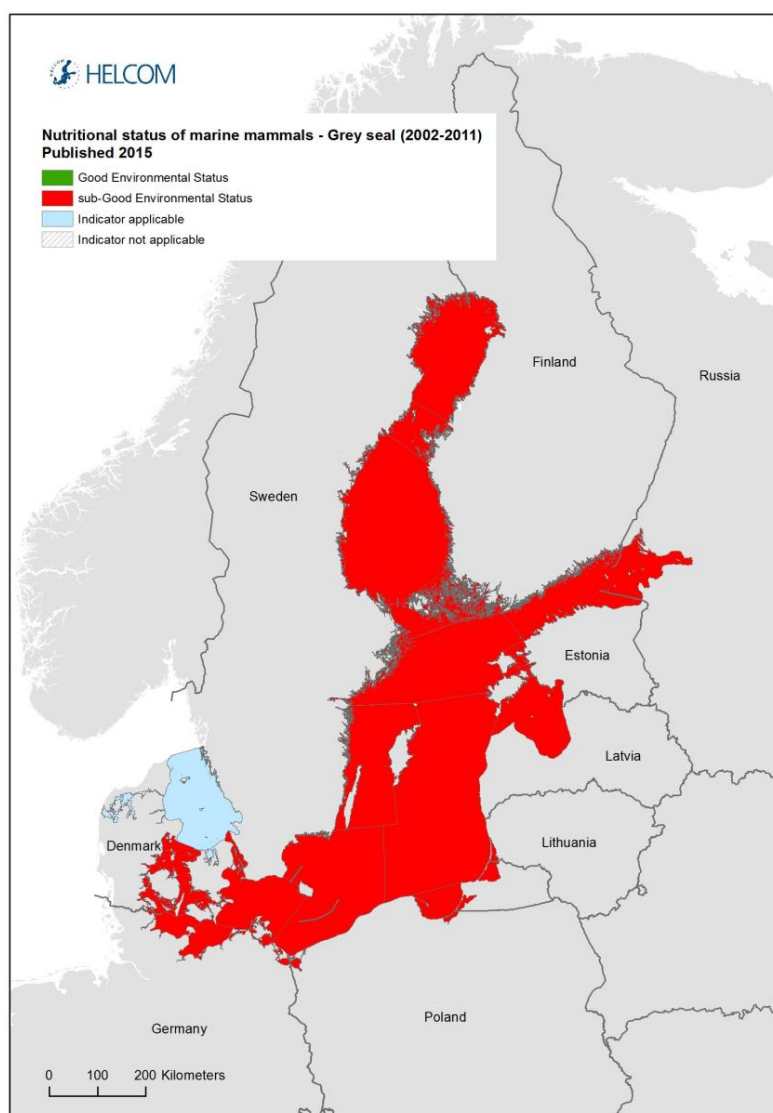


Nutritional status of marine mammals

Key message



The nutritional status indicator signals short term changes in food supply for the seals. Only grey seals have been used in the current evaluation and found not to achieve GES in the time period 2008 and later. In order to be applicable in the whole HELCOM area, the indicator includes all species of seals that occur in the Baltic Sea, however data has so far been insufficient for evaluations using the other seal species or other marine mammals.

Grey seal occurs in the entire Baltic Sea except for the Kattegat where the species has not been breeding since the 1930s except for a few observations from recent years. The grey seal in the Baltic proper is evaluated as a single unit, whereas the Kattegat grey seals are evaluated separately. Grey seals do not achieve GES with regard to nutritional status in the entire Baltic when evaluated as one single population. The confidence of evaluation is high.

Ringed seals occur in the Bothnian Bay, which is one management unit, and the Gulf of Finland, the Archipelago Sea, the Gulf of Riga and the Estonian coastal waters, which is a second management unit. The status of ringed seals is evaluated for 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, the Kattegat and the Limfjord, which all are separate management units. The Kattegat and Limfjord sub-populations may be approaching carrying capacity, since the annual growth rates are levelling off. GES boundaries with regard to blubber thickness are not finally determined.

Harbour porpoises are evaluated in two management units; The Baltic proper and the Kattegat including the Danish Straits.

Relevance of the core indicator

Marine mammals are top predators of the marine ecosystem and good indicators for the state of the 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.

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

Blubber is the energy storage of seals and a reduction in blubber affect reproduction and survival of individual seals and thus gives an early warning of declines in population trends. Blubber thickness respond to short term variations in the environment and is a versatile indicator that complements the population trend and pregnancy rate indicators.

Policy relevance of the core indicator

	BSAP Segment and Objectives	MSFD Descriptors and Criteria
Primary link	Biodiversity <ul style="list-style-type: none"> Viable populations of species 	D1. Biodiversity 1.3. Population condition
Secondary link	Biodiversity: <ul style="list-style-type: none"> Thriving and balanced communities of plants and animals Hazardous Substances: <ul style="list-style-type: none"> Healthy wildlife 	D1. Biodiversity 1.1 Species distribution (range, pattern, covered area) 1.2 Population size (abundance, biomass) D4. Food webs 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: WFD – Chemical quality, Habitat directive		

Cite this indicator

HELCOM [2015] [Indicator name] HELCOM core indicator report. Online. [Date Viewed], [Web link].

Indicator concept

Good Environmental Status

The concept for defining a 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.

