Baltic Marine Environment Protection Commission

Working Group on the State of the Environment and Nature Conservation

Tallinn, Estonia, 7-11 November, 2016

STATE & CONSERVATION 5-2016

Document title	'Nutritional status of marine mammals' – revised core indicator report
Code	4J-24
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Submitted by	Lead Country Sweden

Background

STATE & CONSERVATION 2-2015 agreed on GES-boundaries for the core indicator 'Nutritional status of marine mammals', taking note of general study reservations by Denmark and Germany.

HOD 48-2015, taking note of the study reservations from Denmark and Germany, agreed on indicators and GES-boundaries and further development of the set of indicators (Outcome, Annex 4), including their use in HOLAS II assessment according to the recommendation by the Gear Group (document 3-17), and the publication of agreed core indicator reports at the HELCOM website as they become ready for publishing (para 3.63).

The indicator was considered by SEAL 9-2015 (paragraphs 6.14-6.18) that proposed that the Lead Country representatives and the Seal expert group health team will continue the discussion on the indicators on population condition intersessionally and report the conclusions to SEAL 10-2016.

Revised versions of the indicator reports were submitted for the consideration of STATE & CONSERVATION 4-2016 which encouraged Lead country Sweden and the Seal expert group health team to find a solution as regards the German concerns on whether the indicators can be considered as good indicators of the health status of Baltic seals.

German and Swedish seal experts and HODs of the State and Conservation Working Group met at an ad hoc meeting on 9 September 2016 to discuss the population condition indicators (outcome available via SEAL 10-2016 meeting document 8-2) and the meeting decided to strengthen the cooperation between the indicator Lead Countries and the health team. The ad hoc meeting was of the view that the indicator on nutritional status and development of health indicators can be synchronized and a number of long-term and short-term goals were proposed as outlined in SEAL 10-2016 meeting document 8-2. The further development of HELCOM indicators on marine mammal health will continue with the intention to develop indicators for population dynamics and health for all marine mammal species and for the whole HELCOM area and to set up a database for the health data on seals (paragraph 8.12 in the outcome of SEAL 10-2016)

SEAL 10-2016 considered the revised core indicator report for the indicators 'Nutritional status of marine mammals' and 'Reproductive status of marine mammals' and emphasized that the two indicators are considered as indicators for the demography of seals and a complementary indicator to study trends in occurrence of pathological changes is required to capture other important changes in the environment and causes behind changes in the current indicator on nutritional status.

SEAL 10-2016 noted that the issues behind the Danish study reservation have been acknowledged by the Lead Country, including increasing the number of tentative specimen by defining GES for by-caught seals as well as including reference to improved statistical methods.

This document contains the indicator report for the core indicator 'Nutritional status of marine mammals'. Changes to the document have been tracked. Denmark and Germany still have study reservations on the indicator.

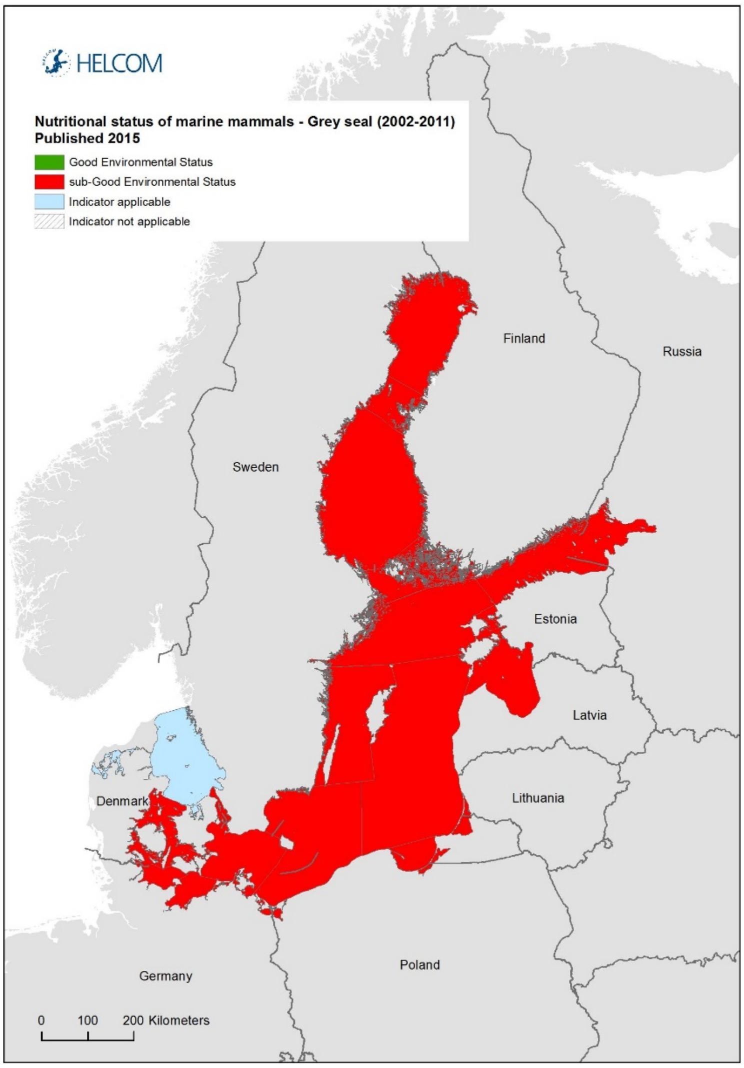
Action requested

The Meeting is invited to consider the revised indicator report.
Denmark and Germany are invited to clarify their study reservations on the indicator.

