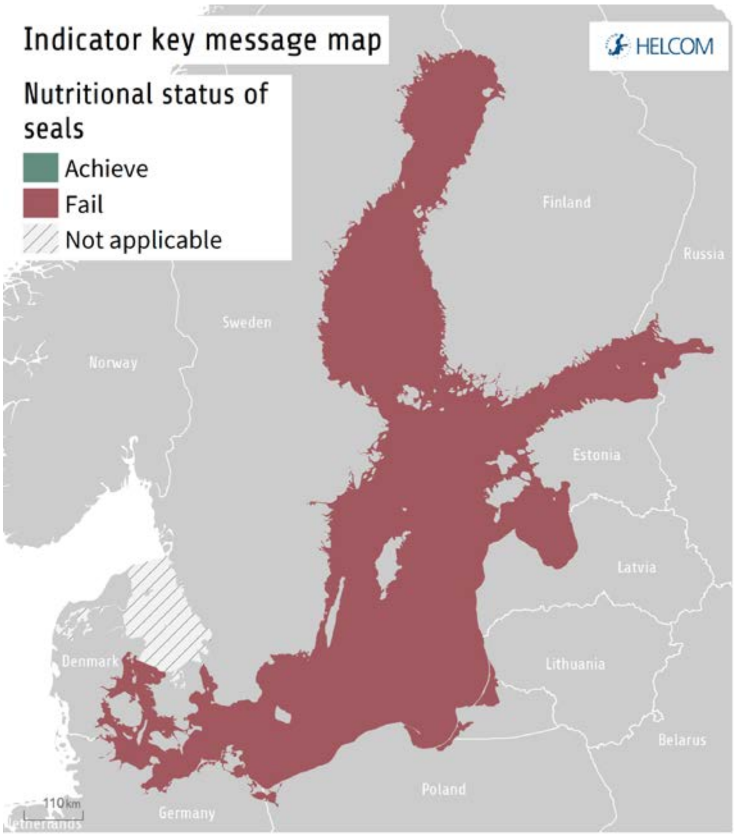
HELCOM core indicator report
July 2018

Nutritional status of seals

Key Message

This indicator and its threshold values are based on a relatively limited data set for the grey seal. *The indicator evaluation is carried out based on current data and methodological approaches, and applied to the whole Baltic Sea scale since the grey seal is known to disperse widely in the region. Work is required and underway for improvements and expansion of the data set to gain a greater spatial coverage.*

This core indicator evaluates the status of the marine environment in terms of the nutritional status of seals, measured as average blubber thickness of seal populations. This signals both long term and short-term changes in food supply and many other stressors. Good status is achieved when the subcutaneous blubber thickness is above the defined threshold value, which reflects good conditions. In the current assessment (2011-2016) the grey seal failed to achieve the threshold value and the population is thus in not good status for the whole Baltic Sea.



Key message figure 1: Status assessment results based on evaluation of the indicator 'nutritional status of seals' 2011-2016. The assessment is carried out using aggregated Scale 2 HELCOM assessment units – whole Baltic Sea excluding the Kattegat and Limfjord (defined in the HELCOM Monitoring and Assessment Strategy Annex 4). Status evaluation is carried out based on blubber thickness in grey seals. **Click here to access interactive maps at the HELCOM Map and Data Service: nutritional status of seals.**

Grey seals occur in the entire Baltic Sea, though in the Kattegat the species is rare and has not been breeding since the 1930s, except for a few observations in recent years. The status of the grey seal in the Baltic Sea is evaluated as a single unit, excluding the Kattegat which is evaluated separately. Grey seals do not achieve the threshold value with regard to nutritional status when evaluated as one single population at the scale of the entire Baltic Sea.

Ringed seals occur in the Gulf of Bothnia (northern management unit), and the Gulf of Finland, Archipelago Sea, Gulf of Riga and Estonian coastal waters (their more souther management unit). The status of ringed seals is not directly evaluated for these two management units in this assessment and no thresholds have been established. However, the nutritional status of ringed seals is suggested to be declining based on a statistical analysis of data from hunted seals (Kauhala et al in prep).

Harbour seals are confined to the Kalmarsund (Western Gotland Basin and Bornholm Basin), Western Baltic Sea (Arkona Basin, Bay of Mecklenburg, Kiel Bay, Great Belt, the Sound), the Kattegat and Limfjord; each of which are separate management units. The Kattegat and Limfjord subpopulations may be approaching carrying capacity since the annual growth rates are levelling off. Threshold values with regard to blubber thickness are not finally determined and no status evaluation is made in the current assessment.

