

Coastal Fisheries Science and Management **HANDBOOK**

GENERALIZED VERSION

Participant Name



FISHKIT

The Nature
Conservancy 

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Introduction

Who is The Nature Conservancy?

The Nature Conservancy (TNC) is a global environmental nonprofit dedicated to creating a world where both people and nature can thrive. Founded in the U.S. through grassroots efforts in 1951, TNC has grown into one of the world's most effective and far-reaching environmental organizations.

What is FishKit?

FishKit is a suite of software tools and guidance designed to help coastal communities efficiently collect, analyze, and apply data to develop targeted fisheries management strategies. By simplifying established fisheries science into an intuitive interface, FishKit addresses two key challenges in small-scale fisheries: data gaps and limited technical capacity for management planning. FishKit is currently used by communities across the Pacific, including in Hawai'i, Mexico, and French Polynesia.

About the Handbook

This handbook, developed by The Nature Conservancy's FishKit team, serves as an introduction to fisheries management and the FishKit platform. Originally created for a course in French Polynesia, it has since been adapted for broader use.

Intended as both a teaching aid and a reference guide, this handbook provides key visualizations and insights into fisheries management. However, it is not a comprehensive resource and should not be the sole reference for fisheries management efforts.

Some materials in this handbook are inspired by the Barefoot Ecologist's Toolbox (Biospherics, 2022) and the Pacific Community (SPC).

Citation: The Nature Conservancy, 2025. Coastal Fisheries Science and Management Handbook.

1. Introduction to the Ocean

Why is the ocean important? What are the major threats facing the ocean? This module is designed to contextualize fisheries management in the broader context of the ocean and the many ways it is intertwined with communities around the world.



The ocean is essential to life on Earth. It provides food, regulates climate, and supports the livelihoods of millions of people worldwide. Coastal communities, in particular, have depended on the ocean for centuries, using its resources for sustenance, culture, and economic stability.

**What does the ocean mean to you?
What are some of the ways you interact with the ocean?**

THE STATE OF FISHING



Oceans provide protein for **3.2 billion people**, feeding nearly **4 out of every 10 people** worldwide.¹

Fisheries generate more than **\$157 billion USD** per year, underscoring their economic importance.¹



More than **500 million people** rely on fisheries for their livelihoods.¹

But this intensive use of ocean resources can stress the system. Around the world, **33% fisheries are overexploited**, causing the decline of harvested marine species.¹



1965

2015



90% of fisheries lack the basic information needed to design effective management

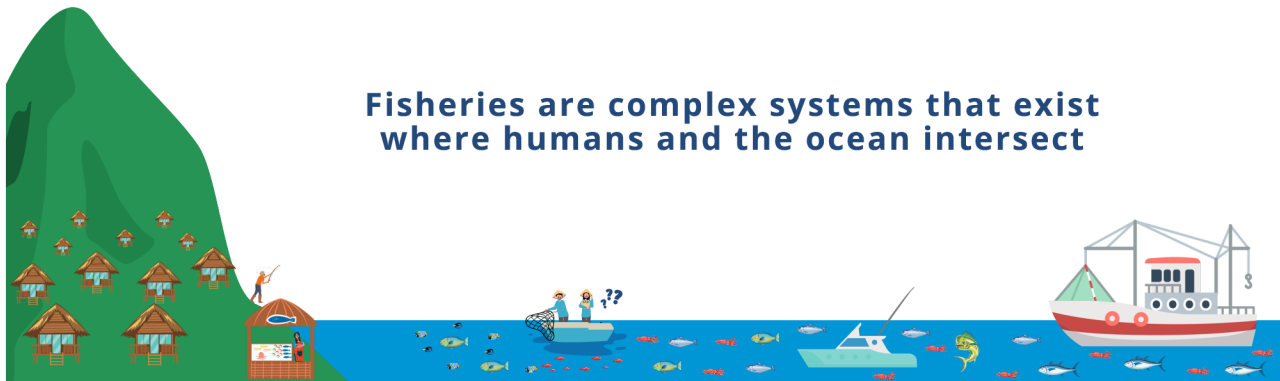
Effective fisheries management can ensure fisheries resources continue to provide food and livelihoods



1] Food and Agriculture Organization of the United Nations. (2022). The state of world fisheries and aquaculture 2022: Towards blue transformation. FAO. <https://doi.org/10.4060/cc0461en>

2. What is a Fishery?

This module provides a foundational introduction to fisheries and their three key components: biological, ecological, and human. This module is essential for understanding how fisheries function. The objectives of this module are to: 1) Break down the concept of a fishery into smaller, more manageable parts. 2) Lay the groundwork for the rest of the course, where we will explore these concepts in greater depth.



The ocean and its marine life are a shared resource. Harvesting fish provides critical nutrition, livelihoods, and cultural importance to communities that have fished for generations. We all must cooperate to have productive harvesting while leaving enough fish in the ocean to ensure there are fish in the future.

A FISHERY IS MADE UP OF THREE COMPONENTS: BIOLOGICAL, ECOLOGICAL AND HUMAN

BIOLOGICAL

An icon representing biological components, featuring a blue fish in a white circle, a bar chart, a red coral-like shape, and a black fishing hook.

This includes characteristics of fished species like how fast they grow, how long they live, etc.

ECOLOGICAL

An icon representing ecological components, showing several blue fish swimming over a colorful coral reef.

This includes characteristics of fished species like where they live, what they eat, how far they move etc.

HUMAN

An icon representing human components, showing four stylized human figures: one fishing, one holding a basket, one holding a plate, and one wearing a hat.

This includes the ways in which people interact with fished species including catching, selling or eating them.

By considering all three of these different dimensions of a fishery, we can gain a holistic understanding of a fishery system and its most important characteristics.

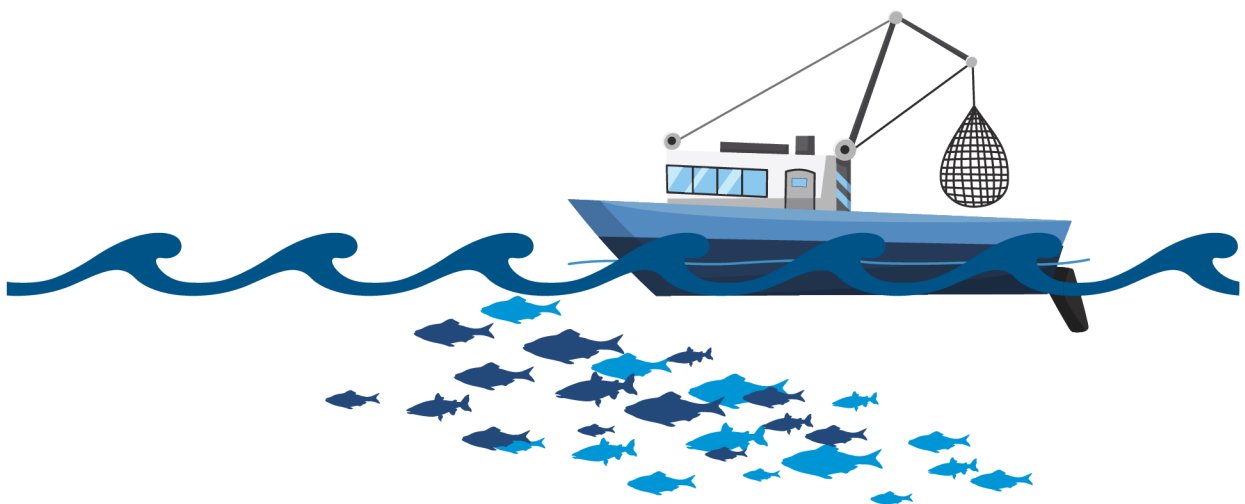
Biological Components of Fisheries

The first important component of a fishery encompasses traits of the fished species itself, that influences how they interact with the world around them, including how they respond to fishing.

A fish population is a group of individuals of the same species that are spatially, genetically, or demographically separated from other groups.



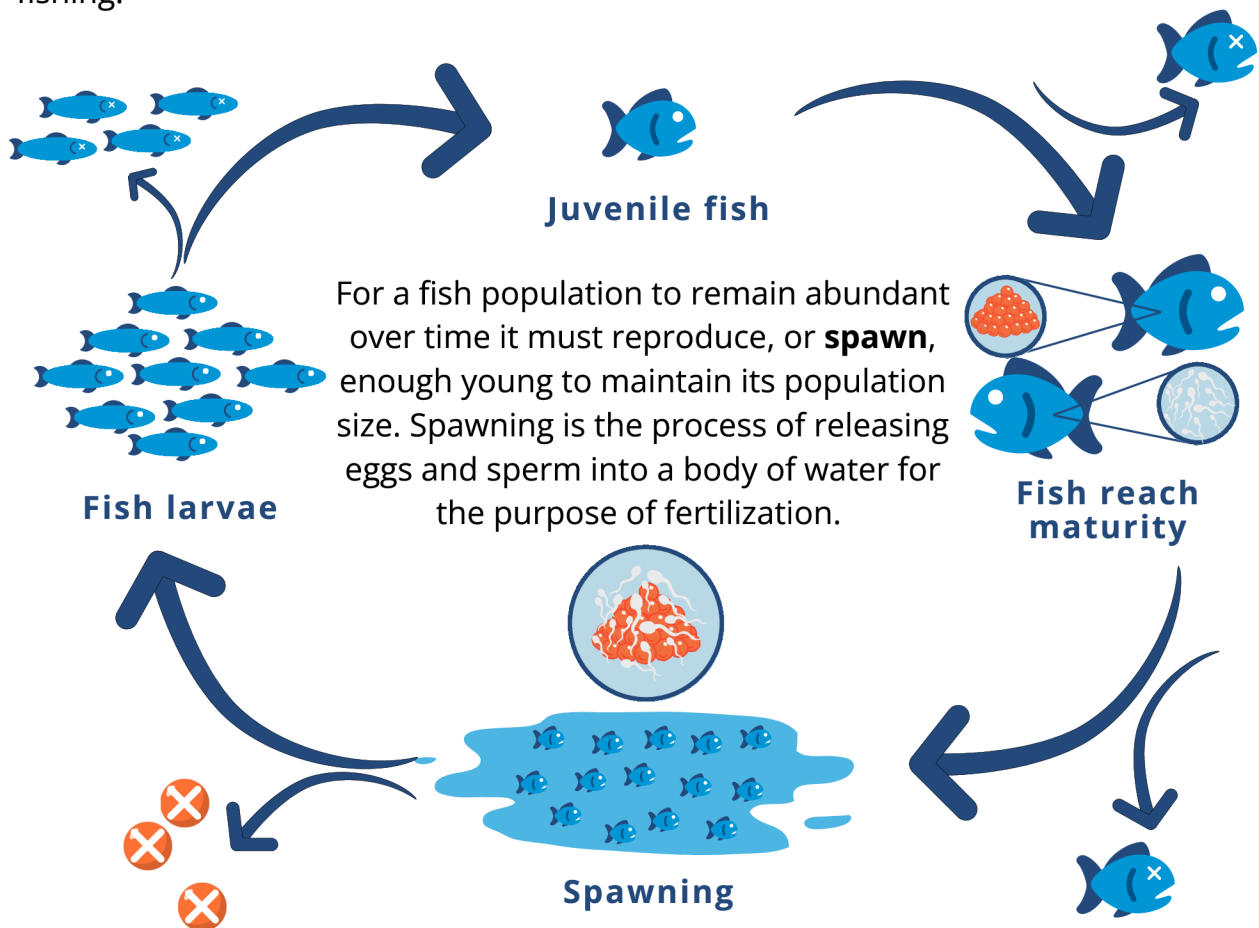
We think of them as a distinct group because they are relatively isolated from other individuals of their species and therefore primarily are reproducing with one another.



A fish stock is a population of fish that serves as a resource for a fishery.

LIFE CYCLE OF A FISH POPULATION

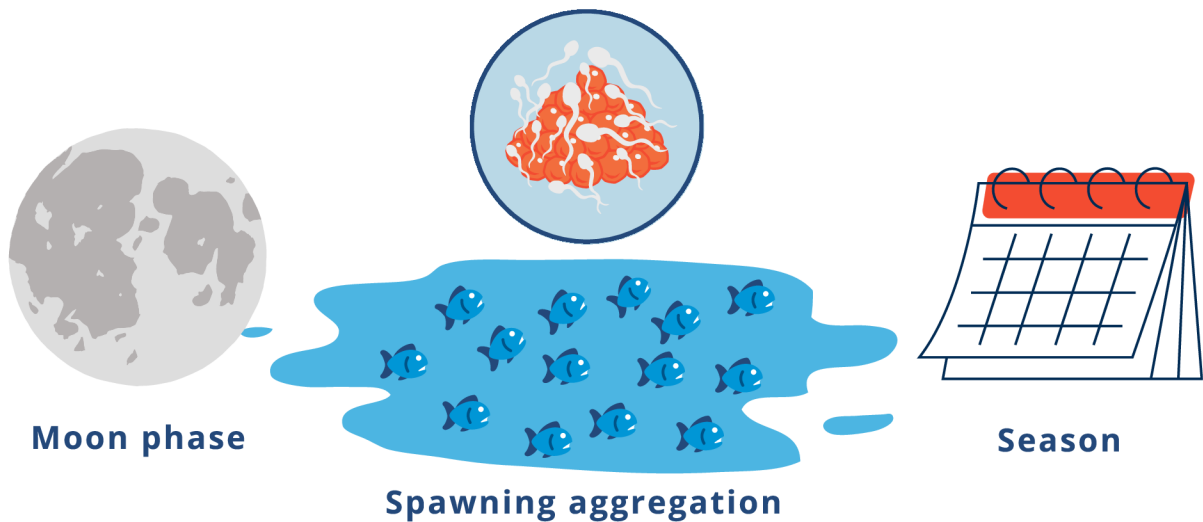
All fishes go through different phases as they grow, reproduce and die. These life phases vary species by species and often take place at different times and in different habitats. While this diagram is a generalized concept, and not all species live in a way precisely reflected by this diagram, all fish species are born (or hatched), grow, reproduce and die in ways reflective of their particular biology. Understanding a fished species' life cycle is integral to understanding how to effectively manage fishing.



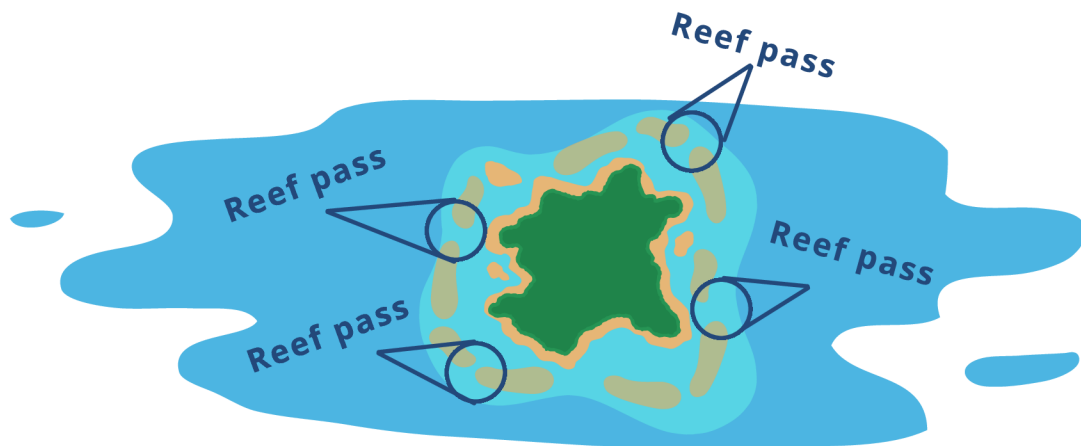
The offshoot arrows represent fish dying at different life stages from predation, fishing, etc.

Ecological Components of Fisheries

Spawning is often a coordinated event timed to maximize the chance of reproducing enough young to maintain a population. A **spawning aggregation** is when individuals of a single species of fish gather together solely for the purpose of spawning. It often corresponds with a time of year and/or a phase of the moon (eg: summer months on full moons).



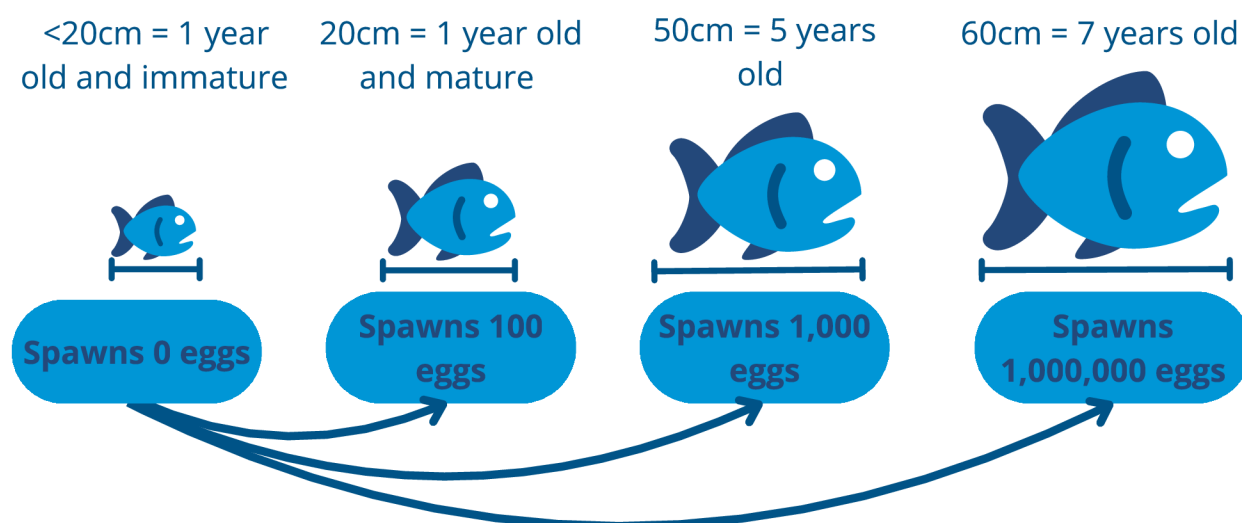
Spawning sites also represent one of a species's required habitats. While some species don't have a particular location where they spawn, many species return to the same area each time they reproduce. Understanding the timing and locations of spawning aggregations is critical to maintaining or rebuilding their populations.



Reef passes are a common spawning site for many fished species in the Pacific. Reef passes are a transition point between the lagoon and open ocean, and are typically characterized by a high diversity of species as individuals move in between these different habitats. These zones also provide an area with a lot of water movement where eggs and larvae can be pushed offshore where there are fewer mouths that might want to eat them.

BIGGER FISH PRODUCE MORE BABIES!

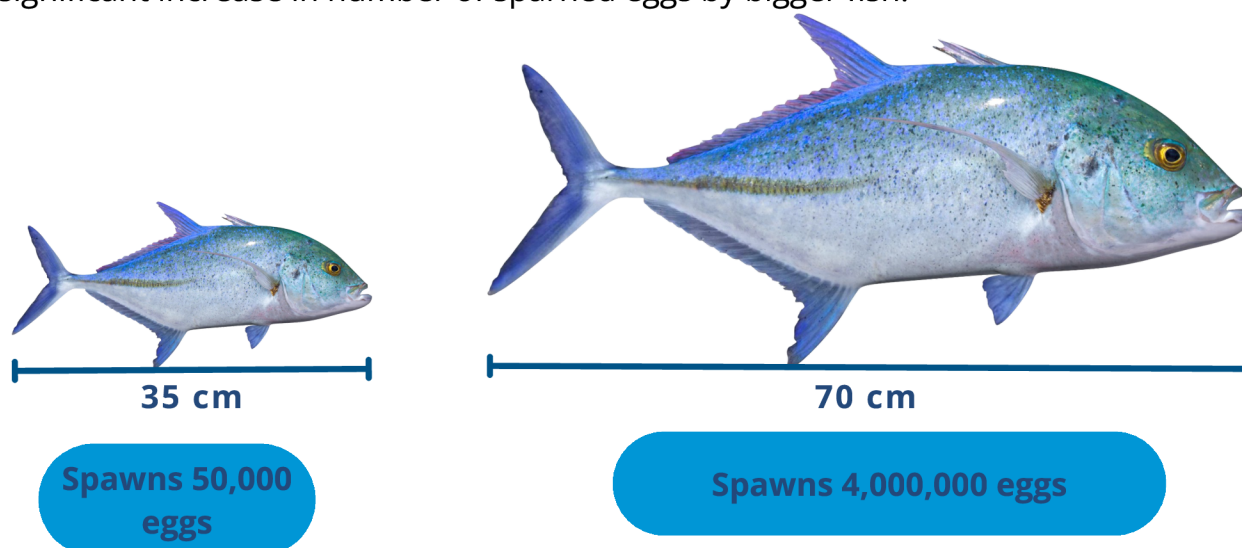
Reproductive output of individual fish also changes as they grow. Larger fish produce many more eggs than smaller fish. The biggest fish are often referred to as mega-spawners because of their oversized contribution to the population.



These eggs can also differ in quality, with eggs from the bigger fish often being healthier and likely leading to more big, healthy baby fish in the future!

EXAMPLE: OMILU IN HAWAI'I

A study on omilu (*Caranx melampygus*) from Hawai'i found that omilu exhibit the significant increase in number of spawned eggs by bigger fish.²

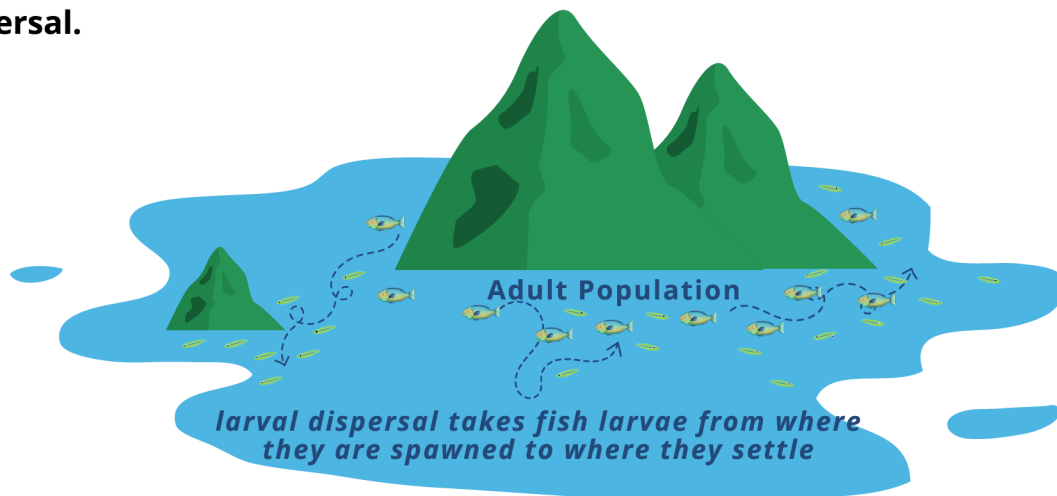


This is why the presence of large, big fish in the population can be an indicator of a healthy fish population. How this concept relates to fish population health will be discussed more later on.

2] Friedlander, A. M., Birkeland, C., Conklin, E., Green, A., & Starmer, J. (2024). The Importance of Fisheries Replenishment Areas in Hawai'i. Illustrations by Ellyn Tong.

LARVAL DISPERSAL

After fish spawn, the fertilized eggs turn into **larvae** or tiny baby fish. These tiny baby fish are transported by water, waves and currents through a process called **larval dispersal**.

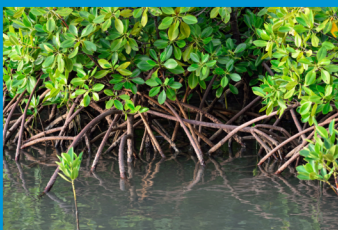


For some species, the larvae can travel further than adults of the species do, but many also wind up close to home. As the larvae mature and some begin to find themselves in suitable habitats, they settle out and begin to grow and live in near shore environments.

REQUIRED HABITATS

Required habitats are all the habitats that a species needs during its lifespan, including spawning sites and nursery habitats. In the previous section, spawning sites were mentioned as well as their importance in ensuring fish reproduction. Below is an overview of some other important habitats that are often utilized by coral reef species at certain points in their lifecycle.

