Improving the Dutch part of the North Sea as a cetacean habitat

by Janet Booij

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PREFACE

As a Biology student in the third year of my study at Leiden University, I was expected to do a traineeship in order to put in practice gained knowledge from former years. I conducted this traineeship for the North Sea Foundation, a non-profit organisation in the Netherlands which stands up for the interests of the North Sea. Topics of importance for this organisation are amongst others shipping, fisheries, area planning, hazardous substances, and education. With the dedication to these topics, the foundation aims to improve the North Sea environment for all organisms. Of all marine wildlife in the North Sea however, special attention goes to the whales, dolphins and porpoises (cetaceans) living in the North Sea. The presence of these top predators is thought to reflect a healthy and productive North Sea. The North Sea Foundation therefore has the slogan 'Dolphins back in the North Sea' and this study aims to improve the Dutch North Sea as a suitable habitat for cetaceans.

This report describes the work I carried out and includes recommendations for Dutch policy. I very much hope that the results of this report will aid the improvement of the Dutch North Sea as a suitable habitat for cetaceans.

Janet Booij

Contents

1. Summary

With the ratification of several international nature conservation agreements and the introduction of national flora and fauna protection laws, the Netherlands commited itself to protect cetaceans in the Dutch part of the North Sea. For this protection, it is useful to focus on (potentially) regularly occurring cetacean species and the threats these animals are confronted with.

Articles based upon strandings, ship-board surveys, coastal surveys and aerial surveys suggest that, of the 24 species which have been documented stranded on the Dutch coast or sighted in the Dutch sector of the North Sea, the harbour porpoise *Phocoena phocoena* and the white-beaked dolphin *Lagenorhynchus albirostris* are species which currently occur regularly in the Dutch part of the North Sea.

The harbour porpoise has been present in Dutch waters during the entire 20th century, but their numbers declined amongst both strandings and sightings between the 1950s and 1980s. This decline was associated to a decline in fish stocks of several species which porpoises are known to feed on, including herring. During this period the concentration of PCBs in the marine environment also reached its peak. Both overfishing and pollution are consequently potential threats to porpoises in Dutch waters.

Without neglecting the possible adverse effects of these two threats however, this study shows that currently by-catch is a major threat to the porpoise in Dutch waters. In other regions of the North Sea, porpoises are known to be by-caught at unsustainable levels in gillnet fisheries and the same fisheries operate year-round in the Dutch part of the North Sea. Due to the feeding behaviour and diet preferences of the porpoise, the species also becomes entangled in gillnets set in Dutch waters. Stranding records showed that at least half of the stranded porpoises are victims of by-catch and the fresh state of the animals furthermore indicated that by-catch is a problem that occurs right at our doorstep.

The white-beaked dolphin entered Dutch waters during the 1960s as a result of favourable changes in water temperature and currents and an increase of prey species such as gadoids. Recently however, a decline appears to have set in amongst reported strandings and animals sighted during aerial surveys. It is difficult to relate this to any changes in the natural situation or to any human impacts, as relatively little is known about the biology of this species and its sensitiveness to human activities. However, whiting and cod, both main prey species of the white-beaked dolphin, are currently overfished and the flexibility of white-beaked dolphins to switch to another prey is not known. Overfishing is therefore likely to be a serious threat to the white-beaked dolphin. Pollution is another potential threat to the white-beaked dolphin. Neither effects on individuals nor on population level are known, but their diet preference and slow recovery rate make them a vulnerable species.

The bottlenose dolphin is a species which at present does not occur regularly in the Dutch part of the North Sea, but has been present for an extensive period of more than 20 years amongst strandings in the past. It disappeared during the second half of the 20^{th} century, probably due to overfishing and pollution. As these are both human impacts, the species may re-occur if the circumstances are favourable. If the bottlenose dolphin would re-occur in Dutch waters, however, pollution would currently still present a serious threat to this species. Its coastal distribution would cause a high exposure to pollutants discharged by rivers like the Meuse and Rhine Bottlenose dolphins reproduce relatively slowly, and, in addition, a reproductive impairment due to exposure to PCBs has been demonstrated.

Other threats which were investigated were the effects of underwater noise produced by for example seismic surveys and vessels, climate change and collissions with boats. Climate change, and in particular its effect on cetaceans, is poorly understood and the impact of boat collissions is regarded as a likely threat to the selected species in Dutch waters. Noise on the other hand may seriously affect species that are already under pressure and should remain a topic of interest among scientists and policy makers.

To reduce the impact of the threats found for the bottlenose dolphin, harbour porpoise and white-beaked dolphin, several policy instruments have been suggested thusfar. These mainly focus on the improvement of environmental planning; the adjustment of procedures and materials used for an activity; and the restriction of the number of activities. The possibility for realization of these instruments were not analysed in this study, but we hope that suggested instruments will inspire fellow scientists and Dutch policy makers to contribute to the improvement of the Dutch sector of the North Sea as a cetacean habitat as action is needed now.

2. INTRODUCTION

Whales, dolphins, and porpoises (cetaceans) are protected by several international agreements. Of these agreements, the Agreement on the Conservation of Small Cetaceans of the Baltic and North Sea (ASCOBANS), focuses especially on conservation and management considering cetaceans. Other conventions have broader targets, such as the Bonn Convention for the conservation of migratory species or the Bern Convention on the conservation of European wildlife and natural habitats. Cetaceans are also protected in the European Habitat Directive.

The Netherlands ratified and enacted these international conventions and consequently commited itself to actively protect cetaceans and their habitat in the Dutch part of the North Sea. In addition, protection targets are also set in national law. The Flora and Fauna Law, formerly the Nature Conservation Act, protects all marine mammals regularly occurring in the Dutch sector of the North Sea, including the harbour and grey seal, and all cetaceans.

Despite these various conventions and laws, it turned out complicated to realize the protection of cetaceans. In the Netherlands, no specific protection measures have been taken yet, as it is difficult to decide how the Dutch part of the North Sea can be improved as an cetacean habitat. The research question which was the drive for this report is therefore:

Which factors influence the occurrence of cetaceans in the Dutch part of the North Sea?

In order to answer this question, we identified the following research topics:

- Regularly occurring species in the Dutch part of the North Sea;
- Biology of the selected species;
- Features of the (Dutch part of the) North Sea;
- The impact of human activities on the selected species.

The information gathered about factors which influence the occurrence of (potentially) regularly occurring species in the Dutch part of the North Sea were used to formulate recommendations for improved cetacean protection in the Dutch part of the North Sea.

3. METHODOLOGY

RESEARCH TOPICS

The research topics as outlined in the introduction were divided in several points. These, together with the sources used, are outlined below.

A) Features of the North Sea

Information about the North Sea is important when one aims to improve this environment for cetaceans. Oceanographic features of the North Sea in general and in the Dutch sector of the North Sea were therefore collated. Furthermore the anthropogenic activities that occurred in the Dutch sector of the North Sea during the 20th century are outlined, together with current developments of the main anthropogenic activities at sea. These developments included the most recent developments and distribution of human activities.

B) Regularly occurring species in the Dutch part of the North Sea

It is likely that not all species benefit equally from a certain protection measure. Selecting cetacean species which should benefit primarily (but certainly not only!) from nature conservation policy may therefore be useful. We suggest that the cetacean species which should profit most from protective measures in the Dutch part of the North Sea are those occurring regularly or those that potentially occur regularly in the Dutch part of the North Sea. The focus points of this part of the study and the main sources of information used are summarized below.

- **Cetacean species reported sighted in the Dutch part of the North Sea or stranded on the Dutch coast**

  An overview was made of all cetacean species recorded stranded or sighted in the Dutch part of the North Sea, the amount of recorded animals for different periods and the sources used.

- **A selection of species occurring regularly or are likely to occur regularly in the Dutch sector of the North Sea**

  We defined *regular occurring species* as species which are currently present in both strandings and sightings for at least twenty years (since structural collection of records started 20 years ago), and *Species which potentially occur regularly* are those which currently do not occur regularly or occur infrequent in the Dutch part of the North Sea, but were present in considerable numbers amongst strandings for at least a period of twenty years during the last century. Furthermore, their disappearance was related to human impacts, rather then by natural changes, as the former is more likely to reverse.

  Trends, as reported from strandings and sightings, were outlined for five species which appeared to match these criteria. Based upon these trends and the above criteria, a final selection of species was made.

- **Abundance and distribution of the selected species**

  The current abundance and distribution of the species were studied in order to check if the selected species indeed still occur in the Dutch part of the North Sea. In addition, this information was furthermore used investigating potential threats to selected species.

The articles used for this study were based on:

1. Strandings

For the Netherlands, data of stranded animals date back to about 1914, when Van Deinse collected reports of stranded animals. Nowadays, data on stranded cetaceans are mainly stored by the National Museum of Natural History (Naturalis) in Leiden. Results are frequently published by Smeenk and Addink in the Dutch mammal magazine Lutra.

Strandings from the beginning of the 20th century were not documented to the extent as how it is documented nowadays. Animals which were rather common at the beginning of the 20th century may be underreported due to a lack of interest. During the Second World War strandings were likely to be under reported, as beaches were not accessible. When Van Deinse died in 1964, stranded animals were not collected systematically until 1970. In conclusion, stranding records from the first half of the 20th century are not as reliable as current records (pers. comm. Smeenk).

Besides above described fluctuations in observer effort, a general problem when interpreting stranding records is that stranded animals cannot be traced back to their origin. Animals stranded on the Dutch coast, for example, may be animals that did not occur in the Dutch part of the North Sea. In addition, stranded animals may not be representative for the whole cetacean population, as not all animals that die become stranded. Especially animals living further offshore and animals that are experienced in navigation in shallow waters will be found stranded less frequently. In contrast to observer effort however, these chances to get stranded have been constant throughout the entire century. In combination with other monitoring projects, strandings will therefore provide indications of trends in cetacean populations.

2. Shipboard and coastal surveys
In the Netherlands, surveys were conducted from seawatching sites on the beach (since 1972) and from ships (since 1987), both performed by the Dutch Seabird Group (Nederlandse Zeevogelgroep) or CvZ. Accidental sightings are also included. The data are stored in their Marine Mammal Database, which can be found at the personal website of Camphuysen (http://home.planet.nl/~camphuys/Cetacea.html; Camphuysen).

Observer effort is the amount of effort (*e.g.* time, trips, distances travelled) spent observing during a certain time span. For these surveys this effort is likely to be biased as this presumably changed over the years and between seasons. Many animals may also not be sighted because they spent an unknown percentage of time under water and/or because the sea state hinders sight. In the case of observing cetaceans from ships animals may also avoid the observers. These aspects may bias estimates of abundance. Interpretation of the data derived from these surveys is furthermore difficult, because they are not conducted on a regular basis and not always the same routes are surveyed. However, as observation time is documented for shipboard and coastal sightings by professionals, corrections can be made for observer effort. Results from different observation trips are therefore comparable. Incidental sightings can however not be corrected for observer effort and as these incidental sightings are only a small fraction of all sightings, they are left out of the analysis of data or are analysed separately.

3. Aerial surveys
In December 1984, an aerial monitoring programme was started by the Dutch National Institute for Coastal and Marine Management (RIKZ). Counts of both seabirds and marine mammals were performed flying every two months following a fixed route. Reports on seabirds and marine mammals have regularly been published, which is nowadays conducted by Berrevoets (RIKZ).

As for boat and coastal surveys, many animals may also not be seen because they spent an unknown percentage of time under water and/or because the sea state hinders sight. This will not biass the perception of population trends, but will certainly bias estimations of population size.

C) Biological parameters of each of the selected species
In order to gather information about factors that could potentially influence the occurrence of the selected species, species eco-profiles were developed. These included information on food, habitat requirements and population parameters, like reproduction parameters. Information about the Dutch populations is presented although this was not always possible. Information was therefore also obtained from other (mainly European) populations, especially concerning the bottlenose dolphin.

The articles used for this study were based on:

1. Autopsies
Autopsies were done on stranded and/or by-caught animals from various regions. Fish otoliths derived from stomachs were examined in order to determine the (main) prey taken by cetaceans; Dentinal Growth Layers (DGLs) were counted in order to estimate the age of animals; and by examining reproductive organs the reproductive state of animals was identified. However, neither the counting of DGLs nor the method used to determine the reproductive state is fully reliable, not even when conducted carefully (Addink, pers. comm.). Information of cetacean in the Dutch North Sea was often combined with data from other cetacean populations. Parameters for other populations are of course likely to be somewhat different from the Dutch population, but they may be used as an indication for the reliability of the Dutch data as differences are not likely to be excessive.

2. Field observations
Field observations usually involve the structural observation and analysis of cetacean behaviour, although incidental observations are sometimes reported as well. Especially when studying population structure and social

behaviour, photo-identification is used to distinguish between individuals. This method has proved rather reliable.

D) The impact of human activities in the Dutch part of the North Sea

In order to obtain information about the impact of human activities we based our study on the following data:

1. Data providing information on (past) population trends together with information regarding the development of human activities in the Dutch part of the North Sea; and
2. Data analysing possible cause-effect mechanisms of threats (as found in scientific documents) and a confrontation of anthropogenic activities in the Dutch part of the North Sea and specific biological parameters of the selected species.

Information based on relations in the past between population trends and human impacts as found by other authors were regarded as a helpful indication before extrapolating these to current or future situations. This report therefore mainly focused on the analysis of potential current threats (*see* point 2).

The following topics were studied regarding six threats (by-catch, pollution, overfishing, noise pollution, climate change and collision with boats):

- **The cause-effect mechanism underlying the threat**

  Understanding the cause-effect mechanism of a threat as defined in the Netherlands or elsewhere may help to identify the existence and extent of the threat in the Dutch part of the North Sea.

- **The existence of the threat to the selected species in the Dutch sector of the North Sea *in the past***

  Reported effects of an anthropogenic activity may support the identification of the existence and extent of the threat. Results of historical analyses were therefore outlined here. These analyses were conducted by fellow scientists and can be considered a 'black-box method': Data on past population trends were associated with information regarding the developments in anthropogenic activities (*see* point 1), without considering cause-effect mechanisms.

- **The *current* existence of the threat to the selected species in the Dutch part of the North Sea**

  This study reports on the existence and extent of human impacts. Firstly, recently reported effects of anthropogenic activities were discussed in this section, as this informs us about the current likelyhood and extent of any impacts. Because these effects may vary between cetacean species and regions and because information is also scarce, recent reported effects from other (mainly) European populations were included. Secondly, the likelyhood and extent of the impact of anthropogenic activities on the selected species in the Dutch sector of the North Sea is discussed based on 1) the biology and distribution of the selected species; 2) the occurrence and distribution of human activities in the Dutch part of the North Sea; 3) the cause-effect mechanism of the various threats; and 4) the recently reported effects.

  To determine the extent of a threat, various predefined criteria were used. An overview of these criteria is presented in a table, upon which a final classification for each threat on a species-specific level was based.

The articles used for this section are based on:

1. Autopsies

Autopsies were done on stranded and/or by-caught animals from various regions, and may reveal information about the direct or indirect cause of death. Identification of by-caught animals for example is possible when examining skin and lung damage. A standard protocol has in addition been formulated for the diagnosis of by-catch and has proved to be very reliable. However, not for all types of autopsies such protocols exist and care should be taken when comparing results of different autopsies.

2. Field observations

Field observations usually involve the structural observation and analysis of cetacean behaviour in response to a change in their environment. Incidental observations are sometimes reported as well. In the case of by-catch, in addition, not only behavioural studies were conducted. Observers were allowed on board operating fishing vessels during a certain period and collected information on fishing effort. Measures for fishing effort are for example the time the net is left under water (soak time), kilometres of net set, number of hauls, tonnage of fish caught and/or days at sea. In addition, the number of by-caught cetaceans was documented, which in combination with the information on fishing effort may lead to an estimation of the total number of by-caught cetaceans in a certain fishing method and a particular area.

3. Laboratory studies

Laboratory studies were conducted on captive animals and included both behavioural studies and toxicological studies. These studies may provide a better understanding of cause-effect mechanisms. However, one should bear in mind that laboratory studies are often a simplification of the natural situation and the response of captive organisms may thus not be comparable to that of free-ranging organisms.

E) Recommendations to improve the North Sea for the selected species

With the current knowledge about the occurrence and extent of each threat to the selected species in the Dutch part of the North Sea, we may now consider what threats are important concerning cetaceans.

QUALITY CONTROL OF THE SOURCES USED

This research is mainly a literature study. However, because not all literature is of the same scientific quality, some criteria are set to control the quality of this work. First, literature was primarily sought in scientific magazines or amongst reports from scientific organisations. These publications were in addition often recommended by marine mammal scientists, amongst whom Marijke de Boer, marine consultant for the Whale and Dolphin Conservation Society (WDCS). Secondly, we tried to avoid the use of unpublished reports. These reports do however contain an overview of valuable information and therefore some information from unpublished reports or data were used. Whenever possible, however, the references were carefully checked. The third source of information used for this research was the internet, as many institutes often provide large databases for public use through this medium. The internet sources used for this report are those hosted by scientists, scientific organisations, and governmental institutes. Additional interviews with scientists have also been used for this report. Information from these interviews used is indicated with (pers. comm.).

4. The North Sea

In this chapter information is provided about both natural characteristics of the North Sea and developments in anthropogenic activities in the Dutch part of the North Sea.

4.1. Natural situation

Oceanographic features such as temperature, water depth, seabed gradient, currents and bottom structure are of importance for the primary productivity of an area, the benthos and fish diversity and consequently the presence of cetaceans. These features are discussed and maps of different areas in the entire North Sea and the Dutch part of the North Sea are presented.

4.1.1. Location

The Greater North Sea, as defined by OSPAR, is situated on the continental shelf of northwest Europe, surrounded by Norway, Denmark, Germany, the Netherlands, Belgium, France and Great Britain. (OSPAR, 2000) Often a division in three parts is made:

- The southern North Sea, which can be found between 51° and 54° N (including the Southern Bight and the German Bight), where the water is generally shallow (less than 40 m in depth);
- The central North Sea, which is located between 54°-57° N, with depths varying from 40 to 100 m, except for the Dogger Bank and coastal banks off Denmark;
- The northern North Sea extending north from 57° N, where the water is mostly 100-200 meter deep, with an exception for the Norwegian Rinne, with water depths reaching more than 700 m (Reid *et al.*, 2003).

Including estuaries and fjords, the total surface area is approximately 750,000 km^2 and the total volume 94,000 km^3 (OSPAR, 2000).

4.1.2. Physics

Currents

The mean currents of the North Sea form a cyclonic circulation, which is caused by the inflow of ocean water in the northern North Sea and in the southern North Sea through the Channel and the effect of the Earth's rotation. As can be seen in figure 1, the northern inflow is the most important. Only 10 % enters the water in the south, through the Channel. As parts of the North Atlantic Current are bending south/southeast after passing the Shetland Islands at the east and approaching the Norwegian coast, Atlantic water enters the northern North Sea. Here it is guided east, following the 100 m depth contour. Only little water is entering through the Fair Isle Channel between Orkney and Shetland. After having entered the Skagerrak, the water returns after a counter clockwise circulation and follows the Norwegian coast back into the Atlantic. A small residual flow into the Channel, mainly steered by wind (on average westerly) and tide, can also be seen (OSPAR, 2000).

Water entering the North Sea in the south is more saline water from the Atlantic. Furthermore, this water is stratified in summer, caused by a difference in temperature between the surface and bottom. Due to the contrast with the Channel water, which is cooler and tidally mixed, a frontal system develops: the Ushant Front. Other fronts caused by differences in temperature and/or salinity can be found close to the Frisian Islands near the Netherlands and Denmark, along the British coast and in the Skagerrak. Frontal systems are very important for marine ecosystems, since they cause up welling of nutrient rich water, thus enhancing plankton productivity. This plankton is the solid basis for the complicated food web that can be found in marine ecosystems (Reid *et al.*, 2003).

Temperature and salinity

As mentioned above, water from the Atlantic is more saline than water from the North Sea. This is caused by less saline water entering the North Sea from the Baltic Sea and fresh water flowing in from several rivers. Seasonal changes in sea surface salinity are comparatively small. On the contrary, annual changes do occur due to changes in climate. A reduced fresh water input and/or an increased influx of Atlantic water may have caused high salinities in past years. (OSPAR, 2000)

The Sea Surface Temperature (SST) shows a yearly cycle, which can be explained by a difference in water depth in the Atlantic Ocean and the North Sea. During the summer, Atlantic water is cooler than the North Sea water, which heats faster due to shallow depths. Near the Dutch, German and Danish coasts the water is warmest. Parallel to the Dutch coastline isotherms can be found decreasing in temperature as they are approaching the Atlantic in the northern North Sea. During winter, the contrary is true: Relatively warm Atlantic water enters the North Sea from the north, decreasing in temperature as it approaches the Dutch, German and Danish coasts (see figure 2). Although the SST varies through time and space, it usually does not reach a temperature below the freezing-point of sea water (-1.9 ^{o}C; Van Aken, 1990).

4.1.3. Characteristics of the Dutch part of the North Sea

The Dutch part of the North Sea is not a uniform area, but can be distributed in several different areas (see figure 3). The largest of these is stretching out over parts of the English, Dutch, German and Danish continental shelves and is known as the Dogger Bank. The Dogger Bank is dominated by a complex pattern of fronts and upwelling (Reid *et al.*, 1988). It is a sandbank, of which the top is only 18 m beneath the water surface. The edges only reach a depth of 40 m, so compared to the surrounding waters, this area is indeed very shallow. As a consequence, light can penetrate the entire water column, enabling plankton to bloom also during the winter months.

Highly productive areas, as the Dogger Bank, are characterized by species richness. The Dogger Bank is known to be spawning grounds for, amongst others, plaice, herring and smelt, on the slopes many fish species exist and the area is also a source of food for many bird species and several cetacean species. Since the Dogger Bank is a transition zone between southern and western species, the bottom fauna also is rather rich in species diversity.

South of the Dogger Bank, another area with a diverse benthic fauna can be found: The Oyster grounds. This area is relatively deep and water flows rather slowly. As a result, sediment and organic compounds sink to the bottom, where bottom dwelling organisms feed on it. In former years, many oysters were amongst these organisms, forming a solid cover of the North Sea bottom as it nowadays can hardly be found in the Dutch sector, probably as a result of intensive fisheries.

The Clover Bank is the only gravel bank in the Dutch sector. Water depths here are about 30 to 40 m, but where this bank is interrupted by the Botney Cut it reaches a depth of 60-80 m. The high diversity in bottom types, caused by the alternation of gravel and areas covered with sand, enables many species to live here. Researchers have reported about 200 larger species!

Further south, the Frisian Front is located. It is a 10-15 kilometres broad zone, stretching out for 70 m. Nutrient rich sediment is transported towards this front by the southern North Sea and settles down. Many rare bottom species can be found here. But not only these rare species are faring well as a result of nutrient richness: fishes, birds and porpoises are often sighted here too.

The last important area in the Dutch part of the North Sea is the coastal zone. This zone is highly dynamical and functions as a transition zone from fresh to salt water. Due to these dynamics, the area is not very rich in species. However, the species found in this zone, amongst others Spisula, occur in high numbers. Besides, the coastal zone is an important area for transport of sediment, nutrients, silt and larvae to areas further down stream. Because of high temperatures during summer, the area also functions as breeding ground for many, and also rare, fish species (Anonymous, 2003).

4.2. Human activities

4.2.1. Fisheries

Developments in fisheries

In Europe, fishing processes became industrialized in the early nineteenth century, when the steam trawler was introduced. After the First World War, in addition, diesel engines were used in fishing vessels and the Second World War contributed to the industrialization of fisheries with the development of freeze trawlers and the introduction of radars and acoustic fish finders (Pauly *et al.*, 2002).

The effect of these developments initially was an increase in total annual landings in the North Sea region. Whereas in 1900, only 1 million ton fish was landed, a doubled amount of 2 million ton was landed in 1960. During the 1960s, landings increased sharply to about 3.5 million ton. This increase was however followed by a decline to less than 3 million tonnes in recent years. Species that especially declined in landings were gadoids. Pelagic species and species for industrial processing on the other hand increased. The recent decrease in total annual landings is striking, since fishing effort in the North Sea has risen between the late 1970s and 1995 (Jennings *et al.*, 1999).

The recent decline in landings may indicate a decreasing fish stock, but Spawning Stock Biomass (SSB) may be a more reliable indication. SSB is a measure for that part of a fish stock that is able to reproduce. The larger, and thus older and mature, the animals are which are caught in fishing gear, the more the SSB declines. Consequently, recruitment will diminish as well and the stock can be expected to reduce. Below a certain limit, $\mathbf{B}_{lim}$, the recruitment is impaired and the stock will become depleted or dynamics of the stock are unknown. A precautionary limit, $\mathbf{B}_{pa}$, is therefore set by ICES to ensure avoiding reducing the stock to or below $\mathbf{B}_{lim.}$ $\mathbf{B}_{pa}$ is the spawning stock biomass below which a stock would be regarded as potentially depleted or overfished (ICES, 2001a).

In the North Sea, many round fish and flatfish stocks have been observed in their lowest SSB in recent years. Landings and SSB for cod, for example, have been lowest on record in 2002 (ICES, 2003a). The absolute level of SSB is unknown, but it is likely to be well below the current $\mathbf{B}_{lim}$. Of whiting, SSB gradually declined over more than 20 years and consumption yield was on the lowest level, past $\mathbf{B}_{\mathbf{pa}}$ and near $\mathbf{B}_{\mathbf{lim}}$, in 2002. Since 1998, however, the SSB has been increasing again (ICES, 2003a). Haddock has shown more variation than whiting and cod, which is due to the occasional occurrence of very strong year classes. Currently, the SSB has increased well above $\mathbf{B}_{lim}$ because of the maturation of the strong year class of 1999. The SSB is however likely to decrease again in the near future, because recruitment after 1999 has been low (see figure 4; ICES, 2003a).

