COMMENTARY

Stop-loss order for forage fish fisheries

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Recent literature has highlighted the exceptional importance of forage fish, which include some of the largest fisheries in the world and produce a sizeable share of the global wild marine fish catch (1). Forage species play an essential and valuable supporting role within marine ecosystems by serving as prey for larger species (2, 3). These findings underscore the importance of (*i*) furthering understanding of the determinants of forage fish collapses, and (*ii*) of devising exploitation strategies that will maintain their crucial ecological and economic roles. Essington et al. (4) significantly advance understanding on both counts, applying novel methods to uncover fishing's fingerprint in regulating population fluctuations and demonstrating the effectiveness of a simple remedy to prevent collapses.

Fishing's Fingerprint

The roles of fishing and environment in governing variation in fish population abundance have been contested for many decades. In the notorious Thompson–Burkenroad debate, Thompson argued that fishing was the predominant cause of Pacific halibut fluctuations, whereas Burkenroad attributed observed abundance variations to natural causes (5). Although it is now largely recognized that fishing, intrinsic, and environmental factors influence the size and trends of most fish populations, forage fish are often considered as a special case. This is because forage species typically exhibit large oscillations in abundance, and collapses of forage fish populations have often been accompanied by major shifts in environmental regimes. These observations have fostered the dangerous notion that fishing plays little if any role in determining population size.

In addition, fishing mortality rates on forage fish tend to increase as abundance declines because their schooling behavior makes fishing worthwhile, even at low population levels. Thus, the effects of fishing and environment are often confounded, making it particularly difficult to disentangle their relative influence on forage fish.

The distinctive fingerprint of fishing that emerges from the Essington et al. (4) study characterizes and firmly establishes the role that fishing plays in determining forage fish population variations. Further implicating fishing as a factor in forage fish collapses are findings that collapses occurred more frequently and were of greater magnitude than would be projected to ensue from natural causes. A particular strength of the Essington et al. (4) study is the wealth of information assembled and used in the investigation of

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the relative roles of fishing and environmental factors. Data for 55 populations of 21 species of forage fish, each with a time series of at least 25 y, were analyzed. Collectively, these populations represent 65% of the average annual global catch of forage fish since 2000.

Remedy: A Stop-Loss Order

Essington et al. (4) propose a simple remedy to reduce the odds of forage fish collapses. Specifically, the authors suggest a harvest rule whereby fishing is suspended when forage fish biomass falls below a minimum biomass threshold, and is allowed to proceed for biomass levels above the threshold. The minimum biomass threshold is analogous to a stop-loss order in the investment arena, which is an order made with a broker to sell a stock when its price reaches a predefined lower limit, known as a stop price. A stop-loss order is a simple, powerful, and frequently used instrument to preserve capital and minimize losses in an uncertain environment. Because it is made in advance, it prevents emotional decision-making that often accompanies emergency situations. Although minimum biomass thresholds have been proposed as a component of fishery management guidance (2, 6, 7), they have not as yet been widely adopted.

Essington et al. (4) provide an evaluation of the performance of a minimum biomass threshold set at 50% of the average observed biomass level. This harvest strategy prevented 64% of collapses, while reducing long-term catches by less than 2%. In addition, biomass of the target forage fish species was maintained at high levels. This result was quite robust to alternative population models, including one that assumed that productivity is completely independent of population size. Given the large number of populations analyzed and the robust results, one would expect the benefits of using a minimum biomass threshold on forage fish populations to be quite high, whereas the costs in terms of yield are minimal.

Although not explicitly shown by Essington et al. (4), it is reasonable to expect substantial benefits of this harvest strategy to the broader ecosystem, given the critical linkages between forage fish and other species (2, 3, 8). Long-term empirical studies have demonstrated that seabird breeding success (and ultimately population size) declines precipitously as the abundance of their forage fish prey decreases and foraging time increases (9, 10). Simulations using ecosystem models indicate that impacts on dependent predators were substantially reduced as the minimum biomass threshold of their forage fish prey increased (2).

Conclusions

It is now abundantly clear that a stop-loss order (i.e., minimum biomass threshold) should be a required component of forage fish fishery management. Although a minimum biomass threshold cannot prevent all collapses, it can substantially reduce the odds of a collapse while producing high yields and reducing the risks of fishing on dependent predator species (11).

The work of Essington et al. (4) has implications far beyond the realm of forage fish science and management. It should lay to rest

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any question that fishing impacts population fluctuations, even in circumstances where environmental factors are clearly exerting a major influence on stock dynamics, and is an important culprit in collapses. The methods developed by Essington et al. (4) are applicable to any population, and should prove useful for detecting the fingerprint of fishing in other situations that have heretofore been seen as an irresolvable challenge. Finally, minimum biomass thresholds for nonforage fish species set at appropriate levels may have substantial ecological benefits and relatively low costs, and deserve much wider evaluation and application.

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