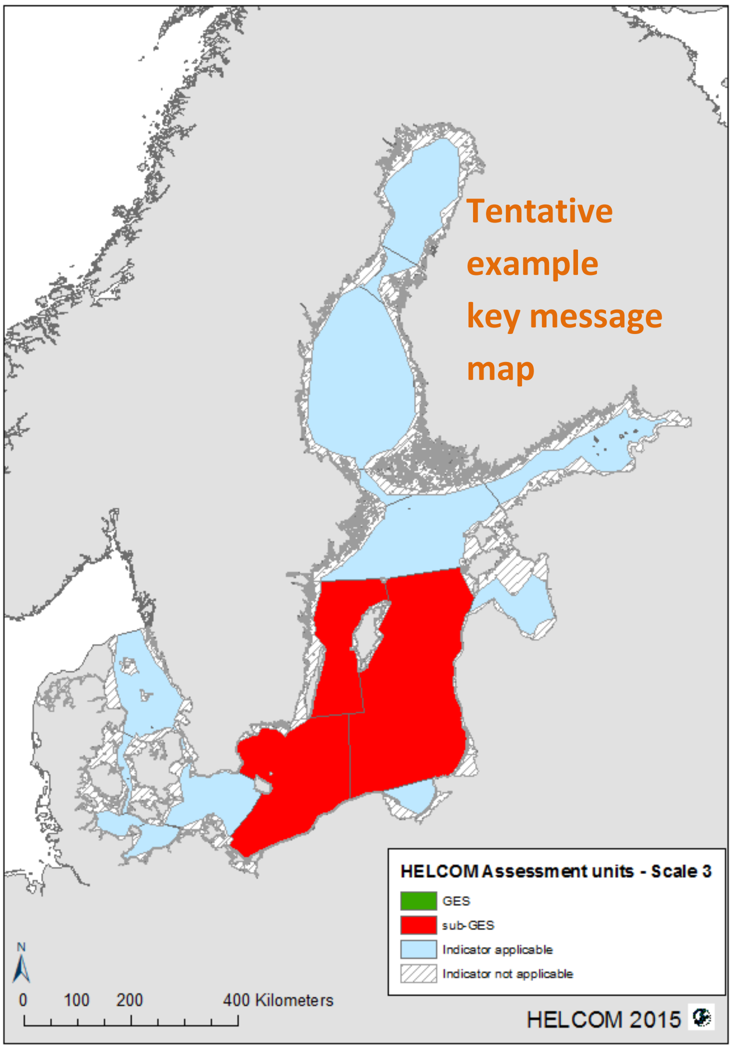
Maximum Length of fish in the pelagic community

[ML off-shore]

Key message



No actual status evaluation has been made for the indicator at this time, as it is still under development and GES-boundary under discussion among experts. The status map is provisional, and it indicates a way to use this indicator for future assessments.

The indicator reflects the status of the environment based on the size structure of the offshore fish pelagic community, the higher the maximum length (ML) of the fish, the better the status is perceived to be. Preliminary analyses show that ML in the open sea waters (whole Baltic Proper) has dropped from the late 1970s to the early-mid 1990s, and have hence remained at very low levels.

Relevance of the core indicator

The Maximum Length (ML) evaluates the size-structure of the fish community. Fish communities dominated by large fish individuals have higher functional diversity than fish community dominated by small fish individuals.

Large fish, especially predators such as cod, are usually the most economically valuable fish and therefore the most targeted components of the fish assemblage. The indicator is therefore expected to respond to fishing pressure. In the Baltic proper there is however also a large fishery for small pelagic species (sprat and herring).

The indicator is a good complement of the core indicator 'Proportion of large fish in the community (LFI)'. LFI provides information on the relative biomass between large and small fish in the community, without providing information on whether any perceived change is due to changes in absolute biomass of small or large fish. ML provides information on the changes in the maximum fish size in the community, which provides information on whether the large fish individuals have decreased. However, changes in ML could be also related to changes in fish growth.

Policy relevance of the core indicator

	Primary importance	Secondary importance
BSAP Segment and Objective	• Viable populations of species (biodiversity)	
MSFD Descriptors and Criteria	4.2. Proportion of selected species at the top of food-webs.	
Other relevant legislation: OSPAR, Common Fisheries Policy, Habitats Directive		

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Cite to this indicator

HELCOM [2015]. [Name of the indicator]**.** HELCOM core indicator report. Online. [Date Viewed], [Web link].

