Document title	'Reproductive status of marine mammals' – revised core indicator report
Code	4J-25
Category	CMNT
Agenda Item	4J – HELCOM indicators and assessments
Submission date	17.10.2016
Submitted by	Lead Country Sweden

Background

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

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

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

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

German and Swedish seal experts and HODs of the State and Conservation Working Group met at an ad hoc meeting on 9 September 2016 to discuss the population condition indicators (outcome available via SEAL 10-2016 meeting document 8-2) and the meeting decided to strengthen the cooperation between the indicator Lead Countries and the health team. The further development of HELCOM indicators on marine mammal health will continue with the intention to develop indicators for population dynamics and health for all marine mammal species and for the whole HELCOM area (paragraph 8.12 in the outcome of SEAL 10-2016)

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

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

This document contains the indicator report for the core indicator 'Reproductive status of marine mammals'. Changes to the document have been tracked.

Action requested

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

HELCOM INDICATORS

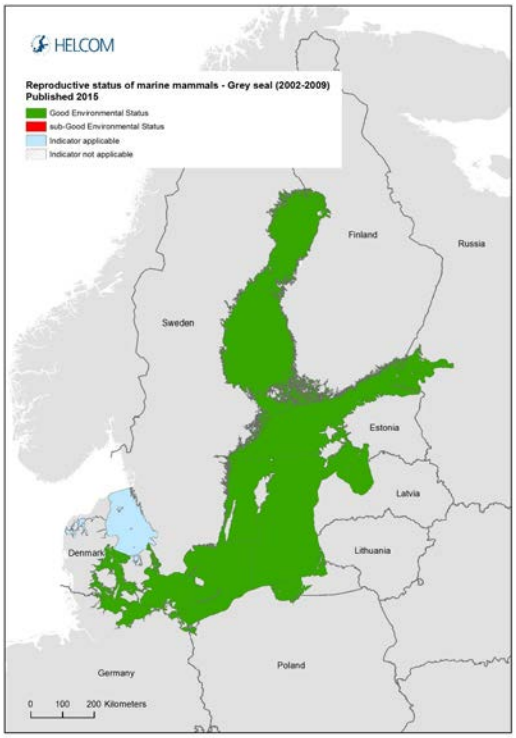
HELCOM core indicator report
September 2016

Reproductive status of marine mammals

Key Message

This core indicator evaluates the status of the marine environment based on the reproductive status of marine mammals in the Baltic Sea. Good Environmental Status (GES) is achieved when the annual pregnancy rate is at least 90% for five years and older harbour seals and six years and older grey and ringed seals. Pregnancy/birth rate of 90% concerns increasing populations. In a stable population at the carrying capacity pregnancy/birth rate may be lower.

Currently, a status evaluation has only been done using the grey seal. In order to be applicable in the whole HELCOM area, the indicator includes all species of seals and marine mammals that occur in the Baltic Sea, however data have so far been insufficient for an evaluation using the other seal species or other marine mammals. The evaluation of grey seal reproductive status is based on data from 2001-2009. The reproductive status in SW Baltic will be avaluated by other measured that remains to be developed.Along sideAlongside with Reproductive status a new Seal Health Indicator should be developed that will provide details about the reproductive health and thus link causes and effects of declining population level trends in reproductive status.



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

Grey seals occur in the entire Baltic Sea except for the Kattegat where the species has not been breeding since the 1930s until 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 achieve GES with regard to pregnancy/birth rate in the entire Baltic when evaluated as one single population.

Ringed seals are evaluated for two management units: 1) the Bothnian Bay and 2) the Gulf of Finland, Archipelago Sea, Gulf of Riga and Estonian coastal waters. A tentative GES boundary is set at 90% pregnancy rate for six years and older seals but there are insufficient data for carrying out an evaluation of GES status at present.

Harbour seals are confined to the Kalmarsund, Southern Baltic Sea, the Kattegat and the Limfjord, which all are separate management units. Harbour seals are evaluated for four management units. A GES boundary is set at 90% pregnancy rate for five years and older seals but data have not been analysed and hence no evaluation of GES status has been carried out.

Confidence of the indicator evaluation for grey seals is considered to be high and for ringed seals low, due to insufficient data. The confidence of the evaluation for harbour seals will be high once the assessment is made.

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

Relevance of the core indicator

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

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

The pregnancy rate/birth rate provides important information on~~signals~~ average, population level female health. It will be important to also develop an additional Seal Health Indicator that links trends in pregnancy rate to the causes behind, such as ~~with regard to~~ disease, food availability or~~and~~ hazardous substances. ~~It is documented to be affected by xenobiotic compounds, i.e. alien and not naturally occurring compounds as well as disturbance.~~

HELCOM INDICATORS

Policy relevance of the core indicator

	BSAP segment and objectives	MSFD Descriptor and criteria
Primary link	Biodiversity • Viable populations of species	D1 Biodiversity 1.3. Population condition
Secondary link	Biodiversity: • Thriving and balanced communities of plants and animals Hazardous Substances • Healthy wildlife	D1 Biodiversity 1.1 Species distribution (range, pattern, covered area) 1.2 Population size (abundance, biomass) D4 Food-web 4.1. Productivity of key species or trophic groups 4.3 Abundance/distribution of key trophic groups/species D8 Contaminants 8.2. Effects of contaminants D10 Marine litter 10.2 Impacts of litter on marine life D11 Introduction of energy (including underwater noise)
Other relevant legislation: In some Contracting Parties also EU Water Framework Directive – Chemical quality, Habitats Directive		

