Nutritional status of seals

Authors

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Contents

Key message

The mean blubber thickness of the Baltic grey seals, which is a measure of the nutritional status of the seal, has decreased significantly over the last 5–10 years in 1- to 3-year-old non-pregnant grey seals that died between August and February. For ringed seal there has been a similar decline among individuals <4 years old whereas for individuals ≥4 years old it has remained somewhat steady during the sampling period (1981 to 2011). However, the blubber thickness has declined also among adults in the springtime samples. Females reserve fat during the pregnancy period in order to prepare for the nursing period and therefore the declined blubber thickness may lead to reduced pup survival.

In grey seals the amount of liver flukes (a parasite of which intermediate hosts are cyprinid fishes) increased significantly in 2008. The diet composition of the grey seals may have changed, including now larger proportions of cyprinid fish.

The prevalence of intestinal ulcers in grey seals increased significantly in investigated juveniles (1–3 years old) in the middle of 1980s and in adults (4–20 years old) in the 1990s. Those trends are now decreasing.

There is no statistically significant correlation between the prevalence of intestinal ulcers or liver flukes and a thin blubber layer in grey seals.

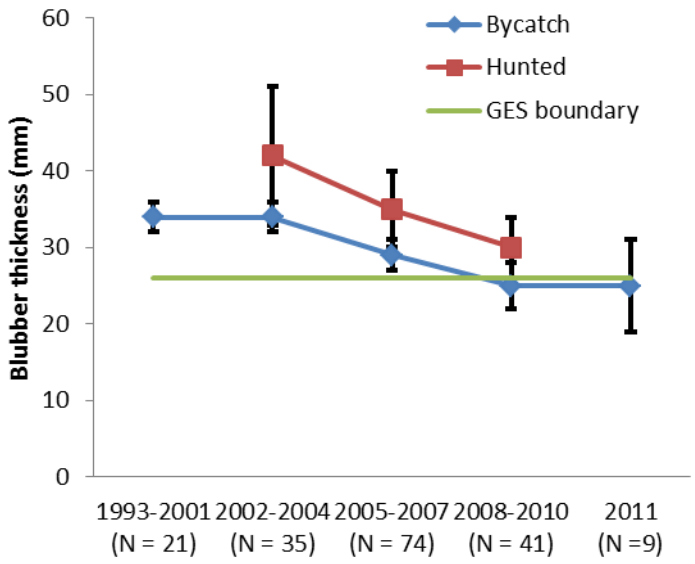

Figure 1. *Grey seals. The mean fall/winter blubber thickness ± SD in examined 1–3 years old non-pregnant by-caught (1993–2011) and hunted (2002–2010) grey seals in Sweden. All were by-caught or shot between August and February. The decrease is significant (p<0.002). N is the number of investigated animals. See Data table 1 for exact values.*

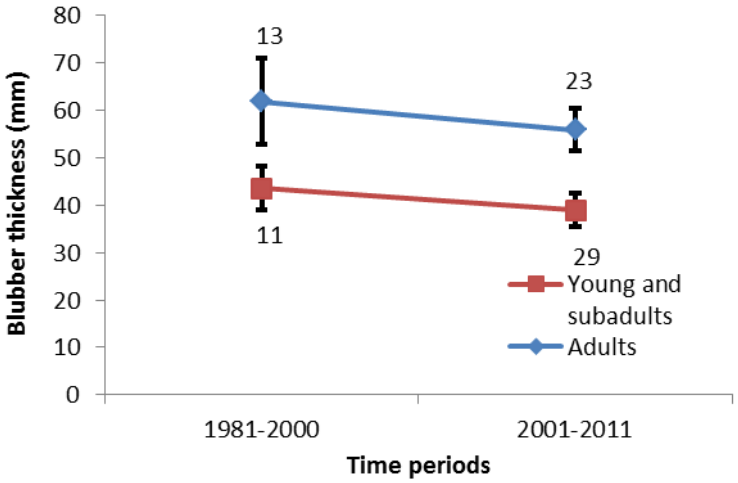

Figure 2. *Ringed seals. The mean fall/winter blubber thickness ± 95% CI in examined 1–3 and 4–20 years-old animals (bycaught or shot). GES boundary has not been agreed but suggested as 35.6 mm and 51.4 mm for young and adult, respectively. Number of samples is given beside the means. See Data table 2 for exact values.*

Description of the indicator

The core indicator 'Nutritional status of seals' follows particularly the thickness of animals' energy reserve, the blubber. Changes in blubber thickness may be affected also by other stressors than prey depletion or poor quality of prey, such as contamination and disturbances affecting foraging. Nutritional indicators consist of blubber thickness measurements, and prevalence of endoparasites and intestinal ulcers.

The primary indicator, blubber thickness, has been found applicable for all the three seal species, whereas its applicability for harbor porpoise has not been shown.

Policy relevance

Blubber thickness is a commonly used method to describe the nutritional state of marine mammals. The sternum blubber thickness in Baltic seals has been measured in by-caught and hunted seals. Blubber thickness has also been noted in harbour porpoises.

Marine mammals may be negatively affected by changes in the food web, contaminants, and anthropogenic activities. Health status of grey seal, ringed seal, harbour seal and harbour porpoise is referred to in several environmental policies in the Baltic Sea:

- HELCOM has a recommendation on Conservation of seals in the Baltic area (27-28/2 2006-07-08) and in the Baltic Sea Action Plan (adopted 2007-11-15, Poland) seal health was defined as an indicator of a healthy wildlife in the Hazardous substances segment.
- The grey seal, ringed seal and harbour seal and harbour porpoise are listed in the EU Habitats Directive Annexes II and V as species of community interest whose conservation requires the designation of Special Areas of Conservation.
- The EU Marine Strategy Framework Directive requires an assessment of environmental status of populations of marine species (EC Decision 477/2010/EU), and marine mammals were recognized by the MSFD Task Group 1 as a group to be assessed.

- The conservation of the harbour porpoise has been specifically set by the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)

What is the nutritional status of seals?

Nutritional status of grey seals

The nutritional status of by-caught 1–3-year-old grey seals during the period 2008–2011 was below GES (see Metadata) (Figure 1). However, GES was reached for the hunted 1-3 years old grey seals. The blubber thickness of both categories has, however, declined since 2004.

The mean 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 (Figure 1). A summary of data is given in Data table 1.

There could be several reasons for the thinned 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.

Nutritional status of ringed seals

In all examined ringed seals in Finland and Sweden, consisting of samples mainly from the Gulf of Bothnia 1981–2011, the mean sternum blubber thickness was 35.0 mm (SD = 14.1, n = 364).

Due to small sample sizes before 2001 (Figure 2), only two time periods were compared in further analyses. The data for young (pups < 1-year-old) and subadults (1–3-year-old) were pooled, because the blubber thickness of these two groups did not differ. There was a significant decreasing trend in blubber thickness for young and subadults ($r = -0.34$, $n = 131$, $p < 0.001$) but not for adults ($r = -0.06$, $N = 211$, ns) during the whole study period (all seasons included) (Figure 2). No significant trend was found within the period 2001–2011.

