Proportion of large fish in the community

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Reference to this core indicator report: [Author's name(s)], [Year]. [Title]. HELCOM Core Indicator Report. Online. [Date Viewed], [Web link].

Contents

Key message

The proportion of large fish in the demersal community has recently increased in the Baltic Sea. The positive development is, however, mostly due to the increase of cod while population structure of the other demersal species has not improved.

The results indicate that good environmental status of the demersal fish community structure is not yet reached, but the development is positive.

Initial results from the pelagic communities indicate that the proportion of large fish and mean length of the community has decreased since the late 1970s. The state of pelagic fish requires further investigation.

What is the status of fish communities in the Baltic Sea?

Demersal community: current state and temporal development

This 'large fish indicator' (LFI) was calculated to the Baltic demersal fish community, which is dominated by cod. There is no Baltic wide conclusion of the boundary for Good Environmental Status (GES) in LFI but one approach is attempted in this core indicator report. Until experience and science is accumulating of the use of LFI in the Baltic Sea, more emphasis could be given to the temporal development of LFI, i.e. GES is approached when there are more large fish in the community.

ICES sub-division 22 – 24

As cod is the dominant species in the demersal community (98 % of the biomass), it was excluded from the analysis to see the development of LFI in the rest of the community (see below 'Description of the indicator'). The LFI>30 cm value has increased from 0.23 (±0.05) in the period of 2001 – 2009 to 0.25 (± 0.02) in 2010–2012 (Figure 2), but the increase is not significant and is due to low values in 2002–2003 The mean value of the LFI between 2001 and 2012 is 0.24 (± 0.04). GES is still not defined.

The mean LFI>30 cm value for the entire demersal community (incl. cod) between 2001 and 2012 is 0.59 (± 0.08) (Figure 2). The current value of LFI (2010–2012) is 0.65 (± 0.05) and shows in comparison with the period of 2001–2009 and a LFI value of 0.57 (0.08) an increase over the last years. GES is still not defined.

ICES sub-division 25 (only Polish zone)

The mean LFI value in the period 2009–2011 amounted to 0.85 (SD = 0.05) and was higher than the calculated average value of 0.60 (SD = 0.12) for the years 2000–2008. The difference between the means was statistically significant. As the boundary for subGES/GES was set at 0.8, the fish community was judged to be in GES (Figure 3 A).

ICES sub-division 26 (only Polish zone)

The mean LFI value in the period 2009–2011 amounted to 0.80 (SD = 0.10) and was higher than the calculated average value of 0.36 (SD = 0.13) for the years 2000–2008. The difference between the means was statistically significant. As the boundary for subGES/GES was set at 0.7, the fish community was judged to be in GES (Figure 3 B).

Temporal trend of LFI in sub-divisions 25–26

The temporal development of the fish community shows an increase in the share of large fish individuals (Fig. 4). The majority of cod is, however, still small compared to the prehistoric situation when the mean length of the Baltic cod was estimated to be 56 cm and 10 % of the fish exceeded 75 cm (Limburg et al. 2008). The increasing trend seems to depend on the decreased fishing mortality of cod (see also Fig. 5), but there may be an increase of fish size also for the community if cod is removed from the calculation (Fig. 4).

