



**NOAA
FISHERIES**

Office of Science and Technology

Implementing a Next Generation Stock Assessment Enterprise

Policymakers' Summary

NOAA Technical Memorandum NMFS-F/SPO-184

June 2018



Foreword

NOAA Fisheries strives to maintain the United States as a global leader in marine resource science and stewardship. The U.S. approach for sustainable fisheries management serves as an international model for addressing the challenges facing global ocean fisheries. As a steward, NOAA Fisheries conserves, protects, and manages living marine resources. Working towards this goal ensures that functioning marine ecosystems and recreational and economic opportunities are available for the American people today and for future generations.

NOAA Fisheries, with our partners, has been managing our nation's fisheries for 40 years under the Magnuson-Stevens Act. During that time, the agency has built a robust and reliable stock assessment enterprise that provides world-class scientific advice to resource managers that is needed to keep our fisheries sustainable. NOAA Fisheries manages nearly 500 fish stocks and stock complexes, and conducts nearly 200 stock assessments each year. This data-intensive endeavor is costly. NOAA Fisheries and our partners therefore continually work to ensure that the funds provided by Congress for this vital work are utilized efficiently to produce the highest-priority and highest-quality data and assessment results possible. This funding, and the work it supports, enables us to sustain and enhance our fisheries and the millions of jobs they support.

In 2001, NOAA Fisheries published the *Stock Assessment Improvement Plan (SAIP)*. We sought to bolster the capacity, content, extent, and infrastructure for conducting stock assessments. The SAIP also led to the development of important performance metrics that gauge progress in the NOAA Fisheries stock assessment enterprise. This has allowed us to measure our progress as we have recovered stocks and dramatically reduced overfishing over the last 40 years.

In light of changes in legal mandates, new research, and development of new scientific tools, we embarked on developing a new strategic document for our stock assessment enterprise. This 2018 update to the SAIP is our plan to implement a next generation stock assessment enterprise. The ocean is a dynamic system. As changes occur, we must adapt and progress toward fishery management approaches that are more holistic and ecosystem linked. We should also continue to improve our assessments through investments in innovative science and technologies, and improvements in the timeliness and efficiency of the stock assessment process. By continued investments in improving our stock assessment enterprise, NOAA Fisheries will help ensure the future sustainability of our valuable living marine resources and the people, businesses, and communities that depend on them.

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U.S. DEPARTMENT OF COMMERCE

**National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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Contents

Executive Summary	6
Overview	8
NOAA Fisheries' Stock Assessments	8
Updating the Stock Assessment Improvement Plan	9
The Next Generation Stock Assessment Enterprise	10
Holistic and Ecosystem-Linked	11
Innovative Science	12
Timely, Efficient, and Effective	13
Priority Actions	17
Holistic and Ecosystem-Linked	17
Innovative Science	17
Timely, Efficient, and Effective	18

Executive Summary

NOAA Fisheries conducts stock assessments to provide fundamental scientific advice in support of sustainable fisheries management. Managers use the results of stock assessments, along with other information, to establish catch targets and limits that strive to maximize yield while ensuring that overfishing does not occur and stocks do not become overfished. While NOAA Fisheries is currently achieving quality stock assessments across the country, there are increasing demands and challenges facing NOAA's stock assessment programs. This document provides a summary of NOAA's Next Generation Stock Assessment (NGSA) framework, which is an update to the 2001 Stock Assessment Improvement Plan (SAIP).

The NGSA strategic vision is designed to complement NOAA Fisheries' other strategic efforts in order to accomplish its mission of sustainable fisheries through resource conservation and management. The NGSA framework has three main themes:

1. Expanding the scope of stock assessments to be more holistic and ecosystem-linked
2. Using innovative science and advanced technologies to improve data and analytical methods
3. Establishing a more timely, efficient, and effective stock assessment process

The new NGSA framework acts as a road map to guide efforts by NOAA Fisheries to address these three themes. First, it advocates for expanding the scope of stock assessments to support harvest policies that are more holistic in nature. This means that more stock assessments will consider ecosystem and socioeconomic factors that affect the dynamics of fish stocks and fisheries. Such expansion aligns with the "Tier III" goal of the 2001 SAIP and it is reemphasized as a priority here, accompanied with decision trees that help determine when this information is of greatest importance and how it should be incorporated. Secondly, it advocates for the continued use of innovative technologies to reliably and efficiently provide data for maximizing use of advanced modeling methods. Examples of clear benefits from this emphasis include improved calibration of data collection methods, streamlined analytical processes, and establishment of robust harvest policies to manage fisheries between assessments. Finally, the plan provides a method for objectively determining stock-specific goals that create a stock assessment process that is timelier, more efficient, and effective at optimizing available resources and delivering results to fishery managers and the public. Ultimately, the NGSA framework will achieve the best balance among the "4Ts" of stock assessment: throughput, timeliness, thoroughness, and transparency.

