AFAM Toolkit Guidance Document

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Contents

Welcome

Welcome to the Adaptive Fisheries Assessment and Management (AFAM) Toolkit Guidance Document!

We've tried to make using the AFAM Toolkit Guidance Document simple and intuitive. This document is meant to be accompanied by the AFAM Toolkit Dashboard, which will help you work through each step and perform the appropriate assessment methods for your fishery.

This toolkit was developed by the Fish Forever partnership, but can hopefully serve the broader fisheries management and marine conservation community. Please contact Gavin McDonald with any questions, comments, or feedback (gmcdonald@bren.ucsb.edu).

Figure 1:

Toolkit Overview

0.1 Purpose Statement

- This toolkit provides you the tools you will need to estimate how your fishery is doing and achieve your fishery goals by managing it adaptively. The toolkit will help you implement fisheries management measures based on your best available science, learn how these management interventions are performing, and then adjust them as necessary.
- This toolkit will help you create an Adaptive Fisheries Management Plan
- See Figure 1 below for a step-by-step process schematic of the toolkit

0.2 Suggested Audience

- The toolkit is designed as a facilitation document that is led by one person. However, during each step, this person would work with a multi-stakeholder group to reach consensus and make decisions
- The person who should facilitate this process will depend on team skills and goals from fishery programs. The toolkit may be used by technical staff members, who may each use the toolkit in different fisheries systems

0.3 Skills Necessary to Use Toolkit

- General knowledge and skills in fisheries science (ecology, management, population dynamics, local policy)
- Familiarity working with fisheries data
- Facilitation skills to coordinate and lead multi-stakeholder discussions
- Communication skills to effectively convey the benefits and tradeoffs of different fisheries assessment and management options to a variety of stakeholders

0.4 Toolkit Objectives

- This toolkit provides a step-by-step process that you can use to analyze data, evaluate the performance of your fishery, choose management measures, and adjust management so that the fishery achieves your management objectives. Specifically, the toolkit helps managers:
  - Select fisheries management controls (regulations) designed to help managers achieve their fisheries goals (i.e. limit fishing mortality, protect ecological and biological function, reduce bycatch, etc.)

  - Determine which and how data should be used to monitor and evaluate target species and/or ecosystem status over time
  - Perform data-limited assessment techniques to evaluate fisheries performance
  - Define a process for how fisheries assessment and management will be reviewed and adapted periodically over time, using the best available scientific data and local ecological knowledge

- By working through the above steps, this toolkit will help you create an Adaptive Fisheries Management Plan.
- Visualizing data collected at your site can be used as a "spot check" to detect problems with data collection sampling protocols. You may wish to revisit the dashboard frequently (every few months) during the beginning stages of any new data collection program to adaptively correct problems.

0.5 When to Use the Toolkit

- This toolkit has been designed to work holistically. To properly assess and manage your fishery, it will be important to have clearly articulated goals, a qualitative characterization of the fishery, prioritized species, and a mechanism under which fisheries management can be implemented. Please see the following section for a more detailed description of data requirements and recommendations.
- The AFAM toolkit should be used on an annual basis at least for the first few years in order to take advantage of the adaptive nature of this framework. As time progresses and more data and information become available for the fishery, different assessment and management tiers should be used. Additionally, as technical capacity for data analysis develops at your site, more advanced assessment methods may be appropriate. Due to changing biological, ecological, environmental, and socioeconomic conditions, it will also be important to perform each assessment method on an annual basis in order to measure changes in the fishery and adjust fisheries management controls accordingly.

0.6 Data Necessary to Use the Toolkit

Below we describe the minimum data requirements as well as additional optional data that is recommended but not required. For each type of data, we list the Fish Forever data stream or toolkit outputs that the AFAM toolkit can use. For each data stream or toolkit output, we also describe exactly what information the AFAM toolkit will use from that source. While we recommend that sites use the toolkits and data stream collection protocols outlined in the Global M&E Plan and the FF Data Collection Manual, we realize some regions may have other tools or data collection processes for getting the same type of information. The AFAM toolkit can be used with whatever data is available, although the most important types of data for data-limited fisheries assessment come from catch reporting, boat intercept or landing site surveys, fishery-dependent length composition surveys, and fishery-independent surveys (using underwater visual surveys or experimental fishing).

Table 1: Minimum required and optional recommended data for using the AFAM Toolkit

+====================================+ | **Minimum Required Data** | +====================================+ | Qualitative characterization of | | the fishery (including local | | history, gear types, target | | species, fishing locations, | | fishing seasons, etc) | +————————————————————+ | TURF and Reserve size and | | location | | | +————————————————————+ | List or prioritized species for | | management | | | | List or prioritized goals for | | management | | | | Estimated vulnerability of | | prioritized target species | +====================================+ |**Additional Recommended Data** | +====================================+ | Landings, effort, and CPUE of key | | target species | +————————————————————+ | Landings, effort, and CPUE of key | | target species | +————————————————————+ | Length composition data of key | | target species | +———————————————+ | Fished:Unfished density ratio | | (key target species) Coral reef | | thresholds (aggregated across | | species – only for underwater | | visual survey) | +———————————————+ | Household survey data on the | | community's knowledge, attitudes, | | interpersonal communication, and | | practices relating to fisheries | | management | +———————————————+ | Household survey data on the | | impact fisheries management is | | having on the community | +———————————————+ | Information on violations of the | | NTZ and violations of TURF | | regulations | +———————————————+ | Qualitative information on the | | community's preparedness for | | implementing fisheries management | | and what barriers that may need | | to first be removed | +===================================+

0.7 Supporting Documents

- There are accompanying Excel workbooks for each assessment method included in the AFAM Toolkit that can be used as training tools for teaching the various assessment methods. It is recommended that individuals without experience in particular methods use these workbooks first to familiarize themselves with the methods. Once familiar with the methods, the AFAM Toolkit Dashboard provides practicioners with a streamlined way of performing the methods.

0.8 How this Toolkit was Developed

This toolkit builds on extensive research over the past decades in data-limited fisheries assessment and management approaches. This toolkit also utilizes extensive first-hand experience in designing a similar Adaptive Management Framework for the Belizean conch and lobster fisheries, an initiative undertaken between the Belize Fisheries Department, Belize Science Team, and several members of the Fish Forever team (McDonald et al., 2017, Harford et al., 2016).

0.9 How to use this toolkit

This toolkit will guide you through an eight-step process that should be conducted on an annual basis. The AFAM Toolkit Dashboard is the easiest way to help facilliate your process through each step and in performing the data-limited assessments. Definitions of many terms throughout this document can be found in the Glossary . Words or phrases that are found in the glossary are often *italicized*.

8 Steps in the Toolkit:

The toolkit process is broken into 8 steps, shown in the schematic (Figure 1) and described below.

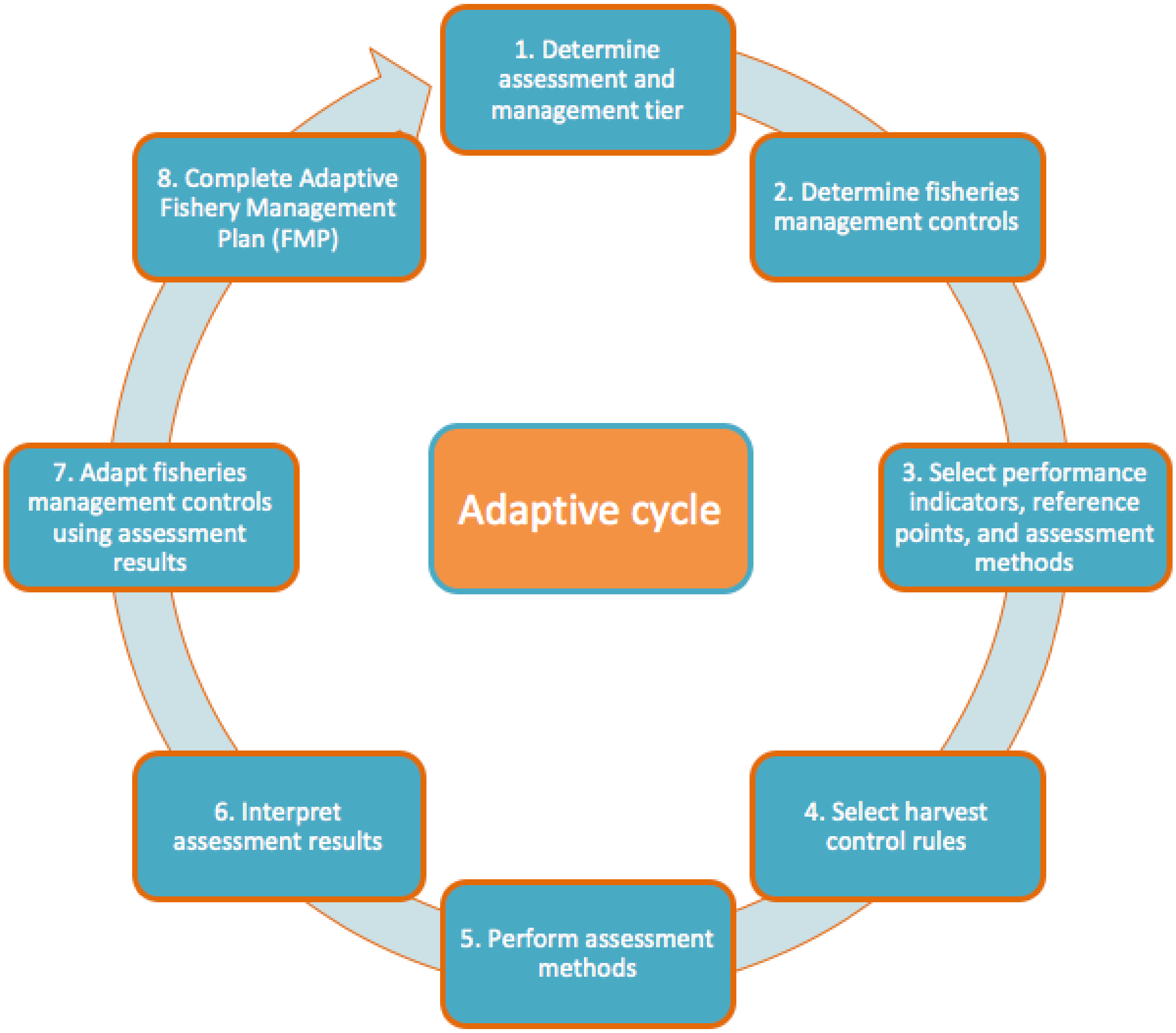


Figure 1: 8-step AFAM Toolkit cycle

1. Step 1 – Determine Assessment and Management Tier
    a. Your assessment and management tier is based on the data you have available and will determine what assessment and management options you have at your disposal
2. Step 2 – Determine Appropriate Fisheries Management Controls
    a. Fishery management controls are what allow managers to limit aspects of fishing behavior to limit fishing mortality or to protect key biological or ecological function (i.e., Total Allowable Catch or seasonal closures to protect spawning aggregations)
3. Step 3 – Select Performance Indicators, Reference Points, and Assessment Methods
    a. Performance indicators are numerical values based on data that give an indication of how the fishery is performing relative to a reference point. Reference points may define either a target where you want the fishery to move towards or a limit where you want the fishery to stay away from. The assessment method is the technique for calculating your performance indicator using available data. For example, a performance indicator could be fishing mortality with a target reference point of natural mortality. In this case, the assessment method to calculate fishing mortality could be Catch Curve.

4. Step 4 – Define Harvest Control Rules
   a. A harvest control rule helps stakeholders to compare performance indicators with reference points and adjust fisheries management controls accordingly. In other words, a harvest control rule is a plan for pre-agreed management actions as a function of variables related to the status of stock in question. For example, a simple harvest control rule could specify that if fishing mortality is above natural mortality, the Total Allowable Catch should be reduced.
5. Step 5 - Perform Assessment Methods
   a. You will learn about the various types of assessment methods and use the appropriate assessment method to calculate your selected performance indicators and reference points. This section provides a "how-to" guide for using each assessment method. Excel workbooks will accompany some assessment methods.
6. Step 6 – Interpret Assessment Results
   a. You will interpret your assessment results, together with local ecological knowledge and other available data, to determine if a management response is required or not.
7. Step 7 – Adjust Fisheries Management Controls Using Defined Harvest Control Rules
   a. You will use the harvest control rules defined in Step 4 and the interpretations generated in Step 6 to adjust fisheries management controls appropriately.
8. Step 8 – Complete your Fishery Management Plan
   a. You will use the outputs of the AFAM toolkit as well as other Fish Forever documents to fill out a Fishery Management Plan template for your fishery. Note that the template provided here may need to be adapted to better suit regional context.

Chapter 1

Step 1 – Determine Assessment and Management Tier

What information do I have, and how can I use it?

In the first step of this toolkit, you will determine the assessment and management “tier” of your fishery based on the types of information and data that are available (Figure 2). Depending on the data that are available, you will have different options for fisheries management controls and assessment methods. The tier you determine during this step will be used throughout the remaining steps of the toolkit. This tiered system is based on the Global M&E Plan. If your site follows this plan, you will automatically begin collecting the necessary data to eventually move to Tier 3.

Figure 2: Schematic of assessment and management tiers

1.1 Step 1a – Fill out your Data Inventory

Fill out your inventory of available data.

1.2 Step 1b – Using your Data Inventory, Determine Assessment and Management Tier

Use the following questions to determine which assessment tier is most appropriate for your site:

1. Do you have two or more years of catch/effort data (from individual catch reporting and/or boat intercept or landing site survey)? Do you also have two or more years of fishery-dependent length-composition survey data?

    a. **Yes** – Use the *Tier 3* category and continue collecting data.

    b. **No - C**ontinue on to question two.

2. Do you have at least one year of catch/effort data (from individual catch reporting and/or boat intercept or landing site survey) and fishery-dependent length-composition survey data?

    a. **Yes -** Use the *Tier 2* category and continue collecting data.

    b. **No** –Use the *Tier 1* category.

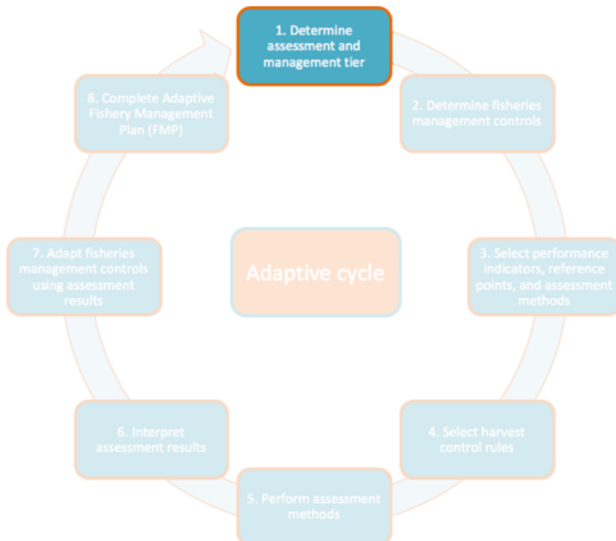


Figure 1.1:

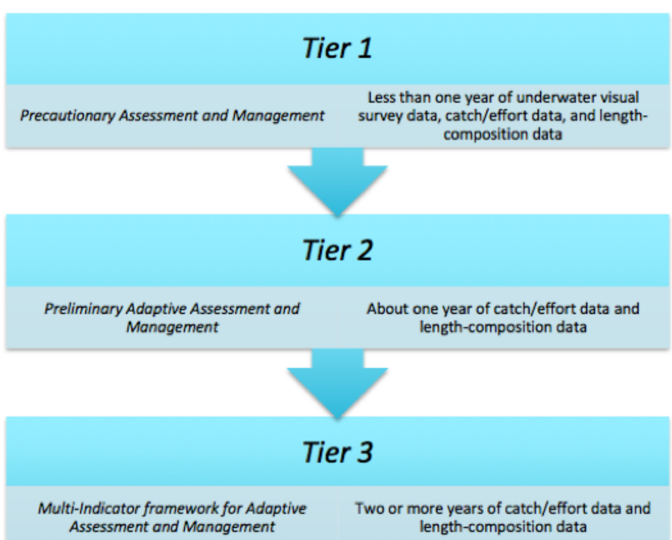


Figure 1.2:

The three assessment and management categories are described in more detail below. We will discuss the specifics of fisheries management controls and performance indicators in the following steps. As you collect more and more data as the Fish Forever intervention progresses, your site will be able to move from one tier to the next.