Nutritional status 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) has been developed for humans, no GES boundaries are available for nutritional status of animal populations, although several studies have shown that seals are in poor condition (Kjellqvist et al. 1995), or that lean seals show increased mortality (Harding et al 2005). At least initially, data from 1-3 year old grey seals of both sexes are used for this indicator for reasons specified in the section “Selection of appropriate data”. GES is defined for two scenarios of which the first is applicable for populations under exponential growth.

The GES-boundary for nutritional status is defined based on what is considered to be a good condition in the current environment. Historical data are not available on the nutritional status of marine mammals that could be used to set a baseline on pristine conditions. This approach of setting a modern baseline is aligned with the approach in OSPAR, 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”.

Table 1. GES-boundary values set for seals applicable in the entire Baltic Sea.

Samples from	GES-boundary value	
	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 for the period 2001-2004 represents first available data, and is used to form a modern baseline for the GES-boundary concept for populations undergoing exponential growth. Graphs in Figure 3 are based on animals of ages 1-4 to increase sample size. The GES-boundary value is set at 40mm blubber for samples from hunted seals and 35mm blubber for by-caught seals. The GES-boundary is applicable in the entire Baltic Sea (Table 1).

Since all growing populations eventually approach the carrying capacity of the ecosystem, vital population parameters will change (see ‘Ecological background’). 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, 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 (Figure 9, Harding et al 2005). The GES-boundary for seal populations at carrying capacity in the whole Baltic Sea is set at 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 (Table 1).

The aim is to evaluate good environmental status by evaluating the nutritional status of all marine mammals present in the Baltic Sea. This includes the harbour porpoise. However, at this stage of the indicator development, insufficient data have been available to derive appropriate GES-boundaries.

Anthropogenic 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 Boat traffic, hunting, under water noise, ice breaking	Contamination by hazardous substance -introduction of synthetic compounds -introduction of non-synthetic substances and compounds

Historically, hunting of seals has been a major anthropogenic 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 to 1912, and the very detailed bounty statistics provide detailed information on the hunting pressure. The original population sizes was about 180,000 for ringed seals, 80,000 for Baltic grey seals and 5,000 for the Kalmarsund population of harbour seals (Harding and Härkönen 1999, Härkönen and 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 and 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 showed that approximately 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 section 'Ecological background'.

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, caused by organochlorine pollution, in both grey seals and ringed seals (Bergman and Olsson 1986). This disease syndrome also included adrenocortical hyperplasia, reduced bone mineral density, loss of teeth, claw deformation (Bergman and 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 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 blubber thickness in Baltic grey seals (also hunted) show a significant decline during the last decade (Bäcklin et al 2011).

Assessment protocol

- 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 (Table 1).
- HELCOM assessment units used; Level 2 for all species of seals. For grey seals spatial units in the Baltic will be merged and treated separately from the Kattegat and Limfjord unit.
- Samples from sub-adult seals (1-3 years) are used in the analysis.
- Data on blubber thickness from samples collected over the year are transformed to reflect the situation in October, by using the polynome $y = 0,7151x^2 - 10,597x + 71,557$, where x is the month of year.
- Observed data is to be 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 growth rate \geq 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 is used in the analysis.

Treatment of data

The blubber thickness of 1-3 year old grey seals shows a seasonal flux as illustrated in Figure 1. A polynome 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 reasonably amount of data in October. Another reason is to make data from Figure 11 and Figure 1 compatible. The mean of all data in 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.

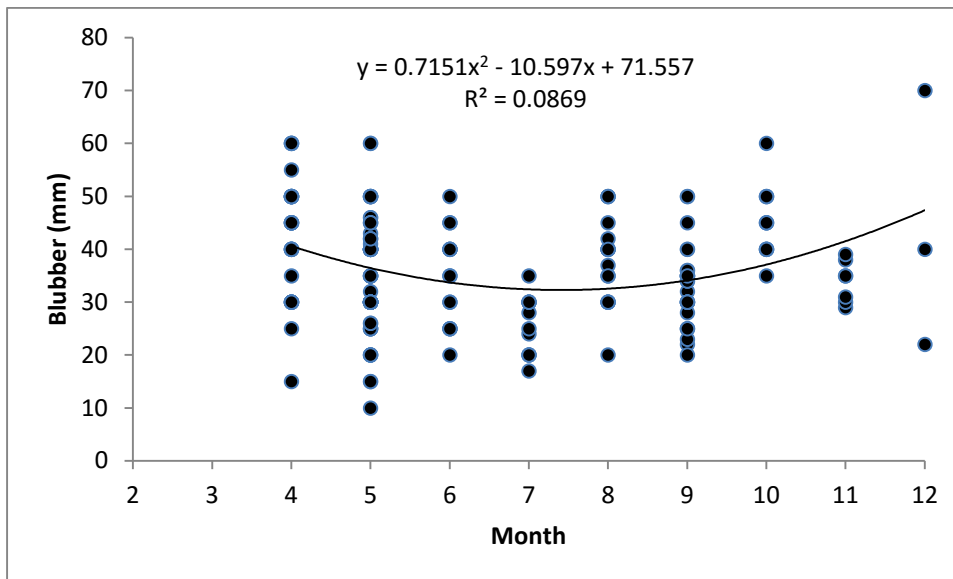


Figure 1. Seasonal changes in blubber thickness of 1-3 year-old hunted grey seals (Combined Swedish and Finnish data, n=210).

Evaluating an assessment unit against the GES-boundary

The Baltic grey seal has been growing exponentially since the mid 1980's at about 8% per year, and are thus not approaching carrying capacity and the GES boundaries at 40 mm for hunted seals and 35 mm for by-caught seals are applicable. Data is merged separately for those categories for years 2007-2009, and a Bayesian analysis is performed, testing if observed data deviate from the GES-boundaries.