MANGROVES



CORAL REEFS



SEAGRASS BEDS

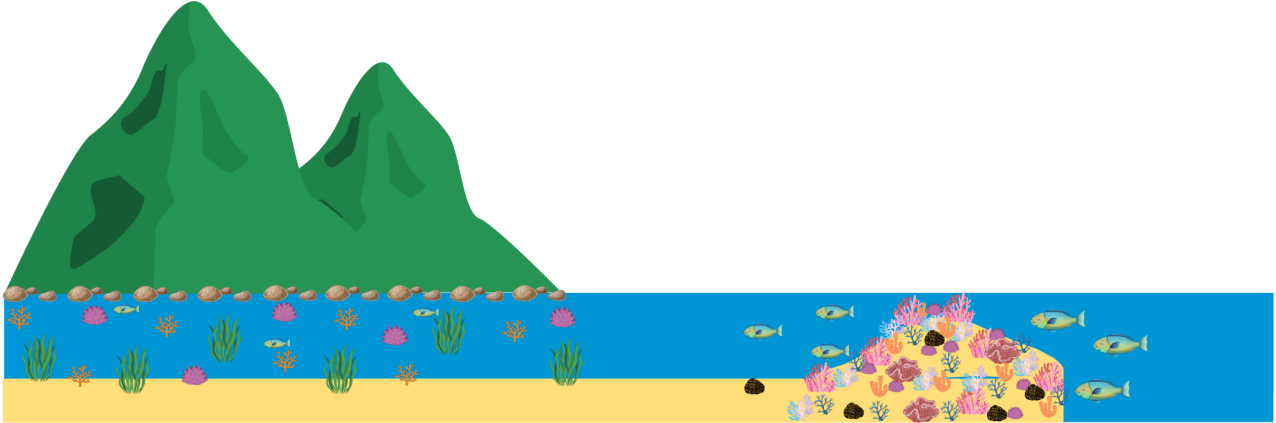


These three habitats have important characteristics that benefit fish species and coastal ecosystems as a whole. They:

- Are complex with small spaces for juvenile fish to hide from predators.
- Are productive areas with lots of food to eat.
- Some have filtering capabilities that reduce sediments and toxins in water and increase overall water quality.
- Some can stabilize coastlines and can protect areas from the impacts of storms.

FISH MOVEMENT

Fishes move around during their juvenile and adult phases for feeding, resting, breeding, migration, and seasonal movements. They may also transition to different habitats as they mature into adulthood. Some coral reef fishes use mangroves, estuaries, or seagrass habitats as juveniles and then move on to reefs as they mature. Other species settle in protected lagoons or fringing reefs and move to deeper reef areas as they get older.



MOVEMENT

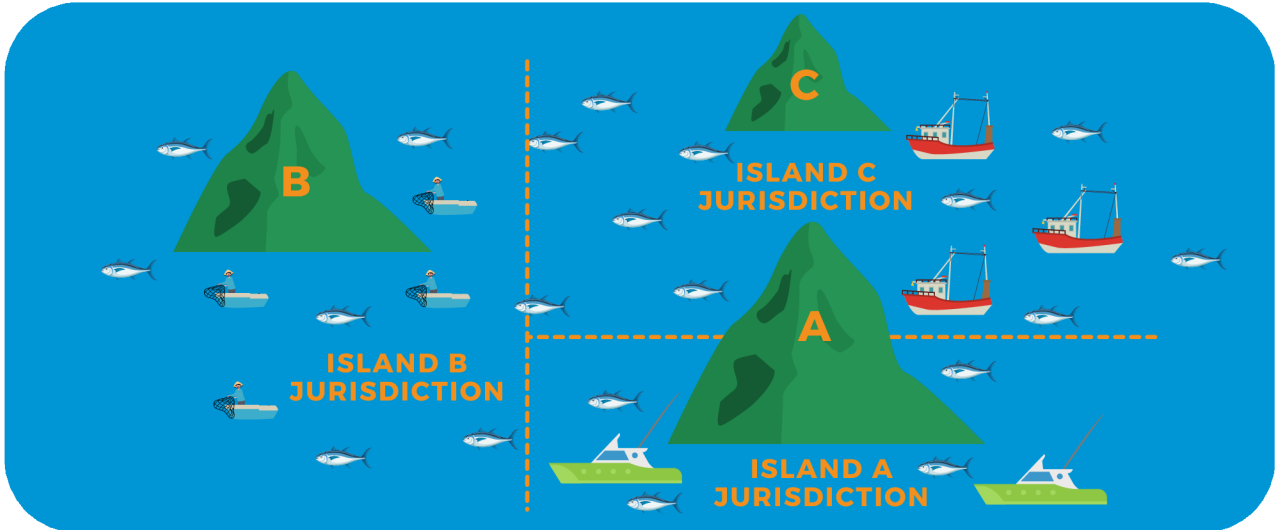
Movement is how far an adult fish in the population typically moves in an average year of its life. This includes movement over the life cycle of the fish, as well as movement to spawn.



How far a species moves is important for fisheries management as it helps to define the fish population being managed and determine which types of management measures may be most effective.

Human Component of Fisheries

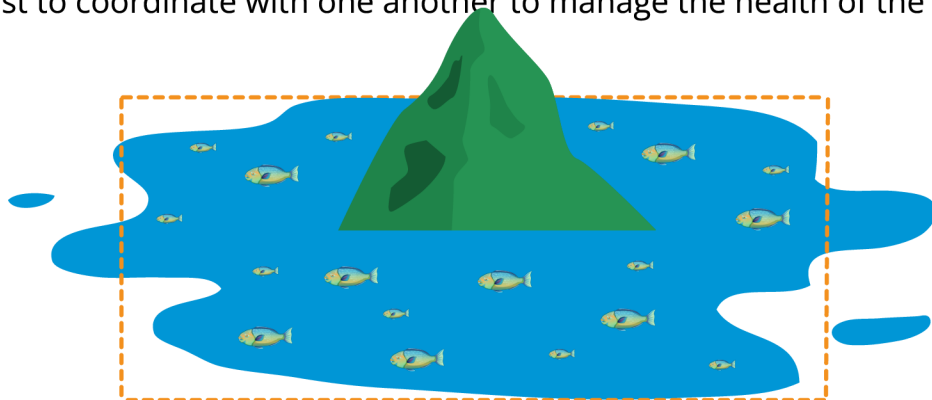
People all over the world interact with fisheries. By catching fish, selling fish, buying fish, eating fish, and even managing fisheries, humans are an important part of fishery systems.



There are often different groups of people and gear types interacting with the same fish population, such as artisanal fishers who fish for tuna with hand lines compared to industrial tuna fisheries that fish with longlines. Different rules and strategies for management may be needed for these different groups.

GOVERNANCE AND SPECIES MOVEMENT

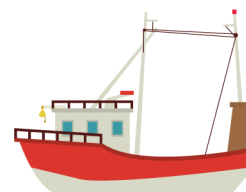
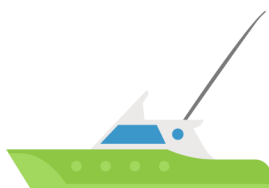
The illustration above shows different scales of governance. Governance is the system that determines how fisheries are managed and decisions made. In this example, Islands A, B and C all fish the same population of tuna and have the authority to make decisions and manage fishing. But because the same population of tuna is spread throughout the jurisdictions of all three islands, it might be in their best interest to coordinate with one another to manage the health of the population.



Alternatively, a population of parrotfish as depicted above, might lie entirely within the jurisdiction of one island. Understanding the relationship between the range of the population and the governance of different groups impacts the way a fishery is managed and what management actions are appropriate.

FISHING METHODS

Different fishing methods (how the fish are caught) and gears (the equipment used to catch the fish) are also important components of the fishery.



Fishing method is important for several reasons:

- Different boats have different ranges in terms of how far they can travel and therefore what areas they can target.
- Different fishing gears may have different impacts, for example a fisher who uses a large net and a spear fisher may both catch parrotfishes but with different impacts on the habitats, target and other species, etc.
- Different fishing methods may also need to be managed differently sometimes (this topic will be revisited in more detail in the management measures section)

Example: O'eo fishery in Rangiroa, French Polynesia

The O'eo (Longnose emperor) fishery in Rangiroa, French Polynesia uses large pens in the water known as “fish traps” to catch large numbers of O'eo. Understanding this fishing method created an opportunity to make the fishery more sustainable by creating a door in the traps where the smaller, immature O'eo could escape before being harvested.



FISHING EFFORT

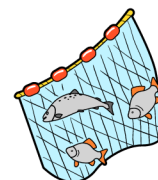
Fishing effort is a term that describes generally the amount of time and resources used to catch fish. It refers to a combination of factors such as:



**The number of
boats or fishers**



**Time spent
fishing**

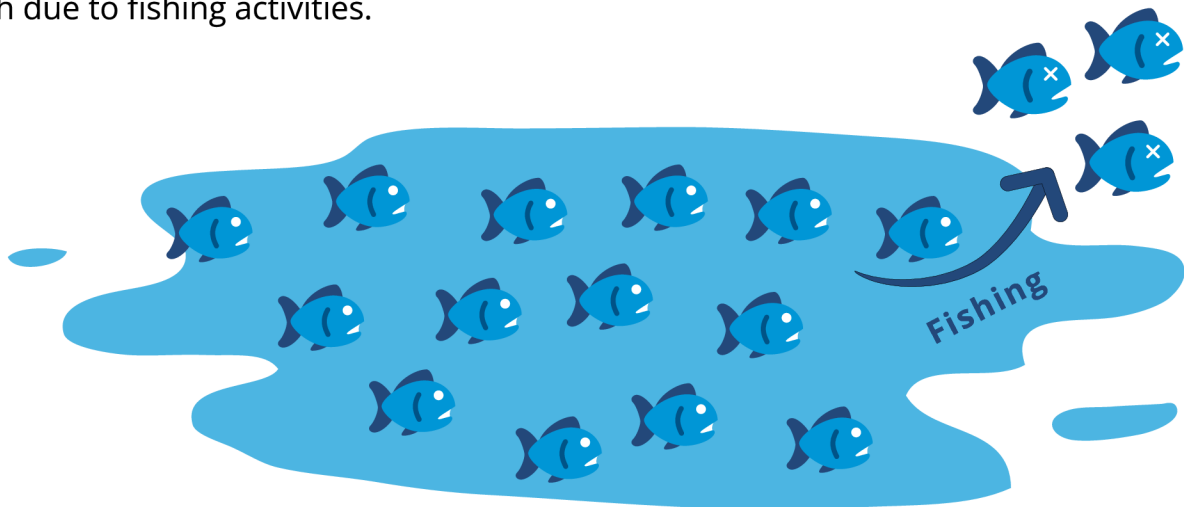


**Type and amount
of gear used**

Fishing effort can be a very difficult thing to measure but understanding fishing effort can often be key to ensuring sustainable fishing.

FISHING MORTALITY

Fishing effort is what results in **fishing mortality**, which is the death or removal of fish due to fishing activities.

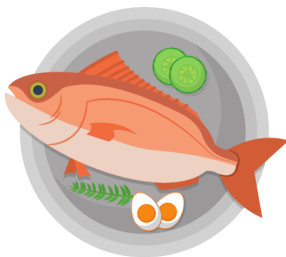


Fishing effort and fishing mortality are closely related, but fishing mortality is a direct measure of the impact fishing effort has on the population.

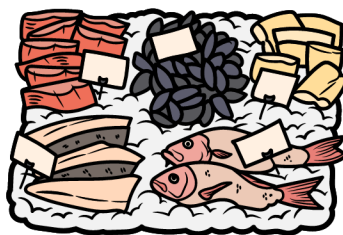
MARKETS

Markets are a transition point where fish change hands from fishers to consumers. Markets can also sometimes influence where, how and when fishers catch fish.

Markets can influence:



The size of fish harvested



The species of fish harvested



When high levels of fishing may occur

Markets are key to understanding economic influences on fishing and often also serve as a convenient aggregator of fish, and therefore a convenient location for sampling as we will discuss later.

Describe Your Fishery

List fished species (one or a few). What habitats are they found in? How far does a single fish of this species travel, from spawning to adulthood?

Who fishes for them? In what depth or habitat do they fish for them in, and when? What is the method used? Are fish consumed by fisher families or sold commercially? What are the key markets/landing points? Is there community or personal significance?

How is it going? Does the fishery appear stable, declining or increasing? How has the fishery changed over the past 10 years? 50 years?

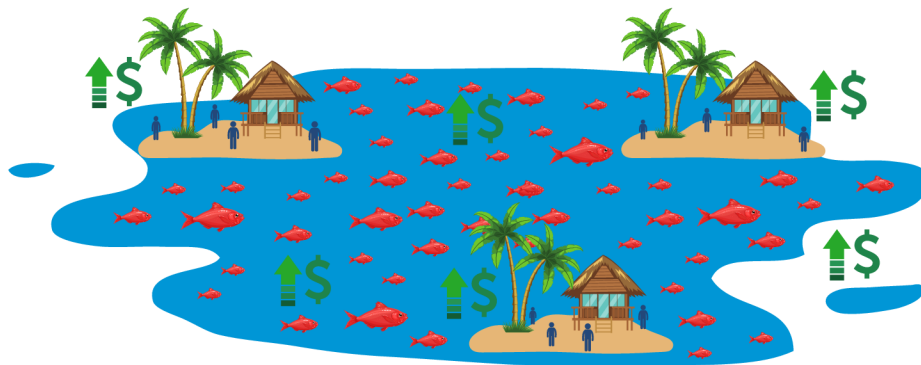
Map it!

Draw a representation of your fishery below. Make an effort to depict key points (if known) such as nursery grounds, spawning sites, fishing docks, fish markets, etc.

3. Introduction to Fisheries Management

This module introduces the concept of a sustainable fishery and explains overfishing and its key signs. The objectives of this module are: 1) Understand what overfishing is and some common signs of overfishing, 2) Learn about traditional forms of fisheries management, 3) Understand what common management measures can be used to address overfishing, and 4) Reflect on management measures being used in your community.

Fisheries are a shared resource, meaning in most cases, no one owns the fish themselves or the fish population



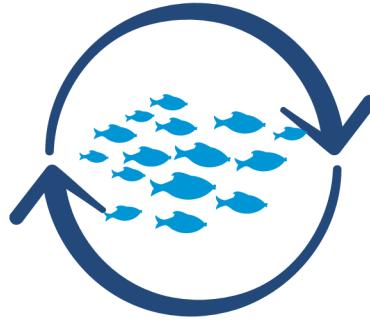
A well-managed fishery maintains the fish population and provides food and income to the local community.

If no management or cooperation



Without coordination, individuals might be incentivized to catch as many fish as quickly as possible, thinking "If I don't catch them, someone else will." This can result in depleted fish population, which can no longer provide food or income to the local community.

Overfishing is when a fishery is taking fish out of the water faster than they can reproduce, which leads to a decline in the fish population or stock.



SIGNS OF OVERFISHING



You are spending more time and money to catch the same number of fish



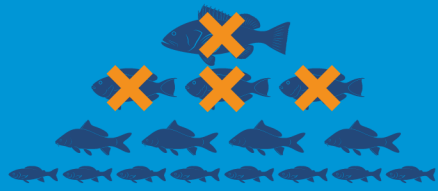
You are seeing fewer and fewer fish



Fish are smaller and smaller when you catch them



You have to go further out to catch the fish



Over time, species that were once prized are fewer and fewer so fishers must shift towards the less desirable species that remain

Signs of Overfishing Activity

Have you seen any signs of overfishing in your community? What makes overfishing happen? What have you seen? How do you feel about the status of fishing in your community?

HOW CAN FISHERIES MANAGEMENT HELP?



Sustainable fishing is about finding the balance between catching enough fish to support the community, but leaving enough large, reproductively mature fish in the ocean to ensure there are fish to catch into the future.

Traditional Fisheries Management

Pacific Island communities have long relied on marine resources for food, livelihoods, cultural heritage, and well-being. Many of these communities practice traditional fisheries management, drawing on ancestral knowledge to sustainably use and protect marine resources. Today, these time-tested approaches are being revived and integrated with modern conservation efforts to prevent resource depletion, support marine ecosystems, and provide for local communities. Below are examples of traditional fisheries management practices from across the Pacific:

RĀHUI | FRENCH POLYNESIA

Rāhui is a traditional Polynesian practice that temporarily restricts access to certain areas or resources, allowing them to replenish. This practice is commonly used in places like French Polynesia and New Zealand. For example, in the village of Tautira, Tahiti, a rāhui was placed on a lagoon to protect fish stocks, leading to a significant increase in fish populations.



The village of Tautira, Tahiti. Photo by Taerea/Shutterstock



Fishermen in Totoya Island, Fiji, marking a sacred reef area as a no-fishing zone. Credit: Keith Ellenbogen

TAPU (OR TABU) | FIJI

In Fiji, tabu or no-take areas were enacted to temporarily ban fishing in an area of the reef when a chief or special community member died. This was considered a sign of respect, and ensured there were plenty of fish to feed visitors months later when the mourning period ended. In other places, particular reef areas were considered sacred and were permanently closed to fishing.

BUL | PALAU

In Palau, the practice of bul involves placing a moratorium on fishing in certain areas to allow marine resources to recover. This community-led management approach is deeply rooted in Palauan culture and applications such as a regional ban on grouper sales has proven effective in sustaining fisheries and marine biodiversity.



KAPU | HAWAI'I



Mullet in Palmyra © Tim Calver

In Hawai'i, the kapu system was used to manage fishing using rules such as closed seasons, fishing areas, size restrictions, gear limitations and catch limits to ensure sustainable harvest. This system relied upon community leaders or "konohiki" to enforce and align practices with the values and needs of the community. A modern day example is the Ka'ūpūlehu Marine Reserve where the area has been closed to fishing for ten years to replenish fish stocks.

TAPOS | MEXICO

In Mexico, the tapos system has been used in estuarine areas along the Pacific Coast as a way to manage shrimp fisheries. It creates corrals that allow shrimp larvae to enter but does not allow all of them to go back to sea. They entail a deep understanding of biophysical and ecological factors such as tides and spawning seasons. When done appropriately, they do not compromise the shrimp population's sustainability.



THE LASTING IMPACT OF TRADITIONAL FISHERIES MANAGEMENT

Traditional fisheries management practices, like rāhui, tabu, and bul, demonstrate the deep connection between Pacific Island communities and their marine environments. These time-honored approaches have helped sustain fish stocks, protect ecosystems, and preserve cultural traditions for generations.



As modern fisheries face increasing pressure from overfishing and climate change, these traditional methods offer valuable lessons in adaptive, community-driven conservation. By integrating Indigenous knowledge with contemporary fisheries management, we can create more resilient and sustainable fisheries—ensuring that marine resources continue to support coastal communities for generations to come.

Experiences with Traditional Fisheries Management

Reflect on the following questions and prepare to either take notes here or share in a discussion with the group.

- Are there any traditional fisheries management practices in your community or region? How do they work?
- Have you seen or experienced a traditional practice that has helped sustain fish stocks or protect marine habitats?
- How do you think traditional fisheries management can be combined with modern conservation efforts?
- What challenges exist in keeping these traditions alive? How might they be adapted for the future?

MANAGEMENT MEASURES

Management measures are how we strive to achieve the balance between feeding people and preserving the health of the marine environment, by modifying fishing practices to ensure the fishery remains sustainable. Management measures are just types of rules and strategies used to manage fisheries.

Management measures include things like:



Size Limits



Bag Limits



Temporary
Closures



Spatial
Management



Gear
Restrictions

These measures may be used individually or in combination to manage a suite of harvested species. They should also be customized and designed to suit the characteristics of any given fishery. Not all management measures will be well suited for every fishery.

COMMUNITY-BASED FISHERIES MANAGEMENT



This is where **communities take a leading role** in managing fisheries and adjacent coastal areas, often in **partnership** with, or with support from, a management agency.

CO-MANAGEMENT

Co-management is the control or organization of something by two or more **people** or **organizations** together



Responsibility and authority is based on collaboration between the community, the agency, and other stakeholders.

Existing Management Measure Activity

Do you know of any management measures that your community, or individual fishers in your community, use to manage the fisheries? If so, what measures are being used? Do you know how they were chosen or designed? Do they appear to be managing the fishery sustainably? What are your reactions to the management measure examples from around the Pacific? Do any of them seem particularly interesting or useful to you and your community?

4. Objective Setting in Fisheries

This module introduces the role of goal and objective setting in fisheries management. The objectives of this module is to: 1) Define goals and objectives and provide examples of common goals in fisheries management, and 2) introduce the concept of adaptive management.

GOALS AND OBJECTIVES

Goals and objectives can both be helpful tools in developing fisheries management approaches. In many fisheries contexts goals can be the starting point, Goals are broad statements characterizing the desired end result. Objectives, in contrast, are intended to characterize specific outcomes which the success of management will be measured against.

MANAGING TO MEET YOUR FISHING GOALS

Communities and governments can work together to implement effective management actions that address overfishing and help to ensure that enough fish get big enough to breed and replenish the population. Some common goals of fishery management may include:

FOOD SECURITY

Feeding the community and fishers' families

ECONOMIC SUSTAINABILITY

Financially supporting fishers' families and the community

ECOLOGICAL HEALTH

Protecting healthy populations, habitats and benefits they provide

COMMUNITY BASED MANAGEMENT

Communities take a leading role in managing fisheries

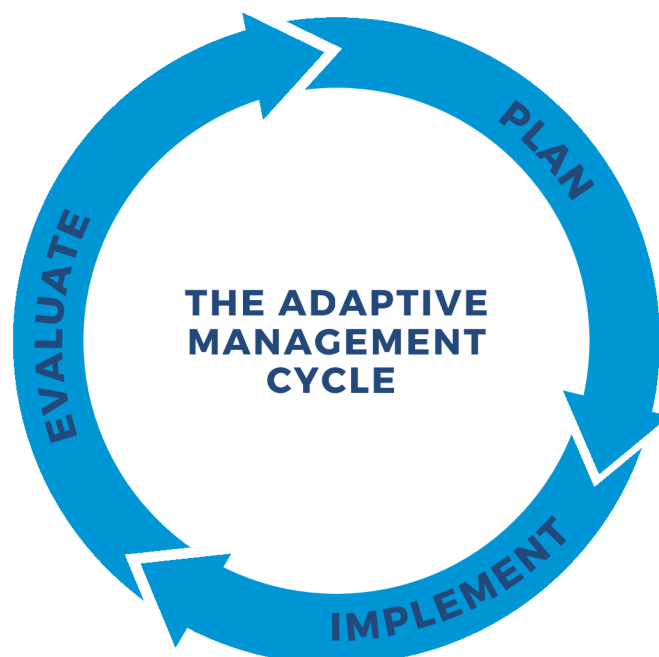
MAINTAINING TRADITIONAL PRACTICES

Supporting traditionally and culturally important practices

Setting goals is an essential component of effective management, and managing to meet those goals may be an iterative process.

ADAPTIVE MANAGEMENT

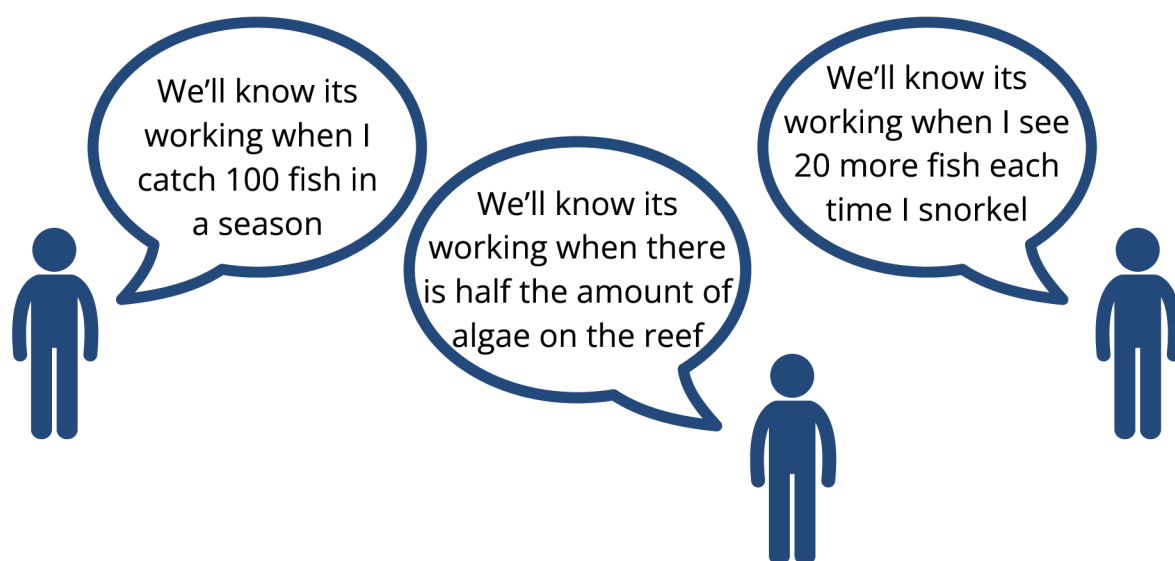
Fisheries management requires continuous learning and adjustment to fishing rules as information or community needs shift. This is a best practice called **adaptive management**, and FishKit tools can be integrated into this process.



