53.8

Indicators for the 'Convention on Biodiversity 2010'

Exploration of the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainability of marine fisheries in the Dutch part of the North Sea

F.E. Fey-Hofstede
H.W.G. Meesters

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Summary

The Marine Trophic Index (MTI) is one of the indicators the Convention on Biological Diversity (CBD) has adopted to assess progress towards the 2010 target. The MTI is proposed by the CBD as an indicator for sustainable fisheries and ecosystem integrity. The MTI is defined as the mean trophic level the way Pauly (1998) conceptualized it in his famous article 'Fishing Down Marine Food Webs'. This report explores the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainable fisheries and ecosystem integrity for the Dutch situation.

The MTI has its place in a number of international programmes mostly because there is more and more cooperation and fine-tuning between monitoring and assessment programmes of the different conventions. It is the only indicator that looks at the sustainability of fisheries and as such is likely to receive an even more official status in the near future by the Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention'), the European Marine Strategy (EMS) and the European Common Fisheries Policy CFP.

The MTI offers the possibility to encapsulate data on fisheries landings in one figure. The use of FAO-data also facilitates comparisons between countries and areas. There are several points of concern, however. It is clear that many other factors apart form overfishing can effect the Marine Trophic Index. Because of the influence of these factors on the MTI, conclusions on sustainable fishing based on the MTI, without the use of additional information on all these factors, may not always be correct. Furthermore, the MTI does not yet have a reference value, which makes it difficult to interpret. And because the MTI combines all fisheries statistics in one figure, it offers no possibilities for precise intervention.

In conclusion, to be able to use the MTI as an indicator for sustainable fisheries for the Dutch EEZ, several adjustments are necessary. Therefore, it should be evaluated first if other indicators (like abundance, species composition, proportion of large fishes, etc.) might not be more straightforward to use for calculation and interpretation.

It should also be kept in mind that the ecosystem is too complex to catch in just one figure, and at least a set of different ecosystem-indicators should be used to base policy decisions on.

1 Introduction

In June 2004, the EU Environment Council welcomed a set of biodiversity indicators, referred to in the 'Message from Malahide', which are based on the first set of indicators adopted under the Convention on Biological Diversity earlier that year. The Council also urged the European Commission to develop, test and finalise the EU set by 2006, taking into consideration its evolving nature. The commitment builds on a global decision taken at the Johannesburg summit in 2002 to significantly reduce the loss of biodiversity by 2010. The framework of 15 headline indicators was also adopted by the EU Council in June 2004 and by the PEBLDS (Pan-European Biological and Landscape Diversity Strategy) Council in 2005. Subsequently the SEBI2010 project was set up to oversee the process on the Pan-European level. The activities addressed by SEBI2010 include three policy contexts:

1. European Union: by implementing the EU 15 biodiversity headline indicators response is given to the ‘Message from Malahide’ as endorsed by the EU Environment Council, as well as support to the Lisbon Agenda, the Sustainable Development Strategy, the Habitats and Birds Directives and the Biodiversity Strategy;
2. Pan-European: as a follow-up to the Kiev Resolution on Biodiversity SEBI2010 is directly responding to the UNECE Environment for Europe process and the PEBLDS;
3. Global: the EU biodiversity headline indicators are based on the CBD trial indicators, customized to the European needs. Therefore SEBI2010 also responds to CBD Decision VII/30. A common element in these three processes is the 2010 target and a common tool is the agreed set of indicators.

The Netherlands has committed itself to the goals of the CBD and in a number of national programmes from different ministries the Dutch government tries to implement and support the ideas and decisions from the CBD.

The CBD states:

‘The intensification of fishing to unsustainable levels has led to the effective removal of species from marine food webs. Most preferred fish catches consist of large, high financial value, high trophic level predatory fish, such as tuna, cod, and swordfishes. Overfishing tends to lead to decline in these large predatory fish so that the relative numbers of low trophic level small fish and invertebrates increases, a phenomenon known as ‘fishing down marine food webs’.

The biomass of top predators in the North Atlantic has decreased by two-thirds in approximately 50 years and the mean trophic level of fisheries landings globally has declined at a rate of approximately 0.1 per decade. Marine Trophic Index, which can be calculated from existing fish catch data, is therefore a good indicator of the sustainable use of living resources’ (UNEP/CBD/AHTEG-2010-Ind/1/INF/5).

This report explores the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainable fisheries and ecosystem integrity for the Dutch situation.

2 Explanation of the Marine Trophic Index (MTI) and its goal as an indicator

2.1 Background

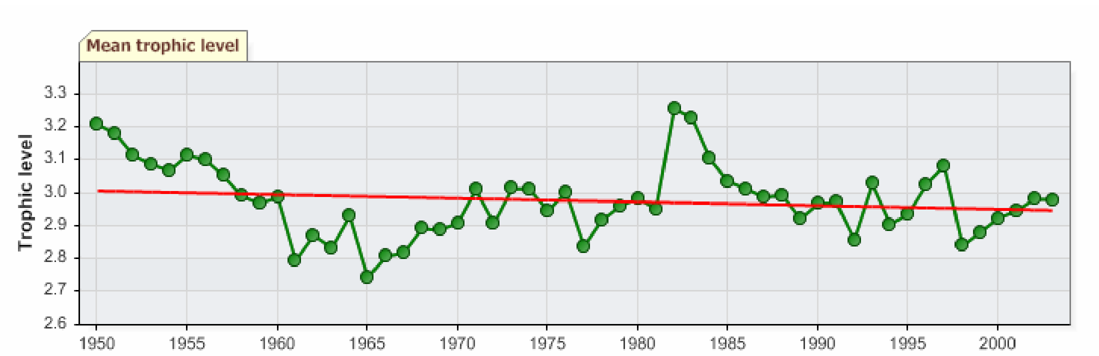
The Marine Trophic Index (MTI) is the name the CBD (Convention on Biological Diversity) gave to the mean trophic level, as Pauly (1998) calculated and defined it in his famous article 'Fishing Down Marine Food Webs'. The mean trophic level in general indicates the mean position marine species in a defined area take in the marine food web. The mean trophic level can be calculated from data on fish occurrences based on fisheries landings or survey data, in combination with estimates of trophic levels of the occurring fish species. The trophic levels of individual fish species can be estimated from diet composition data or with the stable isotopes method.

The Marine Trophic Index (MTI), defined by Pauly (1998), is calculated from a combination of fisheries landings and diet composition data of the landed fish species. The fisheries landings are based on the FAO-database (Food and Agricultural Organization of the United Nations) on fisheries landings of member countries. FAO collects fisheries statistics since 1950. The trophic levels of landed fish species were estimated by a mass balance ecosystem model (ECOPATH) based on observed diet compositions.
With these datasets the MTI for each year (k) was computed from:

$$MTI_k = \frac{\Sigma i (TL_i) * (Y_{ik})}{\Sigma_i Y_{ik}}$$

Y_i refers to the landings of species (group) i, as included in fisheries statistics, and TL = trophic level

The MTI-slope of the Dutch EEZ (Exclusive Economic Zone) is shown in Figure 2.1 and Appendix 1. The landings are based on FAO-data on landings in the Dutch EEZ by all countries fishing in this area (Appendix 1). The TL-levels per species are estimated by the simulation model ECOPATH and based on diet composition data (Pauly 1998; website: www.seaaroundus.org). The regression slope indicates on average a slightly downward trend over the years 1950 up to 2003. In 1950 the MTI level was 3.2, while in 2006 the level had decreased to 3.0.

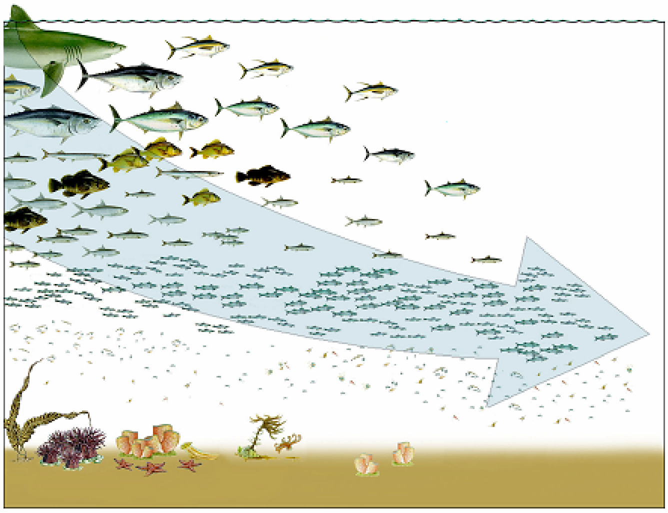


Figuur 2.1. Mean trophic level (TL) of Dutch EEZ from 1950-2000. Regression slope=-0.0011, R^2=0.03 (A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

The MTI offers the possibility to encapsulate data on fisheries landings in one figure, making changes in fisheries behaviour visible in one glance. The MTI can be calculated for all FAO-member countries in the world from the same database. This facilitates international comparison in fisheries behaviour.

Changes of the MTI over years reflect changes in mean trophic level of fisheries landings and thus the position of fisheries in the food web. When the MTI declines over the years fisheries are assumed to 'feed' on lower trophic levels. This might be an indication of 'fishing down marine food webs'[1], which is an indication of unsustainable fisheries, as larger fishes are removed from the food web leaving only smaller ones that have lower trophic levels (Box 2.1). For this reason the MTI is proposed as an indicator for sustainable fisheries (CBD: UNEP/CBD/AHTEG-2010-Ind/1/INF/5-2004).

Box 2.1 Fishing 'down marine food webs'



The arrow indicates how, over time, humans have depleted stocks of larger fish, which were originally closer inshore, and are now targeting smaller species and fishes from deeper water. When bottom fishes are caught using nets dragged on the sea floor (i.e., by trawls), the habitat changes from one rich in organisms living on or near the sea bottom, to a near-lifeless muddy substrate.

Source: Daniel Pauly, Fisheries Centre, University of British Columbia, Canada (UNEP/CBD/AHTEG-2010-Ind/1/INF/5)

Besides of being proposed as an indicator for sustainable fisheries, the MTI is also proposed as an indicator for ecosystem integrity by the CBD. It is stated that landings in a certain area reflect the composition of species in that area. When species from higher trophic levels are no longer landed this might indicate that they are not present anymore in the ecosystem, decreasing ecosystem integrity.

[1] Generally used as a term to indicate that unsustainable fisheries is exploiting ever lower trophic levels over time (Pauly *et al.* 1998)

2.2 Limitations of MTI as an indicator

As stated above, the MTI offers the possibility to encapsulate data on fisheries landings in one figure. The use of FAO-data also facilitates comparisons between countries and areas. There are several points of concern, however, both related to the MTI in general and to the use of this index as indicator for sustainable fisheries and ecosystem integrity (Table 2.1 – Par. 2.3).

2.2.1 MTI in general

The value of the MTI-slope is highly dependent on the quality of the underlying fisheries landings or catch data and of the estimated TL (trophic level) of the landed species.

Pauly (1998) uses the global database of fisheries landings of the FAO to acquire information on the annual fisheries catches of a certain country. Because these statistics are aggregated by the countries where the catches *were landed* and not by the countries were they were *taken*, Pauly (1998) uses all information from countries assumed to fish in a certain area to estimate the yearly catch in combination with information from foreign countries fishing in the EEZ of a certain country. The database of the FAO is based on voluntary submission and the catches can be submitted categorized by species or groups of species, such as genera of families, but also by larger groupings such as 'miscellaneous species'. Unfortunately, over 30% of the landings in the FAO-database are not identified on the species level (Caddy, 1998), which makes assigning a TL to this group precarious. In addition, the database does not include discards and unrecorded catches and can contain misreported data.

Another problem concerning the estimated TL is that assigning one single TL to a fish species is inaccurate, as the TL of fish species change with size and age. For example many fish change their trophic level during life as they change from eating plankton, to small crustaceans and later to small fish species. In some cases the TL might change by as much as three points (Caddy, 1998). Pauly (1998) uses diet composition data to estimate the TL of a certain fish species. Analyses of Marine Trophic Index, using diet composition data, thus focus on the role of changes in species composition rather than size composition, as changes in size within species are not included in the analyses. Other limitations to the diet composition data approach may include the following: failure to detect prey because of rapid transit through the gastrointestinal tract, absence of digestion-resistant hard parts, variable erosion rates of otoliths (a species specific structure in the inner ear), and disappearance of prey remains because of complete digestion (Hammill, 2005). The degree to which these phenomena occur is affected by species composition of the diet, activity levels of the animal, and meal size (Hammill, 2005).

