



The presence of the Harbour Porpoise (*Phocoena phocoena*) in the Oosterschelde, The Netherlands

16th of April – 27th of August, 2010

Ingrid van Dan
890223001



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Under surveillance of F. Zanderink, Velp
and B. van Wijk, Leeuwarden

Van Hall Larenstein
Sept. 2010
Ingrid van Dam
890223001

Picture frontpage: Wouter-Jan Strietsma

PREFACE

The final product after a 20 week internship at the organization Rugvin has been successfully completed. With many thanks to Frank Zanderink, the director of the organization, who made it possible for me to work within the organization. Also many thanks to the fishermen, the family Zoeteweyj, Driessen and Van den Hoek, who provided the study of data.

A special thanks to the researchers Okka Jansen and Mardik Leopold for giving specific information about the stomach contents. Also Rijkswaterstaat for their help and hospitality on the M.S Hammen and the organization Stichting Noordzee for giving information about sightings of the Harbour porpoises. Then I also would like to thank my supervisor, Berend van Wijk, to allow me to do this study.

Ingrid

Leeuwarden, 2010

SUMMARY

In the Netherlands the Harbour porpoise is a native species and is known to occur in the Waddensea and the Northsea. But the species also occurs in the Oosterschelde, a former estuary. Not much is known about this population and is therefore interesting to study. This study is mainly focused on the location of the species in the Oosterschelde, and to find out if there is a relationship between certain fish species and the location of the porpoises. During the study, fishermen were asked to fill in forms that were made for this study, also with the help of Rijkswaterstaat, the location of the porpoises were determined. It was obvious that the species prefers the deepest parts of the Oosterschelde. Due to the lack of information about the distribution of pelagic fish species, no relationship could be found between pelagic species and porpoises, but from the demersal species, a distribution map could be made with the highest density and some of the places the sightings of porpoises matched. From another study of O. Jansen and M. Leopold, the data was found of the stomach contents of the porpoises in the Oosterschelde and were compared with the diet of porpoises from the Waddensea and the Northsea and it turned out that the Oosterschelde population has a slightly different diet than the other populations. So are the Black goby, Common goby, European Common squid and the Common Bobtail found in the stomach contents of the Oosterschelde population and were not found in other populations. About 13% of the stomach contents of the juveniles consists of Common gobies. In the end the Oosterschelde population uses the most deepest parts of the Oosterschelde and have a slightly different diet than the other Dutch populations, but more research is needed to understand more about this population.

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1. INTRODUCTION

In the Oosterschelde dozens of Harbour porpoises (*Phocoena phocoena*) are present, but there is not much known about these mammals living in the Oosterschelde. Harbour porpoises have been nearly extinct in the Dutch waters after World War II, but the species is making its come back. [Osinga, 2007]

1.1 GOALS AND OBJECTIVES

The main goal of this study is to find out on which fish species the Harbour porpoise feeds on in the Oosterschelde and to find out if there is a relationship between the presence of fish species and the location of sightings of the Harbour porpoises. Another goal of this research is to obtain more knowledge about this specific population .

1.2 RESEARCH QUESTIONS

To reach this goal, a main research question was set up and is stated below.

Research question:

- What is the relationship between the sightings of Harbour porpoise (*Phocoena phocoena*) and the location of certain fish species at the Oosterschelde?

To answer this main question some sub-questions were set up to split the main research question into smaller sub-questions which will lead in the end to the answer of the main research question.

Sub-questions

- What kind of fish species are present at the Oosterschelde?
- Where do Harbour porpoises occur?
- What kind of fish species are found in the stomach contents of the Harbour porpoise? And what is the difference between the Oosterschelde population and other Dutch populations?
- What is the relationship between fish species and the sightings of Harbour porpoises?

The target group for this research are organizations such as WWF who are interested in populations and trends of populations. Also organizations like IMARES and NIOZ might use the data which are collected during the study.

The ranging of the report is as followed. The second chapter of this report is about the study species and chapter three about the study area to give more detailed information about these subjects. In the next chapter, the methods and materials are explained. the results of the study will be given in chapter five. In the sixth chapter the discussion about the research will be given including an error analysis. And finally in the last chapter, chapter seven, the conclusion will be given of this study.

2. THE HARBOUR PORPOISE

2.1 DESCRIPTION

The Harbour porpoise (*Phocoena phocoena*) or common porpoise, can be identified as a short, stocky body with a rounded shape which limits heat loss in cold northern climates.

Adults females can reach a length up to 1.60 meters and adults males 1.45 meters. The mean weight is between 50 to 60 kg. [Bjorge and Tolley, 2009] The Harbour porpoise is listed on the IUCN Red List with a status as least concern, which was re-assessed in 2008. The population trend is currently unknown [IUCN, 2010].

