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Marine Mammals

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1. Introduction

Aerial photo of harbour seals on a sand bank (Photo: Sophie Brasseur).

Marine mammals regarded as indigenous species in the Wadden Sea are the harbour (or common) seal *Phoca vitulina*, grey seal *Halichoerus grypus*, and harbour porpoise *Phocoena phocoena*. Several other marine mammal species, both pinnipeds and cetaceans, occur in the Wadden Sea and adjacent North Sea, either as stragglers or as regular visitors. Occasionally five other species of seals are encountered in the Wadden Sea area and adjacent North Sea. These are: harp seal *Phoca groenlandica*, hooded seal *Cystophora cristata*, ringed seal *Phoca hispida*, bearded seal *Erignathus barbatus* and walrus *Odobenus rosmarus*, all of which have a more northerly distribution. Cetaceans documented along the Wadden Sea coast are the white-beaked dolphin *Lagenorhynchus albirostris*, and white-sided dolphin *Lagenorhynchus acutus*. The occurrence (both living and dead) of large cetaceans in the Wadden Sea region since the QSR 2004, notably minke whales *Balaenoptera acutorostrata* and humpback whales *Megaptera novaeangliae*, is remarkable.

This chapter provides an update of the QSR 2004. Therefore it refers only to deviations from trends set out in the QSR 2004 and new information is provided. Issues of concern are given in the context of the Targets set for the harbour and grey seal, and the harbour porpoise in the Wadden Sea Plan as well as in the Seal Management Plans (SMP 1992, 1996, 2002, and 2007). These Targets are:

Viable stocks and a natural reproduction capacity of common/harbour seal, grey seal and harbour porpoise in the tidal areas and the offshore zone.

The present management of the species mentioned in the Targets is laid down in the Seal Management Plan, 2007-2010 (SMP).

(www.waddensea-secretariat.org/management/SMP/seals.html#smp)

Findings of the QSR 2004

The results from the assessment of the Target in the QSR 2004 can be summarized as follows:

Viability

Two components of viability analysis, genetic criteria and risk of extinction, can be used to indicate the persistence of a given population.

The size of the Wadden Sea harbour seal population is far beyond the threshold for inbreeding (5,000 to avoid inbreeding in the long term) and the numbers can therefore be regarded as viable.

It is safe to assume that with the PDV properties as operative in the area during the last epizootic, there is no significant risk of quasi-extinction of the harbour seal population in the Wadden Sea.

The grey seal situation is more complex. Data on life history parameters such as reproductive

performance as well as survival in the colonies is lacking. Therefore, no conclusions can be drawn about the self-supporting capacity of these grey seal colonies.

There has never been a harbour porpoise population in the Wadden Sea and numbers observed reflect the distribution of harbour porpoise population(s) in the adjacent North Sea. Data to evaluate the Target for this species is lacking.

Natural reproduction capacity

No quantification can be given for the natural reproduction capacity of either the harbour seal, grey seal or harbour porpoise, because of insufficient knowledge of this parameter. Based on the data obtained for harbour seal populations in the Wadden Sea and the population in the Kattegat-Skagerrak, it is concluded that the reproduction capacity of the Wadden Sea population is at a satisfactory level.

Grey seals on the "Razende Bol" (Photo: Henk van Wijk).

2. Status

2.1 Grey seals

Following a long term decline since the Neolithic, grey seals became extinct in the Wadden Sea and along the Dutch North Sea coast by about 1500 AD (Reijnders *et al.*, 1995). Up until the mid-19th century, only occasional animals were reported on the Dutch, German and Danish North Sea coasts (Mohr, 1952, van Haaften, 1974). No regular pupping occurred until the end of the 1970s when a breeding colony was established near Amrum in the German Wadden Sea. Somewhat later, additional breeding sites were discovered near Terschelling/Vlieland in the Dutch Wadden Sea (1980) and at Helgoland (Reijnders and Brasseur, 2003, Härkönen *et al.*, 2007). Tracking of movements indicate these seal groups to be linked to larger populations in the UK. However, genetic studies are needed to ascertain population structure and determine the relationships between the populations of mainland Europe and the UK. Interestingly, the timing of both pupping (December/January) and moult (March/April) differ substantially between mainland Europe and the UK. Maximum numbers of grey seals counted during the moult in 2008 in the Wadden Sea are 1716 in the Dutch Wadden Sea, 174 in the Niedersachsen part of the Wadden Sea, 98 in the Schleswig-Holstein Wadden Sea, and 206 at Helgoland, amounting to a total of 2194 animals. The respective figures for the 2009 moult counts are 2108 in The Netherlands, 200 in Niedersachsen, 138 in Schleswig-Holstein, and 310 on Helgoland, bringing the total to 2756. This represents an increase of 26% in this last year. Grey seals are not specifically monitored in Denmark, but they are regularly seen in low numbers during harbour seal counts. The development in maximum numbers of grey seals counted in the last decades in the Wadden Sea is given in Figure 1.