Management units and assessment units

The existing management plans for seals operate based on management units that are derived based on the distribution of seal populations. The management units typically encompass a handful of HELCOM Level 2 assessment units, i.e. sub-basins. Evaluations of assessment units is therefore done by grouping HELCOM assessment units to align with the management units defined for each seal population.

- The Baltic grey seal is a single management unit, although genetic data show spatial structuring (Graves et al. 2013). Also behavioural data suggest some large scale structuring.
- 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 represent two different management units. This subdivision is justified by ecological data that indicate separate dynamics of these 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).
- 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 as compared with other harbour seal populations.

- Southwestern Baltic (Danish Straits, Danish, German, Polish Baltic and the Öresund region including Skåne county in Sweden) harbour seals. This stock is genetically distinct from adjacent populations of harbour seals (Olsen et al. 2014) and should be managed separately.
- Harbour seals in the Kattegat are also genetically distinct from adjacent populations (Olsen et al. 2014). This population has experienced dramatic declines in 1988 and 2002 caused by phocine distemper epidemics. A third epidemic caused by an unknown virus caused substantial mortality in 2007 (Härkönen et al. 2008). And in 2014 this population was again negatively affected, this time by avian influenza (Zohari 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).

Methods to estimate nutritive condition

The nutritional status can be measured as;

1. *Blubber thickness at various points at the body*
2. *Body length at age*
3. *Different indices can be estimated from these parameters, often with the goal to estimate the percentage blubber of the total body mass.*

Index of fat content (%) of total body mass (LMD-index)

All these measures must take into consideration the sex, age and season of collection, and the method of collection, before analysis.

Selection of appropriate data

In this step in developing the nutritional status indicator we will focus on grey seals, since there is much appropriate data available for this species, but other species will be included in the future. The data used is collected opportunistically from seals hunted for other purposes as well as by-caught seals in the fisheries.

The flux in blubber thickness is dependent on age and sex of the seal, where adult females are expected to show the greatest seasonal variation since they spend all their energy during lactation. However, also adult males spend much energy during reproduction, with substantial individual variation depending on size and rank of the male (Figure 2).

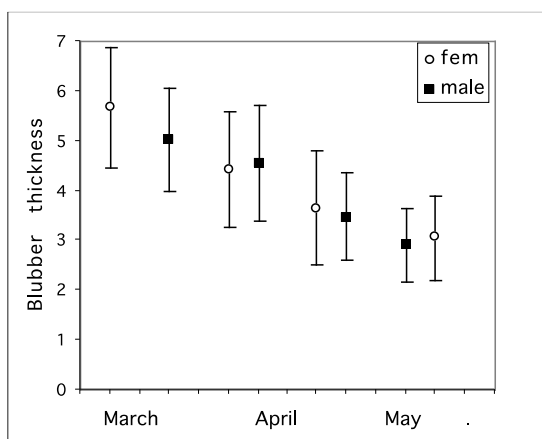


Figure 2. Decline in blubber thickness in Baltic ringed seals during spring. Data from the hunt (n=723) Olofsson 1930.

In this approach, a population segment that is least affected by reproductive activities is to be used, i.e. sub-adult seals of ages 1-3. In this segment energy intake is only used for metabolism, locomotion, somatic growth and storage of energy. There is a seasonal flux in blubber thickness also in this segment (Figure 1), but much less pronounced than in adult seals. The age at sexual maturity is not a fixed parameter, and changes over time depending on fluctuations in e.g. food availability. An example of this is the Antarctic crabeater seals where a change from 3.7 to 6.3 years occurred within a couple of decades (Hårding and Härkönen 1995). However, the 1-3 year segment will still be comparable among years.

To be functional, an indicator must be sensitive enough to detect inter-annual variations, and be applicable in the entire area of distribution. Figure 3 shows that there has been a significant decrease in blubber thickness from 45 mm to 35 mm in seals hunted in the autumn in a 9-year long time series (2002-2009) of sub-adult grey seal. By-caught seals are leaner, but also display a similar trend, here blubber thickness decreased from 35 mm to 25 mm in this category of seals. Thus, both hunted and by-caught seals provide useful information on changes in nutritive condition.