Herring is a species which became almost depleted due to overfishing during the 1970s. In the 1980s the stock could recover again due to the implementation of a herring recovery plan. During the mid-90s low stock size was recorded again, but here too herring responded well to management measures reducing the exploitation of both juveniles and adults. Nowadays, the North Sea herring stock has been classified inside safe biological limits again (ICES 2003b).

Developments of another nature in fisheries are measures which have been introduced in order to prevent cetacean by-catch. In 1992, the European Union restricted the maximum length of driftnets to 2.5 km. In 1998, it was decided to phase out all driftnets used to catch tuna, swordfish and similar listed species, and from 1 January 2002 these nets were totally prohibited in EU waters. Purse seine activities were also restricted. In 2001, it was decided that the encircling of schools or groups of marine mammals with purse seine nets was no longer allowed.

Recently, a new EU regulation was adopted in which acoustic deterrent devices (or pingers) were set mandatory from 2005 onwards. The fisheries which are included are drifnets, bottom-set gillnets and tangle nets in the Baltic Sea, wreck nets and large-mesh bottom-set gillnets in the North Sea and bottom-set gillnets and tangle nets in the Celtic Sea. (Ross & Isaac, 2004).

Fisheries in the North Sea
North Sea fisheries are currently active throughout the entire year and in all areas where fishing is allowed.

In the Netherlands, the most common fishing method is beam trawl fishery. Selected species of this fishery are flatfish for human consumption, such as sole and plaice. These flatfish live on or near the seabed and can only be caught when swimming up. Therefore a chain mat or tickler chains are attached under the net. One of the functions of the chain mat is to stop large objects entering the net and damaging it, the other function is to act as a means of agitating the sea bed, causing fish to be disturbed and swim up into the net. In general, the nets in beam trawl fisheries have a length of 12 m in 2000pk vessels and 8 m in 300pk vessels. Within the territorial waters (12 nautical miles) only vessels up to 300 pk are allowed. Outside, the larger vessels are allowed as well. Bottom trawling with vessels larger than 300pk is also not allowed in the plaice box, which is an area of approximately 40,000 km^2 north of the Dutch and German Wadden Islands and west of the Danish Wadden Islands

Several other Dutch vessels are so-called multipurpose vessels, which are occupied to catch herring, a pelagic fish species, throughout the entire North Sea. The vessels use the pelagic trawl method, which usually involves larger nets than the beam trawl fisheries. Most of the pelagic trawl fisheries operate in the Celtic Sea, Biscay and Channel area of the Northeast Atlantic (Morizur *et al.*, 1999), but some operate in the Dutch part of the North Sea as well.

There are also several fishermen using bottom-set gillnets (or ‘staand want’ in Dutch). These are nets which are anchored to the seabed and are used in order to catch demersal fish including cod, turbot, hake, saithe and dogfish (Ross & Isaac, 2004). The Dutch bottom-set gillnets are mainly set near river mouths and close to shipwrecks, which are present in the entire North Sea.

Whereas, within the 3-mile zone only Dutch and Belgian fisheries are allowed to operate, outside this zone international vessels are active as well. However, these fisheries are not very well monitored (Absil, pers. comm.).

4.2.2. SHIPPING

Ocean transportation is growing as world trade expands. Large bulk carriers convey increasing quantities of raw materials; container traffic is increasing; and maximum container vessel size continues to grow as well (OSPAR, 2000).

Shipping routes in the Dutch sector of the North Sea, including those heading for Rotterdam, the largest port of Europe, are mapped in figure 5. Vessels on these routes at times transport dangerous cargo and often over long distances. Accidents, which are especially likely to occur close to ports and on routes where vessel density is at its highest, may have serious adverse effects on the marine ecosystem. In addition, the majority of the waste produced on board is thought to be discharged during long trips, as onboard storage requires extra capacity. Shipping is therefore thought to be the major source of marine debris in the North Sea.

Vessels are also an important source of pollutants in the North Sea, including oil and anti-fouling products like tributyl tin (TBT). Nowadays, the use of TBT is not allowed on vessels smaller than 25 m, as was decided by the EU. The IMO furthermore agreed on prohibition of the use of organotin holding paint from 2003 onwards and after 2008 no organotin paint is allowed to be used on ships anymore. The input of oil on the other hand is still ongoing as a result of illegal intended release and discharges from bilges and engine rooms or due to accidents with oil tankers. These oil tanker accidents have the most visible effects on the ecosystem and the probability of these accidents has increased as oil transport increased. In the decade to 1995, for example, the worldwide transportation of crude oil increased by 61% in tonnage (OSPAR, 2000). Nevertheless, the chance of an accident is still relatively small. In the Netherlands the standard scenario, on which the oil removal capacity is based, for example, is the spill of 30.000 m^3. In theory, this scenario may occur once every 47 years (Directie Noordzee, 2000).

4.2.3. OIL AND GAS INDUSTRY

The history of gas and oil production in the North Sea started at the end of the 1960s. During the last decade, the number of oil production platforms almost doubled in the North Sea, primarily reflecting an increase in the UK and Norway (OSPAR, 2000).

In the Netherlands, gas production is the most important form of offshore industry. In 2002, approximately 27 billion m^3 gas and 2.24 million m^3 oil were produced at sea from approximately 150 offschore platforms (Ministry of Economic Affairs, 2003). The distribution of installations in the Dutch sector are mapped in figure 6.

The exploration and production of North Sea oil and gas reserves has resulted in the accumulation of large quantities of drill cuttings on the seabed surrounding drill sites (Breuer *et al*., 2004). This complex mixture of man-made and natural substances contains higher concentrations of certain metals and hydrocarbons. The offshore installations may also discharge oil, heavy metals and PAH with the water they produce.

Although the number of installations duplicated from 1990 to 1997, the overall oil input of offshore installations had decreased with 66% in the North Sea area (OSPAR region II). This is due to improved techniques and tighter rules (OSPAR, 2000). PAH emission levels in the North Sea however, are still increasing. One of these PAHs, benzo(a)pyrene, even exceeds the reference point in all locations (RIVM, 2004a).

4.2.4. SAND AND GRAVEL EXTRACTION

Sand and gravel are essential materials for private and industrial construction work, for coastal protection and for beach replenishment. By far the highest demand for marine sand and gravel in all OSPAR regions exists in the North Sea, where production increased from 34 million m^3 in 1989, to 40 million m^3 in 1996 (OSPAR, 2000).

The majority of sand extraction in the North Sea occurs in the Netherlands, where more than 30 million m^3 sand is extracted. Sand extraction in the Netherlands occurs outside the 20-m depth line, as is mapped in figure 5. No gravel extraction takes place in the Dutch part of the North Sea (Stichting De Noordzee, in prep.).

Sand extraction will have various effects on the marine environment. The most direct effects are that of habitat destruction for benthic organisms and the destruction of benthic organisms themselves, as most of these species live in the upper 30 cm of the seabed. A more indirect effect is the change in the species composition of the ecosystem. The composition of benthic organisms is likely to change when deeper pits (>2 m) are dug, because then sediment, water depth and current will change. Phytoplankton growth and composition will also be affected, as both the availability of light and nutrients are affected by sand extraction: Sand extraction causes sand plumes which reduce the penetration of light and due to the routing of the seabed nutrients which were stored in the sediment are released. Sand plumes caused by extraction will furthermore affect filter feeders and predators hunting by sight. At least at a local scale, but possibly also at a larger scale, sand extraction will thus affect the entire ecosystem (Stichting De Noordzee, in prep.).

4.2.5. MILITARY ACTIVITIES

Military activities in the Netherlands are conducted in restricted areas, as is shown in figure 5.

4.2.6. COASTAL DEFENCE

Around the North Sea, coastal defences are common, particularly on the shallow south and east coasts, the Wadden Sea and on islands vulnerable to storm surges and sea level changes. Beach protection is partly accomplished by offshore breakwaters and dunes are occasionally protected by hard structures. The present tendency however is to use artificial nourishment (OSPAR, 2000).

4.2.7. ONSHORE ACTIVITIES

Onshore activities may affect the marine environment through the release of hazardous compounds. Traces of pesticides for example can be found in the Dutch part of the North Sea due to the washing out of the chemicals and atmospheric deposition. The use of the insecticide DDTcame to a halt in 1973, nevertheless, DDT levels still exceed the reference points in most locations due to its high persistence. Also, as in some countries its use is still allowed, DDT may be introduced through atmospheric deposition (RIVM, 2004b).

Onshore activities such as trade, traffic and consumption are also sources of persistant organic pollutants and heavy metals in the Dutch part of the North Sea. More than two decades ago the use and production of PCBs for example was forbidden in the Netherlands. Close to the Dutch coast, the concentration of PCBs consequently fell by nearly 70% during 1981-1996 (Laane *et al.*, 1999). During the last decade, however, the level of PCBs has stabilized in most locations. Only in the coastal zone the level of PCBs still fluctuates. Furthermore, in the coastal zone and the Westerschelde, PCB-153 levels are still exceeding the reference point (RIVM, milieu en natuurcompendium). More recently, PBDEs have replaced the use of PCBs (Boon *et al.*, 2002).

Through cooling, rinsing and cleaning water from coastal industries and through traffic, heavy metals may enter the marine environment. Along the Dutch coast and at open sea, the median concentrations of Cd, Cu, Zn, and Pb were highly reduced during the period 1981-1996 with a percentage ranging between 17% to 71%. Of these metals, Cd was the most reduced, especially north of the outlet of the Rhine (Laane *et al.*, 1999). After 1996, these trends were maintained for Cd, Zn, and Pb, but stabilized for Cu. Mercury emissions have also been reduced since 1995 (RIVM, 2004c).

4.2.8. ANTHROPOGENIC ACTIVITIES IN THE FUTURE: WINDFARMS

Wind farms are growing in number in Europe, since many countries agreed to reduce their carbon emissions. Denmark, the UK, and Sweden already built wind farms at sea and many other countries are planning to build marine wind farms (Dolman *et al.*, 2003).

In the Netherlands, the government planned to obtain 6,000 MW energy from offshore wind farms by 2020. The construction of the North Sea Q7-WP wind farm, at a distance of at least 25 km offshore in water of 20-25m depth, is planned to start in spring 2005. The farm will consist of 60 windmills producing each 2MW. Another farm is planned at 8-23km off Egmond. This farm, the Near Shore Wind Park or NSW, will consist of 36 mills each producing 2.75MW, which is planned to be removed after an exploitation period of 20 years.

More and larger wind parks will be build in future, outside territorial waters. It is expected that at first the parks will be build in an area just outside the 12-mile-zone, roughly between Rotterdam and Den Helder, 25 up to 50 km out of the coast.

5. SELECTION OF SPECIES

The following chapter provides an overview of cetacean species recorded stranded and/or sighted in the Dutch part of the North Sea. Based on the information presented a selection will be made of species which are likely to be naturally abundant in the Dutch part of the North Sea, either seasonally or year-round. Trends, current distribution and abundance will then be discussed in more detail for these selected species.

5.1. STRANDINGS AND SIGHTINGS OF CETACEANS

Table 1 provides an overview of all cetacean species reported in the Dutch part of the North Sea and/or reported stranded on the Dutch coast. Information is derived from strandings, and shipboard, coastal and aerial surveys (combined in one column as sightings). Before interpreting the presented data one should be informed about the obstacles when comparing data from different sources. These obstacles are outlined in the methodology section of this report.

5.2. TRENDS AND CURRENT STATUS OF SELECTED SPECIES

5.2.1. SELECTION OF SPECIES

More than twenty cetacean species have been reported in the Dutch part of the North Sea and/or stranded on the Dutch coast, but most of them are not indigenous. Most species in fact only occasionally entered the Dutch part of the North Sea and subsequently stranded (*e.g.* the Cuvier's beaked whale). Other species have been more abundant over the century, or in a particular period, in both strandings and sightings and are therefore of more interest to this study. Based upon table 1, these species are the harbour porpoise, the white-beaked dolphin, the short-beaked common dolphin, the bottlenose dolphin and the minke whale.

After analysing trends and current distribution and abundance (as described in further detail below), it appeared that of these five species only three are truly (potentially) regular occurring species in the Dutch sector of the North Sea. These are the bottlenose dolphin, harbour porpoise, and white-beaked dolphin. The minke whale on the contrary occurs either further south or further north from the Dutch part of the North Sea (see appendix 4). The common dolphin in its turn has been present in considerable numbers among reported strandings, but its presence appeared to be temporal. This could be explained by a temporary shift in sea surface temperature, which, to this extent, is not known to occur regularly. It is therefore not likely that the common dolphin will return to Dutch waters, not even when general threats to cetaceans are minimised (see appendix 3).

In conclusion, the bottlenose dolphin, harbour porpoise and white-beaked dolphin have been defined as the selected species for this study.

5.2.2. BOTTLENOSE DOLPHIN

Trends

Figure 7 provides a historical overview of the stranding records of the bottlenose dolphin in the Netherlands for the period 1900-1997. Despite the relatively low numbers of recorded strandings before 1920, the dolphin may have been a regular visitor or even a 'resident species' for this period, meaning that at least part of its home range could be found in Dutch waters (Kompanje, 2001). The period 1921-1950 was considered the 'heyday of the Dutch coastal *Tursiops*' (Kompanje, 2001), although sightings in the Marsdiep area during the 1930s started to show a decline since 1939 (Verwey, 1975). The difference with the number of stranded animals during the former period, before 1920, may be explained by 1) an increase in observer effort (a well functioning reporting system had only been present since the 1920s) and/or 2) the number of bottlenose dolphins truly increased (Smeenk, pers. comm.). During 1951-1975, a decline in strandings occurred and afterwards only vagrants stranded on the Dutch coast (Kompanje, 2001). Shipboard surveys showed a total of 44 reported bottlenose dolphins during the last three decades (Camphuysen, 2004).

Abundance and distribution

In Europe, bottlenose dolphins are locally common near Spain, Portugal, north-west France, western Ireland, the Irish Sea, north-east Scotland and in smaller numbers in the English Channel (Reid *et al.*, 2003). In the Netherlands, this dolphin, once common along the Dutch coast, is nowadays rarely reported (Kompanje, 2001; Camphuysen, 2004).

5.2.3. HARBOUR PORPOISE

Trends

The analysis of strandings data based upon strandings revealed a general decline in numbers since the 1950s or even before (see figure 8). A proportional decline of neonates among the strandings after 1950 is also apparent and became even stronger in both neonates and calves after 1970. This decrease appeared to end in 1985, when a small proportional increase in stranded neonates and calves, as well as a general increase in strandings in the north of the Netherlands occurred (Addink & Smeenk, 1999) to a yearly 80-100 stranded porpoises in recent years (Smeenk, pers. comm.). In the late 1980s, seawatching data (figure 9) and aerial surveys (figure 10) also showed an increase in reported porpoises (Camphuysen, 2004; Witte *et al.*, 1998).

Besides a shift in the number of yearly reported porpoises, shifts in seasonal distribution were also noticed. The former summer peak in strandings gave way to an increase in autumn strandings after 1950. Since 1970, most strandings and sightings (during shipboard surveys and aerial surveys) occurred in autumn and winter (Addink & Smeenk, 1999; Camphuysen & Leopold, 1993; Witte *et al.*, 1998). Since the end of the 1990s however, records from aerial surveys increased during summer(pers. comm. Witte).

Both aerial surveys and strandings showed a shift in spatial distribution of the porpoises from northern regions of the Netherlands to more southern areas close to Belgium (Addink & Smeenk, 1999; Witte, pers. comm.). The period during which this shift took place is not clear.

Abundance and distribution

a) Current distribution in the North Sea

Several differentiations for the harbour porpoise population in the North Sea have been suggested (Walton, 1997; Tolley *et al.*, 1999; Andersen *et al.*, 2001), varying from a north south differentiation to an east west differentiation. Andersen (1990) and Kinze (1990) furthermore suggested the existence of three distinct major wintering areas in the entire North Sea and adjacent areas; west England, northern/central North Sea, and Danish inner waters.

For Dutch porpoises, Camphuysen and Leopold (1993) suggested an east-west seasonal migration of porpoises, with most of the animals moving to the eastern shores of the UK in summer and returning to the Dutch waters in winter. Witte (pers. comm.) suggested an even more extended migration pattern, with porpoises being mainly present in the Netherlands during February/March, migrating to the German Bight during April/May, followed by migrating to the Danish coast during June/July and occurring along the British coast during August/September, when herring is spawning there.

b) The current situation in the Dutch part of the North Sea

Estimates

For the SCANS-survey (Small Cetacean Abundance in the North Sea) shipboard and aerial line transect surveys were conducted in 1994, to provide accurate and precise estimates of abundance as a basis for conservation strategy in European waters. The total North Sea population was estimated at 280,000 animals (Hammond *et al*, 1995). Witte *et al.* (1998) calculated that during the summer of 1994 at least 30,000 of these 280,000 animals live just west of the Dutch Continental Shelf. For the Dutch sector itself, an estimate of 11,000 harbour porpoises (not corrected for animals not visible at the surface) was made based upon aerial surveys in April 1996 (Baptist *et al.*, 1997).

Distribution over the Dutch continental shelf

The bimonthly distribution of porpoises as found during aerial surveys is presented in figure 11. These aerial surveys, conducted between 1985 and 1997, as well as ship-based surveys conducted during the period 1987-1992 both show a seasonal distribution of the harbour porpoise with porpoises being most abundant in coastal waters during winter (Camphuysen & Leopold, 1993; Witte *et al.*, 1998). Low densities were recorded further offshore. During summer, sightings were less and more widespread (Camphuysen & Leopold, 1993) and occurred mainly in northwestern regions, north of the Frisian Front, at or around the Doggerbank, and outside the Dutch sector of the North Sea (Camphuysen & Leopold, 1993; Witte *et al.*, 1998). Harbour porpoises were rarely observed in the southern part of the Dutch and in the Belgian sector of the North Sea (Witte *et al.*, 1998).

More recent distribution maps (provided by RIKZ, 2004; see figure 12) based upon aerial surveys during the period 2000-2003 show a somewhat different distribution of the harbour porpoise. Here also porpoises were most abundant during winter, but they did not appear to concentrate mainly in the coastal zone. In addition, porpoises were not restricted to northern areas, but were reported as well in the Southern Bight.

5.2.4. WHITE-BEAKED DOLPHIN

Trends

The white-beaked dolphin appeared to have shifted its southern range further south during the last decades. Since 1960, the species is found more regular amongst stranded marine mammals on the Dutch coast (see figure 13; Bakker & Smeenk, 1987). Further south, several strandings and sightings have been documented too, for example in Belgium, France, Spain and Portugal (Reeves *et al.*, 1999). At present, in Dutch waters, the white-beaked dolphin is even the most common dolphin species reported stranded. During the period 1983-1992, it accounted for 84.8 % of all *Lagenorhynchus*, *Delphinus* and *Tursiops* strandings (see Kinze *et al.*, 1997). It is not clear whether this is permanent. Although Fig. 5 shows a decline in strandings after 1995, this may well be explained by a yearly variation in strandings, or simply said, caused by chance. Furthermore, the last period (2000-…) is incomplete, since data from 2004 are not included. The decline, as seen in the graph, may thus rather be caused by a combination of chance and distortion than by an actual decline in white-beaked dolphins. However, from aerial surveys it also appears that white-beaked dolphin sightings decreased after 1994 (pers. comm. Witte).

Detecting such trends in sea-watching data is very difficult and when trying so, care must be taken when interpreting the results as observer effort varied between years. Figure 14 shows the high variation in sightings of white-beaked dolphins (Camphuysen, pers. comm.). It is striking that the year with the lowest records, 20 animals in 1991, is followed by a peak year of 423 animals in 1992. Part of this fluctuation may, beside a variation in observer effort, also be caused by an aggregation of the species, which is a feature known to occur in white-beaked dolphins (Haasse, 1987). Due to the aggregation of animals, each new sighting may therefore add a considerable number of reported dolphins. Thus, with a relatively small increase in observer effort and consequently in sightings, the total number of reported dolphins may increase rather strongly. Unfortunately, no information on the number of sightings is available.

Trends in spatial distribution were also detected in aerial surveys and strandings. Sightings from aerial surveys presented by Baptist (1987) and Baptist *et al.* (1990) showed a northerly distribution with most animals seen north of 53^{o} N. In addition, 70 % of the strandings along the Dutch coast between 1983-1992, occurred in the northern part in the Netherlands (Smeenk, 1986; 1989; 1992; 1995). Because the stranding records in the North Sea showed substantial fluctuations between years, Smeenk (pers. comm.) suggested that white-beaked dolphins in the Dutch sector occur at the southern edge of their distribution. However, records in southern waters have increased (Kinze *et al.*, 1997). Baptist (1992) for instance reported a group of white-beaked dolphins, estimated at 25 animals, in the northern mouth of the Westerschelde. More recently, a group of about ten dolphins was reported near the province ‘Zeeland’ (De Boeck, pers. comm.). Also further south, in Belgium, sightings and strandings of white-beaked dolphins have been reported (Seys, 1998). No clear (shift in) spatial distribution can be deduced from ship-based surveys.

Abundance and distribution

a) Distribution in the North Sea

For the North Sea and adjacent waters, results from ship born surveys around the British Isles indicated that the distribution of white-beaked dolphins is confined to the shelf areas, showing a general increase in sightings towards land, at least to within a few tens of kilometres from shore (see figure 15; Northridge *et al.*, 1995).

Hammond *et al*. (1995) reported most sightings of white-beaked dolphins in the northern and western edges of the North Sea. The main sightings around the British Islands are off northern Scotland and along parts of the Atlantic coast of Ireland (Northridge *et al*., 1997). Evans *et al.* (2003) reported on sightings between 1992-2002 in UK waters (from land and offshore) and concluded that white-beaked dolphins are most abundantly found in the central and northern North Sea across to north-west Scotland, although it also occurs occasionally in Western and Southern Ireland, St. George’s Channel, and western part of the English Channel. Numbers peaked in August, especially in the northern North Sea.

b) The current situation in the Dutch part of the North Sea

Estimates of abundance

Hammond *et al.* (1995) estimated a population size of 7,856 white-beaked dolphins in the North Sea, based upon extensive sea surveys in June/July 1994. For *Lagenorhynchus* spp. an abundance of 11,760 was estimated. Estimates for the Dutch sector however, could not be made.

Distribution

Figure 16 shows an integrated map for all dolphin sightings made during aerial surveys for the period 1989-2003. The majority of these dolphins are likely to be white-beaked dolphins. Due to the large time span, it is difficult to draw any conclusions. Creating maps for shorter intervals is not applicable either, as dolphin sightings are few.

Ship-based surveys results indicated a northerly distribution. During 2003, observers reported 66 white-beaked dolphins during 17 sightings (Marine Mammal Database). Not all animals were definitely identified as white-beaked dolphins. Furthermore, not all sightings were made by experienced observers. Excluding both incidental sightings and uncertain records, gives a total of 19 animals seen during 10 sightings. All animals were seen in June/July during boat surveys off east England, over the northern Dutch Continental shelf and the northern half of the Dogger Bank. It is not known to the author whether these northern trips were the only trips made. If so, no conclusions about the distribution of the white-beaked dolphin can be drawn from these data and also no further conclusions can be drawn considering the temporal distribution of the animals. The occurrence of white-beaked dolphins records in June and July and the absence of records during the rest of the year may be best explained by variation in observer effort. In other regions however, seasonal changes were demonstrated (Northridge *et al.*, 1997; Evans *et al.*, 2003).

5.3. SELECTION OF SPECIES

All information in literature about trends, population estimates and distribution is based on stranding records, shipboard surveys, coastal surveys, incidental sightings and aerial surveys. As outlined in the methodology chapter, these sources are all biased and care should be taken when interpreting them. The question therefore is now: can we conclude anything from the data presented about trends, population estimates and distribution? We suggest that most of the bias in the surveys are structural and do not influence the overall trends. In addition, the results of strandings and sightings are in general not contradictory and thus give no direct reason for doubting the results and the drawing of conclusions therefore is justified. Findings per species are discussed below.

The harbour porpoise
Harbour porpoises have continuously been present in stranding records from the 20th century. A decline in stranded porpoises was reported since the 1950 until the 1970s. This overlaps with a poor documentation of stranding records during the period between 1964 (which is when Van Deinse died) and 1970. However, the overlap is not complete and low numbers of porpoises were also recorded in shipboard and aerial surveys between 1970 and 1985 respectively, when these surveys were started, until the 1990s. Combining strandings, and results from boats and aerial surveys, it can thus be concluded that a decline was observed after 1950 but that the porpoise population has been increasing since the mid-1980s.

A seasonal distribution of records for the harbour porpoise, with highest numbers found between December and April, is apparent based on strandings and sightings. Both sources also report a recent increase in summer records. However, the spatial distribution differs for shipboard surveys and aerial surveys. Both sources show an offshore movement of porpoises during summer and a part of the population is thought to migrate out of the DCS as sightings are less whilst observer effort remained the same. Results on the distribution during migration however, are not consistent for both sources. This can be best explained by the difference in survey periods: the most recent information from shipboard surveys is an analysis of data between 1987-1992 and results from this analysis are similar to those of aerial surveys conducted between 1985-1997. More recent information from aerial surveys on the contrary show a different, more southerly, distribution over the DCS, as is also reflected in stranding records. We therefore conclude that the harbour porpoise has shifted its range further south.

The continuous presence of the porpoise in both strandings and sightings records and furthermore in relatively high numbers makes this a suitable (selected) species for this study.

