HELCOM core indicator report
July 2018

Number of drowned mammals and waterbirds in fishing gear

Key Message

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

This core indicator provides a descriptive evaluation of whether the number of incidentally by-caught marine mammals and waterbirds are below mortality levels that enable reaching good status. Currently no quantitative threshold values have been defined for the core indicator. Only concepts for determining the threshold values based on removal- and conservation targets have been described and are proposed to form the basis of future core indicator threshold setting activities.

Initial assessment values (i.e. initial threshold values) have been used to develop a first descriptive indicator evaluation. The removal targets are used as tentative threshold values for two populations of harbour porpoises and three species of waterbirds (Key message table 1).

Key message table 1. Assessment availability of incidental by-catch per species and sub-basin.

	Kattegat	Great Belt	The Sound	Kiel Bay	Bay of Mecklenburg	Arkona Basin	Bornholm Basin	Gdansk Basin	Eastern Gotland Basin	Western Gotland	Gulf of Riga	Northern Baltic	Gulf of Finland	Åland Sea	Bothnian Sea	The Quark	Bothnian Bay
Harbour porpoise Baltic Proper population					n.a.	X	X	X	X	X	n.a.	X	n.a.	X	n.a.	n.a.	n.a.
Harbour porpoise Western Baltic, Belt Sea and Kattegat population	X (1)	X	X	X	X	X	n.a.										
Greater scaup	?	X	?	X	X	?	X	X	?	?	X	?	?				
Long-tailed duck	X	?	?	X	X	?	X	X	X	?	X	X	X	?	?		
Common guillemot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		

(1) to be assessed by OSPAR indicator M6 (thresholds should be harmonised), X = incidental by-catch proven, ? = incidental by-catch mortality remains to be shown (occurrence of bird species and gillnet fishery in area but spatial/temporal overlap uncertain), n.a. = not assessed (occurrence of this population in the area uncertain)

Available incidental by-catch estimates (e.g. ICES 2015, 2016a) are evaluated against these threshold values, which also account for other sources of anthropogenic mortality than incidental by-catch to the concerned species. The threshold values have to be refined and further species added as further knowledge is gained. The initial descriptive evaluation shows that the incidental by-catch over all species included so far fails to meet the threshold in all areas where an initial evaluation was possible. Key message table 1 shows in which sub-basins the species assessed occur and where by-catch is proven.

Key message table 2. Initial threshold values based on removal targets for the assessment units of the species to which this tentative assessment applies.

Species	Population	Threshold value
Harbour porpoise	Baltic Proper population	zero incidental by-catch
Harbour porpoise	Western Baltic, Belt Sea and Kattegat population	< 1 % incidental by-catch of the best abundance estimate
Long-tailed duck	Western Palearctic population	PBR = 22,600 birds (including oiling and hunting)
Greater scaup	Western Palearctic population	PBR = 3,700 birds (including oiling and hunting)
Common guillemot	Baltic-breeding population	PBR = 620 birds (including oiling)

For harbour porpoises, increased mortality due to drowning (including death by suffocation) in fishing gears is recognised as the most significant threat to the populations in the Baltic Sea (Hammond 2008a, b, HELCOM 2013). The number of drowned animals exceeds the tentative removal target for the Baltic Proper population. For the harbour porpoise population in the Western Baltic, Belt Sea and Kattegat, the preliminary incidental by-catch estimate is in the same range as the removal target. Due to uncertainties in both the population estimates and estimate of fishing pressure, a bycatch rate close to the tentative threshold does not imply a good status (by-catch rate < tentative threshold) or bad status (by-catch rate > tentative threshold).

Recent modelling efforts have shown that incidental by-catch is a relevant source of human induced mortality in grey seals (Vanhatalo et al. 2014). No recent incidental by-catch estimates are available for ringed seals and harbour seals.

For waterbirds, drowning in fishing gear is believed to be a significant pressure on the populations of long-tailed duck, scoters, divers and some other waterbird species in wintering areas with high densities of waterbirds (Larsson & Tydén 2005, Žydelis et al. 2009, 2013, Bellebaum et al. 2012, European Commission 2012). The initial assessment based on case studies reveals that tentative threshold values are exceeded in all three waterbird species included in this evaluation. A declining trend in numbers of incidentally by-caught birds has been detected in the last two decades, however this is generally not believed to be a result of improved fishing practices but due to declining trends detected in the abundance of wintering waterbirds populations (e.g. due to factors such as poor breeding success) which likely contributes to declining incidental by-catch numbers. Also other anthropogenic sources of mortality such as oiling and hunting contribute to declines and must be considered in the indicator assessment. This means also that progress in the reduction of hunting and oiling would also have a positive effect on the assessment. In countries such as Denmark, Poland and Sweden the reported fishing effort has decreased during this time. Thus, a change in fishing pressure may also have contributed to the declining trend in by-caught birds. However as the fishing effort in some cases is measured in days at sea, the effective effort reduction cannot be quantified.

The overall confidence of the indicator is **low**.

The indicator is applicable in the waters of all countries bordering the Baltic Sea. Only for harbour porpoise, the assessment in the Kattegat has been agreed to be carried out by OSPAR (within their by-catch indicator M6, which does not cover any other species). Since the harbour porpoise assessment is needed for the overall assessment (i.e. all species) as proposed in this indicator, the threshold value for the Western Baltic, Belt Sea and Kattegat population should also be harmonised between HELCOM and OSPAR.

The indicator is applicable in the waters of all the countries bordering the Baltic Sea.

Relevance of the core indicator

The populations of marine mammals (cetaceans, seals and otters) and diving waterbirds evaluated in the indicator represent highly mobile animals in the Baltic Sea that are sensitive to additive mortality caused by fishing gear due to their characteristic slow reproduction rate. The indicator is an important tool for detecting mortality in key populations of the highly mobile species due to fishing activities.

The distribution and abundance of marine mammal populations is closely linked to healthy fish stocks and influenced by many human activities. For harbour porpoises, incidental by-catch has been identified as the main known cause of human-related mortality and it is likely to inhibit population recovery towards conservation targets.

Drowning due to incidental by-catch in fishing gear is a significant pressure on population trends and demography of waterbirds as in vulnerable species the numbers of drowned birds represent a relatively large proportion of the total population size.

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Biodiversity • Viable populations of species. • Thriving and balanced communities of plants and animals.	D1 Biodiversity - D1C1 The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured.
Secondary link	Eutrophication • Natural distribution and occurrence of plants and animals.	D1 Biodiversity - D1C2 (population abundance). - D1C3 (population demographic characteristics). - D1C4 (species distribution). D4 Food web - D4C1 (diversity of trophic guild). - D4C2 (balance of total abundance between trophic guilds).
Other relevant legislation: In some Contracting Parties also EU Birds Directive, EC Action Plan for reducing incidental catches of seabirds in fishing gears, EU Habitats Directive, Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) and Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA).		

Cite this indicator

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Number of drowned mammals and waterbirds HELCOM core indicator 2018 (pdf)

Results and Confidence

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

A complete evaluation of whether good status is achieved in terms of the number of drowned mammals and waterbirds in fishing gear has not yet been carried out. Due to the lack of availability of suitable monitoring-based data, currently only two populations of harbour porpoises, long-tailed duck, common guillemot and greater scaup were included in the descriptive evaluation.

The data are from scientific case studies, not from regular monitoring programmes, as no such data are available. For other species, indicative results are presented. Since case studies used for the indicator evaluation may be not up to date, the assessment has to be considered as preliminary and is rather a descriptive evaluation.

The confidence in the presented results is low but can greatly be improved once a suitable monitoring scheme is agreed on at Baltic Sea level, and in the frame of the EU Data Collection Multiannual Programme DC-MAP (European Commission 2016). A time series of incidental by-catch estimations would best account for uncertainties in the data (see CLA in "alternative threshold setting approaches", below).

Overall initial evaluation result of numbers of drowned marine mammals and waterbirds

The overall tentative assessment is shown in Result table 1. Given the large uncertainties in the underlying data (incidental by-catch and population estimate) for the harbour porpoise population of the Western Baltic, Belt Sea and Kattegat and the small margin between the preliminary assessment and the threshold, the assessment of whether the threshold is met or not should be reconsidered in the future. This reconsideration should also take into account the exact area covered by the by-catch estimate (ICES 2016a) and the abundance estimate (Hammond et al. 2017) as the latter also includes the Western Baltic. It does not change the overall result of the tentative assessment but on the other hand a false positive (green) may open up for the interpretation that incidental by-catches may not be of concern for this population. A later switch to Catch Limit Algorithm (CLA, see "alternative threshold setting approaches", below) which has been proposed by ICES Working Group on Marine Mammal Ecology (WGMME) might change the colour of the assessment even without having new data.

Population estimates, trend analyses, the level of by-catch as well as the estimation of losses of individuals from other anthropogenic impacts is also a serious shortcoming in the assessment of diving waterbirds. Improved information on these parameters would greatly enhance the validity of the assessment.

Results table 1. Tentative assessment of incidental by-catch per species and sub-basin. The data basis for the three bird species lies before the assessment period (Žydelis et al. 2009).

	Kattegat	Great Belt	The Sound	Kiel Bay	Bay of Mecklenburg	Arkona Basin	Bornholm Basin	Gdansk Basin	Eastern Gotland Basin	Western Gotland	Gulf of Riga	Northern Baltic	Gulf of Finland	Åland Sea	Bothnian Sea	The Quark	Bothnian Bay
Harbour porpoise Baltic Proper population					n.a.	X	X	X	X	X	n.a.	X	n.a.	X	n.a.	n.a.	n.a.
Harbour porpoise Western Baltic, Belt Sea and Kattegat population	X	X	X	X	X	X	n.a.										
Greater scaup	?	X	?	X	X	?	X	X	?	?	X	?	?				
Long-tailed duck	X	?	?	X	X	?	X	X	X	?	X	X	X	?	?		
Common guillemot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Overall result One-out-all-out																	

x = incidental by-catch proven, ? = incidental by-catch mortality remains to be shown (occurrence of bird species and gillnet fishery in area but spatial/temporal overlap uncertain), n.a not assessed (occurrence of this population in the area uncertain). Red: not in good status. Grey: status cannot be assessed - by-catch rate close to the tentative threshold does not imply a good status or bad status.

Marine mammals details of the descriptive evaluation result

Incidental by-catch of harbour porpoises and seals is difficult to estimate and reliable studies are scarce, but for harbour porpoise the suffocation through incidental by-catch in fishing gears is believed to be the greatest source of anthropogenic mortality and requires immediate action (ASCOBANS 2009, 2012, 2016b).

Harbour porpoise

For harbour porpoises, the risk of incidental by-catch is highest in various types of gillnets: set gill nets (gear type: GNS), entangling nets (trammel nets, GTR) and driftnets (GND) (ICES 2013a). The latter are banned in the Baltic Sea, but some hybrid nets such as 'semi-driftnets', which are fixed on one end of the net with the other end drifting around this anchor are of special concern.

Only recently have incidental by-catch rates been calculated for the ICES Kattegat and Belt Seas assessment unit (AU) including ICES subdivisions 21, 22 and 23 (ICES 2015, 2016), which is not based on population boundaries. These are based on collated incidental by-catch data from net fisheries (Metier level 3) mainly from a Danish remote electronic monitoring project using CCTV cameras on commercial vessels 10 to 15 m long (see below). For ICES subdivision 24 in the Western Baltic, no estimate of harbour porpoise incidental by-catch has been made.