The mean blubber layer among ringed seals was thicker in autumn than in spring (Figure 8, Data table 2). The blubber thickness for both age groups was lower in spring than in autumn, and it was lower after 2000 than during the earlier time period. Difference between the time periods was significant only in spring: young and subadults: $t = 3.4$, $df = 26.8$, $p = 0.002$, adults: $t = 2.0$, $df = 163$, $p = 0.044$).

The GES boundary has not been set yet, but the declining trend suggests that GES is not maintained or may be lost. The lower limit of 95% confidence intervals was 35.6 mm for young and sub-adult individuals and 51.4 mm for adults in 2001–2011. The sample includes both by-caught and hunted seals from August-February.

The blubber thickness in harbour seals remains to be compiled and evaluated.

Intestinal ulcers in grey seals

In this report intestinal ulcers are discussed as a factor behind the blubber thickness decrease. From the middle of 1980s the prevalence of intestinal ulcers, mostly localized in the ileum-caecum-colon region, has increased (Figure 3). In 1- to 3-year-old grey seals, the intestinal ulcers increased significantly compared to the decade before. Thereafter (1997–2011), the prevalence has decreased. Several years after the increase in young seals, there was a significant increase in 4–20 yearsold grey seals. These results indicate that the ulcers observed in adult seals started to develop in young seals already.

Early intestinal lesions (ulcers) show solitary or multiple, often confluent areas with slight denudation of the epithelium surrounded by Acanthocephalans (Corynosoma sp.). Often the muscular tunic of the diseased part of the intestine is thickened. The size of the ulcers may vary from a few millimeters in diameter to extended ones

encompassing large parts of ileum and colon. If the ulcerous process reaches the muscular tunic the serosa may show chronic inflammation with fibrinous or fibrous adherences between the intestinal portions and closely situated abdominal organs. At this stage perforation of the intestinal wall is common. Death from colonic ulcer occurs at all ages, from one-year-olds (Bergman and Olsson 1985, Bergman 1999). The prevalence of colonic ulcers of moderate and severe degree i.e. lesions exceeding 10 mm in diameters are the only ones that are considered (Bergman, 1999). The high prevalence of intestinal ulcers seems unique for the Baltic population of grey seals. Examination of grey seal intestines from the Scottish east coast and Atlantic coast of Ireland, revealed no signs of ulcers (Bergman, 1999; O´Neill and Whelan, 2002). In Atlantic grey seals Acantocephala (Corynosoma sp.) may create very small lesions in the intestinal mucous membrane but only one case of intestinal ulcer in grey seals has been reported outside the Baltic Sea (Baker 1980, 1987). The high prevalence of ulcers of moderate to severe degree in the young Baltic grey seal indicates an impaired or delayed healing process, which may involve the immune- as well as the hormonal system. Since 1996 in 1–3 years old, and 2007 in 4–20 years old, the prevalence of intestinal ulcers has decreased.

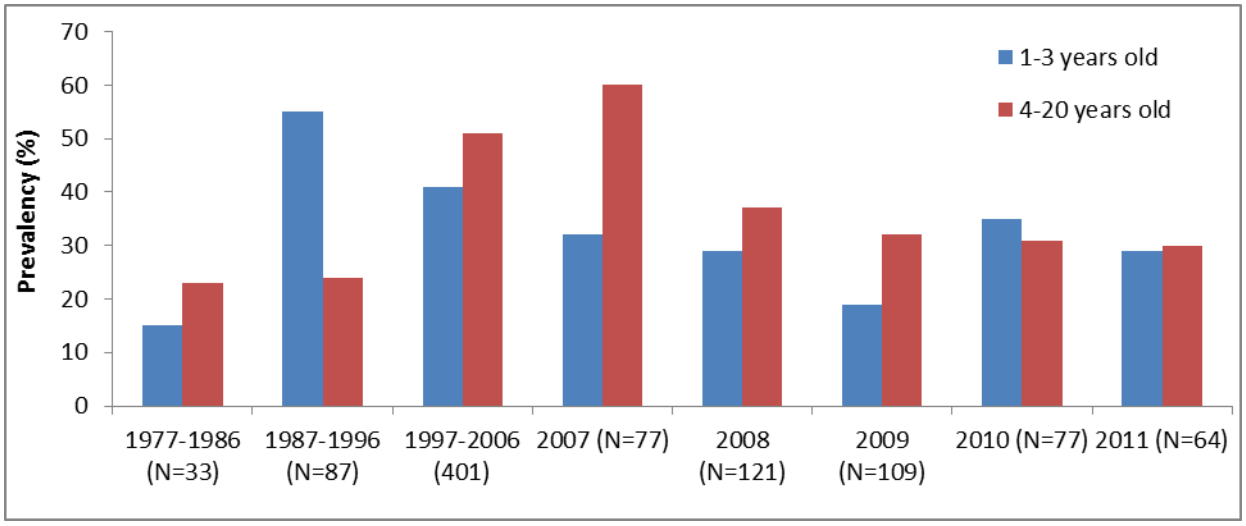

Figure 3. *The prevalence of intestinal ulcers in examined young and adult grey seals in Sweden. N is the number of investigated animals (not separated to young and adults).*

Parasites

Parasites found in Baltic seals are listed in Table 1. There is continuous sampling of parasites in the Baltic seals, but only some analyses have been accomplished. Data on the prevalence of parasite species indicates species of fish consumed and how resistant the seals are against parasite infections since parasite infections often increase as a result of other stressors such as environmental toxins (Lafferty & Kuris 1999).

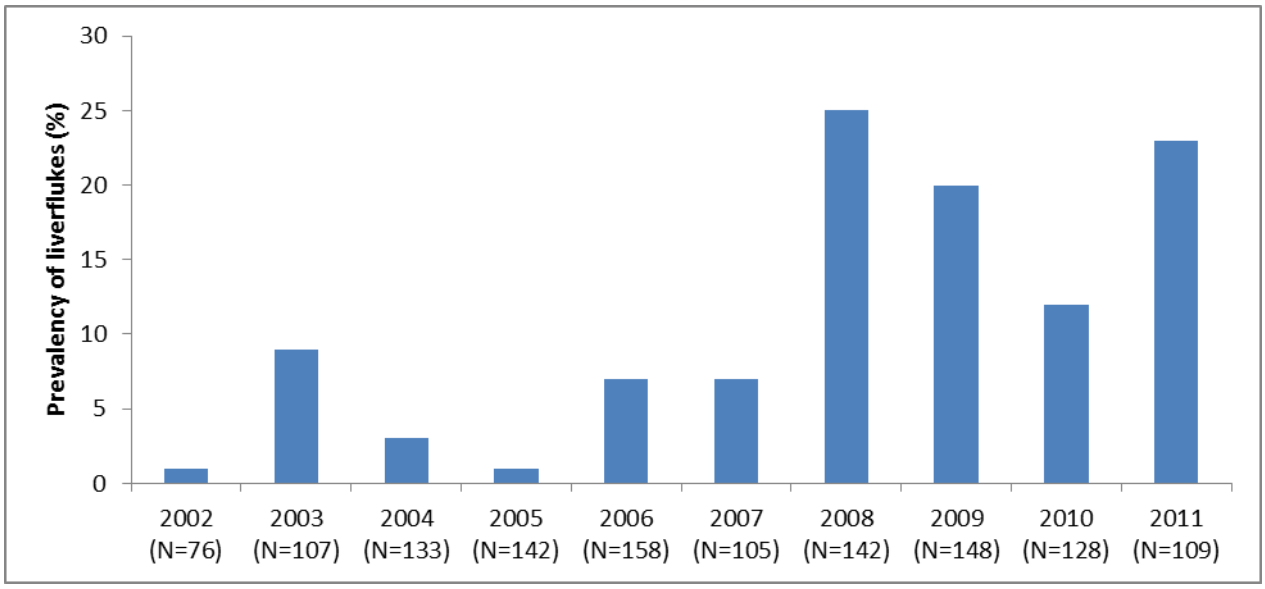

Figure 4. *Liver flukes. The percentage of examined grey seals in Sweden showing liver flukes between 2002 and 2011. The percentage increased significantly in 2008 compared to 2007 (p< 0.0002). N is the number of investigated animals.*

