ECOLOGY

Globalization, Roving Bandits, and Marine Resources

Marine resource exploitation can deplete stocks faster than regulatory agencies can respond. Institutions with broad authority and a global perspective are needed to create a system with incentives for conservation.

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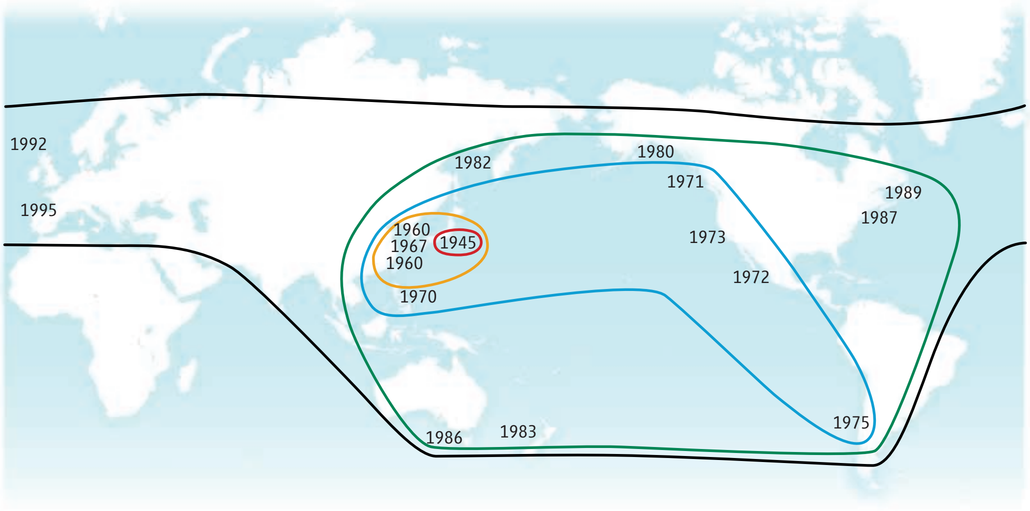

Sequential exploitation of a marine resource. Initiation year by location of major commercial fishery for sea urchins.

Overfishing is increasingly threatening the world's marine ecosystems (*1*, *2*). The search for the social causes of this crisis has often focused on inappropriate approaches to governance and lack of incentives for conservation (*3*, *4*). Little attention, however, has been paid to the critical impact of sequential exploitation: the spatially expanding depletion of harvested species (*5*). The economist Mancur Olson (*6*) argued that local governance creates a vested interest in the maintenance of local resources, whereas the ability of mobile agents—roving bandits in Olson's terminology—to move on to other, unprotected resources severs local feedback and the incentive to build conserving institutions. Distant water fleets and mobile traders can operate like roving bandits (*7*), because global markets often fail to generate the self-interest that arises from attachment to place.

The effect of roving bandits can be explained by "tragedy of the commons," whereby a freely accessible (or open-access) resource is competitively depleted. Harvesters have no incentive to conserve; whatever they do not take will be harvested by others. Developing the institutions to deal with commons issues is problematic and slow (*8*). Roving banditry is different from most commons dilemmas in that a new dynamic has arisen in the globalized world: New markets can develop so rapidly that the speed of resource exploitation often overwhelms the ability of local institutions to respond.

Until recently, exploitation of marine resources was commonly constrained by the inaccessibility of remote and offshore locations. Consequently, early examples of global markets in fisheries (e.g., Newfoundland Grand Banks in the 1500s) were characterized by slow growth and relatively inefficient harvest technology. They were typically based on species that were plentiful, readily caught, and easily transported without refrigeration (e.g., dried, salted, or rendered for oil). Many of these constraints have evaporated with globalization. The trade-induced increases in demand for fisheries resources have resulted in an increasingly serious ecological and management problem.

Ecological Implications

Sequential depletions of species that are major conduits for the flow of energy and materials in marine food webs pose the greatest ecological risks. For example, historic exploitation of sea otters for their pelts in Alaska's remote Aleutian Islands had profound ecological consequences, because this keystone predator controls the abundance of sea urchins that graze on kelp. Depletion of sea otters caused massive deforestation of kelp beds by plagues of sea urchins for over a century, before active reintroductions of sea otters reversed this trend (*9*).

There is a rich history of roving bandits targeting ecologically important large predators such as the cod that historically dominated North Atlantic coastal ecosystems. By the middle of the last century, fishing technology had developed to the point where cod spawning aggregations in the Gulf of Maine could be removed wholesale. Within two decades, local stocks had been depleted, contributing to the rise of invertebrate species such as lobsters, crabs, and sea urchins that had formerly been prey to cod and other apex predators (*10*).

Highly altered ecosystems can often stimulate new fisheries, which typically target lower trophic levels (*1*). In Maine, the green sea urchin (*Strongylocentrotus droebachiensis*) proliferated after the loss of its fish predators in the mid-1980s (*9*), itself in turn becoming a fishery for sushi markets. Spurred by demand from the Japanese market, an unregulated harvest began in 1987. The state of Maine was unprepared to deal with the explosive growth of the fishery, and stocks were rapidly depleted.