Implementation of the NGSA framework will require strong collaboration among NOAA Fisheries, management partners, and stakeholders. There are already strong data collection partnerships in place, and these will need to be leveraged to achieve improvements in data collection, processing, and management. Similarly, enhancing and expanding assessments to include new data types can be accomplished through cooperation and utilization of diverse platforms, such as unmanned systems and industry partnerships that provide innovative approaches and opportunities for interdisciplinary collaboration. Wise investments in advanced sampling technologies must be guided by stock assessment priorities to resolve key information gaps. Unmanned platforms (e.g. aerial systems, moorings, gliders, and autonomous and remotely operated underwater vehicles) will become relatively low-cost options for deploying acoustic and optical technologies, especially when compared to the cost of building, running, and staffing a traditional research vessel. Investments in training and retention of assessment

scientists will be paramount for capitalizing on recent advancements in software and statistical modeling techniques. Finally, standardizing aspects of the assessment process, while emphasizing regional priorities through national initiatives such as classifying data inputs, setting targets for assessment level and frequency, and conducting gap analyses will focus productivity and increase communication to stakeholders and the public. The new NGS framework helps NOAA Fisheries accomplish its mission of conserving healthy ecosystems while achieving productive and sustainable fisheries.

The specific actions and recommendations under each theme facilitate the transition to an NGS enterprise. These are provided as goals that will improve NOAA Fisheries’ ability to meet its mandates. They are not prioritized or associated with specific timelines or resource requirements or reallocations. Rather, the items provide a directional framework that NOAA Fisheries can use to ensure a high quality and quantity of stock assessments that meet the growing demands of the fishery and management process.

Summary of major recommendations to support transition to NOAA Fisheries’ next generation stock assessment enterprise

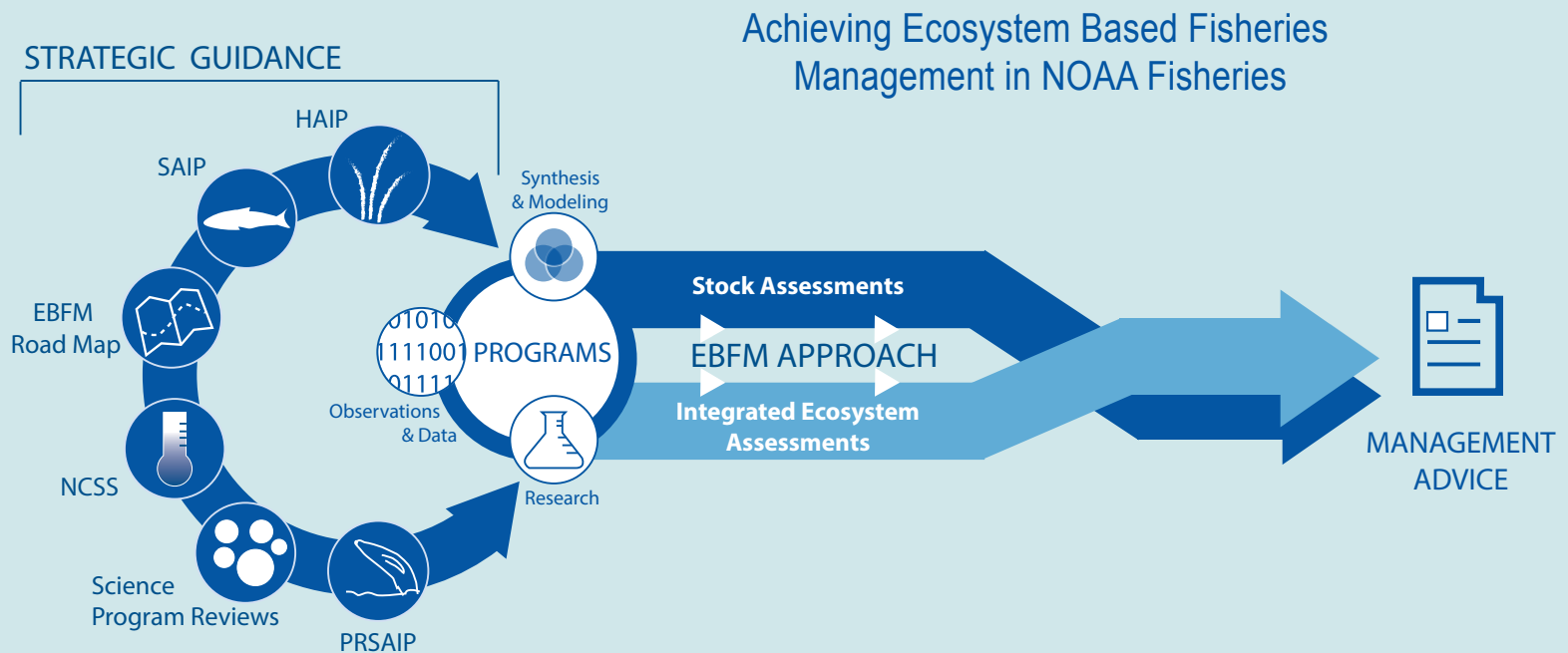
Theme	Recommendation
Holistic & Ecosystem-Linked Stock Assessments	<p>More and routine consideration of ecosystem, environmental, and socioeconomic drivers in the assessment process and in the research conducted to develop operational assessments; use the proposed decision processes, in combination with ongoing research, to determine when and how to expand stock assessments to be more holistic.</p> <p>Coordinate stock assessment results and the advice being provided to managers across stocks; consider broader ecosystem and fishing community factors in a more holistic evaluation of harvest control rules; improve communication of stock assessment issues and gaps to inter-disciplinary researchers.</p>
Innovative Science for Improving Stock Assessments	<p>Maintain and improve fishery-independent data collection capabilities; conduct more studies to directly calibrate fish abundance from surveys; adjust coverage for shifting species distributions; expand broad spectrum collection of ecosystem and environmental data.</p> <p>Maintain and improve fishery-dependent data collection including remote data collection (remote monitoring); develop low-cost fish and environmental survey methods deployable from fishing vessels.</p> <p>Utilize advanced technologies, such as sonar, robotic and unmanned camera systems, automated image processing, e-DNA, and others to expand coverage, reduce stock impacts, and streamline data collection.</p> <p>Improve the assessment modeling approach with a focus on advanced statistical methods, expanding assessment model scope and broader use of management strategy evaluation simulations, and improving characterization of uncertainty, including the use of model ensembles; improve professionalism of the assessment data management and model development process.</p>
Timely, Efficient, and Effective Stock Assessment Enterprise	<p>Prioritize stock assessment activity through implementing the new assessment data classification system and gap analysis.</p> <p>Establish timely and efficient stock assessment processes by separating research from operational assessments; streamlining the operational process; expanding the scope and inclusivity of the research process; and establishing a timely and efficient degree of peer-review focused on relevant issues.</p> <p>Maintain effective stock assessments with standardized approaches and improve communication of data needs and assessment results; improved stakeholder outreach and engagement; improve training of current and future assessment scientists; and improve opportunities for assessment scientists to engage in research.</p>