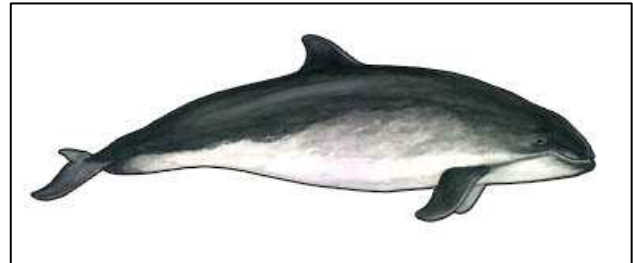


Figure 1 Harbour Porpoise characteristics Source: www.dfo-mpo.gc.ca

The Harbour porpoise is mostly sighted within small groups less than 10 individuals. The swimming motion is usually inconspicuous, which involves surfacing with a rolling motion. The animals occasionally surface with a vigorous vertical motion, causing a splash. The small size of the animals and unobtrusive respiration sequence, makes it quite difficult to spot a Harbour porpoise. Also, the animals are known to be quite shy and avoid boats. [Cetacean Research and Rescue Unit]

The species was hunted until the mid 1940s. This may also caused the decline in the North Sea. The animals were hunted for meat and oil, but nowadays the species is only hunted in the Black Sea and Greenland. Animals are mostly caught as by-catch or drowned in fishing gear [IUCN, 2010].

2.2 DISTRIBUTION

The Harbour porpoise belongs to the originated fauna of The Netherlands [Osinga, 2007] and can be found in the North Atlantic, North Pacific and the Black Sea, at inshore, coastal and shallow waters [ACS, 2010]. Oceans and seas which are native for the Harbour porpoise are the Arctic sea, Atlantic, eastern and central, northeast and northwesterly. The Mediterranean and Black Sea, eastern, central, northwest and northeasterly Pacific. [IUCN, 2010]

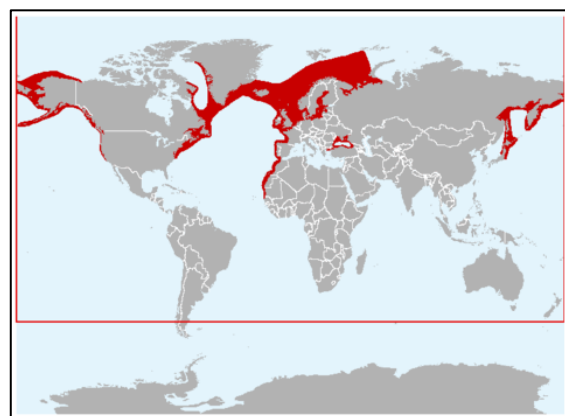


Figure 2 Distribution of the Harbour Porpoise (*Phocoena phocoena*) around the world. Source: IUCN (2010)

2.3 HABITAT

The preference of the species is continental shelf water and enter frequently shallow bays, estuaries and tidal channels which are less than 200 meters in depth. In a population in northern California the porpoises were found in waters less than 60 meters in depth. [IUCN, 2010]

2.4 MAINLY DIET

The diet is a wide variety of fish and cephalopods. The main prey item varies from the location of the population. The species prefers non spiny fish like herring, cod, squid, pollock and sardines. [ACS, 2004] Research by Dewhurst (1834) in the North East Atlantic showed that the Harbour porpoise feeds mainly on small fish species and in 1889 Van Beneden stated that *“the porpoise preys on fish, like herring, but may also feed on crustaceans, cephalopods and even marine plants.”* A study on the population in the Black Sea, which included an examination of 400 stomachs, the study showed that most of the stomachs contained fish species from the benthic system, like goby species, fish species from the pelagic system, like anchovy and mullet, were only eaten when present in large and dense schools [M.B.Santos 2003]. A short overview of the main food preference in different areas: France, Blue Whiting, scad and hake; Denmark, Sweden and Norway, herring and gadoids; The Netherlands, Whiting; and in Poland, Cod, Gobies and Herring. [M.B.Santos 2003].

The porpoise can be seen as an opportunistic feeder. The term “opportunistic” means that the prey availability is the only criteria affecting the diet choice. Some scientists believe that the diversity of eaten prey and the geographical variation found in the diet makes the Harbour porpoise an opportunistic feeder [M.B.Santos 2003].

2.5 THREATS

The species can be found in seas where a lot of fishing occur and therefore the species faces also some threats. A research done in the Baltic has identified some possible threats, such as overfishing of prey species, contaminants such as PCBs and other organochlorine, by-catch at unsustainable levels and noise disturbance [S. Koschinski]. The species might also face the chance of getting entangled in fishing gear [Obis SeaMap].

In the beginning of the twentieth century, the amount of strandings was that low that the amount of individuals that died by by-catch was not significant and important enough. However, with the decrease of hundreds of dead porpoises washing ashore in the beginning of the twenty-first century, the by-catch problems could get serious. It turned out that, not only Harbour porpoises, but also whales and dolphins drowned or suffocated in the nets. The problem became more and more serious. From a time-range between 1970 and 2006 the amount of beached porpoises raised from 17 individuals to 207 each year [M.F. Leopold, 2006].

