Fishing Down Marine Food Webs

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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

- \( n \)
- \( \text{TL}_j = 1 + \sum \text{DC}_{ij} \text{TL}_j \)
- \( j = 1 \)

Where \( \text{DC} \) 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 \( 1 + 0.4 \times 1 + 0.6 \times 2 \) = 2.6

Fisheries Landings Means

- \( \text{TL}_k = \sum \frac{Y_{ik} \text{TL}}{Y_{ik}} \sum_{i=1}^{m} \frac{Y_{ik}}{Y_{ik}} \)

Where \( Y_{ik} \) is landing of species \( i \) in year \( k \), and \( \text{TL}_i \) is its TL
Figure 1. Global trends of mean trophic level of fisheries landings, 1950 to 1994. (A) Marine areas; (B) inland areas.

Figure 2. Trends of mean trophic level of fisheries landings in northern temperate areas, 1950 to 1994. (A) North Pacific (FAO areas 61 and 67); (B) Northwest and Western Central Atlantic (FAO areas 21 and 31); (C) Northeast Atlantic (FAO area 27); and (D) Mediterranean (FAO area 37).
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-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).
Recent Papers

- Sibert, J. Hampton, P. Kleiber, and M. Maunder
  **Biomass, Size, and Trophic Status of Top Predators in the Pacific Ocean**

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

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

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Fig. 2. Estimates of the instantaneous rate of change (% yr⁻¹) in apex predator catches (±SE) during the time period when the mean trophic level was declining in each ecosystem
• This model was of the form \( C(t) = C(0) \exp(t) \), 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 \( C(0) \) were made by using robust linear regression of \( \log(C(t)) \) vs. \( t \).

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