Overview

NOAA Fisheries' Stock Assessments

Stock assessments provide crucial scientific information to resource managers on stock status, forecasts of future catch and abundance, and harvest policy recommendations. They play a key role in the management process by providing the scientific basis for setting annual catch targets and limits to ensure that stocks are not overfished and overfishing does not occur. Stock assessments are a key component to fulfilling NOAA Fisheries' mission as a steward of living marine resources to benefit the nation through science-based conservation and management and to promote a healthy environment.

This road map to the Next Generation Stock Assessment (NGSA) enterprise seeks to balance the various demands on the stock assessment enterprise. NOAA Fisheries is expected to deliver an increasing quantity and quality of stock assessments in support of sustainable fishery management. The NGSA Enterprise complements many other NOAA Fisheries strategic efforts (see box below), which collectively help NOAA Fisheries best accomplish its overall mission and fulfill its mandates under the Magnuson-Stevens Act, the Endangered Species Act, the Marine Mammal Protection Act, and others.



NOAA Fisheries' scientific programs are guided by numerous strategic efforts and products to provide advice to fishery managers under an interdisciplinary ecosystem-based approach to fishery management. Strategic guidance includes the Habitat Assessment Improvement Plan (HAIP), the National Climate Science Strategy (NCSS), the Stock Assessment Improvement Plan for fisheries (SAIP; updated by the NGSA Enterprise) and Protected Resources (PRSAIP), the Ecosystem-Based Fisheries Management Road Map (EBFM Road Map), Science Program Reviews, Agency Strategic Plans, and Legislative Mandates. Ultimately, this process results in scientific advice necessary for implementing an Ecosystem-Based Fisheries Management Framework.

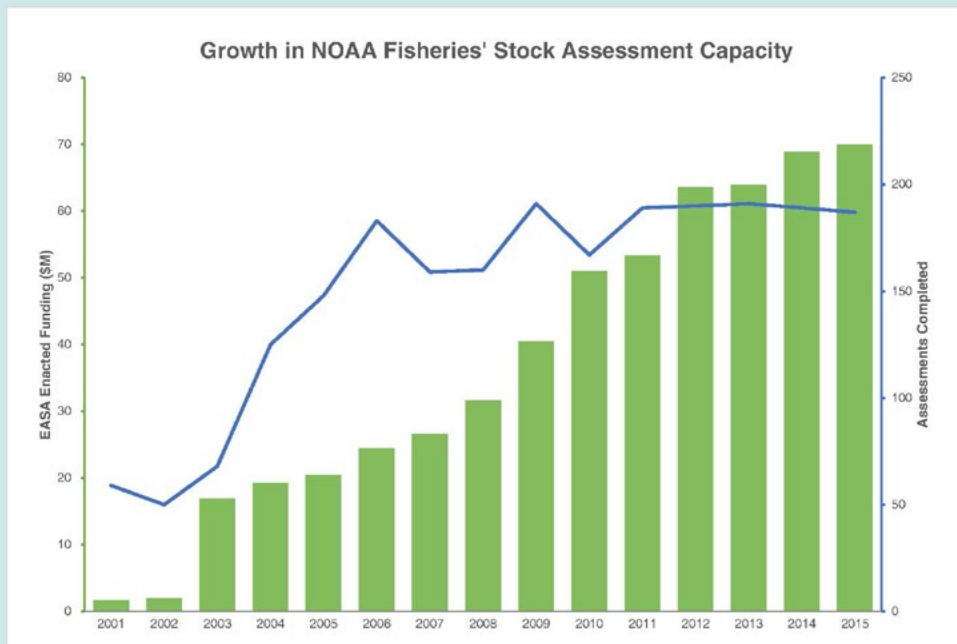
Updating the Stock Assessment Improvement Plan