The indicator structure and methodology is well defined for grey seal populations recovering from low population sizes. Further work to assess the grey seal population using data from a wider spatial region (i.e. more countries) would benefit the assessment confidence. Furthermore, additional work is needed to properly assess all species of seals that occur in the Baltic Sea and for those species/populations or management units/subpopulations approaching carrying capacity (i.e. when the population size is so large that density dependence sets in) the implementation of a suitable revised threshold to correspond to the ecological reality (e.g. food availability) is required.

Confidence of the indicator evaluation for grey seals is considered to be **intermediate**. The methodology is standardised and the grey seal population is highly migratory, travelling widely in the Baltic Sea region, however the sample sizes for the current assessment are somewhat low and limited in spatial coverage.

The indicator described here is applicable in all HELCOM sea regions since the grey seal population can be considered as a shared population. However it should be noted that due to migration patterns, fisheries activities and national hunting regulations, the shared seal population is exposed to differing pressures in each country. To balance for these issues an additional more detailed measure of seal health is being developed to evaluate the causes behind observed trends. A detailed Health Indicator would complement the current Nutritional Status indicator and become a powerful tool to evaluate the state of the environment.

The indicator is applicable in the waters of all the countries bordering the Baltic Sea since the indicator includes one or more marine mammal species that occur in all HELCOM assessment units. In the current document only the grey seal nutritional status is directly assessed and the status evaluation for the entire Baltic Sea region is extrapolated from data gathered from Finland and Sweden. Improved data coverage and data calls/reporting is planned for future updates.

Relevance of the core indicator

Marine mammals are top predators in the marine ecosystem and therefore good indicators of changes in biotic and abiotic environment, for example variation in food webs. Marine mammals accumulate fat soluble hazardous substances such as heavy metals and PCBs in their tissues (so called bioacumulation) and thus reflect the level of pollution in the environment. Seals are also affected by human disturbance such as hunting, fishing by-catch and disturbance (e.g. chemical and noise pollution), as well as infectious diseases and climate change.

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

Blubber acts as the energy storage of seals and thus a reduction in blubber affects reproduction and survival of individual seals and is an early warning of decline in population trends, as confirmed by multiple scientific studies worldwide. Although blubber thickness responds to short-term variations in the environment and is a versatile indicator that complements the population trend and reproductive rate indicators, 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, an increase in intestinal wounds, or a new invasive parasite may also be important indicators of environmental disturbances, but are not captured properly by the current indicator alone. Therefore, a new Seal Health Indicator, indicative of wider population level trends and encompassing a wider range of potential causative factors, is required and is the current focus of further development work.

Temperature variations across the latitudinal extent of the Baltic Sea have been suggested to influence certain biological processes or community factors, however there is currently no documented evidence for a spatial variation in regulation of blubber thickness in sub adult seals from the genetically mixed populations due to temperature. The indicator methodology is thus deemed to be an informative approach in assessing the nutritional status of seals across the entire Baltic Sea region. It is therefore most likely that the average fat layer variations in grey seals between years represent changes in food availability and other stressors and not sea water temperature. Fat layers are built up during the autumn, and selection (i.e. increased mortality in lean seals) occurs after that; in February during the coldest months. Thus fat layer variation in the autumn samples cannot be a response to temperature in the winter to come. Adaptation to warmer water temperature in the long run will be a much more slow evolutionary process over many generations of seals.

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Biodiversity • Viable populations of species	D1 Biodiversity D1C3 Population demographic characteristics of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.
Secondary link	Biodiversity: • Thriving and balanced communities of plants and animals Hazardous Substances • Healthy wildlife	D1 Biodiversity D1C2: The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. D1C4: The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. D4 Food-web D4C4: Productivity of the trophic guild is not adversely affected due to anthropogenic pressures. D8 Contaminants D8C2: The health of species and the condition of habitats are not adversely affected due to contaminants including cumulative and synergetic effects.
Other relevant legislation: In some Contracting Parties also EU Water Framework Directive – Chemical quality, Habitats Directive		

Cite this indicator

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Nutritional status of seals HELCOM core indicator 2018 (pdf)