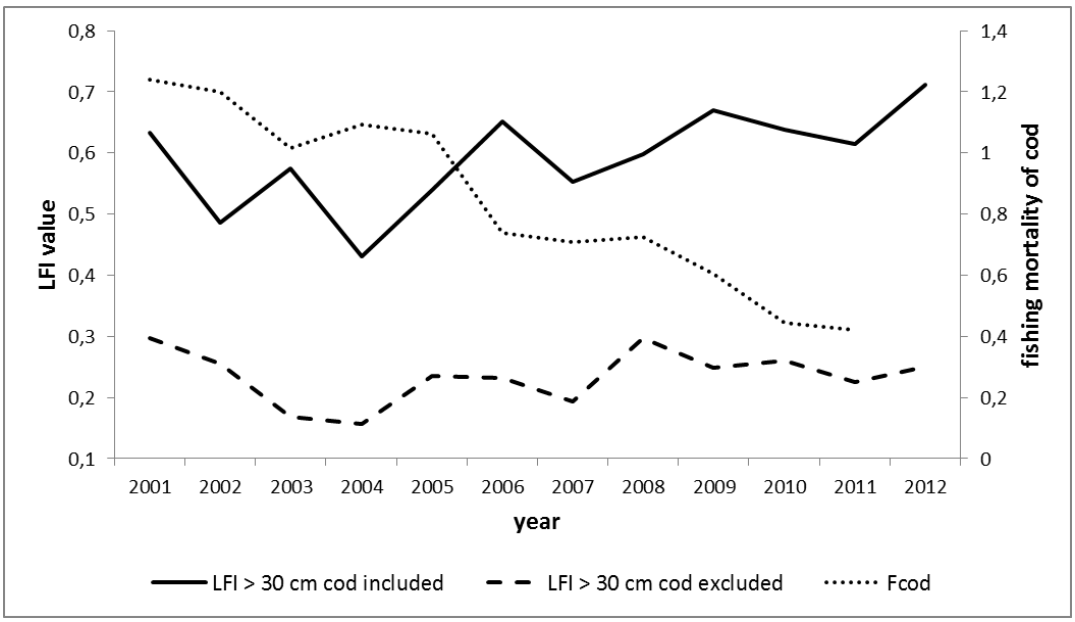

Figure 2. *Temporal development of LFI > 30 cm with (bold solid line) and without cod (bold broken line) in SD 22-24. Cod fishing mortality (Fcod, dotted line) is shown for comparison.*

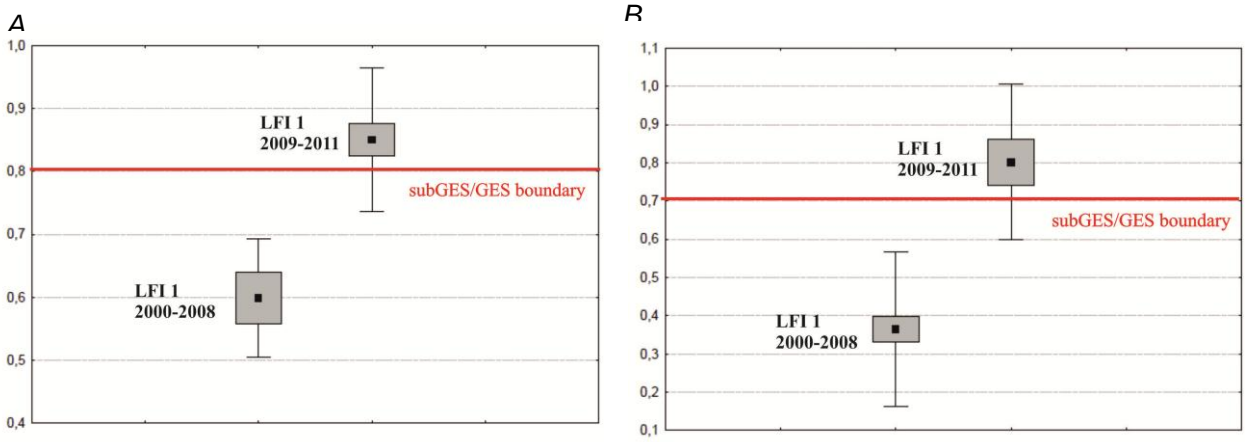

Figure 3. *Proportion of fish >30 cm (mean ± SD [box] and confidence interval [lines]) in the ICES sub-division 25 (panel A) and 26 (panel B).*