The 95% confidence interval (CI) for the incidental by-catch numbers applied to the ICES Kattegat and Belt Seas AU is 165-263 calculated for the known fishing effort in 2014 (ICES 2016a). However, there are several sources of uncertainty to this figure. The fishing effort is given in days-at-sea and not km net * soak time (see chapter Monitoring Requirements). The effort of the monitored vessels may thus not have been representative for total fishing effort by all vessels combined. Whereas recreational gillnet fishermen (in some countries) may only set a few nets, commercial vessels larger than 12 m are allowed to set 21 km of gillnets. Such variations do not allow for a realistic effort estimate. Another possible source for the underestimation of incidental by-catch numbers may be that due to a lack of logbook keeping obligations the effort for part-time fishermen and recreational fishermen is not included in extrapolations because data is not available. Another source of uncertainty, which could result in both an upward or downward bias, is that no account has been taken for differences in mesh sizes or other important gear characteristics that may affect the incidental by-catch rate, or spatio-temporal heterogeneity of fishing effort in relation to harbour porpoise density. It has recently been shown that the combination of both fishing effort and harbour porpoise density produce better predictions of the risk of incidental by-catch, than one factor only (Kindt-Larsen et al., 2016).

The incidental by-catch estimate for subdivisions 21, 22 and 23 (which is used in the initial descriptive evalution) has been calculated by ICES (2016a) on the basis of an incidental by-catch rate and an estimate of gillnet effort relating to "days at sea". Results table 2 lists 95 % CIs for the parameters used in the tentative assessment and the factor between lower and upper confidence limit.

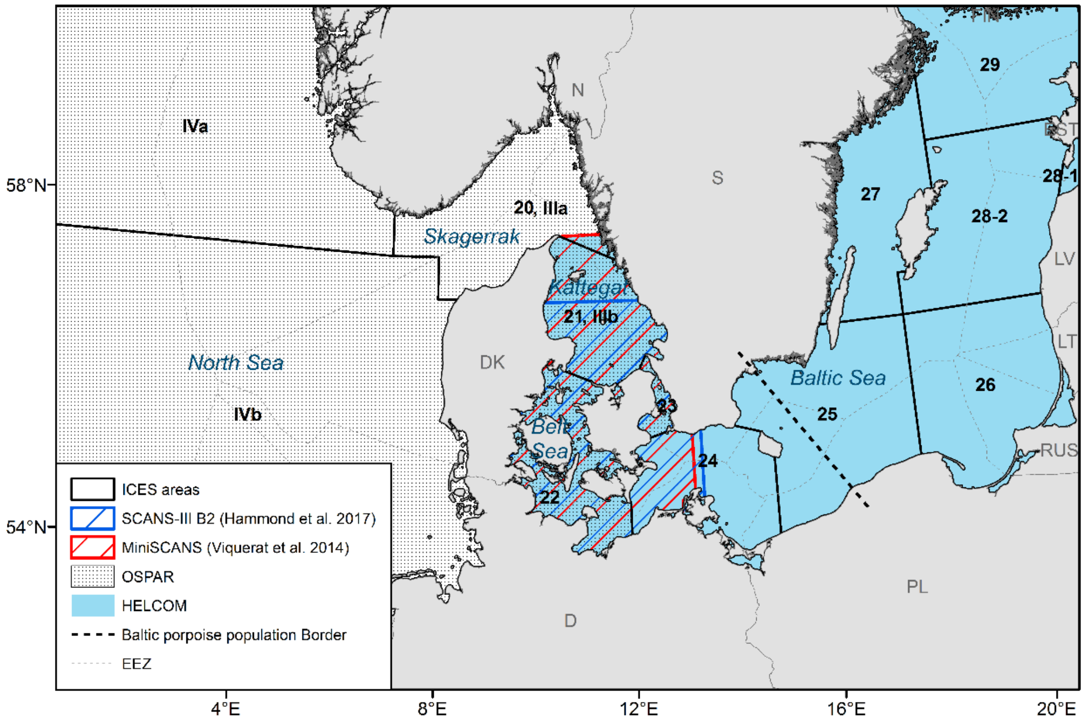
Results table 2. Catch rate, fishing effort total incidental by-catch and abundance used in the tentative assessment of the harbour porpoise population of the Western Baltic, Belt Sea, Kattegat. The high ratios between upper and lower confidence limits in by-catch estimate and especially in abundance estimates, as well as the absence of a 95 % CI in the effort data illustrate the low confidence of underlying data.

	95% CI lower	95% CI upper	Upper/lower
Incidental by-catch rate	0,016	0,025	1,56
Total fishing effort for Kattegat and Belt Sea	no CI given because only reported effort is taken into account		
Estimated total incidental by-catch for Kattegat and Belt Sea	165	263	1,59
2012 Abundance estimate for Kattegat, Belt Sea and Western Baltic (Viquerat et al. 2014)	25 614	65 041	2,54
2016 Abundance estimate for the southern Kattegat, Belt Sea and Western Baltic (Survey block 2 in Hammond et al. 2017)	23 368	76 658	3,28

This overview shows that no uncertainty estimate is available for the estimated total fishing effort. It is based on gillnet effort data for the region directly from the Danish and Swedish fishery. These fishing effort data are likely to be underestimated as it is apparent that effort from smaller vessels and from recreational fisheries which are not obliged to keep a logbook is not represented. On the other hand the data may be biased low because rather large vessels were sampled, which might not have been representative because it is assumed that larger vessels tend to set more nets than smaller vessels. Also, possible differences with respect to by-catch rate between fishing métiers have not been taken into account in this estimate.

Further, the ratio between the lower and upper 95% confidence limits is much bigger for the estimates of abundance than for those of incidental by-catch rate or total incidental by-catch, respectively. Thus, the resources for obtaining the most reliable incidental by-catch estimate should focus on investigating whether it is possible to obtain an estimate for the total fishing effort. Such estimate would have to be described as km of nets*soak time (see 'Monitoring requirements').

So far, incidental by-catch estimates and abundance estimates do not cover the same geographical areas, which adds further uncertainties to the initial assessment. So far no by-catch estimate is available for ICES subdivision 24 (see Results figure 1) of which the western half is covered by the Viquerat et al. (2014) survey which took place in summer 2012 and "Block 2" of the SCANS III survey completed in summer 2016 (Hammond et al. 2017). The latter however does not contain the northern Kattegat, which is on the other hand included in the by-catch estimate by ICES (2016a). Thus, in future abundance monitoring the assessment areas should be based on management needs rather than ICES subdivisions or other artificial boundaries. SCANS (I to III) and Mini SCANS data should then be re-evaluated in order to get a time sequence of abundance data to be fed into CLA calculations.



Results figure 1. Map illustrating the extent of HELCOM, OSPAR, ICES areas and porpoise survey areas mentioned in the text. The depicted OSPAR area do not define the general assessment area used in OSPAR's indicator assessment but is the area used in the specific assessment for Harbour porpoise bycatch. The SCANS-III B2 area is identical to the proposed management area for the Belt sea population (Sveegaard et al. 2015).

Harbour porpoises

ASCOBANS (2016b) compiled available data and literature information on reported incidental by-catch of harbour porpoises in the Baltic Proper. In Latvia, two harbour porpoises were reported as incidentally by-caught in 2003 – 2004. In Poland (period 2010 to 2014), one individual incidentally by-caught in a cod gillnet was reported in 2014. No incidental by-catch had been reported by any other country during 2010-2015. Prior to this (1990-2009) 66 harbour porpoises were reported by Poland as incidentally by-caught, 39% in semi-driftnets, 35 % in cod gillnets, 21 % in other set gillnets, 3 % in pelagic trawls and 2 % in driftnets (banned since 2008). Due to the lack of systematic collection of such data it is not possible to draw any conclusions on trends or spatial distribution of incidental by-catches from these incidental by-catches. Thus, the compiled data must be regarded as minimum numbers.

The population estimate of harbour porpoises in the Baltic Proper assessed by means of 304 acoustic data loggers is 497 animals (95% CI: 80-1091) (ASCOBANS 2016b). The abundance of the porpoises inhabiting the Western Baltic, the Belt Sea and Kattegat has been estimated four times (SCANS in 1994, SCANS-II in 2005, MiniSCANS in 2012 and SCANS-III in 2016). The geographical extent of the survey areas differs between years and only block 2 of the SCANS-III survey (Abundance = 42 324 (CV = 0.304, 95% CI: 23 368 – 76 658), Hammond et al. 2017) corresponds to the proposed management unit (from the Kattegat as far north as the Limfjord to the Western Baltic and east to a line between the Island of Rügen and Scania) of the Belt Sea population (Sveegaard et al. 2015). The survey area from 2012 with an abundance of 40 475 (CV = 0.24, 95% CI: 25 614-65 041) corresponds better to the bycatch estimate in ICES area 22, 23 and 24. Due to the geographical differences, the four survey results are at present not directly comparable although they are not significantly different. The SCANS-III group is currently working on calculating model-based abundance estimates for all the surveys and with this method, abundances for selected areas may be compared.

In the SAMBAH project considerable numbers of harbour porpoises from the Western Baltic, Belt Sea and Kattegat population were estimated in an area east of the Darss Sill and south of the Limhamn ridge in the Sound (ASCOBANS 2016b). Using a different method, the SAMBAH abundance estimation for this area alone is 21 390 (95 % CI: 13 461-38 024) based on data from acoustic data loggers between 2011 and 2013.

The population boundaries of the harbour porpoise population of the Western Baltic, Belt Sea and Kattegat must be better defined. Arbitrarily, the northern boundary of the population of the Western Baltic, Belt Sea and Kattegat can be used from Sveegaard et al. (2015). Tissue samples to be taken during incidental by-catch monitoring would allow assigning specimen to one of the two populations present in the Kattegat through advanced genetic sequencing techniques (such as Genome-wide Single Nucleotide Polymorphism (SNP) analysis) (Lah et al. 2016). An increasing number of analysed specimens would then allow to more reliably identify the boundaries.

Since no incidental by-catch estimate is available for the whole area and there is no reliable correction for North Sea population animals in the overlap zone in the Kattegat, a tentative assessment can currently only be made on the basis of ICES sub-divisions 21, 22 and 23 which accounts for the major part of the population range. ICES (2016a) gives a 95% confidence interval for their incidental by-catch estimate of 165 to 263 harbour porpoises in these ICES sub-divisions. The best geographical fit with these sub-divisions is the abundance assessment by Viquerat et al. (2014) to which the incidental by-catch estimate has been related. A combined 95 % confidence interval for abundance and incidental by-catch rate estimates (Buckland 1992) results in 0.3 to 0.9 % which is in the same range as the removal target. However, fishing effort from small vessels have to be estimated and taken into account additionally. If the abundance estimate from Hammond et al (2017) is taken, which corresponds with the population management borders suggested by Sveegaard et al. (2015), but less with the area for which a by-catch estimate is available, the range of a combined 95 % confidence interval for abundance and incidental by-catch rate would result in a by-catch of 0.26 to 0.92 %

of the abundance estimate. Due to uncertainties in both the population estimates and estimate of fishing pressure, a bycatch rate close to the tentative threshold does not imply a good status (by-catch rate < tentative threshold) or bad status (by-catch rate > tentative threshold).