Relative strongholds for breeding in the Wadden Sea are the western Dutch Wadden Sea, the Kachelotplate and Amrum in the German Wadden Sea, and Helgoland (German Bight). During counts in the pupping season of 2007/2008, 196 pups were recorded in the entire Wadden Sea: 107 in the Dutch Wadden Sea, 25 at the Kachelotplate, 12 pups off Amrum, and 52 pups at Helgoland. The corresponding figures for the season 2008/2009 are respectively 272, 29, 16, and 70, amounting to a total of 387 pups, which is about twice as much as the year before.

It is noted though that, increasingly, more grey seals are observed in other areas. This is particularly so in the eastern Dutch Wadden Sea and the western part of the German Wadden Sea. In the Netherlands, monitoring is therefore being extended to the probable new areas from 2009 onwards.

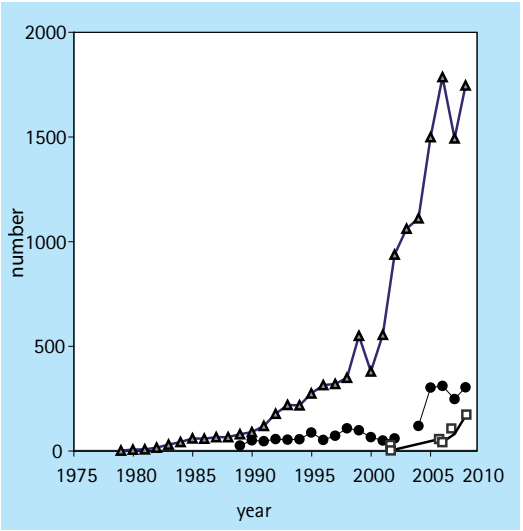

Figure 1: Counts of grey seals in the Wadden Sea during the moult (March/April). ▲ The Netherlands (source: IMARES); ● Schleswig-Holstein and Helgoland (source: National Park Schleswig-Holsteinisches Wattenmeer; □ Niedersachsen (source: Nationalpark Niedersächsisches Wattenmeer).

2.2 Harbour seals

Counts of harbour seals during the moult (August) are used to compare population changes over the years. In 2002, a second PDV-epizootic struck the population and in 2003 only 47% of the expected number of seals was counted: 10,800 animals. Interestingly, the average pup to total ratio in the period 2003-2009 is 27.1% (SD = 3.12), which is much higher than the 21.6% counted following the former epizootic. The surveys for 2003-2009 show that the numbers counted each year increased on average by 12.3% per year, demonstrating a prosperous recovery. Indeed, in 2009 the population counts revealed a total of 21,571 animals. This is clearly above its pre-2002epizootic level of 19,383 animals (Brasseur *et al.*, 2008, 2009). The pup percentage, presently still high, may indicate that the age structure of the population has not yet returned to stable proportions and could still be dominated by adult females. The recruit of young that were born after the epizootic will gradually lessen that influence. The changes in numbers of harbour seals counted in the Wadden Sea are given in Figure 2.

2.3 Harbour porpoise

For the period 2005-2009 five sources are available on harbour porpoise abundance in the Wadden Sea region and adjacent North Sea: the SCANS II North Sea wide cetacean survey in 2005 (SCANS II 2006, SMRU 2008), data from the German MINOS and MINOS+ project (Wollny-Goerke and Eskildsen, 2008; Gilles et al., 2008), a monitoring program in Niedersachsen (Gilles and Siebert, 2008), the

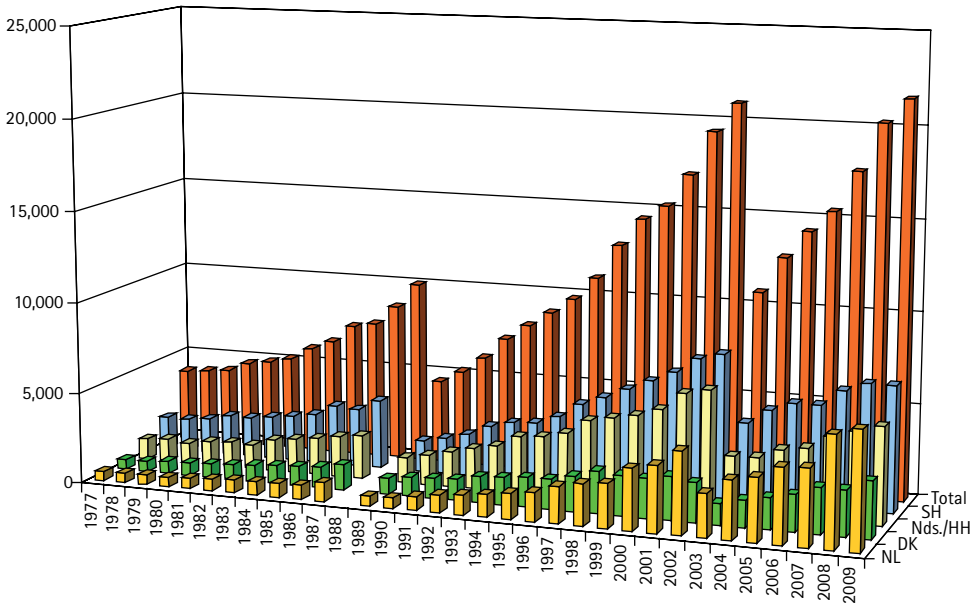

Figure 2: Number of counted harbour seals in the Wadden Sea since 1975; NL = The Netherlands, DK = Denmark, NdS/HH = Niedersachsen and Hamburg, SH = Schleswig-Holstein, Total = entire Wadden Sea

BEMLV project (Scheidat *et al.*, 2006), data from aerial surveys carried out by NERI (Teilmann *et al.*, 2008), and the sea watching data set of the Nederlandse Zeevogelgroep (see Haelters and Camphuysen, 2008).