Results and Confidence

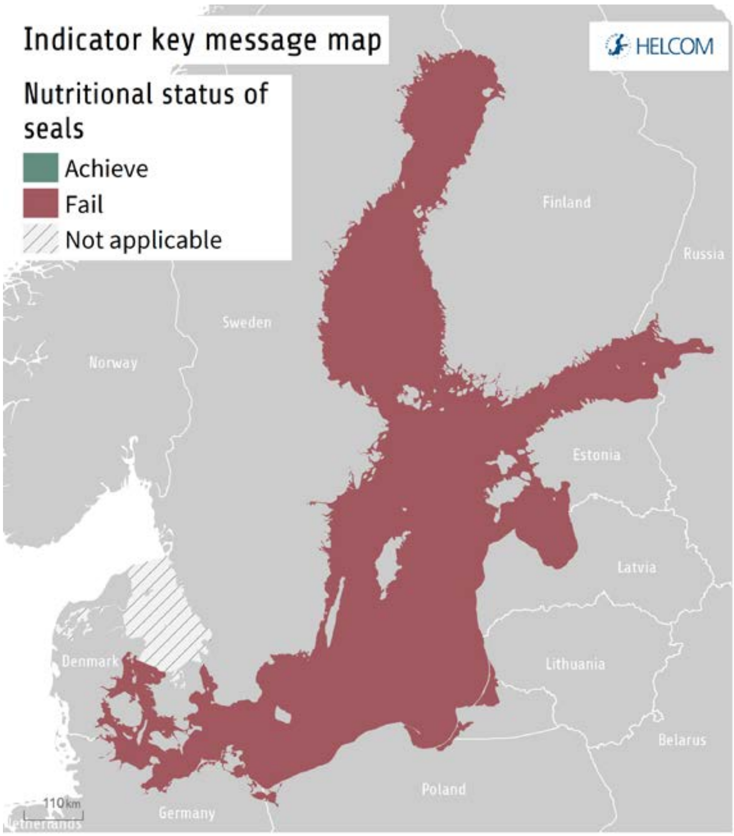
Processed data on blubber thickness are only available for grey seals, and hence the present indicator evaluation only covers this species. Currently, the results are based on combined Swedish and Finnish data but future evaluations will also include German, Danish, Estonian and Polish data.

Grey seal

The current evaluation of the nutritional status of grey seals indicates that good status has not been achieved (Results figure 1). The status evaluation is based on 257 individuals from Swedish and Finnish monitoring programmes (Results table 1).

Results table 1. Number of grey seals – hunted, by-caught and total used in the current assessment.

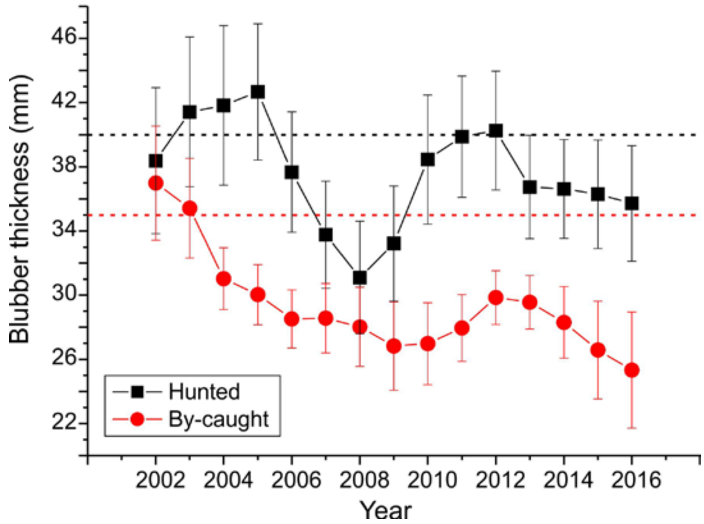
Year	Hunted	By-caught	Total
2011	23	15	38
2012	25	27	52
2013	21	19	40
2014	26	15	41
2015	33	6	39
2016	34	17	51



Results figure 1. Baltic grey seal population does not attain good status with regard to nutritional status, since observed data fails the blubber thickness threshold values of 40mm for hunted seals and 35mm for by-caught seals (in standardised samples).

A strict Bayesian analysis has not been carried out yet, but it is evident that a steep decline in blubber thickness has occurred. Such an analysis would likely support that good status has been achieved for the time periods 1993-2001 and 2002-2005, whereas the status would not be good for data from 2006 onwards for both hunted and by-caught grey seals (Results figure 2), when tested against the threshold values (40 and 35 mm for hunted and by-caught seals respectively).

However, it should also be considered that if the grey seal was identified to be at carrying capacity, which may be statistically confirmed in future assessments of population trend, and status was evaluated against a provisionally proposed threshold value of 25mm (applicable in populations close to carrying capacity) then good status would be achieved.