This summary, and the full NGS document, is an update to the *Stock Assessment Improvement Plan* (SAIP) published by NOAA Fisheries in 2001. The next generation SAIP has been developed in response to the results of recent independent reviews of NOAA Fisheries' science programs, the many strategic drivers and mandates guiding NOAA Fisheries, and the development of new scientific tools and research. It will help build upon improvements made under the original SAIP and facilitate progress toward fishery management approaches that are more holistic and responsive to ecosystem and socioeconomic considerations. NOAA Fisheries has expanded its efforts towards building a robust and reliable stock assessment enterprise. These advances have created a strong foundation that has facilitated the development of the NGS Enterprise described here.

Since the release of the first SAIP in 2001, NOAA Fisheries' capacity to conduct stock assessments has increased (see Box above right). The number of assessments conducted annually has dramatically increased—from 50 in 2001 to nearly 190 in 2015. These assessments provided the science information to help reduce the number of stocks experiencing overfishing by 30 percent over the same period and reduce the number of overfished stocks by 24 percent. The expansion of NOAA Fisheries' data collection and monitoring capabilities has been substantial. Improvements to catch monitoring programs have resulted in better coordination of data for both commercial and recreational fisheries statistics. Investments in educational efforts have allowed NOAA Fisheries and partners to train the next generation of stock assessment scientists. National working groups that are focused on mission-critical topics help NOAA Fisheries to support advancements in fisheries science, and lead to increased opportunities for collaboration with our partners. A rigorous

peer review process for stock assessments led to improvements in the fishery management process, as well as improved levels of quality assurance. NOAA Fisheries has also expended considerable effort to improve communications and public outreach related to stock assessments.

Through these efforts, the NOAA Fisheries stock assessment enterprise has played a major role in establishing the U.S. as a leader in managing fisheries sustainably. Our assessments have directly improved the overall understanding of the current state of U.S. fisheries, and provided the science needed to manage for sustainability.



Since the release of the 2001 Stock Assessment Improvement Plan, NOAA Fisheries' core stock assessment budget line (Expand Annual Stock Assessments; EASA) has increased incrementally (green bars, left axis). These funding increases have improved many aspects of NOAA Fisheries' stock assessments, including the number of assessments completed per year (blue line, right axis).