The SCANS II data showed no difference in the total (North Sea) abundance of porpoises compared to the SCANS I (1994) data. However, in survey blocks north of 56°N the average density was about half of its level in1994, whereas for the survey blocks south of 56°N, the density was twice the one estimated in 1994 (SCANS II, 2006).

Data from Scheidat *et al.* (2006) and Gilles *et al.* (2008) reveal the highest densities in the German North Sea EEZ, in May 2005, when abundance was estimated at 64,506 animals (95% CI = 36,776-127,036) and in summer 2006, with an estimated 51,551 animals (95% CI = 27,879-98,910). Lowest estimates were obtained in autumn 2005 (e.g. 11,573 animals in October/November).

The Gilles *et al.* (2008) data further showed that the spatial distribution is not homogeneous, but animals have clear preferences for discrete areas. Hotspots were detected at Borkum Reef Ground and Sylt Outer Reef. Similarly, the Danish monitoring data showed that the highest densities were

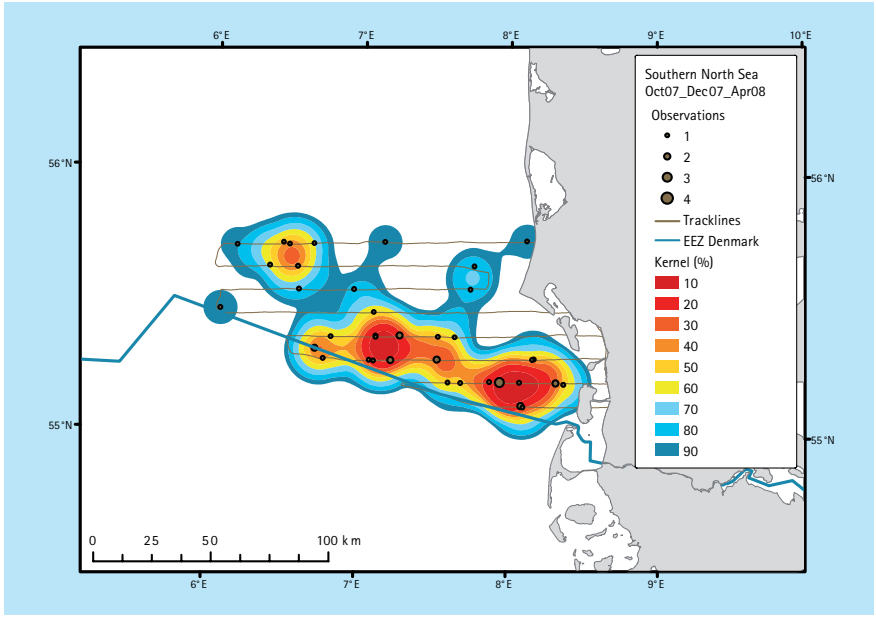

Figure 3: Combined data from three aerial surveys in October, December, 2007 and April 2008 with observations and kernel density contours. The color scale from blue over yellow to red shows increasing concentration of harbour porpoises.

found in the southern part of the Danish North Sea along the German border (Figure 3). Hotspots were also identified here, with one close to the Danish Wadden Sea (Teilmann *et al.*, 2008). The Danish data also showed a strong seasonality in sightings, with maxima in the summer period (Figure 4).

The Dutch sea watching data set demonstrates that the increase in harbour porpoise sightings in Dutch coastal waters mentioned in Reijnders *et al.* (2005) continued. A maximum sighting rate (sightings per hour) was obtained in 2006, thereafter it decreased spectacularly in 2007 (Figure 5) and continued in 2008 (C. Camphuysen, pers. comm.). There is a distinct spring peak in the sightings, with a slight decrease in June followed by a higher level from July onwards (Haelters and Camphuysen, 2008).