For the Baltic proper, the threshold of zero incidental by-catch is exceeded by one by-catch in 2014 officially reported (ASCOBANS 2016b). This can be taken as the absolute minimum number as in earlier years incidental by-catches reported by fishermen to the Hel Marine Station were much higher. The EU driftnet ban in 2008 resulted in the cessation of fishermen reports (Pawliczka 2011).

The next step in refining incidental by-catch estimates could be the identification of high-risk areas for incidental by-catch. The number of harbour porpoises does not only have an effect on the evaluation of the total incidental by-catch in relation to the total abundance, but the local density of harbour porpoises also affects the incidental by-catch rate on a temporal and spatial scale. Given the solitary nature of harbour porpoises, the incidental by-catch rate in a certain fishery is expected to be as dependent on the harbour porpoise density as on the fishing intensity. In other words, if the fishing effort with a certain fishery is doubled in an area, the total number of incidental by-catches is expected to double as well. Or, alternatively, if the fishing effort is kept constant but the harbour porpoise density is doubled, the total number of incidental by-catches is expected to double. This relationship is the basis in a recently published paper on identification of high-risk areas for harbour porpoise incidental by-catch (Kindt-Larsen et al. 2016). All concerns expressed by ICES WGBYC (ICES 2015) on using “imported” observed bycatch rates on fisheries lacking observer data that are quoted in the indicator relate to differences in fisheries parameters, such as vessel size and fishing practices, but never to variation in harbour porpoise density. Even though the “import” primarily is made for fisheries within the same ICES division (e.g. IIId), the spatio-temporal variation in harbour porpoise density may be considerable within these areas. Using the approach of a by-catch risk assessment, it should be possible to estimate a removal rate that includes the uncertainties of both the incidental by-catch rate and the abundance by simulating incidental by-catches from the estimated distributions of both parameters.

Seals

For seals, in addition to various types of gillnets: set gill nets (gear type: GNS), entangling nets (trammel nets, GTR) and driftnets (GND), incidental by-catch risks stem from fykenets (FYK) and push-up traps without excluding devices in their entrance are of special concern (ICES 2013a, Vanhatalo et al. 2014).

Based on interviews of fishermen from Sweden, Finland and Estonia, and accounting for the variability in seal abundance and fishing effort and also for underreporting, the annual incidental by-catch of grey seals in trap nets and gill nets in these countries is estimated around 2,180-2,380 individual seals in 2012, probably representing at least 90% of the total incidental by-catch in the whole Baltic Sea (Vanhatalo et al. 2014). Annual population growth rates were estimated to be 9.4% (2000-2004) and 3.5% (2004-2009) in Finland (Kauhala et al. 2012) and 7.5% along the Swedish Baltic Sea coast since the 1990s. The incidental by-catch rate would result in 7.7-8.4% of counted seal numbers (Finnish Game and Fisheries Research Institute 2013). This rate is an overestimation because not all animals of the population are recorded during counts. Thus a low confidence of data results from the monitoring method and the lack of a population estimate (including confidence intervals).

Waterbirds details on the descriptive evaluation result

Diving waterbirds are especially vulnerable to set gill nets (GNS), entangling nets (trammel nets, GTR) and driftnets (GND), but incidental by-catch also occurs in other static fishing gears such as longlines and traps (ICES 2013a, b). Several studies have shown that the gillnet fishery in the Baltic Sea can in certain places cause high bird mortality. A rough estimate comprised 100,000-200,000 waterbirds drowning annually in the North and Baltic Seas, of which the great majority refers to the Baltic Sea (review of studies in Žydelis et al. 2009, 2013). Locally, incidental by-catch rates have decreased during the last two decades, likely as a result of declined abundance of wintering waterbirds and resulting reduced density at sea (Bellebaum et al. 2013).

Areas where waterbirds aggregate are often overlapping with gillnet fisheries (Sonntag et al. 2012), thus the incidental by-catch risk is high when gillnet fishing is exercised in areas with high abundance of foraging waterbirds, which can be present during the breeding period, during migration, for moulting and for wintering. High incidental by-catch numbers are reported from regions of high bird abundance (e.g. wintering birds on offshore banks and in coastal areas, Larsson & Tydén 2005, Žydelis et al. 2009, 2013, Bellebaum et al. 2013). Taxonomic groups under high pressure from incidental by-catch in the Baltic Sea are divers, grebes, cormorants, alcids, mergansers and ducks.

For waterbirds the potential biological removal (PBR) method (see 'Thresholds and Status evaluation) is used to compare incidental by-catch numbers in a population to its size. The level of pressure on a population is considered to be at an unacceptable level if the contribution of incidental by-catch brings human-caused mortality above the removal target. PBR values by Žydelis et al. (2009) were generally used as tentative threshold values for this descriptive core indicator evaluation. If recent information suggests a sharp decline in abundance a different recovery factor was used. For long-tailed duck, greater scaup (including wintering birds in the Netherlands) and common guillemot, the PBR approach has been applied (Žydelis et al. 2009) in order to derive removal targets that can be provisionally considered.

In contrast to Žydelis et al. (2009), a recovery factor of 0.1 was applied to the long-tailed duck owing to the sharp decrease in population size reported by Skov et al. (2011), Bellebaum et al. (2014) and Nilsson & Haas (2016). The total long-tailed duck incidental by-catch from available estimates was about 22,000 birds by the time of PBR calculation. Adding mortality by hunting (c. 30,000 birds in hunting bag and cripple losses in EU countries alone, Mooij 2005) and oiling ('tens of thousands', Larsson & Tydén 2005), the tentative threshold of 22,600 is clearly exceeded. Incidental by-catch has presumably dropped since then, but so has population size and hence the recent PBR. Hunting has decreased as well, in Finland and Sweden combined from up to nearly 90,000 birds (1994) to less than 10,000 birds annually since 2000 (Skov et al. 2011). The assessment should be refined using more recent data as soon as this becomes available.

For the greater scaup the PBR limit is 3,700 birds (Žydelis et al. 2009), a value exceeded by losses from fisheries in northern Europe alone and intensified by losses owing to other pressures. Due to the large decline in abundance recorded during 1990–2000 and the greater scaup being classified as endangered in EU countries, this PBR limit is based on the recovery factor of 0.1, the lower of two values presented by the authors. Incidental by-catch is known in the southern Baltic but estimates are not available. However, about 2,000 incidentally by-caught birds in the Dutch lakes Ijsselmeer and Markermeer alone impact the same population. An unknown number of incidental by-catches for the southern Baltic contributes to exceeding the pre-defined threshold of human induced mortality for that population which also suffers from hunting and other anthropogenic impacts (the hunting bag is about 2,000 birds). The tentative threshold value of 3,700 birds (valid for the Western Palearctic population) is clearly exceeded.

For the Baltic-breeding common guillemot population, the calculated PBR limit of 620 individuals is more than twice exceeded by the estimated minimum incidental by-catch for the Baltic Sea (Žydelis et al. 2009). 1,500 incidental by-catches are estimated from recoveries of ringed birds alone. Oiled birds have not yet been taken into account and should still be added. In this population however, immature birds are more likely to die in gillnets than adults. Since PBR assumes that all cases of additional mortality are equally distributed, the PBR chosen is rather conservative.

Future Work

All uncertainties identified show that sufficient monitoring of incidental by-catch, fishing effort, population size, trend analyses and other sources of anthropogenic mortality are a prerequisite for getting a more reliable assessment. The European Commission has decided to include incidental by-catch monitoring of protected bird and mammal species in the Data Collection Multiannual Programme DC-MAP (European Commission 2016). Further participation of HELCOM and HELCOM Contracting Parties on a regional scale is necessary for the implementation process in order to ensure suitable monitoring methods and sufficient coordinated coverage, as well as effort monitoring, are developed into meaningful parameters (fishing effort must be measured in net km * days, see Monitoring Requirements, Description of optimal monitoring). So far, only fishing effort from logbooks and VMS data is used for by-catch calculations (ICES 2015, 2016). The additional effort by commercial vessels <10 m for which a logbook is not required and by recreational fishermen must be estimated and taken into account. Then the uncertainty in the fishing effort estimates which underlie the incidental by-catch estimate needs to be specified by also adding a CV or 95 % confidence interval.

Since many species of diving seabirds are prone to accidental by-catch, additional species should be included in the indicator evaluation.

The shortcomings in relation to population estimates, trend analyses and the level of anthropogenic impacts on these populations in common give a low confidence in this indicator. High priority should be given to improvement of these shortcomings.

Confidence of the indicator evaluation

The overall confidence is **low**.

Monitoring data on numbers of incidentally by-caught mammals and waterbirds collected on an annual basis are virtually non-existent. However, limited data from scientific studies and pilot studies can – with the appropriate caution - be used for an initial assessment for a few species. Some of these data may not be up-to-date and thus have to be related to previous abundance data. Also, in some areas gillnet effort may have decreased during in the last two decades. So far, the confidence in any previous estimates of the pressure exerted by incidental by-catch of the relevant populations is low. Estimates are believed to be either underestimates or very uncertain because the proportion of unreported cases is likely to be high. In some areas, there are serious caveats in the underlying data. In other areas, the extrapolation of recorded by-catch numbers to estimated gillnet effort may be problematic due to the unavailability of effort data during that time. For example, in older Polish studies such as Stempniewicz (1994) extrapolations were based on the total number of registered fishing vessels possibly resulting in an overestimation (unpublished information from the Polish National Marine Fisheries Research Institute). Incidental by-catch numbers for seals and harbour porpoises are either absolute minimum numbers (from reported incidental by-catches) or estimates from pilot studies. For harbour porpoises, there is a high degree of uncertainty both in the estimated numbers of incidentally by-caught animals and in the estimated removal targets (see chapter 'Targets', below) needed for evaluation of these. For seals, the study by Vanhatalo et al. (2014) has recently increased the knowledge. For waterbirds, the magnitude of the incidental by-catch has been slightly better clarified on the scale of localised case studies (Žydelis et al. 2009). In order to increase the confidence of the core indicator evaluation, annual monitoring data of incidental by-catches based on a sufficient number of observer days, and associated with well-described fishery effort, is a prerequisite.

Thresholds and Status evaluation

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Due to the lack of sufficient monitoring data, it has not been possible to set quantitative threshold values for this core indicator on the number of drowned mammals and waterbirds in fishing gear for every species concerned. Some tentative threshold values are proposed to allow for a descriptive evaluation, however they should not be considered as finally agreed and are open for revision as more knowledge and monitoring data is accumulated.

The concepts for threshold value setting based on determining removal- and conservation targets are described below. Based on this, initial threshold values for two populations of harbour porpoises and three species of waterbirds can be derived. These have to be refined as further knowledge is gained. Future threshold value setting activities (see sub-chapter 'Alternative threshold setting approaches') are proposed to obtain the basis of a fully operational core indicator.

Initial threshold values used to develop descriptive evaluation

The assessment values applied as initial threshold values for the species and populations assessed in this indicator are shown in Good environmental status table 1.

Thresholds table 1. Initial threshold values based on removal targets for the assessment units of the species to which this tentative assessment applies.

