country markets.[47] The costs of gaining eco-certification put small-scale fisheries in the developed and developing world at a distinct disadvantage compared with more capital-intensive industrialized fisheries.[48] The demands on human and technical capacities present a further barrier.

Nevertheless, seafood sustainability standards offer an invaluable tool for measuring, verifying, and retaining sustainable and legal practices and, as such, represent an essential complement to management reforms and financial investments aimed at promoting the implementation of sustainable production practices.

Conclusion

We know that many of the world's fish stocks are declining and that their condition is causing real concern to fisheries managers and conservationists alike. But there are positive trends in fisheries management, which show that fishery resources can be recovered and that the benefits will go far beyond an increase in yields.

We are optimistic that we now know how to manage fisheries in ways that meet the objectives of both conservation and fisheries managers and that, with more cross-sectoral collaboration, new methods, and the right technologies, we can put the world's fisheries on the path to sustainability.

47. Potts et al., 2016
48. Jacquet et al., 2010

More Information

Fishery Co-Management: A Practical Handbook – A guide to the application of community-based co-management in small-scale fisheries.

Sustainable Fisheries Financing Strategies – An evaluation of the factors that affect the financial viability of sustainable seafood investments.

Investing for Sustainable Global Fisheries – A report describing investment blueprints for small-scale, industrial-scale, and national-scale fisheries.

Taking Steps Toward Marine and Coastal Ecosystem-Based Management – An introductory guide to assist countries and communities with making marine and coastal ecosystem-based management operational—from strategic planning to on-site implementation.

State of Sustainability Initiatives Review: Standards and the Blue Economy – A review of marine sustainability initiatives that offers a framework for understanding their characteristics, important issues, and market trends.

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