NOAA FISHERIES SERVICE

Stock Assessment: The Core of Fisheries Science

NOAA Fisheries' stock assessments form the core of fisheries science by providing high-quality information to fisheries managers on the current status of fish stocks and future trends in fisheries productivity.

"A fish stock is a group of individuals, of the same species, that inhabit the same geographic region and interbreed when mature. 'Stock' may also refer to a multispecies complex that is managed as a single unit."

Why Are Assessments Important?

Fisheries in the United States contribute nearly $100 billion per year to the American economy and generate ~500,000 jobs. Healthy fisheries also provide recreational fishing opportunities to millions of Americans. To continue enjoying these benefits, fish stocks must be carefully managed to ensure sustainable use for current and future generations.

Stock assessments provide important science information necessary for the conservation and management of fish stocks. The Magnuson-Stevens Reauthorization Act of 2006 calls for the best scientific information available to manage U.S. commercial and recreational fisheries. Over 500 fish stocks in the United States are managed under fishery management plans produced by eight regional fishery management councils. Additionally, coastal states and international organizations rely on NOAA Fisheries' stock assessments for the management of non-federal and joint jurisdiction fish stocks.

Stock assessments conducted by NOAA Fisheries are designed to answer difficult questions about the balance between conservation and utilization of marine fish resources. These questions include:

- What is the current status of a fish stock relative to established abundance and fishing mortality targets? (e.g. Is the stock experiencing overfishing? Is the stock overfished?
- How much catch is sustainable?
- If a stock is depleted, what steps must be taken to rebuild it to healthy abundance levels?

Answers to these important questions help managers make the best decisions to ensure a healthy balance between sustainable fish stocks, ecosystem health, and productive coastal communities.

Data for Stock Assessments

NOAA's fish stock assessments collect, analyze, and report demographic information to determine the effects of fishing and other factors on fish populations (Marine Fisheries Stock Assessment Improvement Plan).

Stock assessments require three primary categories of information: catch, abundance, and biology.

Catch: The amount of fish removed from a stock by fishing. A national network of fishery monitoring programs continuously collects catch data and makes this information available to stock assessment scientists and managers. Sources of catch data include:

- Dockside monitoring – Often conducted in partnership with state agencies, dockside monitoring records commercial catch receipts to give an accurate measure of commercial landings and provides

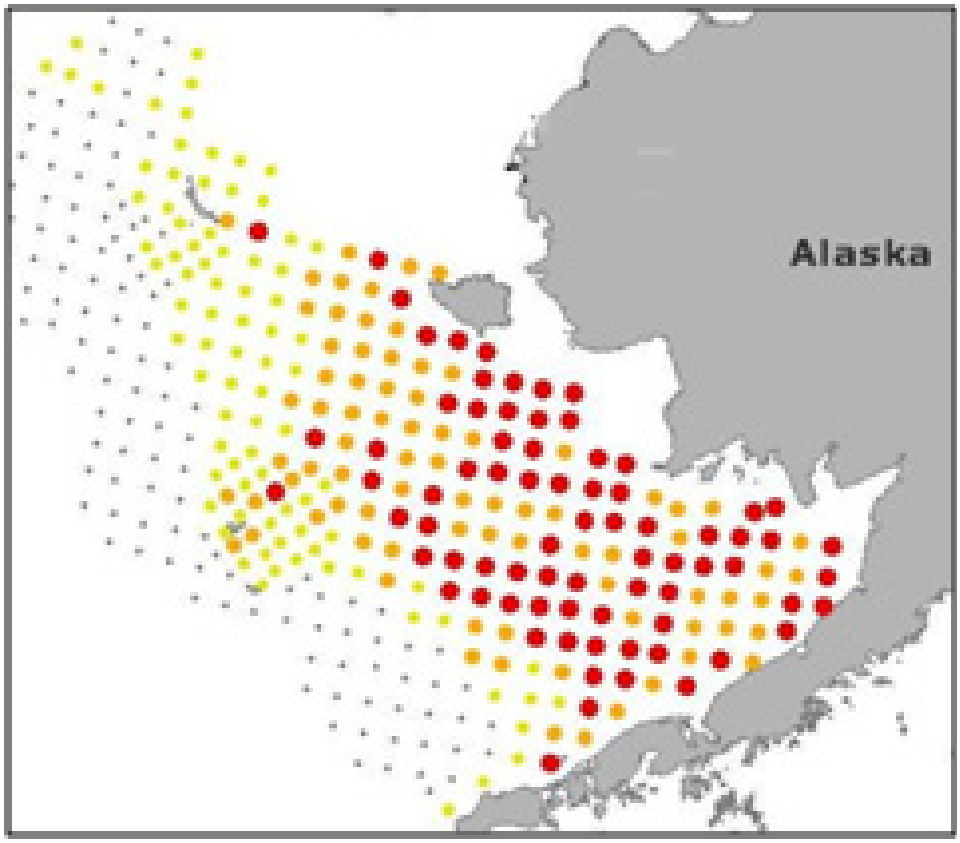

Figure 1. Pattern of stations in the multispecies Bering Sea trawl survey. Larger, darker dots on the map indicate more yellowfin sole were collected at that station during surveys in 2008. (Source: AFSC, www.afsc.noaa.gov)