Indicator concept

Good Environmental Status

The indicator development work is ongoing and it is expected in the future to be applied to evaluate good environmental status (GES) based on the Baltic Sea off-shore pelagic and demersal fish communities. However, it is also noted that suitable monitoring data to test the indicator is only available from the southern and central parts of the Baltic Sea, and that due to environmental gradients such as salinity the fish communities in the northern Baltic Sea are different and the same GES-boundaries and concepts may not be applicable in those regions. More specifically, cod which is dominating the large fish component in the southern Baltic Sea is only periodically present in the northern parts. The GES concept for the maximum length (ML) in the Baltic Sea must recognize the regional differences, and GES-boundaries may need to be specifically set for different regions.

The approach to set GES could be the same as used for the off-shore Large Fish Indicator (LFI) for the pelagic fish community. According to this approach, the pelagic community is considered to reflect a good environmental status (GES) when the ML values for the evaluated period are above the 5th percentile of the median distribution during a baseline period. The current environmental status should be evaluated as a comparison with this GES-baseline. The environmental status is evaluated based on the deviation of the median value of the indicator during the assessment period in relation to the variation of the indicator value during the baseline period.

The pelagic catches from BIAS (Baltic International Acoustic Survey) are dominated (in average 99.9 %, both in abundance and biomass) by four species, sprat, herring, cod and sticklebacks, and therefore only these species were used in the ML estimations. As the indicator is heavily dependent on the presence of cod, it is envisaged to be only evaluated in the assessment units where cod is normally present, i.e. the HELCOM assessment units 31, 33 and 34 corresponding to the ICES Subdivisions 25, 26&28 and 27, respectively.

Since the species of the pelagic off-shore fish community are highly mobile and likely prone to density-dependent habitat occupation (i.e. at high population size the stocks expand, and at low population size it contracts, behaviour especially known for cod, Casini et al. 2012), a single GES-boundary for the pelagic community of the whole Baltic Proper is needed as well as a single evaluation of the community for the whole area.

For the baseline period to be relevant and comparable to the assessment period, it must be carefully selected to reflect time periods with stable environmental conditions, as stated within the MSFD (EC 2010). The baseline period should cover at least 10 years to extend over more than two times the generation time of the typical species representing the indicator. In this case, 50% of the cod population becomes reproductive at 3-years of age, and thus a 10-year baseline period is considered adequate to cater for natural variation in the indicator value due to for example strong and weak year classes. During the last 100 years, the Eastern Baltic cod population has never been as high as in the late 1970s-early 1980s as a consequence of several simultaneous biotic and abiotic circumstances favourable for cod. Therefore, the late 1970s-early 1980s corresponds to a situation that can be hardly re-established in the future and thus the baseline should not be taken during this period. Moreover, a substantial turnover in the ecosystem abiotic conditions in the Baltic Sea has been apparent in the early 1990s, leading to shifts in the baseline state (Möllmann et al 2009). Therefore, it is not advisable to compare the current status to a status before the early 1990s.

The indicator (ML) can be also used as "surveillance indicator" if agreement on GES limits cannot be reached or because of the lack of knowledge of the system (ICES 2015).

The pelagic off-shore ML is based on trawl catches from the currently ICES-coordinated BIAS (Baltic International Acoustic Survey).

Anthropogenic pressures linked to the indicator

	Strong connection	Secondary connection
General	Fishing targeting fish of large size	
MSFD Annex III, Table 2	Biological disturbance: - selective extraction of species, including incidental non-target catch (e.g. by commercial and recreational fishing)	

Fishing activities affect the status of the fish community, and the ML is a strong indicator with significant responses to fishing mortality. Since fishing is highly selective, and extracts from the sea the largest individuals of each species (especially true for large predatory species, such as cod), the indicator is expected to respond to fishing pressure. However through sustainable fishing practices the pressure on the community can be minimized by targeting a broader range of sizes and species.

Assessment protocol

HELCOM areas 31, 33 and 34 (ICES subdivisions 25, 26&28, and 27).

