Stock Assessment Model Descriptions

NOAA Fisheries uses a wide variety of stock assessment models in its stock assessments. This page provides a general description of standard stock assessment model categories, the data they require, and the types of catch advice they provide.

Stock Assessment Models

A fishery stock assessment is the scientific process of collecting, analyzing, and reporting on the condition of a fish stock and estimating its sustainable yield. Stock assessments are the backbone of sustainable fisheries management. Stock assessment models are the mathematical and statistical techniques stock assessments use to analyze and understand the impact of fisheries and environmental factors on fish stocks.

NOAA Fisheries uses a wide variety of stock assessment models in its stock assessments. The selection of a specific model for a stock assessment is tailored to the available data. A stock assessment will typically use a less detailed model when fewer data are available. For example, stocks for which catch totals and basic life history information (growth and death rates) are the only available data. These models provide limited advice, generally in the form of a catch recommendation, and typically cannot estimate reference points or whether a stock is considered overfished.

NOAA Fisheries uses more detailed stock assessment models when more data are available. For example, stocks that NOAA Fisheries samples during its scientific surveys. These models can provide more complete management advice and support overfishing and overfished stock status determinations.

Data-Limited

NOAA Fisheries uses stock assessment methods referred to as “data-limited” when it has little to no knowledge of a stock’s size or fishery characteristics. Data-limited stock assessment models provide management advice for those stocks as well as for those with short or non-traditional life-cycles such as squid. Most data-limited stock assessment models can generate management advice from records of the annual total catch of a stock. However, some data-limited models require estimates of a stock’s growth, reproduction, and death rates.

Data-limited models provide management advice in relative terms. They indicate whether a stock's harvest level should increase or decrease compared to previous years'. That advice typically comes as a recommended maximum amount of fish that can be harvested in a year. Data-limited assessment models do not estimate a stock's current size or minimum stock size threshold. As a result, they cannot determine whether a stock is considered to be overfished.

NOAA Fisheries does not consider data-limited methods a long-term management solution for most stocks. They are a considered a temporary placeholder that provides management advice until sufficient data become available to support more complex models.

Examples of data-limited methods include:

- Depletion-Based Stock Reduction Analysis (DBSRA)
- Depletion Corrected Average Catch (DCAC)
- Mean Length Estimation (MLE)

Index-Based

An index is a standard measurement taken over time. Index-based stock assessment models analyze one or more indices of stock size to provide management advice. NOAA Fisheries uses two types of indices in fisheries stock assessments. The first are "fishery-independent" indices developed from data collected during surveys conducted by NOAA Fisheries and its collaborative partners. The second are "fishery-dependent" indices developed from records of catch and effort from commercial and recreational fisheries through fishermen logbooks and other monitoring programs.

Index-based methods analyze trends over time to provide management advice, typically in the form of catch recommendations. Observing how the index responds to high and low levels of catch help NOAA determine the impact of fishing on the stock and to estimate sustainable levels of catch. They generally do not estimate the total size of a stock, its reproduction rate, or its natural or fishing-related mortality. Most index-based methods do not provide estimates of minimum stock size threshold or evaluate a whether a stock is overfished. Some index-based methods measure the current index value against a critical threshold value, such as the long-term average index value. If the stock index falls below those values it typically triggers management actions such as a reduction in catch.

NOAA Fisheries conducts index-based methods in-between comprehensive stock assessments for some stocks, typically for those assessed using more detailed stock assessment methods. For those stocks, an index-based method serves as a monitor or "rumble strip" by tracking the relative condition of the stock. Index-based methods also serve as a backup approach when more detailed assessment methods fail to perform.

Examples of index-based methods include:

- Basic linear models and time series analyses
- An Index Method (AIM)

Aggregate Biomass Dynamics

Aggregate biomass dynamics models represent the simplest stock assessment method able to provide the full suite of management advice. These models evaluate a stock's size, reproductive rate, and mortality rate through time.

Aggregate biomass dynamics models estimate several key values for a stock, including:

- The maximum population size it can achieve in an ecosystem
- Its growth rate
- Trends in its total biomass
- The rate at which the stock is caught by fishing or survey gears

Management advice produced by aggregate biomass dynamics models includes estimates of current stock size, harvest rates, and management reference points associated with maximum sustainable yield (MSY). NOAA Fisheries uses those reference points to determine whether a stock is subject to overfishing and considered to be overfished.

