

Evaluating the Effectiveness of Fish Stock Rebuilding Plans in the United States

Fish stock rebuilding plans have proven successful in reducing fishing pressure on many overfished stocks and stock sizes have generally increased. However, in some cases fisheries have not rebuilt as quickly as the plans projected, due to factors such as overestimation of the size of stocks and incidental catch by fisheries targeting other species. Even when fishing is reduced appropriately for the actual stock size, the rate at which rebuilding occurs will depend on ecological and other environmental conditions. Because of all these factors, it is difficult to make accurate predictions of the time it will take stocks to rebuild. Therefore, rebuilding plans that focus more on meeting selected fishing mortality targets than on adhering to strict schedules for achieving rebuilding may be more robust to assessment uncertainties, environmental variability, and the effect of ecological interactions.

Well-managed, productive fisheries provide a livelihood, a nutritious source of food, and recreational activity for coastal communities around the country. However, if overfishing takes place and stocks experience serious declines, the lost productivity affects the fishing industry and communities that depend on fishing, and raises concerns about the overall health of the associated marine ecosystem. In the United States, the 1976 Magnuson-Stevens Fishery Conservation and Management Act was the first piece of major legislation to regulate federal fisheries. Although the Act contained language to “prevent overfishing,” it focused on developing the domestic fishing industry. Major declines in the productivity of several important fisheries led Congress to amend the Act 1996. The amendment, called

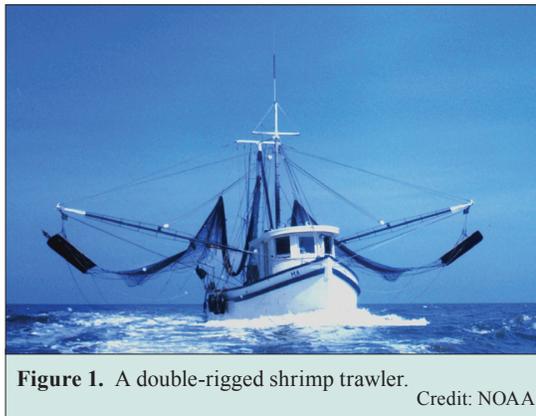


Figure 1. A double-rigged shrimp trawler. Credit: NOAA

the Sustainable Fisheries Act, more clearly defined overfishing and required rebuilding of overfished stocks within a specified time limit. In 2006, Congress made additional mandates for conserving and rebuilding fish stocks and strengthening the role of scientific

advice in fisheries management. The Act now includes regulatory provisions such as ending overfishing immediately, annual catch limits and accountability measures.

To meet these provisions, rebuilding plans have required substantial reductions in catch for many fisheries, resulting in social and economic impacts to fishing communities and industry. This report reviews the technical specifications that underlie current federally-implemented rebuilding plans, and the outcomes of those plans.

A **fishery** is a group of fishing operations targeting similar species, using similar gear, during a similar time of year and/or within the same area.

A **stock** is a single species of fish in one geographical area.

Overfishing occurs when the rate of fishing exceeds F_{MSY} .

A stock is considered **overfished** when the population is driven below the maximum sustainable yield-derived reference point for that stock. For many stocks, this reference point is set at 50 percent of B_{MSY} .

How Rebuilding Plans Work

The National Marine Fishery Service evaluates the status of US fish stocks to determine which stocks are overfished; that is, which stocks are too small in size to sustain continued productive fisheries. Once a stock is classified as overfished, the appropriate Regional Fishery Management Council selects and implements a rebuilding plan.

Rebuilding plans are simple in theory: annual catch limits are set to reduce fishing, which allows the stock to grow and recover. However, in order to design a rebuilding plan, fishery managers need to anticipate how the stock may respond to different levels of fishing pressure. Currently, rebuilding plans use a concept called Maximum Sustainable Yield (MSY) to determine when a stock is overfished, and to set annual catch limits and rebuilding targets for stock size (see Box 1).

The Challenges of Rebuilding Plans

Rebuilding plans based on MSY have proven successful for many stocks. The committee considered a subset of 55 stocks that were put under rebuilding plans at some point between 1997 and 2012. Of these, 10 have rebuilt, 5 are rebuilding, and 11 of the stocks are on the way to rebuilding if recent decreases in fishing mortality are sustained.

However, data from the most recent stock assessments indicate that 20 of the 55 stocks analyzed were not actually overfished at the time they were placed in rebuilding plans, a consequence of uncertainties in estimating fish stock abundance. Such uncertainties cut both ways: retrospective assessments indicate that stock size may also be overestimated, such that some stocks classified as healthy were actually overfished. The remaining 9 of the 55 stocks are still subject to overfishing even though very strict fishing limits have been set (below 75% F_{MSY}). Those failures can reflect problems with implementing the rebuilding plans, difficulties in reducing unintentional harvest of the stock (bycatch), or uncertainties in estimating stock size.

