Revised Draft

2018 Master Plan for Fisheries
A Guide for Implementation of the Marine Life Management Act

February 2018
State of California
The Natural Resources Agency
Department of Fish and Wildlife

Acknowledgements

The Marine Life Management Act (Appendix A) emphasizes the importance of stakeholder engagement in all areas of management, including developing and revising the Master Plan. The Department thanks and acknowledges Tribes and tribal communities, and stakeholders for the thoughtful input that has been provided in a range of venues and formats throughout the two-year development of this Draft 2018 Master Plan. The Department also appreciates the generous funding from the Ocean Protection Council and the Resources Legacy Fund, and the numerous partners who provided background material and tools for consideration as part of the Draft's preparation. Please see Appendix B for a complete list of these partnerships and engagement efforts.

Executive summary

The **Marine Life Management Act (MLMA)** is California's primary fisheries management law. It directs the California Department of Fish and Wildlife (Department) to develop a Master Plan to guide its implementation. The original Master Plan, adopted in 2001, is being updated to reflect new priorities and emerging management strategies for achieving the MLMA's goals, and to better describe the Department's inclusion of MLMA principles in management decisions. The 2018 Master Plan (Master Plan) replaces the original and is re-structured to better meet the specific management objectives identified in the MLMA. It is intended to be both a roadmap and a toolbox for implementation, providing guidance and direction in the following areas:

Prioritization of management efforts

The Master Plan includes an interim list of prioritized species for management action based on the results of a **Productivity and Susceptibility Analysis (PSA)**. It also describes a more comprehensive prioritization framework to be applied as part of Master Plan implementation that includes an assessment of the risks fishing poses to a given **stock** and the **ecosystem**, the extent to which current management is addressing those risks, and socioeconomic and community opportunities. The goal is to allow the Department to focus limited management resources on the fisheries with the greatest need as well as those where there are the greatest opportunities for resource and ecosystem benefits to the state of California.

Meeting stock sustainability objectives

The MLMA identifies sustainability of fish stocks and the fisheries that depend on them as its primary **fishery** management goal as stated in Fish and Game Code Section (§) 7056. There are new tools and approaches available to help consider and identify the most appropriate management strategies for achieving sustainability. Even when limited information is available, it is possible to be explicit about potential benefits and the costs of different management strategies. The Master Plan identifies some of these approaches and provides guidance regarding their use.

Meeting ecosystem objectives

The MLMA also emphasizes the importance of conserving the health of marine ecosystems (§7050(b)(1)), and specifically, the need to consider impacts to **habitat** and **bycatch** species when prioritizing and managing fisheries (§7056(b) and §7085). The Master Plan provides a step-wise approach to considering and addressing these issues.

Integrating Marine Protected Areas into fisheries management

California has an extensive network of **Marine Protected Areas (MPAs)** that affect fisheries management and **stakeholders**. Accounting for these MPAs when considering how to meet stock and ecosystem-related objectives is a key aspect of MLMA implementation. If successful, integration of the MPA network into fisheries management is expected to provide significant benefits to fisheries and resources alike.

Adapting to climate change

The effects of climate change can pose challenges to fisheries management and underscore the need for adaptive and responsive management that can adjust to changing species distribution and **abundance**, habitat alteration, and impacts to port infrastructure. Targeted research, consideration of multiple **indicators**, and collaborations with stakeholders can help make management better able to adapt to these shifts. Climate change considerations factor into species prioritization, scaled management, identification of appropriate management strategies, **adaptive management** structures, and understanding the effects of management on fishery economics and communities.

Engaging stakeholders

Engaging the public in management, research, and decision-making is a central tenet of the MLMA. Ensuring that engagement is meaningful, cost-effective, and leads to well-supported management requires strategies for tailoring efforts to the needs of specific situations. The Master Plan provides guidance on considering and crafting potential engagements.

Collaborating with partners

California is home to a diverse suite of academic and research institutions, Tribes and tribal communities, engaged stakeholders, cooperating agencies, and a range of supplemental public and private funding sources. Well-designed collaborations can be an important means of increasing the Department's limited **capacity** and allowing for enhanced management. The Master Plan seeks to identify a range of areas where collaboration may be beneficial and the conditions necessary to ensure collaborations can achieve their objectives.

Advancing socioeconomic and community objectives

The MLMA has sustainability as its primary goal but also seeks to promote healthy fisheries (§7056). Understanding the range of stakeholders' economic and community interests is critical to identifying opportunities to enhance profitability during prioritization and creating management measures that have the support of those affected. The Master Plan describes key socioeconomic questions and identifies strategies for obtaining related information as part of the Master Plan's implementation.

Making management adaptive

The ocean is a highly variable environment and, as previously noted, climate change may amplify that variability. Adaptive management can help to ensure that harvest strategies reflect current population levels and ocean conditions and can also effectively respond to future changes to the fishery or resources. Targeted data collection, strategically selected indicators, and responsive decision frameworks can help management be as adaptive and flexible as possible. The Master Plan identifies a range of structures, strategies, and recommendations for meeting the adaptive management objectives of the MLMA.

Using the best available scientific information

The MLMA stipulates that decisions shall be based on the best available scientific information and other relevant information (§7050(b)(6) and §7056(g)) and places significant emphasis on the role of scientific peer review in the development of **Fishery Management Plans (FMPs)**, research protocols, and other documents that have a scientific basis (§7062(a)). The appropriate scope, scale, and timing of scientific peer review, however, needs clarification and guidance to ensure that it is carried out in a consistent way. The Master Plan identifies tiers of potential review and considerations for identifying when each may be appropriate.

Enhancing and scaling Marine Life Management Act-based management

The state's fisheries vary dramatically in terms of their complexity, geographic scope, value, level of participation, and management needs. A comprehensive and complex FMP may not be appropriate for all fisheries. The ability to scale management efforts to the needs and characteristics of a specific fishery is critical to optimizing the use of management resources. FMPs remain an important tool for achieving the objectives of the MLMA, but other tools can be used including **Enhanced Status Reports (ESRs)**, targeted **rulemakings**, and more streamlined FMPs. The Master Plan describes a continuum of management intensity and identifies criteria for determining where a given fishery may fall along the continuum. The goal is to make more efficient and effective use of available tools and resources to implement the MLMA across a wider range of California’s fisheries.

Ensuring the Master Plan is an effective resource and guide

The MLMA emphasizes the need for transparency in management and the importance of communicating with the public regarding management decisions and the condition of fisheries (§7056(h)). However, planning documents like the Master Plan can become outdated over time. The Master Plan describes the use of a new, easy-to-navigate, web-based, central repository for its policies and tools, and for California fisheries information. Its goal is to organize and share the considerable efforts that are already underway by the Department and its partners, and to implement the new strategies described in the Master Plan.

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List of acronyms

ABC	Acceptable Biological Catch
ACL	Annual Catch Limit
APA	Administrative Procedure Act
B_{MSY}	Population Biomass at Maximum Sustainable Yield
B_0	Unfished Biomass
BRD	Bycatch Reduction Device
BWG	Bycatch Working Group
CARE	Comprehensive Assessment of Risk to Ecosystem
CCE	California Current Ecosystem
CDFW	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CFR	Collaborative Fisheries Research
CPFV	Commercial Passenger Fishing Vessel
CPUE	Catch Per Unit Effort
CUSUM	Cumulative Sum
DB-SRA	Depletion-Based Stock Reduction Analysis
DCAC	Depletion-Corrected Average Catch
DLMtool	Data-Limited Methods Toolkit
EBFM	Ecosystem Based Fishery Management
EFI	Essential Fishery Information
EM	Electronic Monitoring
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
ESR	Enhanced Status Report
FAO	Food and Agricultural Organization of the United Nations
FMP	Fishery Management Plan
HCR	Harvest Control Rule
ITQ	Individual Transferable Quotas
LED	Light Emitting Device
MBTA	Migratory Bird Treaty Act
MEY	Maximum Economic Yield
MLMA	Marine Life Management Act
MLP	Marine Life Protection Act
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MRC	Fish and Game Commission's Marine Resources Committee
MSA	Magnuson-Stevens Fisheries Conservation and Management Act
MSY	Maximum Sustainable Yield

MSE	Management Strategy Evaluation
NGO	Non-Government Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OFL	Overfishing Limit
OPC	Ocean Protection Council
OST	California Ocean Science Trust
OY	Optimal Yield
PFMC	Pacific Fishery Management Council
PSA	Productivity and Susceptibility Analysis
RCA	Rockfish Conservation Area
SAFE	Stock Assessment and Fishery Evaluation
SMCA	State Marine Conservation Area
SMP	State Marine Park
SMR	State Marine Reserve
SMRMA	State Marine Recreational Management Area
SPR	Spawning Potential Ratio
TAC	Total Allowable Catch
TAE	Total Allowable Effort
TOR	Terms of Reference
VMS	Vessel Monitoring System
WSSCAP	White Seabass Scientific and Constituent Advisory Panel
YPR	Yield Per Recruit

Acronyms and glossary terms are **bolded** upon first use

Chapter 1 – Introduction

Background

California has a rich fishing culture that is an integral part of the history of the state. The state is also home to vibrant marine ecosystems. The MLMA was designed to safeguard both. Enacted in 1999, the law reshaped the management and conservation of **marine living resources** in California. It identified sustainability of those resources as its primary objective (§7056) and emphasized the need for a comprehensive, ecosystem-based approach to the management of the state's fisheries (§7050(b)(1)). The MLMA also underscored the importance of informed public involvement in decision-making and science (§7056(h)).

The Department monitors hundreds of species of fish, invertebrates, and algae (Appendix C) across the state's 1,100 miles of coastline. Actively managing those species that are most abundant in commercial **landings**, recreational **catch**, and subsistence use requires prioritization and strategic use of limited resources. For that reason, the MLMA requires the Department to develop a roadmap for implementation called the Master Plan. The original Master Plan was adopted by the California Fish and Game Commission (Commission) in 2001 and has helped guide MLMA implementation to date. Since that time however, new tools, insights, and priorities have emerged. The 2018 Master Plan seeks to reflect these changes to enhance implementation of the law.

Section 7073 of the MLMA describes the minimally required elements of the Master Plan. The 2001 Master Plan was largely focused on guidance for the development of FMPs. The amendment process presents an opportunity to consider the full range of the MLMA's objectives (§7056(a-m)) and identify additional tools and strategies that will help achieve its vision of healthy ecosystems, sustainable fisheries and fishing communities, and transparent and strategic management.

The scope of the Master Plan includes marine species found in California ocean waters that are managed solely under state jurisdiction. The management of federal species and those managed jointly with the **National Marine Fisheries Service (NMFS)** and the **Pacific Fishery Management Council (PFMC)** is not addressed by the Master Plan. Provisions of the MLMA related to specific topics are identified and discussed in the chapters that follow. However, it is useful to first provide a brief overview of the MLMA and its implementation to date.

Sustainability

The MLMA's overarching policy is to ensure the conservation, **sustainable use**, and, where feasible, restoration of California's marine living resources (§7050(b)). To achieve this goal, the MLMA calls for allowing only those uses that are sustainable. Section 99.5 defines sustainability as:

> (a) Continuous replacement of resources, taking into account fluctuations in abundance and environmental variability; and
>
> (b) Securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining **biological diversity**, and, in the case of fishery management based on **Maximum Sustainable Yield (MSY)**, taking in a fishery that does not exceed **Optimum Yield (OY)**.

The MLMA also emphasizes the importance of **commercial** and **recreational fisheries** to the culture and economy of California and requires that the effects of conservation and management measures be allocated fairly between both **sectors** (§7072(c)).

Principal strategies

To achieve its goals, the MLMA calls for using several basic tools:

- *FMPs*: Management should be strategic and comprehensive (§7072).
- *Status of the Fisheries Reports*: The Department will prepare reports on the status of California's fisheries and the effectiveness of management programs (§7065 and §7066(c)).
- *Science*: Management is to be based on the best available scientific information and other relevant information. However, a lack of information should not be the basis for continued inaction. Research protocols should be used to identify and acquire **Essential Fishery Information (EFI)**. To help ensure the scientific soundness of decisions, scientific documents should be peer reviewed by experts (§7050(b)(6)).
- *Constituent involvement*: The MLMA directs the Department and the Commission to engage in decision-making that involves all interested parties (§7050(b)(7)).
- *Master Plan*: The Master Plan serves as a roadmap for the implementation of the MLMA, by prioritizing management efforts and providing tools to guide them (§7073).

Implementation to date

After more than 15 years, the MLMA still serves as a strong foundation for guiding management of the state's marine fisheries. The Department has prepared FMPs for White Seabass (2002), 19 species of nearshore finfish (2002), Market Squid (2005), and Spiny Lobster (2016), along with a Recovery and Management Plan for abalone (2005). FMPs for Pacific Herring and the recreational Red Abalone fishery are currently under development. The Rock Crab, California Halibut, and **trawl** fisheries are also expressly required to be managed in ways that are consistent with the MLMA (see respectively §8282, §8494, and §8841). In addition, the Department has developed stand-alone rulemakings to help achieve sustainability in a wide range of other fisheries including Kellet's Whelk, saltwater basses, Pacific Hagfish, Pacific Herring, and sea urchin. While the Department has integrated the core principles of the MLMA into its fishery management practices, it has not always been able to clearly track and demonstrate adherence to the MLMA for fisheries without FMPs.

Future MLMA implementation can benefit from the accumulated experience of the Commission, Department, and stakeholders as well as from recent developments in fisheries management. It is with these lessons, experiences, and innovations in mind that the 2018 Master Plan sets out the goals and strategies below.

Orientation to the 2018 Master Plan

To enhance MLMA implementation, the following goals, objectives and approach have been identified:

Goals

- Enhance the sustainability of the state's ocean fisheries.
- Elevate ecosystem health in decision-making.
- Help promote more efficient, effective, and streamlined fisheries management.
- Establish a clear pathway for improving the management of individual fisheries.
- Set clear expectations for managers and the public.
- Foster transparency and flexibility in fisheries management with Tribes and tribal communities, stakeholders, and interested members of the public.

Objectives

- Provide a clear and consistent management framework that conveys how the MLMA is to be implemented and how key issues will be addressed.
- Establish priorities for fisheries management efforts.
- Consistently apply the MLMA's policies and approaches to a greater number of the state's fisheries.
- Capitalize on new innovations to identify effective fishery management strategies.
- Consistently address the MLMA's **Ecosystem-Based Fishery Management (EBFM)** goals, specifically habitat protection, bycatch management, consideration of forage needs, and the use of **ecosystem indicators**.
- Incorporate consideration of the benefits of MPAs for sustainability into how fisheries are prioritized, how individual fisheries are managed, and how the economic impacts of that management are assessed.
- Increase understanding through prioritized and targeted research and data collection.
- Make management more flexible and adaptive in the face of a changing climate.
- Tailor **stakeholder engagement** efforts in a way that makes more efficient and effective use of their time and expertise.
- Use well-designed collaborations to enhance management capacity, increase buy-in, and improve management.
- Use a more consistent and efficient approach to scientific peer review.
- Design and maintain the Master Plan so that it functions as an adaptive and living guide for MLMA implementation.
- Identify resources needed for effective implementation and design management that is cost effective and reflective of available resources.

Framework

Providing a cohesive approach for applying the strategies above is an essential role of the Master Plan. An overarching framework for MLMA implementation will describe how management efforts should proceed and where specific MLMA policies should be addressed (Figure 1). The framework is based on the listed objectives of the MLMA which are referenced at each step. Full application of this framework will require sufficient resources and a collaborative effort among the Department, the Commission, the Legislature, Tribes and tribal communities, stakeholders, and the public.

The Master Plan provides details on the framework's components and guidance in its application. Chapter 2 outlines the approach to prioritization, Chapter 3 describes a continuum of levels of management, and Chapter 4 discusses how stakeholders should be engaged across those levels. Chapters 5-12 provide guidance on how specific issues and MLMA objectives should be addressed in ESRs, FMPs, and management. Chapter 13 outlines the process for updating and amending the Master Plan.

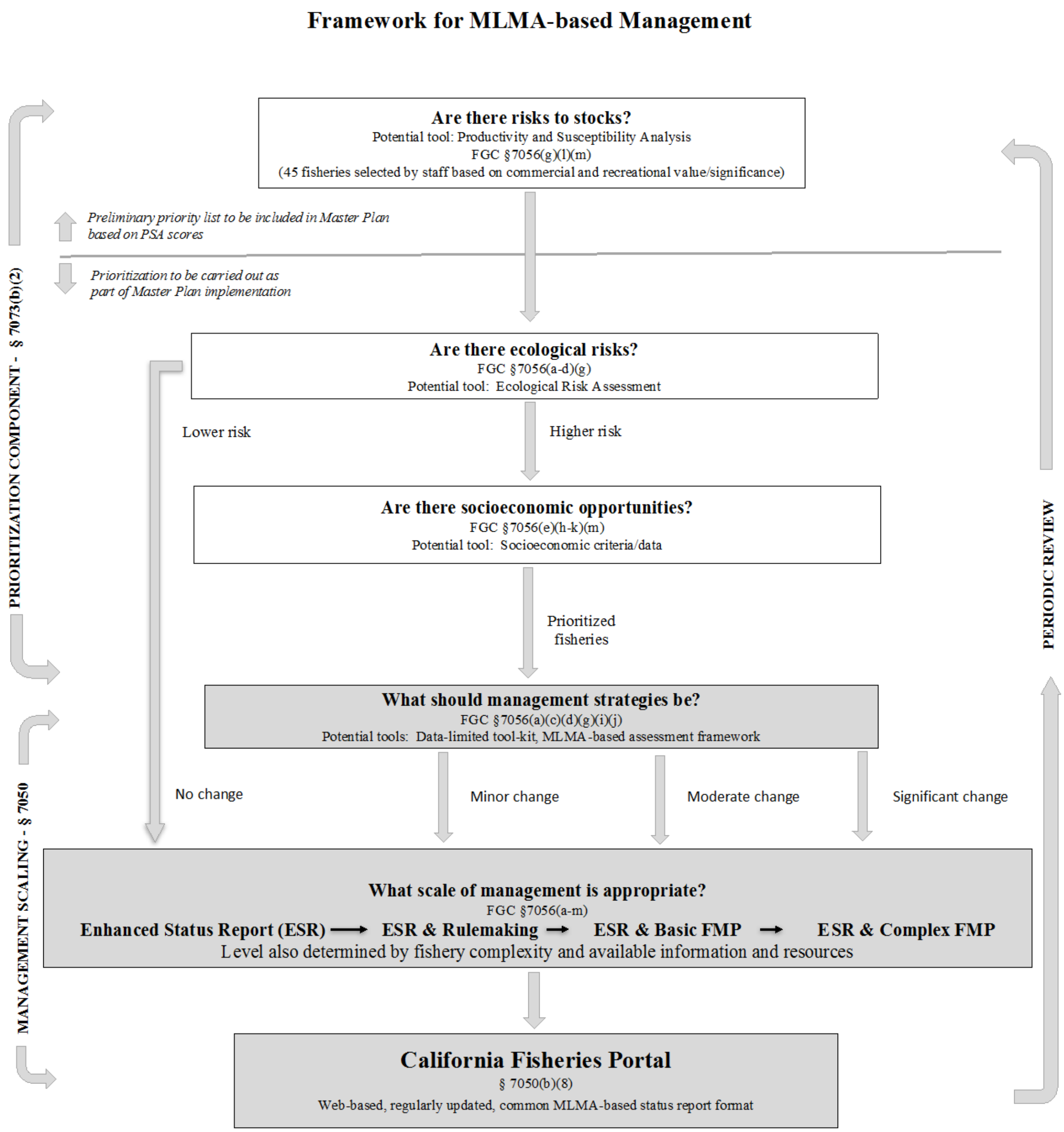


Figure 1. A framework for implementation of the MLMA.

Appendices

The 2018 Master Plan makes significant use of appendices and web links. The main body of the Master Plan provides a high-level overview of topics. However, important details are often in the appendices which are intended to be an additional resource. For example, the main body discusses the value of data-limited **stock assessment** methods, and the appendices describe these methods. The appendices are designed to be updated as new information becomes available and best practices change (see process details in Chapter 13). This approach seeks to keep the Master Plan digestible and allow for updates to help ensure it remains a valuable resource over time.

Guidance

The Master Plan is not prescriptive and does not stipulate specific actions that will be taken. It does, however, contain a wide range of new directions and guidance to help establish a shared set of expectations for how implementation can occur and to guide the Department's efforts.

Glossary and acronyms

Glossary and acronyms are **bolded** on their first use in the Master Plan and detailed definitions are provided in a glossary.

Codes

Unless otherwise specified, the symbol § refers to Fish and Game Code Sections.

Climate change

The Master Plan is primarily structured around achieving the objectives of the MLMA as described above. However, climate change is a growing challenge that was not evident during the crafting of the MLMA. To effectively address climate change, adaptation and flexibility need to be built into the management framework. Climate change is considered in multiple sections throughout the Master Plan and is the focus of a dedicated chapter on climate change-based impacts and management strategies (see Chapter 11).

Marine Protected Areas

California has a network of MPAs, many of which were created under the **Marine Life Protection Act (MLPA)**. These MPAs (and other closures) have implications for fisheries management in a variety of areas including **data-limited** stock assessments, data collection, maintaining stock sustainability, protecting habitat, fishing **effort** capacity, and socioeconomics. MPAs are discussed throughout the Master Plan where relevant. Due to the specific interest and importance of this issue, the Master Plan also includes a dedicated Appendix P that consolidates these concepts into one location.

Workplan

The Master Plan does not stipulate how much is to be accomplished in a specified period. Progress will depend on the resources and capacity that are available for implementation. As part of implementation, the Department will work with the Commission, Tribes and tribal communities, and stakeholders to develop a biennial workplan that will describe what can be accomplished with current resources over a two-year period to help focus effort and establish a shared set of goals and expectations. The workplan will also highlight additional efforts that may be possible with supplemental resources and/or partnerships.

Chapter 2 – Prioritizing management efforts

Given the large number of fisheries under state jurisdiction and limited Department resources, prioritizing management efforts is essential. Section 7073(b) of the MLMA requires the Master Plan to include a priority list of fisheries for the preparation of FMPs; the highest priority is given to fisheries that have the greatest need for changes in management in order to comply with the objectives of the MLMA. The 2001 Master Plan included such a list, however, it proved difficult to focus work solely on priority fisheries. A variety of factors including new and competing mandates, unforeseen events, emergencies, and a changing regulatory landscape hampered the Department's ability to focus efforts exclusively on the priority species. Future prioritization efforts must be made in close coordination with the Commission, Tribes and tribal communities, and stakeholders to ensure there is a shared understanding of how the priorities will be addressed and what resources will be required. It will also be important to establish a shared understanding for when it may be necessary, or desirable, to shift focus away from and/or reevaluate the existing list of priorities. Criteria for considering new priorities are provided below.

Potential approaches to prioritization vary in scope and intensity. The 2001 Master Plan used a method that focused on the **vulnerability** of specific stocks to fishing. However, the MLMA includes other objectives related to the potential impacts of fisheries to habitat and bycatch species, and socioeconomics, which should also be considered when identifying priorities. A prioritization framework that addresses the full range of MLMA objectives should be adopted by the Commission as part of the Master Plan before it is applied. As such, this Master Plan includes both an updated interim priority list to guide near-term Department efforts and to satisfy the requirements of Section §7073, and a framework for more comprehensive prioritization to be conducted as the plan is implemented.

In order to develop the initial priorities described below, the Department identified 36 **finfish** and invertebrate species that are the target of 45 distinct fisheries for initial prioritization. While these 36 species are only a small subset of the hundreds of species under state jurisdiction, the Department selected them for analysis because they represent the vast majority of commercial **landings** value, as well as commercial and recreational participation. These 45 fisheries include specific gear types targeting a single species. For example, the halibut trawl fishery is considered separately from the halibut **gill net** fishery. This is because different gear types are often deployed in different areas and with varying impacts. Note that in order to focus the initial analyses, not all gear types targeting the selected species were included. However, once these initial fisheries have been addressed through the prioritization and management framework depicted in Figure 1, additional fisheries may be selected for analysis.

Interim priority list

The 45 fisheries were evaluated using an established method known as a PSA, which identifies the relative risk fishing may pose to each fishery (Patrick et al. 2009). That relative risk was assessed first by a consultant (MRAG Americas) then reviewed and adjusted by Department subject matter experts, using relative scaling scores ranging from 1 to 3 for two sets of attributes. The first set of attributes measures the **productivity** of the species, which is derived from life-history characteristics such as age at maturity and trophic level. The second is susceptibility which includes, for example, overlap of a species' distribution with fishing effort. This set is designed to assess the species' response to fishing pressure. The PSA metrics are combined to calculate the relative vulnerability of each fishery, relative to other state-managed fisheries, using a prescribed formula. The PSA also includes an index that scores the quality of information and the level of confidence in each attribute.

A PSA does not provide information on the current status of a stock and does not specify harvest guidelines or management actions. Instead, the main purpose of the PSA is to identify fisheries that are likely to be more vulnerable to a particular method of fishing. It also identifies fisheries with more data gaps than others through the inclusion of a data quality factor. The full results, additional details on the methodology, and the interim priority list are available at http://www.oceansciencetrust.org/wp-content/uploads/2017/07/CDFW-PSA-Report-on-Select-CA-Fisheries_Final-.pdf. The relative PSA scores were used to bin the 45 fisheries into low, medium, and high priorities as provided in Table 1 below.

Table 1. Interim priority list based on PSA results.

Priority	Fishery - *(C) commercial (S) sport*	Gear
High	Pacific Angel Shark (C)	Gill net
	Brown Smoothhound Shark (S)	Hook-and-line
	Ocean Whitefish (S)	Hook-and-line
	Giant Red Sea Cucumber (C)	Trawl
	White Sturgeon (S)	Hook-and-line
	CA Spiny Lobster (C)	Trap
	CA Spiny Lobster (S)	Hoop net
	CA Sheephead (C)	Trap
	Kelp Bass (S)	Hook-and-line
	CA Sheephead (S)	Hook-and-line
	Barred Sand Bass (S)	Hook-and-line
	Spotted Sand Bass (S)	Hook-and-line
	Pacific Herring (C)	Gill net
	White Seabass (C)	Gill net
	Red Abalone (S)	Abalone iron
Medium	Pink Shrimp (C)	Trawl
	CA Barracuda (S)	Hook-and-line
	CA Barracuda (C)	Hook-and-line
	Geoduck Clam (S)	Clam fork
	CA Halibut (C)	Gill net
	CA Halibut (C)	Trawl
	CA Halibut (C)	Hook-and-line
	CA Halibut (S)	Hook-and-line
	Market Squid (C)	Purse seine
	CA Bay Shrimp (C)	Beam trawl
	White Seabass (S)	Hook-and-line
	Barred Surfperch (S)	Hook-and-line
	Warty Sea Cucumber (C)	Diver
	Spot Prawn (C)	Trap
	Red Sea Urchin (C)	Trap
Low	Kellet's Whelk (C)	Trap
	Redtail Surfperch (C)	Hook-and-line
	Ridgeback Prawn (C)	Trawl
	CA Corbina (S)	Hook-and-line
	Pacific Hagfish (C)	Trap
	Bonito (S)	Hook-and-line
	Bonito (C)	Hook-and-line
	White Croaker (S)	Hook-and-line
	Pismo Clam (S)	Clam fork
	Brown Rock Crab (C)	Trap
	Night Smelt (C)	A-frame
	Dungeness Crab (C)	Trap
	Dungeness Crab (S)	Trap
	Shiner Seaperch (C)	Trap
	Jacksmelt (C)	Hook-and-line

This interim priority list can help guide Department efforts while the more comprehensive prioritization approach described below is implemented.

Comprehensive prioritization framework

Prioritizing fisheries based on a fuller suite of MLMA objectives will require looking beyond an assessment of just risks to target stocks. To advance the objectives identified in the MLMA, the prioritization framework should:

- Provide a clear and systematic means of utilizing best available science and other relevant information to guide use of limited Department resources in managing the state's fisheries consistent with the MLMA.
- Identify target populations and/or ecosystem features at relatively greater risk from fishing.
- Identify where current management is inconsistent with the policies and requirements of the MLMA, and how those inconsistencies overlap with the ecological risks that have been identified.
- Advance socioeconomic and community objectives in a manner consistent with the MLMA's definition of sustainability.
- Be robust and clear enough for stakeholders to understand and for the Department to implement.
- Provide a strategic means of addressing emerging fisheries without unduly displacing existing priorities.
- Allow for re-evaluation when deemed necessary or at least every five years.

In addition to the sustainability of the target stock, the MLMA is concerned with impacts to habitat and bycatch species. Section 7084 and §7085 are aimed at minimizing the impacts to habitat and bycatch, respectively. In the years since the original Master Plan was adopted, new tools have been developed that can help.

Ecological Risk Assessment

A diversity of **Ecological Risk Assessment (ERA)** frameworks have been developed and used to prioritize management efforts across the globe. These frameworks consider a broader range of risks than a PSA. Specifically, they can examine the following:

- The impact from fishing activity to **target species** (similar to a PSA)
- The risk from fishing activity to bycatch species
- The risk from fishing activity to habitats which it encounters
- Aspects such as the potential benefits to the resource and the fishery from California's network of MPAs

ERAs are similar to PSAs in concept, but may use a broader range of attributes. The **California Ocean Science Trust (OST**) conducted a review of available ERA frameworks worldwide and considered certain approaches appropriate for California. Drawing from this experience, the Department will integrate the PSA and ERA tools into the prioritization process in a way that capitalizes on their respective strengths. Specifically, for potential risk to target fisheries the Department will use the PSA scores with the addition of four attributes from the target species component of the ERA (estimated fishing **mortality** rate, population connectivity, temporal intensity of fishing, and potential benefits from MPAs). For habitat and bycatch, the Department will use the ERA as developed and piloted by OST, and modified by Department and stakeholder input. The pilot ERA process scored 9 of the 45 fisheries that were previously analyzed using PSA. Once the four additional target attributes and bycatch and habitat ERAs are completed for the remaining 36 fisheries, scores will be presented as three groups (low, medium, and high relative risk). Additional details and considerations associated with the ERA can be found at http://www.oceansciencetrust.org/projects/era/.

Application of this approach should provide opportunity for stakeholder input and the results should be used to categorize fisheries into low, medium, and high risk from a biological and ecological perspective. Low-risk fisheries will not require further evaluation or new conservation measures, and current management can simply be characterized through an ESR as described in Chapter 3. High-risk fisheries will be further prioritized based on socioeconomic opportunity as described below. (See also Figure 1.) If an FMP-managed species is identified as high risk, an FMP amendment may be necessary to address those risks.

Climate change

In California and elsewhere, efforts are underway to develop and evaluate tools that assess species' vulnerability and that incorporate risk from climate change into ERAs. Results from such assessments will provide valuable information for categorizing fisheries' level of risk. Until such results are available, the Department will consider augmenting the ERA results with information garnered through other efforts (e.g., federal climate vulnerability assessments of similar species).

Socioeconomics

Among the fisheries that are identified as high priority from an ecological/biological perspective, management efforts should first be directed towards those where ensuring sustainability has the highest economic value to the state. These will generally be fisheries with high commercial value and participation, and/or high recreational participation levels. However, an approach based on just value and participation could result in missed opportunities for the Department to achieve socioeconomic goals. Therefore, the Department will consider augmenting value and participation data with its own understanding of the socioeconomic goals of the fisheries. Additionally, consideration of community vulnerability indices and other human dimensions indicators such as those generated by the **National Oceanic and Atmospheric Association (NOAA)** on the West Coast, can help identify vulnerable ports and regions and provide additional insight into where management action may have the most benefit (see: https://swfsc.noaa.gov/publications/CR/2014/2014Breslow.pdf).

Priority list

Provided that adequate resources and/or funding are available, the Department will apply the comprehensive prioritization framework described, generate a priority list of fisheries, and provide it to the Commission within one year of plan adoption. The priority lists should be evaluated no less than every five years, and if necessary, the prioritization framework should be re-applied.

The information gathered through the PSA, ERA, and socioeconomic analyses described above can also help inform management action with specific fisheries. Whatever form that management action takes, these analyses help provide background information, identify data gaps, and aspects of a fishery that may need management attention. Therefore, as these analyses are conducted, information will be generated, structured, and retained with this additional goal in mind.

Consideration of emerging and emergency issues when implementing priorities

The priorities set through the process described above will help guide implementation efforts. However, changes in fisheries may occur that require special attention and a departure from these priorities. In order for the priority list of fisheries to be meaningful, new or emerging issues should be considered in light of existing priorities, staffing, and other resources. Emergency issues (as defined by Government Code §11346.1(b) and Fish and Game Code §5523, §5654, and §7710) requiring immediate attention will inevitably arise. However, the Department and the Commission should evaluate more discretionary efforts based on the following:

- Does the proposed new priority require immediate action in order to address sustainability or conservation concerns? If so, how?
- Does the proposed new priority require immediate action in order to address serious economic hardship to fishery **participants**? If so, how?
- Do current conditions create a unique or one-time opportunity to address the proposed new priority? If so, how?
- Does the fishery that is the subject of the proposed new priority appear on the current prioritization list? If so, where does it rank?
- Do available data allow for effective decision-making on the proposed new priority?
- How does the proposed new priority advance the goals of the MLMA?
- Are partnership opportunities available to help address the issue and reduce Department resource requirements?
- What would accomplishing the proposed new priority require (FMP, rule promulgation, research, etc.), and what are the required staff, time involved, and other resources?
- What existing priorities on the Department's work plan would have to be eliminated or postponed in order to address the new priority?

Whether it is the Department, the Commission, Tribes and tribal communities, or stakeholders that are proposing the new priority, the proposal or directive to address the new priority should be accompanied by responses to these inquiries. This will help ensure that any deviations from the existing priority list are deliberate, strategic, and serve to advance the goals of the MLMA.

Chapter 3 – Scaled management

Four FMPs have been prepared and implemented since the MLMA was adopted: White Seabass, nearshore finfish (19 species), Market Squid, and Spiny Lobster. FMPs for Pacific Herring and the recreational take of Red Abalone are currently under development. Controversy and complexity in these fisheries led to intense FMP development efforts and high demands on the Department. Each took three to five years to complete, and cost between an estimated 1 million and 11 million dollars. As a result of these intensive processes focused on a few species, most of the state's fisheries have not fully benefited from all the provisions of the MLMA. There is a clear need to identify additional cost-effective approaches to apply the appropriate level of MLMA-based management more broadly and consistently across California's fisheries.

To develop and implement cost-effective FMPs in the future, management approaches and the scope of the public process used to develop them will need to be scaled to the specific fishery. Traditional, resource-intensive FMPs will remain an important tool and an effective way to address the management needs of high-risk or complex fisheries. However, it may not be appropriate or necessary to undergo a complex and comprehensive FMP process for a single-sector fishery whose current management framework already meets the sustainability provisions of the MLMA. Management scaling can extend the MLMA's benefits to a greater number of fisheries in a way that is consistent and explicit.

Current management

In addition to the Master Plan, there are two principal documents that the MLMA identifies for implementing its policies and managing fisheries: Status of the Fishery Reports (status reports) and FMPs. Status reports are overviews of a fishery (including annual landings or catch information), the species' biology, and current management, **monitoring**, and assessment efforts. The MLMA requires the Department to prepare these reports for the sport and commercial marine fisheries managed by the state and is encouraged to partner with outside experts in generating them (§7065(b)). The first status report covering all of California's state-managed living marine resources was published in 2001 and updates were published in 2003, 2006, 2008, and 2011 for some fisheries. (See: https://www.wildlife.ca.gov/Conservation/Marine/Status)

In addition to developing status reports and FMPs, the Department also engages in regular rulemakings to address specific issues. Rulemakings and accompanying analyses are currently required to meet the provisions of the **Administrative Procedure Act (APA)** and the **California Environmental Quality Act (CEQA)**, and efforts are made to address the applicable goals and requirements of the MLMA for the specific regulatory action being taken.

Design principles for management scaling

The current approach can be adapted to apply the MLMA more explicitly to a greater number of the state's fisheries. The design principles below are provided to help guide the management scaling approach towards that goal.

The management scaling strategy should:

- Match the level of management effort with the needs of the fishery, the availability of information useful for management, the Department's capacity, and the interests of stakeholders and the Commission.
- Increase MLMA-based management and create a foundation for MLMA implementation across a broader number of fisheries.

- Be adaptive and identify potential triggers/conditions when a fishery may need more or less intensive management.
- Use assessments to identify the potential management needs of fisheries.
- Provide increased transparency regarding current management efforts and gaps in science and management.
- Be focused on the priorities identified in Chapter 2.
- Make strategic use of collaborations and stakeholder engagement.

Defining the management scale

Fisheries vary significantly in terms of the appropriate intensity of management effort. The scaling concept shown in Figure 2 reflects this range. Figure 2 depicts the basic levels of management responses that might be appropriate for a given fishery under the MLMA. This ranges from an ESR for relatively low-priority species, to a complex FMP for fisheries that are relatively high priority and more complex. The appropriateness of each level is discussed in detail below.

What scale of management is appropriate?

FGC §7056(a-m)

Enhanced Status Report (ESR) → **ESR & Rulemaking** → **ESR & Basic FMP** → **ESR & Complex FMP**

Level also determined by fishery complexity and available information and resources

Figure 2. The management continuum.

Enhanced Status Reports

The base of the continuum is an ESR that systematically addresses the objectives and requirements of the MLMA. Section 7065(b) describes general topics that shall be addressed in status reports including "landings, fishing effort, areas where the fishery occurs, and other factors affecting the fishery as determined by the Department and Commission."

Status reports are currently less effective than they could be in demonstrating management's consistency with the goals of the MLMA. Within the required subject areas, status reports include varying types of information that are not always relevant to management or stakeholders. Currently, status reports are infrequently updated and are not stored or displayed in a way that maximizes their use or takes advantage of web-based technologies.

ESRs may help to better achieve MLMA goals by being more structured, robust, current, and easily accessed. The revised format below purposely aligns itself with the MLMA's requirements for an FMP. The format includes a summary of the available information under each required segment, with a focus on relevance to management. This revised format ensures that a basic standard of MLMA-based management is applied across all fisheries in a consistent fashion. It summarizes all of the available EFI for each fishery, and makes it readily apparent what is not available.

ESRs should follow the following outline:

1. **The fishery**
   Fishing
   - Species of fish and location of the fishery (§7080(a))
   - Number of vessels and participants over time (§7080(a))
   - Historical landings in the sport and commercial sectors (§7080(a))
   - Economic factors (including landing and **permit fees**) related to the fishery (§7080(e))
   - Social factors related to the fishery (§7080(e))

   The species
   - Natural history of the species (§7080(b))
   - Population status and dynamics (§7080(b) and §7081(b))
   - Effects of changing oceanic conditions on the target species (§7080(b))

   The ecosystem
   - Ecosystem role of the target species (§7080(d))
   - Habitat for the fishery and known threats (§7080(c) and §7084(a))
   - Information on the amount and type of bycatch and analysis of sustainability (§7085)

2. **Current management**
   Past and current management measures
   - History of conservation and management measures (§7080(a))
   - Existing conservation and management measures that contribute to a sustainable fishery (§7080(a))
   - Limitations on fishing for target species (§7082(a))
   - Criteria to identify when fisheries are **overfished** or subject to overfishing, and measures to rebuild (§7086)
   - Measures to reduce unacceptable levels of bycatch (§7085(c))
   - Measures to minimize any adverse effects on habitat caused by fishing (§7084(a))
   - Description of and rationale for any **restricted access** approach (§7082(b))
   - The procedure to establish and periodically review and revise any catch **quota** (§7082(c))
   - Requirements for person, gear, or vessel permit and reasonable fees (§7082(d))

3. **Monitoring and EFI** (research protocol)
   - Past and ongoing monitoring of the fishery (§7081(a))
   - Steps to take to monitor the fishery (§7081(c))
   - Steps to obtain EFI (§7081(b))

4. **Future management needs and directions**
   - Research, including **Collaborative Fisheries Research (CFR)** opportunities
   - Data modernization/standardization
   - Management
   - Stakeholder engagement
   - **Climate readiness**

ESRs can be a repository of information documenting the consistency of a fishery's management with the MLMA. They can also serve as sources of information for future analyses and inform FMP development. Given that ESRs serve to focus additional management efforts that may be needed, they should be generated for a fishery before an FMP is developed for that fishery. Up-to-date ESRs should also be generated and maintained for species managed under FMPs.

The information gathered as part of the prioritization process described in Chapter 2, as well as through application of the MLMA-based assessment framework described in Appendix D, can be used to populate some key elements in ESRs. For example, the MLMA-required information on the target species overlaps with the information necessary to determine a productivity score as part of the PSA, and information on the fishery and current management are similar to that needed to determine the susceptibility score. The sections of the ESR on ecosystem impacts and bycatch management correspond with the information necessary to complete the ERA. The MLMA-based assessment framework can help inform the discussion on future needs and directions. Nevertheless, some information will usually be lacking for at least some element of the ESR outline. Missing information should not prevent the development of an ESR for a given species. Gaps in management or understanding should simply be identified as areas needing further attention. The identification of these gaps can also help focus the research efforts of outside partners, and CFR efforts in particular (see Chapter 8).

As depicted in Figure 1, these ESRs can be used to create a web-based fisheries portal that organizes and presents ESRs in a way that is easy to navigate. The fisheries portal also presents an opportunity to provide mapping and data querying tools as well as a place to convey the policies and approaches of this Master Plan.

Enhanced Status Reports plus focused rulemakings

For low-priority fisheries, no additional management activities may be necessary in the near-term and an ESR may be adequate. However, other fisheries may need to adjust management measures to address specific concerns, but at a level that does not warrant a comprehensive overhaul of its management through an FMP (see following section). For these fisheries an ESR plus a tailored rulemaking may be an effective combination.

Regulatory documents developed for the rulemakings can be a source of additional material to address some of the FMP elements related to new conservation measures described below. Specifically, these include the elements focused on new management measures and their anticipated effects. When these elements are addressed and integrated into the ESR, the ESR will contain many of the principal components of an FMP.

Scaled Fishery Management Plans

In cases where the degree of management change, fishery complexity, and information needs are high, and a comprehensive management approach is required, an FMP is appropriate. In these situations, FMP preparation can be streamlined by using material from the ESR as a foundation. The additional MLMA requirements that pertain specifically to new conservation and management measures (§7082–§7086) will then need to be addressed. Although an FMP is a more involved process, it provides an opportunity to address more complex issues, consider multiple sectors, and allow existing statutes and regulations to be rendered inactive if they conflict with the FMP. FMP development is also an opportunity to consider the appropriateness of various forms of fisheries **co-management** as required by (§7059(b)(3)).

Below is an FMP outline that builds upon the ESR outline and adds FMP requirements set forth in Chapter 7 of the MLMA. Elements four through seven are additions to, or modifications of, what will already be contained in the ESR.

1. **The fishery** (*included in ESR*)
   Fishing
   - Species of fish and location of the fishery (§7080(a))
   - Number of vessels and participants over time (§7080(a))
   - Historical landings in the sport and commercial sectors (§7080(a))
   - Economic factors (including landing and permit fees) related to the fishery (§7080(e))
   - Social factors related to the fishery (§7080(e))

   The species
   - Natural history of the species (§7080(b))
   - Population status and dynamics (§7080(a) and §7081(b)))
   - Effects of changing oceanic conditions on the target species (§7080(a))

   The ecosystem
   - Ecosystem role of the target species (§7080(d))
   - Habitat for the fishery and known threats (§7080(c) and §7084(a))
   - Information on the amount and type of bycatch and analysis of sustainability (§7085)

2. **Current management** (*included in ESR*)
   Past and current management measures
   - History of conservation and management measures (§7080(a))
   - Existing conservation and management measures that contribute to a sustainable fishery (§7080(a))
   - Limitations on fishing for target species (§7082(a))
   - Criteria to identify when fisheries are overfished or subject to overfishing, and measures to rebuild (§7086)
   - Measures to reduce unacceptable levels of bycatch (§7085(c))
   - Measures to minimize any adverse effects on habitat caused by fishing (§7084(a))
   - Description of and rationale for any restricted access approach (§7082(b))
   - The procedure to establish and periodically review and revise any catch quota (§7082(c))
   - Requirements for person, gear, or vessel permit and reasonable fees (§7082(d))

3. **Monitoring and EFI** (research protocol) (*included in ESR*)
   - Past and ongoing monitoring of the fishery (§7081(a))
   - Steps to take to monitor the fishery (§7081(c))
   - Steps to obtain EFI (§7081(b))

4. **New conservation and management measures** (*not included in ESR*)
   - Limitations on fishing for target species (§7082(a))
   - Overfishing criteria and measures (§7086)
   - Measures to reduce unacceptable levels of bycatch (§7085(c))
   - Measures to minimize any adverse effects on habitat caused by fishing (§7084(a))
   - Creation or modification of a restricted access fishery (§7082(b))
   - A procedure to establish and periodically review and revise a catch quota (§7082(c))
   - Requirements for person, gear, or vessel permit and reasonable fees (§7082(d))

5. **Anticipated effects of additional management measures** (*not included in ESR*)
   - On fish populations (§7083(b))

- On habitats (§7083(b))
- On fishery participants (§7083(b))
- On Tribes and tribal communities, coastal communities, and businesses that rely on the fishery (§7083(b))

6. **Future management needs and directions** (*as revised from ESR*)
   - Research, including CFR opportunities
   - Management
   - Stakeholder engagement
   - Climate readiness

7. **Review and amendment procedures** (*not included in ESR*)
   - Procedure for review and amendment of the plan (§7087(a))
   - Types of regulations that the Department may adopt without a plan amendment (§7087(b))

While all FMPs are at the high end of the management continuum, they do not all require the same amount of resources, time, or engagement. The need for a cost-effective way to advance MLMA implementation has led to discussion focused on the concept of streamlined FMPs or "FMP-lites".

Providing less intensive FMP options is essential, but none of the required elements described in Chapter 7 of the MLMA can be excluded. Nevertheless, the level of detail of the document and the extent of the process needed to develop it can be tailored to match the needs of the fishery. A fishery with multiple sectors will require a more substantial discussion and analysis to address the distinct issues of each sector. Similarly, a fishery facing resource constraints or controversial **allocation** decisions will require an FMP developed through a more significant public process (strategies for that engagement are addressed in Chapter 4).

Determining where a fishery falls on the continuum

There is no clear distinction between what constitutes a basic and a complex FMP. It is a continuum defined by the scope and scale of the document, and the level of public process required. Every fishery will be unique, but considerations for identifying where on the continuum a fishery may fall are provided here.

The management continuum shown in Figure 2 aims to identify a range of MLMA-based management options. Identifying the scale appropriate for a given fishery's management depends on 1) the degree of management change required to ensure sustainability and improve consistency with the MLMA; and 2) the complexity of the fishery. These are addressed separately below.

What degree of management change is needed?

Determining the degree of management change needed involves identifying the range of management actions that may be needed. A number of tools can help inform this determination. First, the results from the PSA and ERA analyses developed through the prioritization process can help identify areas of relative risk. Second, information on species' climate vulnerability as it becomes available will provide additional insights regarding risk. Third, frameworks such as the MLMA-based assessment framework described in Appendix D can help identify where management may be inconsistent with the goals of the MLMA. Finally, the quantitative assessment tools and approaches described in Chapter 5 can assist in identifying the degree of management change that may be necessary to achieve the sustainability and socioeconomic goals for the fishery. A change in decision-making framework, or from effort- to catch-based controls, may constitute a major change. Examples of relatively minor changes may include a modification to the gear used in a fishery or changing a season or **size limit**.

How complex is the fishery?

In addition to the anticipated degree of management change, the level of complexity of the fishery will influence how extensive the public process will be, as well as the scope and scale of the resulting management document. Each fishery will vary in terms of the scope, amount, and form of stakeholder engagement.

Complexity criteria include the following:

- Number of gear types
- Number of sectors
- Extent of geographic distribution of the fishery
- Number of participants
- Interjurisdictional issues
- Fishery demographics
- Competing regional or port perspectives
- Mobility of the fishery
- Allocation issues
- Bycatch issues
- Stock conditions (healthy, **depressed**, **depleted**)
- Critical ecosystem interactions
- **Limited entry** or permitting issues
- Degree of stakeholder interest and variety of stakeholder views
- Sources and quality of information on which to base management

Taken together, these factors can be used to help identify where on the continuum a fishery may be most appropriately managed. When an FMP is deemed necessary, these factors can help the Department understand the level of resources and staff effort that will be needed. Figure 3 below provides an overarching view of the management scaling framework.

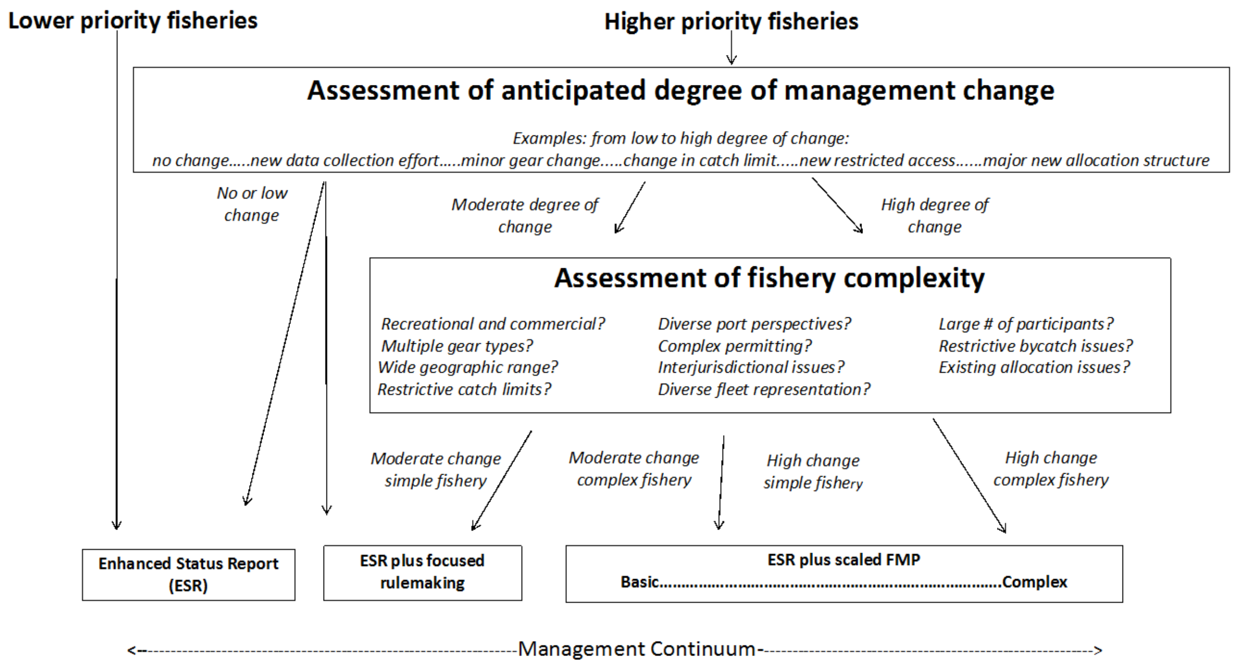


Figure 3. Scaling management efforts.

Increasing efficiency and capacity

Regardless of where on the scale a fishery is, there is opportunity to improve efficiencies and leverage outside resources. Developing the four existing FMPs was a learning process for the Department, the Commission, and stakeholders. After the first three FMPs significantly impacted the Department's limited resources, there was a move to procure outside funding, as well as to outsource individual pieces of subsequent FMPs. However, the Department retained oversight of the processes and the products produced. The FMP processes for Spiny Lobster (completed) and Pacific Herring (in progress) are good examples of leveraging outside funding to advance MLMA implementation while minimizing costs to the Department.

While effective stakeholder engagement is a central goal of the MLMA, it can also be one of the most resource-intensive aspects of the management process. Efficiencies can be gained by carefully focusing engagement on the areas of highest relevance to stakeholders and where their expertise is most informative. Chapter 4 addresses stakeholder engagement in more detail.

There are also opportunities for increasing efficiency through effective process design. For example, creating ESRs as a first step in implementing the Master Plan allows the Department to flag missing EFI in fisheries that have been prioritized for additional management action. This provides an opportunity for the Department to work with outside partners to incentivize the collection of this information. ESRs can also facilitate FMP development efforts by identifying gaps in understanding and management. Finally, strategically focused and timed peer review can provide a solid scientific foundation early in the management process, enabling managers and stakeholders to evaluate management options that are supported by the best available scientific information and other relevant information. Chapter 10 provides guidance on the appropriate scope, scale, and timing of effective scientific peer review under the MLMA.

Chapter 4 – Stakeholder engagement

Engaging stakeholders in the management process is a central theme of the MLMA and can be a critical factor to the long-term success of any management strategy. Effective stakeholder engagement is important to help ensure that stakeholders with relevant local knowledge, and who are most likely directly affected by regulatory changes, are provided the opportunity to be involved in the management process. By adhering to core stakeholder engagement principles, the Department and stakeholders can build trust, create resilient relationships, and increase buy-in for—and ultimately **compliance** with—marine resource management decisions. Best practices and considerations associated with the use of various engagement strategies are drawn from an overview of stakeholder engagement strategies developed to inform the Master Plan amendment (Kearns & West and Center for Ocean Solutions 2017).

Requirements related to stakeholder engagement

In addition to the policies of the MLMA, the Department and the Commission are subject to a variety of other procedural and public participation mandates designed to inform and protect the public's interests. These include CEQA, the APA, and the Bagley-Keene Open Meeting Act. Among their other provisions, these Acts define a minimum level of stakeholder engagement, primarily focused on advanced notice of public hearings and the process for providing public comment. The MLMA builds on the foundation created by these requirements by directing the Department to engage with stakeholders throughout the decision-making process. Section 7059 places significant emphasis on the importance of collaboration and directs the Department to involve interested parties when developing FMPs, status reports, and research plans. It also states that the Department shall periodically review fishery management efforts with a view to improving communication, collaboration, and dispute resolution, seeking advice from interested parties as part of the review.

Key stakeholder engagement principles and guidance

Five overarching principles should be integrated into any stakeholder engagement strategy under the MLMA (Kearns & West and Center for Ocean Solutions 2017):

1. Engage early and often
2. Set clear goals
3. Build relationships
4. Ensure openness
5. Pursue inclusivity

The Department will draw on these key principles when selecting and implementing stakeholder engagement strategies. Table 2 provides details on each principle and provides guidance for applying them.

Every outreach strategy will involve trade-offs. The challenge is to select the most appropriate approach given engagement goals and timing, stakeholder audiences, and available resources.

Table 2. Five key stakeholder engagement principles and implementation guidance (adapted from Kearns & West and Center for Ocean Solutions 2017).

Principle	Description	Why implement?	Guidance to implement in practice
Engage early and often	Engaging stakeholders early and often identifies the boundaries of stakeholder values and preferences around management issues and strives to ensure that management alternatives remain in the public interest.	Early public involvement can reduce delays in the approval process and the likelihood of issues becoming contentious. Engaging stakeholders early can also nurture trust, expand management options, improve communication, improve process efficiency, enable conflict management, and increase representation.	✓ Involve stakeholders in defining the management problem; decision-making reflects the interests and concerns of stakeholders at that time. ✓ Involve stakeholders before management alternatives are identified and solidified to ensure all viable options are on the table ✓ Use consistent mechanisms for updating and engaging stakeholders in the decision-making process (e.g., town hall meetings, website is updated regularly). ✓ Employ engagement strategies over a time frame during which stakeholders can feasibly influence the management decision (e.g., stakeholders are contacted 1-2 months ahead of an engagement opportunity that will inform decision-making; stakeholders are engaged before management decisions are made).
Set clear goals	Setting goals helps ensure that managers and stakeholders work towards a common endpoint.	Clear goals, roles, and responsibilities for stakeholder engagement, particularly when established in collaboration with stakeholders, improve clarity around decision-making expectations and opportunities for public participation.	✓ Involve stakeholders in identifying clear long- and short-term planning and agency management goals (measurable, achievable, and specific). ✓ Have clear goals for stakeholder engagement (e.g., goals based on this checklist). ✓ Employ metrics to determine the efficacy of stakeholder engagement and adapt strategies over time based on this evaluation.
Build relationships	Building key relationships can strengthen trust by putting a human face to management actions, connecting agency staff to communities through key communicators, and increasing understanding between managers and stakeholders.	Relationships and agency visibility contribute to public acceptance and allow timely response to pressing stakeholder concerns, creating social resilience around management decision-making.	✓ Respond to or contact stakeholders individually, and meet in-person when requested or appropriate. ✓ Acknowledge and recognize stakeholders for their efforts to engage. ✓ Interact with stakeholders informally in community settings.
Ensure openness	Openness ensures the goals, motivations, and activities for management decision-making are communicated publicly, and ensures that engagement processes are clearly documented. The public should be aware of how they can, and cannot, influence outcomes, and how their	Openness around decision-making processes builds trust and interest in contributing. It also helps establish stakeholder expectations and illuminates where interpretation or understanding may differ across stakeholders. Clarity in messaging is critical for reducing public	✓ Provide mechanisms for stakeholders to easily identify the status of the decision-making process and how they may engage proactively (website, listservs). ✓ Clearly and openly communicate why and how the management decision is made (i.e., who will make the final decision, what is the role of stakeholders and marine resource users in the decision-making process, what information was used to influence the decision, how the

Principle	Description	Why implement?	Guidance to implement in practice
	perspectives were ultimately considered within decision-making.	misunderstanding, negative views, and distrust of agency actions.	decision will lead to optimal outcomes for the public as well as the Department). ✓ If information is withheld, communicate the reasons for doing so to stakeholders. ✓ Use clear, simple, and accessible language (e.g., language, structure, vocabulary); employ analogies and real-world examples in communications. ✓ If a mistake is made, admit it. Rectify it as soon as possible, and establish processes and procedures to help avoid future errors. ✓ Provide clear rationale and need for stakeholder participation (e.g., stakeholders will be able to contribute to management goal-setting, invitations to engage clearly state how participation is in the stakeholders' best interest).
Pursue inclusivity	Ensuring an inclusive and public process is critical for informed decision-making.	The exclusion of voices can limit the information available to inform decision-making and stakeholder buy-in.	✓ Engage a representative cross section of stakeholder interests affected by the management decision and confirm this selection with the affected communities. ✓ Disseminate information in the languages and formats that all potential stakeholders can understand.

Selecting an effective stakeholder engagement approach

Appendix E includes an inventory of potential engagement strategies (i.e., advisory bodies, townhall meetings, listservs, etc.), as well as resources necessary for their use. Identifying which strategy, or combination of strategies, to employ is driven by several factors. These factors include the following:

1. Potential goals of engagement
    a. *Inform stakeholders*: Educate the affected communities regarding potential or pending regulatory changes or general management efforts.
    b. *Solicit input*: Understand the perspectives of various stakeholders and capitalize on their expertise.
    c. *Involve stakeholders in two-way dialogue to inform management decisions*: Collaborate to develop alternatives.
    d. *Build trust*: Develop a mutual understanding of objectives and transparency regarding the efforts to achieve them.

2. Timing of stakeholder involvement in the planning process (e.g., early, middle, or late phases of the planning or regulatory or implementation process)

3. Stakeholder characteristics
    a. Are the stakeholder communities well defined?
    b. Do organized institutions exist within the fishery?
    c. What is the relative capacity for engagement?
    d. Are there leaders within the fishery?
    e. What is the geographic size and geographical distribution of the fishery?
    f. Are there any language barriers?
    g. To what extent do the stakeholder communities use email and social media?
    h. What is the history of engagement with the stakeholders' communities on regulatory or other issues?

These considerations should also be weighed against additional opportunities and constraints such as the following:

- Whether resources such as funding, staff availability, and necessary skills are available to implement the strategy
- Whether the legal and regulatory landscape affecting the process may place some constraints on which strategies are appropriate (e.g., litigation associated with the management of a particular marine resource can constrain options for stakeholder engagement)
- The history of past experiences associated with the use of specific engagement strategies in the fishery or resource management area; if the strategy was used in previous efforts and resisted by stakeholders, it may not be appropriate for the next management effort
- Whether the current management process is contentious; in some cases, highly contentious stakeholder processes are best addressed using in-person strategies

Engagement strategies for the specific levels of the management continuum

The general considerations provided above have been used to develop some specific recommendations regarding how to engage stakeholders at the various levels of the management continuum described in Chapter 3. Since the characteristics of specific fisheries will vary, the following discussion is intended to guide the development of a strategy for engaging stakeholders when generating three types of management documents: an ESR, rulemakings, and FMPs.

Stakeholder engagement for Enhanced Status Reports

While ESRs do not require a public process like FMPs, they do present an important opportunity for stakeholder input. The following process has been identified for their development:

- Stakeholders and outside experts should be consulted, and partnerships should be employed where helpful in the development of draft ESRs.
- ESRs should be living documents maintained by the Department. Once approved, they can be updated without returning to the Commission. Stakeholders and researchers can suggest changes and provide information at any time.
- Each ESR should identify a contact for the public to direct comments.

A primary purpose of ESRs is to identify gaps in research and understanding that researchers and stakeholders can help fill. ESRs are Department documents, but they are intended to capitalize on the interest and expertise of outside scientific and stakeholder communities.

Stakeholder engagement for Enhanced Status Reports plus focused rulemakings

When an ESR needs to be augmented with a rulemaking, additional public processes are required. In addition to what is legally required, the Department should take further steps to ensure that stakeholders and the public are engaged and involved in decision-making. Every fishery and rulemaking is different and the appropriate course will vary; however, in a typical case the Department should take the following actions:

- Have preliminary discussions with participants in the affected fishery to understand perspectives and underlying issues.
- Brief the **Fish and Game Commission's Marine Resources Committee (MRC)** and the full Commission as directed, on the purpose and need for a rulemaking, and present the Department's approach for engaging stakeholders in the decision-making.
- Conduct broader outreach to stakeholders likely to be affected, to understand their perspectives and ideas regarding potential regulations.
- Discuss proposed regulations with the MRC.
- Refine proposed regulations if possible based on MRC and public input.

Fishery Management Plans

When more comprehensive management changes are needed (see Chapter 3) an FMP may be necessary. While management changes that occur via an FMP may be more substantial, stakeholder engagement should still be as focused and targeted as possible. The development of an ESR (as a first step) should help to focus the FMP development efforts on the areas where change is needed and on issues of most direct relevance to stakeholders. As with rulemakings, the needs of each FMP development process will vary. The following activities can help ensure effective MLMA-based engagement:

- Engage in direct communication with affected stakeholders, including those participating in the fishery.
- Consider opportunities for attracting funding or other resources and leveraging partnerships.

- Where appropriate, engage fishery participants in application of **Management Strategy Evaluation (MSE)** (see Chapter 5 and Appendix J) as a means of scoping FMP issues and options.
- Brief the MRC on the purpose, need, and proposed scope and scale for an FMP, describe the relationship to the priorities identified through Chapter 3, and identify the plan for engaging stakeholders in decision-making.
- Alert the public to the intent to develop an FMP, specifying the issues to be addressed through the use of the Department website, list serves, social media, and mailings.
- Where possible, conduct targeted outreach to help inform management and understand stakeholder perspectives regarding specific issues.
- Convene ad-hoc advisory group(s) as needed to address issues involving new regulations. (As discussed in Appendix E, these groups can be relatively resource intensive, especially when addressing contentious issues. Their use may be a primary difference between streamlined and traditional FMPs in terms of stakeholder engagement and process intensity.)
- Hold standing agenda items at MRC during draft development, highlighting key issues and soliciting input where needed.
- Hold public meetings, conference calls, or webinars during draft development highlighting key issues and soliciting stakeholder input where needed.
- Provide a draft FMP for public review at least 30 days prior to submission to the Commission.

Regardless of the strategy used, the Department should regularly evaluate stakeholder engagement to measure whether current strategies are achieving target outcomes. The most effective approach may change over time, and the Department may need to adapt to better suit the changing needs of marine resources and stakeholders.

Chapter 5 – Stock sustainability objectives

The MLMA declares that it is the policy of the state of California to conserve the health and diversity of marine ecosystems and resources, and encourage the sustainable use of those resources (§7050(b)). This chapter is focused on the specific objectives regarding fish stocks and the tools and approaches for achieving them across different scales of management. As noted in Chapter 1, the MLMA defines sustainability to mean both the continuous replacement of marine resources, taking into account fluctuations in abundance and environmental variability; and securing the fullest possible range of present and long-term economic, ecological, and social benefits. To achieve this goal, the MLMA states the following:

- Each FMP shall specify criteria for identifying when a fishery is overfished (§7086(a)).
- Overfishing is defined as a rate or level of taking that the best available scientific information, and other relevant information that the Commission or Department possesses or receives, indicates is not sustainable or that jeopardizes the capacity of a marine fishery to produce the MSY on a continuing basis (§98).
- If a fishery is overfished or where overfishing is occurring, the FMP shall contain measures to prevent, end, or otherwise address overfishing and to rebuild the fishery (§7086(b)).
- If a fishery is overfished, FMPs or regulations shall specify a time period for addressing overfishing and **rebuilding** the fishery. The time period should be as short as possible, and shall not exceed 10 years except in cases where the biology of the population of fish or other environmental conditions dictate. Overfishing restrictions and recovery benefits must be allocated fairly and equitably among sectors of the fishery (§7086(c)(2)).
- Every sport and commercial marine fishery shall be managed so that the long-term health of the resource is not sacrificed for short-term benefits. In the case of a fishery managed on the basis of MSY, management shall have OP as its objective (§7056(a)).

Achieving sustainability

Sustainable management of fisheries requires information on the status of a population relative to management targets. In other words, it requires estimates of abundance and how many individuals can be removed without harming the population or the ecosystem. To develop these estimates, fisheries scientists have devised increasingly complex statistical **models**, which have become a recognized tool in fisheries management. These models typically require long time-series of catch, effort, biological, and survey data.

Many California fisheries lack this type of information, or have unique biological or ecological characteristics that violate the assumptions of traditional stock assessment models. Such fisheries are often referred to as **data-limited** or **data-poor**. However, a lack of data should not prevent the adoption of management measures. In recent years, alternative approaches have been developed that require less data, rely on basic fishery statistics rather than models, and adjust exploitation rates based on the level of uncertainty. At the federal level, scientists have developed new techniques for setting **Annual Catch Limits (ACL)** for hundreds of previously unassessed stocks and found that it is possible to develop good management policies using limited data. These new approaches create opportunities to advance the MLMA's sustainability goals in California's fisheries as well.

This section provides considerations and guidance regarding traditional and more data-limited approaches to fisheries management at each stage of the fisheries management cycle. It also provides recommendations for making management decisions more consistent and structured through the use of MSE.

The fishery management cycle

The fishery management cycle is composed of the following components (Figure 4, clockwise from top left): 1) data collection on population status, **life history** parameters, and fishing trends and impacts; 2) data analysis to understand stock status; 3) a **Harvest Control Rule (HCR)**; and 4) the implementation of those management measures as regulations. An orchestrated approach to this cycle represents an ideal scenario that may not be necessary or feasible for some California fisheries with very low economic value or participation. Nevertheless, each component contains strategies that should be considered when managing fisheries. These components are summarized below, and guidance and considerations are identified for each. A more detailed discussion of each stage of the cycle is provided in Appendices F-I.

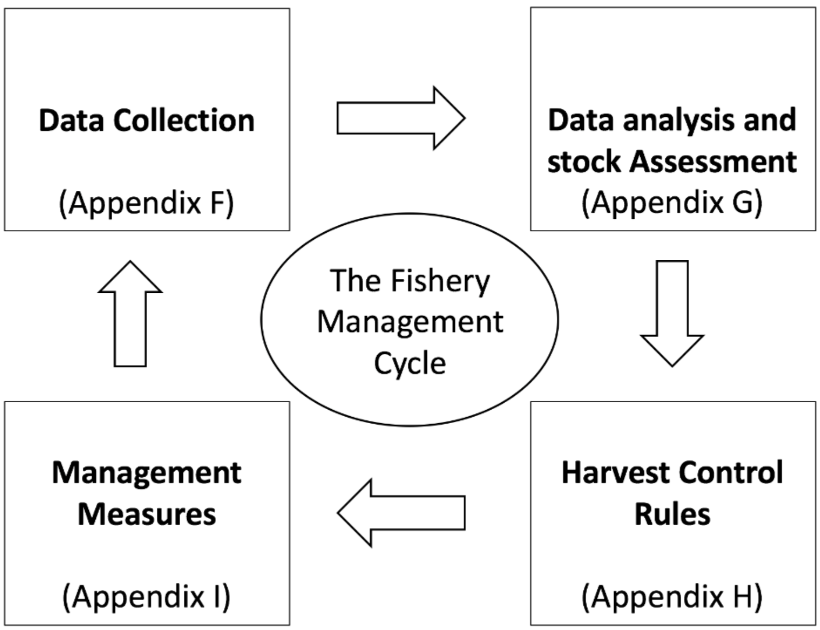


Figure 4. Components of the fishery management cycle.