Grey seals. Grey seals host several species of parasites. In 2008, the proportion of examined grey seals showing liver flukes increased significantly (**Figure 4**). In several cases the liver flukes were specified as *Pseudamphistomum truncatum*. In relation to this parasite, grey seals also show liver lesions. *Pseudamohistomum truncatum* is mostly found in cyprinids, such as roach (*Rutilus rutilus*), for example. Beside parasites listed in **Table 1**, there have been some findings of larval stages of Cestoda (*Schistocephalus solidus and Diphyllobothrium sp.*) in grey seal intestines (Helle and Valtonen, unpublished data). The main hosts of *S. solidus* are fish-eating birds and rodents but the adult stadium is not present in the grey seal. Grey seals get it by eating the three-spined stickleback (*Gasterosteus aculeatus*). Some species of *Diphyllobothrium* may have seals as main hosts but adult stages of this tapeworm haven't been discovered. There have also been findings of *Porrocaecum sp*. (or *Pseudoterranova decipiens*) in the stomach and intestines and *Anisakis sp*. in the stomach (Bergman 2007). Most data on parasite abundance is not available in database yet.

Ringed seals. Parasites found in ringed seals are listed in **Table 1**. *Schistocephalus solidus*, a tapeworm infecting the three-spined stickleback (*Gasterosteus aculeatus*) as an intermediate host, is commonly found in the alimentary tract of ringed seals. The main hosts of *S. solidus* are fish-eating birds and rodents, and neither its adult stage nor effect on the ringed seals has been reported. *Contracaecum osculatum* is common in Baltic grey seals but occurs only sporadically in ringed seals (O'Neill & Whelan 2002). Only one lice species *Echinophthirius horridus* has been detected on ringed seals (Durden & Musser 1994) and it has also been found on Baltic grey seals.

Previous studies indicate that *Corynosoma* spp. are the most prevalent endoparasites (Helle & Valtonen 1980, Helle & Valtonen 1981). Also heartworm (*Dipetalonema spirocauda*) is relatively common in the southern Baltic ringed seal population (Westerling et al. 2005).

Table 1. *Endoparasites in the Baltic grey seals and ringed seals.*

Parasite species	Location in seals	Location in Baltic Sea	References
Parasites in grey seals			
NEMATODA			
Contracaecum osculatum	Stomach	Bothnian Bay	Valtonen et. al, 1988
ACANTHOCEPHALA			
Corynosoma semerme	Posterior parts of intestine	Gulf of Bothnia	Nickol et. al, 2002
Corynosoma magdaleni	Small intestine		
Corynosoma strumosum	Small intestine		
TREMATODA			
Pseudamphistomum truncatum	Liver	not specified	Bergman, 2007
Parasites in ringed seals			
NEMATODA			
Contracaecum osculatum	Stomach	Gulf of Bothnia	Valtonen et al. 1988
Dipetalonema spirocauda	Heart	Gulf of Finland	Westerling et al. 2005
Parafilaroides sp.	Lung		
ACANTHOCEPHALA			
Corynosoma semerme	Posterior parts of intestine	Gulf of Bothnia	Helle & Valtonen 1980, Helle & Valtonen 1981, Nickol et al. 2002, Valtonen et al. 2004
Corynosoma magdaleni	Small intestine		
Corynosoma strumosum	Small intestine		
CESTODA			
Schistocephalus solidus	Alimentary track	Gulf of Bothnia	Chubb et al. 1995, Valtonen et al. 2004, Bergman 2007
Diphyllobothridae sp.	Intestine		

How the indicator describes the Baltic marine environment?

The Baltic seals

The species considered by this indicator are grey seals (Halichoerus grypus), ringed seals (Pusa hispida botnica) and harbour seals (Phoca vitulina). Harbour porpoise (Phocoena phocoena) has been left out as there is uncertainty how the methodology applies to it. The current data supports only the assessment of grey seals and ringed seals.

As fish-feeding mammals, seals are top predators and their health condition reflects the state of the Baltic environment. Grey seals are distributed more or less in the entire Baltic Sea, with the largest populations in the southern parts of the Gulf of Bothnia and the northern parts of the Baltic proper. Ringed seals have assumed to have four populations in the Baltic Sea, the largest one occurring in the Bothnian Bay and the other three in the Gulf of Finland, Gulf of Riga and the Archipelago Sea, but more information of the gene flow between populations are needed to draw firm conclusions of the number of populations. Harbour seal has two distinct populations, one around the island of Öland and the another one on the Swedish West Coast and the southern Baltic.

The Baltic seals have suffered from various health defects during the last decades, which have been associated with the deterioration of the general status of the Baltic Sea. Several health parameters in seals are investigated by the HELCOM Contracting Parties (CPs). The significance or cause of some pathological findings remains to be looked into. Furthermore, Baltic countries have different possibilities and access to conduct marine mammal necropsies. Therefore blubber thickness has been prioritised to roughly reflect the health in marine mammals since it is routinely measured in several CPs (see section on monitoring). Starvation causing a thin blubber layer can seriously affect the survival of the population.

The assessment approach

The seals were assessed on a population level by assessing the population nutritional status, in particular the blubber thickness of the seals. The blubber thickness can only be recorded in examined animals and conclusions for the whole population are statistically depending on the number of seals examined. For the interpretations of the results it is important to record the cause of death in examined grey seals.

Good environmental status is determined when the blubber thickness is above a threshold level (=GES) defined by Norwegian and Swedish hunted seals from 1999–2004 (see details in Metadata). The GES limit will be different between juveniles and adult males and females and between species.

Assessment is made for grey seal and ringed seal. Blubber thickness is also recorded in harbour porpoises and harbour seals, but the low number of animals inhibits assessments at this stage and more knowledge is needed about the season for measure in harbour porpoises. For the determination of the GES boundary, more information is needed for the determination of normal blubber thickness in harbour porpoises, ringed and harbour seals before including them to the assessment.

In addition to the blubber thickness measurements, the assessment of the population health status can be supported by the following indicators.