Cite this indicator

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

Download full indicator report

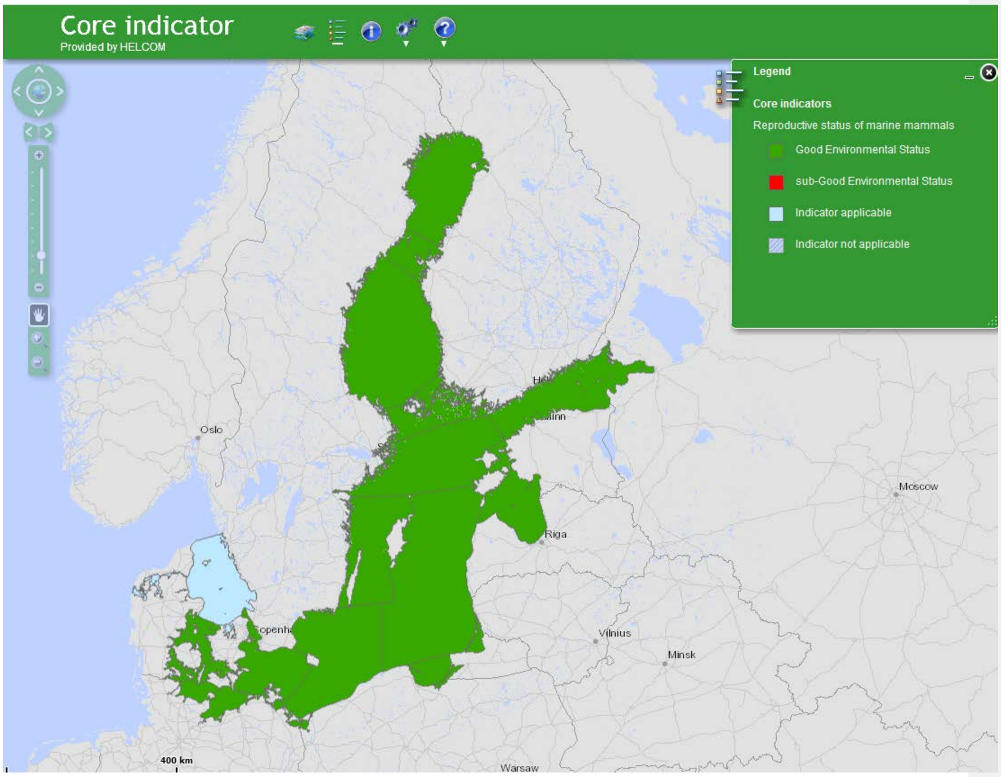
Core indicator report – web-based version November 2015 (pdf)

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

Results and Confidence

Grey seal

The grey seal achieved Good Environmental Status (GES) in the Baltic Sea with regard to reproductive status (pregnancy rate) during 2001-2009 (Results figure 1). However, data need to be updated and recent Finnish data suggest a trend during the time period.



Results figure 1. Baltic grey seals attain GES with regard to pregnancy rate.

The observed pregnancy rate exceeds the GES boundary of 90%, and does not deviate from GES regardless of which statistical tool is used.

Ringed seal

The GES boundary at 90% is not met for ringed seals. There are 28 females > 6 years of age from 2001–2014 from Finland and Sweden, birth rate 68% (SD = 47.6, 95% CI = 49.4–86.3%).

Harbour seal

The GES boundary is set at 90% also for harbour seals, as data from 1988 show that the pregnancy rate was very high at the time. Currently data are available and will be tested for GES in the near future.

Confidence of the indicator status evaluation

Additional data should be retrieved as far as possible and collected annually for grey seals in Finland and Sweden so the confidence of the indicator status evaluation for this species in the central and northern part of the Baltic Sea can be improved. The samples also include Swedish data from the southern Baltic Sea, but it would be desirable to include also samples from Denmark, Germany and Poland.

The confidence of the evaluation for ringed seals is low due to insufficient data for pregnancy rate. Data on post reproductive signs is one way to determine "birth rate" but not "pregnancy rate" in ringed seals, since more data are available from the pre-implantation period. In addition, the difference between birth rate and pregnancy rate gives us valuable data of fetal mortality.

High confidence will be achieved for harbour seals in the Kattegat. Material is collected annually, but need to be compiled and analyzed.

Good Environmental Status

Good Environmental Status (GES) is achieved when the annual pregnancy/birth rate is at least 90% for five years and older harbour seals and six years and older grey and ringed seals.

The concept for defining GES boundaries for pregnancy rates 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. Pregnancy/birth rate is an important aspect of population status, affecting population growth.

GES is achieved when the annual pregnancy/birth rate meets the GES boundary of at least 90% for five years and older harbour seals and six years and older grey and ringed seals in an increasing population.

A modern baseline approach is applied for establishing the GES boundary for all species of seals, since pristine conditions are unknown. The modern baseline is based on the first available data, and data on pregnancy rates from populations with minimal impacts from human activities are used in this indicator.

Good environmental status table 1. Species specific GES boundaries of increasing populations for the marine mammals in the Baltic Sea.

Species	GES boundary Age class [year]	GES boundary Pregnancy rate
Grey seal	≥6	90%
Ringed seal (tentative)	≥6	90%
Harbour seal	≥5	90%
Harbour porpoise	?	?