Tier 1 – Precautionary Assessment and Management (for new sites with less than one year of data)

Under most scenarios, Tier 1 describes a new site, with no pre-existing standardized data collection and monitoring program in place. The only information available will likely come from qualitative information and local ecological knowledge. Even though little to no data is present, managers can still perform a basic fisheries assessment and select precautionary fisheries management controls (FMCs) until more data is collected. The goal of Tier 1 is to implement precautionary assessment and management measures that can benefit a fishery of any status until more data is collected for the fishery. When we are uncertain about the status and dynamics of a resource, it is prudent to interact with the resource in a way that minimizes the risks of something 'bad' happening. One of the most effective precautionary management techniques is to limit the use of destructive fishing gears and/or practices. Another common precautionary management technique is to protect spawning aggregations through the implementation of a seasonal closure.

Tier 2 – Preliminary Adaptive Assessment and Management (for sites with one year of data)

Tier 2 sites will have roughly one year of data that come from some combination of catch reporting, boat intercept or landing site survey, or fishery-dependent length-composition surveys. The goal of Tier 2 is to provide the preliminary assessment and management methods for a fishery, while continuing to collect more data. A suite of FMCs can also be used in combination to meet multiple objectives where appropriate.

Tier 3 – Multi-Indicator framework for Adaptive Assessment and Management (for sites with more than one year of data)

Tier 3 sites will have a time series of data available that can be used to examine trends in multiple performance indicators and implement FMCs such based on an improved scientific understanding of stock status. Under Tier 3, each species should have several performance indicators, which should ideally come from different data streams, in order to gain a more complete understanding of the fishery and reduce uncertainty. Multiple performance indicators from multiple data streams are used to gain a more complete understanding of the fishery and to reduce the implications of uncertainty, bias, or error associated with any single indicator or data stream. Furthermore, corroboration between indicators can allow for a confident interpretation of fishery performance. Additionally, with multiple years of data, limits and targets can be estimated from running averages or the average of the past few years. Running averages take into account variability in the environment and the fishery. Ecosystem-level indicators should be included if the sustainable provision of non-fishery ecosystem services is a management goal.

Chapter 2

Step 2 – Determine Appropriate Fisheries Management Controls

What fisheries management controls are appropriate for your fishery?

2.1 Step 2a – Summarize and Qualitatively Assess Any Existing Fisheries Management Controls

As an important first step, summarize any existing fisheries management controls that may affect your site. If there are no existing FMCs, skip to Step 2b.

Qualitatively assess how existing fisheries management controls are performing. This will help determine whether or not these controls are appropriate, or if other or additional controls should be used instead. Think about the following considerations:

- **Who mandates this FMC?** Is it locally mandated (in which case it could potentially be modified or removed), or is it mandated by a higher body (such as a regional or national body – this may make the FMC more difficult to modify or remove)? This can help frame a discussion around whether or not this FMC could be modified or removed.
- **What is the cost of this FMC?** Does it require expensive data collection or enforcement?
- **What is the level of compliance with this FMC?**
- **What is public attitude towards this FMC?** You may be able to use existing KAP survey data to help quantify this.
- **Are current FMCs helping the fishery reach its goals?** You may use Table A2. 2, Table A2. 3, and Table A2. 4 to see common goals of many FMCs and determine if the goals of your fishery are being met.
- **What are other implementation pros/cons**?

Based on this qualitative assessment, you may be happy with the current set of FMCs in which case you can skip to Step 2c. Alternatively, if the FMCs are not performing as your community may wish, proceed to Step 2b to explore selecting different FMCs. Either way, you will quantitatively assess how well FMCs are doing in terms of fisheries performance in Step 5 by performing data-limited assessments using any available data. Based on this quantitative evaluation, you may wish to change FMCs during the next iteration of the AFAM cycle.

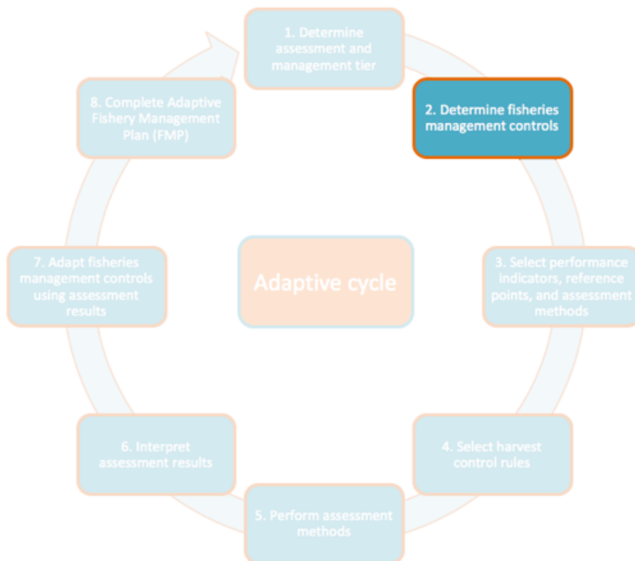


Figure 2.1:

2.2 Step 2b – Preliminary Selection of New Fisheries Management Controls

Fisheries managers have a number of different fisheries management controls (FMCs) to choose from to manage their fishery goals. Many FMCs are designed with the primary objective of limiting fishing mortality such as catch limits; however, other FMCs are designed to protect certain biological or ecological functions in an ecosystem such as seasonal closures to protect spawning aggregations. Descriptions of commonly used FMCs are listed in *Table A2. 1.* This table also includes data requirements and enforcement considerations for the implementation of each FMC. Additionally, case studies are presented below for each FMC that describe situations where the FMC has been implemented in a small-scale fishery. These case studies present some of the opportunities, challenges, and implications these different FMCs bring to small-scale fisheries.

To select a list of preliminary fisheries management controls, use the six questions in the decision tree below (Figure 3) as a general guide and first step to determine what FMCs may be appropriate for your fishery. However, conditions occurring in your specific fishery must be carefully considered as well as the community goals for your TURF-Reserve. Additionally, while this figure is one tool for helping select the type of FMC (i.e., minimum size limit) it does no provide guidance on the specific FMC that should be implemented (i.e., what that minimum size limit should be) Steps 2c and 2d are designed to guide additional considerations when determining appropriate and specific FMCs.

**Figure 3: Decision tree to help identify potentially appropriate Fisheries Management Control(s). Answer questions #1-6 that correspond to your Tier and follow the arrow that best represents your fishery to determine potentially appropriate FMC(s). FMCs are found in the yellow boxes and are listed in bold. Definitions can be found in *Table A2. 1.* Definitions of the italicized terms can be found in the glossary.

2.3 Step 2c – Consider Applying Additional Fisheries Management Controls to Better Meet Goals

There is no prescriptive method for determining the 'perfect' combination of FMCs for every site because the most appropriate FMCs will greatly depend on the specific conditions and characteristics of the TURF-

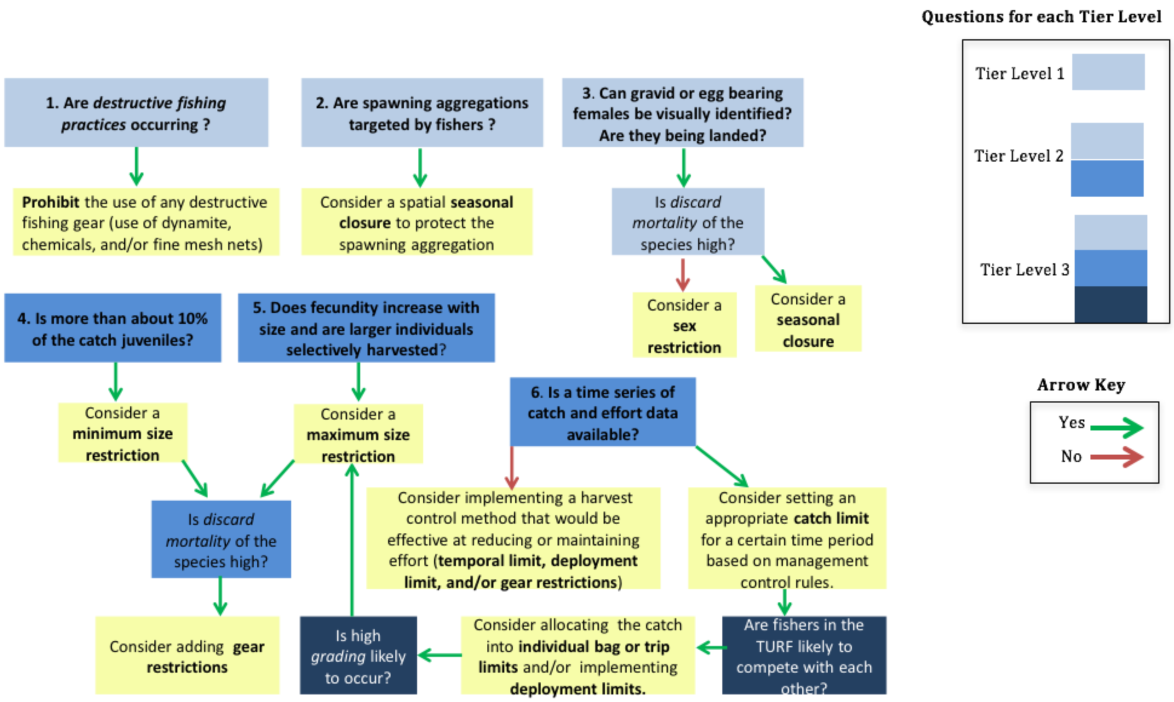


Figure 2.2:

reserve and surrounding community. The following 6 steps, along with the information in in Table A2. 2, Table A2. 3, and Table A2. 4, can serve as a guide to help identify a set of FMCs that may be effective at meeting your site's management goals.

1. Find the FMC(s) that were either existing (Step 2a) or newly selected (Step 2b) in Table A2. 2, Table A2. 3, and Table A2. 4. These tables describe potential negative or positive impacts of each FMC on common biological, ecological, and socioeconomic fishery management objectives.

2. Identify which of the management objectives in the first row of Table A2. 2, Table A2. 3, and Table A2. 4 align with the site's management goals that were identified during the goal setting exercise of the FLAGS toolkit (or other goal setting activities your site has conducted).

3. Review the potential impact of each FMC being considered for your site on each of your management objectives.

4. Determine if the preliminary selection of FMC(s) will conflict with or fail to accomplish any of your site's management goals. For example, a catch limit may have been identified as an appropriate FMC to control harvest at a site but additional management goals of the site may be to protect habitat and reduce bycatch. Table A2. 3 shows that implementing a catch limit may result in an increase in bycatch rates and increased habitat damage if implemented without any other FMCs.

5. Use Table A2. 2, Table A2. 3, and Table A2. 4 to identify FMC(s) that are associated with positive impacts on the sites management objectives. FMC(s) identified here can be chosen in combination with FMC(s) identified in Step 2a to meet multiple management objectives. For example, in some fisheries, combining gear restrictions with catch limits may be effective at controlling harvest, and reducing bycatch and habitat damage.

6. In Table A2. 2, Table A2. 3, and Table A2. 4, some FMCs have similar impacts across management objectives and it may be unclear which FMC is most appropriate for your site. To determine the most appropriate FMC(s) for your site, consider the "ease of implementation" for each FMC listed in Table A2. 1 and how it aligns with the specific conditions and characteristics the site.

2.4 Step 2d – Consider Implications with Relevant Stakeholders

Before finalizing which FMC(s)will be implemented at your site, consider how fishers (as well as other stakeholders such as middlemen, enforcement organizations, etc.) may respond to this management control by considering the following questions:

- What management methods have successfully been implemented in the past?
- Can this management method be effectively implemented and enforced?
- Is this method socially and politically feasible, and will fishers comply with it?

The ability of the selected FMCs to meet the stated community objectives for the TURF-Reserve defined in the FLAGS toolkit should be discussed will all relevant stakeholders, along with any potential tradeoffs of implementing the selected FMC(s).

Additionally, prior to implementing FMC(s), any existing KAP and social Impact Survey data should be reviewed. KAP data can be used to provide insight into individual attitudes towards fishery management in your community. Social Impact Survey data can be used to provide context as to how dependent the community is on the fishery and how changes in FMCs may affect their livelihoods. Any information on enforcement should also be reviewed to gain a better understanding of the likelihood of compliance with implementation of new FMCs.

2.5 Step 2e – General Guidance for Setting Effective FMCs for the First Time

Note – This step is only applicable when developing your Adaptive Fisheries Assessment and Management Framework for the first time. In following years, you will use harvest control rules (defined later) to adaptively adjust these initial controls.

Once you have finalized your list of FMCs that will be implemented in your community, you will need to define the specifics of the FMC for the first time. For example, what will your catch limit actually be? The specifics will depend on the status of your site's resources, the population dynamics of the targeted species at the site, and your site's specific management objectives. If you believe target species are depleted, if little information is available, and/or if enforcement or compliance is low, we recommend taking a precautionary approach using the following suggestions:

- **Catch Limit** - Set annual catch limit at or below the previous year's total catch
- **Bag or Trip Limit** - Divide the previous year's catch by the number of fishers participating in the fishery. Set the Bag or trip limit at that level or below
- **Size limit** - Set a minimum size limit above the minimum size at maturity. A maximum size limit may also be set to protect *megaspawners*.
- **Temporal limits** – Close the fishery during biologically sensitive times or during times (or areas) when the catchability of species greatly increases (such as Spawning aggregations).
- **Vessel/gear restrictions** - Gear and vessel restrictions should be set that minimize the impact of the fishery on habitat. Gear dimensions should also be set that reduce bycatch. For example, small mesh size in nets may be prohibited to reduce the landings of individuals below reproductive maturity.
- **Deployment Limits** - Initial deployment limits may be set to restrict the number of gears being used to the same number of gears that were used in the previous year or below.
- **Sex specific** - Ban the take of females that are egg-bearing or the take of females during a biologically sensitive period.

- **Protection of Ecologically Important Species -** Restrict fishing of specific species in order to protect key ecological function, such as herbivorous parrotfish that control macroalgae cover.