An alternative method to compute TL is to use stable-isotopes. The stable-isotope approach is based on the demonstration that stable-isotope ratios in tissues of consumers are correlated with those of their prey. In contrast to the reconstruction approach, which reflects food ingested over the last few days, the stable-isotope approach estimates the diet assimilated over a longer period of time, varying from a few days up to several months depending on the tissue analysed (Hammill, 2005). Although a case study which compared both methods resulted in strong similarities between the results (Kline & Pauly, 1998), some researchers prefer the stable-isotope method (Piet, 2007; personal communication) as this method can obviate the TL change during the ontogeny of species, when combined with species-size abundance data.

Another point of attention concerns the size of the area for which the MTI is calculated. The Dutch EEZ, for example, is part of the North Sea, but fishes will swim freely from one EEZ to another. Because of this, and because data in the FAO-database is more usable on a larger spatial scale, calculating the MTI for the whole North Sea will be more informative than for the EEZ alone (Appendix 3).

2.2.2 MTI as an indicator

A general problem of the MTI as an indicator is the absence of a reference value. TL-values are known for individual species, but average values for ecosystems, corresponding to an 'acceptable state' of the ecosystem or sustainable fisheries, are not available. One solution to this problem might be to use a value from a period in which human influence was low or absent. It is generally agreed that after the Second World War fish stocks were in an excellent condition. Therefore the 1950 values might be used as a reference. It remains still unclear, however, how to define differences between 'natural' temporal and spatial changes and fisheries induced changes in the MTI. This makes the MTI difficult to understand by non-scientists and those who will decide on its use.

Sustainable fisheries

Overfishing tends to lead to the decline of the preferred high value, high TL fishes and can even result in the removal of these large predatory fish from the food web (Pauly *et al.*, 1998). The decline or disappearance of these large predatory fishes results in a decrease of the Marine Trophic Index. The Marine Trophic Index might therefore be a good indicator of sustainable fishing. When the MTI decreases this might indicate a disappearance of a higher trophic level species from the food web by fisheries, possibly leading to decreasing biodiversity (but not necessarily).
However, to be able to interpret the changes in the MTI would at least require additional information, because other factors can influence the MTI apart from the disappearance of high trophic level fishes by unsustainable fisheries.

Management measures, such as a trawl ban, may reduce the catch of high-TL species in the landing data, although in fact this would be a positive measure. Changes in fishing locations, for instance from shallow to deep water, may influence the Mean Trophic Level of landings, although this may have nothing to do with overfishing. Other management factors that may influence the MTI are gear changes or changes in selectivity and environmental changes in abundance of some species (for instance El Nino effects).

Lower MTI values may also be the result of a deliberate policy of fisheries to catch more fishes with lower TL levels, instead of a lack in high TL fishes in the ecosystem. Marine ecosystems operate as a pyramid wherein the primary production generated at TL1 is moved up towards the higher TL's. During this process a huge fraction of the primary production is wasted in the process for maintenance, reproduction and other activities of the animals in the system (Pauly & Christennsen, 1995). Deliberately fishing at lower TL-fishes would thus result in more of an ecosystem's biological production to be captured by humans, in other words, more fishes to be caught. To compensate for this problem, Pauly defined the FiB (Fishing In Balance) index (Figure 2.2 and Appendix 1). This index computes if the increase in catch due to focusing on lower trophic levels matches the ecological appropriate increase (determined by the transfer efficiencies between TL's). The FiB-index remains constant if the TL-changes match 'ecological appropriate' changes in catch. When the FiB-index decreases this may indicate that fisheries withdraw so much biomass from the ecosystem that it's functioning is impaired (Pauly & Watson, 2005). The department of Fisheries of FAO, for this reason, believe that the FiB-index is preferable compared to the MTI as an indicator for sustainable fisheries.

Eutrophication of coastal areas may result in increasing abundance of planktivores, thus lowering mean trophic level. As a diffuse and general problem eutrophication can modify the ration between predator and prey abundances, which then could be confused with effects of fisheries. To obviate this problem Pauly suggested (Pauly, 2005) that the CBD's MTI should be in fact based on time series that exclude low-TL organisms. This would lead to an indicator labelled as '^{cut}MTI', with the 'cut' referring to the lowest (cut-off) TL value used in the computation. Pauly proposes the cut-off value of 3.25 ($^{3.25}$MTI) (Figure 2.2). With a cut-off value of 3.25 all TL-levels lower than 3.25 are removed from the computation of the MTI, to eliminate the herbivores, detrivores and the planktivores whose biomass tends to vary widely in response to environmental factors (Pauly & Watson, 2005).

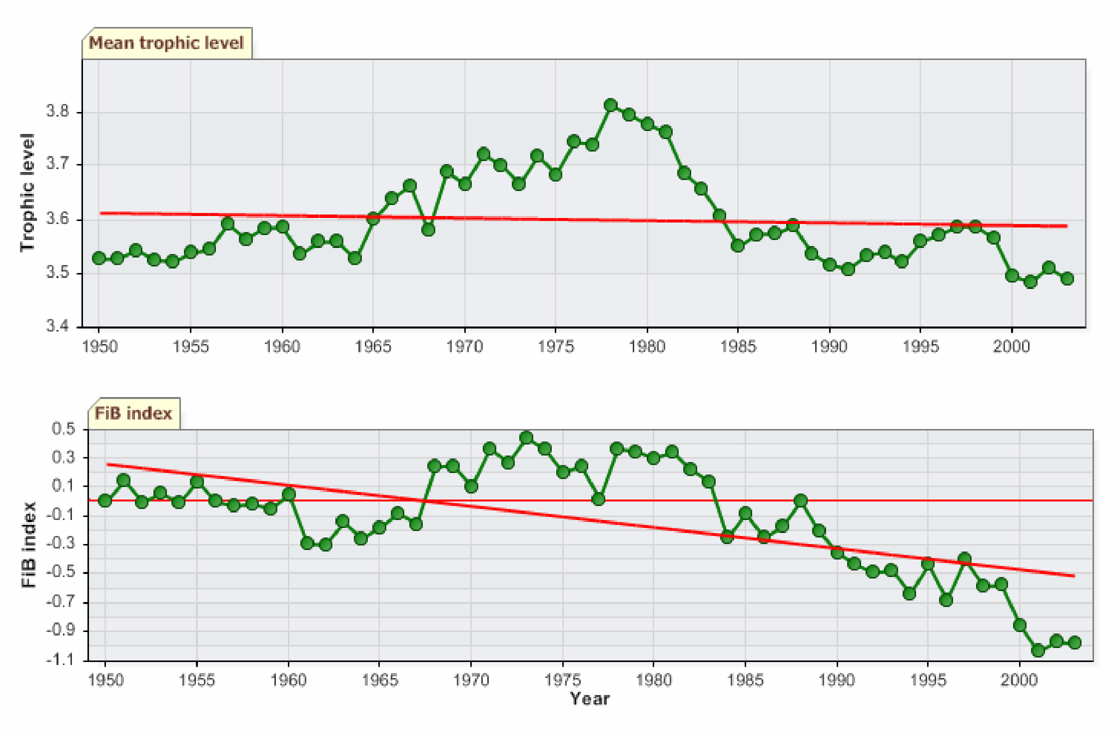


Figure 2.2. MTI and FiB from the Dutch EEZ with a TL cut-off value of 3.25 (A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

Summarised, it is clear that many other factors, besides overfishing, can influence the Marine Trophic Index. Without the use of additional information on them, the influence of these factors on the MTI may lead to conclusions on sustainable fishing based on the MTI that are not always correct.

Ecosystem integrity

Based on the assumption that the relative abundance of taxa in the landing data coincides with ecosystem biodiversity, the MTI-index is proposed as an indicator for ecosystem integrity. In addition to the already mentioned drawbacks, which also apply to the use of the MTI as an ecosystem integrity indicator, it can be argued that the composition of landings is effected by many other factors (gear, fishing technology, natural oscillations in abundance) apart from occurrence in the ecosystem (Caddy, 1998).

2.2.3 Sensitivity of the MTI

There are no studies on the sensitivity of the MTI. This would require the original data used by Pauly *et al.* (1998). However, excluding fish species, using the cut MTI or adjusting the dataset changes the MTI graph and regression slope substantially (Appendix 2), indicating high sensitivity to adjustments in datasets.

The MTI is calculated from data on fisheries landings in a certain area and the diet composition data from the landed species. Alterations in either data series can influence the MTI, and thus the conclusions that are drawn on the sustainability of the fisheries (Appendix 2).

2.3 Conclusion limitations MTI

The quality of the MTI as an indicator is highly dependent on the underlying data series. The quality of FAO fisheries catches and the estimates of TL's based on diet composition may not be detailed enough to offer the quality to calculate the MTI for a small area as the Dutch EEZ. The fisheries landing data which is used by the MTI (FAO) is less suitable for use in smaller sub areas, like the Dutch EEZ.

In addition, the MTI does not yet have a reference value which makes the MTI difficult to interpret. Because the MTI is sensitive to many other factors next to fisheries pressure, no conclusions can be drown without thorough knowledge on these other factors. Because the MTI combines all fisheries statistics in one figure, it offers no possibilities for precise intervention (Table 2.1).

Table 2.1. Summary of advantages and disadvantages of the use of MTI as an indicator of 'sustainable fisheries' and 'ecosystem integrity'.

Advantages	**Disadvantages**
Captures fisheries statistics in one figure	Quality MTI highly depends on underlying data-series (fish-abundance and trophic levels)
Facilitates international comparisons	Fisheries landings data (FAO) less suitable for small areas as Dutch EEZ
Gives indication of Fisheries-behaviour	No reference value, making the MTI difficult to interpret
	MTI is sensitive for other factors besides fisheries pressure
	Fisheries landings less suitable for judgment on ecosystem integrity
	No possibilities for precise intervention

3 Adjustments of the MTI necessary for reaching goal of CBD for Dutch situation

3.1 MTI as indicator for sustainable fisheries

To be able to use the MTI as an indicator for sustainable fisheries for the Dutch EEZ several adjustments are necessary (Table 3.1). First of all, additional improvement in fisheries catch data would be required. Although data sustainability and continuation of the FAO database is excellent (as data are collected on a yearly bases), the data are reported in aggregated format by 18 broad FAO regions. This database may therefore be less suitable when used on a national level. The information to design a better data-series on landings in the Dutch EEZ is available (Piet, 2007; personal communication). This information would, however, require a large investment, as it is largely fragmented and part of the data is not available on digital files. In addition, TL-estimates of landed fish species should be based on stable isotopes when this information is available (Piet, 2007; personal communication) and should be linked to size-abundance data-series in order to prevent looking only at species abundance and not at size distribution of fish species.

When using the MTI as an indicator for sustainable fisheries, additional information on other factors influencing the MTI-slope, should be available, in order to prevent misinterpretations of the index.

3.2 MTI as indicator for ecosystem integrity

To be able to use the MTI as an indicator for ecosystem integrity the database used in the calculation should be replaced. Instead of data-series on fisheries landings, for a state-indicator, data-series of yearly surveys should be used. Such a database is available at IMARES for the south-eastern part of the North Sea from 1969 onwards. This data-base is also used for other state-indicators, for instance the 'percentage of big fishes in catch' (Milieu- en Natuurplanbureau) and would offer a more realistic reflection of the ecosystem biodiversity. Other surveys on the North Sea are the International Bottom Trawl Survey (IBTS), which covers the whole North Sea from 1982 onwards, and the Scottish August Groundfish Survey, which covers the Central and Northern North Sea from 1925 to1996. There are no surveys which focus on the Dutch EEZ specifically. This means that when survey data is used, the mean trophic levels can only be calculated from other parts (or the whole) of the North Sea, instead of the EEZ specifically. Although surveys also use fishing gear which is species specific and do not sample all species present in the North Sea (for example sand eel), they are less vulnerable to data problems like discards, misreports, species aggregation etcetera.

3.3 Conclusions on adjustments of the MTI in relation to Dutch CBD-obligations

To use the MTI as an indicator as is stated in the CBD-obligations, several adjustments are necessary (Table 3.1). First of all the data series on fish abundance (landings or survey) should be improved. There are alternatives for the FAO-database, under which are several long-term surveys on the North Sea. Improvements on landing data in the Dutch EEZ requires extra investments, however. In addition, estimates of trophic levels of occurring fish species should be made on the basis of stable isotope analysis and should be combined with species size abundances. These TL's are available for most occurring species.