The modern baseline approach is also applied in OSPAR (Commission for the Protection of the Marine Environment of the North-East Atlantic). The pregnancy rate would appear to be similar as the OSPAR common indicator M5: 'Grey seal pup production', but pup production is only used for estimating total population size by multiplying numbers of counted pups with a factor between 4 and 5 in HELCOM. For these indicators there is no comparability between HELCOM and OSPAR.

Assessment Protocol

This core indicator assesses the reproductive status of marine mammals in the Baltic Sea.

Seals in each assessment unit are evaluated against the set GES boundaries. Samples from opportunistically collected, hunted, by-caught and diseased seals can be used in the analysis. Observed data for 3-year intervals for each species are regarded as three independent datasets and tested if they deviate from the set GES boundaries using non-parametric tests

Parameter calculation

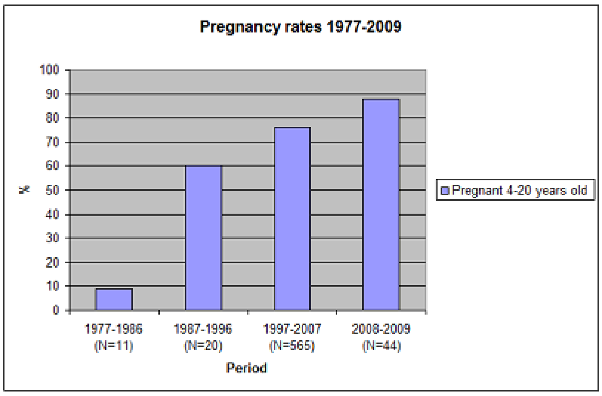
Pregnancy rate is measured as the proportion of 5/6-24-year-old females, depending on the seal species, with an embryo or foetus during the pregnancy period (post-implantation period), . Birth rate is calculated from the pre-implantation sample as the proportion of 6/7-25-year-old females with post-partum signs, i.e. a *corpus albicans*/placental scar.

Grey seals

Pregnancy rate is measured as the presence of a embryo/foetus in the pregnancy period in 6-24 year-old (or ≥ 6 yr) seals. GES compliance based on data is proposed to be evaluated every third year (pooling the data for each 3-year period) for 6-24 years old females. Birth rate is calculated from the pre-implantation sample as the proportion of 7-25-year-old (or ≥ 7 yr) females with a *corpus albicans*/placental scar.

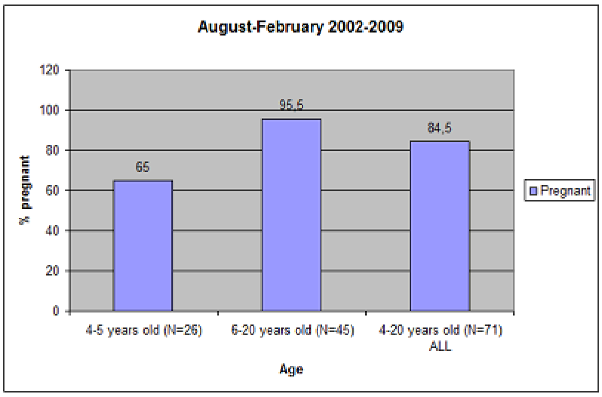
Current data suggest that pregnancy rates exceed 90% in 6-24 year-old females referring to the period 2001-2009. The GES boundary at 90% is believed to be representative of a healthy population. Data should also be tested for trends in a time series and updated.

Estimated age-specific birth rates increase steeply from the age of four to six (Hamill & Gosselin 1995). The birth rates for six-year old females in the Northwest Atlantic, British, Norwegian and Baltic populations ranged between 60-91%. In a sample of 526 female grey seals from the Northwest Atlantic, pregnancy rates were estimated from the presence/absence of a foetus. The pregnancy rate for the Northwest Atlantic population was relatively stable at about 90% after the age of six (Hamill & Gosselin 1995; Harding et al. 2007). In the Baltic grey seal population, the pregnancy rate was 88% in 4-20-year old females in 2008-2009 (Assessment protocol figure 1). Thus, a pregnancy rate of 88% pregnancy seems to be normal in 4-20-year old Baltic grey seals in an increasing population (Assessment protocol figure 1 and Assessment protocol figure 2). This rate is also close to the pregnancy rate of Northwest Atlantic grey seals older than five years.



Assessment protocol figure 1. Pregnancy rate in 4-20-year old female Baltic grey seals (August to March). Finnish data is included in the period 1997-2007.

The pregnancy rate for the 4-5-year old individuals is 65% and for the 6-20-year old individuals is 95.5% among hunted and by-caught grey seals in 2002-2009 in Sweden (Assessment protocol figure 2).



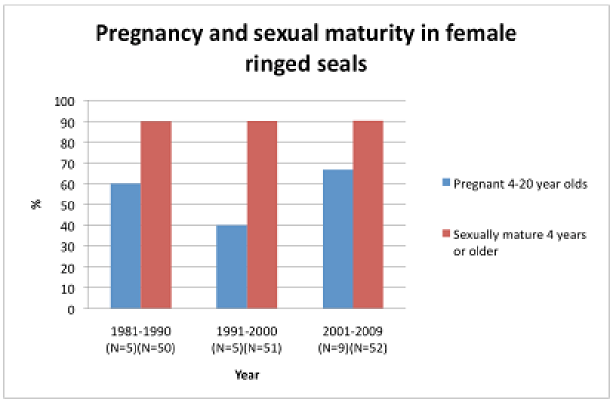
Assessment protocol figure 2. Pregnancy rate in 4-6 year-old females (first column), 6-20 year-olds (second column), and all age classes 4-20. Based on by-caught and hunted seals during 2002-2009.