Species	Initial threshold value
harbour porpoise Baltic Proper population	zero incidental by-catch
harbour porpoise Western Baltic, Belt Sea and Kattegat population	< 1 % incidental by-catch of the best abundance estimate
long-tailed duck Western Palearctic population	PBR = 22,600 birds (including oiling and hunting, recovery factor = 0.1, explanation see text)
greater scaup Western Palearctic population	PBR = 3,700 birds (including oiling and hunting, recovery factor = 0.1, explanation see text)
common guillemot Baltic-breeding population	PBR = 620 birds (including oiling)

The term "initial threshold value" was used as an acknowledgement of the shortcomings of the assessment. Given the uncertainty of the available population estimates, the trend analyses as well as the level of anthropogenically induced mortality, great caution should be given to the current threshold values.

Threshold value development concepts

The concept to apply threshold values supported by species specific removal and conservation targets has been developed in other contexts, including ongoing work carried out under the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), concluded under the auspices of the Convention on Migratory Species (ASCOBANS 2015a). This approach requires setting species specific conservation targets and defining reference points (removal targets) for the annual incidental by-catch rate.

Removal targets are based on 'unacceptable mortality levels' for the indicator species. 'Unacceptable interactions' have been defined for harbour porpoises (ASCOBANS 2000, 2006, 2016a, for details see also species specific targets below). Levels of 'unacceptable interactions' are related to the total human induced mortality of which incidental by-catch is an unknown fraction that may differ regionally. These levels of 'unacceptable interactions' should not be misinterpreted as 'acceptable levels' if the values are below the reference points.

Conservation targets are focused on the state of biological management units (i.e. stocks or populations). A target for a safe human-induced mortality limit (as a consequence of the removal target) is usually the outcome of a simulation over a certain time period using a suitable population dynamic model. During the time period, the conservation target for the stock size is to be reached with a given certainty in a predefined fraction of the simulation time (e.g. at least 95 % likelihood of reaching at least 80 % of carrying capacity within 100 years). In order to set a safe human-induced mortality limit, the time scale of the simulations have to be agreed upon (ICES 2014a, ASCOBANS 2015a). ICES concluded that such human induced mortality limits (or threshold reference points), should account for uncertainty in existing estimates of incidental by-catch and allow for current conservation goals to be met in order to enable managers to identify fisheries that require further monitoring and those where mitigation measures are most urgently required (ICES 2013a).

In the long-term, mortality in a healthy population must not exceed the birth rate (natality) in order to sustain the population. In seriously depleted populations, the human-related mortality must be close to zero to allow for recovery. All the highly mobile indicator species have a slow reproductive rate (K-strategists), and thus the 'unacceptable' mortality due to drowning in fishing gear has to be set at a low level, in order to avoid serious long-term implications for the populations. Due to the fact that the indicator species are affected by several pressures from various human activities, the general aim must be to minimize incidental by-catch of marine mammals and waterbirds as much as possible.

The use of trend-based thresholds of the number of incidentally by-caught animals is not considered appropriate due to the risk of falsely indicating a good status when the threshold value is reached. A slight downward trend may falsely indicate an improvement, as incidental by-catch is less likely to occur in depleted populations close to regional extinction due to the simple fact that fewer animals occur in the area.

Alternative threshold setting approaches

For management purposes, interim objectives or short-term and longer-term removal targets have been set for certain species, such as the harbour porpoise. The simplest management approach for setting an interim target is defining a reference point as a fixed percentage of the best population estimate. However, there are uncertainties regarding both values which have to be taken into account. These have been included in more sophisticated approaches (e.g. potential biological removal (PBR) or catch limit algorithm (CLA)) aiming at more conservative targets. Any interim targets (not only for the harbour porpoise) should be applied keeping in mind the general aim of ultimately reducing incidental by-catches to zero (resolution no. 5- ASCOBANS 2006, 2016a, HELCOM Recommendation 27-28/2 on seals).

The **potential biological removal (PBR)** can be applied for threshold setting, and is used to set removal targets under the US Marine Mammal Protection Act. The conservation goal is the 'optimum sustainable population' defined as being at or above the population level that will result in maximum productivity (ICES 2014a). For harbour porpoises in the Baltic Sea, Berggren et al. (2002) calculated anthropogenic mortality limits based on minimal demographic information using this approach. For birds, the ICES Workshop to Review and Advise on Seabird Bycatch (WKBYCS) recognises PBR as an initial and rapid assessment tool, which can indicate possible unsustainable mortality levels that would have to be followed by more sophisticated methods for reliable analyses (ICES 2013b). In addition, the workshop pointed out that basic assumptions of the PBR concept need testing and validation before applying to birds. Especially in rapidly declining populations such as long-tailed duck, velvet scoter, red-throated diver and black-throated diver (Skov et al. 2011), this approach has to be treated with great caution as any additional anthropogenic mortality speeds up the ongoing decline.

Population viability analysis (PVA) is another tool often used in similar contexts to forecast the consequences of changes in additional anthropogenic mortality for the population size. Several different types of PVA are being used. A demographic PVA is based on multiple simulated time-series of population growth or decline using extensive demographic data or demographic models of a population. The reliability of a PVA increases with the knowledge of specific demographic parameters such as the distribution of vital rates between individuals of different life history stages and between years.

Within a similar framework, a **catch limit algorithm (CLA)** has been developed. It is based on the principles of the International Whaling Commission's (IWC) revised management procedure (RMP) for commercial whaling and has been used to calculate anthropogenic mortality limits for harbour porpoises in the North Sea (Winship 2009). The next step should be to expand the capability of the model by incorporating multiple areas in the model. Further, a CLA for the Baltic Sea populations still needs to be developed. In the calculations by Winship (2009), the underlying conservation objective has been assumed to be the ASCOBANS interim conservation objective 'to allow populations to recover to and/or maintain 80% of carrying capacity in the long term' (see below).

Since 2009, ICES has advised the European Commission that CLA is the most appropriate method to set anthropogenic mortality limits on harbour porpoise, but this advice still has not been acted upon (ICES 2014a). CLA also is a suitable method for depleted populations such as the harbour porpoise population of the Baltic Proper. It is to be noted that all approaches rely on suitable programmes monitoring population sizes and incidental by-catches as prerequisites.

Threshold values for harbour porpoise

Within the frame of ASCOBANS, conservation targets have been agreed for the harbour porpoise and can be applied for the two harbour porpoise management units within the HELCOM area: (1) the Baltic Proper population and (2) the Western Baltic, Belt Sea and Kattegat population. ASCOBANS (2002, 2009, 2012) has adopted an interim goal of restoring (and maintaining) the populations of harbour porpoises to at least 80% of their carrying capacity. ASCOBANS has advised that, to be sustainable, 'the maximum annual anthropogenic induced mortality (including incidental by-catch, but also less conspicuous causes of death such as stress caused by pollutants or noise) for harbour porpoises should not exceed 1.7% of the best estimate of the population size' (Resolution No. 3, Incidental Take of Small Cetaceans, Bristol 2000). It has been reaffirmed in Resolution No. 5, Monitoring and Mitigation of Small Cetacean Bycatch (ASCOBANS 2016a) that "a total anthropogenic removal (e.g. mortality from by-catch and vessel strikes) above 1.7 per cent of the best available estimate of abundance is to be considered unacceptable in the case of the harbour porpoise". Also, the intermediate precautionary aim "to reduce by-catch to less than 1 per cent of the best available population estimate" has been reaffirmed. This aim relates to incidental by-catch explicitly and considers an (unknown) proportion of other causes of anthropogenic mortality. The resolution further states that "where there is significant uncertainty in parameters such as population size or by-catch levels, then 'unacceptable interaction' may involve an anthropogenic removal of much less than 1.7%". To date, there is significant uncertainty in central parameters such as estimations of incidental by-catch, population size and population growth for both harbour porpoise management units in the Baltic Sea.

PBR analyses based on data from a survey of the southern and western part of the Baltic Proper indicate that for the critically endangered **Baltic Proper population**, recovery towards this goal could only be achieved if the incidental by-catch was reduced to two or fewer porpoises per year (Berggren et al. 2002). This resulted in the objective (i.e. a removal target) of the ASCOBANS *Recovery Plan for Baltic Harbour Porpoises* (Jastarnia Plan) to 'reduce the number of by-caught porpoises in the Baltic towards zero' (ASCOBANS 2002, 2009, 2016b). The later SAMBAH survey found the distribution range of the Baltic Proper population to only partially overlap with the survey area of Berggren et al. (2002) (ASCOBANS 2016b). However the very low abundance estimate of the Baltic Proper population from the SAMBAH survey confirms the need for reducing the number of incidental by-catches towards zero. In such a severely reduced population "unacceptable interaction" involves a much lower anthropogenic mortality compared to healthy populations. Thus, the threshold chosen for the Baltic Proper population is zero. ASCOBANS (2009, 2016b) state that 'as a matter of urgency, every effort should be made to reduce the porpoise incidental by-catch towards zero as quickly as possible'.

For the **population of the Western Baltic, Belt Sea and Kattegat** the threshold value is tentatively proposed to be the removal target chosen as threshold for this indicator, which is less than 1% of the best population estimate.

As this limit (as all other target setting options such as PBR and CLA) is applied to the 'best' population estimate, there is a need to better define population boundaries of the population of the Western Baltic, Belt Sea and Kattegat (see Sveegaard et al. 2015 and ASCOBANS 2016b) and estimate the abundance (as well as incidental by-catch numbers) within these boundaries.

For improved management of the harbour porpoise populations in the Baltic Sea, removal targets in the form of 'safe' human-induced mortality limits (including incidental by-catch) should be modelled for the distribution range of each population. It would be appropriate to determine targets primarily using the CLA or possibly the PBR approach as these take the uncertainty of data into account. As soon as the results of such simulations are available, the 1% target should be re-evaluated for the population of the Western Baltic, Belt Sea and Kattegat. In order to obtain a more reliable assessment against threshold values in the future, the extent of the uncertainty in underlying data (which currently is greatest for the abundance estimate, Result table2) should be taken into account. As a priority, a CLA analysis should be developed for this population because the method uses time series of data (both population and incidental by-catch) and thus decreases the overall uncertainty. A consequence of significant uncertainty in parameters, such as in the population estimate of the harbour porpoise population of the Western Baltic, Belt Sea and Kattegat, is that a much lower removal target may be needed to reach the conservation objectives. As ASCOBANS resolution no. 5 (ASCOBANS 2006 and 2016) states "... if available evidence suggests that a population is severely reduced, or in the case of species other than the harbour porpoise, or where there is significant uncertainty in parameters such as population size or by-catch levels, then "unacceptable interaction" may involve an anthropogenic removal of much less than 1.7 %". Incidental by-catch again is an unknown fraction of the total anthropogenic removal target. A CLA analysis could produce more reliable targets than this relatively general resolution statement. Thresholds table 2 shows what data may already be available in order to derive CLA values for an assessment.

Thresholds table 2. Available data for further development of CLA values for harbour porpoise populations in the Baltic Sea (x = some data available to fill the knowledge gaps, - = no data available).