Data collection

A key component of the adaptive management mandated by the MLMA is a process to use the data collected to understand how the system is responding to management. This monitoring process allows managers to learn more about the system generally, and provides inputs for the determination of stock status and the subsequent decision-making process. Fisheries management decisions are ideally based on knowledge of the **biomass** of the stock. This understanding is typically provided by population models that use high-quality data analyzed by staff with quantitative modeling skills.

ESRs and FMPs should identify EFI for the fishery. EFI is defined as any information related to the biology of a fish species or fishing activities that is necessary to manage the fishery in accordance with the requirements of the MLMA (§93). It includes information on the species' life history, habitat requirements, stock status in terms of abundance and size or age structure, fishing effort, catch levels, and fishery impacts on other marine living resources. The data used to monitor and manage fisheries come from two primary sources: **fishery-dependent** and **fishery-independent** monitoring programs.

The following bullets contain some higher-level considerations in designing and implementing data collection efforts. Appendix F provides details on types of EFI, data collection strategies to support decision-making in both **data-rich** and data-limited fisheries, and an overview of the Department's current data collection efforts.

Key higher-level considerations in identifying data collection strategies:

- While the Department is the primary agency responsible for collecting EFI, it shall encourage the participation of fishery participants to the maximum extent practicable (§7060(a-c)).
- Fishery-dependent data, which are collected directly from fishing activities, have lower sampling costs, but may be influenced by how and where the fishery operates, unreliable, inadequate, or missing. These problems may be accounted for if management and market changes influencing fishing behavior are carefully documented.
- Fishery-independent data are collected from surveys designed and conducted by Department staff, fishermen, other scientists, and trained volunteers. These data are less biased but more costly to collect.
- In fisheries that lack any data other than landings or catch information, data on abundance, distribution, and basic biology are often the easiest to collect, and can provide initial information regarding stock status.
- Long-established MPAs may represent an opportunity for assessing data-poor fisheries by acting as a reference area, allowing for the comparison of fished vs. unfished conditions.
- Historical information may be available from non-traditional sources such as **processors**/buyers or from stakeholders or researchers with a long history of involvement in the fishery.
- The transition to electronic data collection programs presents key opportunities to standardize and streamline data collection, involve fishermen and processors, and ensure that data collected helps inform management.
- The FMP development process also represents an opportunity to ensure that data are collected as part of a research protocol that is designed to support decision-making.

Stock assessments

Stock assessment is a generic term for any type of data analysis that can provide an estimate of the status of a fish stock. These analyses can provide one or more indicators of the stock's present and projected abundance given varying conditions including environmental change and fishing pressure. Most commonly this indicator is an estimate of the size of the fish stock (abundance), but it may also be an estimate of the fishing mortality rate or stock resilience. Stock assessment tools range from very simple estimators that rely on a single data stream to complex models that require many different kinds of data and simultaneously analyze those diverse data to find the best overall fit. These complex population models are often referred to as integrated assessments.

Stock assessments can be valuable to the fishery management process. They provide estimates of past and present stock abundance, and of difficult-to-measure processes such as spawner-recruit relationships and annual **recruitment**, which can help managers understand stock productivity and resilience. Assessments also may provide a platform for forecasting how the stock is likely to fare under alternative management measures such as changes in season length or size requirements. Finally, these types of assessment models allow managers to calculate **reference points**, which are quantitative benchmarks that capture the management objectives for the fisheries (either desired targets, or limits to be avoided).

Assessments rely on a number of assumptions, which frequently introduce uncertainty into the process, and their results must be interpreted with an understanding of the nature and degree of that uncertainty. In the federal management process, consideration of uncertainty and evaluation of assumptions and results occurs during a rigorous, multi-day process for stock assessment review before the results are used for management.

Data-limited assessment techniques

There are many reasons why traditional assessment methods may be inappropriate or infeasible for specific fisheries. Small fisheries are often data-limited, and while they may represent important fisheries for their users, their relatively low economic value may make it difficult to justify the allocation of limited resources for monitoring. Fisheries may be in developmental phases, only fished opportunistically given sporadic stock availability, or recovering from collapse or closure. Many nearshore fisheries exhibit high spatial variation within a relatively small area, and this may violate the assumption of uniformity across the stock area required by many traditional assessment methods. For all of these reasons, there has been increasing interest in developing assessment methods that use available information in a less complex modeling environment than for integrated assessments. The choice of the right assessment approach is governed by the types of data available, but there are some other factors involved in the choice, including life history characteristics and management capacity. Data-limited methods have the potential to help advance the MLMA goals in many of California's data-limited fisheries. Appendix G includes a list and description of data-limited assessment techniques and provides considerations associated with their use. A summary of those considerations is provided below.

Key considerations in selecting assessment strategies:

- Traditional stock assessments often rely on time series of fishery-dependent and fishery-independent data. They are a recognized tool for fisheries management, but may not be possible to conduct for fisheries with limited data, or because of the considerable expertise, time, and effort needed to conduct such assessments.
- Data-limited assessments are generally easier and faster to conduct than integrated assessments, and offer potential for improving management for many California fisheries.
- Catch-based methods use historical catch data to attempt to set sustainable **catch limits**. They are most appropriate for management systems that accurately monitor catch and can enforce fishery closures once catch limits are met.
- Some length-based methods use length composition data to estimate key biological processes and the productivity of the stock using a single year of data.
- MPA-based assessment methods compare data collected inside an MPA in which fishing for the target stock is prohibited to data collected from adjacent fishing grounds. These methods are most reliable when the target species is known to receive significant protection from fishing with the state's network of MPAs, the MPAs have been in place for 10+ years, are large relative to the home range of the fish, and are well enforced.
- Empirical indicators do not use an assessment method to calculate stock status. Instead, catch or fishing effort is adjusted up or down depending on where the indicator (such as **Catch Per Unit Effort (CPUE)** falls compared to a target.

The appropriate assessment (and supporting data collection) strategy will depend on goals and acceptable risks. MSE (discussed below and in detail in Appendix J) should be used in both data-rich and data-limited fisheries to evaluate which assessment methods are most appropriate given the fishery's characteristics.

Harvest Control Rules and reference points

A key component of many effective harvest strategies is an HCR, which is simply a set of pre-agreed rules used for determining a management action in response to changes in indicators of stock status with respect to reference points. In the absence of an HCR, once a stock assessment is conducted, decision makers and stakeholders most often negotiate on what management changes are appropriate. This negotiation process can lead to slow management response times and high levels of controversy between user groups with differing objectives. HCRs improve this process by creating pre-determined decision-making frameworks that reflect management objectives as well as the best available science.

Typically, HCRs compare results from the stock assessment phase (also known as indicators) against reference points. Reference points are metrics that combine several components of fishery performance into a single index. Management actions may be required depending on where the indicator falls relative to the reference point. Reference points are commonly expressed as either a biomass level, or as the fishing mortality rate that would achieve that biomass level under long-term equilibrium fishing conditions.

HCRs explicitly link the outcomes of monitoring and assessment with the management response. This is important because while stock assessments often return estimates of parameters such as fishing mortality and abundance, these parameters cannot be directly controlled by managers. Instead, regulations are established to modify fishing behavior in a way that is expected to result in the desired effect on these parameters. HCRs should be developed in the management planning stage with the involvement of stakeholders. One way to involve stakeholders in the process is to seek their input on management objectives and the performance metrics by which to evaluate possible HCRs.

HCRs should be evaluated to ensure they perform reasonably well under a range of uncertainties in stock status, environmental conditions, harvester behavior, and the ability to implement effective regulations. In systems with more uncertainty, the HCR should be more precautionary. Additionally, as discussed in Chapter 11 climate change will underscore the need for adaptive management and responsive HCRs. Appendix H provides details on the types of HCRs available, the use of ecosystem indicators, and considerations for how effective use of HCRs can advance the goals of the MLMA.

Key considerations in selecting HCR strategies:

- The MLMA requires criteria for determining when a fishery is overfished (§7086(a)). Reference points that are quantitative benchmarks defining zones of fishery performance (e.g., healthy, subject to overfishing, and critical/overfished zones) can provide a mechanism for defining these criteria. Different management actions are required based on where a fishery indicator falls relative to these reference points.
- HCRs can range in complexity based on the data availability and needs of the fishery. Examples include triggering a management action when a reference point is passed, a “traffic light” system where multiple indicators are monitored simultaneously, a decision tree where reference points are sequentially assessed, or a mathematical formula linking stock status to the following year’s catch or effort level.
- When insufficient information is available to set reference points, proxies for key biological reference points can be used. Often, these proxies are easier to calculate and require less data.

Management measures to regulate fishing activities

Fisheries managers have a suite of possible regulatory mechanisms, known as controls or management measures, available to them. These mechanisms include restrictions on catch, effort, gear, season, size of fish, number of participants, and areas fished. Fishery controls are usually classified as either **output**

controls or **input controls** (Morrison 2004). If the control measure directly constrains the catch, it is an output control, and if it constrains fishing effort (by restricting who can fish when, where, and how) it is an input control. An appropriate choice will depend on a variety of factors, including the biology of the species, how the fishery is prosecuted, socioeconomic issues, community objectives, and governance capacity. Input and output controls are not mutually exclusive; some fisheries employ both.

Key considerations in selecting management measures:

- Input controls are an indirect way to control the number of fish caught by limiting who, when, where, and how fish are captured. They include restrictions on gear type or amount, season, fishery participation, vessel number and size, geographic area, and time spent fishing.
- Output controls are direct limits on the amounts and kinds of fish that can be caught. These include **Total Allowable Catches (TACs)** and limits on size, sex, or species.
- Fisheries management is usually composed of a suite of input and output controls, because each control type has different advantages and disadvantages. Each requires different kinds of monitoring and enforcement, and each has different socioeconomic and biological implications.
- As discussed in Chapter 11 and Appendix I, management can enhance fish stocks' resilience by using measures that maintain and strengthen the reproductive capacity by ensuring a diverse age structure.
- Working closely with the affected stakeholder community is essential to crafting effective management measures.

Specifics regarding available management measures and the considerations associated with their use are provided in Appendix I.

Management Strategy Evaluation

The fisheries management cycle (Figure 4) functions best when each of the components is chosen with the other components in mind. MSE is the generic term used for a class of analyses that test potential combinations of these management procedures and explicitly address the tradeoffs and levels of uncertainty associated with them. In MSE, the entire fisheries management cycle is simulated over a specified time period (i.e., 50 years) to understand how each aspect of the management procedure is likely to perform in both the short- and long-term. The procedure uses many repeated simulations with randomly drawn variables to explore the risk of unwanted outcomes due to uncertainty stemming from natural variation, lack of knowledge, and imperfect implementation of management measures. MSE allows the identification of what is known and what is unknown, and examination of tradeoffs among alternative management strategies. This examination can include a risk analysis comparing each alternative's probability of achieving the desired management result.

While MSE is useful for evaluating potential management strategies based upon risk tolerance, it can be complex, and requires extensive time and resources to conduct. In the past, significant quantitative expertise was required to build and run simulation models. Recent advances have made MSE faster, more affordable, and more accessible to a wider range of fisheries, including those with limited data. However, even with these technological advances the behavior of the fishery must be modeled as accurately as possible, and that usually requires gathering information from stakeholders, biologists, and managers who know the fishery best. As such, MSE represents an excellent opportunity to partner with stakeholders, academics, and other outside experts to accurately and comprehensively characterize the fishery and its management goals, determine which performance metrics are most informative, interpret results, and evaluate tradeoffs. Appendix J provides guidance on each step of the MSE process.

Available tools

Fisheries scientists have recently recognized that MSE can be used to compare a wider range of management procedures and can be applied to a number of data-limited scenarios with relatively simple data indicators and iterative HCRs (Carruthers et al. 2014). From this premise, fishery modelers at the University of British Columbia developed the **Data-Limited Methods Toolkit (DLMtool)**. The DLMtool can evaluate a wide variety of potential management approaches and allows users to develop customized management procedures and include them in the MSE analysis. The tool can also help managers and stakeholders evaluate methods for stock assessment. For certain high-value, high-volume, or high-risk fisheries, significant investment in management, such as that required to produce an integrated stock assessment, may be warranted, but many stocks can be effectively managed using less data-intensive methods or baseline monitoring. The DLMtool can provide an efficient analytical technique for designing and implementing these types of management procedures. The Department partnered with academic institutions and **Non-Government Organizations (NGOs)** to pilot the tool on a small group of state-managed fisheries (see: http://www.datalimitedtoolkit.org/wp-content/uploads/2017/07/Applying-MSE-to-CA-Fisheries-Case-Studies-Recommendations.pdf).

The DLMtool is one of many similar tools that have been developed. In selecting among available tools, a key criterion should be that it is a peer-reviewed and proven approach for the kind of fishery to which it is applied. Application of these tools and their underlying approaches will be a major step towards extending more active and strategic management to a greater proportion of the state's fisheries and achieving the sustainability goals of the MLMA. They will be applied to priority fisheries wherever resources and capacity permit.

Chapter 6 – Ecosystem-based objectives

The MLMA seeks to preserve the health of fish stocks and the ecosystems that support them (§7050). When the law was passed, the concept of EBFM was relatively new, but has since become a common foundation of fisheries law and policy at the state, national, and international levels. This chapter focuses on three specific objectives described in the MLMA: 1) limiting bycatch to acceptable types and amounts (§7056(d)); 2) maintaining habitat health (§7056(b)); and 3) conserving ecosystem health and diversity (§7050(b)(1)).

Limiting bycatch to acceptable types and amounts

(NOTE: This section draws largely from the work of the ***Bycatch Working Group (BWG)****, a group of stakeholders convened by the Commission in 2015. The BWG was created to help inform MRC and Commission review of bycatch management, specifically through the Department's effort to amend the Master Plan. In developing the section on bycatch below, the Department used as much of the consensus language from their review as possible.)*

Definition of bycatch

During most fishing activity, fishing gear may catch some fish and other marine species in addition to what is being targeted. For example, commercial and recreational fishermen using **hook-and-line** often cannot tell which species of fish they will catch. There are many terms used to describe this: bycatch, **discards**, non-target, **incidental catch**, and so forth. Sometimes these terms are used interchangeably, but their implications differ subtly.

The Department has historically considered the species or species complex managed by an FMP to be the target of that fishery. The definition of bycatch includes target species that are discarded because they are of undesirable size, sex, or quality, or prohibited due to size, season, catch limit, or sex restrictions, as well as non-target species that are either undesirable or required by law to be discarded (§90.5 and §91). The MLMA mandates that unacceptable amounts or types of bycatch be addressed through conservation and management measures.

This section of the Master Plan focuses on what may constitute unacceptable bycatch and how this bycatch may be addressed. To assist this discussion, the following are definitions of categories of catch and the standards to which they should be managed.

- A target species is defined as any species that is a primary target of the fishery and the principal focus of management efforts. Identification of target species is discussed in Step 2 below. These species are managed to the sustainability standard of the MLMA (see Chapter 5).
- Incidental catch is defined as fish caught incidentally during the pursuit of the primary target species, but legal and desirable to be sold or kept for consumption. Some may define these species as secondary targets or retained bycatch. For purposes of ESR or FMP development these species should be accounted for and must be managed either as target species under the sustainability standards outlined in Chapter 5, or as bycatch under the bycatch standard described below. In making this determination, the Department will consult with stakeholders and may consider the criteria associated with identifying emerging fisheries as discussed in detail in Chapter 9. The Department should articulate the basis for its determinations in the relevant ESRs and FMPs. Identification of incidental species is discussed in Step 2 below.
- Bycatch, as defined by California law, means "fish or other marine life that are taken in a fishery but are not the target of the fishery. Bycatch includes discards" (§90.5). The MLMA goes on to clarify that discard means fish that are taken in a fishery but not retained because they are of an

undesirable species, size, sex, or quality, or because they are required by law not to be retained (§91). This includes the following:

- Discretionary discards:
  - Fish that are legal but undesirable or unmarketable fish due to species, size, quality, condition, etc.
  - Legal fish that are less desirable than other fish by species or size (high grading), particularly when total take is limited in number or weight by species, species complex, or not retained due to limited storage capacity
- **Regulatory discards**:
  - Fish that are required by law not to be retained

As noted in Step 3 below, discarded catch may be returned to the sea alive, or dead or dying and it is important to assess the mortality rate to evaluate impacts. While all discards are defined as bycatch (§90.5), the discard of live catch may not pose a risk to a bycatch species, and discarding can be an effective management strategy to protect some individuals (e.g., juveniles, sex-specific) in which survival is expected to be high.

Assessing and addressing bycatch impacts

To achieve the goal of minimizing unacceptable bycatch, the MLMA requires that the Department manage every sport and commercial marine fishery in a way that limits bycatch to acceptable types and amounts (§7056(d)).

Consistent with this objective, each FMP must include all of the following:

- Information on the amount and type of bycatch (§7085(a))
- An analysis of the amount and type of bycatch based on the following criteria (§7085(b)):
  - Legality of the bycatch under any relevant law
  - Degree of threat to the sustainability of the bycatch species
  - Impacts on fisheries that target the bycatch species
  - Ecosystem impacts
- In the case of unacceptable amounts or types of bycatch, FMPs must include conservation and management measures with the first priority to minimize bycatch and the second priority to minimize mortality of discards that cannot be avoided (§7085(c))

Section 7085 can be used as the basis for a four-step process to identify bycatch and consider its impacts, as follows:

<u>Step 1. Collection of information on the amount and type of catch</u>

To determine how to minimize unacceptable bycatch, managers should first gather information on all the species caught in a fishery. Some fisheries require state or federal observers or **Electronic Monitoring (EM)** to record catch data, and some recreational fisheries participate in state observer programs. However, most recreational fisheries and many commercial fisheries operate without such monitoring. If observer data are not available, dockside sampling, **logbooks** and **landing receipts**, Federal Stock Assessment and Fishery Evaluation reports, recreational report cards, creel surveys, directed fishing surveys, or communications with participants can be used to identify the full suite of species caught and the amounts of bycatch.

If information is unavailable or insufficient to understand what is caught in a fishery, the Department can prioritize the collection of these data and clearly state this as a research priority in ESRs and FMPs.

Step 2. Distinguishing target, incidental, and bycatch species

Once information about the type and amount of catch is identified, it is necessary to determine which species are the targets of the fishery, which are incidental catch species, and which are bycatch species. In some situations, target or incidental catch species of the wrong size, sex, or condition may be discarded and become bycatch per the MLMA's definition. Differentiating target species from incidental catch and bycatch species is not always obvious (e.g., recreational "catch and release" species). Targets can change over time and vary among participants. Nevertheless, the development of ESRs and FMPs present opportunities to engage with stakeholders and consider criteria for categorizing catch.

These criteria may include the following:

- The intended target(s) of participants as evidenced by landings data
- The marketability of landed commercial species or the desirability of recreational species
- Historical use patterns of the fishery
- Whether the species is being managed as a target species under another FMP, or under other state or federal law or regulation

While the MLMA creates a distinction between target species and bycatch, regardless of the determination, impacts to any species caught must be understood and addressed appropriately. In the case of target species, impacts need to be managed so that sustainability is maintained. In the case of bycatch, impacts need to be managed so that they are acceptable as discussed below. Incidental catch species need to be managed to either target or bycatch standards according to the needs of the fishery as determined by the Department. While the statutory language surrounding these two standards is different, their goals are similar and as a practical matter, achieving them may often involve the same strategies and management measures.

Step 3. Determining "acceptable" types and amounts of bycatch (§7085(b))

The MLMA assesses the acceptability of the amount and type of bycatch using four criteria: 1) legality of the take of bycatch species; 2) degree of threat to the sustainability of the bycatch species; 3) impacts on fisheries that target the bycatch species; and 4) ecosystem impacts (§7085(b)). These criteria have not been further defined in regulation, and it may not be possible to identify a uniform definition of "acceptable" that is appropriate across California's diverse suite of fisheries. However, structured, MLMA-specific inquiries may provide a practical means of conducting fishery-specific analysis of impacts and identifying means for minimizing unacceptable types of bycatch.

If after considering all four criteria the Department determines the amount and type of bycatch to be unacceptable, then further management action is required. The questions provided below for each of the four criteria (§7085(b)(1-4)) can be used to consistently assess what is "acceptable" bycatch within a particular fishery. Responses to these questions are not proposed to be used in a formulaic or prescriptive way, but are intended to provide a structured basis for managers to consider the issue and articulate the findings.

(1) Legality of take of bycatch species
This criterion includes any species that might be illegal to take or retain under any relevant state, federal, or international law.

Inquiries:

1. Is the species covered under the **Endangered Species Act (ESA)**, **Marine Mammal Protection Act (MMPA)**, the **Migratory Bird Treaty Act (MBTA)**, the Billfish Conservation Act, **Magnuson-Stevens Fishery Conservation and Management Act (MSA)**, the Fish and Game Code, Title 14 of the California Code of Regulations, Title 50 of the Code of Federal Regulations, or another FMP?
2. Are there prohibitions against the take of the bycatch species using a specific gear type employed in prosecuting the fishery?
3. Is the species a target species that requires discard of individuals based on size limits, seasons, or gear type restrictions?
4. Is the discard mortality rate known?
5. Are special permits required to retain or interact with the species (such as incidental take permits), does the fishery currently have such permits, and do the levels of bycatch comply with them?
6. Does the species have incidental catch allowance, an ACLs, or other restrictions on the amount, size, or sex restrictions on catch allowed, and does the catch comply with them?

Recommended actions:

1. If legality is not assessed, this should be conducted.
2. If legality has been assessed and found to be illegal, it may be considered unacceptable and Department action or consultation with responsible state or federal agencies may be necessary.
3. If legally-sanctioned rates of mortality exist, the Department should evaluate if the rate of injury and mortality is being exceeded, potentially through consultations with other responsible state and federal agencies.
    a. If the rate is within legally sanctioned injury or mortality rates, then bycatch is likely acceptable in relation to this criterion.
    b. If the rate exceeds legally sanctioned injury or mortality rates, the bycatch may be unacceptable and management action may be necessary.

(2) Degree of threat to the sustainability of the bycatch species
This criterion considers the impact of the relative level within the fishery on the biological health of the bycatch species: that is, if the type or amount of bycatch compromises the ability of a population to maintain sustainable levels. If the bycatch species is the target of another managed fishery, it may be possible to refer to a state or federal stock assessment or management plan in order to understand how the current level of additional catch is likely to impact that species. If there is little information about the status of the stock, the Department should identify a pathway and a timeline for determining the fishery's impacts. An initial step could be a PSA, which may provide insight on the degree of threat to that species' sustainability. Impacts to species that are identified as relatively vulnerable through a PSA could be identified as research priorities. A level of take that compromises the sustainability of the population would be unacceptable under the standards of the MLMA.

Inquiries:

1. Has a peer-reviewed risk assessment of the vulnerability of bycatch species (e.g., the NOAA PSA method) to overfishing (risk assessment) been conducted?
2. Does a population status/stock assessment exist for this species and is there confidence in that data such that a reasonable determination can be made if the stock is considered healthy, overfished, or depleted?
3. Are there any existing state/federal management measures and are they effective in ensuring sustainability?

4. Is the bycatch the product of recreational catch and release practices?
5. What is the estimated discard mortality rate given the characteristics of the fishery and gear type?
6. Do any post-release studies exist to verify the estimated mortality rate?
7. What is the probability of mortality exceeding levels that have been scientifically determined to be necessary for the continued viability of the species?

Recommended actions:

1. If a risk assessment has not been conducted, the Department should identify it as a research priority in ESRs and FMPs.
2. If a risk assessment has been conducted:
    a. If it is low, bycatch of the species is likely acceptable for this criterion
    b. If it is high, bycatch of the species may be unacceptable and the Department should consider additional management measures

(3) Impacts on fisheries that target the bycatch species
This criterion considers whether the current level of bycatch within the fishery negatively impacts the management of another fishery or the fishermen that target the fishery resource. This is particularly an issue for fisheries which may only land the primary target species (e.g., Spot Prawn). Factors to consider may include increasing competition between fleets that target certain species, by capturing species managed under federal rebuilding plans, or by increasing mortality of juveniles targeted by another fishery.

Inquiries:

1. Does a directed fishery exist for the bycatch species?
2. Has the bycatch and associated discard mortality been accounted for?
3. Is this affecting the directed fishery management strategy (i.e., restrictions on size, sex, or season)?
4. Are the impacts of bycatch considered and made explicit in an ESR or FMP?
5. Is the species constrained under a federal rebuilding plan and will bycatch compete with fleets that target the species?
6. Is there a management allowance for percent of catch or a prohibition on retention?
7. If there is a directed fishery for the species, have there been:
    - Reductions in opportunities or income for participants in fisheries that target the bycatch species?
    - Reductions in fishery quotas or opportunities (time and area closures, for example) based on bycatch issues?
    - Early closures of a fishery based on higher than expected bycatch?
    - Changes in fishing, processing, disposal, and marketing costs due to bycatch?
    - Changes in the social or cultural value of fishing activities due to bycatch?
    - Negative socioeconomic impact from bycatch on fisheries/fishing communities which target or need incidental catch of this species?
    - Negative impacts to juveniles of a species targeted by another fishery?

Recommended actions:

1. If socioeconomic impacts of bycatch have not been considered, this should be done as soon as feasible and integrated into future updates of ESRs or subsequent FMPs.

2. If any impacts under Inquiry 7 above are identified, the Department should consult with fishery participants and others regarding these potential impacts. Depending on the presence and severity of impacts, the Department may find bycatch to be unacceptable, and management measures may be necessary.

(4) Ecosystem impacts
This criterion explores whether the current level of bycatch within the fishery impedes the ability of the bycatch species to fulfill its functional role within the ecosystem. This is difficult to assess for most species, but tools such as ERA may help provide useful guidance and qualitative information, even in data-poor circumstances.

Inquiries:

1. What is the ecosystem role of the bycatch species?
2. Does scientific evidence show the amount of bycatch mortality significantly increases the risk that a bycatch species will be unable to serve its ecosystem role?

Recommended actions:

1. If this information is not available, its collection should be identified as a priority need in ESRs and FMPs. Managers should consider collaborations with external marine ecologists and other researchers to collect this information.
2. If species ecosystem function is unlikely to be impeded then bycatch is likely acceptable under this criterion.
3. If species ecosystem function is likely to be impeded, then bycatch may be unacceptable per this criterion and management measures may be necessary.

<u>Step 4. Addressing unacceptable bycatch (§7085(c))</u>

If the current type or amount of bycatch is deemed to be unacceptable based on the four criteria above, conservation and management measures are required that minimize that bycatch, and in cases where discards are unavoidable, minimize the mortality of those discards (§7085(c)).

Inquiries:

1. Are measures in place to minimize the impact of the fishery on bycatch species and ensure the fishery does not overfish or hinder the recovery of bycatch species?
2. Are bycatch management measures likely to decrease unintended, non-retainable, and/or dead catch of non-target species?
3. Are bycatch management measures being implemented successfully?
4. Have bycatch management measures been shown to be effective at reducing bycatch and/or bycatch mortality in similar fisheries?
5. What is the economic impact of implementing management measures to reduce bycatch and bycatch mortality to those participating in the fishery in which the bycatch occurs?

There are a number of frequently used strategies for reducing bycatch and discard mortality. These measures and considerations associated with their use are detailed in Appendix K. They include minimum mesh size requirements, escape ports, descending devices, closed areas, depth restrictions, acoustic pingers, **Light Emitting Device (LED)** lights, and incidental take caps to name a few. However, understanding and implementing the most effective means of reducing bycatch while maintaining economic viability typically requires input from all stakeholders and close collaboration with the fishing industry.

Maintaining habitat health

The MLMA emphasizes the importance of habitat protection as a means of preserving healthy and productive marine resources (§7056(b)). While there are factors external to fishery management that may negatively impact habitat (e.g., storms, climate change, habitat loss due to development, pollution, etc.), protecting habitat from potential fishery impacts is essential to help maintain fisheries, ecosystems, and communities in California. Healthy habitats provide spaces for the various life history functions necessary to create sustainable marine populations, including spawning, growth, feeding, and reproduction. Marine habitats are often utilized in different ways by an array of different species, so impacts from fishing activities may have cascading effects on the ability of other marine species of ecological or economic significance to sustain themselves. To achieve the goal of protecting habitats the MLMA requires the Department to:

- Manage every sport and commercial marine fishery with the objective that the health of the fishery habitat is maintained, restored, and where appropriate, enhanced (§7056(b)).
- Include in FMPs information about the habitat and known threats to the habitat (§7080(c)).
- Include measures in FMPs that, to the extent practicable, minimize adverse effects on habitat caused by fishing (§7084(a)).

The following describes steps for assessing and addressing impacts to habitat:

<u>Step 1. Describe the habitat utilized by the target species at each life stage</u>

ESRs and FMPs should summarize the readily available information regarding the habitats of the target stock (§7080(c)). While ocean waters and their associated salinities, temperature, and nutrients are an important part of marine habitats, most marine habitat management focuses on **benthic** habitats, including habitat-forming plants and invertebrates. Benthic habitats are usually classified by three general types of **substrate**: hard, mixed, and soft. In addition to substrate types, habitats are frequently classified by depth, which influences the amount of light available to the species that live there. Benthic marine communities are often grouped by depth categories such as coastal, continental shelf, continental slope, and abyssal.

ESRs and FMPs should give particular focus to habitats of particular sensitivity. These include estuaries, sea grass beds, intertidal areas, rocky reef habitats, and kelp forests, which have been found to support a high diversity of species at critical life stages. In addition, these areas are often home to structural or biogenic organisms, which are those species that create habitats for other species. These include some plants, such as Giant Kelp and sea grass, as well as animals such as corals, gorgonians, and sponges.

Marine species may use multiple habitat types during different life stages or for different activities. It is important for managers to describe the habitats utilized for all activities that are crucial to survival and reproduction. If there are some life stages or activities where a species' habitat association is unknown, then that should be noted as an area for future study. ESRs and FMPs should also identify where additional understanding of habitat characteristics, functions, and fluctuations would improve management. See Appendix L for more information on habitat types and their characteristics and sensitivities.

Inquiries and recommended actions:

1. What are the habitat needs of the target stock? How do these needs change throughout its life cycle?
   a. For each life stage and major activity, identify the habitats utilized.

    b. If multiple habitats are used, it may be useful to rank the habitats in order of importance to the target stock.
2. What is the spatial distribution of the habitats utilized by the target stock?
    a. If possible, use existing habitat maps and what is known about the distribution of the stock to determine the spatial distribution of the habitats utilized.
3. Are there particular life stages or activities where the habitat needs of the target stock are unknown or are only partially known?
    a. Identify life stages and/or major activities where the habitats utilized are unknown as uncertain and requiring additional research.

<u>Step 2. Describe the threats to the habitats utilized</u>

After describing the habitats utilized by the target species, the threats (from both fishing and non-fishing activities) to these habitats should be described using available information. For the vast majority of fish habitats, empirical measurements of habitat health over time are unavailable. However, some fishing gears are known to have greater impact than others, and some habitats are more vulnerable to disturbance. Most habitat damage from fishing gears occurs when the fishing gear comes in contact with the seafloor and with biogenic habitats in particular. For this reason, habitat threats from fishing gear are often assessed by considering the gear type, the habitat type, and the interaction between the two. Appendix L contains additional details regarding these interactions. The presence of MPAs or other spatial restrictions may help reduce a fishery's impacts on habitat and should be explicitly considered when assessing impacts. It's important to note that abandoned or lost fishing gear can also have negative impacts on habitats. These potential impacts should also be considered and addressed in ESRs and FMPs.

Threats based on non-fishing activities may include climate change, storms, pollution, coastal development, etc. While these threats are for the most part beyond the Department and Commission's authority to regulate, they are required to be characterized (§7080(c)). Other state and federal agencies that do have authority over some of these impacts may be required by statute, regulation or policy to consult with the Department. Having as complete an understanding as possible of habitat threats will help the Department effectively engage in these consultations and minimize impacts where possible.

Inquiries and recommended actions:

1. What gear types does the fishery utilize? What is the spatial extent and intensity of the use of each gear?
    a. Map the approximate spatial extent of the fishery in terms of location, depth, and preferred fishing habitats.
    b. Map the approximate intensity of fishing gear applied in terms of gear per unit area.
2. Which habitats utilized by the target stock are most vulnerable to that fishing gear?
    a. Characterize the risk each gear type poses. If no local information on habitat impact is available, a resource such as the table in Appendix L may be used to understand the likely impacts of the major gear types.
    b. Rank the habitats utilized by the target stock in terms of their vulnerability to the gear.
3. Taking MPAs into account, what is the spatial overlap between the footprint of the fishing gear and these vulnerable habitats?
    a. Areas with overlap between high impact gear (or high intensity of moderate impact gear) and vulnerable habitats may need habitat mitigation activities.
4. What other (non-fishery) habitat threats exist?
    a. Identify and consider anthropogenic threats.

Step 3. Minimize or mitigate adverse effects fishing activity may have on habitat

There are a number of strategies available to managers to protect habitats, and many of these have already been employed to protect California's most vulnerable marine habitats. The most common strategies include MPAs, restrictions on the type of gear employed, or how and where a gear type can be used. In some fisheries, fishermen have also developed gear modifications that also help lessen the impact of bottom gear on habitat.

Guidance for addressing habitat:

- Identify and describe the habitat needs of the target species at all life stages.
- Identify which of the habitats utilized are most vulnerable to threats from fishing gears and non-fishing activities.
- Note areas where there is no or limited information available.
- Identify the fishing gears used, the spatial extent and intensity of these fishing gears, and how gear usage overlaps with vulnerable habitats.
- Work with stakeholders to determine what mitigation or protection measures may be necessary to lessen impacts in sensitive habitat areas from fishing activities.
- Monitor and evaluate the effectiveness of habitat protection measures.

Conserving ecosystem health and diversity

The MLMA highlights the connection between healthy fisheries and healthy ecosystems and underscores the importance of considering the impact of a fishery relative to the ecosystem. To preserve the function of an ecosystem, impacts should be considered from non-fishery factors such as climate and environmental change. This reflects a broader recognition worldwide of the need for holistic approaches to fisheries management. However, ecosystems are complex and in constant flux, and there is much that we don't know regarding how they function. Making management decisions in this context can be challenging even in data-rich environments.

Fluctuations in environmental or ecological conditions can have significant impacts on the abundance of target species. The development of ecosystem indicators can be a valuable tool to help management track and respond to such changing conditions. The discussion of HCRs in Chapter 5 and Appendix H addresses the development and use of ecosystem indicators.

The section below is focused on impacts of fishing on the ecosystem and provides guidance on ecosystem information to integrate into ESRs and FMPs and how EBFM approaches can be applied using the information and available tools.

An ecosystem-based approach to managing fisheries

EBFM requires that ecosystem impacts be considered broadly and consistently in managing fisheries. It is a departure from traditional single species management, in which management decisions consider each species in isolation and do not account for ecosystem dynamics, such as interactions with other species, the effects of environmental changes or pollution, and other stresses on habitat and water quality. While there is widespread recognition of the importance of taking a holistic approach to fisheries management, implementing such an approach has proven difficult. As with other aspects of fisheries management, lack of data and information can limit understanding of biological and human dynamics but need not prevent taking action based on general principles and thoughtful use of available data and knowledge. It is possible to apply the principles of EBFM when making management decisions even in the absence of the data underpinning complex models of entire ecosystems.

Identification of species that play key roles in the ecosystem

One of the goals of the MLMA is to preserve the ecosystem functions that are essential for sustaining commercial and recreational fishery species over the short- and long-term (§7050). While the literature on ecosystem function continues to evolve, one practical approach to preserving these functions has been to identify the species that play key roles within the ecosystem and their trophic levels, and to ensure that these species are managed in a way that is sustainable. Conserving the species that play these key roles provides a way to protect the ecosystem functions and services these species play, both directly and indirectly.

Types of key species and their ecosystem roles include the following:

- Keystone species are those that have been shown or are expected to have community-level effects disproportionate to their biomass.
- Foundation, structural, or biogenic species are habitat-forming species (e.g., oyster beds, sponges, corals).
- Basal prey species include small **pelagic** forage species such as krill, Pink Shrimp, Pacific Herring, squid, anchovies and sardines. The high natural variability in the dynamics of these species can have large impacts on both their predators and their prey.
- Top (or apex) predators are predators for which the removal of a small number of the species could have large or disparate ecosystem effects.

Changes to the structure of these species' populations, which may include changes to the abundance, size structure, genetic structure, or distribution, should be monitored, and management measures should strive to maintain appropriate population structures for species in these roles to the extent possible. For example, the Commission has adopted a policy specifically for the management of **forage fish**, which play a major role in the **California Current Ecosystem (CCE)** (Commission 2012). Forage fish are small pelagic organisms, such as Northern Anchovy, Pacific Sardine, Market Squid, and Pacific Herring that provide an important food source for larger marine organisms. They fill the critical ecosystem role of transferring energy from planktonic plant and animal life to larger fishes, marine mammals and seabirds. Environmental conditions and climate regimes can have major effects on forage fish distribution and abundance.

Consider management strategies with multiple control measures

Recent studies have found that an integrated management strategy, which is defined as one that involves a combination of management measures (such as size limits, **gear restrictions**, spatial restrictions, effort restrictions, and quotas) to control fishing, is more likely to achieve EBFM objectives than those strategies that rely on a single restriction (Fulton et al. 2014). This is because while a single management measure may maximize catch in a single species management context, different management controls may provide protection to different aspects of ecosystem function. For example, size limits or restrictions on mesh sizes might help preserve more natural size and age structures in a population, so that the target species can continue to fulfill its ecological role (i.e., as predator or prey for other species in the ecosystem). Gear and spatial restrictions may reduce habitat and bycatch impacts. Seasonal restrictions may not only allow the target species to spawn, but may also reduce bycatch of the species that feed on spawn during that time period. In this way, strategically employing a wider range of management measures may have benefits to the ecosystem as a whole.

Conduct Ecological Risk Assessments to understand which ecological links are most critical

The inherent variability, complexity and uncertainty in ecological systems makes a complete understanding of ecosystem dynamics impossible. Nevertheless, the MLMA requires that management be based on the best available scientific information (§7050(b)(6)). Some experts have suggested that even a qualitative understanding of these relationships, such as an understanding of "who eats whom", can be used to make decisions that account for ecosystem interactions (Patrick and Link 2015). In addition, there are analytical tools available, such as the ERA (described in Chapter 2), that can help identify which processes are most likely to impact ecological function, even when only qualitative or semi-quantitative information is available. Understanding the main drivers of a system is important, as-is understanding the major uncertainties. This allows precautionary approaches to be applied only where needed, and can help identify areas for future research.

Inquiries and recommended actions:

1. Has the ecological role of the target species been identified? Does the target species play a key ecosystem role as defined above?
    a. Describe what is known about the trophic level, predators, and prey of the target stock throughout its life cycle.
    b. If the ecological role of the target species has not been identified, consider prioritizing this as a research need in ESRs and FMPs.
2. Is the target species a basal prey species?
    a. If so, additional consideration may be necessary to comply with the Commission's Policy on Forage Species (Commission 2012).
3. Has an ERA been conducted for the target species?
    a. If so, identify any major ecological threats, and consider applying management measures to mitigate those threats.
    b. If not, consider conducting an ERA for the fishery.
4. Have the major areas of uncertainty in ecosystem dynamics been identified?
    a. If not, seek to identify the areas of uncertainty.
    b. Consider additional precaution to reflect the level of uncertainty.
5. Are multiple control measures in place that may help to achieve EBFM objectives?
    a. If not, consider what, if any, additional measures may be needed to create an integrated management strategy as defined above.
6. Has there been an assessment of how the target stock is likely to be impacted by changing environmental or ecological conditions?
    a. If not, consider the collection of EFI that can inform the development of environmental or ecological indicators.
    b. As indicators are developed, integrate into MSE analyses and HCRs as appropriate.

Chapter 7 – Socioeconomic objectives

While sustainability is its primary goal, the MLMA (§7056) requires that the fishery management system consider the long-term interests of people dependent on fishing for food, livelihood, or recreation, including non-consumptive uses (§7050(b)(3)). The MLMA also requires that adverse impacts of fishery management on small-scale fisheries, coastal communities, and local economies be minimized. It also highlights a number of fishery management issues such as excess effort and conflict related to allocation and access, which pertain directly to human behavior and social context. Therefore, both the risk to the sustainability of the target stock and its ecosystem, and the impacts of management measures on the people, communities and economies that depend on those stocks must be considered in developing, evaluating and adapting management.

The MLMA directs the Department to:

- Manage California's marine sport and commercial fisheries in a way that ensures the long-term economic, recreational, ecological, cultural, and social benefits of those fisheries (§7055(a)).
- Work to ensure a sufficient resource to support reasonable recreational use (§7055(c)).
- Encourage the growth of commercial fisheries (§7055(d)).
- Allocate management benefits and restrictions fairly among recreational and commercial sectors (§7072(c)).
- When developing FMPs, describe economic and social factors related to the fishery (§7080(e)).
- Minimize the adverse impacts of fishery management on small-scale fisheries, coastal communities, and local economies (§7056(j)).
- Observe the long-term interests of people dependent on fishing for food, livelihood, or recreation (§7056(i)).
- When developing FMPs, summarize anticipated effects of new management measures on fishery participants and on coastal communities and businesses that rely on the fishery (§7083(b)).

The Master Plan separates the MLMA objectives into those that focus on the biological/ecological system and those that focus on the human system. This is due in large part to differences in information needs, data types, sources and analyses, and practicalities related to how they can be effectively considered and addressed. However, the objectives of biological/ecological and human systems are in fact linked. For example, management issues such as bycatch and depressed fisheries affect the well-being of people dependent on fishing and have adverse impacts on communities and economies. Solutions to ecological issues can hinge on understanding the source of the problem and identifying practical, feasible options for addressing them. As one of the Information Gathering Projects associated with the Master Plan's amendment, California Sea Grant developed an overview of socioeconomic considerations under the MLMA. This chapter draws from that review.

Types and uses of socioeconomic information

In fisheries, human systems consist of diverse components, relationships, and dynamics. They include the people, practices, institutions, and facilities involved, and their environmental, regulatory, economic, and social context. Fisheries should be managed with a clear understanding of current socioeconomic conditions and the likely impacts of regulatory changes. This includes: 1) the direct impacts to resource users; 2) indirect impacts, such as local employment or community identity and cohesion; and 3) how fishery participants are likely to adapt their operations and relationships to adjust to change. The following are basic types of socioeconomic EFI relevant to understanding the human dimensions of the fisheries. Additional details regarding each are provided in Appendix F.

- *Demographics:* Data relating to a population and particular groups that comprise it.
- *Practices:* Where, when, and how fishermen participate in fisheries and fishery-related activities.
- *Motivations:* Why people do the things they do.
- *Institutions:* The norms, rules, and strategies that govern peoples' behavior.
- *Relationships:* The social and economic connections among people.
- *Capital:* The natural, human, physical, and financial resources needed and used by participants.
- *Employment:* Jobs in fishing, seafood production, and supporting infrastructure.
- *Expenditures:* Amounts paid by participants for goods and services to participate in the fishery.
- *Revenue:* Payments received for fish landed, handled, processed, and sold.

Integrating socioeconomic information

The various types of socioeconomic EFI described above should be considered together where possible to provide a more complete and meaningful understanding of the human dimensions of fisheries. For example, combining data on demographics, practices, and use patterns can be used to evaluate the impacts of changes in management on fishery participants and how these impacts are distributed among various groups.

Socioeconomic information must also be considered along with environmental factors. Environmental factors such as changing ocean conditions, resource abundance, and resource distribution can affect access to fishery resources. These factors can also affect the distribution of fishery activity along with the associated social and economic impacts to fishery participants and communities (see Chapter 11). Information about environmental factors and how fishery participants are affected by and respond to them is useful for interpreting fishery trends, designing management, and distinguishing natural and anthropogenic sources of change.

Collecting socioeconomic information

Much of the information on human dimensions described in Appendix F has not been collected, synthesized, and/or analyzed for many of California's fisheries and communities. In some cases, this information is collected by the Department via ongoing programs or one-time, targeted efforts. It is also collected by other state and federal agencies and non-agency researchers, and can be accessed and analyzed to meet management needs. In other cases, the information may not be readily available, requiring new data collection and analyses. Given the breadth and scope of potential data collection efforts, it is important to identify the information that is most essential to informing management decisions, and to develop strategies and partnerships for collecting it. What is realistic in terms of data collection will depend on available resources and capacity.

Using socioeconomic information

ESRs should summarize available socioeconomic information, additional information that is required, and the efforts underway and/or needed to collect it. Rulemakings and FMPs should expand on this by using available information to describe the anticipated impacts of management on participants (§7083(b)). The information described above will help answer case-specific questions (see Appendix M) regarding those impacts and other considerations related to the management of a particular fishery. The information needed to fully address these questions may not always be available. However, whether preparing ESRs, FMPs, or rulemaking packages, these questions provide a means of systematically considering impacts across a range of potential management actions and of identifying important data gaps.

Chapter 8 – Partnerships

The MLMA emphasizes the importance of collaboration in achieving its objectives as well as the value of capitalizing on the expertise and resources that exist outside of the Department (§7056(k)). Collaboration involves working with interested parties on some aspect of the management process, which can vary significantly depending on factors such as responsibility-sharing, structure, and duration. Collaborations can operate across a broad spectrum. On one end of the spectrum is stakeholder engagement, which involves the Department soliciting targeted input on specific management actions. On the other end are partnerships that are more formal, structured, and often intended to be longer-lasting. This chapter focuses on partnerships, their benefits, and the conditions necessary for them to achieve their purposes. It draws from an overview of partnerships in California fisheries developed as part of the information gathering stage for the Master Plan amendment (Wilson et al. 2016). See Appendix N for additional details.

In order to meet the MLMA's objectives regarding collaboration, the MLMA encourages the Department to:

- Involve all interested parties in marine living resource management decisions (§7050(b)(7)).
- Manage fisheries in a way that is collaborative and cooperative (§7056(k)).
- Find creative new ways to involve outside experts with the necessary expertise at colleges, universities, private institutions, and other agencies (§7059(a)(2)).
- Use the collaborative process to develop FMPs, research plans, status reports, and other management documents (§7059(a)(3)).
- Periodically review marine life and fishery management operations with a view to improving communication, collaboration, and dispute resolution, seeking advice from interested parties as part of the review (§7059(b)(1)).
- Develop a process for the involvement of interested parties appropriate to each element in the fishery management process (§7059(b)(2)).
- Consider the appropriateness of various forms of fisheries co-management when developing and implementing FMPs (§7059(b)(3)).
- Consider the gear used, the involvement of different commercial, recreational or processing sectors, and where the fishery is conducted to ensure adequate involvement of fishery participants (§7059(b)(4)).
- Use collaborative approaches to collecting EFI (§7060(a)).
- Encourage the participation, collaboration, and cooperation of fishermen in research design and data collection (§7060(c)).
- Consider contracting with qualified individuals or organizations to assist in the preparation of FMPs (§7075(b)).
- Seek advice and assistance from participants in the affected fishery, marine scientists, and other interested parties when developing FMPs (§7076(a)).

Benefits

California is home to engaged fishermen, active NGOs, a wide range of academic and research institutions, Tribes and tribal communities, and public and private funding institutions that are interested in responsible fisheries management and helping the Department and Commission advance the goals of the MLMA. Well-structured partnerships can help support short and long-term fishery management goals and enhance and increase the state's capacity to effectively manage fisheries under the MLMA. In the face of increasingly variable ocean conditions, partnerships can provide an effective mechanism to promote ecological, social, and economic resilience. In addition, partnerships can consider and use varied skill sets as well as have direct benefits to fisheries managers. For example, CFR presents a valuable opportunity to engage stakeholders in the identification of research needs, the design of research efforts, conducting field work, and interpreting the results.

The following are examples of potential benefits resulting from fisheries partnerships (Wilson et al. 2016):

Ecological benefits

- Fisheries maintain sustainable stock levels with long-term stability in abundance and stock health
- Improved conservation of sensitive habitats, nursery grounds, and spawning grounds

Economic benefits

- Potential decrease in Department's management cost
- Potential increase or maintained revenue streams through stabilized landings, and reduced risk of fishery collapse by improving assessments and harvest levels that reflect actual stock sizes

Political benefits

- A more democratic and participatory system where the interests of government, fishermen, and community members become better aligned
- Reduced conflict in decision-making

Benefits to the Department

- Increased support for cost and task sharing opportunities creating the potential for more efficient and productive management over time
- Support and buy-in for fisheries management regulations and policies leading to enhanced compliance and better working relationships with industry and NGOs

Partnership continuum

Fisheries management consists of a wide variety of tasks, each presenting specific opportunities for partner opportunities. Figure 5 shows categories of common management tasks ordered by the degree of capacity that is needed by partners to effectively engage in a partnership. For these purposes, partner capacity is proposed to consist of three characteristics: 1) how representative the group is of the broader community; 2) the resources the group has available to allocate to the partnership; and 3) how long-standing and durable the partner is.

Partnerships involving sharing responsibility for more inherently agency-led functions will require a greater degree of organizational capacity on the part of partner organization(s). While situations will vary, tasks should be closely matched with the partner's capacity to help ensure a successful partnership. See Appendix N for additional details.

Figure 5. Partnership continuum

Inquiries to assess prospective partnerships

If a partnership is well-designed, it can help advance the objectives of the MLMA. If not, it can distract from other high-priority activities and frustrate partners. To assess a prospective partnership, the Department should consider the following inquiries below. These are not intended to be applied in a prescriptive or formulaic way; rather they are provided to help managers carefully consider prospective partnerships to help ensure they advance the goals of the MLMA:

Regarding the partnership

- Will the partnership advance an identified research or management goal?
- Is there trust among partners or the ability to build trust through the partnership?
- Is there an identified source of funding or capacity to support the partnership?
- Will the partnership involve the exchange of knowledge and information necessary to accomplish the goals of the project?
- Will the partnership place an unduly burden Department staff in partnership management responsibilities?

Regarding the partner

- What is the partner’s motivation to engage?
- Does the partner organization have effective leadership?
- What is the partner’s long-term relationship with the resource or stakeholders who target the resource?
- Does the partner organization have the necessary capacity to effectively collaborate on the proposed task?
- What unique knowledge or skills regarding the resources does the partner have?
- What is the partner’s historical or cultural connection to the resource?
- What is the partner’s economic or social reliance on the resource?
- How compatible are the partner’s interests and uses with those of other stakeholders?

Engaging in constructive partnerships

Once the decision to engage in a partnership has been made, there are number of best practices that can help ensure the partnership is productive. These are informed by the Department’s own considerable experience with partnerships. Examples include the Department’s engagement with the steering committee developing the Pacific Herring FMP, and the efforts to address management needs of the Dungeness Crab fishery by the California Dungeness Crab Task Force.

Guidance:

- Develop clear goals, roles, and objectives at the outset of the partnership.
- Ensure regular and effective communication among parties.
- Ensure transparency by informing stakeholders outside the partnership of its goals.
- Provide stability and direction to partnerships involving multiple groups with diverse perspectives.
- Plan ahead for anticipated funding, resource requirements, and/or uncertainties regarding the partner’s longevity to remain engaged.
- Periodically evaluate if the partnership is meeting its goals and how it affects staff workload and the ability to meet other obligations.

The Master Plan was developed through an extensive suite of partnerships that contributed information, tools, and resources. Similarly, full implementation of the Master Plan will require additional capacity and well-designed partnerships to effectively carry out its strategies and achieve its goals.

Chapter 9 – Adaptive management

The MLMA requires that fishery management be adaptive. Successful adaptive management detects and responds to changing environmental or socioeconomic conditions within an appropriate time scale. The requirement applies across the various issues addressed by the Master Plan, such as determining the appropriate level for management in the continuum, the use of MSE, managing bycatch, or adapting to climate change. However, this chapter seeks to provide a focused discussion of the mechanics of adaptive management, specifically how it should be integrated into ESRs, rulemakings and FMPs, and how it relates to emerging fisheries.

The MLMA defines adaptive management as a policy that seeks to improve management by viewing management actions as tools for learning, even if they fail (§90.1). The MLMA stipulates that management systems should:

- Ensure that decisions are adaptive and are based on the best available scientific information (§7056(g)).
- Ensure that management is proactive and responds quickly to changing environmental conditions and market or other socioeconomic factors, and to the concerns of fishery participants (§7056(l)).
- Periodically review the management system for effectiveness in achieving sustainability goals and for fairness and reasonableness in its interaction with affected stakeholders (§7056(m)).

Adaptive management is a continuous cycle (Figure 6) that applies to any aspect of management, whether the objective is meeting socioeconomic objectives, managing bycatch, or having effective engagement. Most often, however, the process is applied to maintaining the sustainability of the target stock.

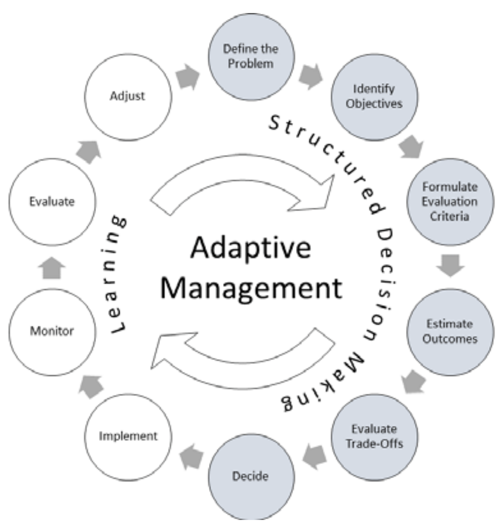


Figure 6. A generalized view of the adaptive management cycle. Gray circles represent the systematic identification of the problem, objectives, and the associated decision-making, while white circles represent the learning associated with implementation.

Adaptive management requires effective stakeholder engagement as outlined in Chapter 4 and well-structured and supportive frameworks described in an ESR or FMP. The following section focuses on the supportive structures and mechanisms that can be included in management documents.

Adaptive management approaches and structures

FMPs require the identification of goals for the fishery, the strategies for achieving those goals, the metrics by which management success will be measured, and the process for assessing and adjusting strategies over time. Since FMPs afford greater opportunities for stakeholder engagement, they are more conducive to the creation of comprehensive and adaptive management strategies. ESRs can be used to articulate the adaptive nature of current management and research efforts.

Chapter 5 and Appendices F-J describe in detail how the use of reference points, HCRs, targeted data collection, and MSE can enable adaptively responding to new information. More generally however, FMPs should identify the following when incorporating adaptive management:

- A research protocol that explains what data will be collected, how observations will be analyzed, and how results of the analysis will be used in management decision-making related to implementation of the selected management strategy.
- The process for strategic review to update understanding of the managed system and revisit selection of the management strategy. This review includes updating models, assumptions, and uncertainties about dynamics of the managed system and comparing the performance of alternative management strategies in light of this updated understanding.
- Uncertainty regarding the current state of knowledge and the implications of that uncertainty in the design and evaluation of management strategies.
- The alternative management strategies that were considered prior to selecting the preferred approach for implementation. MSE can be a valuable tool for accomplishing this.
- Timelines and triggers for re-considering management choices. Clarifying the timelines and triggers improves predictability.
- The necessary institutional capacity for monitoring and analysis.

Current Fishery Management Plan strategies

The White Seabass and Spiny Lobster FMPs include specific examples of adaptive management that should be emulated where appropriate. The Department manages the White Seabass fishery with the assistance of the **White Seabass Scientific and Constituent Advisory Panel (WSSCAP)**, which consists of representatives from the scientific community, recreational and commercial fishers, and NGOs. The FMP requires the Department and the WSSCAP to evaluate the status of the White Seabass fishery against six “points of concern” annually using fishery-dependent data and fishery-independent data on recruitment if available. The Spiny Lobster FMP provides a more recent example through its use of an ‘HCR toolbox’ which describes a variety of indicators, considerations in interpreting them, and a range of potential management responses. While it does not include a standing stakeholder body like the WSSCAP, its use of triggers, the tool-box approach, and targeted research and data collection provide a framework for effective adaptive management as well.

Experimental gear and emerging fisheries

Adaptive management can apply to the management of existing fisheries as described above. However, adaptive management also requires the availability of a policy pathway to address new fisheries and gear that emerge. To that end, the MLMA gives the Commission the regulatory authority to identify and govern these new fisheries. This section provides an overview of the existing pathway for experimental gear and emerging fisheries, and considerations associated with this pathway.

Experimental gear

Any fish species may be landed commercially unless fishing regulations are currently in place to restrict catches of that species (§8140). However, an **experimental gear permit** is needed for new types of commercial fishing gear and new methods of using existing gear that are otherwise prohibited. This is the case for new or existing fisheries in which experimental gear is used. Section 8606(b) states: "A permit may authorize the use of new types of commercial fishing gear and new methods of using existing gear otherwise prohibited by this code and may authorize that use or the use of existing gear in areas otherwise closed to that use by this code."

The Commission's issuance of experimental gear permits presents a good opportunity to strategically take the steps contained in Figure 6. The Commission can be proactive and precautionary by requiring certain measures for the use of that new gear type, including data collection and minimizing damage to the environment and other marine resources. The Commission may also revoke a permit if it finds that the fishery or gear is causing damage or creating conflict among user groups. If the experimental gear is ultimately approved for broader use, the fishery that results may then be managed pursuant to elements of the emerging fisheries policies referenced below.

New fisheries using existing gear

The emerging fisheries provisions in the MLMA are aimed at fostering a proactive approach to management. The goal is to prevent such fisheries from growing faster than the understanding necessary to sustainably manage them. More specifically, the MLMA requires the Department and the Commission to "encourage, manage, and regulate" fisheries that are perceived to be increasing. It also states that the Department shall closely monitor landings and other factors it deems relevant in each emerging fishery and shall notify the Commission of the existence of an emerging fishery (§7090(c)).

Section 7090 of the MLMA defines an emerging fishery as:

1. A fishery that the director has determined is an emerging fishery, based on criteria that are approved by the Commission and are related to a trend of increased landings or participants in the fishery and the degree of existing regulation of the fishery.
2. A fishery that is not an established fishery. "Established fishery" means, prior to January 1, 1999, one or more of the following:
    a. A restricted access fishery has been established in this code or in regulations adopted by the Commission.
    b. A fishery, for which a federal FMP exists, and in which the catch is limited within a designated time period.
    c. A fishery for which a population estimate and catch quota is established annually.
    d. A fishery for which regulations for the fishery are considered at least biennially by the Commission.
    e. A fishery for which the Fish and Game Code or Title 14 regulations adopted by the Commission prescribes at least two management measures developed for the purpose of sustaining the fishery. Management measures include minimum or maximum size limits, seasons, time, gear, area restriction, and prohibition on sale or possession of fish.

The Commission adopted an additional set of criteria to determine whether a fishery qualifies as emerging (see: http://www.fgc.ca.gov/policy/p2fish.aspx#emerging). If the Commission designates a fishery as emerging, it has two possible courses of action. The first is to adopt regulations to limit catch or effort. If adopted, these regulations can stay in effect until an FMP is adopted. The second is to direct the Department to develop a new FMP. The Department may make a recommendation to the Commission regarding the best course of action based on the existing set of priority fisheries. Emerging fisheries are by nature data-poor, and tools such as PSA may be needed to inform management measures and strategies.

Guidance

- Application of the fishery management cycle described in Chapter 5 and Appendices F-J will advance adaptive management goals of the MLMA.
- In particular, the Department should make strategic use of reference points and HCRs wherever appropriate and where resources allow.
- ESRs should describe if and how current management is adaptive (see Chapter 3) and responsive to changing ecological, environmental, or socioeconomic conditions. This includes identification of any indicators considered in management, the data collection efforts that inform decision-making, and any HCRs or processes in place to systematically consider new information.
- In developing FMPs, the Department should include adaptive management mechanisms such as those employed in the White Seabass and Spiny Lobster FMPs.
- As described in Chapter 11, climate change may be a catalyst for emerging fisheries going forward. However, prioritizing management effort is central to effective implementation of the MLMA. Therefore, when the Commission considers new fisheries or new uses of gear it should consider them in light of the criteria for evaluating new proposed priorities described in Chapter 2.

Chapter 10 – Best available information and peer review

Ensuring the use of the best available information in management of fisheries is a central tenet of the MLMA. One step in achieving this is external peer review of certain scientific information used in management. The discussion below describes the requirements of the MLMA regarding best available scientific information and external peer review. As part of the information gathering effort associated with the Master Plan, OST developed a report on best practices regarding peer review under the MLMA (see: http://www.oceansciencetrust.org/projects/peer-review-and-california-fisheries-management/). This chapter as well as the additional details provided in Appendix O draw from that report.

Section 7050(b)(6) of the MLMA states that management should be based on "the best available scientific information and other relevant information." This includes the following:

- Determinations as to whether a fishery is depressed (§90.7)
- Determinations as to whether overfishing is occurring (§98)
- Management of marine living resources (§7050(b)(6), including fishery management decisions (§7056(g)) and FMPs (§7072(b))
- Dissemination of information on the condition and management of marine resources and fisheries (§7050(b)(8))
- The effects of management measures on fish populations, habitats, fishermen, and coastal communities (§7083(b))
- Identification of measures that might minimize damage to habitat from fishing (§7084(a))
- Level of bycatch and its effects on other fisheries, conservation of bycatch species, and the ecosystem (§7085)
- Identification of criteria for determining when a fishery is overfished (§7086(a))

The Department should apply the criteria developed by the **National Research Council (NRC)** in determining the best available scientific information (NRC 2004):

- *Relevance:* Scientific information should be representative of the fish stock, habitat, and socioeconomic context of the fishery being managed, although the data need not be site specific or species specific. In some cases, analogous information from a different region or the biological characteristics of a related species or species with similar life-history strategies will be informative and relevant, and may constitute the best information available.
- *Inclusiveness:* Scientific advice should be sought widely and should involve scientists from all relevant disciplines. The goal should be to capture the full range of scientific thought and scientific opinion on the topic at hand. Critiques and alternative points of view should be acknowledged and addressed openly. Anecdotal (experiential, narrative, or local) information should be acknowledged and evaluated during the process of assembling scientific information. When no other information is available, anecdotal information may constitute the best information available. In addition, anecdotal information may be used to help validate other sources of information and identify topics for research.
- *Objectivity:* Data collection and analysis should be unbiased and obtained from credible sources. Scientific processes should be free of undue nonscientific influences and considerations.
- *Openness:* The public should have information about each phase of the process from data collection to data analysis to decision-making. Decision makers should provide a clear rationale for the choice of the information that they use or exclude when making management decisions. The processes of collecting data and selecting research for use in support of management

decision-making should be open, broad-based, and carefully documented. All scientific findings and the analysis underlying management decisions should be readily accessible to the public. The limitations of research used in support of decision-making should be identified and explained fully. Stock assessments and economic and social impact assessments should clearly describe the strengths and weaknesses of the data used in analyses.

- *Timeliness:* There are two primary aspects to timeliness. First, timeliness refers to the acquisition of data in such a manner that sufficient time exists to analyze it adequately before it is used to make management decisions. Second, timeliness refers to whether the data are applicable to the current situation. Uncertainties that arise from an incomplete study should be acknowledged, but interim results may be better than no new results at all. Management decisions should not be delayed indefinitely on the promise of future data collection or analysis.

Peer review

In §7062, the MLMA requires that the Department "establish a program for external peer review of the scientific basis of marine living resources management documents." Peer review is the most accepted and reliable process for assessing the quality of scientific information. Its use as a quality control measure enhances the confidence of the community (including scientists, managers, and stakeholders) in the findings presented in scientific reports and, consequently, in decisions based on that scientific information.

The MLMA identifies some but not all types of documents that can be submitted to external peer review; these documents are marine resource and fishery research plans (§7062(a)), Interim Fishery Research Protocols (§7074(c) if justified), and FMPs or plan amendments (§7075(a)). The MLMA does not address data sets, analyses, and other documents developed by the Department or other entities, which may be cited within a management document (e.g., ESRs). However, scientific information developed by the Department is subject to the *Department's Policy for Quality in Science and Key Elements of Scientific Work* (CDFW 2008), which allows internal review of documents unless the document will have "a substantial management impact or large expenditure of funds".

The MLMA does not provide guidance on other specific documents that should be submitted to peer review, but limits peer review to the scientific basis of management documents. In general, the Department and Commission should consider submitting to peer review all scientific analyses central to the development of FMPs and management measures as well as the scientific portions of FMPs themselves. The process for this review is described below.

Exemption of documents from external peer review

The MLMA authorizes the Commission, with the advice of the Department, to adopt criteria for exempting certain documents from external peer review (§7074(d) and §7075(c)). In making this determination, the Commission should be guided by the criteria below used by the NRC:

- The product does not contain scientific or technical information upon which decisions are based.
- The work product has already been subject to a prior adequate peer review within a reasonable time period.
- A peer review process would significantly interfere with the need for promptness in decision-making or secrecy of information.
- The information is routine data, generated using properly applied, scientifically accepted methods.
- Information involving a health or safety issue where dissemination is time-sensitive.

- The information consists of accounting, budget, actuarial and financial information.

Scope of external peer review

At a general level, the MLMA characterizes the scope of external peer review as “the scientific basis of marine living resources management documents” (§7062(a)). Section 7062(c) calls for the external review panel to determine whether “a scientific portion of the document is based on sound scientific knowledge, methods, and practices.” Given the breadth of issues in FMPs and related documents, properly establishing the scope of an external peer review so that it focuses upon the scientific elements of the documents is crucial to implementing these provisions of the MLMA. Due to the significant workload associated with conducting an independent peer review, including the logistics and coordination among reviewers, it is expected that it will not be possible to accomplish most reviews with volunteers and therefore contractors will likely be engaged. This will require dedicated funding and capacity to manage.

Regardless of whether contractors or volunteers are employed, to conduct an external peer review, the Department and coordinating entity managing the external peer review process should develop a detailed scope for scientific review of the target documents before selection of the panel of reviewers. The Department should notify the public of the scope upon its formulation. In many cases, it will be useful to delineate between the scientific basis of the management document undergoing review and the management recommendations contained therein, which typically would not be subject to peer review. Table 3 provides guidance on types of reviews, example applications and the benefits and limitations to the use of that review type.

Levels of peer review

Depending upon the document, the intensity of peer review may vary. For example, routine updates based upon previously reviewed methods may be reviewed internally while novel or complex methods, data, and analysis will require more formal review by an external panel of experts. Table 3 identifies four levels of external scientific peer review and considerations associated with each. See Appendix O for additional details on best practices regarding each potential work product.

Table 3: Levels of peer review and associated considerations.

Review mode	Example applications	Potential work product	Benefits	Limitations
Internal review	Routine actions with limited management implications or associated controversy	Status of the Fisheries Reports, fishery research protocols,	Agile, cost-effective	Limited opportunity for alternative perspectives
Expert written review	Products of short to moderate length, and low to moderate complexity Work products that are unlikely to have highly significant management implications	Draft FMP of low to moderate complexity	Quick, less costly Multiple independent reviews offer diverse viewpoints	No group discussion or deliberation Reviewers may have contrasting or opposing views
Panel review (remote)	Moderately complex methodologies, models or data analyses that require group discussion and participation of agency staff Reviews requiring international participants Work products that are likely to have moderately to highly significant management implications	Draft FMPs or methodologies of moderate to high complexity	Allows for deliberation among reviewers and managers Relatively easy to accommodate public participation	Moderately costly, moderately time-intensive Does not allow for in-depth group working sessions
Panel workshop review (in-person)	Complex methodologies, models or data analyses that require group discussion and participation of agency staff Newly applied methodologies (first application in California fisheries management) Reviews requiring additional analyses or model runs Work products that are likely to have moderately to highly significant management implications	Stock assessment, complex or highly complex draft FMP or methodology Highly controversial reviews	Allows for deliberation among reviewers and managers, real-time analysis, discovery and back and forth deliberation. Workshops open to the public may increase buy-in	Requires extensive pre-workshop planning Costly, time-intensive
Journal peer review	Complex methodologies, models or data analyses, and novel science Decisions or scientific information that would benefit from highly rigorous scientific vetting Scientific information that could be built upon or would benefit the wider academic community Controversial findings or results inform influential or costly management decisions	Varied; Methodology, models, new data, analyses	Ensures product meets high standards of scientific quality	Not reviewed openly, may not allay public concerns Time-intensive – may not be appropriate for time-sensitive findings or conclusions; Manuscript must align with journal publication timelines Competitive process

The level of review for specific kinds of documents is included in the table above. However, in determining the appropriate level of review, the following criteria should be considered:

- *Complexity*: The nature and complexity of scientific information presented in models, analyses, and methods.
- *Management risk*: The significance of information and decision-making risk potential impact on sustainability for incorrect management decisions.
- *Uncertainty*: The level of confidence surrounding a body of scientific knowledge.
- *Socioeconomics*: The social and/or economic value of the fishery and economic impacts of decisions that will be informed by the scientific information; cost-benefit analysis of additional review.
- *Level of previous review*: A determination of the type and amount of previous peer review of the information used.
- *Precedent*: Whether science is regarded as “precedent setting,” particularly novel, or is the first application of a new tool or model.
- *Group discussion*: The benefits to be gleaned from group deliberations.