The bottlenose dolphin
More strandings of bottlenose dolphins were reported for the period 1921-1950 than prior 1920. The difference with the former period may be explained by 1) an increase in observer effort (as a well functioning reporting system had only been present since the 1920s) and/or 2) the number of bottlenose dolphins truly increased (pers. comm. Smeenk). As no shipboard and aerial surveys were conducted during this period, no comparison with such data can be made in order to confirm this increase. Sightings in the Marsdiep area, made by Verwey, can also not provide further information for comparison, as these date from the 1930s and only cover a limited area. The bottlenose dolphin was therefore either:

- abundant in the Dutch part of the North Sea throughout the entire century;
- present in small numbers, but increased at the beginning of the century; or
- entered the Dutch part of the North Sea at the beginning of the century.

An increase in strandings during 1921-1950, based on literature, has not been related to any changes in the environment, either of natural or anthropogenic origin. The decrease noted from the 1970s, and almost complete disappearance of this species, on the other hand has been related to human impacts (see also chapter 8). In this report therefore, the bottlenose dolphin is considered a selected species for this study, which potentially could re-occur in the Dutch part of the North Sea.

The white-beaked dolphin
The number of stranding records showed an increase of white-beaked dolphins from the 1960s. Although no data from shipboard and aerial surveys have published this apparent trend , both sources do indeed report the presence of these species over the DCS. The possible decrease in white-beaked dolphin strandings since the 1995s is supported by observations from aerial surveys and is therefore regarded as probable.

The appearance of white-beaked dolphins in the Dutch part of the North Sea has been associated with a shift in natural circumstances (see chapter 8). Although caused by a different mechanism, this is similar to the appearance of the common dolphin in the Netherlands after 1925. The occurrence of the common dolphin was however temporal, whereas this is not known for the white-beaked dolphin. Furthermore, the common dolphin disappeared due to natural influences whereas the probable decrease of white-beaked dolphins can not yet be related to either human or natural impacts. Because the species has been present for an extensive period based on both strandings and sightings and currently still occurs, it was decided to consider the white-beaked dolphin as a regular occurrence in the Dutch part of the North Sea.

6. Biology of the selected species

In this chapter several biological characteristics of the selected species are discussed per species, divided in the following sections:

1. Food;

   Based upon research in which fish otoliths in cetacean stomach have been examined, the main prey species for each cetacean species are outlined in a table. Information from different (where possible only European) countries is included for comparison. In addition, a general description of the diet, including also some less important fish species, is provided.
2. Habitat selection;,

   Abiotic factors and their preferred range are summarized for each species in a table.
3. Population parameters;

   Parameters like longevity (based upon dentinal growth layers), age of sexual maturity, length of sexual maturity, birth season, birth interval and lactation periods are summarized. Here also information from other European countries was presented for the harbour porpoise. For the bottlenose dolphin and white-beaked dolphin worldwide information was summarized, as little information currently exists about these species in European waters (bottlenose dolphin) or in general (white-beaked dolphin). It should be noted that for population parameters at times a distinction was made for male (m) and female (f) animals. For the age of sexual maturity (a statistical mean age at which sexual maturity is attained), at times only information about females is presented. In those cases, not enough samples of males were available. As currently little information is known about birth and mortality rates, we chose not to include these topics.
4. Behaviour;

   Foraging strategy and group size will be summarized here.

6.1. The bottlenose dolphin

6.1.1. Food

European bottlenose dolphins feed on a wide variety of both benthic and pelagic fish, amongst which have been recorded haddock, saithe, cod, hake, blue whiting, snipefish, mullet, silvery pout, trout, bass, sprat and sandeels. Also reported are octopus and other cephalopods (see Reid *et al.*, 2003). This wide variety of prey is consistent with the opportunistic feeding behaviour reported for the US by Mead and Potter (1990).

Diets of European bottlenose dolphins are not similar in all areas, and the information above is a summary only. Table 2 therefore shows the main prey species which have been reported for the bottlenose dolphin in distinct areas in Europe. In the Netherlands, main prey species of the bottlenose dolphin were whiting, haddock and cod (Verwey, 1975).

6.1.2. Habitat selection: abiotic factors

Both coastal and offshore populations of bottlenose dolphins exist (Mead & Potter, 1990; Kenney, 1990; Van Waerenbeek, 1990, Ross, 1977), which both have their own habitat preferences. The US inshore stock for example, showed a more temperature limited distribution than the offshore stock. The inshore animals also tended to be found in significantly warmer waters, which was demonstrated by their distinct northerly distribution and their absence from the studied area during winter (Kenney, 1990). Table 3 presents an overview of bottlenose dolphin preference for abiotic factors. Where possible, the distinction between inshore and offshore dolphins was made. In the North Sea, bottlenose dolphin populations will always be regarded as inshore populations.

In summary, inshore bottlenose dolphin prefer shallow waters (Würsig & Würsig, 1979, De Boer & Simmonds, 2003) and water temperatures above 10 ^{o}C (Bristow & Rees, 2001). During winter, animals are seen further offshore.

6.1.3. Population parameters

Table 4 shows an overview of several population parameters as were found for bottlenose dolphin populations worldwide. The age of sexual maturity varies between populations and sexes, but in general bottlenose dolphins attain sexual maturity at an age of about ten (Cockroft & Ross, 1990; Mead & Potter, 1990; Sergeant *et al.*, 1973) and were on average found to give birth every three years (Cockroft & Ross, 1990). It can thus be concluded that the dolphins reproduce relatively slowly. The animals may however reach an age of more than 40 years (Cockroft & Ross, 1989), although the oldest individual found in Northeast Florida was 25 years old. Bottlenose dolphins (Sergeant *et al.*, 1973).

6.1.4. BEHAVIOUR

The inshore bottlenose dolphin generally occurs in groups existing of up to ten animals, but largers herds are also known. Foraging occurs in groups, often at the surface. In shallow waters bottom-feeding occurs as well (De Boer, pers. comm.).

6.2. THE HARBOUR PORPOISE

6.2.1. FOOD

Harbour porpoises mainly forage independently (see Read, 1999) and are thought to be opportunistic feeders. This is reflected in wide varieties of fish and, be it in a lesser extent, cephalopod species, that were found reported in porpoise stomachs (a.o. Benke *et al.*, 1998; Santos Vázquez, 1998; Aarefjord *et al.*, 1995; Martin, 1995). In general, harbour porpoises feed on small (generally less than 40 cm), schooling clupeoid and gadid fish (Read, 1999). Most of the species are furthermore bottomdwelling and small, pelagic schooling fish with high lipid content (Bjørge & Tolley, 2002). This is however, a rough description as diets tend to vary between areas (see table 5). In the Netherlands, main prey species of the porpoise are whiting and gobies (Santos Vázquez, 1998). Herring is at times reported to be an important prey species for the porpoise as well, as the distribution of porpoises is reflected in the distribution of herring over the Dutch continental shelf (Meininger *et al.*, 2003). Addink & Smeenk (1999) stressed however, that less than 2% (by weight) herring was found in Dutch porpoise stomachs and porpoises did not even seem to be feeding on the concentration of juvenile herring present along the Dutch coast.

6.2.2. HABITAT SELECTION: ABIOTIC FACTORS

Harbour porpoises generally occur in waters with a water tempearture below 17 ^{o}C (De Boer & Simmnonds, 2003, Westgate *et al.*, 2000; Gaskins *et al.*, 1993). Water depth of their habitat is mainly less than 200 m (see Meininger *et al.*, 2003).

6.2.3. POPULATION PARAMETERS

Table 6 shows an overview of several population parameters as found in European harbour porpoise populations. It appears that the age of sexual maturity of porpoises is about three to four years (Benke *et al.*, 1998; Sørensen & Kinze, 1994), but for Dutch female porpoises this age was found somewhat higher (4.48 years; Addink, pers.comm.). In general, females give birth during summer every one or two years (Lockyer, 2003), and it can thus be concluded that the animals reproduce relatively fast. The birth season varies between regions (see table 6). In the Netherlands the birth period is a prolonged period from May to August, with a peak of births in July (Addink *et al.*, 1995).

Porpoises may reach an age over 20 years old (Lockyer, 1995), but the majority of the animals dies before reaching an age of six (Ólafdóttir, 2002).

6.2.4. BEHAVIOUR

Porpoises usually occur in groups of one or two animals (Camphuysen & Leopold, 1993). The animals mainly forage individually and near the seabed (De Boer, pers.comm.). Porpoises are known to show seasonal migration, with a coastal distribution during winter and a more offshore summer distribution (Witte *et al.*, 1998; Camphuysen & Leopols, 1993).

6.3. The white-beaked dolphin

6.3.1. Food

The diet of white-beaked dolphins consists of a variety of fish and cephalopods, to which sometimes benthic crustaceans are added. In all areas where stomach contents have been examined main fish species found were in general clupeids (e.g. herring), gadids (Atlantic cod, *Gadus morhua*, haddock, *Melanogrammus aeglefinus*, poor cod, *Trisopterus minutus*, bib, *T. luscus*, and whiting, *Merlangius merlangus*), and hake (*Merluccius merluccius*; Reeves *et al.*, 1999). An overview for the main prey species found in several European regions is presented in table 7. In the Netherlands, main prey species of the white-beaked dolphin are whiting and cod (Smeenk & Gaemers, 1987).

6.3.2. Habitat selection: abiotic factors

White-beaked dolphins occur in temperate and sub-arctic waters with a depth ranging mainly between 50 and 100 m (Reid *et al.*, 2003).

6.3.3. Population parameters

Table 8 shows an overview of several population parameters as were found in white-beaked dolphin populations worldwide. No information was found about the age of sexual maturity of these animals, nor about the birth interval. It can however be expected that the white-beaked dolphin reproduces relaitvely slowly, just like the bottlenose dolphin. The oldest white-beaked dolphin reported so far is a 28-years-old dolphin stranded on the German coast (Sonntag *et al.*, 1997).

6.3.4. Behaviour

Like bottlenose dolphins, white-beaked dolphin occur in groups of up to ten animals, but larger, and also mixed, herds are also known (Haasse, 1979). Foraging behaviour of the animals is unknwon, but it is thought that the depth they forage on depends on the prey species (De Boer, pers. comm.).

7. CAUSE-EFFECTS MECHANISMS OF THREATS TO CETACEANS

In this chapter the cause-effect mechanisms are discussed, starting with

a) a description of the sources/activities that may cause the threat; followed by
b) an explanation of the mechanisms through which an activity may affect cetaceans.

7.1. BY-CATCH

A) TYPES OF FISHERIES INVOLVED IN BY-CATCH

Bycatch is the unintended catching of non-selected species in fisheries and affects a wide range of species. Amongst this species are fish, shark, turtle and cetaceans species. Mainly based upon observer studies, gill net fisheries and trawl fisheries appear to be the main fisheries causing by-catch amongst cetaceans.

B) MECHANISMS OF ENTANGLEMENT

Gillnets

Behaviour studies conducted on two juvenile porpoises in the Marine Mammal Park in Harderwijk suggested that the main reason for getting entangled in gillnets is likely to be that of failing detection. In addition, a larger mesh size and when approaching the net within an area of 90 degrees further diminishes the chance to detect the nets in time. Research in a basin with different types of gillnets, for example, showed that porpoises were capable of detecting the nets using echolocation at a maximum distance of 3 to 6 meters, depending on net type (Kastelein *et al*., 2000).

A study on the behaviour of the two juvenile harbour porpoises in response to ropes showed that the animals considered ropes as barriers and swam significantly more often under than over ropes. Therefore, these animals are not likely to pass bottom-set gillnets with ease. The introduction of living fish furthermore made the animals move more irregular and consequently they were crossing the ropes more frequently. Evidently, the urge to forage made the animals less cautious. However, they still hesitated crossing the rope closest to the pool floor (Kastelein *et al.*, 1995b).

Another study (Kastelein *et al*., 1995c) showed that porpoises are capable to learn to avoid the nets. Older porpoises, which are more experienced, are therefore less likely to get entangled in fishing gear than juveniles. This is reflected in the relatively high number of juveniles found amongst stranded porpoises known to be by-caught (Addink & Smeenk, 1999, Sabin *et al.*, 2003; Koch & Benke, 1996).

In summary, porpoises become entangled because

1. gillnets are difficult to detect;
2. porpoises are less cautious in the presence of food;
3. porpoises are hesitant to swim over ropes; and
4. juvenile porpoises are more inexperienced in detecting nets than mature animals.

Other species that have been found entangled in gillnets are the common dolphin (UK, Portugal, France), striped dolphin (Portugal, Poland, France), and bottlenose dolphin (Portugal) (see Ross & Isaac, 2004). However, these species have generally been reported in smaller numbers in gillnet fisheries. This may be due to the fact that the porpoise is the most numerous cetacean species in the North Sea and/or because harbour porpoises are more prone to incidental capture in gillnets than other cetacean species. The latter may be explained by

1. the feeding behaviour of porpoises, which is on or near the seabed (see chapter 6.2.4.); and by
2. the overlap in spatial distribution of the porpoise and the gillnet fisheries, which are both (partly) coastal (see chapter 4 and 5).

Trawl nets

By-catch in these fisheries is less well documented than for gillnet fisheries and the mechanism of incidental capture is not very clear. Of all trawling operations nevertheless, pelagic trawl is thought to be the most harmful to cetaceans (Ross & Isaac, 2004). This is partly because in these fisheries, in contrast to demersal trawl fisheries, the nets are not hindered by friction with the bottom and can be towed at high speeds. In addition, the selected species of these fisheries are often important prey of cetaceans as well (Read, 1996). This is illustrated in Dutch horse-mackerel and Irish herring fishery, where bycaught species were observed feeding around the nets. In addition, of the 46 bycaught whitesided dolphins which were brought ashore for examination, 44 had stomachs containing fresh or only partly digested mackerel (Couperus, 1997).

What complicates the mechanism is that the nets are very noisy underwater. It is therefore unlikely that cetaceans get caught because they do not detect them (Ross & Isaac, 2004). It is more likely that dolphins actively approach and enter pelagic nets for foraging purposes. In this case, the disorientation of animals caused during hauling procedures or changes in direction or speed of the towing vessels may be responsible for bycatch (*e.g*. Couperus, 1996).

Species known to be bycaught in pelagic trawl fisheries are mostly common dolphins, but harbour porpoises, bottlenose dolphins, Atlantic white-sided dolphins, white-beaked dolphins, striped dolphins and long-finned pilot whales are also caught. Risso's dolphins have also been reported caught in US pair trawling (Northridge, 2002).

7.2. POLLUTION

A) TYPES OF POLLUTANTS IN THE MARINE ENVIRONMENT

Pollution is the contamination of the marine environment by anthropogenic inputs. Main categories of pollutants in the marine environment are:

- persistent organic pollutants (POPs);

  The POPs are used for different purposes. Brominated flame retardants, amongst which various forms of PBDEs, are added to many plastics and printed circuit boards of electronic household equipment and textile and polyurethane foam in furniture and cars for safety reasons. Formerly, PCBs were used for this purpose. POPs may also be used in agriculture as pesticides. A well known example is the use of DDT as an insecticide.
- heavy metals;

  Like all minerals, natural reserves of heavy metals can be found in stone layers and may enter the environment through erosion, eruptions of volcanoes, etc. Human activities may however also influence the release of heavy metals through delving for industrial processes. Cooling, rinsing and cleaning water from coastal industries and offshore installations are therefore important contributors to heavy metals in the natural environment. The burning of fossil fuels in addition may also introduce heavy metals to the environment.
- oil;
- hydrocarbons, including PAHs;

  PAH are tarry products which are produced when fossil fuels, wood, tobacco and food are not completely burned. The major sources of PAHs are industry, traffic, farms, and consumers. In humans, PAHs may induce cancer (due to smoking for instance).
- butyl tin;

  Since the beginning of the 1960s, organotin compounds are used as anti-fauling treatments upon ship hulls and stationary structures such as piers and drillings. They are further used as slimicides on wood products, sisal ropes, leather and jute; as helminthides by the poultry industry; and as rodenticides. Tin compounds are also used as stabilizers and disinfectants in the production of plastic products, polishes, floor waxes and laundry products (WHO, 1980; 1990).
- marine debris.

B) THE MECHANISM OF EXPOSURE

Many contaminants are relatively poorly metabolised or excreted by animals. As a result, species higher up the food chain tend to carry higher burdens of these contaminants than those lower. Amongst the effects that are suggested of these contaminant burdens are:

- Effects on the endocrine system (for example competition with natural hormones for receptor binding);
- Effects on the neuroendocrine system (for example reduced memory and attention span);
- Impaired sexual development;
- Reproductive impairments; and
- Suppression of the immune system (see Colborn & Smolen, 2003).

For each category of pollutants the cause-effect mechanism through which pollutants are thought to affect cetaceans is outlined below. One should however bear in mind that synergetic effects may occur and simply considering single chemicals or categories of chemicals will in practice not reflect reality.

Persistent organic pollutants
POPs, or persistent organic pollutants, are a wide variety of chemicals which are used for many different aspects. Despite the various functions, however, the chemicals have some aspects in common. The compounds are:

- highly lipophilic and hydrophobic;
- differentially accumulated in lipids of animals and are therefore sometimes found at high concentrations in marine mammal blubber until this tissue is mobilised for energy requirements or for the production of milk (Ridgeway and Reddy, 1995);
- chemically stable and persistent, many of them also being resistant to metabolic degradation;
- present as many different isomers and congeners, and compromise hundreds of different chemical formulations which may have different behaviours and toxicities.
- They have reproductive and immunosuppressive effects, and many are 'endocrine disrupters'- acting as hormone agonists or antagonists.

Many factors can affect the occurrence and distribution of POPs in marine mammals. These include diet, foraging strategies, age, species, sex, and nutritional conditions (Aguilar *et al.*, 1999). Borrell *et al.* (2004) for example, who reported on organochlorine residues in directly caught porpoises from Southwest Greenland, found age and sex related differences in contaminant burden. For male porpoises a significant positive association of age and contaminant burden was found, whereas in females this relation was negative. Differences in contaminant composition were in addition found between calves and mature females. Distribution of a species may also affect the occurrence of POPs in marine mammals. Species in the southern North Sea for instance are exposed to higher concentrations of POPs (De Boer, 1989), especially when these species occur close to river mouths (Boon *et al.*, 2002). A further geographical distinction was made by Covaci *et al.* (2002), who reported higher concentrations of organochlorine compounds found in porpoises stranded on the Belgium/Dutch coast of the North Sea in comparison to the English coast. This can be explained by the discharges from the Rhine, Meuse and Scheldt estuaries or coastal currents from the French to the Dutch coast.

Heavy metals
Szefer *et al*. (2002) determined the concentrations of selected metals in harbour porpoises from three geographical regions and demonstrated that age and diet also played a role in the exposure to heavy metals: The study revealed that the concentrations of Cd in liver and kidney increased with age of the animals and that Greenland porpoises showed higher levels of hepatic and renal Cd than Baltic animals. The latter could be explained by different food compositions in the areas studied, as Baltic porpoises mainly feed on fish (cod, plaice) containing extremely low levels of muscle Cd, whereas an important diet component of Greenland porpoises is squid, characterised by elevated levels of Cd.

Most heavy metals are however not found at concerning levels in cetacean species. Lead (Pb), chromium (Cr), nickel (Ni), copper (Cu), and zinc (Zn) concentrations are low or undetectable in the majority of the animals. Cadmium (Cd) can sometimes be found at high concentrations in the livers of marine mammals (Law *et al*., 1991; Law *et al.*, 2001), but there does not appear to be any published information on cadmium-induced pathology in marine mammals. Mercury on the other hand is currently the main cause of concern.

Mercury is present in the environment as metallic mercury, inorganic salts and in organic forms. Metallic mercury passes through the body unabsorbed, whereas the organic form, methyl mercury, is fat-soluble and may accumulate in organisms. Anaerobic bacteria in the sediment convert metallic mercury in methyl mercury, which is best facilitated in the anoxic conditions of the pelagic marine ecosystem. Some animals using the deep oceans and seas may therefore carry higher burdens of mercury than coastal organisms (see Colborn & Smolen, 2003).

As can be expected from the above-described situation, mercury occurs mostly in the organic form, which is particularly toxic, in fish. In marine mammals, mercury makes up a smaller part of the body burden because of a demethylating process in which methyl mercury is detoxificated and immobilized as mercuric selenide (Reijnders, 1980; Law, 1996). Nevertheless marine mammals tend to have a much higher Hg concentration than other marine organisms, especially in their liver (Law *et al.*, 1991).

Oil
Little is known about the effects of oil and oil vapours on cetaceans. Potential effects may include direct mortality as a result of ingesting or inhaling toxic compounds of oil or its vapour or indirect effects as a result of consuming contaminated prey; oil fouling – possibly resulting in damage to the eyes and skin or obstruction of the gut; and habitat degradation.

Hydrocarbons
The exploration and production of North Sea oil and gas reserves has resulted in the accumulation of large quantities of drill cuttings on the seabed surrounding drill sites (Breuer *et al*., 2004). This complex mixture of man-made and natural substances contains higher concentrations of certain metals and hydrocarbons. A literature review by Breuer *et al*. (2004) revealed that hydrocarbons within cutting piles remain relatively unchanged with time. A considerable proportion of the associated contaminants are likely to remain within the cutting pile unless they are disturbed which will then increase exchanges with the environment resulting in pathways of exposure for organisms.

Butyl tin
TBT is known to accumulate in animals at the top of the food web and in several rodents effects including T-cell suppression, malformation, and thymic atrophy have been reported. In addition, cetaceans are not as efficient in metabolising and excreting TBT as for example pinnipeds, which accumulate TBT in their hair and excrete it when shedding hair (see Colborn & Smolen, 2003). It is thus likely that cetaceans accumulate high amounts of TBT in their organs, resulting in some adverse health effects.

Marine debris
Examples of marine debris often found on the beach are ropes and nets, plastic gloves used in fisheries, and wood. The amount of debris has likely increased as industries developed and mobility grew (see Chapter 4). Marine debris does not affect cetaceans indirectly through the bioaccumulation and/or biomagnification but affects the animals directly.

7.3. NOISE

A) TYPES OF SOURCES OF NOISE

Several significant sources of noise pollution which may impact cetaceans are:

- Military exercises;

  A study of military activities off western Scotland described the exercises performed and the sounds produced in that particular area. The military exercises and activities usually included submarine exercises, torpedo testing, firing ranges and training exercises. During submarine exercises, sonars, which produced a sound of 0.25-200 kHz and 200-230 dB, and submarine-to-submarine communication systems, producing 5-11 kHz and 180-200 dB, were frequently used. Sounds produced by torpedo testing are unknown, but military artillery may produce sounds in excess of 180 dB. The duration of activities varies per activity and location and may range from some hours up to about 80 days (Parsons *et al*., 2000; Pooley, 2000).
- Seismic surveys;

  Seismic exploration is the geophysical exploration of the sea using acoustic means. This involves generating a series of high-energy acoustic pulses in the water column with airguns, gas exploders and vibrators. Sound pressure waves penetrate the seabed to produce seismic waves. The reflected sound provides information about the bottom structure and composition and may indicate the presence of oil or gas sources. Most energy from airgun arrays and other energy sources is below 100 Hz with a source level of 220-255 dB (Richardson *et al*., 1995). Goold and Fish (1998) however also found frequencies up to 22 kHz during an oil industry 2-D seismic survey. Seismic pulse power at this frequency was with 90 dB much lower than at other frequencies, but it still exceeded odontocete hearing threshold. During surveys, shots, or pulses, are generally fired at about every 6-20 seconds along a transect line. Exploring these transect lines may take several hours each and conducting an entire survey can last for several months (Simmonds *et al*, 2003).
- Vessels;

  Many different types of vessels are known, each producing their own typical sound frequencies and intensities. In general, noise levels are related to ship size, speed and mode of operation. Larger, faster and/or loaded ships tend to emit higher sound levels than small, slow and/or unloaded vessels. Dominant emitted frequency on the other hand tends to increase with decreasing vessel size (Richardson *et al*., 1995). This can be demonstrated with a comparison of the sounds produced by jet skis, tankers and containerships. A 650cc jet ski produces a sound of 0.8-50.0 kHz with a source level of 75-125 dB (Evans & Nice, 1996). A tanker (135 m) and a containership (219 m) can be expected to produce higher sound levels than the jet ski, since these vessel are many times larger. Sound frequencies on the contrary can be expected to decrease with increasing vessel size. When checking this in literature, this was confirmed. A 135 m tanker was found to emit 0.43 kHz and 169 dB sounds and a 219 m containership emitted 0.033 kHz and 181 dB sounds (Buck & Chalfant, 1972).

- Drilling activities;

  Drilling noise is generally of low frequency, with highest levels being recorded from drill ships (Richardson *et al*., 1995).

- Acoustic Harassment Devices (AHDs);

  Acoustic Harassment Devices (AHD) are used to scare marine mammals in order to prevent these animals from being killed or injured in fishing nets, but also to prevent their interference with fishing or aquaculture. The success of AHDs varies per model and selected species, which is probably related to the emitted sounds.

- Wind farms;

  Environmental Impact Assessments for the Q7 and NSW wind farms have been conducted in 2001-2002. The effects of the wind turbines on sea mammals have been included in these assessments, but it was concluded that only little is known about the relation between the produced underwater noise and sea mammals (Anonymous, 2002; Van Duin & Kreft, 2003).

B) NOISE MECHANISMS

This section explains why noise may be regarded as a threat to cetaceans. In order to understand which noise frequencies and intensities can be perceived and how this affects cetaceans, the function of noise to cetaceans will be discussed firstly, followed by a description of the hearing abilities of the animals., .

The function of noise and hearing

Toothed whales (odontocetes) can produce mid- or high-frequency sounds and detect objects when receiving returned echoes. With higher frequencies more details of an object may be perceived, but the range of the sound under water is more limited than that of lower frequencies (Simmonds *et al*., 2003). Table 9, shows the frequencies used by bottlenose dolphins, harbour porpoises and white-beaked dolphin for echolocation. Disturbance by man-made sounds of the same frequency of the echolocation signal may cause disorientation and possibly stranding of odontocetes. Difficulties with catching prey may also arise. Cetaceans also use sound for communication purposes and prey stunning. These other functions of noise are described in more detail in Simmonds *et al.* (2003).