MSY Reference Points

A major challenge comes from the fact that current rebuilding plans use a static metric of MSY, which in theory represents average conditions. In reality, ecosystems are dynamic and as a consequence MSY varies with factors such as changes in environmental

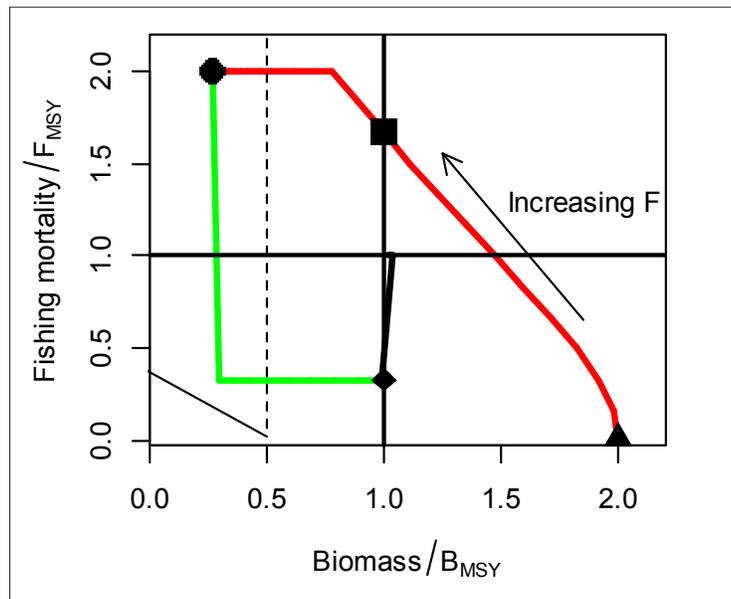


Figure 2. As fishing mortality increases over time (red line), a fish stock will go from an unfished state (triangle in lower right), to gradually becoming overfished (diamond in upper left). At this point, a rebuilding plan might go into effect, leading to reduced fishing (green line). According to theory, this should allow the stock to recover and biomass to increase until it reaches B_{MSY} .

conditions and ecological interactions. Generating reliable estimates of MSY depends on having extensive information about the biology of the species and its abundance in the years before it was overfished. This wealth of information is only available for a relatively few stocks, hence there is considerable uncertainty in the MSY estimates for most stocks. Although the MSY approach has been successful for some fisheries, management based on MSY can fall short in addressing ecosystem complexity and variability and in accounting for uncertainty in the estimates of reference points.

Box 1. Maximum Sustainable Yield

To be considered sustainable, a population of fish should produce enough young to replace the fish that die each year, due to natural causes and to fishing. The maximum, sustainable, long-term average yield that can be taken from a fish stock is called the **Maximum Sustainable Yield (MSY)**.

The population level, or **biomass**, that generates MSY is called the Biomass MSY, or B_{MSY} .

The rate of fishing, called **fishing mortality**, which will maintain the average population size at B_{MSY} is called the fishing mortality $_{MSY}$, or F_{MSY} .

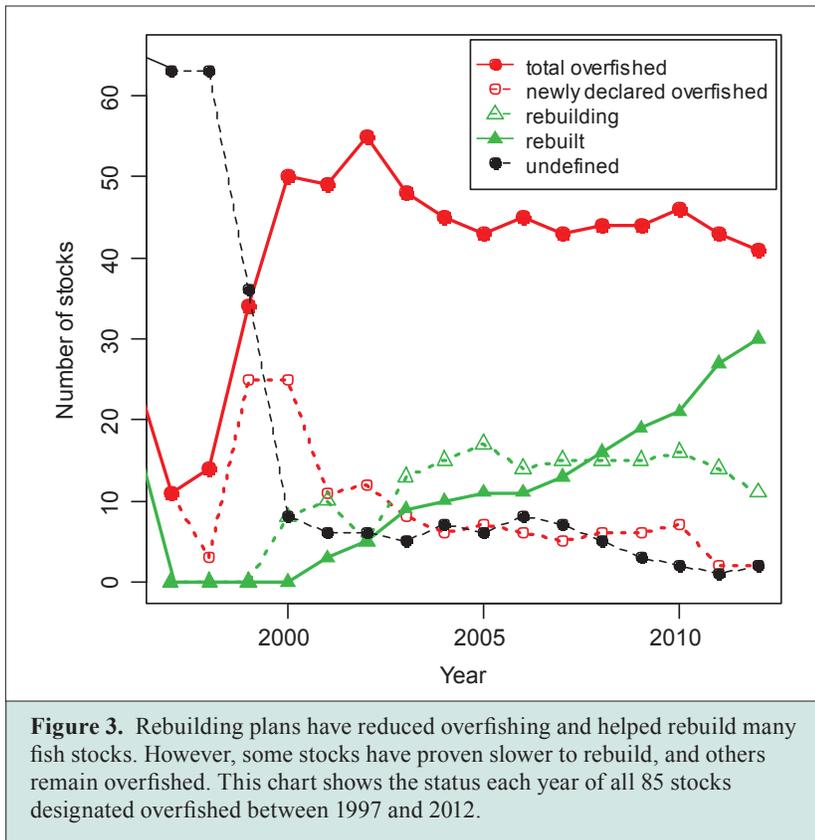


Figure 3. Rebuilding plans have reduced overfishing and helped rebuild many fish stocks. However, some stocks have proven slower to rebuild, and others remain overfished. This chart shows the status each year of all 85 stocks designated overfished between 1997 and 2012.