	Estimates of anthropogenic mortality			Input needed for CLA calculations: Removal limit= $\alpha \times R_{max} (D_T - \beta) \times N_T$		
Species (population)	**Incidental by-catch estimate**	**Hunting bag**	**Estimate of other anthropogenic removal (e.g., collision with vessels, detonations etc.)**	**Population model fit to current population size N_T (time series of population estimates available)**	**Current status D_T**	**Maximum population growth rate R_{max}**
Harbour porpoise (Baltic Proper)	x	x protected	-	-	-	x
Harbour porpoise (Western Baltic, Belt Sea, Kattegat)	x	x protected	-	(x) to be recalculated from original survey data	-	x

Threshold values for seals

No specific removal targets for seal incidental by-catch have been formulated to date that could directly be applied as a threshold value for this core indicator. The HELCOM Recommendation 27-28/2 recommends reducing incidental by-catches of seals to a minimum level and if possible to a level close to zero and to develop efficient mitigation measures.

The conservation target for seals within the HELCOM area is that the populations grows until limited by the environmental carrying capacity of their Baltic Sea habitat. Recovery towards this target will be allowed as a long-term objective. A lower reference limit below which the survival of the population is at risk and a middle reference limit are used for anthropogenic removal licenses. The overall target is to continually improve the situation of the seal species, but no timescale for its achievement is given (Lonergan 2011).

Information about the distribution of Baltic seal species is provided in more detail in the core indicator on distribution of Baltic seals.

No threshold value can yet be given for seals. As a consequence, the three seal species have to be added in the indicator assessment as soon as threshold values are available. Incidental by-catch estimations for grey seals are available from Vanhatalo et al. (2014, see above).

So far, there are no threshold values for incidental by-catches of seals. However, existing data would allow the development of PBR or CLA for some seal species to begin with. Demographic and abundance data as well as population boundaries have been quite well examined. For grey seals, an incidental by-catch estimate is available (Vanhatalo et al. 2014). Thresholds table 3 shows what data may already be available in order to derive assessment values and add further species to the descriptive evaluation.

Thresholds table 3. Available data for further development threshold values based on PBR and/or CLA values (x = some data available to fill the knowledge gaps, - = no data available).

Species (population)	Incidental by-catch estimate	Hunting bag	Estimate of other anthropogenic removal (e.g. oiled birds, vessel collision with mammals, detonations etc.)	Minimum estimate of population size N_{min}	Maximum population growth rate R_{max}	Population trend (in order to set the recovery factor in PBR calculations)	Population model fit to current population size N_T (time series of population estimates available)	Current status D_T	Maximum population growth rate R_{max}
Harbour seal (Kalmarsund)	-	(x) protected	-	x	x	x	x	x	x
Harbour seal (Western Baltic)	-	x	-	x	x	x	x	x	x
Grey seal (Baltic Sea)	x	X	-	x	x	x	x	x	x
Ringed seal (Baltic Sea)	-	x	-	x	x	x	x	x	x

Threshold values for otters

HELCOM (2013) lists incidental by-catch in fishing gear, among others pressures, as a major threat to Eurasian otters. However, the extent of the problem is not known. Fykenets might pose the greatest threat to Eurasian otters (Raby et al. 2011). No goals or threshold value for incidental by-catch reduction have been formulated yet. As a consequence, otters have to be added in the indicator assessment as soon as better data are available.

So far, there are no threshold values for incidental by-catches of otters. Thresholds table 4 shows that no data are available in order to derive assessment values.

Thresholds table 4. Available data for further development threshold values based on PBR and/or CLA values (x = some data available to fill the knowledge gaps, - = no data available).

Species	Incidental by-catch estimate	Hunting bag	Estimate of other anthropogenic removal (e.g. oiled birds, vessel collision with mammals, detonations etc.)	Minimum estimate of population size N_{min}	Maximum population growth rate R_{max}	Population trend (to set recovery factor in PBR calculations)	Population model fit to current population size N_T (time series of population estimates available)	Current status D_T	Maximum population growth rate R_{max}
Eurasian otter	-	(x) protected	-						

Threshold values for waterbirds

A reduction in the number of incidentally by-caught waterbirds is needed to reach their specific conservation goals. For the species concerned, analyses of thresholds for unacceptable losses of individuals are lacking, but are urgently desired as soon as data from incidental by-catch monitoring become available. It has to be stressed that many of the waterbirds species concerned have high longevity, low reproductive rates and late maturity. These characteristics make them vulnerable to the loss of adult individuals in particular (Bernotat & Dierschke 2016). However, knowledge about demographic parameters, such as survival rates, reproductive performance, and delineation of population segments is sparse or unavailable for many of the species affected by incidental by-catch (Žydelis et al. 2009). One option using limited demographic information is the PBR approach. The main advantage of the PBR approach is that it relies on those demographic parameters which are easiest to obtain for many bird species. Further, it is ready for use whereas specific demographic models still have to be developed for species concerned.

Removal targets considered as provisional thresholds for this indicator have been derived using the PBR concept in some initial studies. PBR has been calculated for three waterbird species which are known to be incidentally by-caught in high numbers: long-tailed duck, greater scaup and common guillemot (Žydelis et al. 2009). The use of PBR as provisional targets and thresholds in this indicator will have to be refined at a later stage because this requires further testing and validation before they can be used as a robust basis for threshold value setting (see also Richard & Abraham 2013). For an improved analysis more sophisticated methods may be required in the future of which PVA and CLA are possible options. Ultimately, individual-based modelling has a potential to provide the best assessment, in particular when evaluating multiple anthropogenic pressures in combination.

The thresholds for the waterbird species used in this indicator must not be confused with a 'maximum allowable catch'. The concept of 'maximum allowable catch' of seabirds appears not to be consistent with the EU Plan of Action (European Commission 2012) overall objective to 'minimise and where possible eliminate' incidental by-catch and with Article 5 of the EU Birds Directive, which requires Member States to take measures prohibiting the 'deliberate killing or capture [of birds] by any method'. According to Article 7 of the Birds Directive, exceptions from the prohibition of deliberate killing are allowed in the context of hunting, and some of the species listed in Annexes II/1 and II/2 include species prone to drowning in fishing gear in the Baltic Sea. Also, uncertainties impede the application of PBR in a management context so far to set trigger levels for incidental by-catch in a population (ICES 2013b).

In northern Europe, the impact of incidental by-catch on population dynamics has so far only been estimated for three species by applying the PBR approach. CLAs have not been applied to waterbird populations and would require information on population trends currently unavailable for the majority of Baltic waterbirds. Application of PBR and CLA approaches appears to allow for formulation of species-specific removal targets for waterbirds, as soon as reliable estimates of the species specific mortality levels can be obtained through incidental by-catch monitoring. A prerequisite for the application of PBR and CLA is knowledge about the species specific mortality and population sizes as input parameters, but data are not yet sufficiently available for all species.

An overview of recent estimates for the numbers of waterbirds wintering in the Baltic Sea is given by Skov et al. (2011). Accordingly, the incidental by-catch problem concerns 8,575 red-throated and black-throated divers, 8,300 great crested grebes, 770 red-necked grebes, 2,890 Slavonian grebes, 54,000 great cormorants, 30,450 common pochards, 476,000 tufted ducks, 127,000 greater scaups, 515,000 common eiders, 2,300 Steller's eiders, 1,486,000 long-tailed ducks, 412,000 common scoters, 373,000 velvet scoters, 174,000 common goldeneyes, 12,600 smew, 25,700 red-breasted mergansers and 66,000 goosanders, but also considerable numbers of common guillemot, razorbill and black guillemot (the latter alcid species not quantified by Skov et al. 2011).

For the threshold values in this indicator, so far no calculations have been made. Instead PBR values were derived from Žydelis et al. (2009). It is intended to calculate more PBR values or, in order to account for the large variation between upper and lower confidence levels, to introduce CLA method. For these calculations, preferably recent data on incidental by-catches and population size is needed as well as some demographic data. Good environmental status table 5 shows what data may already be available in order to derive assessment values and add further waterbird species to this initial assessment in the near future.

It is important to consider other relevant anthropogenic mortality than incidental by-catch such as from hunting and oiling when applying PBR or CLA values. Hunting bag data is collected in many - but not all - countries on the migration routes of the waterbirds to be considered. National data must be collected either in form of national reports to HELCOM or in scientific projects. Further, waterbirds are facing the danger of plumage oiling. High numbers of waterbirds (especially long-tailed ducks) were killed due to plumage oiling in the early 21st century (Larsson & Tydén 2005). Since then the number of oil spills and the volume of oil detected in the Baltic Sea have decreased (HELCOM 2017). Scientific studies are required to derive more recent estimates of oil victims per species in areas significantly affected from oil pollution. Recent studies on oiling of waterbirds is available for some coasts of the North Sea which is another overwintering area for some of the waterbirds relevant for this indicator (e.g., Camphuysen et al. 2009).

PBR approach is used in provisional assessments in this indicator because there is data available for three waterbird species of concern. It is however acknowledged, that the CLA approach may produce a more reliable assessment because it uses time series of incidental by-catch and abundance data and thus reduces uncertainties. As in harbour porpoises, priority should be given to develop CLA for the most vulnerable waterbird species. Additional demographic data such as survival rates may be needed for the relevant bird species to improve simulations.

Further demographic modelling and testing of PBR is needed for all species in the future. Whatever approach is used in the assessment, more recent incidental by-catch and population estimates are needed in order to calculate PBR or CLA values (see Monitoring Requirements). Since these indicate a limit of anthropogenic mortality, also estimates for other causes of mortality (especially oiling and hunting) are needed.

Thresholds table 5. Available data for further development threshold values based on PBR and/or CLA values. Hunting bag data from Mooij 2005. Maximum population growth rate (R_{max}) was calculated from data in Bernotat & Dierschke (2016) preliminarily.

	Estimates of anthropogenic mortality			Input needed for PBR calculations: Removal limit= N_{min} x 0.5 x R_{max} x F			Input needed for CLA calculations: Removal limit= α x R_{max} (D_T - β) x N_T		
Species	Incidental by-catch estimate	Hunting bag (incl. cripple loss)	Estimate of other anthropogenic removal (e.g. oiled birds, vessel collision with mammals, detonations etc.)	Minimum estimate of population size N_{min}	Maximum population growth rate R_{max}	Population trend (to set recovery factor in PBR calculations)	Population model fit to current population size N_T (time series of population estimates available)	Current status D_T	Maximum population growth rate R_{max}
greater scaup		2,513		154,000[a]	1.36	fluctuating[a]			1.36
long-tailed duck		30,101		1,430,000[a]	1.25	decreasing[a]			1.25
common guillemot				27,280[b]	1.07	stable[b]			1.07
black guillemot				31,880[b]	1.14	decreasing[b]			1.14
razorbill				66,400[b]	1.12	increasing[b]			1.12
goosander		20,183		134,000[a]	1.36	decreasing[a]			1.36
red-breasted		10,771		87,700[a]		uncertain[a]			
smew				31,500[a]		fluctuating[a]			
common goldeneye		152,663		375,000[a]	1.32	stable[a]			1.32
velvet scoter		8,409		322,000[a]	1.28	decreasing[c,a]			1.28
common scoter		7,103		682,000[a]	1.29	increasing[a]			1.29
common eider		145,374		2,480,000[a]	1.23	decreasing[a]			1.23
Steller's eider				30,800[a]		stable[a]			
tufted duck		137,008		1,040,000[a]	1.58	decreasing[a]			1.58
common pochard		135,821		510,000[a]	1.34	decreasing[a]			1.34
Slavonian grebe				3,700[a]		fluctuating[a]			
red-necked grebe				3,700[a]	1.27	unknown[a]			1.27
great crested grebe				292,000[a]	1.32	fluctuating[a]			1.32
black-throated				9,900[a]	1.18	fluctuating[a]			1.18
red-throated diver				42,400[a]	1.18	increasing[a]			1.18
great cormorant				401,000[a]	1.16	increasing[a]			1.16

[a] European wintering population (BirdLife International 2015), [b] Baltic breeding population (BirdLife International 2015), [c] Baltic wintering population (Skov et al. 2011).

