Population growth rate, abundance and distribution of marine mammals

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In co-operation with the HELCOM SEAL expert group and the JASTARNIA group.

Contents

Key message

The Baltic harbour porpoise density and distribution has declined considerably since the mid-20th century in both the western and Baltic Proper populations, leading to the Critically endangered status of the harbour porpoise in the Baltic Proper. The rate of the decline is uncertain.

Grey seal population growth rate has recently indicated good environmental status, but is currently slightly below it. The rate of increase was slowed a few years ago, but has shown recent increase and GES is likely reached in a couple of years. Even though the species does not yet reproduce in the entire sea area, the abundance is close to 28 000 individuals and the distribution area is increasing.

Ringed seal subpopulation in the Bothnian Bay is increasing but at a reduced rate. The other three subpopulations are declining or stable and distribution area has not increased. The species has been classified as Vulnerable in the Baltic.

Harbour seal population growth rates in different sub-areas indicate that the populations are close to good environmental status. The total abundance is almost 10 000 individuals, but the distribution range has not increased.

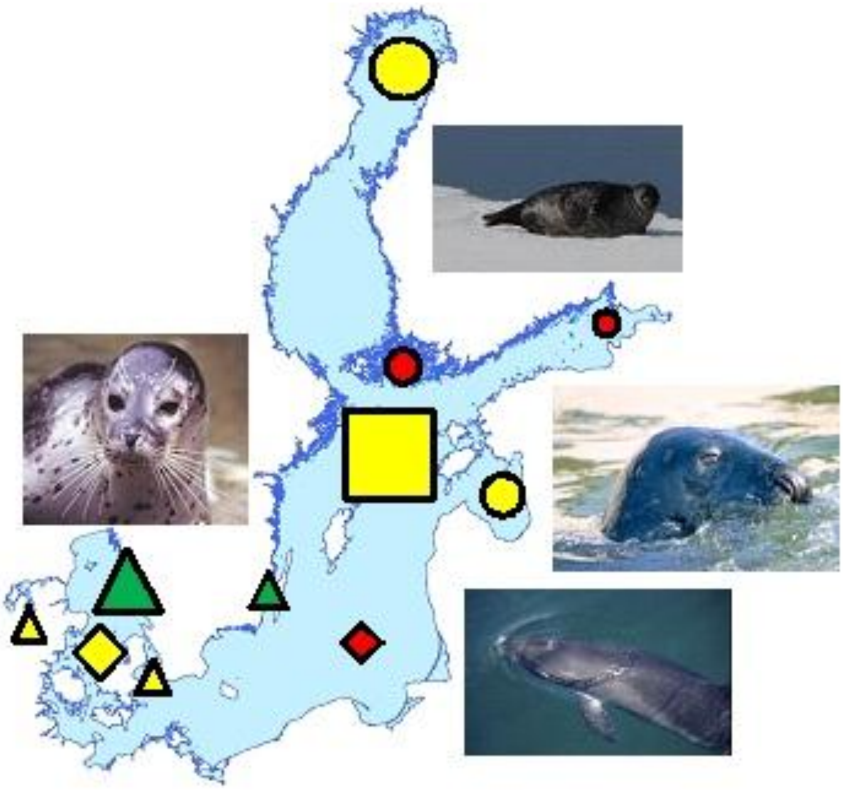


Figure. 1. *The state of the marine mammals in the Baltic Sea.* *The coloured symbols present the state of the population: green indicates good environmental status (GES), yellow indicates less than good status and red indicates a population that is declining or stable with low abundance. The square is for grey seal in the entire Baltic, the circles for the four subpopulations of ringed seal, the triangles for the four harbor seal subpopulations and the diamonds for the two harbor porpoise populations. The size of the symbol is indicative of the abundance of the populations. See text and figures 2–4 for further information.*

Have the populations of marine mammals increased?

Harbour porpoise

The growth rates of the harbour porpoise subpopulations in Kattegat, Belt Sea and Baltic Proper are negative, but the exact rate of decline is not known. The Baltic Proper subpopulation is Critically endangered: its size reaches likely fewer than 250 individuals. Annual maximum rate of increase for most whales, also harbour porpoise, is about 4% (Woodley and Read 1991, Best 1992).

Grey seal

The grey seal population was growing fast (>10 % per year) between the early 1990s and the mid- 2000s in the Baltic Sea (**Figure 2**, see also Halkka et al. 2005, Stenman et al. 2005, Hårding et al. 2007). The rate decreased a few years ago to ~6 %, but the population has started to increase again and the 2012 abundance was the highest ever (**Figure 2**, also Finnish Game and Fisheries Research Institute 2011). The intrinsic growth rate of the species in the Baltic can be 10% (see **Annex 1**) and in this indicator it is compared to the 5-year average of the growth rate. Due to the drop in 2008-2009, the population growth rate of the species does not currently reach the GES boundary.

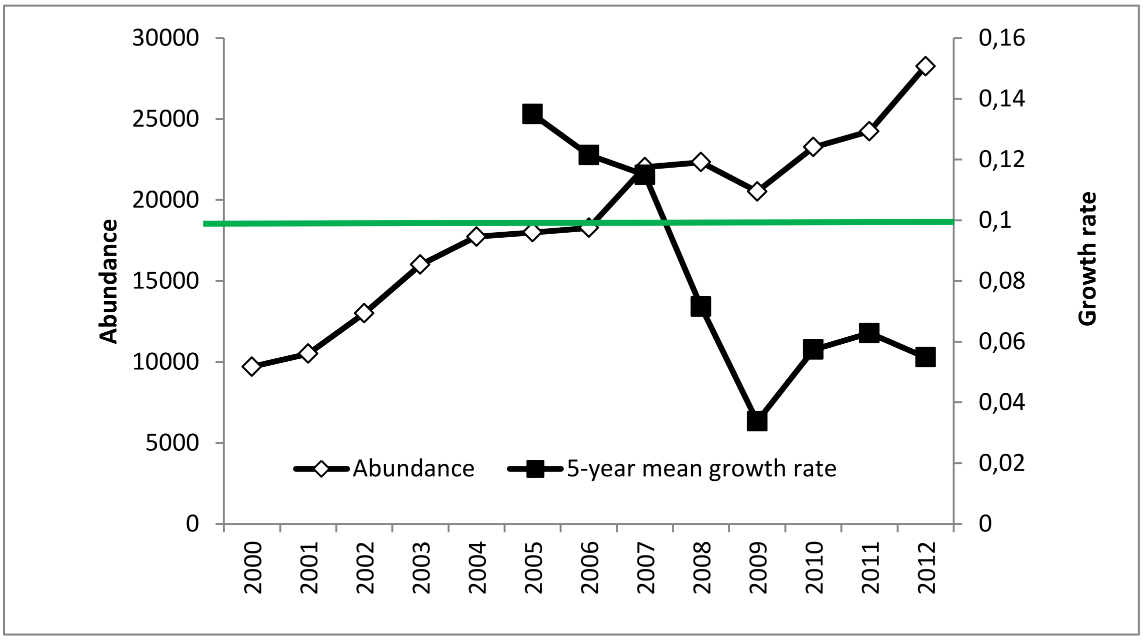


Figure 2. *Changes in the population growth rates (squares) and abundance (diamonds) of grey seal in the Baltic Sea. The population growth rate is shown as a moving average of 5 years. The green line denotes the GES boundary for the population growth.*

Ringed seal

The ringed seal population in the Bothnian Bay has been increasing at a rate of a 4.5% per year since 1988 (Hårding & Härkönen 1999, Karlsson et al. 2009), which is less than half the intrinsic capacity (10%, Karlsson et al. 2007, see also Annex 1). The 5-year means of the growth rate show however very high variability between 0 and 23%, probably reflecting the uncertainty of population censuses (Figure 3). In the southern breeding areas, the Gulf of Riga, the Gulf of Finland and the Archipelago Sea, increasing trend has not been observed (Karlsson et al. 2007). The population in the Gulf of Finland is decreasing and considered very alarming.

