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Agenda Item 4.4: Elaboration of a recovery plan for harbour porpoises in the North Sea

ASCOBANS Recovery Plan for Harbour Porpoise (Phocoena Phocoena) in the North Sea

Submitted by: Secretariat

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ASCOBANS Recovery Plan for Harbour Porpoise (*Phocoena phocoena* L.) in the North Sea

Draft working paper (4th version)

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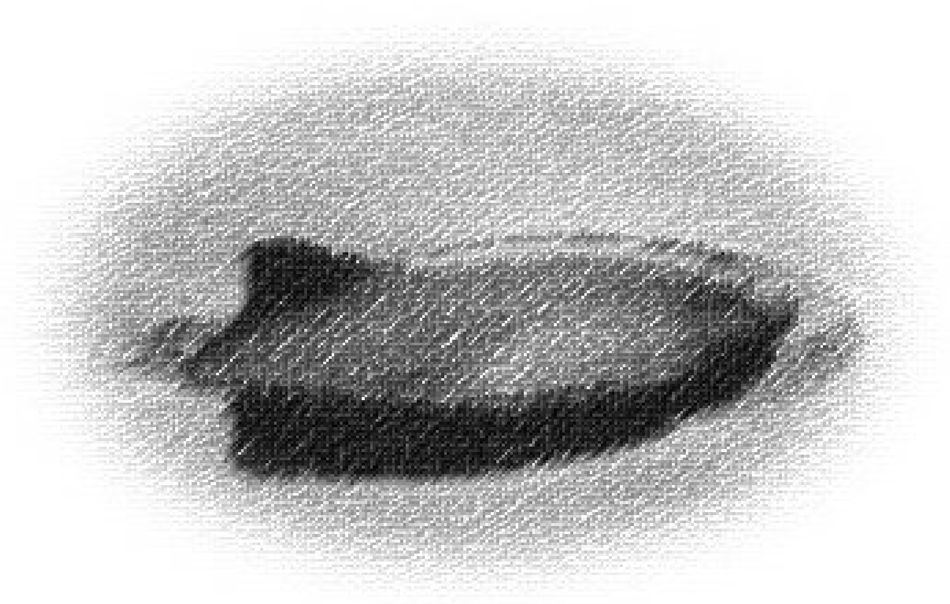

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1. Introduction

Harbour porpoises (*Phocoena phocoena*, Linnaeus 1758) are widely distributed in shelf waters of the temperate North Atlantic and North Pacific Oceans and in some semi-enclosed seas (e.g. Black and Baltic Seas). The small phocoenid is notably the most abundant species of cetacean in the North Sea (Hammond *et al*., 1995, 2002). In spite of relative high population estimates in some areas, concerns have been raised about adverse effects that incidental takes in various fisheries, elevated underwater noise due to seismic activity, high speed ferries, gravel mining, construction of wind farms etc. may have on habitat quality and on population size of many of the North Atlantic porpoise populations, including the populations of the North Sea and adjacent waters.

The harbour porpoise is listed in

- Annex II (Animal and plant species of community interest whose conservation requires the designation of special areas of conservation) and IV (Animal and plant species of community interest in need of strict protection) of the EC Habitats and Species Directive 1992 (92/43/EEC),
- Appendix II (species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled) of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES),
- Appendix II (Strictly protected fauna species) of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and in
- Appendix 2 of the Convention on Migratory Species (Bonn Convention).

It is covered by the terms of the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), a regional agreement under the Bonn Convention, is listed in the IUCN Red List of Threatened Species as *vulnerable* throughout their range and protected through various regional and national acts.

The 5th International Conference on the Protection of the North Sea (Bergen, Norway, 20 – 21 March 2002) called for a recovery plan for harbour porpoises in the North Sea to be developed and adopted (Paragraph 30, Bergen Declaration). The North Sea is defined as the body of water

a) southwards of latitude 62°N, and eastwards of longitude 5°W at the north west side;
b) northwards of latitude 57° 44.8'N from the northern most point of Denmark to the coast of Sweden; and

c) eastwards of longitude 5°W and northwards of latitude 48°30'N, at the south side (Figure 1).

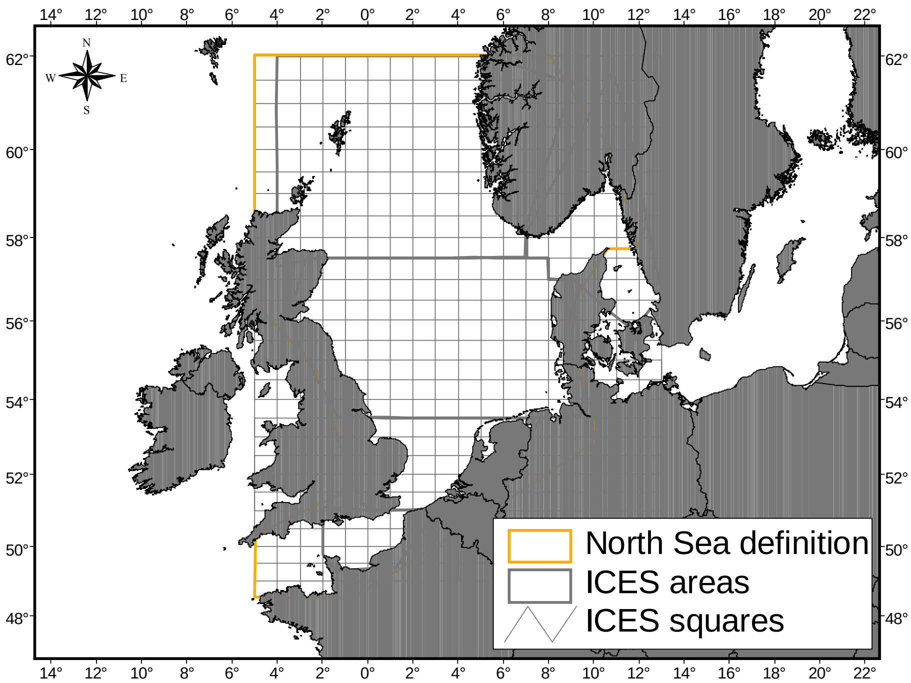

Figure 1: Map of the North Sea as defined at the 5th International Conference on the Protection of the North Sea in Bergen, Norway, 20 – 21 March 2002).

2. Distribution and population structure

The following definitions will be used: the term "population" will be applied only to reproductively isolated large scale groups of harbour porpoises, while both the terms "sub-population" and "stock" will be used to describe genetically or morphologically distinguishable but not completely isolated sub-units of a population in reproductive terms.

Confined to the Northern hemisphere, with a more or less circumpolar distribution in temperate regions (Gaskin, 1984), harbour porpoises generally inhabit coastal areas, and are typically found at depths of less than 200 metres (Carwardine, 2000); although they have been recorded in deeper waters (Reid *et al*., 2003).

In 1984, Gaskin identified 3 regional populations of harbour porpoise in the North Atlantic, North Pacific and Black Sea, and proposed 14 provisional sub-populations spread over the North

Atlantic, 4 in the West and 10 in the East Atlantic. The criteria he used included migratory patterns, geographic isolation by land mass, ice or sheer distance, habitat preferences and availability, and availability of prey items. In a later report by Donovan & Bjørge (1995), 3 sub-populations were distinguished with respect to the Northwest Atlantic, 7 in the Northeast Atlantic, and a separate population each in the Baltic Sea, Black Sea, in West Greenland, and Northwest Africa.

Various studies using allozyme frequencies and microsatellite DNA (Andersen, 1993; Andersen *et al*., 2001), mitochondrial DNA (Walton, 1997; Wang & Berggren, 1997; Tolley *et al*., 1999; Tiedemann & Boysen, 2000) or morphometric techniques (Børjesson & Berggren, 1997; Huggenberger *et al*., 2000 and 2002), as well as contaminant levels (Berggren *et al*., 1999) and tooth ultra-structure (Lockyer, 1999), have attempted to ascertain the boundaries of these sub-populations, but despite all efforts, the relationships between neighbouring populations are still insufficiently understood.

Since the understanding of population structure is vital in evaluating the effects of threats to harbour porpoise – and indeed for the formulation of sound management procedures – the IWC-ASCOBANS *Working Group on Harbour Porpoise* attempted to define the boundaries of alleged sub-populations in order to be able to model the impact of by-catch on individual stocks (IWC, 2000). This determination of sub-populations was primarily carried out using existing mitochondrial DNA studies. They yielded great differences among putative populations. These were subsequently ascribed to potential female philopatry and the comparatively lower dispersal rates of females. Repopulation of depleted areas by females from other stocks is expected to be slow and the movements of the more transient males might not be able to compensate this. The risk of local depletion would increase if females were more resident than males. The "lowest common denominator" should therefore be local and genetically distinguishable sub-populations of females. Based on these findings, five stocks were proposed – their boundaries largely following the borders of ICES areas (see Kaschner, 2001 for review of the basis for the delineation of these areas):

(i) Baltic Sea
(ii) Kattegat, inner Danish waters and German Baltic Sea
(iii) Northern North Sea
(iv) Central and southern North Sea
(v) Celtic Shelf.

In December 2004 (Workshop on the Recovery Plan in Hamburg), a group of scientists based the definition of population borders used in this recovery plan on a review of the existing literature on population structure as well as on the results of Danish tagging work (Teilmann, unpublished data). For the North Sea three populations were identified (Figure 2):

(i) Northern North Sea,

(ii) Central and southern North Sea (including the eastern part of the English Channel)

(iii) Eastern Celtic Sea with the western part of the English Channel

The basis for the delineation of these areas is discussed in detail below.

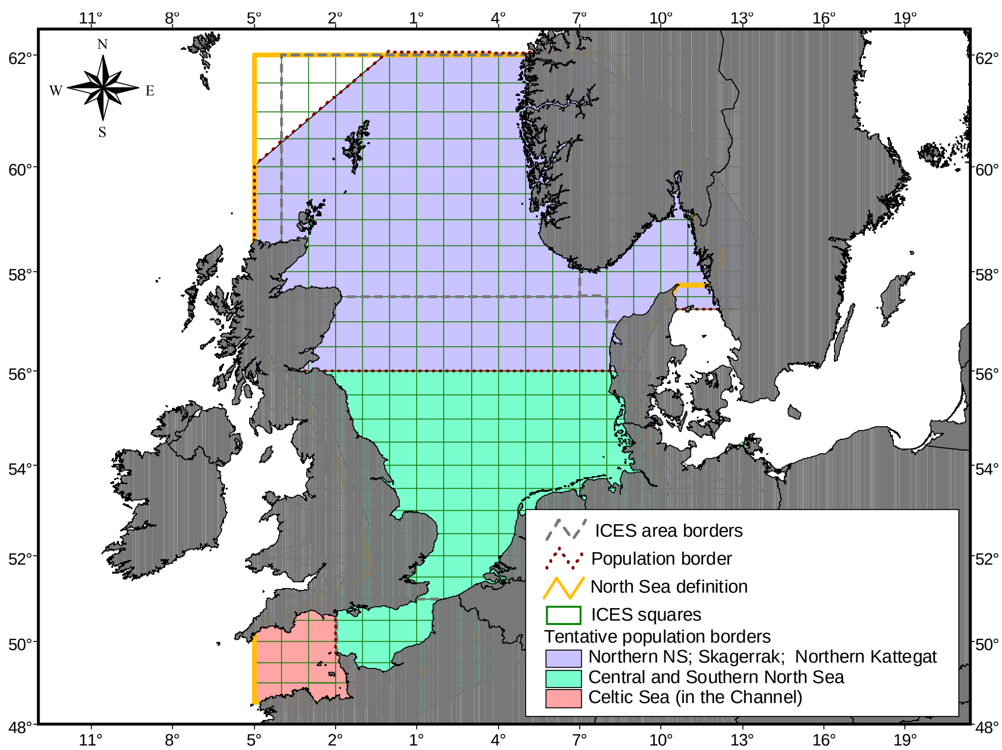

Figure 2: Map showing the tentative harbour porpoise population borders in the North Sea as defined at the Workshop on the ASCOBANS Harbour Porpoise Recovery Plan in Hamburg, December 2004.

2.1 Northern North Sea

Harbour porpoises are distributed across the North Sea with some areas of concentration along the Danish and North-German coasts and only a few regions of low density which may distinguish stock boundaries (Donovan & Bjørge, 1995) (also see under 3). Walton (1997) analysed the population structure of harbour porpoises in British and adjacent waters using mitochondrial DNA and found significant differences between harbour porpoises from the northern North Sea (Northern Scotland) and the southern North Sea (Eastern England). He used south-east Scotland where no animals were found as the provisional border line. Tolley *et al*. (1999), using 66 porpoises sampled from the British northern North Sea that were analysed by Walton (1997), found no significant difference between females from southern Norway (south of 65°) and northern Scotland. However, there was a difference between the northern Scotland and Barents Sea samples. Andersen *et al*. (2001) provided further evidence for a separate northern North Sea stock. Both, the study by Walton (1997) and the tagging work done by Teilmann (Teilmann, unpubl. data), suggest that there is a boundary somewhere in the middle of the North Sea. However, not all genetic studies have clear results and there hasn't been any tagging done in the central and southern North Sea, so the boundary and whether there is a clear year-round boundary, is still uncertain.

The border to the population in the north-west was based on the lack of sightings in the deep channel between the Faeroes and Shetland (Reid *et al*., 2003).

2.2 Central and southern North Sea

Walton (1997) found evidence for genetic differences between animals in the southern North Sea and the northern North Sea, but no differences were indicated between animals from the Dutch coast and animals from the English coast. He did not find evidence which suggested a separate Channel population. His sample size was probably too small (n = 327) to demonstrate a difference. Lockyer (1999) using teeth ultra-structure analysis suggested that porpoises in the North Sea are divided into a northern and a southern North Sea sub-population.

The boundary in the Channel was made based on the lack of sightings noted by Reid *et al*. (2003) in the middle of the Channel. There are sightings in the western part that gradually decrease towards the east. The same picture can be seen in the eastern part of the Channel suggesting movements of porpoises from the Celtic Sea and southern North Sea into the Channel but with no or little overlap in the middle.

2.3. Eastern Celtic Sea

The IWC-ASCOBANS *Working Group on Harbour Porpoise* (IWC, 2000) agreed that the Celtic Shelf sub-populations could extend into the Irish Sea and along the west coast of Ireland, but since the North Sea is clearly defined for the Recovery plan, it was decided that only the eastern part of the Celtic Sea which extends into the English Channel is included.

3. Abundance and distribution

Abundance estimates for cetaceans can be obtained using a number of techniques, all associated with a different degree of uncertainty. Generally, anecdotal evidence is the basis for historic estimates on distribution and abundance. The reliability of these estimates is low. They are considered to be of a qualitative rather than a quantitative nature.

Land-based sightings surveys, stranding records, ship-based and/or aerial sighting surveys as well as by-catch records generally form the basis of current abundance estimates in the North Sea. Obviously, land-based surveys are restricted to coastal areas, allowing observation of a small distributional portion of the species' range only. Interpretation or extrapolation of results is difficult when using strandings records, as the geographical origin of the found animals is not known (Hammond *et al*., 1995). Extrapolation of absolute population numbers or trends from by-catch records are associated with similar uncertainties.

The systematic approach to dedicated sightings surveys using different observer platforms helps to reduce biases and uncertainties, but they are still affected by the elusiveness of cetaceans.

The harbour porpoise is the most numerous marine mammal in north-western European shelf waters. Several surveys have been conducted in the northeast Atlantic to estimate the size of harbour porpoise populations. In 1987 and 1989, the North Atlantic Sightings Surveys (NASS) collected data to estimate minke whale abundance, but also provided an estimate of harbour porpoise abundance in the Norwegian waters of the North Sea west of 7 °E and down to 56 °N (Bjørge & Øien, 1995). Harbour porpoises were also found to be relatively abundant further west around Northern Scotland and the Shetland Islands (Northridge *et al*., 1995).

The Central and Southern North Sea have been surveyed quite extensively applying all commonly used observer platforms (e.g. Heide-Jørgensen *et al*., 1993; Benke & Siebert, 1994, Scheidat *et al*., 2004). These surveys suggested high densities of harbour porpoise throughout the northern part of this region with maximum concentrations occurring off the islands of Sylt and Amrum in the German Wadden Sea. Very low numbers are believed to exist in the Eastern English Channel, though porpoises increase in numbers further West in the Channel (Camphuysen, 1994; Hammond *et al*., 1995; Northridge *et al*., 1995) and on the Celtic Shelf (Leopold *et al*., 1992).

The most wide-ranging survey conducted has been the SCANS survey of summer 1994 (Hammond *et al*., 1995) which produced the most reliable estimates of harbour porpoise abundance in the North Sea and adjacent waters to date. The survey covered almost the combined total area of surveys listed above using ships or planes (Figure 3). The survey produced an estimated North Sea population of approximately 270,000 animals with a further 36,000 in the Skagerrak and Belt Seas and another 36,000 (CV = 0.57) over the Celtic Shelf between Ireland and Brittany (Table 1).

Interestingly, no porpoises were seen in the English Channel or the southern North Sea during this survey. By-catches and strandings are regularly reported from the Dutch and Belgium coast particularly increasing in recent years (Haelters *et al*., 2002, Figure 4).

Bjørge & Øien (1995) published estimates of 82,000 animals (CV = 0.24; g(0) = 1) in the northern North Sea and southern Norwegian waters. Surveys in summer 2002 and 2003 estimated 35,000 – 39,000 porpoises (CV = 0.10) to be present in the German part of the North Sea (Scheidat *et al*., 2004).