OBJECTIVES

Especially in community contexts, discussions about fisheries management may often start with broader and more general goals. But as the group gets a better idea of the tradeoffs they are facing, it can be helpful to create quantitative and specific objectives that will help define what successful fishery management looks like in the eyes of the community.

Example (simple) fisheries objectives:

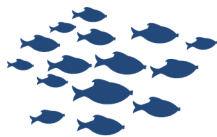


We'll learn more about different indicators and how they can be used to describe successful fisheries management later on.

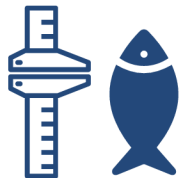
5. Welcome to FishKit

This module introduces FishKit and how it can help with small-scale fisheries management. The objectives of this module are: 1) Understand FishKit's primary goals, 2) Understand how FishKit can help fill the gaps in small-scale fisheries management, and 3) See how collecting data can help a fishery move towards sustainability.

FishKit is a set of tools and resources designed to provide small-scale fisheries with the information needed to assess fishery health and evaluate management actions



**Stock Health
Tracker**



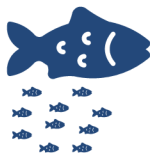
**Size Limit
Builder**



**Bag Limit
Builder**



**Temporary
Closures Tool**



**Data
Repository**



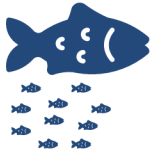
**Spatial Management
Guidance**

FishKit complements a community's existing local ecological knowledge by providing additional scientific insights so the community can make informed management decisions.

Data Repository

The Data Repository is designed to help prepare and store fisheries data and information to be used in analysis.

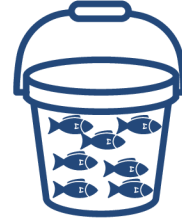
This includes:



**Life History
Repository**



**Length Data
Sets**



**Catch Data
Sets**

Stock Health Tracker

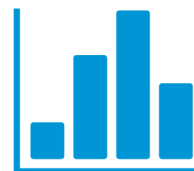
The Stock Health Tracker helps you understand the health of your fishery right now, based on the fishes being caught.



**Data on the length
of fish caught**



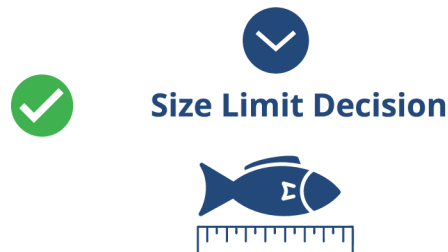
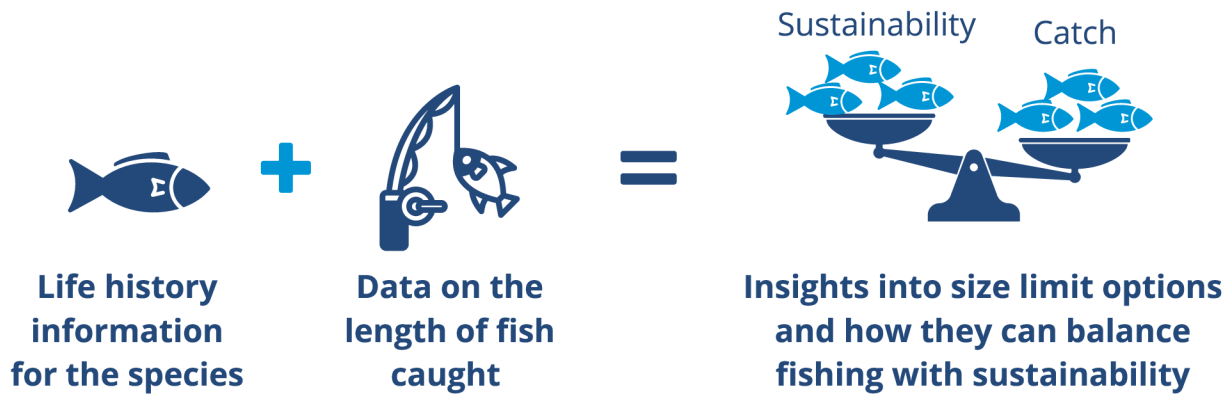
**Life history information
for the species**



**Insights into
fishery health**

Size Limit Builder

The Size Limit Builder lets you explore different size limit options and understand how those options would affect your fishery.



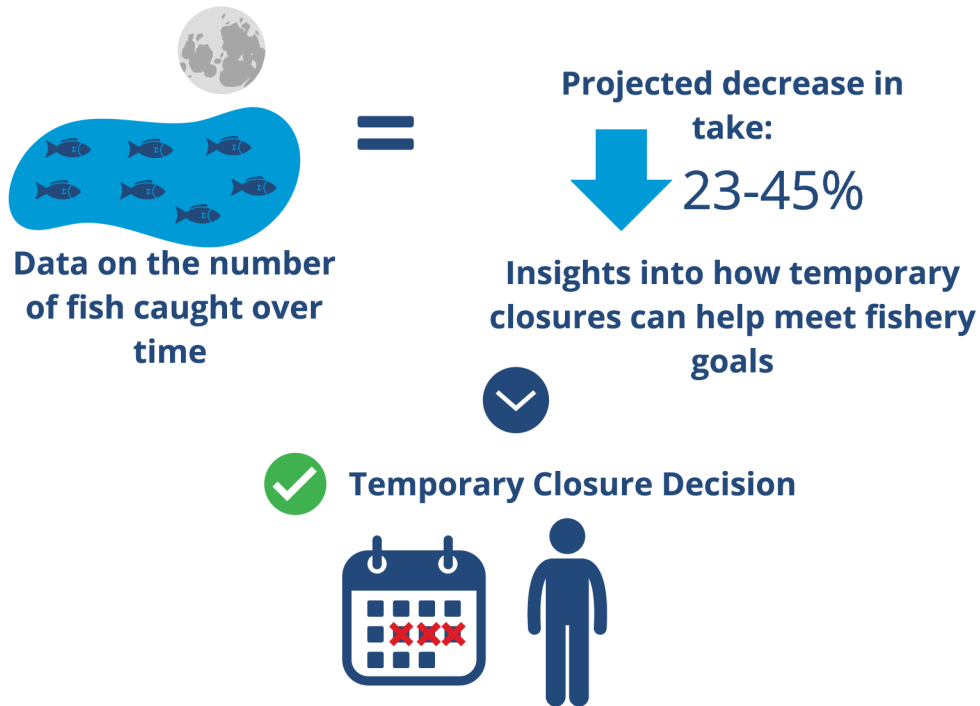
Bag Limit Builder

The Bag Limit Builder lets you explore different bag limit options and understand how those options would affect your fishery.



Temporary Closures Tool

The Temporary Closures Tool lets you explore different seasonal or time closure options and understand how those options would affect your fishery.



Spatial Management Guidance

This Spatial Management Guidance was created to provide simple and accessible guidance on how to design spatial management areas to help rebuild fish populations.

This includes:



Printable
guidance and
activities



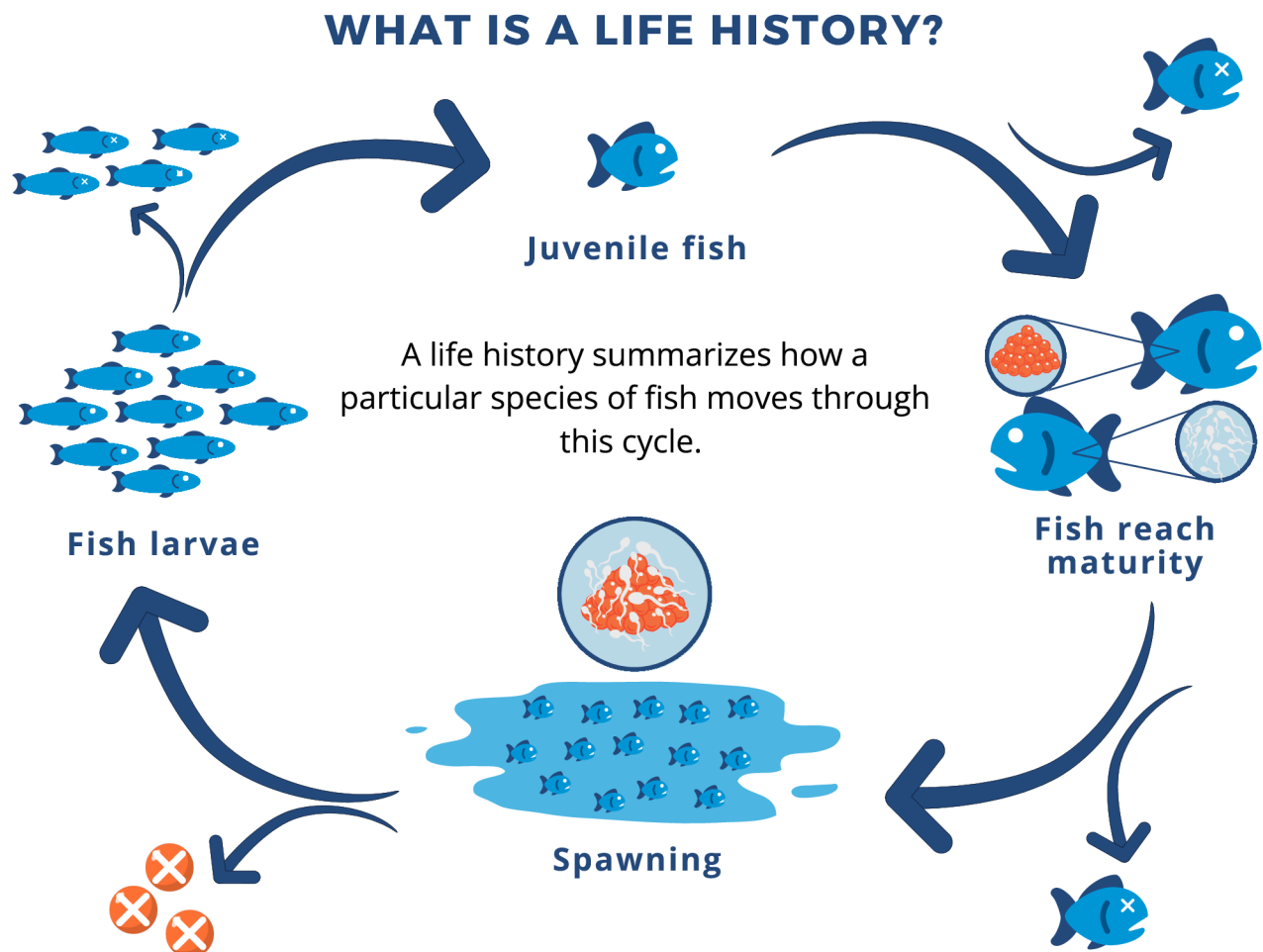
Presentation
materials



Table of fish
ecological
information

6. What is a Life History

This module introduces life histories and the role they play in sustainably managing fishing. The objectives of this module are: 1) Understand what a life history is and why it matters, 2) Learn how life history parameters affect vulnerability to overfishing, and 3) Understand how life histories can inform fisheries management and help ensure sustainability.



A life history is made up of biological characteristics that describe how a particular species or population of fish grows, survives, and reproduces over time.

LIFE HISTORY INFORMATION PLAYS A CENTRAL ROLE IN FISHERIES MANAGEMENT, BY ALLOWING US TO:

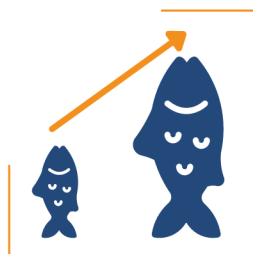
Understand the variability in the biology of different fish species

Conduct assessments of fish population health

Provide insights needed for setting management measures

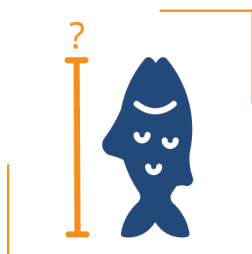
FOUR LIFE HISTORY PARAMETERS ARE KEY TO THE MANAGEMENT OF A FISHERY:

How fast does the fish grow?



**GROWTH
RATE**
K

How large does the fish grow?



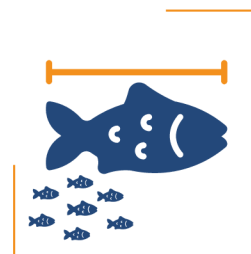
**AVERAGE
MAXIMUM
SIZE**
LINF

At what rate do fish naturally die off?



**NATURAL
MORTALITY
RATE**
M

What is the length at reproductive maturity?



**LENGTH AT
MATURITY**
LM

LIFE HISTORY CHARACTERISTICS ARE VERY IMPORTANT FACTORS IN DETERMINING VULNERABILITY OF A STOCK.

“Vulnerability of a stock” just means the chances the fish population could be depleted or collapse

“Vulnerability” does not say anything about how the fish population is currently doing, just the chances of depletion or collapse in the future

VULNERABILITY IS DETERMINED BY TWO KEY ELEMENTS:

PRODUCTIVITY

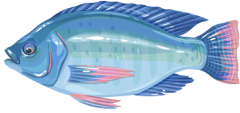
The capacity of the stock to replenish itself once depleted based on the fish population's life history characteristics.

SUSCEPTIBILITY

How easy or hard it is for fishers to have an impact on the population based on characteristics of the fishery itself.

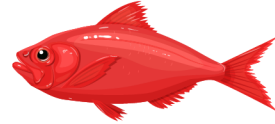
PRODUCTIVITY

Productivity is determined based on the biology of the species.



Example Species B:

- Grows quickly (large K)
- Matures early (relatively small length at maturity)

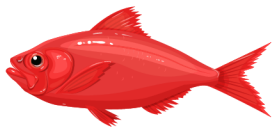


Example Species A:

- Grows slowly (small K)
- Matures late (relatively large length at maturity)

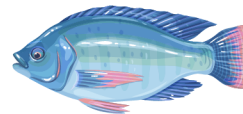
SUSCEPTIBILITY

Susceptibility is determined based on characteristics of the fishery itself.



Example Species A:

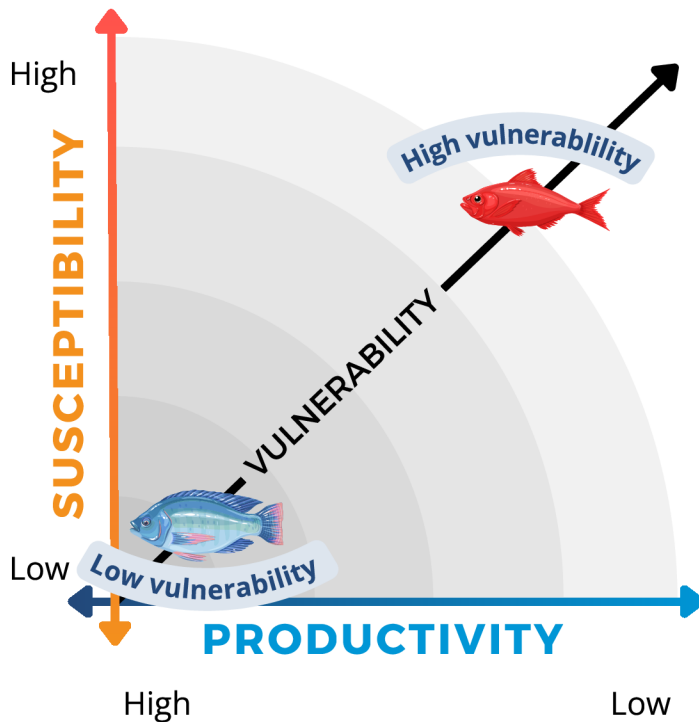
- Very easy to catch
- Highly desirable species



Example Species B:

- Very difficult and time consuming to catch
- Not very desirable

PRODUCTIVITY + SUSCEPTIBILITY



Mapping productivity and susceptibility together allows us to roughly estimate the vulnerability of a species relative to others. It can serve as a useful way to think about different species as well as to potentially prioritize species for management.

EXAMPLES:



Striated Surgeonfish
(*Ctenochaetus striatus*)

This surgeonfish species tends to be quite abundant on reefs across the Pacific, due to its **high** productivity and relatively **low** susceptibility.



Napoleon Wrasse
(*Cheilinus undulatus*)

This well known wrasse species can be a rare sight in many places where it is fished, due to its **low** productivity and **high** susceptibility.

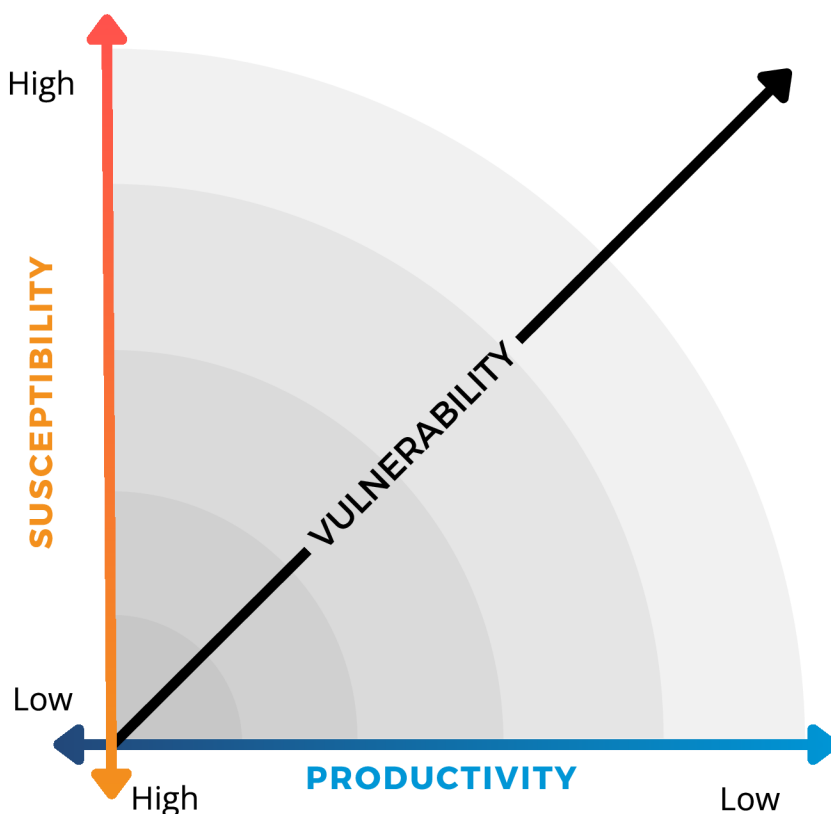
Assessing Vulnerability

Now think about a species you know well and think about both its productivity and susceptibility. Normally vulnerability is calculated numerically, but we can still use this framework to conceptually consider the general vulnerability of a species.

Consider the productivity of the species. Can you use available life history information to guess productivity? Then consider susceptibility, are the populations very susceptible to fishing?

WHAT IS THE LIFE HISTORY OF THE SPECIES?

Growth Rate	Average Maximum Size	Natural Mortality Rate	Length at Maturity
How fast does it grow?	How big does it get?	At what rate do fish naturally die off?	What is the length at reproductive maturity?



Prioritizing Species

When there are numerous fish species harvested, it is often necessary to prioritize species for management due to limited resources and capacity. Estimating the *productivity*, *susceptibility*, and resulting *vulnerability* of a species is one method that can be used to prioritize species for management.

There are other ways to think about prioritizing species such as:

**Economic
importance**

**Cultural
importance**

**Management
feasibility**

**Ecological
importance**

**Availability of
data**

Determining the best way to prioritize species for a given community, agency or group is an important task in fisheries management.

CONSIDER YOUR SPECIES

Consider the species used in the “Assessing Vulnerability” exercise. How might you think about prioritizing them? What insights does considering their vulnerability provide? Are there any other important factors you would want to consider?

7. Introduction to Fisheries Indicators

This module goes over the main indicators found in FishKit and how they can be used to assess fishery health and make management decisions. The objectives of this module are to: 1) Understand indicators that assess stock health and that help to inform fisheries management decisions, 2) Understand the differences between different indicators, and 3) Learn how to interpret the indicators.

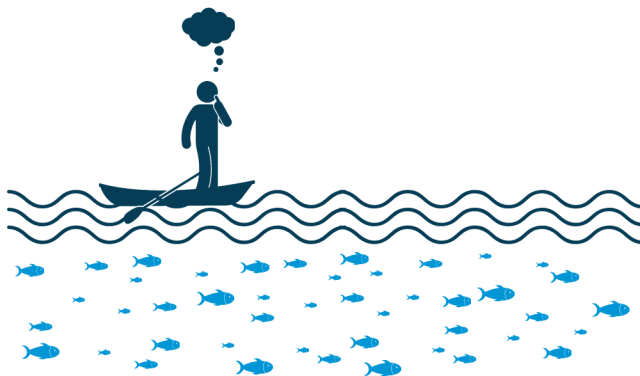
ASSESSING FISHERIES

Assessing fisheries populations can be challenging for several reasons.



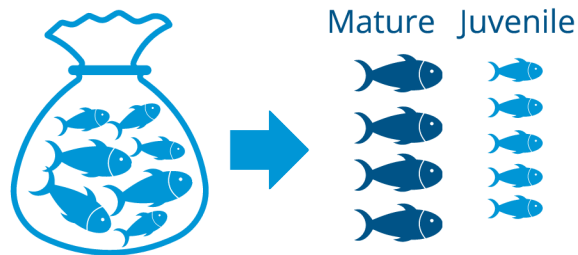
Fish live in the ocean and populations are often moving across large distances on a regular basis, which makes it extremely hard to know exactly how many fish there are or how the population is doing.

THIS IS WHY WE USE OTHER INDICATORS!



There are some common strategies that scientists and managers use to estimate what's going on under the surface.

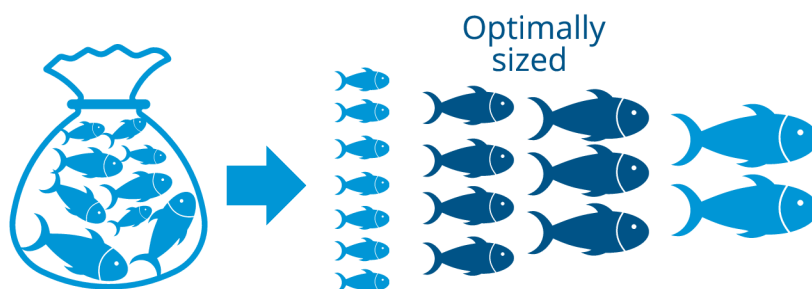
Mature Fish in the Catch



Percentage of fish in the catch that have reached maturity

The target for sustainable fishing for this metric is 100%. We want fish to grow large enough to reproduce (and replenish the population) before they are caught.

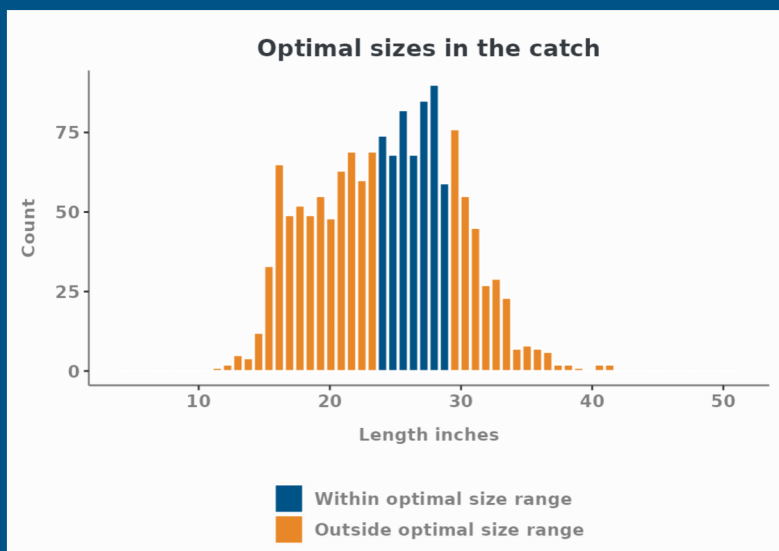
Optimal Sizes in the Catch



Percentage of fish in the catch that are in the range of “optimal lengths,”

which is the range of lengths that should optimize the yield in weight.

