Marine Policy 47 (2014) 71–75

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Short Communication

The requirement to rebuild US fish stocks: Is it working?

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ARTICLE INFO

Article history:
Received 9 September 2013
Received in revised form
30 January 2014
Accepted 10 February 2014
Available online 28 February 2014

Keywords:
Magnuson–Stevens Act
Sustainable Fisheries Act
Rebuilding provisions
US fisheries

ABSTRACT

The Magnuson–Stevens Fishery Conservation and Management Act (MSA) was amended in 1996 to require that overfished stocks be rebuilt in as short a time period as possible, not to exceed 10 years, with limited exceptions. This comment examines the basic but important question of whether the implementation of rebuilding plans under the 1996 amendments has in fact been associated with biomass recovery. Specifically, for each of the 44 stocks examined, this analysis compares the biomass trend before rebuilding plan implementation to the trend after rebuilding plan implementation using a linear trend-break model. The analysis demonstrates a statistically significant positive association between the implementation of rebuilding plans and standardized biomass in 19 of 44 stocks. None of the 44 stocks examined showed a statistically significant negative association. The analysis showed a strong temporal relationship between the implementation of the policy and rebounds in fish stocks.

1. Introduction

The 1996 passage of the Sustainable Fisheries Act (SFA), which reauthorized and amended the Magnuson–Stevens Fishery Management and Conservation Act (MSA), marked a sea change in the United States' approach to fishery management [1]. In response to a large number of depleted fish stocks in federal waters, particularly in the New England region, a requirement was added to the law that rebuilding plans be developed for overfished stocks [2]. These plans must include time periods for rebuilding that are "as short as possible, … not [to] exceed 10 years except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise [3]".

Since its enactment, the new requirement to expeditiously rebuild depleted fish populations has been a focal point of debate, eliciting both support [4,5] and criticism [6]. However, despite the political attention, there has been little statistical examination of whether the provision is working.

Several prior studies do provide an accounting of progress. The first study, published 7 years after the implementation of the rebuilding requirement, found "disappointing" early results, with only three of 76 overfished stocks successfully rebuilt [7]. A more recent report[1] found mounting successes, with 48% of stocks rebuilt in 2013 [8].

The MSA is up for reauthorization in 2014, and the rebuilding requirements may be among the provisions considered for amendment. Thus, the time is right to evaluate the rebuilding requirement's efficacy. This study is the first to explore whether the implementation of the rebuilding policy is correlated with statistically significant changes in population trends of overfished fish stocks.

2. Materials and methods

This study identified 62 fish stocks designated as overfished by the National Marine Fisheries Service (NMFS) and subjected to rebuilding plans following the SFA's enactment.[2] Of these 62 stocks, 44 were identified for which stock assessment data are sufficient to assess biomass trends since the plan's implementation. To satisfy this criterion, a stock must have been in a rebuilding plan since before 2010 and had at least one stock assessment since the plan's implementation.

[1] This assessment identified 28 of 44 fish stocks as "rebuilding successes", based upon the stocks achieving either their rebuilding targets or at least 50% of their rebuilding targets and at least a 25% increase in abundance since rebuilding plan start.

[2] This excludes 13 internationally managed stocks, which are subject to different rebuilding requirements.

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http://dx.doi.org/10.1016/j.marpol.2014.02.007
0308-597X

Biomass and fishing mortality data were compiled from the most recent stock assessments conducted by NMFS. Biomass proxies such as spawning stock biomass were used when they were relied on by the most recent stock assessment. These assessments are utilized by NMFS to evaluate the progress of rebuilding plans and are the best available information. Still, it should be noted that the assessments are limited by how recently they were conducted, the quality of the data sources, and uncertainty in the models used. The present study necessarily excluded more than 200 federally managed fish stocks for which assessments do not exist or are considered out of date by NMFS, and therefore stock status is considered unknown.

For each stock, standardized biomass (biomass or proxy normalized by estimate of biomass at maximum sustainable yield) was analyzed from 1976 (or earliest date available after 1976) to the date the stock was declared rebuilt (or, if the stock has not been rebuilt, the most recent date available). The start date, 1976, was chosen because this is when the MSA was enacted. The MSA significantly changed the fisheries management landscape in the United States, including the creation of a 200-mile conservation zone and the regional fishery management council system.

Since there is no data on overfished stocks that did not receive the policy treatment (and are not listed under the Endangered Species Act), a proper control group does not exist. Following event study literature for testing whether pre-trend growth rates are different from post-trend growth rates [9,10], a continuous linear trend-break model[3] with fishery-level intercepts and slopes was fit to the standardized biomass data using ordinary least squares (Fig. 1). The model assumes similar measurement errors within regions, because of similarities in how fish stocks are assessed and managed within a region by each of the regional fishery management councils. The trend break year was defined using the year of rebuilding plan implementation [8] and its significance was evaluated using *t*-tests. A Bonferroni correction was applied to account for errors from running multiple tests.