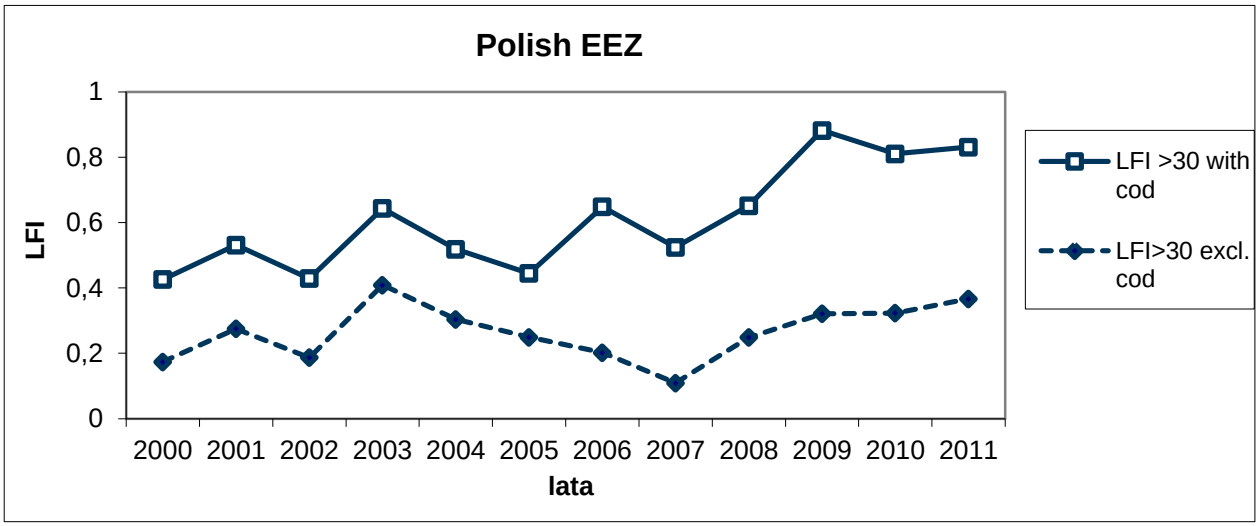

Figure 4. *Proportion of large fish (LFI) by biomass in the Polish EEZ during 2000-2011. LFI was calculated separately for the whole community and the community without cod. Data from 476 polish stations and 261 Danish stations.*

