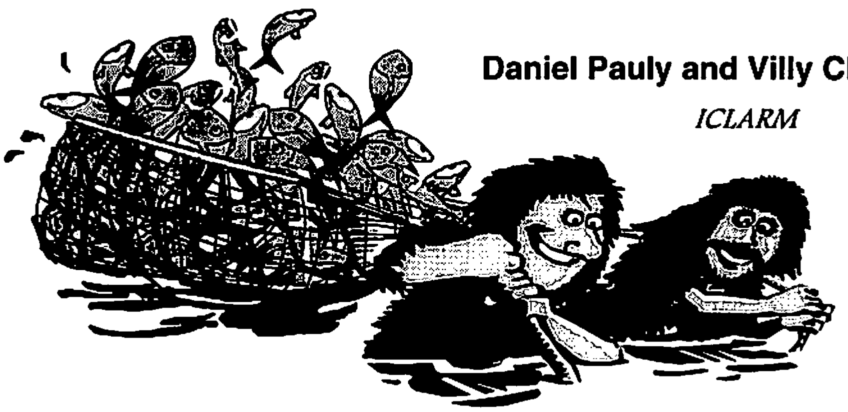
Rehabilitating Fished Ecosystems: Insights from the Past



Daniel Pauly and Villy Christensen

ICLARM

Introduction

There was a time - say 100 years ago - when there were so many fish in the sea that the best scientists thought the fisheries were inexhaustible. One often sees those scientists cited in recent papers, usually to show how little foresight they had being unable to imagine the huge industrial fleets we now have, and which can, indeed, rapidly drive almost any stock of fish, however large, to the point of collapse.

The problem - which can be called the shifting baseline syndrome[1] - is that the information these scientists used is now viewed as anecdotal, and their perception as irrelevant to present-day concerns.

Yet, based on conservative inferences from early accounts (or anecdotes), MacIntyre et al. in the July 1995 issue of *Naga* (p. 4-6), suggested that biomasses of commercial fish and other large vertebrates in the North Atlantic a hundred or so years ago, may have been ten to twenty times larger than they are now.

Small wonder, then, that our predecessors thought we would never run out of fish. What we miss, when we patronize our predecessors, is that their optimistic pronouncements were not only based on inability to imagine modern fishing fleets, but on the fact that there was indeed lots of fish for them to see. And we are the ones who cannot imagine what they saw.

Such numbers represent a challenge and, like MacIntyre and colleagues, we have followed up on their implications. We did so using the ECOPATH 3.0 software applied to two models of marine ecosystems previously published, but modified in steps to include more and more of the top predators i.e., sharks and other large fish, presumed to have occurred in earlier, unfished systems.

The results paint an interesting picture: in both systems, much higher biomasses could be sustained, at all trophic levels, than are presently observed (Fig. 1). This is achieved by a feature typical of "mature" ecosystems: the

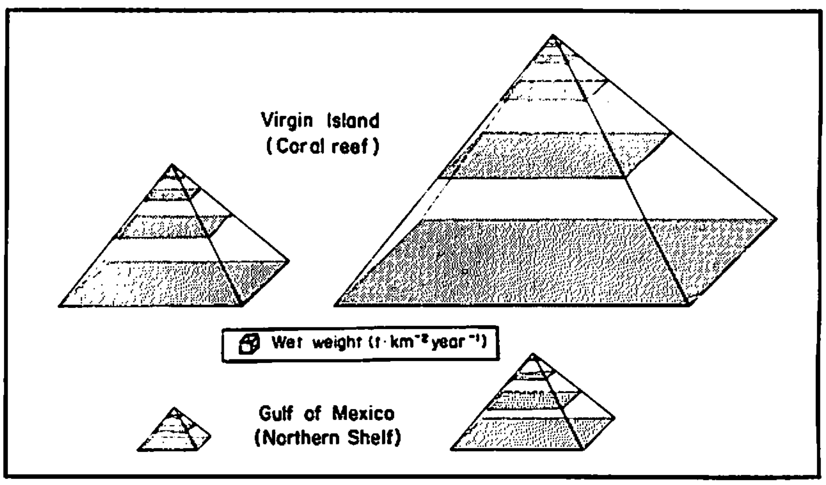


Fig. 1. Comparisons of trophic pyramids representing the flows of energy at different trophic levels of two marine ecosystems, the unfished Virgin Islands (upper pyramids) and the heavily fished northern Gulf of Mexico (lower pyramids). The models are based on Opitz (1993: 259-267), and Browder (1993: 279-284), respectively (in ICLARM Conf. Proc. 26). The left pyramids show the original flow structure while the right pyramids represent the status after the system biomasses were increased as much as possible toward carrying capacity, while keeping primary production consistent. For the Virgin Islands reef the top predator biomasses could be increased fourfold, leading to a doubling of total biomass while the top predator biomasses of the strongly fished Gulf of Mexico could be increased 15 times, leading to a fourfold increase of total biomass. This indicates that the (fished) Gulf of Mexico is further from ecosystem carrying capacity.

increased recycling of detritus by a variety of detritivores and omnivores now either lacking or less abundant (Fig. 2).