2.6 Table A2.1: Descriptions and implementation considerations for different fisheries management controls

Fisheries Management Control	**Primary Objective**	**Descripti on**	**Minimum Data Requirement s**	**Enforceme nt**
Catch Limit	Limit fishing mortality	Sets an upper limit on how many fish can be removed by a fishery in a given time. This can be for an entire fishery or can be allocated to individuals or groups of individuals (such as a fisher association). Limits can be set for individual species or groups of species (also known as a “quota basket). If set correctly and fishers’ incentives are aligned, catch limits are the most direct way of managing fishing mortality. Catch limits can be set on the species basis but also aggregate level based on similar life history traits and vulnerabili ty. If the incentives are not aligned and rights are not allocated, catch limits can perpetuate the race to fish that may lead to safety issues and destructive fishing practices (gear lost, highgrading , etc.) Need at least one year’s worth of catch and effort data to know where to set the limit.	A time series of catch and effort data; information on the stock’s productivit y (length-bas ed DLSA methods can be used for proxies); life history information	Catch limits (individual or group allocated) can be enforced if landings are relatively centralized but may be more difficult if landing sites are more dispersed. Any catch limit program will have associated monitoring costs for implementat ion to be effective.

Fisheries Management Control	Primary Objective	Descripti on	Minimum Data Requirement s	Enforceme nt
Bag or Trip Limit	Limit fishing mortality	Limits the number or weight of fish that can be landed by an individual fisher or vessel on a single day or fishing trip. If no illegal discarding is occurring, than bag limits and trip limits based on number of fish allowed to catch can directly control fishing mortality. Can perpetuate high grading and illegal discarding.	Time series of catch and effort data, information on the stock's productivit y (length-bas ed DLSA methods can be used for proxies), and total number of fishermen participati ng in a fishery	Can be enforced if landings are relatively centralized but may be more difficult if landing sites are more dispersed. Monitoring for every vessel or individual in a fishery will result in significant implementat ion costs.

Fisheries Management Control	Primary Objective	Descripti on	Minimum Data Requirement s	Enforceme nt
Size Limit	Limit fishing mortality	Sets minimum and/or maximum bounds on the size of fish that can be legally landed in a fishery. Size limits can protect age-structu re by controlling the size selectivity of the fishery to ensure fish have the opportunity to spawn before being caught. However, the biology of the species must be considered carefully because size limits can result in unintended, negative consequence s. Size limits don't directly control fishing mortality and may cause size truncation over time by removing the largest individuals from a fishery	Size at maturity and/or size of megaspawner s; discard mortality rates for targeted species are helpful	Can be enforced if landings are relatively centralized but may be more difficult if landing sites are more dispersed. Monitoring is straightfor ward and does not have many associated implementat ion costs.

Fisheries Management Control	Primary Objective	Descripti on	Minimum Data Requirement s	Enforceme nt
Temporal Limit	Limit fishing mortality	Restricts the time period over which a fish can be legally landed. If fishing mortality doesn't increase before or after the closure, temporary closures allow marine resources to increase without disturbance to ensure fish grow bigger and new recruits enter the fishery. Perpetuates the race to fish before and after the closure. Increases fishing effort before and after the closure. Doesn't directly manage fishing mortality.	Temporal dynamics of fishing effort; temporal characteris tics or behavior of target species; information on the relationshi p between catch and effort is helpful	Can be enforced if landings are relatively centralized but may be more difficult if landing sites are more dispersed. Temporal limits are more straightfor ward to monitor if the limit covers all species, but may be more difficult if the limit only covers a certain species in the fishery.
Gear Restriction s – Gear Type	Limit fishing mortality	Restricts the type of fishing gear allowed to participate in a fishery (including banning destructive fishing gear such as dynamite, cyanide, and fine mesh nets) but doesn't directly manage fishing mortality.	Information on the relationshi p between gear characteris tics, fishing effort, and selectivity . If only banning destructive fishing gear, no data is required.	Gear restriction s are relatively straightfor ward to enforce however, gathering information required for an effective implementat ion can be costly. If only banning destructive fishing gear, there are low upfront costs but ongoing monitoring costs should be considered.

Fisheries Management Control	**Primary Objective**	**Descripti on**	**Minimum Data Requirement s**	**Enforceme nt**
Gear Restriction s – Gear Number (also known as Deployment Limits)	Limit fishing mortality	Places a cap on the number of gears each fisher can use (such as the number of fixed traps or the number of hooks on a line). Does not directly manage fishing mortality. Can reduce the number of gear in the water thus decreasing habitat impacts..	Current fishing effort levels in terms of number of gears; information on the relationshi p between catch and effort is helpful	The ease and cost of enforcement will depend on how easily fishing gears can be observed.
Sex-Specifi c Controls	Limit fishing mortality	Protect reproductiv ely important individuals by setting sex-specifi c prohibition s on fishing activity.	Information on reproductiv e traits and sex ratios	Sex-specifi c controls are straightfor ward to enforce if there are obvious differences between the sexes. Monitoring costs will depend on how easily the catch can be observed.
Seasonal Closures to Protect Vulnerable Life History Stages	Protect vulnerable life history stages	Protect vulnerable life history stages by restricting the fishery during certain seasons. Seasonal spawning closures allow spawning to occur without disruption to ensure recruits enter the fishery. Perpetuates the race to fish before and after closure. Increases fishing effort before and after the closure. Doesn't directly manage fishing mortality.	Information on seasonal behavior such as spawning aggregation s and migrations, and the temporal and spatial variability of these behaviors	Can be enforced if landings are relatively centralized but may be more difficult if landing sites are more dispersed. Seasonal closures are more straightfor ward to monitor if the closure covers all species, but may be more difficult if the closure only covers a certain species in the fishery.

Fisheries Management Control	Primary Objective	Descripti on	Minimum Data Requirement s	Enforceme nt
Protection of Ecologicall y Important Species	Protect ecological function	Restrict fishing of specific species in order to protect key ecological functions. Does not directly control fishing mortality.	Information on ecological interaction s and roles	Protection of ecologicall y important species can be straightfor ward but monitoring costs will depend on how easily the species and fishery catch can be observed.

2.7 Table A2.2: Effectiveness of different fisheries management controls in meeting biological objectives

Fisheries Management Control	Protect Spawning Stock Biomass (SSB)	Protect Age-Structure	Protect Vulnerable Life History Stages
Catch Limit	Catch limits directly protect SSB	Catch limits do not directly protect age-structure and may have a negative impact on the age-structure because fishers are choosing an overall quantity indiscriminate of size or age.	Catch limits do not directly protect vulnerable life history stages
Bag or Trip Limit	Bag or trip limits do not directly protect SSB because a increase in total fishing effort can still occur	Bag or trip limits do not directly protect age-structure and may incentivize fishers to choose larger and more valuable fish than they would otherwise catch, which may have a negative impact on age structure	Bag or trip limits do not directly protect vulnerable life history stages

Fisheries Management Control	Protect Spawning Stock Biomass (SSB)	Protect Age-Structure	Protect Vulnerable Life History Stages
Size Limit	Size limits do not directly protect SSB because they do not control total harvest of a stock	Size limits can protect age-structure by controlling the size selectivity of the fishery if discard mortality rates are low. However, the biology of the species must be considered carefully because size limits can result in unintended, negative consequences such as size structure truncation.	Size limits may protect vulnerable life history stages if those stages are associated with a certain size.
Temporal Limit	Temporal limits do not directly protect SSB because they do not control total harvest of a stock	Temporal limits do not protect age-structure and may have a negative impact on the age-structure because fishers may race to catch as much fish as they can, while they can, indiscriminate of size or age.	Temporal limits can be designed to protect vulnerable life history stages associated with the timeframe of the limit.
Gear Restrictions – Gear Type	Gear type restrictions do not directly protect SSB because they do not control total harvest of a stock	Gear type restrictions can be implemented to protect age-structure by modifying selectivity to allow individuals of a specific size to escape harvest.	Gear type restrictions may protect vulnerable life history stages
Gear Restrictions – Gear Number (also known as Deployment Limits)	Gear number restrictions do not directly protect SSB because an increase in effort may occur if new fishers join the fishery	Gear number restrictions do not directly protect age structure	Gear number restrictions do not directly protect vulnerable life history stages
Sex-Specific Controls	Sex-specific controls protect the spawning biomass of the sex targeted by the regulation	Sex-specific controls do not protect age-structure and may have negative consequences for age-structure because fishers may target the largest individuals of the sex that is not protected	Sex-specific controls may protect a vulnerable life stage if that occurs for a specific sex

Fisheries Management Control	Protect Spawning Stock Biomass (SSB)	Protect Age-Structure	Protect Vulnerable Life History Stages
Seasonal Closures to Protect Vulnerable Life History Stages	Seasonal closures protect spawning biomass during specific seasons	Seasonal closures do not directly protect age-structure	Seasonal closures protect seasonal vulnerable life history stages
Protection of Ecologically Important Species	Protection of ecologically important species protects the SSB of the species of interest but does not directly protect SSB of other target species	Protection of ecologically important species protects the age-structure of the protected population but does not directly protect age-structure of other target species	Protection of ecologically important species does not directly protect vulnerable life history stages

2.8 Table A2.3: Effectiveness of different fisheries management controls in meeting ecological objectives

Fisheries Management Control	Protect Habitat	Reduce Bycatch and/or Discards
Catch Limit	Catch limits do not protect habitat and may have a negative impact on habitat unless the use of excessive gear that could damage habitat is mitigated by an individual allocation that stops the race to fish.	Bycatch can often increase under a catch limit if there is not a limit for bycatch species along with target species and/or if a single-species catch limit has been reached in a multi-species fishery.
Bag or Trip Limit	Bag or trip limits do not directly protect habitat	Bag or trip limits often result in an increase in bycatch and/or discards because of the incentives to catch the largest and highest value fish, and/or if a single-species catch limit has been reached in a multi-species fishery
Size Limit	Size limits do not directly protect habitat	Bycatch and/or discards can increase under a size limit because under- or over-sized individuals must be discarded. High discard mortality rates can result in size-limits having unintended, negative consequences. Discard mortality may be less of a problem for invertebrates, however.

Fisheries Management Control	Protect Habitat	Reduce Bycatch and/or Discards
Temporal Limit	Temporal limits do not protect habitat and may have a negative impact if excessive gear is set during the race-to-fish and is lost or abandoned	Temporal limits can be designed to reduce bycatch if a fishery interaction with a bycatch species is seasonal. Temporal limits not designed to reduce bycatch may cause an increase in bycatch because fishers are less selective during the race-to-fish
Gear Restrictions – Gear Type	Gear type restrictions do not directly protect habitat but can be designed to reduce the impact a fishery has on habitat	Gear type restrictions may reduce bycatch by improving selectivity in a fishery
Gear Restrictions – Gear Number (also known as Deployment Limits)	Gear number do not directly protect habitat	Gear number restrictions do not directly reduce bycatch
Sex-Specific Controls	Sex-specific controls do not directly protect habitat	Sex-specific controls can increase discards because individuals of the protected sex must be returned to sea and depending on the species may not survive
Seasonal Closures to Protect Vulnerable Life History Stages	Seasonal closures do not directly protect habitat and may have a negative impact on habitat if excessive gear is set during the race-to-fish and is lost or abandoned	Seasonal closures do not reduce bycatch and can increase bycatch and discards during the race to fish
Protection of Ecologically Important Species	Protection of ecologically important species may protect the habitat if the species of interest plays an important role in maintaining ecosystem health	Protection of ecologically important species can increase discards because individuals of the protected species can be discarded to avoid enforcement penalties.

2.9 Table A2.4: Effectiveness of different fisheries management controls in meeting socioeconomic objectives

Fisheries Management Control	**Increase Fisher Profits**	**Increase Product Quality**	**Maintain Fishing Efficiency	**Fisher Safety**
Catch Limit	Catch limits that are not allocated at an individual level often cause a **short-ter m** decrease in fisher profits because the race-to-fis h incentivize s capital stuffing and may cause market flooding. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits. Effects from the race-to-fis h and capital stuffing may be reduced in the case of individuall y allocated limits.	If market flooding occurs, product may be frozen or spoil, decreasing the product value. Eliminating market flooding by eliminating the race-to-fis h through individual allocation of catch limits can increase product quality.	Catch limits do not directly impact **short-ter m** fishing efficiency. Individual allocation of catch limits can increase fishing efficiency as the race-to-fis h is stopped and fishers have more control over when to fish. Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Catch limits may have a negative impact on the safety of fishing because during the race-to-fis h, fishers may continue fishing even if fishing conditions become unsafe. Individual allocation of catch limits can have a positive impact on fisher safety since they can eliminate the race-to-fis h.
Bag or Trip Limit	Bag limits often cause a **short-ter m** decrease in fisher profits, because fishers are incentivize d to take more trips to maintain landings, increasing fishing costs. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Product quality may increase under bag or trip limits because there is an incentive to catch the biggest and highest value/quali ty fish.	Bag or trip limits fishers do not directly impact **short-ter m** fishing efficiency. Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Bag or trip limits may have a negative impact on safety if increasing the number of fishing trips means that they will need to fish in bad weather

Fisheries Management Control	**Increase Fisher Profits**	**Increase Product Quality**	**Maintain Fishing Efficiency	**Fisher Safety**
Size Limit	Size limits do not increase **short-ter m** fisher profits and may cause a decrease in landings revenue if a large portion of landings is over or undersized and needs to be discarded. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Size limits can be implemented to increase product quality if the quality of the product is related to its size	Size limits do not directly impact **short-ter m** fishing efficiency. Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Size limits do not have a direct impact on the fisher safety
Temporal Limit	Fishers often begin targeting other, less valuable species when a fishery is closed due to a temporal limit, causing **short-ter m** fisher profits to decrease. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Fishers often become less selective during the race-to -fish, resulting in a decrease in product quality	Temporal limits do not directly impact **short-ter m** fishing efficiency. Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Temporal limits may have a negative impact on the safety of fishing because during the race-to-fis h, fishers continue fishing even if fishing conditions become unsafe

Fisheries Management Control	**Increase Fisher Profits**	**Increase Product Quality**	**Maintain Fishing Efficiency	**Fisher Safety**
Gear Restriction s – Gear Type	Gear type restriction s incentivize fishers to invest and improve in unregulated dimensions of gear, increasing fishing costs and reducing **short-ter m** fisher profits. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Gear type restriction s can be designed to increase product quality in a fishery by improving selectivity of higher value individuals	Gear type restriction s reduce **short-ter m** fishing efficiency. Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Gear type restriction s do not typically have a direct impact on fisher safety (unless banning destructive fishing gear that can have unintended negative impacts on fisher, such as dynamite).
Gear Restriction s – Gear Number (also known as Deployment Limits)	Gear number restriction s do not directly impact **short-ter m** profits but may help stabilize fishing costs. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Gear number restriction s do not have an impact on product quality	Gear number restriction s may reduce **short-ter m** fishing efficiency. Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Gear number restriction s do not have a direct impact on fisher safety
Sex-Specifi c Controls	Sex-specifi c controls may decrease **short-ter m** fisher profits because a portion of the catch must be discarded. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Sex-specifi c controls do not affect product quality unless quality is related to sex	Sex-specifi c controls do not directly impact **short-ter m** fishing efficiency. . Once a depleted stock recovers, there may be a **long-term** increase in fishing efficiency.	Sex-specifi c controls do not have a direct impact on fisher safety

Fisheries Management Control	**Increase Fisher Profits**	**Increase Product Quality**	**Maintain Fishing Efficiency	**Fisher Safety**
Seasonal Closures to Protect Vulnerable Life History Stages	Seasonal closures do not increase **short-ter m** fisher profits and may cause a decrease in income because fishers often shift to less valuable species. Once a depleted stock recovers, there may be a **long-term** increase in fisher profits.	Seasonal closures can lead to a decrease in product quality as fishers shift to less desirable species	Seasonal closures do not directly impact **short-ter m** fishing efficiency. . Once a depleted stock recovers, there may be an additional **long-term** increase in fishing efficiency.	Seasonal closure may have a negative impact on fisher safety because during the race-to-fis h, fishers may fish in unsafe conditions
Protection of Ecologicall y Important Species	Protection of ecologicall y important species will decrease **short-ter m** fisher profits. Once ecological function improves and other depleted target stocks recover, there may be a **long-term** increase in fisher profits.	Protection of ecologicall y important species may increase the product quality of other target species if the protected species is prey for the target species	Protection of ecologicall y important species does not directly impact **short-ter m** fishing efficiency. Once a depleted stock recovers, there may be an additional **long-term** increase in fishing efficiency.	Protection of ecologicall y important species does not have an impact on fisher safety

2.10 Fisheries Management Control Case Studies

Please note: These examples do not necessarily come from TURF-Reserve systems, but are still indicative of how these fisheries management control approaches have been used in small-scale near shore tropical fisheries

Catch Limits

In the sea cucumber fishery in the Northern District of New Caledonia, fishermen noticed a decline in commercial sized sea cucumber known as sandfish (*Holothuria scabra*) in the early 2000s. After closing the fishery for a short period of time, they worked with the Fisheries Department in 2008 to set a total allowable catch (TAC) for the fishery, which they then allocated into quotas for individual fishermen. The TAC was set according to the total biomass of legally-sized adult sandfish, taking into account both abundance and body size. This harvestable biomass was calculated through sampling of the sandfish population and was re-assessed periodically. After implementing the TAC, there was an increase in total sandfish biomass and a 142% increase in the number of individuals. There was also an increase in the mean weight of sandfish and the density of individuals. Due to the increases in the sandfish population, the fishermen were able to raise the TAC in subsequent years. They also combined the use of the TAC with a cycle of open and closed periods of fishing.

