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High biological vulnerability and economic incentives challenge the viability of deep-sea fisheries.

ARE DEEP-SEA FISHERIES SUSTAINABLE?

A SUMMARY OF NEW SCIENTIFIC ANALYSIS:

Norse, E.A., S. Brooke, W.W.L. Cheung, M.R. Clark, I. Ekeland, R. Froese, K.M. Gjerde, R.L. Haedrich, S.S. Heppell, T. Morato, L.E. Morgan, D. Pauly, U. R. Sumaila and R. Watson. 2012. Sustainability of Deep-sea Fisheries. *Marine Policy* 36(2): 307–320.

AS COASTAL FISHERIES have declined around the world, fishermen have expanded their operations beyond exclusive economic zones (EEZs) to the high seas beyond EEZs, including the deep sea. Although the deep sea is the largest yet least ecologically productive part of the ocean, seamounts and other habitats can host significant amounts of some deep-sea fish species, especially when they aggregate to breed and feed. Many deep-sea fishes are slow to reproduce, or produce young only sporadically, however, making commercial fisheries unsustainable.

Dr. Elliott Norse of the Marine Conservation Institute and a multidisciplinary team of co-authors analyzed data on fishes, fisheries and deep-sea biology and assessed key economic drivers and international laws to determine whether deep-sea commercial fishing could be sustainable. Ultimately, the authors conclude that most deep-sea fisheries are unsustainable, especially on the high seas. This *Lenfest Research Series* report is a summary of the scientists' findings.

DEEP-SEA FISHERIES

As coastal fisheries have declined, fishing in the deep sea has increased. Technological advances have enabled fishing vessels to travel further from shore and locate aggregations of fish in depths that were unreachable years ago (see graphic). Most commercial fishing in the deep sea involves bottom trawling, which can impact seafloor habitat and catch non-target species as large, heavy, weighted nets are dragged over the sea floor.

As commercial fishermen search for the oceans' last unexploited fish stocks, it is essential to understand the broader ecological and economic impacts of fishing in the deep sea. This study is the first comprehensive analysis of the resilience and vulnerability of deep-sea fish species and the first that integrates these biological realities with the economic drivers of commercial fishing in these waters.

BIOLOGICAL VULNERABILITY

Because the deep sea is very cold and food-scarce, most of its fishes have limited ability to repopulate and thus tend not to rebound easily from fishing pressure (i.e., they have low productivity and resilience). Some deep-sea species do congregate at ocean features such as seamounts (underwater mountains), banks or canyons. But even where they are present in large amounts, deep-sea fishes can have slow growth rates, delayed maturity, long lives and low average reproductive productivity or young survivorship. They can survive only by living long enough to have a good chance of reproducing.

ECONOMIC INCENTIVES FOR DEEP-SEA FISHING

Fishermen target deep-sea habitats with concentrated fish populations where catches are relatively high. Often, fishermen work an area until it is no longer economically profitable, and then move to another spot and repeat the process. This boom-and-bust pattern is called "serial depletion."

This common pattern highlights several problems with deep-sea fishing. First, depleting and moving to new concentrations of fish often masks the decline of deep-sea species by giving the false impression of continued fish abundance. Second, the low productivity of deep-sea fish makes it economically desirable for each fishing operation to liquidate fish populations. Using an economic analogy, capital or principal generates interest. Sustainable fisheries should remove no more than the maximum "interest" produced by the standing stock (or "principal"). However, with slow-growing species, rather than leaving fish ("principal") behind and waiting decades or more for remaining individuals to produce enough new fish ("interest"), it makes more economic sense to liquidate the fish stock and move to new fishing grounds. The combination of high fish biomass and low fish productivity creates an incentive for unsustainable fishing.