2.6 HARBOUR PORPOISE IN THE NETHERLANDS

The Harbour porpoise is a species that is native in The Netherlands. It used to be hunted and sold on the market. After world war II the species still was quite common near Harlingen and Delfzijl. But the Harbour porpoise disappeared almost completely from the Dutch waters. From that moment on, different organizations started to register all Harbour porpoises which were found on the beaches.

In recent years, the number of porpoise sightings is increasing in the Dutch waters. [N. Osinga, 2007]

The species was so abundant in the Netherlands, that beached individuals were not recorded and therefore not data was available to notice any trends in the population. But because of the decline of the number of sightings a general consensus was reached and Harbour porpoises were a rarity in the Netherlands. Since 1951 the number of individuals beached or stranded were recorded. In the mid-80s the number of porpoises increased gradually. [Leopold 2006]

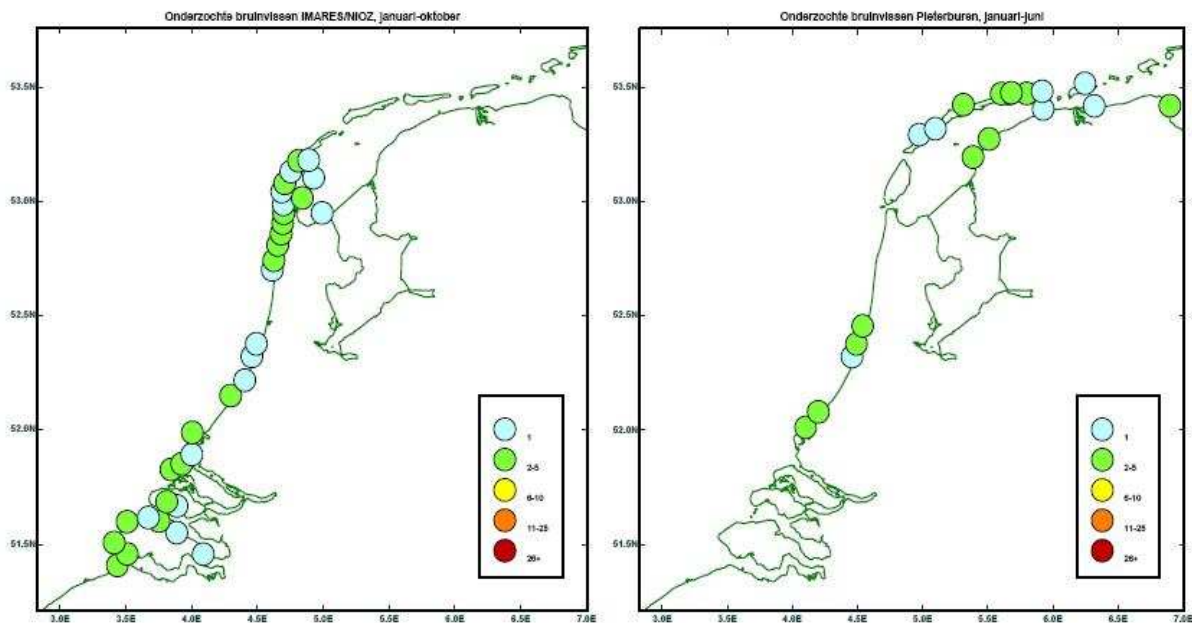


Figure 3 Spatial distribution of the Harbour Porpoise in Dutch waters, done on researched harbour porpoises by IMARES/NIOZ (left) and the individuals that were transported to “Zehondencreche Pieterburen” (M.F. Leopold and C.J. Camphuysen (2006)

3. THE OOSTERSCHELDE

The Oosterschelde can be found in the province Zeeland in The Netherlands and is since 2002 known as a National Park and therefore a protected area [Nationaal Park Oosterschelde, 2010]



Figure 4 The study area during the study on Harbour Porpoises in the Oosterschelde, The Netherlands. Source: www.vlissingen.nl and Meerskant.org

3.1 HISTORY OF THE OOSTERSCHELDE

The Oosterschelde was an estuary, but the flood from 1953 that took the lives of eighteen hundred people, changed the way of the relation between the Dutch people and the sea. To prevent these types of disasters in the future, plans were made to build the Delta works and a Storm Surge Barrier, as seen in figure 5. In 1986 the Oosterschelde Storm Surge Barrier was opened. [Geschiedenis Zeeland, 2010] The barrier has a length of 8 kilometers and the Oosterschelde cannot be called an estuary anymore. [Nationaal Park Oosterschelde]

An estuary is called an estuary when there is a gradually change from fresh- to brackisch -, to salt water. But the Oosterschelde became a permanent salty sea inlet, and therefore, it cannot be called an estuary anymore. [Ecomare, 2010]



Figure 5 The Storm Surge Barrier source ernstroseler.web-log.nl/

3.2 LEGISLATION IN THE NATIONAL PARK

In the National Park there is some legislation to protect the flora and fauna. Some actions require a license before these can be carried out legally. Digging for sea-bait is only permitted with a license for instance.