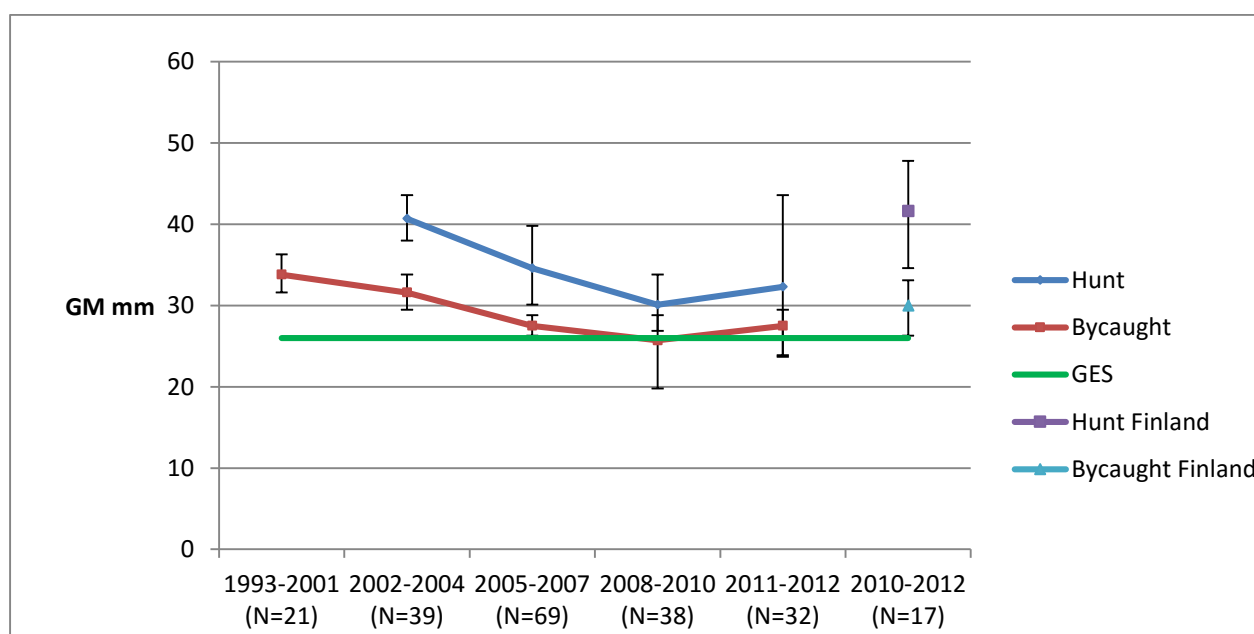


Figure 3. The mean annual blubber thickness \pm SD in examined 1-3 years old non pregnant by-caught (1995-2009) and hunted (2002-2008) grey seals in Sweden and Finland. All were by-caught or shot between August and February (Bäcklin et al. 2013). Green line show GES at carrying capacity.

Relevance of the indicator

Policy Relevance

The Baltic Sea Action Plan has the ecological objective 'Viable populations of species' with the 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 the indicators 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 EU Marine Strategy Framework Directive requires, inter alia, assessments for the state of biodiversity (Descriptor 1), food webs (Descriptor 4) and effects of hazardous substances (Descriptor 8), with specific criteria for population abundance and distribution and productivity (EC Decision 477/2010). Marine mammals were recognized by the MSFD Task Group 1 as a group to be assessed.

The EU Water Framework Directive (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 conditions) and anthropogenic impacts. These impacts can affect fish stocks, levels of harmful substances as well as direct mortality in form of hunting or by-catches. The vulnerability of seals to these pressures makes them good candidates for measuring the environmental status of ecosystems.

The nutritional status of seals can be regarded as a direct link between the environment and individual fitness and population growth rate (Figure 7). Seals fight a constant struggle to reach a critical limit of fat storage each autumn (Figure 4). Failure to reach this level will result in failed reproduction in adults and high mortality in juveniles. Ecosystem effects (in terms of reduced food supply for example) are readily visible in the blubber layer in a few weeks or months. If poor nutritive conditions persist for a prolonged time also total body growth rate during the sub adult ages decline and eventually the asymptotic adult body lengths of the entire population decline. This results in later age at sexual maturity, smaller females that can transfer less energy to their pups, which will have reduced chances of survival. All this will have dramatic effects on the population growth rate and health of the population. The latter because leaner seals are more exposed to parasites, but also to diseases.

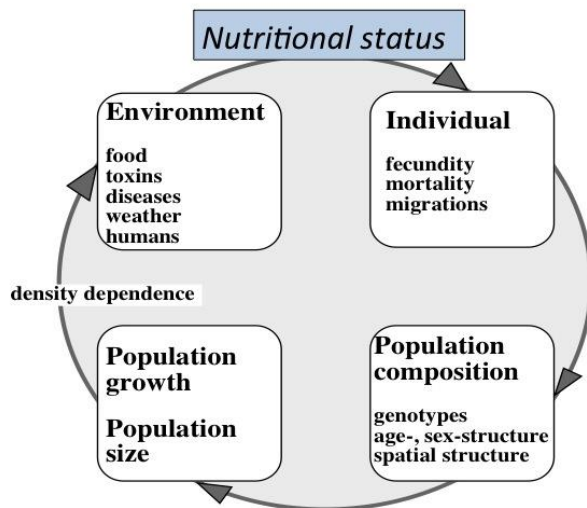


Figure 4. Seal population dynamics is linked to the rest of the ecosystem through individual fitness which in turn is determined by the nutritional status of individuals.

The nutritional status of seals reflects many processes in the Baltic Sea ecosystem, especially abundance of different fish stocks. Nutritional status also reflects levels of pollutants and other stressors, since diseased animals also loose in 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. This is what happened during the PCB catastrophe in the 1970s (Bergman and Olsson 1986.)

For long term trends total body length can provide very important information. The benefit of length as a measure is that available sample size is increased since all animals collected can be incorporated (all seasons all sampling methods). An additional feasible measure 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.

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 for 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 and 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 (Figure 5) (Nilssen et al., 1997; Hauksson, 1997). Failure to reach a critical fat reserve in late autumn result in decreased survival and failed reproduction. 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. Also body length and weight at age are important parameters to monitor year round for evaluation of nutritional status (examples below).