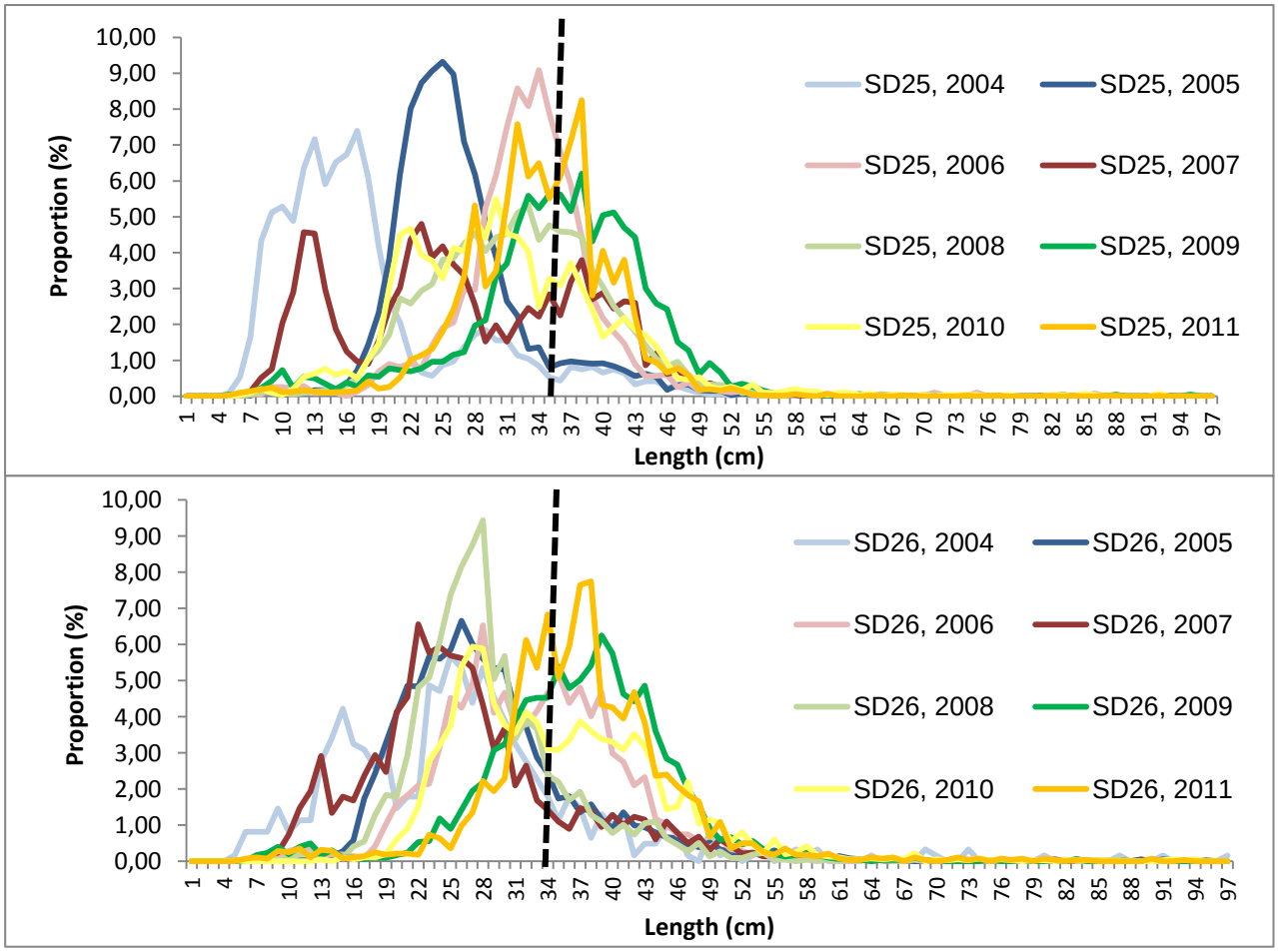

Figure 5. *The length frequencies of the eastern cod population in the ICES sub-divisions 25 and 26 from 2004 to 2011. The dashed vertical line shows the size of 30 cm which is used as a measuring stick for GES classification.*

Pelagic community: current state and temporal development

The state of the pelagic fish community can be assessed by the proportion of large fish individuals, whereas the indicator is also affected by the increasing numbers of small fish species (e.g. sticklebacks) and decreased weight at age of herring and sprat.

The proportion of large fish over 38 cm has decreased greatly in the food web in the Baltic Proper (ICES SD 27–29, Figure 6) and Bothnian Sea (ICES SD 30) since mid-1980s. Three possible explanations are given to the decrease, possibly working in combination: (1) cod abundance has decreased in the Baltic Proper and practically disappeared from the Bothnian Sea (ICES 2012), (2) the abundance of small fish, especially three-spined stickleback, have greatly increased in the pelagic food web (Ljunggren et al. 2011), and (3) the lengths and weights of herring and sprat have decreased in the area (Casini et al. 2006, Casini et al. 2010).

In contrast, the decrease of pelagic LFI cannot be seen in the southern sub-basins (ICES SD 22–26), where the cod population is recovering and the abundance of small-sized fish species has not increased.

Good environmental status (GES) is proposed to be assessed by the temporal trend of LFI; decreasing trend describing potentially sub-GES status. The trend should however take into account the different development in cod abundance in the different sub-basins due to environmental fluctuations and fishing pressure, hence, sub-basin specific consideration is required to assess GES.

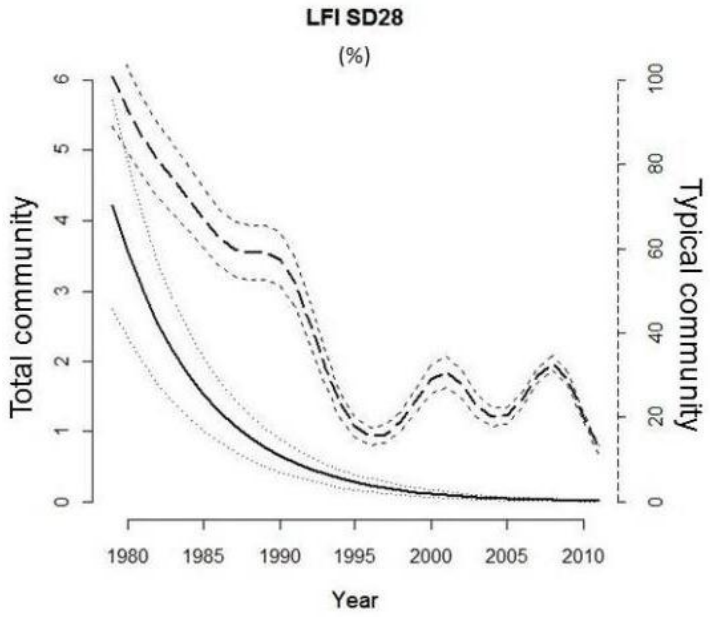

Figure 6. *LFI for the pelagic community in ICES Subdivision 28. The continuous line (total community) includes cod in the calculation of LFI, whereas the dashed line (typical community) includes only the typical pelagic fish species (sprat, herring and sticklebacks).*