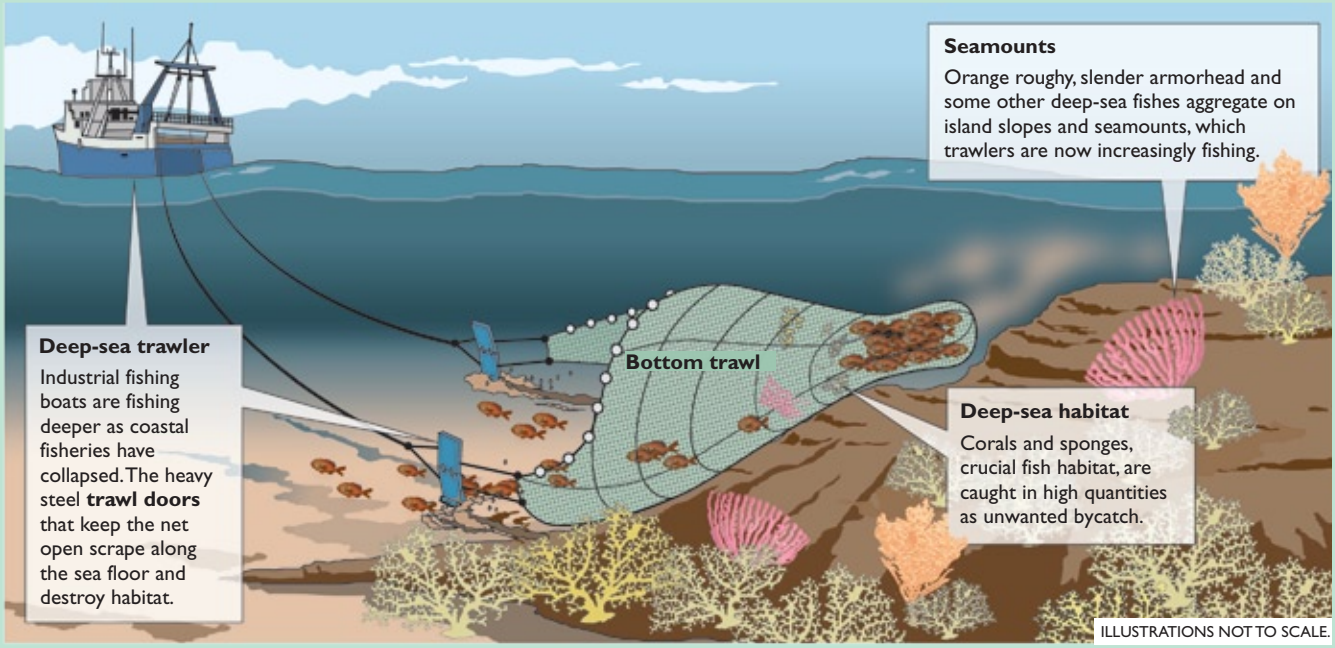
Subsidies to deep-sea fisheries

Widespread subsidies to the deep-sea fishing industry provide further economic incentives for depletion of many species. Although the total catch of deep-sea fish is relatively small (less than 1 percent of the value of the global marine catch), deep-sea fishing is heavily subsidized. Globally, these fishing subsidies are about 25 percent of the total landed value of deep-sea fish catch. Without subsidies, most of the world's bottom trawling fleets in the high seas would operate at a loss and be unable to fish (Sumalia 2010).

INTERNATIONAL GOVERNANCE

The vulnerability of deep-sea species coupled with the economic drivers for their depletion means that stringent precautionary measures may be the only way to conserve these vulnerable species. This is a difficult task in any governance regime, but deep-sea fisheries mainly occur on the high seas in international waters, where it is especially complicated to develop a policy informed by scientific information that all countries can agree upon and enforce.

A LOOK AT DEEP-SEA TRAWLING



AUTHORS STUDIED 41 DEEP-SEA SPECIES ...

(Found in waters more than 200 meters deep)

Authors studied various characteristics of each species, nearly all of which are overexploited. They also calculated vulnerability index ratings, which ranged from 1 to 100, the latter being the most vulnerable to overfishing.

Deep-sea exploited fishes	Other deep-sea fishes
27 in study	**14** in study

INCLUDING ...