Leopold, M., Cornuet, N., Andrefouet, S., Moenteapo, Z., Duvauchelle, C., Raubani, J., Ham, J., & Dumas, P. (2013). Comanaging small-scale sea cucumber fisheries in New Caledonia and Vanuatu using stock biomass estimates to set spatial catch quotas. Environmental Conservation 40(4), 367-379.

Bag/Trip Limits

In the recreational gag *(Mycteroperca microlepis*) fishery in the Gulf of Mexico, bag limits are used to prevent recruitment overfishing. However, discard mortality rates reduce the efficiency of the fishery.

Tetzlaff, J.C., Pine, W.E., Allen, M.S., & Ahrens, R.N.M. (2013). Effectiveness of size limits and bag limits for managing recreational fisheries: a case study of the Gulf of Mexico recreational gag fishery. Bulletin of Marine Science 89(2), 483-502.

Size Limits

1. In Puerto Rico's spiny lobster (*Panulirus argus*) fishery, landings, catch per unit effort, and average body size all increased from 1988-2001, potentially as a result of the implementation of a minimum size limit (Matos-Caraballo et al., 2007).

Matos-Caraballo, D. (2007). Overview of Puerto Rico's small-scale fisheries statistics 2001-2004. Proceedings of the Gulf and Caribbean Fisheries Institute 58: 95–106.

2. Belize's queen conch fishery is managed by a variety of regulations, including a prohibition on fishing with scuba equipment, marine reserves that protect nursery, feeding, and mating grounds, a quota system, and a minimum size limit. The minimum size limit was introduced in 2000 and establishes a minimum shell length of 7 inches and a minimum weight of 3 ounces of partially processed meat. As a result of these regulations, conch landings increased from 1977 to 2011, as have average conch density and mean shell length. The minimum size was set based on the size at maturity.

Gongora, M. (2012). Belize National Conch Report 2012. CFMC/OSPESCA/WECAFC/CRFM Queen Conch Working Group Meeting. Panama City, Panama, 23 October 2012.

Gongora, M., & Carcamo, R. (). Belize. In: Regional Workshop on the Monitoring and Management of Queen Conch, Strombus gigas. *FAO Fisheries Report 832. Kingston, Jamaica. pp. 66-76.*

Huitric, M. (2005). Lobster and conch fisheries of Belize: a history of sequential exploitation. Ecology and Society 10(1), 21.

Temporal Limits

1. On Ahus Island in Papua New Guinea, the community only allows fishing in six specific areas of their lagoon for a certain number of days each year. The locations of the restricted areas are dictated by tradition. Ecological surveys found that the biomass and average size of target species was much greater in the restricted areas than outside, and harvest days did not affect the overall stock.

Cinner, J.E., Marnane, M.J., & McClanahan, T.R. (2005). Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. Conservation Biology 19, 1714-1723.

2. In villages in Madang Province in Papua New Guinea and North Sulawesi, Indonesia, fishers periodically close areas to harvesting and then open them for specified periods of time. Areas managed with periodic closures have higher biomass and average body size of target fish species than unmanaged areas, and both long-lived and short-lived species benefit from periodic closures. Fishers are able to harvest fish for important events without depleting the stock in the periodically harvested areas.

Cinner, J., Marnane, M.J., McClanahan, T.R., & Almany, G.R. (2005). Periodic closures as adaptive coral reef management in the Indo-Pacific. Ecology and Society 11(1), 31.

Gear/Vessel Restrictions

In Ahus Island in Papua New Guinea, the community prohibits spear and net fishing in six areas of the reef lagoon, while line fishing is unregulated. A comparison of the reef ecosystem inside and outside of the areas with gear restrictions found that the areas where spear and net fishing were prohibited had 60% more biomass of fish. The individual fish were also larger and there was less discarded gear inside the restricted area. There was no significant difference in the overall fish abundance, species richness of fish, or coral cover and diversity.

Cinner, J.E., Marnane, M.J., & McClanahan, T.R. (2005). Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. Conservation Biology 19, 1714-1723.

Deployment Limits

In a lagoon fishery in Thua Thien Hue Province, Vietnam, fisheries organizations worked to reduce the fishing capacity by decreasing the number of fixed fishing gears present. The amount of fishing gear had previously been increasing without any control over the number and placement of traps and nets. In 2010, the fisheries organizations began a consensus-based process to determine gear reductions of traps and bottom nets in the lagoon.

Takahashi, B. & van Duijn, A. P. (2012). Operationalizing fisheries co-management: Lessons learned from lagoon fisheries co-management in Thua Thien Hue Province, Viet Nam. FAO Regional Office for Asia and the Pacific, Bangkok. RAP Publication 2012/02. 131 pp.

Sex-specific Controls

The fisheries cooperatives in Baja California, Mexico have been successful at managing their resources sustainably, with increased landings of spiny lobster over the past forty years. Among other regulations, the cooperatives prohibit the capture of egg-bearing females, which contributes to the sustainability of the fishery.

Orensanz, J.M., & Seijo, J.C. (2013). Rights-based management in Latin American fisheries. FAO Fisheries and Aquaculture Technical Paper 582, Rome. pp. 136.

Seasonal Closures

In 1990, the U.S. Virgin Islands Division of Fish and Wildlife and the Caribbean Fisheries Management Council instituted a seasonal closure of a red hind *(Epinephelus guttatus)* spawning aggregation south of St. Thomas, in response to declines in red hind abundance. A subsequent study in 1997 found increases in average length and abundance, as well as normalization of the sex ratio compared to before the creation of the seasonal closure.

Beets, J., & Friedlander, A. (1998). Evaluation of a conservation strategy: a spawning aggregation closure for red hind, Epinephelus guttatus, in the U.S. Virgin Islands. Environmental Biology of Fishes 55, 91-98.

Protection of Ecologically Important Species

In 2010, the government of Bonaire prohibited the harvest of parrotfish with the goal of protecting species that help maintain coral reef health. Parrotfish biomass declined from 2003-2011, but the rate of decline slowed after 2011. From 2011-2013, the density of parrotfish increased, likely in response to the fishing ban.

Stamieszkin, K., & Arnold, S.N. (2013). Trends in Bonaire's herbivorous fish: change over time, management effects and spatial patterns. In: Status and Trends of Bonaire's Reefs in 2013: Causes for Optimism, eds. Steneck, R.S., Arnold, S.N., & Rasher, D.B. University of Maine School of Marine Sciences. Pp. 17-31.

Chapter 3

Step 3 – Select Performance Indicators, Reference Points, and Assessment Methods

What is the best way to determine the status of the fishery?

Steps 3a through 3c will guide you through selecting appropriate performance indicators, reference points, and assessment methods for your fishery.

While we provide best practices in these steps, it should be noted that performance indicators and reference points are not one-size-fits-all. They should be based on community goals for your TURF-Reserve. While setting performance indicators and reference points, consult the goals that were prioritized during the FLAGS toolkit or other goal-setting exercises. For example, if increased landings for food provision is a goal, you may wish to use landings as one of your performance indicators and upward trends in landings as a reference point. If conservation of biomass in the water for dive tourism is a goal, you may wish to use fished:unfished density ratio as one of your performance indicators and a high fished:unfished density ratio as your target reference point.

3.1 Step 3a – Select Performance Indicators

Using Table A3. 1, select appropriate performance indicators for your fishery. Depending on the assessment and management tier your fishery falls under, there will be a number of options for the indicators you may choose to select. Whenever possible, we recommend that multiple indicators are chosen from multiple independent data streams. This will reduce the uncertainty associated with any single data stream and will paint a more complete picture of the fishery. Use the specific guidance below for your tier.

Tier 1 – Precautionary Assessment and Management (for new FF sites with less than one year of data)

Even though limited data will be available for a Tier 1 fishery, managers can still perform a basic qualitative fisheries assessment using local ecological knowledge about the fishery, such as the types of fishing gear that are currently used, changes in the fishing seasons that have been observed over time, and changes in species composition of landings over time. Potential performance indicators for Tier 1 are provided in the table below, along with pros, cons, and the types of species each indicator is appropriate for.

At a minimum, we recommended using the following performance indicators for Tier 1:

- At least one indicator based on qualitative fisheries characterization

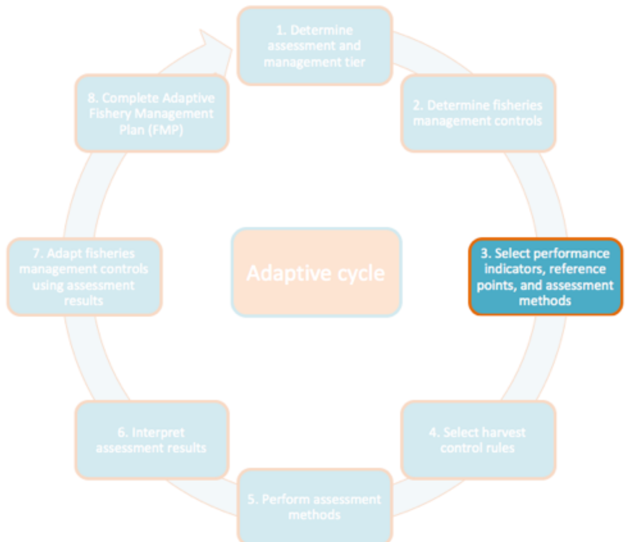


Figure 3.1:

- If available, at least one fishery-independent indicator based on underwater visual survey or experimental fishing

Tier 2 – Preliminary Adaptive Assessment and Management (for FF sites with one year of data)

Data streams in Tier 2 include those under Tier 1, as well as at least one year of fishery-dependent data that may come from a combination of Catch Reporting, Boat-intercept Surveys, and Fishery Dependent Length-composition Surveys. Potential performance indicators for Tier 2 are provided in the table below, along with pros, cons, and the types of species each indicator is appropriate for.

At a minimum, we recommended using the following performance indicators for Tier 2:

- All indicators from Tier 1
- At least one indicator based on fishery-dependent length-composition survey

Tier 3 – Multi-Indicator framework for Adaptive Assessment and Management (for sites with more than one year of data)

Tier 3 sites will have a time series of data available that can be used to examine trends in multiple performance indicators in addition to information and data described under Tiers 1 and 2. Potential Tier 3 performance indicators for each available data stream type or toolkit output are provided in the table below, along with pros, cons, and the types of species each indicator is appropriate for.

At a minimum, we recommended using the following performance indicators for Tier 3:

- All indicators from Tier 2
- At least one trend-based indicator that uses a time series of landings or CPUE data

3.2 Step 3b – Select Reference Points

During this step, select reference points for each of your chosen performance indicators. The table below offers suggestions for generic reference points from the literature that may be appropriate for each performance indicator.

For every performance indicator, select both a target reference point (TRP) as well as a limit reference point (LRP). A target reference point is a numerical value (or trend) that indicates that the performance of the fishery is at a desirable level; often management is geared towards achieving or maintaining this target. This target could be a static value chosen from the literature, or a trend in historic data (for example, a target may be that the indicator is higher than a historic running average). A limit reference point is a numerical value that indicates that the performance of the fishery is unacceptable (*e.g.*, severely overfished), and that management action should be taken to improve fishery performance or population levels. Similarly, these values may come from the literature or historic data.

When selecting reference points, we recommend the following best practices:

- For reference points of length-based indicators and of fishery-independent-based indicators, we recommend using literature-based reference points
- Whenever using reference points from literature, use reference points from studies of comparable species and geographic locations.
- For CPUE- and landings-based indicators, we recommend using a time series of data to generate reference points that are based on trends or running averages.
- If local or international scientists are available for consultation, discuss reference points with them to determine if they are appropriate for your fishery and adjust values as necessary.

3.3 Step 3c – Select Assessment Methods

During this step, select the appropriate assessment method for each of your chosen performance indicators. The table below outlines these options. Most performance indicators have only one associated assessment method; however, the performance indicator of fishing mortality has several options. There are also detailed describtions below for more details about each specific assessment method including inputs, outputs, and caveats.