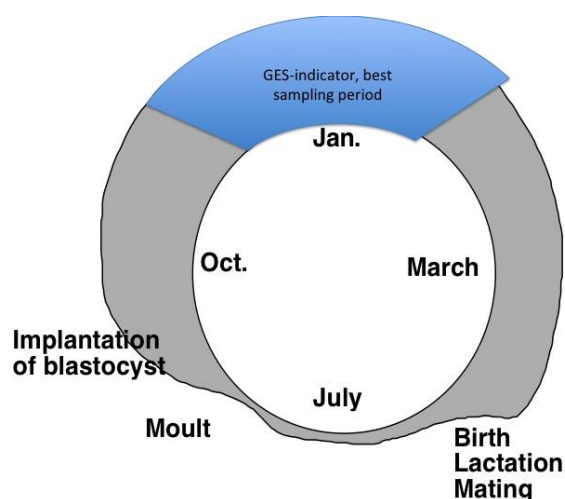


Figure 5. Schematic figure of the blubber thickness during the life cycle of an adult harbour seal in the Baltic Sea and Kattegat. The grey circle illustrates the strong flux in blubber thickness that is connected to the indicated major 'life cycle events'. The figure would be similar if drawn for any 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 Table 2. (Modified from Harding 2000)

Grey seal females spend on average 85% of their energy reserves during lactation (Fedak and Anderson 1987). In harbour seal females the associated mean weight loss is about 40% (Table 2) (Härkönen and Heide-Jørgensen 1990), but females need to forage during the last weeks of lactation to successfully wean their pups.

Table 2. Mean weights of adult female harbour seals decline during the breeding and moulting period (Härkönen and Heide-Jørgensen 1990).

Season	Post partum weight \pm SE
May	72.4 \pm 3.5 kg
June	58.0 \pm 4.2 kg
July	48.9 \pm 2.0 kg
August	45.9 \pm 2.9 kg
Mean weight loss 37 %	

Loss in blubber thickness and weight in ringed seals during the breeding season is also dramatic (Figure 6).

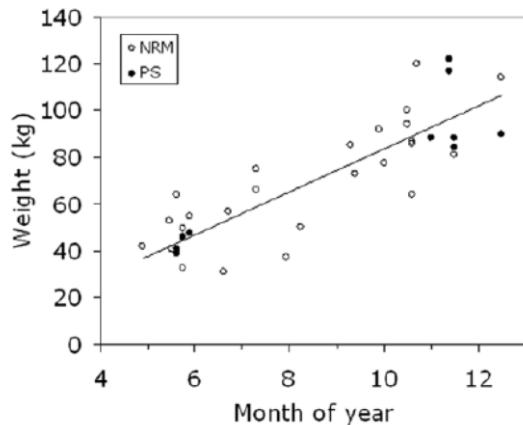


Figure 6. Weight of ringed seal females caught in the open water season. Filled circles refer to data a ringed seal satellite tag study, and open circles are data compiled from the seal data base at the Swedish Museum of Natural History (NRM). A linear regression of pooled data ($y = 9.16x27.97$, $R^2 = 0.83$) suggest that ringed seal females gain 9.2 kg per month from May up to December. Härkönen et al 2006.

In addition to being an energy reserve that make phocid seals able to exploit seasonally rich resources, blubber thickness in pinnipeds also influence thermoregulation, body shape and hydrodynamic drag and buoyancy (Mellish et al 2007).

Ryg et al. (1990) developed a method to estimate the total blubber content of a seal as a percentage of the body weight from three measurement points; length (L) mass (M) and blubber depth (D) (LMD-index) in five seal species (phocids). The investigation was performed on shot or by-caught seals and the blubber of 132 ringed seals, 8 bearded seals, 38 grey seals, 20 harp seals and 3 harbour seals (

Figure 8). The results show that blubber percentage value of the body weight was equal to $4.44 + 5693 \sqrt{L/M} \times d$, and $SE = 3\%$, where L is body length in meters (nose to tail), M is the body mass in kg, and d is the xiphosternal (a site located dorsally at 60% of the body length from nose) blubber thickness in meters.

At SMNH, the relation between the sternum blubber thickness and the LMD index (calculated with the xiphosternal blubber thickness) has also been investigated in Baltic ringed and grey seals. The measured sternum blubber thickness was positively correlated with the calculated LMD-index (Figure 7 and

Figure 8). Thus, the results indicate that the sternum blubber thickness is a good indicator for the nutritional status/body condition in ringed and grey seals.

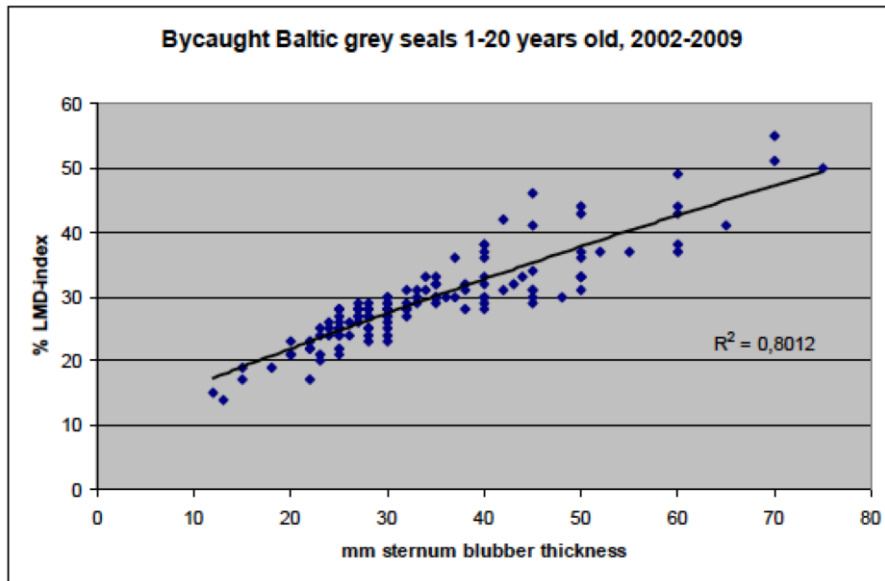


Figure 7. Sternum blubber thickness (mm) in by-caught Baltic grey seals in relation to percentage blubber of the body weight (LMD-index). Trend line is polynomial. Sternum blubber thickness is highly correlated to the LMD index and explains 80% of the variation.