To prevent influence of other factors on the MTI, apart from fisheries pressure a cut-off value of the MTI should be determined for the Dutch situation (^{cut}MTI). The use of a cut-off value prevents the influence of bottom-up-effects (eutrophication). The determination of a cut-off value for the Dutch situation would require a study on trophic levels in the North Sea by a Marine Scientist. In addition a reference value should be determined for the Dutch situation and a study on natural fluctuations of the MTI in the Dutch EEZ should be performed.

Table 3.1. Summary of adjustments necessary for use of MTI as indicator of 'sustainable fisheries' and 'ecosystem integrity' in the Dutch situation.

Adjustments
Improvement of data-series fisheries landings or use of survey data North Sea
Estimation of Trophic Levels of fish species by stable isotope method combined with species-size abundances
Determination of cut-off value MTI for Dutch situation (cutMTI)
Determination of reference value and natural fluctuations of MTI for Dutch situation

3.4 Available studies on Mean Tropic Levels of the North Sea

Jennings *et al* (2002) studied long-term trends in trophic structure of the North Sea fish community. They compared Mean Trophic Levels with changes in size composition. For this study trophic levels were estimated using stable isotope analysis in combination with species - size abundance data. In this way the trophic level was linked to both species and mean size of this species. For species abundance data, two trawl surveys were used. Firstly, the International Bottom Trawl Survey (IBTS) which covers the whole of the North Sea from 1982 onwards, and secondly, the Scottish August Groundfish Survey (SAGFS) data for the central and Northern North Sea from 1925-1996) were used.

Analyses of the IBTS time-series showed that there was a slow but progressive decline in the trophic level of the demersal community (Figure 3.1a). There was no trend in the trophic level of the combined pelagic and demersal community, however (Figure 3.1b). Analyses of the SAGFS time-series suggested that there was no trend in the trophic level of the demersal community.

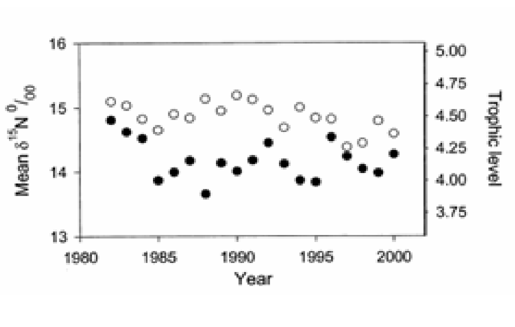


Figure 3.1a. Long term trends in the mean δ15N and equivalent trophic level of the North Sea fish community, as sampled by the International Bottom Trawl Survey. Filled circles: Pelagic and demersal species, open circles: Demersal species (Jennings et al., 2002).

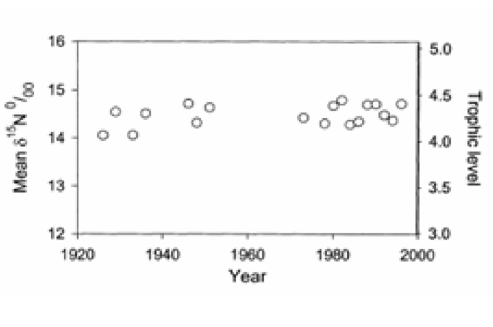


Figure 3.1b. Long term trends in the mean δ15N and equivalent trophic level of the North Sea fish community, as sampled by the Scottish August Groundfish survey (Jennings et al., 2002).

The mean δ15N is a measure for stable isotope analysis. These values are used to calculate the TL-level of animals and is thus directly related to the MTI

The size-based metrics of community structure, however, did show long term trends that were consistent with the effects of increased fishing exploitation (Jennings *et al.*, 2002).

Jennings *et al.,* (2002) attribute the relatively small changes in the North Sea, compared to larger changes in the Celtic Sea, to the long history of fishing and the intensive directed fisheries on species at lower trophic levels.

The analyses of Jennings *et al.,* (2002) suggest that the effect of fishing on the trophic structure of fish communities can be much more complex than previously assumed. First of all, the sampled communities do not reflect all the pathways of energy transfer in a marine ecosystem. The gear used in the surveys is species specific and catches do not represent the composition of the whole community. For instance, Sand eel is not sampled in any of these surveys. Second, there is an absence of historical data on temporal and spatial changes in the trophic level of individuals. This makes it difficult to separate natural changes from fishing induced changes. Jennings *et al.,* (2002) conclude therefore that for the North Sea communities, changes in size structure are a stronger and more universal indicator of fishing effects than changes in mean trophic level.

Yang (1982) studied the Mean Trophic Level of fish catches between 1947 and 1977 in the North Sea. He estimated trophic levels of 34 species by means of food composition data. For the computation of the MTL he used ICES-catch data from the Bulletin Statistique (34 species) concerning the North Sea.

Yang found that although the total catch of these 34 species fluctuates widely, the MTL showed almost no change between 1947 and 1977 (Figure 3.2). This is particularly strange if one considers the huge fluctuations which occurred in this period of herring catch (1.3 million tones in 1965 to 44,000 tonnes in 1977).
Yang concludes from the MTI slope that fishing does not seem to have upset the fundamental ecological balance of the North Sea.

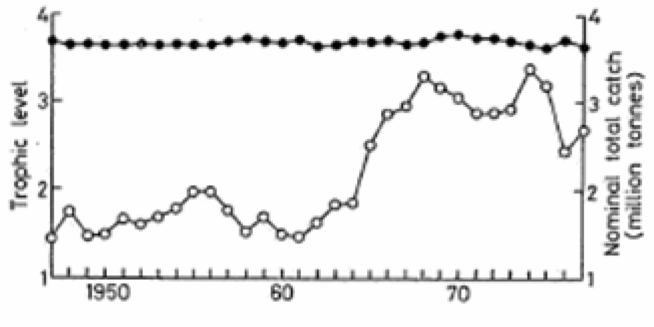


Figure 3.2 Mean Trophic Level of nominal catch (filled circles) and nominal total catch of North Sea fish during 1945-77 (Yang, 1982).

In a study on the response of potential fish community indicators to fishing Piet and Jennings (2005) calculated the mean trophic level of the North Sea fish community from 1980 to 2000. The trophic levels were estimated from length, using relationships between length and trophic level as determined by nitrogen stable isotope analysis (for 31 species, accounting for 90% of the total weight of fishes caught).

$$\overline{TL} = \frac{\sum_i \sum_j (TL_{ij} \times W_{ij})}{\sum_i \sum_j (W_{ij})}$$

The mean trophic level (TL) was calculated per haul from W_{ij} and TL_{ij}. W_{ij} and TL_{ij} are, respectively, the mass and trophic level of species i in length class j.

Fish abundances were generated from time series based on IBTS (International Bottom Trawl survey) and BTS (Beam Trawl survey).
Trophic level only decreased significantly when calculated from IBTS-data (Figures 3.3 and 3.4).

Piet and Jennings (2005) conclude that Mean Trophic Index does not show a (straightforward) linear relationship with fishing effort.

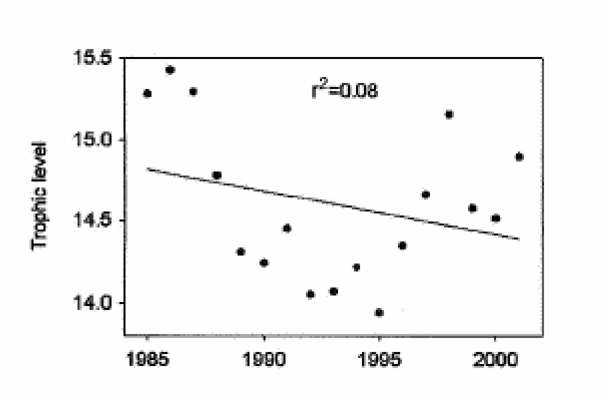


Figure 3.3. Mean trophic level calculated from BTS data (Piet and Jennings, 2005)

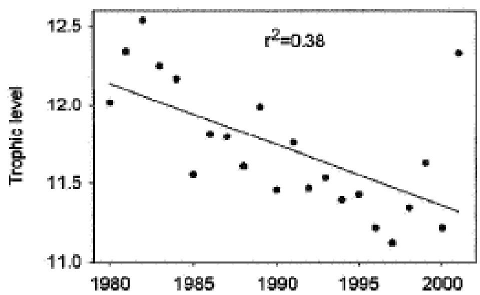


Figure 3.4. Mean trophic level calculated from IBTS data (Piet and Jennings, 2005).

4 Place of MTI in international obligations

The European Environmental Agency (EEA) has developed a core set of indicators, but the MTI is not yet part of it. Apart from this set of core indicators, the EEA uses the MTI within the fisheries theme as 'Fisheries impact habitats and ecosystems'. Though outside the CBD nowhere defined as a 'hard' indicator, monitoring programmes under other conventions do make use of the MTI.

4.1 MTI and OSPAR: How does the MTI fit in the OSPAR EcoQos?

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention') was opened for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992. During the fifth international conference on the protection of the North Sea (2002), the governments of Belgium, Denmark, France, Germany and The Netherlands signed a ministerial declaration. Part of the declaration concerns Sustainable Fisheries (Appendix 4). The ministers are concerned about the fact that the majority of the commercially important fish stocks, some non-target species and the physical environment are threatened due to excessive fishing pressure. For this reason several quality objectives are brought up. The OSPAR EcoQo's (Ecological Quality Objective) concerning sustainable fisheries (Appendix 2) focus on spawning stock biomass of commercial fish species (1a), presence and extent of threatened and declining species in the North Sea (2b), by-catch of harbour porpoises (3e) and changes in the proportion of large fish and hence the average weight and average maximum length of the fish community (Chapter 6; Appendix 4, issue 5.12).

Ecological Quality (Appendix 4, issue 5.12) seems to relate to the MTI, as the size of fishes is often related to their trophic level. The Ecological Quality Element 5.12 (Appendix 4), however, is based on data acquired from surveys and therefore relates more to the ecosystem than to the MTI, which is based on fisheries landings. In addition, the average weight and mean maximum length (Chapter 6) of fishes is a more direct measurement of the composition of the fish community than the trophic level, which is always based on estimations and an extra calculation.

4.2 MTI and the European Marine Strategy (EMS)

The European Commission has proposed an ambitious strategy to protect more effectively the marine environment across Europe on 24 October 2005 (http://europa.eu.int/comm/environment/water/marine.htm). The Thematic Strategy on the Protection and Conservation of the Marine Environment aims to achieve good environmental status of the EU marine waters by 2021 and to protect the resource base upon which marine-related economic and social activities depend. The Marine Strategy will constitute the environmental pillar of the future maritime policy the European Commission is working on and which is designed to achieve the full economic potential of oceans and seas in harmony with the marine environment.

A Marine Strategy Directive (MSD) will establish European Marine Regions on the basis of geographical and environmental criteria. Each Member State, in close cooperation with the relevant other Member States and third countries within a Marine Region, will be required to develop Marine Strategies for its marine waters.

The goal of the EMS is to achieve good environmental status in the EU marine waters by 2021. The Marine Strategies will contain a detailed assessment of the state of the environment, a definition of 'good environmental status' at regional level and the establishment of clear environmental targets and monitoring programmes. The MSD limits itself to a preset list of characteristics, and defines the pressures and impacts that Member States should assess when kicking-off implementation of MSD and starting with the Initial Assessment. Each Member State will draw up a programme of cost-effective measures. Impact assessments, including detailed cost-benefit analysis of the measures proposed, will be required prior to the introduction of any new measure.

Where it would be impossible for a Member State to achieve the level of ambition of the environmental targets set, special areas and situations will be identified in order to devise specific measures tailored to their particular contexts.

The Marine Strategy is consistent with the Water Framework Directive from 2000 which requires that surface freshwater and ground water bodies (lakes, streams, rivers, estuaries, and coastal waters) achieve a good ecological status by 2015 and that the first review of the River Basin Management Plan should take place in 2021.

The European Commission has adopted a Green Paper on Maritime Policy on 7 June 2006 (see Par. 4.3). Publication of the Green Paper is followed by a consultation period up to the end of June 2007 during which the Commission will listen to interested stakeholders.