Detectability of noise

The porpoise, white-beaked dolphin and bottlenose dolphin belong to the toothed whales (odontocetes), for which highest sensitivity is found for sounds above ~10 kHz, but frequencies from 80 Hz to over 100 kHz may be heard by some species (Richardson *et al*., 1995). The lowest noise intensity level at which any sound can be detected by toothed whales varies between species from about 30 to 60 dB.

Besides frequency and intensity, other factors may indirectly influence the detectability of sounds by reducing or masking sound intensity. Under water, sound is continuously present on the background due to tidal currents, wind and waves, water turbulence, rolling stones, etc. This noise is called ambient noise and man-made sounds will only be detectable if its level is higher than that of ambient noise at similar frequencies (Verboom, 1991). The frequency of ambient noise ranges between 1 Hz and 100 kHz (Verboom, 1991) and at a given frequency and location, from one day to another, differences of 20dB or more can be found. Consequently, a given man-made sound may one day be detectable at a given distance from its source whereas another day it may not be detectable at the same distance due to an increased level of ambient noise (Richardson *et al*., 1995).

It should also be noted that low-frequency sounds tend to carry over many (sometimes hundreds of) kilometres, whereas high-frequency sound cannot travel over such distances. During sound transmission through water, as well as through other media, intensity of a sound may in addition decrease due to spreading, resorption, scattering, reflection and rarefaction. This transmission loss increases with distance to the source (Simmonds *et al.*, 2003).

7.4. OVERFISHING

A) TYPES OF FISHERY

In chapter 6.2.2. fisheries and overfishing in the North Sea have been described.

B) THE MECHANISM

Overfishing of a certain species does not only influence the target-species, but may affect other species as well through by-catch and discards. In addition, the entire ecosystem may be affected by the reduction or disappearance of the target-species. Two mechanisms of the effect of overfishing on ecosystems are given below:

1. As a predator fish species is depleted, the prey species may also decline in numbers. Generally, it is thought that the reduction of predation will lead to a growth in prey. However, a predator may operate in more complicated food web which tends to support the production of the main prey. In this case,a decline in the overfished predator will result in a decline in its prey as well. Cetacean species will consequently be affected more if both predator and prey fish species were its prey.

2. Simplification of the food web will occur as certain species disappear or drastically decline in number. Due to this simplification, predators (including cetaceans) can less easily shift to another prey species when necessary. Large fluctuations in stock size can therefore be expected (Pauly *et al*., 2002).

7.5. CLIMATE CHANGE

ENHANCED GREENHOUSE EFFECT

The consequences of the enhanced greenhouse effect are not certain in all cases, but effects are thought to be:

- An increase in average global temperature;
- An increase in average global precipitation;
- A decline in soil moisture in many regions;
- More frequent intense rainstorms; and
- Rising of the sea level due to melting of polar ice caps and expansion of ocean water due to an increased water temperature (see O'Riordan, 2000).

It is difficult to predict the consequences of these effects on cetacean species, although there is much information on changes in sea temperature in the North Sea and English Channel regions between 1920s and today *(see* Hammond *et al*., 1995). Many of these changes have been correlated with distributional changes in plankton, and also changes in recruitment or abundance of fish species. Top predators, like cetaceans, are considered to be particularly susceptible to these changes. For species which in addition have an intrinsically high metabolic requirement, such as the harbour porpoise, the potential cost of changes in prey availability may be significant (Agardy, 1996). In fact, little is known about the ability of cetaceans to react to climatic changes by for example altering their feeding behaviour or changing their distribution..

OZONE DEPLETION

The consequences of ozone depletion will affect all levels of the marine food web causing global changes in the distribution and abundance of organisms, because higher UV-B levels in the upper ocean layer may inhibit phytoplankton activities. For cetaceans, as well as for humans, there may also be direct effects on their health, in the form of skin cancers and eye problems. In addition, if all trace gasses were to be reduced to pre-1990 levels again, it would still take 70 years for net ozone loss to cease (see O'Riordan & Jordan, 2000).

7.6. COLLISIONS WITH BOATS

Boats which are most likely to cause collisions are recreational vessels, like jet-skis, jet-bikes, and speedboats, which move fast and unpredictable. Cetaceans may not be able to avoid these vessels and may thus become run-over. As these recreational vessels are concentrated along the coast line and during summer, species occupying the coastal zone in summer will be most vulnerable.

8. An analysis of threats based solely on data from the past

An analysis on the impact of threats based on data from the past may provide helpful clues whether these threats form potential (future) threats. In order to provide an overview of the impact of (past) threats, on a species-specific level, we based our analysis on a) trends in cetacean populations, and b) trends in anthropogenic activities and natural factors of the North Sea. The results of these analyses, as conducted by other scientists, are outlined in section 8.1. and will be discussed further in section 8.2.

8.1. Reported effcets of past threats in the Netherlands

8.1.1. Causes of trends for the bottlenose dolphin

The gradual decline of the bottlenose dolphin during the second half of the 20th century is generally thought to be associated to human impacts. Pollution is likely to be one of these impacts, as bottlenose dolphins frequently occur in coastal waters throughout Europe and are thus exposed to relatively high concentration of pollutants. As the use, and consequently outflow, of several pollutants increased during the 1960s and 1970, the disappearance of the bottlenose dolphin may be related to pollution (see chapter 4.2.).

Another possible cause for the decline may be the disappearance of herring due to overfishing, as Zijlstra suggested to Verwey (Verwey, 1975). Verwey (1975) however rejected this possibility because firstly herring enters the southern North Sea between October and February, whereas strandings from *Tursiops* were reported to be most numerous during summer. Secondly, according to Verwey (1975), herring may well have been of less importance as a food source for bottlenose dolphins, which also had other species to their disposition.

Although Verwey (1975) doubted the importance of herring for the bottlenose dolphin, he did report a decline in live animals sighted in the Marsdiep from 1939 onwards. The decline was not very well documented, mainly because in 1940 the Second World War broke out in the Netherlands. Although his initial doubt about a correlation to fisheries, Verwey (1975) did suggest it was highly probable that this decline was related to the closure of the Zuiderzee dyke in 1932, which was followed by a gradual disappearance of the Zuiderzee herring.

By-catch may also have played an important role in the disappearance of the bottlenose dolphin in Dutch waters. Bottlenose dolphins are known to be non-selected species of by-catch for pelagic trawl and pair trawl fisheries, driftnet fisheries, pole and line tuna fishery and gillnet fisheries (Ross & Isaac, 2004). By-catch can in addition be especially problematic and thus be of primarily importance to species that are long-lived, have slow growth rates and low fecundity. It can also have catastrophic effects on small populations or populations already under pressure from other environmental stressors (Cox *et al.*, 2003).

The disappearance of the bottlenose dolphin from Dutch waters may however not only be related to human impacts, but also to a natural change in the climate. If lack of reports prior to 1920 truly reflected the low abundance of bottlenose dolphins during that period, this would indicate that the bottlenose dolphin was not an indigenous species in the Netherlands, but a temporary phenomenon due to natural fluctuation –e.g. climate change- (Smeenk pers. comm.). The latter has also been reported for the common dolphin, which entered the Dutch sector of the North Sea due to an increase in water temperature and the related shift in prey species , and disappeared again as temperature decreased back to comparable levels of the former situation (see Booij, 2004). The discrepancy in periods of occurrence for the bottlenose dolphin and the common dolphin indicates a difference in sensitiveness between the two dolphin species and/or their prey. Unfortunately, it is not possible to confirm whether the increase in reported strandings was indeed caused by an increase in observer effort, as suggested by Kompanje (2001), or by a (temporary) change in climate.

8.1.2. Causes of trends for the harbour porpoise

The decrease of the harbour porpoise during the 1950s until the 1980s occurred in combination with a proportional decline in neonates and calves. This indicates a decline in birth rate and/or the avoidance by mature females of Dutch coastal waters as a place for giving birth. The causes are not immediately clear. The avoidance of Dutch coastal waters may be food-related, since the late 1950s/early 1960s saw a strong decline in the stocks of several fish species which porpoises are known to feed on, especially herring (see chapter 4.2.1.). Reproduction and health may be negatively affected by pollutants too (e.g. PCBs, see chapter 4.2.6.). Finally, by-catch of harbour porpoises in fisheries may have aggravated the decline of a population already under pressure (Addink & Smeenk, 1999).

According to Reijnders (1992), the major causes for decrease are postulated to be changes in prey availability and changes in bycatch: Limitations of prey, caused initially by overfishing, followed by a shift in spawning and feeding areas towards the North, caused porpoises to move away from the coastal areas. In addition to this, bycatch reduced their overall abundance. Without ignoring the possible complementary impact of pollution and disturbance, it was believed that bycatch was the only other major threat (Reijnders, 1992).

For the recent increase of the harbour porpoise in Dutch coastal waters, as set in since the 1980s, two explanations seem likely. Firstly, the increase may be a reflection of a more widespread increase in the North Sea at large due to an increase in reproduction rate, but there is little evidence for this. Alternatively, the porpoises may have come back to Dutch waters because of altered food conditions, either because more food became available, or because food resources had deteriorated elsewhere (see Camphuysen & Leopold, 1993). Camphuysen and Leopold (1993) further supported the food-related theory with the following information: certain piscivorous seabirds, which probably use the same food species as porpoises, clearly increased as winter visitors in the southern North Sea since 1980, whilst decreasing in the northern parts. This occurred apparently mainly in response to changes in the availability of sprat in winter in the northern North Sea (see Camphuysen & Leopold, 1993).

According to Smeenk (pers. comm.) the fast increase of strandings during the last years cannot be explained by an increase in reproduction only. Migration could be a more significant cause, as is also suggested by Camphuysen & Leopold (1993). Witte (1998) also suggested that the increase of sightings may be caused by migration rather than by population growth, because of the abruptness of the increase together with a lack of changes in the average group size.

Seasonal distribution was also suggested to be correlated with the abundance of fish (Reijnders, 1992). It was concluded back in 1989, based on the International Young Fish Survey, that sprat was only abundant in winter in the shallow waters of the southern North Sea (see Reijnders, 1992). This coincides with the present harbour porpoise winter distribution in that area as described by Camphuysen and Leopold (1993). The decreasing density of porpoises during summer may moreover also be related to food distribution.

Since 1950, a decline in stranded neonates was observed, which may have had two causes: (1) females no longer gave birth in Dutch coastal waters or (2) the birth rate had strongly declined. This indicates that the Dutch coastal waters were no longer suitable as a nursing area, since nursing females need extra food. The birth period of porpoises covers the months of May to August, so the avoidance of the Dutch coastal waters as a nursing area may indeed explain the decrease of sightings of harbour porpoises during the summer (Addink & Smeenk, 1999).

8.1.3. Causes of trends for the white-beaked dolphin

Evans (1990) suggested that the numbers of white-beaked dolphins possibly decreased in the northern North Sea during the 1980s. This may support the shift in distribution southward, towards the Netherlands, as reported during the 1960s. No reason for the decline in the northern North Sea was given by Evans. Bakker and Smeenk (1990), however, suggested that the increase of white-beaked dolphins in the southern North Sea during the 1960s could be a combined effect of favourable changes in water temperature and currents and an increase of prey species such as gadoids (see chapter 4.3.1.), which had several very good year-classes in that period. Furthermore, competition with other dolphins potentially decreased. In particular competition with bottlenose dolphins could no longer have played an important role during the last decades, since this species almost completely disappeared from Dutch waters during the 1970s.

8.2. AN ANALYSIS OF PAST THREATS

Table 10 summarizes threats underlying trends in cetacean species from the Dutch part of the North Sea as was outlined in the previous section. Noise, climate change and boat collissions have not been related to (past) trends in cetaceans, whereas prey depletion (overfishing and the closure of the Zuiderzeedyke) and pollution were both thought to be causes for the decrease in porpoises and bottlenose dolphins. By-catch was suggested to play a possible role as well, but this was not associated to known trends in certain types of fisheries. Whether the disappearance of bottlenose dolphins was caused by prey depletion can also be doubted. Indeed, the relation between the trends observed in bottlenose dolphins and the depletion of herring by the closure of the Zuiderzeedyke appeared to be a controversial topic, as Verwey suggested that herring was not likely to be an important prey species. If prey depletion did play a role in the disappearance of the bottlenose dolphin, this would more likely have been through depletion of several fish stocks.

For the white-beaked dolphin no threats have thus far been suggested in the Dutch part of the North Sea. Since this species has almost continuously been increasing in strandings and sightings it initially appeared not to be affected by any human impacts. However, one should bear in mind that an increase in reports does not necessarily reflect a growing population. Especially during the 1960s (when the dolphin first entered Dutch waters), the increase may well be caused by a change in migrational patterns.

As the impacts of by-catch, pollution and prey depletion could not be proven and because the situation in the Dutch part of the North Sea has obviously now changed, these activities should solely be regarded as potential (future) threats. However, this analysis provides us with clear (warning) signals to potential threats that have caused reductions or even aided the complete disappearance of species in the past.

9. AN ANALYSIS OF CURRENT THREATS

9.1. RECENTLY REPORTED EFFECTS OF THREATS

In this chapter the reported effects of each threat will be outlined as follows:

a) Reported effects in cetaceans *outside* Dutch waters

When possible, information in this section is limited to the North Sea and adjacent waters, because the situations are probably most similar. However, when useful additional effects have been reported elsewhere, this information is included as well.

b) Reported effects in cetaceans *within* Dutch waters

Effects reported here are restricted to those reported in cetaceans stranded on the Dutch coast or sighted in Dutch waters.

9.1.1. BY-CATCH

a) Reported by-catch outside Dutch waters, e.g. the North Sea and adjacent areas

Gillnet fisheries

Examination of porpoise carcasses of both the North and Baltic Sea showed that of the 112 carcasses of which the cause of death (type of fishing gear) could be established, 95.5% had been caught in set nets (mainly gillnets; Kock & Benke, 1996). Also in Germany, an exceptional high number of stranded porpoises along the German North Sea coast of Schleswig-Holstein could be related to Danish fishing vessels operating close to the German shores during the period of increased strandings (Benke *et al.*, 1998).

In some regions, porpoise by-catch in these fisheries is even known to be unsustainable. It has been agreed internationally that an annual loss of 1% of a population should be a cause of concern and merits investigation as a matter of priority (IWC, 1995). In Denmark, which has the largest gillnet fleet with an estimated 5,000-10,000 km of nets set daily (Lowry and Teilman, 1994), updated estimates of the by-catch of porpoises in Danish gillnet fisheries for cod, hake, plaice, sole and turbot in the North Sea ranged from a low of 3,887 in the most recent year's data (2001) to 7,366 in 1994. The highest annual catch figure of 7,366 represents 4,3% of the porpoise population in the relevant part of the North Sea (170,000 animals) as estimated by SCANS (Hammond *et al*., 1995), and thus exceeds sustainable levels of by-catch. These estimates, however, do not take account of the mandatory use of pingers in the cod wreck net fishery during the third quarter of the year since 2000 and are therefore likely to be overestimates[1] (Vinther and Larsen, 2002). In the Celtic Sea, levels of by-catch in gillnet fisheries as estimated, using SCANS data and extrapolating results from observer schemes, represent 6.2% of the population per annum (Tregenza *et al*., 1997). Because most by-catch records remain unpublished, this percentage is likely to be an underestimation.

In other regions of the North Sea, including the UK, France, and Belgium, by-catch of porpoises in bottom-set gillnets was also reported from observer studies (Northridge & Hammond, 1999) or expected to occur based upon strandings (Sabin *et al*., 2003; Jauniaux *et al.*, 2002; Kirkwood *et al.*, 1997). No estimation of the annual loss of the population could however be made here.

Trawlfisheries

Most of the pelagic trawl fisheries operate in the Celtic Sea, Biscay, and Channel area of the Northeast Atlantic. These fisheries have been subjected to little observer monitoring. Results of observer studies on the bycatch of 11 pelagic trawl fisheries conducted in the Northeast Atlantic have therefore been collated (Morizur *et al*., 1999). Catches of white-sided dolphins and common dolphins have been observed in four of these fisheries studies and probably a bottlenose dolphin was also present. The highest by-catch rate per hour of towing was recorded in the French sea bass fishery.

A Dutch observer study of cetacean by-catch in the pelagic trawl fishery for mackerel and horse mackerel was conducted in 1992-1994. Incidental catches were found to be largely restricted to late winter/early spring in the area along the continental slope south-west of Ireland, with a peak in late February/early March (Couperus, 1997). The main species by-caught was the Atlantic white-sided dolphin (83%) but other species caught were long-finned pilot whale, common dolphin, bottlenose dolphin and white-beaked dolphin. In 1994, a total catch of

[1] It was estimated that the third quarter cod wreck net fishery would have been responsible for 570 porpoise entanglements in 2000 and 405 in 2001.

172 dolphins was recorded by twelve Dutch and two English vessels in this fishery, but the limited data available prevented the researchers from estimating the overall extent of the by-catch problem (*see* Ross and Isaac, 2004).

b) Reported bycatch within the Dutch part of the North Sea

In the Netherlands no observer studies have been carried out so far and by-catch is therefore little known. Some reports of fishermen are known, but these are few because most fishermen are reluctant to report their by-catch. This is due to the fact that the bycaught cetaceans are protected species and some fishermen have been fined when landing a bycaught porpoise. The latter has stopped but the majority of the fishermen still prefers not to report their by-catch. Strandings however indicate that by-catch exist in the Netherlands. García Hartmann and Smeenk (in prep.) analysed 130 porpoises stranded on the Dutch coast between 1990 and 2000. Based upon gross pathological and histological examination, they divided the porpoises in three categories: no by-catch, equivocal or possible by-catch and by-catch. It was concluded that over the investigated period more than 50% of the porpoises stranded on the Dutch coast consisted of by-catch.

Observer studies onboard Dutch vessels have hardly been conducted. Furthermore, these studies mainly focussed on by-catch in pelagic trawl fisheries, which in general do not occur over the Dutch continental shelf. Dutch gillnet fisheries, which do occur over the DCS, have not been subjected to observer studies yet.

9.1.2. POLLUTION

It is difficult to prove effects of pollution in marine mammals, since for ethical as well as practical reasons experiments are not often conducted. Experiments on rodents, on the other hand, have been conducted on a larger scale. However, extrapolation of these results to marine mammals should be done with care because the mechanism of action of chemicals is not fully understood. Furthermore, mechanisms may well also show inter-specific differences. Some effects of pollution are also difficult to detect because they are subtle and can only be demonstrated on a population level in stead of individual level (for instance reduced memory). Also, effects may be indirect, thus complicating detection.

Despite all these difficulties, contaminant burdens and several effects have been reported for marine mammals from all over the world. Below, these will be discussed for the various categories of pollutants.

a) Worldwide reported effects of pollution

Persistent organic pollutants

In stranded porpoises from the UK, Belgium and France, as well as in bottlenose dolphins from the US Atlantic coast, POP levels were found high enough to cause concern among scientists, although no adverse effects of the contaminant burdens could be demonstrated (Hansen *et al.*, 2004; Chu *et al*., 2003; Law *et al.*, 2002). Other studies however provided some evidence for negative impacts of various contaminants in various marine mammal species. Hall *et al*. (2003) suggested a link between thyroid hormones and PBDEs in grey seals during their first year of life and Reijnders (1980,1984) reported that a serious decline in the population of harbour seals in the Wadden Sea might be due to the reproductive effects of contaminant exposure. This was addressed more directly in an experiment using captive harbour seals (Reijnders, 1986). Two groups of female harbour seals were fed fish from different areas; one contaminated with organochlorine compounds (OCs) the other much cleaner. Reproductive success was significant lower in the group fed contaminated fish and failure was thought to occur at the implantation stage of pregnancy. A risk analysis for bottlenose dolphins from the southeast coast of the United States indicated that PCBs may have a similar effect on reproductive success of bottlenose dolphins. Especially in primiparous females, which have not yet diminished their PCB load through lactation, chronic exposure to PCBs significantly increased the likelihood of still birth and neonatal mortality (Schwacke *et al.*, 2002).

Another study followed the outbreak of phocine distemper among harbour and some grey seals in European waters. The study of OC contaminant burdens among animals that were victims and survivors of the epidemic suggested that animals that died of the disease had higher blubber levels of OCs than survivors, although it was not possible to control for all potential confounders (Hall *et al*., 1992). Interestingly, this finding was also repeated in a study of contaminant burdens in striped dolphins following a similar outbreak of dolphin morbillivirus in the Mediterranean Sea in 1990 (Aguilar and Borrel, 1994). More recently a study by Jepson *et al.* (1999) indicated that porpoises stranded along the coast of England and Wales which had died of infectious diseases had significantly higher concentrations of PCBs in their blubber than those which died from trauma, such as by-catch in fisheries or ships strikes. Van Bressem *et al*. (2003a) suggested that organochlorines are associated with a higher prevalence of tattoo disease (*see also* Van Bressum *et al* 2003b) in in-shore than in off-shore adult Delphinidae.

Heavy metals
The effects of cadmium on cetaceans appear to be poorly described. Adverse effects of mercury have been demonstrated in stranded and by-caught cetaceans from the German waters of the north and Baltic Seas: In muscle, kidney and liver samples from 57 porpoises and 3 white-beaked dolphins from this region concentrations of total mercury and methyl mercury were analysed. Pathological, microbiological and parasitology studies revealed that lesions characteristic of acute or chronic intoxication with mercury could not be found. However, there were significant associations between mercury levels and severity of lesions with respect to the nutritional state of the cetaceans examined. In addition, a significant correlation between animal age and total mercury as well as methyl mercury in all examined organs could be demonstrated here (Siebert *et al*., 1999).

In harp seals (*Pagophilus groenlandicus*) an adverse health effect due to high levels of mercury was also demonstrated. One group of seals was fed fish with a relatively low concentration of methyl mercury, whereas another group was exposed to relatively high levels. The first group already showed a decline in appetite, weight loss, and lethargy. The second group even died due to weight loss between 20 and 30 days after exposure (Tessaro *et al.*, 1977).

Oil
Gubbay and Earl (2002) reviewed the effects of oil spills on cetaceans and highlighted the fact that there is limited scientific data and considerable uncertainty surrounding this subject.

Hydrocarbons
The effects of polyaromatic hydrocarbons (PAHs) on marine mammals were reviewed by Geraci and St Aubin (1990) and various responses from effects on the central nervous system, eyes and mucous membranes, thermal regulatory effects from fouling of fur, to indication of metabolic enzymes systems and effects on hormone levels were reported. However, these effects are largely observed following short-term acute exposure.

Butyl tin
Butyl tins, largely tri- and di-butyl tin have been reported in the liver and blubber of pelagic cetaceans and marine mammals in UK waters (Law *et al*., 1999), but no reports on their effects have been published. A first indication of possible adverse effects of TBT on cetaceans has been provided by Kannan *et al.* (1997). They measured TBT levels in bottlenose dolphins stranded along the southeastern US Atlantic Gulf coast between 1989 and 1994 and found concentrations being the highest recorded to date. Consequently, it was suggested that TBT may have been involved in the episodes of high numbers of dolphin strandings.

Marine debris
Considerable amount of plastic debris are found throughout the world's oceans and may impact a diversity of species (Laist, 1997). Animals can be injured or killed by entanglement and by ingesting all sorts of objects. Several reports exist of harbour porpoise ingesting plastic (*e.g.* Baker and Martin, 1992; Kastelein and Lavaleije, 1992; Baird and Hooker, 2000). Baird and Hooker (2000) described how the ingested plastic probably blocked the oesophagus. Plastic bags were found in the stomach of a stranded Risso's dolphin in the Mediterranean, which contributed to the dolphin's poor physical condition (Shoham-Frider *et al*., 2002).

Only recently, the problem of marine debris and creel rope entanglement to minke whales (*Balaenoptera acutorostrata*) and other marine life (*e.g*. seals and turtles) in Scottish waters was presented by Gill *et al*. (unpublished).

b) Reported effects within the Dutch part of the North Sea
Porpoises stranded on the Dutch coast have been examined in relation to POPs. Comparison of this study with results from other areas learned that the PCB and OC burden found in the examined animals belonged to the highest in the North Sea (Van Scheppingen *et al.*, 1996; Covaci *et al*., 2002). However, there appears to be a decline in PCB burden over the last two decades (Van Scheppingen *et al.*, 1996). This decline is probably related to the prohibition of the use of PCBs in Western Europe about two decades ago (Boon *et al.*, 2002). No connection with either reduction of reproductive success or immune response has been examined for these animals.

Of the other pollutant categories no effects on cetaceans from the Dutch part of the North Sea are known.

9.1.3. NOISE

a) Worldwide reported effects of noise

Different categories of the impact of noise have been summarised in table 11, including physical, perceptual, behavioural, chronic and indirect impacts (Simmonds & Dolman, 1999). The following chapter will outline these impacts on cetaceans for the main sources of noise in the North Sea.

Military exercises

Mass strandings of beaked whales were examined and linked to the use of powerful sonars. It was even suggested that Cuvier's beaked whales and perhaps beaked whales generally are particularly vulnerable to being damaged by such sound sources (Simmonds and Dolman, 2003; Vonk and Martin, 1989; Simmonds and Lopez-Jurado, 1991; Frantzis and Cebrian, 1999). It now seems likely that military sonar has been causing beaked whales to strand regularly since the sixties (Hammond *et al*., 1995), which may be due to physical damage caused by these high intensity sounds. Jepson *et al*. (2003) for example reported on gas-bubble lesions in stranded cetaceans. Such lesions are in humans are related to decompression sickness, but were new in marine mammal pathology. The incidence of such observations during a naval sonar exercise indicated that acoustic factors could be important in the aetiology of bubble-related disease. The exact mechanism however is not certain. Another cause for strandings was found by Balcomb (2001), who reported on physical damage to a variety of structures associated with hearing and/or adjacent to air spaces.