About 4-13 dead grey seal females at ages between 4-20 years are collected annually in Sweden during the pregnancy period. From Finland about 30 females (7-25-year-old) are analyzed in spring for calculating birth rate. If the females are divided into younger and older, the annual Swedish contribution will be further reduced. However, the GES should be based on females six years or older (for pregnancy rate) to avoid effects from young females with late sexual maturity. Consequently, GES boundaries should be based on material sampled from age classes 6-24 for pregnancy rate and 7-25-year-old females for birth rate.

Ringed seals

Life history data is similar to grey seals (Harding et al. 2007), which would imply that the GES boundary for ringed seals should be similar to that of grey seals. The GES boundary of 90% is tentatively suggested also for this species until proven false. Age classes to be included in the analysis should encompass six years and older.

The annual number of investigated 4-20-year old Baltic female ringed seals and Baltic harbour seals during the pregnancy period is very small. Assessment protocol figure 3 shows the pregnancy rate of a total number of 19 ringed seals examined during 1981-2009. The pregnancy rate in ringed seals was 68% in 2001-2009, but the sample size is confined to 9 animals. Although later material is limited, single ringed seals are still suffering from uterine occlusions.



Assessment protocol figure 3. The prevalence of pregnant females (blue columns) sampled in the implantation period August to February (Kunnasranta 2010). Proportion of sexually mature (red columns) encompass females with presence of Corpus luteum (4 years or older) sampled year round in Finland and Sweden. Sample sizes must be increased before assessments of GES can be performed.

Harbour seals

The harbour seal historical pregnancy rates are based on samples from Danish and Swedish sampling programs in the Kattegat in 1988. When evaluating the GES boundary at 90%, the age classes to be included are females of five years and older.

Large data sets were collected during the 1988 and 2002 phocine distemper virus (PDV) epidemics that killed thousands of harbour seals. Pregnancy rates were determined either by signs of late abortions or the presence of a Corpus luteum (Heide-Jorgensen & Härkönen 1992). The pregnancy rate was found to be 94% in the 59 females older than 5 years that were sampled, and three of four females that were older than 25 years and senescent. This dataset can be used to establish a GES boundary, and there are many samples available from the 2002 PDV epidemic as well as from later years in Sweden which is stored at the Swedish Museum of Natural History. However, most of is the samples are from the Kattegat, and only few are available from the Southern Baltic Sea and the Kalmarsund.

Harbour porpoise

GES boundaries for harbour porpoise have not yet been developed and will be included at a later stage.

Assessment units and management units

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

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

- The Baltic grey seal is a single management unit, although genetic data show spatial structuring (Fietz et al. 2013). Also behavioural data suggest some large scale structuring. However, grey seals show extensive migration patterns.
- The Baltic Ringed seal is distributed in the Gulf of Bothnia on the one hand and Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga on the other, and is represented by two different management units. This sub-division is justified by ecological data that indicate separate dynamics of 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). See Oksanen et al. 2015 for ringed seal movements.
- 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). 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).
- 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 reproductive status of marine mammals, this indicator will also contribute to the next overall biodiversity assessment to be completed in 2018 along with the other biodiversity core indicators.

Policy relevance

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

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

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

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

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

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

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'

Descriptor 10: 'Properties and quantities of marine litter do not cause harm to the coastal and marine environment' and

Descriptor 11: 'Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment'

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

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

- Criterion 8.2 (effects of contaminants)
- Criterion 10.2 (impacts of litter on marine life)
- Criterion 11.1 (distribution of loud, low and mid frequency impulsive sounds)

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 conditions) and impacts of human activities. These pressures can affect fish stocks, levels of harmful substances as well as direct mortality caused by hunting or by-catch. The vulnerability of seals to these pressures makes them good indicators for measuring the environmental status of ecosystems.

Ecological background to the indicator concept

An adult female seal bears at most one pup annually in healthy growing seal populations. The mean values of fecundity for entire populations will always be lower than the theoretical maximum for an individual, also for populations which live under favourable conditions. Chance events such as failed fertilization or early abortions reduce annual pregnancy rates. Mean pregnancy rates rarely reach 0.96 in samples of reasonable sizes in American (Boulva & McLaren 1979; Bigg 1969), and European harbour seals (Heide-Jørgensen et al. 1992) in age classes >4 years of age. Maximum life span is about 35-45 years in Baltic seal species (e.g. Heide-Jørgensen et al. 1992). Another factor that will decrease mean pregnancy rates is senescence (Heide-Jorgensen et al. 1992), however due to annual mortality rates, only a small fraction of the population becomes older than about 24 years old. Further, extrinsic factors will reduce pregnancy rates. In evaluating changes in mean pregnancy rate among years in this core indicator, it is important to separate the causes into (1) natural decline due to density dependent effects and (2) anthropogenic effects from environmental pollution, this will be linked in the new Seal Health Indicator.. The HELCOM core indicator 'Population trends and abundance of seals' will signal when the populations reach carrying capacity. But at population abundances below carrying capacity, a change in pregnancy rate can be an early warning of unwanted changes in the ecosystem.