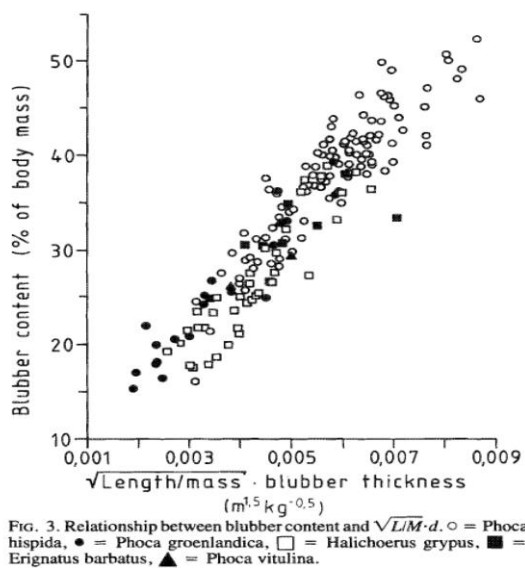


Figure 8. Correlation between blubber content (measured from dissected seals) and the index based on length mass and blubber depth in the study by Ryg et al. 1990. The regression line gave the equation used in the LMD index: $4.44 + 5693 \sqrt{L/M} \times d$.

At NMR the % blubber of the body weight has been tested using the mathematical model from Ryg et al. (1990). The results were compared with the 'real' weight of the blubber as percentage of the body weight in two ringed seals and one grey seal. For these three seals, the calculated LMD-index was almost identical to the weighed % blubber of the body weight (Table 3). This modest experiment confirms that the LMD-index is a good method for calculating % blubber in both ringed and grey seals, if body length, body weight and the xiphosternal blubber thickness are known

Table 3. Calculated % blubber (LMD-index) and respective factors used for calculations (from Ryg et al. 1990).

Seal	Length m	Body weight kg	Blubber m	Blubber weight kg	% Blubber of body weight	Calculated % blubber (LMD)
Ringed	1,25	66,3	0,055	30,7	46	47
Ringed	1,08	23,4	0,009	3,5	15	15
Grey	0,98	21,9	0,013	4,2	19	20

Consequently, blubber thickness is a highly correlated proxy for nutritional status in ringed and grey seals.

Weight and effects on pup survival

Based on a study on individually branded harbour seals, a response to poor nutritive conditions in seal pups could be documented in detail (Härkönen and Harding 2001, Harding et al. 2005). Winter survival in the young of the year was highly dependent on the autumn weight. The range in survival was large, from 96% in well fed pups to only 65% in lean pups (Figure 5) (Harding et al 2005). Similar fluctuations in life history parameters have also been observed in e.g. harp seals, Canadian harbour seals and ringed seals (Harwood and Prime 1978, Fowler 1981, Kjellqwist et al 1995, Krafft et al 2006).

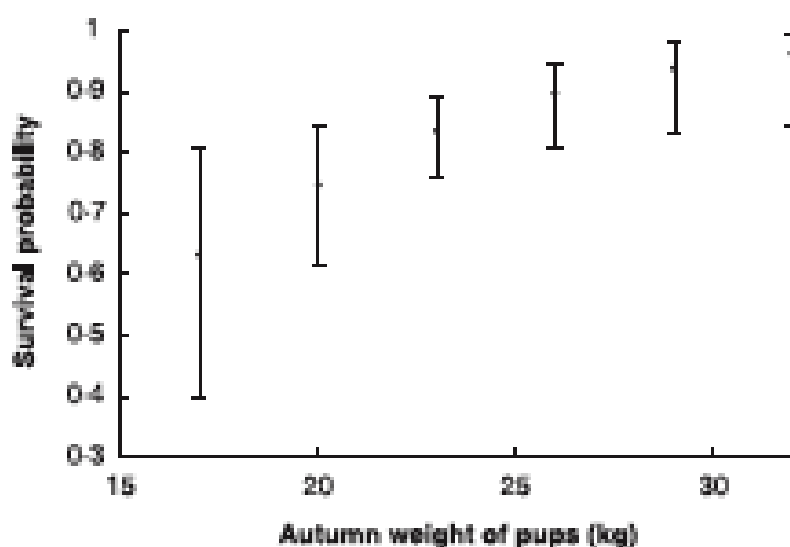


Figure 9. Body weight in pups reflects nutritive conditions. First year winter survival of Harbour Seal pups in the northern Skagerrak is significantly related to their body mass in the autumn. Error bars denote 95% confidence limits for each given weight. From Harding et al (2005).

Energetic modelling

The minimum required energy reserves needed to survive and reproduce can be estimated by bio energetic optimization models. Such models include seasonal variation in water temperature, activity time budgets, metabolism and assumed food availability. Such models can be parameterized to mimic different specific seal populations. The model gives a hint for how important for example changes in food supply or

insulation from different thicknesses of blubber are. In a recent study the balance between relying on fat reserves or feeding during lactation was studied with this framework (Figure 10, Stephens et al. 2014).