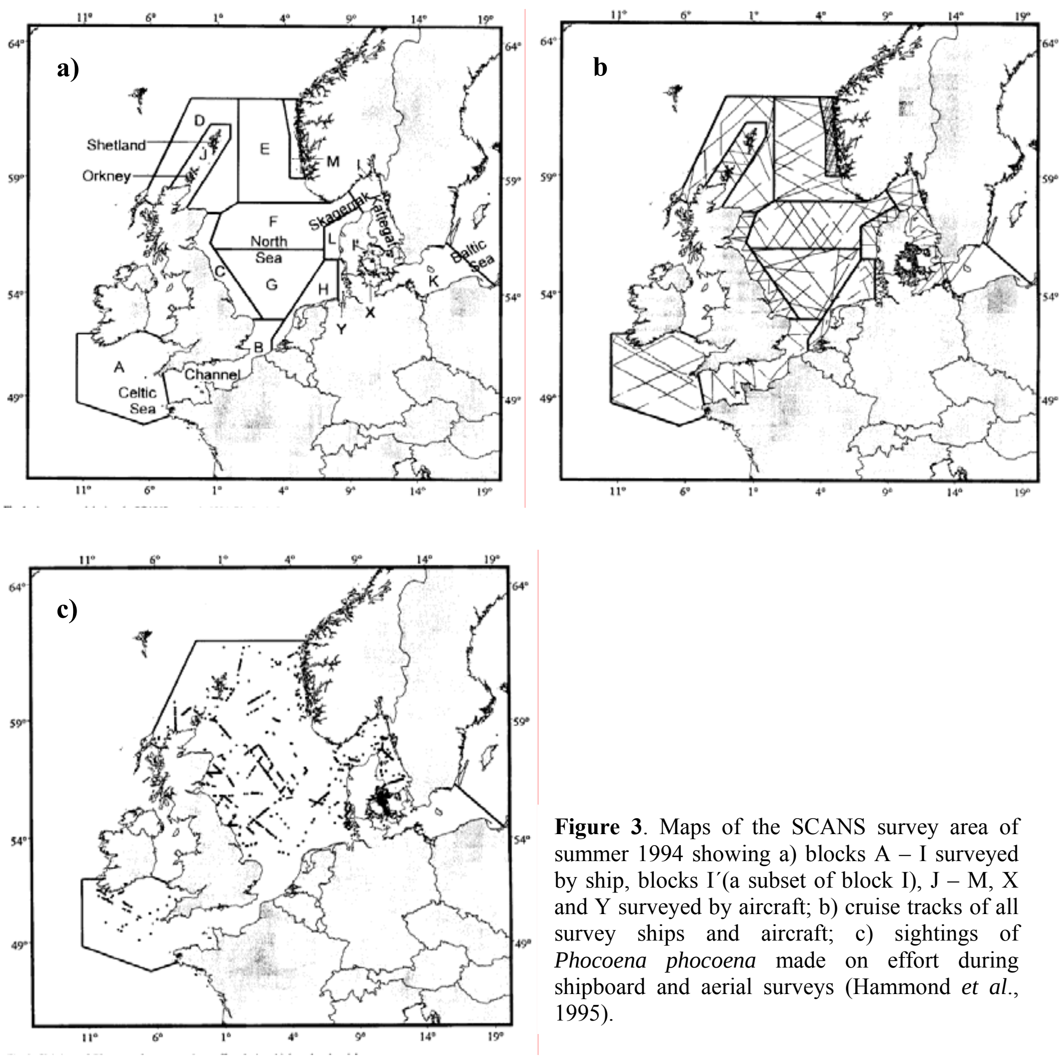

Figure 3. Maps of the SCANS survey area of summer 1994 showing a) blocks A – I surveyed by ship, blocks I´(a subset of block I), J – M, X and Y surveyed by aircraft; b) cruise tracks of all survey ships and aircraft; c) sightings of *Phocoena phocoena* made on effort during shipboard and aerial surveys (Hammond *et al*., 1995).

Table 1: Abundance and densities of harbour porpoises in the North Sea and adjacent waters by SCANS block as estimated by Hammond *et al*., 1995. Subtotals and totals do not include block I' which was a subset of block I. Figures in round brackets are coefficients of variation; figures in square brackets are 95% confidence intervals.

Greater Region	**SCANS block**	**Animal Abundance** [number of animals]	**Animal density** [number of animals/km^2]
Kattegat /IDW/German Baltic	I	36,046 (0.34)	0.725
	I'	5,262 (0.25)	0.644
	X	5,88 (0.48)	0.101
Subtotal (Kattegat/IDW/German Baltic)		**36,634**	
Central & Southern North Sea	C	16,939 (0.18)	0.387
	F	92,340 (0.25)	0.776
	G	38,616 (0.34)	0.340
	H	4,211 (0.29)	0.095
	L	11,870 (0.47)	0.635
	Y	5,912 (0.27)	0.812
Subtotal (C & S North Sea)		**169,888**	
Northern North Sea (partially)	E	31,419 (0.49)	0.288
Northern North Sea (mostly)	D	37,144 (0.25)	0.363
Northern North Sea	J	24,335 (0.34)	0.784
Northern North Sea (partially)	M	5,666 (0.27)	0.449
Subtotal (Northern North Sea)		**98,564**	
English Channel (mostly)	B	0	0.000
Celtic Shelf	A	36,280 (0.57)	0.180
Total		**341,366 (0.14) [260,000 – 449,000]**	-

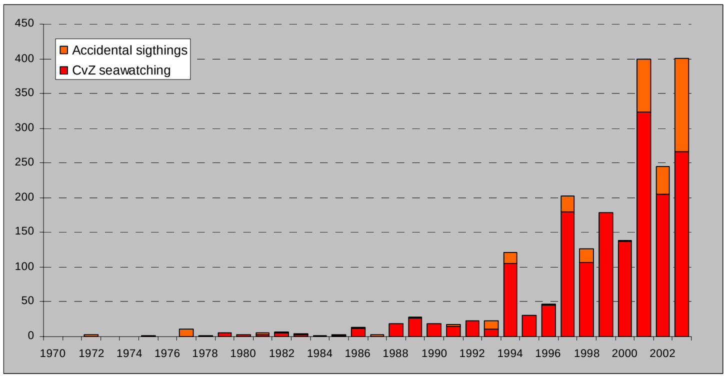

Figure 4: Number of harbour porpoises reported from Dutch coastal sites since 1970 (Marine Mammal Database, updated 03.01.2004, source: http://home.planet.nl/~camphuys/Bruinvis.html).

A newly published cetacean atlas (Reid *et al*., 2003) shows the distribution of harbour porpoise in the North Sea and adjacent waters (Figure 5). The atlas is based on the Joint Cetacean Database, contributed to by the European Seabirds at Sea database (ESAS), Sea Watch Foundation (SWF) and Sea Mammal Research Unit (SMRU). It used most, but not all, effort-related cetacean data for all seasons of the years 1979 – 1997.

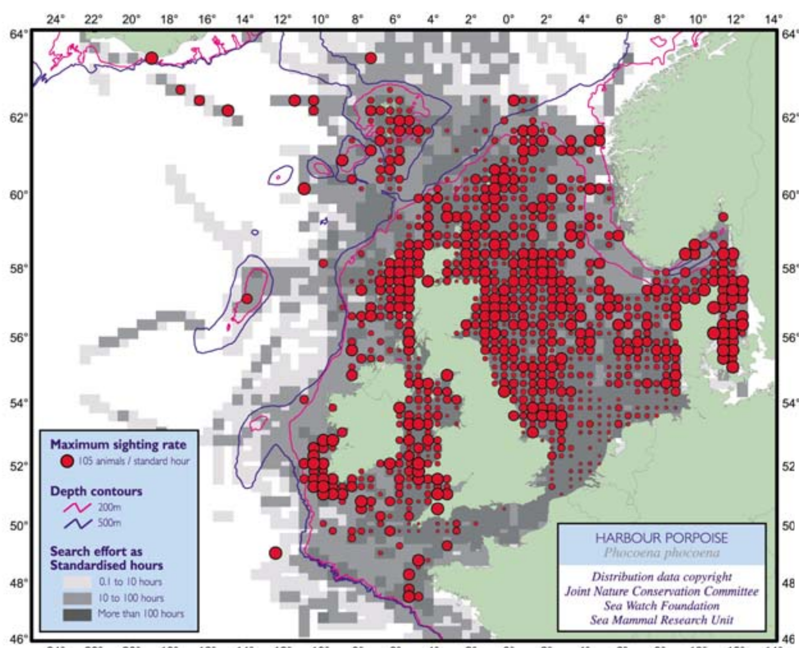

Figure 5: Map showing the distribution of harbour porpoises in the North Sea and adjacent waters. Data have been pooled from 1979 to 1997, all seasons are combined (Reid *et al.*, 2003).

3.1. Seasonal peaks in distribution and movements between stocks

The distribution of harbour porpoises does vary considerably between different seasons and areas. Even a survey as extensive as SCANS can only represent a temporally and spatially limited snapshot of population size for July or the summer season at most.

A number of studies have provided indication about relative seasonal changes in harbour porpoise abundance. They may be indicative of small- and meso-scale annual movements/migrations, movement between different stocks or regionally and temporally limited declines and increases (Northridge *et al*., 1995, Scheidat *et al*., 2004, Teilmann, unpublished data). Northridge *et al*. (1995) have found that harbour porpoise in the North Sea aggregate into two major groupings during early spring (January to March): one in the deeper waters of the north western North Sea, and one off the west coast of Jutland and Schleswig-Holstein. Particularly two shallow banks, the Amrum Bank in German waters and Horn's Reef in Danish waters, appear to be important harbour porpoise habitat (Skov *et al*., 1994). During this time, harbour porpoises have also been found to be most common in Dutch coastal waters, indicating a potential third aggregation (Camphuysen & Leopold, 1993, Figure 6). However, overall total numbers in this area are low compared to the other two areas.

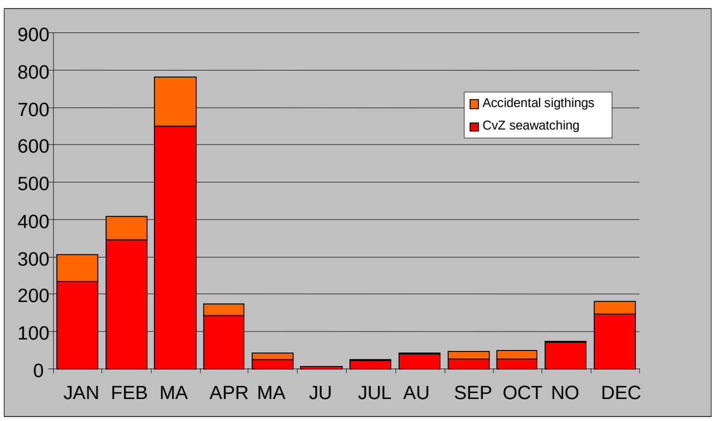

Figure 6: Seasonal pattern of harbour porpoises reported from Dutch coastal sites since 1970 (Marine Mamal Database, updated 03.01.2004, source: http://home.planet.nl/~camphuys/Bruinvis.html)

During the second quarter of the year, coinciding with the calving season at the end, the North Sea harbour porpoises are primarily found in the shallow waters of the Wadden Sea. The area off the island of Sylt (Schleswig-Holstein, Germany) was identified as an important calving ground (Sonntag *et al*., 1999).

During the third quarter of the year, the summer months covered during the SCANS survey, porpoises were distributed throughout the North Sea. However, highest densities occurred along both the West and the East coast of the Schleswig-Holstein – Jutland peninsula (SCANS block Y, L, I; Figure 3) as well as in the region around the Shetland Islands (J). Bjørge & Øien (1995) observed relatively dense aggregations of porpoises in the Northern North Sea, north of 56°N, especially in July. In the southern most part of the North Sea and the English Channel, porpoises were either absent or very rare during these months (Hammond *et al*., 1995, Reid *et al*., 2003; Figure 6).

The animals apparently re-aggregate into the three potential groupings in the north-western North Sea, the waters off Denmark and the Dutch coast during the last quarter of the year.

3.2. Population decline

Little to nothing is known about absolute historic abundances. Numerous reports of changes in distribution and relative abundance of porpoises in certain areas based on time series analysis of stranding records and incidental sightings provide some evidence that Northeast Atlantic harbour porpoise might have declined in some areas such as the southern North Sea and the English Channel (Van Deinse, 1952 cited in Champhuysen & Leopold, 1993; Verwey, 1975; Duguy, 1977; Smeenk, 1987; Champhuysen, 1994; Collet, 1995; Reijnders *et al*., 1996).

Although the causes for declines in this and other areas are not clear, it has been suggested that human activities such as overfishing, incidental catches in fishing gear, pollution, and habitat degradation are likely to have contributed substantially to this demise (Hammond *et al*., 1995).

The latest compilation of data demonstrate that there has been an increase in sightings of harbour porpoises off the Dutch coast that started in the mid 1990s (Figure 5). Similarly, strandings along the Belgian and French coast have increased indicating a possible come-back of the harbour porpoise in these waters (Haelters *et al*., 2002, Jauniaux, *et al*., 2002; Kiszka *et al*., 2004, Camphuysen, in press). This increase might be the result from a distribution shift rather than a recent rise in the local sub-population, because the ratio of juveniles to adults was not modified (Jauniaux *et al*., 2002). As reported by Addink & Smeenk (1999), changes in the abundance of odontocetes in certain regions may be related to the abundance of prey.

4. Objectives

Several political decisions made in response to the increased awareness of the need for biodiversity conservation and sustainability of any use of natural resources directly concern small cetaceans, such as harbour porpoise. The Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) was ratified under the UN Convention on Migratory Species (CMS or Bonn Convention). The aim of ASCOBANS is "to restore and/or maintain biological management stocks of small cetaceans at a level they would reach when there is the lowest possible anthropogenic influence" (ASCOBANS, 2000). The short-term goal of ASCOBANS is "to restore populations to, or maintain them at, 80% or more of their carrying capacity". The figure is based on the assumption that a population below its maximum net productivity level is considered depleted under the US Marine Mammal Protection Act (MMPA), and that the maximum net productivity level of toothed whales and seals is estimated to range between 50% - 85% of their carrying capacity (Taylor & DeMaster, 1993). In 2000, ASCOBANS defined a total anthropogenic removal above 1.7% of the estimated harbour porpoise abundance as unacceptable and adopted the immediate precautionary objective to reduce by-catches to less than 1% of the best available population estimate (ASCOBANS, 2000). The figure of 1%, chosen as a reasonable and precautionary level beyond which one should be concerned about the sustainability of anthropogenic removals, is based on the conclusion that a harbour porpoise population's maximum net production could be lower than 4% per year (Woodley & Read, 1991; Palka, 1996), and that by-catch and abundance estimates are associated with uncertainties (IWC, 1996). In this respect, the primary objectives of the present recovery plan are to

(i) identify risks for harbour porpoise and to
(ii) suggest management measures which will achieve and maintain a favourable conservation status of harbour porpoises in their entire range.

Conservation status can be taken as "favourable" when

- population dynamics data indicate that harbour porpoises are maintaining themselves at an optimum level for their long term survival as a viable component of the marine ecosystem
- the range of harbour porpoises is neither reduced, nor is it likely to be reduced in the future;
- habitat of favourable quality is and will be available to maintain harbour porpoise on a long term basis; and
- the distribution and abundance of harbour porpoise in the agreement area are returned to historic coverage and levels.

If any of the four conditions are not met, the conservation status of harbour porpoise is taken as "unfavourable".

5. Risks for the harbour porpoise

Risks for the harbour porpoise in the North Sea are diverse; they include (in no particular order):

- by-catch/incidental catches in fisheries
- prey depletion from overfishing
- shipping

- wind farms (construction and operation)
- seismic surveys
- military operations (sonar, bombing/firing)
- oil and gas operations
- gravel and sand extraction
- pollution (of the environment and the animals)
- eutrophication
- infections/diseases
- climate change and
- tourism.

The highest risks for the recovery of harbour porpoise that apply widely in the North Sea are considered to be fisheries by-catch, shipping noise and pollution. Nevertheless, too many details about harbour porpoise biology and ecology as well as effects of risks/threats are still unknown, some of the risks listed above might be more important than others on a smaller or more regional scale. The following chapters review the major pressures on harbour porpoise in the North Sea with the attempt to sort them by priority.

5.1. Fisheries

Interactions with fisheries are some of the most pressing risks to the diversity of marine mammals, especially at the stock level (Marsh *et al*., 2003). Interactions between marine mammals and fisheries can be operational, in which the animals interact with fishing gear to the detriment of the animals, gear, or both, as well as ecological, in which animals and fisheries interact through trophic pathways (DeMaster *et al*., 2001). The two types of interactions require different conservation approaches (Northridge & Hofman, 1999).

5.1.1. By-catch

The primary threat to marine mammals from operational interactions comes from the entanglement and mortality of animals in fishing gear (Marsh *et al*., 2003). Early records of incidental takes of harbour porpoise in the North Sea date back to the 19th century (Lockyer & Kinze, 2003). More recently, almost all bordering countries of the North Sea and adjacent waters have reported by-catch in their fisheries (e.g. Donovan & Bjørge, 1995; Tregenza *et al*., 1997; ASCOBANS, 1997, 2004). By-catch levels differ between different types of fisheries, but total mortalities are considered to be unacceptably high in a number of cases (Kraus *et al*., 1995; Murray *et al*., 2000; Vinther, 1999; Northridge & Hammond, 1999). Even at lower levels of by-catch occurring in a certain fishery, this anthropogenic caused removal of the population needs to be seen in the greater context of mortalities caused by all fisheries operating in the same area as well as other anthropogenic impacts.

Highest mortalities of harbour porpoise in fishing nets have been observed in association with large-mesh fixed bottom-set gillnets set for demersal species such as cod, turbot, lumpfish, plaice and skate (Table 2) (e.g. Clausen & Andersen, 1988; Kinze, 1994; Tregenza *et al*., 1997; Northridge & Hammond, 1999; Vinther, 1999). This is probably due to harbour porpoise feeding behaviour on or near the seabed (Ross & Isaac, 2004). Gear employed in these fisheries include trammel nets, tangle nets and gillnets set at different heights and using different mesh sizes. By-catch rates vary depending on gear type and deployment mode (Perrin *et al*., 1994; ASCOBANS 1997).

Tregenza *et al*. (1997) estimated an annual by-catch of 740 harbour porpoise in the hake fishery in the Celtic Sea.

Vinther (1999) documented high by-catch rates of harbour porpoises in the Danish North Sea bottom set gillnet fisheries for turbot, cod, hake and plaice. The estimated annual by-catch was 6,785 porpoises. Vinther & Larsen (2002) then used by-catch rates determined from observer data from 1987 – 2001 to extrapolate by-catch rates based on fleet effort or on landings respectively. The first method estimated a mean annual by-catch of 5,817 porpoises, the second method one of 5,591 porpoises (they probably overestimated by-catch due to use of pingers in cod wreck fishery not accounted for).

In 2003, 16 UK-stranded harbour porpoise carcasses were diagnosed to have died due to by-catch. Of these, 11 were found stranded in the UK (6 in England, 5 in Wales) and five were retrieved directly from fishing vessels as part of observer-based research (Sabin *et al*., 2004).

Between 27 January and 31 May 2004, 23 dead porpoises were found on Belgian beaches. Of these, at least nine but maybe as many as 13 had suffocated in fishing nets, all between 17 March and 8 May. Of these animals, at least five suffocated in nets used in recreational fisheries from the beach. As regards to the four other animals, it was not possible to establish in which type of fishing gear they had suffocated. It is certain that five of the by-caught animals suffocated in recreational gill nets, and it is probable that such nets are responsible for all, or at least the majority of beach fisheries by-catch. Not only external traces pointed at by-catch. Internal examinations during autopsies also clearly showed that the animals had suffocated.

Table 2: Summary of by-catch information and data. Figures in square brackets are 95% confidence intervals.

Greater Region	ICES area	Country	Main gear type	Target species	Size of fisheries	Estimation method	Year	Total reported by-catch	Estimated annual by-catch	Seasonal peaks	Source
Kat./IDW/German Baltic	IIIb	Sweden	bottom trawls			fishermen interviews	2001	-	20	-	ASCOBANS, 2004a
			trammel nets	lumpfish				1	8		Lynneryd *et al*., 2004
			gillnets	sole, cod, crab				6	70		Lynneryd *et al*., 2004
Skagerrak	IIIa	Sweden	gillnets, trammel nets, pelagic trawls	cod		fishermen interviews	2001	-	80	-	ASCOBANS, 2004a
			pelagic trawls	herring				1	11		Lynneryd *et al*., 2004
			bottom trawls	cod				2	25	-	
Northern North Sea	IV	UK	set nets	cod, skate, turbot, sole, monkfish, dogfish			1995 - 2002	-	439 [371 – 640]	-	ASCOBANS, 2004a
	IV	Denmark	wreck nets, gillnets	cod, hake, turbot, plaice, sole	very large	observer program	1987 - 2002	-	5,817/5,591*	-	Vinther & Larsen, 2002
Central & Southern North Sea	IV b	Germany	gillnets	cod, turbot, sole, other demersal fish	small	observer program	2002 - 2003	-	25-30	-	Flores & Kock, 2003
	IVc	Belgium	recreational beach fisheries		small	strandings	1990 - 2003	3	-	-	ASCOBANS, 2004a
	IVc	Belgium	recreational beach fisheries	sole	small	strandings	March – May 2004	13	-	March - May	Haelters & Kerckhof, 2004
Celtic Sea (Channel)	VII e	UK	gillnets	hake		Observer program	August 1992 – March 1994	28	740 [383 – 1097]	-	Tregenza *et al*., 1997

* Extrapolated from by-catch rates determined from observers 1987 – 2001. First estimate is based on fleet effort, second is based on landings as used by Vinther (1999). By-catch is probably overestimated due to use of pingers in cod wreck fishery not accounted for.