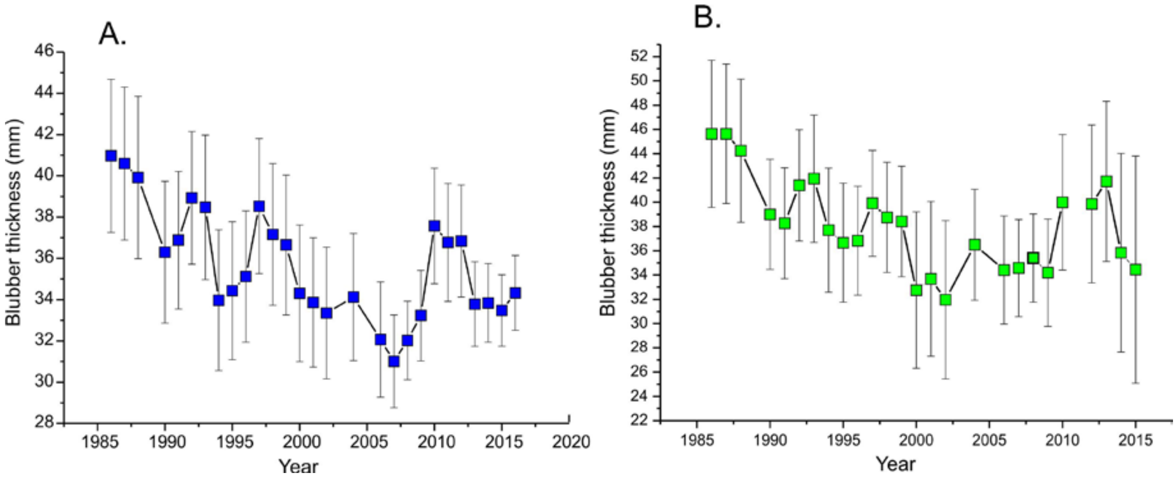


Results figure 2. Grey seal blubber thickness. Three-year moving average of autumn/winter blubber thickness ± SE in examined sub-adult by-caught and hunted grey seals in Finland and Sweden. All were by-caught or shot between August and December. Dashed horizontal lines indicate the thresholds used in the current evaluation for hunted (black) and by-caught (red) grey seals. Adapted from Kauhala et al 2017.

There was significant ($p = 0.014$) annual variation in the blubber thickness of hunted sub-adults from 2002 to 2016 without a significant trend (no significant covariates) (Kauhala et al 2017). No significant annual variation was found in by-caught sub-adults during the same period (original values, sea region and sex were significant covariates). There was, however, a decreasing trend from 37.0 mm in 2002 to 25.3 mm in 2016 when calculated from the smoothed values ($p = 0.001$). Smoothed values were used due to small sample sizes in some years. In addition, in can be mentioned that in a population segment, pups of the year, not included at present in the indicator the same trend can be observed: The blubber thickness of hunted pups (< 1 year) decreased from 37.2 mm in 2002 to 24.6 mm in 2010 ($p < 0.001$, $n = 86$), and that of by-caught pups declined from 29.4 mm in 2003 to 20.2 mm in 2010 ($p <0.001$, $n = 159$). However, blubber thickness of pups has declined in recent years in the Gulf of Finland but increased in Baltic Proper and the values were calculated after adjusting the covariate effect of sea area. The declining trend in the blubber thickness of pups in the Gulf of Finland and by-caught 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 could potentially indicate a major change in the Baltic Sea ecosystem.

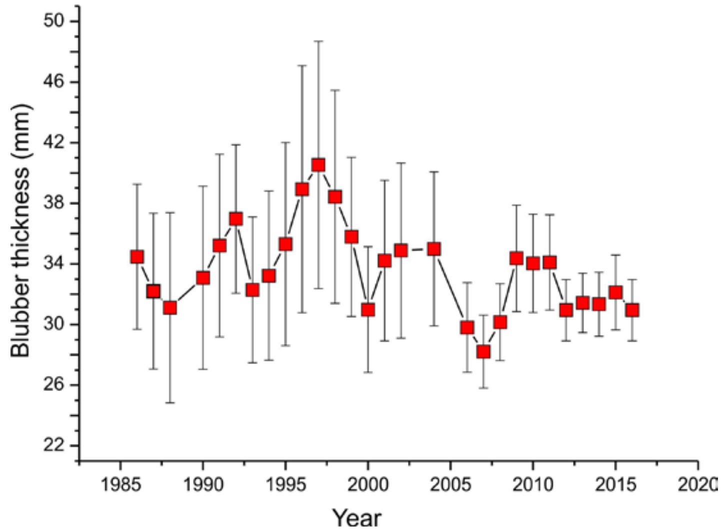
Ringed seal

Although data are currently too scarce to establish a threshold value for ringed seals, the available data indicate that the nutritive condition of ringed seals is also deteriorating (Results figure 3). Decreasing blubber thickness is seen both in juveniles (1-3 year old) and adults (Kauhala et al 2018).