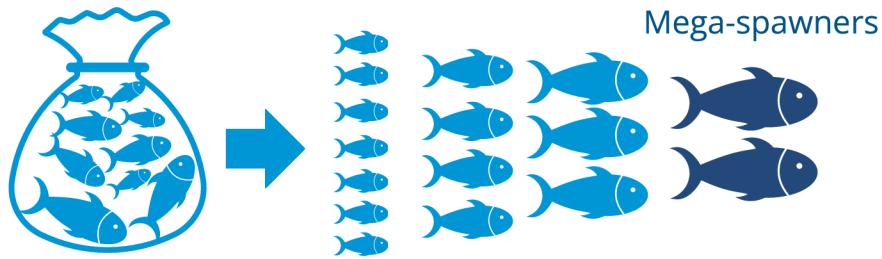
The target for sustainable fishing for this metric is 100%.



The range of optimal lengths balances two opposing factors:

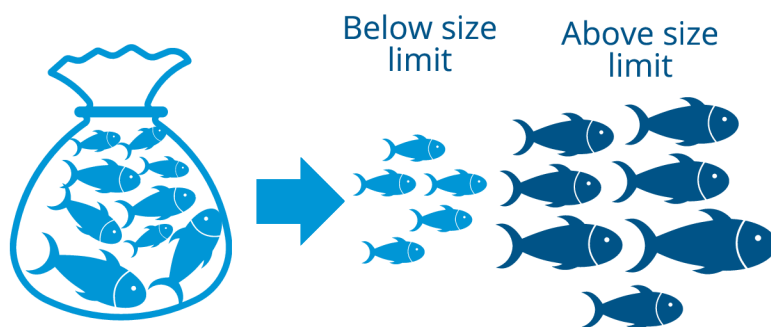
- 1) Letting fish mature and reproduce before being caught
- 2) Fish are caught before they die off from natural causes

Mega-spawners in the Catch



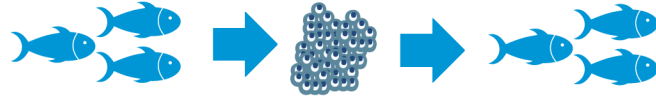
Percentage of fish in the catch that are in the range of “mega-spawners,” which are the fish above the optimal size and this range encompasses the largest individuals of the species. These individuals are referred to as “mega-spawners” because of the principle we learned in module 2: bigger fish make more babies!

Fish Above Size Limit in the Catch



Percentage of fish in the catch that are above the size limit
The target for sustainable fishing for this metric is 100%.

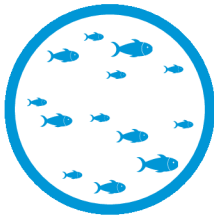
Sustainability Score or Spawning Potential Ratio (SPR)



This metric represents a fish population's ability to replenish itself

The sustainability score is the percentage of eggs produced by a fished population relative to an unfished population

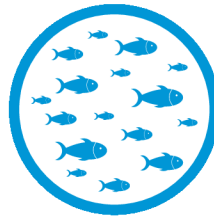
FISHED POPULATION



Egg production of a fished population

VS.

UNFISHED POPULATION



Egg production of a unfished population

The life history of a species is used to predict the egg production of a population under varying levels of fishing.

HUMAN EQUIVALENT

If it's more intuitive, think of humans and how the number of kids the average family has can impact the population as a whole.

More than 2 kids



2 kids

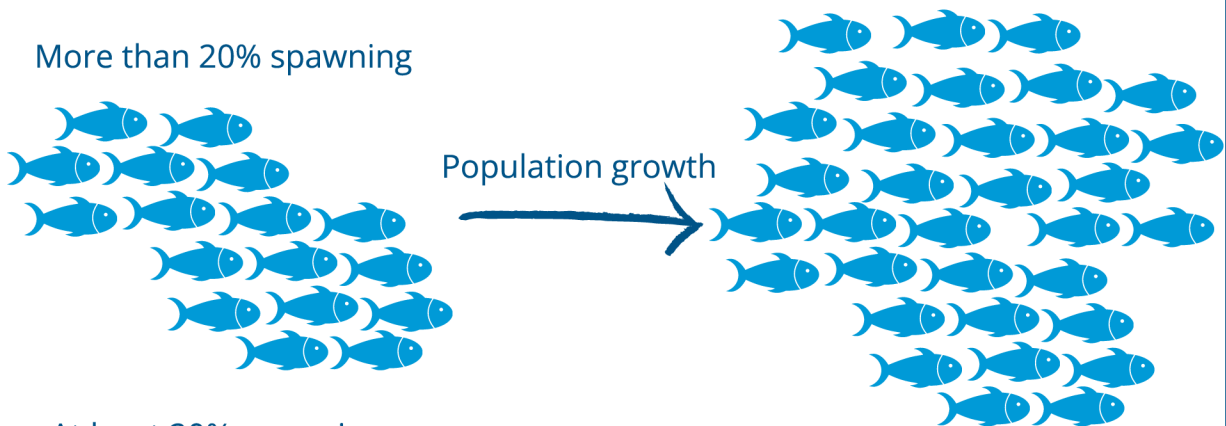


Less than 2 kids



THE LOGIC WITH FISH POPULATIONS IS VERY SIMILAR . . .

More than 20% spawning



At least 20% spawning

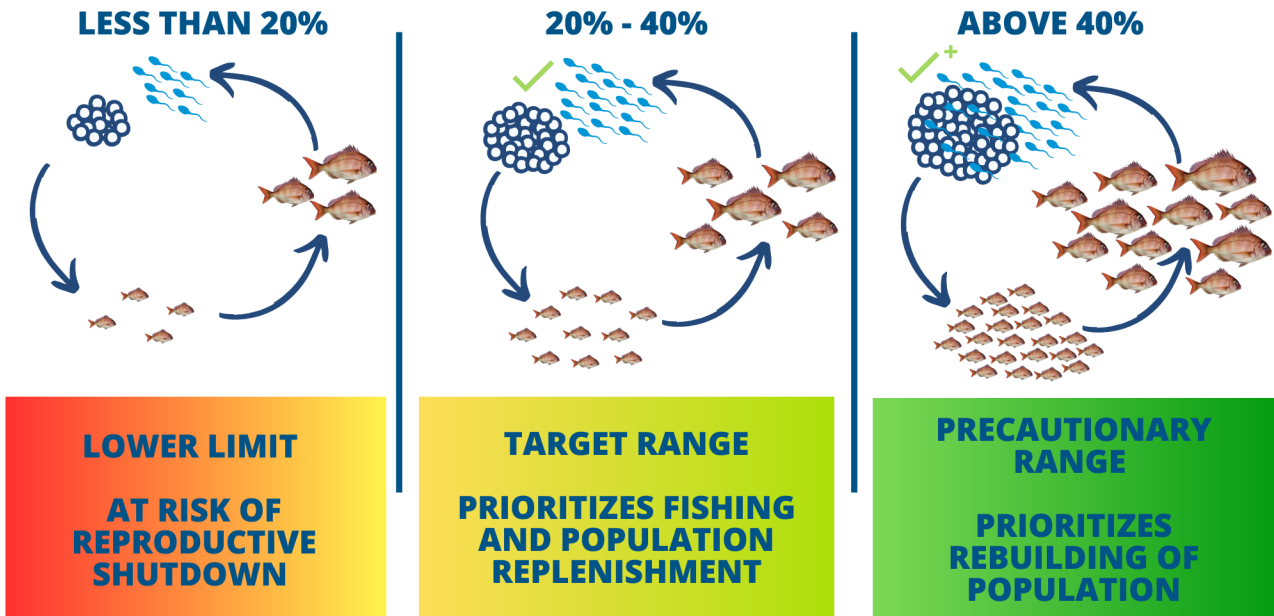


Less than 20% spawning



GENERAL REFERENCE POINTS FOR SPR

The Spawning Potential Ratio appropriate for a particular fishery can be dependent on many factors, including the goals of the fishery, but here are some reference points that generally apply:



A score of 100% represents an unfished population, but 20-40% is considered sufficient to sustain the population over time. The score a given fishery aims for should be aligned with the specific goals of the fishery.



If fish are caught before they get big enough to reproduce, they can't restock the reefs. So each year, there are less fish to catch.

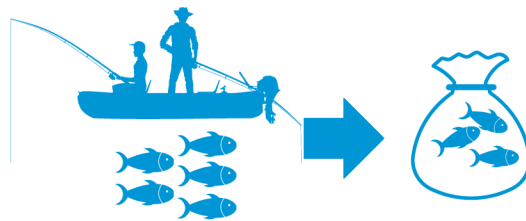


If they are not caught until they are big enough to reproduce, the influx of eggs should keep new recruits coming to the populations so that there will be fish into the future.

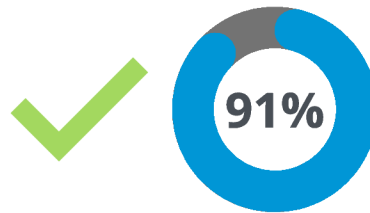
Catch Score or Yield Per Recruit (YPR)

The catch score reflects how close we are to catching the maximum sustainable amount of fish (by weight) in the fishery

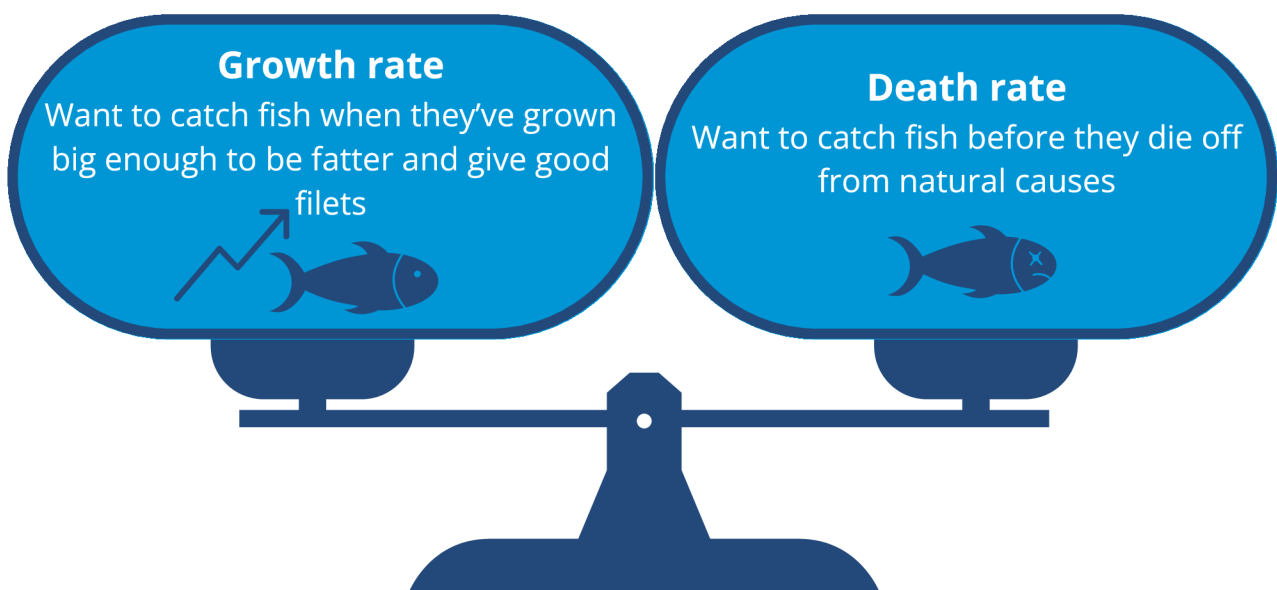
A score of **100%** indicates that the maximum amount of fish that can be sustainably caught, are being caught. This is very difficult to achieve, so we aim for “**pretty good yield**,” a high catch score that is somewhere below 100%. The “right” catch score for any given fishery will depend on the goals for that particular fishery.



For most fisheries, a **score of above 80% is acceptable**, but it should be aligned with the goals of the community.



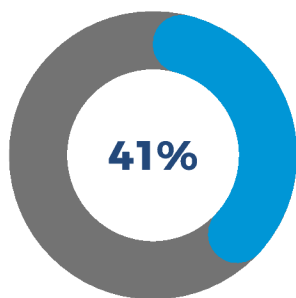
This metric helps fisheries maximize yield while balancing two factors: fish natural mortality (death) rate and fish growth rates in length and weight.



The dilemma for fishers is: to maximize the weight of the harvest, we must wait and let the fish grow. But how long should we wait?

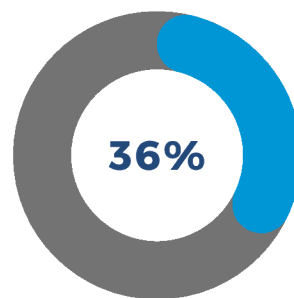
8. Introduction to the Stock Health Tracker

The Stock Health Tracker helps you understand the health of your fishery, based on properties of the fish being caught. This module goes over how the Stock Health Tracker can be used to monitor and assess the health of a fishery. The objectives of this module are to: 1) Understand how FishKit's Stock Health Tracker can help assess the health of your fishery, and 2) Try the Stock Health Tracker for yourself.



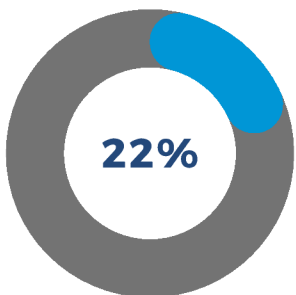
100% Target

MATURE FISH IN THE CATCH



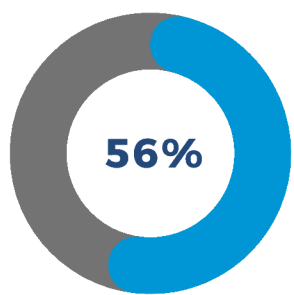
100% Target

OPTIMAL SIZES IN CATCH



20-30% Target

MEGA-SPAWNERS IN THE CATCH



100% Target

FISH ABOVE SIZE LIMIT

These four basic metrics make up the Stock Health Tracker

For any given context, these metrics may be more or less relevant. Be sure to think critically about your fishery and ensure your chosen metrics make sense for your fishery's species and contexts.

Try it for yourself!

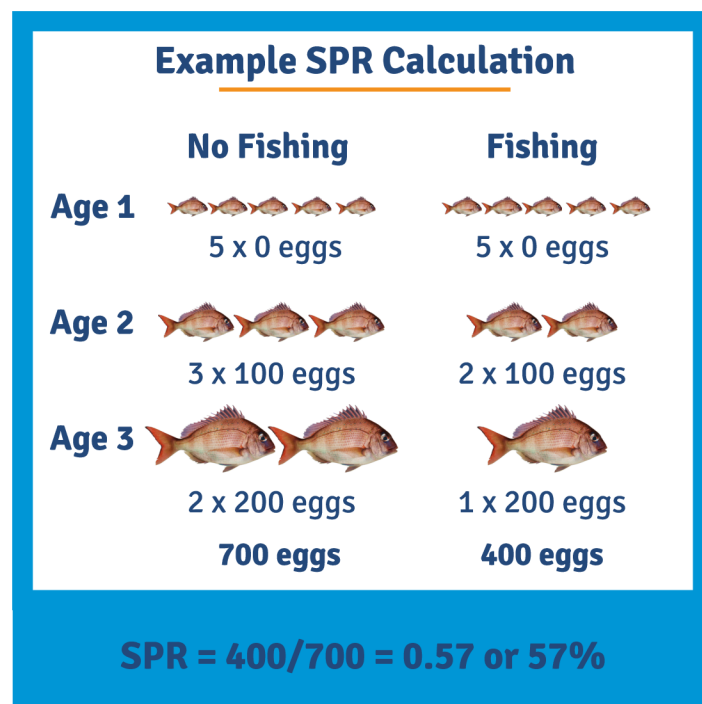
Visit fisheriestoolkit.org to try the Stock Health Tracker for yourself and take notes here to help remember important tips and tricks of how to use it.

9. Stock Health Tracker Advanced: Length-Based Spawning Potential Ratio (LBSPR)

This module introduces the concept of Length-Based Spawning Potential Ratio (LBSPR) and how it can provide additional insights into fish stock health. LBSPR is an advanced functionality of the Stock Health Tracker, and once a reliable and representative length data set has been accumulated, it can be used to help understand the current health of the fishery. The objectives of this module are to: 1) Understand what LBSPR is, and 2) Understand how LBSPR can be used to understand fishery health.

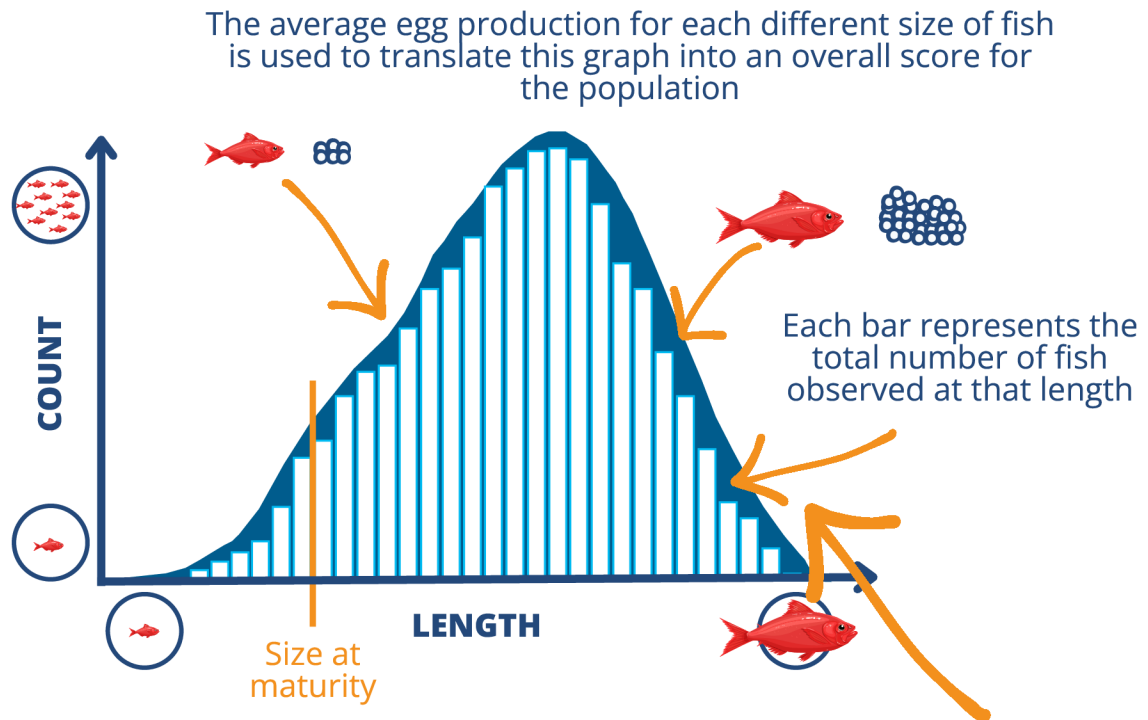
SPAWNING POTENTIAL RATIO (REVIEW)

Recall that spawning potential ratio (SPR) is the amount of eggs produced by a population relative to the amount of eggs that would be produced by an un-fished population. This can be calculated in different ways, but here we will discuss how to calculate this metric using the lengths of fish in the catch.



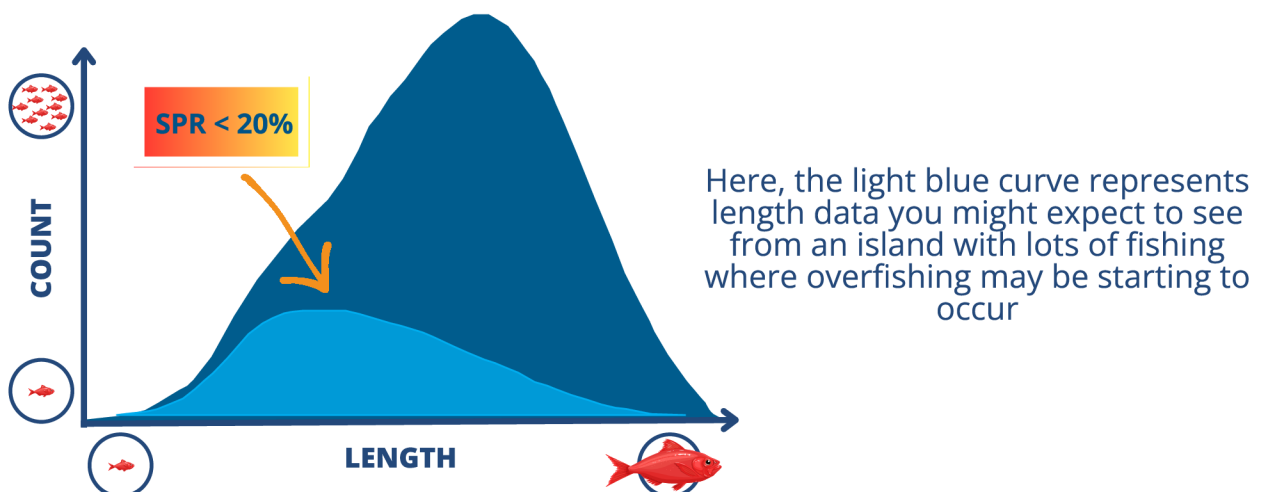
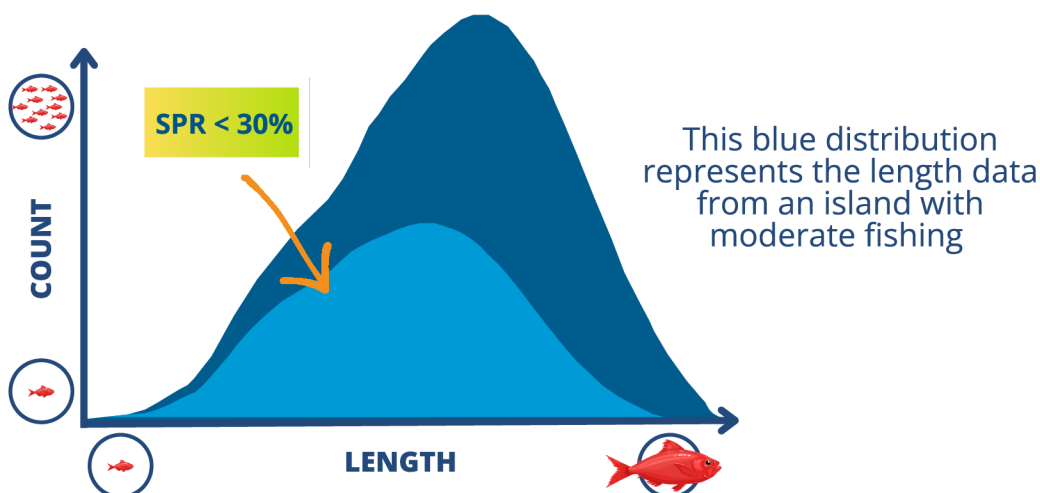
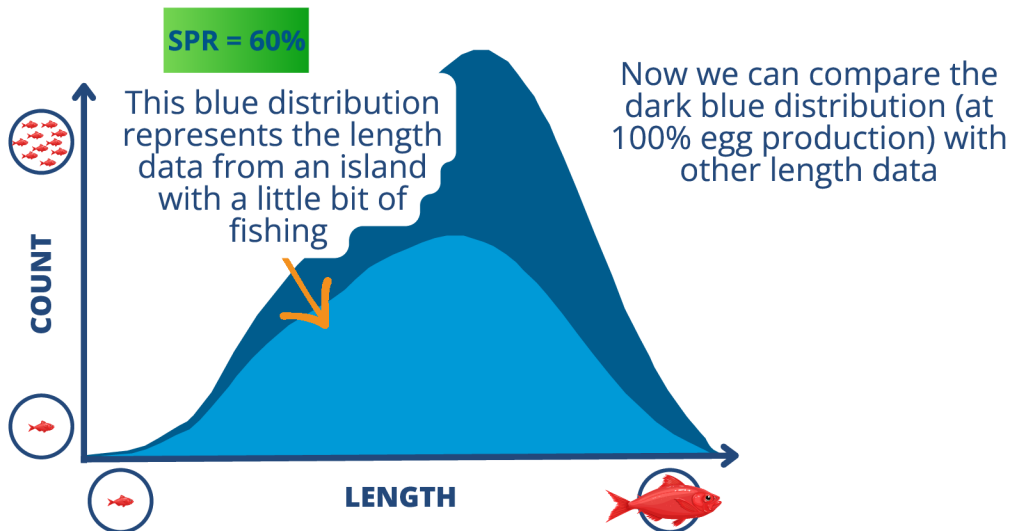
LBSPR

The LBSPR is a method used in fisheries science and management to assess a fish population's reproductive potential and sustainability through calculating Spawning Potential Ratio. It is a tool that helps determine the optimal harvest level of a fish population to ensure its long-term viability and sustainability.