Gear other than set nets appear to be less hazardous for harbour porpoise. However, few other fisheries have been monitored (IWC, 1996). By-catches in trawls have been recorded, but in much smaller numbers (Clausen & Andersen, 1988; Northridge & Lankester, 1990; Kinze, 1994, Flores & Kock, 2003). The few studies in Danish waters suggest that the catch in trawls may represent 2 – 19% of the total by-catch (Clausen & Kinze, 1993, as cited in Lowry & Teilmann, 1994).

In autumn 2001, ICES responded to a request from the European Commission to provide advice on other marine organisms than those targeted by commercial fisheries. The EC requested advice on possible remedial action related to (1) fisheries with a significant impact on cetaceans, (2) other mortality sources for cetaceans, and (3) the risks created by fisheries on identified populations (ICES, 2001). ICES identified the fisheries using the following four criteria:

1. By-catch rates possibly exceed rates considered to be sustainable for the species or population,
2. Populations are severely depressed relative to historic size and by-catch mortality may be a deterrent to recovery,
3. Populations are intrinsically small, and even low numbers of kills represent an important source of mortality to the populations,
4. Experience drawn from similar fisheries and species in other areas should be the basis of management action until fishery-specific data are sufficient to support management actions.

The fisheries identified by ICES to be of most concern for harbour porpoise by-catch are listed in table 3.

Table 3: Fisheries in the North Sea that are most concerning for harbour porpoise by-catch levels. Adapted to the cases of harbour porpoise from ICES (2001). See text for the description of concern criteria.

Gear type	Location	Country	Concern criteria
Gillnets (incl. tangle nets)	Central/Southern North Sea, including coastal waters	Denmark, cod, hake and flatfish	1
		UK for cod and flatfish	1
	Channel and Southern Bight of North Sea	UK, France, Belgium, Netherlands, Denmark	2, 4
	Kattegat, Skagerrak, and Belt Seas[1]	Denmark for cod and flatfish	2,4
		Sweden for cod, flatfish and herring	1

[1] Relevant for this recovery plan is the Skagerrak.

Four different techniques can be used in order to estimate by-catch mortalities, though reliability of estimates might vary considerably depending on the underlying method. Derivation of by-catch from stranded animals bearing net marks can only give a general indication that by-catch may be occurring, but not the magnitude or location of the by-catch (Perrin *et al.*, 1994). Reliability of estimates based on fisherman interviews or dock-side reporting is also considered to be very low due to the obvious conflict of interest for the fishermen involved. The most reliable technique is an independent observer program incorporating a statistical sampling design (IWC, 1996).

5.1.2. Prey depletion

Fisheries represent another potentially important factor in influencing porpoise population dynamics. The North Sea is one of the most intensively fished areas of the world, but the complex nature of the marine environment means that intensive fishing activities do not always have predictable consequences (Northridge & Lankester, 1990). Changes in the distribution and abundance of prey species of harbour porpoise may cause physical effects on individuals and changes in distribution and abundance in harbour porpoise populations. Harbour porpoise live on patchy food resources and are generally considered opportunistic feeders. The term "opportunistic" might not be applicable though, because it is understood to mean that a predator feeds on the most abundant prey available, and it is not known if this is indeed the case for harbour porpoise. Forcing the harbour porpoise to switch prey may constitute forcing it into a sub-optimal niche or habitat which may have long-term adverse effects on survivorship and productivity (IWC, 1996). It has been suggested that its small body size, its energetically demanding reproductive schedule and its relatively cold water habitat all mean that harbour porpoise can never survive without food for more than a few days (Yashui & Gaskin, 1987).

Evans (1995) noted a marked decline in harbour porpoise numbers around the Shetland Islands during the 1980s, whilst major changes occurred in local fisheries. Reijnders (1992) associated the decline in numbers of harbour porpoise seen in coastal waters of the southern North Sea with the massive decline in herring numbers during the 1980s. The fact that herring numbers are recovering and that there has been an increase in sightings of harbour porpoise at the Belgian and Dutch coast supports this argument.

Knowledge on quantitative relationships between feeding ecology and critical levels of prey availability where animals need to choose between switching prey or leaving the area, is still lacking. In order to evaluate the direct and indirect impacts of fisheries on populations of harbour porpoise, efforts should be made to find out more about their foraging habits in relation to various types of fishing gear and the species of fish they catch.

5.2. Noise pollution and disturbance

Ambient noise is generally unwanted environmental background noise which clutters and masks other sounds (Knudsen *et al*., 1948; Richardson *et al*., 1995). The main causes of noise are (a) seismic noise (from volcanic and tectonic activity), (b) shipping and other man-made (anthropogenic) noise, (c) sea state noise (water motion), (d) marine life and (e) thermal noise (Knudsen *et al*., 1948; Richardson *et al*., 1995)

All different noises have characteristic signatures including frequencies and different ranges (Figure 7). Noise from volcanic and tectonic activity (seismic noise) occurs at low frequencies (below 1 Hz) especially in geologically active areas (Richardson *et al*., 1995). This noise is usually transient (short duration sounds with obvious start and finish points). Noise from shipping dominates the ambient noise at frequencies from 20 – 300 Hz (Richardson *et al*., 1995; Au *et al*., 2000). Water motion is a source of noise which is related to weather conditions, its magnitude is largely determined by the motion of the sea surface (waves and whitecaps) usually produced by wind. It is the principal type of noise encountered in open and deep sea water at frequencies between 500 and 50,000 Hz (Knudsen *et al*., 1948; Richardson *et al*., 1995). Thermal noise refers to the random movement of molecules causing pressure fluctuations. Thermal agitation may dominate at frequencies above 30 – 50 kHz, especially when wind speed is low (Richardson *et al*., 1995). Vertebrates and crustaceans are main contributors to natural sounds produced by marine life (Knudsen *et al*., 1948; Richardson *et al*., 1995). However, snapping shrimp who considerably contribute to ambient noise in other oceans, do not occur in the North Sea. Frequencies from biological noises extend from ~ 12 Hz (some blue whale calls) to over 100,000 Hz (echolocation of small odontocetes). Depending on the situation, biological noise can range from nearly absent to dominant over narrow or even broad frequency ranges. When biological noise is dominant in a particular frequency band, it can interfere with detection of other sounds at those frequencies, just like any other ambient noise (Richardson *et al*., 1995). Low frequency sound propagates better over long range, but requires a higher received level to be detected against the higher noise level compared to high-frequency sound (Au *et al*., 2000).

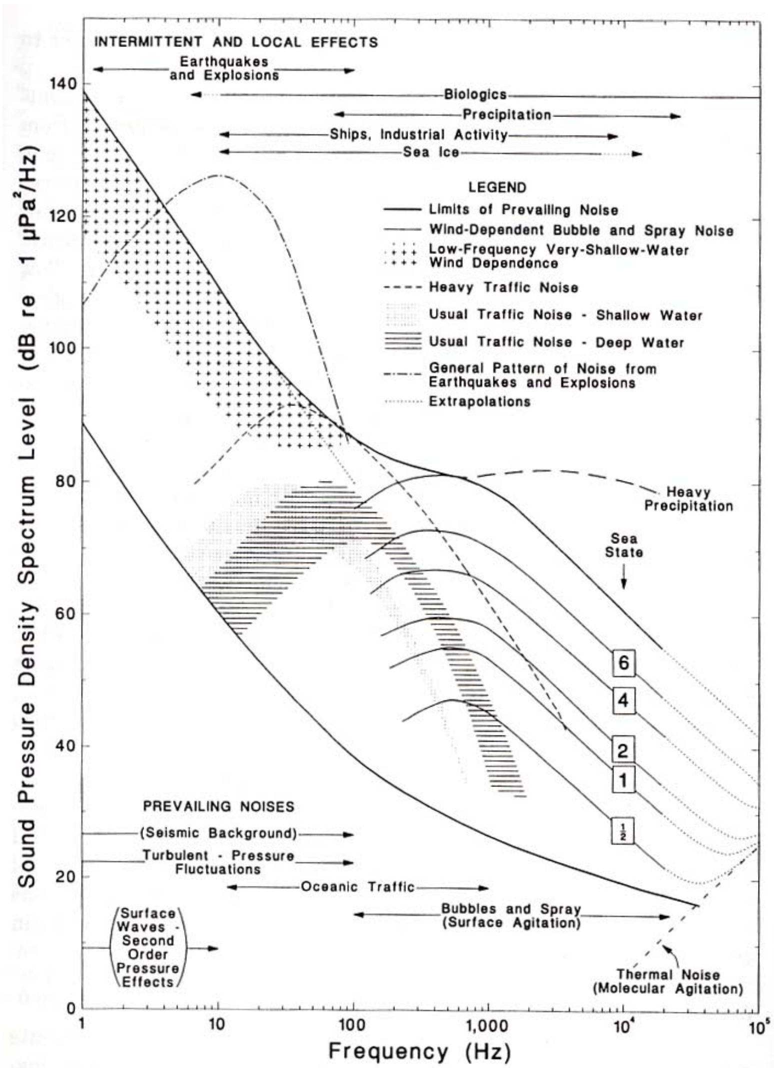

Figure 7: Generalized ambient noise spectra attributable to various sources (from Richardson *et al*., 1995 re-plotted from Wenz, 1962).

Marine mammals rely heavily on the use of sound underwater. They communicate through the use of sounds about their own position, territorial or reproductive status, potential dangers, prey or other animals (Richardson *et al*., 1995). Odontocete cetaceans detect, localize and characterize underwater objects through the use of echolocation sounds (Au, 1993; Verboom & Kastelein, 1995). The underwater hearing of harbour porpoise has not been extensively studied (Figure 8). Available studies so far concluded that harbour porpoise have hearing capabilities from 0.25 to 180 kHz (9.5 octaves) (Kastelein *et al*., 2002). Maximum sensitivity (about 33 dB re 1 μPa) apparently occurs between 100 and 140 kHz and most sensitive hearing (defined as 10 dB within maximum sensitivity) between 16 and 140 kHz (3.1 octaves), with a reduced sensitivity around 64 kHz.

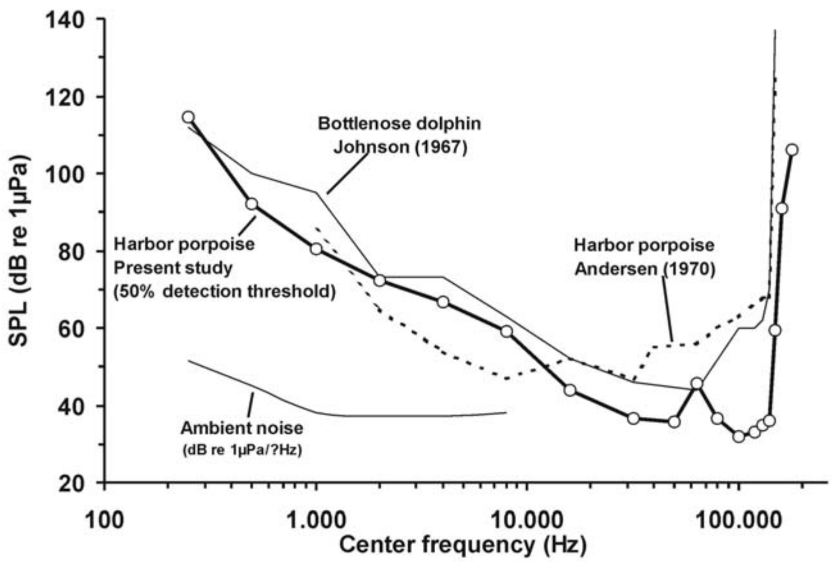

Figure 8: The mean 50% detection threshold of a harbour porpoise in dB re 1 µPa for narrow-band FM signals. Also shown is the audiogram determined by Andersen (1970) for one harbour porpoise (sample size per frequency threshold unknown, and definition of the threshold unknown), and the audiogram of an Atlantic bottlenose dolphin (Johnson, 1976). The spectral level of the ambient noise in the pool is shown up to 8 kHz (note that this is a different unit than the one along the y-axis) (from Kastelein *et al*., 2002).

When assessing the potential effects of man-made noise on marine mammals, it is important to estimate the radius within which acoustic effects are expected. Richardson *et al.* (1995) distinguish four criteria for defining the radius or zone of influence depending on the distance to the sound source (Figure 9):

- The *zone of audibility*: the animal might hear the sound, but there is no reaction
- The *zone of responsiveness*: the animal reacts behaviourally or physiologically. Behavioural reactions might be: increased alertness, panic, disruption of certain behaviours such as hunting, resting, migrating, social interactions, avoidance reactions, and possibly short- or long term displacement from an area.
- The *zone of masking*: the noise is strong enough to interfere with detection of other sounds, such as communication or echolocation calls, prey sounds, or other natural environmental sounds. This zone is highly variable in size.
- The *zone of hearing loss, discomfort, or injury*: the received sound level near the noise source is high enough to cause discomfort or tissue damage to auditory or other systems. It is distinguished between temporary threshold shift (TTS) and permanent threshold shift

(PTS). Generally it is assumed that repeated or continuous TTS leads to PTS (Richardson *et al.*, 1995).

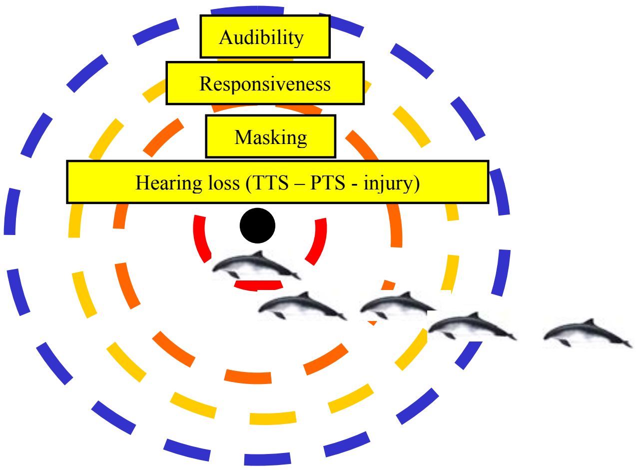

Figure 9: Zones of noise influence (Frank Thomsen, personal communication, adapted from Richardson *et al.*, 1995).

The above mentioned zones furthermore depend on various parameters, such as:

- The hearing abilities of the species in question,
- ambient noise levels,
- sound propagation,
- the sound level of the sound source and
- the distance of the animal to the sound source.

In an ocean which is getting steadily noisier, sending and receiving information becomes increasingly difficult for harbour porpoise. Man-made noise can interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. If the noise is strong enough relative to the received signal, the signal will be masked and undetectable (Richardson *et al.*, 1995). Elevated underwater noise might have a variety of deleterious effects on porpoises including behavioural changes, such as altering migration routes and feeding behaviour, physical or physiological effects, such as temporary or permanent hearing loss and noise-induced stress. Anthropogenic underwater noise is supposed to be able to add cumulatively to other negative environmental factors resulting i.a. in habitat degradation or habitat loss.

5.2.1. Boat traffic

Noise from ships dominates marine waters and emanates from the ships' propellers, machinery, the hull's passage through the water and the increasing use of sonar and depth sounders (Perry, 1998). In general, older and larger vessels produce more noise than newer or smaller ones (Gordon & Moscrop, 1996). Most shipping noise occurs in the low frequency range (< 1 kHz) coinciding with frequencies used mostly by baleen whales for communication and other biological important activities (Parsons *et al*., 2003), but small leisure crafts generate sound from 1 kHz up to 50 kHz (Evans, 1996) potentially impacting toothed whales, too.

The North Sea contains some of the busiest shipping routes in the world. Daily, more than 400 ships pass through and 600 ships cross (including 200 ferries) the Strait of Dover (OSPAR, 2000a). Approximately half the shipping activity in the Greater North Sea consists of ferries and roll-on/roll-off vessels on fixed routes (OSPAR, 2000a).

Increased boat traffic in the North Sea might pose a problem for harbour porpoises as they are generally shy animals which tend to swim away in response to (motor-driven) boats. Polacheck & Thorpe (1990) found that harbour porpoise exhibited an avoidance reaction to survey vessels. Evans *et al*. (1994) observed that harbour porpoise in South East Shetland avoided vessels of all sizes, sometimes even moving out of the area completely. They were more likely to avoid infrequent vessels than routine vessels such as regular ferry services. Scheidat & Palka (1996) also gathered results that indicated a change in behaviour and swimming directions in some animals in response to a survey vessel. Finless porpoise (*Neophocoena phocoenoides*) were observed to significantly increase their dive times in the presence of boats and leapt out of the water, apparently as an avoidance reaction in response to approaching boat traffic (Beasley & Jefferson, 2000). Silber *et al*. (1988) observed that surfacing duration and respiration rate of vaquitas (*Phocoena sinus*) decreased in the presence of boats.

Evans *et al.* (1992) examined the effect of speed boats on bottlenose dolphins (*Tursiops truncatus*) in Cardigan Bay, Wales, and reported responses of shorter surface periods, longer dive times and movement away from vessels at ranges of 150 – 300 m. Quieter, faster boats caused more disturbance than slower larger boats, as noise emitted by a high speed boat rises above ambient noise levels only a short time before closest contact, thereby provoking a startle response.

In contrast, porpoise have been seen to approach catamarans, sailing boats and surfers and accompanied them for a while (Prochnow & Kock, 2000 and references therein). Disturbance from such silent activities therefore seems unlikely.

In recreational areas where there are concentrations of power boats and jet skis, the increased noise level as well as the speed of these vessels might pose a risk to the porpoise though. Observations during the Surf World Cup off the Island of Sylt in 1995, when jet skis were frequently in use, revealed that these crafts had the effect of scaring the harbour porpoise away. They completely disappeared from the area during the competition, but returned again once the event had finished (Prochnow & Kock, 2000).

Another issue of growing concern is the rapidly growing marine tourism industry. There have been concerns over the impact of tourism on cetaceans (e.g. Beach & Weinrich, 1989; Constantine, 2004). Different studies of the reactions of various mammals to human disturbance showed a significant reduction in resting behaviour (dolphins: Lusseau, 2003; Constantine *et al*., 2004; harp seals: Kovacs & Innes, 1990; Henry & Hammill, 2001; howler monkey: Grossberg *et al*., 2003; caribou: Duchesne *et al*., 2000; Amur tigers: Kerley *et al*., 2002). Resting is a fundamentally important behavioural state to the health of many species of animals (Constantine *et al*., 2004). The synchronization of behaviours such as resting and foraging are thought to be important for group cohesion, and that groups benefit through optimising care of offspring, anti-predator defence and increasing efficiency in exploiting food resources (Clark & Mangel, 1986). Chronic disturbance to populations of animals can cause behavioural changes, or even a population decline, that may persist several years after the disturbance has ceased. In some cases human disturbance may cause animals to abandon or not use ideal habitat thereby potentially increasing the risk of mortality to their offspring. Harbour porpoise, being very shy animals, are not (yet) exposed to tourism, but the fact that this industry is growing for other cetacean species (e.g. bottlenose dolphins) makes it necessary to assess short-term behavioural responses to boats and interpret the long-term consequences of these.