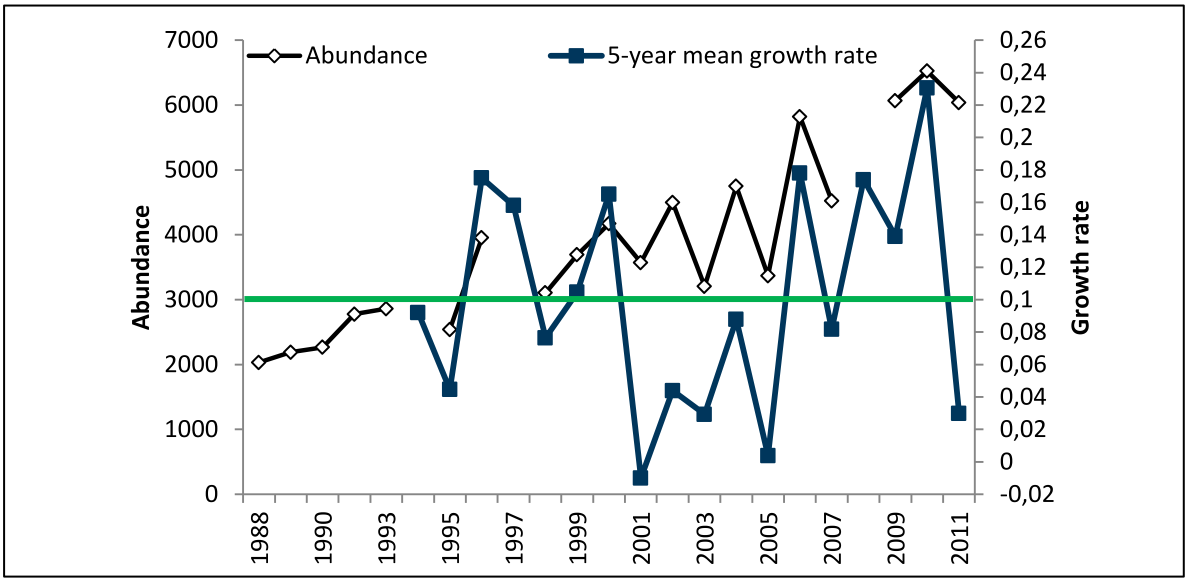
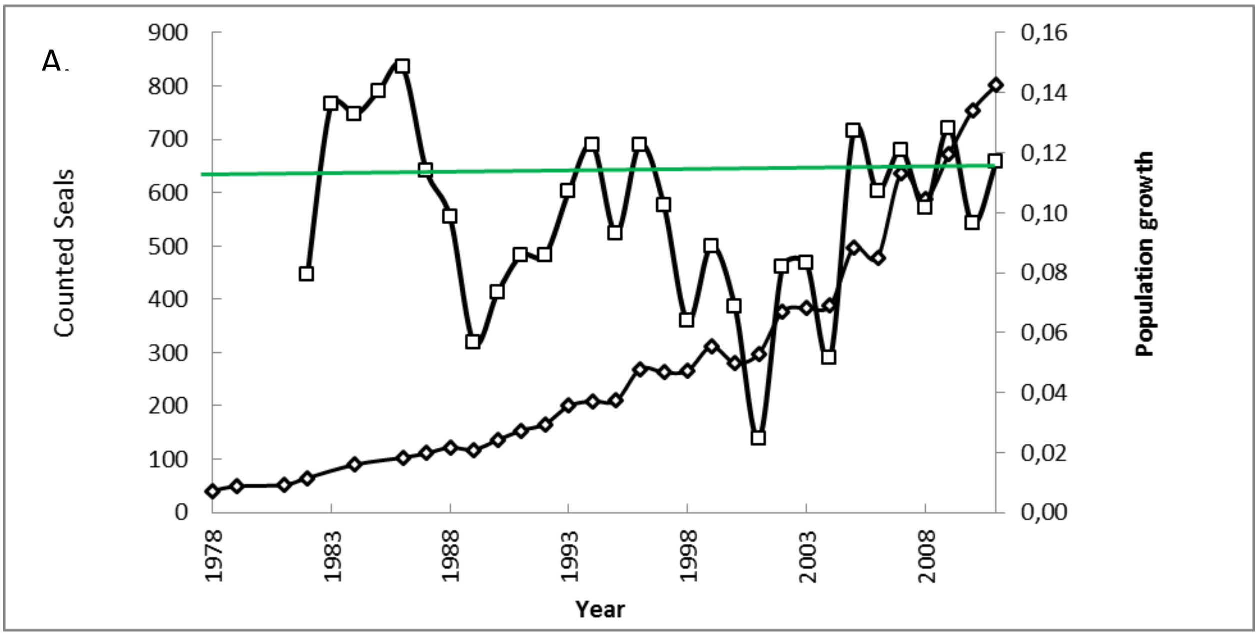


Figure 3. *Changes in the population growth rates (squares) and abundance (diamonds) of ringed seal in Bothnian Bay. The population growth rate is shown as a moving average of 5 years. The green line denotes the GES boundary for the population growth.*

Harbour seal

The harbour seal populations in the Baltic Proper, Kattegat and Limfjorden have experienced a series of population crashes as a result of virus infections. At the moment, the populations of the Baltic Proper and Kattegat are increasing around 12% per year (Figure 4 A, B, see also Härkönen & Isakson 2010). While the abundance of the Limfjorden subpopulation has increased, the population growth rate has declined over the last ten years (Figure 4C). The intrinsic rate of increase in this species is 12% per year (Härkönen et al. 2002, see also Annex 1).



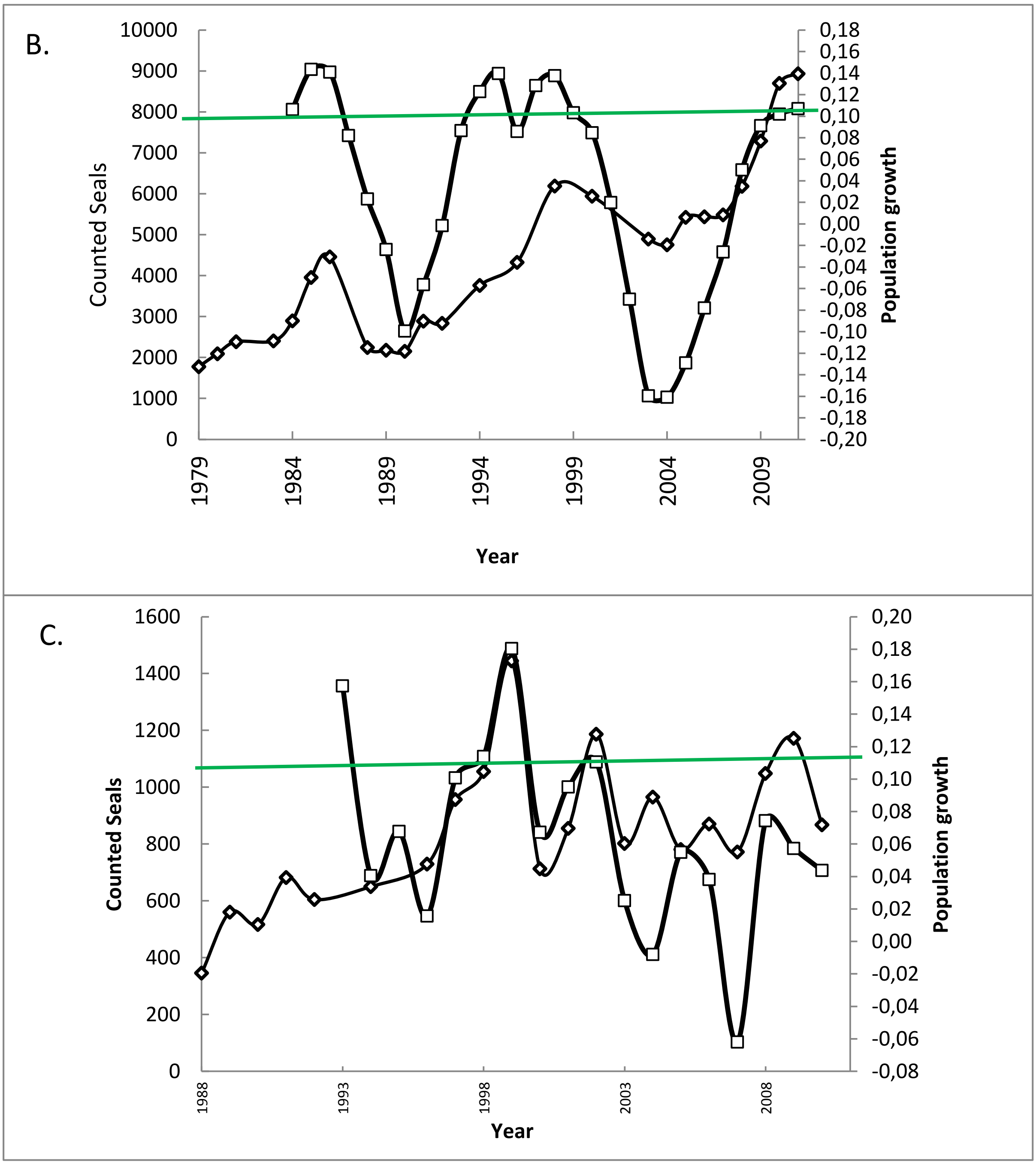


Figure 4. *Changes in the population growth rates (squares) and abundance (diamonds) of harbour seal in (A) Baltic Proper, (B) Kattegat and (C) Limfjorden. The population growth rate is shown as a moving average of 5 years. The green line denotes the GES boundary for the population growth.*

Description of the indicator

Marine mammals are top predators of the marine ecosystem and good indicators for the state of the food webs, hazardous substances and direct human disturbance.

The proposed core indicator follows the population growth rate, abundance and distribution of harbour porpoise, grey seal, ringed seal and harbour seal.

Population growth rate. Population growth rate should be positive until hampered by natural limitations. Deviations from the maximum rate of population growth during the phase of exponential increase are indicative of that the population is reaching its carrying capacity or is affected by human impacts in form of excessive mortality or impaired fertility. Near or within the carrying capacity, the population fluctuates but a continuous decline indicates that the population is not in good environmental status (GES). See Metadata for discussion of the carrying capacity.

Abundance. Population abundances of the marine mammals are informative indicators of the state of the populations.

Distribution. The abundance of populations in different parts of the Baltic Sea gives an indication of the distribution of the population. The distribution indicator also shows also temporal trends of the abundance in the sub-regions.

Policy relevance

The Baltic Sea Action Plan has the ecological objective 'Viable populations of species' with the target 'By 2015, improved conservation status of species included in the HELCOM lists of threatened and/or declining species and habitats of the Baltic Sea area, with the final target to reach and ensure favourable conservation status of all species'.

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

Harbour porpoise

The harbour porpoise is the only cetacean species regularly occurring and reproducing in the Baltic Sea. Harbour porpoise is an Annex IV species of the EU Habitats Directive (1992) which requires the introduction of marine protected areas as well as conservation measures in the entire porpoise distribution range.

International bodies such as the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), the International Whaling Commission (IWC), the International Union for Conservation of Nature (IUCN) and the Helsinki Commission (HELCOM) have recognized the need for an action plan to promote the recovery of the Baltic harbour porpoise. In 2002, the ASCOBANS recovery plan (a.k.a. Jastarnia Plan) was created with an interim goal of restoring the population of harbour porpoises in the Baltic Sea to at least 80% of its carrying-capacity level (ASCOBANS 2002). The objectives of the recovery plan are to implement precautionary management measures e.g. to reduce the bycatch rate to two or fewer porpoises per year.

HELCOM's Baltic Sea Action Plan (BSAP) is aimed at an improved conservation status of the Baltic harbour porpoise by 2015. Its goal is a significant reduction of harbour porpoise bycatch rates to close to zero by 2015. In co-operation with ASCOBANS, a coordinated reporting system and a database on Baltic harbour porpoise sightings, bycatches and strandings is to be developed to increase the knowledge on and protection of this species by 2010.