Watersports are controlled by the Inland Shipping Police Regulations. Between Wemeldinge and Krammersluis it is allowed to sail on high speed. But the difference in the tide can cause some strong currents which can go together with high wave-action.

The Oosterschelde is designated as a integral environmental field and therefore the Provincial Environmental Regulation is operative. This makes it for example prohibited to cause noise disturbance with model ships or -airplanes, audio devices or in any other matter. [Natuur Park Oosterschelde]

3.3 WILDLIFE IN THE NATIONAL PARK

The national park is very important for its wildlife. One of the most famous species that lives in the Oosterschelde is the Gray seal. But the area is also in favour with many birds. Next to the Wadden Islands, the diversity of birds in the area is the highest of the Netherlands.

There are four factors that influence the number of birds. (1) Streaming water with high salinity. (2) Pure and unpolluted water, (3) A quiet and rural environment, (4) Sufficient amount of food.

Next to birds, about 66 different fish species are found in the Oosterschelde. In chapter 5.1 more detailed information is given about the fish species. Species that occur in the Oosterschelde are European Plaice, Common Sole, European Flounder and the European lobster. Some species are only born in the Oosterschelde and will leave the area when old enough such like members of the Pipefish family (*Syngnathinae*) and the Atlantic Herring (*Clupea harengus*).

During the building of the Oosterschelde barrage, different kind of rocks were used, because many organisms prefer different kind of rock. It is known that there are about 42 species of red algae, 34 of brown algae, 30 blue algae and 38 green algae present in the Oosterschelde. [Deltawerken, 2004]

4. METHODS AND METHODOLOGY

4.1 STUDY SPECIES

The study species during this research are the Harbour porpoises present in the Oosterschelde. It is not known how many individuals are present in the Oosterschelde. In chapter 2 more information is given about the species itself.

4.2 STUDY AREA

The study area during this research is the Oosterschelde. It is not known if the Storm surge barrier creates a “sound wall” and prevent the animals to go to the North Sea or that there is a migration going on. But because the species are quite regularly seen in the Oosterschelde it can be said that there is a population in the Oosterschelde.

The Oosterschelde has a total area size of 35076 hectares, of which 30352 hectares is water, which is about 86.8% of the total area that consists of water. [Deltares, 2010]

4.3 DATA SAMPLING

The data is collected from April until the end of August of 2010 by different fishermen and data collected during the Harbour porpoise scan of 22th of May 2010 and during the scan done in late 2009. Also during some trips on the MS *Hammen* and *Frisia* data was collected. The data is collected on two forms, the fish form and Harbour porpoise/Cetecean form. In Appendix 1 and 2 the sheets can be found which were used. On the fish sheet the date and species are filled in. Then the amount of fish species, which is a rough estimate. Then the latitude and longitude to display this on the map. There is also some space for any comments if necessary. On the Harbour porpoise/cetecean form, there is space to fill in the date, time, latitude and longitude, the species, total number of individuals, weather, wind force and wind direction. Also there is some space for any comments if necessary.

4.4 DATA ANALYSIS

The data is analyzed in different ways. So is the stomach contents analyzed with the help of SPSS 15. The data was put into the database and from that the graphs were made. The data that was collected by the fishermen is put into Google Earth. The coordinates were used to locate the individuals on the map. Then a literature study was done to find the species that are present in the Oosterschelde.

4.5 FIELD METHODOLOGY

The data is collected on different ships. With the help of Rijkswaterstaat the Oosterschelde was scanned a few times with the help of the MS *Hammen*. Seen on the picture below.

Because it was not always possible to go on the MS *Hammen*, a passenger boat named *Frisia* was used to scan the Oosterschelde as well. The MS *Hammen* has an overall length of 22 meters and the *Frisia* is 40 meters in length and 8 meters width.

Because the research is also about fish, fishermen were asked to fill in some forms. Which can be found in appendix 1 and 2.

During the surveys the researcher was as high as possible on the boat deck and in front to see everything in front of the boat, so that sightings could be spotted more easily. It made it possible to scan the horizon in front of the boat in the search for Harbour porpoises. During these surveys the height of the waves were an important factor. Because porpoises are easily missed if the waves are too high.