Assessment Protocol

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Due to the lack of data, at this stage the assessment is rather descriptive. The basic principles to be used once the underlying data can be further completed is described. Good status is achieved if the incidental by-catch numbers of all assessed species within a given assessment unit are below the removal target used as the threshold value taking also other human-induced mortality into account. A population-specific evaluation is applied to all HELCOM level 2 sub-basins in which i) the population occurs and ii) fishing methods causing incidental by-catch are spatially overlapping with the distribution of that population.

The evaluation for a single sub-basin is done using the 'one-out, all-out' principle, which for instance is applied in the EU Water Framework Directive (European Commission 2000). In this indicator, this means that good status is not reached if incidental by-catch for a single population contributes to exceeding the pre-defined threshold value of human induced mortality for that population (for waterbirds; for harbour porpoises the removal target is related explicitly to incidental by-catch).

It must be taken into account that not all species are distributed throughout all sub-basins. Consequently, for areas outside the distributional range, no conservation or removal target for the species are needed in the particular sub-basin and the number of species assessed varies among the sub-basins. For the two populations of harbour porpoise and the three waterbird species initially assessed in this indicator the occurrence in the sub-basins is shown in Assessment protocol table 1. Assessment protocol table 2 indicates published data on incidental by-catches per species and sub-basin.

Besides assessing incidental by-catch on a population scale (see below: assessment units), it may be desirable for management purposes to downscale information in order to implement measures on a smaller scale (e.g. sub-basin, HELCOM scale 2). Difficulties exist both in measuring incidental by-catch and population size to a sufficiently high degree of accuracy on such a small scale. If this information becomes available, the assessment units may be downscaled for management purposes. In Assessment protocol table 1, some examples of mammal and waterbird distributions are downscaled (not quantitatively) from populations to HELCOM assessment unit scale 2.

Assessment protocol table 1. Distribution of some marine mammals and waterbirds on the level of HELCOM level 2 sub-basins (after Durinck et al. 1994, Skov et al. 2011, Sveegaard et al. 2011, ASCOBANS 2016b).

	Kattegat	Great Belt	The Sound	Kiel Bay	Bay of Mecklenburg	Arkona Basin	Bornholm Basin	Gdansk Basin	Eastern Gotland Basin	Western Gotland Basin	Gulf of Riga	Northern Baltic Proper	Gulf of Finland	Aland Sea	Bothnian Sea	The Quark	Bothnian Bay
Harbour porpoise Baltic Proper population					?	x	x	x	x	x	?	x	?	x	?	?	?
Harbour porpoise Western Baltic, Belt Sea and Kattegat population	x	x	x	x	x	x	?										
Greater scaup	x	x	x	x	x	x	x	x	x	x	x	x	x				
Long-tailed duck	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Common guillemot	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		

Assessment protocol table 2. Indication of published data on incidental by-catch related to species and sub-basin.

	Kattegat	Great Belt	The Sound	Kiel Bay	Bay of Mecklenburg	Arkona Basin	Bornholm Basin	Gdansk Basin	Eastern Gotland Basin	Western Gotland Basin	Gulf of Riga	Northern Baltic Proper	Gulf of Finland	Aland Sea	Bothnian Sea	The Quark	Bothnian Bay
Harbour porpoise Baltic Proper population					?	?	x	19	19	x	?	x	?	x	?	?	?
Harbour porpoise Kattegat/Belt Sea/Western Baltic population	20	20	20	20	20	20	?										
Greater scaup	x	x	x	5	13, 14	x	4	8, 9	x	x	11, 12	x	x				
Long-tailed duck	1	18	x	5, 6, 18	6	x	4, 7	8, 9	10, 11, 12, 15, 16, 17	x	11, 12	12	12	x	x		
Common guillemot	1	18	3	3, 18	3	3	2, 3, 4, 7	3, 8, 9	2, 3, 10, 12, 16, 17	2, 3	11, 12	2, 3	3	2, 3	3		

x = species occurring, number = reference to incidental by-catch:

1: Oldén et al. 1988: gill nets for cod and herring; 90-95% common guillemot, 3-7% great cormorant, <1% long-tailed duck

2: Lynneryd et al. 2004: Common guillemot in post-breeding season mainly around Gotland, in the Skerries and in the Åland Sea – areas with gillnet fishing. Also common guillemots caught in gillnets with pingers in Hanö Bight.

3: Olsson et al. 2002 and Österblom et al. 2002 (summarzied in Erdmann et al. 2005): map with ring recoveries of common guillemots found in fishing gear (mostly gillnets). Because data are used from 1912 onwards, only sub-basins with many recoveries (i.e. probably including recent ones) are considered.

4: Schirmeister 2003 and Erdmann et al. 2005: Long-tailed ducks very often caught in gillnets off Usedom, to a smaleer amount also greater scaups and common guillemots.

5: Kirchhoff 1982: long-tailed ducks and greater scaups by-caught by gillnet fishery in Kiel Bay.

6: Mentjes & Gabriel 1999: weak to strong bycatch of “ducks” (no species mentioned) west and south of Fehmarn; can be refered to a general bycatch risk for long-tailed ducks in those areas.

7: Kowalski & Manikowski 1982: in gillnets between Dzivnow and Pobierowo (Pomeranian Bay) bycaught birds comprised 53% long-tailed ducks and 0.3% common guillemots.

8: Stempniewicz 1994: in gillnets between Hel, Gdynia and Vistula mouth (Gdansk Basin) bycaught birds comprised 48.3% long-tailed ducks, 7.7% greater scaups and 0.8% common guillemots.

9: Kies & Tomek 1990: in gillnets in Zatoka Pucka (Gdansk Basin) bycaught birds comprised 41% long-tailed ducks, 0.5% greater scaups and 20.5% common guillemots.

10: Dagys & Žydelis 2002: off the Lithuanian coast, the majority of bycaught birds were long-tailed ducks (61%), Alcidae 1%.

11: Urtans & Priednieks 2000: proportions of bycaught birds in the Gulf of Riga: long-tailed duck 35.4%, “diving ducks” 22.9%, auks 5.2%; Baltic Sea (belonging to Eastern Gotland Basin): long-tailed duck 42.5%, “diving ducks” 39.6%. Auks probably include common guillemots and diving ducks probably include greater scaups, although both species are not mentioned in the text.

12: Dagys et al. 2009: Many long-tailed ducks bycaught in Estonian part of Gulf of Finland. There were bycaught long-tailed ducks in other areas of Estonia, and because at least test fishing in the Estonian part of Northern Baltic Proper revealed bird bycatch and the test fishing areas overlap with long-tailed duck distribution (Skov et al. 2011) it can be assumed that this species was actually bycaught there. – Latvia: bycatch occurrence of common guillemot and long-tailed duck in both Gulf of Riga and Eastern Gotland Basin (Latvian parts), greater scaup only in Gulf of Riga. – Lithuania: long-tailed duck 57%, alcids 8% (probably including common guillemot).

13: Bønløkke et al. 2006: report of a greater scaup drowned in fishing net near Rostock (according to German ring recovery database in 1970).

14: Grimm 1985: annual bycatch of 2800 greater scaups in gillnets in Wismar Bay.

15: Larsson & Tydén 2005: incident of 998 bycaught long-tailed ducks on Hoburgs Bank.

16: Žydelis et al. 2006: many beached long-tailed ducks in Lithuania show signs of net entanglement, also some alcids (probably including common guillemot).

17: Bardtrum et al. 2009: turbot gillnet-fishing at east coast of Gotland produces few bycaught common guillemots, and bottom-set gilnnets for cod produced only few bycaught long-tailed ducks on Hoburgs Bank. Two (old?) ring recoveries of greater scaup in fishing gear are reported, but unclear whether east or west of Gotland.

18: Degel et al. 2010: gill net fisheries investigated around Aerø suggest that long-tailed ducks and common guillemots are drowing in gillnets in marine areas belonging to Kiel Bay and Great Belt.

19: ASCOBANS 2016b: Puck Bay incidental catch in semi-driftnets, set gillnets and others

20: ICES 2015, 2016a: estimated bycatch number for ICES subdivisions 22,23 and 24 available, bycatch known in all other areas but without estimate

Assessment units

The indicator is applicable in the whole Baltic Sea, as it is known that incidental by-catches of birds and mammals in fisheries occur in the whole area. The indicator is assessed using HELCOM assessment scale 2 which consists of 17 Baltic Sea sub-basins. The assessment units are defined in the [HELCOM Monitoring and Assessment Strategy Annex 4].

Assessments concerning the incidental by-catch of mammals and birds face the challenge that on the one hand the situation of marine areas needs be assessed on a scale that allows for identification of problem areas where actions should be taken (e.g. within the MSFD framework), but on the other hand the methods available need to be exercised on the level of populations which often additionally are impacted by anthropogenic activities outside the assessment area (especially in migratory waterbirds). Given the high mobility of marine mammals and waterbirds, and the distributional range of populations, assessments will necessarily need to incorporate a scale of the range of a population or management unit, but also needs an adjustment to HELCOM assessment units, with Scale 2 appearing to be an appropriate one.

For example, in the case of the harbour porpoise, two management units exist: 1) the Baltic Proper population and 2) the population of the Western Baltic, Belt Seas and Kattegat. A third management unit is the North Sea population which extends into the Kattegat. Due to the comparatively low fraction of its range and porpoise numbers occurring in the area covered by HELCOM, no separate assessment is made here. Instead we refer to OSPAR M6 indicator. Certain high-density areas (probably representing key habitats) have been identified in the Baltic (Sveegaard et al. 2011; Carlström & Carlén 2016). The preliminary distribution maps produced within the SAMBAH project make it possible to draw a contour around an area where the probability of detecting a porpoise within a given month is e.g. 20% or higher. Based on this, the area around the Midsjö offshore banks south-east of Öland seem to be of crucial importance during the summer months when the Baltic Proper porpoise population is spatially separated from the population of the Western Baltic, Belt Sea and Kattegat. This approach is similar to choosing certain kernel contours based on satellite transmitter data of tagged porpoises (as used in Sveegaard et al. 2011). Incidental by-catch risk assessment can be made combining this data with available information on fishing effort with gear types known for high incidental by-catch risk (e.g. gillnets with large mesh size). A BRA was initially developed for cetaceans at an ICES Workshop (ICES 2010) in order to identify areas and fisheries that are likely to pose the greatest conservation threat to by-caught cetacean species, taking into account the uncertainty of the population structure. The BRA highlights areas where the greatest problems occur and enables educated fisheries management decisions. For an area in the Skagerrak, Kindt-Larsen et al. (2016) demonstrated a clear correlation between incidental by-catch risk and the products of porpoise densities and fishing effort (in terms of soak time). A BRA has been carried out for all Swedish waters and the results will be presented in the revised Swedish action plan for harbour porpoises.