Uncertainty in Stock Assessments

Because it is not possible to count every individual fish in a stock, scientists rely on a variety of sampling and statistical methods to estimate abundance. These estimates are used in models to project trends in future stock size. The accuracy of the population estimates and the projections depends on the quality and amount of data available and the ability of models to reproduce the primary determinants of the species' population growth. The frequency of stock assessments can vary widely, both within and among regions, from stocks that are assessed annually to stocks that have never been assessed. As more data are collected and new models and assessment methods become available, past estimates of the status of fish stocks can change substantially. For example, some stocks that were previously classified as overfished (and put under rebuilding plans) would not have been considered overfished based on the most recent assessments. The inverse may also have occurred, with overfished stocks misclassified as not overfished.

Climate, environmental conditions, and ecosystem interactions can have significant effects on the rate at which a stock rebuilds. Although these factors affect the time it takes for a stock to rebuild, it is not

currently possible to incorporate them into models to improve projections to a degree of accuracy that is useful for management.

Mixed Stock Fisheries

Fish do not live in isolation—each stock is part of a community of species that live in the same waters. For example, when a fishing net is cast into the ocean, it can capture several different fish species. This is called a mixed-stock fishery.

When one stock within a mixed-stock fishery is declared overfished, reductions in fishing required by the rebuilding plans affect all the stocks in the fishery, leading to a loss of yield and income. For example, juvenile red snapper in the Gulf of Mexico are incidentally caught during shrimp trawl fishing, driving the red snapper to overfished status. Devices were installed in shrimp nets to reduce bycatch, but were not sufficient to end overfishing.

Subsequent rebuilding plans included a shrimp trawl fishing threshold, in addition to fishing limits for red snapper.

Alternative Management Strategies

Current rebuilding plans rely on a prescriptive approach, which has had demonstrated successes in identifying and rebuilding some fish stocks. However, the plans' focus on achieving rebuilding targets within set timeframes forces reliance on forecasts and estimates of MSY-based reference points, which often carry a high level of uncertainty. Rebuilding plans that focus on meeting selected fishing mortality targets may be more effective than a plan with an exact time period for rebuilding. The report's authoring committee made several suggestions for alternative management strategies for rebuilding fish stocks.

Gradual Reductions in Annual Catch

Delaying reductions in annual catch until the stock biomass has declined to overfished status means that fishery managers must then make immediate and substantial decreases in fishing. Alternative management actions, such as harvest control rules that promptly but gradually reduce fishing as estimated stock size falls would result in a lower likelihood of a stock becoming overfished.

Fishing Mortality Reference Points

Fishing mortality reference points seem to be more robust to uncertainty than biomass reference points, both in the context of rebuilding and more generally. Estimates of biomass are expected to change, and hopefully improve, as stocks rebuild—but predicting these changes is difficult as it requires predicting average future recruitment of juvenile fish to the adult population. In contrast, setting reference points based on fishing mortality requires comparatively less information.

Environmental Considerations

Most fisheries select for the largest fish, and by doing so reduce the average age of the fished population. A rebuilding strategy based on maintaining reduced fishing mortality for an extended period—longer than the mean generation time of the stock—would help restore the stock's age structure (i.e., increase the average age) and would be more robust to changing environmental conditions than strategies that require rebuilding to pre-specified biomass targets by a given time limit.

Setting Fishing Limits Below F_{MSY}

The Magnuson-Stevens Act specifies that stocks designated as overfished must rebuild within a maximum time period (usually 10 years). This strategy means rebuilding usually occurs quickly once a stock is designated overfished. However, if rebuilding is slower on average than expected when the plan was adopted—for example, due to unfavorable environmental conditions that affect recruitment

of juveniles—ever more severe controls on fishing must be applied to try to keep rebuilding “on schedule”. These reductions in fishing can have significant economic and social impacts to the fishing industry and community. Maintaining fishing at some constant level below F_{MSY} may help achieve rebuilding goals on a schedule that accommodates natural variability in stock productivity.

Data-Poor Stocks

Analytical assessments are not available for many of the stocks classified as overfished because there are not enough data and information to build the required models and to estimate MSY reference points. Without these data, catch limits are difficult to establish. In these cases, empirical rebuilding strategies that rely on input controls to reduce fishing—for example, reductions in fishing operations, or closing fishing areas—may be more effective and defensible than strategies based on annual catch limits and B_{MSY} targets.

Socio-Economic Impacts of Rebuilding Plans

It is clear that reducing fishing to meet rebuilding targets can have severe social and economic impacts on fishing communities and the fishing industry. However, socio-economic information is not readily available to evaluate the broader and long-term impacts of rebuilding plans. Retrospective reviews of the socio-economic impacts of rebuilding plans would help in refining rebuilding plans and objectives, thus improving the consequences of future plans.

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The National Academies appointed the above committee of experts to address the specific task requested by the National Oceanic and Atmospheric Administration. The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

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