As part of the work on the European Marine Strategy (under the 6th European Action Programme of the European Union), a working group is preparing guidance on an ecosystem approach to the management of human activities in the marine environment. The necessary steps are perceived to include the use of ecosystem indicators and reference points to assess the performance towards integrated management of the marine environment. The Working Group on European Marine Monitoring and Assessment (EMMA) is evaluating monitoring in the European Union and will advice in developing the European Marine Strategy. The main goal of EMMA is to develop a roadmap to facilitate, in particular, arriving at the 'initial assessment' under the MSD (for Member States) and pan-European marine assessments (for EC & EEA). Because the EU has committed itself to the CBD the Marine Trophic Index may be incorporated into the EMS.

4.3 MTI and the Common Fisheries Policy (CFP)

The European CFP has so far failed to achieve sustainable fishing. After reviewing the CFP it is recognised that there is a need for an ecosystem-based approach. An ecosystem-based approach for fisheries management will also be necessary to protect the vulnerable marine wildlife and habitats as required by legislation to preserve biodiversity and habitats. The Green Paper on a Future Maritime Policy for the European Union, adopted by the European Commission, is accompanied by a number of background documents which have been produced by European Commission Working Groups and by the Maritime Policy Task Force.

In this Green Paper is stated:

'As regards fisheries, one of the results of the World Summit on Sustainable Development at Johannesburg in 2002 was that fish stocks should be maintained or restored to levels that can produce the maximum sustainable yield by 2015. The Commission will shortly adopt a Communication on how to implement the maximum sustainable yield concept in the Common Fisheries Policy. Reducing overfishing will increase profitability, reduce environmental impact and decrease discards of fish. Larger and higher value fish can be caught, often in larger amounts. There are advantages in market supply and considerable competitive advantages to be gained. The risk of fish stock collapses is greatly reduced'.

Sustainable fishing is one of the pillars of the CFP. Mean Trophic Level has been proposed as an indicator by the Scientific, Technical and Economic Committee for Fisheries (STECF), which is part of the CFP.

4.4 Conclusion

The MTI has its place in a number of international programmes mostly because of increasing cooperation and fine-tuning between monitoring and assessment programmes of the different conventions. It is the only indicator that looks at the sustainability of fisheries and as such is likely to receive an even more official status in the near future by the Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention'), the European Marine Strategy (EMS) and the European Common Fisheries Policy.

5 Utility of MTI as an indicator for sustainable fisheries for the Dutch situation

When all the adjustments can be made (see above), the question remains if the MTI is a useful indicator of sustainable fisheries in the Dutch EEZ (Table 2.1 – Par. 2.3). Trends in indicators in general are sensitive to underlying catch or survey data series (Cury *et al.,* 2005). The MTI uses two data series which might be vulnerable to mistakes. This makes analyzing changes in MTI complicated. Indicators which use only one dataset (abundance, species composition, proportion of large fishes, mean weight, mean maximum length, etcetera) might be less sensitive to this factor.

In addition, trophodynamic indicators like the MTI appear to be conservative because they respond slowly to large structural changes in an ecosystem (Cury *et al.,* 2005).This hampers policy intervention.

The use of the MTI has not yet been considered in policy programmes in the Netherlands.

5.1 Data sustainability

The calculation of the MTI for a certain area is based on two databases; (i) catch data by taxonomic groups, and (ii) one estimate of trophic level for each of these groups. One of the sources for catch data (i) is the FAO-database, which created and maintains a global data set. Data sustainability is excellent, as the FAO collects fisheries statistics on an ongoing basis. For the use of the MTI as an indicator for sustainable fisheries and ecosystem integrity for the Dutch situation, however, the data on fisheries landings should either be improved, because FAO-statistics are not detailed enough, or survey-data should be used. Fisheries landings data of the Dutch EEZ is available, but needs considerable investments before it can be used. Survey-data are available at IMARES and data is collected on an ongoing bases from 1969 onwards.

Trophic estimates for fish (ii) can be based on their diet composition or on stable nitrogen isotopes and should be combined with size-distribution data. Trophic level estimates are available for most fish-species.

5.2 Policy intervention based on the MTI

As the MTI is an aggregated index, it does not show which fishes are reduced in abundancy or which fisheries are not sustainable. This makes policy reactions difficult. In addition, no reference level has been identified for MTI. This makes it difficult to decide whether policy action is required.

For example, the MTI for the Dutch EEZ shows on average a slightly downward trend over the years 1950 until 2003 (Figure 2.1 – Par. 2.1). In 1950 the MTI level was 3.2, while in 2006 the level had decreased to 3.0. It is not known if a decrease of 0.2 is a sign of unsustainable fisheries or still within the natural range of the MTI.

As no reference level is known for the MTI it is not possible to read the ecosystem state from the MTI. A MTI of 3.0 may still be very acceptable, or it may be a sign of a deteriorated ecosystem state.

In addition, trophodynamic indicators such as the MTI appear to be conservative and slow resonding (Cury *et al.,* 2005), which hampers policy intervention.

5.3 Possibilities for policy intervention

The MTI is an aggregated index, and thus offers no possibilities for detailed intervention targeted to certain fish species or fisheries. A strong downward trend in MTI indicates that ocean ecosystems are being damaged by excessive fishing, but which type of fishing is not clear. Reversing this trend would probably require a drastic reduction in fishing effort. Through elimination of destructive fishing practices, and the maintenance and restoration of fishery stocks to sustainable levels, the downward trend in MTI and thus the loss of marine biodiversity in oceans can be reduced.

6 Comparison of MTI with other ‘sustainable fisheries’-indicators

There are several ‘sustainable-fisheries’-indicators in use, from which ‘percentage of big fish in catch’, the FiB-index, mean weight and mean maximum length are discussed in this chapter (Table 6.1 – Par. 6.5).

6.1 ‘Percentage of big fish in catch’-index

The ‘percentage of big fish in catch’ is an indicator at the community level (INDECO, project no. 513754). Size-selective fishing targeting larger fish results in a change in size structure of the community, which is visible in the ‘percentage of big fish in catch’-index. When size-structure of the fish-community changes, the age-structure also changes. When the community mainly consists of young fish, reproduction can be at stake. The ‘percentage of big fish’ indicates changes in species composition and in size composition within a species. These two factors, both influenced by fisheries, can not be separated from each other in this indicator.
The MTI, as was seen in previous chapters, is an indicator on the ecosystem level (INDECO, project no. 513754). The main processes that occur in an ecosystem are production, consumption, respiration, and cycling and transfer of energy. A useful way to better understand relationships among different ecosystem components is the food web analysis. The MTI focuses on changes in this food web. The MTI as defined by Pauly only focuses on changes in species abundance and not on changes in size distribution within a species, which the ‘percentage of big fish in catch’ does.

Jennings *et al.* (2002) in a study on trophic levels and changes in size structures in the North Sea, stated that changes in body size are likely to be a stronger and more universal indicator of fishing effects than changes in trophic level, because changes in trophic structure can become unrelated to changes in size structure.

The ‘percentage of big fish’ indicator is also sensitive to other factors such as eutrophication, but because survey data are used instead of landing data, this indicator is less sensitive to management measures and deliberate fisheries policies.

As the percentage of big fish is determined from survey data (Figure 6.1), whereas the MTI depends on registered fisheries landings (Figure 6.2), the MTI is more related to the practise of fisheries, while the ‘percentage of big fish’ is more related to changes in the ecosystem.
Comparing the two indicators is difficult because of their different origin. However, from the point of data collection, the survey data are founded on a better scientific basis. In addition, the ‘percentage of big fish’ is determined more directly since it takes only one step from survey data to the proportion of large fish, while the MTI also uses TL-estimates, which might add another uncertainty.

Other size-based indicators are biomass size spectra (relationships between $\log^{10}$-normalised biomass by $\log^{2}$ body mass and $\log^{2}$ body mass), mean body size, mean maximum weight/size.

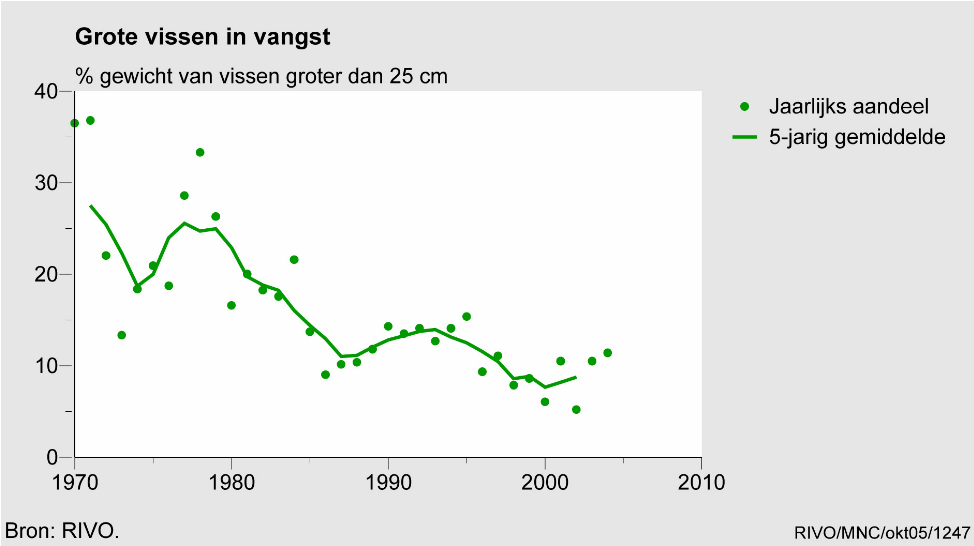


Figure 6.1. Percentage of large fish (>25cm) since 1970 (MNP/CBS/WUR, 2007)

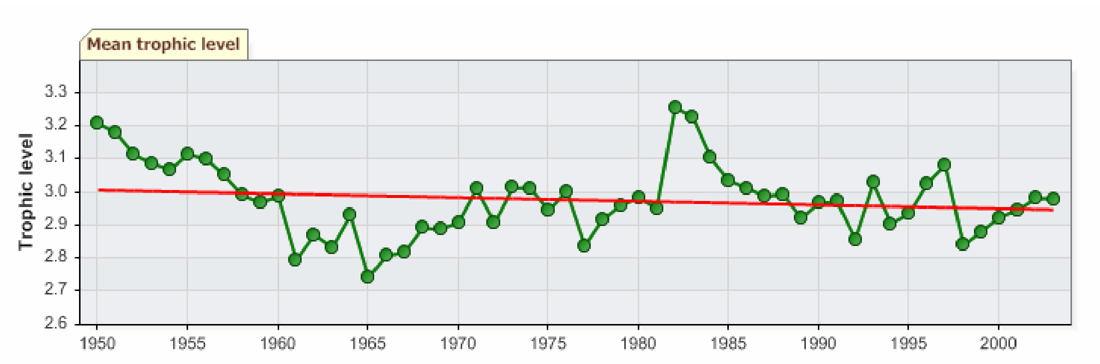


Figure 6.2. MTI from 1950 for the Dutch EEZ (Slope=-0.0011, R^2=0.03) (A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

6.2 Fishing in Balance (FiB)-index

The FiB (Figure 6.3) represents the ratio between the energy required to sustain the fishery landings and a baseline value (mostly the start of the data-series). The FiB was proposed in order to assess whether a certain level of exploitation can be sustained by a given marine ecosystem and to detect bottom-up effects (Pauly *et al.*, 2000; Pauly and Palomares, 2005). The FiB is estimated for time series of landings, using the first year as a reference. It takes into account both the landings and their mean trophic level, which are combined in the following expression:

$$FiB_k = \log\left(\frac{Y_k \cdot \left(\frac{1}{TE}\right)^{mTL_k}}{Y_0 \cdot \left(\frac{1}{TE}\right)^{mTL_0}}\right)$$

Y_k and mean Trophic Level k (mTL_k) represent the total landing and its mean trophic level for the year k; Y_0 and mean Trophic Level 0 ((mTL_0) represent the total landing and its mean trophic level for the first year of the time series (0); TE = Transfer Efficiency

The mean Trophic Level is at the exponent of the inverse of the Transfer Efficiency (TE), which is set initially as 10%, found to be the average value by an analysis of a suite of different marine ecosystems (Pauly and Christensen, 1995).