How the fish communities describe the Baltic environment

Description of the indicator

The proportion of large fish in a community follows the structure of the fish community and particularly the proportion of large predatory fish, which are significant balancing features in a food web but at the same time target of commercial fishery.

The 'large fish indicator' (LFI) is used as a proxy for anthropogenic influence on the ecosystem; while it shall not or only little be influenced by natural variability or processes, like recruitment. Fishing has a direct effect on the structure of fish communities, because it can lead to an increase in the relative abundance of small fish (Jennings et al., 1999) and reduces the mean body size within a population (Beverton and Holt, 1957). Based on this concept, the LFI maps the fishing pressure (Greenstreet et al., 2011). Several studies to understand and improve the LFI for different marine areas and surveys techniques are being prepared at the moment (Oesterwind et al., in prep.; Psuty et al., 2012a; Psuty et al., 2012b).

Due to a number of factors, including the influence of brackish water, the diversity of marine fish species in the Baltic Sea is lower than in other marine areas (Ojaveer and Kalejs, 2005). Additionally, the mean length of marine commercial fish species is smaller in the Baltic compared to the same species in the North Sea. Therefore Oesterwind et al. (in prep.) as well as Psuty et al. (2012a, 2012b) modified the LFI which was defined for the North Sea by Greenstreet et al. 2011.

Oesterwind et al. (in prep.) tested its application in the Western Baltic Sea. Their results are based on data from 821 BITS hauls performed with a standard trawl net (TVS) between 2001 and 2012 in the Western Baltic; ICES subdivisions 22–24. All analyses are based on biomass in the survey catches. Because the biomass of demersal fish species targeted by the Baltic International Trawl Survey (BITS) is strongly dominated by cod (Gadus morhua), they tested whether or not the large proportion of cod could have masked the correlations of the selected demersal species. The result of Spearman's rank correlation indicates that the trend of LFI>30 cm including cod and LFI >30 cm excluding cod are not similar, and they conclude that the biomass of cod dominates the LFI>30 cm. The LFI>30 cm excluding cod correlates negatively with the fishing mortality of cod with a time-lag of two years.

A study of Psuty et al. (2012a, 2012b) indicates that the LFI with a length class of 30 cm could also be a valuable indicator for the polish EEZ including ICES subdivision 25 and 26. The time series of the LFI was significantly (negatively) correlated with the time series of the fishing mortality of cod within a lag of one year.

The studies show the high potential of the LFI as an indicator for the Baltic Sea fish community. The indicator is currently limited to the area where the Baltic International Trawl Survey (BITS) is operated. Due to the salinity gradients the species community in the northern part of the Baltic is not comparable to the western part, and there are fewer BITS stations in the North, where also cod is currently missing. A solution for this could be a "LFI" for the whole Baltic with different definitions or modifications for the different ecological parts, and needs more investigation. Pelagic LFI, covering the whole Baltic Sea, could be used for this purpose.

Policy relevance

The EU's Marine Strategy Framework Directive (MSFD) requests Member States to develop marine strategies for the marine areas under their jurisdiction. These strategies shall contain a detailed assessment of the state of the environment, a definition of the 'Good Environmental Status' (GES), as well as the establishment of clear environmental targets and related monitoring programs. In a guidance document (Anonymous, 2010), the European Commission published a number of criteria and methodological standards how to define GES in marine waters, including a hierarchical system in which the eleven so-called descriptors of the MSFD are grouped into indicators and criteria. One of the possible indicators is the EU Data Collection Framework (DCF) 'Large Fish Indicator'(LFI) which could be used for Descriptor 4 (2010/477/EU).