Seals

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.

General characteristics of the marine mammal populations

Abundances of seals and harbour porpoise

Harbour porpoise

The harbour porpoise population inhabiting the Baltic Proper has been classified by the IUCN as "critically endangered" (Hammond et al. 2008), justified by the consideration that the current population size is likely to be fewer than 250 mature individuals and continues to decline. Although neither the original population size nor the carrying capacity of the Baltic Proper have been quantified, it appears likely that the population size decreased considerably in the 20th century due to anthropogenic impact. Another drastic decline occurred in the extremely severe winter of 1940 when nearly the whole Baltic Sea was frozen over (Schulze 1996). Nonetheless, harbour porpoises can still be found throughout the entire Baltic Proper as shown by opportunistic sightings and bycatch.

Recent studies suggest that three genetically and morphologically distinct populations of harbour porpoises (*Phocoena phocoena*) occur in the HELCOM area: the North Sea population also inhabits the Skagerrak and the northern part of the Kattegat, the Baltic Proper population extends from Finland to about the German island of Rügen, and the population of the Inner Danish Waters lives between Kattegat and Rügen (e.g. Berggren et al. 1999, Tiedemann et al. 2001, Huggenberger et al. 2002, Teilmann et al. 2008).

Two aerial surveys of the southwestern part of the Baltic Proper (between southern Sweden and the coast from Darss Ridge to Gdansk) in 1995 and 2002 resulted in best estimates of 599 and 93 porpoises, respectively (Hiby & Lovell 1996, Berggren et al. 2004). These survey results confirm the extremely low and probably decreasing population abundance in the Baltic Proper. Long-term PAM (passive acoustic monitoring) studies have provided a detailed picture of porpoise occurrence patterns in some subareas (e.g. Gillespie et al. 2005, Carstensen et al. 2006, Verfuß et al. 2007). **Table 5** summarizes the surveys.

For a survey area mainly covering the Skagerrak to the Belt Sea and the Arkona Sea, respectively, the mean abundance of harbour porpoises was estimated to be about 36 000 animals in July 1994 (SCANS-I; Hammond et al. 2002) and about 23 000 individuals in July 2005 (SCANS-II 2008). This 38-51% decline was however, not statistically significant, but should give reason for concern (Teilmann et al. 2008).

Harbour porpoises live in the Baltic Sea year-round, but have to avoid complete ice cover. The recolonization of the entire Baltic Proper cannot rely on immigration from other populations and will thus depend on intrinsic population growth from a very low abundance. Therefore, it is likely to take several decades at best.

Grey seal

The number of grey seals counted in 2012 was ca. 28 000 individuals (**Figure 2, Table 2**). A model calculation has estimated that in the beginning of the 20th century, the estimated population size was in the range of tens of thousands up to 100 000 (Kokko et al. 1999, Hårding & Härkönen 1999), but only 2 000 in the late 1970s (Boedeker et al. 2002).

Ringed seal

The estimated abundance of Baltic ringed seal is 10 000 (Finnish Game and Fisheries Research Institute 2011). The most recent estimates from 2011 suggest that there are about 6 500 ringed seals in the Gulf of Bothnia, whereas counted numbers in the Gulf of Finland and the Gulf of Riga were 50 (Mikhail Verevkin, pers. comm) and about 1 400 –1 500, respectively. The census in 2011 found 104 ringed seals in the Archipelago Sea after two good ice winters, leading to an estimate of 140-300 individuals in the area (Miettinen et al. 2005, Finnish Game and Fisheries Research Institute 2011). In the Eastern Gulf of Finland, almost all individuals are on the Russian territory and in the 1990s the subpopulation was estimated to have 300 individuals.

HELCOM *ad hoc* SEAL Expert Group has expressed its concern about the situation of ringed seal in the southern subpopulations. The Baltic ringed seal subspecies was classified as Vulnerable by the IUCN in 2009.

Population models (based on bounty statistics from Finland and Sweden, and data from Estonia) suggest a population size of roughly 180 000-220 000 at the beginning of the century (Hårding and Härkönen 1999, however, it should be noted that bounty statistics may contain sources of error, decreasing reliability of the estimates). The population was heavily exploited until 1960’s, after which the emerged organochlorine contamination began to cause reproductive failures. During 1970-80, the population was at its minimum: about 5000 individuals in the Baltic Sea.

Harbour seal

There are two distinct populations of harbour seal in the HELCOM convention area: the Kattegat - Belt Sea population and the Baltic Proper population (Härkönen & Isakson 2010). In the Baltic Proper (waters around Öland) there are about 800 individuals scattered to a few areas (**Figure 5**). The Kattegat-Belt Sea population was estimated to be about 8 500 individuals in 2011 (**Figure 6**).

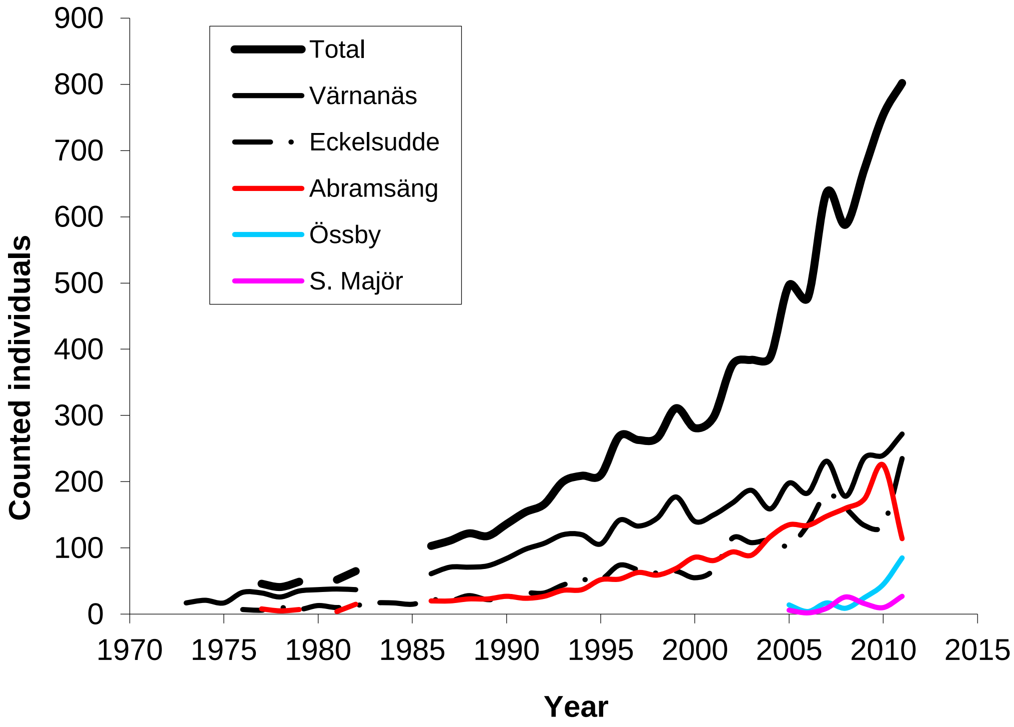


Figure 5. *Abundance of harbour seal in Baltic Proper at specific moulting sites*.

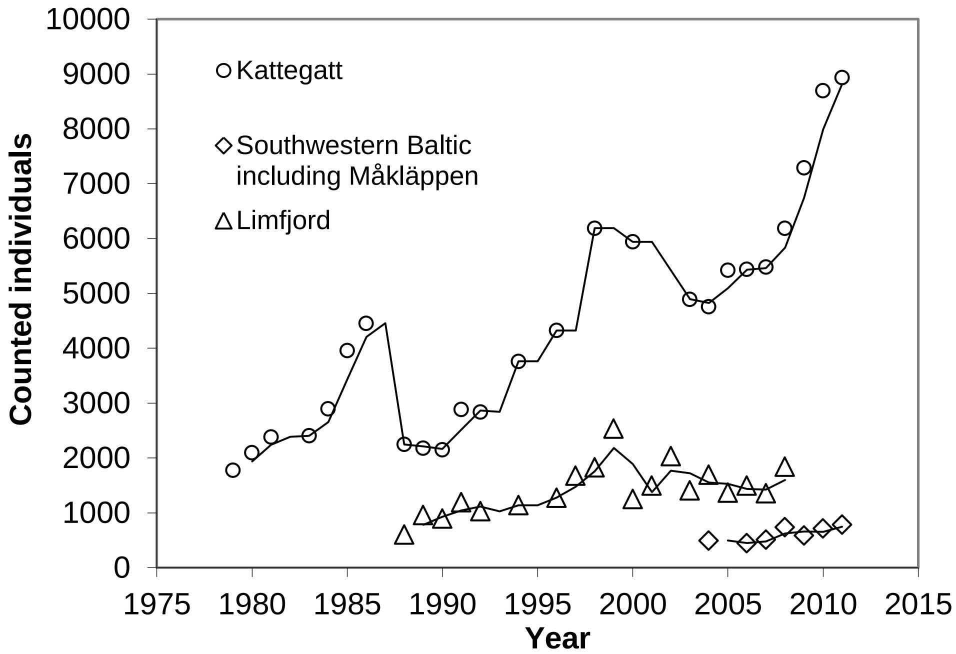


Figure 6. *Abundance of harbour seal in Kattegat, Limfjorden and Belt Sea. The line is the moving average*.

Distribution of seals and harbour porpoise

Harbour porpoise

The distribution of harbor porpoise is hard to estimate in the Baltic Sea as the density of the Baltic Proper population has become so low. Sightings of the species are found however even in Gulf of Bothnia and Gulf of Finland (HELCOM ASCOBANS database). For a distribution of a population there should be however a lower density limit and therefore it is suggested that the presence is indicated by the frequency of >10 registrations/1000km^2 per area in a year.