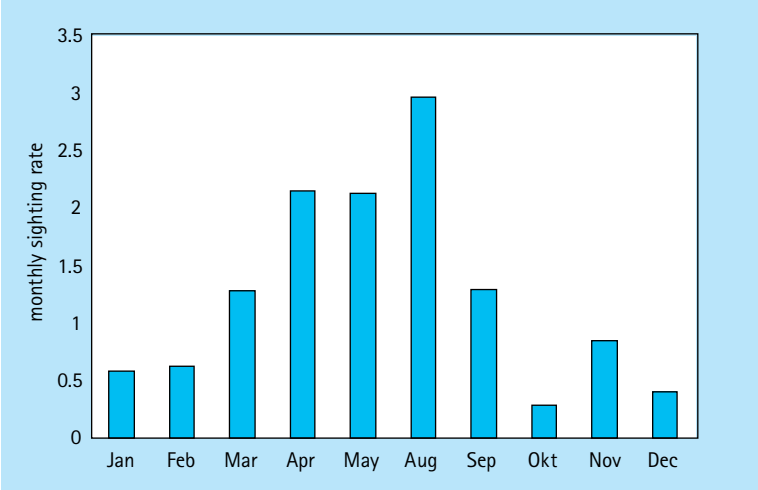

Figure 4: Monthly sighting rate from aerial surveys in the Danish Southern North Sea. Note that June-July is missing from the plot since no surveys were conducted in these months (after Teilmann et al., 2008).

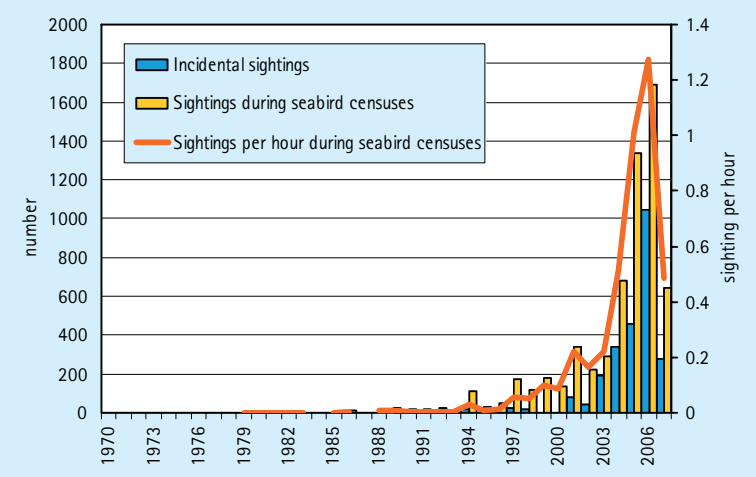

Figure 5: Sightings of harbour porpoises in Dutch coastal waters (coastal observations only), including systematic sightings from seawatchers (number of animals reported, yellow, left y-axis), effort corrected sightings from seawatchers (animals hour^{-1}, orange line, right y-axis) and incidental sightings reported by others (number of animals reported, blue).

3. Factors influencing the status

3.1 Infectious diseases

The health status of seals in the countries bordering the Wadden Sea was monitored through examination of live and dead individuals. Post mortem examinations, including histology, immuno-histochemistry, microbiology, serology and parasitology have been performed since the first epizootic in 1988. Most pathological findings concentrate around the respiratory and alimentary tracts and these findings are compared for three periods: pre-1988, between the epizootics in 1988 and 2002, and 2002-2005.

With respect to parasites in harbour seals, both lungworm infestation and intestinal parasitation were higher between the two epizootics and after 2002, compared to pre-1988. Lower acantocephalan (intestine parasites) and heartworm were also found (Lehnert *et al.*, 2007; Siebert *et al.*, 2007). Bronchopneumonia, gastritis and enteritis all increased after the 2002 epidemic, compared to 1988-2002, but this may have been influenced by the 2002 Phocine Distemper Virus epizootic (Lehnert *et al.*, 2007; Siebert *et al.*, 2007). Bronchopneumonia due to parasitic and/or bacterial infections was the most common cause of death during 1988-2002 and onwards. Septicaemia became the most frequent cause of death or most severe health impact after the second seal die-off (Siebert *et al.*, 2007). Bacteria most frequently causing bronchopneumonia, gastroenteritis, polyarthritis, dermatitis, hepatitis, pyelonephritis, myocarditis and septicaemia in harbour seals and harbour porpoises were isolated and comprised α/β-haemolytic streptococci *Escherichia coli*, *Clostridium perfringens, Erysipelothrix rhusiopathiae, Staphylococcus aureus* and *Brucella maris* (Siebert *et al.*, 2007; Prenger-Berninghoff *et al.*, 2008; Siebert *et al.*, 2009).

A comparison of bacteriological findings in harbour porpoises from different regions of the North Atlantic revealed that organs from animals originating from Greenlandic and Icelandic waters showed clearly less bacterial growth and fewer associated pathological lesions than animals from the German North and Baltic Sea and Norwegian waters (Siebert *et al.*, 2009).

No case of morbillivirus was reported after 2002. But a recent outbreak of a disease, leading to increased mortality of harbour seals in Europe, began in 2007. As in 1988 and 2002, it started on the small Danish island of Anholt and spread to other major seal colonies in the Kattegat and Skagerrak over the next months (Härkönen *et al.*, 2008). Clinical signs of diseased seals and gross pathological findings were similar to those observed in 1988 and 2002. Clinical observations included a dorsally misshaped silhouette with intermittent hump formation in the shoulder region, and restricted movement. In the final stage, animals showed respiratory distress and hemoptysis (Härkönen *et al.*, 2008). Preliminary histopathological findings of four seals displayed multifocal acute catarrhal bronchitis, chronic interstitial pneumonia, severe atelectasis, moderate follicular hyperplasia and acute lymphocytolysis. It was suggested that an unknown virus was most likely the pathogen causing the epidemic. As harbour porpoises showed similar pathological findings, a cross-species infection could not be ruled out (Härkönen *et al.*, 2008).