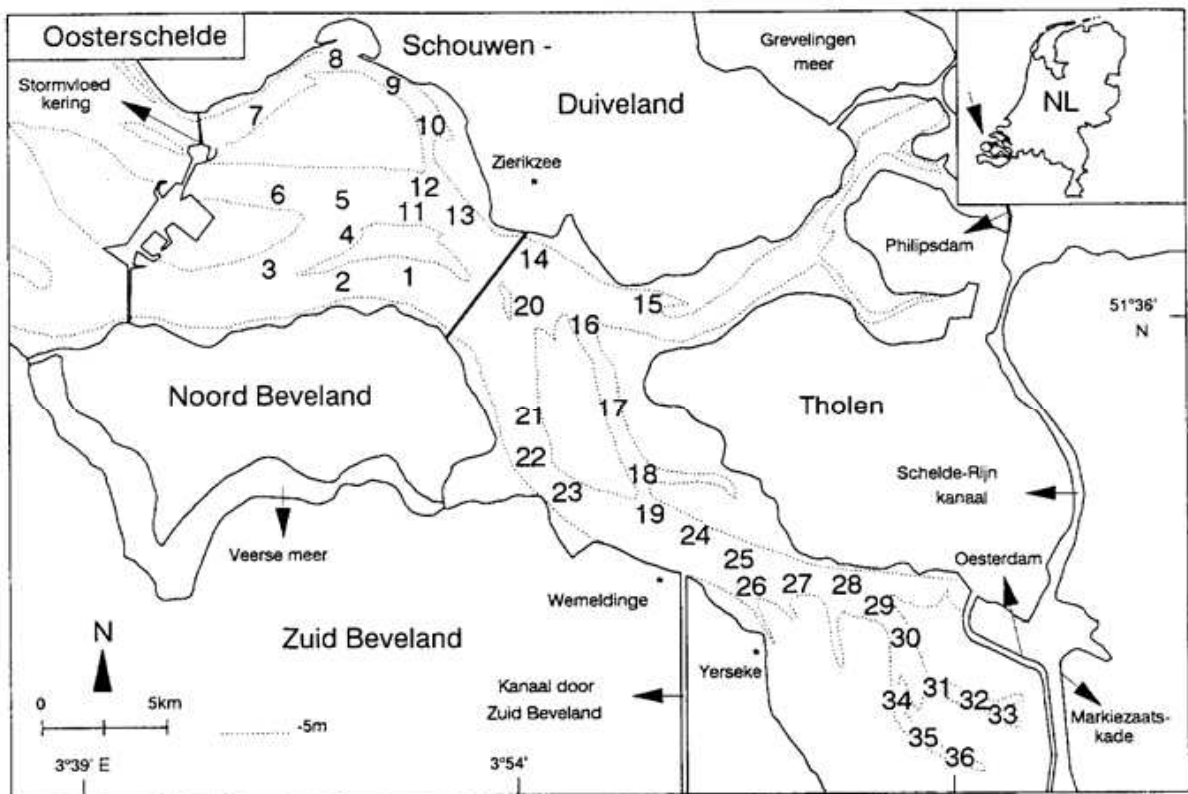


Figure 6 The ships MS *Hammen*, the *Frisia* and a mussel cutter © Ingrid van Dam, *Frisia* cruises and Nederlandse © Mossel.nl

4.6 USED METHODS IN THE PAST

A research done in the years between 1983 and 1990 used 36 locations which were sampled four times a year, this means that in total 28 samples were taken at every location. The fish were counted on board of the ship, some species were determined in the lab for further examination if a species is not known for sure. [H. Maandag, 1999] During the research about 43 different demersal fish species were caught. On the next page a map is shown of the Oosterschelde which was divided into 36 different areas.

To calculate the density, a formula was set up and is also shown on the next page.



The density of the fish species was estimated by using a formula which is mentioned below:

$$\text{Density per } 1000\text{m}^2 = \text{number captured} * 5 \text{ (fishnet efficiency)} * 1000 / [2.70 * [\text{width}]]$$

The information that was gathered by then will be used to give an overview about the species that live in the Oosterschelde. This study was mainly focused on demersal species. Therefore there is a division between demersal and pelagic species. In Appendix 4 all the species that were found in literature and during the study are presented.

On the chart it can be seen that the study divided the Oosterschelde into 36 different sections. This will help also in the study to find a connection between fish species and porpoise sightings.

5. RESULTS

5.1 FISH SPECIES

5.1.1 FISH SPECIES FOUND IN LITERATURE

Earlier research had already found different fish species present in the Oosterschelde. But this research is more focused on species of the demersal system, what will result in less information about the pelagic species.

5.1.1.1 Demersal Fish Species

Demersal species are species that are found at the very bottom of the ocean- or river floor, but can be divided into two groups, the benthic and benthopelagic species.

5.1.1.2 Pelagic fish species

Pelagic fish species are migratory fish that swim in shoals. The fish species can be found to the surface of the water or between two bodies of water. The pelagic environment is highly dynamic. With the tides and currents, high volumes of water are moved around. Temperatures and other physical properties can change rapidly. [Gubbay, 2006]

Within the pelagic fauna, there is a division between the floating organisms (plankton) and free swimming organisms (nekton). Some species move between this division as well as between pelagic and the benthic environment. [Gubbay, 2006]

5.1.1.3 Species known to be eaten

In chapter 5.3 more information about the fish species found in the stomachs of the Harbour porpoises in the Oosterschelde. In another study done by C.J Camphuysen and M.F. Leopold gives some information about the stomach contents of Harbour porpoises stranded in 2006 at the Dutch coast. In appendix 3, there is a table about the species from the 2006 study.