Nutritional status of marine mammals

Key Message

This core indicator evaluates the status of the marine environment in terms of the nutritional status measured as average blubber thickness of marine mammal populationss as it signals both long term and short term changes in food supply and many other stressors for the seal populationss. Good Environmental Status (GES) is achieved when the subcutaneous blubber thickness is above the defined GES boundary which reflects good conditions. The current evaluation is based on data on grey seals from 2002-2011. The indicator should include all species of seals that occur in the Baltic Sea, however data on harbour seals are not analysed at present and ringed seal data are so far insufficient for evaluations using other species than grey seals. The indicator described here is applicable in all of the HELCOM sea regions since it is a shared population. However all countries do not have access to the same segments of the population due to migration patterns, fishery and national hunting regulations. An additional more detailed measure of seal health must also be developed to evaluate the causes behind found trends. A detailed Healt Indicator would complement the current Nutritional Status indicator and become a powerful tool to evaluate the state of the environment.except SW Baltic where an alternativ measure of nutritional status will be developed.



Key message figure 1: Status assessment results based on evaluation of the indicator 'nutritional status of marine mammals'. The assessment is carried out using Scale 2 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4). Click to enlarge.

Grey seals occur in the entire Baltic Sea, in the Kattegat the species is rare and has not been breeding since the 1930s except for a few observations from recent years. The status of the grey seal in the Baltic Proper is evaluated as a single unit~~, except for SW Baltic~~, whereas the status of the Kattegat grey seal population is evaluated separately. Grey seals do not achieve GES with regard to nutritional status when evaluated as one single population in the entire Baltic Sea. GES boundaries are established.

Ringed seals occur in the Bothnian Bay (which is one management unit), and the Gulf of Finland, Archipelago Sea, Gulf of Riga and Estonian coastal waters (which is a second management unit). The status of ringed seals is evaluated for these two management units. The ringed seal nutritional status is suggested to be declining. GES boundaries are not established yet.

Harbour seals are confined to the Kalmarsund, Southern Baltic Sea, the Kattegat and the Limfjord, all of which are separate management units. The Kattegat and Limfjord subpopulations may be approaching carrying capacity since the annual growth rates are levelling off. GES boundaries with regard to blubber thickness are not finally determined.

Confidence of the indicator evaluation for grey seals is considered to be high.

The indicator is applicable in the waters of all the countries bordering the Baltic Sea as the indicator includes all marine mammal species that occur in the Baltic Sea and since at least one of the species occurs in all HELCOM assessment units.

Relevance of the core indicator

Marine mammals are top predators of the marine ecosystem and good indicators for the state of food webs. Marine mammals accumulate fat soluble hazardous substances such as heavy metals, PCB and PFOS in their tissues and thus reflect the level of pollution in the environment. Seals are also affected by human disturbance such as hunting, by-catches and disturbance, as well as climate change.

Distributions of different species during feeding and annual migrations encompass the entire Baltic Sea, although no land-based haul-out sites occur in Germany, Latvia and Lithuania. Monitoring of the nutritional status of marine mammals occurs in all countries where stranded, by-caught or hunted seals are collected.

Blubber is the energy storage of seals and a reduction in blubber affects reproduction and survival of individual seals and thus gives an early warning of declines in population trends as confirmed by multiple scientific studies world wide. Blubber thickness responds to short-term variations in the environment and is a versatile indicator that complements the population trend and pregnancy rate indicators. However, other relevant aspects of seal health for environmental monitoring are not captured by this indicator. For example a sudden increase in pathological changes in the reproductive tract or an increase in intestinal wounds or a new invasive parasite can also be important indicators of environmental disturbancies and can not be captured properly by the current indicators. Therefore a new Seal Health Indicator should be developed providing more details behind population level trends.

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Biodiversity • Viable populations of species	D1 Biodiversity 1.3. Population condition
Secondary link	Biodiversity: • Thriving and balanced communities of plants and animals Hazardous Substances • Healthy wildlife	D1 Biodiversity 1.1 Species distribution (range, pattern, covered area) 1.2 Population size (abundance, biomass) D4 Food-web 4.1. Productivity of key species or trophic groups 4.3 Abundance/distribution of key trophic groups/species D8 Contaminants 8.2. Effects of contaminants
Other relevant legislation: In some Contracting Parties also EU Water Framework Directive – Chemical quality, Habitats Directive		

Cite this indicator

HELCOM (2015) Nutritional status of marine mammals. HELCOM core indicator report. Online. [Date Viewed], [Web link].

Download full indicator report

Core indicator report – web-based version October 2015 (pdf)