3. Results and discussion

This analysis compared the standardized biomass trend for each stock before rebuilding plan implementation to the trend after implementation. In this linear model, 19 of 44 stocks showed statistically significant positive slope changes (trend breaks) in biomass after rebuilding provisions were implemented (Fig. 2). Statistical significance was defined at the 5% level with a Bonferroni correction. None of the 44 stocks showed a statistically significant negative trend break. This allows for the rejection of the null hypothesis that there was no change in biomass trends following rebuilding plan implementation. In other words, there is a strong relationship between the implementation of the rebuilding requirement and rebounds in fish stocks. These results are consistent with observations that stock depletion is reversible when fishing mortality is effectively controlled [11–13].

As a placebo test, the same model was applied to biomass data only from the years prior to rebuilding plan implementation, and then to biomass data only from the years after rebuilding plan implementation. In both cases the trend-break model was run multiple times using randomly chosen trend-break dates. In four of the five tests, none of the 44 stocks examined showed significant trend breaks. In the fifth test, which was performed on post-implementation data using an event date of plus-3 years, six showed significant positive trend-breaks and three negative. Taken as a whole, these checks reinforce the conclusion that the positive relationship between rebuilding plans and biomass recovery is not random.

The regressions in this analysis were run by region rather than by individual fishery because fisheries are managed at the regional level, and because estimating the errors by region compensates for limitations in the data. Not only are the fishery-level time series relatively limited for some stocks, but stock modelers use different modeling techniques and measures of uncertainty are unavailable. However, running the regressions independently by fishery reduces standard errors and would only yield more positive trend breaks,[4] strengthening this study's main findings.

There may be concern as to whether this study's linear model favors stocks with lower biomass variance. Lower variances could result from a natural cause, such as slow-growing stocks or stocks with demersal habitat [14], but they could also be the result of stock assessment scientists smoothing the biomass data with interpolation. However, weighting the trend-break model to favor high-variance stocks using a weighted least-squares regression produced only marginally fewer, positive results.[5] Thus the main study's core finding is not simply the result of artificially low-variance stock assessment-data, and controlling for inter-annual variability would likely yield unchanged or only marginally stronger conclusions.

The results in this study are also consistent with the significant progress in fish stock rebuilding seen in NMFS' reports on the status of stocks [15], while providing an additional lens through which to view and quantify that progress. NMFS generally considers a stock to be rebuilt as soon as its estimated biomass reaches the level that produces maximum sustainable yield (B_{MSY}). This study examined whether there had been a sustained change over time in a stock's biomass trend following rebuilding plan implementation sufficient to produce a statistically significant trend break. There is substantial overlap between the 19 stocks for which this study found significant positive trend breaks and the 21 that have achieved B_{MSY},[6] NMFS' threshold for declaring a stock rebuilt. Of the 19 stocks with significant trend breaks, NMFS has identified 14 as achieving rebuilding targets.

NMFS considers the number of stocks rebuilt so far to be encouraging [15], especially given that rebuilding plans are generally designed to achieve B_{MSY} by a designated target date with 50% probability of success, and many stocks have not yet reached their target dates. Only 17 of the 44 stocks in this study have reached their target dates.

While further study is required to establish causality, this study makes it clear that the fish population rebounds are non-random and linearly correlate with the implementation of rebuilding plans under the Magnuson–Stevens Act. Future research should examine the factors that lead to rebuilding successes, as well as those involved in unsuccessful responses to rebuilding plans. Previous reviews of efforts to rebuild fish stocks worldwide identify numerous primary causes for failures, including insufficient or delayed decreases in fishing mortality, systematic underreporting

[3] $y_{it}=\beta_{0i}+\beta_{1i}t_i+\beta_{2i}(t-t_{0i})I_{(t\geq t0i)}+\varepsilon_{it}$ where y_{it} is the std. biomass for stock $i=1,\ldots,44$ at time $t=1976,\ldots$, time of rebuild or time of most recent stock assessment; t_{0i} is the rebuild implementation date for stock i; ε_{it} is i.i.d. $N(0,\sigma^2_{r(i)})$; and $r(i)$ is the region of stock i.

[4] Running the regressions independently by fishery yielded 29 significant positive trend-breaks and zero negative.

[5] By weighting this study's model using standardized biomass variance by stock, stocks with higher variances are favored, but still found the same stocks had significant trend breaks with the exception of black sea bass, cowcod, monkfish south and haddock Gulf of Maine. Some of these stocks have naturally low biomass variance due to their long generation times and benthic habitat.

[6] Nineteen of these stocks, excluding Gulf of Maine haddock and summer flounder that currently do not have biomass at B_{MSY}, have been formally designated as "rebuilt" by NMFS. However, two additional stocks—Mid-Atlantic tilefish and Southern Georges Bank/Mid-Atlantic red hake—are recognized by NMFS as exceeding their rebuilding targets even though they are not currently designated as rebuilt.