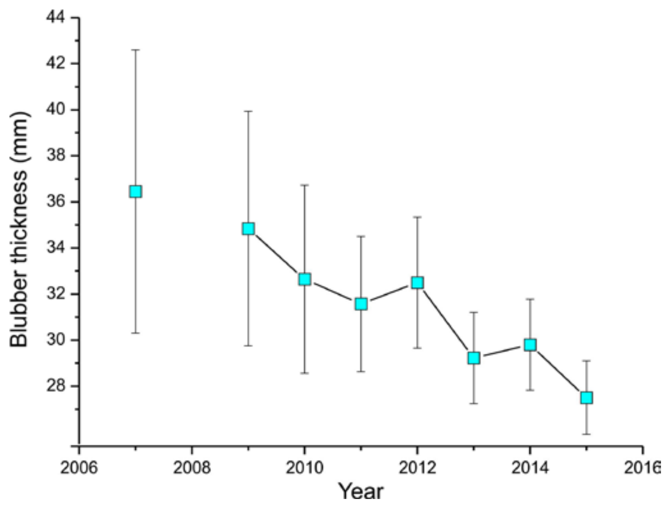
Results figure 3. Blubber thickness of ringed seals: (A) total data (n = 489) with month and cause of death as covariates and (B) hunted adults (n = 208) with month and sex as covariates (3-year moving averages of means and S.E.) (Kauhala et al 2018).

In the overall ringed seals data there was significant annual variation in the blubber thickness (with month and cause of death as covariates), and a significant declining trend from 41.0 mm in 1986 to 31.0 mm in 2007 ($p < 0.001$). After 2007 the blubber thickness fluctuated. There was also significant annual variation (with month and sex as covariates) in the blubber thickness of hunted adults, and a stronger declining trend in blubber thickness, from 45.6 mm in 1986 to 32.0 mm in 2002 ($p < 0.001$). Data including only autumn samples are too small to perform equivalent analysis for this indicator evaluation or to definitively identify specific causes and these data should be considered as a preliminary suggestion of the nutritional status of ringed seals.



Results figure 4. Blubber thickness of ringed seal pups and sub-adults with month and cause of death as covariates (mean of 3-year moving averages ± S.E.).

There was significant annual variation ($p = 0.036$, $n = 228$) in the blubber thickness of pups and sub-adults, though no clear trend was present (Results figure 4). No significant annual variation existed among hunted pups and sub-adults ($p = 0.214$, $n = 138$). There was, however, a declining trend among by-caught pups and sub-adults from 36.5 mm in 2007 to 27.5 mm in 2015 ($p < 0.001$, $n = 90$) (Results figure 5).



Results figure 5. Blubber thickness of by-caught pups and sub-adults (with month as a covariate) from 2007 to 2015 (mean of 3-year moving averages ± S.E.).

Future work

A number of possible developments are planned for this indicator to expand the current approach and hone the accuracy of the assessment. For example, indicator evaluations could be based on animals of several age classes in addition to the current subadults (ages 1-4) to increase sample sizes, i.e. age class 0 (pups of the year) and sexually mature females and males could be included if care is taken to also account for their reproductive status). Should new scientific evidence determine that grey seals spend sufficient time in restricted areas (i.e. utilize only limited areas and thus are only affected by the conditions in those areas) to also represent regional differences, though to do this the thresholds would need to be re-evaluated, and alternative model assumptions should be tested to account for the cyclic nature of blubber thickness. Furthermore, the indicator will also be incorporated into discussions on future developments of a more wide-ranging nutritional status assessment that should be sensitive and able to inform more strongly on specific drivers (health status indicators). Such approaches could also encompass a wider sampling scope, for example also including stranded seals and assessing the impact of parasites or other factors on blubber thickness. Importantly, data collection and reporting through agreed national monitoring programs, to a designated database, need to be developed and expanded for all seal species in all relevant areas of their distribution (i.e. to increase spatial coverage of data underlying the assessment). Secondly, major methodological developments are required to develop and agree suitable thresholds for species of seals other than the grey seal and for populations that are at carrying capacity. Aspects of this work will require new methodological approaches on existing data and also primary research initiatives.

Confidence of the indicator status evaluation

Sufficient material is collected annually for grey seals in Finland and Sweden to enable a status assessment to be made, and the methodological approach is sound, thus the confidence of the indicator status evaluation for the grey seal in the central and northern parts of the Baltic Sea is **high**. Samples used in this evaluation also include Swedish material from the southern Baltic Sea, and considering the know dispersive nature of the grey seal and the single population of grey seals in the Baltic Sea region the scaling of the evaluation to the whole Baltic Sea is considered to have **moderate** confidence. In the future it would be highly beneficial to also include existing and future collected data from other countries (e.g. Denmark, Germany and Poland).

The high confidence in the indicator evaluation 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 the 2000s, especially in 1-3 year-old by-caught and hunted seals (Bäcklin et al. 2011). There could be several reasons for a thin blubber layer in the autumn/winter season, e.g. disease, contaminants, decreased fish stocks, dietary changes, a change in the quality of the diet, or increasing population density. Recent studies of grey seal suggest that the herring quality (weight) may play in an important role. The reason for the decreasing trend in blubber thickness in seals is unknown but so far no correlations to disease have been found.