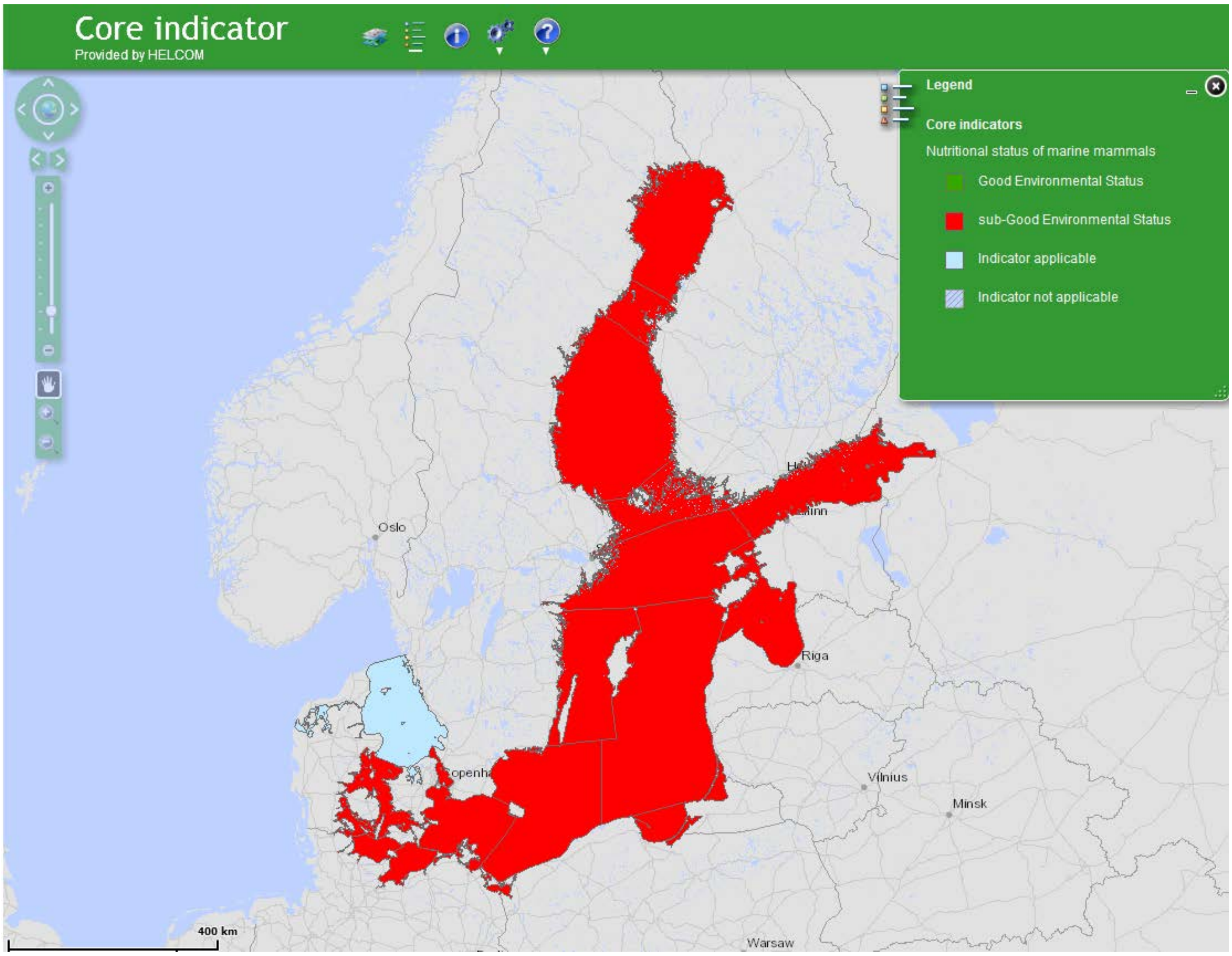
Extended core indicator report – outcome of CORESET II project (pdf)

Results and Confidence

Processed data on blubber thickness is only available for grey seals, and hence the present indicator evaluation only covers this species. Currently, the results are based on combined Swedish and Finnish data but in future evaluations will include also German, Estonian and Polish data.

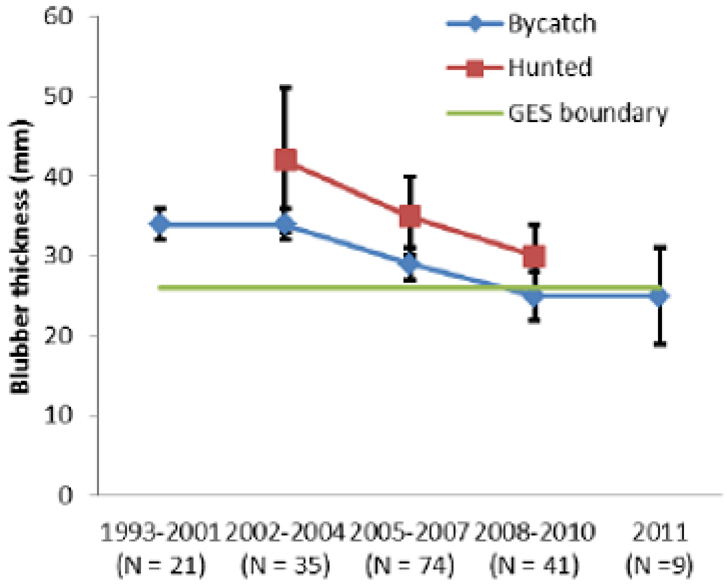
Grey seal

The current evaluation of the nutritional status of grey seals, indicates that Good Environmental Status (GES) has not been achieved (Results figure 1).



Results figure 1. Baltic grey seals do not attain GES with regard to nutritional status, since observed data fails the blubber thickness GES limits of 40mm for hunted seals and 35mm for by-caught seals (in standized samples) Current data suggest that grey seals are approaching the carrying capacity of the Baltic Sea, where the GES boundary of 25 mm is applicable.

A strict Bayesian analysis has not been carried out yet, but it is evident that a steep decline in blubber thickness has occurred, and such an analysis would support that GES has been achieved for the time periods 1993-2001 and 2002-2004, whereas the status would be sub-GES for data from 2008 and later for both hunted and by-caught grey seals (Results figure 2), when tested against the GES boundaries (40 and 35 mm for hunted and by-caught seals respectively). However, it is suggested that GES would be attained in both cases when testing against a GES boundary of 25mm (which is applicable in populations close to carrying capacity).

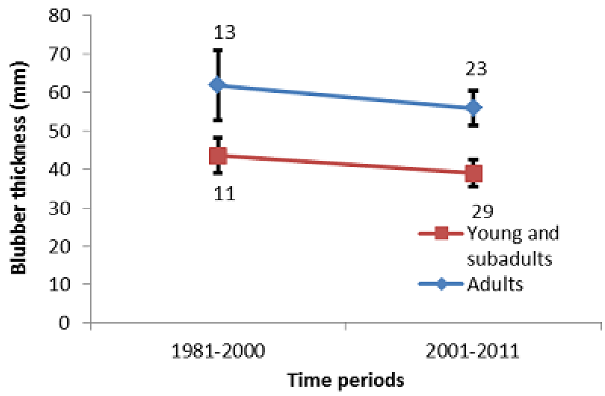


Result figure 2. Grey seals. The mean fall/winter blubber thickness ± SD in examined 1–3 years old non-pregnant by-caught (1993–2011) and hunted (2002–2010) grey seals in Sweden. All were by-caught or shot between August and February. The decrease in blubber thickness is significant (p<0.002). N is the number of investigated animals. Green denotes the GES boundary for populations at carrying capacity. This graph shall be updated continously, new data are available.