Up to the early 20th century, the harbour porpoise was common and widely distributed throughout the Baltic Sea and numbers were sufficient to support an annual drive fishery in Danish waters (Tomilin 1957, cited in Koschinski 2002). Concurrent with a declining population, the northeastern distribution limits gradually receded west and southward over the past decades (Koschinski 2002). Anecdotal information on (pre-industrial) porpoise distribution indicates a probably continuous distribution throughout the Baltic Proper, possibly also covering the entire Gulf of Bothnia as well.

Harbour porpoises perform surprisingly long movements as could be shown by an ongoing Danish satellite-tracking project (Teilmann et al. 2008). Since 1997 more than 60 individuals have been tagged and followed from the Inner Danish Waters and Kattegat/Skagerrak to as far as the Scottish coast and the Shetlands.

Sightings and strandings of harbour porpoise

Although porpoise density in the Baltic Proper is extremely low, it is important to point out that bycatch and occasional opportunistic sightings of harbour porpoises prove the continued presence of this species in nearly all parts of the Baltic Sea. Opportunistic sightings and strandings of harbour porpoises have been reported in almost all countries surrounding the Baltic Sea. A number of data banks collect information about incidental sightings and strandings of harbour porpoises in the Baltic Sea (see also the online resources mentioned above).

Carlén (2005) reported 146 live sightings of harbour porpoises in Swedish waters between May 2003 and September 2004, with three of those located along the Swedish east coast of the Baltic Proper. In Finnish waters, a total of 23 harbour porpoise observations were reported during 2001-2007 (Finnish Environmental Administration 2008). In Polish waters, a total of 10 sightings were reported for 1990-1999 (Skóra & Kuklik 2003). Sighting rates in Danish and German waters are higher in summer than in winter (Kinze et al. 2003, Siebert et al. 2006).

Annual totals of 110, 139 and 107 strandings were reported for the Danish coasts (mostly in the HELCOM area) for the years 2000 to 2002, respectively (Kinze et al. 2003). Along the German Baltic coast, 11 to 158 stranded (inc. bycaught) individuals were reported annually for the years 1990-2007. Skóra & Kuklik (2003) recorded seven strandings for the Polish coast during the years 1990-1999. Such information constitutes minimum numbers as not all sightings and strandings are being reported. From 2002 to 2006, aerial surveys were conducted in the German waters of the southwestern Baltic Sea resulting in abundance estimates ranging from 0 to 9098 individuals, with very high 95% confidence intervals, for the local porpoise population (Scheidat et al. 2008).

Grey seal

Grey seals are found on both sides of the North Atlantic in temperate and sub-Arctic waters. The actual Baltic Sea population is distinct from the eastern North-Atlantic population. Grey seals are mainly distributed north of latitude 58^{o} N, whereas in the beginning of the 20th century the species was frequently abundant over the entire marine area. Although the population size is steadily increasing since the end of the 1970s, the former distribution area south of latitude 58^{o} N is being recolonised only very slowly. **Figure 7** shows, however, increasing distribution in the SW Baltic Sea. In the German Baltic Sea, its status is assessed as "critical" (Merck & von Nordheim 1996).

In the spring during the moulting period, the bulk of the grey seal population is in the Northern Baltic Proper and Archipelago Sea (**Figure 7**). During other seasons the distribution is less aggregated and seals can be found from the entire Baltic Sea.

Grey seals migrate across long distances in the Baltic Sea (Eklöf 2007, Lehtonen et al. 2012), therefore the distribution estimated during the moulting period (**Fig. 7**) does not indicate the occurrence of grey seals outside moulting.

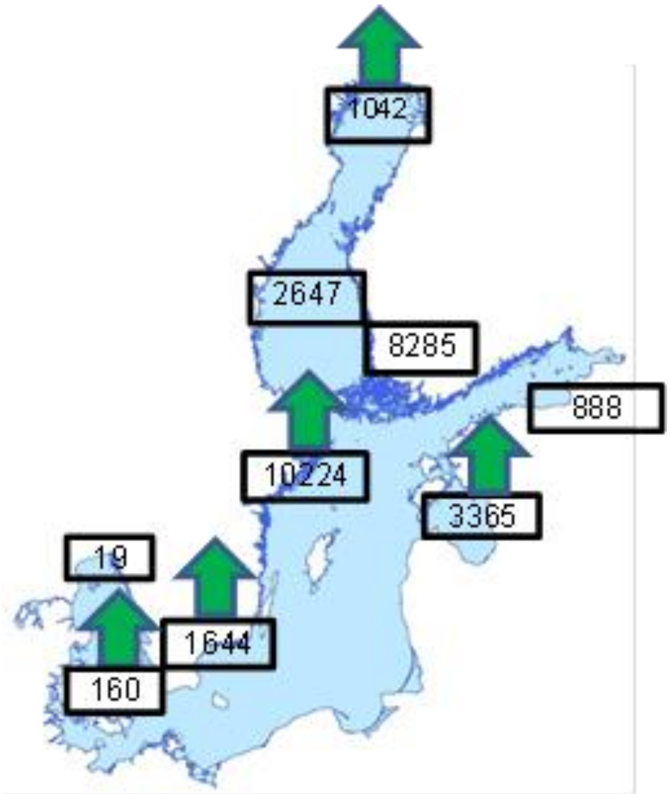


Figure 7. *Abundance of grey seals in the monitoring units during the moulting time in 2012. Temporal trend in abundance (2007-2012), if obvious, is shown by upward and downward arrows. Table 2 gives more detailed information of the abundances and monitoring units.*

Ringed seals and harbour seals

Ringed seals are mainly found in the Arctic and the distribution of the Baltic ringed seal population is patchy. These sub-populations exist as geographically isolated postglacial relicts, not only in the Baltic Sea itself, but also as land-locked in the lakes Ladoga (*P.h. ladogensis*) and Saimaa (*P.h. saimensis*). The reason for the four separate distribution areas in the Baltic Sea is not known but the population decline a couple of decades ago has strengthened the isolation of the southern subpopulations. In addition, the distribution area in the Stockholm archipelago was lost in mid-20th century.

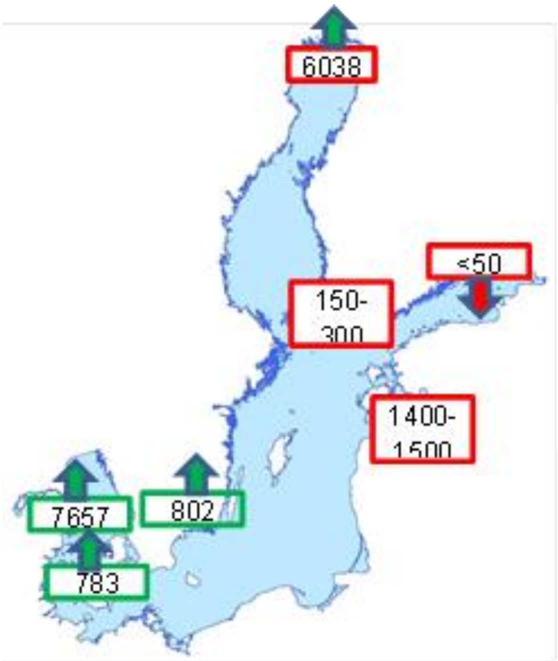


Figure 8. *Distribution and abundance of ringed seal (red) and harbor seal (green) in their monitoring units during the moulting time (harbor seal) and breeding time (ringed seal). Tables 2 and 3 give more information of the abundances and monitoring units.*

The 2011 census aimed to clarify the distribution of ringed seals in the Quarck but failed due to poor weather conditions. Härkönen et al. (2006) have shown that the migrations of ringed seals are not long and the four subpopulations seem not to mix.

Harbour seal distribution covers limited areas in the Western Gotland Basin, Swedish coast of Bornholm and Arkona Basin, Belt Sea, the Sound and Kattegat (incl. Limfjorden). Archeological studies have shown that the species has not likely inhabited the northern parts of the Baltic Sea during the past 8000 years, but the distribution areas have, nonetheless, covered the Baltic coasts southward from Gulf of Riga (Härkönen et al. 2005). The individuals in Kattegat and Belt Sea form a separate subpopulation and there is a distinct subpopulation in the Baltic Proper. The largest of the distribution areas of the Baltic population is around the island Öland in the Western Gotland Basin. Olsen et al. (2010) suggest that there may be genetic reasons to further divide the population to smaller subpopulations.

The current environmental pressures to the marine mammals and the indicator validity

Harbour porpoise

Several types of human activities negatively influence the state of the harbour porpoise. In recent decades, the most important anthropogenic threats to harbour porpoises are the incidental bycatch, prey depletion, noise pollution and chemical toxins. Previously, harbour porpoises have been severely hunted in the Baltic region (Lockyer & Kinze 2003). The core indicator for drowned marine mammals and waterbirds in fishing gears discusses the harbour porpoise bycatch in more detail.

Prey depletion due to over-fishing and climate change is known to lead to starvation of harbour porpoises and the deterioration of health (e.g. MacLeod et al. 2007).

Noise pollution from industrial and military sources may lead to habitat exclusion, hearing loss or death. Before-After-Control-Impact (BACI) studies during wind park constructions in the Danish Baltic Sea showed a lasting reduction in acoustic porpoise detections mirroring a drastic reduction in their abundance in the area (Carstensen et al. 2006). Furthermore, noise simulations show that operating turbines may have a masking effect at short ranges in the open sea (Lucke et al. 2007).

Conventional ammunition removal by blasting, e.g. in Kiel Bight between 2006 and 2009, is a particular hazard for cetaceans as high sound pressure levels and explosion-related shock waves can lead to severe injury and hearing impairment in marine mammals at considerable distances from detonation sites (Koschinski & Kock 2009). Alternative techniques to render old ammunition harmless are available and in order to minimize harm to marine mammals detonations in the marine environment can be avoided in most cases. If underwater detonations cannot be avoided, suitable mitigation measures need to be introduced. Test detonations demonstrated that it was possible to reduce the danger area by over 98% when using a double bubble curtain.

