Economics of Overexploitation Revisited

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About 25% of the world's fisheries are depleted (*1*) such that their current biomass (B_{CUR}) is less than the biomass that maximizes the sustained yield (B_{MSY}). We show that, if B_{CUR} were compared to the biomass that produces the largest discounted economic profits from fishing (B_{MEY}), many more stocks would be considered overexploited, i.e., $B_{MEY} > B_{MSY}$ and $B_{MEY} > B_{CUR}$.

A classic result (*2*) is that it may be optimal for a private owner to overexploit to extinction a renewable resource with low reproductive capacity, whereas B_{MEY} may be either greater or smaller than B_{MSY} depending on the discount rate, sensitivity of costs and revenues to biomass and harvest, and the marginal growth in the biomass (*3*). We show that under reasonable prices, costs, and discount rates it is not economic to exploit fisheries to extinction even with very low growth rates. Moreover, we found that B_{MEY} exceeds B_{MSY}. With use of perturbation methods (*4*), we solved for optimal stochastic harvest and biomass transition paths to B_{MEY}, specified revenues as a nonlinear function of harvest, and allowed for a "stock effect" such that costs are a nonlinear function of the biomass.

Model outputs for four different fisheries are presented (Fig. 1) where equilibrium revenue and economic profit curves (in thousands of U.S. dollars) are plotted against equilibrium fish biomass or spawning stock (in tons). We modeled population dynamics with an age-structured model but used a spawner-recruitment model in the prawn fishery (*5*). The peak of the revenue curves corresponds to B_{MSY}, whereas the maximum of the economic profit curves equals B_{MEY}. We found that $B_{MSY} > B_{CUR}$ except for yellowfin tuna, but in all cases B_{MEY} exceeded B_{MSY} at a discount rate of 5%.

The profit two curve shows the sensitivity of the results to costs [extra 30 cents (U.S.) per liter of fuel] relative to the base-case profit one curve. Higher costs, lower output prices, and smaller discount rates increase the ratio of B_{MEY} to B_{MSY}. The profit curves show that the more overexploited the fishery, the greater the marginal economic gains from stock rebuilding. Although the stock effect may be relatively small in some cases (*6*), our estimates indicate that it is large at current biomass, whereas harvesting costs rise at an increasing rate with declines in the biomass. We also find that a discount rate as large as 25% for the tuna and prawn fisheries and a discount rate as high as 10% for orange roughy still generate $B_{MEY} > B_{MSY}$. In all cases, even at very high discount rates, fishing profits become negative long before biomass is fully depleted.

Theoretically, maximizing discounted economic profits may cause stock depletion or even extinction (*2*). Our results show, however, that in practice $B_{MEY} > B_{MSY}$. This implies a win-win: Conservation promotes both larger fish stocks and higher profits. When B_{MEY} exceeds B_{CUR}, the debate is no longer whether it is economically advantageous to reduce current harvests but how fast stocks should be rebuilt.

Revisiting the economics of overexploitation provides both a target and a framework to help overcome a key cause of overharvesting: fisher opposition to lower catches associated with stock rebuilding. For fast-growing species, rebuilding to B_{MEY} may only take a short time, but for very slow-growing fish it may take decades. Transition costs to B_{MEY} may explain why fishers oppose stock rebuilding, as do stakeholder conflicts over whether to maximize short-run employment, to maximize discounted economic profits, or to achieve ecosystem conservation goals (*7*). Appropriate incentives in the form of individual or community harvesting rights (*8*) can provide security to current fishers that they will benefit from stock rebuilding. Intertemporal transfers from higher, future profits in the form of a quota rental charge (*9*) could also compensate for transition costs and employment losses in moving to B_{MEY}.

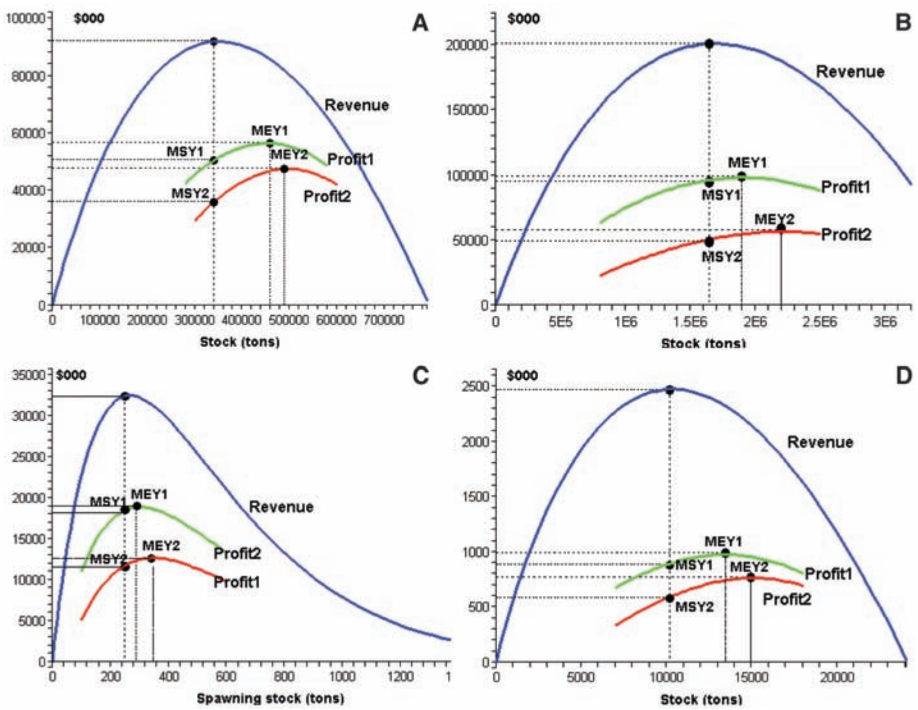

Fig. 1. (**A**) B_{MEY} and B_{MSY} of Western and Central Pacific big eye tuna. (**B**) B_{MEY} and B_{MSY} of Western and Central Pacific yellowfin tuna. (**C**) B_{MEY} and B_{MSY} of Australian northern prawn fishery. (**D**) B_{MEY} and B_{MSY} of Australian orange roughy fishery.

References and Notes

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Materials and Methods
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