Description of the fish community and the fishing mortality

The eight demersal fish species selected for analysis represent more than 98 % of the total demersal biomass of BITS catches taken between 2001 and 2011 in SD 22–24. Cod (Gadus morhua) make up 25–70 % of the total annual biomass depending on the year. Biomasses of the other species demonstrate a large variability. However, cod dominates the total biomass of the eight species, independent of the length classes. The longer the length class, the more prominent the biomass of cod (Figures 6-7).

Therefore two LFI's (including cod and excluding cod) were calculated. Cod was excluded because the high proportion of cod in the survey catch masked the relationship between the LFI and the other seven species. The results reveal a relationship between cod fishing mortality and the LFI >30 cm excluding cod with a lag of two years.

This study reveals that the cod fishery influences the demersal fish assemblage (Figures 2 and 8), and consequently the LFI>30 cm including cod as well as the LFI>30 cm excluding cod responses to the fishing mortality (F) of cod. Due to the current management plan for cod fisheries and the reduction of bycatches within the cod fishery in recent years the fishing mortality is decreasing while the LFI>30 cm including and excluding cod is increasing (Figure 2) (Oesterwind et al., in prep).

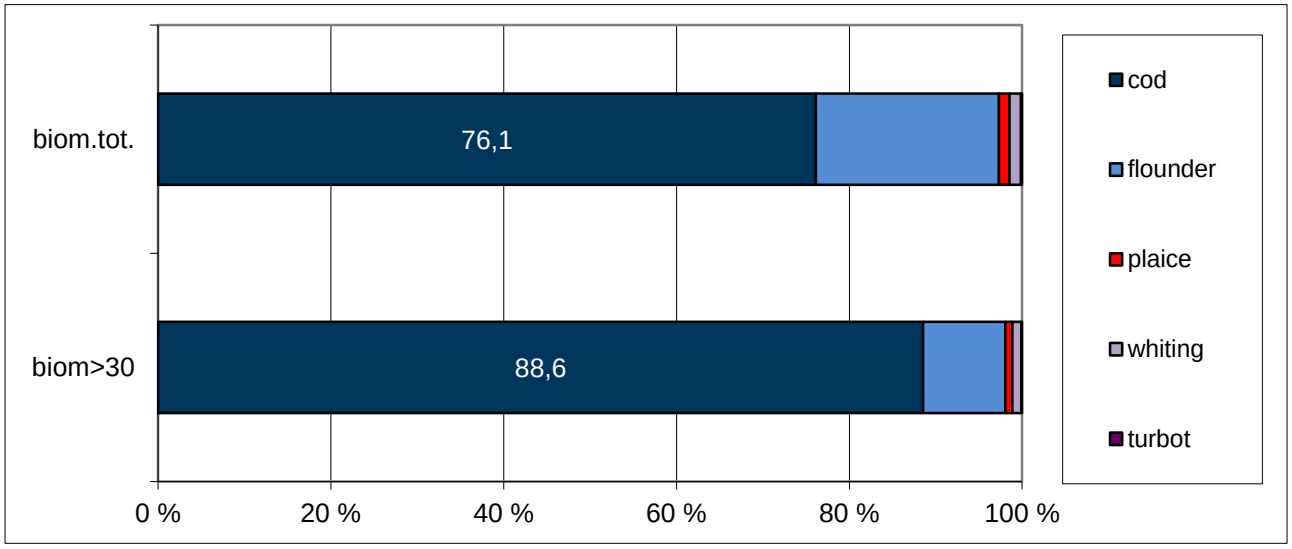

Figure 6. *The total biomass and the biomass of fish >30cm in subdivisions 25 and 26 (period 2000-2011).*