3.4 Table A3.1: Selecting your performance indicators, reference points, and assessment methods

Data stream Options	**Perform ance Indicator Options**	**Target Reference Point**	**Limit Reference Point**	**Assessm ent Methods**	**Target Species**
TURF-R eserve Design Survey	**DESTRUC TIVE FISHING GEAR** *Pros*: relativel y easy metric to monitor using local ecologica l knowledge *Cons*: None	No destructi ve fishing practices being used	Destructi ve fishing practices being used	Qualitati ve assessmen t of TURF-Rese rve Design Survey	All fish and invertebr ates

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
TURF-R eserve Design Survey	**FISHING SEASON** *Pros*: relativel y easy metric to monitor using local ecologica l knowledge *Cons*: Changes in fishing season do not always indicate poor fisheries performan ce; this may also result from changing environme ntal or market condition s	No changes in the fishing season	Increased variabili ty in fishing season, or decreased fishing season	Qualitati ve assessmen t of TURF-Rese rve Design Survey	All fish and invertebr ates
TURF-R eserve Design Survey	**Target SPECIES COMPOSITI ON** *Pros*: relativel y easy metric to monitor using local ecologica l knowledge *Cons*: Changes in target species compositi on do not always indicate poor fisheries performan ce; this may also result from changing environme ntal or market condition s	No change in compositi on of caught species	Change in compositi on of caught species (fewer species, more pelagics) or loss of major fishing targets, predators and grazers	Qualitati ve assessmen t of TURF-Rese rve Design Survey	All fish and invertebr ates

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
FLAGS	**SPECIES VULNERABI LITY** *Pros*: easy to interpret a species' relative vulnerabi lity to overfishi ng relative to other species in the area/ecos ystem. This relative vulnerabi lity score can be used to prioritiz e species for managemen t action/as sessments *Cons*: is not an estimate of stock status	Low vulnerabi lity estimate (< 2.0 PSA score); low- medium susceptib ility and high-medi um productiv ity species are a lower priority for managemen t action relative to species with higher vulnerabi lity estimates (>2.0 PSA score)	High vulnerabi lity estimate (> 2.0 PSA score); high susceptib ility and medium or low productiv ity species should be high priority for managemen t action and frequent assessmen t	Productiv ity & Susceptib ility Analysis	All fish and invertebr ates present in the ecosystem
Underw ater Visual Surveys or Experimen tal Fishing	**FISHED: UNFISHED DENSITY RATIO (FOR KEY TARGET SPECIES) *Pros*: a relative quick and cheap way to assess the status of target species. *Cons*: assumes that a fully-fun ctioning and well-enfo rced NTZ has been sited appropria tely with represent ative habitat, not useful for highly mobile targets.	Fished:un fished density of target species > 0.6	Fished:un fished density of target species < 0.4	Density Ratio	Fish and invertebr ates that are habitat associate d, not a good indicator for highly mobile targets

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
Underw ater Visual Surveys or Experimen tal Fishing	**FISHED: UNFISHED BIOMASS RATIO (CORAL REEF THRESHOLD AGGREGATE D ACROSS SPECIES) – Only for Underwate r Visual Surveys** *Pros*: provides an estimate of ecosystem status and capacity to support fishing, useful for setting precautio nary managemen t to meet EBFM goals. *Cons*: assumes that a fully-fun ctioning and well-enfo rced NTZ has been sited appropria tely with represent ative habitat, not useful for highly mobile targets. Assumes NTZ are represent ative of historica l, unfished biomass.	Fished:un fished biomass ratio > 0.5	Fished:un fished biomass ratio < 0.25	Coral Reef Threshold s	Multi-spe cies finfish fishery

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
Underw ater Visual Surveys or Experimen tal Fishing	**AVERAGE LENGTH** *Pros*: easy, cheap metric to assess changes in the status of a fishery *Cons*: does not capture selectivi ty of the fishery, or is fishing is prosecute d in nursery grounds	Decrease in the size of unfished individua ls outside of the NTZ, in compariso n to previous years	Rapid decrease in the size of individua ls outside of the NTZ, in compariso n to previous years	Average Length	Multi-spe cies, habitat associate d targets, not a good indicator for highly mobile targets
Fisher y Dependent Length-Co mposition Survey	**FISHING MORTALITY DIVIDED BY NATURAL MORTALITY (F/M)** *Pros*: mortality rates are critical for determini ng abundance of fish populatio ns *Cons*: all of the models assume equilibri um condition s. Most of these methods only reflect fish that have recruited to a fishery and does not reflect the full age structure of a stock.	F/M <1 (F is fishing mortality , M is natural mortality)	F=2M	Catch Curve or LBAR	Finfish (groupers , snapper, grunts, etc.), and invertebr ates with indetermi nate growth (lobsters , crabs). Use with care for targets that have determini stic growth and episodic recruitme nt.

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
Fisher y Dependent Length-Co mposition Survey	**SPAWNIN G POTENTIAL RATIO (SPR)** *Pros*: can be used with fishery independe nt and dependent data. *Cons*: Assumes equilibri um condition s and a index based on the early life history of a fish, it must be remembere d that many things can happen to the fish before they are large enough to harvest.	*slow growing species, M/k< 1 (grouper) SPR > 40% (M is natural mortality , k is von Bertalanf fy growth rate) fast growing species, M/k >1 (lobster) SPR =20%*	*slow growing species, M/k< 1 (grouper) SPR <40% fast growing species, M/k >1 (lobster) SPR <20%*	Length-ba sed SPR (LBSPR)	Finfish (groupers , snapper, grunts, etc.), and invertebr ates with indetermi nate growth (lobsters , crabs). Use with care for targets that have determini stic growth and episodic recruitme nt.
Fisher y Dependent Length-Co mposition Survey	**AVERAGE LENGTH** *Pros*: easy, cheap metric to assess changes in the status of a fishery when stratifie d across sampling unit (gear, efforts, fishing zone) *Cons*: With little to no historica l informati on on the length of the catch or with no informati on on gear selectivi ty, the average length could biases the expected potential size distribut ion.	Increase in average length	Decrease in average length or mature adults	Average Length	All targets, especiall y nearshore targets. In an ideal scenario an historic record of average length would be used to compare current to past estimates .

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
Fisher y Dependent Length-Co mposition Survey	**FROESE INDICATOR S** *Pros*: proved estimate of the status of the stock, in compariso n to sustainab ility reference points *Cons*: does not contribut e to biomass sustainab ility reference points	100% of catch – optimal < 30% of the catch are *megaspaw ners* 90% of the catch are mature adults	<80% of catch – optimal < 20% of the catch are *megaspaw ners* 50% of the catch are mature adults	Froese Sustainab ility Indicator s	All fish and invertebr ate target with known length-ag e/maturit y relations hips
Indivi dual Catch Reporting System & Boat Intercept /Landing Site Survey	**CPUE** *Pros*: can be used to infer populatio n trends of an exploited stock. Standardi zed time series of CPUE are often regarded as indices of abundance . *Cons*: seldom proportio nal to abundance history and an entire geographi c range. Can be skewed, depending on sampling regime. May have species-s pecific biases.	Stable CPUE	Rapidly Decreasin g CPUE, previous year or in compariso n to running average	Catch Trends	All targets that do not have high selectivi ty of habitat stratific ation.

Data stream Options	Perform ance Indicator Options	Target Reference Point	Limit Reference Point	Assessm ent Methods	Target Species
Indivi dual Catch Reporting System & Boat Intercept /Landing Site Survey	**TOTAL LANDINGS *Pros*: when sampling is stratifie d, can provide an estimate of abundance *Cons*: seldom proportio nal to abundance history and an entire geographi c range, because of fishing location biases and lack of sampling stratific ation	Increase in Total Landing	Rapidly Decreasin g Total Landings, previous year or in compariso n to running average	Catch Trends	All targets that do not have high selectivi ty of habitat stratific ation.

3.5 Assessment Method Descriptions

Fishery Independent-Data

Coral Reef Thresholds

- **Description**: This method uses the ratio of total fish biomass inside a no-take-zone (NTZ) to the total fish biomass outside the NTZ. For some ecosystems, including coral reefs, recent studies show the existence of quantitative thresholds associated with fish densities (measured in kg/ha). Below these thresholds, ecosystems change from desirable (e.g., high coral cover) to less desirable states (e.g., dominated by algae) that produce fewer ecosystem services. Fisheries in ecosystems with documented fishing thresholds can be managed to remain above these limits, reducing the risk of system collapse. At the moment, thresholds have been documented for coral reefs in the Indian Ocean (McClanahan et al. 2011) and the Caribbean Sea (Karr et al. 2014). Biomass of fished populations and unfished populations can be measured with experimental fishing or visual surveys, and the resulting ratio of biomass from these surveys can then be compared to the threshold limits. Comparing this ratio to a target ratio defined in Karr et al. 2015, fishing pressure can be adjusted accordingly to maintain the fish biomass outside of a NTZ above the 0.5 B_{MSY} (Biomass maximum multi-species sustainable yield) target.

Inputs:

- Estimate of total fish biomass inside and outside of NTZ

Outputs:

- Ratio of fish biomass outside the NTZ to the biomass inside the NTZ

How this can be used by management:

- Integrates many species into an ecosystem community metric

- Provides a reference direction of overall fishing mortality for all species
- Provides precautionary estimate of current status of ecosystem that supports the fishery

Input Sensitivities:

- Assumes no-take reserves are representative of historical, unfished biomass

Caveats:

- This method assumes that a fully-functioning and well-enforced NTZ has been sited appropriately with representative habitat inside and outside of the NTZ, and been in place long enough for the population living inside the NTZ to be a proxy for an un-fished population.

Fished:Unfished Density Ratio (DR)

Description: The DR uses fishery-independent data comparing ratios of density, average length density of a specific life stage (immature, mature adults, optimal size or mega-spawners), or CPUE outside to inside of no-take zones (NTZs). Babcock & MacCall (2011) provide a clear analysis of the use of density ratio (DR) assessment methods. The DR's control rule adjusts fishing pressure according to the distance of the ratio of density outside to inside of the NTZ from a pre-specified target ratio. One drawback of the density ratio is that in situations where populations inside and outside the reserves both crash, the ratio would remain the same and indicate that fishing can commence. In the DR analysis, we modified the DR control rule to account for this dynamic. The adjustment is scaled by the overall health of the population inside the NTZ, measured as the density inside of the NTZ relative to the historic maximum density recorded in the NTZ.

Inputs:

- Density (or length by species) data inside and outside the NTZ (preferably collected in the same manner)
- Historical maximum density inside the NTZ

Outputs:

- Ratio of fish density outside the NTZ to the density inside the NTZ

How this can be used by management:

- Stakeholders set a management target DR
- This DR target ratio is compared to the ratio from assessment
- Effort is adjusted based on how far apart these values are

Input Sensitivities:

- Assumes historical maximum density inside the NTZ

Caveats:

- This method assumes that a fully-functioning and well-enforced NTZ has been sited appropriately with representative habitat inside and outside of the NTZ, and has been in place long enough for the population living inside the NTZ to be a proxy for an un-fished population.
  - *Implication*: May be less accurate for highly-mobile species that do not remain exclusively inside the NTZ such as snapper, tuna and mackerel.
- Time trends in this data can be difficult to interpret if densities inside the MPA are changing rapidly

No-take zone catch-curve (Catch Curve)

Description: This method utilizes length-frequency data (fish lengths) from inside and outside a NTZ to compare the slope of the right-hand side of the log transformed age-frequency histogram from inside the NTZ (an estimate of natural mortality (M)) to the slope of the log transformed age-frequency histogram outside the NTZ (an estimate of total mortality (Z)). Fishing mortality (F) can then be calculated based on the difference between these two ($F = Z - M$).

Inputs:

- Length-frequency data inside and outside NTZ (preferably collected in the same manner)
- Life history parameters (growth parameters)
- How many years the NTZ has been established and well-enforced
- Information on the sizes of fish preferred by the fishery

Outputs

- An estimate of fishing mortality (F)

How this can be used by management :

- Stakeholders set management target F/M based on community objectives and thresholds of risk
- Target F/M is compared with F/M from assessment
- Effort is adjusted through harvest control rules based on how far apart these values are

Input Sensitivities:

- Accuracy of individual fish length measurements
- Accuracy of length-at-age relationships (*Von Bertanalffy growth parameters*
- Correcting fitting of the curve (sensitive to estimates of NTZ age, preferred fish size)

Caveats:

- This method assumes that a NTZ has been sited appropriately, well-enforced, and been in place long enough for the population living inside the NTZ to be a proxy for an un-fished population
  - *Implication*: May be less accurate for highly-mobile species that do not remain exclusively inside the NTZ, such as snapper, tuna and mackerel
- This method depends on reliably tracking population size structure changes, thus may be less accurate with small, fast-growing species

Fishery-Dependent Data

Trends Analyses

Description: This method uses catch data to compare total catch, average catch, CPUE, and/or abundance between years of interests. Comparisons can be derived for sequential years, or as a running average between historical trends. Additionally, comparisons can be made across all species or by species of interest.

Inputs:

- Total catch for more than one year
- Catch-Per-Unit-Effort (CPUE) for more than one year
- Abundance of the catch for more than one year
- Length-frequency of the catch for more than one year

Outputs:

- Total catch and trends in total catch
- CPUE and trends in CPUE
- Abundance and trends in abundance

- Average length and trends in average length

How this can be used by management:

- Catch trends can support the interpretation of other analyses, for example of fishing morality of spawning potential ratio (SPR).
- Understanding how the trends in catch fluctuate from one year to next or in comparison to the historic trends is essential to use catch trends for management.

Input Sensitivities:

- It can be difficult to attribute a change in catch to a corresponding increase or decrease in biomass. Therefore, seeing an increase in catch could provide a false sense of security. Inferring stock status from catch statistics

Caveats:

- This method depends on reliably tracking the total catch
- For example, raw CPUE is seldom proportional to abundance over a > whole exploitation history and an entire geographic range, because > numerous factors affect catch rates.

Catch Curve

Description: This method utilizes length-frequency data (fish lengths) to estimate the fishing mortality affecting the fished population. Total fishing mortality (Z) is estimated using the slope of the log transformed age-frequency histogram. Fishing mortality can then be calculated based on the difference between total fishing mortality and natural mortality ($F = Z - M$). Estimates of M can come from the literature.

Inputs:

- Length-frequency data
- Life history parameters (growth parameters)

Outputs:

- An estimate of fishing mortality

How this can be used by management:

- Stakeholders set management target F/M based on community objectives and thresholds of risk
- Target F/M is compared with F/M from assessment
- Effort is adjusted through harvest control rules based on how far apart these values are

Input Sensitivities:

- Accuracy of individual fish length measurements
- Accuracy of length-at-age relationships (Von Bertalanffy growth parameters)
- Correcting fitting of the curve (i.e., preferred fish size)

Caveats:

- This method depends on reliably tracking population size structure > changes, thus may be less accurate for small, fast-growing species

Froese Sustainability Indicators

Description: This method uses the length-frequency of the catch to estimate the distribution of life stages in the catch (Froese 2004).

Inputs:

- Length-frequency of the catch
- Length at maturity

Outputs:

- Three metrics of fisheries sustainability:
  - (i) percentage of mature fish in catch, with 100% as target;
  - (ii) percent of specimens with optimum length in catch (L_{opt}), with 100% as target;
  - and (iii) percentage of 'mega-spawners' in catch

How this can be used by management:

- By fishing at L_{opt} or the "spawn-at-least-once" principle in > conjunction with the protection of *megaspawners*, sustainability > of the fishery can be maintained.

Input Sensitivities:

- Accuracy of individual fish length measurements
- Accuracy of length at maturity
- Selectivity

Caveats:

- This method depends on reliably tracking population size structure > changes
  - Implication: May be less accurate with small, fast-growing > species

Mean Length (L_{bar})

Description: This method uses fishery-dependent or independent length-frequency data. L_{bar} uses the minimum and maximum fished sizes, and the average length of the fish within the fished sizes from a fished population, along with growth parameters. In the Ault et al. 2005 model, L_{bar} provides an estimate of fishing mortality (F) that can be compared to an estimate of natural mortality (M). Intuitively, increasing fishing pressure will often cause decreasing average length.

Inputs:

- Fishery-dependent or fishery-independent length-frequency data of fished population
- Life history parameters, growth parameters, and natural mortality (M)
- Information on the sizes of fish preferred by the fishery

Outputs:

- An estimate of fishing mortality (F)

How this can be used by management:

- Stakeholders set management target F/M based on community objectives and thresholds of risk
- Target F/M is compared with F/M from assessment
- Effort is adjusted based on how far apart F/M from the assessment is from the F/M

Input Sensitivities:

- Estimate of M and growth parameters
- Accuracy of individual fish length measurements

Caveats:

- This method depends on reliably tracking population size structure > changes

  - Implication: May be less accurate with small, fast-growing > species

- M is assumed to be known, which often it is not
- Assumes equilibrium
- This model is less reliable when mean fish length is very low

Mean Weight

Description: This method can use fishery-dependent or independent weight-frequency data to estimate fishing mortality (F) when no size structure data is available. This method requires the von Bertalanffy growth function, as well as the length-weight relationship and the natural mortality (M). In this method, we construct a Yield-Per-Recruit (YPR) model, which allows us to estimate the theoretical age and weight structure of the population at any size. Similar to Mean Length (L_{bar}), Mean Weight provides an estimate of F that can be compared to an estimate of M. Intuitively, increasing fishing pressure will often cause decreasing average weight and/ or length.