Decreasing blubber thickness in both hunted and by-caught grey seals are statistically significant. In Finnish samples of hunted grey seals (1-4 years old) in 2011–2014 the blubber thickness decreased from 43.2 mm to 34 mm (p = 0.015, n = 63). The values were calculated after adjusting the covariate effects of month and area (which were insignificant). The blubber thickness of pups (< 1 year, hunted) decreased from 38.5 mm in 2011 to 23.1 mm in 2015 (p < 0.001, n = 139). The values were calculated after adjusting the covariate effects of month (insignificant) and sea area. The declining trend in the blubber thickness of pups and sub-adults is alarming, and its causes should be examined. It may be a natural trend, if the population numbers are approaching the carrying capacity but it may as well indicate some disturbance in the Baltic Sea ecosystem.

Ringed seal

Although data are still too scarce to establish a GES boundary for ringed seals, data indicate that also the nutritive condition of ringed seals is deteriorating (Results figure 3). Decreasing blubber thickness is seen both in juveniles (1-3 year old) and adults.



Result figure 3. Ringed seals. The mean fall/winter blubber thickness ± 95% CI in examined 1–3 and 4–20 years-old animals (bycaught or shot). GES boundary has not been agreed but suggested by historical data as 35.0 mm and 50.0 mm for young and adults, respectively. Number of samples is given beside the means. In 2011–2015 in Finland and Sweden (in autumn), the blubber thickness of 0–4-year-old seals was 35.8 mm ± 9.67 (n = 40), including both hunted and by-caught seals. The blubber thickness of adults was 57.9 ± 21.34 (n = 10).

Confidence of the indicator status evaluation

Considerable and sufficient material is collected annually for grey seals in Finland and Sweden, so the confidence of the indicator status evaluation for this particular species in the central and northern parts of the Baltic Sea is high. Samples also include Swedish material from the southern Baltic Sea, but it would be desirable to include also samples from Denmark, Germany and Poland.

High confidence for grey seals is supported by earlier studies which have shown that the autumn/winter blubber thickness has decreased significantly in Baltic grey seals since the beginning of 2000s, especially in 1-3 year-old seals from by-catch and hunt (Bäcklin et al. 2011). This decreasing trend has also been observed in young Baltic ringed seals (Kunnasranta 2010) although the latest material from Finalnd might indicate improved conditions. There could be several reasons for a thin blubber layer in the autumn/winter season, e.g. disease, contaminants, decreased fish stocks and change in diet, or a change in the quality of the diet or increasing population density. The reason for the decreasing trend in blubber thickness in seals is unknown but so far no correlations to disease have been found. Data are still scarce for ringed seals in both management units, resulting in low confidence in the evaluation results for this species. For harbour seals material is collected annually, but needs to be compiled and analyzed further.

Good Environmental Status

For grey seal, Good environmental status (GES) is achieved when blubber thickness of sub-adults is at least 40 mm (for hunted seals), 35 mm (for by-caught seals) or 25 mm (if the population is assessed to be at carrying capacity).

The concept for defining a Good Environmental Status (GES) boundary for nutritional status of seals is derived from the general management principle in the HELCOM Recommendation 27/28-2, which states that the population size is to be managed with the long-term objective of allowing seal populations to recover towards carrying capacity levels. The Recommendation further states that the long-term goal is to reach a health status that ensures the future persistence of marine mammals in the Baltic Sea.

Nutritional status (i.e. blubber thickness) is an important aspect of health, affecting somatic growth, age at sexual maturity, fecundity, age specific mortality as well as vulnerability to parasites and diseases. Although approaches such as body mass index (BMI) have been developed for humans, no GES boundaries are available for nutritional status of animal populations, although several studies have shown that seals with lower body weight and lower fat reserves show increased mortality (Kjellqwist et al. 1995, Harding et al. 2005, Bowen et al 2015). At least initially, data from 1-3 year old grey seals of both sexes are used in this indicator (for more information, see the section 'Selection of appropriate data' in the extended core indicator report). GES boundaries are defined for two scenarios: for populations under exponential growth and for populations at carrying capacity. ~~The problem here is that we do not know the carrying capacity of the Baltic Sea for different seal species.~~To establish levels for carrying capacity require further work, but together with the Trend and Abundance indicators for marine mammals and estimates of historical population sizes this should be possible to assess (Harding et al 2002).

The GES boundary for nutritional status is defined based on what is considered to be a good condition in the current environment. ~~Historical data on the nutritional status of marine mammals that could be used to set a baseline in pristine conditions are not available. Instead a~~A modern baseline approach is used to set the GES boundary. This is aligned with the approach used in OSPAR (Commission for the Protection of the Marine Environment of the North-East Atlantic), where baseline levels are set at pristine conditions 'where influence of human impact is minimal', or alternatively, a 'modern baseline when the former isn't applicable'.

Good environmental status table 1. GES boundary values set for grey seals applicable in the entire Baltic Sea.

	GES boundary value	
Samples from	**Populations undergoing exponential growth**	**Populations at carrying capacity**
Hunted seals	40 mm blubber	25 mm blubber
By-caught seals	35 mm blubber	25 mm blubber

To set the GES boundary for grey seals, data on blubber thickness during the period 2001-2004 represents the first available data and is used to form a modern baseline for the GES-boundary concept for populations undergoing exponential growth. Indicator evaluations can be based on animals of ages 1-4 to increase sample size. The GES boundary value is set at 40 mm blubber for samples from hunted seals and

35 mm blubber for by-caught seals. The GES boundary is applicable in the entire Baltic Sea since the population is panmicitc and highly migratory.