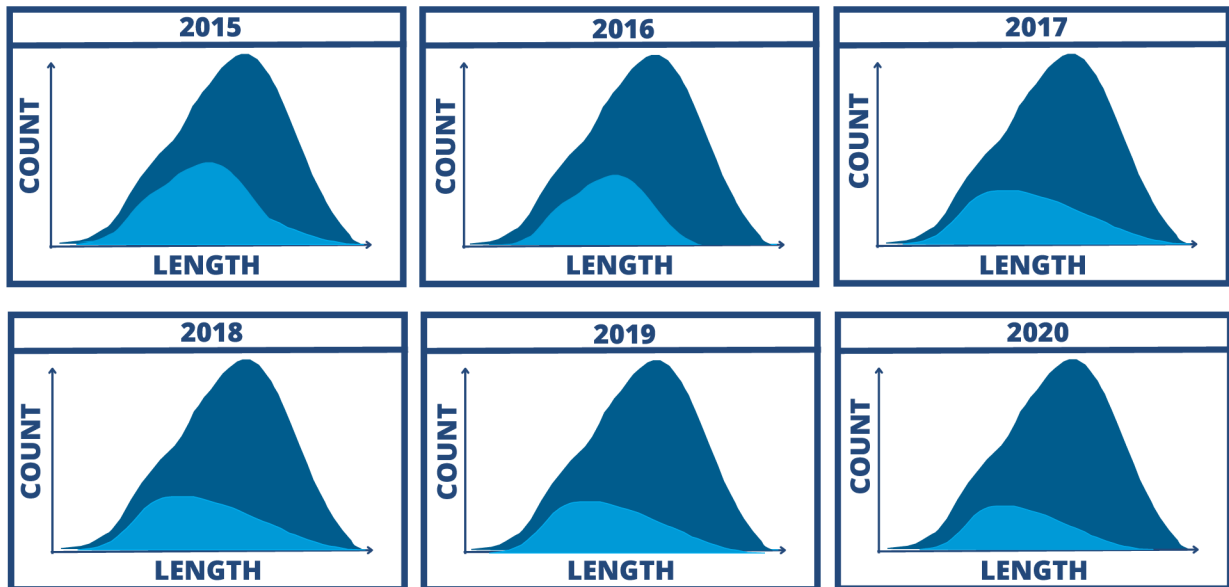
These graphs also may be shown as a smoothed distribution, rather than bars.

Here are some example length distributions and their corresponding Spawning Potential Ratio scores, calculated using LBSPR. The dark blue represents what a unfished population's length distribution might look like. The light blue represents the length distributions of populations with different levels of fishing.



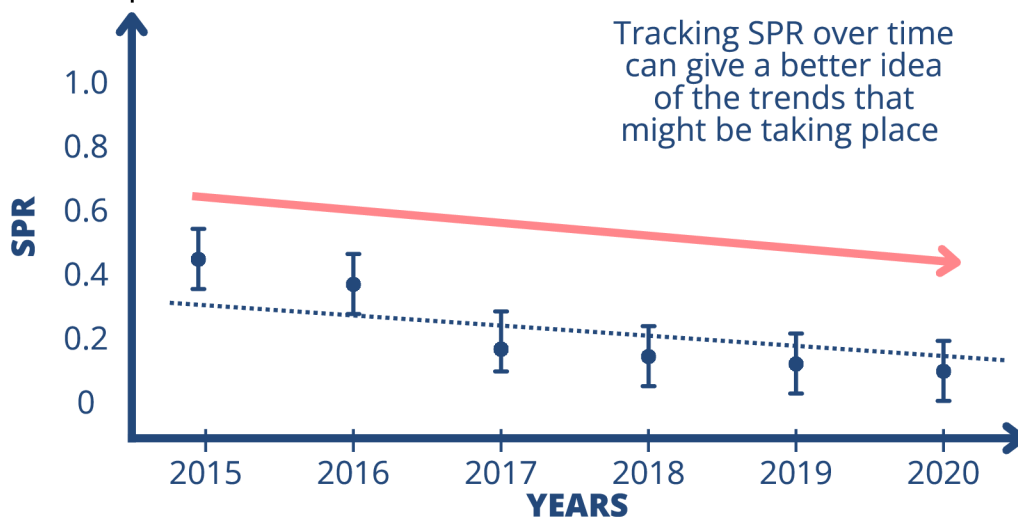
TRACKING LBSPR OVER TIME

Here we see what can be produced if you track LBSPR of a population over years. You can start to see trends in how the Spawning Potential Ratio is changing over time.



In general, we see fewer large fish over time in the catch (in this example).

Here, we might see cause for concern and a downward trend in fishery health over time, which might merit action. Before making a definite conclusion, you would want to double check the quality of your length data and life history information, as well as any other unaccounted for changes in the fishery that may have taken place in the time period in question.



LBSPR is a model that should be applied with care, as multiple factors can influence the calculation of spawning potential ratio. For more information on the considerations associated with LBSPR please visit the FishPath website (www.fishpath.org) where more information about numerous assessment models (including LBSPR) can be found.

10. Management Measure Options

This module goes over the different management options available to help manage fisheries. The objectives of this module are to: 1) Understand factors that drive fisheries management decision-making, 2) Understand common management measures and their benefits and considerations, and 3) Understand how implementing management measures can benefit both fishing and sustainability.

HISTORICAL MANAGEMENT

The marriage of traditional knowledge with more modern forms of management can have a myriad of benefits and honor historical stewards. These measures can be written into law under modern governance structures, or can be adopted voluntarily by communities.

Management Measures

What tools are available to manage fishing? Managing fisheries can be difficult, but using management tools can help lead to more fish in the ocean and more fish in your catch.

SOME OF THE MOST COMMON MANAGEMENT MEASURES FOR MANAGING CORAL REEF FISHERIES:



Size Limits



Bag Limits



**Temporary
Closures**



**Spatial
Management**

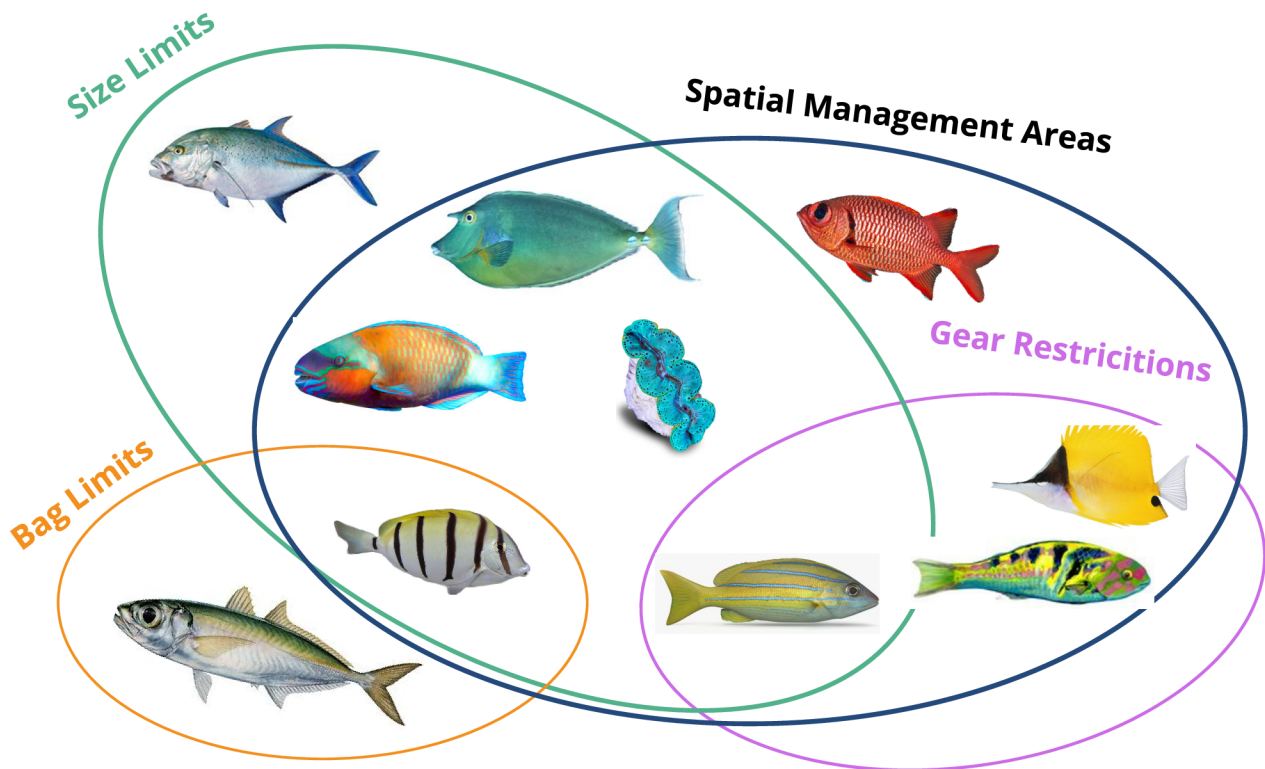


**Gear
Restrictions**

Choosing appropriate management tools for your context is an important part of the decision making process and should be guided by the biological, ecological and human characteristics of the fishery

MULTISPECIES MANAGEMENT

Especially when managing multiple species, it is important to consider how to best use different management tools to provide appropriate protection for each fished species, especially in multispecies fisheries. This might mean overlapping management measures, and can increase management effectiveness overall.



This graphic is a conceptual example to show how different management measures can be used to protect a variety of different species. Together the management measures are a part of a strategy to support a range of different species.

This management strategy also reflects the precautionary principle. By using more than one tool, you increase the likelihood that one will achieve its intended purpose.

PRECAUTIONARY PRINCIPLE

The precautionary principle in fisheries management is a strategy aimed at preventing overexploitation and ensuring the sustainability of fish stocks, even in the face of scientific uncertainty. This approach emphasizes caution and proactive measures to avoid potentially harmful outcomes to marine ecosystems and fish populations.



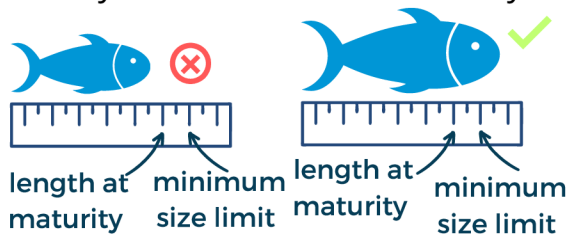
Size Limits

Size limits specify the length at which species can be legally caught. There are two main types of size limits: minimum size limits and slot limits.

TYPES OF SIZE LIMITS

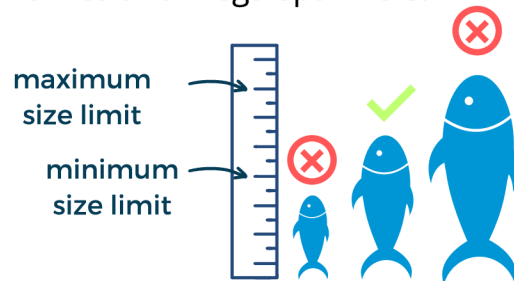
Minimum Size Limit

A minimum size limit sets the shortest length a fish must be to be legally harvested, allowing fish to grow to maturity and reproduce before you catch them. A good size limit should allow the fish to reproduce at least once, and this is why we should set a size limit always above the size at maturity.



Slot Size Limit

A slot size limit sets a range (minimum and maximum) between which fish can legally be harvested. A slot size limit protects both juveniles and mega-spawners.



Larger fish tend to produce more eggs. This means protecting mega-spawners can allow them to replenish the population at a higher rate than other mature fish.

Sex-Changing Species

For sex-changing species, size limits must to be applied with caution. Certain fish species change their biological sex as they age, such as parrotfish and wrasses, who begin life as females and later become functionally male.



Female



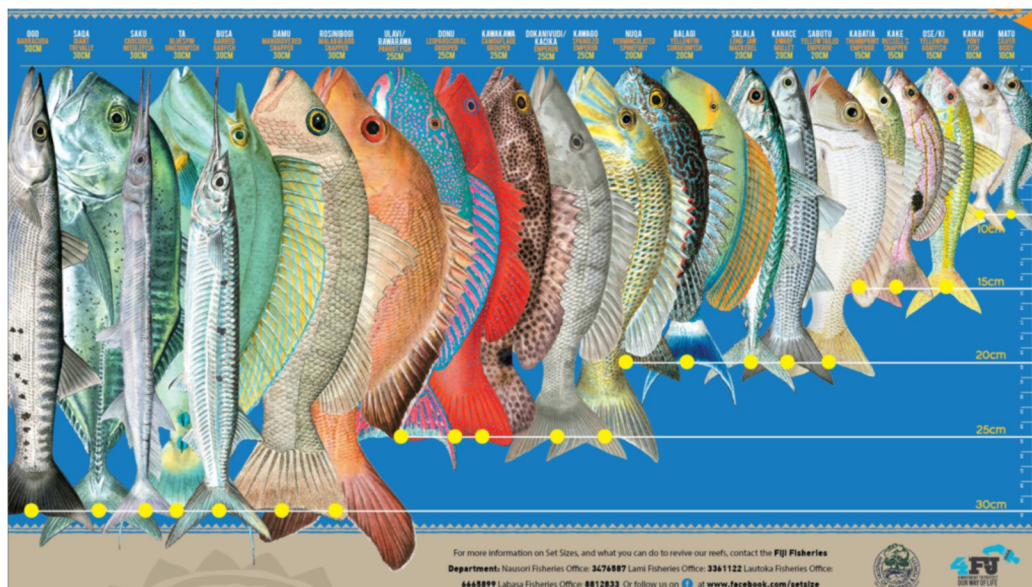
Male

In these species, the application of minimum sizes may concentrate fishing pressure on one sex. If a minimum size limit is applied, it will only protect the smaller females, without protecting reproductive males. This could cause reproductive shutdown. A slot limit can be used to provide protection for mature male and female fish.

EXAMPLE SIZE LIMIT

Size limits are one of the most common management measures and are widely implemented across the Pacific.

Size limits exist for wide range of finfish and invertebrates including: inshore pelagic fish, reef fish, sea cucumber, clam, trochus, green snail, crab and lobster.



In Fiji, for example, there are size limits for a wide array of fin fish species. This poster serves as a simple summary to convey these many size limits to fishers. As pictured here, jacks can only be caught if they are larger than 30cm.³

3] Pacific Community. (n.d.). Coastal fisheries and aquaculture legislation - Pacific Islands region. Retrieved March 28, 2025, from <https://www.spc.int/CoastalFisheries/Legislation/countries>

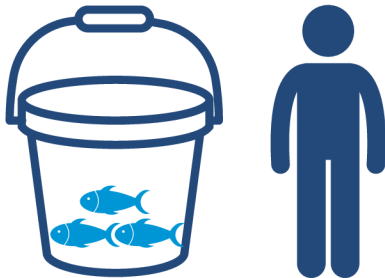
Bag Limits

Bag limits set the maximum number of fish a person can take per day. Bag limits can be set for one species or a group of species. They work by reducing the overall rate at which fish stocks are depleted, leaving more fish in the sea to naturally replenish the stock.

TYPES OF BAG LIMITS

Single Species Bag Limit

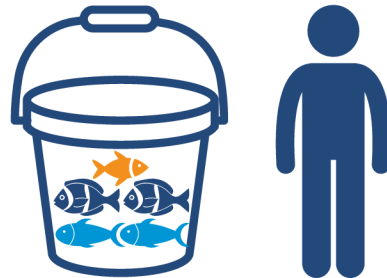
Bag limit = 3 X 



These can be helpful in protecting species that are of particular priority.

Multi-Species Bag Limit

Bag limit = 5 of any fish



These can be helpful in protecting a group of important species.

Species Bans



Species bans are an extreme version of a bag limit where a take of zero is allowed for a particular species or group of species. This management measure may be appropriate for particularly vulnerable species or a measure used for a specific period of time to help an extremely depleted population recover.

EXAMPLE BAG LIMIT



In New Caledonia, non-commercial catch of pelagic species (including wahoo, tuna, bonito), is limited to 10 per vessel per trip.³

3] Pacific Community. (n.d.). Coastal fisheries and aquaculture legislation - Pacific Islands region. Retrieved March 28, 2025, from <https://www.spc.int/CoastalFisheries/Legislation/countries>

Temporary Closures

Temporary closures restrict fishing effort for particular periods of time for any number of species. This can be a particular period of the year, season, phase of the lunar cycle, etc.

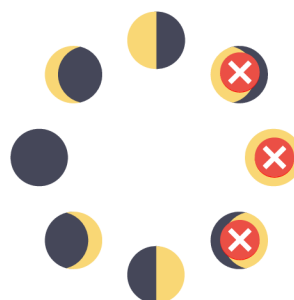
TYPES OF TEMPORARY CLOSURES

Monthly or Date Range Closures



Certain species may be off-limits for months or portions of the year when they are known to be spawning.

Lunar Phase Closures



Species may also be off-limits to fishing for particular moon phases, especially if they spawn in accordance with the lunar cycle.

These temporary closures can be applied across the entire management area or a specific area within it.

EXAMPLE TEMPORARY CLOSURE



Hawaiians on the island of Moloka'i use a traditional moon calendar for holistic understanding and management of marine and terrestrial environments. This allows them to track peak spawning periods for fished species such as giant trevella ("ulua"; *Caranx ignobilis*), bluestripe snappers ("ta'ape"; *Lutjanus kasmira*), Hawaiian flagtail ("aho-leholo"; *Kuhlia sandvicensis*), and surgeonfishes (*Acanthuridae*); and enact traditional closures or kapus to protect the fish during this critical period.⁴

4] Friedlander, A., Poepoe, K., Poepoe, K., Helm, K., Bartram, P., Maragos, J. and Abbott, I., 2002. Application of Hawaiian traditions to community-based fishery management. In Proceedings of the Ninth International Coral Reef Symposium, Bali, 23-27 October 2000, (Vol. 2, pp. 813-815).

Spatial Management

Spatial management involves creating specific areas that have regulations that prohibit fishing on all or some species. There are different types of spatial management designations such as areas that limit use of certain gear or catch of certain species to Fishery Replenishment Areas where little to no fishing is allowed.

TYPES OF SPATIAL MANAGEMENT

Limited-Take Area



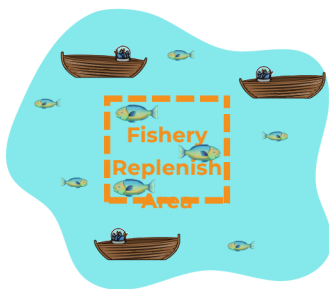
An area in which harvesting of one or more species is restricted or prohibited, while fishing for other species is allowed.

Rotational or Periodic Rest Areas



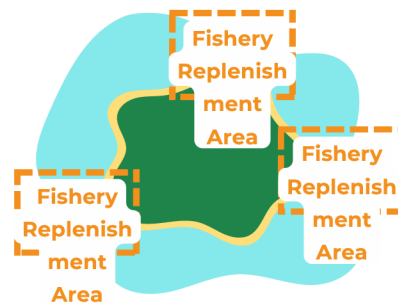
An area that is subdivided into two or more parts which allows for periodic harvesting in some areas, while prohibiting harvest in other areas.

Fishery Replenishment Area



An area that prohibits harvesting of all species, usually for the long-term or permanently.

Network of Fishery Replenishment Areas



Multiple Fishery Replenishment Areas, ecologically connected as a network designed to replenish populations.

EXAMPLE SPATIAL MANAGEMENT

In Fiji, *tabu* or no-take areas are a traditional form of marine management. Now these practices are being revived in combination with modern conservation efforts through the Locally Managed Marine Area Network. Today over 400 villages are working with partners under the umbrella of the network. The Namena Marine Reserve is one example of a spatial management area within this network.^{5,6}



Namena Marine Reserve ©Lill Haugen

5] Govan, H., Aalbersberg, W., Tawake, A. and Parks, J., 2008. Locally managed marine areas: a guide to supporting community-based adaptive management.

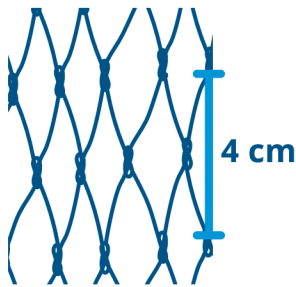
6] Jupiter, S.D., Cohen, P.J., Weeks, R., Tawake, A. and Govan, H., 2014. Locally-managed marine areas: multiple objectives and diverse strategies. *Pacific Conservation Biology*, 20(2), pp.165-179.

Gear Restrictions

Gear restrictions restrict the type and/or design of gear that can be used for fishing. It can also include modifications to gear.

TYPES OF GEAR RESTRICTIONS

Net Mesh Size



Required sized of mesh for nets can prevent unintentional bycatch or catch of individuals that are too small.

Gear Bans



Gear bans can be used to outlaw the use of a particular gear that may be deemed inappropriate, harmful or destructive.

Soak Times



Soak times might limit how long a fishing gear may be deployed, like a crab trap that might be left only for a maximum of 12 hours.

EXAMPLE GEAR RESTRICTIONS



In Papua New Guinea, fishers are not allowed to take any fish or invertebrates at night by use of underwater lights. This provides substantial protection to many species that might be more easily caught at night, such as parrotfish.³

3] <https://www.spc.int/CoastalFisheries/Legislation/countries>

Activity: What's up in your area?

What fishing management measures exist in your area or in another place you have been to? What has worked well or not worked for other communities in your region?

What measure do you think would be interesting for your area?

Consider Community Needs and Aspirations

In all instances, the practical aspects of designing management measures, such as acceptance and enforcement, are crucial considerations.

Considering the social, economic, and cultural impacts of management can help: maximize benefits and minimize costs to local communities and sustainable industries; protect and perpetuate cultural values; and support equitable solutions to resource concerns.

Are they economically acceptable?

How can they be enforced?

Will the community accept and respect the management measures put forward?

Should there be mandatory rules with penalties or a voluntary agreement?



IDEALLY, MANAGEMENT MEASURES SHOULD COMBINE TRADITIONAL KNOWLEDGE AND SCIENTIFIC INSIGHTS, ALL WHILE REMAINING SIMPLE AND ENFORCEABLE.

Incorporating these considerations into the planning process ensures that the design of fisheries management measures reflects human uses and values and addresses the needs and aspirations of local communities and other stakeholders.

PRINCIPLES FOR INCORPORATING SOCIAL, ECONOMIC AND CULTURAL CONSIDERATIONS INTO MANAGEMENT DESIGN:

- 1. Respect traditional knowledge, uses, and cultural values**
- 2. Ensure a fair and inclusive planning process**
- 3. Use best available information to inform design of management measures**
- 4. Prioritize management options with broad community support and likelihood of success**
- 5. Aim for ecological, social, and economic sustainability**
- 6. Ensure social equity and access**
- 7. Prioritize management of resources with cultural, social, and traditional importance**
- 8. Support integrated and collaborative management**
- 9. Design management measures to facilitate stakeholder compliance**



TNC Mexico staff working alongside community members to understand options for fisheries management.

THE PACIFIC WAY

The Pacific Way....is a thoughtful and humble approach that honors people, places, and cultures, and relies on building strong partnerships with the people who live in and care for these special islands. At the heart of these partnerships is RESPECT for the values, traditions, and knowledge that are rooted in each place.



- R** Relationships are paramount. Getting these right from the onset is key.
- E** Ethics underpin success. Learn and respect traditional norms.
- S** Sincerity is essential. Be genuine about what you can offer.
- P** Patience pays off. Listen and learn to find common ground.
- E** Empathy is an asset. Understand local perspectives.
- C** Credibility is crucial. Engage in open and honest dialogue to earn.
- T** Trust takes time. Build that before trying to embark on anything else.

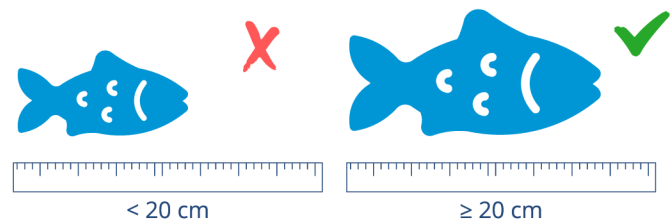
This section and principles draw from and are accompanied by many other wonderful resources on this topic such as the following:

- *The Nature Conservancy, 2017. Capturing and Sharing Knowledge for Community-based marine conservation: the Pacific Way. <https://www.capturingknowledge.org>*
- *Bennett et al. 2017. An appeal for a code of conduct for marine conservation. Marine Policy 81: 411-418.*
- *WorldFish and University of Wollongong. 2021. Community-based Fisheries Management Plan Reviews – Facilitation Guide. Noumea, New Caledonia: Pacific Community. 20 p*

11. Introduction to Size Limits

This module builds on the previous explanation of size limits, and shares some of the benefits and considerations associated with size limits. The objectives of this module are to: 1) Understand the benefits and considerations associated with size limits, 2) Prepare you for orientation to the Size Limit Builder.