Chemical toxins such as persistent organic pollutants and heavy metals may lead to reduced fertility, reduced immune response and illness. Porpoises from the Baltic Sea have been shown to have accumulated PCB levels 0.4 to 2.5 times higher than those from the Kattegat and Skagerrak (Berggren et al. 1999). PCB-related reproductive failure is well known from Baltic grey seals (e.g. Bergmann 1999). A strong increase in infectious disease mortality was shown in British harbour porpoises to correlate with PCB levels above 17 mg/kg lipid (Jepson et al. 2005). Beineke et al. (2005) also found indications for contaminant-induced immunosuppression in stranded harbour porpoises on the German Baltic coast.

Over the last decade, an increase in strandings of dead harbour porpoises has been observed along the German part of the western Baltic Sea (Herr et al. 2009, Koschinski & Pfander 2009). On the other hand, there is no indication of a population increase in the western Baltic that could explain the increase in stranding occurrence.

Mitigation

A number of mitigation measures have been suggested for the threats harming the harbour porpoise population:

Bycatch reduction close to zero calls for the elimination of any contact of porpoises with the responsible gear. This can be done by a reduction of fishing effort to ecologically sustainable levels or by using fishing gear less prone to bycatch. The use of deterrent devices in set nets, so-called pingers, may either be not very efficient or lead to exclusion from key habitats, should they work effectively. Therefore, ASCOBANS (2002) recommends their use only for up to three years to buy time for the development of less problematic mitigation measures. Onboard monitoring and reporting of data are prerequisites to obtaining reliable bycatch numbers and to evaluating the efficiency of any mitigation measure.

A reduction of fishing effort in the responsible fisheries (at least at certain critical times) currently appears to be the only available mitigation measure to avoid prey depletion due to over-fishing.

Noise pollution may be reduced by limiting the maximum speed of vessels, as sound pressure levels increase with increasing vessel speed. Furthermore, fast ferries as well as jet skis should be prohibited in key porpoise areas. The latter measures would also help to avoid the danger of collisions also known as ship strikes. The identification of key areas, however, is inherently difficult in low density areas requiring either intensive research efforts or the rigorous application of the precautionary principle.

Information on the harbour porpoise population status is mainly available for the Western Baltic Sea and the western part of the Southern Baltic Proper. For the Baltic harbour porpoise population, information is scarce and increased monitoring and research is therefore strongly recommended. A long-term passive acoustic monitoring in the entire Baltic Proper with stationary devices is recommended to survey harbour porpoise densities and their trends. Continuation of post-mortem investigations will supply information on the impact of chemical toxins on this top predator. The monitoring of bycatch and the development of mitigation measures continues to be essential.

Grey seals

Grey seals are fish-feeding top predators of the Baltic food web. Still some decades ago their abundance was severely reduced by organochlorine contamination causing reproductive failures. Other anthropogenic pressures reducing the abundance or causing disturbance in nursing, molting and feeding areas are drowning in fishing gears, shifts in fish community (e.g. due to fishing), underwater noise and recreational boating.

Grey seals are gregarious and gather together for breeding, moulting and hauling out at exposed areas. In the Baltic, they grow to an average length of 1.65 – 2.1 meters and a mass of 100 – 180 kg for females and > 300 kg for males. They can reach an age of 25 (males) – 35 (females) years. The main breeding season in the Baltic Sea is from February to March. Pupping in the Baltic Sea takes place mostly on drift ice although in some areas seals also give birth on land. The pup is nursed for about 15-18 days. Grey seals moult on ice and haul-out sites from April-June. Females become sexually mature between 3 and 5 years. The pup is born with a creamy-white woolly lanugo coat, which it will moult after 2-4 weeks for a shorter adult-like coat. Grey seals are sexually dimorphic, e.g. distinct larger sized males with a more convex muzzle, although grey seals in the Baltic do not exhibit the degree of sexual dimorphism generally ascribed to this species (Karlsson 2003). They feed on a wide variety of fish. The diet varies with location, season and prey availability (Stenman & Pöyhönen 2005, Lundström et al. 2007). Fasting occurs during the breeding and moulting seasons. Juveniles in particular are known to travel over long distances (Sjöberg et al. 1995).

National seal conservation and management plans should be developed in order to ensure proper conservation and management of the populations (see Table 1). These should include continuation of long-term monitoring and research programmes, the restoration of suitable habitats where appropriate, as well as the establishment and proper management of seal sanctuaries. Further, the responsible national authorities should coordinate their management and monitoring strategies regarding shared seal populations with neighbouring countries.

Ringed seals

By the 1970s, hunting and pollution had reduced the total population drastically. The main threats ringed seals are facing are the contamination of the Baltic Sea and climate change (Management plan for Baltic seals in Finland 2007). Although the contaminant levels in Baltic seals have decreased since the end of the 1970's, the levels in ringed seals are still high (ICES 2005). Climate change is of particular concern for the southern distribution range (Gulf of Riga, Gulf of Finland and Archipelago Sea), where mild winters might have already significantly affected the reproductive success of these populations (ICES WGMME Report 2005) which are adapted to ice breeding. Other threats include entanglement in fishing gear (by-catch), a wide range of human disturbances (boating, tourism, constructions) and increasing shipping, such as ice breaking vessels destroying the pack ice habitat (Stenman et al. 2005).

Ringed seals grow to an average length of 1.5 – 1.75 meters and a mass of less than 120 kilograms, and can reach a maximum age of 48 years. Females become sexually mature between 3 and 6 years after which they normally generate one pup every year. The moulting season is from mid-April to early May. Ringed seals feed on a wide variety of fish and invertebrates.

National seal conservation and management plans should be developed in order to ensure a proper conservation and management of all sub-populations during all life stages (ICES 2005) (see Table 1). According to ICES WGMME Report (2005), it is important to address possible impacts on ringed seals when planning the use and exploitation of marine areas such as infrastructure development (e.g. shipping, oil transit, fixed links and wind parks). Regulations for shipping should in particular be implemented for ice breaking vessels during winter time. Further improvement of long-term monitoring and research programmes is needed. Ringed seals in the southern distribution range require more attention because current knowledge about vital population parameters is missing (ICES 2005). Further, the responsible national authorities should develop and coordinate their monitoring strategies regarding shared seal populations with neighbouring countries. HELCOM Recommendation 27-28/2 further recommends the Contracting Parties to collaborate within the HELCOM seal expert group to identify and establish a network of protected areas for important actual and potential seal habitats across the Baltic Sea area (re. the EU Habitat Directive, Annex II), and attempt to harmonise the regulations and monitoring of these conservation areas.

Harbour seals

Harbour seal populations in the Baltic Sea have experienced two recent (1988 and 2002) population crashes due to virus infections (reviewed in Olsen et al. 2010).

Intensive hunting in the beginning of 20th century caused a severe decline of the harbour seal population in the Baltic. At the end of 1960s, only 200 seals remained in the Baltic Proper population (Härkönen & Isakson 2010). The population growth in the 1970s was slow and likely inhibited by impaired reproductivity caused by organochlorines (Härkönen & Isaksson 2010). The current population distribution is protected by marine protected areas, but the main threat at the moment is drowning in fishing gears (Härkönen & Isakson 2010). In 1990s. about 20 pups were bycaught annually in eel fisheries (fyike nets) but the situation may have improved even though reliable surveys are lacking (Härkönen & Isakson 2010). There is no information on the health status of the harbour seal population.

National management plans for marine mammals

National management plans for marine mammals which are in force or under development are listed in Table 1.

Table 1. *National management plans for marine mammals. See Table 6 for more details.*

Country	NMPs	Status of the MPs (in 2012)	Species included	Adopted in	Time Period	Planned Updates
Denmark	Yes	MPs for grey seals and harbour seals exist	Grey and harbour seal	2005	2005-2010	Due to review
Estonia	Yes	Being revised for ringed and grey seal	Grey and ringed seal	2001 (gs); 2006 (rs)	2001-2005 (gs) 2006-2010 (rs)	In **2013** for period of **2013-2017**
Finland	Yes	MPs five years old, being updated in 2012	Grey and ringed seal	2007	2007-2012	**Date for the update has not been decided**
Germany	No	No MPs foreseen to be produced	–	–	–	–
Latvia	No	No MPs foreseen to be produced	–	–	–	–
Lithuania	No	–	–	–	–	–
Poland	No	Under development for grey seal and harbour porpoise	–	–		–
Russia	No	No MPs	–	–	–	–
Sweden	No	MPs for grey seal and harbour seal in Skagerrak and Kattegatt (except for the "Kalmarsund population") are in place. MP for ringed seal is in preparation and is to be finished in 2013.	–	2012	2012-	

Metadata

Data source

Monitoring of grey seal abundance during the moulting period (DEN, EST, FIN, SWE).

Monitoring of harbour seal abundance during the moulting period (DEN, SWE).

Monitoring of ringed seal abundance during the breeding period (EST, FIN, SWE).

Harbour porpoise surveys (DEN, GER, SWE).

Project data and scientific literature.

Geographic coverage

The data in the indicator covers the current distribution range of the marine mammals. The monitoring of the indicator is made during the moulting time of grey seals and harbor seals and the breeding time of ringed seal, when their distribution is limited to moulting/breeding sites.

Monitoring is considered adequate at the moment for grey seal, Bothnian Bay ringed seal and harbour seal.

Areas recommended to be monitored

Current monitoring areas are listed in Tables 2-4.

Grey seals: moulting seals do not occur in Latvian, Lithuanian, Kaliningrad region, Polish and German coasts and regular monitoring is, hence, not needed in these areas to support the core indicator. Regular surveys to find new moulting sites are relevant, after which the national monitoring should be established. Porpoise may be relevant from Kattegat to Northern Baltic Proper but that should be verified by the SAMBAH project.

Ringed seal: in addition to Bothnian Bay, the monitoring is recommended in Archipelago Sea, Gulf of Finland, Gulf of Riga. The species does not have moulting and reproduction areas elsewhere and, hence, no monitoring is needed outside the named areas. It is also noted that a better monitoring method must be developed. HELCOM SEAL is working on this.