Inputs:

- Fishery-dependent or fishery-independent weight-frequency data
- Life history parameters, growth parameters, natural mortality (M)
- Information on the sizes of fish preferred by the fishery

Outputs:

- An estimate of fishing mortality (F)

How this can be used by management:

- Stakeholders set management target F/M based on community objectives and thresholds of risk
- Target F/M is compared with F/M from assessment
- Effort is adjusted based on how far apart these values are

Input Sensitivities:

- Estimate of M and growth parameters
- Accuracy of individual fish weight measurements
- Accuracy of length-weight relationship

Caveats:

- This method depends on reliably tracking population size structure changes
  - Implication: May be less accurate for small, fast-growing species
- M is assumed to be known, which often it is not
- Assumes equilibrium
- This model is less reliable when mean fish weight is very low

Bounded mean length mortality estimator

Description: A modification of the Mean Length (L_{bar}) method (Ehrhardt et al. 1992). Does not assume that fishing mortality has been constant over the life span of the fish being assessed, it takes into account the time since a management change, and restricts the data used for this analysis to those fish which have recruited to the fishery during this time period.

Inputs:

- Length-frequency of the catch, since management change

- Mean asymptotic length (cm) of the von Bertalanffy growth equation
- L , the age at L_c (using the von Bertalanffy equation) and adding the number of years since a known harvest rate policy change, then converting back to length
- L_{bar} is the mean length of fish between L_c and L .

Outputs:

- An estimate of fishing mortality (F)

How this can be used by management:

- Stakeholders set management target F/M based on community objectives and thresholds of risk
- Target F/M is compared with F/M from assessment
- Effort is adjusted based on how far apart these values are

Input Sensitivities:

- Estimate of M and growth parameters
- Accuracy of individual fish length measurements

Caveats:

- This method depends on reliably tracking population size structure changes
  - Implication: May be less accurate for small, fast-growing species
- M is assumed to be known, which often it is not
- Assumes equilibrium
- This model is less reliable when mean fish length is very low

Length-based Spawning Potential Ratio (SBSPR)

Description: Length-based Pawning Potential Ratio (SBSPR) method uses length-frequency data from a fished population to calculate the spawning potential ratio (SPR) of a fishery (Hordyk et al. 2014). This method is based on the concept that the equilibrium unfished size structure of a population depends on the average maximum size attained and the ratio of the rate of natural mortality (M) to the individual growth rate (K; Prince et al. 2014). SPR is a measure of current egg production relative to maximum possible production at un-fished levels. Un-fished egg production is estimated using the natural mortality (M), Von Bertanaffy (VBK) growth parameters, age at first maturity, and fecundity at age. The fished SPR is calculated using the same parameters, along with estimates of the fishing mortality rate (F), and the sizes of fish selected by the fishery. By comparing the estimated current SPR with a target SPR defined by stakeholders, a harvest control rule can be used to adjust fisheries management controls accordingly.

Inputs:

- Length-frequency data from a fished population
- Gear selectivity
- Life history parameters (fecundity, VBK parameters, natural mortality, age-at-maturity, length at age relationships)

Outputs:

- SPR of target species

How this can be used by management:

- Stakeholders set management target SPR
- Target SPR is compared to SPR from assessment

- Effort is adjusted based on how far apart these values are

Input Sensitivities:

- Accuracy of individual fish length measurements
- Representativeness of the length data
- Accuracy of life history information, particularly growth and maturity parameters

Caveats:

- This method is dependent on reliably tracking changes in population size structure
  - *Implication*: May be less accurate for small, fast-growing species, such as surgeonfish, scad and spinefoot rabbit fish
- Assumes the fishery is equilibrium and that conditions are relatively stable (environmental conditions, fishing pressure, stock status, etc.)
- This method is less accurate if fishing pressures has been changing dramatically year to year
- This method is less effective for species with highly variable recruitment (addition of juveniles to the population) such as lobster

Chapter 4

Step 4 – Define Harvest Control Rules

How should FMCs be adjusted according to the performance indicators of the fishery?

Harvest Control Rules (HCRs) will be used to adjust FMCs according to where the fishery's performance indicators fall relative to their reference points. The HCR may specify some combination of adjustments to the FMCs that is expected to move the performance indicator towards the target reference point, and away from the *limit reference point*, therefore improving the performance of the fishery. While we provide guidance to define HCRs, it should be noted that HCRs should be based on realistic compliance and enforcement concerns and address community goals for your TURF-Reserve (more guidance is provided in Step 4b).

It is important for stakeholders and managers to agree on the suite of HCRs in a safe and neutral setting before any management decisions need to be made. This can help improve compliance by ensuring management responses are objective, consistent, transparent, and appropriate. Therefore, it is important to identify all foreseeable possible scenarios that could occur in the fishery and create corresponding HCRs for each scenario.

4.1 Step 4a – Define General Harvest Control Rules for All Possible Interpretations

During this step, you will define general harvest control rules (for example, if the performance indicator is below the target reference point, reduce the total allowable catch). In the following step, you will add specificity to your harvest control rules (for example, if the performance indicator is 20% below the target reference point, reduce the total allowable catch by 20%). It is important that you define a HCR for every foreseeable interpretation so that management responses can be transparent and objective when the time comes to implement them.

Use *Table A4. 1*, *Table A4. 2*, and *Table A4. 3* as the framework for defining your general HCRs. The three tables contain the performance indicators that are associated with each tier and suggest HCRs from the literature. For each performance indicator and assessment result, the table lists a number of potential interpretations and corresponding HCRs. This table provides some examples, but is by no means comprehensive or prescriptive – it is illustrative only. During this step, fill out Table A1. 5 using the provided HCRs that you feel are relevant to your fishery, as well as any other foreseeable interpretations and HCRs that you think should be put in place.

Each row also has a traffic light indicator that describes if a management response is necessary:

- Green indicates that either no management response is necessary, or management could be even less restrictive.
- Yellow indicates that a precautionary or more restrictive management response should be implemented.

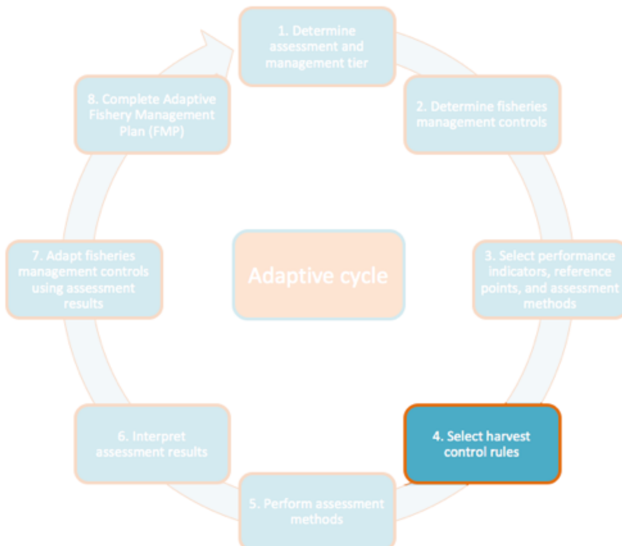


Figure 4.1:

- Red indicates that the fishery should be closed and a fishery recovery plan implemented.

4.2 Step 4b – Add Specificity to Harvest Control Rules

During this step, you will add specificity to your HCRs (for example, if the performance indicator is 20% below the target reference point, reduce the total allowable catch by 20%). Be as specific as possible when defining the magnitude to which FMCs should be adjusted given the fishery's performance indicator.

The magnitude that a HCR should adjust your FMC(s) will depend on:

1. Productivity (life history) of the target species
    a. Productivity of key target species is an output of the FLAGS toolkit. This information may either come from a PSA result or a more data-limited qualitative approach for assessing species productivity.
    b. Species with low productivity will require higher, more restrictive levels of response when changes are necessary; species with higher productivity will require lower levels of response when changes are necessary
2. Likelihood of compliance
3. Social and political feasibility
4. Enforcement capacity
5. Level of uncertainty with data and the estimation of performance indicators,
    a. The more uncertain you are, the more precautionary you may want to make your management
6. Risk tolerance.
    a. Communities with higher risk tolerance may choose to be more lenient when choosing HCRs, while communities with lower risk tolerance may choose more restrictive HCRs to be more precautionary in the face of changing and uncertain conditions.

You should consult any existing KAP and Social Impact Survey data when setting HCRs. KAP data will provide an indication as to individual attitudes towards fishery management in your community. Social Impact Survey data will provide context as to how dependent the community is on the fishery and how changes in fisheries management controls may affect their livelihoods. Additionally, any existing enforcement data should be consulted to gain a better sense for the likelihood of compliance with any new regulations.

You should also consider the size of the NTZ and TURF when setting HCRs. Sites with a small NTZ relative to the size of the TURF may wish the exercise more precaution by setting more restrictive HCRs (i.e., if indicators are interpreted to mean poor fisheries performance, make more drastic adjustments to the FMCs). Sites with an NTZ that is not placed explicitly in areas that protect critical habitat may also wish to exercise more precaution with stricter HCRs. Sites with larger NTZs that protect a significant portion of critical habitat could be more lenient in their HCRs. Often, large and well-placed NTZs can act as a buffer against uncertainty and variability. By completely restricting access to a certain portion of the stock, marine reserves are analogous to an emergency savings account. Protecting a fraction of a fish stock in reserves reduces the risk of overfishing and the chance of stock collapse in the long term. Displaced fishing effort and unintended consequences resulting after implementation of a reserve can be mitigated when effective FMCs are in place outside of the reserve. When harvest levels are appropriately controlled a spillover of biomass from marine reserves to the adjacent fishery may occur that can benefit fisheries.

4.3 Table A4.1: Indicators for Tier 1: Possible interpretations, management implications, and suggested harvest control rules

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
Fishing Gear	Destructive fishing practices being used	Non-destruc tive fishing practices are no longer able to efficiently catch fish and/or destructive fishing practices have not yet been banned	Yellow	1. Ban destruc tive fishing practic es

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
	No destructive fishing practices being used	Non-destruc tive fishing practices are able to efficiently catch fish and/or destructive fishing practices have been banned	Green	1. If there is no reason to believe precaut ionary managem ent is necessa ry, make no changes to fisheri es managem ent control s *__or__ • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
Fishing Season	Increased variability in fishing season, or decreased fishing season	Ecosystem likely not healthy enough to support historical fishing season	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	No changes in the fishing season	Ecosystem may be healthy enough to support historical fishing season	Green	1. If there is no reason to believe precaut ionary managem ent is necessa ry, make no changes to fisheri es managem ent control s ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
Target Species Composition	Change in composition of caught species (fewer species, more pelagics)	Ecosystem likely not healthy enough to support historical target species	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	No change in composition of caught species	Ecosystem may be healthy enough to support historical target species	Green	1. If there is no reason to believe precaut ionary managem ent is necessa ry, make no changes to fisheri es managem ent control s ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
Species Vulnerabili ty	Target species have high vulnerabili ty	Target species have high susceptibil ity and/or low productivit y	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	Target species have medium vulnerabili ty	Target species have medium susceptibil ity medium productivit y	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e effort cap, add or modify certain control s, expand NTZ, etc.)
	Target species have low vulnerabili ty	Target species have low susceptibil ity and/or high productivit y	Green	1. If there is no reason to believe precaut ionary managem ent is necessa ry, make no changes to fisheri es managem ent control s ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
Fished:unfi shed density ratio (for key target species)	Indicator >= Target	Fishing pressure appropriate for maintaining or improving the health of the ecosystem	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e effort cap, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Unfished area has a low density and does not represent a healthy virgin area (significan t illegal fishing is occurring within the NTZ)	Yellow	1. Conside r improve d enforce ment of NTZ ***and*** 2. Conside r targete d social marketi ng to improve complia nce with NTZ ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Unfished area has a low density and does not represent a healthy virgin area (NTZ is new and has not yet led to substantial improvement s in ecosystem health)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Unfished area has a low density and does not represent a healthy virgin area (NTZ is small with large amounts of species movement between fished and unfished areas)	Yellow	1. Conside r expansi on or relocat ion of NTZ ***and*** 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
	Target > Indicator > Limit	High fishing pressure putting ecosystem at risk for impending state change	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Environment al stochastici ty putting ecosystem at risk for impending state change	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Unfished area has a low density and does not represent a healthy virgin area (significan t illegal fishing is occurring within the NTZ)	Yellow	1. Conside r improve d enforce ment of NTZ ***and*** 2. Conside r targete d social marketi ng to improve complia nce with NTZ ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Unfished area has a low density and does not represent a healthy virgin area (NTZ is new and has not yet led to substantial improvement s in ecosystem health)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
		Unfished area has a low density and does not represent a healthy virgin area (NTZ is small with large amounts of species movement between fished and unfished areas)	Yellow	1. Conside r expansi on or relocat ion of NTZ ***and*** 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
	Limit >= Indicator	High fishing pressure has caused an ecosystem state change; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
		Extreme environment al stochastici ty has caused an ecosystem state change; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
Coral Reef Thresholds (aggregated across species)	Unfished biomass Indicator >= Target ***And*** fished:unfi shed biomass ratio >= Target	Fishing pressure appropriate for maintaining or improving the health of the ecosystem	Green	1. Make no changes to fisheri es managem ent control s ***or** • 1. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e effort cap, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Unfished area has a low biomass and does not represent a healthy virgin area (significan t illegal fishing is occurring within the NTZ)	Yellow	1. Conside r improve d enforce ment of NTZ ***and*** 2. Conside r targete d social marketi ng to improve complia nce with NTZ ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Unfished area has a low biomass and does not represent a healthy virgin area (NTZ is new and has not yet led to substantial improvement s in ecosystem health)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Unfished area has a low biomass and does not represent a healthy virgin area (NTZ is small with large amounts of species movement between fished and unfished areas)	Yellow	1. Conside r expansi on or relocat ion of NTZ ***and*** 1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Unfished area does not have comparable habitat to fished area (unfished area habitat not as healthy as fished area)	Yellow	1. Conside r expansi on or relocat ion of NTZ ***and*** 1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	Limit <= Unfished biomass Indicator <= Target ***And*** Limit <= fished:unfi shed biomass ratio <= Target	High fishing pressure putting ecosystem at risk for impending state change	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Environment al stochastici ty putting ecosystem at risk for impending state change	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Unfished area has a low density and does not represent a healthy virgin area (significan t illegal fishing is occurring within the NTZ)	Yellow	1. Conside r improve d enforce ment of NTZ ***and*** 2. Conside r targete d social marketi ng to improve complia nce with NTZ ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Unfished area has a low density and does not represent a healthy virgin area (NTZ is new and has not yet led to substantial improvement s in ecosystem health)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
		Unfished area has a low density and does not represent a healthy virgin area (NTZ is small with large amounts of species movement between fished and unfished areas)	Yellow	1. Conside r expansi on or relocat ion of NTZ ***and*** 1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Unfished area does not have comparable habitat to fished area (unfished area habitat not as healthy as fished area)	Yellow	1. Conside r expansi on or relocat ion of NTZ ***and*** 1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
	Limit >= Unfished biomass Indicator ***Or*** Limit >= fished:unfi shed biomass ratio	High fishing pressure has caused an ecosystem state change; fishery in danger of collapse	Red	1. Close fishery ***and*** 1. Impleme nt fishery recover y plan