1. Occurrence of intestinal ulcers, is describing an observed pathological change with unknown cause;
2. Parasites (species diversity and abundance) describing infection pressure, foraging patterns and Baltic environmental conditions;
3. Cause of death in examined seals. This parameter is divided into three classes (hunt, drowning and disease/other cause).

The concept of the indicator

Blubber thickness is a commonly used indicator for the nutritional state of marine mammals (Ryg et al. 1990). The thickness of the blubber layer is important for the survival of individual marine mammals and in females also for the survival of their offspring. Seasonal variations in blubber thickness with a decrease during the reproduction, lactating and molting periods in the spring and an increasing blubber thickness towards the autumn has been described for adult seals in many studies (Nilssen et al. 1997, Sparling et al. 2006, Hauksson 2007).

The mean sternum blubber thickness has been measured mainly in by-caught seals since 1975. Therefore this site on the seal is used for time trend analysis of blubber thickness. In hunted seals it has been measured since 2002.

In 1977–2002, blubber thickness in seals necropsied at the Swedish Museum of Natural History (SMNH) was only measured ventrally at three sites (either sternum, belly and hips, or neck, sternum and hips) between the muscle layer and the skin. Therefore, at SMNH, only the sternum blubber thickness of seals measured today is comparable with earlier data. Two questions have been addressed when evaluating blubber thickness as a core indicator:

1. Does the sternum blubber thickness reflect the nutritional status/body condition of the animals?
2. What blubber thickness could be considered to be normal?

Investigations of blubber thickness in ringed and grey seals conducted at SMNH and a survey of published data are summarised below.

LMD-index

Ryg et al. (1990) tested a method to estimate the total blubber content of a seal as a percentage of the body weight (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 was measured and weighed. The results showed that blubber percentage value of the body weight was equal to 4.44 + 5693 √L/M x 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 % 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 similar to the weighed % blubber of the body weight (Table 2). The modest experiment also showed 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 2. *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

LMD-index and sternum blubber thickness

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 (Figures 5 and 6). Thus, the results indicate that the sternum blubber thickness is a good indicator for the nutritional status/body condition in ringed and grey seals.

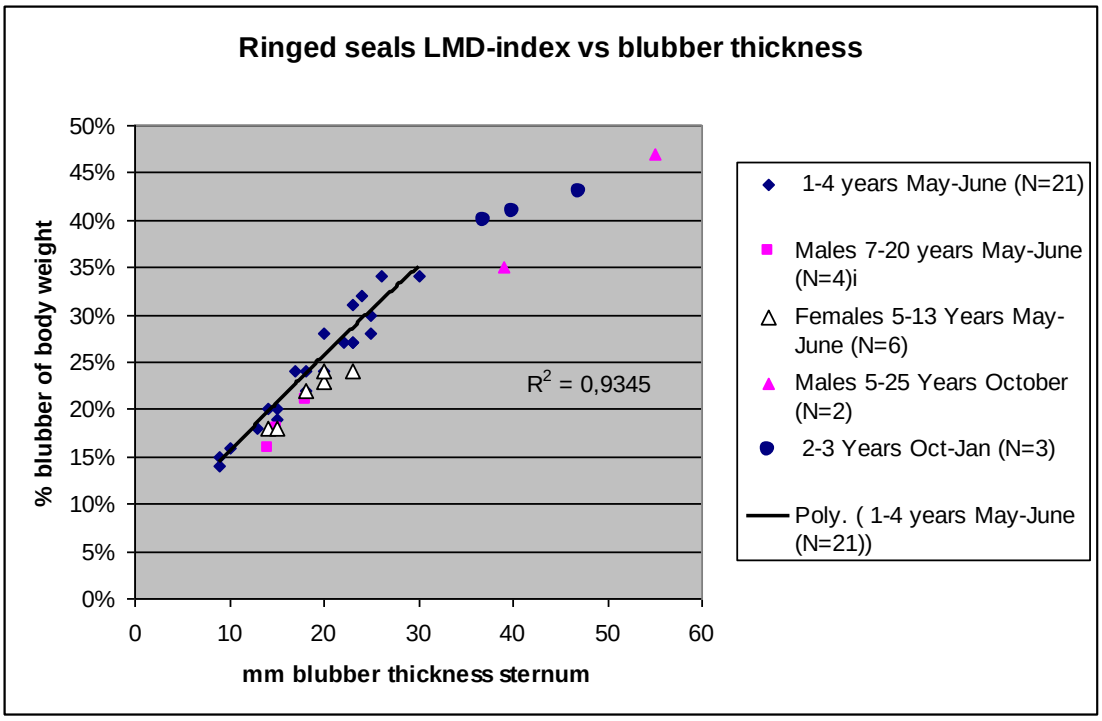

Figure 5. *Sternum blubber thickness (mm) in Baltic ringed seals from hunt in relation to percentage blubber of the body weight (LMD-index). –1-4-year olds include both males and females. Most of the animals were shot in the spring (thinnest season). N= number of investigated ringed seals*

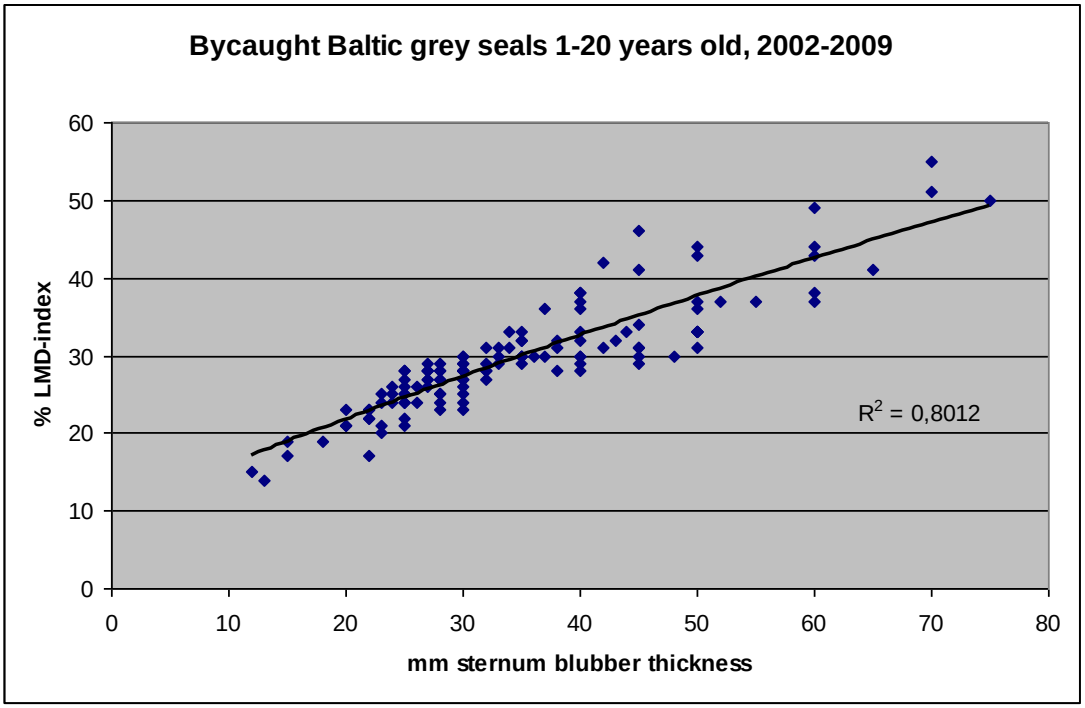

Figure 6. *Sternum blubber thickness (mm) in by-caught Baltic grey seals in relation to percentage blubber of the body weight (LMD-index). Trend line is polynomial.*