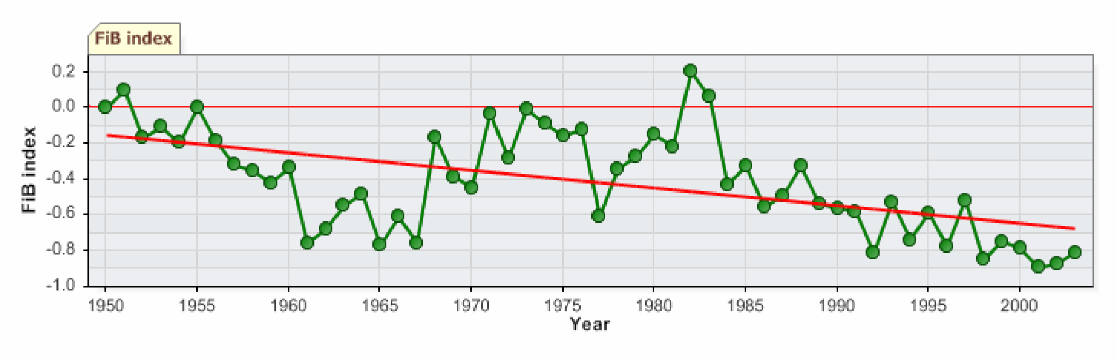


Figure 6.3. FiB from 1950 onward in Dutch EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

A positive trend in the FiB time series may be caused by an increase in the fishing effort (expanding fisheries) or by an increase in the nutrients availability, which in turn leads to an increase in the productivity of the ecosystem and then in the landings (Pauly and Palomares, 2000). Constant values of FiB index over time identify periods during which the fishing pressure and the carrying capacity of the ecosystem have been stable. It also indicates whether fishing efforts have changed, according to the changes in the carrying capacity (balanced exploitation, Pauly *et al.*, 2000).

6.3 Mean Weight

Mean weight is usually based on surveys and calculated per haul. Mean weight is calculated as follows:

$$\overline{W} = \sum_k W_k \Big/ N$$

W is the body mass of an individual; N is the total number of individuals (Indeco).

6.4 Mean Maximum Length

The mean maximum length is indicative of the composition of the fish community in terms of life history types and is generally calculated with the following formula:

$$\overline{L_{max}} = \sum_j (L_{max\,j} N_j) \Big/ N$$

$L_{max\,j}$ is the maximum length obtained by species j; Nj is the number of individuals of species j; N is the total number of individuals.

In a study of Piet and Jennings (2005) the response of several indicators to fishing in the North Sea fish community where compared. They found that although the mean weight, the mean maximum length and the mean trophic level show significant downwards trends over the years, in general there was no straightforward linear relationship between fishing effort and the indicators. They concluded that size-based indicators are vulnerable to indirect effects, such as an increase in small fish in response to the release from predation pressure. This prevents size-based indicators from being 'relatively tightly linked' to fishing, making them less suitable as short-term indicators. The use of these indicators should be underpinned by an improved theoretical understanding of their responses to indirect effects of fishing, historical fishing activities, the environment and relevant spatial processes.

6.5 Conclusion

Several adjustments should be made to the MTI before the indicator can be used in policy making for the Dutch EEZ. It should be evaluated first if other indicators (like abundance, species composition, proportion of large fishes, etcetera) are not more straightforward to calculate and interpret. From the preliminary comparison of other indicators (Table 6.1), which was made for this report it can be concluded that, for the time being, the 'proportion of large fish'-indicator seems to be the most appropriate substitution for the MTI in the Dutch situation.

Table 6.1. Comparison of several indicators for 'sustainable fisheries', based on ideal properties of indicators (among others Piet & Jennings, 2005; + = positive; - = negative; 0 = medium)

Properties	**MTI (Pauly, 1998)**	**MTL (Jennings et al., 2005)**	**% Big Fish**	**FiB**	**Mean weight**	**Mean Max. Length**
Quality underlying data-series	-	+	+	-	+	+
Error rate	-	-	+	-	+	+
Availability data-series	+	+	+	+	+	+
Sustainability data-series	+	+	+	+	+	+
Responsiveness to other factors than fisheries-pressure	-	-	-	+	-	-
Responsiveness to changes in fisheries-pressure	-	-	+	+	+	+
Reference value	-	-	-	+	-	-
Specificity	-	-	-	-	-	-
Relatedness to EEZ	+	-	-	+	-	-
Costs necessary to adjust to Dutch situation	-	+	+	-	+	+
International comparability	+	0	0	+	0	0
Easy to understand	-	-	+	-	+	0
Usefulness for Dutch situation (without any adjustments)	-	+	+	-	+	+

7 Conclusions

The Marine Trophic Index (MTI) is based on the mean trophic level of fisheries landings in a certain area. The CBD nominated this index as an indicator for sustainable fisheries and ecosystem integrity. As an index of the sustainability of the fishing industry the MTI index is likely to receive more support from OSPAR, the European Marine Strategy and the Common Fisheries Policy in the near future.

Using this index as an indicator in the Dutch EEZ is, however, not as easy as it seems. Several adjustments should be made before the indicator can be used in policy making. First of all, additional improvement in fisheries catch data (or survey data) should be used and trophic level (TL) estimates would be required to make the indicator more precise and accurate. Secondly, the indicator is also sensitive to other factors besides overfishing or the integrity of the ecosystem, which makes the MTI not very 'user-friendly' and difficult to understand by those who will decide on its use. To prevent influence on the MTI of other factors apart from fisheries pressure (such as eutrophication), a cut-off value of the MTI should be determined for the Dutch situation (^{cut}MTI). This would require a study on trophic levels in the North Sea by a Marine Scientist. In addition, a reference value should be determined for the Dutch situation and a study on natural fluctuations of the MTI in the Dutch EEZ should be performed.

Adjusting the MTI for the Dutch situation thus requires a lot of effort and it should be evaluated first if other indicators (like abundance, species composition, proportion of large fishes, etc.) may not be more straightforward to use for calculation and interpretation.

For the time being, the 'proportion of large fish'-indicator seems to be the most appropriate substitution for the Dutch situation. Furthermore, it should always be kept in mind that not one single indicator can capture the integrity of an ecosystem in one overall value, since quantifying an ecosystem is extremely complex. Therefore at least a set of different ecosystem-indicators should be used to base policy decisions on.

Literature

Caddy, J.F., J. Csirke, S.M. Garcia and R.J.R. Grainger. 1998. *How pervasive is 'fishing down marine food web'*. Science 282: 1383.

Curry, P.M., L.J. Shannon, J.P. Roux, G.M. Daskalov, A. Jarre, C.L. Moloney and D. Pauly. 2005. *Trophodynamic indicators for an ecosystem approach to fisheries*. ICEs Journal of Marine Science 62:430-422.

Hammill, M.O., V. Lesage and P. Carter. 2005. *What do harp seals eat? Comparing diet composition from different compartments of the digestive tract with diets estimated from stable isotope ratios*. Can. J. Zool. Vol. 83: 324-230.

Jennings, S., S.P.R. Greenstreet, L. Hill, G.J. Piet, J.K. Pinnegar and K.J. Warr. 2002. *Long term trends in the trophic structure of the North Sea fish community: evidence from stable isotope analysis, size spectra and community metrics*. Marine Biology 141:1085-1097.

MNP/CBS/WUR, 2007. Milieu- en Natuurcompendium (www.milieuennatuurcompendium.nl). MNP, Bilthoven/ CBS, Voorburg/ Wageningen UR, Wageningen

Pauly D., V. Christensen and C. Walters. 2000. *Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries*. ICES Journal of Marine Science [ICES J Mar Sci] Vol 57:697-706.

Pauly D, Christensen, V., J. Dalsgaard, R. Froese, and Jr. F.C. Torres. 1998. *Fishing down marine food webs*. Science 279:860–863.

Pauly D. and R. Watson. 2005. *Background and interpretation of the 'Marine Trophic Index' as a measure of biodiversity.* Philos Trans R Soc Lond B Biol Sci 360:415-423.

Pauly D, R. Watson and J. Alder. 2005. *Global trends in world fisheries: impacts on marine ecosystems and food security*. Philos Trans R Soc Lond B Biol Sci 360:5-12.

Piet, G.J. and S. Jennings. 2005. *Response of potential fish community indicators to fishing*. ICES Journal of Marine Science 62: 214-225.

Piet, 2007. Personal communication. IMARES Institute for Marine Resources & Ecosystem Studies, Afdeling Visserij.

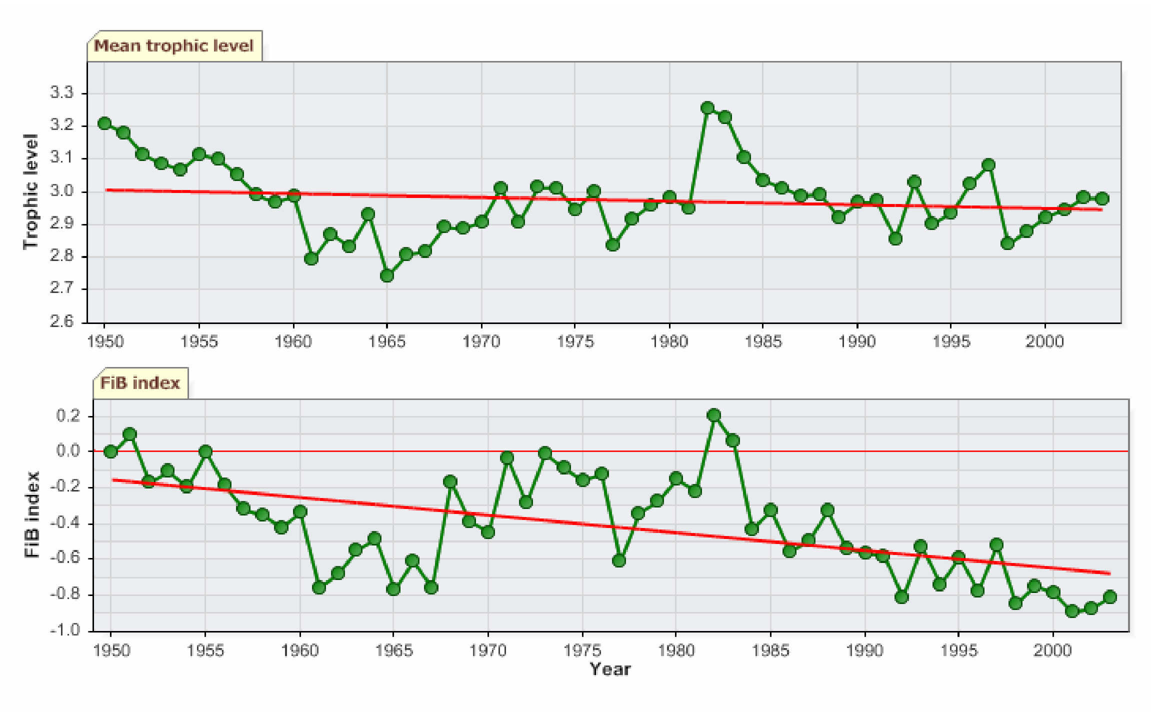
Yang, J. 1982. *A tentative analysis of the trophic levels of North Sea fish*. Marine Ecology-progress series 7: 247-252.

Technical reports:

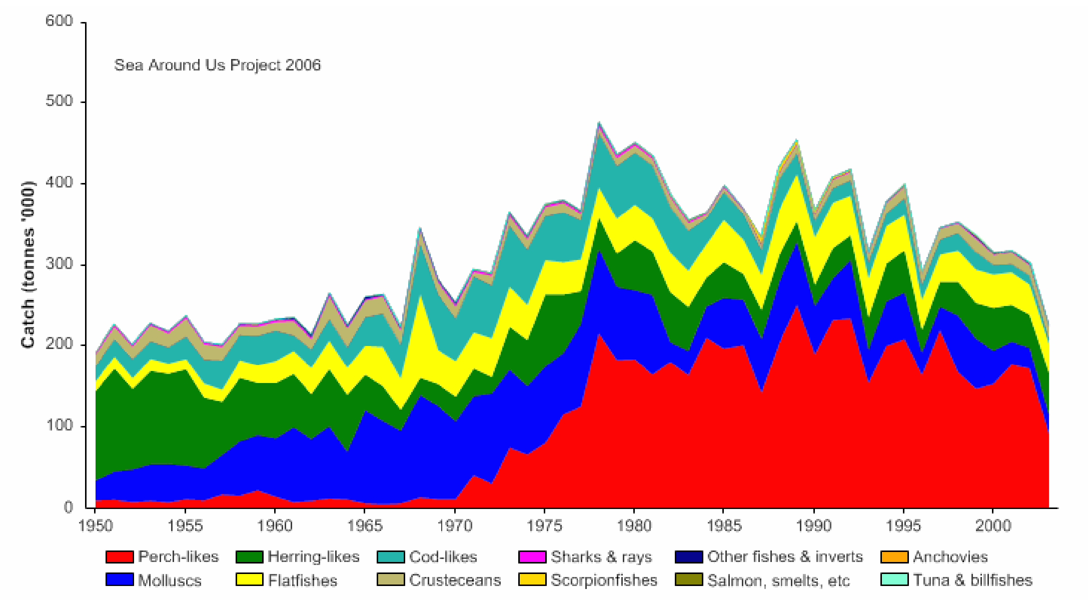
G.J. Piet and F. Pranovi. 2004. *A review of the indicators for ecosystem structure and functioning.* INDECO-report 513754.

