

Fishing Down Marine Food Webs

- Daniel Pauly, * Villy Christensen, Johanne Dalsgaard, Rainer Froese, Francisco Torres Jr.

- *Science* 6 February 1998:
Vol. 279, no. 5352, pp. 860 - 863

- <http://www.fishbase.org/search.php>

Fishing Down the Food Web (FD)

- The sequential replacement of high-value upper-trophic-level species with less valuable lower-trophic-level species as the former are depleted to economic extinction.

Calculation of Trophic Level

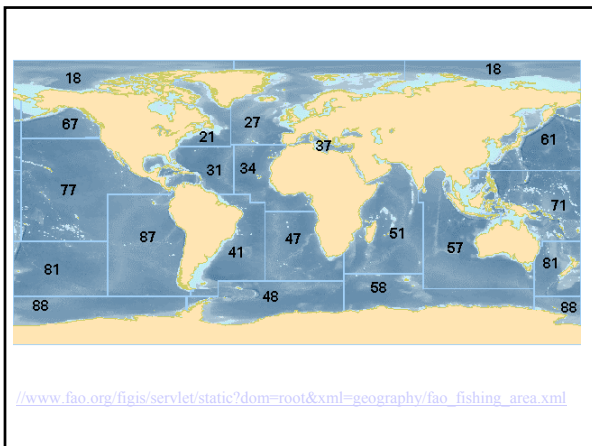
- $$TL_j = 1 + \sum_{i=1}^n DC_{ij} TL_i$$
- Where DC is diet composition as a fraction j in diet of I

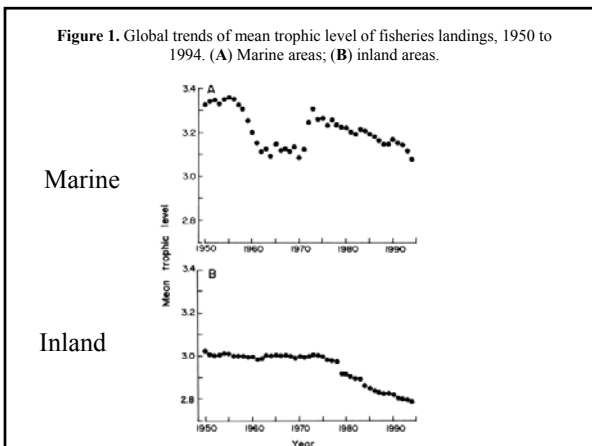
example

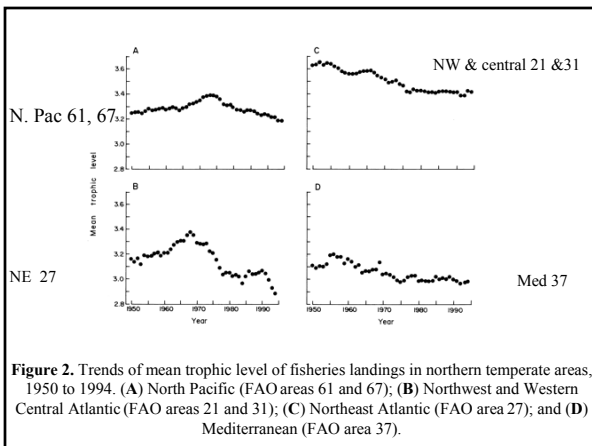
- Consumer eating 40% plants (TL= 1) and 60% herbivores (TL 2) will have TL of $1 + 0.4 * 1 + 0.6 * 2 = 2.6$

Fisheries Landings Means

- $$TL_k = \frac{\sum_{i=1}^m Y_{ik} TL_i}{\sum_{i=1}^m Y_{ik}}$$
- Where Y_{ik} is landing of species i in year k, and TL_i is its TL