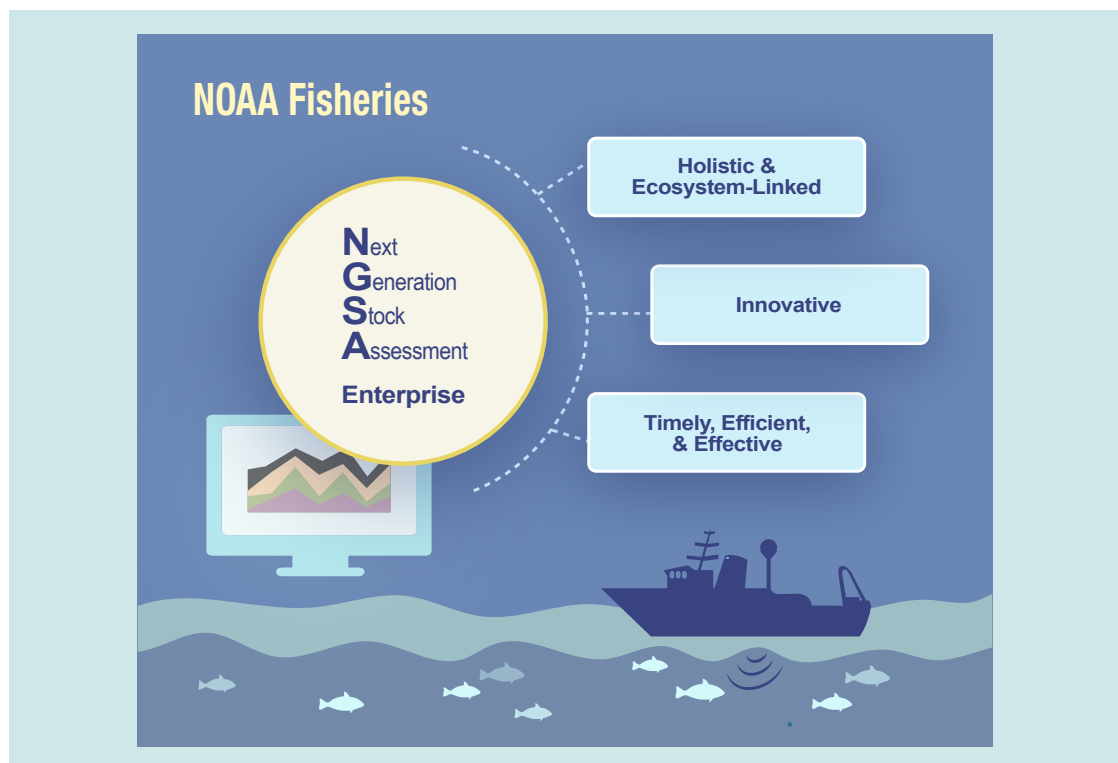


The Next Generation Stock Assessment Enterprise

Despite the improvements made since the last SAIP, numerous developments, advances, challenges, and opportunities have occurred in the last 15 years which warrant the re-evaluation of NOAA Fisheries' stock assessment enterprise. Federal mandates, fishery managers, and stakeholders all provide numerous and sometimes conflicting demands on NOAA Fisheries' stock assessments. Requests to make stock assessments simpler, more comprehensive, based on better data, more transparent, prioritized, updated, quicker to produce, and other demands may be incompatible to varying degrees and must be carefully considered.

The overall goal of the NGSAs document is to offer potential solutions to primary issues currently facing NOAA Fisheries' stock assessment enterprise. There are three main objectives to this NGSAs framework:

1. Expanding the scope of stock assessments to be more holistic and ecosystem-linked
2. Using innovative science and advanced technologies to improve data and analytical methods
3. Establishing a more timely, efficient, and effective stock assessment process



Under the objectives of the NGS framework, this document will help guide NOAA Fisheries towards its vision of resilient ecosystems, communities, and economies for future generations.

Holistic and Ecosystem-Linked

Why?

The common approach to stock assessment is to analyze a dynamic system in which fishing is the dominant driving force and ecological drivers are largely assumed to constitute random variation in assessment models. This has had success in reducing overfishing to date; however, it may prove inadequate in the face of current and future environmental change. This points to a growing need to more thoroughly consider factors beyond fishing, such as ecological and socioeconomic drivers, in stock assessments. Incorporating this information will help increase the precision and accuracy of assessment models, and improve the capability of stock assessment scientists and managers to determine appropriate biological reference points and harvest control rules, particularly in the context of future ecological change.

Three-step process to determine whether and how stock assessments should be expanded to be more holistic

Step 1: Use the prioritization process described in Chapter 10 of the NGS document to set target levels for stock assessments, and identify those stocks that are highest priority for expanded assessments

Step 2: For stocks that are a priority for expanded assessments, use potential linkages between ecosystem/socioeconomic drivers and fish/fisheries (shown in the figure below) and other available information to guide which factors should be considered for in an assessment

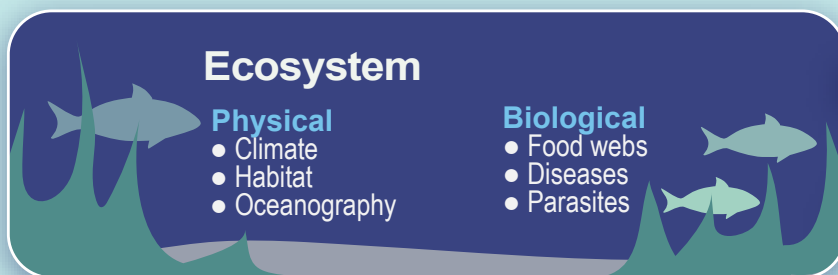
Step 3: Once potential ecosystem or socioeconomic factors are identified, use information described in the NGS document (e.g. Table 8.1 and Box 8.1) to help determine how the factors should be included

How?

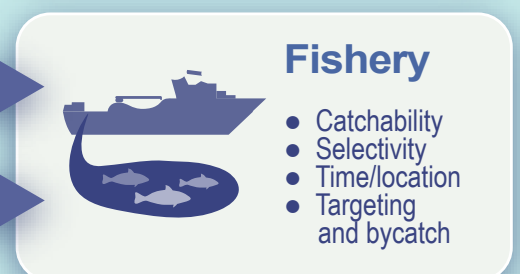
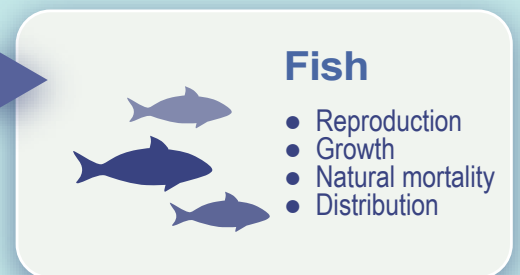
Inclusion of ecological or socioeconomic drivers may not be necessary for all stocks or assessments. Incentives to expand assessments may be based on a stock's value, status, and/or biology. Other considerations include whether there is evidence to suggest that stock or fishery dynamics are tightly coupled with some variable ecosystem or socioeconomic feature.

Potential Linkages Between Ecosystem/Socioeconomic Drivers and Fish/Fisheries

Drivers



Potential Effects





It is important to determine when it is most necessary to include such factors in the assessment process. A systematic, three-step decision-criteria approach (outlined in the box on previous page) is described in the full NGSAs document to guide the consideration of ecosystem and socioeconomic information in the stock assessment process. Such investigations should not come at the expense of NOAA's ability to produce the usual number of assessments each year, and it is expected that this decision process will continue to improve over time. Even for stocks where it is deemed not appropriate to expand the assessment to include ecosystem or socioeconomic linkages, the process of evaluating stock and fishery dynamics from a broader system-level perspective is generally beneficial. Thus, stock assessment terms of reference (ToR) should formally consider ecosystem and socioeconomic information.