The use of high-speed ferries appears to be a growing industry which has potential to impact upon harbour porpoise (ASCOBANS, 2004b), but research on this topic is still lacking.

5.2.2. Oil and gas explorations

Noise is generated during all phases of oil and gas exploration. Noise sources may be continuous or impulsive and can be described as being transient or permanent (Table 4). Seismic surveys (exploration), pile driving, pipe laying (installation), drilling and platform operations (production) as well as explosive wellhead decommissioning (decommissioning) are all activities generating noise and potentially posing a risk on harbour porpoise.

The major oil developments have been in the northern parts of the North Sea in the United Kingdom and Norwegian exclusive economic zones (EEZ). Gas deposits are exploited mainly in the shallower southern regions in the United Kingdom, Dutch, and Danish EEZs as well as in Norwegian waters. There are several gas and oil production platforms in the Wadden Sea (OSPAR, 2000a).

Table 4: Summary of noise sources and activities associated with oil and gas exploration and production (adopted from Parsons *et al*., 2003).

	Activity	Source	Source type	Duration
Exploration	Seismic surveys	Air guns & Seismic vessels	Impulsive	Transient (weeks to months)
	Exploratory drilling	Machinery noise	Continuous	Transient (weeks)
	Transport (equipment & personnel)	Helicopters & Support vessels	Continuous Continuous	Transient (days, weeks)
Installation	Pile driving	Pile driver & Support vessel	Impulsive	Transient (weeks to months)
	Pipe-laying	Pipe laying vessel & support	Continuous	Transient (weeks)
	Trenching	Trenching vessel & support	Continuous	Transient (weeks)
	Transport (equipment & personnel)	Helicopters & ships	Continuous	Transient (weeks)
Production	Drilling	Machinery noise	Continuous	Permanent (years)
	Power generation	Gas turbines	Continuous	Permanent (years)
	Pumping	Gnereators	Continuous	Permanent (years)
	Transport (equipment & personnel)	Pumps, separators	Continuous	
		Helicopters & support vessels	Continuous	Transient (days, weeks)
Decommissioning	Destruction of pipes	Explosives	Impulsive	Transient (days, weeks)
	Transport (equipment & personnel)	Machinery noise	Continuous	Transient (days, weeks)
		Helicopters & support vessels	Continuous	Transient (days, weeks)

5.2.2.1. Seismic surveys (exploration)

Seismic surveys in the marine environment are one of the first stages in the exploration for oil and gas reserves beneath the seabed with a large survey ship towing the sound source and receiver equipment. Seismic surveys often operate over extensive areas for long periods of time. The sound source is generally an array of air guns. These are pneumatic devices (cylinders of compressed air) that produce an acoustic signal by rapidly releasing a volume of compressed air into the water column, forming a rapidly expanding and contracting bubble. The array, typically containing some tens of such cylinders, is discharged simultaneously, to generate a pressure pulse. The receiver equipment is generally a long streamer behind the ship (often several kilometres in length) which includes an array of hydrophones. Sound energy radiating outward from the gun array propagates downward through the seabed up to 4 km into the earth's crust and reflects from discontinuities in the underlying rock strata. The reflected sound waves are received by the trailing hydrophone array and the data processed to provide information about the structure and composition of geological formations below the sea bed and to identify potential hydrocarbon reservoirs (Goold & Fish, 1998; Parsons *et al*., 2003).

The output of air gun arrays is usually designed to produce a concentration of low-frequency energy, but the impulsive nature of the bubble collapse inevitably results in a broadband sound characteristic. In general, source levels at the low-frequency end of the spectrum are high, between 220 – 255 dB re 1 µPa @ 1 m (Richardson *et al*., 1995; Parsons *et al*., 2003). Although the direction of greatest sound intensity is downwards, a considerable amount of energy is radiated in directions away from the beam axis (McCauley, 1994 as cited in Parsons *et al*., 2003, Goold & Fish, 1998). This refers especially to higher frequencies. In shallow waters (like the North Sea) cylindrical sound propagation has a lower attenuation and is thus spreading over farther areas compared to spherical spreading in deep water (Richardson *et al*., 1995). The propagation characteristics imply that the sound levels received by an animal close to the source will depend on the animal's depth and position relative to the array's axis. Animals perpendicular to the axis of the array will experience a given sound pressure level at a greater range than those on the line axis of the array. At medium depths (several hundred meters) and assuming free field propagation, animals deeper in the water column and directly below the array will receive a higher intensity sound than animals closer to the surface but at the same range from the array (Parsons *et al*., 2003).

The extend to which seismic disturbance affects small cetaceans is not known for certain, since only a limited amount of research has been done. Most published research relates to the effects on large whales, and the high-frequency energy in the seismic pulse spectrum (>1 kHz) has generally been ignored in the literature (Goold & Fish, 1998).

Seismic airguns produce predominantly low frequency sounds, but it has been shown that high frequency noise is also produced. Goold & Fish (1998) found significant levels of energy across the recorded bandwidth up to 22 kHz. This high frequency sound, incidental to seismic operations, will overlap with the frequencies used by toothed whales, and could potentially cause disturbance to harbour porpoise. Goold (1996) observed that dolphins were temporarily displaced from areas of seismic activity. At 500 – 800 Hz, Richardson *et al.* (1995) expected components of the seismic sounds from a ship to exceed both the typical ambient noise levels and the absolute auditory threshold of the species 100 km away.

Harbour porpoise could also be affected indirectly as a result of the effects of seismic surveys on prey species. Loud noise over extended periods could cause temporary dispersion of aggregations of fish (e.g. Engås *et al*., 1996; McCauley *et al*., 2000; Engås & Løkkeborg, 2001) Engås *et al*. (1996) observed that seismic shooting severely affected fish distribution, local abundance, and catch rates. Trawl catches of cod and haddock and longline catches of haddock declined on average by about 50% (by mass) after shooting started. In this context it might be important that herring, an important component of harbour porpoise diet in the North Sea, is known to have special auditory capabilities (e.g. Enger *et al*., 1993, Culik *et al*., 2001). Loud noise over extended periods could cause temporary dispersion of aggregations of fish, resulting in a loss to the harbour porpoise, and/or higher energy demands associated with foraging activities.

5.2.2.2. Installation and production

Offshore oil and gas production is usually carried out from bottom-standing metal platforms, from man-made islands/caissons or from drill ships/semi-submersibles. Their design, construction and local oceanographic conditions will affect both the path of the sound in the water column and how much sound is transmitted. The larger the surface area in contact with the water, the more noise an object transmits. Thus drill ships, floating production storage and offloading platforms (FPSOs) and semi-submersibles will transmit more noise into the water column than fixed platforms or man-made islands. Jack-up rigs and rigs mounted on a metal jacket will typically produce less noise than gravity based structures, as they generally have larger surface areas (Parsons *et al*., 2003). Rotary drill tables are noisier than top drive mechanisms and rubber mounting pads for machinery can isolate vibration while baffles can direct noise from exhausts away from water and into the air (Parsons *et al*., 2003). During construction, noise is more efficiently coupled to the water through steel or concrete hulls or caissons than it is through gravel or sand islands. The temperature, salinity and pressure will affect how efficiently sound is transmitted.

Only relatively few studies on the underwater noise around drilling platforms have been undertaken. In all studies low frequency noise (< 200 Hz) was transmitted most efficiently, while broadband noise sources decreased more rapidly to ambient levels than tonal noise sources (Richardson *et al*., 1995).

5.2.2.3. Decommissioning

Oil and gas are extracted from underwater reservoirs by a vertical pipe or casing that has been drilled into the bedrock. At the upper end of this casing, where it leaves the bedrock and enters the water, a wellhead controls the flow and enables the well to be shut off.

As the wellhead protrudes from the seabed, there is a risk of fishing nets snagging on it. Current UK regulations call for the complete removal of offshore oil and gas industry structures once production has finished, to leave a clear, unimpeded seabed (Nedwell *et al*., 2001). For this reason, when wellheads are decommissioned, the casing is filled with concrete and the upper part of the wellhead, including a few meters of the casing below the mud line, is explosively cut and recovered to the surface.

The use of underwater explosives prompts concerns about the possible effects that detonations could have on the marine environment and on marine mammals. Clearly it would be preferable not to detonate explosives during periods when marine mammals are within ranges at which they might be injured by such explosions (either through the noise or the shock wave produced by the explosion), but data are still lacking.

5.2.3. Sand and gravel extraction

The marine aggregate extraction industry is well established and growing in a number of countries, providing up to 15% of some nation's demands for sand and gravel (ICES, 1992). Most commercially workable deposits of sand and gravel occur in the shallower regions of the North Sea. In 1996, about 40 x 106 m^3 were extracted from the sea (Table 5). The exploitation of sand and gravel often has negative impacts on fishing interests, the benthic flora and fauna, coastal protection and on the physical properties of the seabed. The exploitation of shallow banks close to the shore increases the potential for coastal erosion by enhancing wave activity and, therefore, careful assessment of the potential impact is needed. Most countries report increasing concerns about the extraction of aggregates (ICES, 1997).

Exploitation of marine sand and gravel resources is practised mainly using two methods: anchor hopper dredging and trailer suction hopper dredging. In the former, the dredger anchors over the deposit and mines it by forward suction through a pipe resulting in the formation of large pits up to 10 m deep and 10 – 50 m in diameter on the sea floor (Hygum, 1993 as cited in Hermann *et al*., 1999). Trailer dredgers, in contrast, extract the deposit by backward suction through one or two pipes whilst underway, thereby forming furrows on the sea floor of up to 2.6 m in depth.

In both cases, the aggregate and water are sucked aboard the ship's hopper. As the hopper fills, the wanted fractions of grain size are retained, while water and the remainder of the suspended substrate go back to the sea. The suspended fine material forms a large turbidity plume behind the vessel.

Table 5: Quantities of sand and gravel (m^3) taken from marine sources in 1996 and average for 1992 – 1997. (from ICES, 1997; OSPAR, 1998).

Country	1996	Average per year (1992 - 1997)
Belgium	1 444 629	1 833 333
Denmark	3 700 000	5 083 333
France *	590 000	2 200 000
Germany	1 100 000	
Netherlands	23 200 000	17 366 666
Norway **	86 111	118 333
Sweden #	0	5 917
United Kingdom **	9 500 000	13 600 000
TOTAL	39 620 740	

* Data from France.
** m^3 estimated from tonnes.
# Since 1992 no sand and gravel extraction occurs in the Swedish part of the Kattegat and Skagerrak area due to environmental reasons.

Information on potential effects of offshore mining on marine mammals are almost nonexistent. A study associated with locating a dredged material disposal site in Cape Cod Bay stated that evidence available on suspended sediments indicated that elevated levels of suspended sediments would have no effect on whales (Battelle, 1987). This conclusion was based on the speculation that whales often live in turbid environments; and certain species are known to feed on organisms in or on the sediment.

Secondary effects may be significantly more important than direct impacts. The dredgers emit broad-band noise of approximately 180 db (re 1 µPa @ 1m) with highest source levels between 20 and 1000 Hz (Richardson *et al*., 1995). Above 30 Hz, source levels are comparable to those of a large tanker (Richardson *et al*., 1995). While a tanker leaves an area quite quickly, the dredgers used for sand and gravel mining are more or less stationary. There are no data on the effects of noise emitted from dredgers on harbour porpoise.

However, observations on other cetaceans indicated that adverse effects should be anticipated. Gray whales, for example, were virtually absent from a lagoon in Baja California, an important breeding habitat for this species, during several years, because a hopper dredger was operating there (Bryant *et al*., 1984 cited in Richardson *et al*., 1995). The gray whales reoccupied the lagoon after dredging subsided.

Similarly, studies have shown that bowhead whales were displaced from the area after being exposed to playbacks of dredger noise recordings at broadband received levels of 122 – 131 dB (Richardson *et al*., 1985). While the whales stopped feeding and moved until they were over 2 km away from the sound source, vocalizations decreased and change in surfacing, respiration and diving patterns were recorded (Richardson *et al*., 1985).

Regarding these findings from other cetaceans, it would be important to assess the impact of dredging on harbour porpoise.

Impacts on main prey species of harbour porpoise may also be important. Primary effects of dredging will be e.g. on sandeels, as well as on their habitats. Sandeels have been proven to comprise up to 40% of the diet of harbour porpoise in the German Bight (Benke *et al*., 1998). Both zooplankton and phytoplankton can be affected by exposure to elevated suspended sediment. This may cause secondary effects on fish and their marine mammal predators. If fish actively avoid dredging plumes, harbour porpoise in the area may have to exert more effort in feeding or other behavioral changes. The available information presently is inadequate to allow any conclusions to be drawn about this issue, beyond suggesting that a potential for adverse impacts exists.

5.2.4. Wind parks

In order to fulfil the Kyoto Agreement of 1992 that the CO_2 emissions must be reduced by 5.2% of 1990 levels by 2012, many countries have made commitments to reduce their CO_2 emissions. They are commissioned to planning to expand their current renewable energy sectors. Wind farms offer many benefits over traditional energy sources and are expected to contribute significantly to a reduction in climate change in forthcoming years (Dolman *et al*., 2003).

To fulfil their renewable energy commitments, countries have set targets for total wind energy production, for both marine and terrestrial sectors. It is expected that within 10 years, wind parks with a capacity of thousands of megawatts will be installed in European waters.

The potentially negative impacts of marine wind farms on marine wildlife has only recently been recognized. The environmental impacts of marine wind farms can be separated into long or short-term influences: Construction and decommissioning phases have many short-term associated impacts, while the operational phase is likely to be a major source of long-term impacts (Dolman *et al*., 2003, Tougaard *et al*., 2003).

5.2.4.1. Construction

During the construction phase of the wind farm, increased ship traffic and turbidity due to construction and cable laying in the area is likely to have an effect on harbour porpoise to some degree. The most disturbing activity will be the ramming of monopiles into the seabed. This procedure might generate high intensity sounds of more than 250 dB re 1 µPa at a range of 1 m (Maxon, 2000), potentially able to cause permanent hearing damage to marine mammals and likely to affect animals over larger distances (Culik *et al*., 2001; Koschinski *et al.*, 2003, Dolman *et al*., 2003, Tougaard *et al*., 2003). The noise during pile driving has the potential to cause a temporary threshold shift (TTS) in harbour porpoise within 0.5 km of the sound source (Thomsen, pers. comm.). During construction at different neighbouring or even widely spaced sites, an additive effect can be assumed (Koschinski *et al*., 2003). The temporary habitat loss can affect fitness if the remaining low-noise habitat is sub-optimal in terms of maintaining the population (Koschinski *et al*., 2003).

5.2.4.2. Operation

During the operational phase of the wind farm, the continual operational noise and vibrations from the wind turbines have potential to cause long term effects (Dolman *et al*., 2003). Operational farms produce broadband low frequency noise above ambient noise levels (Degn, 2002) which is above the hearing threshold of harbour porpoise (112 dB measured at 250 Hz, Kastelein *et al*. 2002). Hoffmann *et al*. (2000) suggested that harbour porpoise will be displaced more permanently from a smaller area during the operational phase. Unless this area is considered to be a critical habitat, the overall effect is expected to be insignificant. Henriksen *et al*. (2001), however, assumed that harbour porpoise can only hear the turbines in a small part of the wind farm area (up to a distance of 50 m from the wind farm, assuming cylindrical spreading) and will therefore not be affected by the noise. Sightings of harbour porpoise entering the marine wind farm area at Horns Reef, Denmark, illustrate that porpoise do traverse this area, despite the presence of the marine wind farm (Teilmann *et al*., 2002). However, this does not demonstrate if and to what extent porpoises are being affected by the farm nor does it allow any assessment how significant any such impact might be. A porpoise might still enter an area that is important to it, despite negative consequences and exposure to certain sound levels for a prolonged period that might adversely affect the porpoise. Information on noise emissions from

5 MW mills and possible adverse reactions of harbour porpoise is still lacking. Furthermore, cumulative effects from several large wind farms in one region, above that adding to other detrimental anthropogenic impacts are completely unknown.

5.2.4.3. Decommissioning

Even though offshore wind farms are a young business, the possibility arises that turbines are removed from a park or a whole wind park is to be decommissioned. So far, there are no data available on the effects of such an undertaking on cetaceans, but drawing conclusions from the decommissioning of oil platforms, the use of underwater explosives seems most likely and prompts concerns about the possible effects such detonations might have on the marine environment and on marine mammals.

5.2.5. Sonar from military operations and research/survey activities

There is a growing body of evidence pointing to military activities as a major source of underwater noise. Several studies have voiced concern about the potential impacts of military activities upon cetaceans.

There are two basic types of sonars: passive and active. Passive sonars only listen to incoming sounds and are not of concern here. Active sonars are used for many purposes involving detection of objects under water. Most boats and ships have simple depth-finding sonars (fathometers). Other available sonars are used to find fish, to measure currents and to survey plankton and the ocean floor (Richardson *et al*., 1995). Military vessels routinely use active sonar on exercises and during routine activities. Many military sonars are designed to search for, locate, and classify submarines, while others detect obstacles like the seafloor, ice overhead and objects ahead. Sonars are fixed to mines and torpedoes to find targets and can be fixed to the ocean floor, suspended or towed from vessels or helicopters or built into sonobuoys dropped and controlled from aircraft (Richardson *et al*., 1995).

These sonar systems usually emit short pulses of sound and are designed to focus as much energy as possible in narrow ranges of direction (Parsons *et al*., 2003). Sonar frequencies range from a few hundred hertz for long-range search sonars to several hundred kilohertz for sonars used in mine-hunting, accurate mapping and profiling, and plankton surveys (Table 6).

Table 6: The acoustic properties of some active sonar systems (adapted from Richardson *et al*., 1995; Gill & Evans, 2002; Parsons *et al*., 2003; Zimmer, 2003; Evans & Miller, 2003).

Sonar type	**Frequency range (kHz)**	**Source levels (dB re 1 µPa/1m)**

Environmental Sonar		
Echo sounders	12-200	180-245
Bottom profilers	0.4-30	200-230
ADCP[a]	0.075-1.2	216
ATOC[b]	0.06-0.09	195
Short-range Imaging Sonar		
Side-scan	50-500	220-230
Multi-beam	15.5	237
Navigation (transponders)	7-60	180-200
Long-range detection sonar		
a) Tactical (Military) Search & surveillance	2-57	230+
Mine & obstacle avoidance	25-500	220+
Weapon-mounted	15-200	200+
b) LFAS	0.05-0.5	200+
Examples of long-range detection sonar:		
SURTASS LFA	0.1-0.5	240 (18*215)
SLC TVDS LF[c]	0.45-0.65, 0.7	214-228
SLC TVDS MF[c]	2.8-3.2, 3.3	223-226
AN/SQS-53C[d]	2.6, 3.3	223
AN/SQS-56[d]	6.9, 7.5, 8.2	245

[a] ADCP = Acoustic Doppler Current Profiler
[b] ATOC = Acoustic Thermometry of the Ocean
[c] Linked to mass stranding, Greece
[d] Linked to mass strandings in Bahamas & Canaries

Watkins *et al*. (1985 as cited in Perry 1998) noted that sperm whales reacted to military sonar at distances of 20 km or more from the source. Sonar at frequencies of 6 – 28 kHz caused cessation of calling and sometimes avoidance.