External peer review timing

The MLMA does not dictate the timing of peer review within the regulatory process, and practice has varied. In general, the Department should consider seeking peer review of scientific information that will be used to inform management decisions before regulatory options are developed and before agency or stakeholder positions have formed, to the extent that is feasible. External peer review of FMPs and similar documents might begin only upon completion of a draft document and before public review. Where feasible, it is advantageous for the Department to include an opportunity for the **external peer review panel** to review the Department’s responses to panel findings as well as public comments. See Figure 7 for suggested checkpoints for peer review during the management process.

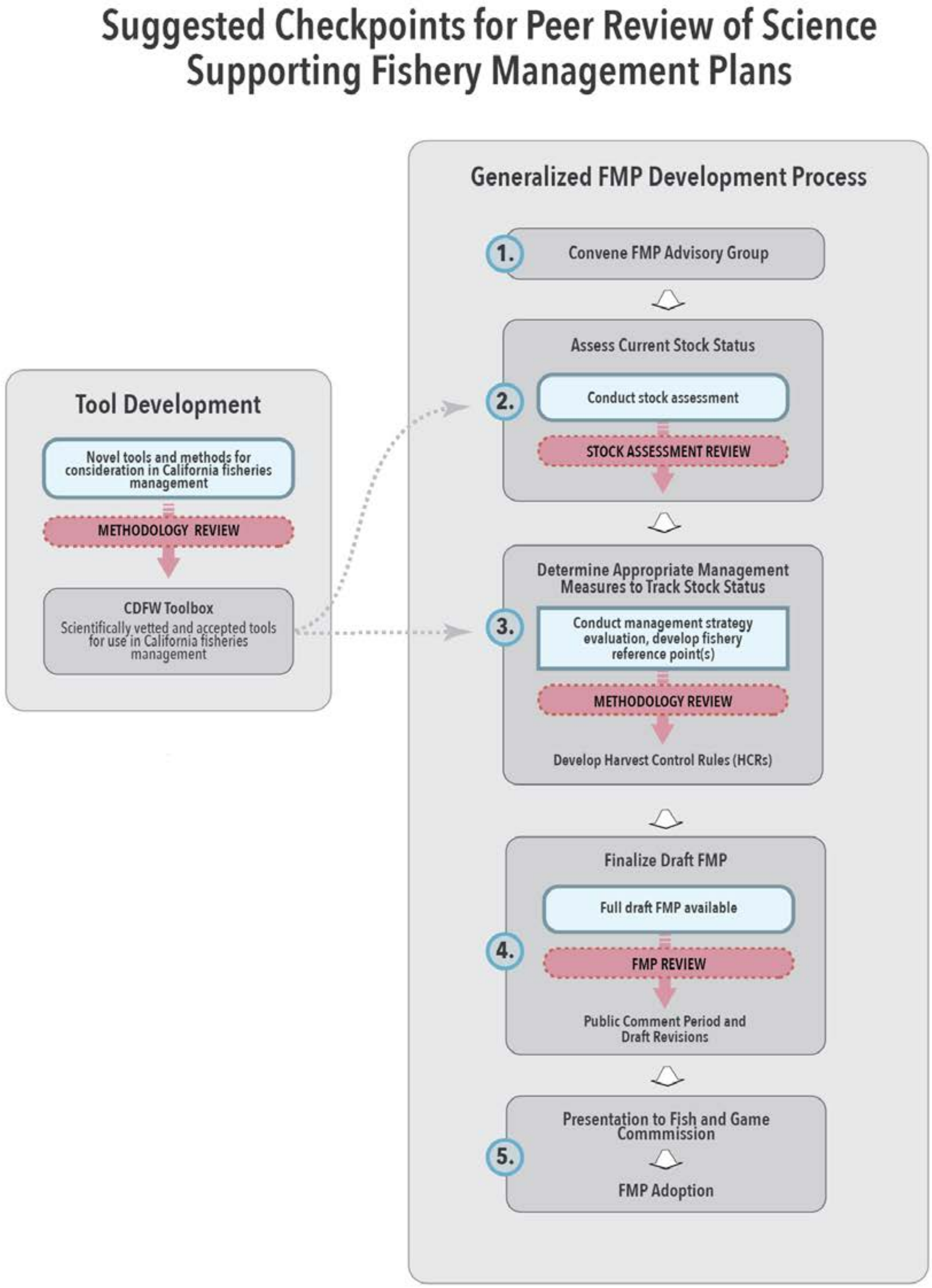


Figure 7. Suggested checkpoints for scientific peer review of science in a generalized FMP development process (OST 2017).

Management and design of the external peer review process

In conducting external peer reviews of scientific information, the MLMA authorizes the Department to enter into an agreement with outside entities "that are significantly involved with research and understanding marine fisheries and are not advocacy organizations" (§7062(b)).

The contracted entity is to select and administer the external peer review panel and is responsible for the scientific integrity of the peer review process (§7062(b)). The MLMA does not define scientific integrity; however, in designing a peer review process with a contracted entity, the Department should aim for a process that has the following characteristics (Office of Management and Budget 2005):

- Incorporates the right expertise and balance.
- Identifies the key scientific issues and provides a clear charge to reviewers.
- Supports deep, focused, and high-quality discussions among members of the panel.
- Ensures that the rationale for the panel's findings is clear and well-documented.
- Produces a highly accurate report summarizing the review findings.

The Department will also seek to ensure that external peer reviews have high process integrity, including the following characteristics:

- Are open and consistent
- Avoid real or perceived conflicts of interest
- Include a workable process for public comment and involvement
- Adhere to their defined procedures

The management and activities of external peer review panels should also be guided by the Department's *Procedural Guidelines for DFG Ad Hoc Independent Scientific Advisory Committees* (CDFW 2012).

Composition of external peer review panels

Among other things, the MLMA mandates that external peer review panels be made up of "individuals with technical expertise specific to the document to be reviewed" (§7062(b)). In addition, "Peer reviewers shall not be employees or officers of the Department or the Commission and shall not have participated in the development of the document to be reviewed." Reflecting best practices, membership of external peer review panels should have the following characteristics:

- Reflect the right types and diversity of expertise relative to the scientific information under review.
- Meet standards for expertise as demonstrated by degrees, publications, experience.
- Have not participated in the development of the information being reviewed.
- Be free from conflicts of interest, including any financial or other interest that could impair objectivity or confer unfair competitive advantage.

The review of highly specialized information may sometimes require exceptions to these conflict of interest rules, particularly where the pool of potential reviewers is narrow. In such situations, the real or perceived conflict of interest should be promptly identified and disclosed to the public.

Dealing with disagreements among reviewers or conflicting reviews

While it is not the goal of peer review to achieve consensus among reviewers, contrasting viewpoints or recommendations about major components of the subject matter can be difficult to resolve. This may occur more frequently during written reviews where experts do not communicate with one another during the process. However, panel workshops may also produce conflicting recommendations.

Any review output should appropriately represent any dissenting or contrasting views, however it is not the role of a review coordinating body to resolve or prescribe which recommendation to consider or accept over another. This role could be deferred to the review committee chair, or, depending on the level and subject of disagreement, the Department or the review coordinating body may choose to consult with an outside expert.

As noted here, the Department is required to provide written explanation if it disagrees with any aspect of the review findings. A written response and justification could also be appropriate when responding to conflicting reviews. The review committee chair, outside expert, or the Commission could serve as moderator to make a final determination of whether an issue was adequately addressed.

Reporting of peer review findings

Section 7062(c) of the MLMA requires that the external scientific peer review entity provide the Department with “the written report of the peer review panel that contains an evaluation of the scientific basis of the document,” including any findings of scientific deficiencies in the document and the basis for those findings. As required by the MLMA, the Department is to then accept the findings and alter the document, or if it disagrees with a finding, to include as part of the record its basis for its disagreement, including its reasons for determining the document is based on sound scientific knowledge, methods, or practice. The MLMA requires that the Department submit the peer review report and its response to peer review findings with the reviewed document to the Commission and will make these materials publicly accessible to strengthen the transparency of the peer review process.

While scientific review can be a resource and time-intensive process, it can help demonstrate that fishery management decisions are based on valid and defensible science. An open process can also demonstrate a commitment to objectivity and help build relationships with stakeholders. Many of the recommendations contained in this chapter require standardizing and formalizing existing practices and processes, as well as dedicated funding, to ensure consistency across review implementations. For additional details regarding the peer review process including a peer review checklist, sample **Terms of Reference (TOR)**, and report template, see Appendix O.

Chapter 11 – Adapting to climate change

The preceding chapters each address a central objective of the MLMA. When each objective is effectively achieved, the management system as a whole is robust, responsive, and resilient. While this is an important goal under typical conditions, the challenges of climate change will require management to be flexible and adaptive, further underscoring the need of effective MLMA-based management.

Since the MLMA was drafted, the potential long-term impacts of climate change have become more clearly understood. As discussed below, climate change is expected to have broad impacts across marine ecosystems, as well as the societies and economies that depend on those ecosystems. Climate change may result in a number of physical changes to oceanic and nearshore systems, including increased temperature, ocean acidification, altered currents, increased storm frequency and severity, and higher sea levels. These physical changes may in turn affect ecosystem productivity and function, species abundances and distributions, habitat use and availability, and cues that some species rely on that indicate changes in the season. They may also affect the ability of fishing fleets to access resources, impact port infrastructure, and potentially change the ability to catch and land fish. These changes are already occurring, and may have wide-ranging implications for California's fish stocks and fishing communities.

This chapter draws from a 2017 report by OST on adapting to climate change, which was developed as part of the information gathering phase of the Master Plan amendment (see: http://www.oceansciencetrust.org/wp-content/uploads/2016/06/Climate-and-Fisheries_GuidanceDoc.pdf, referenced as Chavez et al. 2017). This chapter focuses on how climate change may impact California's fisheries and discusses the various ways in which management can prepare for these changes to maintain resilient ecological and socioeconomic systems.

A naturally variable system

Even in the absence of climate change, the CCE is one of the most variable marine ecosystems in the world due to the influence of the El Niño Southern Oscillation, the Pacific Decadal Oscillation, and the North Pacific Gyre Oscillation (Chavez et al. 2017). Because of these systems, climatic factors fluctuate on yearly and decadal (or longer) timescales. These factors create a challenging management landscape that is further complicated by the additional variability that climate change will bring.

The CCE varies generally between relatively cool and warm regimes that differ in their environmental conditions, species composition and distribution, and overall food web productivity. Historically, warm and cool phases have been relatively consistent in terms of their accompanying conditions. In general, cool phases tend to be more productive, because movement of subarctic water, cooler ocean temperatures, and stronger upwelling results in more nutrients available for phytoplankton, and consequently more food for higher trophic levels (Chhak and Di Lorenzo 2007). Warm phases are generally less productive. As the CCE cycles between cool and warm regimes, these environmental conditions drive recruitment, species composition and distribution, and overall production, all of which affect fishermen and their communities.

Species tend to respond differently to cool or warm periods. Within California, under cool regimes Market Squid, Dungeness Crab, Ocean (Pink) Shrimp, Northern Anchovy, and most **groundfish** are particularly productive. Under warmer regimes, including those associated with El Niño events, Pacific Sardine, Spiny Lobster, and California Halibut tend to thrive (Chavez et al. 2017). These species form the basis of major fisheries in California's waters, and management must become more flexible to deal with potentially increased fluctuations due to climate change. In addition, the extent to which a given species is likely to be affected by climatic fluctuations depends on the life history and trophic level of the species (Chavez et al. 2017). For short-lived, planktivorous species such as Market Squid and Ocean (Pink) Shrimp, populations can respond dramatically to environmental conditions, and these fisheries tend to experience cyclical conditions. Conversely, long-lived piscivores, such as rockfish, are generally able to withstand climatic fluctuations with more modest year-to-year shifts in total population abundance or availability to fisheries (Field et al. 2006).

Measuring change

Understanding how normal climatic fluctuations within the CCE have affected fish stocks in the past may help managers prepare for climate change. Environmental indicators such as sea surface temperature and the Multivariate Ocean Climate Index, which looks at a range of oceanic conditions, can serve as valuable tools to characterize the degree to which the system is operating in a warm or cool regime. This information may be used to help assess the status of fish stocks and determine appropriate management responses. In addition, this information can help provide some insight into how these species, and the fishing communities that depend on them, may fare under climate change scenarios.

Environmental and ecological changes

Increased variability under climate change

Climate change may alter the natural cycles of the CCE by increasing the magnitude of variability in the system, leading to more extreme conditions. These changes are likely to result in large-scale impacts rather than the local-scale impacts that fishing pressure often exerts. For example, changes in atmospheric and oceanographic forcing may change the timing of natural fluctuations by increasing or decreasing the length of warm or cool states. Extreme environmental conditions, in turn, may increase the frequency or intensity of disease, parasite, or biotoxin outbreaks such as withering syndrome in abalone, sea star wasting disease, and harmful algal blooms; such outbreaks can have direct or indirect impacts on fisheries. For example, extremely warm temperatures contributed to unprecedented size and persistence of the 2015-2016 harmful algal bloom event that led to temporary closures of the Razor Clam, Dungeness Crab, and Rock Crab fisheries.

Extended warming events and higher storm activity may also lead to declines in kelp abundance and distribution. Extreme marine heat waves have also contributed to a dramatic reduction in kelp distribution, particularly in northern California. Persistent warming over several consecutive years may reduce the capacity of annual kelp species (e.g., *Nereocystis luetkeana*) to successfully reproduce. Reduction in kelp has had both direct and indirect effects on species that depend on it for food and habitat. If the magnitude and timing of CCE's variability changes, synergism among these impacts could lead to dramatic shifts in CCE dynamics with significant long-term implications for fisheries.

Changes in spatial distribution

Species that favor cool regimes, such as Dungeness Crab, rockfishes, anchovies and salmon, are particularly vulnerable to climate change in California. Such species are predicted to shift poleward where conditions are likely to be more favorable. The distribution of subtropical species such as tunas, White Seabass, and Pacific Sardine is likely to expand poleward, leading to emerging fisheries in the north (Chavez et al. 2017). Some species may decline in abundance, particularly those with characteristics that prevent them from expanding their range (e.g., limited dispersal potential, specific habitat or prey requirements, etc.). Long-lived species such as rockfish are likely to be more resilient to high variability. However, individual species declines or shifts may alter food web dynamics. Highly specialized species are more vulnerable to increased variability (e.g., specialized diets, habitat requirements, or complicated reproductive strategy).

Changes to species life histories and food web dynamics

Changes in temperature may drive changes in the phenology (seasonal timing) and phenotypic expression (physical traits) of fishes and invertebrates. Species may display a shorter pelagic larval duration, faster growth, and younger age at maturity more commonly observed in the tropics (Asch 2015). Changes in life history traits, particularly changes in timing, could lead to recruitment failures if shifts in timing result in temporal mismatches with the seasonal abundance of prey resources (e.g., spring bloom in productivity). For example, earlier spawning and shorter larval stages could result in a temporal mismatch between peak larval production and the production of zooplankton prey. Snyder et al. (2003) found evidence that climate change may lead to delays in the onset of the upwelling season, which further increases the likelihood of a temporal mismatch between larval production and spring blooms in productivity. Species that time reproduction and larval release to the spring bloom in productivity are particularly vulnerable to match mismatch dynamics and, ultimately, reduced recruitment (e.g., rockfishes, Dungeness Crab).

Changing ocean chemistry

California is already experiencing physical changes to the properties of seawater that are consistent with climate change projections and have the potential to contribute to dramatic ecological shifts. Scientists have observed an overall decline in seawater pH (Somero et al. 2016). Additionally, there has been an increase in frequency of conditions that can destabilize, dissolve, or prevent the creation of calcified structures such as shells and urchin tests, and projections indicate that these conditions will continue to increase (Feely et al. 2008; Harris et al. 2013). In addition to declining seawater pH, long-term declines in oxygen content, as well as short-term hypoxic events during upwelling, have also been observed in California Current (Feely et al. 2008; McClatchie et al. 2010). Due to regional differences in oceanography, the impacts of climate change will differ in northern and southern regions of California. Upwelling intensification in northern regions may lead to more extreme acidification and hypoxia relative to the Southern California Bight.

Shifts in ecosystem function

Climate change may cause the CCE to undergo a dramatic shift in community structure, such that food web dynamics and ecosystem function are disrupted. There are many potential causes for this. Global warming and changes to atmospheric forcing in the Northeast Pacific will alter circulation patterns, mixing, and ultimately the physical parameters of seawater. Changing ocean conditions are projected to occur gradually over the coming decades, but the ecological impacts of these changes may manifest in sudden biological tipping points that shift ecosystems into dramatically altered states (i.e., crossing thresholds) (Selkoe et al. 2015). This could result in large changes to ecosystem function, with a possible effect being the rapid change in a fish stock's abundance. Crossing this type of biological tipping point may reverberate through the food web and cause shifts in the state of the ecosystem.

Managing for climate change

Climate change adaptation will require detecting the changes described above and responding to them in a timely manner to maintain sustainable fisheries. The following sections provide an overview of some management approaches that may be applicable to California's fisheries.

Maintaining ecological resiliency

Resilience is defined as the "capacity of an ecosystem to absorb recurrent disturbances or shocks and adapt to change while retaining essentially the same function and structure" (McClanahan et al. 2012). The following management approaches are designed to maintain ecosystem resilience in fisheries affected by climate change.

- *Reduce external stressors*: One strategy for increasing resilience of stocks (and ecosystems) to climate change is to decrease existing stressors already impacting the stocks expected to be negatively affected by climate change (Sumaila et al. 2011; Stein et al. 2013; Pinsky and Mantua 2014). For species expected to be negatively impacted by climate change, the impacts from other stressors are more likely to have rapid and more acute reactions. Some examples of existing stressors include high fishing mortality, habitat degradation, invasive species, disease, and pollution.
- *Identify vulnerable species*: Some species will be more vulnerable than others to the ecological and oceanographic changes that result from a changing climate. Although there is uncertainty regarding the direction and magnitude of some of these changes over time within the CCE, potential changes from a range of climate scenarios can be examined. In California and elsewhere, efforts are underway to develop and evaluate tools for assessing species' vulnerability and risk from climate change. Results from such assessments will provide valuable information to guide many facets of the MLMA-based management including prioritization, ERA, and ESR and FMP development. The Department will explore partnerships available for conducting such assessments as tool availability and resources permit.
- *Apply a precautionary approach to fisheries management*: The precautionary approach guides decision-making by assessing risks and then managing for them. Precaution in management actions is necessary because knowledge of ecosystems is incomplete. The precautionary approach ensures that excessive harvests are not made in the face of the considerable uncertainty associated with environmental variation. While it does not address climate impacts explicitly, the ERA framework described in Chapter 2 can help identify risks in fisheries and where precaution may be particularly warranted. As noted in Chapter 5, MPAs may help to provide additional precaution for some species.
- *Protect age structure*: Protecting or recovering the full age structure of a stock (the fraction of the population at different ages) can increase that population's resilience to a changing environment. In a population with a full age structure, larger females tend to have larger, healthier eggs and more of them, which contribute to subsequent recruitment success. In addition, older and larger fish spawn over a longer time period, greater depth gradient, and an extended area when compared to younger fish. These mechanisms may help buffer stocks from recruitment fluctuations due to environmental conditions. Management options that may improve a population's age structure include use of MPAs, minimum or maximum size limits, gear modifications to avoid catching juvenile fish, or fishery closures during times and over areas when large individuals congregate.
- *Manage for genetic diversity*: There are three components to the adaptive capacity of marine populations: 1) ability to adjust to new conditions; 2) ability to relocate if or when conditions change; and 3) ability to evolve strategies to survive in the new conditions (Beever et al. 2015). Each of these components requires high levels of genetic diversity within the population. Given the high rate of expected environmental change, genetic adaptation to climate change may be necessary, and management should aim to increase or preserve current genetic diversity. This may be difficult due to a lack of information about the genetic makeup of marine populations, but a **precautionary management** approach may help by decreasing existing stressors.
- *Protect key habitats*: As discussed in Chapter 6, protecting key habitats and species can promote healthy marine ecosystems that are more resilient to environmental changes. Gear modifications that reduce impacts on habitats will result in a more resilient ecosystem (Sumaila et al. 2011). If habitats have become degraded, active restoration or creation of new habitat may be a viable management option. Efforts should be targeted at habitats that provide a role for many species during key periods of their lives, such as nursery grounds that protect larval stages, or those that provide a number of ecosystem services, such as wetlands. Since climate change is expected to

decrease important coastal habitats, adaptation efforts aimed at offsetting anticipated losses could be helpful.

MPAs can be a valuable tool for protecting habitats from fishing impacts, and may increase the resiliency to climate effects of both the species being protected and the associated ecosystem. For example, reserves with full protection have been shown to increase the abundance of older females of some species, which in turn improves the age structure of a stock while decreasing the influence of environmental variability on stock abundance (Berkeley et al. 2004). In addition, because marine reserves protect multiple trophic levels, they can help retain the functional diversity of an area, improving its ability to maintain basic ecosystem functions through a changing environment. MPAs also provide locations to observe and study how ecosystems react to climate change without the added stress of fishing.

Maintaining socioeconomic resiliency

As fish stocks adjust their distributions and abundances, fishing effort may also have to adjust by changing the species targeted and the locations and times fished, as well as landing or processing locations. To adapt to a changing climate, fishermen may need to adjust where, when, and what they catch depending on conditions. Enabling them to do so may require changes in management, including permitting. The impacts of changes to the composition, magnitude, and timing of landings could be amplified if the shore-side processing and supply chain is not adaptable as well.

The following approaches are designed to help evaluate and maintain socioeconomic resiliency associated with fisheries affected by climate change:

- *Evaluate options for flexible permitting*: Flexible permitting mechanisms could provide a means to allow fishery participants to hedge their risk, adapt to variable production or unexpected closures, and respond to shifts in species spatial distribution or range shifts. Flexible permitting could include transferrable permits and integrating gear flexibility into permits or other regulations. One of the challenges of flexible permitting mechanisms, however, is effectively controlling effort and balancing the interests of all affected stakeholders. Any such increase in flexibility would need to be consistent with the Commission's restricted access policy (see: http://www.fgc.ca.gov/policy/p4misc.aspx#restrict). As resources permit, the Department and Commission will conduct an analysis of permit transferability in California fisheries and the Commission's policy on restricted access fisheries. This analysis will include how permits are retired and new permits are issued, and the potential for gear switching. Permitting considerations will also be included in the development of new FMPs.
- *Evaluate community vulnerability*: Some communities will be more affected by climate change than others. There is a need to consider vulnerabilities of fishing communities to climate change impacts. For example, a vulnerability index that incorporates social and ecological indicators would allow communities to be ranked by their vulnerability, and could enhance the abilities to minimize adverse impacts on fishing communities when developing management plans and regulations. Vulnerability assessments should be scaled appropriately and should consider the interconnectedness of fishing communities at a regional scale.

Supporting fisheries transitions and emerging fisheries

Changes in species distributions and abundance may lead to emerging fisheries (see Chapter 9). The Department and the Commission will need to carefully balance the needs of fishing communities to remain flexible and diversify their portfolios, while protecting fish stocks during a time when their range may be changing. As noted, the development of emerging fisheries needs to be considered in light of existing priorities. The criteria for evaluating new proposed priorities identified in Chapter 2 can help ensure that limited management resources are effectively targeted.

Strengthening monitoring and data used for management

Monitoring will be an important component of any strategy to detect and respond to climate change, including the following:

- *Prioritize additional monitoring*: Current monitoring programs may benefit from re-evaluation of their design and scope in light of climate change. It may be possible to use existing data collection in a new way to monitor climate change. For example, tracking the spatial distribution of fishing effort and landings may alert managers to range shifts. Newer technologies could also be considered when planning monitoring programs, to improve information acquisition while keeping costs low. For example, cell phones allow stakeholders to provide real-time catch or sightings information, and results from satellite remote sensing can be used to estimate area-specific phytoplankton productivity and predict the fish distribution and abundance. Development of new indicators—such as duration of spring blooms and the size or species composition of phytoplankton—could provide even better information relevant to predicting climate effects on fishing resources (Chassot et al. 2011). Understanding the link between physical oceanographic conditions and ecosystem health is critical and supporting and partnering with organizations that conduct monitoring should be a priority.
- *Incorporate environmental parameters into stock assessments, MSEs, and HCRs*: There is strong evidence to suggest that the productivity of many fish stocks is directly influenced by environmental variables. For species whose productivity is known to be dependent upon environmental conditions, appropriate environmental parameters may be integrated into stock assessments, MSEs, and HCRs. See Appendix J for more details. As knowledge of relationships between managed fish stocks and environmental dynamics continues to improve, there will be more basis for incorporating environmental factors into stock assessment and management.
- *Incorporate spatial information into stock assessments, MSEs, and HCRs*: Changes in species distributions can create management challenges, particularly when they cross jurisdictional boundaries. As the abundance or distribution of fish species is impacted by a changing climate, it may no longer be appropriate to follow the common practice of basing allocations on historical catch rates. Fish may be in a new location because their distribution has shifted or because the population has expanded into new habitat. Additionally, changes in habitat availability may result in changes in fish distribution. Including spatially-explicit information in stock assessments will assist in capturing regional differences in environmental conditions that affect stock productivity. This may require coordination with neighboring states and countries.

Addressing potential climate change impacts in Enhanced Status Reports and Fishery Management Plans

In order to identify and better address the potential impacts of climate change and to allow for the adaptive management, ESRs and FMPs should specifically incorporate information on each of the following aspects:

- *Changes in spatial distribution*: A description of whether the species is anticipated to shift its distribution.
- *Changes in abundance*: A description of whether the species is anticipated to increase or decrease in abundance.
- *Changes to species life histories*: A description of whether the subject species is anticipated to alter breeding, feeding, growth, or other life history patterns.
- *Changing ocean chemistry*: A description of how potential changes in ocean chemistry might affect the species.

- *Measuring change*: A description of how these possible changes could be measured, and if possible, forecast.
- *Potential opportunities*: A description of potential opportunities for CFR to address climate-related research needs.
- *Potential impacts*: A description of how the above changes may impact HCRs and other management strategies.

California's oceanographic and ecological system is dynamic, and this variability is likely to increase as climate change progresses. A flexible and responsive management system will be necessary to mitigate negative ecological impacts while capitalizing on new opportunities. Given the uncertainty inherent in climate change, a multi-pronged approach to facilitate adaption and resilience in California's fisheries must be employed.

Chapter 12 – Tribal consultation

California Tribes and tribal governments are the traditional users and stewards of California's marine resources. Partnerships with Tribes and tribal communities are important to the Department and the Commission to sustainably manage California's ocean fisheries. The Department and Commission are demonstrating their growing commitment through issuance and adoption of policies that provide the foundation to work cooperatively, communicate effectively, and consult with Tribes.

In 2011, the Governor issued Executive Order B-10-11 directing state agencies to encourage communication and consultation with Tribes to allow meaningful input into the development of laws and policies that may affect tribal communities (see: https://www.gov.ca.gov/news.php?id=17223). This was followed in 2012 by the California Natural Resources Agency issuing its Tribal Consultation Policy (see: http://resources.ca.gov/tribal_policy). The purpose of that policy is to improve consultation and communication with Tribes and to promote durable outcomes by including Tribes throughout the decision-making processes of its Departments. The Department adopted its own Tribal Communication and Consultation Policy (Tribal Policy) in October 2014 (see: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=122905&inline). The Tribal Policy is the foundation for the Department's interaction with federally recognized Tribes and Tribes on the contact list maintained by the Native American Heritage Commission for purposes of tribal cultural resource protection. The purpose of the Tribal Policy is to establish effective tools for communication and consultation between the Department and Tribes.

Under the Tribal Policy, the Department seeks tribal input on its actions in order to identify potential issues, to ensure to the maximum extent feasible that tribal interests are considered before undertaking actions, and to avoid or minimize impacts whenever practicable.

In October 2013, the Commission created the Tribal Committee as one of its working committees, to strengthen communication and collaboration between the Commission and California federally recognized Tribes and tribal communities. The Tribal Committee was tasked with the development of an effective government-to-government consultation policy to guide work between the Commission and Tribes on policies that affect California tribal communities. In July 2015, the Commission adopted its Tribal Consultation Policy that focuses on early communication and coordination rather than on formal consultation. This policy created a means by which Tribes and the Commission can effectively work together to sustainably manage natural resources of mutual interest.

Chapter 13 – Periodic review and amendment process

As outlined in Chapter 9, adaptive management to achieve sustainability is a central objective of the MLMA. In order to meet this and the other objectives of the MLMA over time, it is essential that the Master Plan be periodically evaluated and updated as needed. Regular review will provide an opportunity for amendments that address unplanned needs, incorporate new tools, and respond to changes in circumstances and stakeholder interests. Additionally, allowing for minor revisions to the guidance and background information that the Master Plan provides, will help to keep it a living and dynamic document in the interim.

This chapter addresses the following:

- *Initiation*: How any changes to the Master Plan can be initiated.
- *Ongoing revisions*: Minor changes that can be made by the Department at any time and the process for making them.
- *Evaluation*: The process, criteria, and timeline for evaluating Master Plan implementation.
- *Amendment*: Comprehensive updates to the Master Plan and the process and timeline for development.

Initiation

Changes to the Master Plan can be initiated by the Department or in response to requests by members of the public. Requests by the public must be made in writing to the Commission clearly stating the reasons why the Master Plan should be changed. The Commission will determine whether a change recommended by the Department or request by the public is appropriate and may direct the Department to begin an amendment or revision process.

Ongoing revisions

The Master Plan includes background information that can be a resource for ESRs, rulemaking packages, and FMPs. Much of this material reflects current understanding and knowledge that continues to evolve, such as in data-limited stock assessments. The Master Plan is structured to provide guidance that promotes consistency with Commission policy while allowing for this evolution in understanding about effective means of implementation. This information will change over time. For the Master Plan to remain relevant and useful, the Department will need to update it as new information becomes available. At the same time however, the Master Plan is a Commission document and it is necessary to ensure that it continues to reflect Commission guidance over time. To that end, all proposed revisions shall be cited, summarized, justified, and placed on the Commission’s consent file before they are integrated into the Master Plan.

More significant changes should be addressed through the comprehensive amendment process (see the Amendments section below). A significant change for this purpose is defined as any of the following:

1. Re-prioritization of fisheries
2. An addition or deletion to the process for meaningful public involvement
3. Change to the MLMA-based management framework

Any changes other than the three listed above may be considered minor and addressed through the ongoing revision process.

Periodic evaluation

The Department should evaluate implementation of the Master Plan at least every five years. In evaluating effectiveness, the Department should assess the extent to which the framework and approaches described in this plan have been implemented, including the following:

- The number of fisheries that are under active, MLMA-based management (§7065, §7081)
- The quality and number of opportunities for meaningful public engagement in management (§7056, §7059, and §7076)
- The measures the Department has taken to identify and minimize unacceptable bycatch (§7056, §7085)
- The measures the Department has taken to adapt to climate change (§90.1, §7056)
- The efforts the Department has made to collect EFI and manage and present data (§7056)

The MLMA-based assessment framework described in Appendix D can also serve as a tool for assessing progress in individual fisheries. The Department should use this tool for all priority fisheries at the outset of Master Plan implementation, both to inform FMP development efforts, and as a means of tracking progress over time.

The Department will report the results of the evaluation to the Commission. The Commission may choose to initiate Master Plan revisions, amendments, or other action as necessary to address any needs identified through the evaluation.

Amendments

Depending on the outcome of periodic evaluations, the Department may recommend amendments to the Master Plan. Amendments may also be initiated by the public. At the outset of the amendment process, the Department should again evaluate implementation based on the criteria provided above. The Department and Commission will also invite suggestions for the amendment by holding meetings, workshops, or formal hearings, by using advisory bodies, or by taking written comment. After reviewing public suggestions and comments, the Department will initiate drafting of the amendment.

The Department is encouraged to partner with stakeholders and outside experts in the development of information, tools, and analyses that will inform the process. The Department will then submit the amendment to the Commission for adoption. The amendment will be available in written form at appropriate Department offices, and on the Department’s web site at least 45 days prior to Commission adoption. The Commission must hold at least one public meeting before adoption.

References

Asch, R. G. 2015. Climate change and decadal shifts in the phenology of larval fishes in the California Current ecosystem. Proceedings of the National Academy of Sciences 112(30):E4065-E4074.

Berkeley, S. A., M. A. Hixon, R. J. Larson, and M. S. Love. 2004. Fisheries Sustainability via Protection of Age Structure and Spatial Distribution of Fish Populations. Fisheries 29(8):23-32.

Beever, E. A., J. O'Learly, C. Mengelt, J. M. West, S. Julius, N. Green, D. Magness, L. Petes, B. Stein, A. B. Nicotra, J. J. Hellmann, A. L. Robertson, M. D. Staudinger, A. A. Rosenberg, E. Babijj, J. Brennan, G. W. Schuurman, and G. E. Hofmann. 2015. Improving conservation outcomes with a new paradigm for understanding species' fundamental and realized adaptive capacity. Conservation Letters 9(2):131-137.

California Department of Fish and Wildlife (CDFW). 2008. Strategic Initiative to Expand Scientific Capacity: Policy for Quality in Science and Key Elements of Scientific Work. Accessed at https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=ScienceInstitute

California Department of Fish and Wildlife (CDFW). 2012. Procedural Guidelines for DFG Ad Hoc Independent Scientific Advisory Committees. Accessed at https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=ScienceInstitute

California Fish and Game Commission (Commission). 2012. Fisheries Policies: Forage Species. Adopted November 7, 2012. Accessed at http://www.fgc.ca.gov/policy/p2fish.aspx#FORAGE

California Ocean Science Trust (OST). 2017. Peer Review: Guidance and Recommendations for the California Department of Fish and Wildlife. Accessed at http://www.oceansciencetrust.org/projects/peer-review-and-california-fisheries-management/

Carruthers, T. R., A. E. Punt, C. J. Walters, A. MacCall, M. K. McAllister, E. J. Dick, and J. Cope. 2014. Evaluating methods for setting catch limits in data-limited fisheries. Fisheries Research 153 (2014):48-68.

Chassot, E., S. Bonhommeau, G. Reygondeau, K. J. Polovina, M. Huret, N. K. Dulvy, and H. Demercq. 2011. Satellite remote sensing for an ecosystem approach to fisheries management. ICES Journal of Marine Science 68(4):651-666.

Chavez, F. P., C. Costello, D. Aseltine-Neilson, H. Doremus, J. C. Field, S. D. Gaines, M. Hall-Arber, N. J. Mantua, B. McCovey, C. Pomeroy, L. Sievanen, W. Sydeman, and S. A. Wheeler (California Ocean Protection Council Science Advisory Team Working Group). 2017. Readying California Fisheries for Climate Change. California Ocean Science Trust. Accessed at http://www.oceansciencetrust.org/projects/climate-change-and-california-fisheries/

Chhak, K, and E. Di Lorenzo. 2007. Decadal variations in the California Current upwelling cells. Geophysical Research Letters 34(14):L14604-L14610.

Feely, R. A., C. L. Sabine, J. M. Hernandez-Ayon, D. Ianson, and B. Hales. 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. Science 320(5882):1490-1492.

Field, J. C., R. C. Francis, and K. Aydin. 2006. Top-down modeling and bottom-up dynamics: Linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography 68(2-4):238-270.

Fulton, E. A., A. D. M. Smith, D. C. Smith, and P. Johnson. 2014. An Integrated Approach Is Needed for Ecosystem Based Fisheries Management: Insights from Ecosystem-Level Management Strategy Evaluation. PLOS ONE 9(1):84242–84416.

Harris, K., M. D. DeGrandpre, and B. Hales. 2013. Aragonite saturation state dynamics in a coastal upwelling zone. Geophysical Research Letters 40(11):2720–2725.

Kearns & West and Center for Ocean Solutions. 2017. California State Fisheries Stakeholder Engagement User Manual. Accessed at http://ca-fisheries-engagement.s3-website-us-west-2.amazonaws.com/user_manual.pdf

McClanahan, T. R., S. D. Donner, J. A. Maynard, M. A. MacNeil, N. A. J. Graham, J. Maina, A. C. Baker, J. B. Alemu, M. Beger, S. J. Campbell, E. S. Darling, C. M. Eakin, S. F. Heron, S. D. Jupiter, C. J. Lundquist, E. McLeod, P. J. Mumby, M. J. Paddack, E. R. Selig, and R. van Woesik. 2012. Prioritizing key resilience indicators to support coral reef management in a changing climate. PLOS ONE (7):E42884-E42914.

McClatchie, S., R. Goericke, R. Cosgrove, G. Auad, and R. Vetter. 2010. Oxygen in the Southern California Bight: Multidecadal trends and implications for demersal fisheries. Geophysical Research Letters 37(19):L19602-L19607.

Morrison, A. K. 2004. Input and output controls in fisheries management: a plea for more consistency in terminology. Fisheries Management and Ecology 11(6):411-413.

National Research Council (NRC). 2004. Improving the use of the “best scientific information available” standard in fisheries management. Washington, D.C.: The National Academies Press.

Office of Management and Budget. 2005. Final information quality bulletin for peer review. Federal Register 70(10):2664-2677.

Patrick, W. S., and J. S. Link. 2015. Hidden in plain sight: Using optimum yield as a policy framework to operationalize ecosystem-based fisheries management. Marine Policy 62(2015):74-81.

Patrick, W. S., P. Spencer, O. Ormseth, J. Cope, J. Field, D. Kobayashi, T. Gedamke, E. Cortés, K. Bigelow, W. Overholtz, J. Link, and P. Lawson. 2009. Use of Productivity and Susceptibility Indices to Determine Stock Vulnerability, with Example Applications to Six U.S. Fisheries. NOAA Technical Memorandum NMFSF/SPO-101, U.S. Department of Commerce, Washington, D.C. Accessed at http://www.nmfs.noaa.gov/sfa/laws_policies/national_standards/psa.html

Pinsky, M. L., and N. J. Mantua. 2014. Emerging adaptation approaches for climate-ready fisheries management. Oceanography 27(4):17-29.

Selkoe, K. A., T. Blenckner, M. R. Caldwell, L. B. Crowder, A. L. Erickson, T. E. Essington, J. A. Estes, R. M. Fujita, B. S. Halpern, M. E. Hunsicker, and C. V. Kappel. 2015. Principles for managing marine ecosystems prone to tipping points. Ecosystem Health and Sustainability 1(5):1-18.

Snyder, M. A., L. C. Sloan, N. S. Diffenbaugh, and J. L. Bell. 2003. Future climate change and upwelling in the California Current. Geophysical Research Letters 30(15):1823-1827.

Somero, G. N., Beers, J. M., Chan, F., Hill, T. M., Klinger, T., and S. Y. Litvin. 2016. What changes in the carbonate system, oxygen, and temperature portend for the Northeastern Pacific Ocean: a physiological perspective. BioScience 66(1):14-26.

Stein, B., A. Staudt, M. S. Cross, N. S. Dubois, C. Enquist, R. Griffis, L. J. Hansen, J. J. Hellmann, J. J. Lawler, E. J. Nelson, and A. Pairis. 2013. Preparing for and managing change: climate adaptation for biodiversity and ecosystems. Frontiers in Ecology and Environment 11(9):502-510.

Sumaila, U. R., W. W. L. Cheung, V. W. Y. Lam, D. Pauly, and S. Herrick. 2011. Climate change impacts on the biophysics and economics of world fisheries. Nature Climate Change 1:449-456.

Wilson, J. R., H. McGonigal, T. Dempsey, M. Gleason, and S. Rienecke. 2016. Partnerships in Fisheries Management: An Exploration of Ideas for Enhancing Capacity and Resources in California Fisheries. Unpublished manuscript.

Glossary

Adaptive Management
In regard to a marine fishery, a scientific policy that seeks to improve management of biological resources by viewing program actions as tools for learning, particularly in areas of scientific uncertainty. Actions shall be designed so that even if they fail, they will provide useful information for future actions. Monitoring and evaluation shall be emphasized so that the interaction of different elements within the system can be better understood.

Administrative Procedure Act (APA)
Statute that governs the regulatory process for federal agencies such as NOAA and other regulatory bodies. The state of California has its own APA in addition to the federal APA, which governs regulatory bodies such as the Department and Commission. The California APA requires that all proposed agency regulations be published in the California Regulatory Notice Register and remain open for public review and comment for a specified period of time. If a hearing is held, notice must be provided 45 days in advance and public comment by mail or at the hearing must be allowed. If the proposed regulation is then changed, the agency must make the revised regulation public 15 days before final action.

Allocation
In regard to fisheries, allocation means the direct and deliberate distribution of the opportunity to participate in a fishery, or to receive a share of a catch quota, among identifiable, discrete user groups or individuals.

Acceptable Biological Catch (ABC)
The maximum amount of fish stock that can be harvested without adversely affecting recruitment of other components of the stock. The ABC level is typically higher than the total allowable catch, leaving a buffer between the two.

Annual Catch Limit (ACL)
A harvest specification set equal to or below acceptable biological catch in consideration of conservation objectives, socioeconomic concerns, management uncertainty, ecological concerns, and other factors. The ACL is a harvest limit that includes all sources of fishing-related mortality including landings, discard mortality, research catches, and catches in exempted fishing permit activities. Sector-specific ACLs can be used, especially in cases where a sector has a formal, long-term allocation of the harvestable surplus of a stock or stock complex.

Bag Limit
A limit per day or per trip on the number or weight of fish, invertebrates, or plants that a recreational fisherman may legally retain.

Benthic
On or relating to the region at the bottom of a sea or ocean.

Biological Diversity/Biodiversity
A component and measure of ecosystem health and function. It is the number and genetic richness of different species found within a natural community or ecosystem, and of different communities and ecosystems found within a region.

Biomass
The total weight or numbers of a stock or population.

Bycatch
Fish or other marine life that are taken in a fishery but which are not the target of the fishery. Bycatch includes discards.

California Current/California Current Ecosystem (CCE)
The waters of the eastern Pacific Ocean that move south along the western coast of North America, beginning off southern British Columbia, flowing southward past Washington, Oregon and California, and ending off southern Baja California. The California Current is part of the North Pacific Gyre and brings cool waters southward. Additionally, extensive upwelling of colder sub-surface waters occurs, supporting large populations of whales, seabirds, phytoplankton, zooplankton, forage fishes, and important fisheries.

California Environmental Quality Act (CEQA)
This Act (Public Resources Code §21000 et seq.) identifies the significant environmental effects of California's public agencies' actions and avoids or mitigates those significant environmental effects where feasible.

Capacity
The potential of a vessel or a fleet of vessels to capture fish if not restricted by management measures. It is expressed as the number of fishery participants; size, gross tonnage, or horsepower of vessels; or the maximum amount of catch retainable on the vessel.

Catch (noun)
In regard to fisheries, the total amount (numbers or weight) caught, and sometimes only the amount landed or kept. Catch that is not landed is called discards.

Catch Limit
A limit on the total fishing mortality, including both landed catch and discard mortality. See Annual Catch Limit.

Catch Per Unit Effort (CPUE)
The catch obtained by a vessel, gear or fisherman per unit of fishing effort (e.g., number or weight of fish caught per hour of trawling). CPUE is sometimes used as a relative abundance index as well.

Catchability
A value that modifies a unit of fishing effort in the calculation of fishing mortality which usually will depend on the habits of the fish or invertebrate, its abundance, and the type and deployment of fishing gear.

Climate Readiness
Characteristic of a fishery that uses expanded data collection of climate indicators from diverse sources, proactively incorporates climate information into management actions, practices adaptive decision-making that is flexible and responsive, and encourages collaboration with partners.

Co-management
Traditional co-management refers to shared decision-making with government devolving (i.e., transferring or delegating) some of its power to others. The term has been used in a broader sense to refer to a variety of arrangements, with different degrees of power sharing, for joint decision-making by the state and community or user groups, about a set of resources or areas. No single standardized definition is used for fisheries or other natural resource sectors.

Commercial Fishery
Fishing in which harvested fish, invertebrates, or plants, either in whole or in part, are intended to enter commerce through sale, barter or trade.

Commercial Passenger Fishing Vessel (CPFV)
A licensed fishing vessel that takes recreational anglers fishing for a fee. Sometimes referred to as “charter vessels” or “party boats”.

Compliance
In regard to fisheries, compliance means fishing in a manner that is in accordance with fishing regulations such as obtaining the required permits or licenses, with the allowed gears and within allowed areas and within seasons.

Cooperative Fisheries Research (CFR)
A process that involves two or more stakeholders (e.g., scientists, commercial fishermen, recreational fishermen, NGOs in at least some aspect of research on a marine species or fishery.

Data-poor/Data-limited
Classification for a state in which essential fishery information is limited to an extent where traditional stock assessment methods may not be feasible or results have a relatively high degree of uncertainty.

Data-rich
Classification for a state in which there is a relatively high level of essential fishery information.

Depletion
In regard to fisheries, depletion means harvesting to unsustainably low levels, to the point that the population’s ability to grow and replenish is significantly reduced.

Depressed
In regard to fisheries, depressed is the condition of a fishery for which the best available scientific information, and other relevant information that the Commission or Department possesses or receives, indicates a declining population trend has occurred over a period of time appropriate to that fishery. With regards to fisheries for which management is based on maximum sustainable yield, or in which a natural mortality rate is available, depressed means the condition of a fishery that exhibits declining levels of fish abundance below those consistent with maximum sustainable yield.

Discards
Fish that are taken in a fishery but are not retained because they are of an undesirable species, size, sex, or quality (i.e., bycatch), or because they are required by law not to be retained.

Ecosystem
The physical and climatic features and all the living and dead organisms in an area that are interrelated in the transfer of energy and material, which together produce and maintain a characteristic type of biological community. Marine ecosystems can be particularly complex due to the vastness of the marine environment, the large number of organisms, and the intricacies of the physical, chemical, biological, and social processes involved.

Ecosystem-based Fishery Management (EBFM)
An environmental management approach relying on credible science that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation.

Ecosystem Indicator
An indicator that can serve as a proxy for overall condition of the ecosystem. It could be the abundance of a keystone species, biodiversity measurement, or biomass, etc. Selection of appropriate indicators is key to properly communicating between stakeholders and managers.

Ecological Risk Assessment (ERA)
The assessment of environmental effects of certain stressors and their immediate and long-term potential damage or harm to an ecosystem. Risk assessment is aimed at better identifying which species might be most adversely affected by a stressor by assessing the probability, or risk, of effects. Within the context of marine systems, risk assessment has been applied to compare the importance of individual stressors and to identify which species face the greatest threat from individual or multiple stressors.

Effort
The amount of time and fishing power used to harvest fish, invertebrates, or plants, whether by individuals or vessels. For vessels, fishing power includes gear size, boat size, and horsepower. Used to calculate catch per unit effort.

Effort Control
Management action intended to reduce fishing activities in order to conserve resources. These may include limited entry programs, individual transferrable quotas, catch limits per license, and gear restrictions.

Electronic Monitoring (EM)
In regard to fisheries, EM means technologies such as digital cameras, sensors, tablets, and online entries to track fishing vessels’ catch, bycatch, and discards at sea. These are increasingly being used in place of human observers onboard vessels that lack the space or funds for them.

Enhanced Status Report (ESR)
A revised approach to Status of the Fisheries Reports. ESRs are proposed to have sections on the history and socioeconomics of the fishery, the biology and status of target stocks, ecosystem aspects of the fishery, past and current conservation and management measures, essential fisheries information, monitoring and future research and management needs. This revised format would help ensure a basic standard of MLMA-based management is applied across all fisheries in a consistent and transparent fashion. It would summarize all of the available essential fisheries information for each fishery, and make it readily apparent what is not available. This structure is envisioned to assist the Department in planning both short and long-term research activities and inform external parties about research opportunities that may benefit management through a dynamic web-based platform.

Entanglement
In regard to fisheries, entanglement occurs when a marine species become trapped or tangled in fishing gear. It is not used to describe fish that are caught in nets but rather species including sea turtles, marine mammals, and seabirds that are unintentionally entangled.

Essential Fishery Information (EFI)
In regard to fisheries, EFI refers to information about fish, invertebrate, or plant life history and habitat requirements; the status and trends of populations, fishing effort, and catch levels; fishery effects on age structure and on other marine living resources and users, and any other information related to the biology of a species or to its take in a fishery that is necessary to permit fisheries to be managed according to the requirements of this code.

Experimental Gear Permit
Permit issued under special review of the Commission that allows the use of gear that is not permitted under any other permits or licenses in order to allow new gears to be developed and improved.

External Peer Review Panel
In the context of MLMA, this term means a group of experts who review the scientific basis of a fishery management document and evaluate the scientific soundness of the document. The panel members cannot be employees or officers of the Department or the Commission, and cannot have helped with the development of the document.

Finfish
Any species of bony fish (teleosts) or cartilaginous fish (sharks, skates and rays). Finfish do not include reptiles, amphibians, invertebrates, plants or algae.

Fishery
Means either of the following:
(a) One or more populations of marine fish, invertebrates, or plants that may be treated as a unit for purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics; or
(b) Fishing for or harvesting of the populations described in (a).

Fishery-dependent Data
Information collected directly from a fishery, such as sampling catch at landing sites and information from commercial landing receipts and commercial and commercial fishing passenger vessel logbooks.

Fishery-independent Data
Information collected separately or independent of fishery landing or catch data.

Fishery Management Plan (FMP)
A planning document based on the best available scientific knowledge and other relevant information that contains a comprehensive review of the fishery along with clear objectives and measures to ensure its sustainability. Components of an FMP are described in the MLMA.

Fishing Season
A management tool that only permits fishing within set dates. This tool can be used to reduce effort or to protect target stocks during reproductive or other sensitive periods. Different fisheries and species have different seasons as decided by managers; the season is the period of time within which the fish may be caught and retained.

Forage Fish
May refer to vertebrate and invertebrate species that provide food for marine fish, mammals, and birds. Forage fish may be targeted for direct human consumption, such as anchovies or sardines, but are most often targeted for fishmeal production or as bait for other species.

Gear Restrictions
A management tool that is intended to limit fishing effort or impacts from fishing by limiting the use of, or banning, certain gears or types of gear. This may be done by only specifying allowed gears and banning the use of all others, specifying banned gears and allowing the use of all others, and/or banning or requiring gear components or specifications (e.g., mesh size).

Gill Net
A passive capture gear constructed of vertical panels of netting, hung between a ground line and a float line, and set in a straight line, in which fish can become entangled. Gill nets are classified as either set or drift.

Groundfish
Finfish species that live and feed on or near the bottom of the seafloor. Groundfish are often managed as a single multispecies fishery. Common targeted groundfish species include rockfishes, flatfishes, skates, cod, and whiting.

Habitat
The physical, chemical, and biological features of the environment where an organism lives.

Harvest Control Rule (HCR)
A primary mechanism for achieving sustainable use, preventing overfishing, preserving habitat, rebuilding depressed stocks, and recognizing the importance of non-consumptive uses. HCRs must be based on objective, measurable criteria such as population size, productivity, or density, or other inputs. An HCR specifies the approach to setting acceptable biological catch, maximum sustainable yield, or another catch parameter for a stock or stock complex as a function of the scientific uncertainty in the estimate of overfishing limit and any other scientific uncertainty. The HCR may include explicit, stock- or complex-specific definitions of overfished or other categories. Once established, an HCR becomes the default harvest policy for managers. In general, HCRs help identify key management measures appropriate to the fishery.

Hook-and-line
Any type of fishing gear involving a fishing line with attached hooks (e.g., longline, rod-and-reel, troll, and stick gear).

Incidental Catch
Fish caught incidentally during the pursuit of the primary target species, but legal and desirable to be sold or kept for consumption.

Indicator
A measure of a component or process that can serve as a proxy for values that are difficult to calculate, such as abundance of a species or ecosystem health. For example, catch per unit effort is often used as an indicator of stock abundance or availability.

Individual Transferable Quota (ITQ)
A limited access system to harvest a quantity of fish, expressed by a unit or units representing a percentage of the total allowable catch of a fishery that may be received or held for exclusive use by a person.

Input Controls
Regulations created by fishery managers to limit or control fishing impacts by limiting fishing effort, such as fishing seasons and area closures, gear restrictions, and limited access programs.

Landing Receipt
A document provided by the Department to commercial fish markets, fish dealers, fish processors, and fishermen for recording landing information. Information required includes date, port of landing, species or market category of fish, pounds landed, and price paid.

Landing
The number or weight of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. A landing is reported at the point at which fish are brought to shore. Note that landings, catch, and harvest are all distinct metrics.

Life History
The history of changes an organism passes through in its development from egg, spore, or other primary stage until its natural death.

Limited Access/Entry
See restricted access.

Logbooks
Records of fishing activity and catch maintained by commercial fishermen as required for some fisheries.

Management Strategy Evaluation (MSE)
A formal process to evaluate the performance of alternative management procedures for a fishery, prior to any implementation. MSEs vary between fisheries, but typically utilize models to assess the current status of the fishery, as well as assumptions or additional models to determine the effects of potential management actions.

Marine Life Management Act (MLMA)
Passed in 1998 by the California Legislature under Assembly Bill 1241, the MLMA significantly changed the way California's marine fisheries are managed and regulated. It expanded the responsibilities of the Department and Commission, and increased stakeholder involvement in the development of fishery management plans.

Marine Life Protection Act (MLPA)
The MLPA was passed in 1999 by the California Legislature, directing the Department to redesign California's existing system of marine protected areas to increase its coherence and effectiveness for protecting the state's marine life, habitats, and ecosystems.

Marine Living Resources
Includes all wild mammals, birds, reptiles, fish, and plants that normally occur in or are associated with ocean and estuarine waters, and the marine habitats upon which these animals and plants depend for their continued viability.

Marine Mammal Protection Act (MMPA)
Passed in 1978, this Act protects all marine mammals in US waters and prohibits their take except that which is permitted specifically for tribal subsistence, scientific research, and limited incidental catch that is inherent in other fishing activities.

Marine Protected Area (MPA)
A named, discrete geographic marine or estuarine area seaward of the mean high tide line or the mouth of a coastal river, including any area of intertidal or subtidal terrain, together with its overlying water and associated flora and fauna that has been designated by law or administrative action to protect or conserve marine life and habitat. MPAs are primarily intended to protect or conserve marine life and habitat, and are therefore a subset of marine managed areas, which are broader groups of named, discrete geographic areas along the coast that protect, conserve, or otherwise manage a variety of resources and uses, including living marine resources, cultural and historical resources, and recreational opportunities.

Maximum Economic Yield (MEY)
The maximum possible revenue after accounting for the costs of fishing that may be achieved in a fishery. MEY typically is reached at smaller catches than maximum sustainable yield.

Maximum Sustainable Yield (MSY)
The highest average yield over time that does not result in a continuing reduction in stock abundance, taking into account fluctuations in abundance and environmental variability.

Migratory Bird Treaty Act (MBTA)
Implemented in 1916 between Great Britain and the United States, the MBTA prohibited the harvest of birds that migrate between Canada and the United States, as well as the take of their feathers, eggs or nests. Similar agreements have expanded these protections to birds that migrate to/from the United States, Japan, Mexico, and Russia.

Model
An equation that can be used to predict management outcomes based on hypothetical and/or measured values. Management tools such as maximum sustainable yield, optimum yield, and stock assessments utilize models.

Monitoring
In regard to fisheries, monitoring refers to management activities that keep records of fishing and biological data, such as landings records or sampling of the catch. Monitoring may also refer to the monitoring of compliance with environmental regulations during fishing activities.

Mortality (Total or Fishing)
Total mortality is the sum total of individual deaths within a population. Usually, it is stated as an annual rate and calculated as the sum of fishing mortality (deaths due to fishing), deaths due to natural causes (e.g., predation, disease), and deaths due to non-fishing, artificial causes (e.g., pollution, seismic surveys).

Non-consumptive Activities
Activities that do not include removal of resources such as photography, whale watching or diving.

Offshore
All oceanic waters outside state waters or deeper than 100 fathoms, in comparison to nearshore.

Optimum Yield (OY)
In regard to a marine fishery, OY means the amount of fish taken in a fishery that does all of the following:
(a) Provides the greatest overall benefit to the people of California, particularly with respect to food production and recreational opportunities, and takes into account the protection of marine ecosystems;
(b) Is the maximum sustainable yield of the fishery, as reduced by relevant economic, social, or ecological factors; and
(c) In the case of an overfished fishery, provides for rebuilding to a level consistent with producing maximum sustainable yield in the fishery.

Output Controls
Management tools used to limit or control fishing impacts by limiting catch, such as total allowable catch, trip limits, and bycatch limits.

Overfished
A fishery is labeled overfished based on quantitative thresholds established by the agency with authority over that fishery. The MLMA definition is:
(a) A depressed fishery; and
(b) A reduction of take in the fishery is the principal means for rebuilding the population.

Overfishing
A rate or level of take that the best available scientific information, and other relevant information that the Commission or Department possesses or receives, indicates is not sustainable or that jeopardizes the capacity of a marine fishery to produce the maximum sustainable yield on a continuing basis.

Overfishing Limit (OFL)
The maximum sustainable yield harvest level or the annual abundance of exploitable biomass of a stock or stock complex multiplied by the maximum fishing mortality threshold or proxy thereof. OFL is an estimate of the catch level above which overfishing is occurring.

Participants
In regard to a fishery, participants refer to the sport fishing, commercial fishing, and fish receiving and processing sectors of the fishery.

Pelagic
Pertaining to the water column, or referring to organisms living in the water column, as opposed to those living on the seafloor.

Permit Fees
Money paid to the respective regulatory body to obtain a permit. Fees typically go to conservation funds or are used to offset management costs.

Precautionary Management
A resource management framework that implements conservation measures even in the absence of scientific certainty that fish stocks are being overexploited.

Processor
In regard to fisheries, a processor is a business, individual or vessel that is involved in the preparation or packaging of fish/marine resources to render them suitable for human consumption, pet food, industrial uses or long-term storage. This includes but is not limited to: cooking, canning, smoking, salting, drying, filleting, freezing, or rendering into meal or oil, but does not mean heading and gutting unless there is additional preparation.

Productivity
The birth, growth, and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and, as a consequence, has a high turnover. Such stocks can usually sustain higher exploitation rates and, if depleted, could recover more rapidly than comparatively less productive stocks.

Productivity and Susceptibility Analysis (PSA)
A model that scores the productivity (ability to recover following depletion) and susceptibility (potential impacts from fishing) of a species, collectively known as vulnerability.

Quota
A limit on the amount of fish which may be landed in any one fishing season or year. May apply to the total fishery, a geographical area, or an individual share.

Rebuilding
The implementation of management measures that increase a fish stock to its target size. Rebuilding measures are commonly implemented for overfished species.

Recreational/Sport Fishery
Fishing with no intentions of, or ability to, sell catch.

Recruitment
A measure of the number of fish that survive to a particular life stage, often used to predict future population size. Some examples include the number of offspring that survive the larval stage and reach the juvenile stage (larval recruitment), the number of individuals that survive (i.e., recruit) to the next year (e.g., age two recruits), the number of fish that reach sexual maturity (i.e., recruit to the spawning population), or in the case of a fishery, the number of fish that recruit to the catchable component of the population.

Reference Point
Reference points are quantitative (numerical) values that inform managers about the current status of a stock. Two important types must be considered, target and threshold (or limit) reference points. Target reference point is a numerical value that indicates that the status of a stock is at a desirable level; often management is geared towards achieving or maintaining this target. Threshold (limit) reference point is a numerical value that indicates that the status of a stock is unacceptable (e.g., overfished or too small) and management action should be taken to improve stock status.

Regulatory Discard
Fish harvested unintentionally in a fishery that fishermen are required by regulation to discard whenever caught, or are required by regulation to retain but not sell.

Restricted Access
Restriction of the right to participate in a fishery, by the use of permits or other means. This is one method managers may use to ensure sustainable fisheries, reduce fishing effort, or protect recovering or threatened stocks.

Rulemaking
The process of developing regulations which occurs in several steps, including publishing proposed rules, accepting comments on the proposed rule, and publishing the final rule. Rulemaking is used to create specific actions and regulations that are designed to carry out the intent of environmental legislation and policy.

Sector
Different, although sometimes overlapping, groups of fishermen that are subject to their own regulations. For example, the federal groundfish fishery off the West Coast is managed by the following sectors: limited-entry trawl, limited-entry fixed gear, tribal, recreational, and open-access.

Seine
A type of net that is deployed by encircling fish. Purse seines are used to catch fish within the water column or near the surface, while demersal seines are used to target fish on the seafloor.

Set net
A type of gill net that is set in place with buoys and/or anchors and catches fish that swim into it and become entangled.

Size Limit
A regulation requiring that landed fish fall below or above a certain size threshold. Minimum size limits are typically intended to prevent the harvest of juvenile or young individuals before they have reproduced. Maximum size limits are typically intended to prevent the harvest of highly fecund female fish. Size limits may be sex-specific for some species.

Spawning Potential Ratio (SPR)
A ratio of the number of eggs produced during the lifetime of an average female in a fished population to the number of eggs produced during the lifetime of an average female in an unfished population. SPR is used to characterize the amount of impact fishing has on a population's ability to reproduce.

Stakeholder
One who has an impact on, is impacted by, or is interested in something, such as a fishery or marine protected area.

Stakeholder Engagement/Involvement (in the Master Plan)
Also referred to as public involvement in the Master Plan, and may mean establishing communication between managers and stakeholders through outreach, workshops or meetings. It may also involve receiving feedback and input from stakeholders in the creation of management goals.

Stock
In regard to fisheries: a species, subspecies, geographical grouping, or other category of fish, invertebrate, or plant that can be managed as a unit.

Stock Assessment
A management tool that uses modeling and historic and current population data or trends to determine the status (e.g., productivity, biomass, population size) of a fishery, in order to determine at what level it may be sustainably exploited.

Substrate
The surface or medium on or in which an organism lives (e.g., mud, sand, rocks).

Sustainable
"Sustainable," "sustainable use," and "sustainability," with regard to a marine fishery, mean both of the following:
(a) Continuous replacement of resources, taking into account fluctuations in abundance and environmental variability; and
(b) Securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity, and, in the case of fishery management based on maximum sustainable yield, providing for a fishery that does not exceed optimum yield.

Total Allowable Catch (TAC)
A specified numerical catch (including discard mortality) for each fishing season, the attainment (or expected attainment) of which may cause closure of the fishery.

Total Allowable Effort (TAE)
A specified numerical effort objective for each fishing season. This can be expressed in number of boats, amount of gear used, etc., and is controlled and adjusted through permits and licenses.

Trap Limit
A regulatory measure that restricts the number of traps a fisherman may have in the water at the same time.

Trawl
A large net that is tapered and forms a flattened cone. The mouth of the net is kept open while it is towed or dragged, either in the pelagic habitat (midwater trawl) or over the sea bottom (otter trawl or bottom trawl).

Tribal Consultation
In regard to fisheries, Tribal consultation means the process of engaging in government-to-government dialogue with Tribes and Tribes on the contact list maintained by the Native American Heritage Commission in a timely manner and in good faith. Tribal consultation provides Tribes and tribal communities with necessary information and to seek out, discuss, and give full and meaningful consideration to the views of Tribes and tribal communities in an effort to reach a mutually agreed upon resolution of any concerns expressed by the Tribes and tribal communities or the managers.

Unfished Biomass (B_0)
The hypothetical predicted biomass of fish or invertebrates within a stock if no fishing were occurring.

Vulnerability
In regard to fisheries, vulnerability refers to a stock’s susceptibility to suffer mortality from fishing or to experience overfishing.

Yield
The total number or biomass of fish, invertebrates, or plants harvested.

Yield Per Recruit (YPR)
A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

APPENDICES

Appendix A – The Marine Life Management Act

Unless indicated otherwise, all sections were added to the Fish and Game Code in 1998, became effective on January 1, 1999, and are current as of January 1, 2018. Please refer to California Legislative Information page for current statutory language in the Fish and Game Code (see: http://leginfo.legislature.ca.gov/faces/codesTOCSelected.xhtml?tocCode=FGC&tocTitle=+Fish+and+Game+Code+-+FGC).

90.

The definitions in this chapter govern the construction of Chapter 7 (commencing with Section 1700) of Division 2 and Division 6 (commencing with Section 5500) and all regulations adopted pursuant to those provisions.

90.1.

"Adaptive management," in regard to a marine fishery, means a scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that even if they fail, they will provide useful information for future actions. Monitoring and evaluation shall be emphasized so that the interaction of different elements within the system can be better understood.

90.5.

"Bycatch" means fish or other marine life that are taken in a fishery but which are not the target of the fishery. "Bycatch" includes discards.

90.7.

"Depressed," with regard to a marine fishery, means the condition of a fishery for which the best available scientific information, and other relevant information that the Commission or Department possesses or receives, indicates a declining population trend has occurred over a period of time appropriate to that fishery. With regard to fisheries for which management is based on maximum sustainable yield, or in which a natural mortality rate is available, "depressed" means the condition of a fishery that exhibits declining fish population abundance levels below those consistent with maximum sustainable yield.

91.

"Discards" means fish that are taken in a fishery but are not retained because they are of an undesirable species, size, sex, or quality, or because they are required by law not to be retained.

93.

"Essential fishery information," with regard to a marine fishery, means information about fish life history and habitat requirements; the status and trends of fish populations, fishing effort, and catch levels; fishery effects on fish age structure and on other marine living resources and users, and any other information related to the biology of a fish species or to taking in the fishery that is necessary to permit fisheries to be managed according to the requirements of this code.

94.

“Fishery” means both of the following:
(a) One or more populations of marine fish or marine plants that may be treated as a unit for purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics.
(b) Fishing for, harvesting, or catching the populations described in (a).
(Amended January 1, 2003.)

96.

“Marine living resources” includes all wild mammals, birds, reptiles, fish, and plants that normally occur in or are associated with salt water, and the marine habitats upon which these animals and plants depend for their continued viability.

96.5.

“Maximum sustainable yield” in a marine fishery means the highest average yield over time that does not result in a continuing reduction in stock abundance, taking into account fluctuations in abundance and environmental variability.

97.

“Optimum yield,” with regard to a marine fishery, means the amount of fish taken in a fishery that does all of the following:
(a) Provides the greatest overall benefit to the people of California, particularly with respect to food production and recreational opportunities, and takes into account the protection of marine ecosystems.
(b) Is the maximum sustainable yield of the fishery, as reduced by relevant economic, social, or ecological factors.
(c) In the case of an overfished fishery, provides for rebuilding to a level consistent with producing maximum sustainable yield in the fishery.

97.5.

“Overfished,” with regard to a marine fishery, means both of the following:
(a) A depressed fishery.
(b) A reduction of take in the fishery is the principal means for rebuilding the population.

98.

“Overfishing” means a rate or level of taking that the best available scientific information, and other relevant information that the Commission or Department possesses or receives, indicates is not sustainable or that jeopardizes the capacity of a marine fishery to produce the maximum sustainable yield on a continuing basis.

98.2.

“Participants” in regard to a fishery means the sport fishing, commercial fishing, and fish receiving and processing sectors of the fishery.

98.5.

“Population” or “stock” means a species, subspecies, geographical grouping, or other category of fish capable of management as a unit.

99.

“Restricted access,” with regard to a marine fishery, means a fishery in which the number of persons who may participate, or the number of vessels that may be used in taking a specified species of fish, or the catch allocated to each fishery participant, is limited by statute or regulation.
(Amended effective January 1, 2000.)

99.5.