Seasonal changes in blubber thickness

In order to avoid measuring seals that have starved due to natural causes (e.g. poor teeth due to old age or poor survivors due to young age), it is suggested that only seals that are 1–20 years old are included in the assessments of blubber thickness. The blubber layer in the mature ringed and grey seals fluctuates with season and is low after the reproductive season. The intention is to measure how successfully seals have managed to gain blubber after the reproductive season, and hence the measuring period is suggested to be timed for the autumn/winter season. In order to investigate in which month the blubber thickness starts to increase, a mean value was calculated for each month, sex and age class in grey seals from hunt[1]. It seems that the blubber layer is thickest between the pregnancy period (August-February) (Figures 7 and 8). The data presented in Figure 7 represents measurements done by the hunters, who were provided with instructions, and the sternum blubber thickness has thereby been measured by different people using different instruments. For ringed seal the difference between the spring and fall blubber thickness is statistically very significant (p=0.001), whereas the blubber thickness between sexes did not differ from each other (Figure 8).

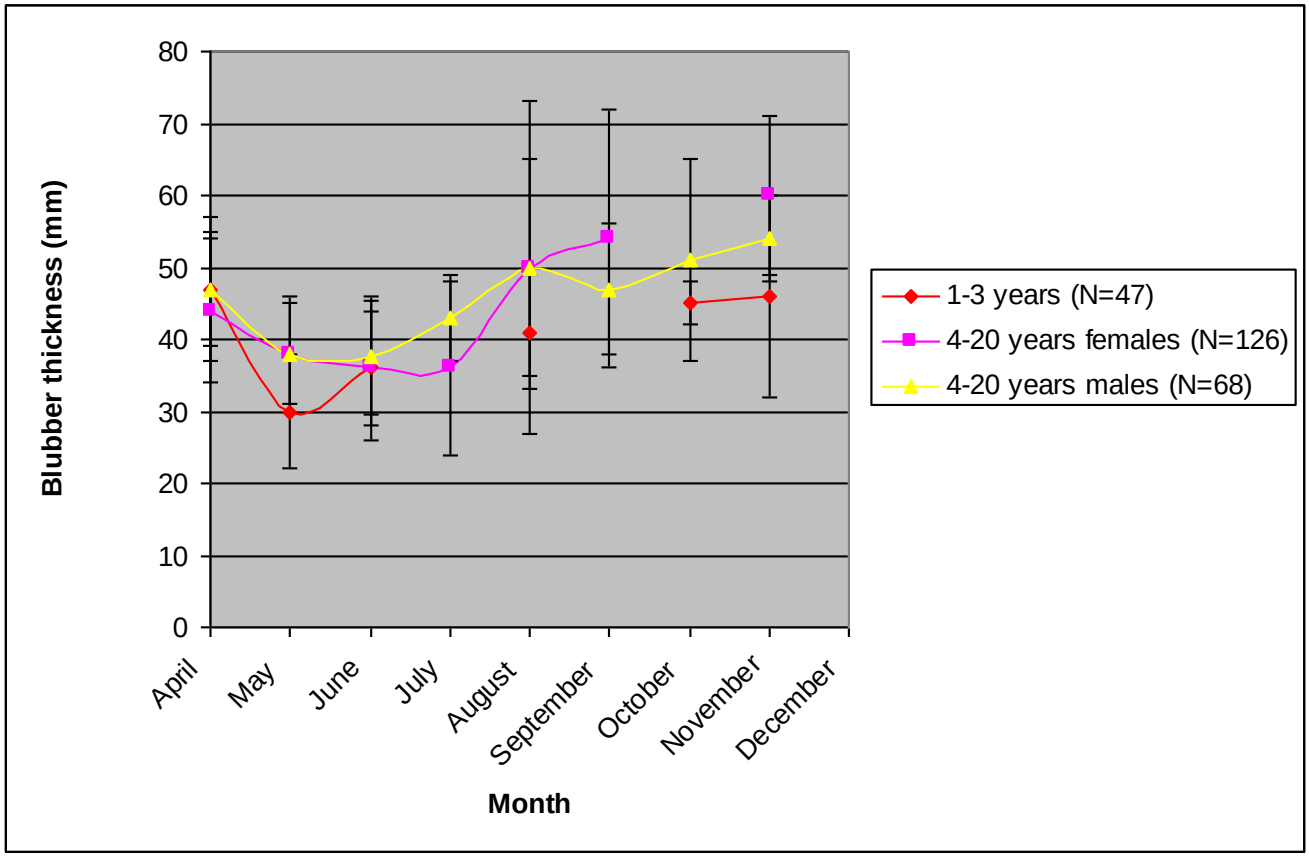

Figure 7. *Grey seal mean blubber thickness (mm) ± SD of at least 3 individuals per month in Baltic grey seals from hunt, 2002–2006. N= total number of animals measured.*

[1] Since 2001, Swedish hunters have sent the inner organs, lower jaws, a piece of blubber with skin,

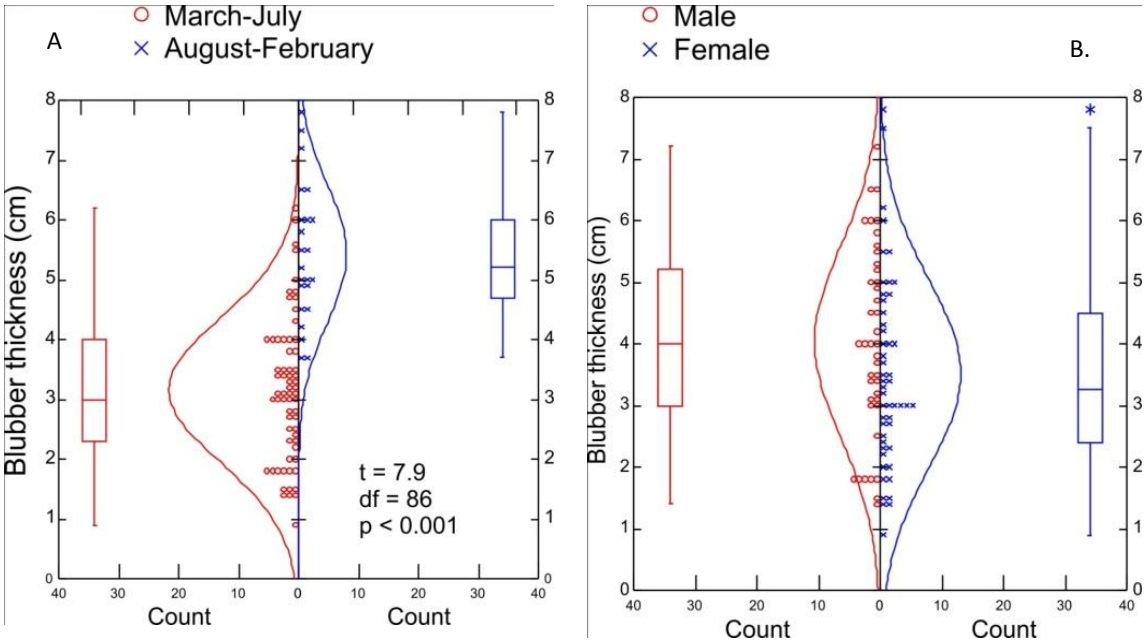

Figure 8. *Ringed seal blubber thickness (cm) ± SD, adult individuals) during 2001–2011 (A) between two seasons March–July and August–February and (B) between the sexes. The seasonal difference is highly significant while the sexes do not differ from each other statistically.*