Maximum Length (ML) is estimated for each trawl haul from the BIAS survey.
A baseline approach is to be chosen to evaluate the environmental status of the off-shore pelagic community. The datasets must meet certain criteria for an evaluation of GES using the baseline-approach:

1) The baseline data set is to cover a minimum number of years that is at least two times the generation time of the species most influential to the indicator evaluation in order to account for the influence of strong year classes. For the off-shore pelagic community the cod is the species with the longest turnover rate, and 50% of the cod population becomes reproductive at 3-years of age.
2) The baseline data set must not display a linear trend within itself ($n>10$, $p>0.05$), as the baseline for evaluation should optimally reflect the community structure at stable conditions and not a development towards a change in the environmental status.
3) Before evaluating GES, it must be decided whether or not the baseline period reflects a period of GES. This could be done either by using data dating back earlier than the start of the baseline period, using additional information, or by expert judgment. If there is data e.g. preceding the baseline period of much higher values than the ones in the baseline period, the baseline might represent sub-GES (in case of an indicator where higher values is indicative of a good environmental status) or GES (in case of an indicator where higher values are indicative of an undesirable status).

During the last 100 years, the Eastern Baltic cod population has never been as high as in the late 1970s-early 1980s as a consequence of several simultaneous biotic and abiotic circumstances having been favourable for cod. Therefore, the late 1970s to the early 1980s correspond to a situation that can hardly be re-established in the future and thus the baseline should not be defined for this period. Moreover, a substantial turnover in the ecosystem abiotic conditions in the Baltic Sea has been apparent in the early 1990s, leading to shifts in the baseline status (Möllmann et al 2009). Therefore, it is not advisable to compare the current status to a status before the early 1990s.

The GES-boundaries have been defined as the value of the indicator at the 5th percentile of the median distribution of the baseline data set. The median distribution is computed by re-sampling (with replacement) from the baseline data set. In each repetition, the number of samples equals the number of years in the baseline data set. In order to improve precision, a smoothing parameter may be added in each repetition. The smoothing parameter is computed as the normal standard deviation of the re-sampled data set divided by the number of years re-sampled.

To evaluate the environmental status during the assessment period the median value of the indicator during the assessment period is compared with the specific GES-boundary. In situations where the baseline dataset represents GES, the median of the years to be assessed should be above the 5th percentile of the median distribution of the baseline data set in order to reflect GES.

The indicator (ML) can be also used as "surveillance indicator" if agreement on GES limits cannot be reached or because of the lack of knowledge of the system (ICES 2015).

Relevance of the indicator

Policy Relevance

This ML indicator could be included to address the MSFD Descriptor 4 (Food webs).Healthy ecosystems are characterised by fish of large size. The EU's Marine Strategy Framework Directive (MSFD) requests Member States to develop marine strategies for the marine areas under their jurisdiction. However, the off-shore pelagic community is constituted by highly motile fish species showing large and natural changes in spatial distributions. Therefore, ML for this community cannot be assessed for too small areas such as national boundaries or economic zones, but must be assessed across national jurisdictions. Off-shore fish communities comprise also other important segments of international policies such as the Common Fisheries Policy (CFP) and the Baltic Sea Action Plan BSAP.

The role of pelagic off-shore fish communities in the ecosystem

The Maximum Length (ML) in a community depict its size structure and is driven by the large species (and fish), which are significant balancing features in a food web but at the same time heavily targeted by the commercial fisheries. Commercial fisheries often target the large, high-value fish species and individuals in the off-shore community. 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 targeted population (Beverton and Holt, 1957). Based on this concept, the ML maps the fishing pressure. Studies to understand and improve the ML for the Baltic Sea are being prepared at the moment (Casini et al., in prep).

ML evaluates the species (or size) composition in the fish community. Fish communities dominated by predatory fish species and large fish have higher functional diversity than fish community dominated by small fish. Natural processes influence the ML to some extent, for example affecting fish growth, however large changes in ML are deemed to be the effect of anthropogenic fishing pressure.

Results and confidence

Time-series of ML for the pelagic community have so far only been made using Swedish data. Sweden has performed standardized acoustic surveys since the late 1970s and has covered a large part of the Baltic Sea, from the Bornholm Basin to the Bothnian Sea, even if with different degree of spatial coverage in different years. Specifically, in the early years Sweden covered basically the whole Baltic Proper, while in the last 15-20 years the Baltic Sea has been divided between the countries and thus Sweden has covered more or less half of the Baltic Proper, basically the Swedish EEZ, but still sampling in all the HELCOM assessment units 31, 33, 34, 36 and 39 (full spatial coverage in areas 34). Hence, even if the use of only Swedish data is certainly a limitation, the spatial coverage might be considered sufficient to produce ML time-series representative of the HELCOM assessment units.