5.2 WHERE DO HARBOUR PORPOISES OCCUR?

With the use of Google Earth the different coordinates were put together in a chart. The final figure is shown below. The red dots are individual sightings of one or more Harbour porpoises.



Figure 7 Distribution of Harbour Porpoises

From this figure no real pattern can be found. But by placing the depth chart above the sightings the result is as followed. The deep blue colour stands for deep water, about 20 to more than 45 meters deep. The lighter blue is from 2 to 20 meters deep. It depends on the coloration.

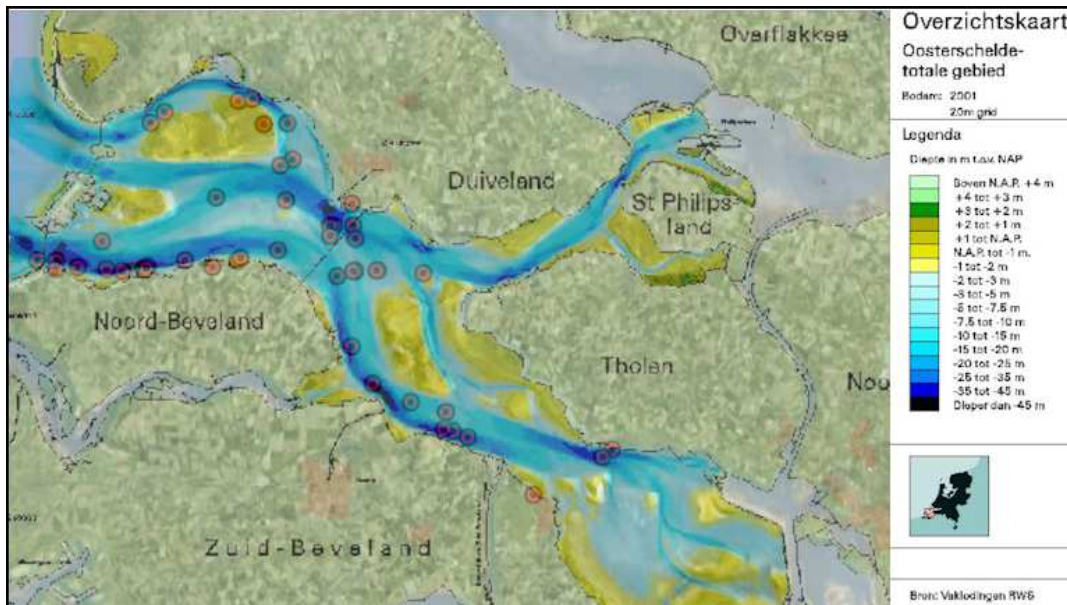


Figure 8 Distribution of the Harbour porpoise and depth chart put together

5.3 STOMACH CONTENTS

The data used to answer the question about the stomach contents, was of a small number of Harbour porpoises. But this gave the results as given below. Adults and juveniles are divided into two sections, to see if there is also a difference between diet and age.

The data collection is done by O. Jansen and M. Leopold, which also have the copyright on this data. The data published in this report was by approval of the copyright holders.

Table 1 Stomach Contents Oosterschelde population. [O. Jansen and M. Leopold]

Latin name	English	Dutch
<i>Alosa fallax</i>	Twait Shad	Fint
<i>Ammodytes tobianus</i>	Lesser Sand Eel	Kleine zandspiering
<i>Clupea harengus</i>	Atlantic Herring	Haring
<i>Callionymus lyra</i>	Dragonnet lyre	Gewone Pitvis
<i>Dicentrarchus labrax</i>	European Seabass	Zeebaars
<i>Gadus morhua</i>	Atlantic Cod	Atlantische Kabeljauw
<i>Gobius niger</i>	Black Goby	Zwarte grondel
<i>Hyperoplus lanceolatus</i>	Great Sandeel	Smelt
<i>Merlangius merlangus</i>	Whiting	Wijting
<i>Nereis diversicolor</i>	-	Veelkleurige Duizendpoot
<i>Nereis longissima</i>	-	-
<i>Perca fluviatilis</i>	European Perch	Baars
<i>Alloteuthis subulata</i>	European Common Squid	Dwerg Pijlinktvis
<i>Pomatoschistus microps</i>	Common Goby	Brakwatergrondel
<i>Pomatoschistus minutus</i>	Sand Goby	Dikkopje
<i>Sepiola atlantica</i>	Atlantic Bobtail	Dwerginktvis
<i>Sepietta oweniana</i>	Common Bobtail	Langwerpige dwerginktvis
<i>Sprattus sprattus</i>	European Sprat	Sprot
<i>Trisopterus luscus</i>	Pouting	Steenbolk
<i>Trisopterus minutus</i>	Poor Cod	Dwergbolk

5.3.1 PERCENTAGES OF SPECIES

The table above says nothing about the amount The percentages of the amount of fish species are present in the figure on the next page. In figure 9, below, it can be seen that almost half of the diet of adult porpoises exists of *G. morhua*. or Atlantic Cod. Thirty percent is Whiting (*M. merlangus*) and Poor Cod (*T. minutus*)