To put the Maine sea urchin fishery in historical context, we show the spatial expansion of harvests (see figure, this page) and the sequential depletion of stocks (see graph, page 1558) by waves of exploitation around the globe. Commercial sea urchin harvest began largely for export to Japanese markets, after Japan's own resources declined. The Chilean fishery, for example, supplied relatively small domestic

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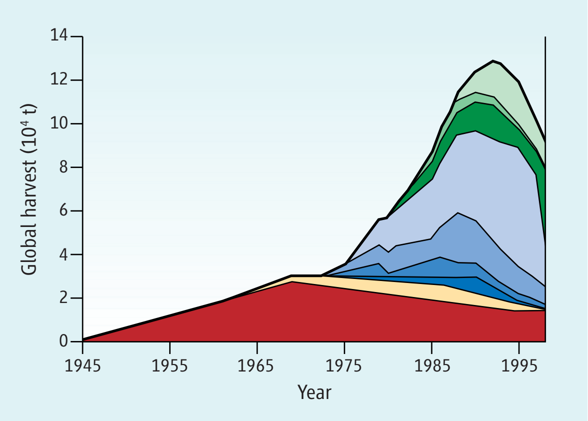
markets until 1975, when it rapidly expanded into an export fishery (*11*). Spatial expansion masked regional depletions, a common characteristic of sequential exploitation (*2*, *5*). Global harvest peaked in about 1990 with the expansion of the fishery to new regions, but declined after that because there were no frontiers left to exploit.

The resulting simplification of food webs and loss of biodiversity are eroding the resilience of marine ecosystems and increasing their vulnerability to environmental change (*12*, *13*). For example, fishing pressure on many coral reefs has increased dramatically with the emergence of export markets for restaurant and aquarium trades, highly mobile boom-and-bust fisheries based on rapid air transport to growing luxury markets. Depletion of herbivorous fishes has contributed to algal blooms on reefs, because algae released from their consumers out-compete corals for space. Consequently, overfished reefs are less resilient to recurrent disturbances, such as hurricanes, and more vulnerable to coral bleaching and mortality caused by global warming (*14*).



Global sea urchin harvests over time. Color coded by region, in chronological ascending order: Japan; Korea; Washington and Oregon; Baja, Mexico; California; Chile; NE Pacific (Alaska and British Columbia); Russia; NW Atlantic (Maine, Nova Scotia, New Brunswick). All data are from (*11*).

Management Implications

There have been few effective responses to this kind of exploitation, because the emergence of specialized export markets for hitherto unexploited stocks is almost always a surprise to managers. In the case of small or highly localized stocks, the resource may vanish even before the problem is noted. In the case of more widely distributed, relatively abundant species, serial depletions of local stocks may be masked by spatial shifts in exploitation (see figure, p. 1557, and graph, this page).

Existing marine protected areas (MPAs) and no-take areas (NTAs) are often too small and too far apart to sustain processes within the broader seascape, and monitoring and enforcement are often inadequate. Even the Great Barrier Reef Marine Park, the largest MPA in the world (33% of which is zoned as NTA) is too small to maintain stocks of marine mammals, turtles, and sharks that migrate across its boundaries. In any case, areas outside NTAs and MPAs also need protection.

At the international scale, CITES (U.N. Convention on International Trade in Endangered Species) bans or controls trade only in species placed on appendix I or II of CITES, respectively. The meetings to vote on proposals to place species in the appendices take place every 2 years, a blunt and ineffective instrument indeed to protect stocks that may be scooped up within months. Even identifying species at risk is a gigantic task. Other than CITES, there are no restraints on trade or even effective reporting mechanisms.

Addressing the ecological impacts of globalization means finding ways to match the growth in demand for local marine products, with the development of institutions to regulate harvesting (*15*). Appropriate restraining institutions must be in place before the resource is at risk. Solutions depend ultimately on changed behavior at the local level, but the problem must be addressed at multiple scales. Global, regional, and national bodies need to monitor trade and resource trends and find ways to disseminate information that stimulates problem-solving consistent with local practices. They need to enable local authorities to learn from the experience of others around the world. Most important, they have to encourage local governance and assist in the development of resource rights that align individual self-interest with the long-term health of the resource.

Checks can be established through harvesting permits, certification, and controls over delivery of products to markets to dampen the rate of increase in demand. Technological changes make detection in global transport of a product possible. Monitoring of foreign direct investments (*7*), increased transparency of vessel flag history, and identification of vessel owners and roving buyers will improve the ability to track potential problems. Costs of regulation must be balanced against the costs of potential losses due to inaction (*16*). For example, Maine's precautionary fisheries laws (adopted in response to the urchin debacle) recognize the need to deliberately seek to slow down the development of new marine products.

Common property theory predicts that the establishment of property rights (*8*) and/or co-management regimes (*17*) counters the tragedy of the commons. Individual or community property rights over resources can internalize costs and benefits to create incentives for local protection and monitoring. Property rights approaches have proved to be particularly effective with stationary resources such as sea urchins and abalone (*3*, *4*). For migratory marine resources, however, the challenge is to establish governance mechanisms that operate at national and international scales (*18*, *19*). If major markets and targeted species are known, the next exploitation wave may be foreseeable from analyses such as the one here and from patterns of depletion and recovery of key species groups (*20*).

Crucially important here are multilevel governance institutions operating at diverse levels, from local to international (*21*). No single approach can solve problems emerging from globalization and sequential exploitation. But the various approaches used together can slow down the roving bandit effects, and can replace destructive incentives with a resource rights framework that mobilizes environmental stewardship, i.e., one that builds the self-interested, conserving feedback that comes from attachment to place.

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