One important consideration in the future when/if grey seals are shown to reach carrying capacity would be the need for the implementation of alternative threshold values that reflect the population density, environmental conditions and dynamics that would be different from the current situation. While signs of the grey seal approaching carrying capacity may be occurring currently there is not sufficient data to confirm this situation and this is also reflected in the moderate confidence value assigned to the current assessment.

A decreasing trend in autumn/winter blubber thickness has also been observed in young Baltic ringed seals (Kunnasranta 2010), although the latest material from Finland might indicate improved conditions. Data are still scarce for ringed seals in both management units, resulting in a **low** confidence in the preliminary evaluation results for this species.

For harbour seals, although material is collected annually, further studies and analysis are required before status can confidently be assessed.

Thresholds and Status evaluation

For the grey seal, good status is achieved when blubber thickness of sub-adults is at least 40 mm for hunted seals and 35 mm for by-caught seals (HELCOM HOD 48-2015, outcome para 3.63, Annex 4). A provisional threshold value of 25 mm is currently proposed if the population is assessed to be at carrying capacity (Thresholds table 1) as this reflects the level below which depleted fat reserves result in interference with thermoregulatory processes.

The concept for defining a threshold value 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, implantation of embryos, maintenance of pregnancy, 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 threshold values 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) and decreased reproductive rate (e.g. Boyd et al. 1999). Currently 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). Threshold values are established for two scenarios: for populations undergoing exponential growth and for populations at carrying capacity. Future work may facilitate a fine tuning of the threshold values for populations at carrying capacity, and careful integration of this information with the ‘’Trends and Abundance indicators’’ for seals and estimates of historical population sizes should provide a robust approach (Harding et al 1999, 2005, 2007).

The threshold value for nutritional status is defined based on what is considered to be a good condition in the current environment (Thresholds table 1). A modern baseline approach is used to set the threshold value. 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'.

Thresholds table 1. Threshold values set for grey seals applicable in the entire Baltic Sea as agreed by HELCOM HOD 48-2015 (outcome para 3.63, Annex 4).

	Threshold 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 threshold value for grey seals, data on blubber thickness during the period 2001-2004 represents the most recent data period that indicated good status and is used to form a modern baseline for the threshold value concept for populations undergoing exponential growth. The threshold value is set at 40 mm blubber for samples from hunted seals and 35 mm blubber for by-caught seals (Thresholds table 1). This threshold is currently applicable in the entire Baltic Sea since the population is panmictic and highly migratory.

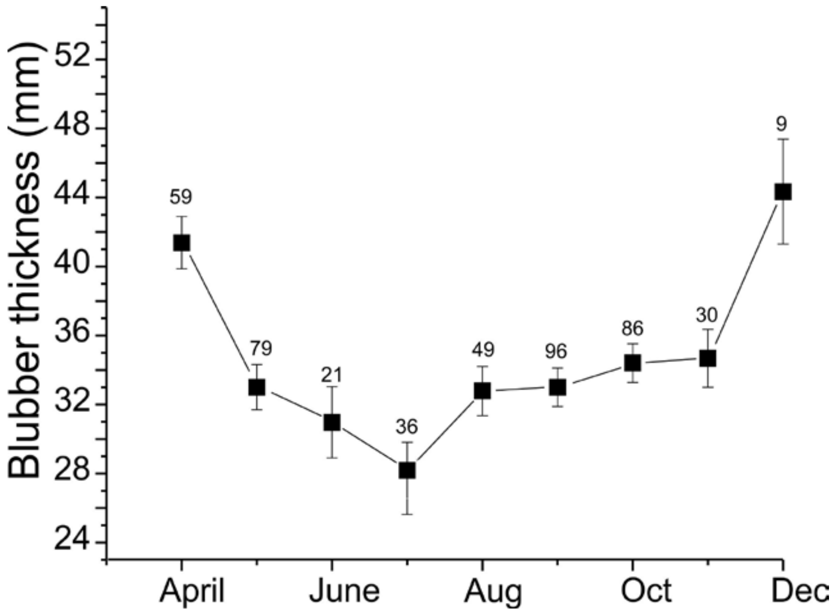
Since all growing populations eventually approach the carrying capacity of the ecosystem unless controlled by hunting, predation or by stochastic events, vital population parameters will change (see Relevance of the indicator). Nutritional status of seals will deteriorate due to limited food supply (occurring naturally or via human pressures such as fishing) or quality of food resources, and pups of the year and sub-adults (1-3) are the first to be affected. This is a natural process when populations are close to carrying capacity, and threshold values set for populations under exponential growth would no longer be applicable. To set threshold 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 threshold value 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. Thus this value is a provisional threshold value, though the exact level of the lower threshold value for each seal species should be further researched.