Besides the physical impacts, behavioural impacts have also been documented. Sperm whales and long-finned pilot whales have both been demonstrated to change vocalisation in response to the use of military sonar (Watkins *et al*., 1985; Rendell and Gordon, 1999). Minke whales and harbour porpoises were observed less near exercise areas during military training exercises. This decrease in sightings was not only clearly visible in graphs, but in some cases was also proved to be significant (Parsons *et al.*, 2000).

Seismic surveys

Some evidence exists showing that porpoises, bottlenose dolphins, white-beaked dolphins and white-sided dolphin temporarily moved away from an area where seismic surveys were taking place around the British Isles (Stone, 2003; Baines, 1993). Common dolphins were also found to avoid the immediate vicinity of the airgun array while firing was in progress (Goold, 1996). Goold and Fish (1998) suggested that common dolphins found the seismic signal levels closer than 1 km distressing and that this may be due to interference with communication. They also detected sound levels above background, at ranges up to 8 km away from a 37-litre array and detection ranges of 100s of miles were not uncommon.

Seismic exploration may furthermore influence cetaceans indirectly by deterring their prey: Norwegian studies of the effects of seismic activities upon fish distribution have shown spatial displacement of fish over an area of c. 5,500 km^2, extending for a period of at least five days. This could have an indirect effect upon species of toothed whales which depend upon those fish for food (see Evans, 2000).

Vessels

Toothed whales are most likely to perceive the high-frequency sounds produced by jet skis and several other relatively small vessels. Figure 17 for example shows the frequencies and intensities of underwater noise produced by ferries. As can be seen, frequencies up to 8 kHz are produced at intensity higher than the hearing threshold of many odontocetes for the frequencies ranging from about 1-8 kHz (see for audiograms Richardson *et al.*, 1995). The noise of an auxiliary ship (see figure 18) even reaches frequencies up to 40 kHz and most frequencies are emitted at intensities loud enough to be perceived by odontocetes.

Being able to hear vessels, however, does not necessarily mean being disturbed by it. Many toothed whales appear to be tolerant of vessel noise and are regularly observed in areas where there is heavy traffic (*e.g*. Simmonds *et al*., 2003). However, at times, a species that used to show tolerance may show avoidance. A phenomenon which often appears to be related to dolphin activity: resting dolphins tend to avoid boats, feeding dolphins ignore them, and socializing dolphins may approach boats (Richardson *et al*., 1995). It is not clear if such observations are related to production of noise or disturbance caused by the presence of boats, but changes in dolphin behaviour including increased swimming speed and changed direction were indeed reported for bottlenose dolphins from Sarasota Bay, Florida (Nowacek *et al.*, 2001), and Bay of Islands, New Zealand (Constantine *et al.*, 2003). Using Markov chains to model the impact of boat traffic on bottlenose dolphins from Doubtful Sound, New Zealand, Lusseau (2003) in addition found that dolphins were significantly more likely to be travelling after an encounter with a boat. However, the overall behavioural budget of the population was not affected according to this model.

Long-term negative effects of boat traffic, such as permanent avoidance of traffic routes or permanent hearing loss, are difficult to investigate and have so far not been described (Verboom, 1991).

Acoustic Harassment Devices (AHDs)
Taylor *et al*. (1997) suggested that zone of audibility of AHDs may for porpoises range from a minimum radius of 2.8 km up to a maximum of 12.2 km from the actual source, depending on the AHD used and the level of ambient noise. This may result in effects as described by Johnston (2002), who found significantly fewer sightings of porpoises within 1,500m during scans when the AHD was active and porpoises tracked with theodolites did not come closer than 645m. Several studies also showed the effectiveness of AHDs in deterring porpoises from fishing gear (e.g. see Vinther & Larsen, 2002; Kastelein & Rippe, 2000; Kastelein *et al.*, 1995) or, unintended, from fish farms (Olesiuk *et al*., 2002; Johnston, 2002).

Deterring of cetaceans is however not the only phenomenon described in AHD studies. In some studies, porpoises and bottlenose dolphins were found to show little response or even habituated too pingers (Cox *et al.*, 2001; Cox *et al.*, 2003). Some pingers may also elicit exploration behaviour in porpoises (Kastelein *et al.*, 1995). It was furthermore shown that echolocation rate and occurrence in porpoises decreased in the presence of the pingers, which may even enlarge the danger of entanglement (Cox *et al.*, 2001). Some pinnipeds learned to associate the AHD sounds with food –'the dinner bell effect'-(Richardson *et al.*, 1995).

Drilling activities
There is little data on the reactions of marine mammals to drilling noise and no clear evidence of avoidance by small odontocetes to drilling noise. Bottlenose dolphins, Risso's dolphins and common dolphins were seen close to oil platforms in the North West Atlantic, and sightings rates were similar in areas with and without rigs (Sorensen *et al*., 1984).

Wind farms
Henriksen *et al.* (2001) used recorded noise levels from different wind turbines and compared this with cetacean audiograms. They calculated that the maximum detection distance of an operational marine turbine was 50 m for a harbour porpoise. In Denmark and Sweden, on the other hand, noise was found to be audible for marine mammals up to only 20 m (Bach *et al.*, 2002 in Dolman *et al.*, 2003).

Koschinski *et al.* (2003) reported on behavioural reactions of free-ranging harbour porpoises and seals to the noise of a simulated 2MW Wind power generator. Results showed that porpoises and seals were able to detect the low-frequency sound generated by offshore wind turbines and that they showed distinct reactions to wind-turbine noise. Furthermore, the number of time-intervals during which porpoise echolocation clicks were detected increased by a factor of 2 when the sound source was active.

But not only operative wind farms may affect cetaceans. Dolman *et al.* (2003) reported on the activities involved in the construction and operation of wind farms that are of particular importance to cetaceans. These are divided in activities that can be expected to cause short-term effects and activities that may cause long-term effects.

Activities likely to cause short-term changes are:
- Seismic exploration;
- Intense noise due to ramming/piling, drilling and dredging operations;
- Increased vessel activities during exploration and construction;
- Increased turbidity due to construction and cable laying; and, later
- Decommissioning of wind farms (this may involve the use of explosives).

Activities likely to cause long-term impacts are:
- The presence of structures (Physical presence of the towers and artificial reef effects);
- Continual operational noise and vibrations emanating from the wind turbines;
- Electromagnetic impacts due to cabling that may impact navigation, and;
- Increased vessel traffic, from maintenance operations.

b) Reported effects in the Dutch part of the North Sea
For porpoises in the North and Wadden Sea it was calculated that small fishery vessels, large ships (cavitating) and fast ferryboats could be perceived. Zone of audibility for these vessels ranged respectively from a maximum of 600 m up to a maximum of 2 km and even 15 km (Verboom, 1991). No effects have been reported of other sources of noise on cetaceans in the Dutch part of the North Sea.

9.1.4. Overfishing

a) Reported effects of overfishing in Europe

Although the effects of overfishing on ecosystems are also likely to influence cetaceans, it is not easy to associate a direct decline in cetacean abundance with overfishing of certain species. Many other factors may be involved in observed declines. Nevertheless, Evans (1990a &b) suggested that past depletion of herring stocks in British waters may have resulted in the disappearance of harbour porpoises from British coastal waters during the last 50 years. Porpoise populations in the southern North Sea but also in the English Channel disappeared after a crash in herring stocks in 1960 (Reijnders, 1992). A similar decline occurred around the Shetlands, following a crash of sandeels in the 1980s, although both sandeels and porpoises made a strong recovery in the 1990s (Evans, 1994).

b) Reported effects in the Dutch part of the North Sea

Effects of overfishing on cetaceans in the Dutch part of the North Sea have nowadays not been shown. However, trends in the past have been associated with overfishing (see chapter 8).

9.1.5. Climate change

For both enhanced global warming and ozone depletion no effects on cetaceans have been reported either worldwide or in the Netherlands.

9.1.6. Collisions with boats

a) Reported effects in Europe

In the UK, some evidence exists for collisions between cetaceans and boats. Two stranded porpoises showed injuries which were thought to have been caused as the animal was run-over by a boat (see Grellier *et al.*, 1995; Bennett *et al.*, 2002). No records of killed bottlenose dolphins are known, but propeller injuries have been found on a wild social dolphin (Bloom & Jager, 1994). Injuries resembling that of propellers have been witnessed during surveys carried out in UK waters, especially concerning Risso's dolphins, Bottlenose dolphins and common dolphins (M. de Boer, pers comm.).

b) Reported effects in the Dutch part of the North Sea

So far, in Dutch stranding records, no carcasses were reported with evident markings of collision (pers. comm. Smeenk).

9.2. THREATS TO THE SELECTED SPECIES IN THE DUTCH PART OF THE NORTH SEA

Using obtained knowledge on cause-effect mechanisms of each threat together with information concerning current human activities in the Dutch part of the North Sea and the biology of each selected species, it is now possible to discuss the occurrence and most importantly the extent of each threat. This is summarized below for each threat separately and, where possible, on a species-specific level.

The criteria that were used in order to classify the extent of each threat were:

1. The scale characteristics of the anthropogenic activity which is thought to affect the selected species in the Dutch part of the North Sea.

    The anthropogenic activity or threat will be described by considering the time span during which it takes place, the spatial scale at which it occurs, and the time that is needed for the environment to recover after the human activity which caused the threat stopped or diminished to a sustainable level. However, since information is scarce, the divisions used here are rather obscure. The temporal scale for a threat was defined either as continuous, regular/incidentally or unknown (presented in decreasing order of 'seriousness'), and the spatial scale characteristics for each threat were either when occurring on a large scale or on a small scale. The suggested recovery rate of the environment was measured to be either relatively slow or relatively fast.

2. The impact of the activity

    A distinction is made between individual consequences and consequences on population level. Individual consequences were divided in lethal consequences/ physical damage, behavioural changes/ subtle and/or indirect effects, and unknown effects. The effect on the population may occur through reduced reproduction. Information concerning cetaceans from the Dutch part of the North Sea is limited and therefore the effects for selected species known from other areas were also included.

3. Biology parameters

    The occurrence or habitat of a species, its (foraging) behaviour and its diet preferences may cause an increase in exposure to threats. The reproduction rate of a species may furthermore affect the recovery rate. These biology parameters have therefore also been included in the analysis and a division was made in a. increased exposure to the threat due to the biological parameters; b. no or little increase in exposure; and c. unknown effect in exposure. The recovery rate of the cetacean species was indicated to be relatively slow, relatively fast or unknown. Again, information from other populations and areas were included when information for the Dutch part of the North Sea was limited.

9.2.1. DISCUSSION OF CURRENT THREATS IN THE NETHERLANDS

1. By-catch

Strandings, observer studies, and reports from fishermen all show that by-catch occurs in gillnet fisheries and trawl fisheries in regions of the North Sea, Celtic Sea and Baltic Sea. For some areas, for example the North Sea near Denmark and the Celtic Sea near Ireland, it could even be calculated that by-catch exceeded the level at which it is thought to be sustainable.

Does by-catch occur in the Netherlands?

Based upon the following facts, by-catch of harbour porpoises certainly occurs in the Dutch sector of the North Sea.

- Several cases of by-catch have been reported by fishermen;
- At least half of the stranded porpoises show signs of by-catch;
- Fisheries which are known to cause by-catch in other areas operate in Dutch waters.

It is however not certain which fisheries are mainly responsible. The most common form of fishing amongst Dutch fishermen, that of beam trawling, is unlikely to capture many cetaceans, because of the small size of the nets. In addition, one should bear in mind that cetaceans found in hauled beam trawl nets, or any other kind of bottom trawl nets, may be animals which have died before and sank to the bottom (Moreno, 1993).

Gillnet fisheries are more likely to play an important role, as these are known to cause extensive by-catch of porpoises in other regions. Gillnet fishing is relatively little conducted amongst Dutch fishermen, but the threat of by-catch is not solely based on Dutch fishing gear. Outside the 3-miles zone, in which only Dutch and Belgian vessel operate, international fisheries, mainly gillnet fisheries, from all nations are allowed. As gillnets are set along the coast ánd close to ship wrecks, they occur throughout the entire North Sea and may be a large scale threat to cetaceans.

By-catch of other species in the Dutch part of the North Sea is likely to be less extensive than porpoise by-catch. Of other cetacean species, no records of fresh (not decomposing) animals with signs of by-catch have been reported stranded on the Dutch coast. Also, pelagic trawling, which is known to cause by-catch of dolphins in other regions, occurs only on small scale in the Dutch part of the North Sea.

The extent of by-catch in the Netherlands
A level of mortality due to by-catch below 1% is generally thought to be sustainable. In the Netherlands, not enough data exist to calculate by-catch mortality, but an indication for the porpoise is given below:

Porpoises which stranded on the Dutch coast and were identified as victims of by-catch are generally found to be fresh animals. Probably the majority, if not all, of these animals therefore origin from within the Dutch sector of the North Sea. Approximately 100 porpoises annually strand on the Dutch coast and the percentage of by-caught animals is at least 50% (García Hartmann & Smeenk, in prep.). This indicates that the absolute minimum of by-caught porpoises in the Dutch sector of the North Sea consists of 50 porpoises annually. It is difficult to say if this absolute minimum of by-catch exceeds the biologically safe limits as uncertainty remains about:

a) the exact number of porpoises in the Dutch continental shelf;
b) the possible formation of one subpopulation, being part of a larger population, or the division into several subpopulations

Several differentiations for the harbour porpoise population in the North Sea have been suggested (see chapter 5), but all suggested that the porpoises on the DCS are part of a larger population. There are no population estimations known for these various suggested subpopulations. For the Dutch sector of the North Sea however, estimates of the present number of porpoises have been made based on aerial surveys. Due to migration these numbers vary between a two-month period, with a peak of about 11,000 porpoise in April/May (Baptist *et al.*, 1997). Because this number is not corrected for animals invisible at the surface and since the population probably exceeds the Dutch boundaries, the true population size is likely to be higher. The absolute minimum level of by-catch in the Netherlands, 50 animals, does certainly not exceed 1% of the population.

A by-catch level of 50 animals is however an absolute minimum as not all by-caught porpoises become stranded and when found stranded the cause of death cannot always be identified. The entire population will furthermore not only suffer from by-catch in the Dutch sector of the North Sea, but, as the animals migrate, also in other areas. In summary, by-catch of porpoises is very likely to be a serious threat in the North Sea and by-catch occurring in the Netherlands will contribute to this.

2. Pollution

In many regions throughout the world, correlations are found between contaminant burden in marine mammal tissues and diminished reproduction or higher numbers of diseased and stranded animals. Cause-effect relations are however more complicated to demonstrate due to practical and ethical restrictions in marine mammal toxicology research. These restrictions should be kept in mind when reading this chapter.

Does pollution affect cetaceans in the Netherlands?
It can be concluded that pollution is likely to affect cetaceans in the Dutch part of the North Sea. We based this conclusion on the following information:

- The southern North Sea is the most contaminated area in the North Sea;
- Measurements of contaminant concentrations in areas of the North Sea currently exceed that of reference points that are set to be biologically safe;
- The distribution of cetaceans at least partly overlaps with areas where high concentrations of contaminants along the Dutch coast have been found;
- High concentrations of PCBs and organochlorines have been demonstrated in porpoises found stranded on the Dutch coast

The extent of pollution in cetaceans in the Netherlands
During the last decades, policies in the Netherlands have aimed to reduce contaminant concentrations below reference points which are regarded to be biologically safe. Consequently, concentrations of many pollutants have indeed dropped, but not in all regions and not for all chemicals these dropped below the set references. In

addition, new compounds are regularly introduced to the marine environment, and as the effects of these have only been tested on several species, the effect when introduced in the entire ecosystem, are rather unpredictable. Furthermore, when the concentration of a hazardous chemical is reduced, a new problem is likely to occur. For example, when submission of PCBs to the environment were reduced they were replaced by PBDEs. It can therefore be concluded that pollution is continuously ongoing.

Even when pollution is reduced, cetaceans will still be exposed to considerable concentrations of the compounds for some more time since many contaminants are poorly degradable. This indicates that the environment, including the cetacean population, will slowly recover. Bottlenose dolphins and perhaps also white-beaked dolphins, are also likely to recover slower than the harbour porpoise, as their reproduction rate is relatively slower. Furthermore, the weaning period in dolphins is longer than that of porpoises, and dolphin calves are therefore more likely to be longer exposed to pollutants which have been reported to concentrate in the mother's milk. Although, one should bear in mind that in particular the first dolphin calf is mostly exposed to these pollutants. Since dolphins, furthermore, also regularly feed on fish which are located higher in the food chain, their exposure to pollution is likely to be higher compared to that of the porpoise. To dolphins in particular, pollution appears to be an important threat.

It can be concluded that there are many signals for a high exposure to contaminants, but the effect of pollutants to Dutch cetaceans is not clear. Expected are reproductive impairment and lethal effects, and synergetic effects may occur. A decreased resistance due to one pollutant may increase the susceptibility to others. The overall effect of contaminants will thus be magnified, but information on this remains largely unknown.

3. Noise

Does noise affect cetaceans in the Netherlands?

The sources of noise discussed in this paper are the main man-made noises in the Dutch part of the North Sea, being military activities, seismic surveys, shipping and drilling, and two new sources which will be introduced in the near future: AHDs and wind turbines. The noise produced by all these sources is detectable for odontocetes, including the harbour porpoise, bottlenose dolphin and white-beaked dolphin, and can sometimes be detected at several kilometres from the source itself. As noise producing activities are also spread out in the entire DCS and occur year-round, we conclude that cetaceans will regularly perceive more or less elevated levels of under water noise.

The extent of the effects of noise

Research about the effects of under water noise on cetaceans only recently received more scientific attention and no reports about effects of noise on cetaceans currently exist for the Dutch part of the North Sea. In fact, no surveys currently focussing on the effects of noise have been conducted. The absence of reported effects does therefore not mean that cetaceans are not influenced by the elevated noise levels. This is supported by an overview of the effects of noise in other regions. One should however bear in mind that in other regions sources of noise may be somewhat different (*e.g.* due to the use of different materials) and variation in the transmission of noise, which is influenced by several characteristics of the environment, may also be different. The effect of a particular source on cetacean species as measured elsewhere can therefore not be extrapolated to animals in the Dutch part of the North Sea. In this analysis we therefore focus on all effects that have currently been reported concerning all different sources of noise. This will supply us with a general overview of noise effects on cetaceans.

Currently, the general effects of noise that have been demonstrated for porpoises, bottlenose dolphins and white-beaked dolphins are behavioural changes in reaction to noise, in particular the avoidance of the area near the source (although a few reports of attraction exist as well). These changes may have subtle effects, for example less efficiency in foraging, and problems with communication and navigation. However, in other odontocetes, beaked whales, a correlation between the presence of noise and strandings has been demonstrated.

4. Overfishing

Does overfishing occur in the Netherlands?

It is not certain if a North Sea SSB for a fish species below $\mathbf{B_{pa}}$ also reflects the situation in the Dutch sector of the North Sea. For the purpose of this study, we concluded that the graphs presented in appendix 1 (figure 4), showing the SSB of several fish stocks in the entire North sea (and adjacent waters), do reflect the situation in the Dutch part of the North Sea: Fishing on a species below $\mathbf{B_{pa}}$ will be reflected in the catch per unit effort and fishermen will undoubtedly travel elsewhere to obtain better catch rates. It is thus not likely that a fish species is intensively fished upon to a level far below $\mathbf{B_{pa}}$ in one area of the North Sea, whereas elsewhere the same species is doing well and is not overfished. It can consequently be suggested that overfishing does affect cetaceans in the Dutch part of the North Sea, because

- the main prey of the target cetacean species exists of commercially fished fish;
- many fish species, amongst which main prey for the selected species, have currently been over-fished in the Dutch part of the North Sea; and
- due to the migratory nature of some cetaceans, they are likely to suffer from over-fished areas outside the Dutch sector as well.

The extent of the effects of overfishing on cetaceans

Overfishing may in the past have severely affected the selected species (see chapter 8.1.) and nowadays, overfishing may (again?) become a problem since the main prey species of the porpoise, white-beaked dolphin and bottlenose dolphin are being overfished. The decrease in these main prey species is however not immediately reflected in the abundance of the porpoise and white-beaked dolphin. In fact, the number of stranded and sighted porpoises is still increasing and only recently a possible decline *may* have set in for the white-beaked dolphins. Possibly the ongoing increase is due to migration into Dutch waters or to the opportunistic feeding behaviour of both species. The animals may have shifted to other prey species as abundance of their main prey decreased. Recently more sandeel was found in Dutch porpoise stomachs (pers.comm. Smeenk), which may reflect such a shift. It may on the other hand also be that sandeel increased in the Dutch sector of the North Sea due to some change in the environment. Porpoises may consequently have shifted their diet as cost-benefit ratio for predating different fish became more beneficial.
However, it is important to notice that overfishing certainly is a potential threat for the future and cetaceans will only slowly recover from its effects as it will take quite some time for fish stocks to recover.

5. Climate change

Our climate has been changing continuously throughout centuries, but it has been suggested that the current trends are too fast to be natural and are more likely to be caused by the enhanced greenhouse effects. Scientists however do not all support this suggestion, which is mainly due to a general lack of understanding of all factors, natural and antropogenic, influencing the complicated positive and negative feedback cycles of the enhanced greenhouse effect. It can consequently not be said if the enhanced greenhouse effect occurs in the Netherlands.

Ozone depletion is currently no problem in the Netherlands. Attention is however still needed, especially at an international level for further monitoring. Failing this, ozone depletion will remain a potential threat.

6. Collisions with boats

Considering the temporal and spatial distribution of boat traffic and porpoises and white-beaked dolphins, collisions with boats will not be a serious threat to porpoises and white-beaked dolphins in the Netherlands. If bottlenose dolphins re-occurred in the Dutch sector, on the contrary, collisions may affect this species due to an overlap in presence of boats and dolphins.

9.2.2. Analysis of the extent of threats to the selected species in Dutch waters

The results for each threat, as discussed in the previous chapter, are summarized on a species-specific level in table 13. In this table, characteristics of the human activities in the Dutch sector of the North Sea and characteristics of each species are used to identify the extent of each threat to each species. Characteristics enlarging a threat are represented in red, less severe impacts are represented in yellow. When the consequences of an activity are not known, not only ‘unknown’ is marked but a question mark is placed for the effects which have been suggested but not proven. The more red squares occur in each collumn in table 13, the more serious is a threat and its impact on the species. A classification of threats is suggested in table 12.

	No. red boxes	**Recommendation**
I	≥6	Serious threat, action is needed now
II	3 to 5	Likely threat, caution is needed
III	≤2	Potential threat, more research is needed

Table 12: Classification of threats into three categories of 'seriousness’ and related recommendations. The number of red squares can be found in table 13.

		Threats															
		Bycatch			Pollution			Over-fishing			Noise			Climate change	Boat collision		
		B	H	W	B	H	W	B	H	W	B	H	W	all	B	H	W
Scale characteristics																	
Time span	continuous		x		x	x	x				x	x	x				
	regular/incidentally	x		x				x	x	x					x	x	?
	unknown													x			x
Spatial scale	large scale		x		x	x	x	x	x	x	x	x	x	x			
	small scale	x		x											x	x	?
	unknown																x
Recovery environment	Relatively slow				x	x	x	x	x	x				x			
	Relatively fast	x	x	x											x	x	x
	unknown										x	x	x				
Impact levels																	
Individual	lethal/physical damage	x	x	x	x	x	?	?	?	?				?	x	x	?
	behavioural changes/ subtle and/or indirect effects	?	x	?	?	?	?	?	?	?	x	x	x	?	?	?	?
	unknown						x	x	x	x				x			x
Population	diminished reproduction				x	?	?	?	?	?	?	?	?				
	no or small reproduction effect	x	x	x											x	x	x
	unknown					x	x	x	x	x	x	x	x	x			
Biological parameters																	
Habitat	increase in exposure		x		x	x					x	x			x	x	
	no or little increase	?		?			x	x	x	x			x	?			x
	unknown	x		x										x			
Behaviour/ foraging	increase in exposure	x	x	x	?	?	?				x		x		x		x
	no or little increase											x				x	
	unknown																
Diet preferences	increase in exposure	?	x	?	x		x	x	x	x				?			
	no or little increase					x			x					?			
	unknown	x		x										x			
Recovery rate cetaceans	Relatively slow	x		?	x		?	x		?	x		?		x		?
	Relatively fast		x			x			x			x				x	
	unknown			x			x			x			x	x			x

Total score																	
	red	3	6	2	8	5	4	4	3	3	5	3	3	2	4	2	1
	yellow	4	3	4	0	2	1	2	3	2	1	3	2	0	4	6	3
	blue	2	0	3	0	1	3	2	2	3	2	2	3	6	0	0	4

Table 13: The impact of anthropogenic activities on the bottlenose dolphin (B), harbour porpoise (H), and white-beaked dolphin (W) in the Dutch part of the North Sea.. Grey squares are presented in the columns which are not relevant. For climate change no species specific information was present and the selected species are therefore combined in one column. The difference between recovery of the environment and of the cetaceans should furthermore be noted. The recovery of the environment is described as the return of the environment to the 'natural'situation after the human activities causing the threat have stopped. The recovery rate of cetaceans is based upon their reproduction rate.

Applying the classification in table 12 results in table 14, in which for each threat the extent of the problem is indicated for each species separately.

	By-catch	Pollution	Overfishing	Noise	Climate change	Collission
Bottlenose dolphin	II	I	II	II	III	II
Harbour porpoise	I	II	II	II	III	III
White-beaked dolphin	III	II	II	II	III	III

Table 14: Classification of the extent of each threat for the three selected species.