Since all growing populations eventually approach the carrying capacity of the ecosystem unless controlled by hunting or limited by stochastic events, vital population parameters will change (see Relevance of the indicator). Nutritional status of seals will deteriorate as a natural consequence of limited food supply, and pups of the year and sub-adults (1-3) are the first segments to be affected. This is a natural process close to carrying capacity, and GES boundary values set for populations under exponential growth are not applicable. To set GES boundary values for populations at carrying capacity thermoregulatory constraints are helpful, since lean seals will have severe problems compensating for heat loss during the winter (Harding et al. 2005). The GES boundary for seal populations at carrying capacity in the whole Baltic Sea is suggested to be around 25 mm blubber for both hunted and by-caught seals, since leaner seals in both categories will have increased risk for not surviving the winter. The exact level of the lower GES should be investigated further.

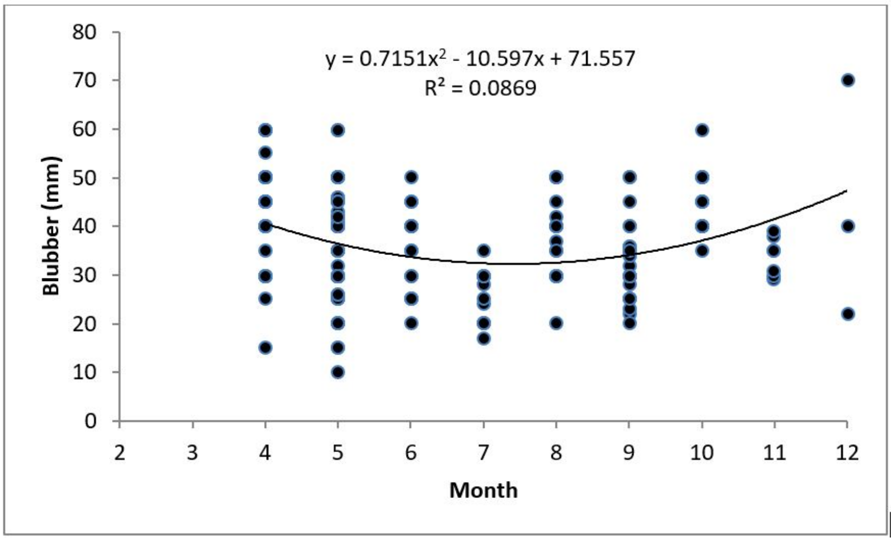
Assessment Protocol

Currently, this core indicator assesses the nutritional status of only grey seals (due to limited data for other marine mammal species).

Each management unit is evaluated against two sets of GES boundaries, the GES boundary for exponentially growing populations and the GES boundary for populations at carrying capacity of the system (see Good environmental status table 1).

The analysis is made using samples from sub-adult seals (1-3 years old)

The blubber thickness of 1-3 year old grey seals shows a seasonal flux as illustrated in Assessment Protocol figure 1. A polynomial model fitted to data can be used to merge data from all months, by recalculating each data point to the month of October. This month was chosen because the fit of the polynome is less affected by outliers here compared with end points (April and December), and that there is a reasonable amount of data in October. The mean of all data in Assessment protocol figure 1 recalculated to October is 39.1 mm (SD 9.9mm). Thus data can be used in this analysis regardless of which month the sample is taken.



Assessment protocol figure 1. Seasonal changes in blubber thickness of 1-3 year-old hunted grey seals. (Combined Swedish and Finnish data, n=210).

Observed data is merged for 3-5 year intervals, depending on sample size, to be used as input values in Bayesian analyses with uninformative priors, where it is evaluated if observed data from an assessment unit achieve the GES boundary value. In this process, 80% support for a blubber thickness ≥ GES is required. If the unit fails GES, the probability distribution is used to evaluate the confidence of the evaluation. The package Bayesian in the program R shall be used in the analysis.

Assessment units

This core indicator evaluates the nutritional status of marine mammals using HELCOM assessment unit scale 2 (division of the Baltic Sea into 17 sub-basins). The assessment units are defined in the HELCOM Monitoring and Assessment Strategy Annex 4.

Existing management plans for seals operate according to management units that are based on the distribution of seal populations. The management units typically encompass a handful of HELCOM scale 2 assessment units. Evaluations are therefore done by grouping HELCOM assessment units to align with the management units defined for each seal population.

For the current indicator evaluation, grey seals spatial units in the Baltic Sea have been merged and are treated separately from the Kattegat and Limfjord unit. For the assessment of nutrirional status in SW Baltic only stranded animals will be used. Nutritional status in SW Baltic is to be analyzed and linked to a new Health Indicator.

The Baltic grey seal is a single management unit, although genetic data show some spatial structuring (Fietz et al. 2013). Data is available both from land-based surveys starting in the mid-1970s and later aerial surveys.

- The Baltic ringed seal is distributed in the Gulf of Bothnia on the one hand and Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga on the other, and is represented by two different management units. This sub-division is justified by ecological data that indicate separate dynamics of the stocks. Since ringed seals from both areas show a high degree of site fidelity, as seen in satellite telemetry data (Härkönen et al. 2008), it is unlikely that extensive migrations occur at current low population numbers, although some individuals can show more extensive movements (Kunnasranta 2010, Oksanen et al. 2015).
- Harbour seals in the Kalmarsund, Sweden, constitute a separate management unit and is the genetically most divergent of all harbour seal populations in Europe (Goodman 1998). It was founded about 8,000 years ago, and was close to extinction in the 1970s as a consequence of intensive hunting, and possibly also impaired reproduction (Härkönen et al. 2005). The genetic diversity is substantially reduced compared with other harbour seal populations.
- Harbour seals in the southwestern Baltic (Danish Straits, Danish, German, Polish Baltic and the Öresund region including Skåne county in Sweden) should be managed separately as this stock is genetically distinct from adjacent populations of harbour seals (Olsen et al. 2014).
- Harbour seals in the Kattegat are also genetically distinct from adjacent populations (Olsen et al. 2014).
- Harbour seals in the Limfjord form the fourth management unit and is genetically distinct from the Kattegat harbour seals (Olsen et al. 2014).

