

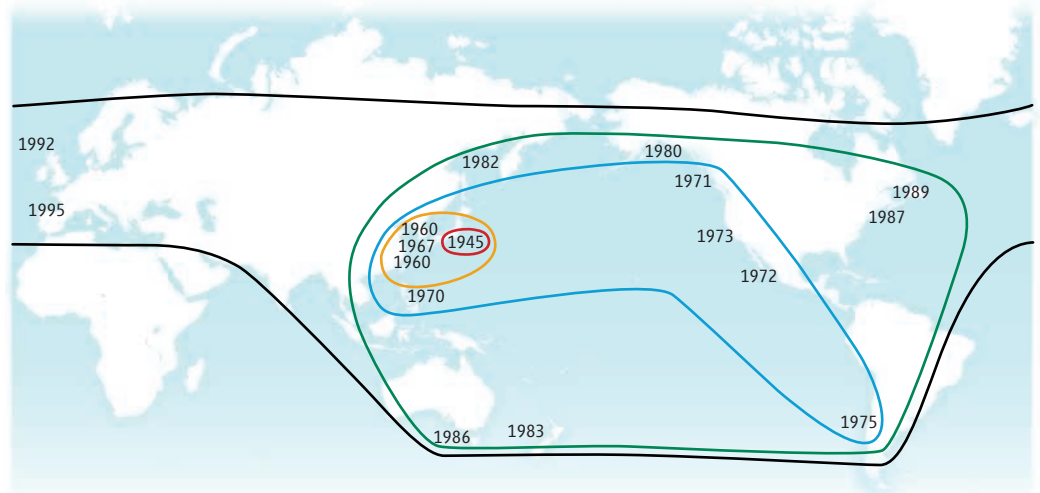
ECOLOGY

Globalization, Roving Bandits, and Marine Resources

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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



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

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).

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.

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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