Table 3. *Number of measured animals each month in Figure 7.*

Age years/sex	April	May	June	July	Aug	Sept	Oct	Nov
1–3	3	15	10	-	10	-	5	4
4–20 /females	3	65	32	7	11	4	-	4
4–20 /males	9	11	8	3	5	8	14	10

Normal blubber thickness in grey seals

Beside Swedish data, data of sternum blubber thickness in grey seals was kindly provided by the UK (P.D. Jepson) and Norway (K.T. Nilssen) and comparisons were made in the pregnancy period[2] of animals examined in and before 2004 (Table 4). It should be noted that the available data include animals with different causes of death (stranded, shot or by-caught).

[2] In UK and Norway; March-September and in the Baltic, August-February

Assuming grey seals from hunt represent a fairly random sample from the population; geometric mean[3] blubber thicknesses with confidence intervals were calculated to represent reference levels from Norwegian and Swedish grey seals from hunt 1999–2004 (Table 4).

Table 4. *Summary of the geometric mean blubber thicknesses and the 95 % confidence interval in grey seals from Norway, the UK and Sweden, during the pregnancy period. GM= geometric mean, CI = 95 % confidence interval and N = number of grey seals.*

Country	**1–3 years old**			**5–20 years old or > 170 cm males**			**5–20 years old or > 170 cm females**		
	mm GM	mm CI	N	mm GM	mm CI	N	mm GM	mm CI	N
Norway hunt (1999–2004	24	21–26	24	34	29–39	25	36	30–44	18
Sweden hunt (2002–2004)	42	34–51	13	52	46–60	16	57	49–68	11
Sweden & Norway hunt (1999–2004)	29	26–32	37	40	36–45	41	43	37–50	29
Sweden by-catch (2002–2004)	34	32–36	22	41	35–48	13	(a)		
UK stranded (1990–2004)				43	36–50	8	49	35–64	8
Finland (2001–2011, mainly hunted, including some by-caught)	39.9	26.8–51.2		53.4	43.8–67.2	(b)	53.4	43.8–67.2	(b)
a) no available by-caught 5–20 years old females in 2002–2004 during the pregnancy period. b) no difference between sexes									

Pregnant grey seals, Farne Islands

Boyd (1984) made sternum blubber thickness measurements on female grey seals around the time of implantation. The mean ± SEM in females with implantation in progress was 36 ±3.5 mm. For females with a fully implanted embryo it was 46 ± 2.5 mm. These results were based on dissections of 72 shot adult grey seal females; however the number of investigated females was not given for the means.

Ringed seals

The number of investigated ringed seals in the autumn/winter season is rather small but there are some data available in Data table 2.

The blubber thickness in harbour seals and harbour porpoises remains to be compiled and evaluated.

[3] Data is not normally distributed

Age determination

Age determination in seals is performed by examination of the annual growth pattern (GLGs) in cementum zones in tooth sections (Hewer 1964). The method is modified for harbour seals (Dietz et al. 1991) and is also used when examining ringed seals and harbour porpoises, however in harbour porposes the annual growth pattern is examined in the dentine.

Metadata

Data source

The National Swedish Monitoring Program of Seas and Coastal areas, top predators, pathology in seals, Swedish EPA, Swedish Museum of Natural History 1977–2011.

Baltic grey seal and ringed seal necropsy data of Finnish Game and Fisheries Research Institute and Finnish Food Safety Authority, years 1977–2008.

Description of data

Necropsy of by-caught and hunted grey seals and ringed seals, sample preparation and evaluation of results has been carried out by the dept. of Contaminant Research at the Swedish Museum of Natural History and by Finnish Game and Fisheries Research Institute and/or Finnish Food Safety Authority.

Geographic coverage

Currently the data is from the Swedish and the Finnish coast of the Baltic Sea. The grey seal results are considered applicable for the whole Baltic Sea population, whereas the ringed seal results may apply only to Bothnian Bay, where most of the samples are from.

For grey seal, which is very mobile across the Baltic Sea basin, the geographically limited monitoring is considered representative for the whole population. Nevertheless, samples from other countries would support the indicator as it is relatively easy to measure. HELCOM SEAL health team is invited to consider alternatives for this.

For ringed seal, the data is predominantly from the Bothnian Bay, whereas there are not enough specimens from the southern subpopulations and therefore the assessment result is considered geographically limited. Every new sample from the southern sub-populations increases the understanding of the state of those sub-populations.

Health of the Baltic marine mammals is investigated in Finland, Lithuania, Poland, Germany, Denmark and Sweden.

Recommendations for monitoring and assessment

The monitoring of blubber thickness can be done in areas where hunting of seals is permitted. For grey seals this gives an adequate assessment result for the entire Baltic Sea. For ringed seals this gives an adequate assessment result for the Bothnian Bay subpopulation. For harbor seals, if permits are given, the results are applicable to the area where of the given subpopulation. Animals drowned in fishing gears give additional (supplementary) data to the indicator.

Assessment should be carried out in accordance to management units defined in HELCOM RECOMMENDATION 27-28/2 i.e. 1) harbour seals in the Kalmarsund region (Sweden);2) Southwestern Baltic harbour seals (Denmark, Germany, Poland, Sweden); 3) Gulf of Bothnia ringed seals (Finland, Sweden); 4) Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga ringed seals (Finland, Estonia, Latvia, Russia); 5) Baltic Sea grey seals (all Contracting Parties to the Helsinki Convention).

Table 5. *Monitoring of the proposed indicators in the Baltic Sea. Information from several countries is missing.*

Country	Area	Coastline	Species	Month	Interval	Type of carcass	Start of data series
Germany	Western Baltic Sea	Hiddensee Westküste	Harbour porpoise			stranded	
	Mecklenburg-Western Pomerania	Bay of Mecklenburg & Pomeranian Bay, internal lagoons	Harbour porpoise	All	always	stranded and bycaught	1990
Lithuania	Southeastern Baltic sea	Lithuania coastline					
Sweden	whole Baltic Sea	Swedish	Grey seal	All	always	by-caught, stranded, hunt	1977
	Baltic proper	Swedish	Harbour seal	All	always	by-caught, stranded	1977
	Western Baltic Sea	Swedish	Harbour seal	All	always	by-caught, stranded, hunt	1977
	Baltic Sea	Swedish	Ringed seal	All	always	by-caught, stranded,hunt *	1977
	W Baltic Sea and Baltic Proper	Swedish	Harbour porpoise	All	always	by-caught, stranded	1977
Finland	Baltic Sea	Finnish	Grey seal	16.April-December	always	hunted	1998
	Baltic Sea	Finnish	Ringed seal	16.April-December	always	hunted	2010
	Baltic Sea	Finnish	Grey seal	All	always	by-caught	1999
	Baltic Sea	Finnish	Ringed seal	All	always	by-caugh	1999
	Baltic Sea	Finnish	Grey seal	All	sporadic	stranded	2010
	Baltic Sea	Finnish	Ringed seal	All	sporadic	stranded	2010

Temporal coverage

The assessment includes data since 1977 (grey seals) and 1981 (ringed seals).