“Sustainable,” “sustainable use,” and “sustainability,” with regard to a marine fishery, mean both of the following:
(a) Continuous replacement of resources, taking into account fluctuations in abundance and environmental variability.
(b) Securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity, and, in the case of fishery management based on maximum sustainable yield, taking in a fishery that does not exceed optimum yield.

CHAPTER 1. General Policies [7050 - 7051]

7050.

(a) The Legislature finds and declares that the Pacific Ocean and its rich marine living resources are of great environmental, economic, aesthetic, recreational, educational, scientific, nutritional, social, and historic importance to the people of California.
(b) It is the policy of the state to ensure the conservation, sustainable use, and, where feasible, restoration of California’s marine living resources for the benefit of all the citizens of the state. The objective of this policy shall be to accomplish all of the following:
(1) Conserve the health and diversity of marine ecosystems and marine living resources.
(2) Allow and encourage only those activities and uses of marine living resources that are sustainable.
(3) Recognize the importance of the aesthetic, educational, scientific, and recreational uses that do not involve the taking of California’s marine living resources.
(4) Recognize the importance to the economy and the culture of California of sustainable sport and commercial fisheries and the development of commercial aquaculture consistent with the marine living resource conservation policies of this part.
(5) Support and promote scientific research on marine ecosystems and their components to develop better information on which to base marine living resource management decisions.
(6) Manage marine living resources on the basis of the best available scientific information and other relevant information that the Commission or Department possesses or receives.
(7) Involve all interested parties, including, but not limited to, individuals from the sport and commercial fishing industries, aquaculture industries, coastal and ocean tourism and recreation industries, marine conservation organizations, local governments, marine scientists, and the public in marine living resource management decisions.
(8) Promote the dissemination of accurate information concerning the condition of, or management of, marine resources and fisheries by seeking out the best available information and making it available to the public through the marine resources management process.

(9) Coordinate and cooperate with adjacent states, as well as with Mexico and Canada, and encourage regional approaches to management of activities and uses that affect marine living resources. Particular attention shall be paid to coordinated approaches to the management of shared fisheries.

7051.

(a) A regulation adopted pursuant to this part shall apply only to ocean waters and bays. Notwithstanding any other provision of this part, nothing contained in this part grants the Department or any other agency of the state any regulatory authority not in existence on January 1, 1999, in any river upstream of the mouth of such river, in the Sacramento-San Joaquin Delta or in any other estuary.
(b) The policies in this part shall apply only to fishery management plans and regulations adopted by the Commission on or after January 1, 1999. No power is delegated to the Commission or the Department by this part to regulate fisheries other than the nearshore fishery, the white seabass fishery, emerging fisheries, and fisheries for which the Commission or Department had regulatory authority prior to January 1, 1999.

CHAPTER 2. Marine Fisheries Generally [7055 - 7059]

7055.

The Legislature finds and declares that it is the policy of the state that:
(a) California's marine sport and commercial fisheries, and the resources upon which they depend, are important to the people of the state and, to the extent practicable, shall be managed in accordance with the policies and other requirements of this part in order to assure the long-term economic, recreational, ecological, cultural, and social benefits of those fisheries and the marine habitats on which they depend.
(b) Programs for the conservation and management of the marine fishery resources of California shall be established and administered to prevent overfishing, to rebuild depressed stocks, to ensure conservation, to facilitate long-term protection and, where feasible, restoration of marine fishery habitats, and to achieve the sustainable use of the state's fishery resources.
(c) Where a species is the object of sport fishing, a sufficient resource shall be maintained to support a reasonable sport use, taking into consideration the necessity of regulating individual sport fishery bag limits to the quantity that is sufficient to provide a satisfying sport.
(d) The growth of commercial fisheries, including distant-water fisheries, shall be encouraged.

7056.

In order to achieve the primary fishery management goal of sustainability, every sport and commercial marine fishery under the jurisdiction of the state shall be managed under a system whose objectives include all of the following:
(a) The fishery is conducted sustainably so that long-term health of the resource is not sacrificed in favor of short-term benefits. In the case of a fishery managed on the basis of maximum sustainable yield, management shall have optimum yield as its objective.
(b) The health of marine fishery habitat is maintained and, to the extent feasible, habitat is restored, and where appropriate, habitat is enhanced.
(c) Depressed fisheries are rebuilt to the highest sustainable yields consistent with environmental and habitat conditions.
(d) The fishery limits bycatch to acceptable types and amounts, as determined for each fishery.
(e) The fishery management system allows fishery participants to propose methods to prevent or reduce excess effort in marine fisheries.
(f) Management of a species that is the target of both sport and commercial fisheries or of a fishery that employs different gears is closely coordinated.

(g) Fishery management decisions are adaptive and are based on the best available scientific information and other relevant information that the Commission or Department possesses or receives, and the Commission and Department have available to them essential fishery information on which to base their decisions.
(h) The management decision-making process is open and seeks the advice and assistance of interested parties so as to consider relevant information, including local knowledge.
(i) The fishery management system observes the long-term interests of people dependent on fishing for food, livelihood, or recreation.
(j) The adverse impacts of fishery management on small-scale fisheries, coastal communities, and local economies are minimized.
(k) Collaborative and cooperative approaches to management, involving fishery participants, marine scientists, and other interested parties are strongly encouraged, and appropriate mechanisms are in place to resolve disputes such as access, allocation, and gear conflicts.
(l) The management system is proactive and responds quickly to changing environmental conditions and market or other socioeconomic factors and to the concerns of fishery participants.
(m) The management system is periodically reviewed for effectiveness in achieving sustainability goals and for fairness and reasonableness in its interaction with people affected by management.

7058.

Any fishery management regulation adopted by the Commission shall, to the extent practicable, conform to the policies of Sections 7055 and 7056.
(Amended effective January 1, 2003.)

7059.

(a) The Legislature finds and declares all of the following:
(1) Successful marine life and fishery management is a collaborative process that requires a high degree of ongoing communication and participation of all those involved in the management process, particularly the Commission, the Department, and those who represent the people and resources that will be most affected by fishery management decisions, especially fishery participants and other interested parties.
(2) In order to maximize the marine science expertise applied to the complex issues of marine life and fishery management, the Commission and the Department are encouraged to continue to, and to find creative new ways to, contract with or otherwise effectively involve Sea Grant staff, marine scientists, economists, collaborative factfinding process and dispute resolution specialists, and others with the necessary expertise at colleges, universities, private institutions, and other agencies.
(3) The benefits of the collaborative process required by this section apply to most marine life and fishery management activities including, but not limited to, the development and implementation of research plans, marine managed area plans, fishery management plans, and plan amendments, and the preparation of fishery status reports such as those required by Section 7065.
(4) Because California is a large state with a long coast, and because travel is time consuming and costly, the involvement of interested parties shall be facilitated, to the extent practicable, by conducting meetings and discussions in the areas of the coast and in ports where those most affected are concentrated.
(b) In order to fulfill the intent of subdivision (a), the Commission and the Department shall do all of the following:
(1) Periodically review marine life and fishery management operations with a view to improving communication, collaboration, and dispute resolution, seeking advice from interested parties as part of the review.
(2) Develop a process for the involvement of interested parties and for fact finding and dispute resolution processes appropriate to each element in the marine life and fishery management process. Models to consider include, but are not limited to, the take reduction teams authorized under the Marine Mammal

Protection Act (16 U.S.C. Sec. 1361 et seq.) and the processes that led to improved management in the California herring, sea urchin, prawn, angel shark, and white seabass fisheries.
(3) Consider the appropriateness of various forms of fisheries comanagement, which involves close cooperation between the Department and fishery participants, when developing and implementing fishery management plans.
(4) When involving fishery participants in the management process, give particular consideration to the gear used, involvement of sport or commercial sectors or both sectors, and the areas of the coast where the fishery is conducted in order to ensure adequate involvement.
(Amended effective January 1, 2000.)

CHAPTER 3. Fisheries Science [7060 - 7062]

7060.

(a) The Legislature finds and declares that for the purposes of sustainable fishery management and this part, essential fishery information is necessary for federally and state-managed marine fisheries important to the people of this state to provide sustainable economic and recreational benefits to the people of California. The Legislature further finds and declares that acquiring essential fishery information can best be accomplished through the ongoing cooperation and collaboration of participants in fisheries.
(b) The Department, to the extent feasible, shall conduct and support research to obtain essential fishery information for all marine fisheries managed by the state.
(c) The Department, to the maximum extent practicable and consistent with Section 7059, shall encourage the participation of fishermen in fisheries research within a framework that ensures the objective collection and analysis of data, the collaboration of fishermen in research design, and the cooperation of fishermen in carrying out research.
(d) The Department may apply for grants to conduct research and may enter into contracts or issue competitive grants to public or private research institutions to conduct research.

7062.

(a) The Department shall establish a program for external peer review of the scientific basis of marine living resources management documents. The Department, in its discretion and unless otherwise required by this part, may submit to peer review, documents that include, but are not limited to, fishery management plans and plan amendments, marine resource and fishery research plans.
(b) The Department may enter into an agreement with one or more outside entities that are significantly involved with researching and understanding marine fisheries and are not advocacy organizations. These entities may include, but not be limited to, the Sea Grant program of any state, the University of California, the California State University, the Pacific States Marine Fisheries Commission, or any other entity approved by the Commission to select and administer peer review panels, as needed. The peer review panels shall be composed of individuals with technical expertise specific to the document to be reviewed. The entity with which the Department enters into an agreement for a peer review shall be responsible for the scientific integrity of the peer review process. Each peer reviewer may be compensated as needed to ensure competent peer review. Peer reviewers shall not be employees or officers of the Department or the Commission and shall not have participated in the development of the document to be reviewed.
(c) The external peer review entity, within the timeframe and budget agreed upon by the Department and the external scientific peer review entity, shall provide the Department with the written report of the peer review panel that contains an evaluation of the scientific basis of the document. If the report finds that the Department has failed to demonstrate that a scientific portion of the document is based on sound scientific knowledge, methods, and practices, the report shall state that finding, and the reasons for the finding. The Department may accept the finding, in whole or in part, and may revise the scientific portions of the

document accordingly. If the Department disagrees with any aspect of the finding of the external scientific peer review, it shall explain, and include as part of the record, its basis for arriving at such a determination in the analysis prepared for the adoption of the final document, including the reasons why it has determined that the scientific portions of the document are based on sound scientific knowledge, methods, or practice. The Department shall submit the external scientific peer review report to the Commission with any peer-reviewed document that is to be adopted or approved by the Commission.
(d) The requirements of this section do not apply to any emergency regulation adopted pursuant to subdivision (b) of Section 11346.1 of the Government Code.
(e) Nothing is this section shall be interpreted, in any way, to limit the authority of the Commission or Department to adopt a plan or regulation.

CHAPTER 4. Commission and Department [7065 - 7066]

<u>7065.</u>

(a) The director shall report annually in writing to the Commission on the status of sport and commercial marine fisheries managed by the state. The date of the report shall be chosen by the Commission with the advice of the Department. Each annual report shall cover at least one-fourth of the marine fisheries managed by the state so that every fishery will be reported on at least once every four years. The Department shall, consistent with Section 7059, involve expertise from outside the Department in compiling information for the report, which may include, but need not be limited to, Sea Grant staff, other marine scientists, fishery participants, and other interested parties.
(b) For each fishery reported on in an annual report, the report shall include information on landings, fishing effort, areas where the fishery occurs, and other factors affecting the fishery as determined by the Department and the Commission. Each restricted access program shall be reviewed at least every five years for consistency with the policies of the Commission on restricted access fisheries.
(c) Notwithstanding subdivision (a), the first annual report shall be presented to the Commission on or before September 1, 2001, and shall cover all the marine fisheries managed by the state. To the extent that the requirements of this section and Section 7073 are duplicative, the first annual report may be combined with the plan required pursuant to Section 7073.
(Amended effective January 1, 2000.)

<u>7066.</u>

(a) The Legislature finds and declares that a number of human-caused and natural factors can affect the health of marine fishery resources and result in marine fisheries that do not meet the policies and other requirements of this part.
(b) To the extent feasible, the director's report to the Commission pursuant to Section 7065 shall identify any marine fishery that does not meet the sustainability policies of this part. In the case of a fishery identified as being depressed, the report shall indicate the causes of the depressed condition of the fishery, describe steps being taken to rebuild the fishery, and, to the extent practicable, recommend additional steps to rebuild the fishery.
(c) The director's report to the Commission pursuant to Section 7065, consistent with subdivision (m) of Section 7056, shall evaluate the management system and may recommend modifications of that system to the Commission.
(Amended effective January 1, 2000.)

CHAPTER 5. Fishery Management Plans—General Policies [7070 - 7074]

<u>7070.</u>

The Legislature finds and declares that the critical need to conserve, utilize, and manage the state's marine fish resources and to meet the policies and other requirements stated in this part require that the state's fisheries be managed by means of fishery management plans.

7071.

(a) Any white seabass fishery management plan adopted by the Commission on or before January 1, 1999, shall remain in effect until amended pursuant to this part.
Notwithstanding paragraph (2) of subdivision (b) of Section 7073, any white seabass fishery management plan adopted by the Commission and in existence on January 1, 1999, shall be amended to comply with this part on or before January 1, 2002.
(b) In the case of any fishery for which the Commission has management authority, including white seabass, regulations that the Commission adopts to implement a fishery management plan or plan amendment for that fishery may make inoperative, in regard to that fishery, any fishery management statute that applies to that fishery, including, but not limited to, statutes that govern allowable catch, restricted access programs, permit fees, and time, area, and methods of taking.
(c) On and after January 1, 2000, the Commission may adopt regulations as it determines necessary, based on the advice and recommendations of the Department, and in a process consistent with Section 7059, to regulate all emerging fisheries, consistent with Section 7090, all fisheries for nearshore fish stocks, and all fisheries for white seabass. Regulations adopted by the Commission may include, but need not be limited to, establishing time and area closures, requiring submittal of landing and permit information, regulating fishing gear, permit fees, and establishing restricted access fisheries.
(Amended effective January 1, 2003.)

7072.
(a) Fishery management plans shall form the primary basis for managing California's sport and commercial marine fisheries.
(b) Fishery management plans shall be based on the best scientific information that is available, on other relevant information that the Department possesses, or on the scientific information or other relevant information that can be obtained without substantially delaying the preparation of the plan.
(c) To the extent that conservation and management measures in a fishery management plan either increase or restrict the overall harvest or catch in a fishery, fishery management plans shall allocate those increases or restrictions fairly among recreational and commercial sectors participating in the fishery.
(d) Consistent with Article 17 (commencing with Section 8585), the Commission shall adopt a fishery management plan for the nearshore fishery on or before January 1, 2002, if funds are appropriated for that purpose in the annual Budget Act or pursuant to any other law.
(Amended effective January 1, 2003.)

7073.

(a) On or before September 1, 2001, the Department shall submit to the Commission for its approval a master plan that specifies the process and the resources needed to prepare, adopt, and implement fishery management plans for sport and commercial marine fisheries managed by the state. Consistent with Section 7059, the master plan shall be prepared with the advice, assistance, and involvement of participants in the various fisheries and their representatives, marine conservationists, marine scientists, and other interested persons.
(b) The master plan shall include all of the following:
(1) A list identifying the fisheries managed by the state, with individual fisheries assigned to fishery management plans as determined by the Department according to conservation and management needs and consistent with subdivision (f) of Section 7056.

(2) A priority list for preparation of fishery management plans. Highest priority shall be given to fisheries that the Department determines have the greatest need for changes in conservation and management measures in order to comply with the policies and requirements set forth in this part. Fisheries for which the Department determines that current management complies with the policies and requirements of this part shall be given the lowest priority.
(3) A description of the research, monitoring, and data collection activities that the Department conducts for marine fisheries and of any additional activities that might be needed for the Department to acquire essential fishery information, with emphasis on the higher priority fisheries identified pursuant to paragraph (2).
(4) A process consistent with Section 7059 that ensures the opportunity for meaningful involvement in the development of fishery management plans and research plans by fishery participants and their representatives, marine scientists, and other interested parties.
(5) A process for periodic review and amendment of the master plan.
(c) The Commission shall adopt or reject the master plan or master plan amendment, in whole or in part, after a public hearing. If the Commission rejects a part of the master plan or master plan amendment, the Commission shall return that part to the Department for revision and resubmission pursuant to the revision and resubmission procedures for fishery management plans as described in subdivision (a) of Section 7075.
(Amended effective January 1, 2000.)

<u>7074.</u>

(a) The Department shall prepare interim fishery research protocols for at least the three highest priority fisheries identified pursuant to paragraph (2) of subdivision (b) of Section 7073. An interim fishery protocol shall be used by the Department until a fishery management plan is implemented for that fishery.
(b) Consistent with Section 7059, each protocol shall be prepared with the advice, assistance, and involvement of participants in the various fisheries and their representatives, marine conservationists, marine scientists, and other interested persons.
(c) Interim protocols shall be submitted to peer review as described in Section 7062 unless the Department, pursuant to subdivision (d), determines that peer review of the interim protocol is not justified. For the purpose of peer review, interim protocols may be combined in the following circumstances:
(1) For related fisheries.
(2) For two or more interim protocols that the Commission determines will require the same peer review expertise.
(d) The Commission, with the advice of the Department, shall adopt criteria to be applied in determining whether an interim protocol may be exempted from peer review.
(Amended effective January 1, 2000.)

CHAPTER 6. Fishery Management Plan Preparation, Approval, and Regulations [7075 - 7078]

<u>7075.</u>

(a) The Department shall prepare fishery management plans and plan amendments, including any proposed regulations necessary to implement plans or plan amendments, to be submitted to the Commission for adoption or rejection. Prior to submitting a plan or plan amendment, including any proposed regulations necessary for implementation, to the Commission, the Department shall submit the plan to peer review pursuant to Section 7062, unless the Department determines that peer review of the plan or plan amendment may be exempted pursuant to subdivision (c). If the Department makes that determination, it shall submit its reasons for that determination to the Commission with the plan. If the Commission rejects a plan or plan amendment, including proposed regulations necessary for

implementation, the Commission shall return the plan or plan amendment to the Department for revision and resubmission together with a written statement of reasons for the rejection. The Department shall revise and resubmit the plan or plan amendment to the Commission within 90 days of the rejection. The revised plan or plan amendment shall be subject to the review and adoption requirements of this chapter.
(b) The Department may contract with qualified individuals or organizations to assist in the preparation of fishery management plans or plan amendments.
(c) The Commission, with the advice of the Department and consistent with Section 7059, shall adopt criteria to be applied in determining whether a plan or plan amendment may be exempted from peer review.
(d) Fishery participants and their representatives, fishery scientists, or other interested parties may propose plan provisions or plan amendments to the Department or Commission. The Commission shall review any proposal submitted to the Commission and may recommend to the Department that the Department develop a fishery management plan or plan amendment to incorporate the proposal.

7076.
(a) To the extent practicable, and consistent with Section 7059, the Department shall seek advice and assistance in developing a fishery management plan from participants in the affected fishery, marine scientists, and other interested parties. The Department shall also seek the advice and assistance of other persons or entities that it deems appropriate, which may include, but is not limited to, Sea Grant, the National Marine Fisheries Service, the Pacific States Marine Fisheries Commission, the Pacific Fishery Management Council, and any advisory committee of the Department.
(b) In the case of a fishery management plan or a plan amendment that is submitted to peer review, the Department shall provide the peer review panel with any written comments on the plan or plan amendment that the Department has received from fishery participants and other interested parties.

7077.

A fishery management plan or plan amendment, or proposed regulations necessary for implementation of a plan or plan amendment, developed by the Department shall be available to the public for review at least 30 days prior to a hearing on the management plan or plan amendment by the commission. Persons requesting to be notified of the availability of the plan shall be notified in sufficient time to allow them to review and submit comments at or prior to a hearing. Proposed plans and plan amendments and hearing schedules and agendas shall be posted on the Department's Internet website.

7078.

(a) The commission shall hold at least two public hearings on a fishery management plan or plan amendment prior to the Commission's adoption or rejection of the plan.
(b) The plan or plan amendment shall be heard not later than 60 days following receipt of the plan or plan amendment by the Commission. The Commission may adopt the plan or plan amendment at the second public hearing, at the Commission's meeting following the second public hearing, or at any duly noticed subsequent meeting, subject to subdivision (c).
(c) When scheduling the location of a hearing or meeting relating to a fishery management plan or plan amendment, the Commission shall consider factors, including, among other factors, the area of the state, if any, where participants in the fishery are concentrated.
(d) Notwithstanding Section 7550.5 of the Government Code, prior to the adoption of a fishery management plan or plan amendment that would make inoperative a statute, the Commission shall provide a copy of the plan or plan amendment to the Legislature for review by the Joint Committee on Fisheries and Aquaculture or, if there is no such committee, to the appropriate policy committee in each house of the Legislature.

(e) The Commission shall adopt any regulations necessary to implement a fishery plan or plan amendment no more than 60 days following adoption of the plan or plan amendment. All implementing regulations adopted under this subdivision shall be adopted as a regulation pursuant to the rulemaking provisions of the Administrative Procedure Act, Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code. The Commission's adoption of regulations to implement a fishery management plan or plan amendment shall not trigger an additional review process under the California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code).
(f) Regulations adopted by the commission to implement a plan or plan amendment shall specify any statute or regulation of the Commission that is to become inoperative as to the particular fishery. The list shall designate each statute or regulation by individual section number, rather than by reference to articles or chapters.

CHAPTER 7. Contents of Fishery Management Plans [7080 - 7088]

<u>7080.</u>

Consistent with subdivision (b) of Section 7072, each fishery management plan prepared by the Department shall summarize readily available information about the fishery including, but not limited to, all of the following:
(a) The species of fish and their location, number of vessels and participants involved, fishing effort, historical landings in the sport and commercial sectors, and a history of conservation and management measures affecting the fishery.
(b) The natural history and population dynamics of the target species and the effects of changing oceanic conditions on the target species.
(c)The habitat for the fishery and known threats to the habitat.
(d) The ecosystem role of the target species and the relationship of the fishery to the ecosystem role of the target species.
(e) Economic and social factors related to the fishery.

<u>7081.</u>

Consistent with subdivision (b) of Section 7072, each fishery management plan or plan amendment prepared by the Department shall include a fishery research protocol that does all of the following:
(a) Describe past and ongoing monitoring of the fishery.
(b) Identify essential fishery information for the fishery, including, but not limited to, age and growth, minimum size at maturity, spawning season, age structure of the population, and, if essential fishery information is lacking, identify the additional information needed and the resources and time necessary to acquire the information.
(c) Indicate the steps the Department shall take to monitor the fishery and to obtain essential fishery information, including the data collection and research methodologies, on an ongoing basis.

<u>7082.</u>

Each fishery management plan or plan amendment prepared by the Department shall contain the measures necessary and appropriate for the conservation and management of the fishery according to the policies and other requirements in this part. The measures may include, but are not limited to, all of the following:
(a) Limitations on the fishery based on area, time, amount of catch, species, size, sex, type or amount of gear, or other factors.
(b) Creation or modification of a restricted access fishery that contributes to a more orderly and sustainable fishery.

(c) A procedure to establish and to periodically review and revise a catch quota in any fishery for which there is a catch quota.
(d) Requirement for a personal, gear, or vessel permit and reasonable fees.

7083.

(a) Each fishery management plan prepared by the Department shall incorporate the existing conservation and management measures provided in this code that are determined by the Department to result in a sustainable fishery.
(b) If additional conservation and management measures are included in the plan, the Department shall, consistent with subdivision (b) of Section 7072, summarize anticipated effects of those measures on relevant fish populations and habitats, on fishery participants, and on coastal communities and businesses that rely on the fishery.

7084.

(a) Consistent with subdivision (b) of Section 7072, each fishery management plan or plan amendment prepared by the Department for a fishery that the Department has determined has adverse effects on marine fishery habitat shall include measures that, to the extent practicable, minimize adverse effects on habitat caused by fishing.
(b) Subdivision (a) does not apply to activities regulated by Chapter 6 (commencing with Section 6650) of Part 1.

7085.

Consistent with subdivision (b) of Section 7072, each fishery management plan or plan amendment prepared by the Department, in fisheries in which bycatch occurs, shall include all of the following:
(a) Information on the amount and type of bycatch.
(b) Analysis of the amount and type of bycatch based on the following criteria:
(1) Legality of the bycatch under any relevant law.
(2) Degree of threat to the sustainability of the bycatch species.
(3) Impacts on fisheries that target the bycatch species.
(4) Ecosystem impacts.
(c) In the case of unacceptable amounts or types of bycatch, conservation and management measures that, in the following priority, do the following:
(1) Minimize bycatch.
(2) Minimize mortality of discards that cannot be avoided.

7086.

(a) Consistent with subdivision (b) of Section 7072, each fishery management plan or plan amendment prepared by the Department shall specify criteria for identifying when the fishery is overfished.
(b) In the case of a fishery management plan for a fishery that has been determined to be overfished or in which overfishing is occurring, the fishery management plan shall contain measures to prevent, end, or otherwise appropriately address overfishing and to rebuild the fishery.
(c) Any fishery management plan, plan amendment, or regulation prepared pursuant to subdivision (b), shall do both of the following:
(1) Specify a time period for preventing or ending or otherwise appropriately addressing overfishing and rebuilding the fishery that shall be as short as possible, and shall not exceed 10 years except in cases where the biology of the population of fish or other environmental conditions dictate otherwise.

(2) Allocate both overfishing restrictions and recovery benefits fairly and equitably among sectors of the fishery.

7087.

(a) Each fishery management plan prepared by the Department shall include a procedure for review and amendment of the plan, as necessary.
(b) Each fishery management plan or plan amendment prepared by the Department shall specify the types of regulations that the Department may adopt without a plan amendment.

7088.

Each fishery management plan and plan amendment shall include a list of any statutes and regulations that shall become inoperative, as to the particular fishery covered by the fishery management plan or plan amendment, upon the Commission's adoption of implementing regulations for that fishery management plan or plan amendment.

CHAPTER 8. Emerging Fisheries [7090- 7090]

7090.

(a) The Legislature finds and declares that a proactive approach to management of emerging fisheries will foster a healthy marine environment and will benefit both commercial and sport fisheries and other marine-dependent activities. Therefore, the Commission, based upon the advice and recommendations of the Department, shall encourage, manage, and regulate emerging fisheries consistent with the policies of this part.
(b) "Emerging fishery," in regard to a marine fishery, means both of the following:
(1) A fishery that the director has determined is an emerging fishery, based on criteria that are approved by the Commission and are related to a trend of increased landings or participants in the fishery and the degree of existing regulation of the fishery.
(2) A fishery that is not an established fishery. "Established fishery," in regard to a marine fishery, means, prior to January 1, 1999, one or more of the following:
(A) A restricted access fishery has been established in this code or in regulations adopted by the Commission.
(B) A fishery, for which a federal fishery management plan exists, and in which the catch is limited within a designated time period.
(C) A fishery for which a population estimate and catch quota is established annually.
(D) A fishery for which regulations for the fishery are considered at least biennially by the Commission.
(E) A fishery for which this code or regulations adopted by the Commission prescribes at least two management measures developed for the purpose of sustaining the fishery. Management measures include minimum or maximum size limits, seasons, time, gear, area restriction, and prohibition on sale or possession of fish.
(c) The Department shall closely monitor landings and other factors it deems relevant in each emerging fishery and shall notify the Commission of the existence of an emerging fishery.
(d) The Commission, upon the recommendation of the Department, may do either, or both, of the following:
(1) Adopt regulations that limit taking in the fishery by means that may include, but not be limited to, restricting landings, time, area, gear, or access. These regulations may remain in effect until a fishery management plan is adopted.
(2) Direct the Department to prepare a fishery management plan for the fishery and regulations necessary to implement the plan.

(e) A fishery management plan for an emerging fishery shall comply with the requirements for preparing and adopting fishery management plans contained in this part. In addition to those requirements, to allow for adequate evaluation of the fishery and the acquisition of essential fishery information, the fishery management plan shall provide an evaluation period, which shall not exceed three years unless extended by the Commission. During the evaluation period, the plan shall do both of the following:
(1) In order to prevent excess fishing effort during the evaluation period, limit taking in the fishery by means that may include, but need not be limited to, restricting landings, time, area, gear, or access to a level that the Department determines is necessary for evaluation of the fishery.
(2) Contain a research plan that includes objectives for evaluating the fishery, a description of the methods and data collection techniques for evaluating the fishery, and a timetable for completing the evaluation.
(f) The Commission is authorized to impose a fee on an emerging fishery in order to pay the costs of implementing this chapter. The fees may include, but need not be limited to, ocean fishing stamps and permit fees. The fees may not be levied in excess of the necessary costs to implement and administer this chapter. The Commission may reduce fees annually if it determines that sufficient revenues exist to cover costs incurred by the Department in administering this chapter. The Commission and the Department, with the advice of fishery participants and other interested parties, shall consider alternative ways to fund the evaluation of emerging fisheries.
(g) An emerging fishery is subject to this section unless the Department incorporates the fishery into a fishery management plan developed under Sections 7070 to 7088, inclusive.
(h) In the event that this section is found to conflict with Section 8606, 8614, or 8615, this section shall prevail.
(Amended effective January 1, 2003.)

ARTICLE 17. Nearshore Fisheries Management Act [8585 - 8589.7]

8585.

This article shall be known and may be cited as the Nearshore Fisheries Management Act.

8585.5.

The Legislature finds and declares that important commercial and recreational fisheries exist on numerous stocks of rockfish (genus *Sebastes*), California sheephead (genus *Semicossyphus*), kelp greenling (genus *Hexagrammos*), cabezon (genus *Scorpaenichthys*), and scorpionfish (genus *Scorpaena*), in the nearshore state waters extending from the shore to one nautical mile offshore the California coast, that there is increasing pressure being placed on these fish from recreational and commercial fisheries, that many of these fish species found in the nearshore waters are slow growing and long lived, and that, if depleted, many of these species may take decades to rebuild. The Legislature further finds and declares that, although extensive research has been conducted on some of these species by state and federal governments, there are many gaps in the information on these species and their habitats and that there is no program currently adequate for the systematic research, conservation, and management of nearshore fish stocks and the sustainable activity of recreational and commercial nearshore fisheries. The Legislature further finds and declares that recreational fishing in California generates funds pursuant to the Federal Aid in Sport Fish Restoration Act (16 U.S.C. Secs. 777 to 777l, inclusive), with revenues used for, among other things, research, conservation, and management of nearshore fish. The Legislature further finds and declares that a program for research and conservation of nearshore fish species and their habitats is needed, and that a management program for the nearshore fisheries is necessary. The Legislature further finds and declares that the Commission should be granted additional authority to regulate the commercial and recreational fisheries to assure the sustainable populations of nearshore fish stocks. Lastly, the Legislature finds and declares that, whenever feasible and practicable, it is the policy of

the state to assure sustainable commercial and recreational nearshore fisheries, to protect recreational opportunities, and to assure long-term employment in commercial and recreational fisheries.
(Amended effective January 1, 2000.)

<u>8586.</u>

The following definitions govern the construction of this article:
(a) “Nearshore fish stocks” means any of the following: rockfish (genus *Sebastes*) for which size limits are established under this article, California sheephead (*Semicossyphus pulcher*), greenlings of the genus *Hexagrammos*, cabezon (*Scorpaenichthys marmoratus*), scorpionfish (*Scorpaena guttata*), and may include other species of finfish found primarily in rocky reef or kelp habitat in nearshore waters.
(b) “Nearshore fisheries” means the commercial or recreational take or landing of any species of nearshore finfish stocks.
(c) “Nearshore waters” means the ocean waters of the state extending from the shore to one nautical mile from land, including one nautical mile around offshore rocks and islands.
(Amended effective January 1, 2000.)

<u>8586.1.</u>

Funding to pay the costs of this article shall be made available from the revenues deposited in the Fish and Game Preservation Fund pursuant to Sections 8587, 8589.5, and 8589.7, and other funds appropriated for these purposes.

<u>8587.</u>

Any person taking, possessing aboard a boat, or landing any species of nearshore fish stock for commercial purposes shall possess a valid nearshore fishery permit issued to that person that has not been suspended or revoked, except that when using a boat to take nearshore fish stocks at least one person aboard the boat shall have a valid nearshore fishery permit. Nearshore fishing permits are revocable. The fee for a nearshore fishing permit is one hundred and twenty-five dollars ($125).
(Amended effective January 1, 2000.)

<u>8587.1.</u>

(a) The Commission may adopt regulations as it determines necessary, based on the advice and recommendations of the Department, to regulate nearshore fish stocks and fisheries. Regulations adopted by the Commission pursuant to this section may include, but are not limited to, requiring submittal of landing and permit information, including logbooks; establishing a restricted access program; establishing permit fees; and establishing limitations on the fishery based on time, area, type, and amount of gear, and amount of catch, species, and size of fish.
(b) Regulations adopted by the Commission pursuant to this section may make inoperative any fishery management statute relevant to the nearshore fishery. Any regulation adopted by the Commission pursuant to this subdivision shall specify the particular statute to be made inoperative.
(c) The circumstances, restrictions, and requirements of Section 219 do not apply to regulations adopted pursuant to this section.
(d) Any regulations adopted pursuant to this section shall be adopted following consultation with fishery participants and other interested persons consistent with Section 7059.
(Amended effective January 1, 2003.)

8589.

Funding to prepare the plan pursuant to subdivision (d) of Section 7072 and any planning and scoping meetings shall be derived from moneys deposited in the Fish and Game Preservation Fund pursuant to Section 8587 and other funds appropriated for these purposes.

8589.5.

The Commission shall temporarily suspend and may permanently revoke the nearshore fishing permit of any person convicted of a violation of this article. In addition to, or in lieu of, a license or permit suspension or revocation, the Commission may adopt and apply a schedule of fines for convictions of violations of this article.

8589.7.

(a) Fees received by the Department pursuant to Section 8587 shall be deposited in the Fish and Game Preservation Fund to be used by the Department to prepare, develop, and implement the nearshore fisheries management plan and for the following purposes:
(1) For research and management of nearshore fish stocks and nearshore habitat. For the purposes of this section, "research" includes, but is not limited to, investigation, experimentation, monitoring, and analysis and "management" means establishing and maintaining a sustainable utilization.
(2) For supplementary funding of allocations for the enforcement of statutes and regulations applicable to nearshore fish stocks, including, but not limited to, the acquisition of special equipment and the production and dissemination of printed materials, such as pamphlets, booklets, and posters aimed at compliance with nearshore fishing regulations.
(3) For the direction of volunteer groups assisting with nearshore fish stocks and nearshore habitat management, for presentations of related matters at scientific conferences and educational institutions, and for publication of related material.
(b) The Department shall maintain internal accounts that ensure that the fees received pursuant to Section 8587 are disbursed for the purposes stated in subdivision (a).
(c) The Commission shall require an annual accounting from the Department on the deposits into, and expenditures from, the Fish and Game Preservation Fund, as related to the revenues generated pursuant to Section 8587. Notwithstanding Section 7550.5 of the Government Code, a copy of the accounting shall be provided to the Legislature for review by the Joint Committee on Fisheries and Aquaculture, and if that committee is not in existence at the time, by the appropriate policy committee in each house of the Legislature.
(d) Unencumbered fees collected pursuant to Section 8587 during any previous calendar year shall remain in the fund and expended for the purposes of subdivision (a). All interest and other earnings on the fees received pursuant to Section 8587 shall be deposited in the fund and shall be used for the purposes of subdivision (a).

Appendix B – Partnerships and Engagement Efforts in the Amendment of the Master Plan

Information Gathering Projects

Beginning in late 2015 and culminating in early 2017, thirteen 'Information Gathering Projects' involving 10 contractor groups of expert scientists and investigators explored and considered new tools, approaches, and products to inform the 2018 Master Plan and development of a draft framework for MLMA-based management.

The following provides an overview of each Information Gathering Projects and supporting contractors include the following:

- *Approach to Marine Life Management Act-based Management*: A proposed framework was developed based on the objectives of the MLMA to help focus the Department's management efforts on fisheries with the greatest management need, and to organize the results of Information Gathering Projects into a comprehensive management system designed to fully implement the principles of the MLMA. The proposed framework was modified throughout the amendment process based on changes in Department priorities and feedback heard from the ocean community during engagement efforts. *Department Lead: Paul Reilly; Contractor: Fathom Consulting*
- *Productivity and Susceptibility Analysis and Ecological Risk Assessment*: Existing PSA and ERA tools were explored as a systematic way to determine the biological and ecological risk of the prosecution of fisheries to target and non-target species as well as habitat. Results from a PSA on 45 commercial and recreational fisheries were used to help the Department prioritize fisheries for FMP development and other management action, as well as inform plans for future data collection and monitoring activities. An existing ERA was modified to meet the Department's needs for assessing the ecological impacts of fisheries to habitat and bycatch species and was piloted on five fisheries with stakeholders during two workshops. *Department Lead: Paul Reilly; Contractor: MRAG Americas and OST*
- *Marine Life Management Act-based Assessment Framework*: A tool was developed to assess the degree of MLMA consistency for any state-managed fishery, and tested on nine fisheries to iteratively co-develop the framework into a robust tool. Please see Appendix D for more details. *Department Lead: Tom Mason; Contractor: Center for Ocean Solutions*
- *Socioeconomic Value and Opportunity*: This project identified the need and opportunities for analyzing and assembling socioeconomic and human dimension information to guide fishery management efforts consistent with the MLMA. *Department Leads: Debbie Aseltine-Neilson and Ryan Bartling; Contractor: California Sea Grant*
- *California Fisheries Data-limited Toolkit*: An existing software tool that uses MSE was customized and tested on four fisheries to compare the performance of a number of stock-assessment approaches for data-limited fisheries. *Department Leads: Pete Kalvass and Chuck Valle; Contactors: Natural Resources Defense Council and University of British Columbia*
- *Streamlined Fishery Management*: This project provided guidance on an approach to scale management efforts to the size and complexity of a fishery. A cost-effective, flexible, and streamlined approach to meeting the goals of the MLMA through an MLMA-based management continuum was proposed and ranged from expanded and better-structured (enhanced) status reports to traditional, resource-intensive FMPs. *Department Leads: Ian Taniguchi; Contactor: Fathom Consulting*

- *Status of the Fisheries Reports and Web-based Fisheries Portal*: A blueprint for a regularly updated, user-friendly, web-based "California Fishery Portal" was developed to serve as a library for fisheries information. Status reports will be transformed from a static paper or digital document to a dynamic website structure. The portal will be available to the public, fisheries managers, scientists, and others to learn about the state of knowledge about a fishery, management issues and current research needs. *Department Lead: Tom Mason; Contractor: Fathom Consulting*
- *Climate Change and Fisheries*: This project considered the issue of climate change in the sustainable management of California fisheries, provided an evaluation of the effects of changing climate and ocean chemistry on fisheries (including social, ecological, and governance dimensions), and explored ways of building resilience to buffer against potential effects. *Department Lead: Debbie Aseltine-Neilson; Contractor: OST*
- *Bycatch*: The BWG composed of fishermen, NGOs, and state agencies was convened by the Commission to review bycatch and associated issues in California's fisheries. The BWG helped to inform the draft Master Plan through their review of bycatch language and definitions, and other action items within the scope of Commission authority. *Department/Commission Lead: Susan Ashcraft and Elizabeth Pope*
- *Data Review*: The Department's current data collection activities were inventoried and their use and relevance to management evaluated. Recommendations were developed for adapting the Department's fishery-dependent data collection activities to more closely meet management needs, and to leverage existing monitoring programs while also considering trade-offs between costs, coverage, timeframes for implementation, and potential strategies and partners. *Department Lead: Kirsten Ramey; Contractor: MRAG Americas and Kate Wing Consulting*
- *Fisheries Partnerships*: Opportunities, benefits, and limitations that partnerships between the Department and fishery stakeholders can play in securing effective and efficient fisheries management were evaluated. The project also explored the necessary elements of effective partnerships and the requirements for collaboration on different types of fisheries management activities. *Department Leads: Elizabeth Pope and Ian Taniguchi; Contractor: The Nature Conservancy*
- *Stakeholder Engagement Toolkit*: This project surveyed the best practices regarding engagement of stakeholders in fisheries management in California and beyond. Tools were developed to help managers foster targeted and meaningful stakeholder involvement in fisheries management; the tools assembled information on a range of stakeholder engagement methods, including costs, necessary expertise, benefits, and challenges. *Department Leads: Toby Carpenter and Elizabeth Pope; Contractors: Center for Ocean Solutions, Kearns & West, and the University of California at Santa Barbara*
- *Peer Review*: Using lessons learned from previous peer reviews under the MLMA (e.g., FMP processes) as well as from best practices of other agencies and scientific organizations, this project developed recommendations to help inform the Department's approach to peer review for FMPs. *Department Lead: Pete Kalvass; Contractors: OST*

Tribal communications and consultation

The Department reached out to Tribes and tribal communities to seek input on the Master Plan amendment process through direct communications and consultation via the following:

- Sent letters in June 23, 2016, July 28, 2017, and October 11, 2017 that provided general information about the amendment process and solicited tribal input and feedback;

- Provided presentations at the March 2016 and June 2017 Commission Tribal Committee meetings that included updates on the amendment process;
- Shared a draft Table of Contents and highlighted tribal communications and consultation as an important component to the draft Master Plan, as well as soliciting input;
- Supported individual conversations with interested Tribes to provide additional information and help to address any questions and concerns; and
- Sent invitations to public discussions (i.e., conference calls, webinars, workshops, and meetings) about the amendment process.

Stakeholder engagement

The Department engaged with the California ocean community to ensure the Master Plan reflects the community's knowledge, expertise, needs, and priorities. Throughout the amendment process, the Department worked to:

- Continue to support and maintain open lines of communication with target audiences (e.g., Tribes and tribal communities, fishermen, NGOs, citizen scientists, academic institutions) and key leaders;
- Learn about the most effective ways to communicate with target audiences and share information about the amendment process;
- Share and discuss draft ideas, tools, approaches, and preliminary findings from the Information Gathering Projects, and solicit feedback and input to inform the development of the Master Plan, including a draft amended framework for MLMA-based management; and
- Develop a draft amended Master Plan that considers the needs, priorities, and input of the ocean community in advance of and throughout the approval process by the Commission.

The Department designed and implemented a suite of formal and informal engagement strategies to:

- Develop an internal communications and engagement strategy that identified key goals, target audiences, anticipated outcomes, timeframes, and other Department priorities;
- Identify and subsequently work with community leaders, or "Key Communicators" that have direct access to target audiences and were willing to play a liaison role to disseminate information and encourage involvement in stakeholder discussions;
- Conduct informal informational interviews with Key Communicators to learn about appropriate communications tools and pathways, identify local events to participate in, and establish interest in providing feedback on outreach materials development;
- Engage with target audiences through in-person meetings and presentations at MRC meetings;
- Develop outreach materials to summarize and help frame the components of the amendment process, as well as present the results and findings of the Information Gathering Projects;
- Utilize a variety of communications channels (i.e., webpage announcements, information blogs, Department e-newsletters, Commission listserv) to share information and outreach materials and promote participation in stakeholder discussions;
- Host a series of stakeholder discussions in the form of in-person meetings, conference calls, and webinars to share information and solicit feedback; and
- Share a pre-draft of the Master Plan for stakeholder review and input in advance of review by the Commission.

Outreach materials

The Department developed several outreach materials to complement stakeholder discussions and provide additional information on the amendment process. The core set of outreach materials include the following:

- Overview of a Draft Amended Framework for MLMA-based Management
- MLMA Master Plan Amendment Timeline
- MLMA Objectives Overview
- Information Gathering Projects Overview
- Frequently Asked Questions

Additional outreach materials were developed to accompany many of the stakeholder discussions. All outreach materials were made available to stakeholders on the Department's MLMA Master Plan Amendment webpage at https://www.wildlife.ca.gov/Conservation/Marine/MLMA/Master-Plan.

Stakeholder discussions

In an effort to ensure the Master Plan reflected and considered stakeholder input, needs, and priorities, the Department engaged with stakeholders through a series of stakeholder discussions during the amendment phase from December 2016 through December 2017. The goal of these discussions was to share information about the projects and components of the amendment process, including the draft Framework for MLMA-Based Management, and invite input and feedback from a broad and diverse audience of interested Tribes and tribal communities, and stakeholders to help inform the development of the Master Plan.

Stakeholder discussions took the form of conference calls, webinars, in-person workshops, and regular updates at public meetings (i.e., MRC and Commission Tribal Committee meetings). Participation at each discussion ranged from 30-75 people. Stakeholders and Tribes and tribal communities provided valuable insight and suggestions that the Department considered during the amendment process.

The following is a complete list of Department stakeholder discussions in chronological order:

- December 13, 2016- A conference call titled "*Marine Life Management Act 101: Orientation Brown Bag Conference Call for Interested Stakeholders*."
- February 1, 2017- A webinar titled "*Draft Approach to Scaled Management and a Fisheries Web-based Data Portal*."
- March 23, 2017- A presentation and discussion at the MRC meeting in San Clemente titled, "*Considering Stakeholder Engagement in Fisheries Management*."
- May 25, 2017- A webinar titled, "*Management Strategies for Achieving Sustainability of Marine Fisheries Under the MLMA*."
- July 28, 2017- A webinar titled, "*Considering Approaches to Fisheries Partnerships Under the MLMA*."
- November 9, 2017- A presentation and discussion at the MRC meeting in Marina titled, "*Update on the Marine Life Management Act (MLMA) Master Plan Amendment*."

Appendix C – List of Marine Species Monitored by the Department, Excluding Those Managed Under a Federal Fishery Management Plan

Common Name[1]	Taxon
ALGAE	
Algae	*Alaria* spp.
Algae	*Chondracanthus* spp.
Algae	*Gelidium* spp.
Algae	*Gracilaria* spp.
Algae	*Saccharina sessilis*
Algae	*Iridia* spp.
Algae	*Lessionopsis littoralis*
Algae	*Mazzaella splendens*
Algae	*Pelvetiopsis limitata*
Algae	*Pelvetti* spp.
Algae, Bladderwrack	*Fucus* spp.
Algae, Bull/Bullwhip Kelp	*Nereocystis luetkeana*
Algae, Dead Man's Fingers	*Codium fragile*
Algae, Feather Boa Kelp	*Egregia menziesii*
Algae, Giant Kelp	*Macrocystis pyrifera*
Algae, Kombu	*Laminaria spp.*
Algae, Marine	*Phycophata*
Algae, Mermaids Hair	*Polysiphonia*
Algae, Nori	*Porphyra spp.*
Algae, Ocean Ribbons	*Lessoniopsis littoralis*
Algae, Pacific Dulse	*Palmaria mollis*
Algae, Sea Fern	*Stephanocystis osmundacea*
Algae, Sea Grapes	*Botryocladia* spp.
Algae, Sea Lettuce	*Ulva* spp.
Algae, Sea Palm	*Postelsia palmaeformis*
Algae, Turkish Washcloth	*Mastocarpus papillatus*
Algae, Turkish Towel	*Chrondracanthus exasperatus*
Algae, Wakame	*Alaria marginata*
INVERTEBRATES	
Abalone, Red	*Haliotis rufescens*
Chione	*multiple species*
Clam, Bean	*Donax gouldii*
Clam, California Jackknife	*Tagelus californianus*

[1] **Bold** = used in initial prioritization for 2018 Master Plan.

Common Name[1]	Taxon
Clam, Fat Gaper	*Tresus capax*
Clam, Gaper	*Tresus nuttalli*
Clam, Geoduck	*Panopea generosa*
Clam, Little Neck	*Venerupis philippinarum*
Clam, Northern Quahog	*Mercenaria mercenaria*
Clam, Pacific Razor	*Siliqua patula*
Clam, Pismo	*Tivela stultorum*
Clam, Soft-Shelled	*Mya arenaria*
Clam, Washington	*Saxidomus nuttalli*
Cockle, Basket	*Clinocardium nuttalli*
Crab, Armed Box	*Playmera gaudichaudi*
Crab, Box	*Lopholithodes foraminatus*
Crab, Brown Rock	*Romaleon antennarium*
Crab, Dungeness	*Metacarcinus magister*
Crab, Graceful	*Metacarcinus gracilis*
Crab, Hermit, unspecified	*Paguristes* spp.
Crab, King, unspecified	*Paralithodes* spp.
Crab, Pelagic Red	*Pleuroncodes planipes*
Crab, Red Rock	*Cancer productus*
Crab, Sand	*Emerita analoga*
Crab, Sheep	*Loxorhynchus grandis*
Crab, Shore	*Pachygrapsus crassipes*
Crab, Tanner	*Chionoecetes tanneri*
Crab, Yellow Rock	*Metacarcinus anthonyi*
Limpet, Keyhole	*Megathura crenulata*
Limpet, Giant Owl	*Lottia gigantea*
Lobster, California Spiny	*Panulirus interruptus*
Mussel, Bay	*Mytilus edulis*
Mussel, California	*Mytilus californianus*
Octopus	*Octopus* spp.
Oyster, Giant Pacific	*Crassostrea gigas*
Prawn, Golden	*Penaeus Californiensis*
Prawn, Ridgeback	*Eusicyonia ingentus*
Prawn, Spot	*Pandalus platyceros*
Sand Dollar	*Dendraster excentricus*
Scallop, Rock	*Crassadoma gigantea*
Sea Cucumber, Giant Red	*Parastichopus californicus*
Sea Cucumber, Warty	*Parastichopus parvimensis*
Sea Hare	*Aplysia* spp.
Sea Pansy	*Renilla koellikeri*

Common Name[1]	Taxon
Sea Urchin, Coronado	*Centrostephanus coronatus*
Sea Urchin, Purple	*Strongylocentrotus purpuratus*
Sea Urchin, Red	*Strongylocentrotus franciscanu*
Sea Urchin, White	*Lytechinus anamesus*
Shrimp, Bay	*multiple species*
Shrimp, Coonstriped	*Pandalus danae*
Shrimp, Ghost	*Callianassa californiensis*
Shrimp, Mantis	*Hemisquilla ensigera californiensis*
Shrimp, Ocean (Pink)	*Pandalus jordani*
Shrimp, Red Rock	*Lysmata californica*
Snail, Bubble	*Bulla gouldiana*
Snail, Moon	*Polinices* spp.
Snail, Tegula	*Tegula* spp.
Snail, Wavy Top	*Megastraea undosa*
Squid, Jumbo	*Doscidicus gigas*
Squid, Market	*Doryteuthis opalescens*
Whelk, Kellet's	*Kelletia kelleti*
FISH	
Barracuda, Pacific	*Sphyraena argentea*
Bass, Barred Sand	*Paralabrax nebulifer*
Bass, Giant Sea	*Stereolepis gigas*
Bass, Kelp	*Paralabrax clathratus*
Bass, Spotted Sand	*Paralabrax maculatofasciatus*
Bass, Striped	*Morone saxatilis*
Bass, Threadfin	*Pronotogrammus multifasciatus*
Blacksmith	*Chromis punctipinnis*
Blenny, Rockpool	*Hypsoblennius gilberti*
Bonefish	*Albula vulpes*
Bonito, Pacific	*Sarda chiliensis*
Combfish, Longspine	*Zaniolepis latipinnis*
Combfish, Shortspine	*Zaniolepis frenata*
Corbina, California	*Menticirrhus undulatus*
Corvina, Orangemouth	*Cynoscion xanthulus*
Corvina, Shortfin	*Cynoscion parvipinnis*
Croaker, Black	*Cheilotrema saturnum*
Croaker, Spotfin	*Roncador stearnsii*
Croaker, White	*Genyonemus lineatus*
Croaker, Yellowfin	*Umbrina roncador*
Cusk-Eel, Spotted	*Chilara taylori*

Common Name[1]	Taxon
Escolar	*Lepidocybium flavobrunneum*
Eulachon	*Thaleichthys pacificus*
Flyingfish, California	*Cypselurus californicus*
Fringehead, Sarcastic	*Neoclinus blanchardi*
Fringehead, Onespot	*Neoclinus urinotatus*
Goby, Bluebanded	*Lythrypaus dalli*
Goby, Chameleon	*Tridentiger trigonocephalus*
Goby, Yellowfin	*Acanthogobius flavimanus*
Greenling, Painted	*Oxylebius pictus*
Greenling, Rock	*Hexagrammos lagocephalus*
Greenling, Whitespotted	*Hexagrammos stelleri*
Grunion, California	*Leuresthes tenuis*
Guitarfish, Banded	*Zapteryx exasperata*
Guitarfish, Shovelnose	*Rhinobatos productus*
Gunnel, Rockweed	*Apodichthys fucorum*
Hagfish, Pacific	*Eptatretus stoutii*
Halfmoon	*Medialuna californiensis*
Halibut, California	*Paralichthys californicus*
Herring, Pacific	*Clupea pallasi*
Herring, Pacific Roe	*Clupea pallasi eggs*
Herring, Pacific Roe On Kelp	*Clupea pallasi/algae*
Herring, Round	*Etrumeus teres*
Jacksmelt	*Atherinopsis californiensis*
Kelpfish, Crevice	*Gibbonsia montereyensis*
Kelpfish, Giant	*Heterostichus rostratus*
Kelpfish, Spotted	*Gibbonsia elegans*
Kelpfish, Striped	*Gibbonsia metzi*
Lamprey, Pacific	*Entosphenus tridentatus*
Lancetfish, Longnose	*Alepisaurus ferox*
Lizardfish, California	*Synodus lucioceps*
Louvar	*Luvarus imperialis*
Mackerel, Bullet	*Auxis rochei*
Mackerel, Frigate	*Auxis thazard*
Marlin, Blue	*Makaira nigricans*
Midshipman, Plainfin	*Porichthys notatus*
Midshipman, Specklefin	*Porichthys myriaster*
Moray, California	*Gymnothorax mordax*
Mudsucker, Longjaw	*Gillichthys mirabilis*
Mullet, Striped	*Mugil cephalus*
Needlefish, California	*Strongylura exilis*

Common Name[1]	Taxon
Oilfish	*Ruvettus pretiosus*
Opah	*Lampris guttatus*
Opaleye	*Girella nigricans*
Pipefish, Bay	*Syngnathus leptorhynchus*
Poacher, Warty	*Chesnonia verrucosa*
Pomfret, Pacific	*Brama japonica*
Pompano, Pacific (Butterfish)	*Peprilus simillimus*
Prickleback, Black	*Xiphister atropurpureus*
Prickleback, Rock	*Xiphister mucosus*
Prickleback, Monkeyface	*Cebidichthys violaceus*
Queenfish	*Seriphus politus*
Ray, Bat	*Myliobatis californica*
Ray, California Butterfly	*Gymnura marmorata*
Ray, Pacific Electric	*Torpedo californica*
Sailfish	*Istiophorus platypterus*
Salema	*Xenistius californiensis*
Sanddab, Longfin	*Citharichthys xanthostigma*
Sanddab, Speckled	*Citharichthys stigmaeus*
Sand Lance, Pacific	*Ammodytes hexapterus*
Sargo	*Anisotremus davidsoniI*
Saury, Pacific	*Cololabis saira*
Scad, Mexican	*Decapterus scombrinus*
Sculpin, Brown Irish Lord	*Hemilepidotus spinosus*
Sculpin, Buffalo	*Enophrys bison*
Sculpin, Bull	*Enophrys taurina*
Sculpin, Pacific Staghorn	*Leptocottus armatus*
Sculpin, Red Irish Lord	*Hemilepidotus hemilepidotus*
Sculpin, Scissortail	*Triglops forficata*
Sculpin, Silverspotted	*Blepsias cirrhosus*
Sculpin, Smoothhead	*Artedius lateralis*
Sculpin, Spotfin	*Icelinus tenuis*
Seabass, White	*Atractoscion nobilis*
Seaperch, Pink	*Zalembius rosaceus*
Seaperch, Rainbow	*Hypsurus caryi*
Seaperch, Rubberlip	*Rhacochilus toxotes*
Seaperch, Sharpnose	*Phanerodon atripes*
Seaperch, Striped	*Embiotoca lateralis*
Seaperch, White	*Phanerodon furcatus*
Searobin, Lumptail	*Prionotus stephanophrys*
Senorita	*Oxyjulis californica*

Common Name[1]	**Taxon**
Shad, American	*Alosa sapidissima*
Shad, Threadfin	*Dorosoma petenense*
Shark, Blacktip	*Carcharhinus limbatus*
Shark, Brown Smoothhound	*Mustelus henlei*
Shark, Gray Smoothhound	*Mustelus californicus*
Shark, Horn	*Heterodontus francisci*
Shark, Pacific Angel	*Squatina californica*
Shark, Salmon	*Lamna ditropis*
Shark, Sevengill (Broadnose Sevengill)	*Notorynchus cepedianus*
Shark, Sicklefin Smoothhound	*Mustelus lunulatus*
Shark, Sixgill	*Hexanchus griseus*
Shark, Smooth Hammerhead	*Sphyrna zygaena*
Shark, Swell	*Cephaloscyllium ventriosum*
Shark, White	*Carcharodon carcharias*
Sheephead, California	*Semicossyphus pulcher*
Skate, Starry	*Raja stellulata*
Smelt, Night	*Spirinchus starksi*
Smelt, Surf	*Hypomesus pretiosus*
Sole, Bigmouth	*Hippoglossina stomata*
Sole, C-O	*Pleuronichthys coenosus*
Sole, Deepsea	*Embassichthys bathybius*
Sole, Fantail	*Xystreurys liolepis*
Sole, Slender	*Eopsetta exilis*
Stingray, Diamond	*Dasyatis dipterura*
Stingray, Pelagic	*Dasyatis violacea*
Stingray, Round	*Urolophus halleri*
Sturgeon, White	*Acipenser transmontanus*
Sunfish, Ocean	*Mola mola*
Surfperch, Barred	*Amphistichus argenteus*
Surfperch, Black	*Embiotoca jacksoni*
Surfperch, Calico	*Amphistichus koelzi*
Surfperch, Dwarf	*Micrometrus minimus*
Surfperch, Kelp	*Brachyistius frenatus*
Surfperch, Pile	*Rhacochilus vacca*
Surfperch, Redtail	*Amphistichus rhodoterus*
Surfperch, Shiner	*Cymatogaster aggregata*
Surfperch, Silver	*Hyperprosopon ellipticum*
Surfperch, Spotfin	*Hyperprosopon anale*
Surfperch, Walleye	*Hyperprosopon argenteum*
Thornback	*Platyrhinoidis triseriata*

Common Name[1]	Taxon
Tomcod, Pacific	*Microgadus proximus*
Topsmelt	*Atherinops affinis*
Triggerfish, Finescale	*Balistes polylepis*
Turbot, Diamond	*Pleuronichthys guttulata*
Turbot, Hornyhead	*Pleuronichthys verticalis*
Turbot, Spotted	*Pleuronichthys ritteri*
Wahoo	*Acanthocybium solanderi*
Whitefish, Ocean	*Caulolatilus princeps*
Wolf-Eel	*Anarrhichthys ocellatus*
Wrasse, Blackspot	*Decodon melasma*
Wrasse, Rock	*Halichoeres semicinctus*
Yellowtail	*Seriola lalandi*
Zebraperch	*Hermosilla azurea*

Appendix D – Marine Life Management Act-based Assessment Framework

This appendix provides an overview of a software-based assessment framework developed by the Center for Ocean Solutions during the information gathering phase of the Master Plan amendment. As referenced in Chapter 3, the MLMA-based Assessment Framework (framework) was co-developed with Department staff and scientists, and is designed to provide a systematic, practical, and flexible means for measuring California fisheries management. The framework can help identify future needs and directions in ESRs and can be applied at the outset of an FMP development process to help scope the effort by identifying areas where management efforts should be directed. This is expected to allow the Department to systematically identify future management needs, prioritize limited resources, and more effectively communicate decision-making rationale.

The framework was created through the careful repurposing of relevant metrics from well-known, widely-applied sustainability assessment frameworks, peer-reviewed literature, and experts. It has been extensively reviewed and tested by Department staff.

Structure and organization of the Marine Life Management Act-based Assessment Framework

The framework comprises six questionnaires, each containing metrics associated with the following requirements of the MLMA, respectively:

1. Manage for abundance of the target stock(s)
2. Minimize unacceptable bycatch
3. Maintain, restore, enhance habitat
4. Conserve entire ecosystems
5. Minimize adverse effects on fishing communities
6. Ensure good management process (compliance, evaluation, and stakeholder engagement)

The main component of the questionnaires is a list of metrics. The first four questionnaires (#1-4 above) deal with the ecological outcomes of management efforts. These questionnaires contain metrics that assess how much scientific information is available on the fishery, the effects of the fishery on the stock(s) and associated marine resources, and the management measures currently in place to address potential and/or known effects. Specifically, the metrics within each questionnaire are organized into the following three categories, consistent with the structure of the MLMA's expectations.

Understand	Managers understand the basic sustainability concerns for each fishery and identify scientific information relevant to affected marine resources and fishing activities.
Assess	Managers assess the magnitude of effect the fishery has on the biophysical system and how management measures affect fishing communities.
Manage	Managers take action to address actual and potential impacts of the fishery and management activity.

The questionnaire on minimizing adverse effects on fishing communities (#5) is based on the broad MLMA goals of recognizing the interests of fishery participants and minimizing adverse impacts to fishing communities. This questionnaire contains metrics that assess understanding of the fishery participants and their concerns and effects of regulation on fishing communities. Metrics within the final questionnaire on management processes (#6) focus on compliance, data needs, research plans, evaluation of management actions and responsiveness to those evaluations, and stakeholder engagement throughout the management process. The metrics are primarily in multiple choice format, but some require the input of narrative information.

The questionnaires that compose the tool are generally linear. The respondent should answer questions in numerical order, except where the questionnaires provide explicit instructions to do otherwise. Guidance and text about navigating to various sub-questions is included in the questionnaire to demonstrate the intended flow of the self-assessment.

In addition to the metrics, each questionnaire has several additional components. User guidance is incorporated throughout the questionnaires, pointing the questionnaire-taker to specific, vetted examples, definitions, and useful tools developed elsewhere. Such guidance is expected to result in more accurate and consistent answers, and directs managers to possibilities for improving management strategies and outcomes. An uncertainty scale and a best available science scale are included to reduce response biases and gain further useful information for scoping and prioritizing future management actions. These components are designed to gauge the precision and rationale underlying responses to each question. The uncertainty scale appears after each question, while the best available science scale follows certain questions (e.g., queries about the collection of scientific information or making decisions based on scientific information). Space for comments is provided after each question where the questionnaire-taker can identify missing information, barriers, or any other comments that allows for more discretionary and narrative responses that can inform future management decisions.

Each questionnaire was developed with several principles in mind.

- Flexible: The questionnaire balances guidance and discretion. Metrics provide enough guidance so that the differences between various responses are clear and defined. The questionnaire also provides enough discretion to enable the assessment of a diverse array of fisheries that may be characterized by different ecological and socioeconomic issues and managed using distinct management strategies.
- Manageable: The questionnaire is a reasonable length.
- Theoretically sound: The questionnaire is based on best available science and best practices in fisheries management.
- Legally accurate: The questionnaire accurately evaluates legal compliance and requires no more or less than the MLMA.

Suggested best practice for utilizing the Marine Life Management Act-based Assessment Framework

<u>Step 1. Identify the appropriate person(s) to complete the questionnaire</u>

Several options for utilizing the framework exist. The Department could self-assess their management outcomes and identify both successes and areas for potential improvement. In a complimentary or collaborative manner, outside entities such as Sea Grant, OST, academic, or other institutions could use the framework as a mechanism for scientific peer review. Lastly, the Department could apply the framework in collaboration with interested constituents as an approach for improved engagement and dialogue.

Step 2. Conduct assessment

Completing the entire assessment may require reference to management documents and/or consultation with colleagues. Two of the questionnaires—bycatch (#2) and habitat (#3)—are designed to be taken for each different sector (recreational and commercial) or gear type in the fishery. The remaining questionnaires are designed to be taken only once for each fishery. However, if the reviewer feels that the geography or fishing activities of different sectors warrants multiple assessments under any of the remaining questionnaires, the reviewer has discretion to do so. For example, if a fishery has a northern and southern component, and different stock health information that is specific to each, the reviewer should take the "managing target stock" questionnaire separately for the two geographic components.

As noted above, each questionnaire contains metrics and several additional components. Each question is accompanied by background and guidance, designed to define key terms and provide specific examples where appropriate. Each question is followed by a comment box that may be used to provide narrative explanations, identify gaps in understanding, or specify other important information. Comments are fully incorporated into the assessment results and have the potential to add valuable information to the outputs where gaps in understanding or uncertainty about the most accurate response exist. Certain questions are also accompanied by confidence scales that track how certain the reviewer is that the response selected fully captures the fishery being assessed. This scale can be used to identify when the reviewer feels that none of the possible responses are entirely accurate, that an accurate response falls somewhere between the possible responses, or that data are too sparse to answer with full confidence. Low confidence scores should be explained in the comment box. Finally, many questions are accompanied by a request to identify the sources of information that support either the scientific understanding of the fishery or the management measures that have been implemented for the fishery. The categories of sources are defined each time they appear.

Step 3. Review results to scope and prioritize future management actions and resource allocation

The results of this framework can be used to scope and prioritize future management actions and to efficiently allocate resources. Designed to evaluate consistency with the MLMA, the framework generates a comprehensive picture of the current status of implementation. The Department can use these results to inform development of management documents (e.g., ESRs and FMPs) within the new scaled management approach and other management actions or decisions. Outputs will also be valuable for informing internal discussions, facilitating communication with constituents about management outcomes and processes, allocating limited resources to focus on areas of need, or directly supporting decision-making through clearer identification of priorities.

The following are suggested options for quantifying and visualizing results:

> **Unweighted:** The possible responses for each metric sum to a maximum value of 1, with each individual response allocated an equal fraction thereof. For example, for a question with four possible responses where the lowest answer represents "no information available" the values are 0, 0.33, 0.66, and 1.0. The mean value is then calculated for each set of answers, per questionnaire.
>
> **Weighted:** A weighting scheme could be applied to individual responses, questions, categories, questionnaires, or some combination of the aforementioned. For example, critical questions can be identified by reviewing the metrics and selecting those deemed most important as a policy matter. Specific multipliers (i.e., 1.5, 2) can then be applied to the results of these questions to

reflect their importance. Proposed weighting schemes should be vetted by experts familiar with California fisheries and the framework.

Threshold: A threshold methodology could set pre-determined results for questions, categories, or questionnaires that are used to indicate an area of concern. Utilizing the underlying scoring methods from either the unweighted or weighted options, selecting thresholds would translate results into a system akin to "pass/fail" or "no concern/concern."

Once a scheme is selected, results can be presented through a series of summary tables with all of the tool's questions and selected responses for a hypothetical fishery. The tables can include descriptions of the questions and display the total response value, the response value per category, and the response value per question (See Table D1). Tables can also include weighting and thresholds (See Table D2).

Table D1. Summary results for the "Manage for Abundance of the Target Stock" questionnaire.

Category	Question #	Short description	Response Value	Value per category	Total value
INFORMATION 2 questions	Q1	Information on fishery and stock to support management decisions	52%	**43%**	**80%**
	Q2	Ongoing collection of data sufficient to support management decisions	33%		
ASSESSMENT 5 questions	Q3	Criteria defining depressed fisheries in place	100%	**92%**	
	Q4	Presence of stock assessment	100%		
	Q5	Result of stock assessment	75%		
	Q6	Presence of risk-based assessment	n/a		
	Q7	Result of risk-based assessment	n/a		
MANAGEMENT 4 questions	Q8	Frequency of revision of the stock assessment	100%	**100%**	
	Q9	Management strategy to control exploitation in healthy fisheries	100%		
	Q10	Management strategy to minimize non-fishing pressures on depressed stock	n/a		
	Q11	Management strategy to control exploitation and rebuild overfished stocks	n/a		

Table D2. Summary results for the "Maintain, Restore, Enhance Habitat" questionnaire. Includes weighting and areas of concern based on pre-determined thresholds.