Innovative Science

Why?

Stock assessments provide reliable, complete, and transparent advice to fishery managers. To provide the best information possible and meet the demands for increased quality and quantity of stock assessments, it is important to continually improve stock assessments with new developments in science and technology. There needs to be a focus on achieving a higher calibration of stock abundance data, an

expansion of the data collection and data delivery system, and utilization of new statistical and mathematical modeling techniques and software. Such investments will result in measurable improvements in the scientific advice from stock assessments made available to resource managers.

How?

Data Collection & Processing

Data collected from fisheries are important sources of information on numerous factors (e.g. total catch levels and catch composition) that are key inputs to stock assessments. This fishery-dependent data collection can be improved through partnerships with fishing and environmental organizations, and by developing low-cost data collection methods as part of normal fishing operations. Additionally, increasing remote fishery data collection (i.e. electronic monitoring and electronic reporting) is recommended to improve the accuracy, timeliness, and cost-effectiveness of fishery-dependent data collection.

The collection of new data types, particularly ecosystem information, can be enhanced by expanding fishery-independent data collection aboard NOAA ships to collect more interdisciplinary data for both fisheries and ecosystem research. Improvements to calibration of stock abundance data can also be accomplished by increased research aboard existing NOAA fishery surveys, focusing on catchability and selectivity, and species distributions and habitat associations, which could also potentially affect survey catchability. Utilizing advanced sampling technology is another important way



NOAA is improving data collection, and NOAA Fisheries will continue to work with partners among academic, industry, and other agencies, for research, development, and evaluation of advanced sampling technologies, including unmanned systems.

To improve data management, NOAA Fisheries will develop a more streamlined system for compiling, processing, and distributing data. As a first step, NOAA Fisheries will work to provide centralized open access to updated and processed stock assessment data that are organized according to standardized formats and data dictionaries.

Stock Assessment Modeling

Advancements in software and the increase in open source software packages and statistical programming languages have greatly facilitated numerous developments in stock assessments. NOAA stock assessment scientists continue to rely on and contribute to the advancement of these statistical modeling platforms. An important component of the NGS framework is the recommended approach to develop and advance assessment models using professional software architecture and creating modular applications to facilitate the rapid incorporation of new features as needed. In advancing the professionalism of assessment model development, the features available and standard practices in stock assessments should expand to include advanced statistical and mathematical methods that will allow a maximum amount of information to be extracted from available data. Also, the characterization of uncertainty will be more complete as NOAA Fisheries’



assessments utilize more ensemble modeling and decision analysis tools to better convey structural uncertainty. Investments in research to develop innovative science and technology and the resources needed to implement these advancements should be decided based on stock assessment priorities.

Timely, Efficient, and Effective

Why?

NOAA Fisheries is responsible for managing many more stocks than can be assessed and reviewed in a given year. However, frequent assessments may not be necessary for all stocks, particularly those which are not highly valued commercially, recreationally, or ecologically. In order to meet the increasing demands being placed on NOAA Fisheries’ stock assessment programs, efficiency in the stock assessment process needs to improve. However, it is



The 4Ts of Assessment Demands



Throughput

Expectation

Conduct a high number of assessments each year to support development of annual catch limits.

Reality

There are many more stocks under NOAA's purview than can be assessed in a year with current capacity.

Solution

Apply consistent prioritization to determine the stocks most needing assessment; conduct more routine update assessments.

Timeliness

Expectation

Utilize current information and rapidly develop advice for management decisions.

Reality

Regional approaches to processing and assembling data, modeling, and reviewing assessments vary substantially.

Solution

Standardize data delivery, modeling options, and peer review.

Thoroughness

Expectation

Assessments should be comprehensive investigations with fully-independent peer reviews.

Reality

Current data availability and assessment capacity do not facilitate comprehensive assessments for all stocks.

Solution

Apply consistent prioritization to determine the stocks in need of comprehensive investigations.

Transparency

Expectation

Results should be fully documented, clearly communicated, and accessible for public understanding.

Reality

Assessments are complicated, produce numerous results, and a variety of communication formats are used.

Solution

Use standardized and tiered reporting templates that summarize results at various levels of detail.

important that an appropriate level of detail, transparency, and review be maintained for each assessment. The full NGS document describes an objective national approach to conducting an assessment portfolio analysis, and offers suggestions for achieving more efficient regional assessment processes.

How?