Assessment Protocol

Currently, this core indicator assesses the nutritional status of only grey seals due to limited data and developmental stages of appropriate methodologies for other species.

Each management unit is evaluated against a threshold value, the threshold value for exponentially growing populations, and a secondary threshold value for populations at carrying capacity is provisionally provided (see Thresholds table 1).

The current 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 the Assessment Protocol figure 1. A polynomial model fitted to data could be used in future developments of the analysis in order to merge data from all months, by recalculating each data point to the month of October. This month is suggested because there is a reasonable amount of data collected in October. Thus data can be used in this analysis regardless of which month the sample is taken.



Assessment protocol figure 1. Finnish and Swedish data of sub-adults (means ± SE) from 2012–2015 with month, area (ICES SD), sex and reason for death as covariates.

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 threshold value. In this process, 80% support for a blubber thickness ≥ the threshold value is required. If the unit does not achieve the threshold value, the probability distribution is used to evaluate the confidence of the evaluation. The package Bayesian in the program R is used in the analysis.

Assessment units

This core indicator evaluates the nutritional status of seals 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 at the scale of the whole Baltic Sea (HELCOM scale 1), with the exclusion of the Kattegat and Limfjord unit.

- The Baltic grey seal (excluding the Kattegat and Limfjord) 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 (one unit - northerly) and Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga (second unit – more southerly), representing 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 seals, 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 seals 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 threshold value 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 draft Commission Decision on GES criteria (European Commission 2016):

- D1C3 Population demographic characteristics of the species
- D1C2: The population abundance of the species
- D1C4: The species distributional range
- D4C4: Productivity of the trophic guild
- D8C2: The health of species and the condition of habitats are not adversely affected due to contaminants

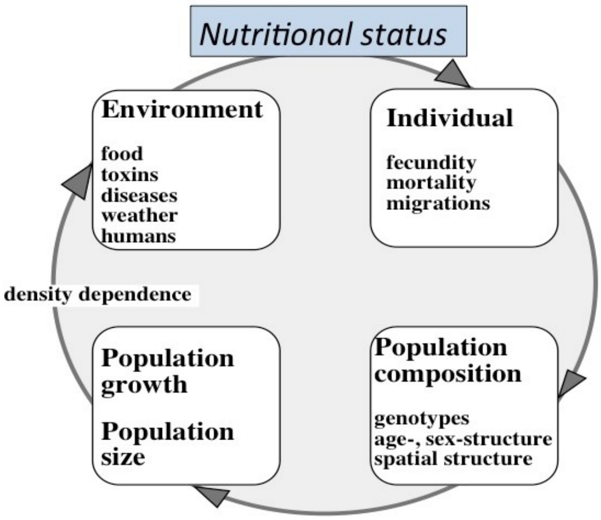
Marine mammals were recognized by the MSFD Task Group 1 as a group to be assessed.

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. Specific pressures such as changes in fish stocks, levels of harmful substances, boat traffic, noise pollution, harmful algal blooms, as well as direct mortality caused by hunting or by-catch are considered significant. 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 rates in juveniles. Ecosystem effects (e.g. reduced food supply or poor quality of food) 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.

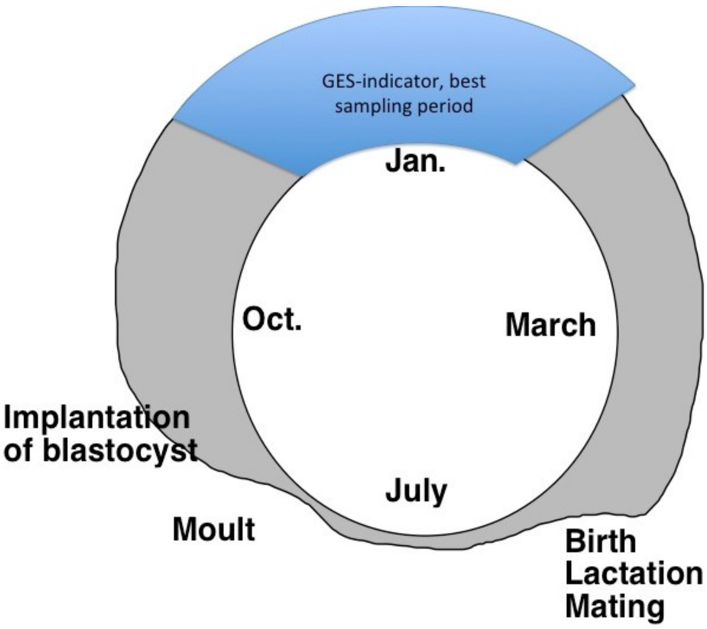


Relevance figure 1. Seal population dynamics is linked to the rest of the ecosystem through individual fitness which in turn is determined by the blubber thickness as an indicator of the nutritional status of individuals.