Size limits restrict the sizes of fish that can be legally harvested in order to maintain the population's ability to replenish itself.



SIZE LIMITS CAN...

Lead to more fish in the ocean **AND** more fish in the catch

enabling current and future generations to keep fishing without losing or a sustainable source of protein

BENEFITS OF SIZE LIMITS

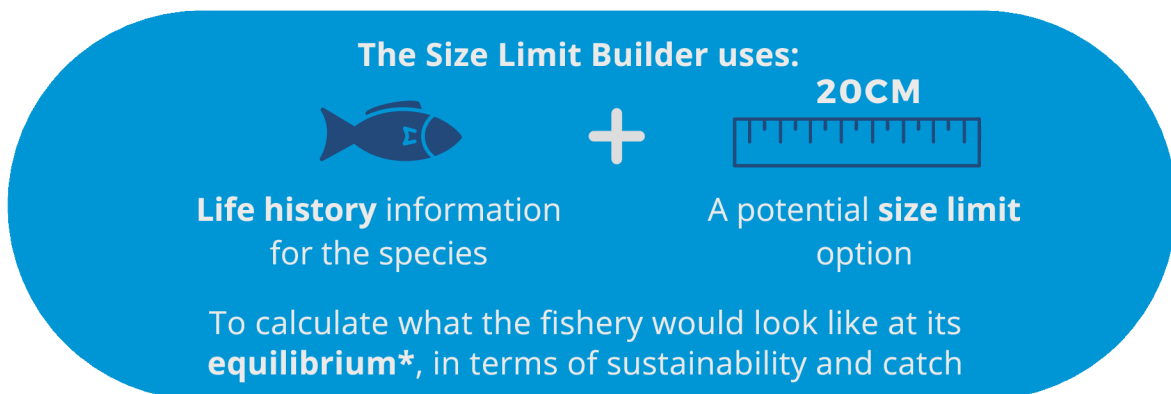
- **Protect juveniles:** Can protect fish from fishing until they've had the chance to reproduce.
- **Simplicity:** Simple to determine and implement with minimal data.
- **Broad applications:** Viable for almost all species.

CONSIDERATIONS FOR SIZE LIMITS

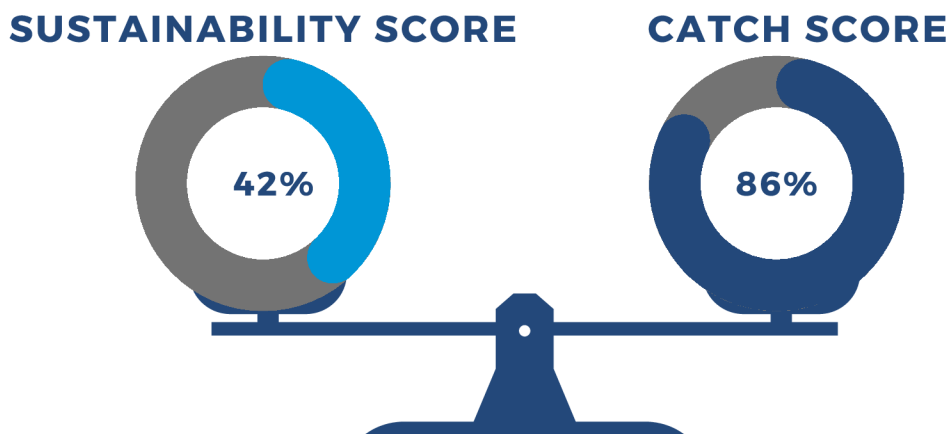
- **Feasibility:** Can be difficult to communicate and costly to enforce for multispecies fisheries.
- **Post-harvest mortality.** Can lead to increased mortality overall if rates of discard (of illegally sized catch) increase, especially for species that are killed when captured. Size-selective gear can mitigate this risk.
- **Data availability:** Need to have access to life history information to set an effective size limit
- **Sex-changing species:** Minimum size limits alone may not be appropriate for some species, such as groupers, parrotfishes, and emperors, that change sex as they mature; it is important to ensure that fishing pressure is not concentrated on just one sex.

12. Introduction to the Size Limit Builder

The Size Limit Builder aims to quickly and easily provide insights into how a size limit will impact a fishery, in terms of the sustainability of the population and the catch available to fishers. *Please review the prior sections on “sustainability score” and “catch score” as needed!* The objectives of this module are to: 1) Understand how FishKit's Size Limit Builder can help you evaluate different size limits for your fishery, and 2) Prepare you to try the Size Limit Builder and explore different size limit options.



The two primary metrics in the Size Limit Builder are: **sustainability score** and **catch score**. A size limit should balance the two, so you can keep fishing into the future.



As a reminder, **sustainability score** reflects the population's ability to maintain its numbers or grow, given a particular size limit (aim for values >20%). Whereas **catch score** reflects the degree to which a particular size limit affects the amount of fish accessible to fishers (aim for values >80%).

We are trying to **balance** these two effects in order to create a size limit that benefits fishers **and** maintains the health of the fished population into the future.

*This calculation is also impacted by the assumed level of fishing impacting the population, or fishing mortality. This calculation is an *equilibrium* quantity meaning it might take several years to reach that potential future, depending on how depleted the fishery is currently.

13. Introduction to Bag Limits

This module builds on the previous explanation of bag limits, and shares some of the benefits and considerations associated with bag limits. The objectives of this module are to: 1) Understand the benefits and considerations associated with bag limits, 2) Prepare you for orientation to the Bag Limit Builder.

BAG LIMITS

Bag limits set the maximum number of fish a person can take per day.

Bag limits can be set for one species or a group of species.



BENEFITS OF BAG LIMITS

- **Protect aggregations:** Can help to protect species that aggregate and can be easily caught in high numbers.
- **Ensure equal distribution:** Can help ensure more equal distribution of harvest.
- **Protect priority groups:** overall limits can help protect reef assemblage as a whole.

CONSIDERATIONS FOR BAG LIMITS

- **Enforcement:** Can be difficult to enforce, requiring mechanisms like cooler inspections.
- **Fishing effort:** Bag limits alone can't account for changes to fishing effort, e.g. new entrants to fishery, and spatially or temporally concentrated effort.
- **Multispecies fisheries:** In a multispecies fishery, catch limits are most successful when applied to aggregates of species, or to most valuable/high-risk individual species.
- **Post-harvest mortality:** May increase overall mortality by incentivizing fishers to select larger fish from their catch and discard smaller fish.
- **Efficiency and cost:** Can decrease fisher's efficiency, requiring more fishing trips, etc. to catch the same number of fish.

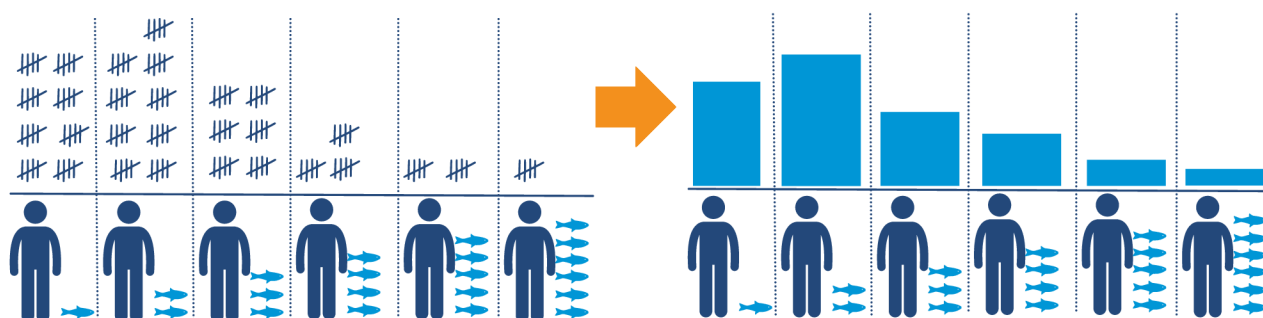
14. Introduction to the Bag Limit Builder

The Bag Limit Builder aims to quickly and easily provide insights into how a bag limit will impact a fishery, in terms of percent reduction in total catch. The objectives of this module are to: 1) Understand how FishKit's Bag Limit Builder can help you evaluate different bag limits for your fishery, 2) Understand what factors to consider when setting bag limits, and 3) Try the Bag Limit Builder yourself.

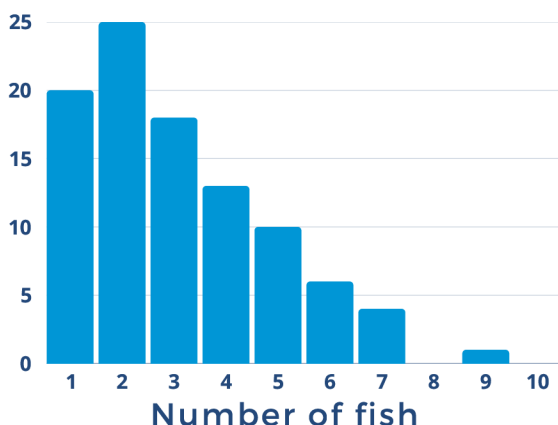
TAKE-PER-TRIP DATA

To understand how a potential bag limit will impact a fishery, we need to understand how many fish fishers typically “take-per-trip”

We often get this information from “creel” data or fisher interviews that record what a fisher caught in a fishing trip, including info on gear, effort, species, etc.



HISTORICAL



Total fish removed: 358

PREDICTED



Total fish removed: 340

APPROXIMATELY 5% REDUCTION IN OVERALL TAKE

This reduction can help manage fishing effort, and result in larger fish populations in the future.

15. Introduction to Temporary Closures

This module provides a more in-depth explanation of temporary closures and some strategies to think about if temporary closures are a management tool well suited to help you accomplish your fishery goals. The objectives of this module are to: 1) To understand the unique role of temporary closures and their context in the Pacific and 2) Equip practitioners to consider how temporary closures might be relevant to their local fishery context.

Temporary closures are used to control fishing pressure by closing fishing for a particular time period. These closures can be for:

DATE RANGES

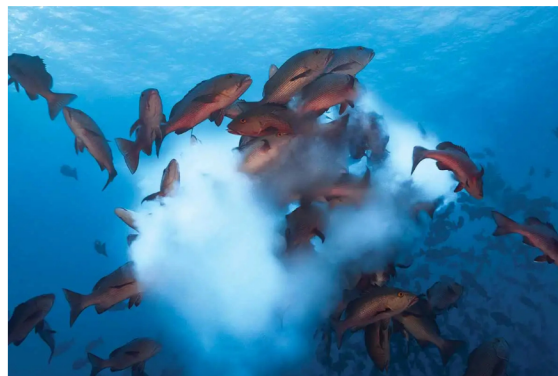


LUNAR PHASES



Temporary closures can be particularly effective to protect species during their reproductive time to allow them to spawn. And for species that aggregate to spawn, to protect them at their spawning sites.

This is because spawning aggregations can make it easy to catch unusually large numbers of fish at once.



This fishing can have an outsized impact on the population, or potentially disrupt the reproduction of the school.

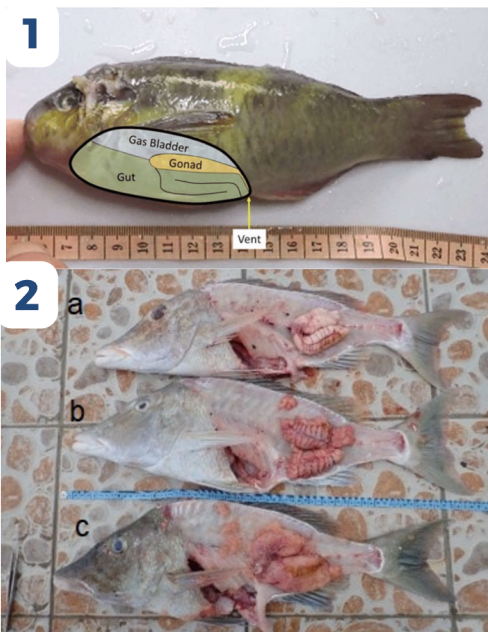
As mentioned in the traditional management section, temporary closures were also a commonly used traditional management tool used by many communities in the Pacific.

DETERMINING WHEN SPECIES ARE SPAWNING

There are many different ways of determining when spawning is taking place for a particular species. Traditional knowledge often provides valuable insights, as coastal communities and fishers have long observed seasonal aggregations, changes in fish behavior, or environmental cues—such as water temperature and lunar cycles—that signal spawning.



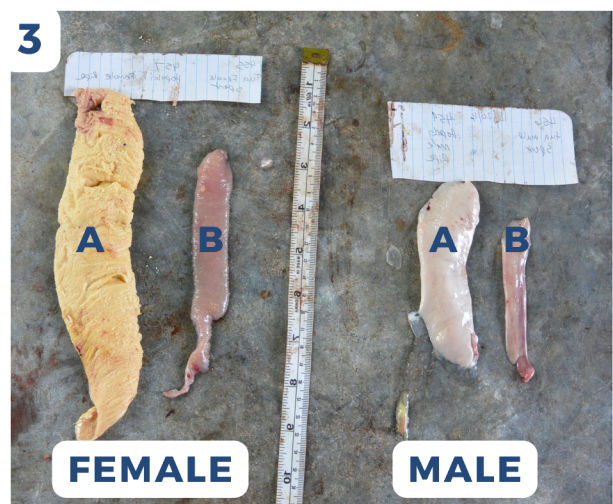
There are also ways of determining spawning using the gonads.



Gonads are the reproductive organs of the fish (image 1). They change in appearance and weight as a function of both the maturity of the fish and the stage of reproduction (image 2).

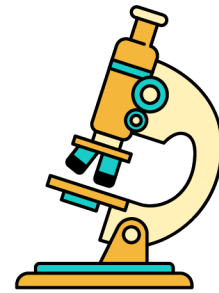
One common approach is gonadal analysis, where researchers examine fish reproductive organs (gonads) to assess their size, weight, and development stage throughout the year. Gonadosomatic index (GSI), which compares gonad weight to body weight, helps identify peak spawning periods when reproductive organs are most developed.

Figure 3 shows an example of the physical differences of both male and female gonads, but also gonads that were extracted from individuals during their spawning season (A) and gonads extracted from individuals outside of their spawning season (B)



There are also ways of determining spawning using more technical scientific methods

Another method is histological analysis, where scientists take tissue samples from gonads and examine them under a microscope. This allows for a detailed assessment of egg or sperm development, identifying whether a fish is preparing to spawn, actively spawning, or has recently completed spawning.



All these methods have their own merits and caveats, but can be an important part of understanding more about the species.

BENEFITS OF TEMPORARY CLOSURES

- **Protect spawning:** Can help to protect species that are particularly vulnerable to fishing while spawning such as fish that aggregate in a known location to spawn where they can easily be caught in high numbers.
- **Simplicity:** Can be reasonably simple to enforce, especially in a community where you can easily identify boats fishing for the prohibited species from shore or enforce by monitoring for prohibited species in markets.
- **Lessen impact:** Can prevent bycatch of important species during particular times of year, such as when turtles appear seasonally and can accidentally be caught by fishers.
- **Protect species when vulnerable:** Can protect a species through their vulnerable season, whether or not you know they are spawning.

CONSIDERATIONS FOR TEMPORARY CLOSURES

- **Timing:** Not all species spawn at the same time so multiple closures during different times of the year can be difficult to communicate and enforce.
- **Careful management:** The benefits of temporary closures can be quickly lost through overharvesting unless the fishery is carefully managed when areas are opened to fishing.
- **Area of closure:** Closures can only benefit species that will remain within the closed area.
- **Fishing effort:** Doesn't protect against certain changes in fishing effort (i.e., people fishing more during other parts of the year) and are unlikely to reduce fishing effort unless coupled with other measures (e.g. size or catch limits).
- **Spawning aggregation fisheries:** For fisheries that specifically target spawning aggregations, this can be unpopular and have large economic impacts.

16. Designing Temporary Closures

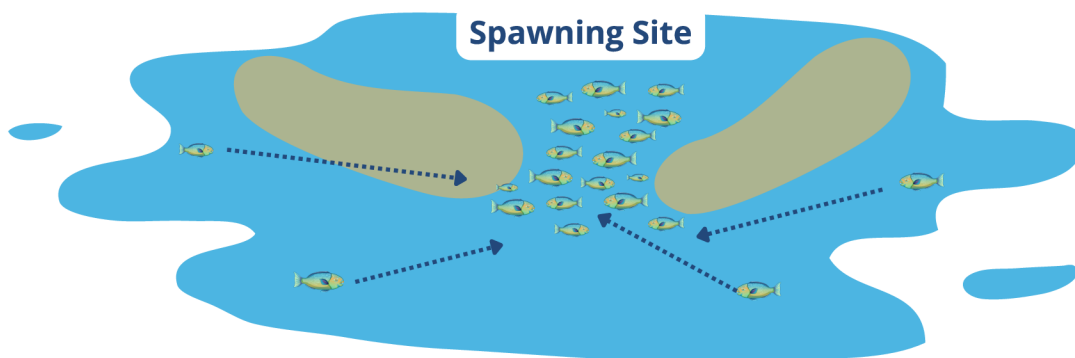
This module discusses some strategies and principles for designing temporary closures. The objectives of this module are to: 1) Introduce key design principles for temporary closures, 2) Equip practitioners to consider how these principles might apply to their fishery context.

If designed appropriately, temporary closures can be a powerful tool for managing a fishery by protecting species during vulnerable times. The objective of this section is to learn how to design temporary closures to meet goals of protecting species at vulnerable times.

Designing temporary closures typically relies on understanding both when different species spawn, and how fishing changes across the year.

SPATIAL COMPONENT OF TEMPORARY CLOSURES

It is important to note that temporary closures also have a spatial component. They can be applied across the entire management area, such as banning harvest of some species everywhere during a specific time (such as their reproductive season). Or they can be applied in specific areas such as banning harvest of some species on their spawning grounds during specific times (if those areas and times are known).

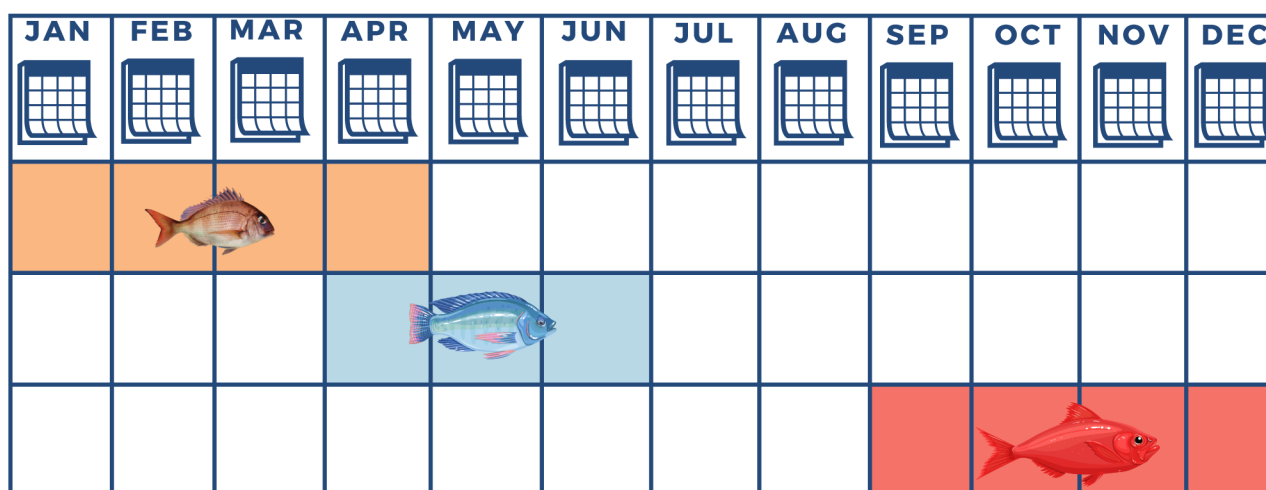


It is also important to protect species on their spawning migration paths to allow them to safely get to their spawning sites and support successful reproduction.

For species that do not use spawning aggregation sites and for species for which we are lacking information on spawning areas and times, more general seasonal closures can be effective.

MANAGING FOR MULTIPLE SPECIES

Temporary closures should be tailored to the life cycles and critical periods (such as reproductive times) of priority species and managed dynamically. When attempting to manage multiple species it can be challenging to efficiently cover all species with the same closure as often species spawn at different times of year. Plotting priority species on a chart with their corresponding spawning seasons, as shown below, can be a useful method of aggregating this information.



When designing a temporary closure, one can prioritize simplicity by trying to design one or two temporary closures that protects multiple species.

Alternatively, if a priority is to always have at least one desirable species available to fish, then one might design numerous back to back closures that protect different species, while ensuring fishers have something to catch year-round.

Activity: Spawning information for priority species

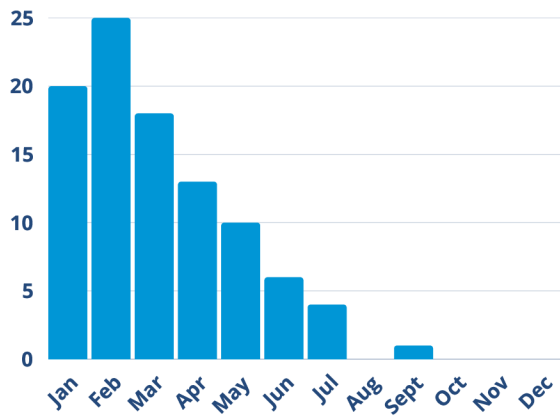
Based on traditional knowledge, local knowledge, and/or scientific understanding, record the spawning seasons or behaviors of priority species in the chart below. It can be helpful to group similar species together. If known, note where they spawn, and if there are other important details associated with their spawning such as moon phase.

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
											

Beyond the consideration of when species are spawning, it is also important to think about patterns of fishing effort across the year, and how fishing effort might be limited or displaced by a temporary closure.

Similar to the Bag Limit Builder, FishKit provides some simple analyses that can be used to inform how fishing pressure might be displaced and how that will impact overall take.

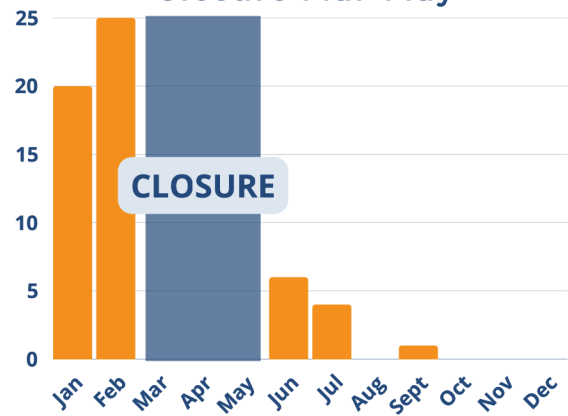
HISTORICAL



Number of fish caught by month
Total fish removed: 358

PREDICTED

Closure Mar-May



Number of fish caught by month
Total fish removed: 317

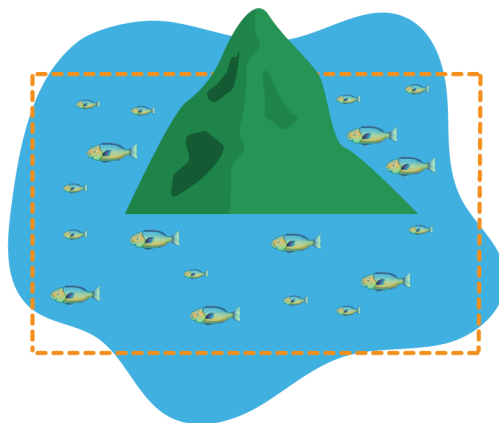
APPROXIMATELY 12% REDUCTION IN OVERALL TAKE

It is important to note that this reduction in take only occurs if fishers do not fish more during other parts of the year to make up for their losses. Shifts in fisher behavior can be tricky to predict and can undermine the effectiveness of temporary closures alone in controlling fishing.

17. Introduction to Spatial Management

Spatial management is another management measure that can be a powerful tool for managing a fishery and helping to rebuild fish populations. The objectives of this module are to: 1) Explain spatial management and its relevance in the Pacific, 2) Illustrate some important concepts relevant to designing spatial management, and 3) Equip practitioners to consider how different types of spatial management might be relevant to their local fishery context.

Fisheries management always has a spatial component - the spatial scale at which the entire fishery is managed, as well as the spatial scale where different regulations apply (e.g. gear restrictions, temporary closures, etc.).