In conclusion, changes in the prevalence of parasitic and bacterial infections have occurred. But the general health status of harbour seals in the Wadden Sea appears to have improved compared with earlier decades. In particular the health of pups (0-6 months old) has improved after 2002 (Siebert *et al.*, 2007). However, the increasing prevalence of lung and intestinal parasites warrant the continued monitoring of the health status of seals.

3.2 Disturbance

Wind farms

Offshore wind farms may affect marine mammals in different ways: through noise related to construction and operation, and through the physical presence of wind turbines, the shipping of material and people during construction and maintenance. Much of the research into possible effects of offshore wind farms on marine mammals in the south-eastern North Sea has until now been focused on seasonal distribution patterns of seals and porpoises to identify preferred areas and investigate possible spatial overlap with planned offshore wind farms (Brasseur *et al.*, 2004; Wollny-Goerke and Eskildsen, 2008; Teilmann *et al.*, 2008). The only extensive studies on the construction and operation of offshore wind farms hitherto are studies in Danish waters: the Horns Rev area in the Danish North Sea, and Nysted in the Danish Baltic Sea (Teilmann *et al.*, 2006; Carstensen *et al.*, 2006). The results of many of the Dutch studies are expected in 2009 and 2010.

This chapter restricts our assessment to the Horns Rev study, of an area approximately 20 km northwest of the Danish Wadden Sea (Tougaard *et al.*, 2006 a, b).

Porpoises' habitat use before, during and after construction of the wind farm was studied

by ship-based surveys and by passive acoustic monitoring. The conclusions were that there was a negative effect of the construction as a whole, but that strong reactions up to 15 km away were observed during pile driving operations. No significant effects were found during operation. Compared to the wind farm in the Baltic Sea, the effects on the porpoises were much weaker in the North Sea. Whether this difference is related to area characteristics or to differences in behaviour of the two populations is unknown. Caution should be used when extrapolating results between wind farms at different locations.

Harbour seals were provided with satellite transmitters to study how they used the area in and around the wind farm area before and after the construction of the wind farm itself. No statistically significant differences in habitat use were seen in the wind farm area and the reference area. However, this should not be interpreted as no influence. With the accuracy of the seal locations obtained via satellite, no detailed analysis of behaviour was possible. Studies should continue because more detailed data on seal and porpoise habitat use are becoming available and, simultaneously, techniques are being developed to model the acoustic underwater world and the possible changes induced by wind farm noise. These new methods enable both more accurate tracking of seal movements and other behaviour, assess the possible impact of noise from wind farms, and moreover provide better opportunities to study and apply mitigation measures.

Recreation

Recreational activities in the Wadden Sea and adjacent waters can adversely affect marine mammals there. Seals will be particularly affected because they use the coastal waters and sandbanks for whelping, feeding, moulting and resting. Serious disturbances can make certain areas unsuitable for seals and in the southern Netherlands this has even led to impairment of recovery of a depleted population (Brasseur and Reijnders, 2001). The detrimental impact of disturbance on seals was recognized by the responsible management authorities and protected areas were established in all Wadden Sea areas in the mid-1980s. This concern is explicitly addressed in the Seal Agreement - concluded between Denmark, Germany and The Netherlands in 1991 (under the Bonn Convention) - and obliges the signatories to create a network of protected areas to "ensure the preservation of all areas essential to the maintenance of the vital biological functions of seals". Momentarily, almost all of the haul-out sites are protected from disturbance during the summer. That is beneficial for harbour seals, but does not cover the demands of grey seal which have their pups, breed and moult in winter/early spring. It is envisaged that this caveat may be adequately addressed when the proposed Natura 2000 Network is designated. One concern though is the increasing, unregulated "seal watching" industry. This is not yet adequately addressed at a trilateral level, and is indicated as a priority action in the current Seal Management Plan. The way the issue has been tackled in Schleswig-Holstein may form a template for the whole Wadden Sea. A combination of protection zones, restrictive shipping regulations and voluntary agreements with shipowners conducting seal watching tours seems to be a promising tool to make seal watching tours ecologically acceptable.

Noise

Marine mammals evolved in a diverse natural sound environment and their hearing sensitivity is well adapted to signals that are biologically significant to them. Pinnipeds and cetaceans produce and receive sound over a great range of frequencies for use in communication, predator avoidance and to interact with their environment. Some toothed whale (odontocete) species have the capability to use echolocation for foraging and orientation in their underwater environment (Tyack and Clark, 2000). For these species, sound is the most important sensory modality, and they rely on hearing for survival.

As far as is known, the three marine mammal species resident in the Wadden Sea area all share the sophisticated and very acute sense of hearing of marine mammals.