For the Bothnian Sea a shorter Swedish time series exists (2007-2012) from the BIAS survey. The time series are however still considered to be too short to evaluate the environmental status based on either trends or the baseline-approach.

The time-series of ML are based on data from Swedish acoustic survey from 1979 onwards. The ML time-series are shown in the figures below for the whole Baltic Proper (assessment units 31, 33 and 34 together). ML dropped from the 1979 to the early 1990s, keeping low afterwards. It must be kept in mind that since the ML is estimated by a GAM modelling approach, smoothing the annual observations, potential year-to-year high frequency variability is not detectable. No GES have been proposed yet.

The fish species representative of the pelagic off-shore community are highly motile responding to external pressures (e.g. fishing) over a large geographical range. For example some species, e.g. cod, can show density-dependent habitat utilization, meaning that an external pressure (e.g. fishing) in one HELCOM assessment area can affect ML not only in that area but also in the others. And conversely, an external pressure (e.g. fishing) in one area could appear not to produce changes in ML just because this area could be filled up by cod coming from an adjacent area. Moreover, in the case of the Baltic Sea, separate fishing mortality estimates do not exist by assessment area.

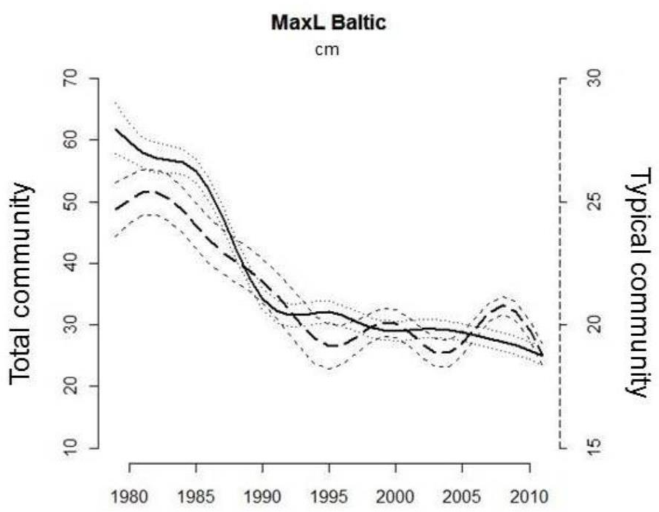

Figure 2. Time-series of ML for the whole Baltic Proper.

Confidence of the indicator status evaluation

The confidence of the status indicator evaluation is judged to be **moderate**, because the spatial coverage in the different HELCOM assessment units is not complete due to the use of only Swedish data. Specifically, in the early years Sweden covered basically the whole Baltic Proper, while in the last 15-20 years the Baltic Sea has been divided between the countries and thus Sweden has covered more or less half of the Baltic Proper, basically the Swedish EEZ, but still sampling in all the HELCOM assessment units 31, 33, 34 (full spatial coverage in areas 34) used in this evaluation. Hence, even if the use of only Swedish data is certainly a limitation, the spatial coverage is considered sufficient to produce ML time-series representative of the Baltic Proper. However, the use of all data form all the countries performing the BIAS survey would improve the quality and confidence of the indicator status to high. Especially needed are the data from the southern parts of the HELCOM assessment units 31 and 33, and the eastern part of the assessment unit 33.

Monitoring requirements

Monitoring methodology

General information about the HELCOM common monitoring activities for off-shore fish communities are presented in the HELCOM Monitoring Manual:

http://helcom.fi/action-areas/monitoring-and-assessment/monitoring-manual/fish-fisheries-and-shellfish/offshore-fish

Common guidelines are to be included in the HELCOM Monitoring Manual during 2015-2016. The monitoring methodologies in BIAS are described in detail in ICES (2010) and could form the basis for an agreed common HELCOM guideline.

The BIAS (Baltic International Acoustic Survey) sampling frequency and spatial resolution are based on 2 pelagic trawl haul for each ICES statistical rectangle every year. The maximum length (ML) is estimated using the maximum fish length caught in each trawl haul.