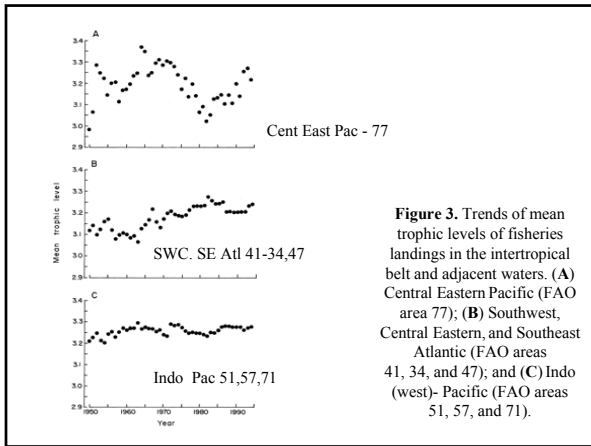


Figure 3. Trends of mean trophic levels of fisheries landings in the intertropical belt and adjacent waters. (A) Central Eastern Pacific (FAO area 77); (B) Southwest, Central Eastern, and Southeast Atlantic (FAO areas 41, 34, and 47); and (C) Indo (west)-Pacific (FAO areas 51, 57, and 71).

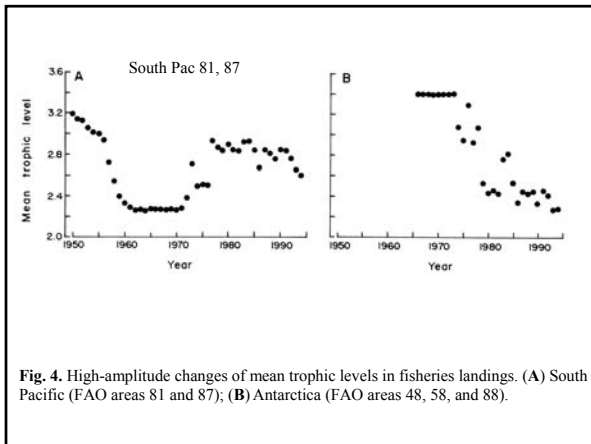


Fig. 4. High-amplitude changes of mean trophic levels in fisheries landings. (A) South Pacific (FAO areas 81 and 87); (B) Antarctica (FAO areas 48, 58, and 88).

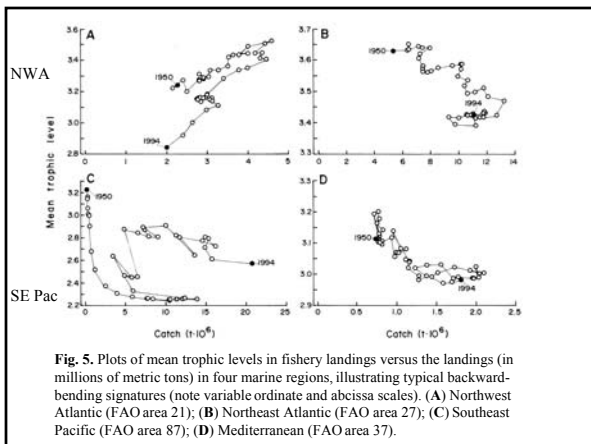
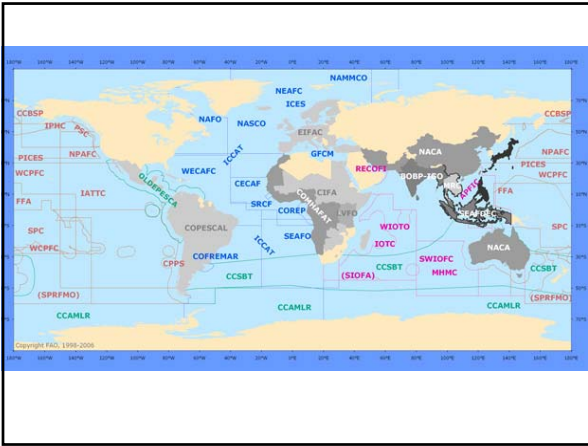


Fig. 5. Plots of mean trophic levels in fishery landings versus the landings (in millions of metric tons) in four marine regions, illustrating typical backward-bending signatures (note variable ordinate and abscissa scales). (A) Northwest Atlantic (FAO area 21); (B) Northeast Atlantic (FAO area 27); (C) Southeast Pacific (FAO area 87); (D) Mediterranean (FAO area 37).



<http://www.fao.org/fi/body/rfb/chooserfb.htm>

Recent Papers

- Sibert, J. Hampton, P. Kleiber, and M. Maunder
Biomass, Size, and Trophic Status of Top Predators in the Pacific Ocean
 Science, December 15, 2006;
 314(5806): 1773 - 1776.