Methodology and frequency of data collection

The blubber thicknesses and the pregnancy rates of marine mammals can be obtained from institutional necropsies or hunters. By sampling the female reproductive organs (reproductive status), the lower jaw (age determination) and measuring the sternum blubber thickness and reporting the date of death, position, and sending it to an institute, it should be possible to collect more data than at present. See Bergman (1999).

The core indicator report is always updated with data from seal hunt and by-caught seals, resulting in yearly updates of the last two years.

Methodology of data analyses

Change in blubber thickness was analysed using one-way ANOVA as well and post hoc tests were performed using Tukey's test. All results were considered significant with $p < 0.05$. Tests were performed using xlstat software (Addinsoft 2009).

Ringed seal blubber thickness should be measured both from individuals < 4 years of age and those > 4 years of age (significant difference between age groups, $p < 0.001$).

Approach for defining GES

Blubber thickness is measured at the sternum between the muscle layer and the skin during the season of pregnancy (August-February for grey and ringed seals). Suggested reference levels for GES are the lower limit of the 95 % confidence interval for the geometric mean. These have been calculated for 1–3 years old, 5–20 years old males, and 5–20 years old females in the Norwegian and Swedish grey seals from hunt in 1999–2004 (Table 5). The reason for basing the proposed GES boundary to data from before 2005 is that since this year the available data indicates a trend of decreasing blubber thickness. In support for this approach, the lower limit of 95 % confidence intervals for the 1–3-year-old grey seal is 26.8 mm also in Finland.

Table 6. *Suggestion GES boundaries for grey seals during the season of pregnancy from stranded, by-caught or hunted animals (based on Table 4).*

Age class	Sex	GM – CI = GES boundary
1–3 years	females and males	≥26
5–20 years	males	≥36
5–20 years	females	≥37

In order to get enough data, assessment could be renewed every third year (i.e. pooling the data for each 3-year period) for grey seals.

In the Baltic, the causes of death have been shown to influence the result of the blubber measurements. Stranded seals often show a thin blubber layer (starvation due to disease or old age) and by-caught seals are often thinner than seals received from hunt (Bäcklin et al. 2010, 2011). Therefore, these groups are suggested to be presented separately (Figure 1) since their proportions will influence the GES determination. However, the comparisons of data from stranded (exceeding 25 mm), shot or by-caught grey seals from different countries in Table 4, did not reveal big differences (no data from 1–3 year old animals).

It has been discussed in the HELCOM SEAL health team that the lower 95 % CI could be used as the GES boundary for ringed seal as well. The lower limit of 95 % confidence intervals was 35.6 mm for young and sub-adult individuals and 51.4 mm for adults in 2001–2011. The sample includes both by-caught and hunted seals from August-February.

GES limits for blubber thickness in ringed seals and harbour seals are still to be considered or investigated as well as for harbour porpoises.

Strengths and weaknesses of data

Quality information

Sweden: During these three decades two persons (veterinarian and patho-biologist) have performed the necropsies.
Finland: During these three decades several persons (veterinarians, seal biologists) have performed the necropsies.

National consultations and synchronisations were made continuously between persons. Age determinations of the seals were performed by counting growth layer groups (GLGs) in the cementum of teeth according to a well-established method. Readings of tooth sections were made independently by two persons.

Weaknesses/gaps

Monitoring of the Baltic marine mammals started in the 1970s when the health of the seal populations was seriously threatened by contaminants, especially organochlorine. The populations have slowly recovered but new threats have arisen (e.g. other contaminants). Therefore, it could be said that the knowledge of normal pregnancy rate and blubber thickness is limited in Baltic marine mammals. The 'point of no return' for blubber thickness has not been reached according to any report. There is some evidence that historically the blubber layers in the Baltic grey and ringed seals were thicker and the pregnancy rates were lower. If this is the case, it would be appropriate to use older data (before and early 2000s) for normal blubber thickness and more recent data for normal pregnancy rate.

Data from outside the Baltic could be used to determine normal limits but the possible issue here is that the ecosystem outside the Baltic Sea is different with dissimilar opportunities to forage. In the Baltic, grey seals also have a smaller body size than in the northeast Atlantic (UK and Norway) which in turn are smaller than in the northwest Atlantic (McLaren 1993). The proposed GES boundaries for blubber thickness is partly based on data measured by different Swedish hunters compared to data from by-caught grey seals that have been measured by the SMNH. In order to investigate the accuracy of the blubber thickness measurements made by hunters, an additional measurement on 37 blubber samples was made at the SMNH in 2005, if skin; blubber and muscle layer was visible in the sample. The means of the measurements did not differ significantly (42.4 ± 9,6 vs. 42,2 ± 10,4) between the hunters and SMNH. This indicates that the mean measurements of blubber thicknesses were comparable (Bäcklin et al. 2011).

There is a lack of data, especially for southern populations of ringed seals. Data from investigations on the western population of harbour seals could probably serve as normal data also for determine GES in the Kalmarsund harbour seal population.

It is important to combine population and distribution investigations for the evaluation of the significance of decreased pregnancy rate or mean blubber thickness.

References

Baker, J.R. 1980. The pathology of the grey seal (Halichoerus grypus). II. Juveniles and adults. British Veterinary Journal 136, 443–447.

Baker J.R. 1987. Causes of mortality and morbidity in wild juvenile and adult grey seals (Halichoerus grypus). Br. Vet. J. 143: 203–220.

Bergman A. 2007. Pathological changes in seals in Swedish waters: The relation to environmental pollution. Tendencies during a 25-year period. Thesis No.2007:131, Swedish University of Agricultural Sciences, ISBN 978-91-85913-30-5.

Bergman A. 1999. Health condition of the Baltic grey seal (Halichoerus grypus) during two decades. APMIS 107:270–82.

Boyd I. 1984. The relationship between body condition and the timing of implantation in pregnant grey seals (*Halichoerus grypus*). J Zool., Lond, 203, 113-123.

Bredhult, C., Bäcklin, B-M., Bignert, A., and Olovsson, M. 2008. Study of the relation between the incidence of uterine leiomyomas and the concentrations of PCB and DDT in Baltic grey seals. Reproductive Toxicology, 25: 247–255.

Bäcklin B-M, Moraeus C, Kunnasranta M, Isomursu M. 2010. Health assessment in the Baltic grey seal (*Halichoerus grypus*). HELCOM Indicator Fact Sheets 2010. Online. [Date Viewed], http://www.helcom.fi/environment2/ifs/en_GB/cover/.