I. Serious threat, action is needed now
II. Likely threat, caution is needed
III. Potential threat, more research is needed

Based upon table 14, by-catch appears to be a major threat to porpoises and action is needed now. As outlined in in the previous chapter, by-catch is not a serious threat for dolphin species and this is reflected in the table. For the white-beaked dolphin, by-catch is even indicated as a potential threat, category III, which may suggest it is currently not occurring. It is however more likely that the indication of by-catch as a category III threat is due to the poor description of the white-beaked dolphin ($N_?$=16; see table 13) compared to the harbour porpoise ($N_?$=5) and bottlenose dolphin ($N_?$=6). As a result, more unknown boxes were marked for this species, of which some are likely to be substitutes for red boxes.

Pollution is indicated to be a serious threat to bottlenose dolphins if these species would re-occur in Dutch waters. The vulnerability of this species is, amongst others, due to its coastal distribution, the composition of its diet (consisting of fish species higher up in the food chain) and its slow recovery rate. Important also is a diminished reproduction which was demonstrated for this species, whereas this is only suggested to occur in the other two cetacean species.

Overfishing and noise, for all species, are both defined as likely threats, category II, and climate change and collissions are category III threats, which indicates that they are potential threats. More research is needed for these threats, especially considering climate change as little information is available.. Boat collissions scored no question marks at all for the bottlenose dolphin and harbour porpoise. For these two species the classification of collissions as a category III threat may also be considered an indication for the (currently) small extent of the problem. For white-beaked dolphins, on the contrary, again little is known and here the classification as a category III threat certainly indicates that more research is needed.

The problem of this analysis is that the amount of red squares is used as an indication for the impact of a threat on cetaceans, whereas yellow ('less serious aspects') and blue ('unkown aspects') squares were left out of the classification criteria. These are however important to consider as well: A threat without red squares but a high amount of blue squares in the table, may in reality still be a serious threat, as is demonstrated in the paragraphs above. In addition, not all red squares on which the classification is based are the same. One red square for example represents the lethal effect on cetaceans, whereas another square may represent the large spatial scale at which a threat occurs. Adding up red squares is consequently adding up completely different characteristics. Table 14 should therefore be interpreted with care and should only be presented in combination with table 12 and 13. Nevertheless there can be no doubt that the threats identified as a category I threat in this table are indeed serious threats for which action is needed now, as these threats scored at least six red squares out of the possible 8 or 9 (depending on the presences of non-relevant –grey- squares). These threats are well understood and many different factors are involved.

One should also bear in mind that cetaceans in the Dutch part of the North Sea are faced with a combination of all above described threats, and where each single threat may not affect the selected species at an unsustainable level, exposure to all threats together and both in and outside the Dutch part of the North Sea may cause the species to disappear from these waters. The still increasing number of reported porpoises may certainly not be a reason to suppress this concern, as this increase is mainly due to a changing migration pattern instead of an actual increase in population and reproduction. More reports of porpoises in the Dutch part of the North Sea therefore consequently does not necessarily indicate that the North Sea population(s) is/are doing well. On the contrary, the increase in strandings must be regarded as a warning, as the majority of these strandings are that of animals that did not die a natural cause of death.

10. How to improve the Dutch part of the North Sea for cetaceans?

The Netherlands ratified and enacted international agreements to protect cetacean species and their habitat. As cetaceans occur throughout the entire Dutch sector of the North Sea, it is most necessary to develop a proper and effective North Sea policy, which is beneficial for the entire ecosystem. Overfishing and pollution are therefore topics which should have a priority status in the North Sea policy.

At a species-specific level, other topics should be included, especially those considering the cetaceans which occur regularly in the Dutch part of the North Sea. Based upon strandings and sightings, these species currently are the white-beaked dolphin and the harbour porpoise. If conditions in the North Sea improve, the bottlenose dolphin may also re-occur in the Dutch sector of the North Sea. These three (potential) regular occurring species are therefore recommended to be selected species for the North Sea policy.

The increase in strandings of the harbour porpoise may indicate that the species is coming back to Dutch waters and do so far not suffer from any threats. However, strandings data also indicate a high number of bycaught animals. At least half of the animals stranded on the Dutch coast was identified as bycaught and porpoises were often found in a very fresh state, indicating that bycatch is a problem that occurs right on our doorstep. But also outside Dutch waters, this highly mobile species is exposed to high levels of bycatch, which may not only severely impact the population, but also involves a major welfare dimension. Cetaceans are adapted to remain underwater for prolonged periods of time. For example, the maximum dive duration for porpoises may be five and a half minutes (Westgate *et al.*, 1995). Veterinary studies indicated that cetaceans trapped in nets probably remain conscious until they die from lack of oxygen. In the case of porpoises, the duration of conscious and painful suffering may be several minutes (Ross *et al.*, 2001).

The effects of bycatch on the individual porpoise as well as on population level further stress that action is needed now. Fortunately, the problem of bycatch was also addressed by the European Union, which resulted in the mandatory use of pingers in certain fisheries from 2005 onwards. We would however like to express our concern about the use of these devices as these may either result in an increased level of bycatch (due to the 'dinner-bell effect' or elicitation of exploration) or, when 'succesful', may result in habitat reduction, especially when pingers are concentrated in a certain area. Indirectly, cetaceans may also be affected when pingers not only deter porpoises, but also deter their prey. We therefore advice to better explore the effects of using these and other devices before placing them in porpoise sensitive areas. The latter of which need to be identified for Dutch waters.

In the short term, the effect of overfishing on porpoises appears to be less harmful as information regarding the porpoise diet indicates that this species is an opportunistic feeder that will find other prey when favourite prey species are overfished. In the long-term, however, overfishing may reduce species richness in the North Sea and porpoises will consequently struggle to shift their diet to another energy-rich fish species. We should therefore draw our lessons from the past and develop swift precautionary measures in order to prevent the threat of overfishing.

Overfishing has not only considerably reduced porpoises in Dutch waters in the past. The disappearance of bottlenose dolphins was also related to this threat. Pollution however also played an important role and is shown to be currently the major threat to bottlenose dolphins, if this species would re-occur in Dutch waters. This is partly due to the general coastal distribution of the dolphin, which exposes the animals to higher concentrations of pollutants. This distribution also causes an increased exposure to noise and boat collissions, as recreational vessels and several other human activities are mainly concentrated in these coastal zones. Effects of noise and collissions may on one hand not always be lethal, but they may seriously affect a species already under pressure. As the bottlenose dolphin reproduces relatively slow, we feel further concerned about the combined effects of pollution and noise. If we want to facilitate the return of the bottlenose dolphins to Dutch waters, action is needed now to especially reduce pollutant levels (in particular that of PCBs) of the Dutch part of the North Sea.

The problem with the protection of the white-beaked dolphin is that only little is known about its biology, its response to local climate changes and its vulnerability to human activities. All these uncertainties, however, should not be used to conclude that no action for increased protection measures are needed. On the contrary, the white-beaked dolphin deserves most attention of all species, as both strandings and aerial survey records show the first signs of a decline of this species in Dutch waters. Action should therefore be taken to prevent the species from disappearing completely.

Our findings showed that whiting and cod, both main prey species of the white-beaked dolphin, are currently overfished. As the flexibility of white-beaked dolphins to switch to another prey species have not been described, we feel very concerned and suggest that action is taken to put a halt to the overfishing of these fish. We would also like to express our concern about the effects of pollution on the white-beaked dolphin. Neither effects on individuals nor on populations of the white-beaked dolphin are known, but their diet preference and slow recovery rate make them very vulnerable. For the protection of the white-beaked dolphin, overfishing and pollution are therefore identified as the threats that urgently need attention.

Policy instruments which may possibly contribute to the reduction of the described threats are outlined in Appendix 5. These mainly focus on the improvement of environmental planning; the adjustment of procedures and materials used for an activity; and the restriction of the number of activities. Not included in the Appendix, but probably very important, is public awareness. These suggested instruments have however not yet been examined for their costs and efficiency. Furthermore,the social acceptance of these instruments by the Dutch society was not studied and we wish to highlight the importance of further studying such topics here.

Another important recommendation for further studies is identifying cetacean sensitive areas within the Dutch part of the North Sea. We understand that the elimination of certain human anthropogenic activities throughout the Dutch part of the North Sea is a difficult, if not an impossible task. By identifying cetacean sensitive areas and/or seasons, we aim to be able to significantly improve the habitat requirements and therefore the conservation status of different species in those areas where this is mostly needed.

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13. Appendices

13.1. Figures

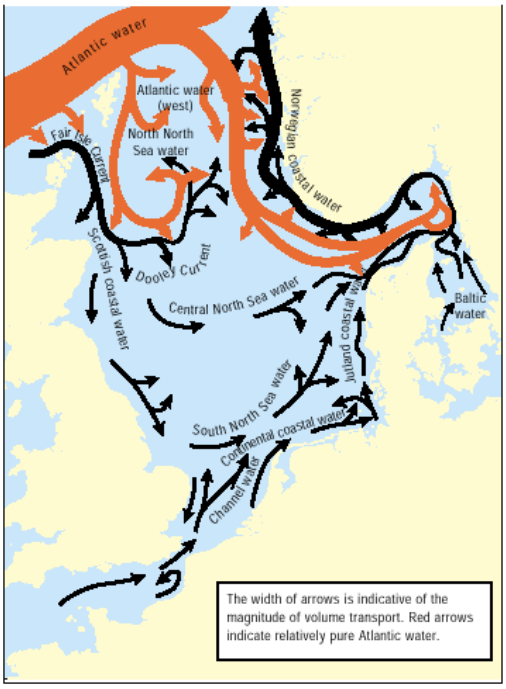

Figure 1: Currents in the North Sea (from OSPAR, 2000)

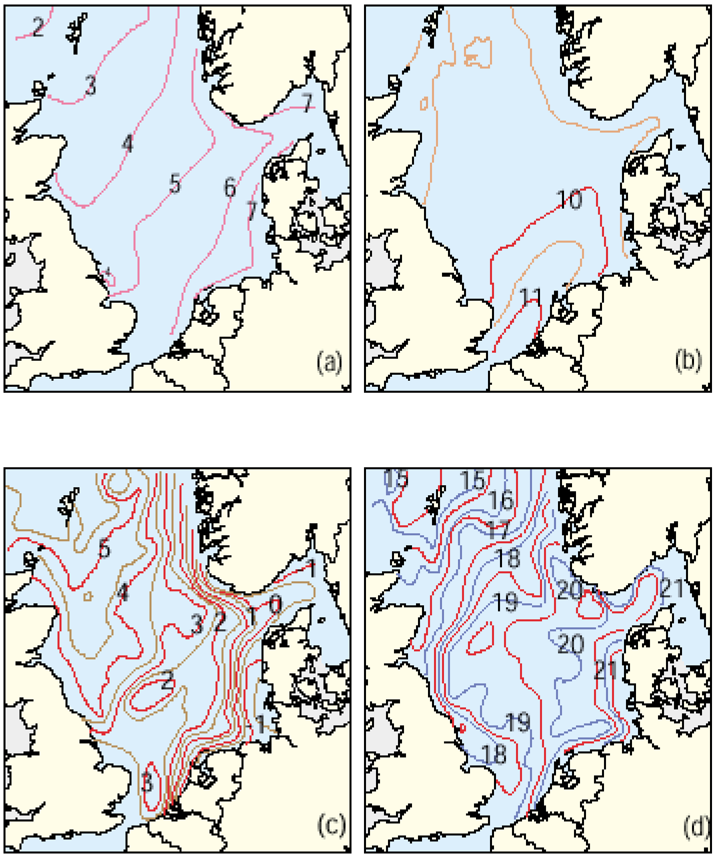

Figure 2: Sea surface temperature distribution in °C for the period 1969-1993. a) amplitude of the yearly cycle b) average c) minimum (winter) d) maximum (summer) (from OSPAR, 2000)

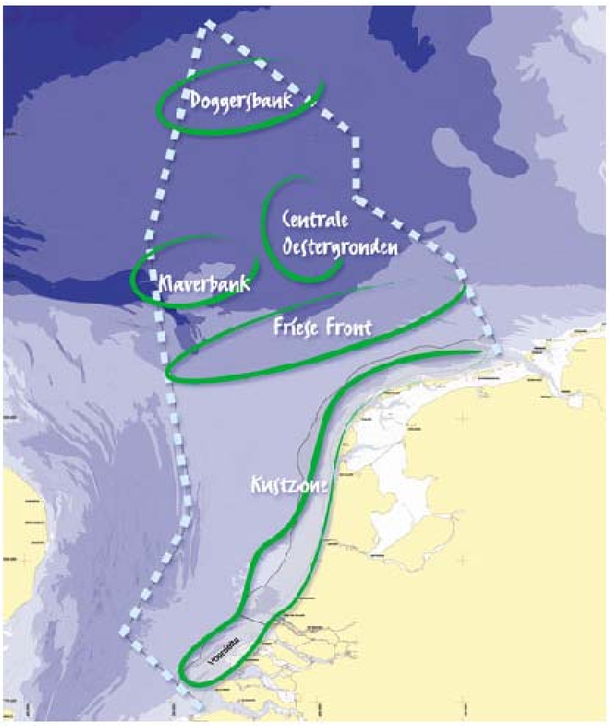

Figure 3: Different zones in the North Sea: The Dogger Bank (Doggersbank), Clover Bank Klaverbank), Oyster grounds (Oestergronden), Frisian Front (Friese Front) and coastal zone (kustzone) (from anonymous, 2003)

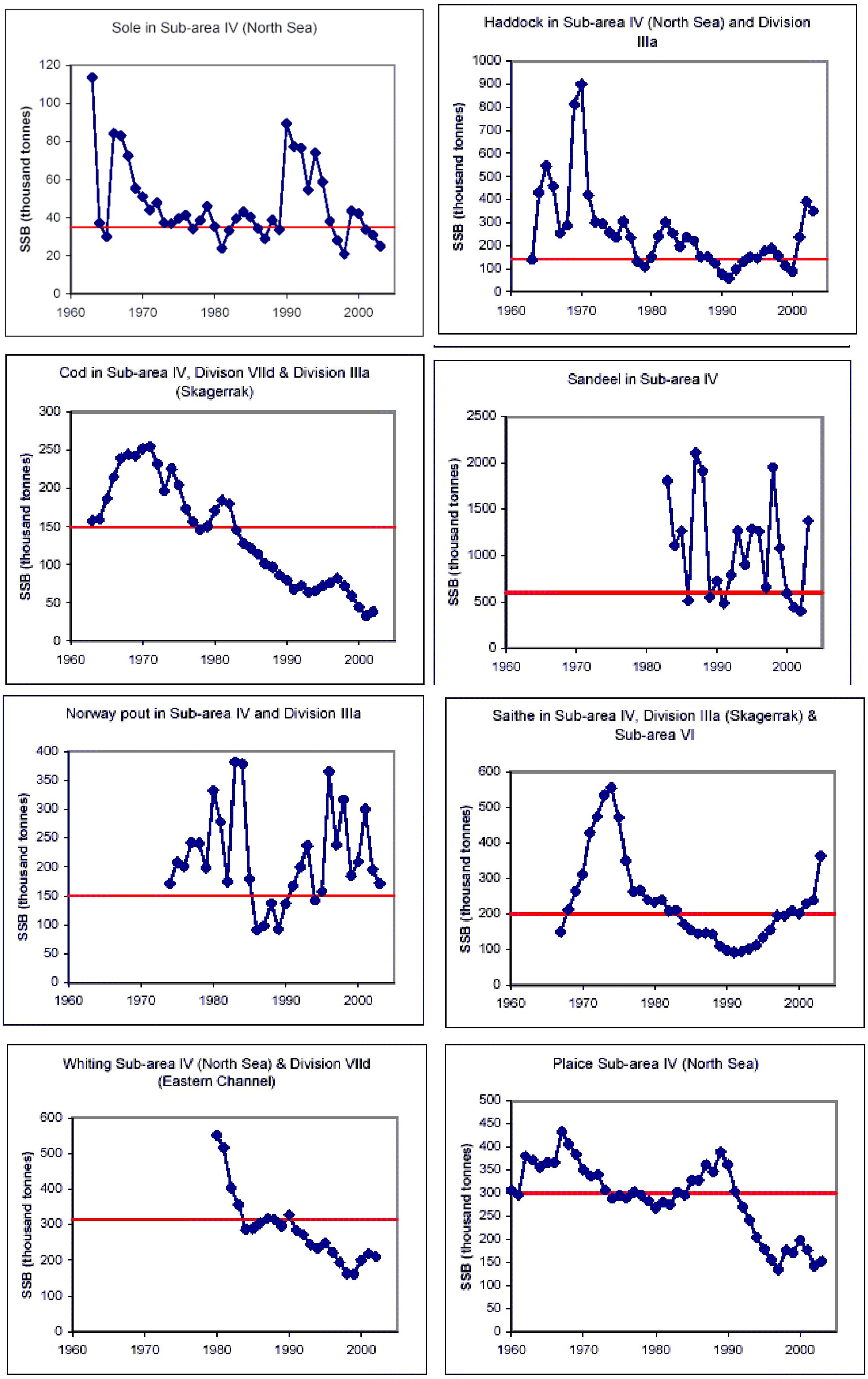

Figure 4: Spawning Stock Biomass for several commercially fished fish stocks in the North Sea (and adjacent waters when the population is not restricted to the North Sea). The red line represents the precautionary limit. Caution: biological reference points are under revision and may no longer be applicable (source: ICES, 2003).

FIGUUR 5: scheepvaartroutes, militair

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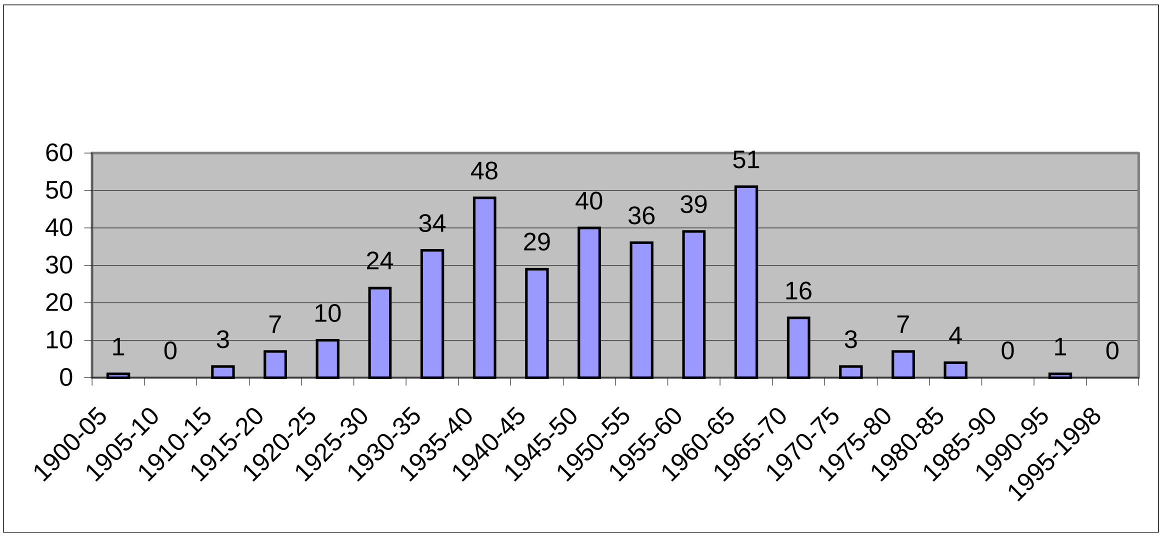

Figure 7: Strandings of bottlenose dolphins Tursiops truncatus on the Dutch coast for the period 1900-1997 (Bakker and Smeenk, 1987; Smeenk 1989, 1992, 1995, 2003)

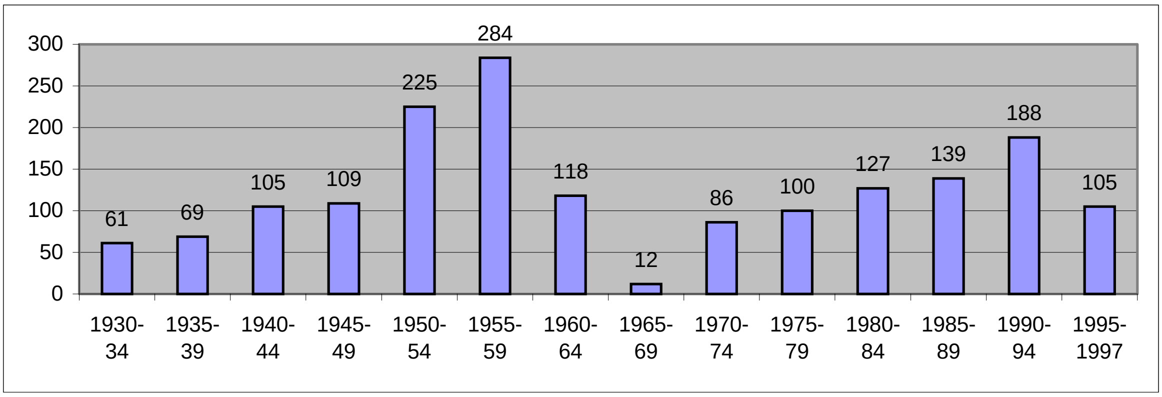

Figure 8: Strandings of harbour porpoises Phocoena phocoena on the Dutch coast during 1930-1997 (sources: Smeenk, 1986; 1987; 1989; 1992; 1995; 2003)

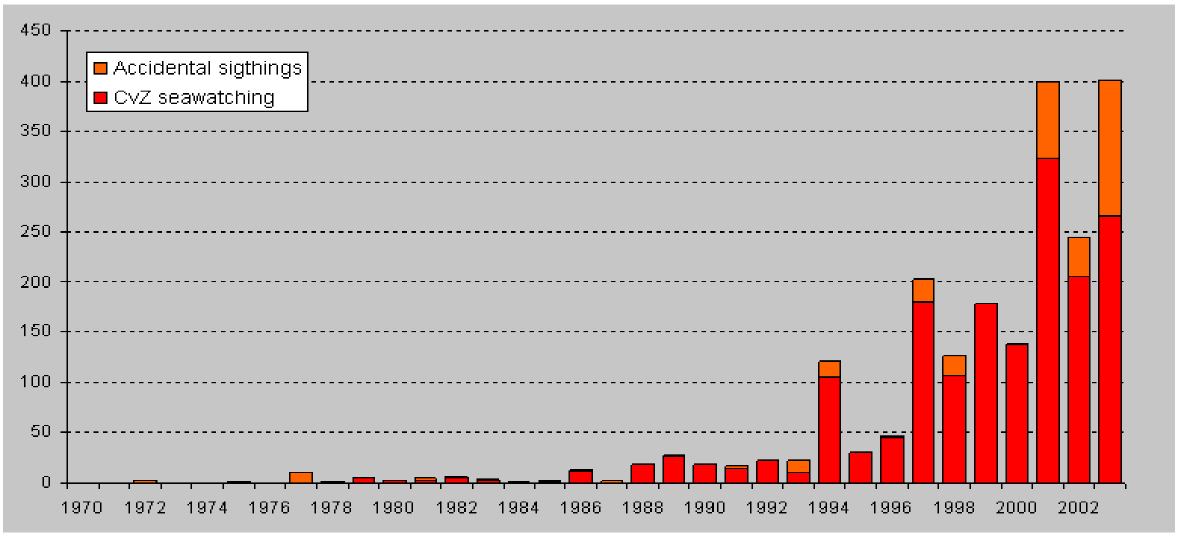

Figure 9: Harbour Porpoises reported from coastal sites in the Netherlands since 1970 (Camphuysen, 2004). Please note that the data are corrected for observer effort for the CvZ seawatching, but not for the included accidental sightings.