ORANGE ROUGHY, HIGHLY VULNERABLE TO DEEP-SEA FISHING

Orange roughy are vulnerable to overfishing due to their tendency to aggregate over certain seamounts, their late maturity and low survivorship of their young.

Vulnerablity index number: **73**

Reproduction: Orange roughy appear to have sporadic young survivorship.

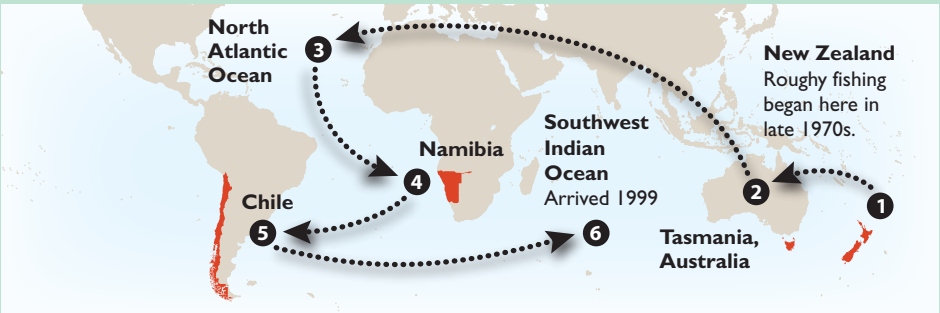
Aggregating behavior: Orange roughy aggregate on seamounts for feeding and breeding, making it relatively easy for trawlers to find them.

Growth: Orange roughy grow slowly, mature later and live longer than many other commercial fish.

Mature: About 30 years — **Maximum age:** About 150 years

Expansion and overexploitation of orange roughy fishery

Orange roughy fisheries have shifted geographically as stocks have depleted. Orange roughy stocks continue to decline, even as catch levels have been reduced.



BLACK SCABBARDFISH: A RARE EXCEPTION

Black scabbardfish in Madeira, Portugal and the Azores are a rare exception to unsustainable deep-sea fisheries. Hook and line fishing from small boats and strong regulation has allowed the fishery to remain sustainable. Bottom trawl fisheries for black scabbardfish are not sustainable.

Vulnerablity index number: **70**

Age: The fast growth of black scabbardfish may also help explain its apparent sustainability.

Maximum age: About 24 years

Mature: 3 to 4 years

STUDY METHODS

The authors assessed characteristics of deep-sea fishes, including the maximum population growth rate, body length, age at maturity, average length of life, reproductive capacity and growth rates and used these characteristics to calculate a vulnerability rating for 41 species of deep-sea fishes. The authors then compared these findings with the economic drivers and governance context for commercial deep-sea fishing.

KEY FINDINGS

- **With few exceptions, deep-sea fisheries are unsustainable.** High vulnerability to fishing is typical of deep-sea fishes, and subsidies support otherwise unprofitable fishing practices. The combination of high fish biomass and low fish productivity creates an incentive for unsustainable fishing. Weak international protection for deep-sea species exacerbates the challenges these species face.
- **Particularly long-lived species** that are caught accidentally as bycatch (such as deep-sea corals), that produce few young (such as deep-sea sharks) or that aggregate to feed or spawn (such as orange roughy) are vulnerable to overfishing.
- **Examples of sustainable deep-sea fisheries are very rare.** Fisheries have a better chance of being sustainable if the fishes: 1) also live in waters shallower than 200m; 2) have relatively high population resilience; and 3) are fished with low-tech, non-trawl methods. Black scabbardfish fisheries in the Azores and Madeira, Portugal, are examples; black scabbardfish trawl fisheries elsewhere are not sustainable.
- **Given the widespread subsidization of deep-sea fisheries compared with the small catches they generate,** the authors argue for shutting down deep-sea fisheries, rebuilding coastal fish populations for more productive fisheries closer to shore and re-directing the subsidies to the affected fishermen.

Literature Cited

Sumaila, U.R., A. Khan, L. Teh, et al. 2010. Subsidies to high seas bottom trawl fleets and the sustainability of deep-sea demersal fish stocks. *Marine Policy* 34: 495-497.

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