The tentative assessment for this core indicator is made using HELCOM assessment units. For the population of the Western Baltic, Belt Sea and Kattegat, the HELCOM open sea assessment units Kattegat, the Sound, Great Belt, Kiel Bay, Bay of Mecklenburg and Arkona Basin should be combined. Because the assessment for the Kattegat is to be made by OSPAR within their by-catch indicator M6 (which in contrast to this indicator does not include any birds and seals), the threshold should be harmonised between OSPAR and HELCOM.

For the Baltic Proper population, a combination of the assessment units Arkona Basin, Bornholm Basin, Western and Eastern Gotland Basin, Gdansk Basin, Northern Baltic Proper and Åland Sea is necessary (Table 1). More northern and eastern regions may be added as information becomes available if these areas are inhabited by harbour porpoises. In the overlapping area where both populations occur (i.e. Arkona Basin), incidental by-catches should be assigned to both populations as a precautionary approach.

Some waterbird populations extend into areas outside the Baltic. The tentative assessment is made in sub-basins in which the species is known to occur (Assessment protocol table 1) attempting to also consider pressures from areas outside of these areas into account.

Relevance of the Indicator

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Biodiversity assessment

The level of pressures affecting the status of biodiversity is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. This indicator provides an indicator-based evaluation of the numbers drowned mammals and waterbirds in fishing gear, and this information should be considered together with other biodiversity core indicator evaluations in order to achieve an overall assessment of the status of biodiversity, particularly once further developed.

Policy Relevance

The core indicator on number of drowned mammals and waterbirds in fishing gear addresses the Baltic Sea Action Plan's (BSAP) Biodiversity and nature conservation segment's ecological objectives 'Viable populations of species' and 'Thriving and balanced communities of plants and animals' as well as the Eutrophication segment's ecological objective 'Natural distribution and occurrence of plants and animals'. It also addresses the following specific target:

'By 2015 by-catch of harbour porpoise, seals, water birds and non-target fish species has been significantly reduced with the aim to reach by-catch rates close to zero'.

In the BSAP, it was further agreed to set up a reporting system and database for harbour porpoise incidental by-catch, and competent fisheries authorities were urged to minimize the incidental by-catch of harbour porpoises.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining Good Environmental Status (European Commission 2008a):

Descriptor 1: 'Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions' and

Descriptor 4: 'All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity',

and the following criteria of the Commission Decision (European Commission 2010):

- Criterion D1C1 (mortality rate from by-catch)
- Criterion D1C2 (population abundance)
- Criterion D1C3 (population demographic characteristics)
- Criterion D1C4 (species distribution)
- Criterion D4C1 (diversity of trophic guild)
- Criterion D4C2 (balance of total abundance between trophic guilds)
- Criterion D4C4 (productivity)

For the three seal species occurring in the Baltic Sea, the HELCOM Recommendation (27-28/2) adopted in 2006 relating to seals recommends:

- to take effective measures for all populations in order to prevent illegal killing, and to reduce incidental by-catches to a minimum level and if possible to a level close to zero;
- to develop and to apply where possible non-lethal mitigation measures for seals to reduce incidental by-catch and damage to fishing gear, as well as to support and coordinate the development of efficient mitigation measures.

Presently, management objectives for all protected species are unclear at the EU level (ICES 2013a). While broad commitments have been made to achieve Good Environmental Status (GES) under the EU Marine Strategy Framework Directive (MSFD), and to Favourable Conservation Status (FCS) under the Habitats Directive, translating these goals into specific targets on incidental by-catch limits is as yet unspecified by the EU.

The EU Habitats Directive lists harbour porpoise as a strictly protected species (Annex IV). The harbour porpoise and the three seal species are listed in Annex II, meaning that they are to be protected by the means of the Natura 2000 network. Article 12, paragraph 4 of the Habitats Directive states that Member States shall establish a system to monitor the incidental capture and killing of the animal species listed in Annex IV (a) (European Commission 1992). In the light of the information gathered, Member States shall take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned. Member States of the EU are further obliged to develop national programmes for monitoring fisheries, including on board monitoring, under Article 3 of Council Regulation 199/2008, Commission Regulation 665/2008 and the Annex of Commission Decision 2010/93/EU (European Commission 2008b, 2008c, 2009a). These plans include detailed data on fleet capacity and fishing effort by metier and fishing area.

The EU Birds Directive aims to protect, inter alia, habitats of endangered and migratory birds to ensure their conservation in the Europe (European Commission 2009b). This not only refers to birds needing special conservation measures (Article 4 (1)) and listed in Annex I (black-throated diver, red-throated diver, Slavonian grebe, Steller's eider, smew), but also to all migratory species (Article 4 (2)). Therefore, all waterbird species breeding, wintering and staging during migration in the Baltic Sea are covered by this Directive.

EU legislation clearly requires Member States to take measures prohibiting deliberate killing or capture by any method (Article 5 Birds Directive; Article 12 Habitats Directive) which also includes the mere acceptance of the possibility of killing or capture (Case C-221/04 Commission v Spain [2006] ECR I-4515, paragraph 71). Further, the Habitats Directive requires that incidental capture or killing of cetaceans is monitored, and that it should not have a significant negative impact on the species.

As a voluntary instrument within the framework of EU and international environmental and fishery legislation and conventions, the EU Commission has adopted an 'Action Plan for reducing incidental by-catches of seabirds in fishing gears' (European Commission 2012). It aspires to provide a management framework to minimise incidental by-catch as much as possible in line with the objectives of the reformed EU Common Fisheries Policy (CFP), i.e. to cover all components of the ecosystem. Among others, proposed action includes the monitoring of seabird incidental by-catch with a minimum coverage of 10% of the fisheries and mitigation measures.

The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) aims to achieve and maintain a favourable conservation status of small cetaceans. Six of the nine Baltic Sea countries are Parties to the Convention (Denmark, Germany, Sweden, Poland, Lithuania and Finland).

All waterbird species occurring in the Baltic Sea are subject of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA).

Role of the pressure exerted through incidental by-catch on the ecosystem

There was a substantial increase in gillnet fisheries in parts of the region, while in other parts gillnet fishing has declined.

In Baltic Sea fisheries, the use of anchored gill nets substantially increased in the 1990s, and because of the change in stock age composition of cod also in the late 1990's and early 2000 (ICES 2016b), intensifying the conflict between certain fisheries and bird and mammal species. Waterbirds diving during foraging in order to catch demersal or pelagic fish (divers, grebes, cormorants, mergansers, alcids) and benthic invertebrates (ducks), respectively, are prone to become entangled in various types of nets and to die by drowning. In addition to hunting (Mooij 2005) and oiling (Larsson & Tydén 2005), drowning in fishing gear is a quantitatively important source of mortality for waterbirds living in the Baltic.

The intensification in use of anchored gill nets in the coastal waters of Estonia, Latvia and Lithuania has substantially increased the risk of drowning for the indicator species in the last decades (Žydelis et al. 1990). In other areas, such as Polish, Swedish and Danish waters, fishing efforts have decreased in recent years, (Katarzyna Kaminska, Ida Carlén & Finn Larsen, pers. comm.).

In the wide range of parameters that influence the population dynamics of birds in general, waterbirds belong to those species with high longevity and low reproductive rates. They are therefore vulnerable to the loss, especially of adult individuals, as it takes a relatively long time to compensate for such losses (Bernotat & Dierschke 2016). For waterbirds living in the Baltic Sea, the mismatch between the loss of individuals and the effort to replace them is most pronounced in alcids, whereas ducks may compensate more easily owing to higher reproductive rates and lower ages of first breeding. However, other factors promoting or impeding population growth rates may override this pattern. For example, changing population sizes are at least partly influenced by favourable food supply (increase of alcids; Österblom et al. 2006), reduced mussel stocks (common eider; Laursen & Møller 2014) or low reproductive success (long-tailed duck; Hario et al. 2009).

The same applies to harbour porpoise and seals, which are top predators in the Baltic Sea marine food web and which, due to their population dynamics, are vulnerable to additive mortality (Bernotat & Dierschke 2016). Incidental mortality that exceeds the potential rate of increase will drive a population to extinction. It is thus necessary to keep the sum of all anthropogenic mortality, including incidental by-catch, below a critical value. From the conservation perspective, immediate management consequences are needed if this critical value is exceeded. In 1991, the Scientific Committee of the International Whaling Commission recommended that incidental mortality should not exceed half of the potential rate of increase (IWC 1991). Furthermore, incidental mortality greater than one fourth of the potential rate of increase should be considered cause for concern (IWC 1996). The figure for the potential rate of population increase for harbour porpoises used for population model simulations by ASCOBANS and the IWC is 4% per annum based on their known life history parameters. Given the high levels of environmental contaminants, including heavy metals and PCBs, of harbour porpoises in the Baltic Sea and impaired immune function (e.g. Siebert et al. 1999, Beineke et al. 2005, 2007a,b, Ciesielski et al. 2006) and the correlation between lower PCB burdens and reproductive failure in UK harbour porpoises (Murphy et al. 2015), the reproductive rate of harbour porpoises in the Baltic Sea may be lower than this generically used rate of increase.

For harbour porpoises, the incidental by-catch risk is highest in various types of gillnets: set gill nets (gear type: GNS), entangling nets (trammel nets, GTR) and driftnets (GND) (ICES 2013a). The latter are banned in the Baltic Sea, but some hybrid nets such as 'semi-driftnets' which are fixed on one end of the net with the other end drifting around this anchor are of special concern (Skora & Kuklik 2003). In a number of cases, fisheries have tried to circumvent driftnet restrictions of the EU Common Fisheries Policy (CFP) through minor technical modification (Caddell 2010). Due to their properties (one end freely drifting around an anchor), semi-driftnets which are locally used in Poland may thus attract close attention from the Commission in future years, if they remain widely used on a commercial scale (Caddell 2010). These nets have been reported as GND until 2007, and now (after the ban of GND) are considered GNS (Hel Marine Station, pers. comm.). The Proposal for a Regulation on the conservation of fishery resources and the protection of marine ecosystems through technical measures (COM(2016)134 final-2016/0074, 11.3.2016) is still preliminary as work is still in progress. Therefore the Commission has not finally decided a definition of set-nets in Art. 6(21) which accounts for the hybrid nature of semi-driftnets .

The mean longevity of harbour porpoises is only 8-10 years (Read & Hohn 1995; Lockyer & Kinze 2003; Bjørge & Tolley 2009). Stranding data show that only 5% of porpoises live beyond 12 years (Lockyer & Kinze 2003). Sexual maturity is reached late, at the age of 3 to 5 years (Sørensen & Kinze 1994; Adelung et al. 1997; Benke et al. 1998; Lockyer & Kinze 2003). Based on this, it is estimated that a female with a longevity of about 10 to 12 years can deliver only 4 to 6 calves during its life span (Lockyer & Kinze 2003), which would only allow for slow recovery.

Monitoring Requirements

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Monitoring methodology

Monitoring relevant to the indicator is described on a general level in the **HELCOM Monitoring Manual** in the **sub-programme: Fisheries by-catch**.