A portfolio approach will help NOAA Fisheries maximize the return on available stock assessment resources, guide future investments, and achieve sustainable fisheries and resilient communities. This approach includes five main components:

1. Classifying stock assessments
2. Setting stock-specific targets for frequency and level of assessment
3. Developing annual prioritized lists of stock assessments for each region

4. Conducting gap analyses
5. Using the resource assessment to evaluate stock assessment capacity and determine where expansions are of highest priority

Classifying Stock Assessments

Having a standardized approach to classifying stock assessments is essential for tracking assessments and can help in determining frequencies and levels at which to conduct assessments. The 2001 *Stock Assessment Improvement Plan* (SAIP) described a stock assessment classification system based on five categories. This previous system lacked the detail needed to fully categorize modern assessments, particularly with regard to how they utilize ecological data inputs. The new Stock Assessment Classification System described in the full NGS document includes high-level model categorization, tracks the age of the assessment, and expands the categorization of data used in

assessments. For example, this system includes a new category specific to ecosystem-linkages. The expansion of the classification system, particularly the addition of categories relating to ecosystem linkages and size and age data, will provide a more comprehensive understanding of how these key aspects of fisheries dynamics are incorporated into stock assessments.

Prioritizing Stock Assessments and Setting Targets

The full NGS document expands on the existing framework for prioritizing stock assessments. This prioritization process is being conducted regionally, and it helps NOAA Fisheries and its partners to determine how to best allocate limited federal resources to address regional needs. Additionally, this framework creates a transparent and predictable annual prioritization process that increases the utility of the overall

assessment enterprise to meet national mandates. Within each region, the prioritization framework is being used to determine stock-specific target assessment frequencies and the stocks that are top priorities for assessment each year; the expanded framework provides guidance on determining the level of assessment needed for each stock. The protocol improves the overall efficiency of the stock assessment process, and seeks to enhance, not replace, ongoing regional approaches to prioritization.

Standardized Approach

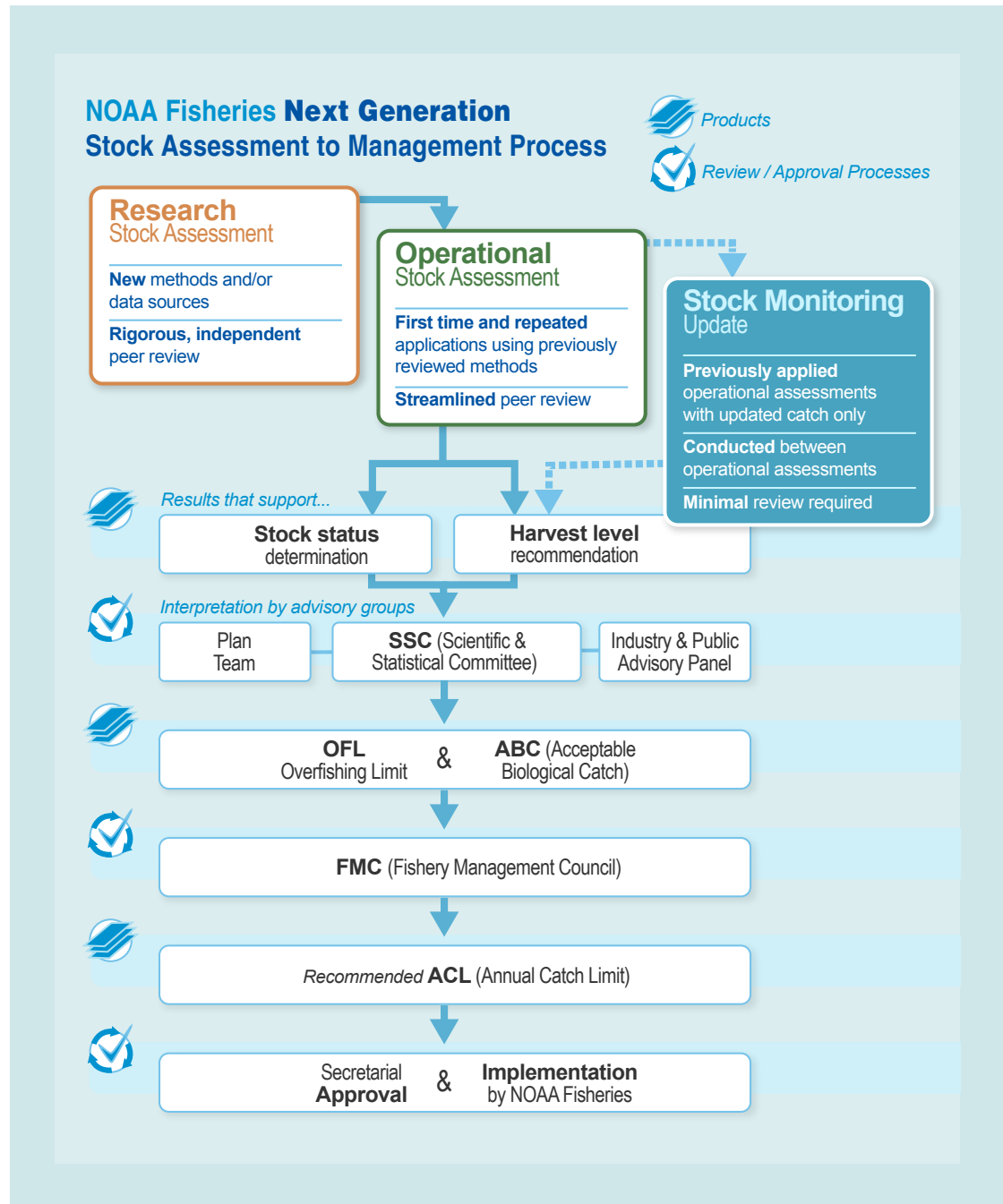
Each region has its own species, habitats, and fisheries. This variability makes it challenging to create a standardized approach to stock assessments. However, establishing a more standardized approach across regions can help to improve efficiency and increase transparency and understanding of the assessment process.