Maintain, Restore, Enhance Habitat

Category and number of question per category	Area of concern	Weight	Question #	Response Value	Value per category	Total value	New Value per category	New Total value
INFORMATION 3 questions		1	Q1	50%	63%	**72%**	69%	**75%**
		1.5	Q2	100%				
		1	Q3	40%				
ASSESSMENT 4 questions		1	Q4	n/a	78%		73%	
	X	2	Q5a)	33%				
		1	Q5b)	100%				
		2	Q5c)	100%				
MANAGEMENT 3 questions		1.5	Q6	50%	75%		82%	
		1	Q7	75%				
		3	Q8	100%				

X area of concern

(yellow) critical question ("up-weighted")

(red) score of a critical question under a certain threshold (e.g. <35%)

Results can also be translated into visual representations of data (e.g., figures, charts, or diagrams) to compare areas of concern within a fishery, or to compare overall results for multiple fisheries. Example conceptual results for hypothetical fisheries are included below:

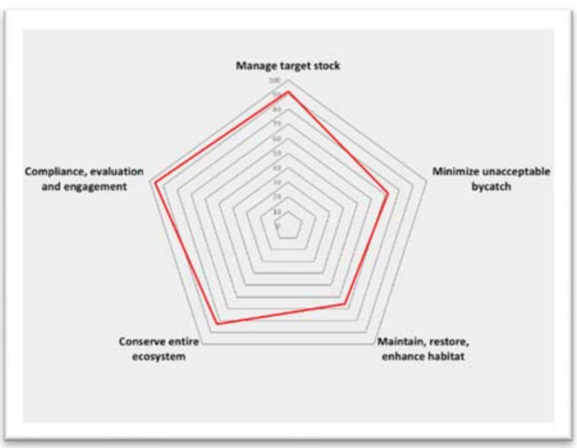


Figure D1. The current state of MLMA implementation for a hypothetical fishery across five questionnaires on a scale from 0% to 100%.

Figure D1 provides a visual way to compare elements of an individual fishery, as a step toward allocating resources and prioritizing management action. Specifically, this figure demonstrates that for this hypothetical fishery, focusing management efforts and resources on minimizing bycatch and maintaining habitat would likely result in more meaningful and significant gains than focusing on managing the target stock or conserving ecosystem functions.

Figure D2 provides an example visual to compare the overall implementation results for a suite of hypothetical fisheries. Specifically, this figure demonstrates that hypothetical Fishery 1 is furthest from full achievement of the goals of the MLMA, while Fishery 9 is the closest. A cutoff line of 55% implementation is included to demonstrate the possible use of a threshold for triggering resource allocation or management review.

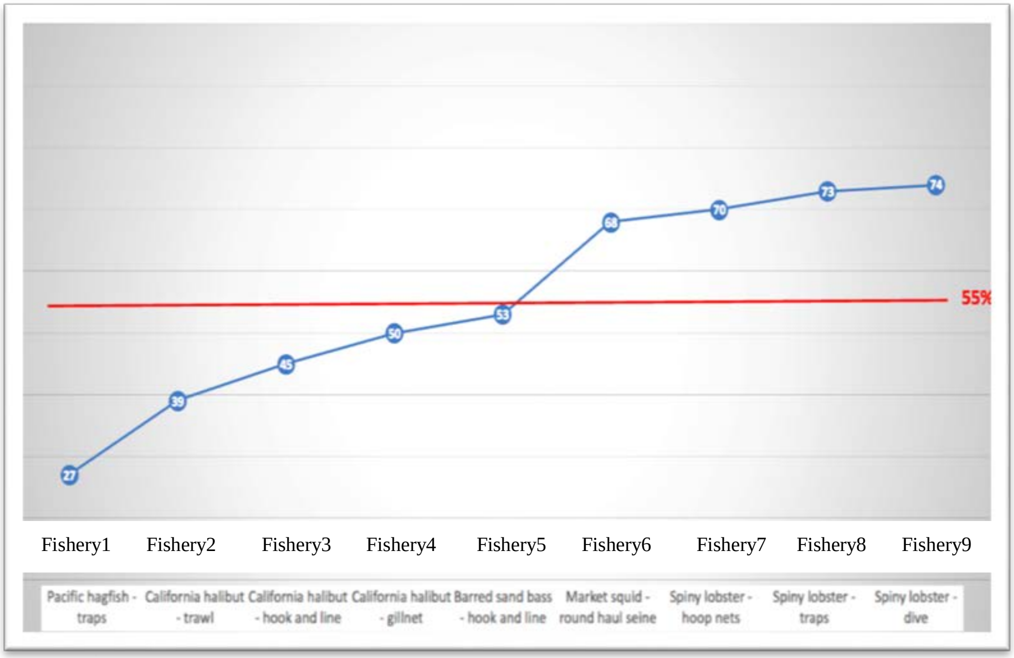


Figure D2. Overall response values for a suite of hypothetical fisheries on a scale from 0% to 100%.

<u>Step 4. Regularly revisit and review</u>

After using the framework for scoping initial management actions and priorities, the Department can reapply it periodically, on an as-needed basis or as resources permit. If conducted regularly, this self-reporting exercise will allow the Department to monitor the effectiveness of management, prioritize efforts and allocation of resources, and facilitate adaptive management. The assessment process and/or results can also serve as a stakeholder engagement and communication tool. While an initial assessment is expected to take several hours to complete, subsequent assessments will likely require significantly less time and resources, as the results of previous assessments will provide a baseline. If the need exists to only analyze or reanalyze one component of management (e.g., bycatch), the Department can use the questionnaires individually.

Appendix E – Stakeholder Engagement Strategies and Considerations

This appendix contains brief descriptions and considerations associated with individual strategies for stakeholder engagement. The appendix draws from an overview of stakeholder engagement strategies by Kearns and West and the Center for Ocean Solutions. The overview was developed with the input of a range of stakeholders including commercial Halibut, Herring, Spiny Lobster and Sea Urchin fishermen. Recreational Abalone, **Commercial Passenger Fishing Vessel (CPFV)**, private vessel, kayak, spear, and pier fishermen also provided input, as well as NGOs. Table E1 (located on the page E-13) provides guidance regarding which strategy may be most effective at achieving the possible management goals identified in Chapter 4 of the Master Plan.

Potential strategies are organized into two groups: passive strategies and active strategies. Passive strategies do not require direct engagement with individual stakeholders, are generally easier to conduct, and have the potential to reach large audiences. Passive strategies provide less feedback and do not necessarily build the same relationships, or engage or empower stakeholders to the same degree. They are often best used when the need is purely information sharing. Active strategies provide a better chance of receiving information and engaging stakeholders in meaningful ways. Active strategies, however, typically require greater effort and need to be carefully planned to ensure the engagement is effective.

Passive Engagement Strategies

BLOGS

Description:
- Blogs are an internet-based method for writing informally about management status and processes. Managers use blogs to share information and ideas.
- Comments can provide a forum for more active engagement, but must be carefully moderated, which can significantly increase workload and effort.

Purpose:
- Managers can use this forum as an online Frequently Asked Questions message board, increase the visibility of management staff perspectives, and highlight current management interests and concerns.
- Stakeholders can use blogs to highlight their own perspectives, and share information, updates, and ideas about the marine resource.

Required resources:
- Staffing: Low – Medium
    - Write blog posts and, if needed, respond to comments on a regular basis.
- Budget: Low

EMAILS

Description:
- Emails typically include relatively brief messages used to inform or share information with intended recipients. Emails may also contain attached documents. Recipients may range from individuals to large groups of stakeholders accessed via a listserv.

Purpose:
- Personal emails to key individuals can help build relationships and create two-way dialogue between active marine resource participants and managers.
- Mass emails to stakeholders and listservs can serve to efficiently disseminate timely information to a targeted audience.

Required resources:
- Staffing: Low
- Budget: Low

NEWSLETTERS

Description:
- Electronic newsletters can be used to disseminate information to a large number of stakeholders in a formal and consistent manner.

Purpose:
- Newsletters communicate a message to a large number of stakeholders (e.g., upcoming management changes or rulemaking processes).

Required resources:
- Staffing: Low – Medium
  - Draft, vet, and send newsletters on a consistent, as-needed basis, and maintain and update the newsletter listserv contacts.
- Budget: Low

PHONE APPLICATIONS

Description:
- Phone applications provide cell phone users with a method to input information about marine resource conditions and catch, or to quickly and efficiently receive information.

Purpose:
- Phone applications provide a fast and easy method for managers to collect real-time data about resource collection, marine resource conditions, and socioeconomic and demographic information.
- Managers can use applications to disseminate timely information about updated resource regulations, current rulemaking processes, and other relevant information.

Required resources
- Staffing: Low
- Budget: Medium

SOCIAL MEDIA

Description:
- Facebook, Twitter, Instagram, Flickr, and YouTube are online social media tools that can be used to inform a large number of people (beyond those on existing listservs) of key information, and increase the visibility of managers among specific stakeholder groups.

Purpose:

- Social media is a low-cost and efficient method for reaching a large number of people, including marine resource stakeholders who may be underrepresented in other engagement processes or the general public. Social media requires more effort to ensure it is current, interesting, and providing the information that users are seeking. It does not engage people who are more passively waiting for information to be delivered.
- Comments can provide a forum for more active engagement, but must be carefully moderated, which can significantly increase workload and effort.

Required resources:

- Staffing: Low – Medium
    - Maintain social media accounts and current content. If applicable, respond to comments and manage dialogue.
- Budget: Low

PRINTED MATERIAL (Pamphlets/Flyers/Posters)

Description:

- Educational and information pamphlets, flyers, and posters can be placed in locations where recreational and/or commercial fishermen are known to frequent. Tackle shops, fuel docks, marine supply stores, and other marine-related businesses are located throughout the California coast. Management information in the form of flyers or brochures can be placed at the check-out counter or storefront or posted on bulletin boards in these locations to disseminate details to stakeholders that are not electronically connected.

Purpose:

- Distribute timely information efficiently to a broad stakeholder audience. Sharing messages in this fashion is particularly helpful when the stakeholder groups are undefined, speak a different language, or are difficult to reach using electronic methods.

Required resources:

- Staffing: Low
    - Develop, vet, and distribute flyers.
- Budget: Low – Medium
    - Print and distribute materials.

WEBSITES

Description:

- Websites are internet sites where organizations can share structured and searchable information.

Purpose:

- Websites have the capacity to inform a large number of stakeholders about agency structure, process, and activities.
- Websites can have varying degrees of interactivity, with online comment sections, videos, live feeds, or links to other methods of engagement (e.g., blogs, newsletters, documents, etc.). Websites require people to seek information out and will not reach passive stakeholders who are expecting information to be provided more directly.

Required resources:

- Staffing: Low – Medium
    - Maintain the website and generate material.
- Budget: Low – Medium
    - Custom website designs and applications increase costs.

PRESS RELEASES

Description:

- Press releases are written or recorded communication directed at members of the news media to announce something newsworthy (often a major project milestone or regulatory decision).

Purpose:

- Press releases reach a broad audience quickly, inform members of the public about a major decision or milestone, and target individuals who may not otherwise be aware of marine resource management. Publications carrying releases typically have a broader customer base than agency listservs.

Required resources:

- Staffing: Low
- Budget: Low

Active Engagement Strategies

WRITTEN PUBLIC COMMENT

Description:

- Written public comment is an opportunity for members of the public to provide input (e.g., via email, letter, or website) on draft policy and regulatory documents. This can take place as part of a formal regulatory process; resource managers can also solicit written comments on draft materials or concepts in the pre-regulatory phase.

Purpose:

- Public comment provides marine resource managers or agency staff with a formal written record of public opinion on a regulatory process.
- Public comment provides stakeholders with an opportunity to provide input to inform management decisions, both early in planning processes and during formal regulatory processes.
- Public comment does not necessarily require response but can help influence responses at a later date.

Required resources:

- Staffing: Low – High
    - Staff time for written public comment is entirely dependent on the number of comments received and on whether marine resource managers plan to, or are required to, respond to the comments (this acknowledges that agencies cannot always respond to all comments).
    - At a minimum, one staff or project/regulatory lead and one support staff will be needed to manage, catalogue, and respond to public comments as they come in. Resource managers often contract these services out to an outside consulting firm to support large-scale efforts.

- Budget: Low – Medium
    - For larger projects, likely will require use of external consultant.
    - Assumes consultant would manage, catalogue, and respond to public comments as they come in.

ONLINE FISHING FORUMS

Description:

- Online forums are similar to social media feeds targeted to a specific interest group. Proactive participation in forums allows staff to virtually meet stakeholders to exchange ideas and build an understanding of stakeholder interests.

Purpose:

- Online forums provide a venue to increase the visibility of management staff, promote agency messaging within trusted channels, and limit the proliferation of unclear or inaccurate information.
- Online forums, if not moderated by the agency, can often lead to ineffective, off topic, or even inappropriate engagement that is counterproductive to the intended use.

Required resources:

- Staffing: Low – Medium
- Budget: Low

SURVEYS

Description:

- An evaluation or information collection technique consisting of a series of questions designed to solicit opinions from stakeholders on specific marine resource management issues and/or to collect data (e.g., human dimensions of the resource or otherwise). Surveys can be distributed online or via hard copy (to be completed in-person or mailed by the respondent at a later date).

Purpose:

- Surveys solicit input on a specific topic, such as evaluating the socioeconomic demographics of a marine resource or soliciting feedback on a proposal for a management alternative, from a targeted list of stakeholders.
- Surveys need to be carefully designed to achieve the desired outcome and can suffer from low response rates, limiting their applicability in some cases.

Required resources:

- Staffing: Medium
- Budget: Low

POLLING

Description:

- Polling samples or collecting opinions on a subject, taken from either a selected or a random group of stakeholders. Polling can be done through a survey or real time using mobile devices (mobile polling).

Purpose:

- Polling is similar to surveys but with a greater level of specificity (usually a single or small number of questions). The purpose of a poll is to solicit input on a specific issue quickly.
- If taken in person, polling results can provide greater participation than simple surveys.

Required resources:

- Staffing: Medium – High
  - Staff are needed to design, implement, compile, and interpret results of a poll.
- Budget: Medium – High

PHONE CALLS

Description:

- Phone calls are an opportunity for staff to communicate orally with individual stakeholders. These may be initiated by staff or the stakeholder.

Purpose:

- Phone calls provide staff with an informal opportunity to reach out directly to individual stakeholders to ask questions, receive input, and build relationships.
- Phone calls initiate two-way communication to test ideas on sensitive subjects; this may be useful in cases where stakeholders or marine resource managers don't feel comfortable creating a written record.

Required resources:

- Staffing: Low (requirements are variable depending on communication needs)
- Budget: Low

CONFERENCE CALLS

Description:

- Managers engage a group of stakeholders remotely via telephone.

Purpose:

- Conference calls facilitate two-way dialogue between marine resource managers and stakeholders.
- They provide an efficient and accessible method of engagement by reducing the cost and travel time for participants.

Required resources:

- Staffing: Low – Medium
  - Plan, convene, schedule and lead calls. Notes and summary documents are often provided after calls to provide a written record of the discussion.
- Budget: Low

FISHERIES ASSOCIATION MEETINGS

Description:

- Managers attend marine resource association meetings convened by industry associations or recreational marine resource users to make announcements and meet stakeholders.

- Association meetings usually involve their membership, but may also include the broader resource user community.

Purpose:
- Attending association meetings provides marine resource managers with the opportunity to present and share information directly to resource users.
- Managers can receive input from resource users in an environment where they are likely to share information more freely than in a venue with more conflicting interests present (e.g., an advisory group).
- Attending association meetings is an efficient method for meeting marine resource users face-to-face and building relationships.

Required resources:
- Staffing: Low – Medium
    - Effort depends on the number and location of meetings, and level of pre-planning (e.g., presentation development).
    - Marine resource association meetings are often 1-3 hours and take place close to the docks. Some meetings, however, are full days or even multiple days depending on the association and topic.
- Budget: Low – Medium
    - Travel costs need to be considered.

TRADE SHOWS

Description:
- Trade shows are periodic events (typically annual) that bring together gear suppliers and resource users (commercial and recreational). Agency staff can host a booth at trade shows to disseminate general information about and increase visibility of agency structure, process, and activities.

Purpose:
- Trade show booths can be used to target underrepresented stakeholder groups in conversation, distribute information about agency processes, and generally build trust and visibility among the general public. They are a good opportunity for agency staff to engage in informal, one-on-one discussion with interested resource users.

Required resources:
- Staffing: Low – Medium
    - Plan for and attend trade shows. Frequency of attendance impacts staffing.
- Budget: Low – Medium
    - Travel costs for staff, depending on location, any communication materials for dissemination and booth banners.

INFORMAL MEET AND GREETS

Description:
- Small group or one-on-one discussions between marine resource managers and stakeholders, often located in public establishments close to the docks.

Purpose:
- Meet-and-greets provide marine resource managers with the opportunity to build personal relationships with individual marine resource users in an informal environment.

- They allow marine resource stakeholders to share concerns and input with marine resource managers in an informal environment.

Required resources:
- Staffing: Low (per meeting)
  - One staff per meeting, with additional staff support as needed.
- Budget: Low

LISTENING SESSIONS

Description:
- Listening sessions are in-person meetings between managers and stakeholders focused on providing a venue for stakeholders to voice their interests and concerns. Managers are present primarily in a listening (rather than information presentation) capacity.

Purpose:
- Listening sessions help managers get a pulse on the range of options for crafting management alternatives, potentially identify creative management opportunities by introducing new perspectives, and elevate the voices of underrepresented stakeholder groups.

Required resources:
- Low – Medium (depending on the number of sessions)
- Budget: Low – Medium (depending on the number of sessions)
  - Facilitation materials and travel costs for staff.

OPEN HOUSES

Description:
- Open houses are often structured in an open-floor format with different ‘stations’ placed around a large room. Stakeholders may engage in dialogue with content experts and provide comment as desired.

Purpose:
- Individual stakeholders interact directly with agency staff and build relationships.
- Agency staff have the opportunity to learn of stakeholder issues and key concerns.
- Interested marine resource stakeholders become more knowledgeable about a specific rulemaking process.

Required resources:
- Staffing: Medium – High
  - Develop materials, plan, and participate in the event.
- Budget: Low – High
  - Outreach materials and travel costs for staff.

WEBINARS

Description:
- Webinars are virtual meetings with auditory and visual components that allow participants to share information and dialogue across distances.

Purpose:

- Webinars can be used to communicate management options early in the rulemaking process, educate stakeholders about a particular issue, or electronically stream public meetings. More advanced webinars allow for breakout groups, instant polling, and other innovative tools to provide a high degree of stakeholder input and collaboration in virtual meetings.

Required resources:

- Staffing: Low – Medium
    - Design, market, and manage webinars, plus staff time for individual presentation development and implementation per webinar.
- Budget: Low

KEY COMMUNICATORS

Description:

- Managers work with key members (usually leaders) of a marine resource community and other stakeholder groups as nodes for building trust, communicating with other participants within their marine resource community about management processes, and providing critical feedback on management options.

Purpose:

- By disseminating information to key communicators and requesting they distribute it to their representative communities, key communicators can help build relationships and ensure resource management information is distributed to and received from key stakeholders.
- Key communicators provide a means of engaging hard-to-reach marine resource groups; they speak the same language as users; have established, positive relationships within the particular resource community; and are sometimes seen as being able to speak for the resource in question.

Required resources:

- Staffing: Low (variable effort: depends on the project and how often communication is needed)
    - At least one agency staff member per fishery who is aware of the relevant key communicators for that fishery and maintains contact with them throughout the management process.
- Budget: Low

WORKSHOPS

Description:

- In-person meetings (one hour to two days) that are informal, problem-solving focused, interactive, and often involve a combination of small group and plenary discussions.

Purpose:

- Workshops provide marine resource managers and stakeholders with the opportunity to interact directly with each other in a small group format as well as in a standard, plenary format.
- Workshops are useful spaces for brainstorming, sharing ideas, joint-problem solving, and trust and relationship building.

Required resources:

- Staffing: Medium – High
    - Workshops tend to be staff intensive events although the effort may only be required over 2-3 months.

- Budget: Medium – High
    - Often requires facility rental and use of contractors to assist with planning and facilitation. Travel costs for staff need to be considered.

EDUCATION PROGRAMS

Description:

- Education programs train stakeholders and increase their understandings of the management process and capacity to engage in scoping or revising management rules.
- Education programs can occur over single or multiple days with the goal of training key stakeholders in how to engage effectively, participate in management processes more generally (e.g., rulemaking 101), and where attendees are given the opportunity to socialize with other stakeholders and agency staff.

Purpose:

- Education programs increase stakeholder understandings of management and engagement processes and thereby better equip them to more fully participate in dialogues about the resource and take on leadership roles.

Required resources:

- Staffing: High
    - Dedicated staff to develop, implement, and manage the educational aspects of agency decision-making processes.
- Budget: Low – High
    - Depends on facility needs and curriculum development.

TOWN HALLS

Description:

- Town hall-style meetings are open, public meetings often structured around a brief presentation on a specific topic followed by time for questions and discussion.

Purpose:

- Town halls give stakeholders an opportunity to speak freely about a specific or general issue of management concern. They can also be structured to disseminate information to a geographically-specific stakeholder community. They are helpful during rulemaking processes or while implementing a management policy, as a means of disseminating information and clarifying uncertainties among geographically-specific communities.

Required resources:

- Staffing: Medium – High
    - Develop materials, plan, and participate in the event.
- Budget: Low – High
    - Outreach materials and travel costs for staff.

PUBLIC HEARINGS/TESTIMONY

Description:

- Public hearings are opportunities for members of the public to provide oral testimony at formal public meetings or as part of a regulatory process.

Purpose:

- Public hearings provide marine resource managers or agency staff with a formal spoken record on a regulatory process.
- They provide stakeholders with a formal opportunity to provide input to inform management decisions.

Required resources:

- Staffing: Medium – High
    - Public hearings often require high-level staff and support staff.
- Budget: Low – High (Depends on whether external facilitation is needed and how many meetings are involved)
    - Low (if a single meeting and if convened and facilitated by an existing Board or Commission).
    - Medium – High (if multiple meetings, facilities, and external facilitation is required).

STAKEHOLDER ADVISORY GROUPS

Description:

- Stakeholder advisory groups are multi-interest bodies of appointed stakeholders convened for a pre-determined period of time to provide individual or collective advice to a decision-making body. Stakeholder advisory groups can serve to identify key issues, generate management alternatives, or liaise between managers and advisory group constituencies. They typically have charters describing their core charge and participants, and they can meet once or multiple times.
- There are two kinds of stakeholder advisory groups:
    - Standing stakeholder advisory groups (often required by statue or regulation):
        - Typically focused on a particular fishery.
        - Typically meet at set intervals throughout a year.
        - Formalized, rotating membership.
    - Ad hoc stakeholder advisory groups:
        - Typically focused on a particular policy, planning, or regulatory issue.
        - Typically convened for multiple meetings. May range from a few months to multiple years.

Purpose:

- For either ad hoc or standing advisory groups, the purpose is to solicit input from a group of individuals representative of larger interest groups (e.g., NGOs, fishing industry, recreational interests, research, regulators, etc.) collaboratively to support development of solutions to policy challenges.

Required resources:

- Staffing: High
    - Staffing assignments are largely dependent on the size of the group in question. For smaller advisory groups, a single staff member, one support staff, and one group facilitator may be sufficient. Larger groups may require additional staff to support group activities.
- Budget: High (assuming at least four advisory group meetings)
    - Cost will depend on the number of meetings and the complexity of the advisory process.
    - Third-party neutral, professional facilitation is often necessary.

COLLABORATIVE RESEARCH

Description:

- Managers, researchers, and fishermen co-design and co-conduct research to assess marine resource status or test a management option. Note that the engagement component of CFR is secondary to the primary purpose of conducting research.

Purpose:

- CFR evaluates hypotheses around the efficacy of various management alternatives or tests specific management-relevant technology.
- Collaborative research serves to engage marine resource stakeholders with relevant context or expertise in a rigorous and intensive process of formulating research questions and executing research design, thus fostering and building relationships and trust in the process.
- Collaborative research increases buy-in and ownership of the decision-making process, increases transparency around the use of data in decision-making, improves the valuation of scientific information in decision-making, and motivates co-development of management goals.

Required resources:

- Staffing: High
- Budget: High

References

Kearns & West and Center for Ocean Solutions. 2017. California State Fisheries Stakeholder Engagement User Manual. Accessed at http://ca-fisheries-engagement.s3-website-us-west-2.amazonaws.com/user_manual.pdf.

Table E1: Engagement strategy effectiveness for achieving specific engagement goals.

Engagement Strategy	Build Trust	Efficiency Educate	Build Relationships	Engage Underrepresented Stakeholders	Socioeconomic	Research	Inform	Solicit Input	Involve	Collaborate	Empower
Passive Strategies											
Blogs	SL	ML	SL	LL	LL	LL	ML	SL	SL	LL	LL
Emails	SL	SL	SL	ML	SL	LL	ML	SL	SL	SL	LL
Newsletters	LL	SL	SL	ML	SL	LL	ML	LL	SL	SL	LL
Phone Apps	LL	ML	LL	LL	LL	ML	ML	LL	SL	LL	LL
Social Media	SL	ML	SL	SL	ML	LL	ML	ML	ML	LL	LL
Printed Material	LL	SL	LL	LL	ML	LL	ML	LL	SL	LL	LL
Websites	LL	ML	LL	LL	LL	LL	ML	LL	LL	LL	LL
Press Releases	LL	ML	LL	LL	LL	LL	ML	LL	LL	LL	LL
Active Stratetgies											
Written Public Comment	LL	SL	LL	LL	LL	LL	LL	LL	SL	LL	LL
Online Fishing Forums	SL	SL	LL	SL	SL	LL	ML	SL	SL	LL	LL
Surveys	LL	ML	LL	LL	LL	ML	LL	LL	LL	LL	LL
Polling	LL	SL	LL	LL	LL	ML	LL	LL	LL	LL	LL
Phone Calls	SL	SL	LL	SL	SL	LL	ML	SL	LL	SL	LL
Conference Calls	LL	ML	LL	SL	LL	LL	ML	SL	SL	LL	LL
Fishery Association Meetings	ML	ML	SL	ML	LL	LL	ML	SL	SL	LL	LL
Trade Shows	SL	SL	LL	SL	ML	LL	ML	SL	LL	LL	LL
Informal Meetings	ML	SL	SL	ML	ML	LL	ML	ML	ML	LL	LL
Listening Sessions	SL	SL	LL	SL	SL	LL	SL	ML	SL	LL	LL
Open House	ML	ML	ML	ML	SL	LL	ML	SL	SL	LL	LL
Webinar Meetings	SL	ML	SL	LL	LL	LL	ML	SL	SL	LL	LL
Key Communicators	ML	ML	ML	ML	ML	LL	ML	ML	ML	LL	LL
Workshops	SL	SL	SL	SL	LL	LL	ML	ML	ML	SL	LL
Education Programs	ML	ML	ML	ML	SL	SL	ML	ML	ML	LL	LL
Townhalls	LL	SL	LL	SL	LL	LL	ML	LL	SL	LL	LL
Public Hearings	LL	SL	LL	LL	LL	LL	SL	ML	LL	LL	LL
Stakeholder Advisory Groups	ML	LL	SL	ML	ML	LL	ML	ML	ML	ML	SL
Collaborative Research	ML	LL	ML	ML	SL	SL	SL	ML	ML	ML	ML

KEY: ML = Most Likely to be Effective
SL = Somewhat Likely
LL = Least Likely

Appendix F – Essential Fishery Information and Data Collection Strategies

Data collection is an essential component of fisheries management. Data collected through ongoing monitoring provides the scientific and technical information necessary to understand fishery operations, estimate the status of exploited stocks, evaluate fishery impacts on the ecosystem, and develop appropriate management regulations. It is this ongoing source of information that allows future management decisions to be adaptive, even when there is uncertainty during the design phase. A well-designed data collection and monitoring program is central to meeting management objectives.

The Master Plan is required to contain a description of the research, monitoring and data collection efforts that the Department conducts (§7073(b)(3)). This appendix defines the various kinds of biological, ecological, and socioeconomic EFI, and maps them onto the categories of data needed to make fishery management decisions. It then gives an overview of the types of data collection protocols that can be used to collect the various kinds of data required for fisheries management, and describes the monitoring procedures in place in California. Finally, it describes some alternative sources of data that may be available when it is necessary to assess data-poor fisheries that lack historical information.

As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Primary data needs for fisheries management

Fisheries management is primarily concerned with estimating the abundance of a fish stock, and determining whether that abundance is at a healthy level. Data is collected in order to monitor fish stocks, and these data are then analyzed to estimate stock status. This is primarily done by fitting this data to population models (known as stock assessments), or by using other analytical techniques to estimate some metric of stock status (see Appendix G for more information).

Stock assessments usually require three primary categories of information: abundance, biological, and catch data. These three types of data and their collection methods are described in Table F1.

Table F1. Description of types of data used in fisheries management, and their collection methods.

	Definition	Types of Data	Collection Methods
Abundance	Absolute or relative index of the number or weight of fish in the stock.	Size and or weight of fish collected or observed per sample unit.	Statistically-designed, fishery-independent survey that samples fish at many locations throughout the stock's range. CPUE can be used as a proxy for abundance.
Biological	Information on population dynamics processes.	Fish size, age (via otoliths or scales), maturity, fecundity, natural mortality, and movement.	May be collected during fishery-independent surveys or tag-recapture studies, or be obtained from observers and other fishery sampling programs. Academic programs and cooperative research with the fishing industry are other important sources of biological data.
Catch	The amount of fish removed from a stock by fishing, and the effort used to remove those fish.	Number, weight, and species composition of removals (including discards). Effort data, including type and amount of gear used, time, day, location of fishing.	Dockside monitoring (also known as port sampling), logbooks, on-board observers, EM, telephone surveys.

Additional data needs for fisheries management

While Table F1 summarizes the core data needs for assessing the status of target stocks and developing HCRs, the population health of target stocks is just one component of fisheries. Fisheries are complex socioecological systems, and in recognition of this, the MLMA specifies both socioeconomic and ecological goals and objectives for management of the state's fisheries.

As discussed in Chapter 7, the MLMA's socioeconomic objectives for fishery management include: 1) observing the long-term interests of people dependent on fishing for food, livelihood, or recreation (§7056(i)); 2) minimizing the adverse impacts of fishery management on small-scale fisheries, coastal communities, and local economies (§7056(j)); and 3) being proactive and responding quickly to changing environmental conditions and market or other socioeconomic factors, and to the concerns of fishery participants (§7056(l)). In addition, the MLMA requires that FMPs include: a summary of the economic and social factors related to the fishery (§7080(e)). If additional conservation and management measures are included in an FMP, a summary of the anticipated effects of those measures on relevant fish populations and habitats, on fishery participants, and on coastal communities and businesses that rely on the fishery (§7083(b)).

Additionally, as fisheries management agencies around the world move towards EBFM, there is increased focus on collecting data to monitor the impacts of fishing at the ecosystem level. The MLMA lists the following as an objective: *Support and promote scientific research on marine ecosystems and their components to develop better information on which to base marine living resource management decisions* (§7050(b)(5)). This suggests that the ongoing collection of ecological data is also important for managing California's fisheries in a holistic manner.

Essential Fisheries Information

The MLMA states that FMPs are to summarize the best scientific and other relevant information available, and to collect necessary additional information if this does not significantly delay FMP preparation (§7072(b)).

Table F2 demonstrates how the major EFI categories link to the major types of data required to make fishery management decisions, and provides examples of each. In addition, the various EFI categories are explained in detail below.

Table F2. Summary of the kinds of information that may be applicable for each EFI category, and how they meet the basic data requirements necessary for fisheries management.

Data needs for fishery decisions	EFI categories	Examples
Abundance	Estimates of abundance	Absolute or relative abundance of fishable population, standardized CPUE index
Biological	Age and growth characteristics	Size at age, length frequency, max length, max age
	Distribution of stocks	Habitat preferences by life history stage, range, genetics, depth preferences
	Movement patterns	Seasonal migration, ontogenetic movements, changing environmental conditions, home range
	Reproductive characteristics	Fecundity, size/age at maturity, sex ratio, spawning periodicity and areas, size/age of sex change
Catch	Total mortality	Landings, dead loss, discard mortality rate, discards (species and amount), research take, natural mortality, target species catch in other fisheries
	Effort	Gear type and specifications, fishing location, # trips, fleet capacity, effort/trip, boat size/capacity. Note: CPUE can be used as an index of abundance.
Socioeconomic	Economic	Price/lb., market dynamics revenues, business costs, cost of management
	Social	Gear type and specifications, fishing location, # trips, fleet capacity, effort/trip, boat size/capacity
Ecological	Ecological interactions	Endangered, threatened, or protected species interactions, predator/prey, trophic role, other species encountered, habitat interaction, amount and type of bait

Target stock Essential Fisheries Information

<u>Age and growth</u>
Age and growth studies typically measure how long a species lives, the age at which it reproduces, and how fast individuals grow. This information is very important to determine a population's ability to

replenish itself, the rate at which it might be harvested, and the age at which individuals will reach a harvestable size. Changes in the age structure and growth rate of a population also serve as indicators of that population's health. Fish age often cannot be determined externally, so individuals must be harvested for age information.

Stock distribution

A stock is a population unit that is selected for management purposes. It may be defined based on its ecology, genetics, harvesting location, and/or geographic separation. Discrete stocks of a given species may have very different growth rates, reproductive schedules and capacity, and even ecological relationships. Stock distribution refers to where a stock is found, and is important in addressing jurisdictional issues.

Indices of abundance

By its very nature and size, the ocean prevents highly accurate animal population counts. Managers and scientists rely instead on estimates and indices of abundance. An index of abundance is an indirect measure of the size of a population, and is often obtained by counting a portion of the population in the same way each year, or by comparing counts between areas using similar techniques. This information is used by managers to calculate estimates of the total population size that are then used to determine appropriate harvest levels.

Movement patterns

Information on distribution patterns and movement of fish is important to resource managers because of the insights gained about a stock's vulnerability to harvest. Certain species may aggregate in specific areas for spawning, travel in predictable patterns, or move to certain locales that make them especially vulnerable. Insights into the movement patterns of fish are vital to the development of management strategies based on regional catch quotas or MPAs.

Recruitment

Recruitment refers to a measure of the number of fish that survive to a particular life stage, and is often used to predict future population size. Some examples include: the number of offspring that reach the juvenile stage (larval recruitment), the number of individuals that survive (i.e., recruit) to the next year (e.g., age two recruits), the number of fish that reach sexual maturity (i.e., recruit to the spawning population), or in the case of a fishery, the number of fish that recruit to the catchable component of the population. Young-of-the-year (individuals less than one year old) are frequently counted for many fish species and used as an index of larval recruitment success.

Many highly-valued species depend on successful recruitment events for replenishment. Recruitment success can be highly variable because it depends on the proper combination of many factors. As a result, sustainable harvest of the fishery may depend on only a few strong cohorts (born the same year) to provide harvestable stocks until the next successful recruitment event. Resource managers must consider this variable recruitment success when setting harvest levels by allowing sufficient portions of stocks to escape harvest and provide spawning biomass for future recruitment successes.

Reproduction

Reproduction encompasses information such as the number of eggs a female produces, the average age an individual becomes sexually mature, and whether a female bears live young or broadcasts eggs in the water. This type of information helps managers determine the ability of a population to replenish itself, and at what level it might be harvested. This knowledge allows them to set appropriate open seasons, areas, size limits, escape mechanisms for traps, and net mesh-size restrictions based on spawning considerations.

Total mortality

Natural and fishing mortality rates comprise the sum of all individuals removed from a population over a fixed period of time (often over one year). Fishing mortality is the rate at which animals are removed from the population by fishing, and can be calculated from landings information if the population size can be estimated. Natural mortality refers to all other forms of removal of fish from the population such as predation, old age, or disease. This information is used to predict how many animals remain to reproduce and replenish the population. Mortality figures are used by managers to calculate the number or weight (biomass) which may be safely harvested from a population or stock on a sustainable basis.

Ecological Essential Fisheries Information

Ecological interactions

Studies of ecological interactions assess the relationship of the species with other animal and plant species and its physical environment. For example, the harvest of an organism has an effect on its predators and on the prey organisms upon which it feeds. In addition, fishing activity may have unintended effects on fish habitat or on other species inhabiting the area. Ecosystem-based studies consider how oceanographic parameters, habitat, trophic (i.e., food, energy) dynamics, community structure, competition, or fishing mortality affect the health and abundance of organisms.

Oceanographic features include many biological (e.g., primary production, nutrient levels) or physical variables (e.g., current, temperature, salinity patterns) that can provide valuable insights into the abundance, distribution, and condition of a particular species or stock. Their predictive value makes long-term trends in oceanographic data, coupled with other biological information parameters, especially important in fisheries management.

Certain biological and physical variables may prove to be valuable as indicators of climate change.

Habitat

Habitat investigations are useful to fisheries managers because they can identify the importance of specific physical parameters to the species of interest, and to associated biological assemblages.

Socioeconomic Essential Fisheries Information

It is important that fisheries managers have a clear understanding of the current economic condition of the community and fishery under regulation, and of the likely socioeconomic consequences of regulatory changes to the fishery. This includes direct impacts to resource users, such as reduction in landings revenue due to lower catch quotas and shorter fishing seasons, as well as indirect or “downstream” economic impacts to local employment or associated industries.

Demographics

Demographic information typically consists of data relating to a population and particular groups that comprise it. Examples of demographic data include age, gender, ethnicity, race, education level, income level, residence location and type, and household size. In a fisheries context, the population includes fishery participants (i.e., commercial, recreational and subsistence fishermen, and fish buyers), those who provide goods and services in support of their activities, other members of the communities where they are based or operate, and consumers of seafood. Demographic data and analyses may be used to: characterize individuals, communities and other aggregates of people, including sociocultural groups, fisheries, and associated communities; to identify historic variability and change in populations and groups; and to measure change (impacts) resulting from management action or other factors. Demographic changes, in turn, can signal changes in motivations, values and practices.

Practices
Practices are the ways people do things and include where, when and how they participate in fisheries and fishery-related activities. More specifically, practices include how vessels, equipment and gear are configured and used, whether and how certain species are targeted, caught and handled, and how the catch is distributed. Practices also include patterns of use in time and space of fishery resources and marine areas, and coastal harbors and infrastructure. These necessarily includes analyses of characteristics such as vessel length, hull material, fish holding capacity, engine type and horsepower; type of navigation, fish-finding, and gear-handling equipment; gear types, configurations and number of units; and number of crew and their roles. The characteristics of the shore side operations may value in many ways, including whether operations for receiving fish may be mobile or fixed, the size and function of these operations; and handling, processing and distribution operations. Understanding fishery-related practices is key to identifying sources and solutions for ecological concerns as well as socioeconomic concerns.

Motivations
Motivations are the reasons why people do the things they do. Although it often is assumed that individual behavior is fully rational and driven by reason, with economic motivations, growing evidence indicates that individuals are motivated by a complex mix of social, cultural, and economic values. Understanding of fishery participants' motivations in fishing and related activities can be used to develop management options that create appropriate and effective incentives for compliance, and to evaluate those options in terms of their acceptability, compliance, and socioeconomic outcomes.

Institutions
Institutions are the norms, rules, and strategies that govern peoples' behavior, whether formally (e.g., regulations) or informally (e.g., shared understandings of where and how gear is set, the distance between operations). Formal institutions include not only those specific to a given fishery, but those that pertain to other state and federally-managed fisheries, broader marine space use, coastal land use, environmental protection, food production, public heath, and other relevant topics. Understanding the formal and informal institutions that affect fishery participants and associated communities is useful for evaluating the potential efficacy and outcomes of fishery management actions, and for guarding against unintended consequences such as effort shifts from one species or area to other, potentially sensitive or vulnerable areas.

Relationships
Relationships include the social and economic connections among people that are ongoing and meaningful to those people. In fisheries, such relationships include those among fishermen, buyers and providers of supporting goods and services, within and among fishing families and communities, and between fishery participants and fisheries managers. Relationships can also be among organizations and communities, through which information and social and economic resources flow. They reflect interdependencies among those connected for a range of tangibles (e.g., income, goods, services, practical support) and intangibles (e.g., information, shared identity, sense of belonging). Information about these relationships is useful for understanding how the fisheries human system functions, and for assessing social and economic impacts of change.

Capital
Fisheries-relevant capital includes the natural, human, physical, and financial resources needed and used by fishery participants and communities to sustain their activities and generate associated benefits (e.g., livelihood, recreation, sustenance). Natural capital consists of the ecological system including living resources and habitat. Human capital includes people, and the skills and knowledge they possess, individually and collectively. Physical capital includes vessels, equipment, gear, ports and other landing sites and facilities, and seafood processing facilities. Financial capital includes the monetary resources used to purchase or provide physical capital and goods and services to enable human activities.

Understanding the types of capital needed, available and used by fishery participants, fisheries, and communities is useful for better understanding fisher-related behavior, social and economic impacts, and opportunities and challenges to effective adaptation to environmental and regulatory change.

Employment

Employment relevant to fisheries and their management includes not only part- and full-time, seasonal and year-round jobs in fishing and seafood production, but also those associated with the provision of supporting infrastructure, goods and services, including related research and management activities. Changes in fishing opportunities and activities can have direct, indirect, and induced effects on employment among fishery participants, goods and service providers, and others in the associated communities and economies. Jobs gained or lost in one part of the human system affect those in other parts of the system. Employment information is useful for evaluating the impacts of management change on fishery participants, communities and economies.

Expenditures

Expenditures are the amount paid by fishery participants for goods and services used directly in fishing or indirectly to enable fishery-related activities to occur. Expenses related directly to fishing include those for durable goods such as vessels, equipment and gear, licenses and permits, and expendable items such fuel, bait, and ice. Indirect expenditures include items that are ancillary to fishing per se such as vessel taxes, medical insurance, and worker's compensation, angling accessories and clothing. Expenditures also include those by fish receivers and others engaged in seafood production and other fishery-related activities. Information on these types of expenditures is used to help estimate the economic value of fisheries and the impacts of changes in resource availability and management on those fisheries and associated businesses and communities. For example, changes in expenditures related to fisheries affect the viability and wellbeing of associated businesses and communities.

Revenue

Revenues consist of payments received by fishery participants and businesses for fish landed, handled, processed, and sold. Revenue also includes payments received for fishery-related goods and services, ranging from charter fishing trips to vessel, gear, equipment, gear sales, boat rentals, fuel, bait, and ice. Revenues may originate and circulate primarily within a community, although they typically come from and/or circulate outside a given community. Information about fishery-related revenues is useful for assessing the impacts of changing resource availability and management on fishery participants, fisheries, fishing communities, and the overall economy. Moreover, changes in revenues, such as the ex-vessel price for commercially caught species can signal a change in fishing practices.

Data collection strategies for fisheries management

The EFI outlined above provide a comprehensive list designed to guide fisheries managers in improving their understanding about a stock. While ideally managers would have all categories of EFI for all stocks, the Department is working with limited resources and currently information is lacking for many fisheries in California. In prioritizing data collection efforts to support the acquisition of EFI, it is necessary to think about how the data collected will inform management. One strategy for this is to consider all of the components of the management strategy (data collection protocol, data analysis/assessment HCRs, and management measures) simultaneously because the available data will dictate which assessment methods and HCRs are feasible. Managers will need to assess the potential costs and benefits associated with implementing additional data collection activities. To aid in that process, this section gives a broad overview on the various monitoring options available to fisheries managers, their relative costs, and the type of data they produce.

Fishery-dependent data

The MLMA dictates that, while the Department is the primary agency responsible for the acquisition of EFI, collection of the necessary data is best collected through the ongoing cooperation and collaboration of participants in fisheries (§7060(a-c)). For this reason, fishery-dependent monitoring is often the primary mechanism for monitoring fish stocks. Fishery-dependent data are collected directly from the commercial and recreational fisheries. Data are usually collected via dockside monitors, at-sea observers, self-reporting through logbooks, EM and reporting systems, telephone surveys, **Vessel Monitoring Systems (VMS)**, or cooperative research initiatives, and can provide information on fishing effort, landings, CPUE, discards, species composition, and biological information.

Fishery-dependent data are generally more economical to collect and typically consist of a relatively large sample size. Because of this, fishery dependent sampling protocols usually form a core component of any management strategy. Table F3 summarizes the kinds of data that can be collected with commonly used fishery-dependent monitoring protocols, as well as the relative cost of each, while Table F4 summarizes the Department's current monitoring activities. These tables can be used to help select the type of monitoring program needed to implement a particular stock assessment technique and HCR when developing a new management strategy. Additionally, it can be used to assess an existing monitoring protocol to determine whether the existing protocol is providing all possible data.

There are known biases associated with data obtained via fishery-dependent monitoring. These biases must be identified before fishery-dependent data can be incorporated into stocks assessments. For example, the most common (and easily collected) fishery-dependent data is catch and effort information from commercial or recreational fishers, usually summarized in the form of CPUE, or catch rate. CPUE is often used as an index of abundance in stock assessments when fishery independent abundance data are absent, because it can be assumed that the catch is proportional to the product of fishing effort and the density of the fish. If catch and effort can be measured, then density (and abundance) can be estimated. However, CPUE can change for many reasons, including changes to the gear over time (either through increasing efficiency or regulations designed to decrease efficiency), changes in the spatial distribution of fishing, or changes to the time of day or year when fishing occurs. Changes in any of these variables may lead to a change in the CPUE when there is actually no change in the underlying abundance of the stock, sometimes limiting the applicability of CPUE as an index of abundance. The impact of these additional factors can be accounted for through a statistical process called 'catch-effort standardization'. For this reason, it is important to fully document any historical management or market changes that may have influenced these factors, and FMPs provide managers with an opportunity to do this in a comprehensive manner. Additionally, a comprehensive management program that employs both fishery-dependent and fishery-independent studies in a complementary fashion can be used to help identify these biases and provide a more complete picture of the stock status.

Table F3. Common fishery-dependent sources and the type of data they can produce.

Monitoring approach	Landing receipts/sales dockets	Logbooks	Creel surveys/ dockside monitoring	Onboard observers	Interviews with fishery participants	Market/processor sampling
Description	Records the species, weight landed and price paid by processors receiving fish. May also record sex or size composition (categorical) if prices differ.	Information the Department requires all licensed fishermen to report. Vulnerable to self-reporting errors.	Sampling protocol used to intercept fishermen when they are fishing from shore or landing their catch.	Viable option for large-scale, industrial fleets. Can provide fine-scale information on all aspects of the fishery. A high proportion of observer coverage may be required.	Useful for gathering historical information when data is lacking. Often provides qualitative rather than quantitative information.	Sampling catch at the processor/market site. Useful when fishing activities spatially disparate, but there are a small number of processors/ marketing sites.
Data collected						
Historical Information					x	
Socioeconomic/ Operational information	x				x	x
Gear Type/Amount Used		x		x	x	
Effort	x	x	x	x	X	
Fishing Location		x	x	x	x	
Catch per Vessel	x	x	x	x	approximate	
Total Catch for Fleet	x	x	x			
CPUE	x			x		
Species Composition			x	x	x	x
Bycatch/Discards		possibly		x		
Size Composition (detailed)	possibly		x	x		x
Size Composition	possibly		x	x	x	x
Sex Composition	possibly		x		x	
Reproduction/Maturity	possibly		x			
Age composition			x			
Relative cost to implement	Low	Low	Moderate	High	Moderate	Low to moderate

Table F4. Summary of Department's current data collection activities. *(NOTE: this table is still in development)*

Tool	Sector	Collection frequency	Description
License applications	Both	Annual	Online registration (vessels and individuals) with fee collection using third-party software, managed by the Department.
Logbooks	Commercial	Per trip	Paper except for CPFV logs, which run on dedicated tablets.
Landing receipts	Commercial	Per landing	Paper, except for eight dealers registered with eTix system. Full transition to eTix in 2019.
Report cards	Recreational	Per season	Paper, but anglers can enter data online via Automated License Data System web portal.
On-board observers	Commercial	Set percentage of fleet covered per season	Usually only for federal fisheries through NOAA federal observer program. Data not easily available to the Department.
Port/dock samplers	Both	Set percentage of fleet/docks covered per season	Coverage varies by fishery and by season; core component of California Recreational Fishery Survey.
Catch monitors	Commercial	Per landing	Independent staff who oversee landings; may or may not also be certified to collect biological samples.
Vessel Monitoring Systems	Commercial	Constant data stream while vessel is fishing	Required for some federal fisheries, data collected by NMFS but not readily available to Department science/management staff.
Electronic monitoring/ video cameras	Commercial	Constant data stream while vessel is fishing	Only for a limited number of federal trawl fishery participants. Summarized data treated as federal observer data and may be unavailable to Department staff or available only in aggregate.

Landing receipts

The Department's first major attempt to gather EFI began in 1916 with the use of landing receipts, or "fish tickets," as they are commonly known. Commercial buyers are required to complete landing receipts when the catch is off-loaded onshore to track the amount of fish landed by weight or number, along with the fee due on those landings. These forms contain information on the species, general location fished, weight of the catch, and price paid for the catch. Many fish species are often grouped into multispecies market categories, based on similar market value, rather than separated into species-specific categories. This can present a problem when attempting to use this information in analyses. Although limited in scope and accuracy, information on landing receipts are often the only information available on a particular fishery.

Logbooks

Logbooks were developed to augment information obtained from landing receipts and require that fishermen record information such as catch, location fished, and time spent fishing for each time their fishing gear is deployed. The log is then sent to the Department. Logbooks seek to access the professional knowledge and observations of fishermen to improve fishery management. The utility of the information that they provide is dependent on its accuracy, timeliness, and return rate. Logbooks have the potential to be a very valuable source of fishery dependent information, especially considering the relatively low cost to administer the program statewide.

The Department is in the process of shifting from paper to electronic logbooks, and this transition provides an opportunity to revise the data that is collected, as well as overcome the lags associated with return and data entry that have been obstacles to the use of the data in the past. A 2017 review in support of the Department's transition to electronic logbooks suggested that logbooks be redesigned to collect the information in Table F5 to increase their utility.

Table F5. Suggested data to be collected using the logbook format.

EFI category	Data element	Example data fields
Effort	Activity and capacity	Boat size/capacity Date & time of trip start/end (# of trips) # of hooks # of traps set # of anglers on a charter boat Gear type and specifications Time of gear in water Time spent targeting a species Fishing location (fishing block) Lat/long, automated as much as possible
Total mortality	Landed and discarded catch	Number of individuals weight Weight Length Species Sex
Economic	Price	Price per pound landed condition
Ecological interactions	Bycatch and discards	Predation of hooked or discarded fish, by species

Creel surveys

Creel surveys entail interviews of sport fishermen at boat-launching ramps or at points where they are fishing from land (e.g., beaches, piers, and rocky coastline). Samplers typically gather information on: number of each species caught, number of each species kept, size and sex of kept fish, number of fish returned to the water, type of gear used, number of fishermen in the party, and total hours fished. Certain creel surveys may also collect socioeconomic data such as distance traveled from home or from port, length of stay in the area, and expenditures. The accuracy and precision of these surveys depend largely on a good working relationship between Department staff and the fishermen being surveyed. Information collected on catch composition, CPUE, size limits, and fishing mortality are used to determine how the recreational sector of a fishery affects a resource.

Dockside/market sampling

Dockside or fish market sampling is used to collect commercial landings data after the catch has been off-loaded and, in the case of multiple-species landings, separated into market categories. These data provide important information on total weight, species composition, size, sex, age, and maturity of the species being landed. It is important to note, however, that this type of sampling provides imprecise estimates of fishing effort, and little or no information on bycatch or discards. Fishery landing statistics collected from this sampling allow fishing mortality rates to be calculated (excluding any discard mortality).

On-board sampling

Scientific observers accompany commercial and sport fishermen on fishing trips to collect biological and socioeconomic data at sea. Observers collect information on the location fished, total catches (not just landed), and the species, size, sex, and maturity of fish caught. In some fisheries they also collect (or have collected in the past) data on bycatch, discards, and interactions with birds and marine mammals. This information also can be used to verify logbook and creel survey data. On-board sampling also has the potential to address socioeconomic gaps in EFI. On-board observers collect EFI that cannot be obtained by other means (e.g., bycatch, precise fishing locations of each unit of fishing effort, etc.).

Fishery-independent data

Fishery-independent data come from sources other than directly from the fishery. They are collected from surveys designed and conducted by scientists for the purpose of gathering information on fish stock abundance and biology. These surveys are specifically designed to follow consistent methods using the same gear for the duration of the survey in order to develop unbiased and independent indices of abundance. Since the data are not influenced by specific management measures (e.g., size and **bag limits**, season closures, mesh sizes) or socioeconomic factors, they present an unbiased accounting of stock health. These surveys often collect biological data and abundance information, and may be able to sample components of the fish stock that are not accessible using commercial gears (e.g., juvenile fish). They can also collect information on fish habitat characteristics and environmental factors.

Fishery independent survey methods vary widely, and may include standardized trawl surveys, dive surveys, hook-and-line surveys, etc. The choice of survey mode is driven principally by the species being monitored, availability of suitable vessels and personnel, and the ability to maintain continuity of survey time series. The Department may contract with commercial fishing vessels to conduct sampling provided it occurs separately from fishing activities.

Fishery-independent research collects standardized information, often on all life stages, not just what is marketable or utilized by the fishery. Often greater technology and more sophisticated equipment are required than for typical fishery-dependent data collection. While fishery-independent data usually have fewer biases they are relatively more expensive to collect, they may have smaller sample sizes, smaller spatial scales, and may not be collected every year. Historical data collection protocols, and any changes in protocols that may have occurred over time, should be fully documented in an FMP or elsewhere.

Fishing surveys
Rather than rely on a commercial or recreational fishery to provide the Department with samples, biologists often collect their own using a variety of gear. Since fisheries often use gear that selects certain sizes or a sex of fish or invertebrates, their catches usually do not represent the entire population. By using gear that catches a representative sample of the entire population, such as trawls for some fisheries, the Department avoids such limitations of fishery-dependent samples.

Tagging
Tagging animals provides EFI such as their movement, age, growth, and population size. Fish or invertebrates are captured alive, size and catch location recorded, tagged externally (typically), and released. If they are recaptured at a later date, information can be obtained on how far they traveled, how much they grew, and how old they are since being released. Tagging studies are most frequently conducted with the advice and participation of fishermen, who are most likely to recapture tagged animals and return the tag and/or the animal to the Department. Information on distribution patterns and movement of fish is valuable to resource managers because it allows insight into the areas and times that stocks are most vulnerable to harvest or environmental effects.

Egg abundance surveys
Surveys to estimate the abundance of eggs spawned by a particular species of fish or invertebrate are also used to estimate the size of a population, especially the reproductive portion of a population. This method also provides information on the amount of reproduction that has occurred, its locations, and spawning habitat preferences.

Underwater (in situ) surveys
The ability to deploy divers or equipment underwater to make direct observations of animals and habitats is important. These methods allow a variety of EFI to be collected which cannot be collected in any other way such as: detailed habitat preferences, many ecological interactions, movement patterns, and non-lethal size/abundance information. Scuba-based projects are equipment-intensive, and require a relatively large staff or partnership to ensure the requisite sampling effort.

Submarines and remotely operated vehicles are also capable of direct, in situ observation of the environment and living resources. Unlike divers, however, their operation is not as severely constrained by depth, ocean conditions, or operating time. In addition, these units are capable of carrying a wide array of sensory equipment.

Hydroacoustic surveys
Hydroacoustic technology is familiar to most fishermen because it is the same technology used by depth finders and sonar to locate schooling fish or the ocean bottom. This method can be used to measure the size, distribution, and movement of fish schools, and to map and characterize the associated bottom or habitat type. It is most useful for species that exhibit schooling behavior.

Genetic investigations
Recently, scientists have refined genetic assessment techniques to sample populations to differentiate discrete fish or invertebrate stocks. Separate stocks of a given species may have very different life histories and this type of EFI may be used by resource managers in regional management strategies.

Alternative data sources for use in data-poor management

In many fisheries, management is hampered by a lack of data, specifically time series of the kinds of data described above. Data-poor fisheries are characterized by uncertainty in the status and dynamics of the stock or species, uncertainty in the nature of fishing (e.g., in terms of fleet dynamics and targeting practices), or having only basic or no formal stock assessments. Under this definition many of California's fish stocks can be characterized as "data-limited".

However, the MLMA requires that the fishery management systems in place protect the sustainability of the stock, regardless of the level of information available. When data are insufficient for a conventional stock-assessment, alternative methods can be used to inform management decisions. Frequently, and as discussed in Appendix G, stock assessment methods rely on time series of catch, CPUE, or abundance to estimate how fishing has impacted a stock over time. Without information on historical conditions, it becomes difficult to estimate the current stock status relative to sustainable targets. However, a number of simple length-based assessment methods have been developed to provide insight into stock status from size composition data. Measurements of length composition of an exploited stock are inexpensive and simple to collect via port sampling, and representative samples of the catch can often be obtained within a single fishing season.

The addition of no-take MPAs to California's seascape also provides an opportunity to improve the monitoring of California's data-poor fish stocks. MPAs represent an opportunity for the assessment of data-poor fisheries by acting as a reference area, allowing for the comparison of fished vs. unfished conditions in much the same way as comparisons against historical data. MPA-based stock assessment methods have relied on comparisons of catch rates, survey data, and size compositions inside and outside of MPAs. The Spiny Lobster FMP identifies reserve monitoring as a primary source of data used to estimate growth rates, longevity, natural mortality, fishing mortality, and stock size structure.

Market based sources provide an additional opportunity for the gathering the data necessary to assess fish stocks. Size and species composition data may be available from processors and other buyers, who often keep records of the approximate size of fish purchased. This data may be binned into categories, but can still provide some sense of how fishing is impacting the stock, often over many years. Market-based data can also provide information on how stock composition and trophic level has changed over time, which provides a means of estimating the level of fishing pressure.

In fisheries that are essentially data-free, it's possible to gather qualitative information on the fishery from participants. By gathering information on the history of the fishery, the gear types used, species caught, fishing locations, and how things have changed over time it is possible to characterize the likely risk fishing poses to the stock. This is especially true when this method is paired with what's known as the "Robin Hood" approach (Punt et al. 2011), which borrows biological parameters estimated from related fish stocks in data-rich systems to understand the biological vulnerability based on the species life history. Additionally, a number of 'rule of thumb' reference points have been developed based on life-history characteristics, and borrowing this information may allow these reference points to be applied to stocks for which no local data exists.

References

Punt, A. E., D. C. Smith, and A. D. M. Smith. 2011. Among-stock comparisons for improving stock assessments of data-poor stocks: the "Robin Hood" approach. ICES Journal of Marine Science 68(5):972-981.

Appendix G – Stock Assessment and Data-limited Techniques

This appendix provides an overview of stock assessments and data-limited techniques in particular. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Overview

Existing data, and the quality of those data, will generally dictate what types of assessment options are available to aid managers in making management decisions. The term assessment is generally interpreted to mean a quantitative analysis, but there are a number of data-limited assessment techniques to assist managers in analyzing the available information and making management recommendations. In fisheries with little data, qualitative assessments that rely on stakeholder information, expert judgment, and borrowed information from related fish stocks can be used to fill in gaps and understand relative vulnerability.

This appendix groups different data types into tiers and suggests some data-limited assessment techniques that may be available at each. The tiers are in ascending order with higher levels having more data available. The data required at each tier are explained in more detail below, along with types of data-limited techniques available at that level. The types of reference points that these assessments produce are also provided. This is intended to both assist managers in understanding what assessment techniques are available now, as well as what data should be collected in the future to employ a particular assessment technique.

<u>Tier 1: Qualitative information</u>

In the lowest informational tier, there is little or no quantitative data available with which to conduct an assessment. However, there is generally qualitative information that can be used to make management decisions. Table G1 provides a summary of these types of methods. Some of them are frameworks that have been developed to address vulnerabilities and threats at a wide variety of scales, including for target species, bycatch species, and entire ecosystems. In these tools, the current level of knowledge about the fishery is assessed using information gathered from managers, stakeholders, and expert judgment. Extrapolation, or borrowing information from related fish stocks, can be used to fill in the gaps to better understand the biology of the species (Punt et al. 2011). Outputs from this tier might include whether this fishery is likely to be vulnerable to exploitation, and recommendations on what data are most valuable to collect to improve the current level of understanding of the fishery (for example, size of maturity and mean length of the catch).

In highly data-limited California fisheries, the Department may be able to use data collected through landing receipts to monitor for major changes in species landed, participation, price, gear used, spatial extent, etc. A significant change in these indicators over a short period time could alert managers to changes in abundance or fishing effort that might need to be addressed through increased management or data collection.

<u>Tier 2: Size data</u>

A number of methods have been developed to infer fishing mortality and the reproductive capacity of the stock from size information. One of the simplest indicators of stock status is the average length of fish in the catch. If an understanding of the approximate mean size of the catch is available, this can be compared against the size at first maturity to understand how much of the catch is composed of mature vs. immature individuals (size relative to size-at-maturity; see Table G1). Management recommendations from this tier might include altering size limits, seasons, or gear selectivity to target mature fish, and suggested data collection protocols may involve collection of an unbiased size structure that is representative of the population. For some species, MPAs could protect a portion of the adult biomass in unfished areas which could increase spawning stock biomass and potentially allow for less stringent fishery controls. This is described in more detail in the MPA data section below.

With some additional knowledge of growth parameters, average length can be used to estimate the total mortality (both fishing and natural) the stock is undergoing. With an estimate of the natural mortality (which can be empirically derived, estimated from the maximum age of the stock, or borrowed from a related stock), the fishing mortality can then be calculated by subtracting the natural mortality from the total mortality (mean length; see Table G1). While this method only requires a single year of data, multiple years of size data could be used to track exploitation trends over time, and can be compared against targets.

Length composition data can be used to calculate the proportion of mature fish, optimally sized fish, and large, highly fecund females in a population to determine if stock spawning biomass is at or above a specified target reference point (length-based reference point; see Table G1). Length composition data can also be used to infer the **Spawning Potential Ratio (SPR)**, which is the ratio of the total egg production in fished and unfished states, of the stock (fractional change in lifetime egg production and length-based SPR; see Table G1).

Length-based methods are relatively straight forward to use, but it is important to understand the implications of each method. Typically, these methods assume that the current population is in equilibrium, which allows them to be applied with only a single year of data. Length-based methods are not appropriate for very short-lived stocks, which tend to be dominated by a single year class, or stocks whose abundance fluctuates a great deal from year-to-year. Additionally, length-based methods assume a constant growth rate, and thus are not appropriate for species that have highly variable growth between cohorts or from year to year.

Tier 3 – Catch data

If time series of catch data are available, data-moderate assessment methods may be used. There are a number of methods that have been developed to estimate a sustainable catch level based on the logic that historic catches during times of stock stability reflect a level of exploitation the stock can sustain (Zhou 2013). Thus, a simple average catch taken from a period of stability is assumed to be sustainable. The **Depletion-Corrected Average Catch (DCAC)** (Table G1) method is based on this principle, but it uses historical catch data and an estimated natural mortality rate to correct for the initial **depletion** in fish abundance typical during the “fish-down” phase in many fisheries (MacCall 2009). The **Depletion-Based Stock Reduction Analysis (DB-SRA)** (Table G1) combines DCAC with a probability analysis to account for uncertainties in historical biomass estimates (Dick and MacCall 2011). The **Cumulative Sum (CUSUM)** (Table G1) technique uses catch data as an indicator of trends in abundance. It looks for deviations beyond the standard deviation from the mean to determine trends in catch and, by extension, biomass.

With historical catch information, biological parameters, and approximate estimates of the biomass in the first and last years of data, it’s possible to use what’s known as a Schaefer production model to calculate annual biomass. The Schaefer production model is most widely known as the model which is used to estimate the biomass that will produce MSY. This can be used to set catch limits, even with uncertainty about the carrying capacity and growth rate of the population. With in-season CPUE data, it is possible to use the in-season depletion estimator (Table G1) to set sustainable catch limits. This method assumes that effort efficiency is constant throughout the season, and thus any declines in CPUE are due to a reduction in abundance. By graphing the cumulative catch and effort over the season it is possible to see the point at which an additional unit of effort no longer yields additional catch.

Catch based methods tend to be thought of as data-moderate assessment techniques, because many data-poor fisheries have very little historical data, or have no way to accurately monitor catch. However, with California's logbook system, catch-based methods may be appropriate for many fisheries that lack the other types of data necessary for a stock assessment. Catch based methods are primarily used to set catch limits, and they are most appropriate for fisheries with systems in place to monitor catch in real time and enforce closures once catch limits have been reached.

<u>Tier 4: Age or size structure, time series of catch, and indices of abundance</u>

At this information level, there are a large number of quantitative stock assessment methods available to managers. Nearly all of these models are based on some kind of population dynamics model. They use mathematical equations to model the recruitment, growth from one age or size class to the next, and mortality (from fishing and natural causes) that happen each year to a fish population. Modelers fit these population models to the available data to estimate parameters of interest (usually, the number of fish in the stock and the current fishing mortality rate). Having time series of a number of different types of data makes the ability to estimate these parameters more robust. Table G1 doesn't provide information on the various types of quantitative stock assessment models available for use, but there are a number of resources available online and in the literature which describe the kinds of analytical techniques available (see http://www.pewtrusts.org/~/media/legacy/uploadedfiles/peg/publications/report/aguidetofisheriesstockassessmentpdf.pdf for a simple description of the different stock assessment models available).

Marine Protected Area data – Fishery-independent surveys within MPAs

MPAs present new opportunities for fisheries management by acting as reference areas and sources of biological information, and a number of data-poor assessment methods have been developed to use data from MPAs to assess stock status. One such method, called the density ratio control rule, compares a survey-based estimate of the density of fish outside an MPA to an estimate of density inside the MPA, which provides a representation of the stock under unfished conditions. Another MPA-based method, a decision tree that compares size and CPUE data inside and outside MPAs (Wilson et al. 2010), uses no-take areas as a proxy for historical conditions to determine targets. One potential benefit of this method over those that compare current stock status against historical unfished conditions is that the MPA incorporates contemporary environmental conditions. MPAs may also provide a way to estimate biological parameters that are usually biased by the effects of fishing. In particular, natural mortality is very difficult to estimate in any fished system, but is one of the most informative biological parameters for fish stocks because it provides information about their natural productivity level.
Length-based mortality estimators have been applied to size data sampled from inside MPAs in the Channel Islands to estimate natural mortality of Spiny Lobster (Kay and Wilson 2012).

While MPA-based assessment methods are promising, they have some caveats. Because no fishing is allowed in MPAs, these methods rely on fishery independent sampling protocols, which are typically costlier. Additionally, the MPA must be well enforced. The size of the MPA relative to the size of the species' home range must also be considered, because MPAs can provide effective protection from species that spend a significant portion of time in fished areas. Thus, MPAs generally provide more appropriate information for relatively sedentary species with local reproductive input. Finally, MPAs take time to return to equilibrium unfished conditions, and so may not be useful in assessing fish stocks for 15+ years, depending on the life history of the species.

Stock assessments traditionally assume that the stock in question is homogeneously distributed over the management area and targeted with uniform fishing intensity. MPAs violate this assumption (Bohnsack 1999), creating patches of high biomass inside their borders, and potentially fueling stock depletion outside (Hilborn et al. 2006). As such, MPAs and their effects on the spatial distribution of both fish and fishermen may introduce biases in stock assessments (McGilliard et al. 2015). This can lead to mis-specification of catch or effort limits. There is also the question of whether populations within MPAs should be considered "on the table" or "off the table" when assessing depletion levels and setting harvest limits (Field et al. 2006). Given the mandates to rebuild populations, there is an incentive for managers to count protected biomass in stock assessments to demonstrate increased stock health (Field et al. 2006). There may be pressure from the fishing industry to count the fraction of population in MPAs as part of the total stock when setting catches. Including protected fish when calculating catch limits based on the total vulnerable biomass can lead to unsustainable fishing mortality rates because in reality only a portion of the stock is targeted. Conversely, not taking protected populations into account when determining stock status is likely to lead to a reduction in catch limits in the short-term as well as extend the time period until recovery targets are achieved, both of which may have severe economic impacts.

Empirical vs. model-based indicators to assess stock status

Usually, the output of a stock assessment model is some form of indicator (for example, an estimate of fishing mortality or stock abundance) that can then be compared against a pre-determined reference point in order to assess whether the stock is overfished, or if overfishing is occurring. However, empirical indicators, which are based on directly measurable indicators such as CPUE or average length, are being used in a number of data-poor fisheries (Dowling et al. 2016). In some cases, these empirical indicators lead directly to HCRs, and so the monitoring aspect of the harvest strategy effectively replaces the assessment. In others, the data feeds into an HCR, which includes calculations that effectively function as a type of stock assessment such as decision tree type HCRs (Prince et al. 2011; Dowling et al. 2016). The Department's Spiny Lobster FMP uses two empirical indicators (catch and CPUE) and one modeled indicator (SPR). As long as empirical indicators can be used to infer stock status and make decisions to adjust fishing behavior, they can serve as a type of stock assessment tool. Empirical harvest indicators are not constrained by the need for quantitative population models, but are still able to provide some measure of exploitation status. As quantitative models are often difficult to apply to data-poor fisheries, empirical harvest strategies are often more applicable to data-poor fisheries management. Even in data-poor fisheries, it is possible to design indicators that reflect whether the stock is in an acceptable state, in an unacceptable state, or somewhere in between.