Fourteen beaked whales stranded or were found dead at sea in September 2002, on the coast of Fuerteventura and Lanzarote in the Canary Islands (Anonymous, 2002, Jepson *et al*. 2003, Fernandez *et al*. 2004). Individuals of three species, Cuvier's, beaked whale (*Ziphius cavirostris)*, Gervais' beaked whale *(Mesoplodon europaeus)* and Blainville's beaked whale *(Mesoplodon densirostris)* were involved, concurrent with the 11 nation NATO "Neo Tapon 2002" naval exercise that was said to be operating a joint force of 58 surface vessels, six submarines, and 30 aircraft between the Canaries and Gibraltar. Some of the force was operating near Fuerteventura when the whales came ashore. Special investigations of the heads of six Cuvier's beaked whales indicated ear and brain trauma consistent with trauma from acoustical impacts. Although similar strandings have since been correlated with other naval manoeuvres using mid-frequency sonar, the relationship was only identified after similar incidents in Greece 1996 and in the Bahamas in 2000 (Balcomb & Claridge 2001). A mass stranding of 17 cetaceans on the Bahamas in March

2000 has clearly been linked to mid-frequency (3 – 7 kHz, AN/SQS-53C and AN/SQS-56) sonar tests conducted by the U.S. Navy. The whales suffered haemorrhaging in the inner ears and cranial air spaces consistent with impulsive trauma, intense, loud sound that did not come from a nearby explosion (Parsons *et al*., 2003 and references therein).

During the period of May to June, 2003, the National Marine Fisheries Service (NOAA Fisheries) Northwest Marine Mammal Stranding Network received reports of 14 stranded harbour porpoise in Washington State, an abnormally high number when compared to the average stranding rate of 6 per year recorded over the past decade. The reports coincided with use of AN/SQS53C mid-range sonar by the naval vessel *USS SHOUP* in Haro Strait between Vancouver Island (Canada) and San Juan Island (USA) in May 2003 and observations by researchers and the public who reported altered behaviour of marine mammals in the area. Eleven porpoise were collected for necropsy. The examinations did not reveal definitive signs of acoustic trauma in any of the porpoises examined. The possibility of acoustic trauma as a contributory factor in the mortality of any of the porpoises could not be ruled out, though, as lesions consistent with acoustic trauma can be difficult to interpret or obscured, especially in animals in advanced post mortem decomposition (Norman *et al*., 2004).

5.3. Pollution

In recent years a growing concern has been expressed about the possible adverse effects pollutants may have on marine mammal populations. Awareness of the threat of environmental contaminants to marine mammals is widespread. High concentrations of certain compounds in the tissues of these animals have in the past been associated with organ anomaly, impaired reproduction and immune function, as shown by large die-offs among seal and cetacean species. Indeed, recent mass-mortalities and stock declining among several marine mammal populations from highly polluted areas have among others been attributed to the contamination by organochlorines such as PCBs.

5.3.1. Organic pollutants

Pollutants in the marine environment can be divided into organic and inorganic pollutants. Organic pollutants include all the compounds which have carbon as their main constituent and include many of the pesticides, for example dichlorodiphenyl trichloroethane (DDT) and other groups of compounds such as the polychlorinated biphenyls (PCBs), dioxins, oil-derived polyaromatic hydrocarbons (PAHs) and brominated flame retardants such as polybrominated diphenylethers (PBDEs). Many of them are molecules that are very stable and persistent in the environment and are termed “persistent organic pollutants” (POPs). The following chapters function as examples of such organic pollutants, but only represent a small fraction of organic pollutants in the marine environment.

5.3.1.1. Organochlorines

Organochlorines are synthetic molecules consisting of a hydrocarbon molecule with a variable number of chlorine substitutions. PCBs and DDTs have been in use since the 1930s, PCBs mainly in electrical equipment and in automobile manufacture, DDTs as an insecticide (Hughes, 1998). Once in use, organochlorines entering the terrestrial environment increased rapidly and over the years seeped into freshwater systems and finally into the marine environment.

Cetaceans are particularly vulnerable to organochlorines because of their position as top predators in the food chain. As top predators and due to a low metabolic capacity for degradation both in the animals themselves and components of their food chain, harbour porpoise accumulate high concentrations of lipophilic and persistent organic compounds through their diet (Law *et al.*, 1998). As organochlorines are lipophilic, they accumulate in lipid-rich tissues, such as the blubber of harbour porpoise. Levels of contamination depend largely upon the diet, sex, age and behaviour of the marine mammal in question. Coastal species tend to accumulate higher levels than more oceanic species due to closer proximity to discharge points. The long life span of cetaceans means that they accumulate pollutants over long periods, thus concentrations of organochlorines tend to increase with age. This is seen in females only until their first calf is born, at which time a large part of the contaminant load is transferred to the newborn via gestation and lactation (Clausen & Andersen, 1988; Grillo *et al*., 2001 and references therein).

The reported effects of high PCBs and other contaminant loads include immuno-suppression, a higher susceptibility to infectious diseases and physiological changes that lower the reproductive potential of marine mammals through hormone imbalance (for a detailed summary see Hughes, 1998). Jepson *et al*. (1999) found a significant relationship between elevated blubber PCB concentrations and mortality due to infectious disease in harbour porpoise. This suggests a causal relationship between chronic PCB exposure and mortality due to infectious diseases.

5.3.1.2. Hydrocarbons

Activities and accidents in the exploration, extraction and transportation of crude oil result in a large proportion of the global input of hydrocarbons in the marine environment. The North Sea is subjected to several sources of oil pollution. There are waterborne industrial effluents, discharges from shipping, and inputs from emissions and flaring operations by the offshore oil and gas industry.

The compounds making up oil can be divided into two broad groups, aliphatic compounds which have comparatively low toxicity, and an aromatic fraction which contains the more toxic compounds, such as the polycyclic aromatic hydrocarbons (PAHs). Their lipophilic nature enables them to cross biological membranes and accumulate in organisms, causing considerable damage (Marsili *et al*., 2001).

The effects of hydrocarbon pollution on cetaceans are poorly known, but it could potentially cause damage or irritation of the skin, eyes and in baleen whales, the baleens through physical smothering; poisoning, through ingesting contaminated prey or oil directly, and/or inhalation, changes in prey populations and reduction in suitable habitat. Gubbay and Earll (2000) reviewed the effects of oil spills on cetaceans and highlighted the fact that there is limited scientific data and considerable uncertainty surrounding this subject.

Cetaceans do not seem to be so vulnerable to "fouling" by oil, since they have neither fur nor feathers for thermal insulation. In experiments with four odontocetes in which crude oil was applied to discrete areas of skin, there was no reaction after 75 minutes (Geraci, 1990). It was suggested that this was due to the extraordinary thickness of the epidermis presenting an effective barrier to the noxious chemicals found in oil and the tight intercellular bridges in the skin. It was concluded that contact with oil spills is likely to have no effect on the skin of cetaceans.

Ingestion of oil may occur when cetaceans are in direct contact with a spill. In mammals generally, ingestion of oil can cause a number of effects including irritation of the gastrointestinal tract (Zieserl, 1979), liver damage and high doses can adversely effect the nervous system (Caldwell & Caldwell, 1982 as cited in Hughes, 1998). Ingestion through their prey is also possible, since hydrocarbons persist in the food chain, particularly in species lacking the correct detoxification mechanisms. Particularly benthic feeders such as gray whales (*Eschrichtius robustus*) are the most at risk of contamination through their diet (Würsig, 1990).

Oil may also limit prey resources as exposures to PAHs are known to affect egg production of fish. PAHs have the potential to affect the numerous early life stages that reside in the surface micro layer of the oceans, where PAHs can become concentrated (WWF, 1997).

Cetaceans can detoxify hydrocarbon compounds to some extend, hence toxic effects may be minimized within the relatively short periods of contact of a cetacean with an oil spill. Harbour porpoise might be at greater risk from the toxic effects of oil because of the likelihood of prolonged exposure due to the fact that they reside close to the shore and in bays and estuaries.

5.3.1.3. Perfluorooctanes

Over the past few years, perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS) and similar compounds have emerged as an important class of persistent global pollutants referred to as perfluorochemicals (PFCs). PFCs are compound of chains of fully fluorinated carbon atoms of varying lengths, yielding chemicals that are extremely resistant to heat, chemical stress, and that repel both water and oil. Because of these properties, PFCs have widely been used since the 1950s as surfactants and emulsifiers, stain or water protectors for carpet, textiles, auto interiors, camping gear and leather; food packaging; folding cartons and other paper containers; floor polishes; photographic film; shampoos; dental cleaners; inert pesticide ingredients; and lubricants for bicycles, garden tools and zippers (Brown, 2003).

PFOS and PFOA have been detected in various animals, including cetaceans from the Mediterranean and Baltic (Kannan, *et al*., 2002). Studies on the effects of PFCs on marine mammals are nonexistent, but laboratory studies with PFOA involving rats showed low birth weight, small pituitary gland, altered maternal care behavior, high pup mortality, and significant changes in the brain, liver, spleen, thymus, adrenal gland, kidney, prostate, testes and epididymides (Thayer *et al*., 2003). All studies to date indicate that perfluorinated compounds damage the immune system.

5.3.2. Inorganic pollutants

In addition to organic pollutants, there are inorganic pollutants such as trace elements. Trace metals are usually divided into essential (e.g. zinc, copper, chromium, selenium, nickel, aluminum) and non-essential metals (e.g. mercury, cadmium, lead), the latter being potentially toxic even at low concentrations. Very few studies have tried to link metal concentrations measured in free ranging marine mammals and health status (Hÿvarinen & Sipilä, 1984; Siebert *et al*., 1999; Bennet *et al*., 2001). A clear cause and effect relationship between residue levels of organic contaminants and the observed effects has been demonstrated in a few studies only. Assessing the impact of other contaminants such as trace metals on marine mammal populations is even more difficult as metals are not strictly man-made chemicals. They are driven to the oceans by rivers, dumping discharges, atmospheric inputs and can be found naturally in all compartments of the biosphere. Once in the system, the metals concentrate in protein rich tissues such as liver and muscle (Grillo *et al*. 2001). The levels of trace metal in the tissue (liver and kidney) of the harbour porpoise depend on several factors including the age, the diet, the geographic location and the nutritional status (Siebert *et al*., 1999; Bennet *et al*., 2001, Das *et al*., 2003; 2004).

High trace metal burdens in cetaceans have been associated with a variety of adverse responses including lymphocytic infiltration, lesions and fatty degeneration and decreasing nutritional state and lung pathology (Grillo *et al*., 2001, Siebert *et al*., 1999; Bennet *et al*., 2001; Das *et al*., 2004, Sabin *et al*., 2004).

Specifically in harbour porpoises, Siebert *et al*. (1999) examined the possible relationship between mercury (Hg) tissue concentrations and disease in harbour porpoise from the German waters of the North and Baltic Seas. A higher mercury content has been measured in organs of harbour porpoise from the North Sea compared to those of the Baltic Sea, indicating that mercury is a more important threat for animals of the North Sea than for Baltic Sea. High mercury (Hg) concentrations were associated with prevalence of parasitic infection and pneumonia. Bennet *et al*. (2001) have also used this indirect approach to investigate the prediction that increased exposure to toxic metals results in lowered resistance to infectious disease in harbour porpoises from the coasts of England and Wales. Mean liver concentrations of Hg, selenium (Se), Hg:Se ratio, and zinc (Zn) were significantly higher in porpoise that died of infectious diseases (parasitic, bacterial, fungal and viral pathogens such as pneumonia), compared to porpoise that died from physical trauma (most frequently entrapment in fishing gear). Liver concentrations of lead (Pb), cadmium (Cd), copper (Cu), and chromium (Cr) did not differ between the two groups. Similarly, high Zn and Hg concentrations were also observed in some porpoises collected along the southern North Sea coast compared to individuals by-caught in Iceland, Norway or the Baltic Sea (Das *et al*., 2004). Increasing Zn levels were observed with degrading body condition (emaciation and bronchopneumonia), while Hg increase was not significant. These increasing concentrations were not related to a shrinking of liver mass, remaining unchanged during the emaciation (Das *et al*., 2004).

5.3.3. Marine debris/litter

Despite pertinent laws and regulations, litter is still a considerable problem for the marine environment and the coastal communities. Potential sources of litter are mainly related to waste generated by shipping (fishing, commercial) and touristic and recreational activities. It has been estimated that the North Sea has to cope with about 70 000 m^3 of litter per year, and some 6.6 million pieces (or 8 600 t) were estimated to be present in the Dutch sector alone (OSPAR, 2000a).

Lightweight, strength and durability are properties of plastics which make them favourable for the manufacture of many products. It is these properties which also pose a threat to wildlife when plastics are released into the environment. Entanglement in discarded plastics (including so-called "ghostnets" that continue to impact upon cetaceans and their prey) and ingestion of marine debris have been shown to cause death through injury, drowning or starvation (e.g. Kastelein & Lavaleije, 1992; Walker & Coe, 1990; Baird & Hooker, 2000). Findings by Kastelein & Lavaleije (1992) indicated that large debris pollution may be a more directly lethal problem to individual marine mammals than chemical pollution as the latter reduces reproductive rate and longevity to some extent, but only rarely leads to immediate death.

5.3.4. Eutrophication

The increase of discharges form domestic, industrial and agriculture activities, the growth of industrial sectors such as basic chemistry and food processing industries, the application of increasing amounts of fertilizers on agricultural soils, the intensification of cattle farming and the use of polyphosphates in detergents have all contributed to increases in nutrient loads in coastal waters. The introduction of large quantities of nutrients can lead to increases in primary production and algal biomass. Degradation of this biomass requires large quantities of oxygen. This can be a major problem in areas with restricted water exchange capacity or stratified bodies of water. In these cases major algal blooms have led to serious damage to aquaculture through oxygen depletion and toxin formation.

5.3.4.1. Algal blooms

In the North Sea, the main harmful consequences of algal blooms are a reduction in food resources for zooplankton as the size of the colony often precludes most species form grazing it, increased deposition of organic material to the bottom, and accumulation of organic material either dissolved or in the form of a slimy foam (Lancelot *et al.*, 1987). Algal blooms also contribute to atmospheric sulphate levels as some microscopic algae produce dimethyl sulphoniopropionate (DMSP) which is released into the water when they die where it breaks down into dimethyl sulphide (DMS). DMS is a natural sulphate aerosol which contributes to climate change.

Harbour porpoise may be affected through consumption of fish contaminated by algal blooms. For example, analyses conducted on dolphins stranded along the Florida Panhandle in spring of 2004 found brevetoxins, naturally occurring neurotoxins produced by *Karenia brevis*, the Florida red tide, at high levels in the stomach contents of all dolphins examined, and at variable levels in the tissues of these animals (NOAA, 2004). The concentrations of brevetoxins observed in the analyzed sub-sample of the stomach contents were greater than or equal to those observed in previous marine mammal mortality events associated with Florida red tides in the Gulf of Mexico. In most of the dolphins, the first chamber of the stomachs was gorged with large amounts of fish, some of which were partially whole and undigested indicating recent feeding. Fish (planktivorous, herbivorous, and omnivorous fish species) collected from St. Joseph Bay tested positive for brevetoxins in stomach contents and in muscle, liver, and gill tissues. The presence of toxic fish and water suggests that there was an undetected bloom somewhere either in the bay itself or in waters in which the fish or dolphins were feeding. A similar dolphin unusual mortality event (UME) occurred in 1999-2000 in the same area of Florida and was correlated with a *Karenia brevis* bloom.

5.3.4.2. Disease

Sewage effluent entering coastal waters also can contain a variety of harmful substances including viral, bacterial and protozoan pathogens (Grillo *et al.*, 2001). In many coastal countries, urban and industrial sewage and wastewaters are discharged into coastal waters, the contents of these wastewaters pose a potential threat to marine species inhabiting these waters and their associated ecosystems. Domestic sewage discharged into coastal waters contains a mix of both harmless and infectious micro-organisms (Rees, 1993).

There is limited information on the effects of sewage-borne pathogens on the marine ecosystem and the species therein, including the harbour porpoise. However, porpoise, being mammals, are vulnerable to a number of diseases, parasites and pathogens which can be transmitted either via human or agricultural sewage waste or may occur naturally in the marine environment (Grillo *et al.*, 2001).

Heavy loads of parasites are often reported in porpoises without disease. Nevertheless, parasitism is often associated with macroscopical and microscopical lesions. Jepson *et al*. (2000) found the airways to be commonly infested by more than one parasite species.

Bronchopneumonia is frequently associated with parasitosis or emaciation, or both. These are chronic, debilitating processes which might predispose to fatal bronchopneumonia, lung parasitism, often leading to secondary bacterial infection (Jauniaux, *et al*., 2002). After entanglement in fishing nets, this combination has been identified as the most frequent cause of porpoise death in British (Baker & Martin, 1992; Jepson *et al*., 2000), Dutch (García Hartmann, 1997) German (Benke *et al*., 1998, Siebert *et al*., 1999, 2001), Belgium and northern French (Jauniaux, *et al*., 2002) waters. The most significant consequence of pulmonary nematodiasis is probable impairment of pulmonary clearance and organ-specific immunological functions, resulting in bacterial infection (Siebert *et al*, 2001). Siebert *et al*., (2001) suggested that heavy parasitic infestation in the airways and pulmonary blood vessels may reduce the ability of animals to dive and hunt efficiently.

Nematode and trematode infections can cause chronic inflammatory lesions of the stomach and liver. Such lesions might interfere with digestion and occasionally serve as a portal of entry for fungal or bacterial pathogens (Siebert *et al*., 2001, and references therein). Nematode infections of the middle ear might provide a portal of entry for bacterial infection (García Hartmann, 1997) and might interfere with navigation (Howard *et al*., 1983 as cited in Jauniaux *et al*., 2002).

Viruses belonging to 9 families have been detected in cetaceans (van Bressem *et al*., 1999). Some of these (cetacean morbillivirus and a "porpoise herpesvirus") cause serious lethal diseases while the health consequences of infections by influenza-, rhabdo-, and adeno-viruses remain unkown (van Bressem *et al*., 1999). Infection with an unrecognised hepadnavirus was associated with chronic persistent hepatitis. Viruses of the families Poxviridae, Papovaviridae, Herpesviridae and Caliciviridae cause epithelial lesions of the skin and/or genital tract. In Burmeister's porpoise (*Phocoena spinipinnis*) from Peru, lesions in 10% of the males were sufficiently severe to at least hamper, if not impede, copulation (van Bressem *et al*., 1999). The dolphin and porpoise morbilliviruses (DMV and PMV, family Paramyxoviridae) can cause serious, potentially lethal diseases in cetaceans (Van Bressem *et al*., 2001). PMV caused some mortalities in harbour porpoise along the coasts of Ireland (n = 6) and The Netherlands (n = 2) in 1988 – 1990 (McCullough *et al*., 1991, Visser *et al*., 1993). Some viruses appear to be species- (e.g. papillomaviruses) or order- (e.g. morbillivirus) specific, while others (influenza-, rhabdo- and caliciviruses) have a broader host range including animals from different classes and/or phyla. A study of DMV and PMV by Taubenberger *et al*. (1996) indicated that these viruses are not species specific.