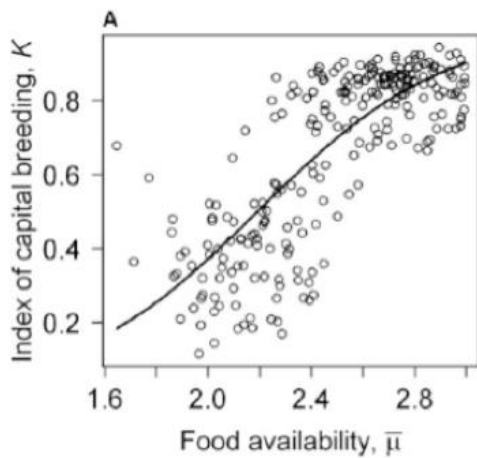


Figure 10. Results from an energy optimisation model. Harbour seals must forage during lactation when food availability is low (left hand side of the graph). As food availability increases female seals can rely to a larger extent on their body reserves (right hand side of the graph). The y-axis gives the proportion of the energy transferred to a weaned pup that came from the mothers stored resources (capital) and from feeding during lactation (income) (Stephens, Houston, Harding, Boyd and McNamara 2014). Harbour seals feed during lactation, but grey seals and ringed seals rely solely on stored reserves and thus on a high food availability during the autumn.

Somatic length and nutritive condition

Nutritional status also affect the body length, just as in other mammals the nutritive condition during childhood affects the final adult body size after sexual maturation. Large decline in body length 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 in the Kattegat-Skagerrak harbour seals collected during the last decades (Figure 11).

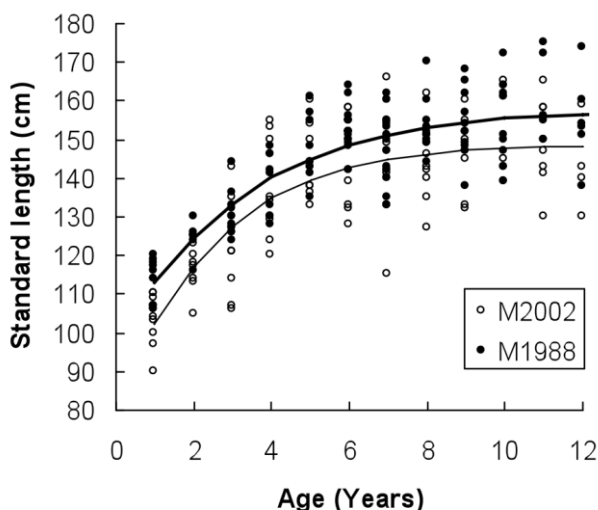


Figure 11. Overall body growth curves and final adult body length respond to food availability and stress and reflect the nutritive condition of seals over longer time periods (decades). In the graph above is an example from harbour seals at different population densities. In 2002 adults are 10 cm shorter on average due to higher population density.

Results and confidence

Processed data is only available for grey seals, which will be evaluated in the following. Results are based on combined Swedish and Finnish data. Future evaluations will include German, Estonian and Polish data.

Grey seal

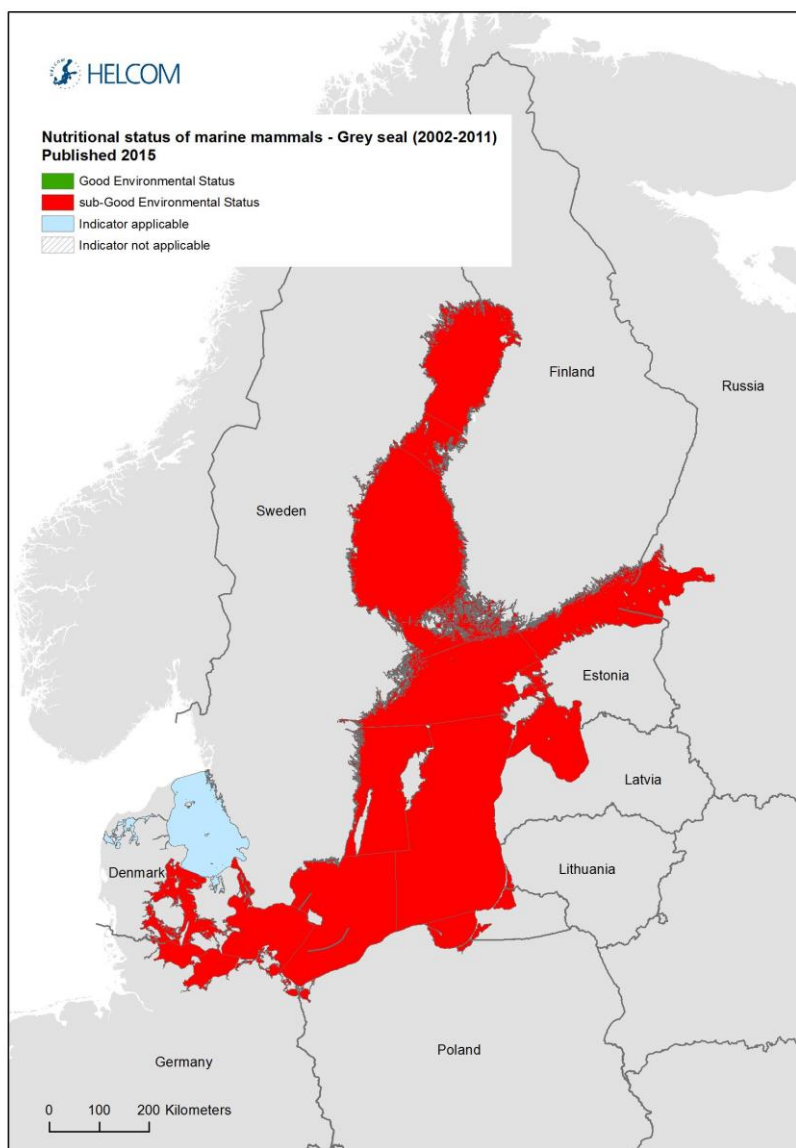


Figure 12. Baltic grey seals do not attain GES both with regard to nutritional status, since observed data fails the GES limits 40mm for hunted seals and 35mm for by caught seals. However, current data suggest that grey seals are approaching the carrying capacity of the system, where the GES boundary of 25 mm is applicable.