CBD-report UNEP/CBD/AHTEG-2010-Ind/1/INF/5/2004. Ad Hoc Technical Expert Group on indicators for assessing progress towards the 2010 biodiversity target.

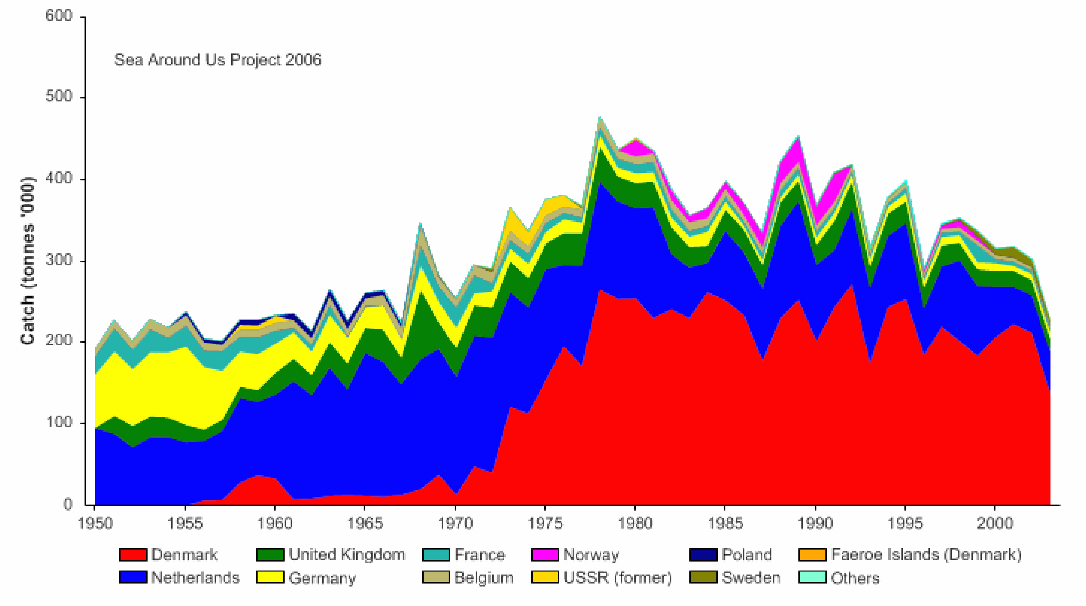
Appendix 1. MTI and the situation in the Netherlands



MTI and FIB in Dutch EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada)

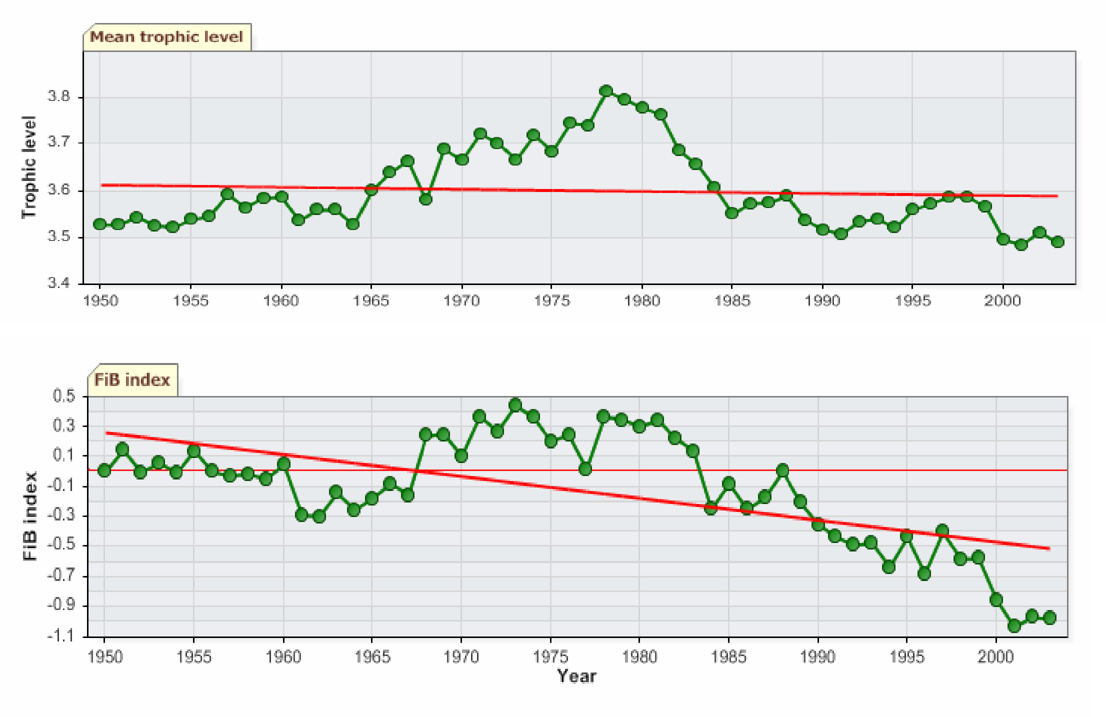


Catches (in tonnes) in Dutch EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

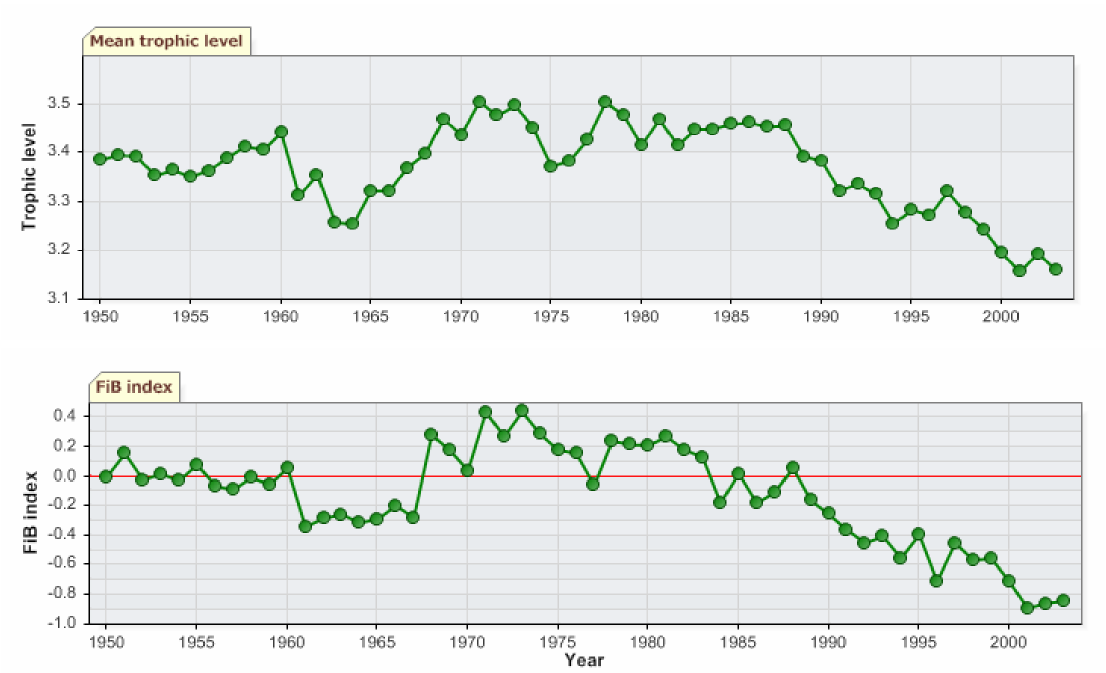


Countries fishing in Dutch EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

Appendix 2. Sensitivity of MTI



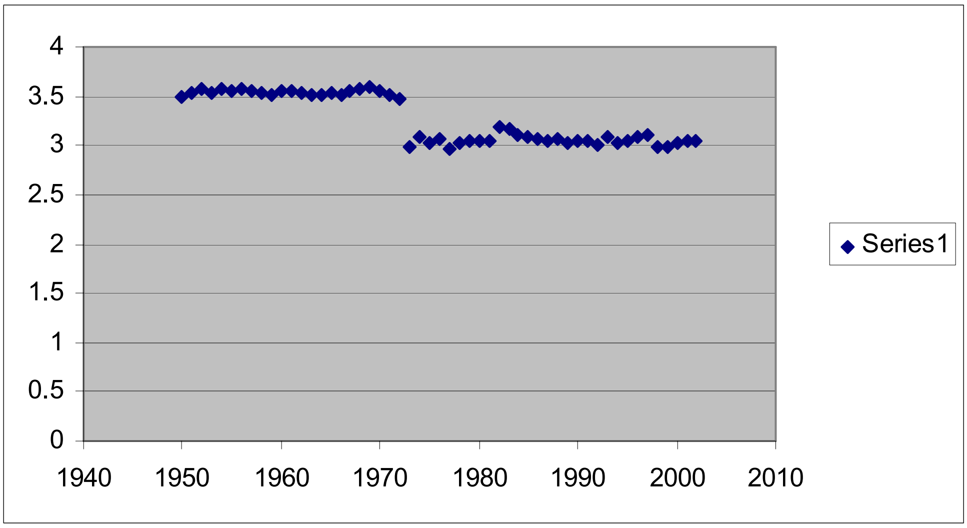
3.25MTI and 3.25FIB in Dutch EEZ (cutMTI) (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))



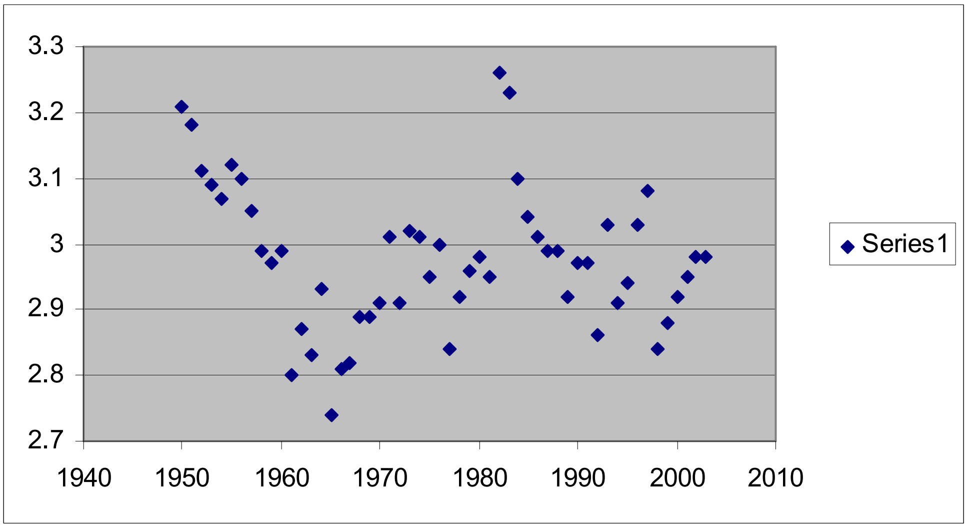
MTI and FIB computed without shellfish in Dutch EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

Changes in underlying databases can change the MTI considerably. Note the differences in the MTI of the Dutch EEZ as shown by the website Sea-around-us in December 2005 and April, 2006. Pauly (pers. comm.) explained the changes in the following way:

'Between December 2005 and May 2006, two things happened which affect TL-trends. We incorporated another, more recent set of catch statistics (from FAO and Eurostat). These statistics do not simply update the time series, but are often revised backward in time; We removed the 'inferred catches' from the computation of mean TL.'