Relevance of the Indicator

Biodiversity assessment

The status of biodiversity is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based evaluation of the nutritional status of marine mammals, this indicator will also contribute to the next overall biodiversity assessment to be completed in 2018 along with the other biodiversity core indicators.

Policy relevance

The core indicator on nutritional status of marine mammals addresses the Baltic Sea Action Plan's (BSAP) Biodiversity and nature conservation segment's ecological objective 'Viable populations of species'.

The core indicator is relevant to the following specific BSAP target:

- 'By 2015, improved conservation status of species included in the HELCOM lists of threatened and/or declining species and habitats of the Baltic Sea area, with the final target to reach and ensure favourable conservation status of all species'.

The HELCOM Recommendation 27/28-2 'Conservation of seals in the Baltic Sea area' outlines the conservation goals which the indicator's GES boundary is based on. The explicit long-term objectives of management plans to be elaborated are: Natural Abundance, Natural Distribution, and a health status that ensures the persistence of marine mammals in the Baltic.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status (European Commission 2008):

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'.

Descriptor 8: 'Concentrations of contaminants are at levels not giving rise to pollution effects'

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

- Criterion 1.1 (species distribution)
- Criterion 1.2 (population size)
- Criterion 1.3 (population condition)
- Criterion 4.1 (Productivity of key species or trophic groups)
- Criterion 4.3 (abundance/distribution of key trophic species)
- Criterion 8.2 (Effects of contaminants)

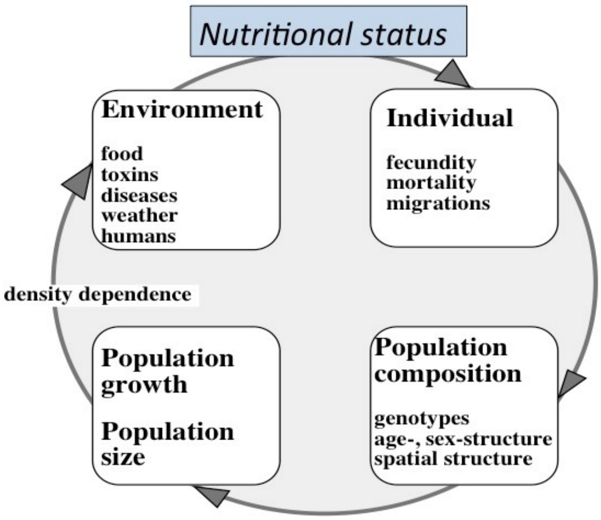
Marine mammals were recognized by the MSFD Task Group 1 as a group to be assessed.

In some Contracting Parties the indicator also has potential relevance for implementation of the EU Water Framework Directive (WFD, Chemical quality) and Habitats Directive. The WFD includes status categories for coastal waters as well as environmental and ecological objectives, whereas the EU Habitats Directive (European Commission 1992) specifically states that long-term management objectives should not be influenced by socio-economic considerations, although they may be considered during the implementation of management programmes provided the long-term objectives are not compromised. All seals in Europe are also listed under the EU Habitats Directive Annex II (European Commission 1992), and member countries are obliged to monitor the status of seal populations.

Role of marine mammals in the ecosystem

Being top predators in the Baltic ecosystem, seals are exposed to ecosystem changes in lower trophic levels, but also to variations in climate (length of seasons and ice and snow conditions) and impacts of human activities. These pressures can affect fish stocks, levels of harmful substances as well as direct mortality caused by hunting or by-catch. The vulnerability of seals to these pressures makes them good indicators for measuring the environmental status of ecosystems.

The nutritional status of seals can be regarded as a direct link between the environment, individual fitness and population growth rate (Relevance figure 1). Seals fight a constant struggle to reach a critical limit of fat storage each autumn (Relevance figure 2). Failure to reach this level will result in failed reproduction in adults and high mortality rate in juveniles. Ecosystem effects (e.g. reduced food supply) are readily visible in the blubber layer in a few weeks or months. If poor nutritive conditions persist for a prolonged time period also total body growth rate in sub-adults is stunted and eventually the asymptotic adult body lengths of the entire population decline. This results in delayed sexual maturity, smaller females that can transfer less energy to their pups, which will in turn have reduced chances of survival. All this will have dramatic effects on the population growth rate and health of seals. The latter because leaner seals are more exposed both to parasites and diseases.

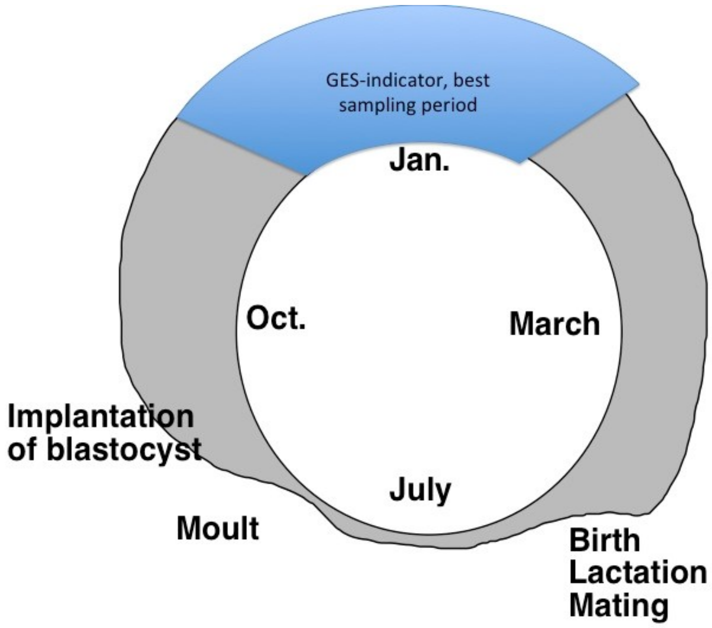


Relevance figure 1. Seal population dynamics is linked to the rest of the ecosystem through individual fitness which in turn is determined by the nutritional status of individuals.

