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METHODS

Portfolio management of wild fish stocks

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Abstract

Managing fish stocks in terms of a portfolio of economic assets is likely to significantly increase benefits for society relative to single-species approaches. A portfolio framework systematically combines fish stocks that are joined by ecology (e.g., predation, competition) and unspecialized fishing technologies (e.g., mixed-species trawls) into a portfolio which balances expected aggregate returns against the risks associated with stock-attribute and other uncertainties. To be productive, however, this framework must be combined with property rights institutions that clearly state management objectives, create long-run time-horizons among harvesters, internalize spillovers caused by ecological and technological jointness, and reduce uncertainty through research and adaptive management. Although the cost of reducing scientific uncertainty about ecological interactions may limit the portfolio approach to intensive management of relatively few species, its scope can be broadened to integrate tradeoffs among more types of marine resources, such as nature preserves and oil and gas deposits.
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> "Once we accept the concept of multispecies management, we are faced with the question, what (and how) do we optimize? We cannot answer this entirely in ecological terms but must introduce social and economic values such as return on investment." (National Research Council, 1980).

1. Introduction

The predominant approach that governments use to regulate harvests of finfish and invertebrate resources treats species in isolation from each other. In the United States, the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) hints at multi-species management of stock complexes and the prey of managed species, but, in practice, overfishing, bycatch, and optimum yield are defined in terms of maximum sustainable yield (MSY) from individual stocks.

The so-called single-species approach to fisheries management conflicts with policy advice since the 1960s, however. Primary production probably is not sufficient to support all fish stocks in an ecosystem at estimated MSY levels (Brown et al., 1976). Further, there can be an infinite number of MSYs for each stock which are contingent on the populations of other species in the community and environmental states

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(Larkin, 1966; May et al., 1979; Pontecorvo, 1986; Steele, 1998), making MSY and its economics counterpart, MEY, short-run policy objectives. Unspecialized fishing technologies that harvest several species jointly similarly affect MSY and MEY steady states (Quirk and Smith, 1970; Anderson, 1975; Huppert, 1979). As a result of these considerations, many prominent biologists, mathematicians, and economists have spoken strongly against using MSY in policy, including Larkin (1977) who mocked the concept while it was being institutionalized in the statutory laws of several countries. May et al. (1979, p. 275) concluded from the results of multi-species models "that simple considerations of MSY, species by species, are insufficient for enunciating management principles". Clark (1976, p. 1) began his popular book about mathematical bioeconomics stating that "the MSY concept is, in many respects, far too simplistic to serve as a valid operational objective for the management of most living resource stocks". Finally, Arnason (1998, p. S151) commented "that in virtually all fisheries, single-species analysis is liable to lead to serious mistakes in the interpretation of the observed data, not to mention in policy recommendations and predictions."

Recent promising research on system models of fish communities and fisheries (e.g., Pope, 1991; Walters et al., 1997; Arnason, 1998) underscores difficult questions that have been sidestepped by single-species policies, namely what is the appropriate mix of species and population sizes in a managed ecosystem, how do we manage environmental and stock-attribute uncertainty affecting species complexes, and what sorts of institutional arrangements can operationalize multispecies management. There is no reason to expect biological yield objectives to coincide with society's preferences for food or economic growth (e.g., Clark, 1976), including variations on the single-species approach which avoid extinctions of slow-growing species and top predators while maximizing assemblage yield (see Tyler et al., 1982). This view is widely held by social scientists and harvesters, and is shared by some fisheries biologists (e.g., Larkin, 1977; Hilborn et al., 2001). Indeed, Gulland (1982, p. 8) was blunt: "[T]he scientific community, as represented by ICES, has no special responsibility or competence in deciding what objective should be chosen". Likewise, Beddington et al. (1984, p. 236) stated "that efforts to partition and reduce the 'fishery problem' to its biological essentials are misguided. And, by extension, the 'solutions' thereby determined and presented by biologists are too often suboptimal—if not irrelevant—to the actual needs of those trying to make the best use of the resource." The notion of optimum yield as defined in statutory laws such as the Magnuson-Stevens Act does not help to resolve the question of objectives because in addition to being conditional on MSY, it is too vague to be operational and evaluated (e.g., Clark, 1976).

Our paper builds on Hanna's (1998) thought to reorient fisheries management from single species to portfolios of species. Unlike the related diversification of harvest opportunities for individual fishermen recently advocated by Hilborn et al. (2001) as a response to random recruitment and serial depletion of fish stocks, our use of portfolio theory explicitly recognizes fishery resources as risk-bearing capital assets that can provide society with benefits indefinitely. That is, strategies that accommodate depletion of valuable fish stocks are counterproductive under the portfolio approach. Our application of portfolio theory to multi-stock management also differs from the small literature in fisheries economics which has to do with harvesting a multicohort stock (Baldursson and Magnusson, 1997) and seafood product diversification (Larkin et al., in press).

The portfolio approach to multi-species fisheries management has two complementary and necessary parts. One is a framework which systematically evaluates tradeoffs in fishery benefits that result from ecology (e.g., predation, competition) or unspecialized fishing technologies (e.g., mixed-species catches), and balances the expected aggregate benefits from manipulating stock levels against the risks associated with various natural, market, and institutional uncertainties. The second part designs property rights institutions that create long time-horizons among harvesters which are necessary for fish stocks to become economic assets, that resolve common pool spillovers (e.g., "your fish eats my fish") cost-effectively, and that protect investments in information which reduce uncertainty. These two components of the portfolio approach are described in turn below and followed by a discussion of factors that will affect implementation.

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