Determining the appropriate level of complexity for assessments

Management strategies based on integrated stock assessments have been shown to outperform those based on data-poor assessments or empirical indicators, which is why they are considered the gold standard for fisheries management (Punt et al. 2002). However, these kinds of assessments require many different kinds of data, collected over many years. It is very costly to initiate and maintain these types of sampling programs. This type of investment may be practical only for specific situations, such as high value fisheries or high-risk stocks. For other stocks, alternative assessment methods that have been shown to adequately achieve management targets and prevent stock collapse, may be more appropriate. In addition, harvest strategies based on simple assessment methods can be designed in such a way that they scale in complexity as needed by requiring further data collection or a more defensible assessment when a reference point is passed.

In deciding on what complexity of management system is warranted, tradeoffs between ecological and economic risks, as well as the costs associated with management must be considered. In scenarios with lower data quality and quantity, management responses can be adjusted in proportion to data limitations in order to buffer against scientific uncertainty. This may result in less catch than might be obtained under a management system with higher levels of monitoring to offset uncertainty, but the increase in potential management costs to implement such a system might outweigh the potential benefits of increased yield. MSE (discussed in Appendix J) can provide objective methods for deciding what level of assessment is appropriate for a given fishery.

Table G1. A summary of the data-limited assessment techniques available at various levels of information.

Tier	Method	Description and reference	Necessary data	Assumptions/caveats	Reference point
1	**Ecological risk assessment**	Information from the literature, surveys and stakeholder interviews are used to generate a risk assessment that identifies the most vulnerable parts of the system. This is used to detect high-risk activities that require immediate management attention and to screen out low-risk activities from further analysis (Smith et al. 2007).	• Knowledge of the fishery • Knowledge of other activities that could potentially impact the system	Assumes fishing to be the most important threat facing any given system. Predicts potential future risk based on current (static) conditions.	None
1	**Comprehensive assessment of risk to ecosystems**	Quantitatively considers the interaction of all system threats and assesses the risk to the entire ecosystem through inclusion of a comprehensive suite of attributes to characterize system productivity and functioning. CARE generates risk values for each Threat-Target pair, for ecosystem service production, and for the ecosystem as a whole.	• Knowledge of the fishery and external threats • Knowledge of ecosystem characteristics and processes • Life history parameters (may be borrowed)	Relies on expert knowledge (where data are missing). Precautionary approach may result in overestimation of risk. Predicts potential future risk based on current (static) conditions.	None
1	**Productivity-susceptibility analysis**	Productivity is ranked from low to high and based life history parameters. Susceptibility of the stock to fishing pressure is scaled from low to high based on the fishing mortality rate (including discards) and species behavior, such as schooling and seasonal migrations, which may alter **catchability** (Patrick et al. 2009).	• Knowledge of the fishery • Life history parameters, including fecundity	Assumes that risk depends on the extent of the impact due to fishing, and the productivity of the stock. Where information is missing the scores are set "high", so final risk scores may overestimate actual risk.	None
1	**Monitoring for major changes**	Examining logbook/landing receipt data for major changes in a fishery over five-year period. Could be changes in participation, price, spatial extent of fishery, gear type, etc., that would signal a change in either fishery demand or population status (Dowling et al. 2016).	• Knowledge of 1 or more of the following: species ratios, dominant species landed, spatial extent of fishing, price, number of participants, or gear type	Assumes that sudden changes in peripheral fishery information may be indicative of changes in fishing mortality or abundance.	None
2	**Length-based reference point**	Catch length data are used to calculate the proportion of mature fish, optimally sized fish, and large, highly fecund females in a population to determine if stock spawning biomass is at or above a specified target reference point (Cope and Punt 2009)	• Length data for at least one year (catch data are not needed) • Life history parameters	Does not estimate optimal harvest levels. Assumes length data are representative of the stock.	Proxy for depletion

Tier	Method	Description and reference	Necessary data	Assumptions/caveats	Reference point
2	**Size relative to size-at-maturity**	Compares the size of the catch to the average size at maturity to understand whether the fishery is catching mature fish. If a large proportion of the catch is immature a size limit should be recommended (Punt et al. 2001).	• Mean size or approximate proportions at size • Size at maturity data	Assumes length data are representative of the stock.	Proxy for fishing mortality (F)
2	**Mean length**	Uses average length and biological parameters from a single year of data to estimate exploitation status (Ault et al. 2005).	• Length data from the catch and independent monitoring • Life history parameters	Assumes length data are representative of the stock and equilibrium dynamics.	F
2	**Fractional change in lifetime egg production**	Length-frequency data from an unfished (or early exploited) population and the current population, along with information on growth and maturity, are used to determine a limit reference point that represents the persistence of a population. The fractional change is calculated as the ratio of lifetime egg production between the unfished and current populations (O'Farrell and Botsford 2006).	• Length data from the fishery and an unfished population • Length-egg production relationship • Life history parameters	Does not estimate optimal harvest levels. Can use historical size data or data from an MPA.	SPR and F
2	**Length-based spawning potential ration)**	Uses length composition, life history, and selectivity information to estimate SPR and fishing mortality. SPR has been shown to track depletion for some life history types (long lived, slow growing) (Hordyk and Prince 2013)	• Length data from the fishery • Selectivity at length • Life history parameters	Assumes length data are representative of the stock. Assumes an equilibrium population.	SPR, F, and depletion
2	**Visual survey spatial assessment**	Uses visual survey of fish length frequencies and habitat quality/extent to extrapolate stock depletion estimates (Prince 2010).	• Fishery independent length frequency and habitat data	Assumes species-habitat associations are a good indicator of species presence.	Depletion
2	**Spawning Potential Ratio-based decision tree**	The SPR-Based Decision Tree uses length data from the catch and CPUE to improve an initial allowable catch limit by adjusting it based on changes in the size composition of the catch using a SPR as a reference point. Size composition of the catch is broken down into three length classes: small (recruits), medium (prime), and large (old). The decision tree then uses CPUE of each length class (Prince 2011).	• Length data from catch • CPUE • Life history parameters, including fecundity	Assumes linear relationship between CPUE and abundance.	Over fishing limit
3	**In-season depletion estimator**	Calculates the current stock biomass of target species. Abundance data from completed seasons is compared to current season information, allowing managers to apply harvest rates to biomass estimates to determine appropriate catch limits.	• Life history characteristics. • CPUE over the course of the season. • Cumulative catch	Trend indicator only. CPUE is not always accurate due to effort creep, fishermen behavior, and/or stock dynamics. Assumes ecosystem and fishery dynamics in equilibrium.	Over fishing limit

Tier	Method	Description and reference	Necessary data	Assumptions/caveats	Reference point
3	**Cumulative sum**	Uses catch data as an indicator to detect trends in abundance and discern significant changes away from the mean (Scandol 2003).	•Time series of landed catch	Assumes that the underlying dynamic of the system have remained constant over time. Assumes that catch is proportional to abundance.	Depletion
3	**Static average catch**	Average catches are used to estimate an **Overfishing Limit (OFL).** Catches can be adjusted downward to reflect uncertainty about stock status (Carruthers et al. 2014).	•Historical average catch for a period where there was no evidence of decline •Adequate catch data stream to objectively identify such a time period.	Assumes a period of no depletion existed, assumes average catch during this period is representative of MSY.	Over fishing limit
3	**Depletion-corrected average catch**	Uses historical catch data (10+ yrs) and an estimated natural mortality rate (preferably 0.2 or smaller) to determine potential sustainable yield. An extension of potential-yield models, DCAC is based on the theory that average catch is sustainable if stock abundance has not changed substantially. DCAC divides the target stock into two categories: a sustainable yield component and an unsustainable “windfall” component, which is based upon a one-time drop in stock abundance for a newly established fishery. DCAC calculates a sustainable fishery yield, provided the stock is kept at historical abundance levels (MacCall 2009).	• Catch records >10 years • Estimated initial catch • Life history parameters	Requires reliable catch data (landings plus bycatch); does not work well for highly depleted stocks.	Over fishing limit
3	**Depletion-based stock reduction analysis**	Combines DCAC with a probability analysis to more closely link stock production with biomass and evaluate potential changes in abundance over time. Using Monte Carlo simulations, DB-SRA provides probability distributions for stock size over a given time period, under varying recruitment rates (Dick and MacCall 2011).	• Catch records >10 years • Estimated initial catch • Life history parameters	Requires reliable catch data (landings plus bycatch); does not work well for highly depleted stocks.	Over fishing limit
3	**Catch maximum sustainable yield**	Estimates MSY from catch data, resilience of the respective species, and simple assumptions about relative stock sizes at the first and final year of the catch data time series. Uses the Schaefer production model to calculate annual biomasses for a given set of r and k parameters (Martell and Froese 2012).	• Catch records • Estimated ranges of stock size in the first and final years of the catch data • Life history parameters	Assumes population growth rate and carrying capacity do not change over time.	Over fishing limit

Tier	Method	Description and reference	Necessary data	Assumptions/caveats	Reference point
MPA	**Marine Protected Area density ratio**	Fish densities (measured in kg/ha) inside and outside the MPA can be estimated from the results of fishing or visual surveys. The MPA density ratio (fished/unfished fish density) can then be calculated to serve as an indicator of stock status (McGilliard et al. 2015)	• Fish density inside and outside effectively managed MPAs • Life history parameters	Assumes reserves are well-enforced and conditions inside represent an unfished population.	Depletion
MPA	**Reserve-based spawning potential ratio**	Combines age or length data from inside and outside no-take marine reserves with life-history characteristics to estimate sustainable yield from SPRs (Kay and Wilson 2012).	• Length or age data inside and outside MPAs • Life history parameters, including fecundity	Assumes reserves are well-enforced and conditions inside represent an unfished population.	SPR and F
MPA	**Marine Protected Area-based decision tree**	Similar to the Length-Based Reference Point method, the MPA-based Decision Tree uses spatially explicit, easy to gather catch and age-length data to set and further refine TAC. Additionally, data gathered from inside no-take MPAs are used as a baseline for an unfished population. TAC is calculated using the current CPUE and target CPUE levels, and then further adjusted with each successive step of the decision tree (Wilson et al. 2010).	• CPUE, fish density surveys, or visual census data • Age-length data inside and outside MPAs • Life history parameters	Assumes reserves are well-enforced, conditions inside represent an unfished population and CPUE surveys are unbiased by targeting or aggregation behavior. Assumes linear relationship between CPUE and abundance.	Over fishing limit

References

Ault, J. S., S. G. Smith,, and J. A. Bohnsack. 2005. Evaluation of average length as an estimator of exploitation status for the Florida coral-reef fish community. ICES Journal of Marine Science 62(3):417-423.

Bohnsack, J. A. 1999. Incorporating no-take marine reserves into precautionary management and stock assessment. In: Providing Scientific Advice to Implement Precautionary Approach Under the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum NMFS-F/SPO-40.

Carruthers, T. R., A. E. Punt, C. J. Walters, A. MacCall, M. K. McAllister, E. J. Dick, and J. Cope. 2014. Evaluating methods for setting catch limits in data-limited fisheries. Fisheries Research 153:48-68.

Cope, J., and A. E. Punt. 2009. Length-based reference points for data-limited situations: applications and restrictions. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 1(1):169-186.

Dick, E. J., and A. D. MacCall. 2011. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. Fisheries Research 110(2):331-341.

Dowling, N. A., J. R. Wilson, M. B. Rudd, E. A. Babcock, M. Caillaux, J. Cope, D. Dougherty, R. Fujita, T. Gedamke, M. Gleason, N. Gutierrez, A. Hordyk, G. W. Maina, P. J. Mous, D. Ovando, A. M. Parma, J. Prince, C. Revenga, J. Rude, C. Szuwalski, S. Valencia, and S. Victor. 2016. FishPath: A Decision Support System for Assessing and Managing Data- and Capacity- Limited Fisheries. In: T.J. Quinn II, J.L. Armstrong, M.R. Baker, J. Heifetz, and D. Witherell (eds.). Assessing and Managing Data-Limited Fish Stocks. Alaska Sea Grant, University of Alaska Fairbanks. Accessed at: http://doi.org/10.4027/amdlfs.2016.03

Field, J. C., A. E. Punt, R. D. Methot, and C. J. Thomson. 2006. Does MPA mean 'Major Problem for Assessments'? Considering the consequences of place-based management systems. Fish and Fisheries 7(4):284-302.

Hilborn, R., F. Micheli, and G. A. De Leo. 2006. Integrating marine protected areas with catch regulation. Canadian Journal of Fisheries and Aquatic Sciences 63(3):642-649.

Hordyk, A., and J. Prince. 2013. Extending the principle of Beverton-Holt Life History Invariants for length based assessment of SPR. In: ICES World Conference on Stock Assessment Methods for Sustainable Fisheries. Boston, USA.

Kay, M. C., and J. R. Wilson. 2012. Spatially explicit mortality of California spiny lobster (*Panulirus interruptus*) across a marine reserve network. Environmental Conservation 39(3):215-224.

MacCall, A. D. 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES Journal of Marine Science 66(10):2267-2271.

Martell, S., and R. Froese. 2013. A simple method for estimating MSY from catch and resilience. Fish and Fisheries 14:504-514. doi:10.1111/j.1467-2979.2012.00485.x

McGilliard, C. R., A. E. Punt, R. D. Methot, Jr., and R. Hilborn. 2015. Accounting for marine reserves using spatial stock assessments. Canadian Journal of Fisheries and Aquatic Sciences 72(2):262-280.

O'Farrell, M. R., and L. W. Botsford. 2006. Estimating the status of nearshore rock fish (Sebastes spp.) populations with length frequency data. Ecological Applications 16(3):977-986.

Patrick, W. S., P. Spencer, O. Ormseth, J. Cope, J. Field, D. Kobayashi, T. Gedamke, E. Cortés, K. Bigelow, W. Overholtz, J. Link, and P. Lawson. 2009. Use of Productivity and Susceptibility Indices to Determine Stock Vulnerability, with Example Applications to Six U.S. Fisheries. NOAA Technical Memorandum. NMFSF/SPO-101, U.S. Department of Commerce, Washington, D.C. Accessed at http://www.nmfs.noaa.gov/sfa/laws_policies/national_standards/psa.html

Prince, J. D. 2010. Managing data poor fisheries: Solutions from around the world. Managing data-poor fisheries: Case studies, models and solutions. 1:3-20.

Prince, J. D., N. A. Dowling, C. R. Davies, R. A. Campbell, and D. S. Kolody, 2011. A simple cost-effective and scale-less empirical approach to harvest strategies. ICES Journal of Marine Science 68(5):947-960.

Punt, A., R. Campbell, and A. Smith. 2001. Evaluating empirical indicators and reference points for fisheries management: Application to the broadbill sword fish fishery off eastern Australia. Marine and Freshwater Research 52:819-832.

Punt, A. E., A. D. M. Smith, and G. R. Gui. 2002. Evaluation of management tools for Australia's South East fishery 3. Towards selecting appropriate harvest strategies. Marine and Freshwater Research 53(3):645-660.

Punt, A. E., D. C. Smith, and A. D. M. Smith. 2011. Among-stock comparisons for improving stock assessments of data-poor stocks: the "Robin Hood" approach. ICES Journal of Marine Science 68(5):972-981.

Scandol, J. P. 2003. Use of cumulative sum (CUSUM) control charts of landed catch in the management of fisheries. Fisheries Research 64(1):19-36.

Smith, A. D. M., E. J. Fulton, A. J. Hobday, D. C. Smith, and P. Shoulder. 2007. Scientific tools to support the practical implementation of ecosystem-based fisheries management. ICES Journal of Marine Science 64(4):633-639.

Wilson, J. R., J. D. Prince, and H. S. Lenihan. 2010. A management strategy for sedentary nearshore species that uses Marine Protected Areas as a reference. Marine and Coastal Fisheries 2:14-27.

Zhou, S. 2013. Catch-only methods: a brief review and possible improvement. In: Knowledge Based BioEconomy workshop. Hobart TAS, Australia.

Appendix H – Harvest Control Rules

This appendix provides an overview and considerations associated with a range of HCR approaches. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Harvest Control Rules

As discussed in Chapter 5, HCRs are simply rules for the management of a fishery. They are usually composed of an equation, formula, or procedure that links a change in one or more indicators with a corresponding change in fishing behavior. The HCR connects the current status of the stock (as determined via the data collection and assessment procedures) with the measures that will control fishing.

HCRs can be based on either a single indicator or multiple indicators. Those indicators can be model outcomes (an estimate produced by a stock assessment method, such as the current fishing mortality or biomass of the stock) or empirical metrics (measured directly from the fishery, such as the mean length of the catch or the CPUE. Regardless of whether the indicator is empirical or estimated, it provides information on the status of the stock. HCRs provide a pre-determined method for comparing that indicator against a target or limit reference point, and adjusting fishing behavior either up or down as needed to avoid limits and reach the target.

Reference points

Reference points are metrics that combine several components of fishery performance into a single value. Reference points are commonly expressed as either a biomass level, or as the fishing mortality rate that would achieve that biomass level under long-term equilibrium fishing conditions. Management actions may be required depending on where the indicator falls relative to the reference point. Commonly used reference points include the following:

- F_{max}, the fishing mortality rate (F) that produces the maximum **Yield Per Recruit**
- $F_{0.1}$, the fishing mortality rate corresponding to 10% of the slope of the yield-per-recruit curve at the origin
- $F_{X\%SPR}$, the fishing mortality rate that would achieve X% of the spawning potential under no fishing
- F_{MSY}, the fishing mortality rate which maximizes the total catch
- **B_{MSY}, (Population Biomass at Maximum Sustainable Yield)** the biomass which produces the maximum catch

Fishery managers also frequently use target and limit reference points. Limit reference points are the point beyond which fishing is no longer considered sustainable, and target reference points define the ideal fishery state. The use of these reference points is designed to constrain harvesting within safe biological limits. They are used in part because stocks fluctuate in response to natural ecological and environmental variability, and achieving a single point value is unlikely.

Some management strategies include a threshold reference point between target and limit reference points. The threshold reference point is defined as an “early warning” reference point, to reduce the probability that a limit point would be passed due to estimation or observation uncertainty or due to slow management reaction. Under these management approaches, limit points should never be reached, and if they were to be reached, severe and corrective management actions should be implemented. Thresholds are advisable when there is an especially high probability of a negative outcome when the limit is crossed (e.g., in a highly variable environment, when species are at the edge of their geographic range or are relatively susceptible to overfishing), or other circumstances when the cost of exceeding the limit is high.

Because reference points are often set using biological models, it can be difficult to determine reference points for data-poor stocks. In situations where there is insufficient knowledge to develop a model, proxies can be used. Proxies are substitutes for key biological reference points, which are used in place of those key reference points because they are easier to calculate, or require fewer data, or are more robust. For example, 40% of **unfished biomass** is considered a proxy for MSY for rockfish off the west coast, though the true MSY value is likely different depending on the specific biology of each species.

In general, reference points from YPR and spawning-stock-biomass-per-recruit analyses are easier to calculate because they only require biological information. For this reason, YPR and spawning-stock-biomass-per-recruit reference points are often used as proxies for other reference points that require stock and recruitment data. However, it is also possible to set empirical reference points when biological or recruitment data is missing. Empirical reference points are functionally similar to model-based reference points in that they trigger some kind of management action when crossed, but they are not necessarily directly related to the biological productivity or resiliency of the stock. For many data-poor stocks, catch history, catch at length, or CPUE may provide empirical indicators that can be used to understand stock status relative to reference points and make management decisions, and reference points might be set based on historical trends during a time period when the fishery was perceived to be stable. See Appendix G for more details. In extremely data-poor situations, target and limit reference points may be identified by expert judgment, but these should be paired with a monitoring program to decrease uncertainty in the future.

The MLMA requires that Fishery Management Plans (FMPs) include criteria for determining when a fishery is overfished (7086(a)). Limit reference points provide a simple and straightforward mechanism for defining this criterion. When a limit reference point is crossed, the MLMA requires that a recovery or rebuilding plan be implemented (7086(c)). A recovery plan is usually built into a comprehensive HCR, which specifies the appropriate management action at all stock levels. The HCR should be tested to ensure that it complies with MLMA requirements for overfished stocks, including the time requirements for rebuilding.

Harvest Control Rule frameworks

Data-rich Harvest Control Rules

The most common types of HCRs provide a link between the current estimated stock status and the desired catch, effort, or fishing mortality level for the fishery. This relationship can take many functional forms. Figure H1 shows a suite of different kinds of HCRs that link a generic stock status parameter with the TAC, **Total Allowable Effort (TAE)**, or fishing mortality prescribed for each value of that stock status parameter. The types of HCRs illustrated demonstrate a tradeoff between simple but less responsive HCRs (such as the constant and threshold forms) and more responsive but more complex forms. These more complex forms are most commonly employed in data-rich fisheries, in which a quantitative stock assessment model is used to estimate biomass. They are usually designed and tested using MSE as described in Appendix J.

Data-poor Harvest Control Rules

While most data-poor fisheries lack the means of obtaining an estimate of biomass for use as a single metric of stock status, there is still a need to link the information that is available to control measures.

This is often achieved through identifying empirical reference points, which specify that some kind of action must take place when the indicator passes a certain level. Under this type of framework, the indicator can be any type of data collected via the monitoring of the fishery (whether it undergoes analysis via a data-limited assessment technique or not), and the control measure can be any kind of mechanism for altering fishing behavior. For example, a simple HCR could specify that if the mean length of the catch (the indicator) drops below the average size of maturity (the trigger), a size limit will be instituted (the control measure).

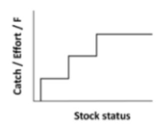
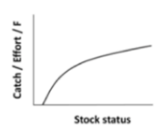
HCR	General Description and Implications	Graphic
Constant	A constant control rule maintains a single target value for the controlling measure, regardless of stock status. - TAC/TAE: promote stability but at the cost of either lower overall yields or higher levels of risk associated with reaching undesirable population states - TAF: harvest remains proportional to stock status	
Threshold	A threshold rule also maintains a single target value for the controlling measure up until a limit is reached at which point fishing ceases. - TAC/TAE: promote stability at healthy population sizes - reduces risk of fishery collapse - potential for fishing closures	
Step	A step rule incorporates discrete (or step-wise) increments in the control measure such that higher levels are permitted with improved stock status. - control measure adjusts with stock status - increased variation in yield - abrupt changes in the value of the control measure	
Sliding (simple linear)	A sliding (or "state-dependent" or "adjustable rate") rule allows for a continuous adjustment in the control measure. Higher levels are permitted with improved stock status. - moderate yields but generally with low levels of risk - increased variation in yield - gradual change in the value of the control measure	
Sliding (complex linear)	Same as above but linear combinations can be complex. - incorporate multiple transition points (e.g., according to limit, trigger, target, etc. management reference points) - contention from uncertainty in stock status when near transition points	
Sliding (non-linear)	Same as two above except continuous adjustment is non-linear. - smooth function - no major transition points so uncertainty in stock status tends to be less contentious	

Figure H1. Examples of six basic functional forms for HCRs (Reproduced from Aaron M. Berger et al., Introduction to Harvest Control Rules for West-Central Pacific Ocean Tuna Fisheries (November 2012) at https://www.wcpfc.int/node/3503.

There are many different kinds of indicators, triggers, and control measure combinations. For each fishery, the appropriate combination will depend on what types of data and biological information are available on a regular basis given the resource constraints of the managing agencies, the objectives of management, and which control measures are appropriate to the fishery. There are also many different ways to specify how the control measure should be adjusted. Table H1 provides examples for how various controls can be adjusted in response to changes in indicators.

Table H1. Examples of the types of HCRs than can be implemented for each kind of management control response (adapted from Dowling et al. 2016).

Harvest Control Rule families	
Catch or effort limits	Adjust by fixed proportions up and down Adjust in proportion to distance from a reference point or proxy Adjust according to assessment outcomes Adjust from monitoring closed areas or MPAs
Gear	Adjust gear selectivity to achieve targets Adjust to counteract effort creep Adjust to avoid capture of undesired/overfished/at-risk species. Restrict location and or season in which certain gears can be employed to avoid bycatch or habitat impacts
Spatial restrictions	Open or close areas in response to stock triggers Rotate after catch is achieved in a specific area
Size limits	May be invoked or modified to adjust selectivity in response to targets May be indirectly achieved via temporal, spatial, or gear restrictions
Sex restrictions	May be invoked in response to targets or triggers
Temporal restrictions	Adjust time of day when fishing is allowed in response to trigger Adjust season duration in response to trigger Start and stop fishing in response to trigger Implement seasonal closure
Other management responses	Trigger data collection (for example, when a catch or participation trigger is passed) Application of additional precaution/buffers Overrides in cases of exceptional circumstances Retain Status quo (apply a wait and see approach) Taxes, fees, or other financial incentives to alter fishing behavior

These trigger systems are useful because they are readily understood by stakeholders. For this reason, they provide an opportunity for involving stakeholders in management by helping to identify triggers and consequent actions. They are inherently adaptive as the trigger level values can be revised as understanding improves. The HCR can also trigger increased monitoring, which provides management agencies with a way to keep management costs low provided the fishery stays in the healthy zone, but increases management activities when the fishery moves into a precautionary zone.

Multi-indicator Harvest Control Rules

Increasingly, HCRs are being designed to respond to multiple indicators, instead of a single indicator. HCRs that are based on multiple indicators perform better because they track different aspects of the population. Sometimes there can be unidentified biases in indicators, and using multiple indicators provides a safeguard against being overly reactive, or not reactive enough. Additionally, attempting to control one aspect of fishing (e.g., instituting a size or catch limit) can have unintended consequences (e.g., an increase in regulatory discards, which may result in increased mortality). For this reason, there is usually a need to monitor the population health on multiple fronts, and to institute or alter a number of different control measures in order to achieve management objectives.

"Traffic light" HCR frameworks are an example of a trigger system with multiple indicators. Indicators that pass their limit reference points function as "red lights", signaling to stop fishing. Those between their target and limit reference points function as "yellow lights", signaling to "proceed with caution", and indicators that are within a reasonable range of their target reference points are "green lights", signaling that the fishery is in a healthy zone. One issue that can arise with the traffic light approach is how to respond to "mixed signals", which occur when different indicators achieve different colors (Punt et al. 2001; Basson and Dowling 2008). These scenarios must be carefully thought through during the design phase to ensure that the management response is appropriate.

Hierarchical decision tree frameworks allow for a decision to be reached by a sequential series of intermediate decisions. The most important decision criteria are in the upper part of the tree and applied first, which is a useful filtering system. The questions lower down on the tree refine the management approach. Decision trees allow for more complex management than traffic light systems, but each decision point on the tree is relatively easy for stakeholders to understand, so transparency can be maintained. Because of this, decision tree HCRs are a powerful tool that allow for a series of simple HCRs to be combined in to form a relatively sophisticated management tool.

Ecosystem-based indicators in Harvest Control Rules

There is a broad understanding of connection between ecosystem health and sustainable fisheries, and this has spurred calls for the implementation of EBFM to try and mitigate fishing impacts at the ecosystem level (Pikitch et al. 2004). In designing HCRs to make management decisions for target stocks, managers are embracing several of the central tenets of EBFM (Long et al. 2015), including the following:

- Long term sustainability
- Adaptive management
- Precautionary management
- Acknowledge uncertainty
- Use of scientific knowledge
- Appropriate monitoring
- Management decisions that reflect societal choice.

However, the complexities and scale of holistic ecosystem management have made it difficult to operationalize EBFM in a practical way, especially for data-poor fisheries. Including ecosystem indicators in HCRs facilitates implementation of some core principles of EBFM (Long et al. 2015), including the following:

- Consider ecosystem connections
- Account for dynamic nature of ecosystems

- Preserve ecological integrity and **biodiversity**

By including ecosystem indicators such as sea surface temperature in HCR frameworks, managers are able to explicitly acknowledge links between the decisions made for a target stock and the impacts of those decisions on the wider ecosystem. Many HCRs have bycatch indicators, in which fishing activities are altered or curtailed based on the catch of indicator bycatch species as a means of limiting the ecosystem impacts of fishing. Bycatch, especially of threatened or ecologically important species, has direct impacts on biodiversity and ecosystem integrity, and this is one way to attempt to mitigate those impacts.

Fishing has indirect impacts on other species that are not bycatch but that are trophically related to the target species, either as predators or prey. However, few predators are solely dependent on a single prey item, and the health of predators is likely dependent on a wide range of factors in addition to food availability, and so care must be taken to ensure that the HCR is not overly-reactive to predator fluctuations. In these situations, the HCR might require managers to assess the population of the predator in question during each decision-making cycle, but only trigger a change in fishing activities when very specific conditions are met. For management of a forage fish, it may be possible to include an indicator of alternative forage to assess whether the needs to the ecosystem's predators are being met. A quantitative alternative forage indicator is currently being developed as part of the NOAA's Integrated Ecosystem Assessment program for the CCE[2].

Including ecological and environmental indicators in HCR frameworks also provides a way to acknowledge and incorporate ecosystem dynamics, which are constantly fluctuating, into decision-making processes. Many fish species, especially those at lower trophic levels, are highly responsive to environmental changes that affect the productivity of the system as a whole. Examples of these types of indicators include temperature, salinity, or plankton levels. For example, the Pink Shrimp (*Pandalus jordani*) fishery uses a combination of ecosystem indicators (April sea surface height) and fishery dependent indicators (CPUE and number of age-0 shrimp in the catch) to determine the start and end dates of the season (Hannah 1993). The Pacific Sardine fishery is managed using an HCR that includes a temperature indicator to determine the harvest rate (Hurtado-Ferro and Punt 2014).

It is important to establish a link, usually via a regression analysis, to look for correlations between indicators and metrics of population health. This requires time series of data, and may not be possible for data-poor fisheries. Additionally, when looking for correlations between indicators and response variables it is important to consider alternative temporal lags and spatial scales, because correlations might go undetected at the yearly timescale at which we normally consider stock management. If links between the environmental or ecological indicators and the productivity of the stock can be established it might allow mangers to recognize changing conditions, such as regime shifts or climate change, and proactively manage for these situations.

Note that the science on using ecosystem indicators in HCRs to make harvest decisions for target stocks is emerging, and should be applied cautiously. HCRs are usually crafted so that the indicator and the management control are causally linked. This helps ensure that managers can see results in the indicator of interest when they alter fishing behavior, which is an important component of the adaptive management process. However, because the links between ecological indicators and target stocks are rarely understood, implementing these types of indicators in an HCR framework may be difficult, and managers should proceed with caution.

[2] https://www.integratedecosystemassessment.noaa.gov/regions/california-current-region/index.html

References

Basson, M., and N. A. Dowling. 2008. Development of a robust suite of stock status indicators for the Southern and Western and the Eastern Tuna and Billfish fisheries. Canberra, Australia: Fisheries Research and Development Corporation Project No. 2003/042. 348 pp.

Dowling, N. A., J. R. Wilson, M. B. Rudd, E. A. Babcock, M. Caillaux, J. Cope, D. Dougherty, R. Fujita, T. Gedamke, M. Gleason, N. Gutierrez, A. Hordyk, G. W. Maina, P. J. Mous, D. Ovando, A. M. Parma, J. Prince, C. Revenga, J. Rude, C. Szuwalski, S. Valencia, and S. Victor. 2016. FishPath: A Decision Support System for Assessing and Managing Data- and Capacity-Limited Fisheries. 37 pp.

Long, R. D., A. Charles, and R. L. Stephenson. 2015. Key principles of marine ecosystem-based management. Marine Policy 57:53-60.

Hannah, R. W. 1993. Influence of environmental variation and spawning stock levels on recruitment of ocean shrimp (*Pandalus jordani*). Canadian Journal of Fisheries and Aquatic Sciences 50(3):612-622.

Hurtado-Ferro, F., and A. E. Punt. 2014. Revised Analyses Related to Pacific Sardine Harvest Parameters. Pacific Fishery Management Council, Portland, Oregon. 31(15): 97220.

Pikitch, E., C. Santora, E. A. Babcock, A. Bakun, R. Bonfil, D. O. Conover, P. A. O. Dayton, P. Doukakis, D. Fluharty, B. Heneman, and E. D. Houde. 2004. Ecosystem-based fishery management. Science 305(5682):346-347.

Punt, A. E., R. A. Campbell, and A. D. M. Smith. 2001. Evaluating empirical indicators and reference points for fisheries management: Application to the broadbill swordfish fishery of eastern Australia. Marine and Freshwater Research 52:819-832.

Appendix I – Management Measures to Regulate Fishing Activities

This appendix provides an overview and considerations associated with a range of management measures and approaches that are applied globally. Applicability of a specific management measure to California fisheries needs to be considered on a case-by-case basis. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Overview

Managers have a suite of possible regulatory mechanisms, known as controls, available to them to ensure sustainability. These include restrictions on catch, effort, gear, season, size of fish, and fishing areas. The best choice will depend on a variety of factors, including the biology of the species, how the fishery is prosecuted, socioeconomic issues, and governance capacity.

When used properly, fishery controls not only provide conservation benefits but help make the fishery more sustainable and economically stable. Controls can also allow depressed stocks to recover, and prevent collapse. Controls on effort that limit fishing capacity may be especially useful in fisheries that experience increases in fishing due to volatile prices for fish.

Fishery controls are usually classified as either "input controls" or "output controls". If the control measure implemented directly constrains fishing effort, it is an input control, and if it constrains the catch, it is an output control (Morrison 2004). The controls summarized in this appendix provide an overview of the kinds of tools available in the fishery manager's tool box as well as considerations associated with each.

Input controls

Input controls relate to who does the fishing, and when, where, and how they can fish. They include restrictions on the type and amount of fishing gear used, the number and size of fishing vessels, the amount of time fishing vessels are allowed to fish, and the number of participants in the fishery. Each of these restrictions effectively limit the amount of fishing effort and are thus referred to as **effort controls**.

Input controls are based on the assumption that fishing effort is a useful proxy for the amount of the fish stock captured each year. When fishing effort increases, all else being equal, managers expect the magnitude of fish caught to increase. As a result, managers may use input controls as a means of limiting catches and, by extension, fishing mortality. However, there is frequently uncertainty regarding the relationship between effort and catch. This section discusses the various types of input controls available to managers, as well as their respective strengths and weaknesses (see Table I1 for a summary).

Table I1. Summary of types of input controls and associated considerations. Note that multiple controls may be applied simultaneously.

Type	Description	Benefits	Considerations and limitations
Effort limits	Limits on number of vessels or participants.	Highly applicable across a wide range of fisheries. Requires less monitoring and is easier to enforce than catch limits. Limiting entry may help prevent over capitalization.	Requires knowledge of relationship between effort and catch to set limits. Usually requires multiple controls to curb “effort-creep”. Limiting entry to fisheries may restrict access to fisheries and limit employment opportunities.
Gear restrictions	Restrictions on the number, type, or size of fishing gear used.	Widely applicable to any fishery that uses gear. Often paired with other controls. May be used to: ● limit fishing efficacy ● protect particular size/age classes from harvest ● prevent bycatch of other species ● reduce the negative impacts of fishing gear on the habitat	Restrictions may increase the cost of fishing for fishermen. Restrictions may limit ability for fishermen to innovate new gear types.
Temporal restrictions	Restrictions on the time when fishing can occur. Includes: ● seasonal closures ● restrictions on time of day/ days of the week when fishing is allowed ● tending requirements for passive gear	Temporal closures can indirectly reduce fishing mortality by reducing the number of days that fishing is allowed each year. Seasonal restrictions may be used to protect vulnerable life history stages (spawning aggregations, reproductive stages). Tending requirements reduce lost gear, bycatch mortality, and ghost fishing in passive gear fisheries.	May not reduce fishing mortality if efficiency or amount of fishing gear is very high. May encourage fishing during hazardous sea conditions. May encourage change in type/amount of gear used in response to closure; may encourage illegal fishing.
Spatial restrictions	Restrictions on where fishing can take place. May be rotational, in response to triggers, or permanent.	Easily understood by user groups. Easy to enforce in nearshore environments.	May increase crowding and cause a race to fish in remaining open areas. Not appropriate for managing highly mobile species. May require an understanding of spatial distribution of fishing and habitat.

Effort limits
Effort limits restrict the amount of effort that can be used in a fishery, and can come in many variations, such as limits on the number or capacity of vessels, number of participants, trip length, etc. These are primarily designed to reduce or cap the efficiency of the fleet by limiting how much can be caught in a given time period.

The number of permits and vessel size are common metrics for assessing or limiting fleet capacity. Fisheries where the number of participants is capped are referred to as “limited entry” or “restricted access” fisheries. The Commission has adopted a policy that guides the development and implementation of commercial restricted access programs in the state (see: http://www.fgc.ca.gov/policy/p4misc.aspx#RESTRICT). The development of these programs is often controversial, resource intensive, and can lead to litigation. They are nevertheless an invaluable tool for management.

If a restricted access program is already in place and it is determined that the existing fleet is too large to meet biological or socioeconomic goals, additional management actions may be needed to reduce fleet capacity. One option is to create permit transfer restrictions such as requiring new entrants to acquire two permits to enter the fishery or making some permits non-transferable. However, it may take many years to achieve the desired fleet size with this approach. Reducing fleet size on a faster time scale, which may be necessary in fisheries that are near collapse may require a permit buyback program, which often removes the least efficient and/or least active vessels in a fishery.

Effort limits usually require less management resources than catch limits, making them an attractive option for many fisheries. However, they provide managers with limited ability to achieve a specific catch level or harvest rate. And even with effort limits in place, effort often tends to gradually increase. This means that overfishing can occur even with effort limits in place. Effort restrictions that limit the number of participants can also reduce access to the fishery and employment opportunities.

Gear restrictions
Gear restrictions place limits on how the fishing gear is configured as well as prohibit certain types of gear in a fishery (e.g., prohibition on use of bottom trawls to take Spot Prawns). This could include mesh size requirements on trawl or gill nets, size of vessels, number of traps, length of nets, etc. Gear restrictions can be used in three different ways: 1) reduce the capacity or efficiency of each individual fisher, in order to reduce the amount each person can catch in a given time period; 2) modify the selectivity of the fishery so that particular sizes or species of fish are vulnerable to the gear, while others are immune; and 3) minimize or reduce habitat destruction and bycatch. Gear modifications are the primary way in which fisheries manage for ecosystem impacts.

Spatial restrictions
Spatial restrictions, which limit or dictate the area in which fishing activities can occur, are another form of input control. They provide areas of refuge from harvest, which can reduce fishing mortality. These might be used to reduce the spatial footprint of the fishery, protect particular habitat, or remove fishing from areas where fish aggregate to spawn. Spatial restrictions can be either permanent, such as with MPAs, semi-permanent, such as **Rockfish Conservation Areas (RCAs)**, or be part of a rotational management scheme designed to spread fishing activities over a wider area. Closures can also be invoked in response to stock related targets and limits.

Spatial restrictions are easily understood by user groups, and are relatively easy to enforce in nearshore settings. However, spatial restrictions might increase crowding and competition in open areas. In addition, they require a relatively high level of understanding about habitat types, as well as how those habitats relate to the health of the fish population. While fish in the closed areas are protected from fishing, fishing mortality may be very high in the open areas, which can have negative consequences for the stock. Additionally, spatial management is not suitable for high mobility species, because they are likely to range beyond the extent of the spatial closure and thus become vulnerable to fishing activities.

Temporal restrictions
Temporal restrictions limit the period in which fishing activities are allowed to take place. This can be done by specifying the time of day or particular days of the week when fishing activities can take place. Temporal restrictions can also take the form of a seasonal limit. Seasonal limits can be used to limit fishing mortality provided there is some understanding of how fishing effort over time corresponds with harvest level. Seasonal limits are also used to protect species during important life stages. Examples include closures to protect spawning aggregations or to remove fishing effort during the reproductive season. Seasonal closures can also be used to restrict catch of non-target species. This type of management approach can both limit fishing mortality and make monitoring or enforcement easier for the managing agency. It has also been used in fisheries targeting spawning aggregations to allow some spawning to take place in the absence of fishing pressure.

As with other controls, temporal restrictions have potential drawbacks. If a fishery is constrained to a specific time frame, fishers may be incentivized to deploy more gear and/or make more trips, in an attempt to catch as much as possible before the fishery closes. This can lead to negative impacts from excess fishing gear on habitat and bycatch. In addition, increases in the amount or efficacy of fishing gear could undermine the ability of temporal closures to restrict fishing mortality.

Output controls

Output controls dictate what is allowed to be harvested. These include catch limits, which are restrictions placed upon the weight or number of fish that may be caught in a given period of time. Output controls also include limits on the species, size, and sex of fish that may be landed. Output controls provide a more direct mechanism to control harvest than input controls. However, output controls may require higher levels of data collection and enforcement to apply them effectively. This section discusses considerations associated with each (see Table I2 for a summary).

Catch limits
Catch limits are the most direct way to control harvest and achieve a desired harvest rate. They also provide a direct way to build a precautionary buffer into a management strategy when there is uncertainty about the dynamics of the stock. The most common form of catch limit is a TAC, which is an annual aggregate limit for all sectors (recreational and commercial) set at a level expected to maintain resource sustainability. TAC-based management will generally have higher data collection and analysis needs in order to identify an appropriate catch limit. This is because catch limits are usually set based on the current stock size and productivity of the stock, which in turn is usually determined through population modeling and quantitative stock assessment (see Appendix G). Additionally, to be effective, TACs also require in-season monitoring to ensure catch limits are not exceeded. This can be achieved either by monitoring the catch in real-time using self-reporting of landings (via fishers or processors), onboard observers, or dockside monitoring. As TACs generally have higher data collection, analytical, and enforcement needs than other types of controls, they may be most appropriate for higher value fisheries with more centralized landing sites.

When a TAC is reached the fishery is closed. Because this creates uncertainty around how long the season will be open, a TAC can create a "race to fish". This can have a number of unintended consequences. It can fuel excess capacity in terms of larger boats, more gear, etc. TACs also provide an incentive for under-reporting of catches, as well as high-grading, where fishermen discard in favor of higher value catch. These discards may result in fishing mortality that is not accounted for in the landed catch data. In some fisheries TACs are monitored by having a series of short open periods and then counting the landed catch during the closures. These are known as “derby fisheries”, and can encourage fishing when conditions are dangerous. Derby fisheries can have adverse effects on fishery profits by flooding the market and driving down the price, or by reducing the quality of the landed product due to time constraints. Allocating portions of the TAC to individuals (such as in the federally-managed Pacific groundfish trawl fishery) can help address these issues but the costs of ensuring individual accountability through observers or EM can be high.

Trip limits are another form of catch limit, in which the total catch per trip is capped. Often times this type of control is paired with a limit on the total number of trips to achieve a desired total catch level. Trip limits can be an effective means of controlling or reducing effort; however, they also require sufficient monitoring and enforcement to be effective. Similar to TACs, trip limits can encourage discards as fishermen high-grade in order to maximize the value of their catch.

Bag limits
A bag limit is a form of recreational catch limit that restricts of the number of fish, invertebrates, or plants that may be landed in a day. Bag limits do not limit the total aggregate catch in the fishery unless there is some type of limit on participation as well (such as that realized through the requirement of a report card), but they may be effective mechanisms to limit harvest in small scale fisheries. They are primarily designed to limit recreational catch to what could be reasonable utilized by an individual or family. They are usually combined with an overall possession limit to be most effective. Bag limits have the advantage of being simple for user groups to understand and relatively easy to enforce. However, bag limits do provide an incentive for high grading, and thus may result in discard mortality.

Size, sex, and species restrictions
Size limits are another output control that can be used to regulate what is landed in a fishery. Minimum size limits prohibit the take of fish until they reach a certain size, which can ensure that all fish have the opportunity to reproduce at least once before they become vulnerable to the fishery. Minimum size limits are simple to employ, easily understood by users, and highly effective at protecting breeding capacity of the stock. However, they require an understanding of the relationships between size/age and reproductive maturity to ensure that the size limit is appropriate. Maximum size limits can be used to protect the age structure of the stock by removing fishing pressure on older fish, which are more likely to be large mega-spawners. When minimum and maximum size limits are used in concert it is known as a “slot limit”.

Sex restrictions are prohibitions on taking fish or invertebrates of a particular sex, usually females. These types of controls are similar to size restrictions in that they are designed to protect the breeding capacity of the stock. Prohibitions on landing a particular species is another kind of output control used to manage bycatch. These are usually implemented to reduce the catch of non-target species, especially those that are ecologically sensitive. Regulations of this type may result in “regulatory discards,” in which restricted species are returned to the water, sometimes dead or injured, leading to fishing mortality not accounted for in catch reporting.

Table I2. Summary of types of output controls and associated consideration. Note that multiple controls may be applied simultaneously.

Type	Description	Benefits	Considerations and limitations
Total Allowable Catch	Restricts the total catch that can be taken by all sectors in aggregate during a particular time period (e.g., ACLs)	With proper data and enforcement, an effective means of achieving a desired harvest level. Appropriate for higher value fisheries with centralized landing sites.	May create an incentive for discarding/high grading as fishers attempt to maximize catch. May create a "race-to–fish" scenario. Allocating to individuals can help but has costs. Requires higher levels of monitoring and enforcement than other controls. Difficult in multi-species fisheries due to variable resilience/stock status.
Trip limits	Limits on the amount of catch that can be landed on a single trip or within a specified time period	With proper accounting and enforcement, an effective means of achieving a desired harvest level. When combined with a TAC, can be an effective means of increasing the season length by protracting the time required to reach catch limit. This can reduce market gluts and improve price.	Requires higher levels of monitoring and enforcement than other controls. May create an incentive for discarding/high grading as fishers attempt to maximize catch. Can make fishery less economically efficient
Bag limit	A limit on the daily amount a fisher can take.	Used to restrict catch in recreational fisheries.	May lead to high grading and discard mortality as fishers attempt to maximize their catch.
Size restrictions	Minimum size limit	Increases the number of times a fish will reproduce before they are caught. Easily understood by participants. Easy to enforce.	Requires maturity at age/size information to be applied effectively. May result in unaccounted for injury/mortality as undersized individuals are handled and released. Not appropriate for fisheries where barotrauma or other conditions result in high discard mortality
	Maximum size limit	May provide some protection for the natural age structure of the stock. Protects larger spawning females (mega-spawners).	Not an effective means of protecting breeding capacity on its own. Not appropriate for fisheries where barotrauma or other conditions result in high discard mortality
	Slot limit (upper and lower size limit)	Provides size refuge for both juvenile and large mega-spawners.	Not appropriate for slow growing species. May lead to unaccounted for injury/mortality as fishers discard restricted fish. Not appropriate for fisheries where barotrauma or other conditions result in high discard mortality
Sex selective fishery	A restriction on the harvest of one sex (usually on females)	Prohibition on the take of external egg-bearing females (crustaceans) is another sex selective provision that could be considered.	May lead to unaccounted for injury/mortality as fishers discard restricted fish. Not appropriate for fisheries where barotrauma or other conditions result in high discard mortality
Species restrictions	A restriction on what species can be landed	Used to reduce bycatch of threatened or vulnerable species.	May lead to unaccounted for injury/mortality as fishers discard restricted fish.

References

Morrison, A. K. 2004. Input and output controls in fisheries management: a plea for more consistency in terminology. Fisheries Management and Ecology 11(6):411-413.

Appendix J – Guidance for Conducting Management Strategy Evaluation

This appendix provides an overview and best practices for conducting MSE. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Management Strategy Evaluation

The fisheries management cycle functions best when each of the components is chosen with the other components in mind. For many fisheries, the data collection protocol is designed with an understanding of the species' biology and what data can be collected given the available resources. The stock assessment in turn should provide indicators and reference points that can be used in the HCR, and the HCR should recommend regulations that are appropriate given biological constraints, management capacity, and objectives for the stock. To make these choices, it is necessary to consider the performance of the fisheries management cycle as a unit. Each component of the strategy should be chosen in order to maximize the likelihood of achieving management objectives given the current level of uncertainty, as well as the management agency's capacity for governance. MSE has been successfully employed around the globe to aid managers in making decisions and achieving their goals. This section explains what MSE is, how it is used, and provides guidance on considerations when conducting one.

What is Management Strategy Evaluation?
MSE is a simulation technique to evaluate the expected performance of management strategies prior to selection and implementation. The two main elements of an MSE are an operating model of the ecosystem and a management model of the management system. During an MSE, everything that is known about the fishery, including the population dynamics of the stock and the behavior of the fishing fleet, is simulated in the operating model. The second main element, the management model, incorporates the four components that make up a management strategy, data collection, stock assessment, harvest control, and the implementation of management measures to control fishing.

The operating model and the management model are separate, but pass information back and forth during each simulated management cycle. That information is simulated data based on the actual data collection protocols in a fishery. The simulated data are then analyzed by a stock assessment component, and an indicator is produced. That indicator is passed to the HCR, which dictates a management action that should be applied during the following simulated fishing season. That management measure is then passed from the management model back to the operating model, and the following fishing season is simulated with that management control in place. This process is repeated for a pre-specified number of management cycles (e.g., 50 years), and performance metrics such as fishery yield and population status are tracked to understand how the management strategy is likely to perform in both the short and long term.

The separation between the operating model and the management model is one of the strengths of MSE, because it allows managers to test how well a management strategy performs when some aspects of the ecological system are either unknown, or are misunderstood. For example, MSE would make it possible to assess how management performance is affected when the value for a factor in an assessment methodology in the management model is different from the value actually governing the population biology in the operating model. Another strength of MSE is that the process is repeated many times with randomly drawn parameter values to simulate either the natural variation of the system, lack of knowledge about a particular biological process, or imperfect implementation of management measures.

For these reasons MSE is widely considered to be the best way to quantify the impacts of uncertainty inherent in the system being managed, and to evaluate the trade-offs in the performance of alternative management strategies.

How does Management Strategy Evaluation differ from traditional (assessment focused) management? The traditional approach to providing fisheries management advice has involved conducting a stock assessment using all available information to estimate the status of the resource. Uncertainty in stock status was evaluated using confidence intervals and sensitivity tests, and then a projection model, in which a static management policy (such as a set harvest rate or quota), was used to assess the risk associated with that management policy. MSE overcomes many of the shortcomings of this approach. MSE simulates data collection during each management cycle, and then management advice resulting from that data is fed back into the system and used to update the stock and fleet dynamics in the next time-step (Walters and Martell 2004).

Best practices for Management Strategy Evaluation

While MSE is useful for creating adaptive management strategies, the analyses can be complex, and time and resources are required to conduct them. In the past, significant quantitative expertise was required to build and run simulation models, though recent advances have made MSE faster, more affordable, and more accessible to a wider range of fisheries, including those with limited data. The behavior of the fishery must be modeled as accurately as possible, and that usually requires gathering information from the stakeholders, biologists, and managers who know the fishery best. This usually requires an iterative process to accurately and comprehensively characterize the fishery and its management goals, determine which performance metrics are most informative, interpret results and evaluate tradeoffs.

This section breaks down the steps required to conduct an MSE (Figure J1), and provides some guidance on each. This process should typically be re-applied every five years.

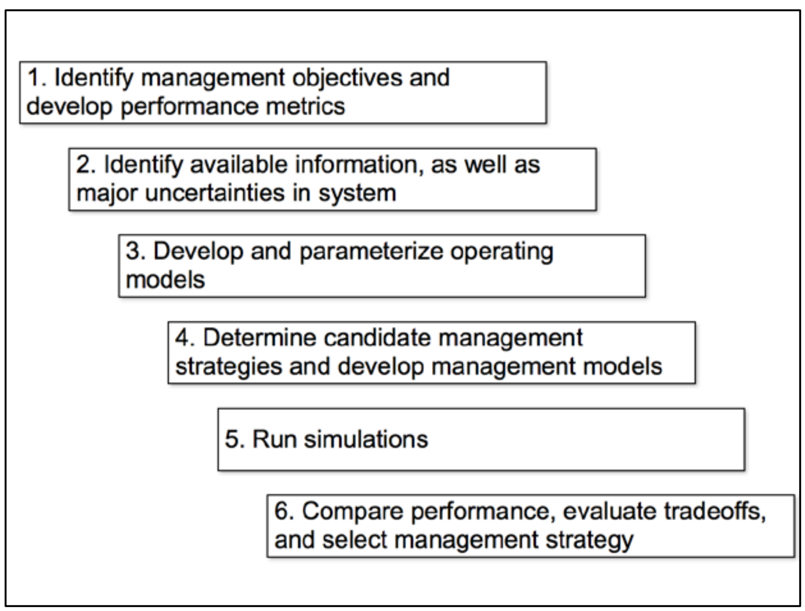


Figure J1. The six steps involved in conducting an MSE.

<u>Step 1: Identify management objectives, and develop quantitative performance metrics that reflect those objectives.</u>

The first step of any MSE process is to identify the management goals and objectives of the fishery. This discussion should involve managers and stakeholders, and include biological, ecological, and socioeconomic objectives, because different user groups may have different goals. Once a suite of management objectives is agreed upon, quantitative performance metrics that reflect those objectives should be defined. This is a very important part of the MSE process because simulation models can track a huge amount of information about the health of the stock and fishery yield for every management strategy and scenario tested. Performance metrics condense this vast amount of information down into a manageable suite of meaningful metrics, and provide a means for comparing each potential harvest strategy directly against each other. However, translating generic, high-level policy goals and conceptual definitions of sustainability into concrete, quantifiable performance metrics can be difficult.

One method for translating goals into quantitative performance metrics is to ensure that, for each management objective, three elements are defined: 1) the element to be achieved; 2) a time frame for achieving the objective; and 3) an acceptable rate of failure for achieving the objective (also known as an acceptable risk level). For example, a high-level policy goal for a fishery may include maintaining sustainable stock levels. Unsustainable levels are usually defined as those where recruitment may be impaired. For rockfish along the West Coast of North America, PFMC has defined this to be 10% of unfished biomass. Managers who are translating the goal of “maintaining sustainable stock levels” into a performance metric may decide that they want their management strategy to achieve biomass levels >10% of unfished biomass over a 50-year time period with 90% probability. This performance metric clearly defines the objective (biomass above 10% of unfished), the time frame (50 years), and the acceptable rate of failure (above the objective 90% of the time or more).

Common management objectives for fisheries include maximizing economic benefits while minimizing the risk to the stock (Punt 2015). As a result, performance measures for MSEs usually focus on three dimensions of performance: catch, biomass of the target species, and variability of catch. However, there are many ways that performance within these categories can be tracked, and Table J1 provides examples of the different kinds of performance metrics that have been used.

Careful consideration should be given when choosing performance metrics. The appropriate number of metrics will depend on the fisheries objectives, but in general it is difficult to compare more than about six metrics simultaneously. Performance metrics should be chosen so that they are easy for decision-makers and stakeholders to understand. For example, a common fishery objective includes minimizing large swings in the TAC from year-to-year. Performance metric design should be an iterative process and involve stakeholders to determine which metrics are best for each situation.

Guidance:

- Performance metrics should reflect management objectives. For each management objective, define the objective, time frame, and acceptable failure rate.
- Involve stakeholders in the process to clarify management objectives and define performance metrics
- Keep the number of performance metrics as small as possible.
- Choose performance metrics that are easily understood by a wide audience.

Table J1. Types of management objectives and example performance metrics.

Type of Management Objective	Example Performance Metrics
Population Health (Target species)	
	Biomass
	Biomass relative to unfished biomass (B_0)
	Biomass relative to reference biomass (such as B_{MSY})
	Biomass relative to initial/historical biomass
	Lowest biomass
	Lowest biomass relative to unfished biomass (B_0)
	Probability of local depletion
	Probability biomass is above or below threshold
	Number of consecutive years biomass is above or below threshold
	Percent of older/larger individuals in catch
	Average age of catch
Catch and Catch Variability	
	Catch - total, average, or median
	Catch variability
	Catch relative to reference value
	Probability catch < threshold value
	Lowest catch
	Probability of catching fish above a certain size
	Number of consecutive years catch > threshold value
	CPUE, or catch rate
	Catch rate relative to the reference catch rate
	Catch composition (percent of each species)
Socioeconomic Performance	
	Discounted revenue
	Costs (monitoring, enforcement)
	Profit
	Profit variability
	Profit per ton or per unit effort
	Access and distribution equity among sectors and ports
	Conflict among sectors
	Effort
	Displaced effort
	Amount of quota trading
	Employment
Ecosystem Impacts	
	Biomass of non-target species
	Catch composition of non-target species
	Percentage of discards (by weight or number)
	Number or biomass of at-risk species
	Probability of interaction with at-risk/threatened species
	Proportion of total habitat fished

Step 2: Identify what information is known about the fishery as well as major uncertainties.

The next step in conducting an MSE is to gather all the available data and information for the fishery, as well as to identify the gaps in information. This should include all available data on catch and effort, any other information that has been collected via monitoring, biological parameters, fishery management, ecological impacts, etc.

This step serves two important purposes. First, this information will be used to develop the operating model (Step 3). Second, by collecting what is known, it will be possible to identify where the major areas of uncertainty lie in terms of biology, the environment, the fishery, and the management system. This is an important step, because part of the MSE process involves determining which management strategies are robust to these uncertainties. For data-rich stocks, this step usually coincides with a stock assessment model, which analyzes all of the available data to estimate stock status as well as other biologically important parameters. Stock assessments also provide quantitative information where there are major uncertainties. However, MSEs can be conducted for fisheries that are too data-poor to have a formal stock. For these fisheries, the process of gathering information may be more qualitative, but is no less important. This can be done through consultations among stakeholders, biologists, and other experts; by borrowing biological information from closely related stocks; or through a more formal risk assessment process such as a PSA, where participants are required to score how certain they are about each piece of information.

Guidance:

- The best available information for the fishery should be considered, and key areas of uncertainty should be identified.
- Many different forms of uncertainty should be considered, including process uncertainty, parameter uncertainty, model uncertainty, assessment uncertainty, and implementation uncertainty.
- Uncertainty scenarios should be ranked based on the participants' assessment of plausibility, and high and medium plausibility scenarios should form the basis for operating models.

Step 3: Develop a set of operating models representing the fishery.

An operating model is a mathematical representation of all of the biological components of the system to be managed, as well the fishery which targets that modeled population. Usually, multiple operating models are required because of the need to cover the range of the ever-present uncertainties. The most plausible hypothesis about how the system functions is usually considered the reference (or base case) operating model, and a set of "uncertainty scenario" operating models are also developed to represent the major uncertainties (Rademeyer et al. 2007). The reference operating model is usually based on the stock assessment model that best fits the data. The operating models should be developed using a widely available programming language so that the analysis is repeatable and the results can easily be reproduced. In addition, the mathematical structure of each operating model should be well documented.

Guidance:

- Operating models should be created to represent all high and medium plausibility scenarios from step three.
- The most plausible scenario is considered the reference operating model.
- All models should be developed in a commonly used, widely available programming language, and should be well documented and reproducible.

Step 4: Develop candidate management strategies, and create implementation models to simulate the application of those management strategies.

An implementation model that reflects how management regulations are applied in practice must also be developed for each candidate management strategy. This model describes how data are collected from the managed system (including the effect of measurement noise), how that data is analyzed during the assessment phase, and how fishing activities should be changed in the following simulated time step (HCR). Ultimately, the choice of candidate management strategies should reflect the governance and scientific capacity of the managing agency, and should be realistic and implementable.

MSE developers should strive to simulate data collection as realistically as possible, with careful consideration given to the current and future sampling effort the management agency can employ. In addition, multiple error structures for the sampled data should be considered. Commonly, MSEs generate age/length composition data from the survey or fishery catch in a way that matches the distributions, which can underestimate the number of samples needed when sampling is employed in the real world. As with the operating models, implementation models should be developed using a widely available programming language so that the analysis is repeatable and the results are easily reproducible.

Guidance:

- The choice of candidate management strategies should reflect the capacity of the managing agency.
- The implementation models should attempt to capture the various aspects of each management strategy as realistically as possible.

Step 5: Run simulations.

In this process, all of the candidate management strategies (implementation models) are applied to all of the uncertainty scenarios (operating models). This means that an MSE that tests six candidate management strategies on six different uncertainty scenarios will produce results from 36 different combinations. In addition, because each test simulates management over many years (usually at least 20), and includes repeated runs to understand how random variability impacts performance (frequently 1,000 individual trials), considerable time, computing power, and an organized approach to storing and summarizing results is required. The calculation of the performance metrics selected in step one is coded into the MSE test so that these statistics will be readily available. Running simulations is frequently an iterative process, because frequently things are learned during the simulation process that cause the developers to alter either the candidate management strategies, the operating models, or both.

Step 6: Compare performance, evaluate tradeoffs, and select a management strategy

Once the simulations are run, it is necessary to examine the results and select a management strategy that best meets management objectives, and is robust to the various types of uncertainty in the fishery. The analyst that conducted the MSE should participate in the process by explaining results and facilitating discussion, but the ultimate choice of which management strategy is “best” should be determined by the managing agency. Stakeholders and decision-makers should be fully involved in selecting among management strategies. This will not be a one-time exercise, but will likely be an iterative process where the analyst interacts with and respond to the needs of decision-makers. Consequently, there needs to be an investment of time in working with decision-makers to ensure that they understand what they are being presented.

When comparing the performance metrics for each candidate management strategy, it is necessary to determine a process for deciding on the best option. Occasionally a single management strategy will clearly dominate the others in all performance categories, but more likely there will be tradeoffs between the performance metrics (e.g., a strategy that results in high yield, but also higher risk to the population). The ideal way to select among management strategies is to define a utility function that puts an a priori weight on each performance metric (essentially, a numeric factor reflecting how important it is), and then find the management strategy that achieves maximum utility. However, this method is very difficult to implement in the real world because stakeholder groups often have different values for different performance metrics, and those values are difficult to quantify objectively. Instead, the most commonly used method for selecting performance metrics usually involves the following steps:

1. The analyst explains all of the options and presents the relative results.
2. Those management strategies that do not meet the minimum sustainability criteria are eliminated, as these strategies often cannot legally be implemented, and would likely be considered unviable by all stakeholder groups.
3. Any management strategies that are outperformed in all performance metrics are eliminated to reduce the number of options as quickly as possible.
4. Decision makers select from the remaining candidates using either a satisficing or trading-off approach. Satisficing involves specifying minimum performance standards for all performance measures and only considering management strategies that satisfy those standards. In contrast, trading-off acknowledges that any minimum performance standards will always be somewhat arbitrary, and that decision-makers should attempt to find management strategies that achieve the best balance among performance measures.

Climate change and MSE

Climate change and environmental variation can drive changes in a wide array of biological processes affecting fishery management, including spawning, spatial distributions, migratory patterns, gear selectivity, and diet, as well as growth, survival, mortality, and recruitment rates. Changes in any one of these parameters can profoundly affect the estimated value of fishery reference points such as B_0, MSY, OY, etc. MSE's provide an opportunity to examine how those types of changes are likely to affect the performance of a given management strategy by modeling environmental and climate impacts on population dynamics. These simulations can be used to evaluate the benefits of adopting a management strategy that explicitly accounts for environmental and climate impacts.

Two approaches have been developed to apply MSE to evaluate the impact of environmental variation on the performance of management strategies: the mechanistic approach and the empirical approach. The mechanistic approach estimates the relationship between the environment and elements of the population dynamics of the fished species and makes predictions for population trends using the outputs from global climate models (Punt 2015). This approach can be very difficult, especially in data-poor fisheries. A key step when applying this approach is to represent uncertainty appropriately, because fishery models estimate how populations will respond to changing conditions by looking at past performance, which is not necessarily a representative of changes under future climate scenarios (Reifen and Toumi 2009).

The second approach is the empirical approach, which examines broad impacts of climate change, environmental variation, and ecosystem shifts without explicitly specifying a mechanism (Punt 2015). This is done by imposing trends in the values of key parameters of the operating model in order to simulate plausible changes that might occur at the stock level under climate change, without attempting to link the operating model explicitly to global climate change models. The empirical approach can be used to understand how robust a management strategy is to changing conditions even when there are no actual environmental data available to use to relate to future changes in the parameters of the operating model, and has been recommended as a more appropriate approach for the majority of fisheries (Szuwalski and Punt 2013).

Guidance

- Stakeholders should be involved in the decision-making process, which usually requires some investment in explaining the process along the way.
- The analyst should refrain from deciding which management strategy is “best”; the decision should be made by the management agency and reflect their objectives.
- A four-step approach is usually used to eliminate unviable candidate procedures. At that point, decision makers will need to use either a trading off or a satisficing approach to decide on a management strategy.

References

Punt, A. E. 2015. Strategic management decision-making in a complex world: quantifying, understanding, and using trade-offs. ICES Journal of Marine Science 74(2):499-510.

Rademeyer, R. A., E. E. Plaganyi, and D. S. Butterworth. 2007. Tips and tricks in designing management procedures. ICES Journal of Marine Science 64(4):618-625.

Reifen, C., and R. Toumi. 2009. Climate projections: Past performance no guarantee of future skill? Geophysical Research Letters 36(13): L13704.

Szuwalski, C., and A. E. Punt. 2013. Regime shifts and recruitment dynamics of snow crab, *Chionoecetes opilio*, in the eastern Bering Sea. Fisheries Oceanography 22(5):345-354.

Walters, C. J., and S. J. Martell. 2004. Fisheries Ecology and Management. Princeton, USA: Princeton University Press. 448 pp.

Appendix K – Bycatch Mitigation Measures and Considerations

This appendix provides an overview of considerations associated with a range of bycatch mitigation and discard mortality measures. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Overview

As discussed in Chapter 6 of the Master Plan, bycatch can increase the time, cost, and effort required to catch a desired amount of target species and can have adverse consequences for vulnerable stocks and ecosystems. As a result, fishermen, scientists, engineers, and resource managers have developed a wide array of strategies to reduce bycatch.

The MLMA requires that bycatch be limited to acceptable types and amounts. Where unacceptable bycatch occurs in a fishery, management measures that minimize bycatch and discard mortality should be implemented. This appendix provides a non-exclusive list of common bycatch mitigation measures that have been demonstrated to minimize bycatch and discard mortality when appropriately designed and implemented. It also provides associated considerations and existing California or West Coast examples of implementation where available.

Identifying appropriate methods for addressing bycatch concerns requires an intimate understanding of the fishery in question. This includes knowledge of the fishing gear and operational practices, details regarding the distribution and behavior of bycatch species, the spatial and temporal characteristics of fishing activity, and other variables. In most cases, some combination of bycatch mitigation measures may be necessary to effectively address unacceptable bycatch. For example, gear modifications are often paired with incentive programs for fishermen and supplemented by a time/area closure that prevents fishing when sensitive bycatch species are most likely to be present.

Evaluating and monitoring bycatch

Information on the type and quantity of bycatch in an individual fishery is necessary to select appropriate bycatch mitigation measures. This information is not always available with sufficient certainty to identify mitigation strategies. In such cases, increased data collection may be the most appropriate short-term strategy. Data collection efforts using dockside monitoring, logbooks, observers, or fisheries independent or dependent studies can establish the information necessary to make informed decisions about bycatch mitigation strategies. Each of these data collection methods has its own set of considerations. For example, logbooks can be used to collect information at minimal cost to the Department, but fishermen may not have the knowledge or incentives to report completely and accurately. Dockside monitoring surveys or landing receipts can only collect data on retained species and thus will provide no information on discards. Observers are likely the most reliable and comprehensive data collection method, but costs can be prohibitive and observers may influence normal fishing activities.

No single data collection technique can effectively establish estimates of bycatch in the diverse range of state-managed fisheries. Different fishery-specific characteristics and factors must be considered when determining the appropriate methods of data collection and reporting. Standardized reporting methodologies can help ensure that effective bycatch data collection programs are developed for each fishery. See Appendix F for more details on data collection strategies.

Categories of bycatch mitigation measures and associated considerations

The International Guidelines on Bycatch Management and Reduction of Discards—prepared by the **Food and Agriculture Organization of the United Nations (FAO)** and endorsed by the United Nation's Committee on Fisheries—states that best practices for bycatch mitigation measures include ensuring that all measures are: "(i) binding; (ii) clear and direct; (iii) measurable; (iv) science-based; (v) ecosystem-based; (vi) ecologically efficient; (vii) practical and safe; (viii) socioeconomically efficient; (ix) enforceable; (x) collaboratively developed with industry and stakeholders; and (xi) fully implemented" (FAO 2011). In some circumstances, however, voluntary or experimental measures may be the most appropriate.