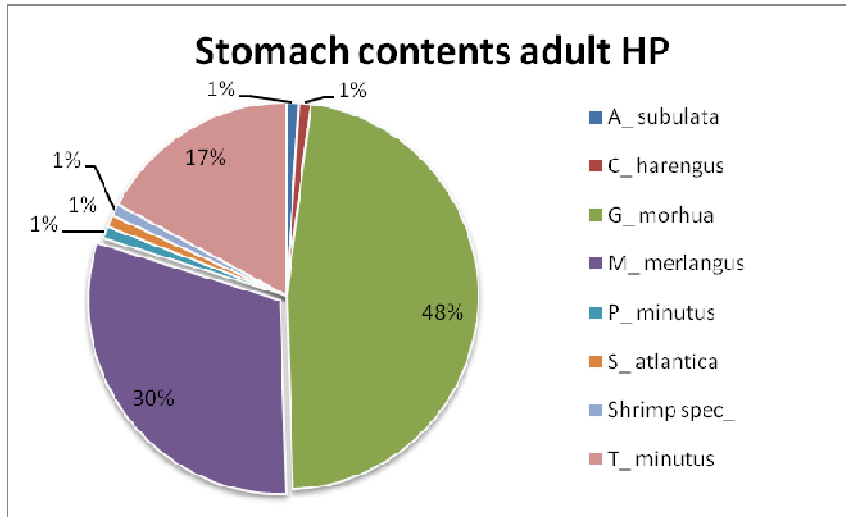


Figure 9 Percentages of adult stomach contents

In figure 10, below, it can be seen that almost three quarter of the juvenile diet exists of Whiting (*M. merlangus*), thirteen percent of Poor Cod (*P. minutus*) and Common Goby (*P. microps*). The herring is about twelve percent of the juveniles diet. About nine percent of the diet is Twait Shad (*Alosa fallax*).

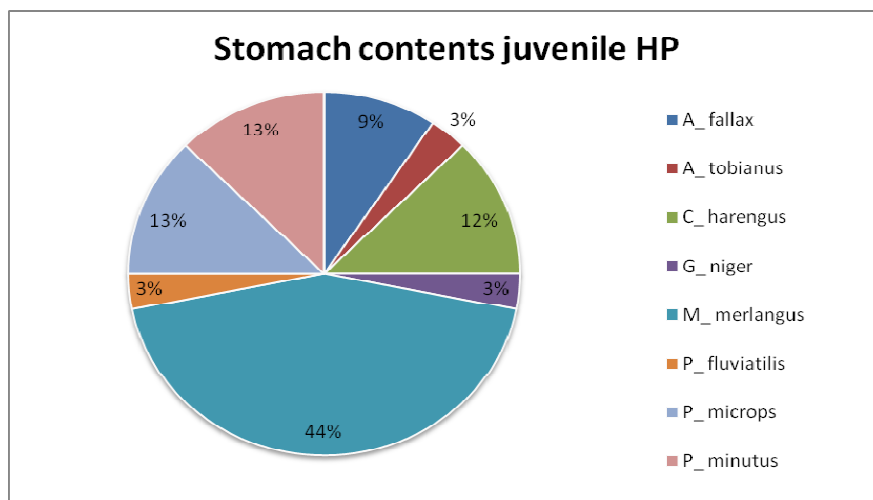


Figure 10 Percentages of juvenile stomach contents

Not all species mentioned in table 10 can be found in both figures again. This is because the percentage is too small to take into account. The species were found in the stomachs, but in a very low density. This does not mean that the species were not present in the stomach.

5.4 RELATIONSHIP FISH SPECIES AND HARBOUR PORPOISE SIGHTINGS

In the study of H. Maandag the spatial distribution of species was also studied. The density of the species was overall very low, but in The Hammen, an area known of its rich silt, had a high species density.

In the figure below, the abundance of only the demersal fish species are given. The abundance was taken > 300 density and gave the result as in figure 9.