Spatial management is a specific type of management measure that limits fishing on all or some species in a specific area. Spatial management areas also have a time component - they may be temporary, long-term, or permanent.

It is important to attempt to align the scale of governance with the spatial scale of the fish population. While that can at times be challenging, it is the best way to ensure that fisheries management will have its intended benefits. It may require working with neighboring communities, agencies, or states to coordinate on management efforts for species that move across different areas of governance.

Recall the fish movement concepts introduced in the “What is a fishery” module. This information about how far different species of fish move on a day to day basis and throughout their lifetimes are critical to ensuring that the spatial scale of the population aligns with the spatial scale of management.

THERE ARE DIFFERENT TYPES OF SPATIAL MANAGEMENT AREAS:

Limited-Take Area

An area in which harvesting of one or more species is restricted or prohibited, while fishing for other species is allowed.

Rotational or Periodic Rest Areas

An area that is subdivided into two or more parts which allows for periodic harvesting in some areas, while prohibiting harvest in other areas.

Fishery Replenishment Areas

An area that prohibits harvesting of all species, usually for the long-term or permanently with the goal of rebuilding fish populations.

Network of Fishery Replenishment Areas

Multiple fishery replenishment areas, ecologically connected as a network designed to replenish populations.

While each of these types of spatial management areas vary in how much harvest they allow, they have many similar benefits, considerations and design principles.

BENEFITS OF SPATIAL MANAGEMENT AREAS

- **Fishing effort:** Reduces fishing pressure and allows depleted fish populations to rebuild. Longer-term protection allows fish to grow big, protecting the spawning population and supporting fisheries productivity.
- **Protect important areas:** Can protect spawning sites, areas with large fish aggregations, fish nurseries, and areas with healthy fish habitat. Can also protect vulnerable fish habitats and support ecosystem health.
- **Spillover effect:** Fully-protected and permanent Fishery Replenishment Areas promote a high density and biomass of fishery species with more larger, mature fishes with higher spawning potentials (that produce more eggs/larvae) within closed areas. This benefits the fishery outside through spill-over of larvae, juveniles, and adults into fished areas many kms away.

CONSIDERATIONS FOR SPATIAL MANAGEMENT AREAS

- **Community acceptance:** Active participation by the community in the design and implementation of spatial management to meet management objectives is needed to build acceptance and ensure compliance.
- **Appropriate design:** Spatial management will only be effective if it is well designed and managed effectively to meet objectives. The location, configuration (size and spacing) and duration of spatial management areas should be designed by considering habitat use, movement patterns and recovery rates of fisheries species.
- **Enforcement:** Active enforcement may be required to monitor compliance, which can be difficult especially in remote areas. Marking and communicating the closure boundary may require resources like maps, buoys, GPS, etc.

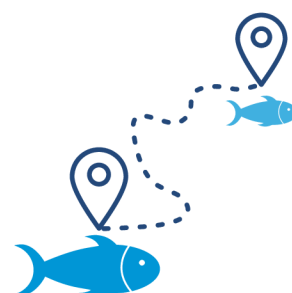
Informing Spatial Management Design

Just like with all management measures, to be successful spatial management must have clear objectives and be designed appropriately to meet those objectives.

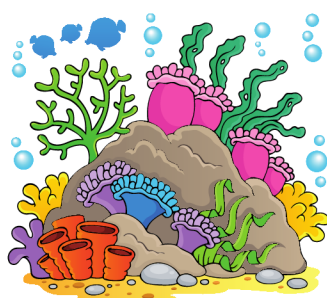
It is important to determine if priority fishery species would likely benefit from spatial management and how **big and long-lasting** those areas would need to be to protect those species and rebuild their populations. Some key ecological information includes:

MOVEMENT DISTANCE

Fish move around during their juvenile and adult stages for feeding, resting, breeding, migration, and seasonal movements. The management area needs to be large enough to accommodate fish movement over the course of their lifespan, **generally 2-3 times their movement distance.**



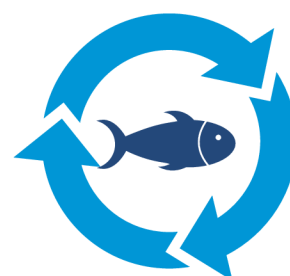
HABITAT REQUIREMENTS



Fish may utilize multiple habitat types during their life stages and over the course of days or months within life stages. **Spatial management areas should include all the habitats required by priority species.**

TIME TO RECOVERY

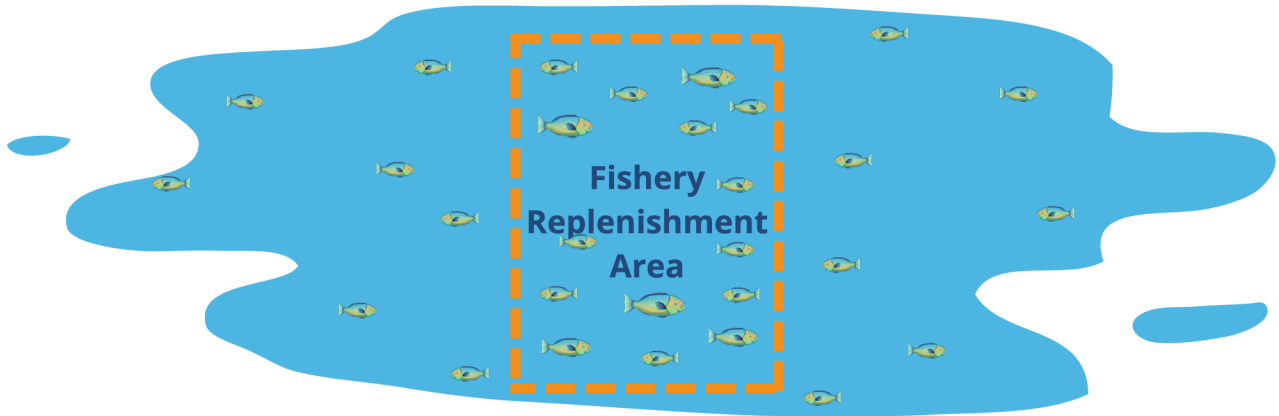
Species differ in how long they take to grow and reproduce over time, as we learned in the Life History section. Understanding how long it takes for fish populations to recover from fishing pressure is essential for setting realistic goals and timelines. **Long-term or permanent areas may be needed for species that are slow-growing or long-lived.** Temporary closures can help with protecting certain life stages or important areas (e.g. spawning aggregations) or for shorter-lived and faster-growing species that recover quickly.



Fishery Replenishment Areas

Long-term or permanent spatial management areas (referred to here as Fishery Replenishment Areas) where fishing is either heavily restricted or not allowed are the most powerful type of marine managed area and are one of the most effective ways to build up populations of marine species within their boundaries.

Fishery Replenishment Areas can lead to more, larger fish within their boundaries.



Fish have the opportunity to grow larger and live longer when fishing effort is not removing fish from the population.

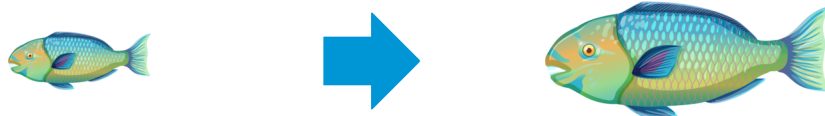
BENEFITS OF FISHERY REPLENISHMENT AREAS:



Fishery benefits: While it might seem counter intuitive, as fishery replenishment areas do not allow fishing, they can have substantial fishery benefits.

1. Bigger Fish!

Fishery Replenishment Areas allow for fish to grow big inside their boundaries!



These bigger individuals produce more fish larvae that replenish the population both inside and outside of the Fishery Replenishment Area.

2. Spillover effect

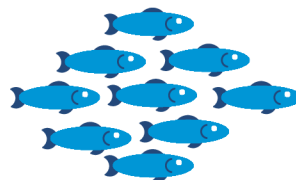
The **spillover effect** is the process by which these Fishery Replenishment Areas can benefit fisheries in the surrounding areas. This effect takes place in two primary ways:

Spillover of adults through fish movement



Adult fish move different distances and times depending on their species. Especially as the Fishery Replenishment Areas might become crowded with so many big fish inside, we sometimes see that adults will spread out of the protected area where they can then be caught by fishers! This is what makes the boundaries of Fishery Replenishment Areas often very popular fishing sites.

Spillover of larvae through larval dispersal



Larvae also move out of Fishery Replenishment Areas and into surrounding waters through a process called larval dispersal. Especially because there should be many large, mature, adults inside the replenishment area they should release a substantial amount of larvae into the water that will then be carried by currents to the surrounding reefs! This benefits those populations and again means more fish for fishers to catch.

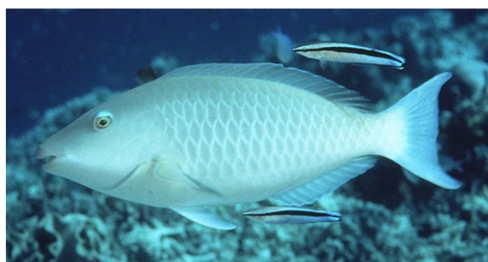
3. Ecosystem benefits

Increasing abundance of important species, such as herbivores, can help to enhance the health of the reef as a whole. Herbivores are species that eat algae. Many of these species play important roles in protecting and maintaining coral reef health. For example, herbivores can help coral reefs recover from disturbances, such as coral bleaching, by eating the algae that would overgrow and smother young corals recolonizing the reef.

Examples of different types of herbivorous fish:

Parrotfishes keep corals clear of algae and help to keep the reef healthy. They feed by scraping the substrate, leaving bite scars and bare areas on the reef where new corals can settle and grow.^{7,8}

- Small scrapers and excavators include small parrotfishes in *Scarus* and *Hipposcarus* genera.
- Large scrapers and excavators include some large parrotfishes like *Bolbometopon muricatum*, *Cetoscarus bicolor* and all *Chlorurus* species.



Surgeonfishes, rabbitfishes, small angelfishes, and other species are grazers and detritivores. They remove different types of algae, turf, and organic matter and help to keep reefs healthy.^{7,8}



Many unicornfishes, batfishes, and rudderfishes are browsers who feed on different types of fleshy algae and help to keep reefs from being overgrown.^{7,8}



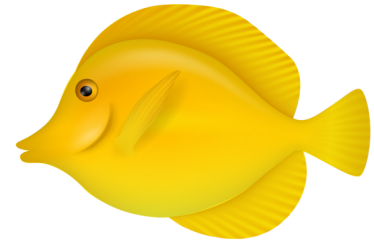
7] Green and Bellwood 2009. Monitoring functional groups of herbivorous reef fishes as indicators of coral reef resilience: a practical guide for coral reef managers. IUCN

8] Chung et al. 2019. Building Coral Reef Resilience Through Spatial Herbivore Management. Frontiers in Marine Science]

Fishery Replenishment Area Case Studies

YELLOW TANG IN WEST HAWAI'I

In West Hawai'i, a network of nine no-collecting Fishery Replenishment Areas were established in 1998 to rebuild populations of yellow tang (*Zebrasoma flavescens*), an important aquarium fish. Monitoring in 2006 showed that higher densities of adult yellow tang in reserves and in adjacent boundary areas. High densities in boundary areas indicate "spillover" of fish from reserves to adjacent open area up to a kilometer or more away.^{9,10}



PROTECTING HERBIVORES IN MAUI



In response to concerns about declining coral cover and recurring macroalgal blooms, the Kahekili Herbivore Fisheries Management Area (KHFMA) was established, where herbivorous fishes and sea urchins are protected, but other fishing is allowed. This management area was specifically designed to protect herbivores and after 6 years of implementation mean parrotfish and surgeonfish biomass both increased within the KHFMA (by 139% and 28% respectively).¹¹

9] Williams I.D., Walsh W.J., Claisse J.T., Tissot B.N. and Stamoulis K.A. 2009. Impacts of a Hawaiian marine protected area network on the abundance and fishery sustainability of the yellow tang, *Zebrasoma flavescens*. *Biological Conservation* 142(5):1066–1073.

10] Friedlander A.M., C. Birkeland, E. Conklin, A. Green, J. Starmer. 2024 (in prep). The Importance of Fisheries Replenishment Areas in Hawaii.

11] Williams ID, White DJ, Sparks RT, Lino KC, Zamzow JP, Kelly ELA, et al. (2016) Responses of Herbivorous Fishes and Benthos to 6 Years of Protection at the Kahekili Herbivore Fisheries Management Area, Maui. *PLoS ONE* 11(7): e0159100. <https://doi.org/10.1371/journal.pone.0159100>

MARINE SANCTUARIES IN POHNPEI

Local fishers in Pohnpei identified the top ten priority fishery species, including groupers, rabbitfishes, parrotfish, surgeonfish and snapper. Scientists then assessed the adequacy of existing marine sanctuaries to protect those species given how far they move and what habitats they need to survive and reproduce. Armed with that information in community workshops, stakeholders could evaluate which species were well protected in

marine sanctuaries, and which species were not. As an example of how this information was used, Palikir Pass Marine Sanctuary was redesigned to be larger and include key habitats required by some priority species, as well as a grouper spawning area.¹²



RAHUI TO REBUILD BONEFISH POPULATIONS

In Anaa atoll in the Tuamotus, traditional management, or rahui, including spatial and temporal management were initiated by the community to help recover populations of bonefish (*Albula glossodonta*). Bonefish are traditionally harvested in traps, known as *kaua*, as they transit from the lagoon to the outer reef during spawning migrations. Local elders' knowledge and fisheries research confirmed that the stocks were overexploited. Through a combination of marine education and involvement of local school children, fisheries research, and community outreach rahui was implemented and resulted in the deactivation of some traps in migratory corridors during the spawning season for five years. Subsequent monitoring showed higher SPR for this species following these actions.¹³



12] Weeks, R., A. L. Green, E. Joseph, N. Peterson and E. Terk. 2016. Using reef fish movement to inform marine reserve design. J. of Applied Ecology. doi: 10.1111/1365-2664.12736

13] Filous A., R. J. Lennox, J. P. Beaury, H. Bagnis, M. Mchugh, A. M. Friedlander, E.E.G. Clua, S. J. Cooke, T. K. Fuller, and A.J. Danylchuk. 2021. Fisheries science and marine education catalyze the renaissance of traditional management(rahui) to improve an artisanal fishery in French Polynesia. Marine Policy Vol 123.

Activity: Ecological information for key species

Priority Species: _____

How far do they move? Are they wide-ranging, sedentary, or somewhere in between?

Which habitats do they use during each of their life stages?

How long do they live? How long would it take their populations to recover (< 5 years, 5-10 years, >10 years)?

Do they have special behaviors that need to be considered for management (e.g., fish spawning aggregations, nursery habitats)?

Given that information, would spatial management likely help to rebuild their populations? How big would the management areas need to be and how long-lasting?

Designing Fishery Replenishment Areas

There are several design principles that are critical for designing successful Fishery Replenishment Areas. The objectives of this module are to: 1) Explain each of the biophysical guidelines for designing Fishery Replenishment Areas, and 2) Equip practitioners to consider how these guidelines might apply in their context.

When a community decides to consider Fishery Replenishment Areas as a part of their fisheries management strategy, it is important to check in with their goals and ensure that the type of spatial management and how it is designed will help to meet those goals. There are important biophysical design guidelines for Fishery Replenishment Areas that should be considered to help meet goals of rebuilding priority fishery populations and promoting ecosystem benefits. These design guidelines are also relevant to other types of spatial and temporal management, depending on their associated goals.

Designing Fishery Replenishment Areas can be a complex process. To design effective Fishery Replenishment Areas, it is important to consider all aspects of a fishery system.

Biophysical Design Guidelines for Fishery Replenishment Areas

1. Represent and replicate habitats

2. Protect critical , special, and unique areas

**3. Incorporate connectivity:
Movement of adults, juveniles and larvae**

4. Allow time for Recovery

5. Maintain Ecological Integrity

6. Protect healthy areas and avoid local threats

7. Adapt to changes in climate and ocean chemistry

8. Integrate within broader management frameworks

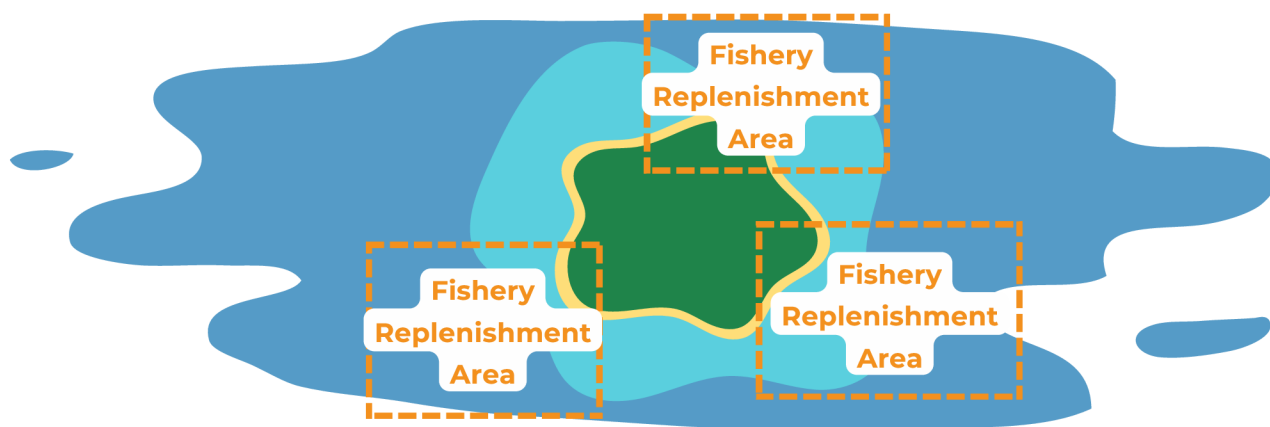
1. REPRESENT AND REPLICATE HABITATS

1.1 Represent 20-30% of each major habitat type in Fishery Replenishment Areas

- **Fish habitats:** Different species use different habitats, so examples of each major habitat (e.g., each type of coral reef, mangrove forest and seagrass bed) that fish require should be protected in Fishery Replenishment Areas.
- **Percent Representation:** Percent habitat representation will vary depending on several factors including fishing pressure and if there is effective fisheries management in place outside Fishery Replenishment Areas. In heavily fished areas where there is no effective fisheries management, >30% of each major habitat should be represented within Fishery Replenishment Areas to sustain populations of priority fisheries species. Where fishing pressure is low, or there is effective fisheries management outside the areas, 20% of each major habitat type may be sufficient. Percent habitat representation should also consider the vulnerability, diversity or rarity of each habitat, and the ecosystem services it provides.

1.2 Replicate and spread risk by including multiple examples of each major habitat type in at least three widely separated Fishery Replenishment Areas

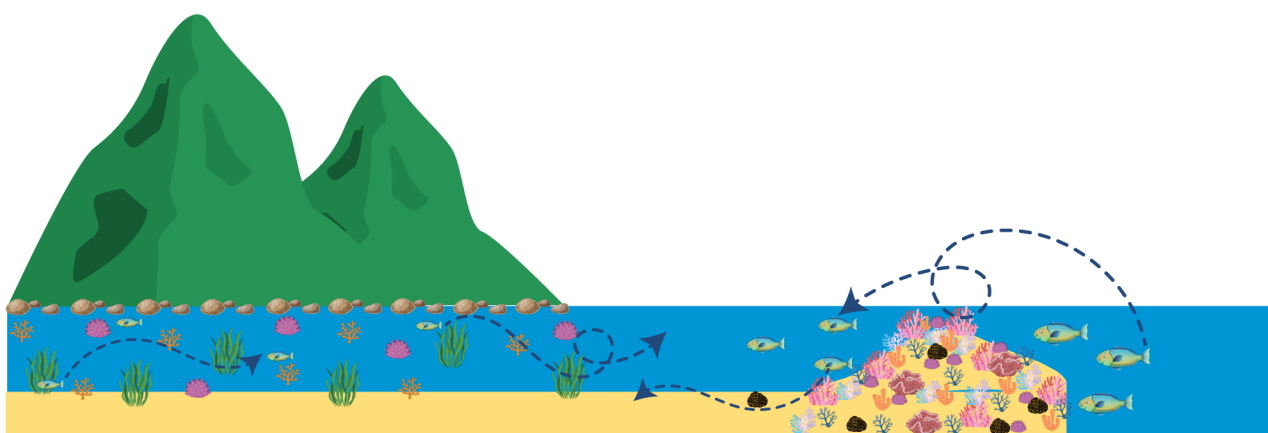
- **Replication:** Include examples of each major fish habitat type in at least three widely separated Fishery Replenishment Areas. This 'spreads the risk' and reduces the chance that all the areas will be impacted by the same disturbance at the same time, allowing damaged areas to be replenished by larvae from unaffected areas.



2. PROTECT CRITICAL , SPECIAL, AND UNIQUE AREAS

2.1 Protect critical areas in the life history of fisheries species in Fishery Replenishment Areas

- **Critical Areas:** Some species concentrate in areas that are critically important for their population maintenance, including spawning areas and nursery grounds.
- **Duration of Closure:** While they use these areas, these species are particularly vulnerable to disturbance or overexploitation. Therefore, these areas should be protected in Fishery Replenishment Areas or temporary closures, in combination with other management approaches (i.e., fishing season or gear restrictions).



The figure above shows a fish species and multiple distinct areas used by that species, including (from left to right) nursery grounds, reef flats and a reef pass. All of these areas are examples of what might be considered critical areas for the species and should be included in the design of Fishery Replenishment Areas.

3. INCORPORATE CONNECTIVITY: MOVEMENT OF ADULTS, JUVENILES AND LARVAE

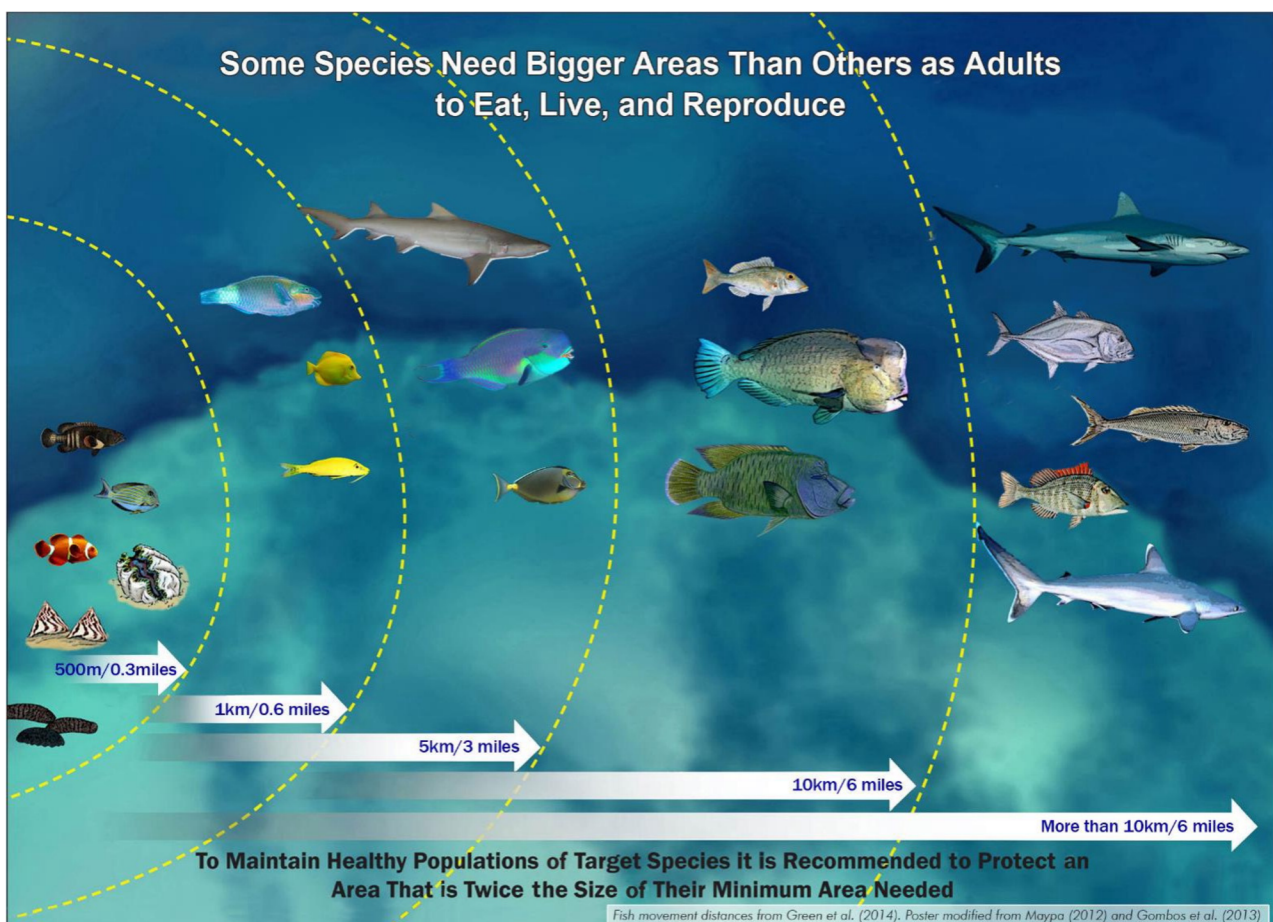
3.1 Ensure Fishery Replenishment Areas are large enough to sustain adults and juveniles of priority fisheries species within their boundaries, by considering how far they move.