Standardized data management systems and modeling frameworks make it easier for data to be prepared and utilized in models, especially by less-experienced stock assessment analysts. Additionally, it makes it easier to review model results and communicate those results to partners and stakeholders.

Standardization should not stand in the way of innovation. Two parallel tracks are recommended

for stock assessment: operational assessments and research to improve operational assessments (see box below). While research assessments will be subject to more intensive review by independent experts compared with operational assessments, all scientific products that are used to support fishery management decisions should have some level of review, appropriate for the novelty of the work, and the level of controversy and importance of the resulting management action.



Priority Actions

The NGS document recommends a series of priority actions to improve NOAA Fisheries' stock assessment enterprise; these actions are categorized below. The list is broken into the three main objectives for NOAA Fisheries' stock assessments: Holistic and Ecosystem-Linked; Innovative; and Timely, Efficient, and Effective. The full NGS document contains specific recommendations under the categories listed here. Successful implementation of

these recommendations will require strong communication and collaboration with our partners and stakeholders, as well as continual review and evaluation to ensure the highest priority actions are being implemented. Transitioning to the Next Generation Stock Assessment Enterprise will not come at the expense of NOAA's ability to meet current mandates, but rather will improve that ability over time.

Holistic and Ecosystem-Linked

- Apply more and routine consideration of ecosystem, environmental, and socioeconomic drivers in the assessment process and in the research conducted to develop operational assessments; use the proposed three-step decision process (see box on page 11), in combination with ongoing research, to determine when and how to expand assessments to be more holistic.
- Coordinate stock assessment results and the advice being provided to managers across stocks; consider broader ecosystem and fishing community factors in a more holistic evaluation of harvest control rules; improve communication of stock assessment issues and gaps to inter-disciplinary researchers.

Innovative Science

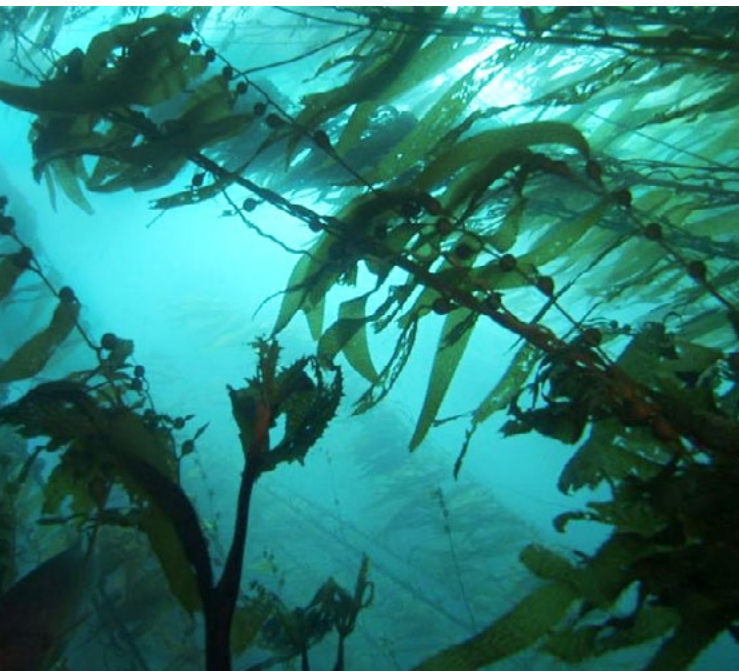
- Maintain and improve fishery-independent data collection capabilities; conduct more studies to directly calibrate fish abundance from surveys; adjust coverage for shifting species distributions; expand broad spectrum collection of ecosystem and environmental data.
- Maintain and improve fishery-dependent data collection including remote data collection (electronic monitoring); develop low-cost fish and environmental survey methods deployable from fishing vessels.
- Utilize advanced technologies, such as sonar, robotic camera systems, automated image processing, environmental-DNA, and others to expand coverage, reduce stock impacts, and streamline data collection.



- Improve the assessment modeling approach with a focus on advanced statistical methods, expanding assessment model scope and broader use of management strategy evaluation simulations, and improving characterization of uncertainty, including the use of model ensembles; improve professionalism of the assessment data management and model development process.

Timely, Efficient, and Effective

- Prioritize stock assessment activity through implementing the new assessment data classification system and gap analysis.
- Establish timely and efficient assessment processes by separating research from operational assessments; streamlining the operational process; expanding the scope and inclusivity of the research process; and establishing a timely and efficient degree of peer-review focused on relevant issues.
- Maintain effective stock assessments with standardized approaches and improve communication of data needs and assessment results; improve stakeholder outreach and engagement; improve training of current and future assessment scientists; and improve opportunities for assessment scientists to engage in research.



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For more information, including access to the entire document,
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