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

Continued on page 2 - MTI

The Sea Around Us Project Newsletter

Issue 29 – May/June 2005

MTI - Continued from page 1

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.

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

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).

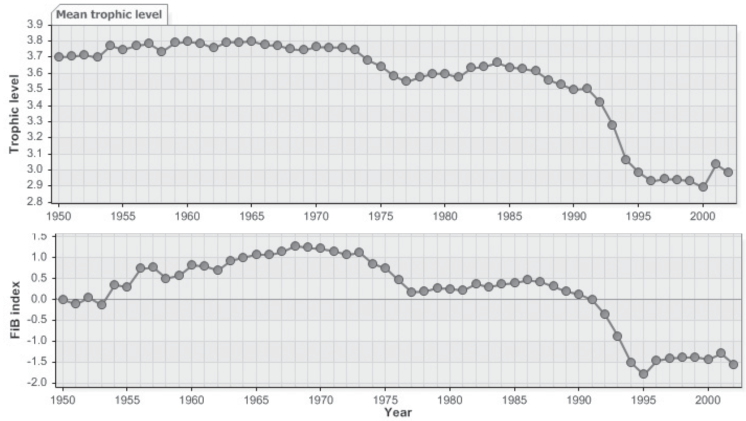

Figure 1. Time series of MTI and FiB index for the east coast of Canada, 1950-2002. Top: time series of MTI (mean trophic level), showing strong decline, especially in the 1990s ; Bottom: Corresponding series of the FiB index, indicating that the decreasing TL were not matched by increasing catches (see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

Continued on page 3 - MTI

The *Sea Around Us* project newsletter is published by the Fisheries Centre at the University of British Columbia. Included with the Fisheries Centre's newsletter *FishBytes*, six issues of this newsletter are published annually. Subscriptions are free of charge.

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

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:

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

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:

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

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:

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

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).

MTI - Continued from page 2

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.

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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.

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

Reconstructing the *John Murray/Mabahiss* expedition

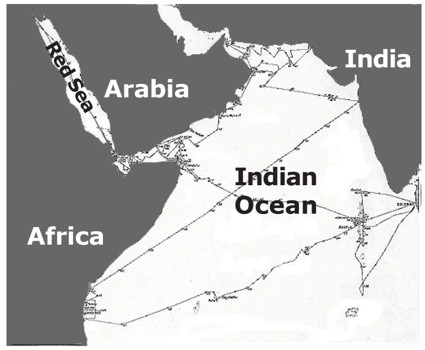
by Dawit Tesfamichael

Expeditions are a good source of bio-geographical information (Palomares and Mohammed 2005). A famous example is the expedition of *Challenger,* which is commonly accepted to have ushered in the birth of modern oceanography. In this article, I present another expedition, done in the west Indian Ocean - the geographic area of my PhD research. Both expeditions have a lot in common and one strong link.

At the end of the expedition, 2700 fish specimens representing 276 species had been collected

The *John Murray/Mabahiss Expedition*, known for short as the *John Murray Expedition* was intended to investigate the physical, chemical and biological characteristics of the West Indian Ocean and adjacent seas. The expedition was named after John Murray, a Canadian-born oceanographer, and was largely funded by money he bequeathed twenty years before the expedition. Murray was a member of the *Challenger* expedition and was responsible for the expedition's final report.

The *John Murray* was an Anglo-Egyptian expedition, which started on Sept 3, 1933 from Port Alexandria, Egypt and finished May 25, 1934 at the same port (see map). It was carried out aboard the 138' Egyptian research vessel, *Mabahiss* (Arabic for 'research'), rented by a committee of scientists mainly from the British Natural History Museum, with chief scientist, R. B. Seymour Sewell. The expedition covered the Red Sea, the Gulf of Aden, the South Arabian Coast, the Gulf of Oman, the Arabian Sea, Zanzibar and the Maldives (see Rice 1986).



Track of the voyage of Mabahiss *in the John Murray expedition.*

The vessel was equipped with water samplers, plankton nets, trawls and dredges. Water, plankton and fish samples were taken from 209 major and some minor stations over a period of 9 months and 3 weeks. At the end of the expedition, 2700 fish specimens representing 276 species had been collected. The specimens are kept in the Zoology Department of the British Museum of Natural History.

My task was to create an electronic database of the expedition, based on published reports and web resources. The database consists of descriptions of the sampling stations; depth; temperature at the surface and different depths; bottom type; gear used; and salinity. Information about stations was obtained mainly from Sewell (1935). Data on fish specimens were obtained mainly from Norman (1939). For each specimen the following data are given: scientific name, station sampled, sex, length and life stage. The valid scientific name is according to the Eschmeyer Catalogue of Fishes (Eschmeyer, 1998). The database of the British Natural History Museum (http://flood.nhm.ac.uk/cgi-bin/perth/fish/indextaxon.dsml) was used to obtain the catalogue number of the specimens.

Reconstructing expeditions can be a painstaking, but worthwhile job. When I first took this assignment, I thought it would take me a month. However, a month was gone before I was even halfway, although I am happy to say I finished it in less time than the actual expedition!

The database is now available in the expedition table of FishBase (www.fishbase.org) and from the *Sea Around Us* project (www.seaaroundus.org).

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