- **Fish Movement Distances:** The movement of individuals (e.g. home ranges, habitat shifts over their lives, and spawning migrations) is a key ecological factor to consider in designing Fishery Replenishment Areas, and networks, since it has important implications for the protection of fish populations and their recovery.
- **Twice Size of Home Range of Priority Species:** Fishery Replenishment Areas should be more than twice the size of the home range of adults and juveniles of priority species for protection. The areas must be large enough to sustain adults and juveniles of fishery species within their boundaries, allowing individuals to grow to maturity and increase in biomass and reproductive potential, while providing recruitment subsidies to fished areas.
- **Large or Networked Fishery Replenishment Areas:** Fishery Replenishment Areas of different sizes will be required depending on which species require protection, how far they move, and if other effective protection is in place outside the areas. Larger areas will protect more species. Multiple areas can be spaced so they can function as mutually replenishing networks, connected by larval recruitment.
- **Fish Habitats:** Recommendations regarding the minimum size of areas must be applied to the specific habitats that priority species use, rather than the overall size of the area (which may include other habitats).
- **Integrate With Other Measures:** Species whose movement patterns are larger than the size of the closure(s) will only be afforded partial protection. Fishery Replenishment Areas must be integrated with other fisheries management tools to manage wide ranging species.



3.2 Ensure priority species can move among habitats they use throughout their lives, protected in either individual Fishery Replenishment Areas or networks of Fishery Replenishment Areas.

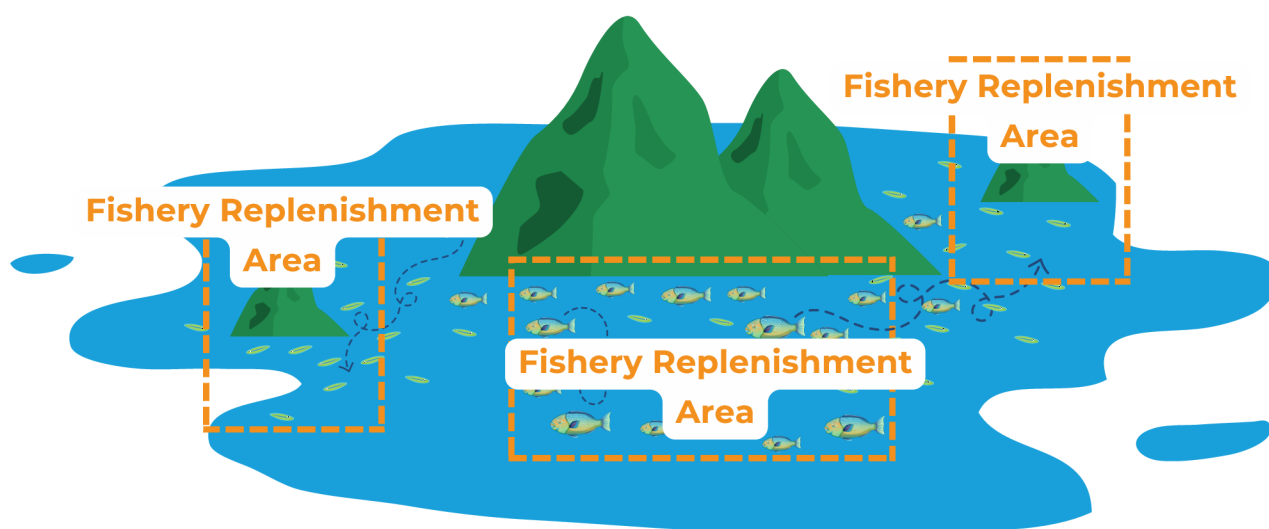
- **Juvenile and Adult Habitats:** Some species use different habitats throughout their lives and all habitats needed by juveniles and adults of priority species should be protected within individual Fishery Replenishment Areas. Where movement patterns among habitats (e.g., habitat shifts over their life span or spawning migrations) cover distances too great to be included in individual Fishery Replenishment Areas, different habitats used by priority species should be protected in multiple Fishery Replenishment Areas that are located to allow for movements of priority species among protected habitats.
- **Areas Important for Reproduction:** For species that undertake long distance spawning migrations, like some economically important grouper and snapper species, it is important to protect their spawning aggregation sites, migratory corridors and staging areas, in addition to protecting the home range of a sufficiently large proportion of their population. If the location of these areas is not known, or if their scale of movement is too large to include in individual Fishery Replenishment Areas, other management actions will be required (i.e., temporary closures during spawning times).



Example fish movement distance graphic from Green et al. (2014).

3.3 Ensure Fishery Replenishment Areas are self-sustaining for priority species, either individually or as part of a network.

- **Population Persistence:** Larval dispersal plays an important role in ensuring that fish populations recover from disturbances and persist through time. Fishery Replenishment Areas should be designed to ensure populations of priority species persist within those areas and to maximize larval dispersal to support fisheries outside the areas and to replenish other areas that may be impacted by disturbances.
- **Larval Connectivity:** Patterns of larval connectivity (and population persistence) vary with species and in different places. Where possible, use local information on larval dispersal to design networks for Fishery Replenishment Areas.
- **Isolated Areas:** Spatially isolated areas such as remote atolls are largely self-replenishing and may have low connectivity with other areas. This makes these assemblages, species and populations less resilient to disturbance. Protecting them in Fishery Replenishment Area may be necessary to ensure their persistence.

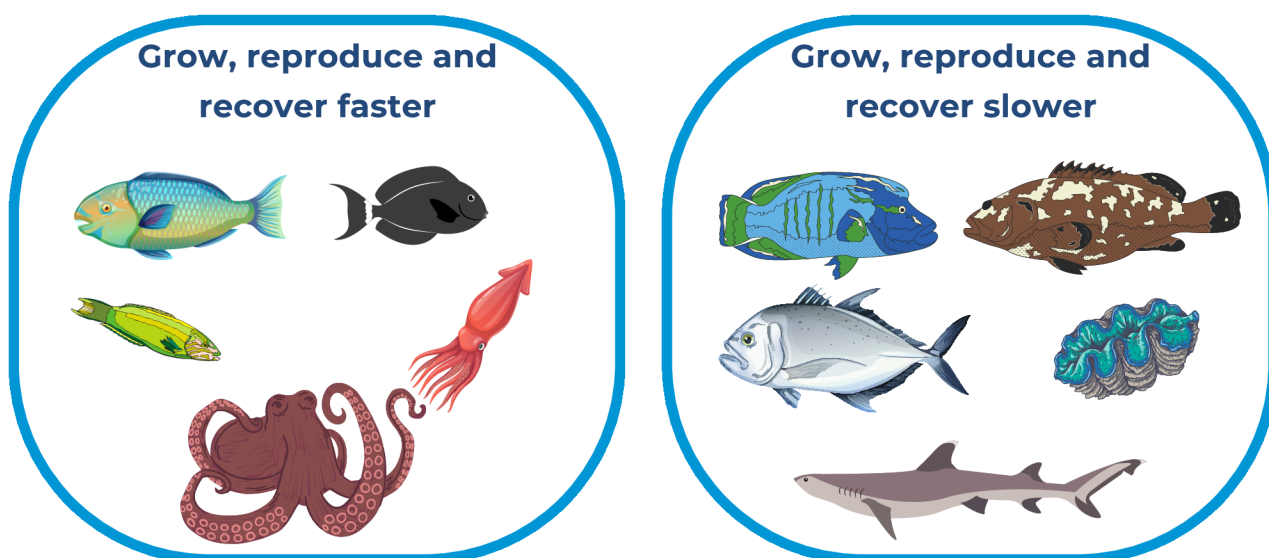


This figure illustrates a network of Fishery Replenishment Areas spanning a group of small islands. The dotted blue arrows show how these areas might be connected by fish movement and larval dispersal.

4. ALLOW TIME FOR RECOVERY

4.1 Establish Fishery Replenishment Areas for a duration of time that aligns with the biology of priority species, local ecology, and fishery goals. Long-term (20 to 40 years) or permanent areas may be needed for some contexts and species. Use short term (<5 years) or periodically harvested areas in addition to, rather than instead of, long-term or permanent Fishery Replenishment Areas.

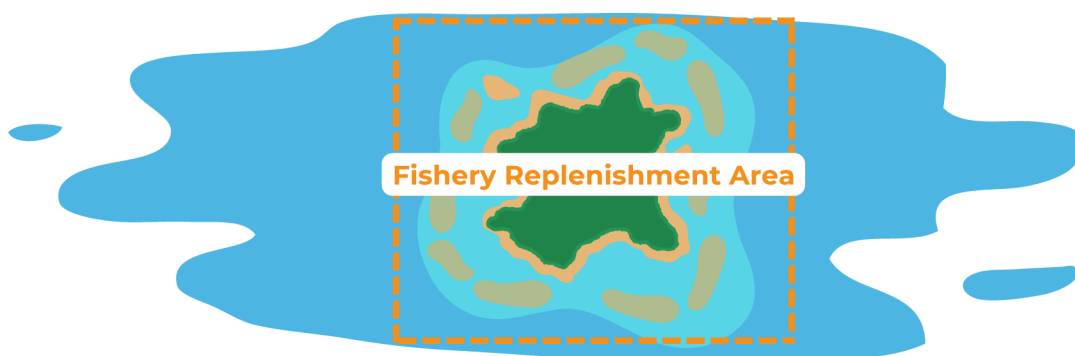
- **Duration Affects the Outcome:** Different types of spatial management areas can vary by how long they are left in place, from permanent to short-term, and with very different potential outcomes and contributions towards meeting management objectives. Populations of priority species recover at different rates depending on their life history characteristics and other factors.
- **Long Term/Permanent Fishery Replenishment Areas:** Recovery of all priority fisheries species may take decades (>20 to 40 years). Therefore, long term protection in Fishery Replenishment Areas may be required for all species to grow to maturity, increase in biomass and contribute more robust eggs and larvae to replenish populations in managed areas, enhance adjacent fisheries, and maintain ecosystem health and resilience. Permanent protection and strict enforcement will ensure that these benefits are maintained in the long term.
- **Short Term Spatial Management Areas:** Short term (<5 years) or periodically harvested rotational areas only provide short-term benefits for some species (that grow, reproduce and recover quickly). These benefits are quickly lost once these areas are reopened to fishing unless they are managed very carefully. Therefore, they have limited benefits for longer-term goals of rebuilding fisheries, conserving biodiversity, or building ecosystem resilience. Thus, short term (<5 years) or rotational areas should be used in addition to, rather than instead of, long-term or permanent Fishery Replenishment Areas. Where periodic managed areas are used, the timing and intensity of harvesting must be carefully controlled.



5. MAINTAIN ECOLOGICAL INTEGRITY

5.1 Where possible, include whole ecological units and use compact shapes for Fishery Replenishment Areas, except when protecting naturally elongated habitats.

- **Whole Ecological Units:** Features like offshore reefs, bays, or reefs surrounded by sand can be included in Fishery Replenishment Areas to minimize fishing mortality, since many species are likely to stay within their preferred habitats in these areas.
- **Shape of the zone:** Compact shapes (e.g., squares or circles) minimize edge effects by limiting spillover of adults and juveniles more than other shapes (such as long thin rectangles), which helps maintain the ecological integrity of the Fishery Replenishment Area. Compact shapes should be used whenever possible for closures, except when protecting naturally elongated habitats (i.e., long narrow reefs).

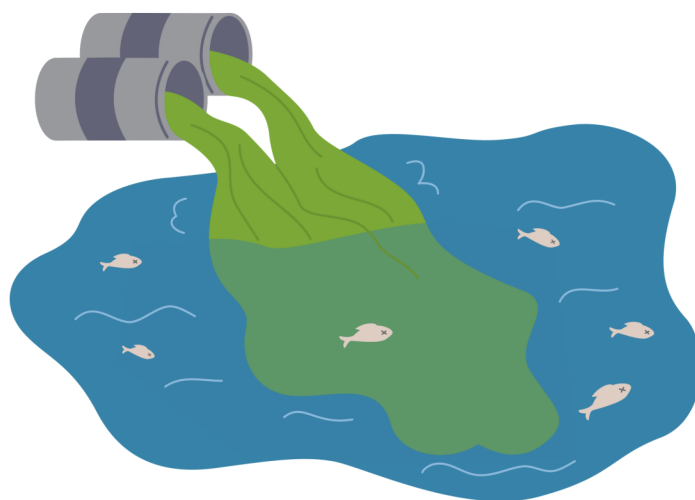


This uninhabited and unique island pictured above might make sense to protect as a whole unit so that populations that span the whole island have the opportunity to recover and ecological integrity is maintained.

6. PROTECT HEALTHY AREAS AND AVOID LOCAL THREATS

6.1 Prioritize placing Fishery Replenishment Areas in places where ecosystems are healthy or have good recovery potential and where threats can be managed effectively to help rebuild fisheries.

- **Marine and Land Based Threats:** Marine ecosystems have been degraded by local threats in many locations, including by unsustainable fishing or tourism activities, destructive fishing practices, coastal development, land-based runoff, and pollution. These threats decrease ecosystem health, fisheries productivity, and resilience to climate change. Minimize or avoid these threats in Fishery Replenishment Areas and prioritize areas for protection that are more likely to contribute to fisheries productivity, ecosystem health, and resilience to climate change.
- **Protect Healthy Areas:** Protect healthy areas where resources are in good condition (e.g. where standing stocks of key fishery species are still high, habitats are healthy and productive, fishing effort is low).
- **Avoid Unmanageable Threats:** Avoid placing Fishery Replenishment Areas where ecosystems have been, or are likely to be, degraded by local threats that cannot be managed effectively (e.g., in areas where there is high human population density, coastal development, land-based run-off and pollution).
- **Recover and Restore Resources:** Where Fishery Replenishment Areas must be in places where habitats and populations of priority species are in poor condition due to local threats, reduce threats as much as possible, protect larval sources and species that play important functional roles in ecosystem resilience (such as herbivores), facilitate natural recovery, and consider costs and benefits of restoration of habitats and species.



Highly polluted / impacted areas may not serve as productive Fishery Replenishment Areas. Consider avoiding these areas in design of Fishery Replenishment Areas while supporting or advocating for separate efforts to remediate these environmental harms.

7. ADAPT TO CHANGES IN CLIMATE AND OCEAN CHEMISTRY

7.1 Include areas in Fishery Replenishment Areas where habitats and species are likely to be more resilient to, or able to adapt to, global environmental change.

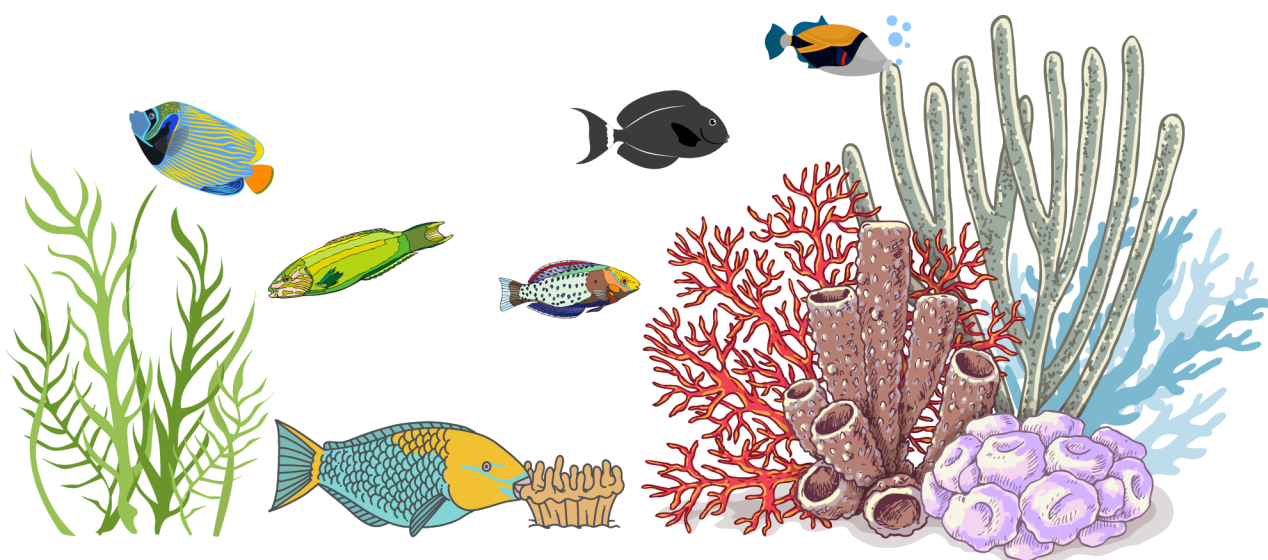
- **Climate Threats:** Changes in climate (e.g., from rising sea temperatures and sea levels) and ocean chemistry represent a serious and increasing threat to major habitats (e.g., coral reefs, mangrove forests and seagrass beds) and associated fishery species. Effects of these changes will vary in space and time, and some areas may have habitats and species more likely to be resistant or resilient to climate and ocean change (known as refugia).
- **Protect Refugia:** Where refugia can be identified, they should be protected in Fishery Replenishment Areas that protect larval sources that may be important to support reef and fishery recovery following disturbance.
 - Refugia from rising sea levels may include coastal habitats (e.g., mangrove forests and turtle nesting beaches) adjacent to low-lying inland areas without infrastructure that they can expand into as sea levels rise.
 - Refugia from rising sea temperatures may include coral reefs with:
 - Few local stressors (e.g., pollution, overfishing and unnaturally high levels of sedimentation and nutrification).
 - Habitats and species that have shown resistance or resilience to thermal stress in the past.
 - Historically variable sea surface temperatures, where habitats and species are more likely to withstand changes in those parameters in future.
 - High fish and coral diversity (particularly heat-tolerant corals).
 - High coral recruitment and low macroalgae abundance to facilitate recovery.



7.2 Increase protection of species that play important functional roles in ecosystem resilience (i.e. herbivores) in fully protected Fishery Replenishment Areas.

- **Reef Resilience:** Some species play important roles in maintaining reef resilience to local and global threats. Herbivores are a key functional group that supports the ability of coral reefs to recover from disturbances such as mass coral bleaching, by preventing algal overgrowth that can inhibit coral settlement and survival.
- **Protect Key Herbivores:** Functionally important species, such as herbivorous reef fishes, should be protected in Fishery Replenishment Areas, integrated within broader fisheries management regimes.

Resilience includes two components: resistance and recovery. Resistance is the ability of an ecological community to resist or survive a disturbance. Recovery refers to the ability of a system to return to its original condition.



Some species play important roles in ecosystem function and maintaining resilience to local and global threats. For example, in some situations, herbivores can be a key functional group that underpins the ability of coral reefs to recover from disturbances such as mass coral bleaching, by preventing algal overgrowth that can inhibit coral settlement and survival. Examples of herbivorous fish include: parrotfish, rabbitfish, and surgeonfish.

8. INTEGRATE WITHIN BROADER MANAGEMENT FRAMEWORKS

8.1 Locate Fishery Replenishment Areas where they can benefit from and enhance other management actions.

1. **Spatial and Non-Spatial Fisheries Management:** Fishery Replenishment Areas, and other spatial management areas, can be powerful tools for achieving fisheries objectives. However, in many situations, depending on the biology and ecology of the species and the intensity and nature of fishing pressure, spatial management may need to be integrated with other fishery management measures to be effective.
2. **Integrate with Other Management Efforts:** Additionally, in many situations, fisheries management measures cannot be effective on their own and need to be integrated within broader marine spatial planning and management regimes (e.g., Ecosystem Based Management and Integrated Coastal Management) to address other threats to marine resources.
3. **Land-Sea Connectivity:** It is also important to recognize the critical connection between land and sea. For example, there may be benefits to locating Fishery Replenishment Areas adjacent to terrestrial and estuarine areas that are already well-managed and in good condition.

These biophysical design guidelines should be integrated with the socioeconomic-cultural guidelines (in the management measures section starting on page 63) to ensure that human benefits and considerations are also addressed.

Activity: Existing Spatial Management Areas

Are there existing or proposed spatial or temporary management areas in your community? If so, evaluate and discuss which species are likely to be protected within those areas given their size, habitat composition, and duration.

Existing/Proposed Area	Type of Management	Size of Area	Habitats Included	Duration

How well do existing or proposed spatial management areas protect your priority species based on their ecology (e.g. habitat requirements, movement distances, recovery times)?

Priority Species	Habitat Requirements	Movement Distance	Recovery Time

If the existing or proposed management areas do not support rebuilding populations of your priority species, what could you do? Could the management area be bigger, better located or in place for longer? Could you use another management tool to enhance rebuilding of fish populations outside of the managed area?



Size Limits



Bag Limits



**Temporary
Closures**



**Spatial
Management**



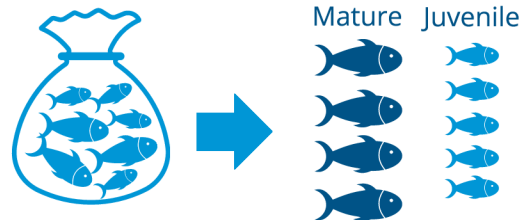
**Gear
Restrictions**

Cheat Sheet for FishKit Metrics

STOCK HEALTH TRACKER

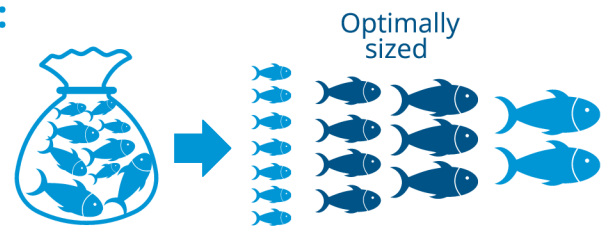
MATURE FISH IN THE CATCH:

The percentage of fish in the catch that have reached maturity (Target = 100%)



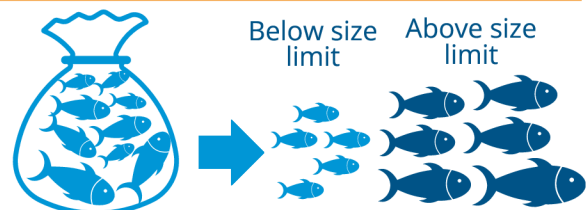
OPTIMAL SIZES IN THE CATCH:

The percentage of fish in the catch that are in the range of "optimal lengths," which is the range of lengths that should optimize the yield in weight (Target = 100%)

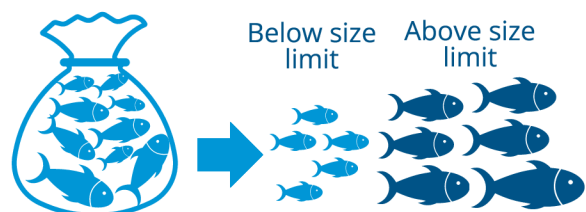


MEGA-SPAWNERS IN THE

CATCH: The percentage of fish in the catch that are above the optimal size and comprise the largest individuals in the population (Target = 20-30%)



FISH ABOVE SIZE LIMIT: The percentage of fish in the catch that are above the size limit (Target = 100%)



SUSTAINABILITY SCORE (SPAWNING POTENTIAL RATIO

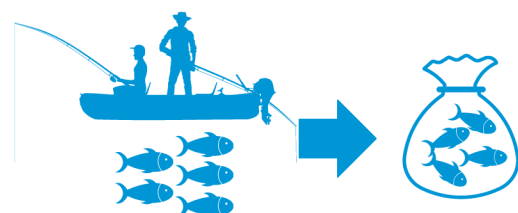
- **SPR**): Represents the egg production of a population on a scale from 0 to 100, where 100 is the maximum egg production of a population



SIZE LIMIT BUILDER

CATCH SCORE (YIELD-PER-RECRUIT) (YPR):

Represents the total yield of a fishery in weight of fish caught on a scale from 0 to 100, where 100 is the theoretical maximum sustainable yield



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