The bycatch mitigation measures outlined below fall under seven main categories, each with general considerations regarding implementation:

1. *Gear modifications*: Modifying gear design, materials, and configuration has proven effective as a bycatch mitigation measure in many fisheries. Effective modifications are fishery-specific, depending on the type of gear used and the portfolio of bycatch species. As a result, fishery-specific studies may be necessary to establish the efficacy of particular gear configurations to mitigate bycatch. Gear modifications result in up-front and possible ongoing maintenance costs for fishermen, which can be defrayed by programs such as financial incentives. Dockside gear checks or patrols can ensure that fishing vessels are taking steps to comply with gear modification requirements, but on-board monitoring is necessary to ensure full compliance.

2. *Bycatch catch limits*: Placing limits on the number of individuals or weight of bycatch in a fishery is perhaps the most straightforward way to reduce bycatch. Catch limits can include zero quotas and required release, quotas requiring full retention and reporting of bycatch, or hard caps that completely close a fishery after they are exceeded. Depending on the design of a bycatch quota program, monitoring may be a substantial cost that's borne by participants, the Department, or a combination of the two. Landing receipts or logbooks may provide some assurance of compliance, but on-board monitoring (human or electronic) is the only way to ensure full compliance. Catch limits may result in lost fishing opportunities if hard caps are imposed. To ensure that catch limits or hard caps are protective of the species without unjustifiably damaging economic opportunities, data on the abundance, productivity, and mortality of the bycatch species is required.

3. *Spatial and temporal measures*: Spatial and temporal measures restrict fishing or use of certain gear types at a time of year and/or in a geographic location when bycatch is expected. Other measures that fall under this category may dictate the manner and timing of gear deployment, such as night setting or depth restrictions. Establishing spatial and temporal measures will require sufficient scientific information to demonstrate their efficacy. Enforcement can be accomplished by patrols, VMS, or on-board observers. These measures may result in lost fishing opportunities and may have direct costs to fishermen depending on how responsibility for monitoring costs is assigned.

4. *Incentive/disincentive programs*: Programs that provide incentives or disincentives related to bycatch can encourage fishermen to innovate their practices to avoid bycatch. Certain incentive programs can also ease the burden of regulatory requirements on fishermen. For example, rebates, tax breaks, or other discounts/subsidies can facilitate the transition of a fishery to more selective

gear. Likewise, establishing a system of performance standards (e.g., rewards and/or penalties based on bycatch rates) can spur innovation and encourage good practices. These programs will have some administrative costs, but can ultimately be revenue neutral or positive if penalties are designed to equalize or exceed rewards. Purchasing incentive programs will have minimal enforcement needs, while performance standards may require significant monitoring to guarantee fairness.

5. *Strategies to minimize "ghost fishing"*: The ongoing effects of abandoned or lost fishing gear can be mitigated by these strategies, including gear recovery programs and design standards. These programs will have some administrative costs, particularly gear recovery programs that require vessel trips to recover gear. These costs can be defrayed by mandatory or voluntary buyback of recovered gear that is marked with ownership identification. Gear design using degradable materials may have some up-front and ongoing costs to fishermen.

6. *Full retention programs*: Full retention reduces discard mortality to zero. These programs may not improve bycatch outcomes on their own, but they can reduce waste, enable comprehensive monitoring of bycatch, and may incentivize fishermen to innovate gear or fishing practices to avoid low-value bycatch. Full retention programs may reduce overall profit from fishing due to low-value catch. These programs have minimal direct cost to the Department, but may result in increased analysis and reporting needs if paired with requirements to report the type and amount of bycatch in the fishery.

7. *Other*: Several other strategies have demonstrated success in reducing bycatch or discard mortality. These include descending devices, use of predictive mapping applications to avoid bycatch hotspots, education and training programs, and improved monitoring and enforcement. Burdens on the Department and fishermen vary depending on the strategy.

In addition to the bycatch mitigation strategies outlined above, many management measures focused on target species have incidental benefits for bycatch. For example, where a target stock is overfished, a reduction in overall effort may be necessary. Such effort reductions will often also reduce total mortality of bycatch species. Please see Appendix I for more information.

Table K1 below provides a range of common bycatch mitigation strategies and identifies considerations and examples associated with each. Considerations include evidence for the efficacy of the mitigation measure under different circumstances, the potential economic effect on fishing communities, and implementation and enforcement needs.

Table K1. Common bycatch mitigation strategies, and associated considerations and examples.

Table K1 – Available Bycatch Mitigation Measures						
Category	**Sub-category**	**Concept**	**Considerations**			**California (or Pacific) examples**
			Efficacy in mitigating bycatch	**Economic effects on fishermen**	**Enforcement requirements**	
Gear modifications	Acoustic devices (e.g., pingers)	Alert animals to presence of fishing gear. Effective for sound sensitive species (e.g., marine mammals).	Several trials of pingers on fishing nets resulted in 70-90% reduction in cetacean bycatch (Cox et al. 2007). Pingers recommended by the International Whaling Commission in 2001 (IWC 2001).	Cost of individual pingers is low. Longer nets will require more pingers at increased cost. These costs may be offset by reductions in net damage or loss from interactions with marine mammals (NMFS 1997).	Dockside gear checks or patrols can ensure presence of pingers.	As part of the Pacific Offshore Cetacean Take Reduction Plan, all drift gillnets must have acoustic deterrent devices. 50 C.F.R. § 229.31(c). Studies show a 75% reduction in cetacean **entanglement** (NMFS 1997).
	Visual devices (e.g., Light Emitting Devices, bait dyes, colored gear)	Alert animals to presence of fishing gear. Effective for light/color sensitive species.	The use of LED lights along the fishing line dramatically reduces bycatch of threatened and depressed fishes in pink shrimp trawl nets with no effect on target catch (Hannah et al. 2015).	Cost of bait dye and lights of LED systems is relatively low.	Dockside gear checks or patrols can ensure use.	LED lights are suggested for pink shrimp trawl nets to reduce bycatch of eulachon smelt and other sensitive species, although no regulations are currently in place. Studies show a 70-90% reduction in bycatch (Hannah et al. 2015).
	Mesh size optimization	Alterations to mesh size in nets.	The use of larger mesh sizes results in a reduction of smaller and sub-legal sized bycatch (Alverson et al. 1994).	Changes to mesh size requirement may require production or purchase of all new netting, or alterations to existing netting. Cost and time required will vary.	Dockside gear checks or patrols can ensure appropriate mesh sizes.	Trawl vessels targeting California Halibut in California Halibut Trawl Grounds must use a minimum cod end mesh size of 7.5 inches. Cal. Fish & Game Code § 8496 (g–h). Studies show a reduction in bycatch of sub-legal halibut (Schott 1975).
	Bycatch Reduction Devices (BRDs) in trawl nets	A hard grid, large-hole mesh, and/or escape hatch designed to allow escape or exclude catch of turtles, debris, large animals, free swimming fish in trawl nets.	BRDs are recognized as effective in reducing bycatch. The efficacy of specific BRDs depends on their design, the fishery in which they are used, and the profile of bycatch species (Eayrs 2007; Alverson et al. 1994).	Cost of BRDs varies considerably. Small mesh windows may cost a few dollars, while large steel grates may cost up to $1,000 (Eayrs 2007).	Dockside gear checks or patrols can ensure presence of BRDs.	Pink shrimp trawl nets must have bycatch reduction devices to reduce bycatch of groundfish (e.g., Pacific hake, sablefish, yellowtail rockfish). Cal. Fish & Game Code § 8841; Cal. Code Regs. tit. 14 § 120.1 (c). Studies show a 66-88% reduction of bycatch (Hannah and Jones 2007).
	Escape ports in traps	Allow bycatch species to escape traps.	Escape ports reduce sub-legal sized individuals in traps (Stewart 1974).	The use of escape ports in pots and traps is common practice. Any increases in the	Dockside gear checks or patrols can ensure presence of escape ports.	Lobster and crab traps must have escape openings of varying number and size. Cal. Fish & Game Code § 9010–9011.

Table K1 – Available Bycatch Mitigation Measures						
Category	**Sub-category**	**Concept**	**Considerations**			**California (or Pacific) examples**
			Efficacy in mitigating bycatch	**Economic effects on fishermen**	**Enforcement requirements**	
				minimum port size would require alterations to existing traps.		
	Streamers	A line runs from a high point of a vessel to a drag buoy towed behind. Streamers are attached to the line and scare birds away from surface lines, bait, and hooks.	Streamers reduce seabird interactions with longline gear (Melvin et al. 2004).	This measure does not require significant changes to the fishing gear or vessel and has minimal costs (Sato et al. 2012).	Dockside gear checks or patrols can ensure presence of streamer lines.	Groundfish longline vessels in Alaska state and federal waters must have streamers. 50 C.F.R. § 679.24(e)(3–4); Alaska Admin. Code tit. 5 § 28.055. Streamers are most necessary for use with pelagic longlines, which are not currently used in California.
	Hook selection	Some hooks types—such as circle hooks—may result in reduction in bycatch and/or increase in post release survival of bycatch.	Circle hooks can reduce rates of bycatch and post-release mortality in longline fisheries or hook-and-release fishing (NMFS 2008; PFMC 2000). Hook size also influences bycatch mitigation.	Transitioning hook type or size will have relatively low cost to fishermen. May impact catch rates of target species.	Dockside gear checks or patrols can ensure presence of appropriate hook type and size.	Use of circle hooks required for some Salmon fishing. Cal. Code Regs. tit. 14 § 27.80(a); Cal. Code Regs. tit. 14 § 182(c).
	Bait selection	Use of different baits can increase selectivity.	The use of fish instead of squid as bait reduces bycatch of turtles and sharks in longline fisheries (NMFS 2008).	Transitioning bait type will usually have minimal cost to fishermen but may impact fishing efficacy.	Dockside gear checks or patrols can ensure presence of appropriate bait.	No existing regulatory examples in California.
	Marine mammal entanglement gear modifications	Several modifications to the material or configuration of gear have been proposed to reduce marine mammal entanglements in lines (CDFW/OPC 2017; PSMFC 2017).	Suggested gear modifications include reducing length of vertical and trailer lines to minimize slack and changing rope color and material. Preliminary evidence suggests reducing slack and accessory lines may have the greatest positive effect (CDFW/NOAA 2017).	Adjusting length of lines may take some time when changing set location across depths. Breakaway lines may have more materials cost and potential for lost gear. Straightforward gear modifications are likely less costly than a Take Reduction Team (PSMFC 2017).	Dockside gear checks or patrols can ensure appropriate gear configuration.	Updated best practices guide for crab fishing strongly recommends reducing slack in vertical lines and the number of accessory lines and trailer buoys (CDFW/NOAA 2017). Measures are not mandatory at this time.
Bycatch catch limits	Quotas/catch limits/hard caps /triggers	Reduce absolute numbers of bycatch. May have no/minimal effect on post-release	Catch limits reduce landings of bycatch. Defensible quotas or hard caps should be	Costs to fishermen may include monitoring costs and any lost fishing opportunities (O'Keefe	Requires significant monitoring and reporting to achieve compliance. High monitoring needs.	Bycatch of sturgeon, halibut, salmon, Steelhead and Striped Bass may not be taken by or possessed on

Table K1 – Available Bycatch Mitigation Measures						
Category	Sub-category	Concept	Considerations			California (or Pacific) examples
			Efficacy in mitigating bycatch	Economic effects on fishermen	Enforcement requirements	
		mortality. Can be vessel or fishery specific and transferable or nontransferable.	based on the abundance, productivity, mortality, and ecosystem role of species and subject to effective monitoring. Quotas can function as incentive to change fishing gear or practices to avoid bycatch (Alverson et al. 1994). Quotas can exacerbate discard mortality and derby fishing unless paired with comprehensive tracking of catch and consequences for quota exceedance (Marine Fish Conservation Network 2004).	et al. 2012; Patrick and Benaka 2013). For example, hard cap limits lead to fishery closures when exceeded.	Hard caps typically require 100% monitoring (NMFS 1997).	any herring fishing vessel. Cal. Code Regs. tit. 14 § 163(e). Federal groundfish management on the west coast allows for and utilizes sector- and vessel-specific total catch limits for some bycatch species and prohibits retention of others (PFMC 2016; 50 C.F.R. §660.55(m)). These bycatch limits have led to early season closures several times. E.g., 73 Fed. Reg. 53,763. Proposed hard caps for marine mammal and sea turtle interactions in California drift gillnet fishery were withdrawn in 2017 due to potential economic impacts. 82 Fed. Reg. 26,902

Table K1 – Available Bycatch Mitigation Measures						
Category	**Sub-category**	**Concept**	**Considerations**			**California (or Pacific) examples**
			Efficacy in mitigating bycatch	**Economic effects on fishermen**	**Enforcement requirements**	
Spatial and temporal measures	Closures with temporal (time) and/or spatial (area) dimensions	Restrict fishing or use of certain gear types at a time of year and/or in a geographic location when bycatch is expected.	Time/area closures can reduce bycatch when target and bycatch species segregate spatially or temporally (Alverson et al. 1994). The occurrence of bycatch species can be gleaned from behaviors and physiological traits of the species (Dunn et al. 2011).	Depending on the size and complexity of time/area closures, they could be either an inconvenience for or adversely affect fishermen (Erickson and Berkeley 2008).	Closed areas must be monitored and enforced. Patrols or VMS (see below) are likely necessary to ensure compliance.	Depth and season restrictions apply in Cowcod Conservation Areas to protect several rockfish species. Cal. Code Regs. Tit. 14 § 27.50 Certain areas of the California Habitat Trawl Grounds are closed to fishing to protect bycatch, as well as habitat and ecosystems. These closures have spatial but no temporal dimension. Cal. Fish & Game Code § 8495 (c). CDFW data shows a range of bycatch and discard percentages for each of the closed areas that are now avoided (CDFG 2008). Spatial restrictions can also be voluntary. The California Goundfish Collective and the Nature Conservancy work together to develop fishing plans to manage bycatch risk in the Pacific groundfish fishery (see: www.cagroundfish.org).
	Dynamic ocean management	Adaptive closures or avoidance schemes based on real-time information sharing between government, scientists, and fishermen. May be mandatory or voluntary.	Implementation of dynamic ocean management can both reduce overall restrictions on fishing communities and mitigate bycatch concerns (Dunn et al. 2016).	Complexity of the program and possible information reporting may present some cost or inconvenience to fishermen. Possible benefits by replacing large static closures with smaller dynamic closures.	Closed areas must be monitored and enforced. Patrols or VMS (see below) are likely necessary to ensure compliance with mandatory closures	Proposed use of the "EcoCast" model to avoid areas of predicted bycatch in California drift gillnet fishery Exempted Fishing Permit (NMFS 2016). University of Massachusetts Dartmouth School for Marine Science & Technology Bycatch Avoidance Program collects the geographic location of yellowtail bycatch from scallop fishermen in New England. Each day, the data is compiled in an email notice describing spatial areas to avoid based on bycatch of yellowtail from

Table K1 – Available Bycatch Mitigation Measures						
Category	Sub-category	Concept	Considerations			California (or Pacific) examples
			Efficacy in mitigating bycatch	Economic effects on fishermen	Enforcement requirements	
						the previous day (O'Keefe and DeCelles 2013). Use of Sea State in the Pacific Whiting fishery cooperative to avoid bycatch.
	Altering the time or depth of gear setting	Can influence bycatch by avoiding parts of water column or times of day in which bycatch is most active.	The time or depth of setting can reduce certain types of bycatch in certain fisheries. For example, setting drift gillnets lower in the water column reduces cetacean and sea turtle bycatch (NMFS 1997). Likewise, night setting can reduce seabird bycatch in longline fisheries (Peterson 2008).	Minimal direct cost. Possible lost opportunity costs, but study on depth setting requirements for the California drift gillnet fishery show minimal effect on target catch rates. Potential loss of catch may be offset by reductions in net damage or loss (NMFS 1997).	Human or EM and/or patrols required to effectively enforce.	As part of the Pacific Offshore Cetacean Take Reduction Plan, all drift gillnets must have extenders, which ensure nets are a minimum of 36 feet below the surface of the water. 50 C.F.R. § 229.31(b). Studies show a 25% reduction in marine mammal bycatch (NMFS 1997).
	Limit soak time	Reducing the amount of time gear is in the water can reduce bycatch and improve survival of discards.	Mortality of catch increases with increased soak time in pelagic longlines (Erickson and Berkeley 2008). Appropriate soak time will vary by fishery.	Minimal direct cost. Possible lost opportunity cost, but studies show that limiting soak time has no effect on target catch of some species (Erickson and Berkeley 2008).	Human or EM and/or patrols required to effectively enforce.	All traps have maximum soak times of 96 hours. Cal Fish & Game Code § 9003.
	Performance standards	Reward (e.g., increase quota, longer season,	Rewards and/or penalties can	This program could provide rewards for	May require 100% monitoring.	NA

Table K1 – Available Bycatch Mitigation Measures

Category	Sub-category	Concept	Considerations			California (or Pacific) examples
			Efficacy in mitigating bycatch	Economic effects on fishermen	Enforcement requirements	
Incentive / disincentive programs		monetary reward) or penalize fishermen based on conformity with pre-determined bycatch or bycatch mortality performance standards.	incentivize compliance and innovations in fishing practice (PFMC 2007).	voluntary reductions in bycatch. May provide for penalties as well.		
	Permit attrition programs or buybacks	Buying out capacity of certain permit types or allowing transition to other permit types.	Selectively-targeted buybacks can facilitate transition to more selective gear or reduce overcapacity (Squires et al. 2007).	Possible costs to outgoing fishermen, depending on administration of the program. May result in increased revenues if overcapacity is addressed (Squires et al. 2007).	Dockside gear checks and/or patrols needed to ensure phased out gear types are not in use.	A buyback was conducted in the Pacific groundfish fishery in 2005, however, the motivation was primarily related to target stock sustainability.
	Gear recovery programs	Government program or incentive for fishermen. Focused on recovering lost gear.	Gear recovery programs are an established method to reduce ghost fishing (Macfadyen et al. 2009).	No cost to fishermen, unless recovery costs must be reimbursed by identified gear owners. Possible compensation for fishermen that participate in recovery.	No enforcement needs.	California Lost Fishing Gear Recovery Project has removed more than 60 tons of fishing gear from California waters since 2006 (Seadoc 2009). Also see SB 1287 (McGuire).
Strategies to avoid / reduce ghost fishing by lost or derelict gear. Lost gear is known to continue catching target and non-target species (Macfadyen et al. 2009).	Use of degradable materials or destruct devices in gear design	Use of materials in gear design that will destruct over time and allow trapped catch to escape.	Use of biodegradable materials in nets and pots reduces ghost fishing (Macfadyen et al. 2009).	Use of biodegradable gear is likely to have upfront and ongoing maintenance costs for fishermen	Dockside gear checks or patrols can ensure appropriate gear configuration. Full observer coverage necessary to ensure 100% proper use.	All traps must have one destruction device. Cal. Fish & Game Code § 9003. Approved destruction devices are outlined in regulation. Cal. Code Regs. tit. 14 § 180.2.
	Ownership identification on gear	Establishes accountability and places more responsibility on the owner to track and recover their lost gear.	Required marking of gear facilitates gear recovery programs and encourages responsible fishing (Macfadyen et al. 2009).	Minimal costs to fishermen. Fishermen incentivized to do this already to indicate gear ownership.	Enforcement efforts not likely necessary, as this is common practice with non-regulatory incentives.	All traps must be marked with a buoy that identifies the operator. Cal. Fish & Game Code § 9006. Herring gillnets must be marked with a buoy that identifies the vessel number. Cal. Code Regs. tit. 14 § 163(f)(2)(F).
	Require full retention of all or a portion of a vessel's catch	Reduce discards and increase utilization of species that would otherwise be dead discards. Useful when	Full retention programs can be effective when tailored to avoid increases in total mortality of overfished	Possible costs to fishermen if required to land species with lower economic values (PFMC 2007).	Must be accompanied by an appropriate monitoring and enforcement strategy. Full monitoring coverage	Participants in EM EFPs in the Pacific groundfish fishery are required to operate under full retention rules with limited exceptions for some species (see:

Table K1 – Available Bycatch Mitigation Measures						
Category	**Sub-category**	**Concept**	**Considerations**			**California (or Pacific) examples**
			Efficacy in mitigating bycatch	**Economic effects on fishermen**	**Enforcement requirements**	
		retained catch cannot be released alive. Must consider the status and productivity of bycatch species. This does not necessarily minimize mortality.	species. Retention programs enable more comprehensive enumeration of bycatch and encourage fishermen to alter their activities so they are less likely to encounter non-target species (PFMC 2007).		only way to ensure 100% compliance.	http://www.pcouncil.org/groundfish/trawl-catch-share-program-em/em-efps/).
Full retention programs	Restrictions on offal discharge	Require offal discharge away from lines to distract seabirds, or prohibit discharge.	Discharging offal on the opposite side of the vessel from gear deployment minimizes seabird bycatch (Cox et al. 2007).	Minimal costs to fishermen.	Full monitoring coverage only way to ensure 100% compliance.	Groundfish longline vessels in Alaska state and federal waters must discharge offal in a manner that distracts seabirds from baiter hooks. 50 C.F.R. § 679.24(e)(2)(v); Alaska Admin. Code tit. 5 § 28.055.
Other bycatch mitigation, accountability, and data collection strategies	Training	Share fishing methods or proper handling and release techniques to minimize bycatch and maximize post release survival	Education and training programs are a recognized method to mitigate bycatch concerns (PFMC 2007).	Government funded trainings may have some attendance cost to fishermen. Costs can be defrayed by travel reimbursements or stipends.	Minimal enforcement costs. Administration of training program will have monetary costs that depend on the length and complexity of trainings.	As part of the Pacific Offshore Cetacean Take Reduction Plan, all drift gillnet vessel operators must attend skipper education workshops after notification from NMFS. 50 C.F.R. § 229.31(d). This program is expected to facilitate successful implementation of the take reduction plan and accompanying regulations (NMFS 1997).
	Descending and de-hooking devices	Increase post release survival of bycatch	Appropriate use reduces post-release mortality (Hannah and Matteson 2007).	Cost of devices vary from homemade to commercial devices (CDFW 2014).	Dockside monitoring to ensure all vessels are equipped.	The Department currently encourages the use of a variety of descending devices for rockfish (CDFW 2014). When descending devices are utilized, survival rates increase.
	Observers and Electronic Monitoring	Observers and EM can collect data on bycatch and fishing operations. Observers can function as a spotter for protected species and/or report violations.	Observer and EM programs can ensure compliance with many regulations and support management decisions through data collection. Possibility of inaccurate data due to the presence of observers or EM influencing fishing	Costs to fishermen will depend on the cost-sharing arrangement between government and fishermen for observers (NMFS 2013). Observers can have significant logistical costs to fishermen.	In some fisheries, observers report violations themselves, while in others law enforcement officers can use the data. Observer programs are some of the most expensive and funding is a primary concern (Department of	Tanner Crab permittees must have observers on board who collect a variety of information including bycatch, incidental take, and discards. Cal. Code Regs. tit. 14 § 126(a)(8). This observer program was vital for understanding the effects of this relatively new fishery and establishing its management approach (Commission 2005).

Table K1 – Available Bycatch Mitigation Measures						
Category	**Sub-category**	**Concept**	**Considerations**			**California (or Pacific) examples**
			Efficacy in mitigating bycatch	**Economic effects on fishermen**	**Enforcement requirements**	
			behavior (Alverson et al. 1994; NMFS 2013). Observers may be most useful for emerging or experimental fisheries with no data on their effect (Commission 2005)		Commerce 2003; NMFS 2013). EM can reduce these costs but typically collect more limited information focused on accountability.	
	Vessel monitoring systems	VMS allows monitoring of the location of vessels.	VMS is a more cost-effective method to ensure compliance with area closures (Department of Commerce 2003).	Equipment and communication costs are estimated at $3,250–$6,750 up front and $1,750 annually per boat. Costs to fishermen will depend on the cost-sharing arrangement between government and fishermen (Department of Commerce 2003).	Monitoring personnel required. High potential costs of implementation, but the VMS program costs are significantly less than traditional surveillance methods using ships and aircraft (Department of Commerce 2003).	Certain vessels in the west coast groundfish fishery must carry and operate a VMS unit when at sea. 50 C.F.R. § 660.14. VMS data is communicated to NOAA's office of law enforcement for use in focusing patrol efforts, preventing violations, and as evidence in prosecutions. (see: http://www.nmfs.noaa.gov/ole/about/our_programs/vessel_monitoring.html).
	Avoiding protected species through operational techniques	Using spotters or fleet communications to avoid bycatch hotspots; establishing procedures (e.g., back-down procedure for purse **seines**) to release protected species caught in gear.	Changes in operational techniques and patterns can effectively avoid bycatch of large or easily identifiable protected species.	Possible lost opportunity costs if large bycatch species impede fishing efforts.	Patrols or observers may be necessary to ensure compliance with required procedures.	Use of Sea State and operational and communication protocols in the Pacific Whiting fishery cooperative designed to avoid bycatch (see: http://www.pacificwhiting.org).

References

Alverson, D. L., M. H. Freeberg, J. G. Pope, and S. A. Murawski. 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. No. 339. Rome, FAO. Ch.9.

California Department of Fish and Game (CDFG). 2008. Review of California Halibut Trawl Fishery in the California Halibut Trawl Grounds, Report to the Fish and Game Commission. Accessed at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=36120&inline=true

California Department of Fish and Wildlife (CDFW). 2014. Bring That Rockfish Down. Accessed at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=36345&inline

California Department of Fish and Wildlife and the Ocean Protection Council (CDFW and OPC). May 2017. California Whale Entanglement Discussion, Dungeness Crab Fishing Gear Working Group, Meeting Summary. Accessed at http://www.opc.ca.gov/webmaster/_media_library/2016/08/Whales_WGSummary_May2017_FINAL.pdf

California Fish and Game Commission (Commission). 2005. Initial Statement of Reasons for Regulatory Action Re: Commercial Tanner Crab Fishery Provisions. Accessed at http://www.fgc.ca.gov/regulations/2005/126isor.pdf

Cox, T. M., R. L. Lewison, R. Zydelis, L. B. Crowder, C. Safina, and A. J. Read. 2007. Comparing effectiveness of experimental and implemented bycatch reduction measures: the ideal and the real. Conservation Biology 21(5):1155-1164.

Department of Commerce, Office of the Inspector General. 2003. NMFS Should Take a Number of Actions to Strengthen Fisheries Enforcement (IPE-15154). Accessed at https://www.oig.doc.gov/OIGPublications/IPE-15154.pdf

Dunn, D. C., A. M. Boustany, and P. N. Halpin. 2011. Spatio-temporal management of fisheries to reduce by-catch and increase fishing selectivity. Fish and Fisheries 12(1):110-119.

Dunn D. C., S. M. Maxwell, A. M. Boustany, and P. N. Halpin. 2016. Dynamic Ocean Management Increases the Efficiency and Efficacy of Fisheries Management. 113 Proceedings of the National Academy of Sciences 113(3):668.

Eayrs, S. 2007. A Guide to Bycatch Reduction in Tropical Shrimp-Trawl Fisheries. FAO.

Erickson D. L., and S. A. Berkeley. 2008. Methods to Reduce Bycatch Mortality in Longline Fisheries. In Camhi M. D., Pikitch E. K., Babcock E. A. (eds) Sharks of the Open Ocean: Biology, Fisheries and Conservation.

United Nations Food and Agriculture Organization (FAO). 2011. International Guidelines on Bycatch Management and Reduction of Discards. Accessed at http://www.fao.org/docrep/015/ba0022t/ba0022t00.pdf

Hannah, R. W., and K. M. Matteson. 2007. Behavior of nine species of Pacific rockfish after hook-and-line capture, recompression, and release. Transactions of the American Fisheries Society, 136(1):24-33.

Hannah, R. W., and S. A. Jones. 2007. Effectiveness of bycatch reduction devices (BRDs) in the ocean shrimp (*Pandalus jordani*) trawl fishery. Fisheries Research 85(1-2):217-225.

Hannah, R.W., M. J. M. Lomeli, and S. A. Jones. 2015. Tests of artificial light for bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl: Strong but opposite effects at the footrope and near the bycatch reduction device. Fisheries Research 70:60-67.

International Whaling Commission (IWC). 2001. Report of the Scientific Committee Annex I. Report of the sub-committee on small cetaceans. Journal of Cetacean Research and Management 2(Suppl.):235–257.

Marine Fish Conservation Network. 2004. Individual Fishing Quotas: Environmental, Public Policy, and Socioeconomic Impacts. Accessed at http://www.pcouncil.org/bb/2004/0404/C16d_PC_Apl04BB.pdf

Macfadyen G., T. Huntington, and R. Cappell. 2009. Abandoned, lost or otherwise discarded fishing gear. FAO Fisheries Technical Paper. No. 523. Rome, FAO.

Melvin, E. F., B. Sullivan, G. Robertson, and B. Wienecke. 2004. A review of the effectiveness of streamer lines as a seabird bycatch mitigation technique in longline fisheries and CCAMLR streamer line requirements. Commission for the Conservation of Antarctic Marine Living Resources Science 11:189-201.

National Marine Fisheries Service (NMFS). 1997. Environmental Assessment of Final Rule to Implement the Pacific Offshore Cetacean Take Reduction Plan. Accessed at http://www.nmfs.noaa.gov/pr/pdfs/interactions/poctrp_ea.pdf

National Marine Fisheries Service (NMFS). 2008. Report of the U.S. Longline Bycatch Reduction Assessment and Planning Workshop. NOAA Technical Memorandum NMFS-OPR-41.

National Marine Fisheries Service (NMFS). 2013. National Observer Program FY 2012 Annual Report. NOAA Technical Memorandum NMFS F/SPO-127.

National Marine Fisheries Service (NMFS). 2016. Magnuson-Stevens Fishery Conservation and Management Act; General Provisions for Domestic Fisheries; Application for Exempted Fishing Permit. 81 Fed. Reg. 10,593. (Mar. 1, 2016). Accessed at https://www.gpo.gov/fdsys/pkg/FR-2016-03-01/pdf/2016-04368.pdf

O'Keefe, C .E., S. X. Cadrin, K. D. E. Stokesbury. 2012. Evaluating Success of Bycatch Mitigation Measures. ICES CM 2012/C:17.

O'Keefe, C. E., and G. R. DeCelles. 2013. Forming a partnership to avoid bycatch. Fisheries 38:434-444.

Pacific Fishery Management Council (PFMC). 2000. Salmon Technical Team Recommendations for Hooking Mortality Rates in 2000 Recreational Ocean Chinook and Coho Fisheries.

Pacific Fishery Management Council (PFMC). 2007. Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species, Appendix C.

Pacific States Marine Fisheries Commission (PSMFC). 2017. Crab Gear/Whale Entanglement Workshop Summary. March 2017. Accessed at http://www.psmfc.org/crab/2017workshop/1-Summary%20final.pdf

Patrick, W. S., and L. R. Benaka. 2013. Estimating the economic impacts of bycatch in U.S. commercial fisheries. Marine Policy 38:470-475.

Petersen, S. L. 2008. Understanding and mitigating vulnerable bycatch in southern African longline and trawl fisheries. PhD thesis, University of Cape Town.

Sato N., D. Ochi, H. Minami, and K. Yokawa. 2012. Evaluation of the Effectiveness of Light Streamer Tori-Lines and Characteristics of Bait Attacks by Seabirds in the Western North Pacific. PLOS ONE 10.1371/journal.pone.0037546.

Schott, J. W. 1975. Otter trawl cod-end escapement experiments for California halibut. California Fish and Game 61:82-94.

Seadoc Society, U.C. Davis Wildlife Health Center. 2009. California Lost Fishing Gear Recovery Project Policies and Procedures. Accessed at http://www.seadocsociety.org/wp-content/uploads/p+pmanual2009.pdf

Segerson, K. 2010. Policies to reduce stochastic sea turtle bycatch: an economic efficiency analysis. In Dutton P, D Squires, and M Ahmed (eds) Conservation of Pacific Sea Turtles. Honolulu: University of Hawaii Press.

Stewart, N. 1974. Discussion on the Use of Escape Ports in Crab Traps. Report to the State/Federal Dungeness Crab Management Program Policy Committee Meeting.

Squires D., J. Joseph, and T. Groves. 2007. Buybacks in Fisheries. In Bayliff, W.H., and J. Majkowksi. Methodological Workshop on the Management of Tuna Fishing Capacity. FAO Fisheries Proceedings. No. 8. Rome, FAO.

Appendix L – Habitats, Gear Impacts, and Management Strategies

This appendix provides a general overview of potential fishing impacts on some California marine habitats. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Overview

California's marine habitats are vast and diverse with a wide range of fisheries that interact with them. Fortunately, significant mapping and research efforts have provided an array of resources for managers to draw on. These include:

- CDFW Marine Biogeographic Information and Observation System https://www.wildlife.ca.gov/Conservation/Marine/GIS/MarineBIOS
- United States Geological Survey California Seafloor Mapping Program https://walrus.wr.usgs.gov/mapping/csmp/
- California State University Monterey Bay Seafloor Mapping Lab statewide database http://seafloor.otterlabs.org/SFMLwebDATA.htm
- Essential Fish Habitat Data Portal http://efh-catalog.coas.oregonstate.edu/overview

While these resources provide detailed information and spatial data regarding habitats and their distribution, this appendix provides an overview of concepts for understanding potential fishing impacts to habitats.

Concepts for understanding habitat resilience

Not all habitats respond the same way when subjected to the same fishing activities. For instance, an area of soft muddy habitat that is trawled may show no ecological changes, while even one pass of a trawl in deep rocky habitat could destroy coral habitat that could take decades to recover (Auster and Langton 1999; Lindholm et al. 2015). For the purposes of fishery management, biological and geological habitat components are typically the most important when evaluating potential impacts from fishing activities. Biological habitat components include organisms that provide physical structure that can increase growth, survival, and productivity, such as structure-forming invertebrates. Many seafloor habitats are comprised of structure forming organisms, or, biogenic structures. Kelp, other algae, seagrass, sea whips, and sea pens, are some of the more common biogenic structures in California waters. Plant and algae species can typically regrow quickly, while structure forming invertebrates (corals, pens, etc.) are often slow growing or are slow to repopulate depleted areas. Geological habitat components include nonliving structures where organisms can seek shelter and feed, such as rocky crevices that protect juvenile fish from predators, burrows, depressions, and mounds (Baillon et al. 2012).

Common habitat classifications

Soft sediment seafloor
This habitat is characterized by expanses of unconsolidated sediments, such as sand and silt. Because they are unconsolidated, the sediments shift and are frequently disturbed by bottom currents, though the intensity of this disturbance lessens with depth. This prevents many sessile organisms from growing.

However, species like sea whips and sea pens are exceptions and can commonly be found in deep (50-2,600 meters) soft sediment (Stone 2006). Sea whips can create miniature forests in high concentrations. Studies have found that sea whip aggregations are frequently associated with several groundfish species (Brodeur 2001). Sea pen fronds have been observed to be important habitat for rockfish and other fish species larval settlers once they leave their planktonic life stage in the water column (Bailon et al. 2012). For roundfish, these organisms can provide habitat forming structure (Auster et al. 2003). Sea whips have a thin rigid stem that is vulnerable to breakage. Studies have found evidence that they can break with very little force and begin to die over the course of a year following breakage or abrasion (Malecha and Stone 2009). Lindholm et al. 2009 found a negative correlation between trawling activity in California and density of sea whips.

The most abundant physical structure within soft sediment habitat are depressions and crests. They can be created by flatfish or rays as they kick up the sediment, or from bottom currents (these structures are then referred to as wave form depressions). In shallower soft sediment habitats that experience stronger currents these depressions are especially important forms of shelter for flatfish and juvenile roundfish (Auster et al., 1996).

Fishing impacts: Fishing activities that contact the seafloor in these habitats are primarily traps and pots for crabs, lobster, groundfish, and hagfish, as well as bottom trawling for California Halibut, groundfish, and sea cucumbers. Other bottom tending gear used in California such as bottom longline and **set nets** have a smaller footprint in terms of area impacted and have limited impacts on the bottom (Chuenpagdee et al. 2003). The impacts from bottom trawling to physical structures created in the sediment may be temporary (Lindholm et al. 2015). The impacts to biogenic habitat such as sea whips and pens is potentially more significant and long-lasting (Wilson et al. 2002, Lindholm et al. 2009).

Mixed substrate seafloor

These seafloor habitats are comprised of low-relief cobble and boulders, sometimes mixed with silt and mud. Structure forming organisms such as anemones, sponges, and algae may be found covering these rocks. In shallow mixed substrate habitats that are subject to frequent disturbance from high wave action, long-lived sessile organisms are rare and species diversity is lower (Collie et al. 2000). Other areas may be home to soft sediment species as well, such as sea whips and pens that can sometimes grow in the sediment that aggregates between cobbles. Deeper mixed substrate habitats tend to be populated by species that are more vulnerable to disturbance, such as branching corals and sponges (Asch and Collie 2008). This habitat has been shown to provide shelter to small groundfish species and juvenile rockfish as they transition to deeper offshore waters (Yoklavich et al. 2000). Small scale habitats such as amphipod tubes that form encrusting colonies over cobbles have been shown to be vital to many fish species throughout their life stages (Auster et al. 1991). These structures can be vulnerable to disturbances significant enough to move or disturb the rocks on which these encrusting organisms grow, however they can recover from disturbance faster than sponges and corals (Henry et al. 2006).

Fishing impacts: Trawling has been shown to have varied impacts on the biomass of biogenic habitat (Freese et al. 1999; Freese et al. 2001; Henry et al. 2006). The higher and more varied the relief of the substrate, the more likely it will be that habitat will be damaged (Auster et al. 1996). In areas that lack corals and sponges and are instead covered with encrusting species like coralline algae, there may be little to no detectable differences in their biomass even after repeated trawling (Henry et al. 2006). In deeper mixed substrates where corals and sponges are more common, there have been significant decreases in biomass and biogenic structures following trawling activity (Freese et al. 1999; Freese et al. 2001). Traps and bottom longlines have less impact given their smaller spatial footprint and lower intensity of bottom contact (Auster and Langton 1999).

Rocky seafloor

Hard rock, shale, or compacted substrate allows for a wide variety of organisms to grow on their surface. At greater depths the rock is often covered with sponges, anemones, and branching corals that provide food and shelter for crustaceans and fish (Auster et al. 1991, Auster et al. 2003). Vast expanses of skate eggs have been found in deep reef in the Southern California Bight (Love et al. 2008). In rocky areas with high relief, the rock itself provides shelter for mobile species and is closely associated with rockfish species (Yoklavich et al. 2000). Deep offshore bare rock faces are also vital nurseries. In California's waters, these deep rock faces are frequently covered in corals and sponges. Corals in deep rocky reefs are home to high levels of biodiversity. They provide shelter for small organisms, and are correlated with aggregations of larger fish species (Tissot et al. 2006, D'Onghia et al. 2010).

Fishing impacts: Deep rocky reef is the most susceptible to long-lasting damage from fishing activity (Watling and Norse 1998; Freese et al., 1999). The corals that provide habitat are extremely long lived, slow growing and often very fragile. Even minor lacerations can lead to mortality in these species (Henry and Hart 2005). Bottom trawling poses the greatest potential threat to this habitat, however spatial restrictions and footrope requirements that reduce access to high relief areas mitigate this risk in many locations. Other bottom tending gear types, even those with relatively small spatial footprints such as bottom longlines, can have impacts on deep rocky reefs.

Kelp Forest

Kelp forests are among the most productive and biodiverse habitats on the planet (Mann 1973). Kelp forests are well adapted to strong disturbance forces from storms and wave action. Kelp has very large dispersal distances and canopies can regrow within months of a storm event. The distribution of kelp forest is constrained by physical factors including light, substrate, sedimentation turbidity, nutrients, water motion, salinity, and temperature (Steneck and Dethier 1994). If water becomes too turbid or if kelp blades become smothered by sediment or algal growths, then kelp cannot receive enough light to grow. California kelp beds experience seasonal die-offs from warming waters and winter storms, but quickly regrows in the spring and summer. However, extreme marine heat waves can have more severe and longer lasting effects.

Many commercially and recreationally important species such as California Sheephead, Spiny Lobster, abalone and seabass reside in kelp forests. Several juvenile rockfish and bass species rely on kelp fronds for shelter from predators in their juvenile stage (DeAlteris et al. 2000). Urchins and abalone are voracious kelp grazers, requiring large amounts of kelp to grow. Kelp forests are sustained through complex food-web interactions; removal or disruption of one species has led to massive kelp deforestation event on the West Coast (Steneck et al. 2002). Managers must therefore be mindful of the physical disturbances that can hinder kelp growth, as well as prevent the depletion of species that maintain healthy ecosystems.

Fishing impacts: While there is some limited entangling of gear and impacts from vessels, fishing has minimal direct impacts on kelp.

Common gear types

Habitat impacts and appropriate management strategies will be unique to each fishery. However, Table L1 below provides an overview of common gear types used in California and the impacts and management responses that are often associated with them.

Table L1. California gear types, associated habitat impacts, and common mitigation measures.

Common gear types	Common gear interactions	Habitat risks	Common management response	California examples
Bottom trawl	Net, footrope, and doors dig into sediment and organisms on the seafloor; can create large sediment plumes in soft habitat (DeAlteris et al. 2000).	Contact with gear can kill biogenic habitat and burrowing species and alter species composition; can reduce food and shelter for other fish species (Bergman and Stanbrink 2000).	Limiting trawling to more resilient soft bottom habitats; use of lighter touch gear to reduce bottom contact and sediment plume (Oniell and Summerbell 2011).	Footrope regulations and closures of Essential Fish Habitat areas protect sensitive habitat (Cal Code regs tit 14 § 27.51); designation of California Halibut Trawl Grounds with requirements for light touch gear (Cal Fish & Game Code § 8494 – 8497).
Set nets	Weights pulled along sea floor as net is hauled up; net itself snags and may pull up organisms growing on seafloor (Chuenpagdee et al. 2003).	Area of seafloor that weights contact may lose structural species and fragile species may catch and break on net (Auster 1998).	Limit length of net to reduce long hauls; limit use to areas of low relief with few structure forming organisms.	NA
Pots and traps	Gear rests on seafloor; storms may cause them to drag; can drag during hauling.	Structure forming organisms or high relief habitat may be damaged as gear is dragged during hauling or storms; large numbers of traps can have a cumulative impact (Jenkins and Garrsion 2013).	Limit number of traps per line; limit use in high relief habitat.	**Trap limits** cap the total amount of traps being fished at the same time, thereby limiting total impacted area (Cal Fish & Game Code §8276.5).
Drift gill nets	Net hangs from buoys in water column and rarely contacts habitat.	NA	NA	NA
Purse seine	Net only contacts bottom when deployed in very shallow water.	Has potential to impact bottom in shallow locations but risk is relatively low (Dayton et al. 1995).	Limit use in heavily vegetated shallow waters.	NA
Mid-water trawl	Trawl doors and net are dragged through water column rarely touching seafloor with most of the weight supported by the water (Sala et al. 2009).	Has potential to impact bottom but risk is low.	NA	NA
Hook-and-line	Light line suspends hook above seafloor, sometimes very light weight or hooks come into contact with seafloor.	Gear may snag on structure forming organisms, but risk is relatively low (Dayton et al. 1995).	NA	NA
Bottom longline	Weighted longline with multiple hooks must be dragged across seafloor to retrieve but it contacts a very small area.	Gear may snag on structure forming organisms, but risk is relatively low (Chuenpagdee et al. 2003).	NA	NA

References

Allen, J. I., S. D. Archer, J. C. Blackford, F. J. Gilbert, A. H. Taylor. 2006. Changes in DMS production and flux in relation to decadal shifts in oceanic circulation. Tellus 58B:242-254.

Asch, R., and J. Collie. 2008. Changes in a benthic megafaunal community due to bottom fishing and the establishment of a fishery closure. Fishery Bulletin 106(4):438-456.

Auster, P. J. 1998. A conceptual Model of the Impacts of Fishing Gear on the Integrity of Fish Habitats. Conservation Biology 12(6):1198-1203.

Auster, P. J., R. J. Malatessta, S. C. LaRosa, R. A. Cooper, and L. L. Stewart. 1991. Microhabitat utilization by the megafaunal assemblage at a low relief outer continental shelf site - Middle Atlantic Bight USA. Journal of Northwest Atlantic Fishery Science 11:59-69.

Auster, P. J., R. J. Malatesta, R. W. Langton, L. Watling, P. C. Valentine, C. L. S. Donaldson, E. W. Langton, A. N. Shepard, and W. G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): implications for conservation of fish populations. Reviews in Fisheries Science 4(2):185-202.

Auster, P. J., J. Lindholm, and P. Valentine. 2003. Variations in habitat use by acadian redfish, *Sebastes fasciatus*. Environmental Biology of Fishes 68(4):381-389.

Auster, P. J., and R. W. Langton. 1999. The effects of fishing on fish habitat. J. of American Fisheries Society Symposium 22:150-187.

Baillon, S., J. F. Hamel, V. E. Wareham, and A. Mercier. 2012. Deep cold water corals as nurseries for fish larvae. Frontiers in Ecology and the Environment 10(7):351-356.

Bergman, M. J. N., and J. W. van Santbrink. 2000. Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea in 1994. ICES Journal of Marine Science 57(5):1321-1331.

Brodeur, R. 2001. Habitat-specific distribution of Pacific Ocean Perch (Sebastes alutus) in Pribilof Canyon, Bering Sea. Continental Shelf Research 21(3):207-224

Collie, J. S., G. A. Escanero, P. C. Valentine. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. ICES Journal of Marine Science 57(4):987-1001.

Chuenpagdee, R., L. Morgan, S. Maxwell, E. Norse, and D. Pauly. 2003. Shifting gears: assessing collateral impacts of fishing methods in US waters. Frontiers in Ecology and the Environment 1(10):517-524.

Dayton, P. K., S. F. Thrush, M. T. Agardy, and R. J. Hofman. 1995. Environmental effects of marine fishing. Aquatic Conservation: Marine and Freshwater Ecosystems 5(3):205-232.

Dayton, P. K., M. J. Tegner, P. B. Edwards, and K. L. Riser. 1999. Sliding baselines, ghosts, and reduced expectations in kelp forest communities. Ecological Applications 8(2):309-322.

DeAlteris, J. T., L. G. Skrobe, and K. M. Castro. 2000. Effects of mobile bottom fishing gear on biodiversity and habitat in offshore New England waters. Northeastern Naturalist 7(4):379-394.

D'Onghia, G., P. Maiorano, L. Sion, A. Giove, F. Capezzuto, R. Carlucci, and A. Tursi. 2010. Effects of deep-water coral banks on the abundance and size structure of the megafauna in the Mediterranean Sea. Deep-Sea Research 57:397-411.

Eno, N. C., D. S. MacDonald, J. A. M. Kinnear, S. C. Amos, C. J. Chapman, R. A. Clark, F. Bunker, and C. Munro. 2001. Effects of crustacean traps on benthic fauna. ICES Journal of Marine Science 58:11–20.

Freese, L., P. J. Auster, J. Heifetz J., B. L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. Marine Ecology Progress Series 182:119-126.

Freese, J. 2001. Trawl-induced damage to sponges observed from a research submersible. Marine Fisheries Review 63(3):7-13.

Henry, L. A., and M. Hart. 2005. Regeneration from injury and resource allocation in sponges and corals: a review. International Review of Hydrobiology 90(2):125–158.

Henry, L., E. L. R. Kenchington, T. J. Kenchington, K. G. MacIsaac, C. Bourbonnais-Boyce, and D. C. Gordon Jr. 2006. Impacts of otter trawling on colonial epifaunal assemblages on a cobble bottom ecosystem on Western Bank (northwest Atlantic). Marine Ecology Progress Series 306:63-78.

Hughes, B., K. Hammerstrom, N. Grant, U. Hoshijima, R. Eby, K. Wasson. 2016. Trophic cascades on the edge: fostering seagrass resilience via a novel pathway. Oecologia 182(1):231-241.

Jenkins L. D., and K. Garrison. 2013. Fishing gear substitution to reduce bycatch and habitat impacts: An example of social–ecological research to inform policy. Marine Policy 38:293-303.

Lindholm, J., M. Kelly, D. Kline, and J. de Marignac. 2009. Patterns in the local distribution of the sea whip (Halipteris willemoesi), in an area impacted by mobile fishing gear. Marine Technology Society Journal 42:64-68.

Lindholm, J., P. Auster, and P. Valentine. 2004. Role of a large marine protected area for conserving landscape attributes of sand habitats on Georges Bank (NW Atlantic). Marine Ecology Progress Series 269:61-68.

Lindholm, J., M. Gleason, D. Kline, L. Clary, S. Rienecke, A. Cramer, M. Los Huertos. 2015. Ecological effects of bottom trawling on the structural attributes of fish habitat in unconsolidated sediments along the Central California outer continental shelf. Fisheries Bulletin 113:82-96.

Love, M. S., D. M. Schroeder, L. Snook, A. York, and G. Cochrane. 2008. All their eggs in one basket: a rocky reef nursery for the longnose skate (Raja rhina Jordan and Gilbert 1880) in the Southern California Bight. Fisheries Bulletin 106:471-475.

Malecha, P. W., and R. P. Stone. 2009. Response of the sea whip Halipterus willomoesi to simulated trawl disturbance and its vulnerability to subsequent predation. Marine Ecology Progress Series 388:197-206.

Mann, K.H. 1973. Seaweeds: their productivity and strategy for growth. Science 182:975–981.

Morrisey, D. J., L. Howitt, A. J. Underwood, and J. S. Stark. 1992. Spatial variation in soft-sediment benthos. Marine Ecology Progress Series 81:197-204.

O'Niell, F. G., and K. Summerbell. 2011. The mobilisation of sediment by demersal otter trawls. Marine Pollution Bulletin 62(5):1088-1097.

Steneck, R. S., M. H. Graham, B. J. Borque, D. Corbett, J. L. Erlandson, J. A. Estes, and M. J. Tegner. 2002. Kelp forest ecosystems: biodiversity, stability, resilience and future. Environmental Conservation 29(4):436–459.

Stone, R. P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25(2):229–238.

Tissot, B. N., M. M. Yoklavich, M. S. Love, K. York, and M. Amend. 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral. Fisheries Bulletin 104(2):167–181.

Sala, A., J. D. P. Farran, J. Antonijuan, and A. Lucchetti. 2009. Performance and impact on the seabed of an existing- and an experimental-otterboard: Comparison between model testing and full-scale sea trials. Fisheries Research 100(2):156-166.

Steneck, R. S., M. H. Graham, B. J. Bourque, D. Corbett, J. M. Erlandson, J. A. Estes, and M. J. Tegner. 2002. Kelp forest ecosystems: biodiversity, stability, resilience and future. Environmental Conservation 29(4):436–459.

Steneck, R.S., and M. N. Dethier. 1994. A functional group approach to the structure of algal-dominated communities. Oikos 69:476–498.

Watling, L., and Norse E.A. 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12(6):1180-1197.

Wilson, M.T., A.H. Andrews, A.L. Brown, and E.E. Cordes. 2002. Axial rod growth and age estimation of the sea pen, Halipteris willemoesi Kolliker. Hydrobiologia 471:133–142.

Yoklavich, M. M., H. G. Greene, H. M. Calliet, D. E. Sullivan, R. N. Lea, and M. S. Love. 2000. Habitat associations of deep-water rockfishes in a submarine canyon: an example of natural refuge. Fisheries Bulletin 98(3):625-641.

Appendix M – Socioeconomic and Community Considerations

As discussed in Chapter 7, the following questions are provided to help managers systematically considered the socioeconomic impacts of management whether developing an ESR, an FMP, or a rulemaking package. They are suggested as a starting point for building information and understanding about the human dimensions/socioeconomics of the state's fisheries to support management consistent with the MLMA. Most of the following questions can be applied across fishery sectors: commercial (including for-hire), recreational, and subsistence. Further definition and operationalization of the questions and terms is fishery-specific.

SOCIOECONOMIC OBJECTIVES

Sustainable use

1. How do people use the state's fishery resources?
2. What social, cultural, and economic benefits do fishery participants derive from fishing?
3. What aesthetic, educational, scientific, and non-consumptive recreational benefits do non-fishery participants derive from the state's marine resources?
   a) Scuba and free diving and associated newsletters/blogs by diving organizations
   b) Photography and filmmaking
   c) Scientific research inside and outside of MPAs
   d) Public education through dissemination of results of above
4. What is necessary (and sufficient) to sustain resource use?
5. Is the fishery's human system sustainable (viable ecologically and socioeconomically)?
6. How do fishery management actions affect:
   a) Fishery participation?
   b) Fishery activity/production?
   c) Infrastructure?
   d) Fishing communities?

Long-term well-being of fishing-dependent people observed

1. How are people dependent on fishing for food, livelihood, or recreation?
2. How does fishing contribute to the well-being of:
   a. Fishing-dependent people?
   b. Fishing communities?
   c. Fishing economies?
3. What conditions/factors affect people's fishing for food, livelihood or recreation?
4. How do changes in management, individually and cumulatively, affect their long-term well-being?

Adverse impacts on small-scale fisheries, fishing communities and economies minimized

1. How does management affect the function of:
   a) Small-scale fisheries?
   b) Fishing communities?
   c) Fishing economies?
2. How does management affect the well-being of:
   a) Small-scale fisheries?
   b) Fishing communities?
   c) Fishing economies?
3. What are the cumulative impacts of management on:

a) Small-scale fisheries?
b) Fishing communities?
c) Fishing economies?

Catches allocated fairly

1. What are the criteria for allocating resources among fishery participants (e.g., equal shares, need, fishing history)?
2. How is fairness defined and perceived by fishery participants?
3. Do allocation options meet criteria for fairness?
4. What are the social and economic impacts and implications of allocation options for:
   a) Fishery participants?
   b) Fishing communities?
   c) Fishing economies?

Prevent/reduce excess effort

1. What constitutes excess effort in the fishery?
2. What factors contribute to excess effort in the fishery?
3. How does excess effort affect the fishery's human (as well as ecological) system?
4. What are the impacts and implications of measures to reduce excess effort for the fishery's human system?

MANAGEMENT SYSTEM OBJECTIVES

Proactive/responsive to changing environmental, market or other socioeconomic factors and concerns

1. What environmental factors or concerns affect the fishery?
2. What market (or broader economic) factors or concerns affect the fishery?
3. What social factors or concerns affect the fishery?
4. Are there new/emerging opportunities in the fishery?
5. Are there new/emerging challenges or problems in the fishery?
6. What are the impacts and implications of changing factors, concerns or opportunities for the fishery's human system?

Conflict resolution

1. Are there actual or potential conflicts related to gear, access to the resource, or other aspects of the fishery?
2. What are the impacts and implications of conflict for the fishery's human (as well as the ecological) system?
3. What are the options for avoiding, mitigating or eliminating conflict?
4. What are the impacts and implications of measures to avoid, resolve or mitigate conflict?

ECOLOGICAL SYSTEM OBJECTIVES

Sustainable resource

1. How do fishing practices affect the long-term health of the resource?
2. What are the options for modifying or eliminating fishing practices that negatively affect the long-term health of the resource?
3. How do those options affect:
   a) Fishery participation?
   b) Fishery activity/production?
   c) Infrastructure?
   d) Fishing communities?

Healthy habitat

1. What are the impacts of fishing practices (gear, equipment, and their use) on habitat?
2. How do measures to maintain, restore and/or enhance habitat affect the fishery's human system?
3. How do fishery participants' responses (e.g., changes in practices) to management change affect the achievement of fishery objectives?

Restore/rebuild depressed fisheries

1. What factors contribute to the depressed fishery?
2. What are the impacts and implications of the depressed fishery for the human system?
3. How do management options for rebuilding the depressed fishery affect the human system?
4. How do human system responses, in turn, affect the fishery's human and ecological systems?

Bycatch limited

1. What fishing practices are associated with unacceptable types and amounts of bycatch?
2. What are the social and economic impacts of modifying these practices to address bycatch concerns?
3. What are the implications of modifying these practices for fishery's human and ecological system?

Appendix N – Partnerships

This appendix draws information and conclusions from a report by The Nature Conservancy that was prepared during the information gathering phase of the Master Plan review (Wilson et al. 2016). It provides additional details regarding the potential role of partnerships in fisheries management. It also elaborates on the varying levels of capacity and longevity that stakeholder organizations should possess in order to effectively partner with the Department on certain tasks. As with the other appendices, it is anticipated that this overview will continue to be expanded and refined as part of Master Plan implementation so that it can serve as an effective resource to managers and stakeholders.

Fishery Partnerships

As discussed in Chapter 8, partnerships between agencies, Tribes and tribal communities, fishing communities, NGOs, funders, and others span a broad continuum and differ in how responsibility and authority are shared. Regardless of the exact arrangement, the principles of partnerships typically infer that some management or governance tasks—research and monitoring, regulatory scoping, decision-making, enforcement and surveillance, and conflict resolution—are shared with non-government actors.

Where a particular fisheries partnership falls on this continuum depends on numerous features, particularly the complexity of the task to be addressed and the capacity of the partnering entities. On the low end of this continuum, individuals might participate in a one-time stakeholder engagement process, which requires minimal investment and commitment. The opposite end of this continuum includes formal partnerships typically laid out in a Memorandum of Understanding detailing their contribution to a shared management goal to be achieved by sustained collaboration over a long-time period. Between these two extremes lie numerous opportunities for partnerships with varying formality, investment, and duration. Key to forming a successful partnership is understanding the capacity of partnering individuals or entities to fulfill what is expected of them. The discussion below identifies specific common tasks that the Department engages in as part of management. These tasks are generally ordered by the degree of capacity and longevity required on the part of stakeholders (see Figure N1).

Figure N1. A spectrum of partnership-based approaches. The management tasks and types of partnerships are arranged along this continuum in terms of how much organizational capacity, funding and longevity is required for successful partnerships to help meet management objectives or tasks. (Adapted from Wilson et al. 2016.)

All partnerships require investment. In considering new partnership opportunities to improve fisheries management, the Department will need to evaluate whether a proposed partnership is mutually beneficial. The investment of funds, staff time, and other resources must be weighed against the benefits that will be realized from the partnership under consideration. As detailed below, some management activities likely lend themselves to beneficial partnerships more than others. Nevertheless, well-conceived fisheries partnerships can enhance the Department's ability to fulfill its mission and achieve the objectives of the MLMA.

Benefits of partnerships

When designed effectively and thoughtfully, partnerships are a powerful tool to support short and long-term management and conservation goals, as well as strengthen the scope and integrity of data used to inform management decisions. Empowering Tribes and tribal communities, fishermen, local community members, and NGOs to become active partners in management can help tailor regulations and decisions to reflect current fishing practices and realistic on-the-water conditions. Localized knowledge and expertise can provide additional context to improve approaches to management. Previous studies have found that fishermen that possess an understanding of the rationale and legitimacy for certain decisions typically operate more responsible fishing practices and exhibit better compliance (McCay and Jentoft 1996).

In the face of increasingly variable ocean conditions, partnerships provide an effective mechanism to promote ecological and social resilience as discussed in Chapter 11. Fisheries management systems that rely on cooperative approaches and partnerships are often better equipped to address environmental change when compared with conventional, top-down approaches (McClenachan et al. 2015). Resource users and harvesters, such as fishermen, are often first to notice changes in the environment (Dietz et al. 2003). Furthermore, effective climate change adaptation in marine fisheries demands improved knowledge of future ecosystem states. Developing collaborative partnerships with university researchers provides the opportunity to integrate best-available climate science directly into fisheries management decisions.

While the involvement of stakeholders as partners can require an investment of resources to support high start-up costs (Nielsen and Vedsmand 1997; Coglan and Pascoe 2015), the long-term investment in building support and cultivating stewardship offers ecological, economic, and social benefits, as well as direct benefits to fisheries managers. Below are examples of the ecological, economic, social, and direct benefits that have been realized through fisheries partnerships elsewhere.

Potential ecological benefits

- Maintain sustainable stock levels that are represented by long-term increases in abundance and stock health (Gutiérrez et al. 2011; Defeo et al. 2014)
- Improved conservation of sensitive habitats, nursery grounds and spawning grounds (Pinkerton 2009)

Potential economic benefits

- Decreased cost of management for government agencies, especially in high value fisheries (Coglan and Pascoe 2015)
- Increased or maintained revenue streams through stabilized landings, and prevention of fishery collapse by ensuring assessments and harvest levels reflect actual stock sizes (Gutiérrez et al. 2011)

Potential social benefits

- Increased community empowerment (Gutiérrez et al. 2011) and a more democratic and participatory system where the interests of government, fishermen, and community members become better aligned

Potential benefits to the Department

- Increased support for cost and task sharing opportunities (Pinkerton 1994; Pinkerton 2009)

creating the potential for more efficient and productive management
- Support and buy-in for fisheries management regulations and policies leading to enhanced compliance and better working relationships with industry

Success of partnerships

Lessons learned in California and elsewhere provide some guidance and best practices for forming successful partnerships. The following elements are crucial to realize the potential of partnerships to contribute to fisheries management in California:

- The need for durable and lasting fisheries organizations and strong fishing leadership
- The important role of change agents
- Access to consistent funding by stakeholder organizations
- Multi-directional generation and exchange of knowledge/information
- Presence of strong top down governance and management regulations
- Ability to build trust and social capital
- The degree to which management decisions are decided upon in an open and transparent process

Fisheries organizations and fishing leadership
Fisheries organizations, from legislatively mandated arrangements to volunteer associations, can differ in their motivation and capacity depending, in great part, on the size and diversity of the fleet. Typically, high valued fisheries with complex regulations tend to be better organized and have identifiable leadership that can play a direct role in informing and/or overseeing management decisions. Organizations that have a formal legal structure can more readily offer more secure partnerships with agencies like the Department. Fishery organizations that do not have a legal structure have greater opportunities with being successful in long-term partnerships if they are designed and/or equipped to be durable, resilient, and flexible.

Change agents
Through their role as intermediaries, external change agents or "bridging organizations" can help empower fishermen, scientists, and Department staff to enhance their capabilities and available resources (Pomeroy et al. 2001). Change agents can provide resources and expertise in plan development, brainstorming, problem solving, information gathering and sharing, and participatory facilitation and communication. Change agents are often NGOs organizations, academic and research institutions, or development agencies that rarely play a role in decision-making. Rather, they are objective and seek to expedite the partnership process by setting in place a process of discovery and social learning. External change agents' connection with local communities, their ability to focus on community objectives, and linkages with donors and other supportive organizations are factors that favor their role.

Consistent funding
Partnerships take time to become established and can take years to evolve into a process that can support collaborative decision-making. Consistent funding sources for fishery organizations and agencies contribute to the success of partnerships, providing the security for both resource managers and fishermen to invest time and resources in establishing relationships, identifying common goals, implementing collaborative efforts, and evolving from lessons learned.

Typically, there is infrastructure established to support fisheries partnerships that evolve beyond initial start-up funds and grow to diversify their funding portfolio. Fundraising and project management skills, good financial judgment, and political savvy increase a partnership's likelihood of long-term viability and success. For example, partnerships involving researchers and/or NGOs skilled in grant writing and aware of funding cycles can play important roles in the long-term sustainability of a partnership. Additionally, these entities may have mechanisms in place to receive funding from various sources (e.g., NGOs) and the Legislature has clearly recognized the need and value for alternative sources of revenue to fund the Department's necessary marine conservation, restoration, and resource management, and protection responsibilities (§710.7(c)). Roles and responsibilities of those charged with developing and implementing strategies to acquire partnership funding should be fully outlined to ensure everyone involved in the partnership is operating within the same expectations.

Information exchange
Generating and/or sharing information between partners can take many forms. Informal, one-on-one conversations between fishermen and resource managers can be used to address clarifying questions or to share information about what fishermen are experiencing on the water. Agency staff may use surveys to poll fisheries lacking in fisheries independent data, and researchers may request fishermen to interpret fisheries dependent data.

Involving fishermen in the gathering, interpretation, and reporting of fisheries management data is considered a gateway or "entry point" to more comprehensive forms of collaborative management (Trimble and Berkes 2013). Fishermen involved in these projects typically see value in their participation in a collaborative research team, and see their involvement as direct recognition by resource managers and academic scientists of the quality and importance fishermen's input has in shaping research questions and designing surveys (Pinkerton 2009). Involving fishermen from the "ground up" helps build trust in the scientific process, credibility in the results, and creates an atmosphere where fishermen play a role in championing the research project within their fishery, ports, and communities (Pinkerton 2009). The exchange of ideas and information can be equally as valuable to Department staff involved in the partnership, who gain local and experiential knowledge (Hovel et al. 2015).

Anticipated changes in regulations
Resource managers, agency staff, decision makers, and funders are increasingly interested in understanding the motivations for the continued participation and mobilization of fisheries partnerships. Anticipated changes in management regulations can act as a catalyst to activating—or reenergizing—fisheries partnerships. International experiences show that fisheries management regulations are unlikely to succeed without support from fishermen, because fishermen often find ways of by-passing those regulations (Hanna 1995).

Establishing trust and developing social capital
Trust is an essential building block to successful fisheries partnerships and efficient fisheries management. Investment in relationship building and establishing confidence across partnership participants should be considered and integrated. Solid and long-lasting relationships can also act as an incentive to maintain on-going collaborative efforts**.** The core concept of social capital is "interactions among individuals" with the inherent goal to strengthen social interactions in and between groups concerned with a given issue.

Potential role of partnerships in management

Six fundamental management tasks that can benefit from fisheries partnerships and identifies the degree of stakeholder capacity required to effectively partner on each (Table N1).

Table N1. Overview of the level of capacity needed for stakeholder groups to effectively partner with the Department to accomplish particular management tasks. (Adapted from Wilson et al. 2017)

Management Task	STAKEHOLDER CAPACITY		
	Representativeness	**Funding**	**Longevity**
Prioritization of Fisheries Management	Medium	Low	Low
Fishery Specific Planning	High	Medium	Low
Research and Monitoring	Low	Medium	Medium
Stock Assessment	High	High	Medium
Decision Rules	High	Medium	High
Compliance and Enforcement	High	High	High

- Representativeness is defined by whether the group represents the broader constituency through democratic or otherwise egalitarian means. If a low level of representativeness is required it means that a relatively few members of the fishery may participate effectively in a partnership. A high level of representativeness indicates that in order to successfully partner in a particular management task, a more representative constituency is needed.
- Funding refers to the ability to raise funds for participatory processes. A small group of fishermen may score in the low, whereas a marketing association (e.g., California Sea Urchin Commission) or NGO may score towards the higher end.
- Longevity refers to the ability of the group to participate as a lasting partner without concern for erosion of duties and responsibilities over time. A small group of disorganized stakeholders may not be as durable as an academic institution for example.

Collectively, these attributes reflect a prospective partner's capacity.

<u>Management Task 1: Prioritization of management efforts</u>

As described in Chapter 2, the Department has many responsibilities but limited capacity. Prioritization approaches that incorporate the expertise and perspectives of stakeholders can help identify the fisheries in most urgent need of management attention. Stakeholder engagement (and structured partnerships with groups like OST) has and will continue to play key roles in setting priorities. Prioritization does not require an ongoing or durable partnership with the same entities and partners only need minimal capacity to participate.

<u>Management Task 2: Fishery-specific planning</u>

Partnerships can facilitate the fishery management planning process in a number of ways, including by helping to provide or secure external funding and outside expertise. Additionally, stakeholders (fishermen in particular) have vital roles to play in the assembly and interpretation of EFI, the development of a practical and focused research protocols, and the identification of appropriate management strategies and control rules. How the effort looks in terms of incorporating additional stakeholder input will vary based on the dynamics of the fishery. For example, for the Pacific Herring FMP, the nature of the fishery allowed for a small focused steering committee to work closely with the Department and have a high degree of involvement in process management and decision-making (Pacific Herring Discussion Group 2015). Other fisheries, such as California Halibut, are more complex in terms of user groups, gear types, and port perspectives and thus a different approach to engagement will be necessary. The benefits of partnerships in fishery-specific planning extend beyond the FMP model to non-FMP fishery-specific documents, such as the development of ESRs as described in Chapter 3.

The primary benefit of a partnership-based approach to planning is that it can attract the funding and provide the organization that allows for comprehensive management reform where it would otherwise not be possible. This can facilitate regulatory changes that enhance the biological and economic sustainability of the fishery. It can also focus limited research funding on the most instructive areas. Further, this partnership-based approach empowers individuals and promotes buy-in to the process and its results. In order to partner with the Department to help initiate and advance planning efforts, stakeholder groups need to be representative and have the capacity to help organize the effort, seek funding, and communicate with their constituents. Durability of the stakeholder group is not an issue to the same extent it is with long term efforts given the shorter-term, project-based nature of fishery planning.