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Extreme environment al stochastici ty has caused an ecosystem state change; fishery in danger of collapse	Red	1. Close fishery ***and*** 1. Impleme nt fishery recover y plan

4.4 Table A4.2: Indicators for Tiers 2 and 3: Possible interpretations, management implications, and suggested harvest control rules

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
Fishing Mortality (F)	Indicator >= Limit	High fishing pressure negatively affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
		Extreme environment al stochastici ty negatively affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
	Limit > Indicator > Target	High fishing pressure affecting size structure and spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Fishers targeting nursery grounds	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Gear shift towards less selective gear (more small individuals in catch)	Yellow	1. Conside r impleme nting a gear restric tion on less selecti ve gear ***and/ or*** 2. Conside r impleme nting a minimum size limit (if one does not already exist)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Strong recruitment pulse (more small individuals entering the catch)	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)
		Market selectivity for smaller individuals	Yellow	1. Conside r impleme nting a minimum size limit (if one does not already exist)
		Emigration of large individuals from fishing area	Green	1. Make no changes to fisheri es managem ent control s

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Environment al stochastici ty affecting size structure and spawning stock biomass	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
	Target >= Indicator	Fishing pressure appropriate for maintaining or improving size structure of population	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Gear shift towards more selective gear (fewer small individuals in catch)	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)
		Market selectivity for larger individuals	Yellow	1. Conside r impleme nting a maximum size limit (if one does not already exist)

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
		Weak recruitment pulse (fewer small individuals entering the catch)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Immigration of large individuals to fishing area	Green	1. Make no changes to fisheri es managem ent control s
Average Length	Indicator <= Limit	High fishing pressure negatively affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 1. Impleme nt fishery recover y plan
		Extreme environment al stochastici ty negatively affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
	Limit < Indicator < Target	High fishing pressure affecting size structure and spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Fishers targeting nursery grounds	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Gear shift towards less selective gear (more small individuals in catch)	Yellow	1. Conside r impleme nting a gear restric tion on less selecti ve gear ***and/ or*** 1. Conside r impleme nting a minimum size limit (if one does not already exist)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Strong recruitment pulse (more small individuals entering the catch)	Green	1. Make no changes to fisheri es managem ent control s *or • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Market selectivity for smaller individuals	Yellow	1. Conside r impleme nting a minimum size limit (if one does not already exist) ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Emigration of large individuals from fishing area	Green	1. Make no changes to fisheri es managem ent control s
		Environment al stochastici ty affecting size structure and spawning stock biomass	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	Target <= Indicator	Fishing pressure appropriate for maintaining or improving size structure of population	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Gear shift towards more selective gear (fewer small individuals in catch)	Green	1. Make no changes to fisheri es managem ent control s ***or** • 1. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Market selectivity for larger individuals	Yellow	1. Conside r impleme nting a maximum size limit (if one does not already exist) ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Weak recruitment pulse (fewer small individuals entering the catch)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Immigration of large individuals to fishing area	Green	1. Make no changes to fisheri es managem ent control s

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
Spawning Potential Ratio	Indicator <= Limit	High fishing pressure affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
		Extreme environment al stochastici ty affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
	Limit > Indicator < Target	High fishing pressure affecting size structure and spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Fishers targeting nursery grounds	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Gear shift towards less selective gear (more small individuals in catch)	Yellow	1. Conside r impleme nting a gear restric tion on less selecti ve gear ***and/ or*** 2. Conside r impleme nting a minimum size limit (if one does not already exist)
		Strong recruitment pulse (more small individuals entering the catch)	Green	1. Make no changes to fisheri es managem ent control s *__or__ • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e effort cap, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Market selectivity for smaller individuals	Yellow	1. Conside r impleme nting a minimum size limit (if one does not already exist) ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Emigration of large individuals from fishing area	Green	1. Make no changes to fisheri es managem ent control s
		Environment al stochastici ty affecting size structure and spawning stock biomass	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
	Target <= Indicator	Fishing pressure appropriate for maintaining or improving size structure of population and spawning stock biomass	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e effort cap, etc.)
		Gear shift towards more selective gear (fewer small individuals in catch)	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e effort cap, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Market selectivity for larger individuals	Yellow	1. Conside r impleme nting a maximum size limit (if one does not already exist) ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Weak recruitment pulse (fewer small individuals entering the catch)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Immigration of large individuals to fishing area	Green	1. Make no changes to fisheri es managem ent control s ***or** •

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
Froese Indicators	All Indicators at or better than Target (Lopt=100%, Lmat>90% , Lmega<30 %)	Fishing pressure appropriate for maintaining or improving size structure of population and spawning stock biomass	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e effort cap, etc.)
		Gear shift towards more or less selective gear	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Change in recruitment	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Change in spatial distributio n of stock	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	Target > Lopt > Limit ***And/or*** Target > Lmat > Limit	Market selectivity for smaller individuals	Yellow	1. Conside r impleme nting a minimum size limit (if one does not already exist) ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		High fishing pressure affecting size structure and spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Fishers targeting nursery grounds	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Strong recruitment pulse (more small individuals entering the catch)	Green	1. Make no changes to fisheri es managem ent control s ***or** • 1. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)
		Emigration of large individuals from fishing area	Green	1. Make no changes to fisheri es managem ent control s
		Environment al stochastici ty affecting size structure and spawning stock biomass	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	Limit > Lmega > Target	Market selectivity for larger individuals	Yellow	1. Conside r impleme nting a maximum size limit (if one does not already exist) ***or** • 2. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		High fishing pressure affecting size structure and spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Weak recruitment pulse (fewer small individuals entering the catch)	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
		Immigration of large individuals to fishing area	Green	1. Make no changes to fisheri es managem ent control s *or •
	Lopt < Limit (Lopt<80 %)	High fishing pressure affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
	Lmat < Limit (Lmat<50 %)	High fishing pressure affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan
	Lmega < Limit (Lmega < 20%)	High fishing pressure affecting size structure and spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan

Table A4.3: Indicators for Tier 3: Possible interpretations, management implications, and suggested harvest control rules

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
CPUE	Indicator >= Target	Fishing pressure appropriate for maintaining or improving spawning stock biomass	Green	1. Make no changes to fisheri es managem ent control s *__or__ • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)
		Change to more efficient gear type	Yellow	1. Conside r impleme nting a gear restric tion on less selecti ve gear ***and/ or*** 2. Conside r impleme nting a minimum size limit (if one does not already exist)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Serial depletion (fishers have moved from depleted fishing grounds to less depleted fishing grounds, such as offshore areas)	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e effort cap, add or modify certain control s, expand NTZ, etc.)
		Misreportin g of effort; reported effort too low	Yellow	1. Modify catch reporti ng protoco ls ***and/ or*** 2. Perform social marketi ng dedicat ed towards increas ing catch reporti ng complia nce ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
		Fishing of spawning aggregation s / hyperstabil ity	Yellow	1. Ban fishing of spawnin g aggrega tions

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
	Target > Indicator > Limit	Environment al stochastici ty negatively affecting spawning stock biomass	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
		Change to less efficient gear type	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Misreportin g of effort; reported effort too high	Yellow	1. Modify catch reporti ng protoco ls ***and/ or*** 2. Perform social marketi ng dedicat ed towards increas ing catch reporti ng complia nce ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)
		High fishing pressure negatively affecting spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e effort cap, add or modify certain control s, expand NTZ, etc.)
	Limit >= Indicator	High fishing pressure negatively affecting spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan

Performan ce Indicator	**Assessmen t Result**	**Interpret ation**	**Result**	**Managemen t Response**
Previous Year's Total Landings	Indicator >= Target	Fishing pressure appropriate for maintaining or improving spawning stock biomass	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)
		Fishing effort increased last year	Yellow	1. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., increas e TAC, increas e allowab le effort, add or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Misreportin g of landings; reported catch too high	Yellow	1. Modify catch reporti ng protoco ls ***and/ or*** 2. Perform social marketi ng dedicat ed towards increas ing catch reporti ng complia nce ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
	Target > Indicator > Limit	High fishing pressure negatively affecting spawning stock biomass	Yellow	1. Make fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e effort cap, add or modify certain control s, expand NTZ, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Fishing effort decreased last year	Green	1. Make no changes to fisheri es managem ent control s ***or** • 2. If trends have persist ed for more than one year and there is no reason to believe precaut ionary managem ent is necessa ry, make fisheri es managem ent control s less restric tive (i.e., increas e TAC, increas e allowab le effort, remove or modify certain control s, etc.)

Performan ce Indicator	Assessmen t Result	Interpret ation	Result	Managemen t Response
		Misreportin g of landings; reported catch too low	Yellow	1. Modify catch reporti ng protoco ls ***and/ or*** 2. Perform social marketi ng dedicat ed towards increas ing catch reporti ng complia nce ***and*** 3. Conside r precaut ionary managem ent by making fisheri es managem ent control s more restric tive (i.e., decreas e TAC, decreas e allowab le effort, add or modify certain control s, etc.)
	Limit >= Indicator	High fishing pressure negatively affecting spawning stock biomass; fishery in danger of collapse	Red	1. Close fishery ***and*** 2. Impleme nt fishery recover y plan

Chapter 5

Step 5 - Perform Assessment Methods

What do my assessment methods say about the fishery?

During this step, you will use your data to calculate performance indicators using the chosen assessment methods. Refer to *Assessment Method Descriptions* under Step 3 for detailed descriptions of the assessment methods. To do the calculations, you may use the AFAM Toolkit dashboard.

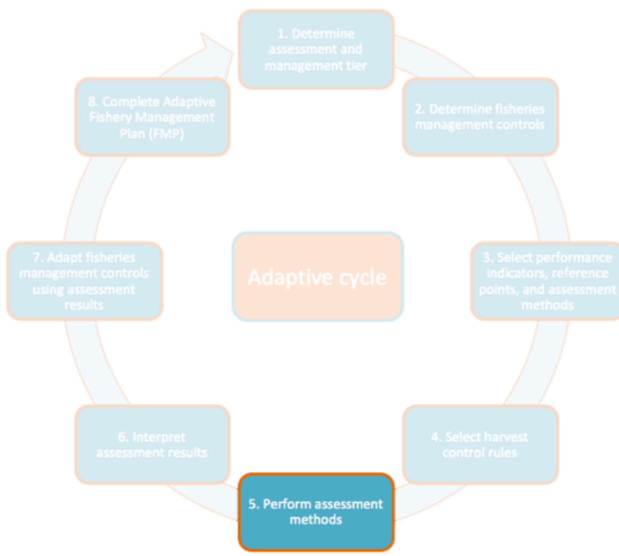

1. Determine assessment and management tier
2. Determine fisheries management controls
3. Select performance indicators, reference points, and assessment methods
4. Select harvest control rules
5. Perform assessment methods
6. Interpret assessment results
7. Adapt fisheries management controls using assessment results
8. Complete Adaptive Fishery Management Plan (FMP)
Adaptive cycle

Figure 5.1:

Chapter 6

Step 6 – Interpret assessment results

What is the current status of the fishery?

6.1 Step 6a - Determine the Most Likely Possible Interpretation for Each Performance Indicator

After assessment methods have been completed, use your harvest control rule table to determine the possible interpretation and management implication for each performance indicator using the following steps:

a) Using your assessment results Step 5, use your harvest control rule table to look up the most likely interpretation from the choices provided in the "Possible Interpretation" column.

b) Once the most likely possible interpretation has been chosen, determine the management implication by locating the colored circle traffic light in the "Management Implication column"

6.2 Step 6b – Verify Assessment Result and Interpretation

Verify the assessment result using the following steps:

1. Double-check calculations by reviewing the assessment calculations.
2. Double-check that each assessment performed was stratified to the spatial extent of the fishery; for example, run analyses for each gear type, boat type, and/or fishing area.
3. Double-check that reference points are appropriate for your fishery using available literature, expert opinion, and local ecological knowledge
4. Review fishery-dependent sampling protocol; assess whether or not the spatial extent of the fishery-dependent survey overlaps with known or assumed distribution of fish population as well as fishing effort and gear type. If the sampling protocol, fish population, and fishing effort do not overlap, there may be biases in the assessment results that should be considering in your interpretation.
5. Review fishery-independent sampling protocol; assess whether or not the spatial extent of the fishery-independent survey overlaps with known or assumed distribution of fish population as well as fishing effort. If the sampling protocol, fish population, and fishing effort do not overlap, there may be biases in the assessment results that should be considering in your interpretation.
6. Examine any effort metrics to determine if they are consistent with your interpretation

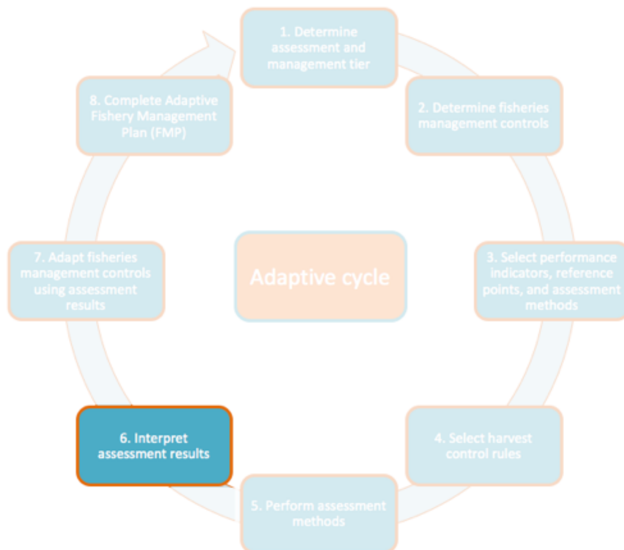


Figure 6.1:

7. Groundtruth assessment result and interpretation with community. Consult with local experts to determine if the assessment results align with their knowledge of the fishery (fishers, middlemen, village elders, academic research groups, etc.) Often, assessment results can be counterintuitive, and multiple performance indicators may be conflicting in their message. Fishers can be especially helpful in interpreting performance indicators that seem counter-intuitive but can be explained by fishermen behavior – for example, if fished:unfished density ratio is down but catch and CPUE are up, the fishermen might say that although fish abundance seems low (low fished:unfished density ratio) prices were high that season and the weather was good, resulting in better targeting (higher CPUE) and higher catches. This process can either take place in a focus group discussion or structured interviews with key stakeholders. Through this process, try to arrive at a consistent interpretation.

8. If trends persist, each performance indicator points towards a consistent interpretation, and if the community agrees with the interpretation, proceed to Step 7

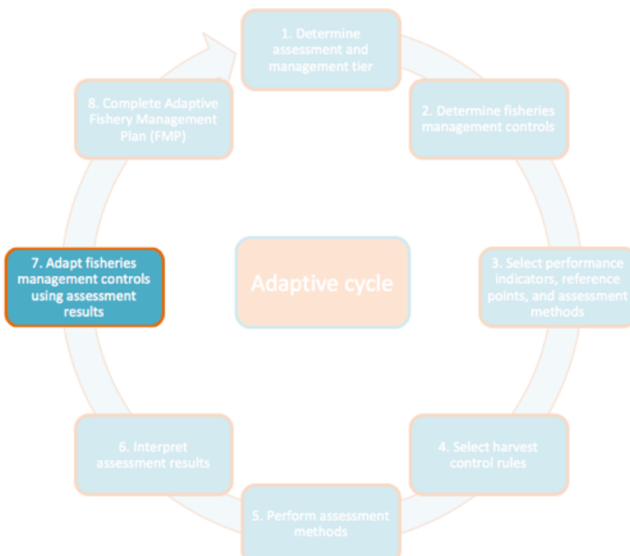
9. In situations where conflicting indicators cannot be rectified, or if the community cannot corroborate the assessment results, additional community outreach or other forms of social marketing may be necessary to arrive at consensus. *It's important that all stakeholders are comfortable and confident with the assessment interpretation because it will be used to trigger a harvest control rule in Step 7.*

Chapter 7

Step 7 – Adjust Fisheries Management Controls Using Defined Harvest Control Rules

How should I adjust fisheries management controls based on my assessment results and interpretation?