The nutritional status of seals reflects many processes in the Baltic Sea ecosystem, especially quality and quantity of different fish stocks. It also reflects levels of pollutants and other stressors, since diseased animals are in poor body condition. Baltic seals' nutritional status acts as an early warning when new hazardous substances begin to accumulate in the food chain since they are at the top of the food chain and are likely to first show symptoms, as was the case with PCBs in the 1970s (Bergman & Olsson 1986).

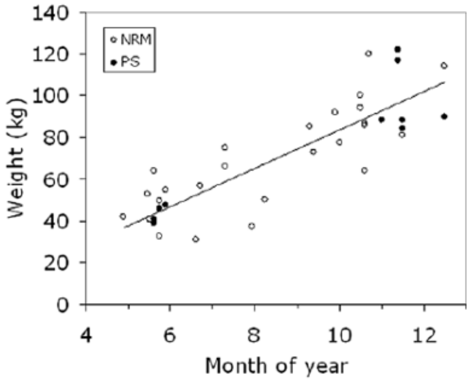
Ecological background to the indicator concept

The three seals included in this indicator description are all phocid seals that have a life history where they rely on stored fat reserves for over-winter survival and reproduction. Their pups are lactated during a few weeks in the spring (grey and ringed seals) or summer (harbour seals) and female weight loss during this short period is massive, up to 30-50% of total body weight (Kovacs & Lavigne 1986; McCann et al. 1989; Haller et al. 1996). During summer and autumn, seals intensively search for prey to build up their fat reserves (Relevance figure 2; Nilssen et al. 1997; Hauksson 2007). Failure to reach a critical fat reserve in late autumn results in decreased survival and failed reproduction, including foetal mortality. Thus food abundance and other factors that influence feeding success during the autumn are important. Blubber thickness is one vital component of most measures of nutritional status and is most informative during late autumn and winter at its annual maximum (however samples collected year round can be used by treating month of collection as a co variate in the statistical testing). Also body length and weight at age are important parameters to monitor year round for evaluation of nutritional status (examples below).



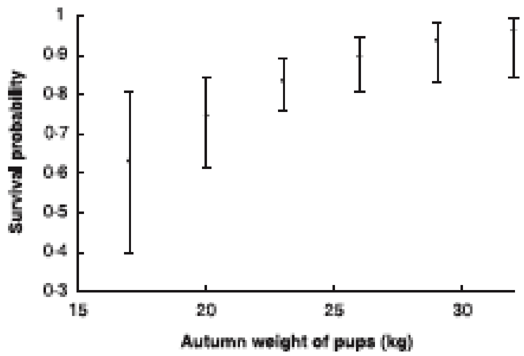
Relevance figure 2. Schematic figure of the blubber thickness during the annual cycle of an adult harbour seal in the Baltic Sea and Kattegat. The grey circle illustrates the strong flux in blubber thickness that is connected to the indicated major 'annual cycle events'. The figure would be similar if drawn for any true seal (Phocidae), if the months are rotated to fit the cycle for each population. The true size of the weight loss is exemplified in Relevance table 1. Modified from Harding 2000.

Grey seal females spend on average 85% of their energy reserves during lactation (Fedak & Anderson 1987). In harbour seal females the associated mean weight loss is about 40% (Härkönen & Heide-Jørgensen 1990), but females need to forage during the last weeks of lactation to successfully wean their pups. Loss in blubber thickness and weight in ringed seals during the breeding season is also dramatic (Figure 6).



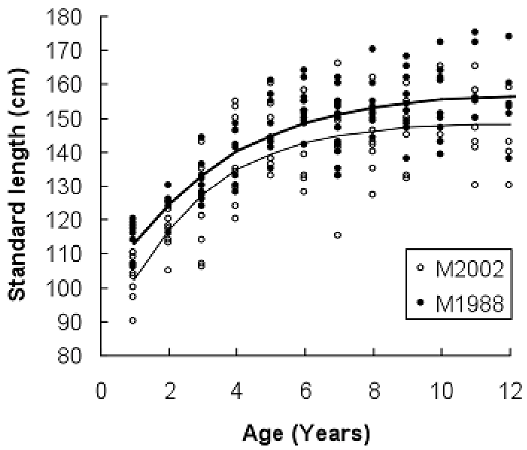
Relevance figure 3. Weight of ringed seal females caught in the open water season. Filled circles refer to data from a ringed seal satellite tag study, and open circles are data compiled from the seal database at the Swedish Museum of Natural History (NRM). A linear regression of pooled data (y = 9.16x27.97, R2 = 0.83) suggests that ringed seal females gain 9.2 kg per month from May up to December. Härkönen et al 2006.

A study on individually branded harbour seals also shows that winter survival in the young of the year was highly dependent on the autumn weight (Härkönen & Harding 2001, Harding et al. 2005). The range in survival was large, from 96% in well fed pups to only 65% in lean pups (Relevance figure 4). Similar fluctuations in life history parameters have also been observed in e.g. harp seals, Canadian harbour seals and ringed seals (Harwood & Prime 1978; Fowler 1981; Kjellqwist et al. 1995; Bowen et al. 2003; Kraft et al. 2006).



Relevance figure 4. Body weight in pups reflects nutritive conditions. First year winter survival of Harbour Seal pups in the northern Skagerrak is significantly related to their body mass in the autumn. Error bars denote 95% confidence limits for each given weight. From Harding et al (2005).

Nutritional status also affects body length, and just as in other mammals the nutritive condition during childhood affects the final adult body size after sexual maturation. Large declines in the average body length of adult seals has been documented in harbour seals and harp seals during periods of limited food supply (Kjellqwist et al. 1995). There is, for example, a statistically significant difference at almost 10 cm in average adult mean lengths of harbour seals collected during the last decades in the Kattegat-Skagerrak (Relevance figure 6).