Natural decline in fertility due to limited food supply

As seal populations approach carrying capacity and food limitation becomes an issue, body growth rate in sub-adult seals declines and the age at sexual maturation is delayed. In poor nutritive conditions, age at sexual maturity in phocid seals can be delayed up to three or four years (Kjellqvist et al. 1995; Harding & Härkönen 1999). Another response to poor nutritive conditions is so called 'year skipping', i.e. the female does not become pregnant when her fat stores are too low (Kjellqvist et al. 1995). Seals have delayed implantation and the fertilized egg does not attach to the uterine wall unless the female is well fed. Decreased pregnancy rate due to food shortage at carrying capacity is thus a natural phenomenon and shall not be confused with reproductive failure caused by disease or xenobiotics.

Reproductive failure caused by disease or xenobiotics

The Baltic ringed and grey seal populations became the main subjects in the PCB scandal. The mean level of PCB in seals from the northern Baltic Proper was about 450 parts per million (PPM) lipid in the early 1970s, which eventually declined to considerably lower values in accordance with lower concentrations in their prey (Jensen et al. 1969; Olsson 1977; Bignert et al. 1998). A sample of 225 adult ringed seal females revealed an alarmingly low pregnancy rate of 30% which dropped further to 20% during the period 1973-1979 (Helle 1980). The low reproductive rates were largely explained by occlusions in the uterine horns. The prevalence of this pathological change increased from 35% to 59% during the same time period (Helle 1980). The occlusions caused permanent sterility in ringed seals and the frequency of occlusions also increased with the age of the animals (Helle 1979; 1980). Also in grey seals, severe reproductive disturbances were documented (Bergman & Olsson 1986; Bergman 1999). An underlying cause of some of the toxic effects of PCBs may be alterations in hormonal levels (Bäcklin et al. 2003). Experiments carried out on the American mink (*Neovison vison*) showed that the early formation of the placenta is disrupted in animals exposed to PCBs, which leads to the death of the foetus (Bäcklin et al. 2003).

In populations of harbour seals, concentrations of PCBs vary with the level of industrialization and the extent of water exchange of different sea regions. This is demonstrated by mean values of concentrations of different PCB fractions in harbour seals in the Atlantic, where Icelandic harbour seals have the lowest concentrations of about 1.5-5.0 PPM lipid, while seals in the heavily industrialized and enclosed St. Lawrence Estuary show concentrations of about 17.1 PPM (Safe 1984). The harbour seals in the Baltic Sea and Wadden Sea had mean concentrations of 85 PPM lipid (Bernt et al. 1999) in the late 1970s. The effects of high levels of PCBs are generally very difficult to quantify. One reason is that levels of PCBs vary substantially depending on which part of the season, which age groups, individuals and which parts of the body are sampled (Safe 1984; Bignert et al. 1993). However, a controlled feeding experiment revealed lowered pregnancy rates in captive seals fed with Baltic herring compared to the control group that got North Sea herring (Reijnders 1986). The most likely candidate responsible for the former low gynaecological health among Baltic seals was high concentrations of PCB (Helle 1979; Bredhult et al. 2008).

In 2008-2009, the pregnancy rate was 88% in 4-20 years old grey seal females hunted in the Bothnian Sea and the Baltic Proper. The last case of uterine obstruction in grey seals investigated in Sweden was seen in 1993 (Bergman 1999). And in 2009, one unilateral occlusion was seen in a 13-year old female grey seal in Finland. In the 2000s, about 20% of examined Baltic ringed seals still suffered from uterine obstructions, which likely explain the 68% pregnancy rate in ringed seals in 2001-2009, which is lower than "normal" (Helle et al. 2005; Kunnasranta 2010). After the year 2000 there are 62 females which are at least four years old (data from Finland and Sweden), and 8.1% of these had occusions. The last observed case is from 2011. There are no observations or reports of uterine obstructions in Baltic harbour seals or harbour porpoises.

It is important to distinguish between pregnancy rate, birth rate, pup production (= pups that survive until weaning), and the role of pregnancy/birth rate rate for the population growth rate. Even if a female weans her pup successfully, a study on individually branded harbour seals showed a delayed response to poor nutritive conditions (Härkönen & Harding 2001; Harding et al. 2005). Winter survival in the young of the year was highly dependent on the autumn weight. Consequently, pregnancy/birth rate is an important indicator of status of the population, but in evaluations for population consequences also other information is needed, the new Seal Health Indicator aims to assess the causes behind shifting trends in pregnancy rates.

Human pressures linked to the indicator

	General	MSFD Annex III, Table 2
Strong link	Contamination by hazardous substance Fisheries and food availability Ecosystem changes (food web, introduction of pathogens and non-indigenous species) Noise pollution Diseases	Biological disturbance: -selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing) Contamination by hazardous substance: - introduction of synthetic compounds - introduction of non-synthetic substances and compounds
Weak link	Hunting	

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). Changes in population density will affect pregnancy rates.

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 show a significant decline during the last decade (Bäcklin et al. 2011). Food limitation is expected to lead to declining pregnancy rates in all species.

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 HELCOM Monitoring Manual.

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

Current monitoring

The monitoring activities relevant to the indicator, which 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 tem of the HELCOM Seal expert group.