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

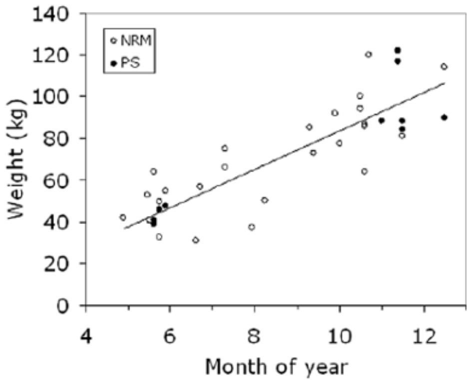
Ecological background to the indicator concept

The three seal species included in this indicator 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 may result in decreased survival and failed reproduction, including foetal mortality. Thus, food abundance/quality and other factors that influence feeding success during the autumn are important. Blubber thickness is one vital component indicative of nutritional status and is most informative during late autumn and winter as it is at it annual maximum (however, samples collected year round can be used by treating month of collection as a covariate 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).



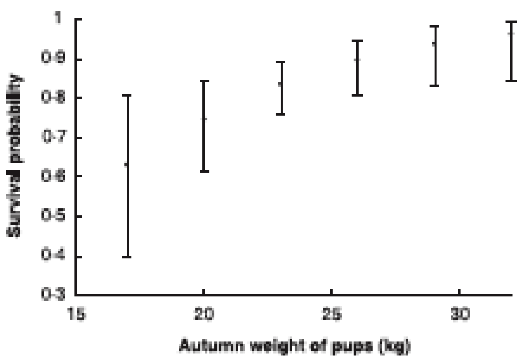
Relevance figure 2. Schematic figure of the blubber thickness during the annual cycle of an adult female harbour seal in the Baltic Sea and Kattegat. The grey circle illustrates the strong flux in blubber thickness that is connected to the indicated major 'annual cycle events'. The figure would be similar 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. The best sampling period in winter is difficult to apply to sample collection in Finland because the hunting season ends in December, thus most samples are collected earlier in autumn (or in spring).

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 (Relevance figure 3).



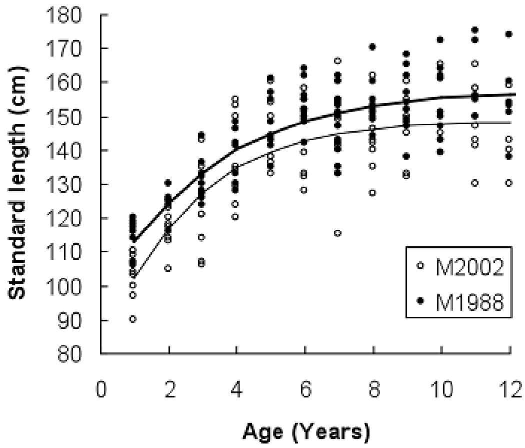
Relevance figure 3. Weight of ringed seal females caught in the open water season. Filled circles refer to data from a ringed seal satellite tag study, and open circles are data compiled from the seal database at the Swedish Museum of Natural History (NRM). A linear regression of pooled data (y = 9.16x27.97, 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 marked harbour seals also showed 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 (Harding et al 2018, Fig 6). Large declines in the average body length of adult seals have 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 of almost 10 cm in average adult mean lengths of harbour seals collected during the last decades in the Kattegat-Skagerrak (Relevance figure 5).



Relevance figure 5. 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 were 10 cm shorter on average, presumably due to higher population density (Harding et al 2018).

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.	Theme: Biological - Disturbance of species (e.g. where they breed, rest and feed) due to human presence. - Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities).
Weak link	Diseases Effects of climate change are 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.	Theme: Substances, litter and energy Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) 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) shows a significant decline during the last decade (Bäcklin et al. 2011). These factors could indicate that the population is at the early stages of reaching carrying capacity and that seals unable to compete for food in 'risk-free' areas will approach fishing gear in search of food, however, both subjects currently require greater scientific exploration.

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

Current data for this indicator only include data collected in Swedish and Finnish waters.

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

Optimal monitoring should expand the current data collection to encompass the entire region in which the relevant seal species occur, and reporting through a dedicated data call and database should be developed.

Specifically, for grey seals the greater spatial coverage of data is required to include all relevant areas which this species inhabits. 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 (2018) Nutritional status of marine mammals**.** HELCOM core indicator report. Online. [Date Viewed], [Web link].

Metadata

Result: Nutritional status of seals

Data: Nutritional status of seals

Initiatives have been taken to compile national data annually by the HELCOM Seal Expert Group. Much of Swedish and Finnish data have been merged. Danish, 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

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

Nutritional status of seals HELCOM core indicator 2018 (pdf)

Earlier versions of the indicator are available at:

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

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

2013 Indicator Report

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