High levels of organochlorines contaminants or mercury in harbour porpoise populations may reduce host immune resistance and contribute to the severity of infections (Aguilar & Borrell, 1994, Ross *et al*., 1996, both cited in Van Bressem *et al*., 2001; Jepson et al., 1999; Siebert et al., 1999; Jauniaux *et al*., 2002). Van Bressem *et al*. (2001) presented data that suggest that the populations of harbour porpoises from the NE Atlantic and North Sea are losing their immunity to the dolphin morbillivirus and may be soon at risk from new virus introductions. The re-introduction of cetacean morbillivirus into these populations could cause new epidemics which would further deplete their numbers. Van Bressem *et al*. (1999) suggested that the synergistic interactions between mortalities in fisheries and morbillivirus epizootics could significantly reduce the numbers of individuals of some populations and increase their risk of extinction.

5.4. Global warming and climate change

Climate change, resulting from increased concentrations of greenhouse gases in the atmosphere, is the most serious global problem. The growing scientific consensus is that this warming is largely the result of emissions of carbon dioxide and other greenhouse gases from human activities including industrial processes, fossil fuel combustion, and changes in land use, such as deforestation. Projections of future warming suggest a global increase of 1.4^{o}C to 5.8^{o}C by 2100. This warming, along with the associated changes in precipitation and sea-level rise will have important consequences for the environment (Pew Center on Global Climate Change, 2005).

Global warming is expected to increase ocean temperatures and to increase the flow of freshwater into the ocean through precipitation, run-off, and melting of glaciers. Many climate models have projected that increased surface ocean temperatures and reduced salinity could slow the thermohaline circulation. A few models have projected a complete shutdown of the thermohaline circulation in the case of severe global warming, but this is being debated by the scientific community. The probability of the thermohaline circulation shutting down is not known. It depends on how much and how quickly the atmosphere warms. In general, it is considered possible, but not very likely. If it were to occur, it would probably not happen within the next 100 years, and circulation would eventually recover, after decades or centuries (Pew Center on Global Climate Change, 2005).

Climate change will directly and indirectly affect cetaceans. The rise in temperature will affect the habitat of the whales, as the distribution and abundance of prey species in the oceans will change. Harbour porpoise live in a broad geographical range from warm temperate seas to the sub arctic and might be not immediately vulnerable to slow changes in the ocean climate of the North Sea. However, as top predators, harbour porpoise are very vulnerable to changes in the lower levels of marine productivity (Scheidat & Siebert, 2003). Should the prey be unable to adapt to such changes, harbour porpoise reproductive success and therefore their abundance and population structure will be in jeopardy.

Another negative effect is the depletion of the ozone layer which protects the earth from ultraviolet (UV) radiation. Experiments have shown that UV-B radiation inhibits the photosynthesis of phytoplankton (e.g. Wangberg *et al*., 1999) and that krill dies within a week when exposed to very high doses of UV radiation (Newman *et al*., 1999). Effects on the lower trophic levels will most certainly have an effect on the higher levels. For cetaceans there may also be direct affects on their health in the form of skin cancer and eye problems (de Boer & Simmonds, 2003).

6. Mitigation measures and recommendations to support the recovery of harbour porpoise in the North Sea

6.1. By-catch reduction

By-catch reduction should have the highest priority for a recovery plan for North Sea harbour porpoise. Measures to achieve such reduction should begin immediately. As there is no universal solution to by-catch reduction, since the suitability and efficiency of mitigation measures depends on the specific circumstances associated with a fishery, strategies should have multiple mitigation approaches as a way of dealing with the uncertainty of outcome associated with any individual measure (Read, 2000). As noted in the Jastarnia Plan (ASCOBANS, 2002), it is important that fishermen and their representatives are closely involved in the implementation process. They should be included in any discussions and decision-making that may have implications for their livelihoods. It is also important to underline that the same by-catch reduction measures might not be appropriate on the same time schedule for the whole of the North Sea – as harbour porpoise are not a homogenously distributed over the area.

There are a large number of international and regional treaties, conventions and agreements that target the protection of the marine environment, many of them covering fisheries or the exploitation of living resources, several making specific commitments or resolutions on the matter of incidental capture of cetaceans. The United Nations Convention on the Law of the Sea (UNCLOS) of 1982 requires of states to make sure that species associated with or dependent on harvested species are not depleted to levels at which they would become seriously threatened. The Rio Earth Summit (1992), the UN Food and Agriculture Organisation Code of Conduct for Responsible Fishing (1994) and the Rome Consensus on World Fisheries (1995) all address the problem of indiscriminate fishing methods.

The International Whaling Commission (IWC) recommended as early as in 1975 that member nations begin to record the by-catch of small cetaceans. The Convention on Migratory Species of Wild Animals (CMS) passed a Resolution 6.2 in 1999 which recognises by-catch as one of the major causes of mortality of migratory species in the marine environment and requires Parties to the Convention to minimise as far as possible the incidental mortality of migratory species (CMS, 1999). In 2002, this resolution was reaffirmed when the CMS Parties emphasised that by-catch remains one of the major causes of mortality from human activities in the marine environment and recommended a fast implementation of CMS Resolution 6.2 (CMS, 2002).

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) of 1998 highlights the need for more research and information on the effects of fishing on non-target species such as marine mammals amongst other impacts, and for improvement in the monitoring and reporting of by-catch and discards (OSPAR, 2000b).

Article 2 of the Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora (Habitats Directive) of 1992 places a duty on member states to ensure that any measures taken under the Directive are designed to "maintain or restore, at a favourable conservation status, natural habitats and species of wild fauna […] of community interest" (which include all cetaceans). Furthermore, article 12.4 requires member states to establish a system to monitor the incidental capture and killing of Annex IV species, which includes the harbour porpoise.

The European Council Regulation No 812/2004 of April 2004 lays down measures concerning incidental catches of cetaceans in fisheries. The Regulation contains three main provisions which relate to:

a) the use of acoustic deterrent devices (pingers) in gillnet fisheries,
b) onboard observer monitoring of by-catch, and
c) the phase-out and elimination of driftnet in the Baltic Sea (which is not relevant for this recovery plan).

These provisions only apply to certain fisheries and areas within EU waters as listed in the Annexes of the Regulation. Additionally, the Regulation makes provisions for reporting, assessing and reviewing of its implementation (more about the Regulation in detail in the following chapters).

6.1.1. Reduction of fishing effort

There appears to be a direct relationship between fishing effort and the total number of animals caught in a specific type of fishery. Reduction in fishing effort in these fisheries should lead to a proportional reduction of by-catch (Read, 2000; CEC, 2002a). Bottom-set gillnets and entangling nets are a major source of incidental mortality. The reduction in fishing effort in the Danish gillnet fisheries in the most recent years has led to a reduction of the level of by-catch (Vinther & Larsen 2002).

Reduction in fishing effort may include a reduction in soak time (amount of time the nets are in the water) and/or net lengths, as well as time and area fishery closures (ICES, 2001) and days at sea limitations. It should be noted, however, that certain fisheries, such as the gill net fishery on turbot may be no longer viable if soak time and net length are reduced significantly. Reduced catch quotas or reduced fleet sizes will not necessarily reduce by-catch, since reductions in catch quotas and/or fishing capacity are not the same as reductions in fishing effort. It is important to note that fisheries closures need to be permanent or long-term. Spatial temporal closures are only reasonable if enhanced monitoring and data analyses indicate harbour porpoise by-catch hotspots (ICES, 2001).

It is recommended that North Sea range states should take measures to reduce all fishing effort using bottom-set nets in the North Sea until effective measures to reduce the by-catch from this type of fishing have been developed.

6.1.2. Mandatory use of pingers

Acoustic deterrents, or pingers, have been widely demonstrated to reduce harbour porpoise by-catch in gillnet fisheries. There currently exist two types of pingers:

- Permanently/continuously active pingers, and
- interactive pingers which only emit signals upon being triggered by a porpoise click.

Read (2000) has extensively reviewed the use of pingers in US fisheries and reported that by-catch rates for certain fisheries were reduced significantly (10-fold for harbour porpoise). Work carried out by the UK's Natural Environment Research Council's Sea Mammal Research Unit (SMRU) on the set net fishery in the Celtic Sea, yielded a 92% reduction in by-catch of harbour porpoise in pingered nets compared to unpingered nets (SMRU, 2001). Since August 2000, the use of pingers has been mandatory in the Danish cod wreck fishery between August and October. Here, the effect of pinger use is reported to be as close to 100% reduction in by-catch in the observed part of the wreck fishery (Larsen *et al*., 2002; Vinther & Larsen, 2002).

Despite the obvious effectiveness in reducing by-catch in set net fisheries, however, there are a number of drawbacks and concerns about the use of pingers among fishermen. Essentially, pingers are

- considered to be expensive,
- they need a high level of maintenance,
- some types of pingers are prone to failure, and
- they may interfere with the setting and hauling of nets (reviewed by Read, 2000; Ross & Isaac, 2004).

These are factors which may make them unpopular with fishermen.

Other shortcomings raised by scientists are:

- pingers may reduce the level of by-catch significantly but do not ensure zero by-catch
- the effective monitoring and enforcement of pinger use may prove to be very difficult. This has to be addressed through a costly, large-scale and independent observer program. The importance of independent on-board observation at an appropriate sampling level to obtain reliable data on cetacean by-catch is well documented. Despite the associated difficulties with high fishing effort and low by-catch rates, by-catch monitoring should be made an integral part of any pinger implementation programme where feasible, and especially in the high-risk areas identified.
- an additional concern is that porpoises might habituate to pingers – rendering the technology ineffective over time . For example, Carretta & Chivers (2004) report that the observed kill rate of short-beaked common dolphins in Californian waters in 2003 has been higher than rates observed in 2001 and 2002, and has been the second-highest kill rate observed in set nets using pingers since their use began in 1996.

- the continuous and widespread use of pingers might frighten animals away from some areas and so may deprive them of foraging grounds. This would have potentially adverse effects on their conservation status (CEC, 2002a), and
- pingers emitting sound permanently would substantially contribute to noise pollution in the ocean

Several of these concerns have been addressed in recent studies:
Experimental studies in Canada have demonstrated that after a period of weeks of exposure to pingers, the animals began to surface closer to the acoustic devices (Cox *et al*., 2001). This did not mean that the pingers were necessarily ignored, but simply that they reacted less severely to their presence (Cox *et al*., 2001). Lockyer *et al*. (2001) demonstrated on captive porpoises that once the source of sound emission was removed, the animals rapidly returned to the area from which they had been displaced. On this basis, harbour porpoises in the wild could be expected to move back into areas once pingered fishery operations had been terminated.
More recent research has been directed towards interactive pingers with a deterrent device that only emits sound when triggered by the sonar clicks of an approaching porpoise (Amundin *et al.*, 2002, Poulsen, 2004). This approach addresses the concerns of noise pollution and habituation with the pingers transmitting sounds only when needed, thereby delaying potential habituation and habitat exclusion. First trials with free-ranging harbour porpoise were promising (Poulsen, 2004).

Council Regulation EC 812/2004 lays down in its articles 2 and 3 that specified gillnet and entangling fisheries in ICES areas IV (North Sea), III a (Skagerrak), VII e (Celtic Sea) and VII d (English Channel) are required to use pingers during specified periods or all year. Introduction of pingers is not required until 2005 for areas IV and III a, until January 2006 (VII e) and January 2007 (VII d) respectively (see Annex 1). Furthermore, the Regulation specifies the type of pinger to be used (see Annex II).
Member States may authorise the temporary use of acoustic deterrent devices which do not fulfil the technical specifications or conditions of use defined in annex II of the Regulation, provided that their effect on the reduction or incidental catches of cetaceans has been sufficiently documented. Such authorisations shall not be valid more than two years.
However, the Regulation has some shortcomings. Boats less than 12 m long are exempt, which means that many gill-netters, particularly in inshore fleets, will not be required to use pingers, furthermore putting inshore populations of harbour porpoise at risk.

The pinger provision does not have to be implemented until June 2005 at the earliest and January 2006 and 2007 in different areas. Thus, pinger deployment can be delayed in fisheries where by-catch is well documented with the consequence of porpoise's deaths in the meantime.
Furthermore, vessels using pingers are not required to carry observers, so there will be little if any monitoring of whether the devices are being used correctly or if by-catch rates are being reduced in these fisheries.
Article 2.4 requires member states to monitor and assess, by means of scientific studies or pilot projects, the effects of pinger use over time in the fisheries and areas concerned. The Regulation provides no specification for the detail, timeframe or extent of these studies, it only states that the reporting of these studies by member states should ensure that sufficiently high quality standards are reached in their design and implementation (Article 6.2.), leaving this provision to being conducted inadequately or neglected.

Each EU member state has powers under the Common Fisheries Policy (CFP) to apply further fisheries management measures to its own vessels in its own waters as long as they are compatible with the objectives of the CFP and are no less stringent than existing Community legislation (Article 10, Council Regulation EC 2371/2002).

To reduce porpoise deaths in the North Sea, the following measures should be taken as soon as possible at the absolute minimum:
It is recommended to introduce mandatory pinger deployment in all gillnet and entangling fisheries listed in Annex I as soon as possible.
To achieve adequate protection of vulnerable inshore populations and prevent redeployment of gillnet and tangle net effort to vessels less than 12 m long, it is recommended to undertake an assessment of static net effort. This will identify areas where gillnet use should be restricted or halted and areas where mandatory pinger deployment should be introduced.
The conduction of compulsory observation of vessels that deploy pingers is recommended, to ensure their correct and effective use as well as monitoring of their impacts.
Further trials with interactive pingers are recommended to be conducted in the near future. If proven to successfully alleviate potential problems of habituation and noise pollution, interactive pingers should be introduced as quickly as possible in all North Sea bottom-set gillnet and entangling fisheries.

Implementation of pingers (no matter if interactive or not) should be short-term and therefore should be reconsidered within 3 years, with the expectation that pinger use will be replaced by longer-term mitigation measures at that time. The rapid development of medium- and long-term approaches to mitigation (e.g. reduced fishing effort in high-risk areas, conversion to fishing gear and practices that are much less likely to result in porpoise by-catch) is crucial and should not be compromised. This work should be initiated immediately and in parallel with the identification of high-risk areas and targeted pinger implementation efforts.

6.1.3. Gear modifications

There are a number of modifications of fishing gear and deployment practices that have been tested in the context of by-catch mitigation. Existing modifications range from relatively minor alterations, such as changes in mesh size, twine diameter and deployment depth, to more substantial structural modifications, such as excluder grids in pelagic trawls (Northridge, 2003), and attempts to enhance the acoustic visibility of nets either through the use of nets with hollow cores or acoustic reflectors (Goodson *et al*. 1994, Silber *et al*., 1994; Koschinski & Culik, 1994), or nets impregnated with a metal compound such as barium sulphate or iron oxide, so called high-density nets (Larsen *et al*., 2002; Mooney *et al*., 2003; Trippel *et al*., 2003). Acoustic enhancement has a number of advantages relative to pingers of which the most important are:

- no habituation of porpoises
- no noise pollution, and
- no need for an energy source.

However, the reduction of by-catch through the better detectability of nets rests upon the unproven assumption that odontocetes are entangled because they fail to detect nets, or if they detect them, that they do not perceive them as hazardous. Larsen *et al*. (2002) present several possible reasons for an animal to fail in detecting nets:

- animals do not use their sonar to scan for obstacles sufficiently often (or fail to pay attention to them, even though echolocating)
- animals orient themselves in a way that the net is out of the sound beam
- echoes from the nets are masked by echoes from swimming or entangled prey in and around the net, or

- the net itself is not detectable by the odontocetes at a sufficiently large distance to avoid entanglement.

Enhancing the detectability of nets could reduce by-catch in the two latter situations, while it alone will not have an effect on by-catch in the former two cases. Studies of detection distances for porpoise and delphinids suggest that they are capable of detecting gillnets, although the detection distance can be quite short depending on factors such as ambient noise levels, angle of incidence, the net itself and attached materials such as floats or lead lines (Au, 1994; Kastelein *et al*., 2000). If harbour porpoise get entangled because they do not perceive the nets as a hazard, it could be because the echo from the nets is not sufficiently strong, in which case enhancing the detectability again could reduce by-catch.

Experiments with high-density nets have produced ambiguous results so far: by-catch rates were smaller (e.g. Read, 2000; Mooney *et al*., 2003; Trippel *et al*., 2003), but observed by-catch reductions have been connected to unacceptably high decreases in catch of the target species (Larsen *et al.*, 2002). Read (2000) reported, that in experiments in the Bay of Fundy with nets impregnated with barium sulphate by-catch was reduced significantly, while no significant difference was recorded in the take of the target fish species. Cox & Isaac (2004) concluded from observations on free-ranging harbour porpoise around chemically enhanced (barium sulphate) gillnets in the Bay of Fundy that porpoise do not respond to the acoustic reflectivity of the modified nets. They rather accounted the effectiveness of these nets to some other mechanical property, such as increased stiffness as a result of the metal filler.

If porpoises do get entangled because of failure to detect the nets in time, then increasing the target strength of the nets seems a viable strategy. However, it is not known whether failure to detect the nets is the fundamental problem for the animals. Kastelein *et al*. (1995) demonstrated that detection may not be the problem *per se*, but rather the attention of the animal. In their studies, the porpoise kept well clear of a suspended gill net in their pool for a long time, but eventually they were all entangled, perhaps due to lack of attention or distraction from the net. If the target strength is the fundamental problem, fairly large increases of target strength are needed in order to produce significant effects. Kastelein *et al*. (2000) calculated that an increase in target strength of 10 dB is needed to increase net detection distance from 4 m to 7 m for porpoises. Only substantial changes in either material properties as density and compressibility or dimensions of twine can cause such a large increase in target strength and will likely affect catch of target species and/or ease of handling for the fishermen.

Results from these trials are ambiguous enough to explore other strategies for increasing target strength then manipulation of the net material itself. As suggested by Larsen *et al*. (2002), this could be done in form of a limited number of added reflectors of a reasonable size to create strong echoes or a larger number of smaller reflectors such as glass or metal beads in all or some of the knots of the net. Another possibility would be to increase the animal's attention for the net by using a float line equipped with a sound generating unit producing 2.5 kHz tones. Such tones have been found to entice the echolocation activity of harbour porpoise. Experiments by Culik & Koschinski (2004) have shown that enticing sounds could increase the percentage of echolocating animals by a factor of four compared to controls.

Further research into harbour porpoise behaviour around fishing nets and the reasons for their entanglement, as well as possibilities to enhance either the attentiveness of the porpoise or the acoustic visibility of nets without affecting catch rates are recommended.

6.1.4. Change of fishing methods

Another method by which to achieve by-catch reduction whilst maintaining a fishery would be to implement changes to fishing gear and methods considered less harmful to porpoises. The investigation of potential benefits of gear switches in the Baltic – from driftnets and bottom-set gillnets to fish traps, pods and longlines – form an important part of the Jastarnia Plan (ASCOBANS, 2002). This could also become a recommended course of action for the North Sea set-net fisheries**.**

Any replacement or changeover to potentially less harmful gear needs to be considered in view of potential impacts to harbour porpoise, the target fish species, and other biota such as seabirds.