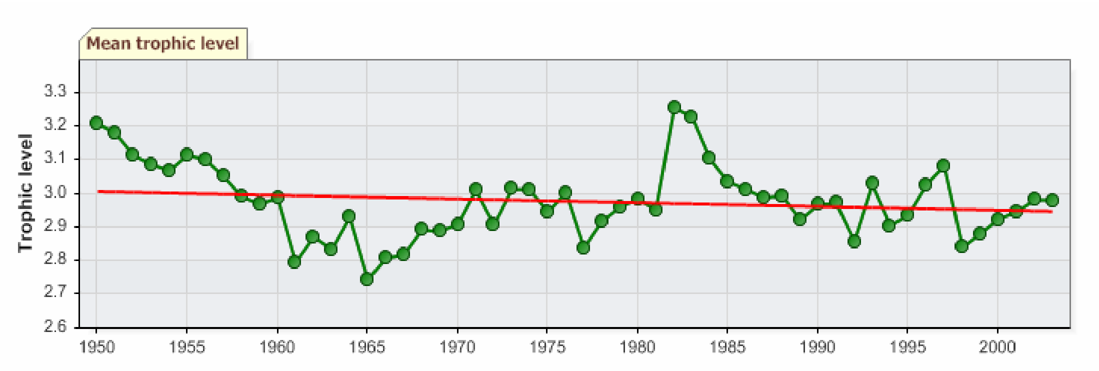


MTI of Dutch EEZ as downloaded in December, 2005. Number of species used in calculation: 215

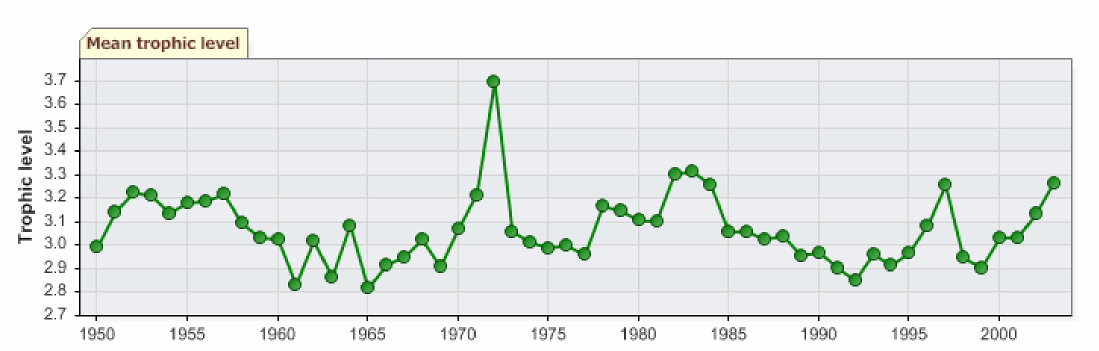


MTI of Dutch EEZ as downloaded in April, 2006. Number of species used in calculation: 83

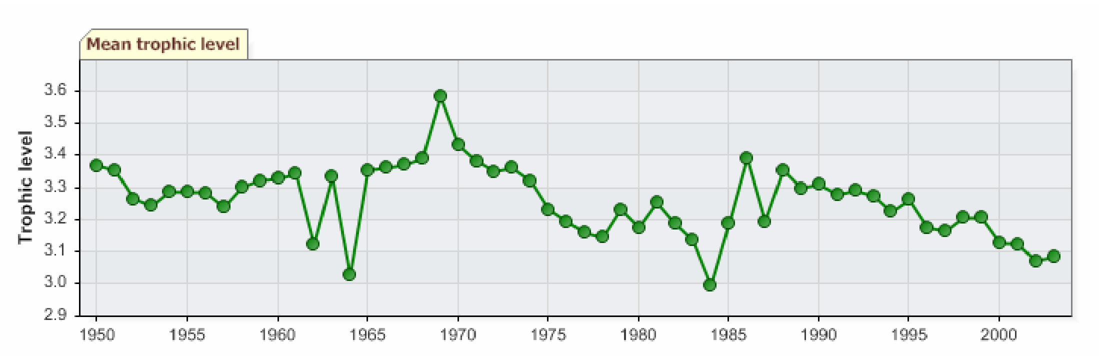
Appendix 3. MTI of 'North Sea' countries



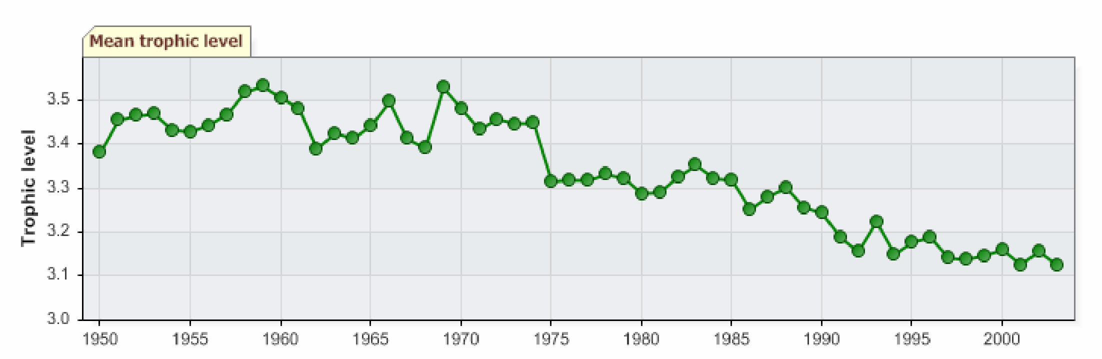
MTI Dutch EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))



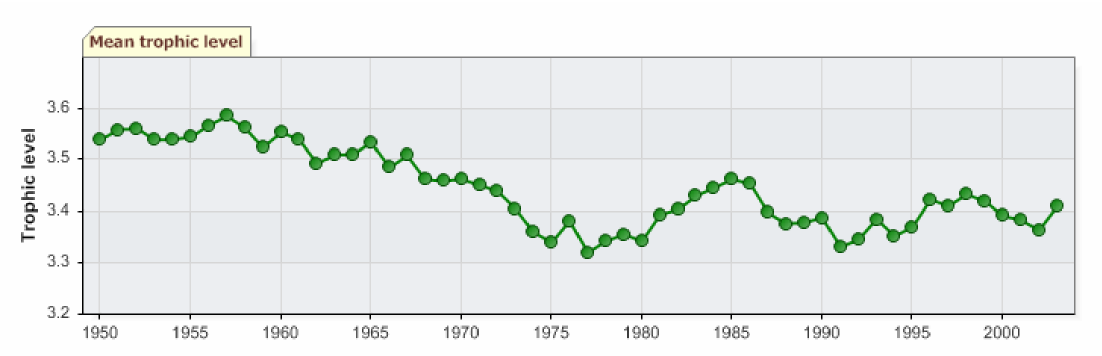
MTI Belgium EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))



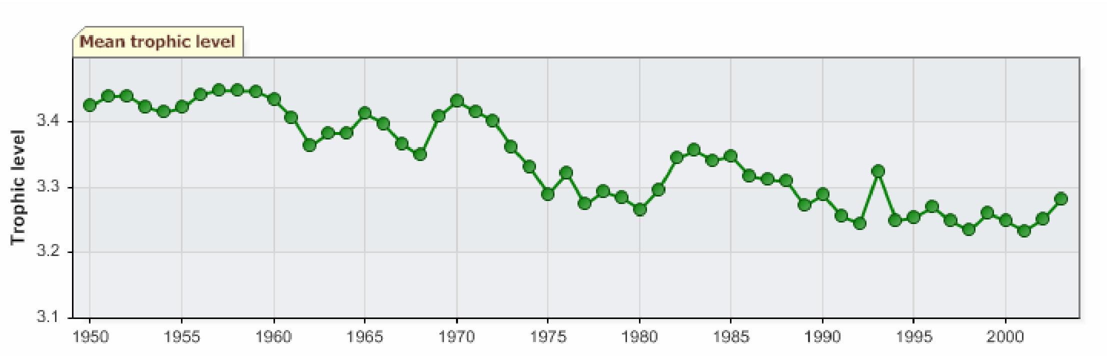
MTI German EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org.. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))



MTI Danish EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))



MTI English EEZ (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org.. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))



MTI North Sea (Sea Around Us, 2006. A global database on marine fisheries and ecosystems. Website: www.seaaroundus.org. Fisheries Centre, University British Columbia, Vancouver (British Columbia, Canada))

Appendix 4. Bergen Declaration (EcoQO)

Ecological Quality Elements are defined in the Bergen declaration (2002). An Ecological quality is defined as 'An overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities'. Ecological Quality Elements are 'the individual aspects of overall Ecological quality'. An Ecological Quality Objective (EcoQO) is the desired level of an ecological quality. Such a level may be set in relation to a reference level.

Issue	Ecological quality element
1) Commercial fish species	1. Spawning stock biomass of commercial fish species
2) Threatened and declining species	2. Presence and extent of threatened and declining species in the North Sea
3) Sea mammals	3. Seal population trends in the North Sea
	4. Utilisation of seal breeding sites in the North Sea
	5. By-catch of harbour porpoises
4) Sea birds	6. Proportion of oiled common guillemots among those found dead or dying on beaches
	7. Mercury concentrations in seabird eggs and feathers
	8. Organochlorine concentrations in seabird eggs
	9. Plastic particles in stomachs of seabird
	10. Local sand eel availability to black kittiwakes
	11. Seabird populations trends as an index of seabird community health
5) Fish communities	12. Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community
6) Benthic communities	13. Changes/kills in zoobenthos in relation to eutrophication
	14. Imposex in dog whelk
	15. Density of sensitive species
	16. Density of opportunistic species
7) Plankton communities	17. Phytoplankton Chlorofyl a
	18. Phytoplankton indicator species for eutrophication
8) Habitats	19. Restore and/or maintain habitat quality
9) Nutrient budgets and production	20. Winter nutrient (DIN and DIP) concentrations
10) Oxygen consumption	21. Oxygen

Indicators for the Convention on Biodiversity 2010

In de reeks 'Indicators for the Convention on Biodiversity 2010' zijn de volgende documenten verschenen (*In the series 'Indicators for the Convention on Biodiversity 2010' the following documents have been published):*

2007

53.1 *Reijnen, M.J.S.M.* National Capital Index version 2.0

53.3 *Windig, J.J., M.G.P. van Veller & S.J. Hiemstra.* Biodiversiteit Nederlandse landbouwhuisdieren en gewassen

53.4 *Melman, Th.C.P. & J.P.M. Willemen.* Coverage protected areas.

53.6 *Weijden, W.J. van der, R. Leewis & P. Bol.* Indicatoren voor het invasieproces van exotische organismen in Nederland

53.7a *Nijhof, B.S.J., C.C. Vos & A.J. van Strien.* Influence of climate change on biodiversity.

53.7b *Moraal, L.G.* Effecten van klimaatverandering op insectenplagen bij bomen.

53.8 *Fey-Hofstede, F.E. & H.W.G. Meesters.* Exploration of the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainability of marine fisheries in the Dutch part of the North Sea.