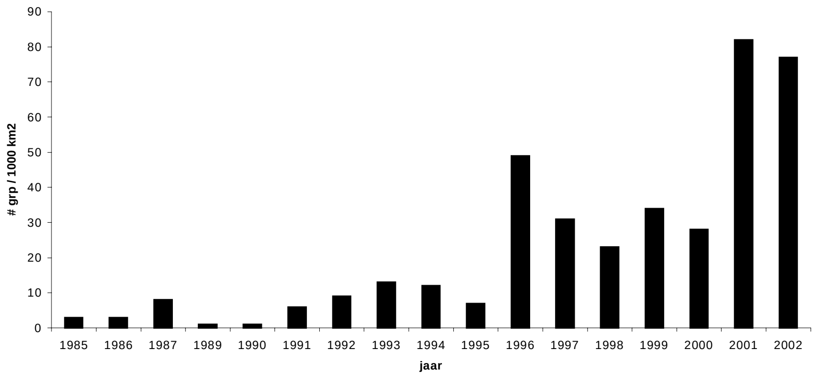

Figure 10: Number of porpoise groups observed per 1000 km2 for the period 1985-2002 (adapted from the Biological monitoring programme of RIKZ conducted in connection with the MWTL-programme)

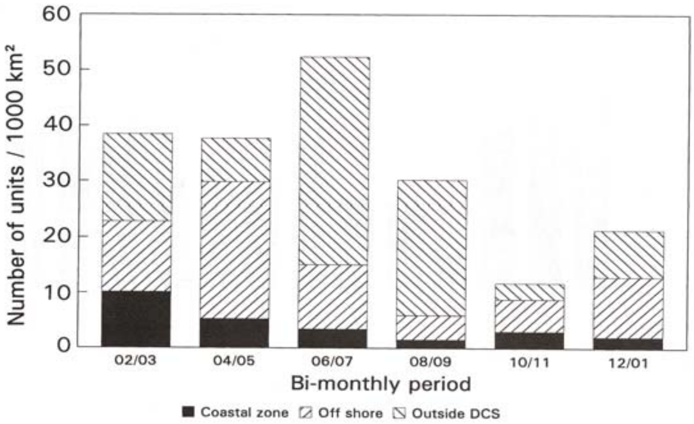

Figure 11: Average number of units porpoises encountered per 1000 km2 surveyed by plane per two months' period (from Witte *et al*., 1998)

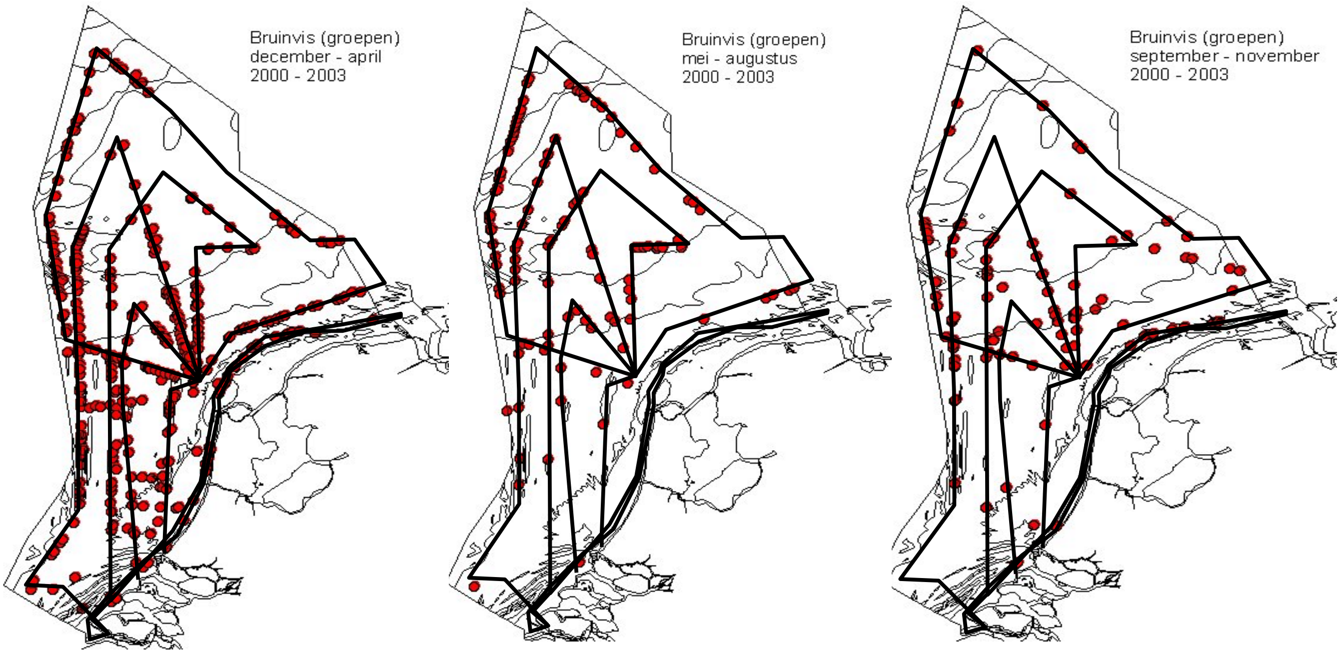

Figure 12: Porpoise groups observed during aerial surveys in the period 2000-2003, divided in the seasons December-April, May-August, and September-November. The black lines represent the flying routes (RIKZ, 2004).

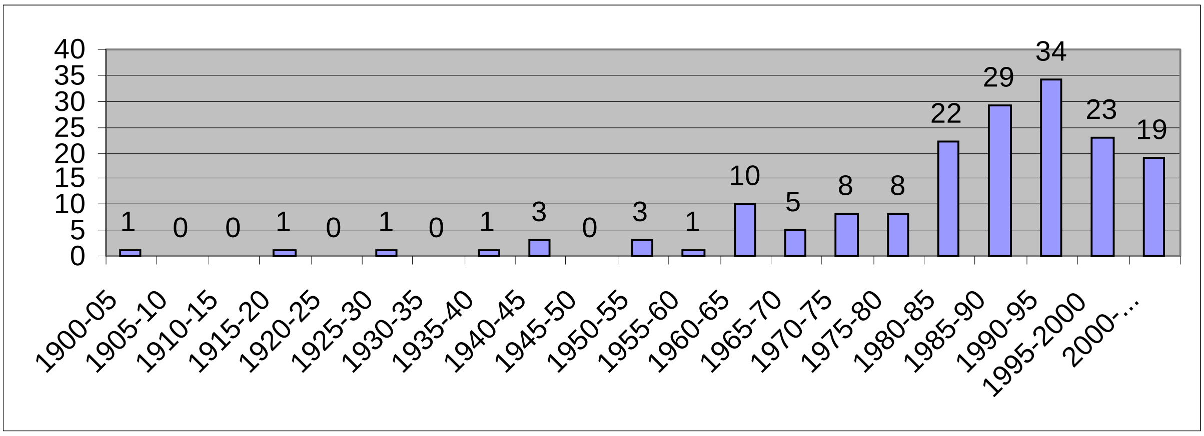

Figure 13: Strandings on the Dutch coast of white-beaked dolphins Lagenorhynchus albirostris for the period 1900-2003 (data sources: Bakker & Smeenk, 1987; Smeenk, 1995; 2003; pers. comm.)

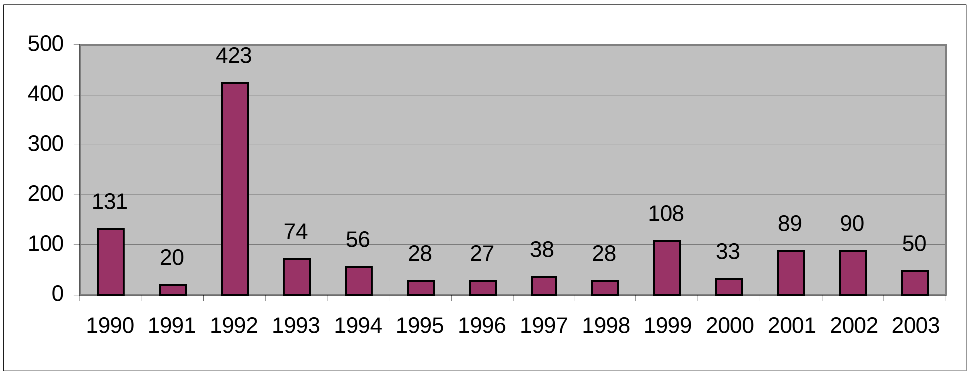

Figure 14: Number of white-beaked dolphins reported in Dutch waters for the period 1990-2003, not corrected for observer effort (Camphuysen, pers. comm.)

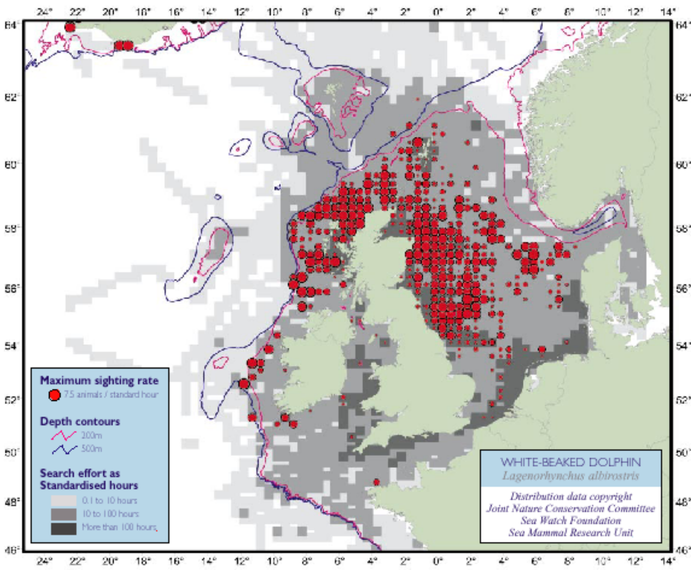

Figure 15: Distribution and abundance of the white-beaked dolphin *Lagenorhynchus albirostris*, an integration of data from 1979 to 1997 (Reid et al., 2003). The grey squares on the map indicate observer effort in standardised hours, varying from 0 hours (white) to more than 100 hours (dark grey). The red dots show sighting rates.

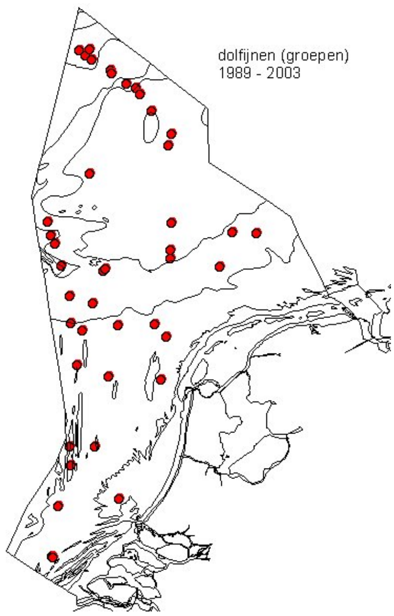

Figure 16: Sightings from dolphins reported from aerial surveys in the period 1989-2003 (RIKZ, 2004)

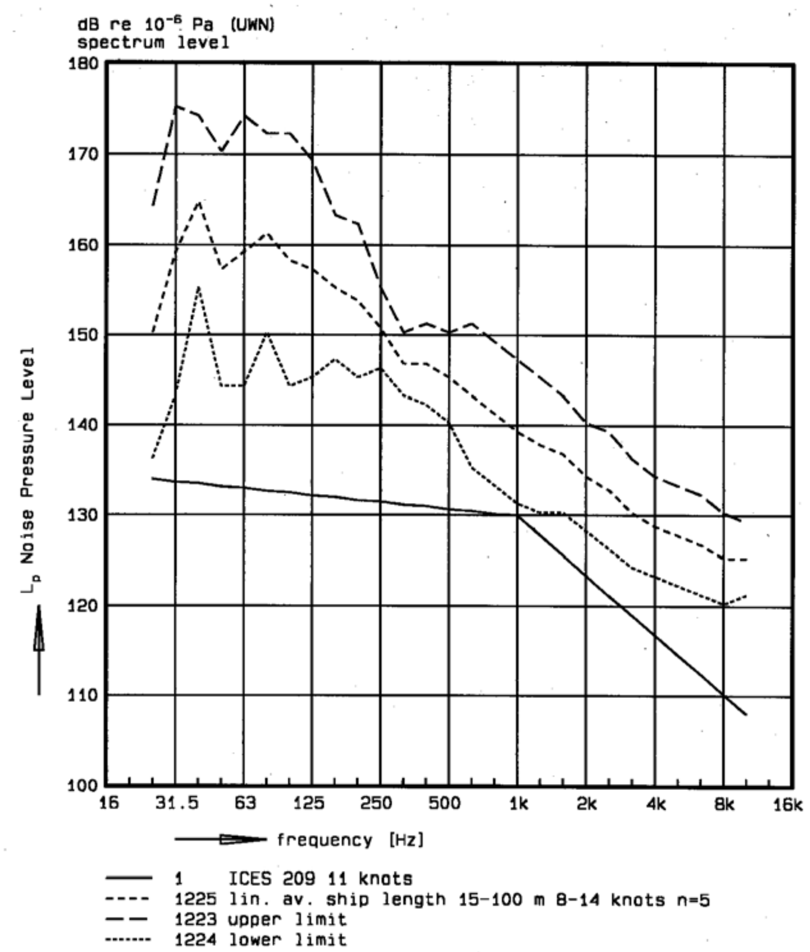

Figure 17: The underwater noise produced by ferries, based on the noise recorded for 5 ferries of a length ranging from 15 to 100 m, travelling between 8 and 14 knots. Band width was 1 Hz. The different graphs show upper and lower limits and the linear average (source: W.C. Verboom, TNO TPD, pers. comm.).

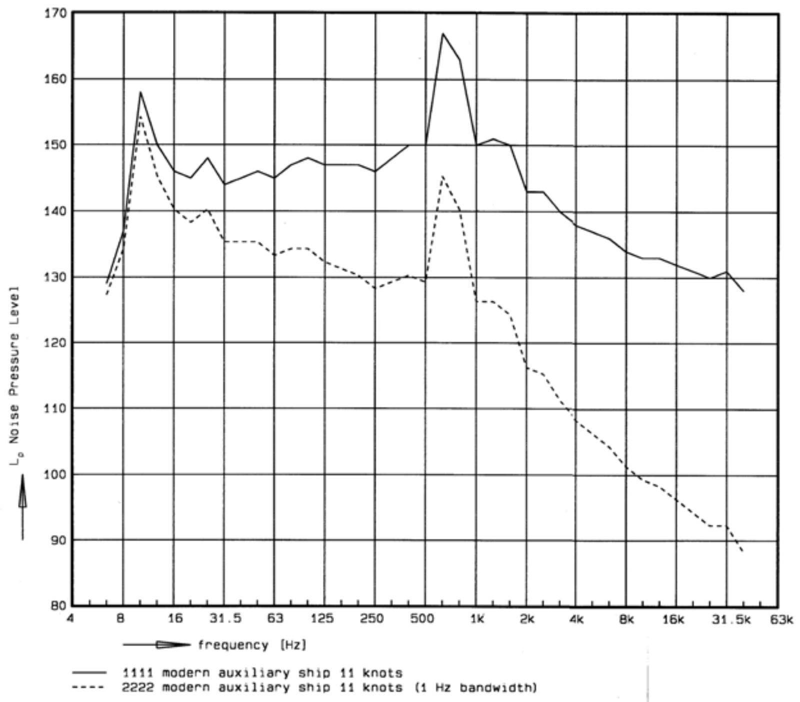

Figure 18: Underwater noise produced by a modern auxiliary ship travelling at 11 knots. Both graphs represent different bandwidths (source: W.C. Verboom, TNO TPD, pers. comm.).

13.2. TABLES

Species	Strandings	Sightings	Ref.
Northern right whale *Eubalaena glacialis*	In 1178, 1 animal found near Oostenende and in 175, 1 animal near Blankenberge.	x	1
Minke whale *Balaenoptera acutorostrata*	26 Strandings are reported, of which 8 animals stranded between 1970-2003.	In the period 1970-2003, 122 minke whales were seen.	2 - 11, 14
Sei whale *Balaenoptera borealis*	Three strandings are known, of which the most recent in 1986.	x	3, 8, 13, 14
Blue fin whale *Balaenoptera musculus*	In September 1840, a female was found stranded.	x	14
Fin whale *Balaenoptera physalus*	23 strandings are reported, of which two in the second half of the 20th century.	In 1970-2003, 4 sightings were made, of which one in 1998 near IJmuiden.	13 - 16
Beluga or white whale *Delphinapterus leucas*	x	In 1711, a specimen was caught near Grembergen. 4 sightings were made between 1970-2003	1, 13
Short-beaked common dolphin *Delphinus delphis*	Between 1925 and 1960, the common dolphin frequently stranded on the Dutch coast. Peak years were 1940-1950. After the 1960s the animal almost disappeared.	Between 1970 and 2003, 94 common dolphins were seen.	8 - 13
Long-finned pilot whale *Globicephala melas*	Two mass strandings are known (1825 and 1956). In other years, single animals washed ashore. Most recently in 2003.	In 1970-2003, 227 pilot whales were sighted.	1, 4, 11, 13, 14
Risso's dolphin *Grampus griseus*	Four strandings are known. The most recent dates back to 1970.	For the period 1970-2003, three sightings are documented.	1, 2, 3, 13
Northern bottlenose whale *Hyperoodon ampullatus*	For the period 1584-1958, 17 strandings occurred. Afterwards, one stranding in 1984 and two in 1993 are known.	two sightings were done in the period 1970-2003.	3, 8, 11, 13
Pygmy sperm whale *Kogia breviceps*	On November the 13th 1925 a female stranded near Noordwijk aan Zee	x	14
White-sided dolphin *Lagenorhynchus acutus*	Since about 1965 occasional white-sided dolphin strands on the Dutch coast. The total number of animals stranded between 1965 and 2004 is 9.	A large mixed herd of white-sided and white-beaked dolphins was seen in the Dutch sector in 1987, which is unusual. Sightings since 1970 count 275 animals.	8 - 13, 17
White-beaked dolphin *Lagenorhynchus albirostris*	Since the 1960s, strandings of white-beaked dolphins increase. The last decade however a decline may have set in.	The white-beaked dolphin is the second most frequently sighted species (2258 in the period 1970-2003), but probably only since the 1960s or later.	8 - 13
Humpback whale *Megaptera novaeangliae*	On September the 29th and on December the 20th 2003, death humpback whales washed ashore. No other records exist.	December 18th 2003: A female and her calf were seen. In January 2004, a single humpback whale was seen.	13, 14, 16
Sowerby's beaked whale *Mesoplodon bidens*	From 1896 onwards 13 animals stranded on the Dutch coast.	x	14
Gray beaked whale *Mesoplodon grayi*	In 1927, a specimen stranded on the Dutch coast.	x	14
Killer whale *Orcinus orca*	26 orcas stranded on the Dutch coast.	x	1
Harbour porpoise *Phocoena phocoena*	It is thought that the harbour porpoise used to be very common, but a decline in strandings was noticed in the 1940s. In the 1960s a decrease was evident. Since the 1980s, porpoise strandings increased.	Coastal (since 1972), shipboard (since 1987) and aerial surveys (since 1984) all show an increase in sightings. The were most frequently seen over the period 1970-2003.	13, 18 - 22
Sperm whale *Physeter macrocephalus*	Few strandings occurred until the beginning of the 20th century. High numbers of sperm whales stranded in 1577, 1723, 1761/62, 1993, 1994/95, 1997, 2000 and 2003.	In 1970-2003 18 whales were seen. 10 of these were seen together in 1993.	13, 14, 23, 24
False killer whale *Pseudorca crassidens*	In 1935, two false killer whales stranded near Ijmuiden.	For 29 records (Marine Mammal Database) there is doubt between *Globicephala* and *Pseudorca*. No definate *Pseudorca* is recorded.	13, 14
Striped dolphin *Stenella coeruleoalba*	In 1967, 1987, 1993, 1996, 1997, and 1999 one animal was found stranded.	x	2, 11, 14
Rough-toothed dolphin *Steno bredanensis*	x	In 1825, a specimen was caught in the Scheldt estuary.	1
Bottlenose dolphin *Tursiops truncatus*	Before 1920, 22 strandings. In 1920-1950, 195 strandings occurred, in 1951-1975, 135 and in 1975-present, 14.	For the period 1970-2003 the Marine Mammal Database documented 44 sightings.	13, 25
Cuvier's beaked whale *Ziphius cavirostris*	One stranding is known: 1914.	x	26

Table 1: Overview of all cetacean species reported in the Dutch part of the North Sea and/or reported stranded on the Dutch coast. Each row in the table provides information on strandings and sightings of a certain species. When no information on strandings or sightings was found for the species, a 'x' was entered.

References:

2. De Smet, 1974
3. Husson & Van Bree, 1972
4. Van Bree & Husson, 1974
5. Husson & Van Bree, 1976
6. Van Bree & Smeenk, 1978
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12. Smeenk, 2003
13. Bakker & Smeenk, 1987
14. Marine Mammal Database, 2004
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19. Addink & Smeenk, 1999
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22. Witte *et al.*, 1998
23. Reijnders *et al.*, 1996
24. Smeenk & Addink1993
25. Smeenk, 1997
26. Kompanje, 2001
27. Waerenbeek *et al.*, 1997

Country	**Main prey species**	**References**
Spain (Galicia)	blue whiting *Micromesistius poutassou*	Santos Vázquez, 1998
	hake *Merluccius merluccius*	
Scotland	haddock *Gadus aeglefinus*	Santos Vázquez, 1998
	saithe *Pollachius virens*	
Netherlands	whiting *Gadus merlangus*	Verwey, 1975
	haddock *Gadus aeglefinus*	
	cod *Gadus morrhua*	

Table 2: Main prey species of the bottlenose dolphin as reported for several European countries

Characteristics	***Range***	***Reference***
Sea Surface Temperature (°C)	1.1-31.1, mode and mean around 20 (in- & offshore, USA); preference >10 (inshore, UK)	Kenney, 1990; Bristow and Rees, 2001
Water depth (m)	offshore: no specific limits; inshore: preferably shallow water (<30 m; UK, Argentin, southern Africa)	Kenney, 1990; Würsig and Würsig, 1979; De Boer and Simmonds, 2003
Distance to coast (km)	0.72 - 6.02 km (autumn); up to 23km (winter)	De Boer and Simmonds, 2003; De Boer pers. comm

Table 3: Abiotic factors which influence the occurrence of the bottlenose dolphin

Parameter	***Country***	***Findings***	***Reference***
Longevity	Northeast Florida	25 years	Sergeant *et al.*, 1973
	Southern Africa	>40 years	Cockcroft & Ross, 1989
Age of sexual maturity	Northeast Florida	12 years (f),13 years(m)	Sergeant *et al.*, 1973
	Central Atlantic coast of the USA	10.64 years (f)	Mead and Potter , 1990
	Southern Africa	9-11 years (f), 8-9 years (m)	Cockcroft & Ross, 1990
Length of sexual maturity	Northeast Florida	220-235 cm (f), 245-260 cm (m)	Sergeant *et al.*, 1973
	Central Atlantic coast of the USA	233.5 cm (f)	Mead and Potter, 1990

Birth season	Central Atlantic coast of the USA	prolonged calving season with a peak in March	Mead and Potter, 1990
	Southern Africa	seasonaly diffuse, but peak in summer	Cockcroft & Ross, 1990
Birth interval	Southern Africa	3 years	Cockcroft & Ross, 1990
Lactation period	general	several years, but from about 4-11 months also solid food	Wells & Scott, 1999
	Southern Africa	18 months to 2 years	Cockcroft & Ross, 1990

Table 4: Population parameters as found for several (worldwide) populations of bottlenose dolphins

Country	**Main prey species**	**References**
UK	gadid family *Gadidae*	Martin, 1995
German Baltic Sea	gobies *Gobiidae*	Benke *et al.*, 1998
German North Sea	sandeel *Ammodytidae*	Benke *et al.*, 1998
	common sole *Solea solea*	
West Greenland	capelin *Mallotus villosus*	Lockyer *et al.*, 2003
Norway	capelin *Mallotus villosus*	Aarefjord *et al.*, 1995
Iceland	capelin *Mallotus villosus*	Víkingsson *et al.*, 2003
Netherlands	whiting *Gadus merlangus*	Santos Vázquez, 1998
	gobies *Gobiidae*	

Table 5: Main prey species of the harbour porpoise as reported for several European countries

Parameter	***Country***	***Findings***	***Reference***
Longevity	Iceland	20 years, but 90% <6 years	Ólafdóttir *et al.*, 2002
	Germany	18 years	Benke *et al.*, 1998
	UK	24 years	Lockyer, 1995
Age of sexual maturity	Germany	4 years (f)	Benke *et al.*, 1998
	Denmark	3.64 years (f), 2.93 years (m)	Sørensen & Kinze, 1994
	Netherlands	4.48 years (f)	Addink, pers. comm.
Length of sexual maturity	Netherlands	149 cm	Addink and Smeenk, 1999
Birth season	The Netherlands	May to August, peak in July	Addink *et al.*, 1995
	UK	peak in June	Lockyer, 1995
	Denmark	peak in June	Sørensen & Kinze, 1994
	Germany	May and June	Benke *et al.*, 1998
Birth interval	general	1-2 years	Lockyer, 2003
Lactation period	general	probably at least 8 months	Lockyer, 2003

Table 6: Population parameters reported for European harbour porpoise populations

Country	Main prey species	References
Germany	cod *Gadus morrhua*	Lick *et al.*, 1995
Denmark	cod *Gadus morrhua*	Kinze *et al.*, 1997
	whiting *Gadus merlangus*	
	hake *Merluccius merluccius*	
Scotland	herring *Clupea harengus*	Evans, 1980; Camphuysen *et al.*, 1995
Netherlands	cod *Gadus morrhua*	Smeenk and Gaemers, 1987
	whiting *Gadus merlangus*	

Table 7: Main prey species of the white-beaked as reported for several European countries

Parameter	***Country***	***Findings***	***Reference***
Longevity	Newfoundland	16 years (f), 13 years (m)	Hai *et al.*, 1996
	Germany	27 years	Sonntag *et al.*, 1997
Age of sexual maturity	?	?	?
Length of sexual maturity	The Netherlands	240-246 cm (f), 250.5-257 cm (m)	Kinze *et al.*, 1997
	Germany	241-? cm (f)	Kinze *et al.*, 1997
	Denmark	242-245 cm (f)	Kinze *et al.*, 1997
Birth season	UK	July-September	Harmer, 1927; Fraser, 1934, 1946, 1953, 1974; Sheldrick *et al*, 1994; Kinze *et al.*, 1997
	Southern North Sea	summer	Kinze *et al.*, 1997
Birth interval	?	?	?
Lactation period	?	?	?

Table 8: Population parameters as found for several worldwide populations of white-beaked dolphins

Species	***Frequencies used for echolocation***
Bottlenose dolphin	50-130 kHz
Harbour porpoise juveniles/adults	Energy peak around 145 kHz / 120-150 kHz
White-beaked dolphin	Up to 325 kHz

Table 9: Frequencies of echolocation signals for three odontocete species (Au, 1993; Goodson *et al*., ?; Kamminga & Wiersma, 1981; Mitson, 1990)

	By-catch	**Pollution**	**Prey depletion**	**Noise**	**Climate change**	**Boat collisions**
Bottlenose dolphin	?	x	x			
Harbour porpoise	?	x	x			
White-beaked dolphin						

Table 10: An overview of suggested human induced causes for trends of the bottlenose dolphin, harbour porpoise, and white-beaked dolphin in the Dutch part of the North Sea. A question mark is presented when a threat was found to be suggested but was not supported by any trends in human activities.

