Science, Vol 293, Issue 5535, 1589-1591 , 31 August 2001

Factors in the Decline of Coastal Ecosystems

In their review "historical overfishing and the recent collapse of coastal ecosystems," Jeremy B. C. Jackson and colleagues argue for the "primacy" of overfishing in the collapse, in contrast to pollution, species introductions, climate change, diseases, and other human impacts (special issue on Ecology Through Time, 27 Jul., p. 629). They suggest that overfishing had the earliest impacts and was a necessary precondition for the occurrence of other maladies. Although we agree that fishing has contributed to major changes in coastal ecosystems, we believe Jackson and co-authors overstate the case for its primacy. The overfishing and nutrient pollution of coastal seas, for example, have frequently proceeded simultaneously and contributed to degradation synergistically (1).

In Chesapeake Bay, as the authors point out, the process of eutrophication began with land clearing in the 18th century, well before the mechanized harvest of oysters in the late 19th century. Although most of the filtration capacity of oyster populations had been reduced by the 1930s, the dramatic intensification of hypoxia and the extensive loss of seagrasses occurred later, during the last half of the 20th century, associated with a more than doubling of the already elevated nitrogen loading (2).

Recognizing that rebuilding oyster populations could help to mitigate planktonic overproduction due to nutrient pollution (3), the multistate Chesapeake Bay Program has established the ambitious goal of a 10-fold increase in oyster biomass. But restoration of oysters even to precolonial abundances is unlikely to eliminate algal blooms and hypoxia and recover seagrasses without also significantly reducing nutrient loading. Decreasing bottom-up stimulation and increasing top-down controls will be required.

Although the degradation of oyster reefs by overfishing might have made oysters more susceptible to endemic diseases, a particularly virulent pathogen (*Haplosporidum nelsoni*) was introduced from a nonindigenous oyster host in the 1950s (4). This introduced disease now greatly limits the ability to reestablish oyster populations.

Similarly, it is not likely that intact populations of large consumers, such as green turtles and sea cows, would have prevented the deleterious consequences of nutrient pollution, sedimentation, and other human-induced stresses on tropical seagrass ecosystems witnessed in the late 20th century in such regions as Australia (5) and Florida Bay (6). And there were no similar large consumers of temperate seagrasses, which have also undergone decline. Regardless of the historical sequence of human stresses, amelioration of multiple stresses must take a multi-pronged approach to restore coastal ecosystems.

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Response

Our review is indeed about the deep historical roots of human degradation of a diverse suite of coastal marine ecosystems, caused by and preconditioned by fishing exploitation and attendant damage to biogenic marine habitats. The novelty of our study lies in its use of multiple associated disciplines, such as paleontology, archaeology, governmental record analysis, and maritime natural history, to provide ecological baselines of the past that long predate the formal discipline of ecology, as it can be traced to Elton, Lotka, Park, Birch, and other early 20th-century founders. Synthesis of such historical information for a variety of coastal marine ecosystems revealed a large impact of fishing and sea hunting that generally predated other human impacts, independent of the system.

If our review can be construed as arguing that restoring the overfished species and habitats degraded by fishing would be sufficient in themselves to counteract the deterioration of coastal marine ecosystems, we apologize. No amount of success in restoring the sharks and sea turtles to remote coral reef ecosystems, for example, will counteract the growing impacts of coral bleaching induced by global warming and other physical causes. Furthermore, we concur that reduction in nutrient loading to the world's estuaries and coastal seas is a critical component of management strategies to restore lost ecosystem services and reverse eutrophication.

Likewise, if our narrative implies that fishing acts independently of other stressors, we welcome this opportunity to reject such an interpretation. The synergistic interaction among multiple factors is the essence of our argument that impacts of historical fishing preconditioned many coastal ecosystems to subsequent collapse when later stressors were applied. For example, the reduction in height of subtidal oyster reefs through incremental mining of shell matrix by dredge fishing in Chesapeake Bay and Pamlico Sound interacts with oxygen depletion of bottom waters (1) and exposure to oyster disease (2) to influence oyster health. Additionally, restoring the extent and stature of oyster reefs in Chesapeake Bay and other bays worldwide is likely to restore substantial levels of water filtration--even if oyster life-spans are still shortened by disease--because these reefs provide the unique hard substratum not only for the rapidly growing juvenile oysters, but also for other epibiotic filter feeders like tunicates (3). Oyster reef restoration must be valued for ecosystem services to water quality and estuarine habitat, even if restoration of traditional oyster fisheries is also a goal over a longer time frame (4).

We prepared our review not to deny the impacts of other human activities on marine ecosystems but rather to document and emphasize the significance of fishing impacts upon apex consumers, critical biogenic habitat engineers, and important grazers that occurred so far in the past as to be often forgotten and ignored in restoration plans. Human-induced extinctions in the marine environment have lagged behind those of terrestrial ecosystems, so there still exists the biological potential with which to rebuild coastal marine ecosystems. We need to recognize these historical fishing impacts to appreciate the importance of apex consumer and grazer restoration in our integrated plans.

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