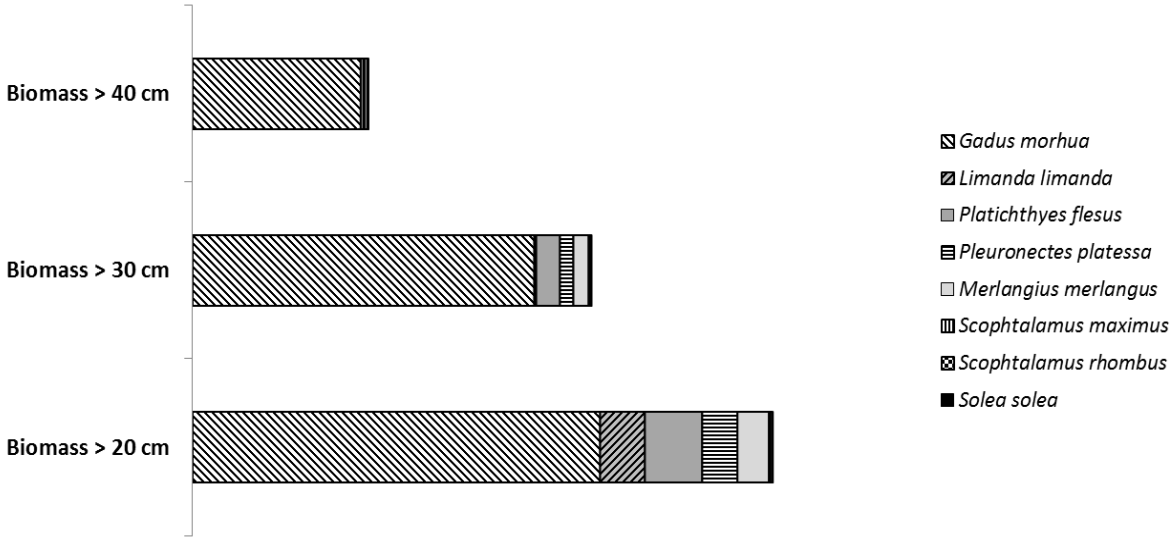

Figure 7. *Species biomass in percentage of the eight selected demersal fish species, concerning the different length classes caught during the Baltic International Trawl Survey in Quarter 1 between 2001 and 2011 in SD 22-24 (Oesterwind et al., in prep).*