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- **Fishing through marine food webs**
- **Timothy E. Essington, Anne H. Beaudreau, and John Wiedenmann**
- School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195

- An alternative to this view, that declining mean trophic levels indicate the serial addition of low-trophic-level fisheries ("fishing through the food web"), may be equally severe because it ultimately leads to conflicting demands for ecosystem services.

Fishing Thru the Food Web

- Sequential addition of lower-trophic-level fisheries within an ecosystem.
- Fisheries for high-trophic-level species are maintained despite a decline in the overall mean trophic level of landings.

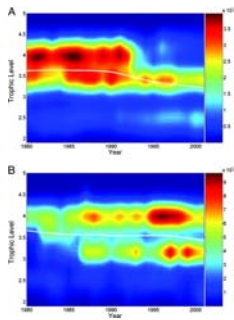
- By analyzing trends in fishery landings in 48 large marine ecosystems worldwide, they found fishing down the food web was pervasive (present in 30 ecosystems) but that the sequential addition mechanism was by far the most common one underlying declines in the mean trophic level of landings.

Outcomes of Each

- Commonness of each of these alternative mechanism by examining the temporal dynamics of upper-trophic-level fishery catches.
- Under the sequential collapse/replacement mode, a decline in the mean trophic level should be accompanied by reduced catches of high-trophic-level species as these species become economically extinct.
- Under the sequential addition mode, catches of upper-trophic-level species may be maintained or even increase.

- The sequential addition mode of fishing through the food web appears at first glance to be more benign,
- Yet, from a policy standpoint, the fishing through the food web process gives rise to potentially untenable conflicts, because developing fisheries that demand different ecosystem services (e.g., productive apex predator stocks vs. productive forage fish stocks) will ultimately force policy makers to make judgments and assign values to these alternative fisheries

Fig. 1. Illustrative examples of the sequential collapse/replacement (A) and sequential addition (B) mode of fishing down the food web



Essington, Timothy E. et al. (2006) Proc. Natl. Acad. Sci. USA 103, 3171-3175

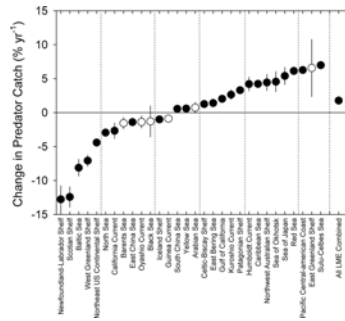
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Table 1. Interpretations of fishing down the food web as determined through review of scientific literature citing Pauly et al. (6)

Context of citation	No. of citations
Ecosystem effects of fishing	65
Overfishing	52
Replacement of high-trophic-level fisheries with low-trophic-level fisheries	35
Description of phenomenon	26
Method (ecopath)	17
Other	14
Economic value of large fish	6
Need for marine reserves	4
Susceptibility of large fish	4
Thermodynamic basis of fishing down the food web	2
Sequential addition	0

Fig. 2. Estimates of the instantaneous rate of change (% yr⁻¹) in apex predator catches (\pm SE) during the time period when the mean trophic level was declining in each ecosystem

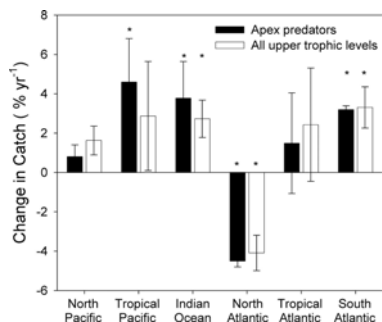


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Fig. 3. Comparison of the mean (\pm SE) instantaneous rate of change in apex predator catches (trophic level > 4; solid bars) and all upper-trophic-level catches (trophic level > mean trophic level; open bars) among ocean regions



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- This model was of the form $C(t) = C(0)\exp(-\lambda t)$, where $C(t)$ is the catch rate during year t , $C(0)$ is the catch rate for the initial year, and t is the number of years since the mean trophic level initiated its decline. Estimates of λ were made by using robust linear regression of $\log(C(t))$ vs. t

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• <http://www.afsc.noaa.gov/Quarterly/jas2006/divrptsREFM2.htm>