Aggregate biomass dynamics models require more data than data-limited or index-based approaches. They require total catch over time and an abundance index for the stock. Aggregate biomass dynamics models also perform best when the input data have high levels of contrast, with periods of high and low abundance and catch. This contrast enables the models to provide better estimates of stock productivity.

Examples of aggregate biomass dynamics methods include:

- Schaefer Models
- Pella-Tomlinson Production Models

Virtual Population Analysis

Virtual Population Analysis (VPA) is a stock assessment method that focuses on age-classes or cohorts – fish born in specific years. Starting in the present, VPAs use year-by-year information on the catch and trend for each age class to estimate how big it must have been in order to have supported those catches.

VPAs provide the full suite of management advice for a stock. They estimate age-specific abundance and fishing rates over time. Subsequent analysis can provide estimates of a stock's reproduction and growth rate as well as sustainable harvest rates. Similar to biomass-dynamics methods, reference points for VPAs are based on MSY, fishing rate at MSY, and stock size at MSY.

NOAA Fisheries uses those estimates and their related reference points to determine whether stocks are subject to overfishing or are considered overfished.

VPA methods are relatively data-intensive. For each age class, they require information on catch, body weights, and the assumed mortality rate due to natural causes. They also require at least one index of stock size for testing and fine-tuning. These data needs are difficult to satisfy for many stocks, because obtaining complete information on each age-class is cost-prohibitive.

Examples of Virtual Population Analyses methods include:

- VPA (ADAPT)
- Dual Zone VPA (VPA-2BOX)

Statistical Catch-at-Length

Statistical catch-at-length methods analyze data on the size (length) of fish captured in scientific surveys and by commercial and recreational fisheries to provide management advice. NOAA Fisheries uses these methods when size information is collected, but age data are unavailable. For example, for species such as crabs and lobsters, which are difficult to age. Catch-at-length methods require a large amount of data. To operate properly, they require information on the number of fish caught at each size during annual surveys and by all relevant fisheries. Their performance also depends on information on a stock's natural mortality, growth, and reproduction. While catch-at-length methods can function when some data are missing, they have two notable weaknesses. They are less informative on stock growth rates than methods that incorporate age data (see below), and less precise regarding reproduction, growth, and death rates for larger animals that are approaching their maximum size.

Catch-at-length model results provide the full suite of management advice. They estimate a stock's current size, harvest rate, and its management reference points associated with maximum sustainable yield (MSY). Catch-at-length models also provide forecasts of catch and biomass that managers can use to evaluate the risk associated with a range of harvest options.

Examples of statistical catch-at-length methods include:

- Statistical Catch-At-Length (SCALE)
- Stock Synthesis (SS)
- MultifanCL
- Crustacean models

Statistical Catch-at-Age

Statistical catch-at-age methods analyze data on the age of fish captured in scientific surveys and by fisheries to provide management advice. They require at least one index of stock size, such as a

survey index or record of commercial fishery catch and effort. They also require records of the total catch from each fishery targeting a stock over time. Despite those requirements, catch-at-age models tolerate situations where some of those data are missing or incomplete.

Much like VPA models, catch-at-age models require data that are specific to individual age-classes (although contrary to VPA, an abundance trend for each age-class is not required). An age-class is a collection of all of the fish born in a specific year. They utilize statistical techniques to match those data to assumptions about a stock's birth, growth, and death rates.

Catch-at-age model results provide the full suite of management advice. They estimate a stock's current size, harvest rate, and its management reference points associated with maximum sustainable yield (MSY). Catch-at-age models also provide forecasts of catch and biomass that managers can use to evaluate the risk associated with a range of harvest options. Several of these models can simultaneously use a combination of age and length data.

Examples of statistical catch-at-age methods include:

- Stock Synthesis (SS)
- Age-Structured Assessment Program (ASAP)
- Assessment Model for Alaska (AMAK)
- Beaufort Assessment Model (BAM)
- MultifanCL
- C++ Algorithmic Stock Assessment Library (CASAL)