The trawl hauls during the BIAS are taken corresponding to high fish concentrations as detected by the acoustic device (2 trawl hauls for each ICES statistical rectangle), without a-priori fixed sampling scheme accounting for trawling depth, bottom depth etc. Therefore, the catch data (CPUE, catch-per-unit-effort, Kg/hour) have to be standardized for other effects that can mask the annual signal. For standardization, Generalized Additive Models (GAMs) were used, using the following formulation:

$$\text{CPUE} \sim s(\text{Year}) + s(\text{lat, long}) + s(\text{Ttime}) + s(\text{Tdepth, Odepth}) + \varepsilon$$

where *Year* is the Year-effect and *(Lat, Long)* fits the overall spatial distribution. *Ttime* is the trawling starting time, and was included in the model because of the potential difference in cod catchability in the pelagic waters depending on the fishing time. In fact, in other areas cod has been shown to perform diel vertical migrations in the water column, generally concentrating close to the bottom at day-time and more dispersed in pelagic waters at night-time. *Tdepth* is the mean trawling depth (i.e. the mean depth of the gear headrope) and was included in the model because of the potentially different catchability of cod at different depth (e.g. due to the demersal nature of the cod, we expected higher catches in deeper waters). Cod in the Baltic has been shown however to avoid oxygen concentrations below 1 ml l^{-1} (Schaber *et al.*, 2012), and therefore we used *Odepth* (depth at which oxygen was 1 ml l^{-1} at the trawl haul location) as interactive effect with *Tdepth*. In the case the whole water column was well oxygenated (i.e. no *Odepth* was present), *Odepth* was set equal to bottom depth. *s* are the smoothing functions and ε the error term. A thin-plane regression spline was used to model the interaction between year and geographic coordinates. A cyclic cubic regression spline was used to smooth the *Ttime* predictor because it forces the estimated effect to have the same value (and up to second derivative) at its start and end points (Wood, 2006). Based on the fitted models, we showed cod CPUE time-series in each assessment area, by extracting the Year-effect from the model, after having accounted for the effect of the other covariates. In this way, we obtained time-series of ML in the pelagic water to be used to evaluate the environmental status of the pelagic off-shore fish community.

Description of optimal monitoring,

In order to provide a high confidence evaluation of the environmental status based on the ML indicator, monitoring would regularly need to be carried out covering the whole area of the HELCOM sub-basins.

For the off-shore pelagic community, the data needed to estimate ML and evaluates the environmental status basically exist, but are held in the national laboratories performing the BIAS, either in digitalized or paper formats. No international database exists impeding smooth regional evaluations.

Current monitoring

From ICES SD 25 (Bornholm Basin) to SD 32 (Gulf of Finland), excluding SD 31 (Bothnian Bay).

The HELCOM Contracting Parties performing the BIAS are Sweden, Germany, Poland, Russia, Lithuania, Latvia, Estonia and Finland, covering nearly the whole Baltic Sea.

The evaluation of ML for off-shore pelagic community is currently based on standardized catch data from Swedish acoustic survey from 1979 onwards. There is no easy availability of data from other countries, since no international database exists. The stations used in the current assessment of the status of the indicator are shown in Fig. 3 below. Sweden covers entirely ICES Subdivision 27, the northern part of Subdivision 25, the western parts of Subdivision 26 and 28 and the southern part of Subdivision 29. Subdivision 30 is nowadays (since 2012) covered by Finland. Therefore, to have a full spatial coverage, the data from other countries should be collated. However, since Sweden covers a large part of the Baltic Proper the use of Swedish data can be considered as representative for the HELCOM assessment units analysed. The data needed to estimate ML standardized catches by length-classes from some countries are in some circumstances digitalized, in other cases in paper format.

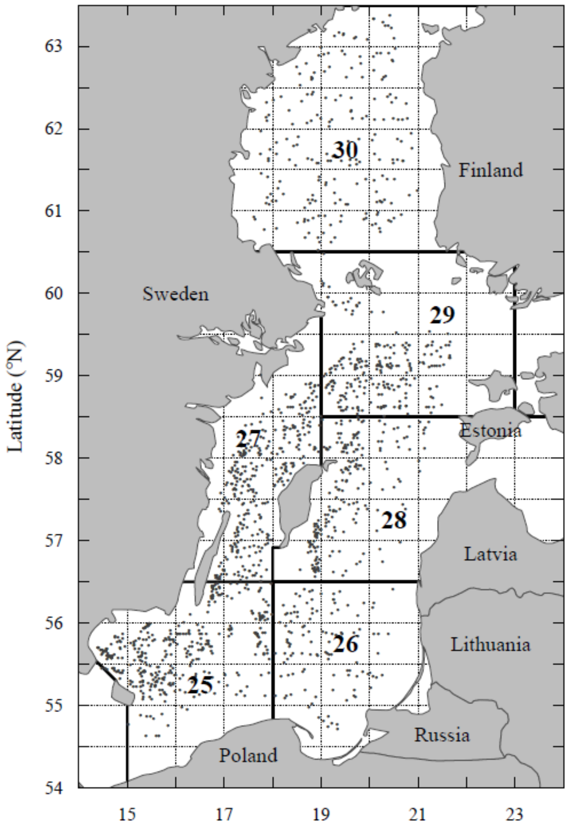

Figure 3. Trawl hauls swept by Sweden during the national acoustic survey from 1979 to 2013. The evaluation of the environmental status was done for the whole area encompassing ICES SDs 25, 26, 27 and 28.