Harbour seal: the distribution of harbor seal is patchy in the Baltic Sea; the species is found only in Kalmarsund area, Danish Belt Sea and Swedish Måkläppen, Kattegat and Limfjorden. Elsewhere its monitoring is not needed at the moment.

Harbour porpoise: The monitoring of harbour porpoise may be relevant from Kattegat to Northern Baltic Proper, but that remains to be seen as new results become available (e.g. SAMBAH project).

Areas where the indicator is relevant

Seals are important part of the food webs in the entire Baltic Sea outside the moulting/breeding period. Harbour porpoise may be more relevant from Kattegat to Northern Baltic Proper, but that remains to be seen from as new results become available.

Temporal coverage

The abundance and distribution of seal species represents the situation during the moulting period when the seals are aggregated on ice, reefs and/or shores.

Methods to estimate the population abundance

Harbour porpoise

The harbour porpoise density and abundance in the western Baltic Sea and the Kattegat have been estimated in a number of studies during the last 15 years, primarily by conducting visual surveys from ships or aircraft but also by using acoustic survey methods (for details see Table 5, Figure 9). Reported sightings and strandings provide additional information on the distribution of the harbour porpoise.

Currently, porpoise densities are regarded as too low to make visual surveys any longer viable. Therefore, an ongoing international research project ("SAMBAH") uses static acoustic monitoring in 300 locations in the Baltic Proper in water depth between 5 and 80 metres and first results regarding the geographical distribution are expected to become available in the year 2014 (www.sambah.org).

Grey seal

The grey seal populations are counted by aerial surveys (Denmark, Finland and Sweden) and shore/boat counts (Estonia and Russia) in the late May – early June in their main distribution area, when the seals are molting. While molting, the seals are often lying visibly on reefs or on last remnants of ice and are more aggregated to a smaller distribution area than in other seasons. The aerial photographs are used to count the number of individuals in dense aggregations. The census is made at the same time in five countries: Denmark, Estonia, Finland, Russia and Sweden.

It is clear that not all individuals can be counted during the flights as some are always foraging, but the reefs of the main distribution area are counted 2-3 times during the 2-week period and the maximum daily sum of those repeated counts is included in the estimates.

Until mid-1970s the seal abundance estimates were based on bounty statistics.

Ringed seal

The ringed seals are counted in April when the seals are molting and laying on ice. The census is made along line routes and is thus based on a sample of the total distribution area. For ringed seal in Archipelago Sea, Gulf of Finland, Gulf of Riga, a better monitoring method must be developed. HELCOM SEAL is working on this.

Harbour seal

The count of harbour seals is done in mid-June in Sweden and Denmark when the species is molting. The method is described in Olsen et al. (2010).

Methodology of data analyses

The seal and harbor porpoise surveys and the results are coordinated internationally and results discussed in the HELCOM SEAL. A coordinated database of the annual censuses is maintained by the group.

Determination of GES boundary

The GES is determined primarily from the population growth rate. The growth curves of Baltic ringed seals (Bothnian Bay), Kalmarsund harbour seals and grey seals indicate that they are growing exponentially. Given the variance of the slopes of the trendlines, obviously there is no significant deceleration, which would indicate that populations are approaching the carrying capacity. Svensson et al. (2011) shows that there needs to be a substantial change over an approximately 9-year period to detect a change in growth rate. Another method to detect the proximity of the carrying capacity is that the proportion of young seals decreases in the population (higher mortality). Currently, we don't have useful data on age structure in this context.

As long as the populations have not reached the carrying capacity of the environment, a rate close to the intrinsic growth rate indicates GES. In the carrying capacity or near it, the GES is maintained when the populations do not decrease more than 10% over 10 years.

At the moment all the populations are assessed against their intrinsic growth rate:

Grey seals and ringed seals: 10 % intrinsic growth rate.

Harbour seals: 12 % intrinsic growth rate.

Harbour porpoise: 4 % intrinsic growth rate.

Assessment units

The assessment unit for grey seal is the entire Baltic Sea, but the distribution parameter clarifies how the population is developing in the different parts of the distribution range during the moulting period.

Assessment units for ringed seal are Bothnian Bay, Archipelago Sea, Gulf of Finland and Gulf of Riga.

Assessment units for harbor seal are Western Gotland Basin, SW Baltic including Måkläppen, Kattegat and Limfjorden.

Assessment unit for harbor porpoise are set temporarily for Kattegat+Danish Straits and the Baltic Proper (from Arkona Basin to Northern Baltic Proper).

Strengths and weaknesses of data

Harbour porpoises are highly mobile. Surveys in southern parts of the Belt Sea and Arkona Basin (summarised in Table 5 and Figure 9) recorded a high inter-annual variability (Scheidat et al. 2008) and annually recurring seasonal changes with low porpoise densities during winter and high densities during summer and autumn (Verfuß et al. 2007). Furthermore, a decrease in harbour porpoise densities from the Kattegat and Belt Sea eastward is obvious (e.g. Gillespie et al. 2005, Scheidat et al. 2008, Verfuß et al. 2007). In low density areas, acoustic survey methods appear to provide a better indication of porpoise densities and trends.

Neither the two porpoise population estimates from the Inner Danish Waters (1994 and 2005) nor the two estimates for the Baltic Proper population (1995 and 2002) are significantly different from each other due to the wide confidence intervals of all surveys. Moreover, the boundaries of the survey areas changed (as portrayed in Fig. 9).

Further work required

Currently this fact sheet focuses on the harbour porpoise in the southwestern Baltic Sea with the goal to update the information on harbour porpoises in the remaining Baltic Sea as soon as further information becomes available. It has been suggested that outstanding research should concentrate on the Baltic-wide distribution and abundance using static acoustic monitoring (e.g., the proposed SAMBAH project 2010-2014 under Swedish coordination) as well as information on the magnitude of the current bycatch.

To measure the success of conservation measures that results in an increase of porpoise distribution range (and by analogy in porpoise numbers), a SAMBAH-like survey should be periodically repeated e.g. every ten years. Additionally, the number of sighted and locally stranded porpoises may provide a useful indicator for the regular presence of porpoises as well as insights into population health. Such information could be based on promotion of new or already existing voluntary reporting schemes such as provided in Poland, Germany, Sweden, and Finland. Ultimately their entire historical range throughout the Baltic Proper should be recolonised by Baltic harbour porpoises. By then porpoises densities should have recovered sufficiently to allow reliable abundance estimation and the setting of alternative conservation targets. The Baltic Sea Action Plan, for example, also recommends pregnancy rate, fecundity rate, and the occurrence of pathological findings as indicators and targets for the ecological objective.

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View data

Table 2. *Distribution and abundance of grey seals in the Baltic sub-basins in their moulting season*.

	2004	2006	2007	2008	2009	2010	2011	2012
Bothnian Bay + Quarck	1330	1270	1049	1340	1154	642	1667	1042
Bothnian Sea (1, 2	870	610	1834	2483	1460	1288	1494	2647
Mid-Swedish archipelago	3900	4460	6349	4721	5804	7508	8494	10224
Archipelago and Åland Sea	7735	8040	8516	8308	6701	8361	5994	8285
Gulf of Finland	870	880	803	965	1040	615	1417	888
Western Estonia	2690	2660	2890	3875	3441	3476	3541	3365
Southern Sweden	245	350	550	637	795	1249	1334	1644

Eastern Baltic coast								
Polish and German coast								
The Sound (Måkläppen)	59	NA	NA	NA	NA	NA	NA	
Danish Baltic (without Måkläppen, but with Christiansø)	14	NA	NA	NA	115	121	281	160
Kattegat	15	NA	32	NA	11	NA	19	NA
Total	**17728**	**18270**	**22023**	**22329**	**20521**	**23260**	**24241**	**28255**

1) Sandbäck and Södra Sandbäck in the Bothnian Sea, near the Archipelago Sea. 2) Gräsö included in the Bothnian Sea.

Table 3. *Distribution and abundance of harbour seals in the Baltic sub-basins in their moulting season.*

	2004	2005	2006	2007	2008	2009	2010	2011
Western Gotland Basin	388	497	478	637	588	672	754	802
Southwestern Baltic including Måkläppen	494		448	511	737	586	715	783
Kattegat	4354		5440	5484	6518	6727	8346	7657
Limfjorden (1)	1693	1369	1496	1354	1839			
Total	**4848**		**5888**	**5995**	**7255**	**7313**	**9061**	**9340**

1) After Olsen et al. 2010.

Table 4. *Distribution and abundance of ringed seals in the Baltic sub-basins in their moulting season*.