Impact	Type of Damage Possible
Physical *Non Auditory* *Auditory*	- damage to body tissue - induction of the 'bends' - gross damage to ears - permanent hearing threshold shift - temporary hearing threshold shift
Perceptual	- masking of communication with conspecifics - masking of other biologically important noises - interference with ability to acoustically interpret environment - adaptive shifting of vocalisation
Behavioural	- interruption of normal behaviour - behaviour modified (less effective/efficient) - displacement from area (short or long term)
Chronic/Stress	- decreased viability of individual - increased vulnerability to disease - increased potential from impacts from negative cumulative effects - sensitisation to noise – exacerbating other effects - habituation to noise – causing animals to remain near noise source – although damaging
Indirect Effects	- reduced availability of prey.

Table 11: Categorisation of possible impacts of noise on marine mammals (adapted from Simmonds & Dolman, 1999)

13.3. FINDINGS ON THE COMMON DOLPHIN

Distribution and habitat

The common dolphin occurs in the warm-temperate and tropical waters throughout the world. There are currently three species described, of which the short-beaked or offshore common dolphin *Delphinus delphis* occurs in the temperate North Atlantic (see Reid *et al.*, 2003).

In European waters this species is mainly found south of around 60^{o} N. In Atlantic waters, it is found in continental shelf waters, notably in the Celtic Sea and Western Approaches to the Channel and off southern and western Ireland.

Encounters in the North Sea are not frequently and occur mainly in summer (Reid *et al.*, 2003). Evans *et al.* (2003) reported that in some years common dolphins occurred further north and east into the northern North Sea. However, it is generally rare in the central and southern UK North Sea waters and also in the eastern portion of the English Channel.

Trends in the Dutch part of the North Sea

Stranding data from Bakker and Smeenk (1987) and Smeenk (1989; 1992; 1995; 2003) are combined in figure 4. No records of stranded common dolphins are known for the Dutch part of the North Sea before 1925. After 1925, the species entered the area in some numbers. Peak years were 1940-50. Because the stranded animals were not accessible during the Second World War (1940-1945), many *Delphinus* strandings were unreported and the actual number of strandings is therefore probably even higher.

During the 1940-50 period, highest numbers of stranded common dolphins occurred during summer.

In the period 1950-1960, a decline can be seen in strandings and between 1960 and 1997 only six more strandings have been reported.

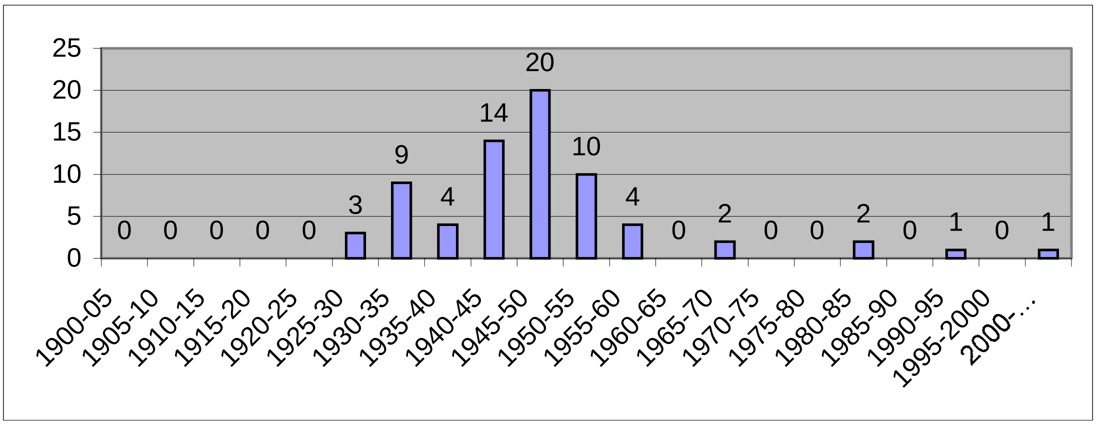


Figure 1: Common dolphins *Delphinus delphis* stranded on the Dutch coast during the period 1900-1997 (Bakker and Smeenk, 1987; Smeenk, 1989; 1992; 1995; 2003; archief Naturalis)

Possible causes for trends

The diet of common dolphins comprises a large range of small fish and squid. Stomach content analyses are few, but from those published it can be concluded that the common dolphin feeds on mackerel, sprat, pilchard, anchovy, scad,herring, hake, blue whiting, *Trisopterus* spp. and cephalopods. (see Reid *et al.*, 2003; Santos Vázquez, 1998) A shift in prey species occurrence possibly affected the distribution of common dolphins (Bakker & Smeek, 1990).

Cushing (1982) discussed a northward movement of animals between the 1920s and 1940s, which he related to a period of warming in the Channel and North Sea between 1925 and 1935. These changes in temperature and ecosystems reversed between 1965 and 1979. Among the five prominent components of this cycle, called the Russell cycle, Cushing (1982) mentioned the appearance and disappearance of a pilchard population, one of the prey species of the common dolphin.

Bakker and Smeenk (1990) and Evans (1990) indeed related the Russell cycle to the temporal occurrence of the common dolphin in the Dutch part of the North Sea. Caldwell and Caldwell (1978) reported a similar situation for the western Atlantic, where common dolphins were once common along the north-eastern coast of Florida. The species disappeared from these waters since 1960, probably as the result of natural fluctuation associated with oceanographic changes. Bearzi *et al.* (2003) however stressed that such fluctuations affect dolphin distribution and /or abundance indirectly, primarily by influencing the distribution of their prey.

It is not clear whether the Russell cycle indeed is a cycle or a once-only phenomenon (Lindeboom, pers. comm.). It can therefore not be predicted if and when common dolphins will return to the Dutch part of the North Sea.

The seasonal distribution of common dolphins, with most strandings occurring in summer during 1940-1950, may be related directly to water temperature (Bakker & Smeenk, 1990). The species lower temperature limits appear to lie between 10^{o} and 14^{o}C (see Bakker & Smeenk, 1990). The average surface temperatures in the southern North Sea range between 5 ^{o}C in winter and 16 ^{o}C in summer.

13.4. FINDINGS ON THE MINKE WHALE

Distribution and habitat

The minke whale is mentioned as one of the five indigenous species of the North Sea (North Sea foundation). Hammond *et al.* (1995) reported on sightings of minke whales concentrated in the north-western North Sea (north of 55 degrees North and west of 2 degrees East). The estimated number for minke whales was 8,445 (CV=0.24; 95% CI 5,000-13,500; Hammond et al., 2002).

Northridge *et al.* (1995) reported on minke whale distribution around the UK and Ireland. Minke whales were mainly recorded off north-east England and off the Hebrides. More recently, minke whales were reported in the northern North Sea and central North Sea as far south as Yorkshire (UK), but it is rare in the southernmost North Sea and eastern half of the English Channel. Scattered sightings were also reported off northern Ireland, in the Irish Sea, and in the central and eastern North Sea. In general, coastal waters seemed preferred (see Northridge *et al.,* 1995). Reid *et al.* (2003) confirmed these observations.

Several minke whales have stranded on the Dutch, Belgian, German and Danish coast, probably entering the North Sea from the north. Most of these animals stranded in autumn (see Van Waerenbeek *et al.*, ?).

Minke whales in Dutch waters?

Minke whale strandings on the Dutch coast are scarce. Between 1970 and 1997, only four records of stranded minke whales were reported (Husson & Van Bree, 1972; 1976; Van Bree & Husson, 1974;Van Bree & Smeenk, 1978; 1982; Smeenk, 1986; 1989; 1992; 1995; 2003). This suggests the absence of a minke whale population in the Dutch waters and/or populations living further offshore.

If there is indeed a minke whale population further offshore, the few strandings can be explained as follows. Dead minke whales have to be transported by sea currents from relatively far to the coast and the majority of the animals probably sink before they could ever reach the coast. Sightings from ships and planes however should in the case of an offshore population report on minke whales in Dutch waters. The Marine Mammal Database does so, but the number of documented minke whales is relatively low. Over the period 1970-2003 only 122 animals are seen.

The few sightings reported in the Marine Mammal database support the observations made by Northridge *et al.* (1995). In 2003, for example, only five animals were seen, two of which were seen swimming off east England, and the other three were seen at or near the Dogger Bank.

It can be concluded that there are no indications for the existence of minke whale populations in the Dutch part of the North Sea. Populations are either found further south or further north in the central and eastern North Sea and off north-east England. This is further supported by stranding records from The Natural History Museum in London (figure 2) and Reid *et al.* (2003; figure 3).

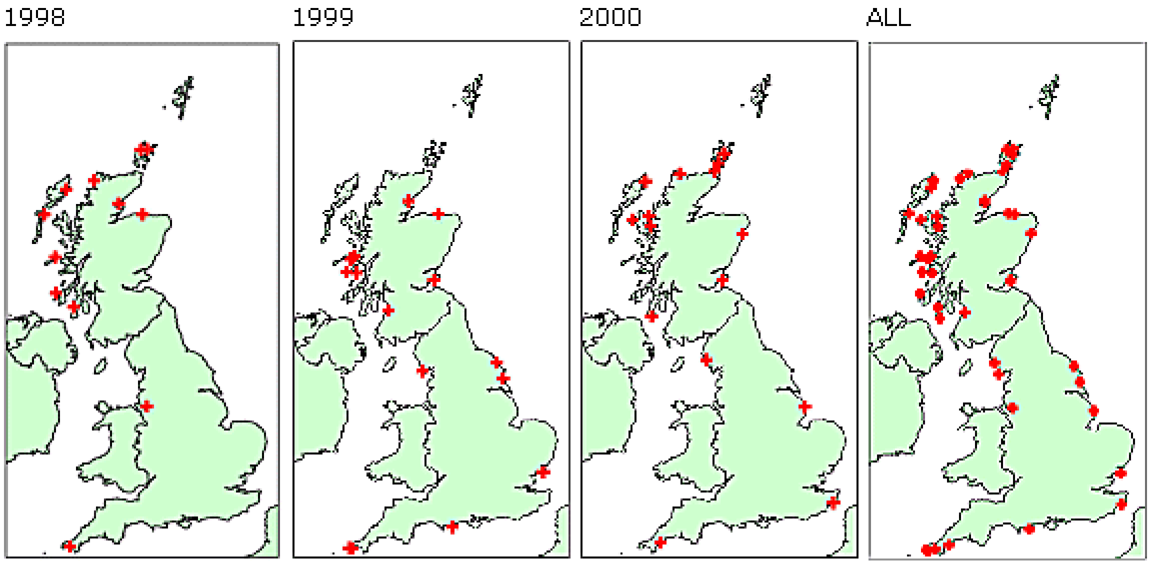


Figure 2: Stranding records of the minke whale *Balaenoptera acutorostrata* on the British coast in 1998, 1999 and 2000 (The Natural History Museum, London)

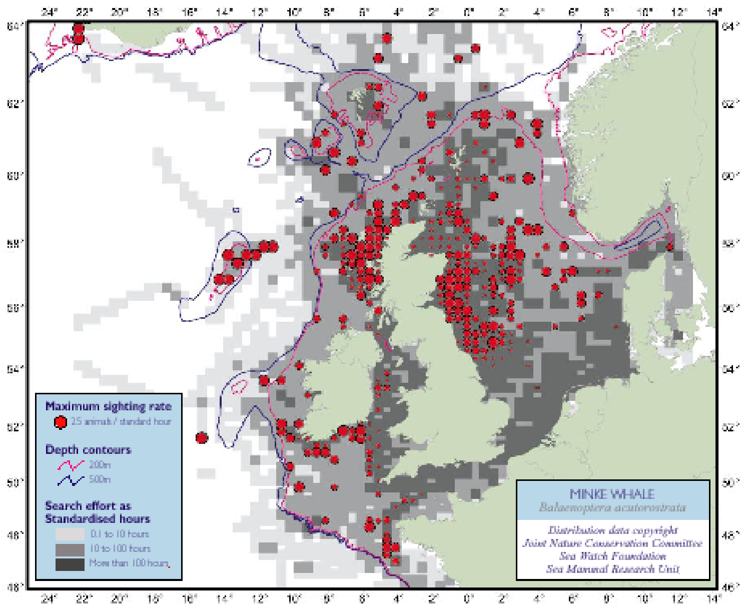


Figure 3: Occurence of the minke whale *Balaenoptera acutorostrata* in north-west European waters (Reid *et al*., 2003). The grey squares on the map indicate observer effort in standardised hours, varying from 0 hours (white) to more than 100 hours (dark grey). The red dots show the sighting rate.

13.5. POLICY INSTRUMENTS TO REDUCE HUMAN IMPACTS ON CETACEANS

Mitigation measures for by-catch, pollution, overfishing, noise, climate change and boat collissions are discussed separately here.

By-catch mitigation

Several mitigation measures to reduce cetacean by-catch have been suggested by scientists and action groups. Some of these measures, for example the introduction of pingers in the Danish cod wreck fisheries (see Vinther & Larsen, 2002), have already been implicated in other countries and have proved successful, others have not. Below an overview of these measures is given. A more thourough description of most of the measures can be found in Ross and Isaac (2004).

Pingers

Pingers, or acoustic deterrent devices, can be used to make cetaceans better aware of the presence of fishing gear and may thus prevent their entanglement. This method has proved effective in reducing gillnet by-catch of porpoises in Denmark (see Vinther & Larsen, 2002), but it's effectiveness in many other fisheries as well as for other cetacean species has not yet been proved. Furthermore, pingers may not only have positive effects. The emitted noise may actually have long term effects in cetacean populations.

Exclusion devices

By-catch of cetaceans and some other unwanted species such as turtles may be prevented when nets are equiped with excluding devices, also known as selection grids. The grid leads larger animals out of the nets, whereas the smaller ones are maintained in the net and yield of the fishery is not negatively affected.

Net modification/alternative gear use

Nets can be made more visible for cetaceans by adjusting the material, colour or mesh-size. These changes may diminish capture of cetaceans, but may also reduce catches of the target species.

Reduction of fishing effort

A reduction of fishing effort reduces the chance of cetaceans encountering fishing nets and getting entangled. Most efficient will probably be the reduction of those fishing methods causing most by-catch. However, fishermen will probably not easily agree with these restrictions.

Time and area restrictions

Many cetacean species show seasonal migration and are thus not year-round present in a certain area. In areas where cetaceans do occur restrictions may be needed. Especially in the period and area of giving birth.

Storage of discard

It is not sure if cetaceans feed on discarded fish and consequently get entangled in nets, but if this is the case, discards may be stored on board in order to prevent cetacean by-catch.

Mitigation of pollution

Adequate mitigation measures may diminish the influence of pollution on cetaceans, but it is difficult to formulate adequate policy in a matter being as broad as pollution is. An option to overcome this problem is to appoint the major polluting chemicals as priority. However, harbour porpoises and white-beaked dolphins occurring near the Dutch coast are clearly not resident to a certain area, but show migratory behaviour. As they do so, the animals are exposed to different pollutants and different concentration in different areas and periods. It is therefore difficult, if not impossible, to indicate main sources of pollution which may affect these animals. Furthermore, their prey species, through which they ingest a substantial part of the pollutants, may also show migratory behaviour, thus carrying a contaminant burden that may vary highly between areas and seasons.

Possible options for the mitigation of pollution of the marine environment are:

- Tighter rules for discharge at sea by offshore industry, shipping, and fisheries;
- Increased control on the observance of rules;
- Better facilitation of delivery of waste in harbours;
- Introduction of alternative, less harmful, chemicals to replace chemicals of concern;

- Phasing out of concerning chemicals, as is for example done for PCBs;
- More extended research on the effect of a chemical before it is introduced in the marine environment;
- More extensive monitoring of sea life in order to shorten response time.

Mitigationof noise pollution

Military exercises

More information is needed about military exercises and it may be interesting to discuss the environmental risk assessment report, if this exists, for these activities in the Netherlands. The following points should be reviewed:

- is the exercise area chosen at a place where effect on the environment are reduced to a minimum?;
- are the periods in which exercises are done chosen at a time in which effects on the environment are reduced to a minimum?;
- is the number of exercises reduced to a minimum?

Seismic surveys

The following recommendations form the basis behind guidelines established by JNCC in consultation with a wide variety of interested parties:

- Seismic surveys could be confined to those seasons where cetaceans are known to be at low abundance in the area;
- Airgun detonation might only be undertaken once the survey area had been searched for cetaceans and none detected;
- Power from seismic equipment may be built up slowly (e.g. by starting with the smallest airgun in the array and gradually adding in others over a period of 20-30 mins);
- Sound levels are kept to the lowest practicable level (JNCC, 1998).

These recommendations may be of interest for mitigation of seismic exploration in the Netherlands.

Vessel noise

Restricting boat traffic to certain areas and/or certain period may minimize any adverse effects of vessel noise on cetaceans.

Drilling noise

At the moment, drilling activities are no cause for concern considering the noise they produce.

Acoustic harassment devices (AHDs)

Pingers will be mandatory in 2005, but the type of pingers that should be used is not clear. More research is needed about this aspect and the government should, when possible, enact a law about pinger types that should be or should not be used.

Wind farms

Further research is needed considering the impact of wind farms on cetaceans, because very little is known about these impacts and suggestions range from positive to negative impacts. Some suggestions for the management are:

- Introduction of the obligation to monitor cetacean occurrence near the wind farms, starting at least more than one year before the construction of the farm. The effects of the wind farms on cetaceans may in this way become better known;
- Taking precaution: wind farms should be constructed in areas where no or only few cetaceans occur. These areas are probably also of little importance to the cetaceans for feeding and reproduction. The development of an offshore wind farm there minimizes the effect on cetaceans;
- More research is needed about the underwater noise operational wind turbines produce and about measures to reduce these noise levels;
- Potential effects of the construction of a wind farm should be mapped and measures should be taken to reduce these impacts (*e.g.* construction should be restricted to a period in which cetaceans are largely absent from the area).

Mitigationof overfishing

Mitigation measures used nowadays to diminish the impact of fisheries are

- the setting of the Total Allowable Catch (TAC);
- technical measures (such as minimum mesh size, minimum landing size);
- fleet reduction programmes; and
- effort restrictions (OSPAR, 2003).

Mitigation of climate change

Projects to reduce greenhouse gasses and their effects may be:

- Forest protection, reforestation and forest expansion. As forests function as a sink for carbon dioxide, reforestation and forest expansion may contribute to reduction of atmosferic carbon dioxide. Forest protection is a precautionary measure.
- Shifting from fossil fuel energy to ‘clean’ energy such as wind or solar energy, thus reducing carbondioxide emission;
- Changing consumer patterns. A general decrease in energy use will also decrease carondioxide emissions.

These measures will however only be effective if globally levels of greenhouse gasses are reduced.

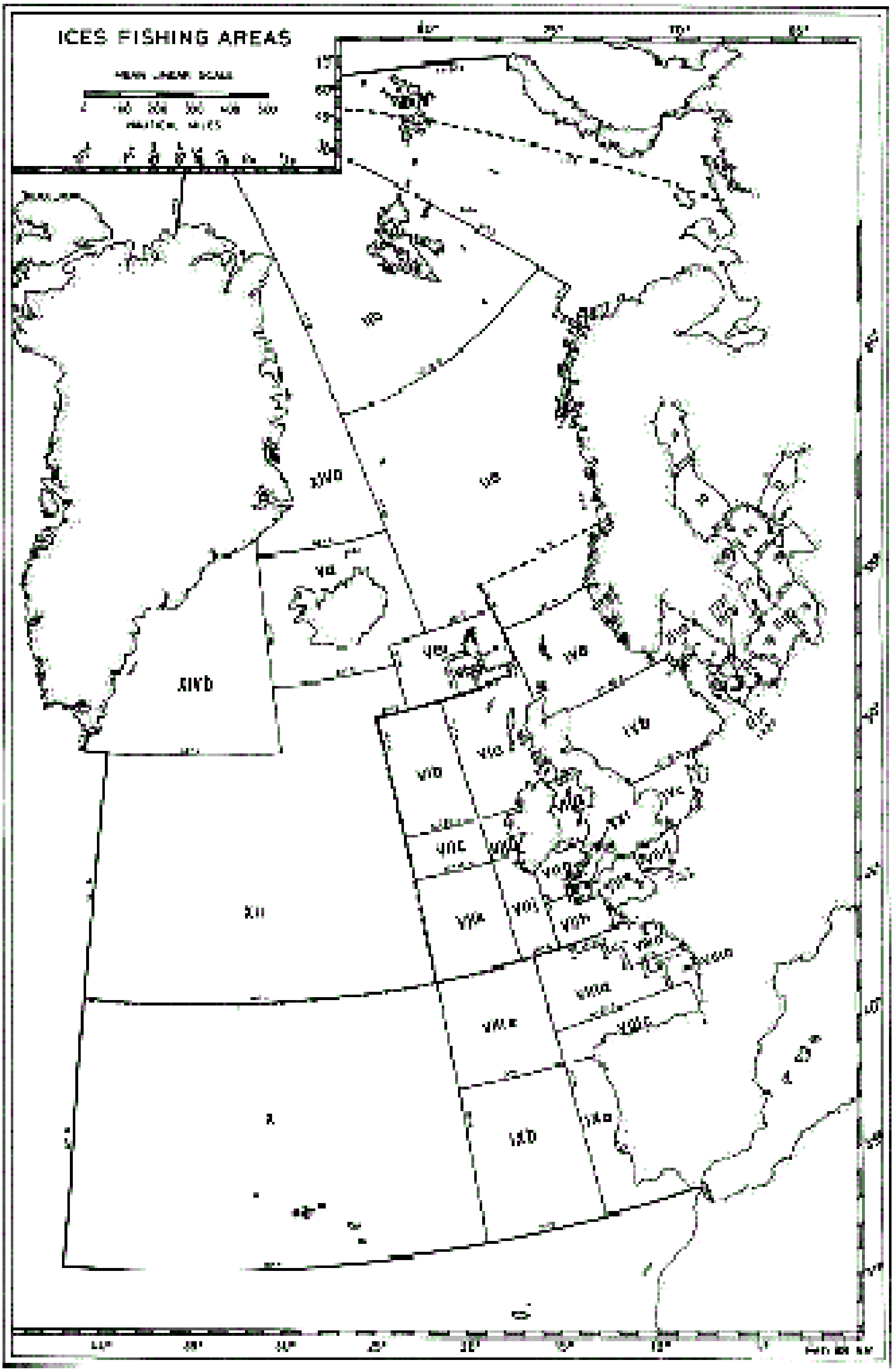
Mitigationof boat collisions

If necessary, boat collisions may be minimized or avoided by restricting recreational vessels to an area where no or little cetaceans are present. This may be combined with seasonal restrictions. To end with, maximum speed limits may be introduced in order to give cetaceans the chance to avoid approaching vessels.

13.6. Scientific names

Scientific name	Common name: English	Comon name: Dutch
Cetaceans		
Eubalaena glacialis	Northern right whale	Noordkaper
Balaenoptera acutorostrata	Minke whale	Dwergvinvis
Balaenoptera borealis	Sei whale	Noorse vinvis
Balaenoptera musculus	Blue fin whale	Blauwe vinvis
Balaenoptera physalus	Fin whale	Gewone vinvis
Delphinapterus leucas	Beluga or white whale	Beluga
Delphinus delphis	Short-beaked common dolphin	Gewone dolfijn
Globicephala melas	Long-finned pilot whale	Griend
Grampus griseus	Risso's dolphin	Gramper of grijze dolfijn
Hyperoodon ampullatus	Northern bottlenose whale	Butskop
Kogia breviceps	Pygmy sperm whale	Dwergpotvis
Lagenorhynchus acutus	White-sided dolphin	Witflankdolfijn
Lagenorhynchus albirostris	White-beaked dolphin	Witsnuitdolfijn
Megaptera novaeangliae	Humpback whale	Bultrug
Mesoplodon bidens	Sowerby's beaked whale	Spitssnuitdolfijn
Mesoplodon grayi	Gray beaked whale	Gray-spitssnuitdolfijn
Orcinus orca	Killer whale	Orca
Phocoena phocoena	Harbour porpoise	Bruinvis
Physeter macrocephalus	Sperm whale	Potvis
Pseudorca crassidens	False killer whale	Zwaardwalvis
Stenella coeruleoalba	Striped dolphin	Gestreepte dolfijn
Steno bredanensis	Rough-toothed dolphin	Snaveldolfijn
Tursiops truncatus	Bottlenose dolphin	Tuimelaar
Ziphius cavirostris	Cuvier's beaked whale	Dolfijn van Cuvier
Fish		
Ammodytidae	Sandeel	Zandspiering
Clupea harengus	Herring	Haring
Dicentrarchus labrax	Sea bass	Zeebaars
Engroulis encrassicolus	Anchovy	Ansjovis
Gadiculus argenteus ssp. Thori	Silvery pout	Zilverwijting
Gadus aeglefinus	Haddock	Schelvis
Gadus morhua	Cod	Kabeljouw
Gobiidae	Gobies	Grondel
Macroramphosus scolopax	Snipefish	Snipvis
Mallotus villosus	Capelin	Lodde
Merlangius merlangus	Whiting	Wijting
Merluccius merluccius	Hake	Heek
Micromesistius poutassou	Blue whiting	Blauwe wijting
Mugilidae	Mullet	Harder
Pleuronectes platessa	Plaice	Schol
Polachius virens	Saithe	Zwarte koolvis
Psetta maxima	Turbot	Tarbot
Raja batis	Skate	Vleet
Salmo trutta	Trout	Forel
Sardina pilchardus	Pilchard or sardine	Sardien
Scomber scombrus	Mackerel	Makreel
Solea solea	Sole	Tong
Sprattus sprattus	Sprat	Sprot
Trachurus trachurus	Horse mackerel or scad	Horsmakreel
Trisopterus esmarkii	Norway pout	Kever

13.7. ICES AREAS



ICES fishing areas (source: www.ICES.dk, 2004)

13.8. Marine terminology explained