Sound in general can have diverse negative effects on marine mammals. It can cause acute or chronic stress (Fair and Becker, 2000); it may impede the perception of other biologically meaningful sounds ("masking") (Richardson *et al.*, 1995; NRC, 2003; Janik, 2005; Madsen *et al.*, 2006); it can trigger behavioral reactions (NRC, 2005; Southall *et al.*, 2007; Nowacek *et al.*, 2007); and even lead to direct physiological or physical impairment and injury (Ketten *et al.*, 1993; Finneran *et al.*, 2002; Kastak *et al.*, 2008). Most of these processes are still poorly understood in marine mammals.

Based on the available information of the sound emissions from pile driving and other intense sound sources on the one hand, and known effects of intense sound on terrestrial as well as

some marine mammals on the other hand, it can be hypothesized that both seal species as well as harbour porpoises will be able to perceive these anthropogenic sound emissions and are likely to be impacted by them to varying degrees.

So far, the only available data on behavioural reactions in harbour porpoises to impulsive sound have come from visual and acoustic (T-POD) observations during the construction of wind turbines at Horns Rev, Denmark, where a significant effect on the presence and swimming behaviour was observed at a distance of up to 15 km from the sound source (Tougaard *et al.*, 2003). In the BROMMAD study (Gordon *et al.*, 2000), by contrast, no obvious behavioural reactions were observed in free-ranging harbour porpoises in response to airgun exposures.

Recent studies have shed some light on other sound-induced effects, namely masking and the acoustic tolerance of harbour porpoises to impulsive sound. Results from a dedicated study showed that the operational sound emitted by a 2 MW wind turbine would only mask the acoustic perception of harbour porpoises at close ranges (Lucke *et al.*, 2007). In another study, intense impulsive sounds were tested for their potential auditory effect in a harbour porpoise (Lucke *et al.*, 2008). The animal's auditory tolerance was tested by systematically increasing the received levels of an intense sound stimulus (an airgun impulse). At a sound pressure level of above 200 dB re 1µPa and a sound energy of 164 dB re 1µPa^2·s the animal's hearing threshold shifted temporarily, thus providing the first scientific basis for a noise exposure criterion for this species. Future studies might shed light on the effect this type of pollution might have at the population level of the different marine mammal species.

Taking

"Taking" is defined here as the removal of living seals from the natural environment to check the health condition of the animal. The decision is then taken to either (1) release the animal in its environment; (2) to euthanize it; or (3) to try to rehabilitate the animal and subsequently release it into the wild. Most often "taking" relates to seal pups found without mothers, or to weak or sick seals.

It is clearly stated in the Seal Management Plan (1991-1995), pursuant to the Seal Agreement (concluded in 1991), that taking of seals is prohibited. This was later on further defined and explicitly declared in the so-called Leeuwarden Declaration (LD § 60) by the Trilateral Management Authorities at their 7th Trilateral Ministerial Conference (CWSS, 1994). They agreed "to reduce the taking of seals to the lowest level possible". These decisions were made because 1) taking was not necessary any more to maintain the harbour seal popula-

Table 1: Estimated percentage of born harbour and grey seals that were taken alive from the Wadden Sea in 2000–2005, excluding 2002

Country / species	NL Harbour seal	Nds Harbour seal	SH Harbour seal	DK Harbour seal	Total Harbour seal	NL Grey seal
%	16.2	5.9	5.8	5.1	7.7	44.9

Table 2: Percentages and numbers of seals rehabilitated at seal stations in the period 2000–2005 excluding 2002, and number of released seals.

Country / species	NL Harbour seal	Nds Harbour seal	SH Harbour seal	DK Harbour seal	NL Grey seal	Other areas Grey seal
% rehabilitation	99.9	82.3	30.3*	0	99.7	62.1
n	792	429	702	110	592	58
% released	92.0	86.7	88.3	0	97.1	100.0
n	791	353	213	0	590	36

* 2003 – 2007: 40 – 46 % (Borchardt, unpublished)

Table 3: Percentage of harbour and grey seals in the Wadden Sea that have been in human care between 2000 – 2005, excluding 2002

Country / species	NL Harbour seal	Nds Harbour seal	SH Harbour seal	DK Harbour seal	Total Harbour seal	NL Grey seal
%	14.9	4.2	1.5*	0	4.6	43.5

* 2.7 % in 2003 – 2007 (Borchardt, unpublished)

tion, because by then the population was in a good state and large enough to be considered as not vulnerable anymore; 2) taking can have negative effects on the wild population, namely interfering with natural selection and population regulation; and 3) released animals can carry exotic pathogens to the wild population so that diseases suppressed by medical treatment in the seal station can harm the wild population.

Abt (unpublished manuscript, 2006) has analyzed the data about seal taking from Denmark (DK), Schleswig-Holstein (SH), Niedersachsen (Nds) and the Netherlands (NL) in the years, 2000-2005. The vast majority of seals taken are pups. To calculate the level of taking, the number of taken animals was related to the number of newborn seals in each year. The year 2002 was excluded, because this year was atypical due to the second Phocine Distemper Virus outbreak.