Description of optimal monitoring

The optimal monitoring should encompass sufficient numbers of samples from all species of seals in all areas where they occur. Monitoring occur opportunistically when dead seals are recoverd by stranding, by catches or hunting. Hunting is not motivated by environmental monitoring but is decided upon by national authorities for other resaons (mainly to protect fishing gear).

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

Monitoring of harbour seals is sufficient in the Kattegat, but more data is needed from the Kalmarsund and the Southern Baltic from Danish waters could prove to be important in the future.

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

Data and updating

Access and use

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

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

Metadata

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

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

Contributors and references

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Archive

This version of the HELCOM core indicator report was published in November 2015

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

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

Older versions of the core indicator report are available:

[2013 Indicator report]

References

Anon. (1895) Svensk fiskeritidskrift 1895.

Bäcklin, B., Eriksson, L., Olovsson, M. (2003) Histology of uterine leiomyoma and occurrence in relation to reproductive activity in the Baltic grey seal (*Halichoerus grypus*). Veterinary Pathology 40: 175–180.

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 Journal of Marine Science 68: 183–188.

Bergman, A., Olsson, M. (1985) Pathology of Baltic grey seal and ringed seal females with special reference to adrenocortical hyperplasia: Is environmental pollution the cause of a widely distributed disease syndrome. Finnish Game Res 44: 47-62.

Bergman, A. (1999) Health condition of the Baltic grey seal (*Halichoerus grypus*) during two decades. Apmis 107(1-6): 270-282.

Bernt, K.E., Hammill, M.O., LeBoeuf, M., Kovacs, K.M. (1999) Levels and patterns of PCBs and OC pesticides in harbour and grey seals from the St Lawrence Estuary, Canada. Sci. Total Environ. 243/244: 243-262.

Bigg, M.A. (1969) The harbour seal in British Columbia (No. 172). Fisheries Research Board of Canada.

Bignert, A., Göthberg, A., Jensen, S., Litzén, K., Odsjö, T., Olsson, M., Reutergårdh, L. (1993) The need for adequate biological sampling in ecotoxicological investigations: a retrospective study of twenty years pollution monitoring. Sci. Total Eniron. 128: 121-139.

Bignert, A. et al. (1998) Temporal trends of organochlorines in Northern Europe, 1967-1995. Relation to global fractionation, leakage from sediments and international measures. Environ. Poll. 99: 177-198.

Boulva, J., McLaren, I. A. (1979) Biology of the harbor seal, *Phoca vitulina*, in eastern Canada. Fisheries Research Board of Canada.

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

European Commission (1992) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive). Off. J. Eur. Union 206: 7–50.

European Commission (2008) Directive 2008/56/EC of the European Parliament and the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off. J. Eur. Union L 164: 19-40.

European Commission (2010) Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU). Off. J. Eur. Union L232: 12-24.

Fietz, K., Graves, J.A., Olsen, M.T. (2013) Control Control Control: A Reassessment and Comparison of GenBank and Chromatogram mtDNA Sequence Variation in Baltic Grey Seals (*Halichoerus grypus*). PLoS ONE 8(8): e72853. doi:10.1371/journal.pone.0072853.

Goodman, S.J. (1998) Patterns of extensive genetic differentiation and variation among European harbor seals (*Phoca vitulina vitulina*) revealed using microsatellite DNA polymorphisms. Molecular Biology and Evolution 15(2): 104-118.

Hamill M.O., Gosselin J.F. (1995) Reproductive rates, age of maturity and age at first birth in Northwest Atlantic grey seals (*Halichoerus grypus*). Ca J. Fish. Aquat. Sci. 52: 2757-2761.

Harding, K.C., Härkönen, T.J. (1999) Development in the Baltic grey seal *(Halichoerus grypus)* and ringed seal *(Phoca hispida)* populations during the 20th century. Ambio 28: 619-627.

Harding, K.C., Fujiwara, M., Härkönen, T., Axberg, Y. (2005) Mass dependent energetics and survival in harbour seal pups. Functional Ecology 19: 129-135.

Harding, K.C., Härkönen, T., Helander, B., Karlsson, O. (2007) Status of Baltic grey seals: Population assessment and risk analysis. NAMMCO Scientific Publications 6: 33-56.

Härkönen, T., Heide-Jørgensen, M.-P. (1990) Density and distribution of the ringed seal in the Bothnian Bay. Holarctic Ecology 13 (2): 122-129.

Härkönen, T., Harding, K.C. (2001) Spatial structure of harbour seal populations and the implications thereof. *Can. J. Zool*. 79: 2115-2127.

Härkönen, T., Harding, K.C., Goodman, S., Johannesson, K. (2005) Colonization history of the Baltic harbor seals: Integrating archaeological, behavioural and genetic data. Marine Mammal Science 21: 695-716.

Harkonen, T., Bäcklin, B-M., Barrett, T., Anders Bergman, A., Corteyn, M., Dietz, R., Harding, K., Malmsten, J., Roos, A., Teilmann, T. (2008) Mass mortality in harbour seals and harbour porpoises caused by an unknown pathogen. The Veterinary Record 162: 555-556.

Harkonen, T., Jüssi, M., Jüssi, I., Verevkin, M., Dmitrieva, L., Helle, E., Sagitov, R., Harding, K.C. (2008) Seasonal activity budget of adult Baltic ringed seals (*Phoca hispida botnica*). PLoS ONE 3(4): e2006.doi:10.1371/journal.pone.0002006.