Relevance figure 6. Overall body growth curves and final adult body length respond to food availability and stress and reflect the nutritive condition of seals over longer time periods (decades). In the graph above is an example from harbour seals at different population densities. In 2002 adults are 10 cm shorter on average, presumably due to higher population density.

For long-term trends, total body length can provide very important information. The benefit of length as a parameter is that available sample size is increased since all animals collected can be incorporated (all seasons, all sampling methods). An additional feasible parameter is pup weaning weight in grey seals, where reference data is available from repeated studies. For harbour seals pup autumn weight is a sensitive parameter (Harding et al. 2005) that could be elaborated in the future.

Human pressures linked to the indicator

	General	MSFD Annex III, Table 2
Strong link	Hunting By-catches Disturbance causing stress Ecosystem changes (food web, introduction of pathogens and non-indigenous species) Fishery and food availability	Biological disturbance: -selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing)
Weak link	Diseases Effects of climate change is a threat to the ringed seal that breeds on sea ice, and also to grey seal pups. Boat traffic, hunting, under water noise, ice breaking	Contamination by hazardous substance: - introduction of synthetic compounds - introduction of non-synthetic substances and compounds Must be confirmed by further analysis.

Historically, hunting of seals has been a major human pressure on all the seal species in the Baltic Sea. A coordinated international campaign was initiated in the beginning of the 20th century with the aim of exterminating the seals (Anon. 1895). Bounty systems were introduced in Denmark, Finland and Sweden over the period 1889-1912, and very detailed bounty statistics provide detailed information on the hunting pressure. The original population sizes were about 180,000 for ringed seals, 80,000 for Baltic grey seals and 5,000 for the Kalmarsund population of harbour seals (Harding & Härkönen 1999; Härkönen & Isakson

2011). Similar data from the Kattegat and Skagerrak suggest that populations of harbour seals amounted to more than 17,000 seals in this area (Heide-Jørgensen & Härkönen 1988).

By-catches are known to have substantial effects on the population growth rate in species like the Saimaa and Ladoga ringed seals (Sipilä 2003). The current knowledge on the level of by-catches of Baltic seal species is limited to a few dedicated studies which suggest that this factor can be substantial. An analysis of reported by-caught grey seals estimated that more than 2,000 grey seals are caught annually in the Baltic fisheries (Vanhatalo et al. 2014), but numbers of by-caught ringed seals and harbour seals are not known. Both hunting and by-catches will affect population density and thereby the nutritional status of seals via mechanisms described in the above section 'Ecological background of the indicator concept'.

In the beginning of the 1970s grey seals were observed aborting near full term foetuses, and only 17% of ringed seal females were fertile (Helle 1980). Later investigations showed a linkage to a disease syndrome including reproductive disorder, most probably caused by organochlorine pollution, in both grey seals and ringed seals (Bergman & Olsson 1986). This disease syndrome also included adrenocortical hyperplasia, reduced bone mineral density, loss of teeth, claw deformation (Bergman & Olsson 1986). These manifestations should have had severe effects on the general nutritive condition of seals.

Climate change poses a pressure on species breeding on ice because shorter and warmer winters lead to more restricted areas of suitable ice fields (Meier et al. 2004). This feature alone will severely affect the Baltic ringed seals and the predicted rate of climate warming is likely to cause extirpation of the southern subpopulations (Sundqvist et al. 2012). Grey seals are facultative ice breeders and their breeding success is considerably greater when they breed on ice as compared with land (Jüssi et al. 2008). Furthermore, the weaning weight of grey seal pups was substantially greater when born on ice as compared with land. When a larger proportion of the grey seal pups are born on land in the future, they will be leaner and experience greater juvenile mortality. Consequently, both ringed seals and grey seals are predicted to be negatively affected by a warmer climate.

By-caught grey seals are significantly leaner as compared with hunted seals (Bäcklin et al. 2011; Kauhala et al. 2015), which may suggest that food is a limiting factor for by-caught grey seals. It is possible that food limitation is becoming an important factor also for the entire population since data of blubber thickness in Baltic grey seals (also hunted) show a significant decline during the last decade (Bäcklin et al. 2011).

Monitoring Requirements

Monitoring methodology

HELCOM common monitoring relevant for the seal population trends is documented on a general level in the HELCOM Monitoring Manual under the **sub-programme: Seal abundance**.

HELCOM monitoring guidelines for seals were adopted in 2014 and currently all monitoring guidelines are being reviewed for inclusion in the Monitoring Manual.

The monitoring methodology is described in detail in the core indicator report from 2013.

Current monitoring

The monitoring activities relevant to the indicators that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the Monitoring Concept Table.

Sub-programme: Seal Abundance
Monitoring Concept Table

Current monitoring is carried out on a national basis, but initiatives of coordinating methodology have been taken by the Health team of the HELCOM Seal Expert Group.

Description of optimal monitoring

The optimal monitoring should encompass sufficient numbers of samples from all species of seals in all areas where they occur.

For grey seals, sufficient material is collected in the central and northern Baltic Sea, but it would be important to include more material on nutritional status from the southern Baltic for analyses of regional differences.

Monitoring of harbour seals is sufficient, but more data from Danish waters could prove to be important in the future.

For ringed seals more samples are required from the entire area of distribution.

Data and updating

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 (2015) Nutritional status of marine mammals**.** HELCOM core indicator report. Online. [Date Viewed], [Web link].

Metadata

Initiatives have been taken to compile national data annually by the HELCOM Seal Expert Group. Much of Swedish and Finnish data have been merged. German and Polish data remain to be included.

The data collected and used in the indicator are based on national databases. The health team of the HELCOM seal expert group is given the responsibility to compile, store current national data, and investigate future arrangements for establishing a HELCOM database.

Contributors and references

Contributors

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Archive

Core indicator report – web-based version November 2015 (pdf)

Extended core indicator report – outcome of CORESET II project (pdf)

2013 Indicator Report

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