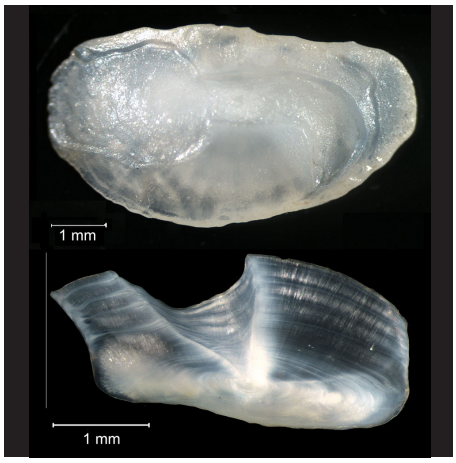

Figure 2. Fish ages are determined from annual marks on otoliths (fish ear bones). This otolith from a spot indicates the fish was 4 years old. (Source: FWC)

biological samples of the length, sex, and age of fish.

- Logbooks: Records from commercial fishermen of their location, gear, and catch.
- Observers: Biologists observe fishing operations on a certain proportion of fishing vessels and collect data on the amount of catch and discards.
- Recreational sampling: Telephone interview surveys and dockside sampling estimate the level of catch by the recreational fishery.

Abundance: A measure of the number or weight of fish in the stock, a segment of the stock (e.g. spawners), or a portion of the stock area. Data typically come from a statistically-designed, fishery-independent survey that samples fish at hundreds of locations throughout the stock's range (*Figure 1*). Most surveys are conducted annually and collect data on all ecosystem components. NOAA Fishery Survey Vessels and chartered fishing vessels use standardized sampling methods to collect data the same way each year, providing a relative index of abundance over time. Depending on the biology of the species and the habitat in which the stock lives, some surveys use standardized versions of fishing gear, while others use acoustics, plankton nets, or other methods. Additionally, data from fishermen's logbooks can sometimes be statistically processed as an indicator of trends in fish abundance, although with less standardization than a dedicated survey.

Biology: Provides information on fish growth rates and natural mortality. Biological data includes information on fish size, age (*Figure 2*), reproductive rates, and movement. This data may be collected during fishery-independent surveys 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.

Stock Assessment Models

Fish stock assessment models compute the historical levels of fish stock abundance and fishing mortality that are most consistent with observed trends in abundance data, the fish's biology, and historical catch levels. Today's most complete assessment models, termed statistical catch-at-age analysis or more broadly as integrated analysis, work as computer simulations of fish populations. Conceptually, these models are similar to those used by NOAA Weather to calibrate a dynamic atmospheric model with diverse weather observations, although stock assessments oper-

ate on much longer time intervals.

An integrated analysis model consists of 3 sub-models: 1) the population sub-model, 2) the observation sub-model, and 3) the statistical sub-model. The population sub-model first computes key population estimates such as fish abundance, mortality, growth, reproduction, and movement. The observation sub-model then translates these population estimates into factors for which we have data, including survey abundance index, catch, fish size and age composition, and others as available. Finally, the statistical sub-model adjusts the parameters of the model to achieve as good a match as possible to all the data.

Hundreds of parameters may be needed in complex situations with multiple stock areas, several fishing fleets and long time series. Modern statistical methods and powerful computers make this all possible. The precision of the final model fit to the data determines the statistical confidence on the historical estimates and future predictions (*Figure 3*).

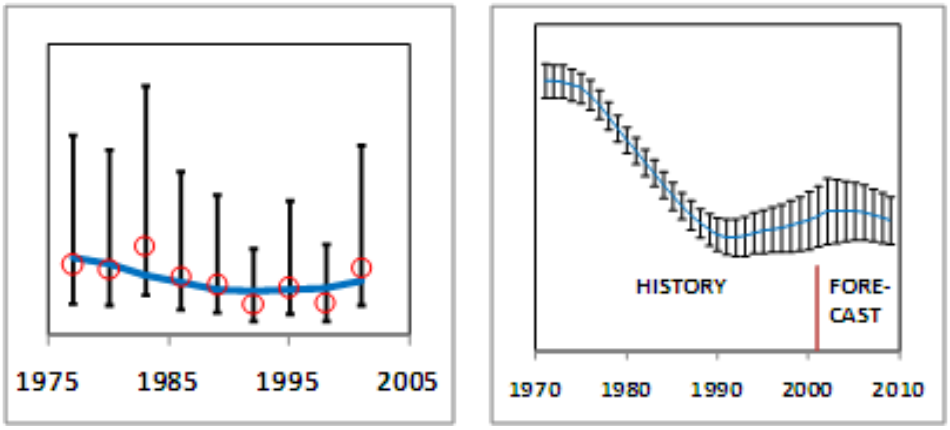

Figure 3. Left, Model predictions (blue line) compared to the observed survey abundance trend (red dots with vertical error bars) for a simulated stock surveyed every third year. Right, Time series of estimated historical and forecast abundance for the simulated stock. Vertical bars are confidence intervals on the estimates.