Harkonen, T., Isakson, E. (2011) Historical and current status of harbour seals in the Baltic proper. NAMMCO Scientific Publications 8: 71-76.

Heide-Jørgensen, M.-P., Härkönen, T. (1988) Rebuilding seal stocks in the Kattegat-Skagerrak. Marine Mammal Science 4(3): 231-246.

Heide-Jørgensen, M.-P., Härkönen, T., Dietz, R., Thompson, P. (1992) Retrospective of the 1988 European seal epizootic. Diseases of Aquatic Organisms 13: 37-62.

Helle, E. (1979) Structure and number of seal populations in the northern Baltic Sea: a study based on Finnish bounty statistics, 1956-1975. Aquilo Ser. Zool. 19: 65-71.

Helle, E. (1980) Lowered reproductive capacity in female ringed seals (*Pusa hispida*) in the Bothnian Bay, northern Baltic Sea, with special reference to uterine occlusions. Annales Zoologica Fennici 17: 147-158.

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 2005. Helsinki, Finland.

Jensen, S., Johnels, A.G., Olsson, M., Otterlind, G. (1969) DDT and PCB in marine animals from Sweden. Nature 224: 247-250.

Kauhala, K., Kurkilahti, M., Ahola, M., Herrero, A., Karlsson, O., Kunnasranta, M. Tiilikainen, R. & Vetemaa, M. 2015: Age, sex and body condition of Baltic grey seals: Are the problem seals a random sample of the population? – Annales Zoologici Fennici 52: 103-114.

Kjellqwist, S.A., Haug, T., Øritsland, T. (1995) Trends in age-composition, growth and reproductive parameters of Barents Sea harp seals, *Phoca groenlandica*. ICES Journal of Marine Science 52: 197–208.

Kunnasranta, M. (2010) Merihylkeet vuonna 2010. Riistajakalatalous. Selvityksiä 21/2010: 21–22.

Formatted: Finnish

Oksanen, S. M., Niemi, M. Ahola, M. P. & Kunnasranta, M. 2015. Identifying foraging habitats of Baltic ringed seals using movement data. Movement Ecology 3:33. DOI 10.1186/s40462-015-0058-1.

Olsen, M.T., Wesley Andersen, L., Dietz, R., Teilmann, J., Harkonen, T., Siegismund, H.R. (2014) Integrating genetic data and population viability analyses for the identification of harbour seal (*Phoca vitulina*) populations and management units. Molecular Ecology 23: 815-831.

Olsson, M. (1977) Mercury, DDT and PCB in aquatic test organisms. Baseline and monitoring studies, field studies on biomagnification, metabolism and effects of some bioaccumulating substances harmful to the Swedish environment. Report from the National Swedish Environment Protection Board 1977. SNV PM 900 139pp.

Reijnders, P.J.H. (1986) Reproductive failure in common seals feeding on fish from polluted coastal waters. Nature 324: 456-457.

Safe, S. (1984) Polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBBs): biochemistry, toxicology, and mechanisms of action. CRC Crit. Rev. Toxicol. 13: 319-395.

Additional relevant publications

Bäcklin, B.-M., Moraeus, C., Kauhala, K., Isomursu. M. (2013) Pregnancy rates of the marine mammals - Particular emphasis on Baltic grey and ringed seals. HELCOM web portal.

Caswell, H. (2001) Matrix population models: Construction, analysis, and interpretation. Second edition. Sinauer, Sunderland. Massachusetts, USA.

Dietz, R., Heide-Jørgensen, M.-P., Härkönen, T. (1989) Mass deaths of harbour seals *Phoca vitulina* in Europe. Ambio 18(5): 258-264.

Galatius, A., Ahola, M., Härkönen, T., Jüssi, I., Jüssi, M., Karlsson, O., Verevkin, M. (2014) Guidelines for seal abundance monitoring in the HELCOM area 2014. Availabe at: http://helcom.fi/Documents/Action%20areas/Monitoring%20and%20assessment/Manuals%20and%20Guidelines/Guidelines%20for%20Seal%20Abundance%20Monitoring%20HELCOM%202014.pdf.

Harding, K.C., Härkönen, T., Caswell, H. (2002) The 2002 European seal plague: epidemiology and population consequences. Ecology Letters 5: 727-732.

Harding, K.C., Härkönen, T., Pineda, J. (2003) Estimating quasi-extinction risk of European harbour seals: a reply to Lonergan and Harwood. Ecology Letters 6: 894-897.

Härkönen, T., Lunneryd, S.G. (1992) Estimating abundance of ringed seals in the Bothnian Bay. Ambio 21: 497-510.

Härkönen, T., Stenman, O., Jüssi, M., Jüssi, I., Sagitov, R., Verevkin, M. (1998**)** Population size and distribution of the Baltic ringed seal (*Phoca hispida botnica*). In: Ringed Seals (*Phoca hispida*) in the North Atlantic. Edited by C.Lydersen and M.P. Heide-Jørgensen. NAMMCO Scientific Publications 1: 167-180.

Härkönen, T., Dietz, R., Reijnders, P., Teilmann, J., Harding, K., Hall, A., Brasseur, S., Siebert, U., Goodman, S., Jepson, P., Dau Rasmussen, T., Thompson, P. (2006) A review of the 1988 and 2002 phocine distemper virus epidemics in European harbour seals. Diseases of Aquatic Organisms 68: 115-130.

