

Changing Size Structure in Exploited Deep-Sea Fish Communities

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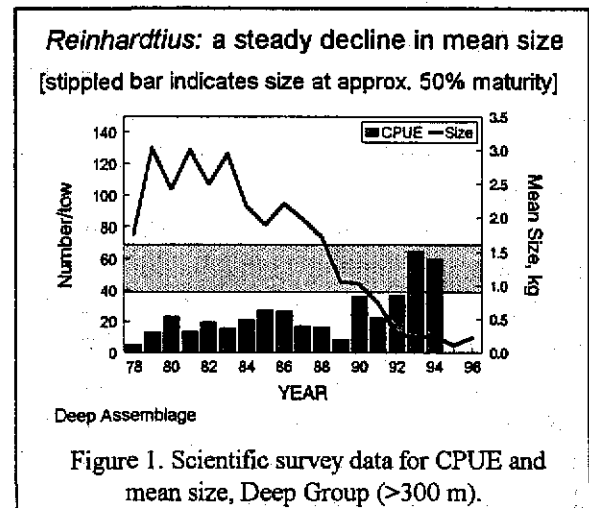
Abstract: Fisheries tend to selectively remove the larger, older individuals from demersal fish communities. Over time this results in smaller average size of both target and by-catch species. At the community level, therefore, unrelenting fishing pressure should eventually cause the dominant modes in the biomass spectrum to shift downward to the left. There is evidence that such shifts are occurring in exploited continental slope fish communities in the North Atlantic. Should this trend continue for too long, the stage is set for the community to shift to a new stable state from which recovery to the original condition may prove very difficult.

Overly aggressive fishing in the late 1980s lead to the collapse of northwest Atlantic groundfish (Sinclair & Murawski, 1997). Populations of northern cod (*Gadus morhua*) reached such low levels that the fishery was totally closed in 1992. The impact on Newfoundland's economy and traditional way of life has been immense. Today, the fishery is still closed and the cod stock shows little sign of recovery.

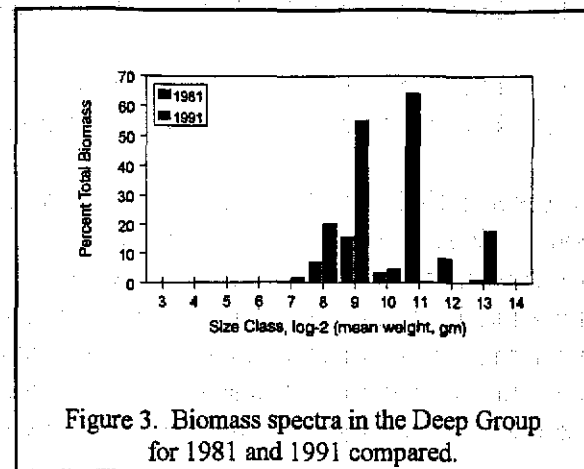
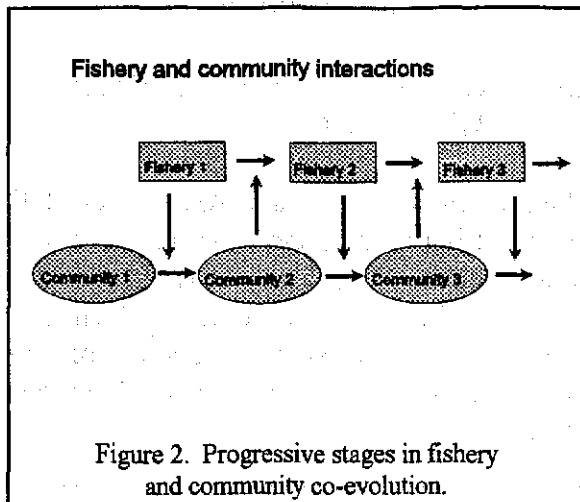
But fisheries affect more than their target species; they impact the entire fish community. Scientific survey time series from Newfoundland show that the less abundant, non-commercial, by-catch fishes declined in the face of increased fishing effort just as the dominant, commercial species did (Gomes *et al.*, 1995). In addition to similar decreases in abundance, most species of both commercial and non-commercial fishes displayed declines in their average size over time (Haedrich and Barnes, 1997).

Such impacts are more clearly seen in shallower, continental shelf fish communities than they are in deeper, continental slope ones. Nonetheless, there is evidence that deepwater fish communities have been affected by fishing (Merrett and Haedrich, 1997). The Deep Assemblage (Gomes *et al.*, 1995) off northeast Newfoundland is one where there have been declines in both abundance and average size of many fish

species. For Greenland halibut (*Reinhardtius hippoglossoides*) there, scientific surveys show the average size has continued to decline and remains well below the size at maturity (Fig. 1), a situation which bodes ill for the fate of that deepwater fishery.



So fisheries clearly have the potential to change the structure of communities. In turn, however, a changed community means that the fishery based on it must also change. The result is a ratcheting effect of change from one state to another (Fig. 2), with the implication that recovery of a fishery to some past state may never be possible. The fish history of the Great Lakes illustrates this point well, and Deimling and Liss (1994) describe how it has occurred in the northeast



Pacific.

Biomass spectra offer one way to assess community change. The dominant mode in a spectrum indicates the size classes where most of the energy is concentrated in the community and represents, presumably, a stable state. Even if overall abundance declines greatly, some likelihood of recovery remains as long as relative biomass does not change, and this will be reflected in an unchanged mode in the biomass spectrum over time.

By the arguments presented above, the impact of fishing could be to shift the biomass mode to smaller size classes. According to allometric rules, smaller fish will exploit smaller prey (for example macrozooplankton rather than fish) and will have a shorter generation time. These attributes will, once the smaller fish is established in significant numbers, give it a competitive advantage over a larger fish whose numbers have markedly declined. The result would be for the system to re-organise around a new stable state. The change in biomass spectra for the Deep Assemblage, compared between 1981 and 1991 (Fig. 3), suggests such a shift may be underway in that exploited deepwater fish community.

References

- Deimling, E.A. and Liss, W.J. 1994. Fishery development in the eastern North Pacific: a natural-cultural system perspective. *Fisheries Oceanography*, 3: 60-77.
- Gomes, M.C., R.L. Haedrich and M.G. Villagarcía. 1995. Spatial and temporal changes in the groundfish assemblages on the NE Newfoundland/Labrador Shelf, Northwest Atlantic, 1978-1991. *Fisheries Oceanography* 4(2): 85-101.
- Haedrich, R.L. and Barnes, S.M. 1997. Changes over time of the size structure in an exploited shelf fish community. *Fisheries Research*, 31: 229-239.
- Merrett, N.R. and R.L. Haedrich. 1997. *Deep-sea Demersal Fish and Fisheries*. Chapman & Hall, London. 282 pp.
- Sinclair, A.F., and S.A. Murawski 1997. Why Have Groundfish Stocks Declined? In: J. Boreman, B.S. Nakashima, J.A. Wilson and R.L. Kendall, eds., *Northwest Atlantic Groundfish: Perspectives on a Fishery Collapse*, pp. 71-93. Bethesda MD: American Fisheries Society.