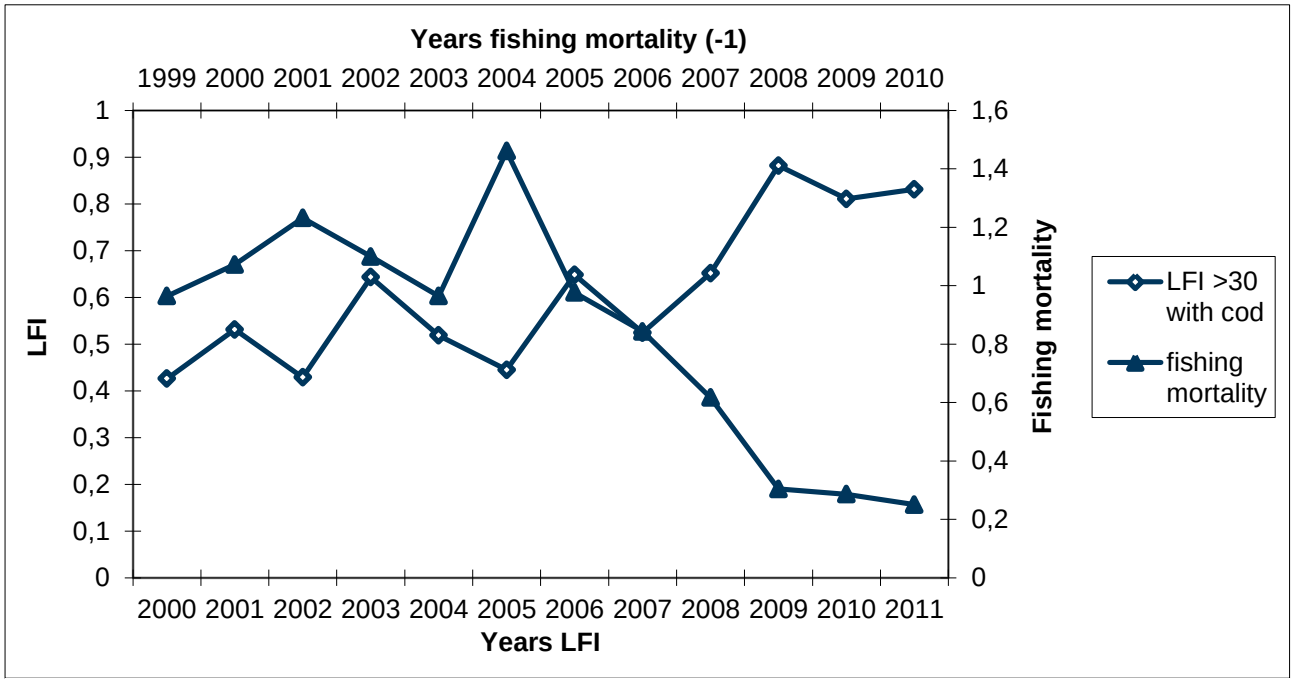

Figure 8. *LFI (>30 cm fish, cod included) by biomass in the Polish EEZ (data from 476 Polish stations and 261 Danish stations. Response to fishing mortality of cod with a lag of 1 year shows statistically significant negative correlation. The data series (2000-2011) was too short to determine breakpoints.*

Metadata

Data source and description

Baltic International Trawl Survey (BITS). See http://datras.ices.dk/Home/Descriptions.aspx

Baltic hydroacoustic survey (BIAS). See http://www.ices.dk/community/groups/Pages/WGBIFS.aspx

Geographical area

Demersal community: ICES sub-divisions 22 (Kattegat) to 26 (SE Baltic Proper).

Pelagic community: ICES SD 27 (Western Gotland Basin) to 30 (Bothnian Sea).

Methodology of data analyses

ICES subdivision 22–24

Analyses were based on data from the BITS (ICES, 2011a) using data from Quarter 1. New survey standards were implemented in 2001. The actual standard haul is performed with two different sizes of demersal trawls (TV3) for different sizes of research vessels. To avoid bias on the selected fish assemblage caused by declining salinity in the Baltic from west to east, we focused our analysis on the western Baltic, ICES Subdivisions 22–24. In addition due to the different gear sizes used and the implementation of the new standards we decided to use only data from the smaller gear (TVS) between 2001 and 2012. Catch numbers per length per haul of eight demersal species were converted into weight-at-length. The sum of biomass of individuals was calculated, grouped in two size classes: larger than 30 cm, and larger than 40 cm. For every year, these sums were divided each by the sum of total biomass of the eight species caught in the BITS, resulting in two different LFI's. To see whether the eight demersal species represents the main demersal community in the Western Baltic, the total biomass of the BITS during 2001 and 2012 was calculated on the basis of the ICES 'Exchange Data' downloaded from ICES DATRAS on 18 February 2013.

Data on fishing mortality (F) as an indicator for anthropogenic pressure and number of recruits as an indicator for natural conditions were available for the demersal species only for cod. A cross-correlations analysis between the different LFI time-series and Fcod and cod recruits in addition with a bootstrap hypothesis testing for the cross correlation estimations were performed for each of the two different size classes (Oesterwind et al. in prep).

ICES subdivision 25, 26

The BITS data was analyzed with and without cod, the dominant fish species in the dataset. As the other demersal fish species are shorter, also the limit size of LFI was difficult to set. Based on trial and error, the limit was set to 30 cm in order to get flat fishes into the indicator. It was, however, recognized that 30 cm is a small size for cod. Therefore the GES boundary based on 30 cm can give overly positive picture of the state of the fish community.

Determination of GES boundary

Demersal community

There is no Baltic wide conclusion of the boundary for Good Environmental Status (GES) in demersal LFI but one approach is attempted in this core indicator report. Until experience and more scientific work is accumulating of the use of LFI in the Baltic Sea, more emphasis could be given to the temporal development of LFI, i.e. GES is approached when there are more large fish in the community.

Analysis in ICES subdivision 22–24: no analysis of GES boundaries were performed

Analysis in ICES areas 25 and 26: the determination of GES boundaries was based on expert evaluation (using trends in data series): GES boundary was set between years 2008/2009, when the cod fishing mortality decreased significantly. Thus, if the average LFI score in 2009-2011 is statistically significantly higher than the score in 2000-2008, it means GES.

Pelagic community

No static GES boundary has yet been set for the pelagic LFI. The assessment is made on the basis of temporal trends, while noting that the temporal trend is heavily dependent on the presence of cod in the area.

Strengths and weaknesses of data

The LFI is a strong indicator with significant responses to fishing mortality.

It is a weakness that the demersal community can be assessed by this indicator only in the southern and central areas of the Baltic Sea.

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