MARINE TROPHIC INDEX		
Oceans, Seas and Coasts	**Marine Environment**	

1. INDICATOR

(a) Name: Marine Trophic Index.

(b) Brief Definition: The marine trophic index measures the change in mean trophic level of fisheries landings by region and globally. Trophic level is defined as the position of an organism in the food chain, and ranges from a value of 1 for primary producers up to a level of 5 for marine mammals and humans.

(c) Unit of Measurement: None, the mean trophic level of landings is a numerical value that ranges from 1 to 5.

(d) Placement in the CSD Indicator Set: Oceans, Seas and Coasts/Marine Environment.

2. POLICY RELEVANCE

(a) Purpose: In addition to being an indicator of the sustainability of fisheries, the marine trophic index provides a measure of ecosystem integrity. Declining trophic levels result in shortened food chains, leaving ecosystems less able to cope with natural or human-induced change. The long term sustainability of fisheries is, in turn, directly linked to human livelihoods and well-being.

(b) Relevance to Sustainable/Unsustainable Development (theme/sub-theme): The majority (70.8%) of the Earth is covered by marine systems. The oceans, besides representing repositories of biodiversity, play a significant role in climate regulation, the freshwater cycle, food provisioning, and energy and cultural services, including recreation and tourism. They are also an important source of economic growth, with capture fisheries alone worth approximately 81 billion USD in 2000.
Excessive fishing is the most widespread and dominant human impact on ocean ecosystems and is a major impact on marine biodiversity. The lowered biomasses and fragmented habitats resulting from the impacts of fishing are predicted to lead to local extinctions especially among large, long-lived, slow growing species and any endemics. In addition, the capacity of component ecosystems and their embedded species to withstand stresses resulting from climate change and other human impacts is likely reduced. Through elimination of destructive fishing practices, and maintenance and restoration of fisheries stocks to sustainable levels, the loss of marine biodiversity in the oceans can be reduced.

(c) International Conventions and Agreements: The United Nations Convention on Law of the Sea (UNCLOS), FAO Code of Conduct for Responsible Fisheries, a variety of fisheries agreements, Regional Seas Conventions and Action Plans.

(d) International Targets/Recommended Standards: No international targets have been established for this indicator.

(e) Linkage to Other Indicators: This indicator could be linked with all the indicators related to biodiversity.

3. METHODOLOGICAL DESCRIPTION

(a) Underlying Definitions and Concepts: The marine trophic index is a state indicator. The mean trophic level of landings is a numerical value. Trophic levels range from a definitional value of 1 for primary producers up to a level of 5 for marine mammals and humans.

Trophic level is defined as the position of an organism in the food chain, determined by the number of energy-transfer steps to that level. The role of fishes within ecosystems is largely a function of their size: small fish are more likely to have a vast array of predators than very large ones. On the other hand, various anatomical and physiological adaptations may lead to dietary specialization, enabling different fish species to function as herbivores, with a trophic level of 2.0, or as carnivores, with trophic levels typically ranging from 3.0 to about 4.5.

Moreover, trophic levels change during the life history of fishes. Larvae, which usually feed on herbivorous zooplankton (TL= 2.0) consequently have a trophic level of about 3.0. Subsequent growth enables the juveniles 1 to consume larger, predatory zooplankton and small fishes or benthic invertebrates; this leads to an increase in trophic level, often culminating in values around 4.5 in purely piscivorous, large fishes.

Because of the close relationship between trophic level and size, mean trophic levels reflect changes in both size composition and position in the food chain, and therefore ecological roles. Overfishing tends to lead to decline in large, high trophic level fish relative to low trophic level small fish and invertebrates. This leads to "fishing down marine food webs", where fisheries, first having removed the larger fishes at the top of various food chains, must target fishes lower and lower down, and end up targeting very small fishes and plankton.

Trophic decline, combined with decreasing biomass, leads to changes in the structure of ecosystems. Long food chains are being replaced by shorter ones, which expose top predators to strong environmentally-driven fluctuations exhibited by plankton organisms at the base of food webs. Such fluctuations were previously dampened by food webs with a variety of strong and weak links. Thus the biomass of fish species targeted by fisheries will fluctuate more widely than before, making fisheries increasingly difficult to manage and increasingly vulnerable to environmental changes, such as climate change.

It should be noted that environmental factors, such as eutrophication of coastal areas, may cause an increase in plankton-eating lower trophic level fish, particularly in semi-enclosed seas. Upwelling of nutrient-rich water may result in a similar increase in lower trophic species, as can periods of warmer water temperatures. However, environmental effects alone cannot explain the steady decline in global mean trophic levels seen in figure 1, as such effects are restricted to certain coastal areas and will therefore likely have only a relatively minor impact on the overall trend. This observation is supported by a recent study undertaken in the Celtic Sea, where a significant decline in mean trophic level of both survey catches and landings was observed, implying a substantial change in underlying structure of the Celtic Sea fish community as a result of intensive fishing, though long-term climate variability may have been a contributing factor. It is also possible to filter out these environmental effects when calculating mean trophic level trends by excluding fish and invertebrates below a certain trophic level from the calculations.