Management Task 3: Research and Monitoring

CFR—where fishermen and the fishing industry are actively involved in the design and implementation of research and monitoring that supports management—is key to helping the Department manage fisheries in a cost-effective way. CFR can help the Department in the following ways:

- Expand the capacity to do research and fill information gaps that the Department currently does not have staff or expertise to do. Given that Department capacity and resources for research are not likely to increase in the near-term, external partnerships are a potential vehicle to achieve more.
- CFR partnerships can play a key role in conducting research, potentially enabling staff to focus more on an oversight and management role.
- Lend credibility and trust to management approaches by avoiding “cloistered” approaches (either the Department doing science and making management decisions alone, or an academic doing research and bringing “the answer” to the agency).
- Involve key stakeholders to ensure that the resulting management approach has more buy-in and is designed to achieve desired outcomes.

There is a distinction between the levels of capacity and durability required for ad-hoc research versus long term monitoring. Generally, research is more short-term, and project-based. Stakeholder partners do not need to be representative of the fleet, or have significant capacity beyond being able to reliably participate in the research. They also do not need to be particularly durable given the typically short-term nature of the work. By contrast, monitoring involves regular, consistent sampling over time to build a time series of data.

Partnerships require organizations that have sufficient capacity to engage over time and are sufficiently long-standing that the Department can be reasonably assured that efforts to incorporate the group into monitoring will be worthwhile and will not pose a threat to the stability and integrity of the monitoring effort. The organization does not need to be particularly representative as the perspectives of the broader fleet are not directly at issue.

Management Task 4: Stock assessments

In the face of limited resources for carrying out full stock assessments, alternative assessment approaches open the door for increased stakeholder participation in data collection, determination of appropriate performance indicators and reference points, as well as the selection of appropriate stock assessments. Partnerships can play a role in facilitating, developing, and carrying out both empirical and model-based stock assessment approaches for improved management of California fisheries. Partners can be leveraged to assist with stock assessments through a variety of avenues, several of which are described below.

Similar to the potential collaborations and partnerships described in Task 3 regarding research and monitoring, universities and other academic institutions can play an important role in supporting stock assessments. A strong out-of-state example is the University of Washington and NOAA's Joint Institute for the Study of the Atmosphere and Ocean (http://www.jisao.washington.edu/about-jisao), which funds graduate students to work on applied fishery management issues, in particular stock assessments, primarily for federally-managed fisheries. Private research institutions, stakeholder working groups, and NGOs are also capable of fulfilling several duties associated with assessments. As described in Chapter 5, NGO and academic partners worked with the Department to apply data moderate stock assessments to a suite of California fisheries and in the process, develop a California specific DMLtool. Similarly, a working group on data-limited fisheries, funded through the Science for Nature and People Partnership, developed a decision support system for choosing an appropriate management strategy for data- limited fisheries (SNaP 2015; Dowling et al. submitted).

The use of fishing industry funds to help hire independent contractors to fulfill stock assessment requirements is an approach that the Department has used before and is embraced by a number of national governments across the globe (Castilla and Fernández 1998). The California Sea Urchin Commission has funded independent research to determine biological characteristics important to the long-term sustainability of the fishery for many years (Ebert et al. 1994). Such funding has also been leveraged to understand the biological and economic value of adjusting the minimum size limit in the fishery. In the Pacific Herring fishery, the San Francisco Bay Herring Research Association, an NGO formed with money from the Cosco-Busan spill funded a stock assessment in partnership with herring fishermen.

In order to effectively engage in partnerships focused on assessments, stakeholders need a comparatively high degree of organization. Assessments are technical and even simplified approaches require sufficient funding to conduct. The use of industry funds to support assessments implies adequate representativeness to first collect funding and then sufficient structure and strategy to decide how those funds should be spent. Academic institutions typically have the capacity required to engage in assessment-based research as well as the technical abilities to assist in helping to select and conduct assessments. Because assessment work is comparatively short-term and project-based, proven stakeholder group durability is potentially less of a concern.

Management Task 5: Harvest Control Rules

To achieve harvest sustainability, managers are charged with prescribing a system of decision rules that meet target objectives for fisheries management. The development of HCRs is arguably the single most important component of a management strategy. Development of decision rules that meet multiple objectives can be enhanced through active participation among managers, scientists, industry participants and constituents (FAO 1995). Using static decision rules such as the prescription of a TAC set at a fraction of historical landings or an assumed unfished spawning stock biomass (Restrepo et al. 1998; Berkson 2011), often fails to meet the needs of a diverse set of stakeholders.

As discussed in Chapter 11, with climate change there is a need to develop adaptive decision rule frameworks that allow for rapid adjustments to management measures without the need for lengthy legislative, or otherwise bureaucratic approaches to fishery management. Such processes need to be transparent, objective, and simple in order to be readily integrated into state fisheries management. Working with partners to help develop, test, and implement these systems is critical toward helping prepare for an uncertain future that will require nimbleness and flexibility in decision-making.

Partners can participate in the development of decision rules in many ways, including via an MSE process as discussed in detail in Appendix J. MSE is a procedure that allows for the objective and explicit consideration of tradeoffs between alternative management strategies including the management measures and control rules that link assessment outcomes with the management response (Smith 1994). The use of MSE as a guide for selection and implementation of decision rules must be informed by partners since it is dependent on a number of assumptions about stakeholder objectives, ecological dynamics and behavior of fishermen. MSE can streamline decision-making and can reduce the costs of management when appropriately designed.

There is a continuum of potential stakeholder involvement with the development and adjustment of HCRs. On the lower, stakeholder engagement end, stakeholders do not need to be as well organized. The Department can solicit specific input from stakeholders without concerns regarding the durability of organizations or their capacity. This is a form of stakeholder engagement. On the other hand, in more formal and structured approaches, stakeholders will need to be more organized and need greater capacity to engage in framework approaches described above. Given the potential for direct consequences, fishermen in MSE working groups need to be representative of the interests of the broader fleet. The durability of stakeholder organizations is of particular concern if structured adaptive management processes identify stakeholder organizations by name. However, as in the White Seabass FMP, adaptive management structures need not be dependent on particular organizations.

Management Task 6: Compliance and enforcement

Effective law enforcement, as well as consistent voluntary compliance with fishery management measures, is critical for protecting California's marine resources and the fisheries and communities that depend on them. Given the state's more than 1,100 miles of coastline and numerous existing fishery regulations, the Department faces some significant logistical, economic, and capacity challenges in achieving desired compliance and enforcement outcomes across the state.

The Department has already incorporated partnerships into its compliance and enforcement. In addition to partnering with managers and industry groups and providing specific fisheries-related training for allied enforcement agencies and tribal entities, the Department has:

- Provided outreach and education to MPA Collaborative Network members on regulations pertaining to MPAs and what to do if they encounter a potential violation
- Provided support and specialized training for the Natural Resource Volunteer Program, whose members provide education and outreach regarding marine regulations in partnership with the Department
- Furthermore, CalTIP (Californian's Turn in Poachers and Polluters) now has a dedicated mobile device application for ease of use in reporting violations (see: http://caltiponline.org/)

Building off these successful existing partnerships and looking to models from around the country and the world, almost every aspect of a comprehensive compliance and enforcement strategy can be improved by expanded partnerships. However, due to the sensitive nature of enforcement activities, any partnerships must be formed with a great deal of consideration and forethought.

Engaging fishing leaders in the development of important regulations and management changes can improve the outcomes, increase buy-in and awareness and support high-levels of voluntary compliance as well as peer-to-peer education. Industry cooperatives, advisory committees, sport fishing groups, and other organizations can provide significant assistance in improving the awareness and understanding of existing and new relevant regulations by working directly with the Department to organize and host workshops and education sessions and distributing informational materials to members. These groups could also take on significant responsibilities in encouraging best practices among their members to support management and enforcement objectives.

References

Berkson, J., L. Barbieri, S. Cadrin, S. Cass-Calay, P. Crone, P. Dorn, C. Friess, D. Kobayashi, T. J. Miller, W. S. Patrick, S. Pautzke, S. Ralston, and M. Trianni.2011. Calculating Acceptable biological catch for stocks that have reliable catch data only. NOAA Technical Memorandum, NMFS-SEFSC-616. Accessed at http://www.pifsc.noaa.gov/tech/NOAA_Tech_Memo_SEFSC_616.pdf.

Castilla, J. C., and M. Fernandez 1998. Small-scale benthic fisheries in Chile: on co-management and sustainable use of benthic invertebrates. Ecological Applications 8(sp1):S124-S132.

Coglan, L., and S. Pascoe. 2015. Corporate-cooperative management of fisheries: A potential alternative governance structure for low value small fisheries? Marine Policy 57:27-35.

Defeo, O., M. Castrejón, R. Pérez-Castañeda, J. C. Castilla, N. L. Gutiérrez, T. E. Essington, and C. Folke.2014. Co-management in Latin American small-scale shellfisheries: assessment from long-term case studies. Fish and Fisheries 17(1):176-192.

Dietz, T., E. Ostrom, and P. C. Stern. 2003. The struggle to govern the commons. Science 302(5652):1907-1912.

Dowling, N. A., J. R. Wilson, M. D. Rudd, E. A. Babcock, M. Caillaux, J. Cope, and N. Gutierrez. 2016. FishPath: A decision support system for assessing and managing data-and capacity-limited fisheries. In Tools and strategies for assessment and management of data-limited fish stocks. 30th Lowell Wakefield fisheries symposium. Alaska Sea Grant. Anchorage, Alaska.

Ebert, T. A., S. C. Schroeter, J. D. Dixon, and P. Kalvass. 1994. Settlement patterns of red and purple sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) in California, USA. Marine Ecology Progress Series 111(1):41-52.

Food and Agriculture Organization (FAO). 1995. Precautionary approach to fisheries. Part I: Guidelines on the precautionary approach to capture fisheries and species introductions. Elaborated by the Technical Consultation on the Precautionary Approach to Capture Fisheries (Including Species Introductions). Lysekil, Sweden, 6-13 June 1995. FAO Technical Paper 350, Part 1. 52 pp.

Gutiérrez, N. L., R. Hilborn, and O. Defeo.2011. Leadership, social capital and incentives promote successful fisheries. Nature 470(7334):386-389.

Hanna, S. 1995. Efficiencies of User Participation in Natural Resource Management. In Property Rights and the Environment - Social and Ecological Issues (pp. 59–67). Washington, D.C.: Beijer International Institute of Ecological Economics and The World Bank.

Hovel, K.A., D. J. Neilson, and E. Parnell. 2015. South Coast Baseline MPA Final Report: Baseline characterization of California spiny lobster (Panulirus interruptus) in South Coast marine protected areas. California Sea Grant. Accessed at https://caseagrant.ucsd.edu/sites/default/files/SCMPA-25-Final-Report.pdf. Last visited May 14, 2015.

McCay, B. J., and S. Jentoft. 1996. From the bottom up: participatory issues in fisheries management. Society and Natural Resources 9(3): 237-250.

McClenachan, L., G. O'Connor, and T. Reynolds. 2015. Adaptive capacity of co-management systems in the face of environmental change: The soft-shell clam fishery and invasive green crabs in Maine. Marine Policy 52:26-32.

Nielsen, J. R., and T. Vedsmand. 1997. Fishermen's organizations in fisheries management. Perspectives for fisheries co-management based on Danish fisheries. Marine Policy 21(3):277-288.

Pinkerton, E. 1994. Local fisheries co-management: a review of international experiences and their implications for salmon management in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 51(10):2363-2378.

Pinkerton, E. 2009. Partnerships in Management. A Fishery Manager's Guidebook, pp 283–300.

Pomeroy, R. S., B. M. Katon, and I. Harkes. 2001. Conditions affecting the success of fisheries co-management: lessons from Asia. Marine Policy 25(3):197-208.

Restrepo, V. R., G. G. Thompson, P. M. Mace, W. L. Gabriel, L. L. Low., A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P. R. Wade, J. F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson–Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum, NMFS-F/ SPO-31. 54 pp.

Smith, A. D. M. 1994. Management strategy evaluation: the light on the hill. In Population Dynamics for Fisheries Management, pp. 249–253. Ed. by D. A. Hancock. Australian Society for Fish Biology, Perth, Western Australia.

Trimble, M., and F. Berkes. 2013. Participatory research towards co-management: lessons from artisanal fisheries in coastal Uruguay. Journal of Environmental Management 128:768-778.

Wilson J., McGonigal, H., Dempsey, T., Gleason, M., and Rienecke, S. 2016. Partnerships in Fisheries Management: An Exploration of Ideas for Enhancing Capacity and Resources in California Fisheries. Unpublished manuscript.

Appendix O – Peer Review under the Marine Life Management Act

This appendix draws from of a 2017 overview by OST of best practices in peer review under the MLMA. It provides additional details regarding best practices and resources to help managers plan for and navigate the peer review process including a peer review checklist, TOR, and a sample report template.

Best practices for common work products

Draft Fisheries Management Plan review

As discussed in Chapter 10, the scientific components of FMPs are subject to external peer review. Scientific analyses, including stock assessments, should be peer reviewed before they are used as a basis for identifying management strategies. Review of methodologies, complex models, or stock assessments supporting an FMP should occur separately from review of a full draft FMP.

Review of a complete draft FMP should then occur late in development when a full high-quality draft is completed (reviewers should not be used as FMP development teams/advisory committees), and preferably before public comment so that the science has been reviewed, and any issues addressed.

Following the operating procedures of the PFMC, an FMP peer review should evaluate statistical, biological, economic, social, and other scientific information, analyses, analytical methodologies, literature, research, and other information relevant to decision-making. Rather than a line-by-line assessment, an FMP review should consider addressing the following questions:

- *Do the scientific and technical components within and supporting the FMP form a rigorous framework that can support sound fishery management decisions?*
- *Are there critical discussions or literature that should be factored into the FMP that would substantially strengthen the document?*
- *Are the models' interpretations technically sound, appropriate and supported by the best available data?*
- *Are the proposed reference points scientifically sound and supported by the best available data (as presented in the FMP and additional Department presentations/materials)? Are the thresholds sufficient and appropriate for identifying important changes/trends in stock status?*
- *Are research and monitoring needs comprehensive to allow the Department to collect and maintain EFI necessary to achieve management targets for the stock? Are there any priority gaps in research and monitoring that should be addressed or included?*

If the FMP is at the draft stage and the supporting models and methods have already been reviewed, it is likely best to consider a written review. Considering the level of previous review of the scientific analyses underlying the FMP, the draft may not necessitate a highly processed technical review. However, if enough concern were to emerge, then a follow-up webinar and/or workshop review could be conducted.

Methodology reviews

Methodology reviews are appropriate when a major new data source is introduced, when a new tool is developed for consideration in management, or when a major change is made to a method or model. Ideally, the scientific and technical merits of a new methodology proposed for use should be reviewed prior to and separately from application to help ensure any issues are worked out in the tool before it is applied in an FMP or other management work product. A reviewed model can then be included in an "accepted" toolbox for use in fishery management, and any application will not need the same level of review, unless there are exceptional circumstances.

A methodology review scope will vary depending on the work product under review, but should consider addressing the following questions:

- *Are the analytical methods used appropriate and technically sound?*
- *Are the research, data collection, and analyses comprehensive and representative of the best available science, and support the methodology?*
- *If it is a new methodology proposed for use, how does it improve on existing approaches, and how can it be applied in support of management targets for the stock?*
- *What research and/or monitoring are needed to improve the methodology in the future?*

The modes of peer review most appropriate for methodologies are remote panel reviews, panel workshops, and/or journal peer review. The methods tend to be novel, untested, and can be subject to controversy.

Stock assessment and Management Strategy Evaluation reviews

Stock assessments use fishery dependent and independent data to describe past and current status of a fish population or stock to help managers make predictions about how a fishery will respond to current and future management measures. MSE are simulations that compare among different combinations of data collection efforts, methods of analysis and subsequent management actions in order to identify an appropriate strategy, or to understand the effectiveness or associated risk of an existing management strategy. Stock assessments have only been completed for a handful of marine species in California due to the resource-intensive nature of the exercise and the data required for a fishery. However, as more data-poor, rapid stock assessment and MSE methods become available, the Department will likely conduct more frequent assessments and evaluations that require peer review. A stock assessment and/or MSE review may consider posing the following questions to the review team:

- *Are the underlying assumptions, data inputs, model parameters and other pertinent information scientifically sound and appropriate?*
- *Are additional sensitivity runs, analyses, or data required to support the peer review process?*
- *Does the stock assessment or MSE represent the best available scientific information to inform the development of HCRs? Are there any deficiencies in the input data or analytical methods?*
- *What additional research and monitoring are needed to improve the assessment and fishery management in the future?*
- *What data sets were considered but rejected for the final model, and why were they rejected?*

The mode of peer review most appropriate for a stock assessment or MSE is a panel workshop because of the need for group discussion and additional data analyses. In addition to reviewers, stock assessment and MSE review workshops often include the FMP management team and Department scientists, as well as additional stock assessment and MSE experts. Stock assessment review processes have been well established for federal fisheries management. Groups like South East Data Assessment and Review and NOAA PFMC Stock Assessment Review Panels may provide informative examples of successful approaches that vary in detail and level of time and analyses required.

Review of science supporting focused rulemaking or routine management measures

Routine management measures are those that are likely to be adjusted annually or more frequently, and may include changes to conservation area boundaries and trip limits, bag limits and size limits among other measures. Often, the science supporting these measures has been previously reviewed or relies on expert judgment. Given the need for timeliness, the mode of peer review most appropriate for science supporting focused rulemaking or routine management measures may vary, but will likely fall under internal review or external expert written review depending on the significance and implications of the rulemaking. Where there is an advanced knowledge that the issue may be controversial, it should be determined whether the benefits of a panel or remote panel review with public, stakeholder, and agency input may mitigate the costs of the more extensive process.

Additional considerations

Stakeholder buy-in of a review process and outputs may be of particular importance for highly politicized, controversial or sensitive fisheries. Understanding who key stakeholders are, and how they are likely to react to a review, can help identify the best ways to engage them in the process. The Department should consider whether a transparent process is consistently applied across all reviews, or whether stakeholder involvement is determined on a case-by-case basis depending on the needs of a review. See Appendix E for strategies regarding stakeholder engagement.

Terms of reference and sample report template

TOR documents lay out general procedures and responsibilities that contributors should aim to adhere to when conducting a formal process such as developing and peer-reviewing a work product. A TOR is typically developed for each type of review (e.g., stock assessment review, methodology review) and for each fishery. TOR documents detail the objectives, approaches, reporting requirements, and responsibilities of participants. For transparency, they are made publicly available. Each individual review will likely have unique requirements that can be defined in a specific TOR document or scope or work which conform to the more general terms.

Drawing on experience of the PFMC, the Department should develop TORs that include information on:

- Review process goals and objectives
- Roles and responsibilities of participants
- Structure and qualifications of the review panel participants
- Structure of meetings and/or workshops
- Process for requesting additional data or analyses
- Guidelines for dealing with uncertainty and areas of disagreement
- Guidance on structure of the review report (see below)

Sample Council TOR reports

- *Terms of reference for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2017-2018 (*June 2016*)* at http://www.pcouncil.org/wp-content/uploads/2017/01/Stock_Assessment_ToR_2017-18.pdf
- *Terms of reference for the Methodology Review Process for Groundfish and Coastal Pelagic Species for 2017-2018 (*June 2016*)* at http://www.pcouncil.org/wp-content/uploads/2017/01/Methodology_ToR_CPSGF-2017-18.pdf

- All Center of Independent Experts reports append the review scope/statement of work, which includes the TOR. These are available by year and title at: https://www.st.nmfs.noaa.gov/science-quality-assurance/cie-peer-reviews/peer-review-reports

General Fisheries Peer Review Checklist

Below is a checklist that should be used by the Department and review coordinating bodies to plan for an upcoming peer review process. Note that timelines often shift, so review coordinators should maintain a high level of flexibility (given that end products are often time sensitive).

PEER REVIEW SCOPING

4-6 months prior to start of a review

Department

Determine whether product is subject to or exempt from review

- ☐ If review is required, determine whether review is ***internal*** or ***external***
- ☐ If external, contract with an appropriate review coordinating body

1-2 months prior to start of review

Department

- ☐ Deliver draft report to review coordinating body

Review Coordinating Body

- ☐ Work with the Department to develop a “Specific TOR” or scope of work indicating:
- ☐ Mode and level of review
    - Roles and responsibilities of all parties involved in the review
    - Process, timeline, and budget
    - Level of stakeholder involvement
    - Required reviewer expertise an appropriate number of reviewers
    - Product(s) from the review
- ☐ Select and convene reviewers
- ☐ Have reviewers complete and sign a conflict of interest policy and a non-disclosure agreement (if required)
- ☐ Develop review instructions based on draft report and “Specific TOR”
- ☐ Develop collateral (e.g., webpage, communication materials, stakeholder listserv)

CONDUCT PEER REVIEW

Reviews take from 6 weeks to several months

Review Coordinating Body

- ☐ Distribute Specific TOR, review materials, and review instructions to reviewers
- ☐ Administer review based on mode selected (e.g., individual written reviews, panel workshop, etc.)
- ☐ Gather and submit additional data and analyses requests to the Department
- ☐ Develop draft product(s)
- ☐ Manage reviewers approve of/sign-off on final product
- ☐ Deliver product to the Department for a management preview prior to public release
- ☐ When appropriate, conduct a results briefing with the client and/or stakeholders
- ☐ Post final report online and distribute to interested partners and stakeholders

PEER REVIEW FOLLOW-UP

Revisions to the product under review may occur from several weeks to several months after delivery of the review report

Review Coordinating Body

- ☐ Facilitate discussions between reviewers and the Department as they consider review feedback and revise the work product
- ☐ Where appropriate, present results of review in a public meeting (e.g., Commission public meeting)
- ☐ Work with the Department to develop text to include in the final work product that appropriate represents the review process and outcomes

Table O1. Summary of scientific peer reviews of Department work products from the period of 2001 – 2017.

Work product reviewed	Review year	Review type	Coordinating entity	Review format	Public participation	Number of reviewers	Review output
Draft Nearshore FMP	2001	FMP	Sea Grant	1-day workshop	None	6	Individual written reports, consolidated report
Draft White Sea Bass FMP	2001	FMP	Sea Grant	1-day workshop	None	4	Individual written reports, consolidated report
Draft Market Squid FMP	2002	FMP	Sea Grant	2-day workshop	None	5	Compiled summary report written by review panel (internal)
Draft Abalone Recovery and Management Plan	2002	FMP	Sea Grant	2-day workshop	None	4	Compiled summary report from California Sea Grant (internal)
Model Supporting the Herring Stock Assessment	2003	Methodology	Sea Grant	2-day workshop	None	3	https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=31413
Sheephead Stock Assessment	2004	Stock assessment	Department	Meeting	unknown	3	https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=31413
California Halibut Assessment	2011	Stock assessment	Department	3-day workshop	Workshop open to public (with public comment)	3	https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=41074
Spiny Lobster Stock Assessment	2011	Stock assessment	Department	2-day workshop	None	3	https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=41074&nline
Abalone Density Estimation Method	2014	Methodology	OST	Multiple remote meeting and a 1-day workshop	Several remote meetings open to public (with public comment)	6	http://www.oceansciencetrust.org/wp-content/uploads/2016/11/Abalone-Executive-Summary-FINAL.pdf
Draft Spiny Lobster FMP	2015	FMP	OST	Multiple remote meetings	None	4	http://www.oceansciencetrust.org/wp-content/uploads/2016/11/Lobster-FMP-Scientific-Review-Report-6-9-15.pdf
White Seabass Stock Assessment	2016	Stock assessment	Pfleger Institute	2-day workshop	Workshop was open to public (with public comment) and many participants	2	http://www.capamresearch.org/sites/default/files/WSB_SA_2016_Reviewer_Report_Final.pdf
Pacific Herring Stock Assessment	2016/17	Stock assessment	Department	2-day workshop	No public	3	In progress

Appendix P – Marine Protected Areas and Fisheries Management

The MLPA was adopted in 1999 and mandated the state to reexamine the array of existing state MPAs and redesign them as an interconnected network. Its goal was to enhance the effectiveness of MPAs in protecting the state's marine life, habitats, and ecosystems (§2853). Through an extensive, collaborative, and unique public planning process, California implemented a network of MPAs iteratively across four coastal regions from 2004 to 2012 (CDFW 2016a). Operating within the statewide MPA Management Program, a collaborative statewide approach to management, the Commission is the primary regulatory authority for California's MPA network, the Department is the primary managing agency, and the **Ocean Protection Council (OPC)** is responsible for the direction of the state's MPA policy. The MLPA has six goals, which informed MPA design, and now inform adaptive management of the statewide MPA network (§2853). While the primary MLPA goals are to protect biodiversity, habitats, and the integrity of marine ecosystems, the MLPA goals and MPA network also have implications for the management of fisheries. In that regard, California's MPA network presents both opportunities and challenges for fishery management.

This appendix provides an overview of the different types of MPAs in California, and the various ways in which they can be used as a tool to meet the management goals of the MLMA. While MPAs can help protect habitat and diversity as discussed in Chapter 6 and Appendix L (also see CDFW 2016a), this appendix is primarily about the relevance of MPAs for meeting the fisheries sustainability objectives of the MLMA. It is also focused on the MPAs created through the MLPA process, however, it's important to note that there are other spatial closures created for fishery management purposes under separate state and federal authority (such as the RCAs, state trawl closures, the Cowcod Conservation Area, and Essential Fish Habitat closures).

Types of Marine Protected Areas in California

Following the MLPA redesign and siting process, California now has 124 MPAs encompassing 852 square miles, or approximately 16% of state waters. The six goals of the MLPA recognize the importance of protecting marine resources for various purposes, and therefore include multiple types of **Marine Managed Areas**[3] **(MMAs)** to achieve these distinct goals. MPAs are a subset of MMAs (however throughout this document the more common term MPA is used as an umbrella term to refer to all types of protected areas), and include three MPA designations: **State Marine Reserve (SMR), State Marine Conservation Area (SMCA)**, and **State Marine Park (SMP)**, and one MMA classification: **State Marine Recreational Management Area (SMRMA)**. Table P1 describes the different kinds of protected areas designated under the MLPA, the kind of protection they offer, and the amount of area protected in each designation. There are two designations for no-take MPAs, which collectively cover approximately 9.6% of state waters (about 9.0% in SMRs and 0.6% in no-take SMCAs). The remaining designations, SMCAs, SMCA/SMP, and SMRMAs cover approximately 6.5% of California's state waters, and allow multiple uses including limited specific types of take. A special closure, is not an MPA, but is a relatively small, discrete marine area that protects nesting and roosting seabirds and marine mammals from disturbance by restricting seasonal or year-round access, and further contributing to the goals of the MLPA (CDFW 2016a). The California State Parks and Recreation establish SMPs. This is a separate process outside the MLPA. Therefore, SMPs are not included in the current MPA Network.

Much of the global research on the benefits of MPAs to fisheries, as well as the use of MPAs as reference areas, assumes that MPAs are large, well enforced, and completely no-take (Halpern and Warner 2002; Hastings and Botsford 2003; Lester et al. 2009). There is also limited information relative to benefits of

[3] California Public Resources Code §36600-36900

limited take MPAs compared to no-take MPAs (Lester and Halpern 2008; Coleman et al. 2013; Kelaher et al. 2014). For this reason, it is important to consider the type of MPA when assessing the impacts on nearby fisheries. Approximately 40% of California's MPA area (or about 6.5% of state waters) is limited in take, which provides a unique opportunity to build scientific knowledge about the effects of different types of MPAs (CDFW 2016a).

Table P1. MPA designations in California state waters.[4]

Type	Name	Summary	Number	Area protected (sq. miles)
No take	*State Marine Reserve*	• Prohibits all take and consumptive use (commercial and recreational, living or geologic). • Scientific take may be allowed under a Scientific Collection Permit. • Non-consumptive uses are allowed.	49	474.7
	"No-take" State Marine Conservation Area	• Prohibits all take and consumptive use, except for take incidental to existing permitted activities such as infrastructure maintenance or water quality operations.	10	33.2
Limited take	*State Marine Conservation Area/State Marine Park*	• MPA designated as SMCA by the Fish and Game Commission and SMP by California State Park and Recreation Commission. • Only one MPA (Cambria SMCA/SMP) currently has this dual designation, as it was adopted by both Commissions at separate times with the same set of regulations and boundaries.	1	6.3
	State Marine Recreational Management Area	• Provides sub-tidal protection equivalent to an MPA while allowing legal waterfowl hunting, scientific research, and non-consumptive uses.	5	4.4
	State Marine Conservation Area	• May allow select recreational and commercial harvest to continue. • Scientific research and non-consumptive uses are allowed. • Fishing restrictions may vary by focal species, habitats, and goals and objectives of individual MPAs.	59	333.4
	State Marine Park[*]	• Prohibits commercial take, but may allow select recreational harvest to continue. • Scientific research and non-consumptive uses are allowed. • Prohibits injuring, damaging, taking, or possessing for commercial use any living or non-living marine resources.	0	0

[4] CDFW 2016a; statistics are from the Department's Marine Region Geographic Information System unit. Values are current as of March 2016 and are subject to change as improvements in geographic data become available: https://www.wildlife.ca.gov/Conservation/Marine/GIS

Type	Name	Summary	Number	Area protected (sq. miles)
Special closure	*Special Closure*	• A special closure is an area designated by the Commission that prohibits access or restricts boating activities in waters adjacent to seabird rookeries or marine mammal haul-out sites. • This designation is used by the Commission for relatively small, discrete marine areas to also achieve the goals of the MLPA.	15	3.3
TOTAL[**]			**124**	**852**

[*] At present, no SMPs exist in California's redesigned coastal network of MPAs. As such, they are not included in the statewide counts. Eight MPAs, including seven SMPs, exist within San Francisco Bay and were established prior to the MLPA, and therefore were not part of the MLPA redesign and siting process from 2004-2012.

[**] Totals do not include special closures or SMPs.

Benefits of Marine Protected Areas to Fisheries

A number of studies have examined the possible benefits MPAs could have for fisheries. This section provides a review of those benefits.

Increased catches via spillover

Two types of spillover from an MPA(s) can exist: ecological spillover and fishery spillover (Di Lorenzo et al. 2016). Ecological spillover is the net movement of fish biomass from non-fished areas into fished areas. This may happen when a species exhibits density-independent movement such as home range behavior (Moffitt et al. 2009) or ontogenetic shifts with increasing age (Grüss et al. 2011), or when high densities inside the MPA(s) compete for scarce resources, causing some individuals to leave the MPA(s) in search of food or shelter (Goñi et al. 2010). Fishery spillover is the proportion of fish biomass available to a fishery given existing regulations and access constraints. This is most likely to occur when the rate of emigration from the MPA(s) is low enough that the MPA(s) provides some refuge from fishing, but high enough that a certain proportion of the population exit the MPA into fishable areas (Di Lorenzo et al. 2016). This distinction is essential in helping facilitate conversations between stakeholders and policy makers when discussing how spillover may produce effects on fisheries.

While both ecological and fishery spillover of most benthic species requires habitat corridors extending from inside the MPAs to fished areas (Bartholomew et al. 2008; Kay and Wilson 2012), this is not always the case. While a different habitat may bisect preferred habitat, if competition within a given habitat is strong, individuals may cross-unsuitable or undesirable habitats, searching for other places to settle without an existing habitat corridor (Tupper 2007). This potential outward movement from within MPAs supports the importance of California's redesigned and interconnected network of MPAs, which resulted in a substantial increase in both the representation and replication of marine habitats protected within MPAs across the state (Saarman et al. 2013; CDFW 2016a).

Increased productivity via larval export

Due to the creation of many new MPAs, California's MPA network also resulted in a considerable reduction in the distance between habitats protected within MPAs, in order to provide for the dispersal of larvae for a range of species and to promote connectivity throughout the network (Saarman et al. 2013; CDFW 2016a). MPAs can contribute directly and indirectly to fisheries yields through increased survival and spawning. Protection from fishing within MPAs can result in higher abundances and/or larger female fish, which in turn can result in more eggs (Hastings 1999). The maintenance of unfished size and age structures in fish populations may also boost fecundity and subsequent larval recruitment because older, larger females can produce larvae that are more robust and grow faster than the offspring of younger fish, increasing the probability of successful settlement in some species (Berkeley et al. 2004). In fact, one study predicted that increased larval production from protected species within no-take MPAs may offset reductions in yields from MPA creation (Halpern et al. 2004). However, if the species managed is mobile rather than sedentary, there may be no larval spillover across the MPA boundary, because highly mobile species will likely move outside the closed area and be exposed to fishing mortality (Hastings and Botsford 2003). Finally, larval dispersal patterns must also transport larvae to areas where larval recruitment is less than the maximum possible, and prior to any density-dependent effects, that might negate the benefits within the closed areas (Parrish 1998). Thus, MPAs may only increase yields in fisheries in which fishing has reduced larval recruitment, and if the above conditions are met.

Reduced fishing mortality

Spatial closures to fishing like MPAs, whether temporary or permanent, are a mechanism to reduce overall fishing mortality (Beverton and Holt 1957). They are functionally similar to increasing the age of fish at first capture or reducing fishing effort (Botsford et al. 2003). It is thus important to remember that the response of harvested populations to protection, and increase in yield outside no-take MPA boundaries, will fundamentally depend on the level of fishing endured by the population prior to no-take MPA implementation (Botsford, Micheli and Hastings 2003; Hart 2006; Ralston and O'Farrell 2008). MPAs may also provide additional benefits over more traditional fishery management methods because they can prevent incidental habitat damage or the take of vulnerable bycatch species if strategically placed.

The capacity for MPAs to reduce effective fishing mortality also depends on the mobility of the target species as well as the placement of the MPA relative to the location of fishing effort. For fished species that are migratory or have large home ranges relative to the MPA (i.e., Market Squid, Dungeness Crab, salmon, tuna, etc.), but are targeted by spatially-explicit fishing effort, a strategically-placed MPA can provide a refuge from fishing for a portion of the fish or invertebrate's life history. This in turn can reduce mortality, enhance reproductive potential, or conserve the population through positive influence on another demographic process. For example, market squid (*Doryteuthis (Loligo opalescens)* are highly migratory, with adults offered little protection from established MPAs. However, market squid prefer to spawn on soft bottom substrate with a preferred depth range of 65- 230 feet (20-70 meters) (Zeidberg et al. 2011). Within these conditions, California's MPA network protects, at a minimum, approximately 14% of available market squid spawning grounds south of Point Conception in Santa Barbara County (CDFW 2016a).

In general, MPAs protect sedentary species or those species with limited mobility within their boundaries. The Department has compiled lists of species likely to benefit from MPAs (see: http://www.dfg.ca.gov/marine/mpa/species.asp). MPAs may increase mortality outside of the MPA due to the shift or concentration of existing fishing effort in fishable areas (Guenther 2010). However, following a 10-year study on temperate rocky reefs at California's northern Channel Islands, Caselle et al. (2015) found that not only had the biomass of targeted/fished species such as Cabezon and Kelp Rockfish within the MPAs increased, but biomass of the same-targeted species outside of the MPAs had also increased.

Insurance against management miscalculations and environmental fluctuations

MPAs can provide a buffer against management miscalculations and environmental fluctuations (Allison et al. 1998; Lauck et al. 1998). Science guidelines for sufficient replication of habitats when redesigning California's MPAs were indeed incorporated, in part to buffer against catastrophic loss and from environmental fluctuations (Saarman et al. 2013; CDFW 2016a). Because estimates of sustainable catch limits are based on predictions about the average productivity of a stock, there is always the potential to set limits too high during periods of environmental stress, which can reduce recruitment success or increase natural mortality (Roberts et al. 2005). In such cases, protected populations and habitats could potentially serve as natural heritage sites or biological sources if they provide spillover and/or larval replenishment. For some species, MPAs may also dampen variability in recruitment from year-to-year by keeping spawning biomass at higher levels, increasing population resilience to overfishing and buffering against decreases in reproductive success or increases in mortality (Guénette et al. 1998). Theoretical studies suggest MPAs may also reduce year-to-year variation in catch size, an important economic benefit for fishing communities (Sladek Nowlis and Roberts 1999). Therefore, MPAs offer a way for managers to be precautionary, especially in fisheries with little or no data available (Bohnsack 1999).

Protection of natural size and age structures

Management tends to make fishing more, rather than less, selective by modifying gear to focus fishing mortality on specific age or size classes (Reddy et al. 2013). While successful gear modifications direct fishing towards mature rather than immature age classes, recent work has shown that highly selective fishing (i.e., only males, of a certain size class, during a specific time of year) can have detrimental ecological impacts depending on the species (Zhou et al. 2010; Rochet et al. 2011; Garcia et al. 2012; Worm and Lenihan 2014). For example, large and mature female fish often produce far more and often larger eggs than smaller mature females, and their larvae grow faster and appear better able to withstand starvation (Berkeley et al. 2004; Hixon et al. 2014). MPAs may provide fishery benefits, such as protecting the natural age and size structure of the stock, that management regulations, such as catch limits or gear modifications, do not (Bohnsack 1999; Roberts et al. 2005; Kay et al. 2012).

Preserving genetic variation

Protecting natural age structures may preserve genetic variation in species in addition to boosting the egg production of a population (Bohnsack 1999). A number of studies have documented the effects of intensive fishing on the selection of specific heritable traits in the population (Ricker 1981; Quinn and Adams 1996; Drake et al. 1997). In particular, size-selective fishing can select for faster growth rates, younger age at first maturity, smaller maximum sizes, and behavioral changes (Worm and Lenihan 2014). Over multiple generations of intensive fishing, the alleles associated with other traits may be lost from the population. MPAs can help maintain the genetic diversity of a stock by providing refuges from fishing (Baskett and Barnett 2015).

Marine Protected Areas as fishery reference areas

The significant increase in the size and number of MPAs to the management landscape adds a new class of ecological indicators that may be highly informative. As the species protected within MPA borders approach carrying capacity they may provide robust estimates of unfished density (Bohnsack et al. 2004; Wilson et al. 2014), an important reference point in the assessment and management of fish populations. Stock assessments estimate the size of a fished population by looking for contrast between data collected from a time when the population was lightly fished and recently collected data. The larger the contrast between these two data streams, the easier it is to estimate the current population size. However, data streams for many fisheries lack historical time series necessary for this comparison. MPAs, if on a spatial scale appropriately representative of a species home range, represent an opportunity for the assessment of data-poor fisheries by acting as a reference area with which to estimate unfished biomass (Bohnsack 1998; CDFW 2002; Hilborn et al. 2004; Wilson et al. 2014). The potential effectiveness of reserves as reference areas will also depend on larval and adult movement rates, and should be constrained to the management of stocks at the same spatial scale as the reference area (Babcock and MacCall 2011; McGilliard et al. 2011). Depending on the siting process involved, MPAs may be placed in areas with high conservation value at the expense of socioeconomic considerations, and thus may have naturally higher carrying capacities than neighboring unprotected areas (Klein et al. 2008); potentially leading to an overestimate of unfished stock size outside the MPAs. Conversely, other MPAs may be cited in areas with lower carrying capacities where fishing is not occurring and political opposition is low. However, California's MPA network was designed with both ecological and socioeconomic concerns in mind, potentially eliminating this bias for MPA placement (Klein et al. 2008; Gleason et al. 2013; Saarman et al. 2013; CDFW 2016a).

MPAs are subject to the same environmental fluctuations and non-fishing anthropogenic effects as nearby fished areas, so they represent contemporary rather than theoretical unfished conditions. Because of this, they act as important control sites that can provide both an understanding of anthropogenic versus natural disturbances as well as a buffer against the uncertainty caused by shifting baselines (Bohnsack 1999; CDFW 2002; Hilborn et al. 2004). This is the theoretical basis for a number of assessment methods and HCRs that rely on data from inside MPAs (see Appendix H).

MPAs may also provide a way to estimate biological parameters that are unbiased by the effects of fishing (Bohnsack 1999). As mentioned previously in the Preserving Genetic Variation subsection, fishing mortality that is very high, or consistent over many years, can bias estimates of biological parameters. Fishing can alter the age at first maturity by selecting for fish that mature prior to recruiting to the fishery, and can skew growth estimates due to fishing frequently removing the largest individuals from the population. Data from inside MPAs can also be used to estimate natural mortality (Garrison et al. 2011), which is EFI for all stocks but is difficult to infer due to the fact that it is frequently confounded by fishing mortality (Jamieson and Levings 2001; Kenchington 2014).

Fisheries management challenges and opportunities associated with Marine Protected Areas

The previous section examined the possible benefits MPAs could have for fisheries, such as buffering against uncertainty, reducing bycatch and habitat damage, and improving knowledge, to name a few. However, at the same time, MPAs can also pose challenges for fisheries management such as socioeconomic impacts, shifts in fishing effort, and disruption of stock assessment research. When managing MPAs with a goal of enhancing fisheries management, the target species and associated potential effects, including both challenges and opportunities alike, should be considered. In recognition of the MPA network's potential effects on California fisheries, the Department has convened two workshops to strengthen the link between MPAs and fisheries. In 2011, leaders in MPA and fishery management discussed and developed recommendations to help understand the potential effects of the newly designed MPA network on California's marine fisheries.[5] For example, expected biological effects of MPAs will vary by species and fishery, accruing at different rates and time scales. While nearly immediate impacts may include but are not limited to effort displacement, possibly followed by localized depletion; gradual contributions may include spillover, increased biomass, and changes in age and size structure. Since data requirements for managing fisheries are different than those needed to evaluate MPAs, workshop participants recommended monitoring that addresses both MPA and fisheries priorities, such as focusing on those species most likely to be affected by the network and metrics that inform stock assessment (abundance, density, age and growth, sex ratios inside and outside MPAs).[3] In 2014, workshop participants discussed how MPA monitoring and historical data could help inform management of California's fisheries and MPAs, including core priorities moving forward, such as focusing on fished species that are data-rich and recognized as species likely to benefit from MPAs, identifying reference sites to model the effects of MPAs on fisheries, utilizing seafloor mapping technology to correlate habitat and spatially-explicit catch rates, determining how to couple environmental data with stock assessment data, and collecting socioeconomic data at a finer spatial scale.

[5] Wertz, S., Aseltine-Neilson, D., Barnes, T., Vasques, J., Ashcraft, S., Barsky, K., Frimodig, A., Key, M., Mason, T., and Ota, B. 2011. *Proceedings of the Marine Protected Areas and Fisheries Integration Workshop*. Retrieved Oct, 2017 from https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=42306&inline=true

The Department and OST have also developed recommendations to better align fisheries and MPA monitoring within regional MPA baseline monitoring plans.[6,7,8] Recognizing the differences in the scope and information needs for MPA and fisheries monitoring, these regional monitoring plan appendices layout various options to maximize data collection, particularly for fished species sampled at an appropriate geographic scale with adequate replication over a sufficient time scale to detect change.

Reduction in quality and quantity of fishery-dependent data available to stock assessments

The most commonly used type of fishery-dependent data in assessments is CPUE. The fishery CPUE, which is an index of abundance in fished areas, will not reflect any potential increasing abundance of sedentary species within MPAs, and may initially be lower after MPA creation due to the concentration of fishing effort in the remaining open space. For species with limited mobility, spillover may result in a concentrated fishing effort along the border of the MPA as fishermen "fish the line" (Murawski et al. 2005; but see Guenther et al. (2015) for alternative fishing responses). Managers should be aware that if data are spatially aggregated over the entire management range, the inflated catch rates near the borders of MPAs may mask declines in catch rates in other areas (McGilliard et al. 2015), leading to biased assessments (Maunder et al. 2006). Thus, as reserves protect an increasing proportion of the population, standardization techniques must be applied to counteract the higher biases in indices of abundance before they are used in stock assessments (Ono et al. 2015).

Fishery-independent sampling that relies on trawl gear, may have habitat impacts and thus be prohibited inside MPAs. For Phase 1 regional baseline MPA monitoring, California has relied primarily on a variety of fishery-independent sampling methods for MPA monitoring including, but not limited to, collaborative fishing surveys (Starr et al. 2015), scuba surveys (Caselle et al. 2015), remotely operated vehicle surveys (Rosen and Lauermann 2016), and rocky intertidal surveys (Blanchette et al. 2008). For Phase 2 long-term statewide MPA monitoring, the state is prioritizing surveys that extend beyond a regional basis to a statewide scale. Sampling within California's MPAs, which can offer the best available method to obtain samples of age structure, age-length and age-weight relationships that are unbiased by years of selective fishing pressure, is allowed (even in no-take zones) upon approval of a Department scientific collecting permit. Much of this fishing is catch and release.

Spatial heterogeneity in stock assessments

Stock assessments traditionally assume that the species in question is homogeneously distributed or targeted with uniform fishing effort. MPAs may violate this assumption (Bohnsack 1999), creating patches of high biomass inside their borders, and potentially leading to stock depletion outside (Hilborn et al. 2006). As such, MPAs and their effects on the spatial distribution of both fish and fishermen may introduce biases in stock assessments. For example, over estimations of the population size (Punt and Methot 2004; McGilliard et al. 2015). This can lead to misspecification of catch or effort limits.

Solutions include a greater use of spatially specific modeling, but this may require data collection on a finer scale (Bohnsack 1999; Holland 2002). In addition, spatial models require an understanding of the connectivity (of both larval and adult fish) between the various spatial patches, which is rarely known with much certainty (Botsford et al. 2009). It may be necessary to conduct separate assessments of the

[6] MPA Monitoring Enterprise, OST. 2010. *North Central Coast MPA Monitoring Plan. Appendix A-1: Possible Supplemental Fisheries Monitoring Module*. Retrieved Sept 21, 2015 from http://oceanspaces.org/sites/default/files/regions/files/ncc_monitoring_plan_and_appendices.pdf

[7] MPA Monitoring Enterprise, OST. 2011. *South Coast MPA Monitoring Plan. Appendix A-1: Supplemental Fisheries Monitoring Module*. Retrieved Sept 21, 2015 from http://oceanspaces.org/sites/default/files/regions/files/sc_mpa_monitoring_plan_full.pdf

[8] MPA Monitoring Enterprise, OST. 2014. *Central Coast MPA Monitoring Plan. Appendix A: Integrating Fisheries Monitoring and MPA Monitoring*. Retrieved Sept 21, 2015 from http://oceanspaces.org/sites/default/files/regions/files/central_coast_monitoring_plan_final_october2014.pdf

open and closed areas to achieve accurate estimates, but this requires separate data streams for the fished and unfished areas (Punt and Methot 2004). The additional data required for spatial assessments increases the cost of fisheries monitoring and assessment programs, unless data collected for MPA monitoring can be used to inform fisheries stock assessments on finer spatial scales. An example of such an application was presented by White et al. (2016), who developed an approach to use diver survey data fit to a size-structured model to provide estimates of the fishing mortality rate at the spatial scale of an MPA. They found a much higher pre-MPA fishing mortality rate on blue rockfish in the Point Lobos region MPAs than cited in the 2005 blue rockfish regional stock assessment.

Accounting for populations inside Marine Protected Areas

It is unclear whether the populations within MPAs should be considered “on the table” or “off the table” when assessing depletion levels and setting harvest limits (Field et al. 2006). Given the mandates to rebuild populations, there is an incentive for managers to count protected biomass in stock assessments to demonstrate increased stock health (Field et al. 2006). However, some research has shown that including protected fish when calculating catch limits based on the total vulnerable biomass may lead to unsustainable fishing mortality rates in the fished region because in reality only a portion of the stock is targeted (Hilborn et al. 2004, 2006). Conversely, in some cases, opposition to MPAs has been tempered via predictions of healthier spawning stocks and increased yields, and so there may be pressure from the fishing industry to count the fraction of population in MPAs as part of the total stock when setting catches. While the Nearshore FMP contemplated the use of MPAs in management, the recently adopted Spiny Lobster FMP is the first instance in which the Department has integrated MPAs through the use of a SPR model. The model accounts for the percentage of lobster habitat protected by MPAs that prohibit take of lobster; thus, providing a reproductive benefit that reflects the importance of MPAs to reproductive potential of lobster (CDFW 2016b).

The effects of overfishing on the vulnerable stock biomass may negate the benefits of the MPA population because overfishing reduces the age structure of the population, impacting both the YPR and the lifetime spawning output of each individual (Greenstreet et al. 2009). Conversely, not considering protected populations when determining stock status is likely to lead to a reduction in MSY, resulting in reduced catch limits, and can extend the rebuilding period for overfished stocks. All of this may have severe economic impacts on the fishery participants. Movement and larval dispersal between the closed and open populations can alter these predictions.

Economic effects of Marine Protected Areas

Limitations on fishing access can have both short- and long-term effects on the fishing economy (Hannesson 2002; Sanchirico et al. 2002; White et al. 2013). For this reason, globally, MPA designation and placement may be the result of either political convenience (Francour et al. 2001; Monaco et al. 2007; Walls 1998) or to minimize socioeconomic impacts (Aswani and Lauer 2006; Manson and Die 2001). When MPAs are established to address ecological concerns first, often the potential socioeconomic effects of such implementation are evaluated after the MPAs have been designed and implemented (Scholz et al. 2004; Sumaila et al. 2000). If the most biologically productive areas are set aside for protection, this can undermine performance if the goal is to improve both the economic and biological conditions in the fishery (Sanchirico and Wilen 2002). Catch rates may decrease in the short-term due to fishermen having to relearn how and where to fish when they are displaced from favored fishing grounds (Guenther et al. 2015). Fishers may also have to travel farther to access fishing grounds with high catch rates, increasing their costs and altering the distribution of fishing effort (Smith and Wilen 2003). Such short-term losses present an obstacle to stakeholder support for MPAs as well as to managers looking to maximize the socioeconomic benefits of fisheries.

Stakeholders, including fishermen and conservationists alike, designed California's new MPA network reflecting tradeoffs between ecosystem protection and socioeconomic considerations (Saarman et al. 2013; Gleason et al. 2013; CDFW 2016a). During the MLPA redesign and siting process, California engaged in a novel and unique approach to MPA planning in regards to economic analyses alongside biological considerations using two complementary analytical approaches (White et al. 2013). One approach was to estimate the maximum potential dollar value economic impacts over a short time under static socioeconomic "worse case" scenario (i.e., account for no spillover, no relocation of fishing effort, etc.). The second approach to estimate the maximum potential dollar value economic impacts over a dynamic long-term, equilibrium-based scenario (i.e., account for changes in spatial distribution of biomass and catch, oceanographic models of larval connectivity, etc.). This approach to MPA design allowed for the consideration of usual MPA factors (i.e., MPA size, age, degree of protection, level of fishing effort pre-MPA, etc.) but also a suite of non-MPA factors such as the variability in target species abundance, catchability, and market value/infrastructure, when the stakeholders were designing MPA proposals.

Informational and management needs for Marine Protected Areas

A primary objective of California's MPA network was to improve the existing design and management of MPAs relative to the goals and requirements of the MLPA. The MPAs were intended to be used as potential tools to complement fisheries management to maintain and improve ocean resources (CDFW 2016a). While MPAs have a number of potential benefits for fisheries, they are not a panacea for fisheries management (Sainsbury and Sumaila 2003; Willis et al. 2003; Hilborn et al. 2004; Kaiser 2005). Multiple studies have shown that the ability of MPAs to benefit fisheries requires that very specific conditions be met, including: 1) the presence of specific habitat and life history characteristics; 2) the source-sink dynamics between closed and open areas; and 3) properly siting MPAs to take advantage of these conditions (Agardy et al. 2011).

Monitoring within MPAs is essential to integrating MPAs into existing fishery management frameworks. This appendix has highlighted some of the informational needs that must be met to ensure that MPAs benefit nearby fisheries. They include, but are not limited to the following:

- An understanding of the level of fishing prior to MPA implementation
- Home range of species relative to size of MPA
- Larval connectivity between fished and unfished areas
- Size and age structure of species protected within MPAs, and how this changes over time
- Abundance/density of stocks within MPAs
- Whether the habitat inside MPAs is representative of nearby areas outside MPAs

Moving forward, the Department and the OPC are collaborating to develop a statewide MPA Monitoring Action Plan. This Action Plan will provide an opportunity for the Department to ensure that long-term monitoring design and data collection efforts assist in the management of California's fisheries.

References

Agardy, T., G. N. di Sciara, and P. Christie. 2011. Mind the gap addressing the shortcomings of marine protected areas through large scale marine spatial planning. Marine Policy 35(2):226-232.

Allison, G.W., J. Lubchenco, and M. H. Carr. 1998. Marine reserves are necessary but not sufficient for marine conservation. Ecological Applications 8(1):S79-S92.

Bartholomew, A., and J. A. Bohnsack. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries 15(1-2):129-154.

Bartholomew, A., J. A. Bohnsack, S. Smith, J. Ault, D. Harper, and D. McClellan. 2008. Influence of marine reserve size and boundary length on the initial response of exploited reef fishes in the Florida Keys National Marine Sanctuary, USA. Landscape Ecology 23:55-65.

Baskett, M. L., and L. A. Barnett. 2015. The Ecological and Evolutionary Consequences of Marine Reserves. Annual Review of Ecology, Evolution, and Systematics 46:49-73.

Berkeley, S.A., M. A. Hixon, R. J. Larson, and M. S. Love. 2004. Fisheries Sustainability via Protection of Age Structure and Spatial Distribution of Fish Populations. Fisheries 29(8):23-32.

Beverton, R., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fishery Investigations Series II Volume XIX, Ministry of Agriculture.

Blanchette, C. A., C. M. Miner, P. T. Raimondi, D. Lohse, K. E. Heady, and B. R. Broitman. 2008. Biogeographical patterns of rocky intertidal communities along the Pacific coast of North America. Journal of Biogeography 35(9):1593-1607.

Bohnsack, J. A. 1998. Application of marine reserves to reef fisheries management. Austral Ecology 23(3):298-304.

Bohnsack, J. A. 1999. Incorporating no-take marine reserves into precautionary management and stock assessment. In Providing Scientific Advice to Implement Precautionary Approach Under the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum NMFS-F/SPO-40.

Bohnsack, J. A., J. S. Ault, and B. Causey. 2004. Why have no-take marine protected areas? American Fisheries Society Symposium 42:185-193.

Botsford, L.W., F. Micheli, and A. Hastings. 2003. Principles for the design of marine reserves. Ecological Applications 13(1):25-31.

California Department of Fish and Wildlife (CDFW). 2002. Nearshore Fishery Management Plan. Adopted by the CGFC in October 2002. Accessed at https://www.wildlife.ca.gov/Conservation/Marine/NFMP.

California Department of Fish and Wildlife (CDFW). 2016a. California Marine Life Protection Act Master Plan for Marine Protected Areas. Adopted by the CGFC on August 24, 2016. Accessed at www.wildlife.ca.gov/Conservation/Marine/MPAs/Master-Plan.

California Department of Fish and Wildlife (CDFW). 2016b. California Spiny Lobster Fishery Management Plan. Adopted by the CGFC on April 13, 2016. Accessed at https://www.wildlife.ca.gov/Conservation/Marine/Lobster-FMP.

Caselle, J. E., A Rassweiler, S. L. Hamilton, and R. R. Warner. 2015. Recovery trajectories of kelp forest animals are rapid yet spatially variable across a network of temperate marine protected areas. Scientific Reports 5:14102.

Coleman, M. A., A. Palmer-Brodie, and B. P. Kelaher. 2013. Conservation benefits of a network of marine reserves and partially protected areas. Biological Conservation 167:257-264.

Di Lorenzo, M., J. Claudet, and P. Guidetti. 2016. Spillover from marine protected areas to adjacent fisheries has an ecological and a fishery component. Journal for Nature Conservation 32:62-66.

Drake, M. T., J. E. Claussen, D. P. Philipp, and D. L. Pereira. 1997. A Comparison of Bluegill Reproductive Strategies and Growth among Lakes with Different Fishing Intensities. North American Journal of Fisheries Management 17(2):496-507.

Edwards, M., G. Beaugrand, G. C. Hays, J. A. Koslow, and A. J. Richardson. 2010. Multi-decadal oceanic ecological datasets and their application in marine policy and management. Trends in Ecology and Evolution 25(10):602-610.

Field, J. C., A. E. Punt, R. D. Methot, and C. J. Thomson. 2006. Does MPA mean ‘Major Problem for Assessments'? Considering the consequences of place-based management systems. Fish and Fisheries 7(4):284-302.

Garcia, S. M., J. Kolding, J. Rice, M. J. Rochet, S. Zhou, T. Arimoto, J. E. Beyer, L. Borges, A. Bundy, D. Dunn, E. A. Fulton, M. Hall, M. Heino, R. Law, M. Makino, A. D. Rijnsdorp, F. Simard, and A. D. M. Smith. 2012. Reconsidering the Consequences of Selective Fisheries. Science 335(6072):1045-1047.

Gleason, M., E. Fox, S. Ashcraft, J. Vasques, E. Whiteman, P. Serpa, E. Saarman, M. Caldwell, A. Frimodig, M. Miller-Henson, J. Kirlin, B. Ota, E. Pope, M. Weber, and K. Wiseman. 2013. Designing a network of marine protected areas in California: achievements, costs, lessons learned, and challenges ahead. Ocean and Coastal Management 74:90-101.

Greenstreet, S. P., H. M. Fraser, and G. J. Piet. 2009. Using MPAs to address regional-scale ecological objectives in the North Sea: modelling the effects of fishing effort displacement. ICES Journal of Marine Science 66(1):90-100.

Guenther, C., D. Lopez-Carr, and H. S. Lenihan. 2015. Differences in lobster fishing effort before and after MPA establishment. Applied Geography 59(C):78-87.

Guenther, C. M. 2010. A socio-ecological analysis of marine protected areas and commercial lobster fishing in the Santa Barbara Channel, California.

Guénette, S., T. Lauck, and C. Clark. 1998. Marine reserves: from Beverton and Holt to the present. Reviews in Fish Biology and Fisheries 8(3):251-272.

Halpern, B. S., and R. R. Warner. 2002. Marine reserves have rapid and lasting effects. Ecological Letters 5(3):361-366.

Halpern, B. S., S. D. Gaines, and R. R. Warner. 2004. Confounding effects of the export of production and the displacement of fishing effort from marine reserves. Ecological Applications 14(4):1248-1256.

Hannesson, R. 2002. The Economics of Marine Reserves. Natural Resource Modeling 15(3):273-290.

Hastings, A. 1999. Equivalence in Yield from Marine Reserves and Traditional Fisheries Management. Science 284(5419):1537-1538.

Hastings, A., and L. W. Botsford. 2003. Comparing designs of marine reserves for fisheries and for biodiversity. Ecological Applications 13(sp1):65-70.

Hilborn, R., F. Micheli, and G. A. De Leo. 2006. Integrating marine protected areas with catch regulation. Canadian Journal of Fish and Aquatic Sciences 63(3):642-649.

Hilborn, R., K. Stokes, J. J. Maguire, T. Smith, L. W. Botsford, M. Mangel, J. Orensanz, A. Parma, J. Rice, J. Bell, K. L. Cochrane, S. Garcia, S. J. Hall, G. P. Kirkwood, K. Sainsbury, G. Stefansson, and C. Walters. 2004. When can marine reserves improve fisheries management? Ocean Coast Manage 47(3-4):197-205.

Hixon, M. A., D. W. Johnson, and S. M. Sogard. 2014. BOFFFFs: on the importance of conserving old-growth age structure in fishery populations. ICES Journal of Marine Sciences 71(8):2171-2185.

Hughes, B. B., R. Beas-Luna, A. K. Barner, K. Brewitt, D. R. Brumbaugh, E. B. Cerny-Chipman, S. L. Close, K. E. Coblentz, K. L. de Nesnera, S. T. , Drobnitch, J. D. Figurski, B. Focht, M. Friedman, J. Freiwald, K. K. Heady, W. N. Heady, A. Hettinger, A. Johnson, K. A. Karr, B. Mahoney, M. M. Moritsch, A.-M. K. Osterback, J. Reimer, J. Robinson, T. Rohrer, J. M. Rose, M. Sabal, L. M. Segui, C. Shen, J. Sullivan, R. Zuercher, P. T. Raimondi, B. A. Menge, K. Grorud-Colvert, M. Novak, and M. H. Carr. 2017. Long-Term Studies Contribute Disproportionately to Ecology and Policy. BioScience 67(3):271-281.

Jamieson, G. S., and C. O. Levings. 2001. Marine protected areas in Canada — implications for both conservation and fisheries management. Canadian Journal of Fish and Aquatic Sciences 58(1):138-156.

Kaiser, M. J. 2005. Are marine protected areas a red herring or fisheries panacea? Journal of the Fisheries Research Board of Canada 62(5):1194-1199.

Kay, M. C., and J. R. Wilson. 2012. Spatially explicit mortality of California spiny lobster (*Panulirus interruptus*) across a marine reserve network. Environmental Conservation 39(3):215-224.

Kelaher, B. P., M. A. Coleman, A. Broad, M. J. Rees, A. Jordan, and A. R. Davis. 2014. Changes in fish assemblages following the establishment of a network of no-take marine reserves and partially protected areas. PLOS ONE 9(1):E85825.

Kenchington, T. J. 2014. Natural mortality estimators for information-limited fisheries. Fish and Fisheries 14(4):533-562.

Klein, C. J., A. Chan, L. Kircher, A. J. Cundiff, N. Gardner, Y. Hrovat, A. Scholz, B. E. Kendall, and S. Airame. 2008. Striking a balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas. Conservation Biology 22:691-700.

Lauck, T., C. W. Clark, M. Mangel, and G. R. Munro. 1998. Implementing the precautionary principle in fisheries management through marine reserves. Ecological Applications 8(1):S72-S78.

Lester, S. E., and B. S. Halpern. 2008. Biological responses in marine no-take reserves versus partially protected areas. Marine Ecology Progress Series 367:49-56.

Lester, S.E., B. S. Halpern, K. Grorud-Colvert, J. Lubchenco, B. I. Ruttenberg, S. D. Gaines, S. Airamé, S., and R. R. Warner. 2009. Biological effects within no-take marine reserves: a global synthesis. Marine Ecology Progress Series. 384:33e46.

Maunder, M., J. Sibert, A. Fonteneau, J. Hampton, P. Kleiber, and S. Harley. 2006. Interpreting catch per unit effort data to assess the status of individual stocks and communities. ICES Journal of Marine Sciences 63(8):1373-1385.

McGilliard, C. R., A. E. Punt, R. D. Methot Jr, and R. Hilborn. 2015. Accounting for marine reserves using spatial stock assessments. Canadian Journal of Fish and Aquatic Sciences 72(2):262-280.

Moffitt, E. A., L. W. Botsford, and D. M. Kaplan. 2009. Marine reserve networks for species that move within a home range. Ecological Applications 19(7):1835–1847.

Murawski, S. A., S. Wigley, M. Fogarty, P. Rago, and D. Mountain. 2005. Effort distribution and catch patterns adjacent to temperate MPAs. ICES Journal of Marine Sciences 62:1150-1167.

Parrish, R. 1999. Marine reserves for fisheries management: why not. Symposium of the CalCOFI Conference: a continuing dialogue on no-take reserves for resource management, Asilomar, CA, USA; 4 November 1998. California Cooperative Oceanic Fisheries Investigations Report 40:77-86.

Punt, A. E., and R. D. Methot. 2004. Effects of marine protected areas on the assessment of marine fisheries. American Fisheries Society Symposium 42:133-154.

Quinn, T. P., and D. J. Adams. 1996. Environmental changes affecting the migratory timing of American Shad and Sockeye Salmon. Ecology 77(4):1151.

Reddy, S. M., A. Wentz, O. Aburto-Oropeza, M. Maxey, S. Nagavarapu, and H. M. Leslie 2013. Evidence of market-driven size-selective fishing and the mediating effects of biological and institutional factors. Ecological Applications 23(4):726-741.

Ricker, W. E. 1981. Changes in the average size and average age of Pacific salmon. Canadian Journal of Fish and Aquatic Sciences 38(12):1636-1656.

Roberts, C.M., J. P. Hawkins, and F. R. Gell. 2005. The role of marine reserves in achieving sustainable fisheries. Philosophical Transactions of The Royal Society Biological Sciences 360(1453):123-132.

Rochet, M. J., J. S. Collie, S. Jennings, and S. J. Hall. 2011. Does selective fishing conserve community biodiversity? Predictions from a length-based multispecies model. Canadian Journal of Fish and Aquatic Sciences 68:469-486.

Rosen, D., and A. Lauermann. 2016. It's all about your network: using ROVs to assess marine protected area effectiveness. OCEANS 2016 MTS/IEEE Monterey doi:10.1109/oceans.2016.7761055

Saarman, E., M. Gleason, J. Ugoretz, S. Airamé, M. Carr, E. Fox, A. Frimodig, T. Mason, and J. Vasques. 2013. The role of science in supporting marine protected area network planning and design in California. Ocean and Coastal Management 74:45-56.

Sainsbury, K., and U. R. Sumaila. 2003. Incorporating Ecosystem Objectives into Management of Sustainable Marine Fisheries, Including "Best Practice" Reference Points and Use of Marine Protected Areas. In Responsible Fisheries in the Marine Ecosystem. Edited by M. Sinclair and G. Valdimarsson. FAO, Rome. pp. 343-361.

Sanchirico, J. N., and J. E. Wilen. 2002. The Impacts of Marine Reserves on Limited- Entry Fisheries. Natural Resource Modeling 15(3):291-310.

Sanchirico, J. N., K. A. Cochran, and P. M. Emerson. 2002. Marine Protected Areas: Economic and Social Implications. Resources for the Future, Discussion Paper 02-26.

Sladek Nowlis, J., and C. M. Roberts. 1999. Fisheries benefits and optimal design of marine reserves. Fishery Bulletin 97(3):604-116.

Smith, M. D., and J. E. Wilen. 2003. Economic impacts of marine reserves: the importance of spatial behavior. Journal of Environmental Economics and Management 46(2):183-206.

Starr, R. M., D. E. Wendt, C. L. Barnes, C. I. Marks, D. Malone, G. Waltz, K. T. Schmidt, J. Chiu, A. L. Launer, N. C. Hall, and N. Yochum. 2015. Variation in Responses of Fishes across Multiple Reserves within a Network of Marine Protected Areas in Temperate Waters. PLOS ONE10(3): E0118502.

Tupper, M. 2007. Spillover of commercial valuable reef fishes from marine protected areas in Guam, Micronesia. Fishery Bulletin 105(4):507-537.

White, J. W., A. J. Scholz, A. Rassweiler, C. Steinback, L. W. Botsford, S. Kruse, C. Costello, S. Mitarai, S., D. A. Siegel, P. T. Drake, and C. A. Edwards. 2013. A comparison of approaches used for economic analysis in marine protected area network planning in California. Ocean and Coastal Management 74:77-89

White, J. W., K. J. Nickols, D. Malone, M. H. Carr, R. M. Starr, F. Cordoleani, M. L. Baskett, A. Hastings, and L. W. Botsford. 2016. Fitting state-space integral projection models to size-structured time series data to estimate unknown parameters. Ecological Applications 26(8):2677-2694.

Willis, T. J., R. B. Millar, R. C. Babcock, and N. Tolimieri. 2003. Burdens of evidence and the benefits of marine reserves: putting Descartes before des horse? Environmental Conservation 30(2):97-103.

Wilson-Vandenberg, D., T. Larinto, and M. Key. 2014. Implementing California's Nearshore Fishery Management Plan – twelve years later. California Fish and Game, 100(2):186-217.

Worm, B., and H. S. Lenihan. 2014. 20. Threats to marine ecosystems: overfishing and habitat degradation. In Marine Community Ecology and Conservation. Eds M.R. Bertness, B.J. Silliman, and J.J. Stachowicz. pp. 449-476.

Zeidberg, L. D., Butler, J. L., Ramon, D., Cossio, A., Stierhoff, K. L. and Henry, A. 2012. Estimation of spawning habitats of market squid (*Doryteuthis opalescens*) from field surveys of eggs off Central and Southern California. Marine Ecology, 33(3):326-336.

Zhou, S., A. D. M. Smith, A. E. Punt, A. J. Richardson, M. Gibbs, E. A. Fulton, S. Pascoe, C. Bulman, P. Bayliss, and K. Sainsbury. 2010. Ecosystem-based fisheries management requires a change to the selective fishing philosophy. Proceedings of the National Academy of Sciences 107(21):9485-9489.