After interpreting and verifying the assessment results, implement the appropriate HCR defined in Table A1. 5. Depending on the severity of the HCR and likely community reaction, it may be necessary to conduct additional community outreach or other social marketing activities to ensure buy-in and compliance. For example, if a limit reference point is reached and the fishery for a particular species must be closed, this will likely require significant community outreach.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Adaptive cycle

Figure 7.1:

Chapter 8

Step 8 – Complete Your Fishery Management Plan

How do I take the outputs of the AFAM toolkit to create a concrete Fishery Management Plan?

We have provided a template Fishery Management Plan in Appendix 9 – Fishery Management Plan Template. To complete this template, we recommend you use the outputs of the AFAM Dashboard. You may also use outputs from the FLAGS toolkit, the TURF-Reserve Design Survey, Site Level Research Plan, Global Monitoring and Evaluation Plan, and Data Collection Manual to fill out sections of this template. We recommend you complete a fishery management plan for each species to be managed. Note that the template provided here may need to be adapted to better suit your regional context.

8.1 Fishery Management Plan Template

- **Fishery Overview:**

  You may use the outputs of the TURF-Reserve Design Survey and FLAGS toolkit to help complete this section.

  - **Location of the Fishery**: Country, state, city, management zone (if applicable).
  - **History**: Provide a brief history of the fishery.
  - **Type(s) of Fishery**: Commercial, recreational, etc. and whether near shore, off shore, or mixed.
  - **Participants**: Number of fishers, number of vessels, number of communities (if applicable), and spatial distribution of participants/ communities.
  - **Fishery Characteristics**: Describe the gear types utilized in the fishery (i.e. fixed gear, mobile gear, etc), including numbers for each if possible, as well as the general timeframe (i.e. season) of when the fishery occurs.
  - **Management Characteristics**: Type of method currently used to manage the fishery (i.e. seasons, catch limits, size limits, effort limits, etc.). Also describe the general management decision-making process.
  - **Governance**: Briefly describe key legislation and regulations, as well as types of committees and/or legislative land claims which are part of the decision making process (based on zones, areas, regions, international considerations).
  - **Economic, Social, and Cultural Importance of the Fishery**: Provide a brief overview of economic conditions and social, cultural and economic issues.

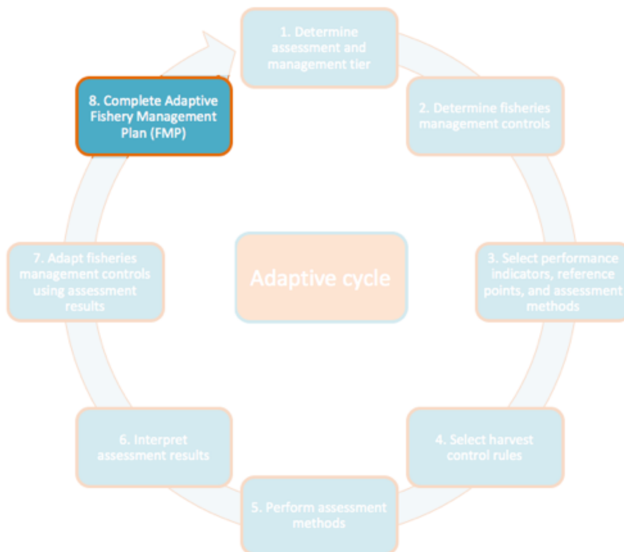

Figure 8.1:

  - **Species Characteristics**: Provide a brief overview outlining the main biological characteristics of the species with emphasis on the aspects which impact on management of the species. Factors to be covered include range (both globally and locally), populations/stock structure, habitat requirements (including key location where applicable), migration routes and reproductive characteristics (i.e. season, behavior, fecundity, growth rates, spawning grounds).
  - **Ecosystem Interactions**: Briefly describe interactions with other species and the physical environment. Where the information is available briefly describe the effect of climate regime changes on stock status, particularly recruitment and stock productivity.

- **Fisheries Objectives and Challenges:**

You may use the outputs of the FLAGS toolkit to help complete this section.

- **Management Objectives**: Clearly state long-term objectives for fishery management under the following potential headings:
  - **Yield/ Economic**
  - **Stock Conservation**
  - **Ecosystem**
  - **Social and Cultural**
  - **Compliance**
    * For each long-term objective, outline short-term objectives specific for the duration of the plan.
- **List all Trade-Offs Associated with these Objectives**: Provide a brief explanation of which objectives conflict with each other, such that one objective may have to be sacrificed to achieve another. Where possible, discuss potential management modifications that may lessen these trade-offs.
- **Current Management Issues**: Provide an overview of current issues in the fishery, including those related to the target species, as well as by-catch and ecosystem concerns. Potential examples of management issues include:

  - ***Fisheries Issues*** such as conflicts between gear sectors, catch monitoring, by-catch problems and other resource user issues.
  - ***Depleted Species Concerns***, including species listed under CITES, and/ or any local endangered/threatened species legislation. Reference existing recovery strategies/management plans where appropriate.
  - ***Oceans and Habitat Considerations***, including habitat impacts and discussions of ecologically significant areas that have been identified and documented within the geographic range of the fishery (including marine protected areas (MPAs) or no-take zones. Where information is available on the effect of climate regime change on stock status, it should be considered when developing harvest decision rules and other management measures. Any management measures in place to control aquatic invasive species should also be included.
  - ***Gear Impacts***, including losses and resulting impacts.
  - ***International Issues***

- **Science and Traditional Knowledge:**

You may use your Site Level Research Plan, the Global Monitoring & Evaluation Plan, and the Data Collection Manual to help you complete this section.

- **Available Data:** Provide brief overview of all available data, with references to sources.
- **Data Collection:** Provide a brief overview of the data collection process for the stock(s), including types of data sources utilized (i.e. research vessel trawl surveys, tagging, index fisheries, CPUE, landing statistics, sentinel fisheries, etc.) and frequency of assessment.
- **Traditional Knowledge:** Provide brief overview of all traditional/ local knowledge.
- **Research:** Provide a brief overview of research projects being conducted during the period of the plan and their purpose. Also include any research needs not currently being addressed. Consider not just the target species, but also research on associated by-catch and habitat.
- **Precautionary Approach (PA)**: Where available, provide a brief overview of any PA references established for this resource, including removal references, limit reference points, and upper stock reference points.
- **Adaptive Assessment and Management:**

  Provide a brief overview of the **Adaptive Fisheries Assessment and Management Plan**, including data sources, design of data collection and sampling programs, timeline for completion of new/ updated assessments (e.g., yearly), and performance indicators to be evaluated.

  - **Step 1: Assessment and management tier chosen**.
    - **Data sources:**
      - **Tier:**
  - **Step 2: Fisheries Management Controls**
    - **Species Productivity score:**
  - **Step 3:** List **performance indicators, reference points, and assessment methods** chosen.
    - **Performance indicators:**
      - **Data Streams:**
      - **Target RP**
      - **Limit RP**
      - **Assessment method**

        - **Results/Reasoning:**
      - **Performance indicators:**
        - **Data Streams:**
        - **Target RP**
        - **Limit RP**
        - **Assessment method**
        - **Results/Reasoning:**
      - **Performance indicators (if applicable):**
        - **Data Streams:**
        - **Target RP**
        - **Limit RP**
        - **Assessment method**
        - **Results/Reasoning:**
      - **Performance indicators (if applicable):**
        - **Data Streams:**
        - **Target RP**
        - **Limit RP**
        - **Assessment method**
        - **Results/Reasoning:**
  - **Step 4: Define Harvest Control Rules**
      - **First performance indicators:**
        - **Assessment Result:**
        - **Interpretation (s):**
        - **Management Implications:**
        - **HCR suggested in literature:**
        - **Implemented HCR:**
      - **Second performance indicators (if applicable):**
        - **Assessment Result:**
        - **Interpretation (s):**
        - **Management Implications:**
        - **HCR suggested in literature:**
        - **Implemented HCR:**
      - **Third performance indicators (if applicable):**
        - **Assessment Result:**
        - **Interpretation (s):**
        - **Management Implications:**

        · **HCR suggested in literature:**
        · **Implemented HCR:**
      * **Fourth performance indicators (if applicable):**
        · **Assessment Result:**
        · **Interpretation (s):**
        · **Management Implications:**
        · **HCR suggested in literature:**
        · **Implemented HCR:**
      * **Fifth performance indicators (if applicable):**
        · **Assessment Result:**
        · **Interpretation (s):**
        · **Management Implications:**
        · **HCR suggested in literature:**
        · **Implemented HCR:**
  – **Step 5:** Interpret assessment results.
      * **First method applied:**
        · **Results:**
        · **Interpretations:**
      * **Second method applied (if applicable):**
        · **Results:**
        · **Interpretations:**
      * **Third method applied (if applicable):**
        · **Results:**
        · **Interpretations:**
      * **Fourth method applied (if applicable):**
        · **Results**
        · **Interpretations:**
      * **Fifth method applied (if applicable):**
        · **Results**
        · **Interpretations:**
  – **Step 6: Adjust fisheries management controls using defined harvest control rules**
      * **Triggered Harvest Control Rules:**
- **Additional Management Measures for the Duration of the Plan:**
  – **Management measures:** Specify if plan is for a single year or multiple years. In the latter case, identify expected management changes in each successive year. Where relevant, include any mandatory financial arrangements required with fish harvesters and other stakeholders.
  – **Monitoring measures** may include:

    * ***Observer coverage***
    * ***Dockside monitoring***
    * ***Logbooks***
    * ***Hailing***
    * ***Electronic vessel monitoring systems***
    * ***Etc.***
  - **Enforcement measures** may include:
    * ***Fines***
    * ***Sanctions***
    * ***Quota revocations***
    * ***Vessel suspensions***
    * ***Criminal***
- **Stock Scenarios**: Briefly describe expected stock prospects (i.e. trends) for period of the plan, and beyond, if available.
- **Management Plan Performance Review**: Outline indicators that will be used to determine if the plan objectives are met. Where applicable, include results of previous year's review.

Chapter 9

Glossary

Assessment Method - The method for using raw data to calculate performance indicators.

Boat intercept / landing site surveys - Baseline boat intercept and landing site surveys are meant to gather information on catch and effort in order to establish a baseline catch-per-unit-effort (CPUE) indicator. These surveys can be useful in establishing baseline CPUE in areas where individual catch reporting systems are not yet in place. This information should be broken down by species and gear type. Boat intercepts involve at-sea intercepts of fishing boats, and are typically conducted in areas where fish is landed at a large number of sites. Landing site surveys are typically conducted where fish is landed at a relatively small number of sites. To establish baseline CPUE we recommend landing site surveys. The information from these surveys can be used to inform fisheries management as well as impact monitoring over time as it relates to productive and profitable fisheries. Refer to the FF Data Collection Manual for more details.

Bycatch - A species or individual fish that is caught unintentionally. This term may refer to any landings that do not contain the species that as targeted or it may refer to a certain size class or sex of a species that was unintentionally landed. For example, a juvenile fish landed that is under the specified size limit would be considered bycatch.

Control – See **Fisheries Management Control (FMC)**

Discard Mortality – How likely a fish is to die after it has been landed and released (and not counted as part of total harvest). Discard mortality rates will vary with different fishing gears and between species.

Destructive Fishing Methods - These are unselective fishing methods that result in high discard mortality and are defined in this tool as: dynamite fishing, fishing with chemicals or harmful substances, the use of nets with fine mesh.

Experimental Fishing – Fishery-independent experimental fishing surveys gather ecological information on the finfish of a particular area. This information can include biomass and species richness. Individuals who are trained in local species and ecology conduct these surveys. Local fishers can be employed to use a specific gear in specified sampling locations and at specified sampling times. This type of information can be used to better understand the health of a particular ecosystem and inform fisheries management, and is also important for monitoring impact as it relates to ecosystem conservation and resilience.

Fisheries Management Control (FMC) – Fisheries management controls are measures that managers may implement to limit fishing activity with the main objective of either limiting fishing mortality or protecting key biological or ecological features of the fishery. Definitions of recommended FMCs for FF sites are provided in Table A2.1.

Fishery-dependent species length composition survey - The survey will gather individual fish length measurements of key target species in order to construct length frequency compositions of those species. A fishery dependent length composition indicates how many fish of each size are being caught in the fishery. This information can inform how well the fishery is doing through key indicators such as average length or fishing mortality. This can be used to inform fisheries management as well as impact monitoring over time as it relates to productive fisheries. Refer to the FF Data Collection Manual for more details.

Harvest Control Rule (HCR) - A harvest control rule helps stakeholders to compare performance indicators with reference points and adjust fisheries management controls accordingly. In other words, a harvest control rule is a plan for pre-agreed management actions as a function of variables related to the status of stock in question.

Highgrading - When fishermen selectively only keep harvested fish that are the highest quality (ex. The largest) and discard the lower quality catch. Typically occurs when only a limited number of fish can be harvested.

Individual Catch Reporting System - This is the system that will gather catch and effort data for the fishery as well as price and cost data necessary for computing profit. This information should be broken down by species and gear type, and in ideal circumstances would cover all landings and effort of all fishers. Additionally, fishers should indicate the location where their catch was caught if possible. Ideally, all fishers report their catch daily in log books. Refer to the FF Data Collection Manual for more details.

Limit Reference Point (LRP) - a numerical value that indicates that the status of a stock is unacceptable (e.g. overfished).

Megaspawner - Old, large fish that contribute a disproportionately significant amount of reproductive potential of the stock

Performance Indicators - a numerical value (or range of values) that is used to determine the current state of the fishery. Performance indicators can be examined over time, space or against a predetermined reference point**.**

'Race to Fish'- Occurs when fishermen are fishing against a single quota or for a limited time frame. Fishermen begin to race each other to catch as many fish as possible before the fishery is closed. This often leads to fishermen investing in more efficient gear, using too many gears, fishing during unsafe weather conditions, higher bycatch rates, and reduced value of catch due to market floods.

Reference Point: A reference point is what your performance indicator is compared with when assessing the performance of your fishery. By comparing your performance indicator on an annual with a pre-determined reference point, you can assess how your fishery is doing. There are two types of references points: limit reference points (LRPs) and target reference points (TRPs).

Target Reference Point (TRP) - a numerical value (or range of values) that indicates that the status of a stock is at a desirable level, often times management is geared towards achieving or maintaining this target.

Underwater Visual Survey – Fishery-independent underwater visual surveys gather ecological information on the finfish, invertebrate, and benthic habitat composition of a particular area. This information can include biomass, species richness, and coral and macroalgal cover. Individuals who are trained in local species and ecology conduct these surveys. SCUBA or snorkeling is used in order to conduct linear transects, quadrats, patch reef surveys, manta tows, or roaming surveys. This type of information can be used to better understand the health of a particular ecosystem and inform fisheries management, and is also important for monitoring impact as it relates to ecosystem conservation and resilience.

Chapter 10

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