Description of data and up-dating

Metadata

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

The pelagic off-shore ML is based on trawl catches from the currently ICES-coordinated BIAS (Baltic International Acoustic Survey). There is currently no complete international database for this survey, and therefore the information has to be directly collated from the single countries.

Arrangements for up-dating the indicator

Data from regular monitoring activities is collected annually and thus arrangements for up-dating the indicator annually are under consideration. HELCOM Contracting Parties currently report the monitoring data from the BITS survey to the ICES database DATRAS where it is annually processed by the ICES group WGBIFS. The same group also compiles national acoustic assessments (abundance estimates) for herring and sprat based on the BIAS surveys, but no common international database exists.

The HELCOM State WG will annually evaluate the outcome of the indicator and agree to publish up-dated information.

Publications and archive

(Archive)

Publications used in the indicator

Beverton, R. J. H., and Holt, S. J. 1957. On the dynamics of exploited fish populations. Fishery Investigations, Series II, 19: 1–533.

Cardinale, M., Linder, M., Bartolino, V., Maiorano, L. and Casini, M. (2009). Conservation value of historical data: reconstructing stock dynamic of turbot (*Psetta maxima*) during the last century in the Eastern North Sea. Marine Ecology Progress Series, 386: 197-206.

Casini, M., Lövgren, J., Hjelm, J., Cardinale, M., Molinero, J.C. and Kornilovs, G. (2008). Multi-level trophic cascades in a heavily exploited open marine ecosystem. Proceedings of the Royal Society B, Biological Sciences, 275: 1793-1801.

Casini, M., Blenckner, T., Möllmann, C., Gårdmark, A., Lindegren, M., Llope, M., Kornilovs, G., Plikshs, M. and Stenseth, Nils Chr. (2012). Predator transitory spillover indices trophic cascades in ecological sinks. Proceedings of the National Academy of Sciences of the USA, 109: 8185-8189.

Casini, M., Sorais, M., Tian, H., Larson, N. (in prep). Mapping the ecological status of the pelagic fish community: spatio-temporal trends in size-based indicators in the Baltic Sea.

EC 2010. Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters. Official Journal of the European Union, 2010/477/EU, 11pp.

Jennings, S., Greenstreet, S. P. R., and Reynolds, J. D. 1999. Structural change in an exploited fish community: a consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology, 68: 617–627.

ICES. 2010. Report of the Baltic International Fish Survey Working Group (WGBIFS), 22–26 March 2010, Klaipeda, Lithuania. ICES CM 2010/SSGESST:07. 461 pp.

ICES. 2012. Report of the Baltic International Fish Survey Working Group (WGBIFS), 26–30 March 2012, Helsinki, Finland. ICES CM 2012/SSGESST:02. 531 pp.

ICES. 2014. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 3-10 April 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:10. 919 pp.

ICES. 2015. EU request on revisions to Marine Strategy Framework Directive manuals for Descriptors 3, 4, and 6. ICES special request advice, 20 March 2015.

Möllman C, et al. 2009. Reorganization of a large marine ecosystem due to atmospheric and anthropogenic pressure: a discontinuous regime shift in the Central Baltic Sea. Global Change Biology, 15: 1377–1393.

Schaber, M., Hinrichsen, H.-H., and Gröger, J. 2012. Seasonal changes in vertical distribution patterns of cod (*Gadus morhua*) in the Bornholm Basin, central Baltic Sea. Fisheries Oceanography, 21: 33-43.

Shin, Y,J et al. Using indicators for evaluating, comparing, and communicating the ecological status of exploited marine ecosystems. 2. Setting the scene. ICES Journal of Marine Science, 67: 692–716.

Wood, S.N. 2006. Generalized Additive Models: an Introduction with R. Chapman & Hall/CRC, 391 pp.

Additional relevant publications