(b) Measurement Methods: Two data sets are needed to calculate the indicator: (i) catch data by taxonomic groups, and (ii) one estimate of trophic level for each of these groups.

One of the sources for (i) (catch data by taxonomic group) are the FAO, which created and maintains a global data set, available online (at www.fao.org). This data set can be used for calculating the indicator, from 1950 to the present minus 2 years, for the landings of individual countries, the landings of 18 statistical areas largely representing ocean basins, and globally. Another source of data for (i) is the online database of the Sea Around Us Project (www.seaaroundus.org), whose geo-referenced data pertain to the Exclusive Economic Zones (EEZ) of all maritime countries, to Large Marine Ecosystems (LME) and to the High Seas, outside of EEZ.

Trophic level estimates for fish, based on their diet composition, may be found in FishBase, the global online database on fish, and for invertebrates, in the Sea Around Us database. Another source are the ecosystem food web models constructed using the widely used Ecopath software (see www.ecopath.org). Stable nitrogen isotopes of stomach contents have also been used in one study.

By combining these two data sets, mean trophic levels of landings can be estimated for any of the world's country or area.

The FAO has collected data on capture fisheries from all maritime countries and analysed global trends in fisheries stocks since 1950. These data are reported in aggregated format, by 18 broad FAO regions, and present a solid basis for undertaking a global analysis of mean trophic level change.

In an effort to provide fisheries data on a finer scale, the Sea Around Us Project (SAUP) (www.seaaroundus.org) has disaggregated the FAO data into spatial cells measuring ½ a degree latitude by ½ a degree longitude. This procedure makes it possible to report landings taken with a range of statistical boundaries, including by country EEZs, large marine ecosystems, and high seas areas. In this process, the SAUP has also substituted data from regional organizations such as the International Council for the Exploration of the Sea (ICES) (www.ices.int/fish/statlant.htm), the Northwest Atlantic Fisheries Organization (NAFO) (www.nafo.ca/) and others. This provides a finer spatial catch breakdown for most of the Atlantic and the Mediterranean. Where possible, they have also added national datasets such as that from Canada's Department of Fisheries and Oceans (DFO) for Atlantic Canada. Plans are underway to include more national and smaller scale datasets in other areas as well, thus mitigating the problem of taxonomic resolution and incomplete coverage mentioned above.

(c) Limitations of the Indicator: The marine trophic index is a powerful indicator of marine ecosystem integrity and sustainability of fisheries. Its main limitations are (i) the use of catch composition data as index of relative abundance in the ecosystems, and (ii) the quality of the underlying fisheries landings or catch data. The current data quality is sufficient for global and regional level analyses. For some maritime countries, the quality of the data is low (little taxonomic resolution, failure to cover inshore fisheries), and hence the computed index is not as indicative as it could be. Note, however, that no one indicator alone can provide a comprehensive picture of the "health" of the oceans, and that such an assessment would require a number of additional data sources/indicators.

(d) Status of the Methodology:

(e) Alternative Definitions/Indicators:

4. ASSESSMENT OF DATA

(a) Data Needed to Compile the Indicator: Two data sets are needed to calculate the indicator: (i) catch data by taxonomic groups, and (ii) one estimate of trophic level for each of these groups.

(b) National and International Data Availability and Sources: The marine trophic index provides a robust indicator of ecosystem integrity and the sustainability of fishing at the global and regional levels. Depending on data quality, this indicator can also be used nationally. However, in many cases, data quality may not, as of yet, be sufficient to support the undertaking of such calculations for each country. Additional improvement in fisheries catch data would be required before the indicator can be used on the national level by all countries.

(c) Data References:

5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR

(a) Lead Agency: The lead agency is the Food and Agriculture Organization of the United Nations (FAO). The contact point is the The Director Fishery Resources Division, FAO; fax no. (39 06) 5705 XXXX.

(b) Other Contributing Organizations: None.

6. REFERENCES

(a) Readings:

FAO 2004. The State of World Fisheries and Aquaculture. FAO. Rome.

(b) Internet sites:

FAO Fisheries Department: http://www.fao.org/fi/
The State of World Fisheries and Aquaculture: http://www.fao.org/sof/sofia/
Fishery Resources Monitoring System (FIRMS): http://firms.fao.org/
Sea Around Us Project: http://www.seaaroundus.org