	2004	2005	2006	2007	2008	2009	2010	2011
Bothnian Bay	4748	3368	5820	4523		6068	6525	6038
Archipelago Sea								150-300
Gulf of Finland								<50
Gulf of Riga								1400-

								1500
Total								

Table 5. *Results of dedicated aerial and shipboard surveys (visual and acoustic), as well as stationary acoustic monitoring for harbour porpoises in the Baltic Sea. Study areas of the different investigations are given in Figure 1. CV: coefficient of variation, CI: confidence interval; SE: standard error.*

SOURCE	**PLATFORM, METHOD**	**DATE**	**AREA**	**Animal (A) / Pod (P) ABUNDANCE**			**DENSITY**	
			(see Fig. below)	**Mean (CV)**	**CI**	**A/P**	**Mean (SE)**	**Unit**
Hammond et al. 2002	ship, visual	July 1994	I (inc. I')	36 046 (0.34)		A	0.725	animals/ km²
			I'	5 262 (0.25)			0.644	
			X	588 (0.48)			0.101	
Siebert et al. 2006	plane, visual	October 1995	B	980	360-2 880	A		
			C	601	233-2 684			
		July 1996	B	1 830	960-3 840			
			C	0	-			
Hiby & Lovell 1996[a]	plane, visual	June 1995	tracklines	599 (0.57)	200-3 300	P		
Gillespie et al. 2005	ship, visual	June-August 2002	1				8.2	sighted groups/1 00 km
			2				1.03	
			3				0	
			4				0	
		August-September 2001	5				0.34	
	ship, acoustic	June-August 2002	1				16.8 (3.71)	detectio ns/100 km
			2				10.5 (1.96)	
			3				3.2 (0.75)	

			4				0.1 (0.08)	
		August-September 2001	5				0	
Berggren et al. 2004	plane, visual	July 2002	tracklines	93	10-460	P		
Scheidat et al. 2008[b]	plane, visual	March 2003	E+F+G	457 (0.97)	0-1 632	A		
		May 2005		4610 (0.35)	2 259-9 098			
Verfuß et al. 2007[c]	stationary, acoustic	July-September 2004	I				97%	days with detections/quarter
			II				78%	
			III				1%	
		Januar-March 2005	I				60%	
			II				6%	
			III				1%	
SCANS-II 2008	plane, ship, visual	July 2005	S	23 227 (0.36)		A	0.340	animals/km^2

[a] The area covered by Hiby & Lovell (1996),cited in Berggren et al. (2004), is comparable to that covered by Berggren et al. (2004) excluding Polish coastal waters

[b] Only the minimum and maximum values are shown of surveys conducted in 2003-2006

[c] Only representative values are provided here to show seasonal and geographical variation during the study period (2002–2005)

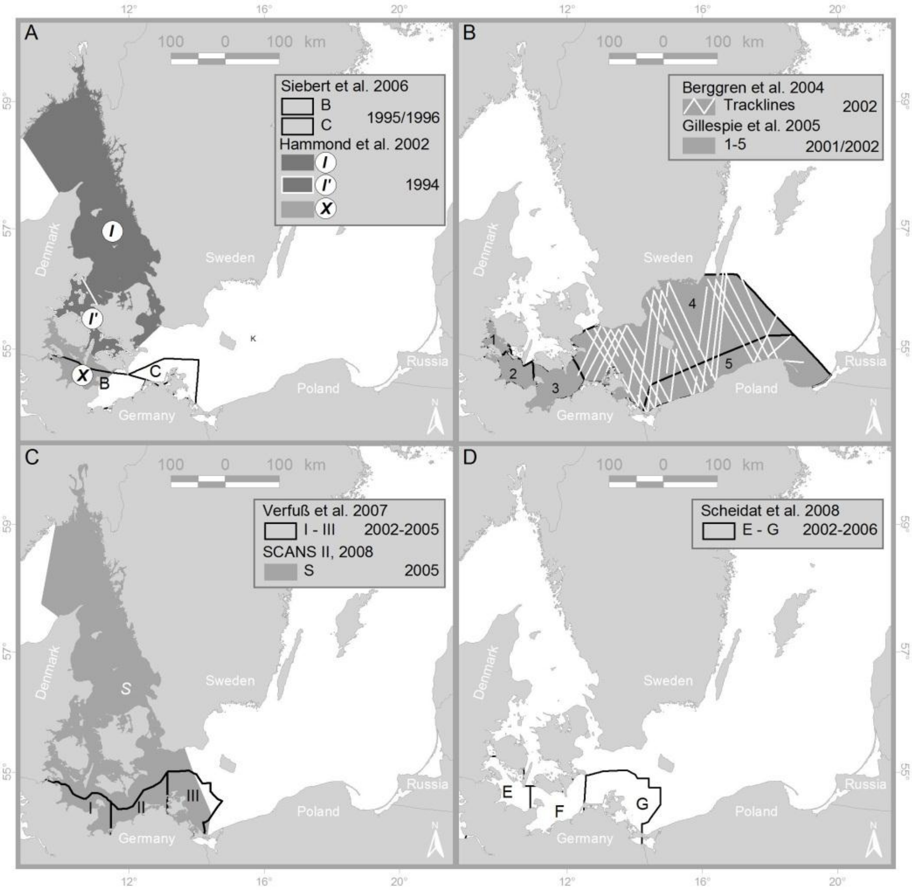

Figure 9. *Survey areas for the studies listed in Table 1. The area of Hiby & Lovell (1996), (not shown), cited in Berggren et al. (2004), matches the survey area of Berggren et al. (2004) shown in (B) excluding a narrow area along the Polish coast. Survey area I' of Hammond et al. (2002) (in A) is part of survey area I*

ANNEX 1.

Description of the indicator *Population growth rate of marine mammals' in the interim report of the HELCOM CORESET project (BSEP 129B)

Tero Härkönen

Introduction

Several international initiatives have suggested means to measure the environmental quality of marine ecosystems. The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) has been ratified by all North Sea countries. This convention lists a number of Ecological Quality Objectives (EcoQOs) for the North Sea, which were developed in collaboration with the International Council for the Exploration of the Sea (ICES) and aim to define a desirable state for the North Sea. EcoQOs have been developed for some components of the ecosystem, e.g. commercial fish species, threatened and declining species, and marine mammals. An EcoQO is a measure of real environmental quality in relation to a reference level where anthropogenic influence is minimal. The ecological quality elements "population trends" and "utilization of breeding sites", which have been suggested for marine mammal populations, may serve as suitable tools for evaluating current population status. The term "population trend" is defined for this purpose as a change in abundance of a population, increasing or decreasing within a specified area over a certain number of years. The EU Water Framework Directive (WFD) includes status categories for coastal waters as well as environmental and ecological objectives, whereas the EU Habitats Directive (European Commission 1992) specifically states that long-term management objectives should not be influenced by socio-economic considerations, although they may be considered during the implementation of management programmes provided the long-term objectives are not compromised. In line with both the OSPAR Convention and the Marine Strategy Framework Directive, the Helsinki Commission (HELCOM) in its HELCOM CORESET project is developing a framework using indicators for the Baltic ecosystem. 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. Consequently, the Coreset core indicator "Population trend" is similar to the EcoQ element with the same name in the ICES and OSPAR frameworks, with the distinction that two latter EcoQ:s include "No decline in population size or pup production exceeding 10% over a period up to 10 years" for populations "minimally affected by anthropogenic impacts". We suggest this condition to be appropriate also for the Coreset indicator "Population trend" when seal populations are close to natural abundances.

The OSPAR and ICES frameworks provide some guidance also for populations far below "natural" or "pristine" abundances. Applying the term "anthropogenic influence is minimal" would imply that a population should grow close to its intrinsic rate of increase when not affected by human activities. The theoretical base for this measure is outlined below and compared with empirical data from seal populations.

Approach for defining GES for populations below carrying capacity

Long term maximum growth rates in seals

The maximum rate of population growth is limited by several factors in grey seals and ringed seals. Females have at most one pup a year, and first parturition occurs at about 5.5 years of age. It is also evident that not all adult females bear a pup each year, especially not young females (Pomeroy et al. 1999, Bäcklin 2011). An additional limitation for the population growth rate is given by the survival of adults. In most seal species the highest measures of adult survival are about 0.95-0.96, and for grey seals the best estimate available is 0.935 (Harwood and Prime 1978). An additional constraint is the observation that pup and subadult survival is always found to be lower and more variable compared to adult survival in all studied species of seals (Boulva and McLaren 1979, Boyd et al. 1995, Härkönen et al. 2002).

These biological constraints impose an upper ceiling of possible rates of long-term population growth for any seal species which can be found by manipulations of the life history matrix. In **Figure 6** we illustrate how fertility and mortality rates known for grey and ringed seals can combine to produce different long-term population growth rates. It is found that growth rates exceeding 10% (λ= 1.10) per year are unlikely in healthy grey seal populations (top stipled line in Fig. 1). Reported values exceeding 10% should be treated sceptically since they imply unrealistic fecundity and longevity rates. Such high growth rates can only occur temporally, and can be caused by e.g. transient age structure effects (Härkönen et al. 1999, Caswell 2000), but are also to be expected in populations influenced by considerable immigration.

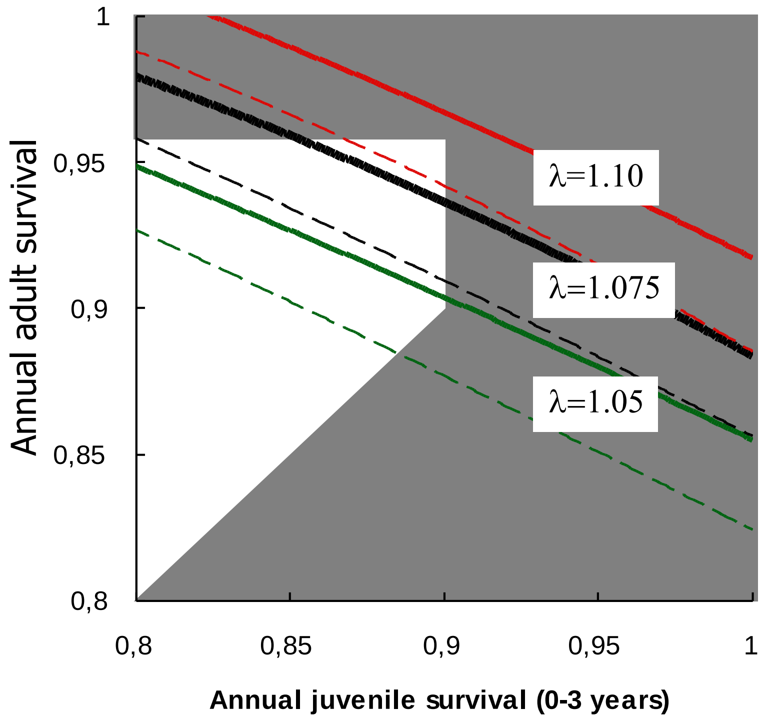

Figure 7. *Biological constraints delimit the maximum possible rate of increase in populations of grey and ringed seals. The shaded area denotes unlikely combinations of adult and juvenile survival rates. Any given point along the 6 lines shows a combination of adult survival and juvenile survival that produces a given growth rate (λ). The two uppermost lines are for λ = 1.10, the two lines in the middle for λ = 1.075, and the lowest two lines show combinations that result in λ = 1.05. The stippled lines show combinations of adult and juvenile survival rates given that the mean annual pupping rate is 0.95. The bold full lines show the possible combinations given that the pupping rate is 0.75.*