6.1.5. Monitoring schemes

The establishment of independent observer schemes to monitor harbour porpoise by-catch in all European fisheries with a potentially high risk of cetacean by-catch is vital (CEC, 2002b). The Subgroup on Fishery and the Environment (SGFEN) recommended that a minimum recording of marine mammal by-catch should be made mandatory. This scheme should be extended to obtain cetacean by-catch data on a "statistically meaningful level" (CEC, 2002a). As afore mentioned, the EU decided in 2004 that its member states should establish marine mammal observer schemes in specified fisheries to monitor the incidental capture and killing of cetaceans (Council Regulation EC 812/2004, articles 4 and 5). Fishing vessels with an overall length of ≤ 15 m, however, are exempt from this requirement, which again means that many vessels, particularly in inshore fisheries, will not be monitored for their by-catch. Fisheries listed in Annex I of the Regulation (see annex I this document) i.e. required to use pingers (which includes most of the fisheries of concern with respect to harbour porpoise), are not listed in Annex III of the Regulation excluding them from the observer provisions as well. This means that pinger deployment and by-catch rates in these fisheries will not be adequately monitored. Monitoring of vessels less than 15 m in length in fisheries listed in Annex III of the Regulation is addressed by a requirement to collect scientific data on incidental catches of cetaceans by means of appropriate scientific studies or pilot projects. Again, no specification is provided for those studies to ensure adequate coverage of the relevant fisheries in a certain timeframe. Observer coverage levels of pilot schemes in previously unstudied fisheries are with 5% of fishing effort for most fisheries and 10% for pelagic trawl fisheries set at or below the minimum levels recommended in scientific advice (e.g. Northridge & Thomas, 2003). As fisheries specified in Annex I of the Regulation (subject to pinger use) are not included in Annex III (subject to observer schemes), vessels under 12 m are not required to use pingers or to assess by-catch levels through observer schemes. This leaves those fisheries where there is known to be a by-catch problem, such as the western English Channel, unmonitored and the harbour porpoise population there unprotected.

It is recommended to extend observer schemes to include boats ≤ 15 m in length where possible and for those fisheries subject to pinger requirements (Annex I). Observers should be used where physically possible and alternative monitoring methods, e.g. remote monitoring methods, should be devised for those vessels where onboard observation is not possible.

6.2. Reduction of noise pollution and disturbance

6.2.1. Boat traffic

It is more likely that the number of vessels cruising the North Sea will increase rather than decrease in coming years, therefore finding mitigation measures to reduce noise should be made a priority. Richardson and Würsig (1995) spelled out basic noise mitigation techniques, and these largely apply here:

- **equipment should be designed to be as silent as possible**. Propeller shrouding that has been used to silence ships of war is an example; as are also acoustic uncoupling of generators from hulls, engine trains from drive shafts and propellers, and other engineering techniques. It is important to note that this must be counterbalanced against increased risk of ship strikes.
- **Changes of locations** can help to mitigate sounds, so that industrial supply vessels, for example, do not move directly through near-shore feeding grounds, but actually route around the main concentration of animals with only minimal increase in expense of fuel and time.
- Other operational changes include **keeping vessel speed down**.

Regulation of cetacean-watching boat trips should seek to prevent, or at least minimise, the potential for disturbance. In the absence of any firm evidence for disturbance, the precautionary approach should be adopted. There are a number of ways in which disturbance could be reduced. These include:

- Education of operators and tourists about appropriate behaviour to adopt in the presence of cetaceans. A **voluntary Code of Conduct** (see Annex III for an example) could be distributed to operators in leaflet form, as well as being displayed on notice-boards on piers and harbours.
- This Code of Conduct could also be linked to a **system of quality control**, administered by a body such as Scottish Natural Heritage in the UK for example. Under this system, some form of seal of approval would be awarded to operators of whale watching boats only after their methods of working (e.g. efforts to minimise disturbance) had been carefully examined, modified if necessary and then approved. Tourists could then be encouraged only to use approved operators.
- **Prohibiting or limiting access to vulnerable areas**.

6.2.2. Oil and gas exploration (all phases)

There clearly is a lack of information on the potential impacts of noise from oil and gas explorations on harbour porpoise. Future studies are necessary to assess the impact and critical values of noise with respect to exploration, construction, production and decommissioning as well as the practicality of possible mitigation measures, such as:

- real-time monitoring,
- creating safety zones,
- scheduling activities to minimise impact, e.g. avoid work during calving and reproductive seasons in critical areas,
- following a ramp-up procedure (Richardson & Würsig, 1995; Tougaard *et al*., 2003)
- reducing sound emissions via technical measures such as bubble curtains (Würsig *et al*., 2000), or
- using alternative equipment such as a marine vibrator to survey the seabed (Deffenbaugh, 2001 as cited in Dolman, 2003).

6.2.2.1. Real-time monitoring

It may be difficult to localize the positions of marine mammals. Detectability varies with procedure, species, distance, weather, and day/night. Round the clock visual monitoring could be enhanced through thermal and acoustical recognition as suggested by the HESS panel (cited in Moscrop & Swift, 1999). The use of night vision equipment (e.g. image intensifying telescopes) and development of infrared detection devices for whale blows might be useful to improve round the clock visual monitoring during seismic surveys. Acoustic methods can be used in seasons and at times of the day when visual surveys are impossible, and can detect porpoise at greater ranges than visual methods.

To increase the detection rates and therefore assist in minimizing disturbance to harbour porpoise, a combination of visual and acoustic methods of detection is recommended.
Upon detection of cetaceans in the vicinity of a survey, a construction or decommissioning site, a shut down of the system or a halt of the work respectively is recommended. Avoidance of critical habitats (long range) and critical times is also recommended. Such monitoring is widely practiced now with respect to seismic activities (e.g. JNCC, 1998).

6.2.2.2. Safety zone

The safety zone for activities that emit intense underwater noise is currently based on the appropriate distance for visual detection of cetaceans. Work methods that utilize distance criteria are easy to implement and to monitor. All guidelines and/or regulations should realize though that observers cannot see a reasonable percentage of animals within a radius of even several hundred metres.

In the past there have been proposed isopleth safety zones of 180 dB (e.g. the High Energy Seismic Survey Team, HESS (cited in Moscrop & Swift, 1999 or the US-Navy for the use of the SURTASS-LFAS (Low Frequency Active Sonar) (US-DoN, 2001)). However, there do not exist any commonly accepted critical values/thresholds for received sound pressure levels yet. To develop "safety thresholds", an "equal energy immission criterion" must be considered over a given time instead of a simple sound pressure level due to the complexity of underwater sound and its potential effects on marine mammals. Above that, such an "equal energy immission threshold" must be species specific. No single sound pressure level (in dB) is appropriate as a general safety threshold (e.g. MMC, 2004).

The amended EC Directive on environmental impact assessment, EIA, (97/11/EEC) demands consideration of the main alternatives studied and the reasons for the final choice – for example, to avoid a protected area. The developer is required to provide certain specified appropriate information to the case to enable a decision to be made by the authorities. The information supplied should consider significant direct and indirect effects including to flora, fauna and landscape and the interrelationship of these with other aspects. Details of measures to reduce significant adverse effects should be included within the assessment. Cumulative effects must be assessed also. Cumulative effects can result in significant changes in the landscape and to biological diversity.

Therefore, in the case of oil and gas exploration, before conducting any work in sensitive areas (as defined in the Habitats Directive), an EIA according to the Habitats Directive article 6 is recommended to investigate and predict the impacts of noise and to elaborate a set of alternatives and mitigation measures on the basis of the impact assessment. In the end, the best available technique (BAT) and the best environmental practice (BEP) should be applied.

6.2.2.3. Ramp-up procedure

It is assumed that marine mammals nearby will move away before a loud noise reaches full power if the sound source is increased gradually (ramped-up). This would allow any nearby harbour porpoise to move away before the received power becomes high enough to cause hearing damage or physiological effects, and to mitigate against a powerful source being turned on at full power while a mammal is nearby. However, it is possible that ramping up a high energy sound source could be harmful (Pierson *et al*., 1998 as cited in Dolman, 2003), as animals might be attracted to the source by initially weak sounds and thus exposed to potentially harmful levels as sound intensity increases.

While ramp-up must be considered as a minimum standard in the absence of other methods, it cannot be assumed that these measures are reducing harm to animals in the area, as it is not known that they do actually move away from the source.

Studies of effectiveness/efficiency of ramp-up procedures are recommended.

6.2.2.4. Noise reducing methods related to construction works

It might be possible to reduce or baffle unnecessary high frequency noise or other acoustic energy sources during construction and operation of oil platforms through the use of air bubble curtains. The use of air bubbles to attenuate pressure waves from drilling makes use of both the density difference between air and water and the resonance characteristics of bubbles to extract energy from the outward propagating pulses. This technique has not been widely investigated, but first experiments in Hong Kong (Würsig *et al*. 2000) and Canada (Vagle, 2003) demonstrated the potential of a bubble curtain to shroud percussive sounds produced during pile driving. In Hong Kong, bubbles created by running air into a perforated hose surrounding the pile driver reduced broadband noise generated by the pile driver by approximately 3 – 5 dB at distances of 250 and 1000 m, greatest reduction occurring at frequencies between 400 – 600 Hz (Würsig *et al*. 2000). In Canada, a noise reduction of approximately 20 dB was measured 30 m outside the bubble curtain (Vagle, 2003). The study also indicated that by making the bubbles smaller, the sound attenuation characteristics of any particular screen would be greatly enhanced. However, a problem with bubble screens observed is that the bubbles are not evenly spread around the circle, resulting in “holes” where the sound can escape. A second problem is that in the presence of currents the bubble screens loose their attenuating characteristics. Bubble curtains reinforced by tissue-fabric walls have further improved sound attenuation (minus 10 – 25 dB source level), effectively attenuating frequencies above 800 Hz, as well as reduced bubble spreading (CdoT, 2001).

Further trials with tissue reinforced bubble curtains and other methods/techniques to enhance attenuation of sound close to the source are recommended. Above that, the same recommendations concerning EIA as mentioned under 6.2.2.2. are applicable here.

6.2.2.5. Alternative methods

Another method for a seabed survey is the marine vibrator. It has a lower peak amplitude, slower rise time and significantly less energy above 100 Hz (Deffenbaugh, 2001 as cited in Dolman, 2003). It may be a realistic alternative to airgun arrays currently in worldwide use for seismic activities.

Further research into the practicability of marine vibrators and other alternative methods to survey the seabed are recommended.

6.2.3. Sand and gravel extraction

In addition to monitoring effects on trophic energy transfer, the potential physical interactions and impacts to harbour porpoise and other marine wildlife need to be monitored as there is little information on the behaviour or reactions of harbour porpoise around dredging vessels and on effects on prey species such as sandeels.

Before permission for extraction is given, an environmental impact assessment (EIA) should be required as for example as it is the case in the UK. If concerns are expressed about possible effects on the environment, the ecosystem or marine animals, extraction should not be permitted to go ahead.

It is recommended that during dredging activities, especially in areas where harbour porpoise are likely to occur, trained marine wildlife observers are aboard the dredge vessel or an ancillary vessel to observe the presence of any harbour porpoise or other cetacean in the dredge area and to document their behaviour in response to the dredging activities. Also, as suggested by Nairn *et al.* (2004), marine wildlife observers should be in communication with federal, state and local agencies responsible for documenting marine wildlife strandings concurrent with the dredging operations and for a certain period after completion of the operations (depending on time, duration and severity of the previous operation). Research on habitat alteration with all side effects is needed. Recommendations for an EIA as mentioned above are applicable here.

The ICES Code of Practice for the Commercial Extraction of Marine Sediments provides step-by-step advice on how marine dredging should be conducted in order to minimise conflicts with other users of the sea and to optimise the use of marine resources.

6.2.4. Wind parks

There clearly is a lack of information on the potential impacts that marine wind farms have on harbour porpoise. As it is the case for oil and gas explorations, future studies are necessary to assess the impact and critical values of noise with respect to construction, as well as the practicality of possible mitigation measures, such as:

- real-time monitoring,
- creating safety zones,
- scheduling activities to minimise impact, e.g. avoid work during calving and reproductive seasons in critical areas,
- reducing sound emissions via technical measures such as bubble curtains (Würsig *et al*., 2000) or a coating of the ramming device (UFOPLAN-FKZ 204 53 102)
- or following a ramp-up procedure (Tougaard *et al*., 2003).

6.2.4.1. Real-time monitoring

As mentioned under 6.2.2.1., it may be difficult to localize marine mammals, but it is necessary to monitor the area of a marine wind farm construction site to ensure that harbour porpoise are not too close to be harmed by construction work. Acoustic methods can be used in seasons and at times of the day when visual surveys are impossible, and can detect porpoise at greater ranges than visual methods. PODs (Porpoise Click Detectors, a type of bioacoustic data logger) also proved to be very effective in detecting the presence of harbour porpoise (Teilmann *et al*., 2002; Henriksen *et al*., 2003; Tougaard *et al*., 2003).

To increase the detection rates and therefore assist in minimizing disturbance to harbour porpoise, a combination of visual and acoustic methods of detection is recommended.
Upon detection of cetaceans in the vicinity of a wind farm construction site, it is recommended to stop the construction work.
It is recommended to avoid any construction work during the months of April to August if the area is important breeding ground.

6.2.4.2. Safety zone

The safety zone for activities that emit intense underwater noise is currently based on the appropriate distance for visual detection of cetaceans. This would apply for a safety zone around marine wind park building sites as well (during the construction phase of the wind farm). However, as mentioned above, PODs proved to be very effective in detecting the presence of harbour porpoise (Teilmann *et al*., 2002; Henriksen *et al*., 2003; Tougaard *et al*., 2003).

As mentioned under 6.2.2.2., there do not exist any commonly accepted critical values/thresholds for received sound pressure levels yet. Exposure to high levels of sound energy must be avoided though in order not to risk auditory damage or other physical injuries.

Therefore, the same recommendations as under 6.2.2.2. are applicable here.

6.2.4.3. Ramp-up procedure

The same recommendations as mentioned under 6.2.2.3. are applicable here.

6.2.4.4. Noise reducing methods related to construction works

The same recommendations as mentioned under 6.2.2.4. are applicable here.

6.2.5. Sonar/Military operations

The potential of military activities (e.g. use of sonar) to encroach cetacean habitats has to be considered, since military activities are undertaken in all oceans of the world, including the North Sea. As public information on the exact nature and extent of military activities are highly restricted for security reasons, the total impact of the military's ensonification on the North Sea is difficult to quantify.

The effect of mid-range sonar, especially under particular environmental circumstances, where the combination can tear apart the whale's inner ear and brain tissue, leading to haemorrhaging, disorientation and death, needs to be studied.

As far as military activities are concerned, the armed forces are expected to act in accordance with articles 236 and 237 paragraph 2 of the Convention on the Law of the Sea of 1982 to undergo any reasonable efforts to avoid any disturbance to harbour porpoise.

6.3. Pollution

Pollution is a global issue and measures to reduce pollution have been laid down in the OSPAR Convention of 1992.

However, a greatly improved understanding is needed of the linkages between specific chemical exposures (type and amount) and endpoints of concern (e.g. impaired health, immunosuppression, reproductive disorders). No single approach is likely to be adequate for resolving the critical uncertainties that arise in relation to contaminants and marine mammals. Thus, there is a need for multidisciplinary studies that integrate physiological, behavioural, reproductive, clinical, pathological, and toxicological data, with the ultimate goal of linking immune status, health, reproduction, and survival of individuals to trends observed or predicted at the population and ecosystem level.

6.4. Establishment of Protected Areas

Surveys from the SCANS project and local censuses have demonstrated that the area west of the islands of Sylt and Amrum has very high densities of harbour porpoise, with a high proportion of calves (Hammond *et al.*, 1995, 2002; Heide-Jørgensen *et al.,* 1993; Sonntag *et al.,* 1999). The animals are present all year round (Koch *et al.,* 1993, as cited in Prochnow & Kock, 2000) and the area is apparently a favourable habitat as well as an important breeding ground (Sonntag *et al*., 1999). In October 1999, the parliament of Schleswig-Holstein state, Germany, decided to create a small cetacean sanctuary within the existing National Park "Wadden Sea of Schleswig-Holstein" to protect harbour porpoise. This park is part of the Wadden Sea Nature Reserve – an international reserve administered jointly by Germany, The Netherlands and Denmark. Since 1999 the area of 124,000 ha inside the 12 nm zone in front of the islands of Sylt and Amrum has been nominated as a special area of conservation (SAC) for harbour porpoise. Unfortunately, so far the cetacean sanctuary is not marked on official nautical charts and, as a result, many motorboats still go through the area at high speed. Fixed fishing gear under 2 metres height are still permitted, and a ban of higher nets has not yet been approved by the EU. Current regulations thus are only binding for German fishermen. In February 2005, the government of Schleswig-Holstein, Germany, amended the Coastal Fisheries Regulation of Schleswig-Holstein (Küstenfischereiverordnung, KüFO) to allow only nets with a maximum height of 1.30 m and a maximum mesh size of 150 mm in the sanctuary. This excludes the gillnet fishery for turbot which has very high by-catch rates, as the minimum mesh size for this fishery has been determined to be 220 mm (EC Regulation 850/98). It is very important now that the EU ratifies the regulations made by the KüFO as quickly as possible to not only bind German, but also Danish and Dutch fishermen who are fishing in the area, too. Recent aerial surveys in the German Exclusive Economic Zone (EEZ) in the North Sea indicate high densities of harbour porpoise slightly further offshore than the whale sanctuary, close to the Danish border (Scheidat *et al*., 2003, Scheidat *et al*., 2004).

The European Union Habitats Directive (92/43/EEC) together with the Birds Directive (79/409/EEC) is designed to provide a network of marine- and land-based protected areas in the European Community, a coherent network "NATURA 2000". Under the Habitats Directive, a number of SACs have been proposed as candidate areas to protect bottlenose dolphins and harbour porpoise habitat in several of the member countries.

As part of the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, signed in 1992, the parties are obliged to identify marine species, habitats and ecosystems that need to be protected, conserved or restored. In 2003, the OSPAR Commission adopted the Recommendation 2003/3 on the establishment of a network of well-managed Marine Protected Areas (MPAs) to be put in place by 2010 to ensure the sustainable use, protection, and conservation of marine biological diversity and ecosystems. The initial list of threatened and declining species and habitats, aimed to set priorities for the conservation process, includes harbour porpoise.

In 2004, Germany nominated three areas in the German EEZ in the North Sea, Sylter Außenriff, Doggerbank and Borkum-Riffgrund as candidate sites (pSCI, proposed Sites of Community Interest) for the NATURA 2000 network under the EC Habitats Directive, protecting harbour porpoise among other species. Harbour porpoise provided the rationale for the selection of these sites, Sylter Außenriff, for example, harbours the largest known concentration of harbour porpoise in German waters in this area. The two other sites have been selected for additional nature conservation targets, i.e. sandbanks and reefs. However, the habitats Directive protects all species of Annex I in all protected areas as well as *per se*.

While the area of Sylter Außenriff appears to be large enough to protect harbour porpoise to an extent, the two other areas proposed by Germany might be too small by themselves to provide protection to harbour porpoise in German waters, but could be reasonably enlarged by added MPAs, forming a network of MPAs under EU legislation in Denmark, The Netherlands and the United Kingdom, if they meet the criteria for site selection in those countries. The UK proposed part of the inner Moray Firth in NE Scotland and Cardigan Bay in West Wales as SACs to protect the resident bottlenose dolphin populations there. Harbour porpoise are known to reside in both areas as well.