Or put differently: just like tropical forests which, once logged over, lose nutrients and then their ability to regrow, marine systems can be so depleted by fisheries that the fish or invertebrates disappear which either utilize primary production that otherwise would be lost to sedimentation, or transfer secondary (zooplankton) production to higher trophic levels. [This scenario does not consider marine mammals, whose abundant wastes are thought by MacIntyre et al. to have once fertilized now barren ocean gyres.] Increased loss of unutilized algae has been reported from the Baltic Sea, where over the past 100 years, detritus fluxes have increased tenfold while primary production - due to eutrophication - has increased by a factor of only two.[2]

These considerations may seem academic, yet they have a clear implication for our long-term use of marine resources: allowed to reestablish their original structures and biomasses, marine ecosystems could generate, on a sustainable basis, higher and certainly more valuable catches than are now taken from depleted stocks.

Local successes with marine protected areas (see *Naga*, July 1994, p. 8-12) confirm this for coral reefs: leaving a given reef area unfished long enough for biomasses to be rebuilt leads to increased catches in adjacent areas, well in excess of that needed to compensate for the "loss" of the protected area.

In addition, we may consider what impact well-functioning ecosystems may have for the coastal environment. "Development" as a whole leads to eutrophication, and hence, usually, to increased sedimentation and anoxic conditions. One reaction to this, in more and more countries, has been to set up costly wastewater treatment plants. Could not rehabilitated ecosystems, which would have much larger populations of herbivores, function as natural treatment plants while at the same time sustaining higher fisheries than at present?

Our final message is that our predecessors were no fools when they saw lots of fish, and drew the inferences they did. It is we who are foolish in reducing coastal fish biomasses to the extent that they can only consume 8% of global primary production.[3]

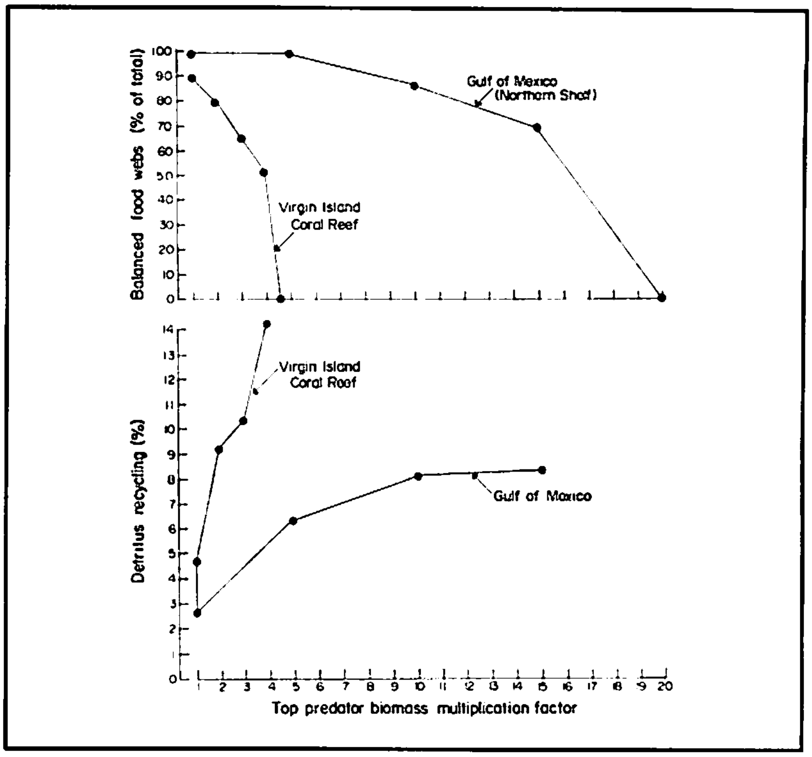
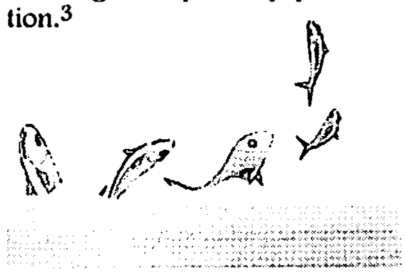


Fig. 2. Response of two ecosystem models to changes of their top predator biomass, simulated using the EcoRanger routine of ECOPATH[4], and assuming primary production to remain constant throughout. Upper graph shows that the percentage of balanced food webs (in which production = consumption) decreases as top predator biomass increases. This is due to gradually insufficient production to satisfy predator food requirements, and/or those of their preys; the region of low percentages defines "carrying capacity". Note that this increases from the unfished Virgin Islands system to the strongly fished Gulf of Mexico systems. Lower graph shows that higher biomass can be supported in a system if more detritus is recycled, and this is reflected in increasing recycling of detritus.



Further Reading

[1]Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends Ecol. Evol. 10(10):430.
[2]Walsh, J.J. 1989. How much shelf production reaches the deep sea, p. 175-191. *In* W.H. Bergen, V.S. Smetacek and G. Wefer (eds.) Productivity of the ocean: present and past. John Wiley & Sons, New York, USA.
[3]Pauly, D. and V. Christensen. 1995. Primary production required to sustain global Fisheries. Nature 374:255-257.
[4]Christensen, V. and D. Pauly. 1995. Fish production, catches and the carrying capacity of the world oceans. Naga, ICLARM Q. 18(3):34-40.

D. Pauly *is ICLARM's Principal Science Adviser, and a faculty at the Fisheries Centre, The University of British Columbia, Vancouver, Canada.* **V. Christensen** *is an ICLARM Scientist based at the North Sea Centre, Hirsthals, Denmark.*

ICLARM Contribution No. 1313.