53.9 *Reijnen, M.J.S.M.* Connectivity/fragmentation of ecosystems: spatial conditions for sustainable biodiversity

53.11 *Gaaff, A. & R.W. Verburg.* Government expenditure on land acquisition and nature development for the National Ecological Network (EHS) and expenditure for international biodiversity projects

53.12 *Elands, B.H.M. & C.S.A. van Koppen.* Public awareness and participation

WOt-onderzoek

Verschenen documenten in de reeks Werkdocumenten van de Wettelijke Onderzoekstaken Natuur & Milieu

Werkdocumenten zijn verkrijgbaar bij het secretariaat van Unit Wettelijke Onderzoekstaken Natuur & Milieu, te Wageningen. T 0317 – 47 78 44; F 0317 – 41 90 00; E info.wnm@wur.nl
De werkdocumenten zijn ook te downloaden via de WOt-website www.wotnatuurenmilieu.wur.nl

2005

1 *Eimers, J.W.* (Samenstelling). Projectverslagen 2004.
2 *Hinssen, P.J.W.* Strategisch Plan van de Unit Wettelijke Onderzoekstaken Natuur & Milieu, 2005 – 2009.
3 *Sollart, K.M.* Recreatie: Kennis en datavoorziening voor MNP-producten. Discussienotitie.
4 *Jansen, M.J.W.* ASSA: Algorithms for Stochastic Sensitivity Analysis. Manual for version 1.0.
5 *Goossen, C.M. & S. de Vries.* Beschrijving recreatie-indicatoren voor de Monitoring en Evaluatie Agenda Vitaal Platteland (ME AVP)
6 *Mol-Dijkstra, J.P.* Ontwikkeling en beheer van SMART2-SUMO. Ontwikkelings- en beheersplan en versiebeheerprotocol.
7 *Oenema, O.* How to manage changes in rural areas in desired directions?
8 *Dijkstra, H.* Monitoring en Evaluatie Agenda Vitaal Platteland; inventarisatie aanbod monitoringsystemen.
9 *Ottens, H.F.L & H.J.A.M. Staats.* BelevingsGIS (versie2). Auditverslag.
10 *Straalen, F.M. van.* Lijnvormige beplanting Groene Woud. Een studie naar het verdwijnen van lanen en perceelsrandbegroeiing in de Meierij.
11 *Programma Commissie Natuur.* Onderbouwend Onderzoek voor de Natuurplanbureau-functie van het MNP; Thema's en onderzoeksvragen 2006.
12 *Velthof, G.L. (samenstelling).* Commissie van Deskundigen Meststoffenwet. Taken en werkwijze.
13 *Sanders, M.E. & G.W. Lammers.* Lokaliseren kansen en knelpunten van de Ecologische Hoofdstructuur – met informatie van de terreinbeheerders.
14 *Verdonschot, P.F.M., C.H.M. Evers, R.C. Nijboer & K. Didderen.* Graadmeters aquatische natuur. Fase 1: Vergelijking van de graadmeter Natuurwaarde met de Natuurdoeltypen en KRW-maatlatten
15 *Hinssen, P.J.W.* Wettelijke Onderzoekstaken Natuur & Milieu. Werkplan 2006
16 *Melman, Th.C.P., R.G. Groeneveld, R.A.M. Schrijver & H.P.J. Huiskes* Ontwikkeling economisch-ecologisch optimaliseringmodel natuurbeheer in combinatie met agrarische bedrijfsvoering. Studie in het licht van LNV-beleidsombuiging "van verwerving naar beheer"
17 *Vreke, J., R.I. van Dam & F.J.P. van den Bosch.* De plaats van natuur in beleidsprocessen. Casus: Besluitvormingsproces POL-aanvulling Bedrijventerrein Zuid-Limburg
18 *Gerritsen, A.L., J. Kruit & W. Kuindersma.* Ontwikkelen met kwaliteit. Een verkenning van evaluatiecriteria
19 *Bont, C.J.A. de, M. Boekhoff, W.A. Rienks, A. Smit & A.E.G. Tonneijck.* Impact van verschillende wereldbeelden op de landbouw in Nederland. Achtergronddocument bij 'Verkenning Duurzame Landbouw'
20 *Niet verschenen*

2006

21 *Rienks, W.A., I. Terluin & P.H. Vereijken.* Towards sustainable agriculture and rural areas in Europe. An assessment of four EU regions
22 *Knegt, B. de, H.W.B. Bredenoord, J. Wiertz & M.E. Sanders.* Monitoringsgegevens voor het natuurbeheer anno 2005. Ecologische effectiviteit regelingen natuurbeheer: Achtergrondrapport 1
23 *Jaarrapportage 2005.* WOT-04-001 – Monitor- en Evaluatiesysteem Agenda Vitaal Platteland
24 *Jaarrapportage 2005.* WOT-04-002 – Onderbouwend Onderzoek Natuurplanbureaufunctie
25 *Jaarrapportage 2005.* WOT-04-385 - Milieuplanbureaufunctie
26 *Jaarrapportage 2005.* WOT-04-394 – Natuurplanbureaufunctie
27 *Jaarrapportage 2005.* WOT-04 - Kennisbasis
28 *Verboom, J., R. Pouwels, J. Wiertz & M. Vonk.* Strategisch Plan LARCH. Van strategische visie naar plan van aanpak
29 *Velthof, G.L. en J.J.M. van Grinsven (eds.)* Inzet van modellen voor evaluatie van de meststoffenwet. Advies van de CDM-werkgroep Harmonisatie modellen
30 *Hinssen, M.A.G., R. van Oostenbrugge & K.M. Sollart.* Draaiboek Natuurbalans. Herziene versie
31 *Swaay, C.A.M. van, V. Mensing & M.F. Wallis de Vries.* Hotspots dagvlinder biodiversiteit
32 *Goossen, C.M. & F. Langers.* Recreatie en groen in en om de stad. Achtergronddocument bij Natuurbalans 2006
33 *Turnhout, Chr. Van, W.-B. Loos, R.P.B. Foppen & M.J.S.M. Reijnen.* Hotspots van biodiversiteit in Nederland op basis van broedvogelgegevens
34 *Didderen, K en P.F.M. Verdonschot.* Graadmeter Natuurwaarde aquatisch. Typen, indicatoren en monitoring van regionale wateren
35 *Wamelink, G.W.W., G.J Reinds, J.P. Mol-Dijkstra, J. Kros, H.J. Wieggers.* Verbeteringen voor de Natuurplanner
36 *Groeneveld, R.A. & R.A.M. Schrijver.* FIONA 1.0; Technical description
37 *Luesink, H.H., M.J.C. de Bode, P.W.G. Groot Koerkamp, H. Klinker, H.A.C. Verkerk & O.Oenema.* Protocol voor monitoring landelijke mestmarkt onder een stelsel van gebruiksnormen
38 *Bakker-Verdurmen, M.R.L., J.W. Eimers, M.A.G. Hinssen-Haanen, T.J. van der Zwaag-van Hoorn.* Handboek secretariaat WOT Natuur & Milieu
39 *Pleijte, M. & M.A.H.J. van Bavel.* Europees en gebiedsgericht beleid: natuur tussen hamer en aambeeld? Een verkennend onderzoek naar de relatie tussen Europees en gebiedsgericht beleid

40 *Kramer, H., G.W. Hazeu & J. Clement.* Basiskaart Natuur 2004; vervaardiging van een landsdekkend basisbestand terrestrische natuur in Nederland

41 *Koomen, A.J.M., W. Nieuwenhuizen, J. Roos-Klein Lankhorst, D.J. Brus & P.F.G. Vereijken.* Monitoring landschap; gebruik van steekproeven en landsdekkende bestanden

42 *Selnes, T.A., M.A.H.J. van Bavel & T. van Rheenen.* Governance of biodiversity

43 *Vries, S. de. (2007)* Veranderende landschappen en hun beleving

44 *Broekmeijer, M.E.A. & F.H. Kistenkas.* Bouwen en natuur: Europese natuurwaarden op het ruimtelijk ordeningsspoor. Achtergronddocument bij Natuurbalans 2006

45 *Sollart, K.M. & F.J.P. van den Bosch.* De provincies aan het werk; Praktijkervaringen van provincies met natuur- en landschapsbeleid in de periode 1990-2005. Achtergronddocument bij Natuurbalans 2006

46 *Sollart, K.M.& R. de Niet met bijdragen van M.M.M. Overbeek.* Natuur en mens**.** Achtergronddocument bij de Natuurbalans 2006

2007

47 *Ten Berge, H.F.M., A.M. van Dam, B.H. Janssen & G.L. Velthof.* Mestbeleid en bodemvruchtbaarheid in de Duin- en Bollenstreek; Advies van de CDM-werkgroep Mestbeleid en Bodemvruchtbaarheid in de Duin- en Bollenstreek

48 *Kruit, J. & I.E. Salverda*. Spiegeltje, spiegeltje aan de muur, valt er iets te leren van een andere plannings-cultuur?

49 *Rijk, P.J., E.J. Bos & E.S. van Leeuwen.* Nieuwe activiteiten in het landelijk gebied. Een verkennende studie naar natuur en landschap als vestigingsfactor

50 *Ligthart, S.S.H.* Natuurbeleid met kwaliteit. Het Milieu- en Natuurplanbureau en natuurbeleidsevaluatie in de periode 1998-2006

51 *Kennismarkt 22 maart 2007; van onderbouwend onderzoek Wageningen UR naar producten MNP in 27 posters*

52 *Kuindersma, W., R.I. van Dam & J. Vreke.* Sturen op niveau. Perversies tussen nationaal natuurbeleid en besluitvorming op gebiedsniveau.

53.1 *Reijnen, M.J.S.M.* Indicators for the ‘Convention on Biodiversity 2010’. National Capital Index version 2.0

53.3 *Windig, J.J., M.G.P. van Veller & S.J. Hiemstra.* Indicatoren voor ‘Convention on Biodiversity 2010’. Biodiversiteit Nederlandse landbouwhuisdieren en gewassen

53.4 *Melman, Th.C.P. & J.P.M. Willemen.* Indicators for the ‘Convention on Biodiversity 2010’. Coverage protected areas.

53.6 *Weijden, W.J. van der, R. Leewis & P. Bol.* Indicatoren voor ‘Convention on Biodiversity 2010’. Indicatoren voor het invasieproces van exotische organismen in Nederland

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53.7b *Moraal, L.G.* Indicatoren voor ‘Convention on Biodiversity 2010’. Effecten van klimaatverandering op insectenplagen bij bomen.

53.8 *Fey-Hofstede, F.E. & H.W.G. Meesters.* Indicators for the ‘Convention on Biodiversity 2010’. Exploration of the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainability of marine fisheries in the Dutch part of the North Sea.

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53.11 *Gaaff, A. & R.W. Verburg.* Indicators for the ‘Convention on Biodiversity 2010’ Government expenditure on land acquisition and nature development for the National Ecological Network (EHS) and expenditure for international biodiversity projects

53.12 *Elands, B.H.M. & C.S.A. van Koppen.* Indicators for the ‘Convention on Biodiversity 2010’. Public awareness and participation

54 *Broekmeyer, M.E.A. & E.P.A.G. Schouwenberg & M.E. Sanders & R. Pouwels.* Synergie Ecologische Hoofdstructuur en Natura 2000-gebieden. Wat stuurt het beheer?

55 *Bosch, F.J.P. van den.* Draagvlak voor het Natura 2000 gebiedenbeleid. Onder relevante betrokkenen op regionaal niveau

56 *Jong, J.J. & M.N. van Wijk, I.M. Bouwma.* Beheerskosten van Natura 2000 gebieden

57 *Pouwels, R. & M.J.S.M. Reijnen & M. van Adrichem & H. Kuipers.* Ruimtelijke condities voor VHR-soorten

58 *Bouwma, I.M.* Quickscan Natura 2000 en Programma Beheer.

59 *Schouwenberg, E.P.A.G.* Huidige en toekomstige stikstofbelasting op Natura 2000 gebieden

60 *Hoogeveen. M.* Herberekening Ammoniak 1998 *(werktitel)*

61 *Jaarrapportage 2006.* WOT-04-001 – ME-AVP

62 *Jaarrapportage 2006.* WOT-04-002 – Onderbouwend Onderzoek

63 *Jaarrapportage 2006.* WOT-04-003 – Advisering Natuur & Milieu

64 *Jaarrapportage 2006.* WOT-04-385 – Milieuplanbureaufunctie

65 *Jaarrapportage 2006.* WOT-04-394 – Natuurplanbureaufunctie

66 *Brasser E.A., M.F. van de Kerkhof, A.M.E. Groot, L. Bos-Gorter, M.H. Borgstein, H. Leneman* Verslag van de Dialogen over Duurzame Landbouw in 2006

67 *Hinssen, P.J.W.* Wettelijke Onderzoekstaken Natuur & Milieu. Werkplan 2007

68 *Nieuwenhuizen, W. & J. Roos Klein Lankhorst.* Landschap in Natuurbalans 2006; Landschap in verandering tussen 1990 en 2005; Achtergronddocument bij Natuurbalans 2006.

69 *Geelen, J. & H. Leneman.* Belangstelling, motieven en knelpunten van natuuraanleg door grondeigenaren. Uitkomsten van een marktonderzoek.

70 *Didderen, K., P.F.M. Verdonschot, M. Bleeker.* Basiskaart Natuur aquatisch. Deel 1: Beleidskaarten en prototype

71 *Boesten, J.J.T.I, A. Tiktak & R.C. van Leerdam.* Manual of PEARLNEQ v4. (unofficial draft version of manual)