Among the seal pups taken, authorised seal stations try to rehabilitate only a certain percentage. Those percentages are given in Table 2.

From the percentages of seals taken, accepted for rehabilitation and released, it is possible to calculate the percentage of animals in the wild which have been in human care.

Table 3 shows that in Denmark no seals are rehabilitated and released, and seals are taken and released on a relative low level in Schleswig-Holstein and Niedersachsen. In the Netherlands the level of taking is relatively high for harbour seals, and strikingly high for grey seals: nearly every second grey seal has spent some time in a seal station.

Despite the declarations of the trilateral official authorities and repeated statements in successive Seal Management Plans aiming to reduce taking to a low level, this management goal is not being achieved equally in the different Wadden Sea regions. It is being fulfilled in Denmark and Germany, but not in The Netherlands. The high proportion of seals passing through the Dutch seal stations might have negative impacts, especially on the health of grey seals. Basically there are two extremes in seal management: while the focus in Denmark is on the wild population, in The Netherlands it is in practice focused on the individual seal. The latter is contradictory to the general trilateral objective and the agreed Target: to guarantee the natural functioning of the ecosystem.

The population can only achieve a good health status if natural selection processes can occur. From a biological and wildlife management point of view, human activities should not interfere with these basic processes. Even if animal welfare is considered, human handling of seals should be restricted to a low level.

Bycatch

Bycatch or accidental drowning is considered the most serious threat to harbour porpoises in the North Sea (Vinther and Larsen, 2004; EC, 2004; ASCOBANS, 2000; Reijnders *et al.*, 2009). The European Commission tried to address this by issuing Council Regulation 812/2004, aiming at preventing bycatch through the mandatory use of pingers in certain fisheries, and assessing the extent of bycatch through observer schemes. However, fishing boats of less than 12 m (15 m for observer schemes) are exempt and recreational set net fisheries with trammel/tangle/gill nets presumably continue to catch porpoises (Haelters and Camphuysen, 2009). Bycatch also occurs in coastal waters close to the Wadden Sea (e.g. Siebert *et al.*, 2006, Haelters and Camphuysen, 2009). From early November 2008 till mid-March 2009, a total of 167 dead harbour porpoises were found on the Dutch coast and at least 60 of them were mutilated (Camphuysen and Oosterbaan, 2009). The majority of mutilated porpoises were found around the islands of Texel and Vlieland. The injuries point to these mutilated animals being bycaught (Camphuysen and Oosterbaan, 2009).

Regrettably data are lacking on the actual level of bycatch as well as the sort of fisheries' activities involved. This latter includes the types of fishery, the intensity of activity, the spatial distribution and seasonality. We concur with the generally accepted view that this problem needs to be urgently addressed, for instance as described in Camphuysen *et al.* (2008), Haelters and Camphuysen (2009), and Reijnders *et al.* (2009).

Though probably of a much lower scale, drowning of seals in fyke nets is a known phenomenon. The extent is unclear. In The Netherlands, fyke net fishermen are obliged to put a guard net in front of the fyke to prevent seals entering (Reijnders *et al.*, 2005). This may be an approach worth using in other areas of the Wadden Sea.

4. Conclusions

4.1 Scientific assessment – Issues of concern

Grey seals

The number of grey seals observed in the Wadden Sea area has continued to increase since the last QSR (2004). The earlier concern about the lack of effective protection of their breeding and moulting grounds (especially in The Netherlands) has been largely addressed. The waters north of the Dutch Frisian Islands, encompassing grey seal breeding, moulting and resting sandbanks, have been designated as part of the Natura 2000 network and implementation into national law follows. A remaining concern is the lack of knowledge about some basic aspects of the biology of the grey seal in the Wadden Sea and adjacent North Sea. Knowledge on actual numbers using the area is lacking, and the same holds for numbers of pups born, population structure within the Wadden Sea and genetic relationship with other populations elsewhere in the North Sea. This lack of knowledge prevents the design of a management plan tailored to this species.

Harbour seals

The harbour seal population has prosperously recovered from the last virus epizootic in 2002. Given the observed continued population growth, the question arises as to when the population may reach the carrying capacity of the area. This is an important issue, because when approaching that limit, biological regulating processes will occur. These include lowered reproduction and survival rates, resulting in decreased or stagnating growth, and increasing prevalence of parasites and diseases. This should not be interpreted as a population being in distress but simply a natural regulation process.

Harbour porpoises

A major issue of concern is the growing offshore wind farm industry. Many plans are presented to build wind farms in coastal waters, including some close to the Wadden Sea Conservation Area. This is a potential threat to harbour porpoises and detailed knowledge of distribution, abundance and specific habitat use is necessary to assess the situation. These data are largely missing for the coastal waters north of the western/middle part of the Wadden Sea and it is questionable whether the valuable monitoring of the waters west of the northern and eastern Wadden Sea will be prolonged. These kinds of data are also essential to assess bycatch, the other issue of concern. Next to numbers of animals bycaught, the population structure and the size of the stocks/populations from which these animals are removed needs to be known to assess whether this removal is sustainable.