Bäcklin B-M, Moraeus C, Roos A, Eklöf E, Lind Y. 2011. Health and age and sex distributions of Baltic grey seals (Halichoerus grypus) collected from bycatch and hunt in the Gulf of Bothnia. ICES J of Marine Science, 68(1), 183–188.

Chubb JC, Valtonen ET, McGeorge J, Helle E. 1995. Characterisation of the external features of Schistocephalus solidus (Mueller, 1776) (Cestoda) from different geographical regions and an assessment of the status of the Baltic ringed seal Phoca hispida botnica (Gmelin) as a definitive host. Syst Parasitol 32:113–123

Dietz, R, Heide-Jorgensen, M-P, Härkönen, T, Teilmann, J, Valentin, N. 1991. Age determination of european harbour seal, *Phoca vitulina* L. Sarsia, 76; 17–21

Durden LA, Musser GG (1994) The mammalian hosts of the sucking lice (Anoplura) of the world: a host-parasite list. Bulletin of the Society of Vector Ecology 19:103-168

Hamill M.O. and Gosselin J.F. 1995. Reproductive rates, age of maturity and age at first birth in Northwest Atlantic grey seals (*Halichoerus grypus*). Can J. Fish. Aquat.Sci. 52:27572761.

Harding K., Härkönen T., Helander B. and Karlsson O. 2007. Status of Baltic grey seals: population assessment and extinction risk. In: Grey seals in the north Atlantic and the Baltic. The North Atlantic Marine Mammal Commission (NAMMCO) vol. 6, 2007, pp 38–39. ISBN 978-82-91578-19-4.

Hauksson, E. 2007. Growth and reproduction in the Icelandic grey seal (*Halichoerus grypus*). NAMMCO Scientific Publications, 6: 153–162.

Helle E., Olsson M. & Jensen S. 1976a. DDT and PCB levels and reproduction in ringed seal from the Bothnian Bay. Ambio 5, 188–189.

Helle E., Olsson M. & Jensen S. 1976b. PCB levels correlated with pathological changes in seal uteri. Ambio 5, 261–263.

Helle E. 1981. Reproductive trends and occurrence of organochlorines and heavy metals in the Baltic seal populations. International Council for Exploration of the Sea (CM papers and reports) E: 37.

Helle E, Nyman M, Stenman O. 2005. Reproductive capacity of grey and ringed seal females in Finland. International conference on Baltic seals, 15–18 February Helsinki, Finland.

Helle E, Valtonen ET. 1980. On the occurence of Corynosoma spp. (Acanthocephala) in ringed seals (Pusa hispida) in the Bothnian Bay, Finland. Canadian Journal of Zoology 58:298–303

Helle E, Valtonen T. 1981. Comparison between spring and autumn infection by Corynosoma (Acanthocephala) in the ringed seal Pusa hispida in the Bothnian Bay of the Baltic Sea. Parasitology 82:287–296

Hewer, H.R. 1964. The Determination of Age, Sexual Maturity, Longevity and a Life-table in the Grey Seal (*Halichoerus grypus*). Proc. Zool. Soc. Lond 142 (4): 593–624

Jepson Paul D. Institute of Zoology, Zooligical Soc. of London, Regent's Park, London, NW1 4RY.

Kunnasranta M, Isomursu M, Bäcklin B-M, Puntila R, Moraeus C. 2010. Health assessment in the Baltic ringed seal (*Phoca hispida botnica*). HELCOM Indicator Fact Sheets 2010. Online. [Date Viewed], http://www.helcom.fi/environment2/ifs/en_GB/cover/.

Lafferty KD, Kuris AM (1999) How environmental stress affects the impacts of parasites. Limnology and Oceanography 44:925–931

McLaren I.A. 1993. Growth in pinnipeds. Biol.Rev. 68:1–79

Nickol, BB, Helle E and Valtonen ET 2002. Corynosoma magdaleni in gray seals from the Gulf of Bothnia, with emended descriptions of Corynosoma strumosum and Corynosoma magdaleni. J. Parasitol. 88(6), 1222–1229.

Nilssen, K, Haug, T., Grotnes, P., and Potelov, V.1997. Seasonal variation in body condition of adult Barents Sea harp seals (Phoca groenlandica). Journal of Northwest Atlantic Fishery Science, 22 :17–25.

Nilssen Kjell T. Institute of Marine Research, Postboks 1870 Nordnes, 5817 Bergen, Norway.

Olsson, M., Johnels, A. & Vaz, R. 1975. DDT and PCB levels in seals from Swedish waters. The occurrence of aborted seal pups. *Proc. From the Symposium on the Seal in the BALTIC, June 4–6, 1974, Lidingö, Sweden. SNV*

O'Neill G and Whelan J. 2002. The occurrence of Corynosoma strumosum in the grey seal, Halichoerus grypus, caught off the Atlantic coast of Ireland. Journal of Helminthology, 76, 231–234.

Ryg M., Lydersen C., Markussen N. 1990. Estimating the blubber content of Phocid seals. Can. J. Fish. Aquat. Sci., Vol. 47, 1223–1227.

Sparling, C., Speakman, J., and Fedak, M. 2006. Seasonal variation in the metabolic rate and body composition of female grey seals: fat conservation prior to high-cost reproduction in a capital breeder? Journal of Comparative Physiology Biochemical, Systems, and Environmental Physiology, 176: 505–512

Valtonen ET, Helle E, Poulin R. 2004. Stability of Corynosoma populations with fluctuating population densities of the seal definitive host Parasitology 129:635–642

Valtonen, ET, Fagerholm, HP and Helle E. 1988. Contracaecum osculatum (Nematoda: Anisakidae) in fish and seals in Bothnian Bay (Northeastern Baltic Sea). Int. J. Parasitol. 18(3): 365–370.

Westerling B, Stenman O, Rudbäck E (2005) Pathology of seals from the Finnish coastal waters, Lake Saimaa and Lake Ladoga in the years 1982-2004. In: Helle E, Stenman O, Wikman M (eds) Symposium on Biology and Management of Seals in the Baltic area. Game and Fisheries Research, Helsinki, Finland

View Data

Data table 1. *Blubber thickness of 1–3-year-old grey seals.*

	Bycatch	sd	Hunted	sd
1993–2001 (N = 21)	34	2		
2002–2004 (N = 35)	34	2	42	9
2005–2007 (N = 74)	29	2	35	5
2008–2010 (N = 41)	25	3	30	4
2011 (N =9)	25	6		

Data table 2. *The mean blubber thickness of young/subadult and adult ringed seals in spring and autumn during different time periods.*

Time period/season	Young and subadults		Adults	
	Mean (n)	95% CL	Mean (n)	95% CL
1981–2000				
Spring	31.4 (21)	26.2–36.7	35.1 (100)	33.1–37.2
Autumn	43.6 (11)	39.0–48.2	61.9 (13)	52.8–71.0
2001–2011				
Spring	22.1 (57)	20.0–24.1	31.5 (65)	28.6–34.5
Autumn	39.0 (29)	35.6–42.4	55.9 (23)	51.4–60.3