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Sea Around Us

The Marine Trophic Index: A new output of the *Sea Around Us* website

by Daniel Pauly

The first demonstration that the mean trophic level of fisheries is declining (i.e., that global fisheries catches increasingly consist of smaller fish and invertebrates low in the food web) occurred in the late 1990s (Pauly et al. 1998). Over the next few years, this finding was replicated and refined by a number of authors and this led to the process, now known as 'fishing down marine food webs', becoming widely known and accepted (review in Pauly and Watson 2005). As a result, the Parties of the Convention on Biological Diversity decided, at a meeting held in Kuala Lumpur in February 2004, to use mean trophic level of fisheries catches, renamed the 'marine trophic index' (MTI), as an indicator of biodiversity, specifically of the richness and abundance of large, higher trophic-level fish species (CBD 2004). This implies that the Parties (i.e., member countries of the CBD) will have to report annually on the MTI of their fisheries, along with seven other indicators of biodiversity. The point here is that if the mean trophic level of the fisheries catches (= MTI) from the marine ecosystems of a given country is steadily declining, then these fisheries are not exploiting the resources sustainably, whatever one's definition of sustainability. As a result, the biodiversity of these resources will be threatened as well.

To facilitate reporting to the CBD and other applications, we have incorporated into the *Sea Around Us* website (www.seaaroundus.org) a routine which computes the MTI from 1950 to the present, for any country's EEZ, Large Marine Ecosystem (LME) or High Seas area (see box on p. 3 for summary of how the MTI and related indices are calculated).

Experience indicates that the MTI is very sensitive to fisheries catches being accurate, and particularly not being taxonomically and spatially over-aggregated. Thus, we are working on disaggregating the catch statistics for many countries. Until this is completed for all countries for which this is necessary, we cannot guarantee that the catch database of the *Sea Around Us*, mapped by countries' EEZ, LME and High Sea areas, will allow accurate MTI trends to be computed. Trends of MTI and related indices (see Figure 1 for an example) are thus offered mainly for indicative purpose, and must always be interpreted with caution, especially when the underlying catch statistics are unreliable.

To enable various definitions of the MTI, particularly MTI computed from certain cut-off values of trophic levels to exclude the strongly fluctuating lower trophic-level fishes (Pauly and Watson 2005), we allow for the user to identify groups to be deleted from the computation of the MTI. In many cases, this will make apparent a fishing down

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trend that was not visible initially.

Ecosystem indicators related to the MTI

Besides a fractional trophic level (see box on p. 3), which is needed for computing the MTI, each taxon included in the world marine fisheries statistics (species, genus, family, etc.) has an approximate maximum length (ML, in cm) assigned to it. This enables computation of time series of mean ML as another ecosystem and biodiversity indicator - again on the assumption that an ecosystem is not managed for sustainability if the catch extracted from it consists of ever-smaller species.

Thus, mean ML (which on the *Sea Around Us* website is output only in tabular form, see below) is complementary to the MTI. Another indicator, like the MTI output in graphic and tabular form, is the FiB index, a measure of the 'balance' between catches and trophic level. The FiB index is designed so that its value remains constant if a decline in trophic level is matched by an ecologically appropriate increase in catch, and conversely for increasing trophic level (see box, p. 3). Thus, a time series of the FiB index can be useful in interpreting a series of MTI values, as it allows us to determine whether a decrease in trophic level was 'worth it', in terms of increasing catches (see Figure 1). Also, the FiB index allows assessment of whether fisheries have been expanding geographically (the logic involved here is detailed in a note available as a pop-up window).

[The indices] can all be accessed under the 'Ecosystem' button for any country's EEZ, LME or High Sea area

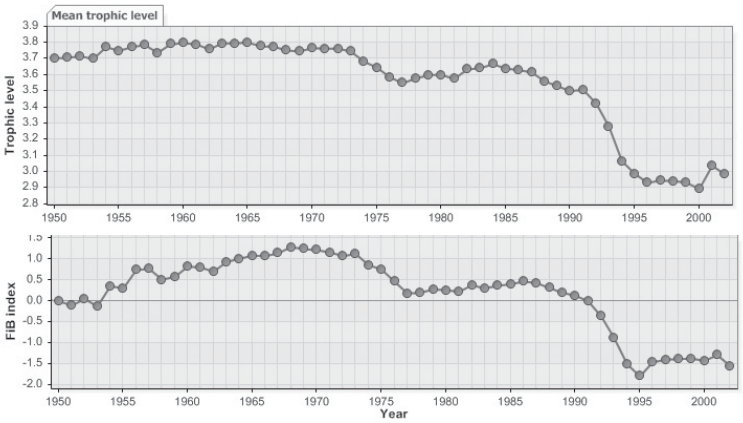

Figure 1. Time series of MTI and FiB index for the east coast of Canada, 1950-2002. Top: time series of MTI (mean trophic level), showing strong decline, especially in the 1990s ; Bottom: Corresponding series of the FiB index, indicating that the decreasing TL were not matched by increasing catches (see text).