Härkönen, T., Brasseur, S., Teilmann, J., Vincent, C., Dietz, R., Reijnders, P., Abt, K. (2007) Status of grey seals along mainland Europe, from the Baltic to France. NAMMCO Scientific Publications 6: 57-68.

Härkönen, T., Harding, K., Rasmussen, T.D., Teilmann, J., Dietz, R. (2007) Age- and Sex-specific Mortality Patterns in an Emerging Wildlife Epidemic: the Phocine Distemper in European Harbour Seals. PLoS ONE 2(9): e887. doi: 10.1371/journal.pone.0000887.

Harkonen, T., Harding, K.C. (2011) Predicting recurrent PDV epidemics in European harbour seals. NAMMCO Scientific Publications 8: 275-284.

Harwood, J., Prime, J.H. (1978) Some factors affecting the size of British grey seal populations. Journal of Applied Ecology 401-411.

Heide-Jørgensen, M.-P., Härkönen, T. (1992) Epizootiology of seal disease. J. Appl. Ecol. 29: 99-107.

Hiby, L. et al. (2013) Estimates of the size of the Baltic grey seal population based on photo-identification data. NAMMCO Scientific Publications [S.l.] 6: 163-175. Oct. 2013. ISSN 2309-2491. Available at: <http://septentrio.uit.no/index.php/NAMMCOSP/article/view/2731>.
Doi: http://dx.doi.org/10.7557/3.2731.

Jüssi, M., Härkönen, T., Jüssi, I. Helle, E. (2008) Decreasing ice coverage will reduce the reproductive success of Baltic grey seal (*Halichoerus grypus)* females. Ambio 37: 80–85.

Karlsson, O., Härkönen, T., Bäcklin, B.-M. (2008) Populationer på tillväxt. Havet, 2008: 91-92.

Kauhala, K., Ahola, M. & Kunnasranta, M. 2014. Decline in the pregnancy rate of Baltic grey seal females during the 2000s, estimated with different methods. – *Annales Zoologici Fennici* 51: 313-324.

Formatted: Finnish

Kokko, H. Helle, E, J., Ranta E., Sipilä, T. (1999) Backcasting population sizes of ringed and grey seals in the Baltic and Lake Saimaa during the 20th century. Annales Zoologici Fennici 36: 65-73

Meier, H.E.M., Döscher, R., Halkka, A. (2004) Simulated distributions of Baltic Sea-ice in the warming climate and consequences for the winter habitat of the Baltic Ringed Seal. Ambio 33: 249–256.

Mortensen, P., Bergman, A., Bignert, A., Hansen, H.J., Härkönen, T., Olsson, M. (1992) Prevalence of skull lesions in harbour seals *Phoca vitulina* in Swedish and Danish museum collections during the period 1835-1988. Ambio 21: 520-524.

Olsen, M.T., Andersen, S.M., Teilmann, J. Dietz, R., Harkonen, T. (2011) Status of the harbour seal in Southern Scandinavia. NAMMCO Scientific Publications 8: 77-94.

Palo, J.U., Mäkinen, H.S., Helle, E., Stenman, O., Väinölä, R. (2001) Microsatellite variation in ringed seals (*Phoca hispida*): genetic structure and history of the Baltic Sea population. Heredity 86: 609–617. doi: 10.1046/j.1365-2540.2001.00859.x.

Teilmann, J., Riget, F., Harkonen, T. (2010) Optimising survey design in Scandinavian harbour seals: Population trend as an ecological quality element. ICES Journal of Marine Science 67: 952–958.

Sipilä, T. (2003) Conservation biology of Saimaa ringed seal (Phoca hispida saimensis) with reference to other European seal populations. PhD Thesis. Available at: http://ethesis.helsinki.fi/julkaisut/mat/ekolo/vk/sipila/conserva.pdf?q=phoca.

Stenman, O., Halkka, A., Helle, E., Keränen, S., Nummelin, J., Soikkeli, M., ... Tanskanen, A. (2005) Numbers and occurrence of grey seals in the Finnish sea area in the years 1970-2004. In Symposium on Biology and Management of Seals in the Baltic area. Kala-ja riistaraportteja (346): 58-61.

Svensson, C.J., Hansson, A**.,** Harkonen, T., Harding, K. (2011) Detecting density dependence in growing seal populations. Ambio (2011) 40: 52–59. DOI 10.1007/s13280-010-0091-7.

Sundqvist, L., Harkonen, T., Svensson, C.J., Harding, K.C. (2012) Linking climate trends to population dynamics in the Baltic ringed seal - Impacts of historical and future winter temperatures. Ambio. DOI 10.1007/s13280-012-0334-x.

Vanhatalo, J., Vetemaa, M., Herrero, A., Aho, T., Tiilikainen, R. (2014) By-Catch of Grey Seals (*Halichoerus grypus*) in Baltic Fisheries—A Bayesian Analysis of Interview Survey. PLoS ONE 9(11): e113836. doi:10.1371/journal.pone.0113836.

Zohari, S., Neimanis, A., Härkönen, T., Moraeus, C., Valarcher, J.F. (2014) Avian influenza A(H10N7) virus involvement in mass mortality of harbour seals (*Phoca vitulina*) in Sweden, March through October 2014. Euro Surveill. 19(46): pii=20967. Available at: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=20967.