To maintain a healthy marine ecosystem, conservation management needs to use research to uncover and take into consideration all the key links within the ecosystem, as well as manage human activities and their impacts. It is necessary to manage fisheries, chemical and noise pollution, vessel traffic, climate change, agriculture and industrial activities that produce run-off, offshore oil, gas and other mineral industries, among other things, to minimize adverse impacts and to maintain a healthy functioning ecosystem.
Effective implementation of MPAs relies on the involvement of the community and relevant stakeholders in developing management plans.

Although encouragement of authorities to implement management measures within protected areas, as outlined above, is strongly recommended, such measures should not be considered to serve as substitutes for conservation initiatives recommended elsewhere in this recovery plan.

6.5. Research and Monitoring

There are still many aspects of harbour porpoise conservation that remain uncertain and require further attention. However, they should not be used as an excuse to further delay implementation of a recovery plan and the implementation of as many suggestions made in the plan in order to substantially reduce incidental mortality due to fisheries. As the Northeast Atlantic population and especially the southern North Sea population lives perhaps in one of the most polluted and heavily fished marine environments in the world (Aguilar & Borrell, 1995) and living above that in a region of heavy ship traffic, there are also other potential risks apart from by-catch that additionally have to be taken into consideration with respect to a recovery plan for harbour porpoise.

Research is needed to gather information on stock structure, population abundance, spatial distribution and population dynamics (including population growth rates) of harbour porpoise in the North Sea. Methods need to be developed to allow for a monitoring of trends in selected areas or populations between the large-scale surveys like SCANS. There is a particular need for population details and movements of porpoises within the Celtic Sea, English Channel and Southern North Sea.
The SCANS-II survey, planed for July 2005, is designed to determine the absolute abundance of small cetacean populations, particularly of harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*) and common dolphin (*Delphinus delphis*) inhabiting shelf waters of the Atlantic margin, the North Sea and adjacent waters. In addition to the area surveyed during

SCANS, this project will also cover continental shelf waters to the west of Britain, Ireland, France, Spain and Portugal. The northern boundary will be approximately 62° N and the southern limit will be the boundary of the region covered by the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area (ACCOBAMS).
To estimate absolute abundance, a combination of shipboard and aerial surveys will be carried out. Both visual and acoustic survey methods will be used to detect cetaceans on the shipboard surveys The visual data collection and analytical methods developed for SCANS will form the basis for this project to maintain consistency and comparability but methods will be revised to incorporate recent developments for shipboard and aerial surveys.
Technical advances in the construction and deployment of passive acoustic arrays in recent years mean that, with some further development, this methodology could provide a reliable means of monitoring harbour porpoises and other species, and aid in absolute abundance estimation. Visual and acoustic methods will be standardised and shipboard protocols tested during an experimental survey in spring 2005, which will also be used for training and testing equipment and methodologies.
A second objective of SCANS-II is to develop and test methods to monitor cetacean populations. An essential part of long-term management of cetacean populations is a robust and cost-effective means of monitoring relative abundance between major decadal SCANS-type surveys. SCANS-II will develop and test potential methods, which may include the use of passive acoustics and vessels of opportunity, and recommend a suite of monitoring protocols tailored by species and area.
The third objective is the development of a framework for management of by-catch. The information on abundance is essential to assess the impact of by-catch and other anthropogenic threats to cetacean populations. SCANS-II will develop a management framework based on abundance estimates and other available information to enable conservation objectives to be met in the short and long-term.

By-catch needs to be quantified yearly by all member states. This could be done by sufficient onboard observer schemes where possible. Forensic investigations of stranded animals should be continued to determine cause of death by gear type (where possible). An assessment of effectiveness of mitigation measures should be done annually and further research into alternative mitigation measures (e.g. gear modifications, alternative fishing methods) is necessary. Investigations on the effect of effort reduction or possible future effort increases are needed.

Harbour porpoise hearing and communication needs further examination. Do they use or perceive lower frequencies? What is the impact of noise on behaviour on the population level? Research is needed on the possible effects of navigational sonars from ships on harbour porpoise and on the impacts of noise on prey species of the harbour porpoise.

Appropriate indicators of "health status" need to be defined to be able to declare a population as healthy or not.

The monitoring of new toxins is vital.

However, gaps in knowledge must not inhibit the implementation of measures that can minimise already identified risks and that might contribute to a favourable conservation status of harbour porpoise in the North Sea.

6.6. Raising public awareness

There is an increasing database of information about small cetacean conservation. However, such information is rendered useless if the overall message of the research isn't communicated to policy makers and the public.

Public awareness must be an essential and integral part of any recovery plan. Unless people are convinced that porpoises are present in their local waters, that these creatures are worth saving, and that the animals' existence is threatened, they are not likely to support recovery efforts. Whereas other elements of the plan depend largely on the decision-making processes of national or supranational governmental agencies and international regulatory bodies, public awareness is an area in which ASCOBANS has an autonomous role to play. Parties to ASCOBANS have ongoing responsibilities and commitments to disseminate reliable information about North Sea harbour porpoises and to actively promote their protection and recovery.

Because they are among the people likely to interact most directly and most frequently with harbour porpoises, fishermen must be viewed as a key audience. At the same time, it is important to reach members of the general public, as they are consumers of fishery products and the ultimate arbiters of public policy (via the democratic process). It is vital that public awareness efforts be objective, attendant to and respectful towards cultural and linguistic differences, and candid about scientific uncertainty. In fact, one of the greatest challenges to the implementation of this recovery plan is the uncertainty surrounding the porpoise population's status and the nature and level of risks and threats to its existence.

In promoting public awareness, ASCOBANS should avoid duplication of effort and cooperate with other institutions and programmes pursuing similar aims. Moreover, ASCOBANS should strive to be represented in relevant for such as the European Marine Strategy.

Recommendations:

- While acknowledging the proven value of national programmes in raising public awareness, ASCOBANS should **develop and promote a regional approach to North Sea harbour porpoise conservation**. This should aim to improve **general awareness of the presence of harbour porpoises in the North Sea and understanding of the risks and threats they face** with a view to enlisting the support of **both the general public and stakeholders** for the objectives of the plan, possibly using as a model the programme "Look out for harbour porpoises" initiated by GSM (Society for the Conservation of Marine Mammals).

- In relation to the preceding recommendation, explicit efforts should be made to **enlist the help of the general public in obtaining reports of porpoise observations** throughout the North Sea. This can be expected to improve understanding of porpoise distribution, relative abundance, and by-catch, while at the same time enhancing public support for recovery efforts. However, it is important that opportunistic reports by untrained observers be interpreted cautiously, and that the need for documentary evidence (i.e. photographs, tissue samples in the case of strandings) be stressed when soliciting such reports.

- The ASCOBANS Secretariat should aim to establish direct communication links with fishermen and other stakeholders at the international level and seek their assistance in determining how to reach fishing communities and other target groups more effectively, e.g. via newsletters, tabloids, displays at fishing exhibitions etc.

- The North Sea Range States should establish national focal points, with responsibility for coordinating public awareness efforts. These focal points would be responsible for establishing and maintaining working relationships with fishing communities and other stakeholders at the national level and supporting the ASCOBANS Secretariat in its efforts to establish links with those groups.

7. Summary of recommended actions and measures

Reduction of harbour porpoise by-catch in fishing gear					
Objective	**Relevant variable**	**Actions**	**Time frame**	**Actors**	**Monitoring methods**
Reduce by-catch Short-term aim: reduce by-catch as quickly as possible Long term aim: reduce by-catch to < 1% of population size per year. For this target to be met, information on population size is needed!	By-catch rate	Reduction of fishing effort: Reduction of net lengths and soak times Time/area closures to high risk gear Mandatory use of pingers on **all** fishing boats Extend observer schemes to include boats ≤ 15 m in length where possible & for those fisheries subject to pinger requirements	Within next 5 years Immediately for the next 3 years	Relevant authorities	Direct observation of fishing through on-board observers Strandings network Employ remote tracking systems to monitor fishing boat movements Random sampling of fishing boats to control if pingers are used
Recommendations	Further research into harbour porpoise behaviour around fishing nets and the reasons for their entanglement, as well as possibilities to enhance either the attentiveness of the porpoise or the acoustic visibility of nets without affecting catch rates are recommended. In certain high-risk areas, it is recommended to set a limit to the heights of the nets as well as to the mesh size. Investigations of potential benefits of gear switches from bottom-set gillnets to fish traps, pods and longlines. Any replacement or changeover to potentially less harmful gear needs to be considered in view of potential impacts to harbour porpoise, the target fish species, and other biota such as seabirds.				

Reduction of noise pollution and disturbance				
Objective	**Relevant variable**	**Actions**	**Actors**	**Monitoring methods**
Reduce disturbance and noise from boats	Noise levels and number of boats in areas where harbour porpoise are known to occur in high numbers	Equipment design to be as silent as possible Changes of location of boat lanes Keeping vessel speed down Establishment of a voluntary Code of Conduct	Relevant authorities & boat manufacturers Vessel operators	Employ remote tracking systems to monitor boat movements System of quality control by an administrative

		for Eco-tourism Prohibit or limit access to vulnerable areas		body with a seal of approval for the vessel operators
Reduce noise and disturbance from oil and gas explorations	Noise levels	Conduct Environmental Impact Assessment (EIA) before conducting any work and calculate a safety zone Conduct real-time monitoring and stop work if porpoise are in the area Study the effectiveness of ramp-up procedures Examine methods to enhance the attenuation of sound Research the practicability of alternative methods to survey the seabed	Oil and gas industry and relevant authorities	Require EIA Reports before any operation can begin Use independent observers
Reduce noise and disturbance from sand and gravel extraction	Noise levels	Conduct EIA before conducting any work and calculate a safety zone Conduct real-time monitoring	Extraction industry and relevant authorities	Require EIA Reports before any operation can begin Use independent observers
Reduce noise and disturbance from wind parks	Noise levels	Conduct EIA before conducting any work and calculate a safety zone Conduct real-time monitoring Study the effectiveness of ramp-up procedures Examine methods to enhance the attenuation of sound Research the practicability of alternative methods to survey the seabed	Wind park industry and relevant authorities	Require EIA Reports before any operation can begin Use independent observers
Recommendations	Further research into harbour porpoise hearing and communication is recommended. Do they use or perceive lower frequencies? What is the impact of noise on the behaviour on the population level? What effects have navigational sonars from ships on harbour porpoise? What is the impact of noise on prey species of harbour porpoise?			

Other management actions			
Objective	**Relevant variable**	**Actions**	**Actors**
Develop cetacean stranding networks to obtain information and biological material from stranded animals	Number of strandings recorded, investigated and sampled	Create expertise and conditions for the development of networks concerned with the monitoring of and response to cetacean strandings (if networks already exist, optimal data collection and sampling should be promoted) Funding of organizations involved in the monitoring of and response to strandings International communication of findings between networks	Local Institutes, NGOs, Universities
Link immune status, health, reproduction and survival of individuals to trends observed or predicted at the population and ecosystem level.	Health status	Define appropriate indicators of "health status" to be able to declare a population as healthy or not Develop multidisciplinary studies that integrate physiological, behavioural, reproductive, clinical, pathological, and toxicological data	Local Institutes, NGOs, Universities
Establish Special Areas of Conservation (SACs)	Suitable habitat known to be important to harbour porpoise (feeding/breeding ground)	Identify habitat important for feeding or breeding for harbour porpoise Nominate areas to the European Union	Local Institutes, Universities, NGOs, Relevant authorities
Raise public awareness	Number of events/leaflets Knowledge of the public/stakeholders	Create programs to improve the general awareness of the presence of harbour porpoise and to understand the risks and threats to them Develop a Voluntary Code of Conduct for boats and distribute it as a leaflet or on notice boards on piers and harbours Publicise list of approved Eco-tourism operators (those who follow the voluntary Code of Conduct) Enlist the help of the general public to obtain reports of porpoise observations	Local Institutes, NGOs, ASCOBANS secretariat, vessel operators

		Establish direct communication links between fishermen and other stakeholders at the international level and seek their assistance in determining how to reach fishing communities and other target groups more efficiently Establish national focal points to establish and maintain working relationships with fishing communities and other stakeholders	
Recommendations	It is recommended to monitor new toxins.		

8. Re-evaluation of this Recovery Plan

It is important that this recovery plan and the actions outlined within it be implemented without delay, and that ASCOBANS undertake a formal process of re-evaluation and revision of the plan no less often than every five years. The first review should occur three years after the first implementation of pingers. It is also suggested that North Sea range states (ASCOBANS members and non-members alike) be asked to supply ASCOBANS with updated information on an annual basis concerning progress in implementation.

9. Implementation

An initial attempt to outline steps for implementation of this plan is given below, in order of importance[1]:

***1. Stock structure, population abundance, spatial distribution and population dynamics (including population growth rates) of harbour porpoise in the North Sea need to be clarified. Methods need to be developed to allow for a monitoring of trends in selected areas or populations between the large-scale surveys like SCANS. There is a particular need for population details and movements of porpoises within the Celtic Sea, English Channel and Southern North Sea.

This will be done through SCANS-II which will commence in July 2005.

1.1. Knowledge on quantitative relationships between feeding ecology and critical levels of prey availability where animals need to choose between switching prey or leaving the area, is still lacking. In order to evaluate the direct and indirect impacts of fisheries on populations of harbour porpoise, efforts should be made to find out more about their foraging habits in relation to various types of fishing gear and the species of fish they catch.

***2. Introduce mandatory pinger deployment in all gillnet and entangling fisheries listed in Annex I as soon as possible.

[1] *** Top priority/immediate implementation
** High priority/ implement without major delay
* to be implemented as soon as feasible

2.1. To achieve adequate protection of vulnerable inshore populations and prevent redeployment of gillnet and tangle net effort to vessels less than 12 m long, it is necessary to undertake an assessment of static net effort. This will identify areas where gillnet use should be restricted or halted and areas where mandatory pinger deployment should be introduced.

2.2. Develop and implement a strategy for getting fishermen to support by-catch mitigation measures. A key element of any pinger implementation will be to educate fishermen how to use them properly.

2.3. Conduct compulsory observations of vessels that deploy pingers, to ensure their correct and effective use as well as monitoring of their impacts.

**3. Improve effort and protocols for data collection from stranded or incidentally caught harbour porpoise especially in the southern North Sea and the English Channel.

**4. Initiate a review of all experiments to date with alternative gear and fishing practices that might be used to replace the current use of bottom-set gillnets in the North Sea. The objective of this review will be to identify promising gear for further development and testing.

**5. Initiate tests of the efficiency/effectiveness of ramp-up procedures during construction work or seismic surveys.

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Annex I

Fisheries in which the use of acoustic deterrent devices is mandatory (from EC 812/2004, annex I)

Area	Gear	Period	Starting date
A. Baltic Sea area delimited by a line running from the Swedish coast at the point at longitude 13° E, thence due south to latitude 55° N, thence due east to longitude 14° E, thence due north to the coast of Sweden; and, Area delimited by a line running from the eastern coast of Sweden at the point at latitude 55°30' N, thence due east to longitude 15° E, thence due north to latitude 56° N, thence due east to longitude 16° E thence due north to the coast of Sweden	(a) Any bottom-set gillnet or entangling net	All year	1 June 2005
	(b) Any drift-net	All year	1 June 2005
B. ICES sub-area IV and division III a	(a) Any bottom-set gillnet or entangling net, or combination of these nets, the total length of which does not exceed 400 metres	(a) 1 August - 31 October	1 August 2005
	(b) Any bottom-set gillnet or entangling net with mesh sizes > 220 mm	(b) All year	1 June 2005
C. ICES divisions VII e, f, g, h, and j	(a) Any bottom-set gillnet or entangling net	(a) All year	1 January 2006
D. ICES division VII d	Any bottom-set gillnet or entangling net	All year	1 January2007
E. Baltic Sea subdivision 24 (except for the area covered under A)	(a) Any bottom-set gillnet or entangling net	(a) All year	1 January 2007
	(b) Any drift-net	(b) All year	1 January 2007

Annex II

Technical specifications and conditions of use of acoustic deterrent devices (pingers) (from EC 812/2004, annex II).

Any acoustic deterrent devices used in application of Council Regulation EC 812/2004, article 2(1) shall meet one of the following sets of signal and implementation characteristics:

	Set 1	**Set 2**
	Signal characteristics	
Signal synthesis	Digital	Analogue
Tonal/wide band	Wide band/tonal	Tonal
Source levels (max - min) re 1 mPa@1m	145 dB	130 -150 dB
Fundamental frequency	(a) 20 - 160 KHz wide band sweeps (b) 10 kHz tonal	10 kHz
High-frequency harmonics	Yes	Yes
Pulse duration (nominal)	300 ms	300 ms
Interpulse interval	(a) 4 - 30 seconds randomised; (b) 4 seconds	4 seconds
	Implementation characteristics	
Maximum spacing between two acoustic deterrent devices along nets	200 m, with one acoustic device fixed at each end of the net (or combination of nets attached together)	100 m, with one acoustic device fixed at each end of the net (or combination of nets attached together)

Annex III

Example of a code of conduct for minimising disturbance to dolphins, basking sharks and other marine animals (from The Wildlife Trusts Cornwall, http://www.cornwallwildlifetrust.org.uk/nature/marine/harassment.htm)

Dolphins, porpoises, whales, basking sharks and turtles are some of the animals that share these waters with you. They are sensitive to disturbance so please show understanding when in their vicinity.

Certain vessels can disturb their daily activities, scaring them away and even causing injury. If you see anyone harassing or recklessly disturbing them, please report it to the police.

It is an offence to intentionally kill or injure cetaceans (dolphins, porpoises and whales). It is also an offence to disturb cetaceans and basking sharks. To do so intentionally or recklessly[2] may result in a prison sentence.

By following this code of conduct, and any local guidance that is in place, you will not commit an offence and will minimise stress to marine animals when you encounter them at sea.

1. On sighting cetaceans and other marine animals, fast vessels should gradually slow down to a slow speed (less than 6 knots). Wait until well clear of animals before gradually resuming original speed.
2. On encountering marine animals continue on your intended route. This will present predictable movements. Avoid erratic movements such as circling around the animals or sudden changes in speed.
3. Let the animals approach you. If they do choose to approach the vessel or bow-ride, maintain a steady speed without changing course.
4. Allow groups of animals to remain together. Avoid deliberately driving through, or between, groups of animals. Proceeding slowly on a steady course will enable them to remove themselves from the path of a vessel as a group.
5. Leave cetaceans or sharks with young alone and avoid coming between a mother and her calf.
6. Always allow animals an escape route. Be aware of your surroundings. If there is more than one vessel in the vicinity avoid boxing animals in.
7. Do not swim with, touch or feed the animals, for your safety and theirs.
8. Do not throw rubbish or food near or around marine animals.
9. Minimise possible sources of noise disturbance and take care to avoid collision with animals when using sailing boats or boats with low engine noise as the animals are less likely to hear the vessel until it is close.
10. There should be no more than 1 vessel in close proximity to marine animals (less than 100m), and no more than 3 vessels in the vicinity (100m-1km) at any one time. Refrain from calling other vessels to the animals.
11. Presence in the watching area should be limited if there are other vessels in the vicinity interested in watching the marine life (15 minutes). The Wildlife and Countryside Act makes provision for licences to be issued to allow certain activities such as research and survey to take place.
12. Move away slowly if you notice signs of disturbance, such as erratic changes in speed and direction, or lengthy periods underwater.

[2] Recklessness is a legal term. A person who is heedless of the consequences of his actions or of danger will be reckless.