Many modern assessment models now come with graphical interfaces that improve standardization between individual assessments and make it easier for assessment scientists to use these models in collaborative assessment workshops. Extensive computer simulation studies are used to evaluate the potential performance of data collection, assessment, and management systems.

Assessments and Ecosystem Factors

Factors other than fishing can have an important role in determining the health and abundance of fish stocks. Ecosystem factors such as complex interactions among species in the marine food web, changes in marine coastal habitat, and constantly changing ocean environmental factors may be important.

Traditionally, fish stock assessments have relied on direct measurement of fish stocks and catch to determine a stock's abundance and potential catch levels. This approach is effective for looking at present and historical conditions, but limited when trying to understand why changes occurred because it only accounts for the effects of fishing. This approach is also limited for making accurate forecasts of sustainable catch levels because it does not account for ecosystem factors that could impact fish abundance.

Integrated analysis models have the capability to include environmental and ecosystem factors. For example, time series of environmental factors such as ocean temperature and currents help scientists to better understand historical fish stock changes and improve forecasts. Ecosystem food web studies can provide more accurate values for important fish assessment parameters such as the level of natural mortality.

Much additional research is needed to determine the most important factors that cause changes in fish populations so these factors can better be included in stock assessment models. Fish stock

Improving Data Collection

Good stock assessments require high quality data inputs. How is NOAA Fisheries working to improve data collection programs?

- Electronic catch data collection for rapid access
- Advanced monitoring equipment attached to traditional sampling gear to collect concurrent environmental information during surveys
- Visual surveys in complex habitats using imaging systems on robotic and autonomous underwater vehicles
- Non-extractive abundance sampling using hydroacoustic technology
- Better define stock boundaries, habitat use, and fish movements through use of electronic fish tags, genetic analysis, and elemental composition of fish bony parts

"There is currently considerable interest from the public, stakeholders and the scientific community to move towards more comprehensive ecosystem-based fisheries stock assessments and management." (Marine Fisheries Stock Assessment Improvement Plan, 2001)

assessment results often feed back to holistic ecosystem studies by providing long time series of information on historical fish abundance and productivity.

Next Generation Assessments

Increasing demands for improved information to support fishery conservation and management efforts requires the continued improvement of fish stock assessments. The advancement of NOAA Fisheries' stock assessment program to the 'next generation' (*Figure 4*) will provide NOAA, fisheries managers, and the public with more timely, accurate, and complete information on sustainable catch levels and fish stock status. This information is crucial to support 21st century management measures implemented under the Magnuson-Stevens Reauthorization Act such as annual catch limits.

Assessment Research Priorities

NOAA's stock assessment program has outlined a number of research priorities and goals to better meet management and conservation needs in future years. These include:

- Increase the number of stocks with adequate stock assessments by collecting more catch, abundance, and biological data.
- Integrate stock assessment results with socio-economic models of fishery costs and benefits.
- Improve the capability of stock assessment models to characterize the degree of uncertainty so the risks and benefits of management decisions can be better communicated.
- Increase the number of NOAA scientists trained in stock assessment methods through support of focused educational programs.
- Improve understanding of effects of ecosystem and environmental factors on fish stocks.

Next Generation Stock Assessments

Prioritized	**Timely and Efficient**
Establish assessment goals (target assessment level and frequency) and prioritize activities to achieve goals. Priorities are based on a range of factors, including fishery importance, ecosystem importance, stock status, stock biology, and assessment history.	Key steps are streamlined data systems, standardized modeling approaches, and an efficient, focused review process to maintain a high level of quality and provide timely management advice. Better communication tools will keep the public better informed.
Ecosystem Linked	**Utilize Advanced Technology**
Link assessments to ecosystem factors such as climate, habitat, multispecies effects, and other environmental variables. Focus on key stocks within each region. Provide information to support Integrated Ecosystem Assessments and Coastal and Marine Spatial Planning.	Maximize data collection to support assessments through increased use of advanced sampling technologies such as hydroacoustic systems, autonomous underwater vehicles, automated image processing, and others. Support continued development of such technologies.

Figure 4. Next generation assessments include four primary components – they are prioritized, timely and efficient, ecosystem linked, and utilize advanced technology.

Learn More

NOAA Fisheries Office of Science and Technology:
www.st.nmfs.noaa.gov

NOAA Fisheries Stock Assessment Toolbox:
nft.nefsc.noaa.gov

NOAA Species Information System Public Portal:
www.st.nmfs.noaa.gov/sisPortal

Questions?
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