A strict Bayesian analysis has not been carried out yet, but it is evident that such an analysis will support GES for time periods 1993-2001 and 2002-2004 for data in Figure 13, whereas it would fail for data 2008 and later for both hunted and by-caught grey seals, when tested against GES boundaries (40 and 35 mm for hunted and by-caught seals respectively) for populations experiencing exponential growth. (However, it is suggested that GES would be attained in both cases when testing against a prior at 25mm, which is applicable in populations close to carrying capacity.)

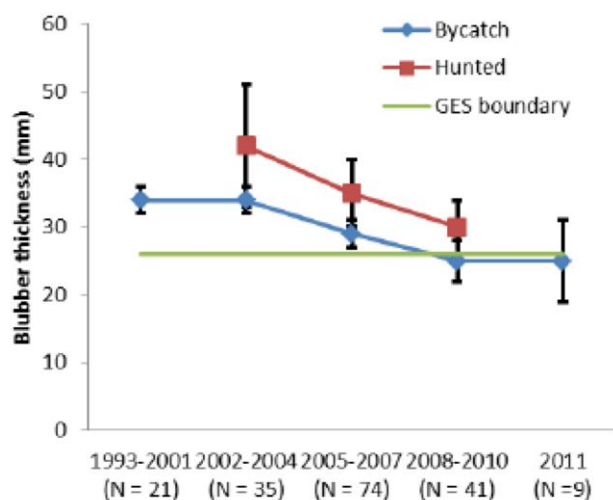


Figure 13. Grey seals. The mean fall/winter blubber thickness \pm SD in examined 1–3 years old non-pregnant by-caught (1993–2011) and hunted (2002–2010) grey seals in Sweden. All were by-caught or shot between August and February. The decrease is significant ($p < 0.002$). N is the number of investigated animals. Green denotes the GES boundary for populations at carrying capacity

Decreasing blubber thickness in both hunted and by-caught grey seals are statistically significant.

Ringed seal

Although data still is too scarce to establish a GES-boundary for ringed seals, data indicate that also the nutritive condition of ringed seals is deteriorating (Figure 14). Decreasing blubber thickness is seen both in juveniles and adults (Figure 14)

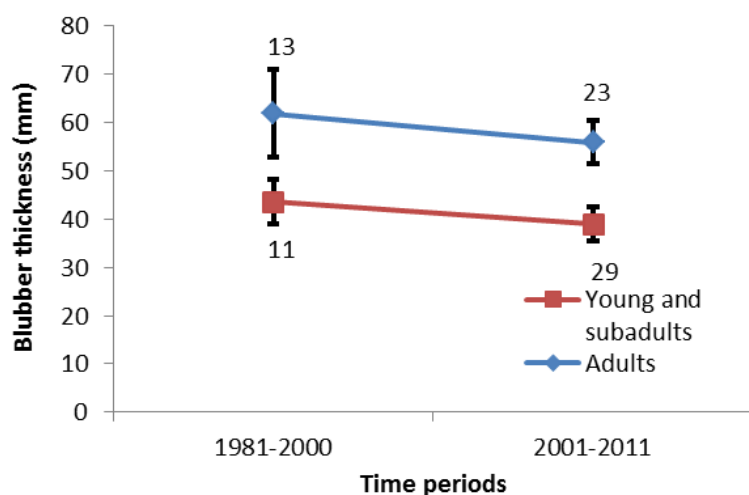


Figure 14. Ringed seals. The mean fall/winter blubber thickness \pm 95% CI in examined 1–3 and 4–20 years-old animals (by-caught or shot). GES boundary has not been agreed but suggested as 35.6 mm and 51.4 mm for young and adult, respectively. Number of samples is given beside the means.

Confidence of the indicator status evaluation

Considerable and sufficient material is collected annually for grey seals in Finland and Sweden, so confidence is **high** for this particular species in the central and northern part of the Baltic. The samples also include Swedish material from the southern Baltic, but it would be desirable to include 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 1-4 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). 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. The reason for the decreasing trend in blubber thickness in seals is unknown but so far no correlations to disease have been found. Data is still scarce for ringed seals in both management units, resulting in low confidence in this species. For harbour seals material is collected annually, but needs to be compiled and analyzed further.

Monitoring requirements

Monitoring methodology

HELCOM common monitoring of relevance to the indicator is described on a general level in the HELCOM Monitoring Manual in the [sub-programme: Seal health status](#).

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

Description of optimal monitoring

The optimal monitoring should encompass sufficient numbers of samples from all species of seals in all areas where they occur. Sufficient material is collected for grey seals in the central and northern Baltic, but it would be important to include more material from the southern Baltic for analyses of regional differences.

Current monitoring

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.

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 data and up-dating

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. Remains to include German and Polish data.

The data collected and used in the indicator are based on national data bases. 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, archive and references

Contributors

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Archive

[2013 Indicator Report](#)

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