The FiB index is computed using 1950 as a baseline year, but this can be changed as required. Also, the FiB index requires a measure of the transfer efficiency (TE) between the trophic level of an ecosystem, and a default value of 10 % is provided. The routine allows this to be changed but, as may be seen, the overall shape of time series of the FiB index are little affected by the precise value of the transfer efficiency.

Implementation and prospects

On the *Sea Around Us* website, ML and the FiB index can all be accessed under the 'Ecosystem' button for any country's EEZ, LME or High Sea area. The outputs are two graphs (as illustrated in Figure 1) and a table listing the values of all indices from 1950s onward. Also, a list of species included or excluded, and their mean trophic level and maximum size, as used in the computation, can be printed. Under the 'Method' button, a note is provided as a 'pop-up'

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Our mailing address is: UBC Fisheries Centre, Lower Mall Research Station, 2259 Lower Mall, Vancouver, British Columbia, Canada, V6T 1Z4. Our fax number is (604) 822-8934, and our email address is SeaNotes@fisheries.ubc.ca. All queries (including reprint requests), subscription requests, and address changes should be addressed to Robyn Forrest, *Sea Around Us* Newsletter Editor.

The *Sea Around Us* website may be found at saup.fisheries.ubc.ca and contains up-to-date information on the project.

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The *Sea Around Us* project is a Fisheries Centre partnership with the Pew Charitable Trusts of Philadelphia, USA. The Trusts support nonprofit activities in the areas of culture, education, the environment, health and human services, public policy and religion. Based in Philadelphia, the Trusts make strategic investments to help organisations and citizens develop practical solutions to difficult problems. In 2000, with approximately $4.8 billion in assets, the Trusts committed over $235 million to 302 nonprofit organisations.

The Marine Trophic Index and related indicators

Trophic levels (TL) express the position of an animal in a food web, relative to the primary producers (which have a definitional TL of 1). TL can be calculated from:

$$TL_i = \Sigma_j TL_j \times DC_{ij} \quad \ldots 1)$$

where TL_j represents the fractional trophic levels of prey j, and DC_{ij} represents the fraction of j in the diet of i. Using catch data, and TL estimates for species (or groups thereof), mean TL and, hence, Marine Trophic index values, can be computed, for each year k from:

$$\text{Mean } TL_k = \Sigma_i (Y_{ik} \times TL_i) / \Sigma_i Y_{ik} \quad \ldots 2)$$

where Y_i refers to the landings of species (group) i, as included in fisheries statistics. [Note that, ideally, mean TL should be based on catches - i.e., all animals killed by fishing (landings + discards) - rather than only on the landings included in most fisheries statistics. This is ignored here, where we deal only with landings]. Mean maximum length (ML) is calculated similarly to mean TL, by weighting by the catches.

The fishing-in-balance (FiB) index is defined as:

$$FiB_k = \log[Y_k \times (1/TE)^{TL_k}] - \log[Y_0 \times (1/TE)^{TL_0}] \quad \ldots 3)$$

where all parameters and subscripts are defined previously, except TE, the mean transfer efficiency (specific to an ecosystem, often set at 0.1), and 0, which refers to any year used as a baseline to normalize the index. This definition implies that the FiB index:
- Does not change (remains = 0) if TL changes are matched by 'ecologically correct' changes in catch;
- Increases (>0) if: either 'bottom up effect occurs, e.g., increase in primary production, or if a geographic expansion of the fishery occurs (and the 'system' definition has in fact changed);
- Decreases (<0) if the fisheries withdraws so much biomass from the ecosystem that its functioning is impaired.

Further details on these indicators and their interpretation are given in the literature cited, and on the website in pop-up windows which present further details on TL and their estimation, and on the MTI and related indicators (www.seaaroundus.org).

We hope that this routine, elaborated in collaboration with the CBD, will be found useful and we look forward to your feedback

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window, which explains the concept presented here and provides access to peer-reviewed literature on the MTI and related indices.

We hope that this routine, elaborated in collaboration with the CBD, will be found useful and we look forward to your feedback. Notably, we would like in-country collaborators, which would help us (and their country) to improve the fisheries statistics upon which these indicators are based.

References

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Funding news

We are pleased to announce that we have been officially informed that the Board of the Pew Charitable Trusts approved continuation of the *Sea Around Us* project grant in its last meeting.

Also, UNESCO has officially approved a project proposal by Villy Christensen to expand his work on Large Marine Ecosystems. Details of this project soon.