The upper limit of individual reproductive rate is reflected at the population level, and gives an upper theoretical limit for the population rate of increase (**Figure 6**). The mean values of fecundity and mortality will always be lower than the theoretical maximum rate of increase, also for populations which live under favourable conditions. Chance events such as failed fertilisation or early abortions reduce annual pregnancy rates, and in samples of reasonable sizes, mean pregnancy rates rarely reach 0.96 (Boulva and McLaren 1979, Bigg 1969, Härkönen and Heide-Jørgensen 1990). Another factor that will decrease mean pregnancy rates is senescence (Härkönen and Heide-Jørgensen 1990). Further, environmental factors will reduce fecundity and survival rates. The impact from extrinsic factors may occur with different frequency and amplitude. Environmental pollution and high burdens of parasites can decrease population-specific long-term averages of fecundity and survival (Bergman 1999), while epizootic outbreaks and excessive hunting have the capacity to drastically reduce population numbers on a more short-term basis (Dietz et al. 1989, Harding and Härkönen 1999, Härkönen et al. 2006). The type of variation in fecundity and survival rates will determine the structure of a population. In a population with a constant rate of increase (thus no temporal variability), the age- and sex-structure quickly reaches a stable distribution, where the frequencies of individuals at each age class are constant. Populations with low juvenile survival typically have steeper age distributions compared to populations with higher juvenile survival rates (Caswell 2001). We have shown the full span of theoretically possible combinations of vital rates at different population growth rates (**Figure 6**). It turns out that population growth rate of grey seals can only reach 10% if fertility rates are high (0.95).

Harbour seals mature about one year earlier than grey seals and ringed seals, which is why maximum rate of increase in this species is 12-13% per year (Härkönen et al. 2002).

Long term maximum growth rates in whales

Work carried out under the umbrella of the International Whaling Commission (IWC) have shown that that an appropriate dafault value for the realized annual maximum rate of increase for most whales is about 4% (Best 1992). Similar values have also been estimated for harbour porpoises (Woodley and Read 1991).

Empirical evidence

With few exceptions, most populations of seals have been severely depleated by hunting during the 20th century. Detailed historical hunting records for other pinnipeds are available for the Saimaa ringed seal Baltic ringed seal Baltic grey seal and the harbour seal in the Wadden Sea, Kattegat and the Skagerrak. Analyses of these hunting records documented collapses in all populations, which were depleted to about 5-10% of pristine abundances before protective measures were taken. After hunting was banned and protected areas were designated most populations started to increase exponentially.

Harbour seal populations outside the Baltic increased by about 12% per year between epizootics in 1988 and 2002, whereas all seal species in the Baltic showed lower increase compared with oceanic populations (**Table 5**).

Regression analyses of time series of abundance data can thus be used to test (ANOVA) if the observed rate of increase in exponentially growing populations deviates significantly from expected values.

Table 5. *Rates of increase in seal populations depleted by hunting. Grey seals from the UK, Norway, and Iceland are not included here since they have been consistently hunted over the years. Canadian grey seals have life history data similar to harbour seals.*

Species	Area	Annual growth rate	Period	Reference
Harbour seal	Skagerrak	+12%	1978-1987	Heide-Jorgensen & Härkönen (1988)
Harbour seal	Skagerrak	+12%	1989-2001	Härkönen et al. 2002
Harbour seal	Kattegat	+12%	1978-1987	Heide-Jorgensen & Härkönen (1988)
Harbour seal	Kattegat	+12%	1989-2001	Härkönen et al. 2002
Harbour seal	Baltic	+ 9%	1972-2010	Härkönen & Isakson 2011
Harbour seal	Wadden Sea	+12%	1980-1988	Reijnders et al. 1994
Harbour seal	Wadden Sea	+12%	1989-2001	Wadden Sea Portal

Grey seal	Baltic	+8.5%	1990-2002	Karlsson et al. 2009
Grey seal	Canada	+ 13%		Bowen et al 2005
Ringed seal	Baltic (BB)	+4.5%	1988-2011	Härkönen unpublished

Proposed GES boundaries

The proposed core indicator "Population trend" is appropriate for marine mammals when used in the OSPAR and ICES contexts. It is feasible in two scenarios of population growth: exponential rate of increase and when the population is close to carrying capacity. A depleted population can evaluated as obtaining GES, when its observed rate of increase doesn't deviate significantly from its intrinsic rate of increase (harbour porpoises 4%, grey and ringed seals 10%, and harbour seals 12%). When populations are close to their carrying capacities, populations obtain GES if the rate of decrease is less than 10% over a period of 10 years as stated in the OSPAR convention. Variances for these maximum estimates are available for all management units, and the statistical analyses can be performed using e.g. ANOVA tests. There is currently not a clear agreement whether the Baltic grey seal population has reached the carrying capacity or not.

Existing monitoring data

Information derived from national reports to HELCOM CORESET (*note that not all countries have reported their monitoring*)

Table 6. *Monitoring of marine mammal abundance.*

Country	**Area/Basin**	**Species**	**Method**	**Noted parameters**
Germany	Kiel Bay & Little Belt, Bay of Mecklenburg	subpopulation *Phocoena phocoena* western Baltic	line transect sampling	n individuals, n pups
Germany	Kiel Bay, Bay of Mecklenburg, Southern Baltic Proper	subpopulation *Phocoena phocoena* western Baltic	POD (Porpoise detectors = self-contained submersible data logger for cetacean echolocation clicks)	See method
Germany	Bay of Mecklenburg & Pomeranian Bay, internal lagoons	Harbour Seal	observation of potential haul-out sites; collection of accidental sightings	n individuals
Germany	Bay of Mecklenburg & Pomeranian Bay, internal lagoons	Grey Seal	observation of actual and potential haul-out or resting sites; collection of accidental sightings	n individuals
Lithuania	Southern Baltic proper			n individuals?
Sweden	Baltic Proper, Gulf of	Grey seal	Aerial, boat or land of grey seal	n individuals

	Bothnia		haulouts	
Finland	Gulf of Bothnia, Kvarken, Åland Sea, Archipelago Sea, Gulf of Finland	Grey seal	Aerial surveys of grey seal haulouts during the molting season in spring	n individuals
Finland	Archipelago Sea	Grey seal	Aerial surveys of grey seal pupping islands during the breeding season in early spring	n individuals, n pups
Finland	Archipelago Sea, Gulf of Bothnia	Baltic ringed seal	Aerial surveys of ringed seals during the molting season in spring	n individuals
Finland	Gulf of Bothnia, and the Quark	Baltic ringed seal	Aerial surveys of ringed seals during the molting season in spring	n individuals
Sweden	Gulf of Bothnia and the Quark	Baltic ringed seal	Aerial surveys of ringed seals during the molting season in spring	n individuals
Sweden	Kalmarsund	Baltic harbour seal	Aerial surveys during moult	n individuals
Sweden	Kalmarsund	Baltic harbour seal	Landbased pup counts in June and July	n pups
Sweden/Denmark	Southern Baltic and the Kattegat	Harbour seal	Aerial surveys during moult	n individuals

Sampling

Monitoring of marine mammal abundance require methods tailored for the different species. Whales and porpoises have usually been surveyed using ship based line transect methodology, where a certain proportion of the sea surface is covered during favourable weather conditions. Large-scale surveys such as SCANS have monitored the abundance of whales in the entire North Sea and adjacent waters (Hammond et al. 2002). This method is appropriate in areas where whale abundance is relatively high, but gives very wide confidence limits in low abundance areas such as the Baltic. The cost in man hours is also very high which is why such surveys only have been repeated about once a decade.

Alternative methods in low density areas include submerged hydrophonic devices that record sounds produced by whales. Such devices have been used in the Southern Baltic and an on-going project is deploying sonic equipment elsewhere in the Baltic. This method provides information on the distribution of porpoises but still needs to be evaluated for abundance estimates.

Ringed seals are monitored annually in the Bothnian Bay using strip sensus methodology (Härkönen et al. 1998), where more than 13% of the sea ice is covered during peak moulting season in the end of April (20th of April to the 1st of May) each year. Such surveys have been conducted since 1988 in the Bothnian Bay, whereas the southern populations in the Archipelago Sea, the Gulf of Finland and the Gulf of Riga and Estonian coastal waters only can be surveyed with this method when ice cover is permitting. Land based surveys of hauled out ringed seals provide complementary information from the Gulf of Finland.

Harbour seals in the Kalmarsund, southern Baltic and the Kattegat are surveyed during the peak moulting season in the latter half of August each year. All seal sites are photographed and seals are later counted on the photos. All seal sites are surveyed three times each season, and the mean number hauled out in the two highest counts are used for abundance estimates and trend analyses (Teilmann et al. 2010). Surveys are coordinated between Sweden and Denmark.

Grey seals are surveyed in a similar way as harbour seals, where all haul-out sites of seals are photographed and where seals are counted on the photos retrospectively. Surveys are conducted during peak haul-out season in the last week of May and the first week of June. Flights are coordinated among teams from Estonia, Finland and Sweden.

Methodology of data analyses

All methods except for the sonic method used for harbour porpoises give data on relative abundance since some seals always are submerged. However, since the surveys are standardized, a similar proportion of the seals can be expected to haul out during surveys among years. Consequently, estimates of relative abundance can be used for trend analyses, and the growth rate of populations can be estimated with good precision (Teilmann et al. 2010). Using capture/recapture methodology photo-id studies or branded or tagged animals can be used to estimate total abundance.

Sub populations are treated separately in the analyses where abundance and trend estimates are given for the following management units:

- Ringed seal: The Bothnian Bay including the North Quark, the Archipelago Sea, the Gulf of Finland, Estonian coastal waters including the Gulf of Riga.
- Harbour seal: Kalmarsund, the Southern Baltic, and the Kattegat.
- Grey seal: The entire Baltic.

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