Current national discard/by-catch monitoring programmes carried out under the EU data collection framework (DCF) do not target marine mammal and bird incidental by-catches. Monitoring under the EU council regulation 812/2004 protecting cetaceans against incidental by-catch (European Commission 2004) lays measures concerning incidental by-catches of cetaceans in fisheries using onboard observers but is limited to larger vessels and hence results in the lowest observer coverage of fisheries posing greatest threat to porpoises and seals in the Baltic Sea (ICES 2013a).

Current monitoring

No regular monitoring activities relevant to the indicator are currently carried out by HELCOM Contracting Parties (see **HELCOM Monitoring Manual** in the Monitoring Concept Table).

Sub-programme: Fisheries by-catch

Monitoring Concept Table

All HELCOM Contracting Parties which are also EU Member States are obliged to carry out monitoring to provide estimates of population sizes in accordance with the requirements of the Habitats Directive and the Birds Directive.

Contracting Parties currently do not comply with Article 12 Habitats Directive as there is no monitoring in place that gives information that serves the target that incidental capture and killing does not have a significant negative impact on the species. Even more, current monitoring practice led to the unsatisfactory situation that the extent of the incidental by-catch problem is still not known and as a consequence only minor conservation measures regarding incidental by-catch (such as the use of pingers in a small fraction of the fishing fleet) are implemented. Some countries have been engaged in developing monitoring based on onboard video cameras recently. To date, it is not clear if this work (from pilot studies) will be extended to a monitoring programme on an annual basis and a representative fraction of the fishing fleets.

A monitoring programme is carried out under the EU Data Collection Framework (DCF). However, fishing métiers under DCF have been selected with respect to fishery data needs rather than bird and mammal incidental by-catch data needs. It is aimed at monitoring the selectivity of gears with respect to fish discarded and thus incidental by-catch of marine mammals and waterbirds are not even specifically addressed but rather recorded opportunistically at best. Only adding opportunistic incidental by-catch data to monitoring programmes focusing otherwise on size and (fish) species selectivity of certain fishing gears does not provide the needed data to enhance the confidence of the indicator. To some minor extent, waterbird incidental by-catch was monitored in Denmark, Germany, Poland and Sweden, while cetacean incidental by-catch was monitored under DCF in Denmark, Germany, Latvia, Lithuania, Poland and Sweden (ICES 2013a).

EU Regulation 812/2004 obliges Member States to monitor cetacean incidental by-catch in gillnets. It has been debated what gears are covered by the Regulation, as gear definitions were not formulated clearly enough for fisheries managers of some Member States (ICES 2010). This is why e.g. some Member States omitted monitoring of trammel nets (GTR) although it is known that porpoises are also by-caught in these nets (Pfander et al. 2012). Further, monitoring under Regulation 812/2004 is not suited to the data needs for this indicator or the original idea behind the Regulation because only vessels >15 m are covered by the observer programme and the majority of Baltic gillnet fisheries is carried out by small vessels which use the same gear. Vessels <15 m are allowed to set 9 km (vessel length <12 m) or even 21 km (vessel length >12 m) of gillnets, respectively, illustrating the high risk of incidental by-catch even by small vessels.

The Regulation also requires that Member States should design pilot schemes for small vessels; this has often not been done. The idea of scientific pilot studies is to give some indication on incidental by-catch numbers and provide information on what monitoring method might be suitable for small vessels, although cannot replace monitoring in this large fishing segment.

Only very limited data are collected for protected waterbird taxa under DCF, and it is not possible to estimate effort or coverage. Besides national differences there are large differences in coverage between fishing métiers favouring larger vessels and mainly trawlers. As a result, there are no agreed numbers of by-caught waterbirds and marine mammals for various types of fishing gear (mainly gillnets and entangling nets) in the Baltic Sea, because so far no adequate observer coverage has been achieved with existing monitoring programmes such as DCF and Regulation 812/2004. On the other hand, the results of pilot studies such as interviews are frequently questioned by fishermen and fisheries authorities. Especially in métiers which have been identified by pilot studies as fisheries with a high risk for mammal or bird incidental by-catch, monitoring is inadequate and a revision of existing monitoring programmes is urgently needed.

Description of optimal monitoring

Monitoring of by-caught marine mammals and waterbirds should enable the estimation of annual (seasonal) mortality from all kinds of specific fisheries to be compared to the population dynamics of the respective species. Besides effort and incidental by-catch data, data on population size and delineation of sub-populations is also required in order to relate incidental by-catch numbers to the adequate population unit. Monitoring results should not only address the problem of incidental by-catch in general, but should allow to quantify impacts in order to propose management measures such as (temporary) closures of specific fisheries or fishing areas. Optimal monitoring would therefore also provide reliable population size estimates for all species considered from the incidental by-catch perspective.

The indicator requires estimates of population sizes for those species suffering from incidental by-catch. While such estimates are available for a number of marine mammals (especially seals) due to target-oriented surveys, they are quite crude for most waterbird species, especially those wintering in offshore areas. Further, uncertainties in population estimates and incomplete knowledge on spatial and temporal distribution patterns have to be addressed. Thus, internationally coordinated surveys need to be organized and should be embedded into the respective HELCOM abundance indicators.

The species covered by the indicator are highly mobile and fishing methods differ between sub-regions or even on a local level. Due to the resulting variability in incidental by-catch risk, a regionally and fishing method differentiated métier monitoring approach that considers fishing activity per spatial unit is recommended. A By-catch Risk Approach (BRA) can be used to identify areas and fisheries that are likely to pose the greatest conservation threat to incidentally caught species, taking into account the uncertainty of their population structure. A BRA was initially developed for cetaceans at an ICES Workshop (ICES 2010). It can also help optimising different methods of monitoring. The BRA highlights areas where the greatest problems occur and enables educated fisheries management decisions such as proactive mitigation measures before incidental by-catches occur. This is especially important for the critically endangered Baltic Proper harbour porpoise population.

Effort monitoring, as well as incidental by-catch monitoring, has to be carried out on a fine spatial scale in order to relate incidental by-catch to both fishing effort and abundance of mammals and birds. Fishing effort must be monitored in a meaningful parameter (length of nets * soak time instead of simply days at sea). The documentation of net length in the logbook (i.e. for vessels 10 m and longer) used is obligatory in EU fisheries since 2015 (EU Regulation of Implementation 2015/1962). Some national peculiarities apply. E. g. in Sweden, the coastal gillnet fishermen (vessels <8m in the Baltic marine region and <10m in the Atlantic marine region) are obliged to report their effort in meters*days for each gillnet type, mesh size and fishing location. Larger vessels are obliged to report number of nets, net length, and time for set and haul for each gillnet type, mesh size and fishing location. Since not all effort is recorded (small vessels, recreational net fisheries) and thus has to be estimated the uncertainty in the fishing effort estimates which underlie the incidental by-catch estimate needs then to be specified by adding a CV or 95 % confidence interval.

Appropriate monitoring is needed, so as not to put more burden than necessary on fisheries from management measures to fulfil legal conservation obligations. Monitoring must be able to cover all fisheries and all kinds of vessels. A comprehensive monitoring would use on-board and off-board observers, onboard CCTV cameras (also called Remote Electronic Monitoring, REM, Kindt-Larsen et al. 2012), and possibly additional methods such as interviews (ICES 2013b). In some cases, such as in fisheries with small open boats, self-sampling may be a component of the monitoring programme, but data quality must be verified independently.

Human observers are an important component to sample incidental by-catch and collect information on composition and number of incidental by-catch and to deliver specimen to the relevant authorities in order to conduct further examinations regarding age, sex, nutritional state, and injuries. In addition, stomach contents may help to identify in more detail the conflict between marine areas selected by fisheries and habitat demands of mammals and birds. Stranding networks can provide further incidental by-catch information if collected specimen are examined for net marks and previous injury which could have caused incidental by-catch. However, limitations in data quality have to be accounted for (e.g. beached bird surveys may indicate incidental by-catch but never give any information on the type of gear or nationality of the fishing vessel which caused the fatality).

ICES (2013a) has addressed the question of whether it is possible to combine monitoring of protected and endangered species and discard sampling (which will be the main focus of fishery monitoring due to the discard ban) in the same sampling scheme. However, it is unlikely that protected and endangered species will be kept on board or landed since this could infringe on existing national legislation of numerous Member

States (ICES 2013a). As a minimum requirement, provisions must be taken that detailed, meaningful photographs of by-caught mammals and birds can be taken if landing is not possible.

It is hoped for that the knowledge on incidental by-catch of waterbirds and marine mammals will greatly be improved once a suitable monitoring scheme is implemented on regional and national levels within the revised DCF, now termed *EU Data Collection Multi-Annual Programme* DC-MAP: The DC-MAP will guide future fishery monitoring and data collection within the EU, covering a broad range of objectives including the discard ban. It is crucial that in the regional implementation process an adequate sampling coverage plan is developed including mammal and waterbird incidental by-catch in all relevant fisheries (commercial, part-time and recreational) in the Baltic Sea including all vessel sizes.

Further actions for optimizing electronic monitoring

Pilot studies using cameras for monitoring harbour porpoise and bird incidental by-catch have shown that these have the potential to be a practical and economic tool for obtaining reliable incidental by-catch data. Further work is required to demonstrate the potential of the technique to perform consistently with regard to species identification and that all incidents are being detected (ICES 2013b). However, fishermen may reject these systems for personal reasons, hence research and international collaboration is needed on how to create a trustful attitude and to overcome personal reservations against onboard CCTV camera systems.

A main drawback of the onboard camera monitoring of bird and mammal incidental by-catch is that a large footage has to be viewed to verify the data from fishermen's protocols. In order to further reduce costs of a monitoring programme based on video observation, it may be helpful to computerize the work and view only preselected footage. Thus, the development and validation of reliable automated recognition systems for onboard camera systems is desirable.

Data and updating

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Access and use

The data and resulting data products (tables, figures and maps) available on the indicator web page can be used freely given that the source is cited. The indicator should be cited as following:

HELCOM (2018) Number of drowned mammals and waterbirds in fishing gear. HELCOM core indicator report. Online. [Date Viewed], [Web link].

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Metadata

There is currently no source of monitoring data which specifically compiles and analyses the numbers of by-caught waterbirds and marine mammals in a representative manner. Some information on harbour porpoise incidental by-catch is taken from the ICES WGBYC database (as presented in the reports ICES 2015, 2016a) which is based on information in Reg. 812/2004 National Reports.

Temporal coverage of monitoring data is poor. Some studies can be used for historical sporadic information on numbers of by-caught waterbirds and mammals. These sporadic data have a very poor spatial coverage (see map in Žydelis et al. 2009).

In the BSAP, it was agreed to set up a reporting system and database for harbour porpoise incidental by-catch which have not yet been developed.

Contributors and references

This pre-core indicator and its threshold values are yet to be commonly agreed in HELCOM.
The indictor is included as a test indicator for the purposes of the 'State of the Baltic Sea' report, and the results are to be considered as intermediate.

Contributors

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Archive

This version of the core indicator report was published in July 2018

Number of drowned mammals and waterbirds HELCOM core indicator 2018 (pdf)

Earlier versions of this indicator are available at:

HOLAS II component - Core indicator report – web-based version July 2017 (pdf)

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