Another specific issue of concern is the recent bycatch of porpoises along the western Dutch Wadden Sea. Despite the lack of information on how the actual level of bycatch affects sustainability, the frequency of strandings and mutilations are exceptional and unprecedented for this area. It therefore needs to be addressed with high priority.

4.2 General issues of concern

Impact of disturbance, whether exerted through recreational activities (including "seal watching") or noise (e.g. wind farms, shipping, seismic explorations, and military sonar) on marine mammals is hitherto less well studied. Given the increasing use of the Wadden Sea and adjacent North Sea for both professional and recreational use, we consider it relevant to include these aspects in future studies (see section on recommendations for research). Insight into the cumulative effects of the various factors at work is lacking and especially needed. Taking of seals, especially in The Netherlands, is a continuing serious concern. The level of taking, especially grey seals in The Netherlands, is so high that one may question whether the population can still be regarded a natural wild population. This is not only a matter of concern from a wildlife biological point of view, but also raises the question of whether such a level of human handling of wild animals is acceptable from an animal welfare perspective, let alone its undermining of a joint trilaterally agreed policy.

5. Target assessment

5.1 Viability

Viability can be defined as the survival of a population in a state that maintains its vigour and its potential for evolutionary adaptation (Soulé, 1987; Mills, 2008; Sinclair *et al.*, 2006). It is generally agreed that there is no single value that can be globally applied in all situations. Two components of viability analysis may serve to indicate the persistence of a given population: genetic criteria and risk of extinction. From an inbreeding point of view, the short term minimum size of a mammal population with life history parameters such as the harbour seal is considered to be 500 individuals. However, if a population should also be able to survive catastrophes – in other words retain evolutionary potential on the long term – the minimum size is estimated to be at least 5000 animals. The harbour seal population has only increased since the QSR 2004, validating the conclusions in that report that the size of the Wadden Sea harbour seal population is far beyond even the threshold of 5000 animals, and can be regarded as viable.

The situation with respect to the grey seal is still as complex as it was in 2004. Colonies have generally increased considerably, but data on life history parameters such as reproductive performance and survival in the colonies, is still lacking. Immigration from elsewhere is assumed to still have a prominent influence on the development of these colonies, but its extent is unknown. Therefore no conclusions can be drawn about the self-supporting capacity, in essence viability, of these grey seal colonies. The other criterion, risk of extinction, can only be addressed for harbour seals, as data for grey seals is lacking.

For the harbour porpoise population in the Wadden Sea, actual numbers observed probably reflect the distribution of harbour porpoise population(s) or stocks in the adjacent North Sea, rather than a resident Wadden Sea population. Data to evaluate the Target for this species is lacking.

3.2 Natural reproduction capacity

No quantification can be given for the natural reproduction capacity of either the harbour seal, grey seal or harbour porpoise, because of insufficient knowledge of this parameter. It is possible to provide a qualitative indication on the reproductive status of the harbour seal. Though no data is available on a straightforward measure such as fertility amongst the females in the population, comparison of growth rate, expressed as per capita birth rate and death rate in this population with similar data from harbour seal populations elsewhere may provide some insight. Based on the data obtained for the Wadden Sea harbour seal population (Reijnders *et al.*, 1997; Abt, 2002; Reijnders and Brasseur, 2003; Brasseur *et al.*, 2008) and the population in the Kattegat-Skagerrak (Härkönen *et al.*, 2002), it is concluded that the reproduction capacity of the Wadden Sea harbour seal population is at a satisfactory level.

5.3 Summary of the Target evaluation:

The population of harbour seals in the Wadden Sea can be considered viable with a satisfactory reproduction capacity.

The Target regarding grey seal and harbour porpoise cannot be evaluated due to insufficient population data.

6. Recommendations

6.1 Recommendations for management

At the request of the responsible seal management authorities, the Trilateral Seal Expert Group designed an effective aerial survey scheme for harbour seals in the Wadden Sea to tune the Trilateral Seal Agreement and EU Habitats Directive requirements (Meesters *et al.*, 2009). It is recommended that the proposed annual monitoring scheme should be closely followed trilaterally and in particular that the proposed minimum survey frequency should be respected.

The taking of seals in some parts in the Wadden Sea is excessive and it is recommended that takes should be brought into line with the practice in Niedersachsen, Schleswig-Holstein and Denmark, according to the trilaterally agreed policy. For detailed management recommendations see the SMP 2007-2010.

6.2 Recommendations for research and monitoring

Lack of knowledge of grey seal biology in general and in particular knowledge of relationships between colonies in the Wadden Sea and other colonies in the North Sea, should be improved through dedicated research, including population biology and genetics.

It is recommended that monitoring of harbour and grey seal and harbour porpoise populations should be continued and in some cases initiated in order to track population developments and health in order to address the concerns expressed earlier in this chapter.

In addition, priority should also be given to promoting studies on habitat use of harbour seals, including feeding ecology, impact of wind farms on harbour and grey seals and harbour porpoises, and bycatch of porpoises. For details see e.g. the SMP 2007-2010.

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