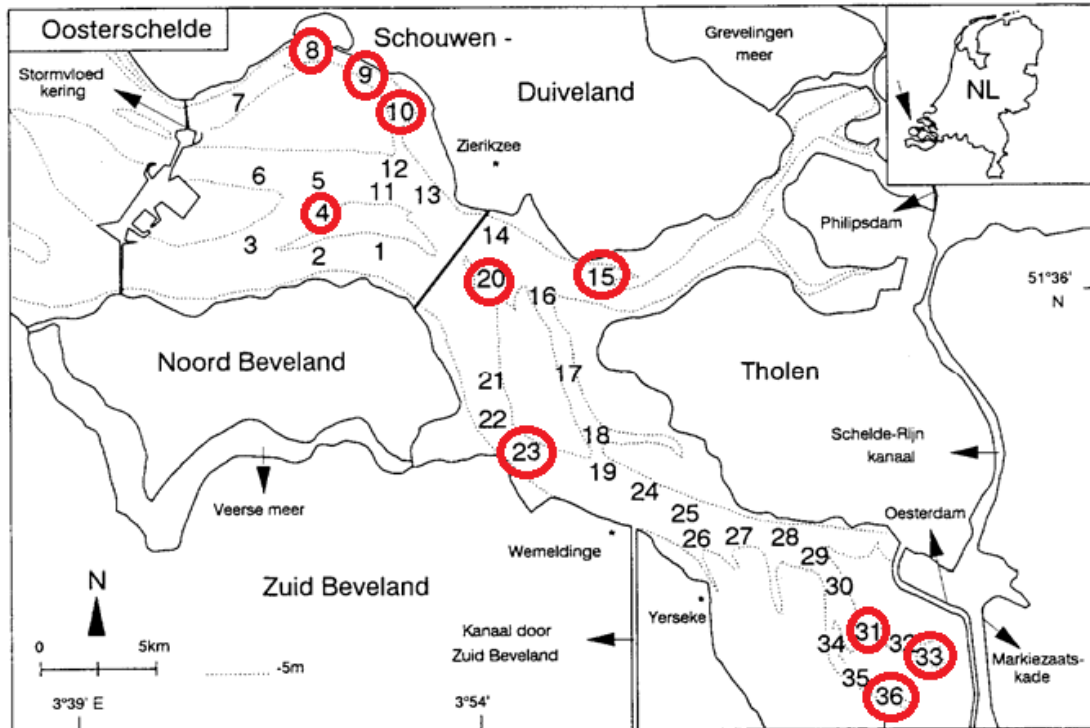


Figure 11 The density of Demersal fish species in the Oosterschelde higher than 300 are encircled.

The distribution is the highest near the coast of Schouwen-Duiveland and Markiezaat. Here are the numbers more concentrated.

6. DISCUSSION

6.1 EXPLANATION QUESTIONS

- What kind of fish species are present at the Oosterschelde?

In the results it is shown that the Oosterschelde is a very rich environment with a great biodiversity of different fish species. In total about 60 species were named. The reason for this was to see if the Oosterschelde is biodiversity rich and what kind of species do occur. By comparing the information of Oosterschelde and North Sea Harbour porpoises it will be seen if some fish species are present in the Oosterschelde and not eaten or that fish species are not present in the Oosterschelde and that the Harbour porpoises therefore changes its diet.

- Where do Harbour Porpoises occur?

As can be seen on the maps Harbour porpoises mostly occur in the middle of the Oosterschelde. As can be seen on the depth map in Appendix 6 this is where mostly the deeper waters are. During the study it was told that the porpoises can also be found near “the harbour of Zierikzee”, this is where the Oosterschelde is at its deepest point as it was a dumping point for old ammunition.

About 80 sightings took place of which some were double, as in the same coordinates, and were counted once. In total about 50 sightings of Harbour porpoises were included during the study.

The distribution map is only a record of a moment, every time the data is collected again, the map will result in another map, but as seen on the results, most data was collected in the deeper parts of the Oosterschelde. If more research is done,

- What kind of fish species are found in the stomach contents of the Harbour porpoise?
And
- What is the difference between the Oosterschelde population and other Dutch populations?

Two different studies showed information about the stomach contents of Harbour porpoises and it can be said that there is a difference in diet. There was a limited amount of stomach contents that were examined from the Oosterschelde population, only 12 individuals. This small amount of studied stomachs, makes the results not representative. When there are more individuals studied, the information will become more reliable.

More research should be needed to draw any conclusions, but it can already be said that the Harbour porpoises in the Oosterschelde eat Black gobies, *Nereis longissima*, European Common squid, Common Goby and the Common Bobtail, which is aberrant from the study done by Camphuysen on stranded porpoises.

The animals also showed what the porpoises are known to eat, but were not found in the stomach contents of the porpoises in the Oosterschelde. The Raitt's sand eel for example was not found in the stomach contents of the Oosterschelde population, the cause may be that the Raitt's sand eel is not present in the Oosterschelde at all.

But species that are present such as the Lozano's goby, Greater- and Lesser pipefish,

European flounder, Common sole, European plaice, the Common dag, Atlantic Horse mackerel and the Sand smelt, were also not eaten by the Oosterschelde population. This can tell something about the diet of the Oosterschelde population, but more research should be done to confirm any of these assumptions.

Juveniles of the population from the Oosterschelde have a lot of Common gobies in the diet, about 13%, which is remarkable, as in no other populations Common gobies were found in the diet.

- What is the relationship between fish species and the sightings of Harbour porpoises?

As mentioned before there are no results of the distribution of pelagic fish species. No conclusion or assumption can be made from this and therefore more research should be carried out to understand more about the distribution of pelagic fish species. Then, when there is also a distribution map of these species, a conclusion or assumption might be made between fish species and porpoises.

From the results of the demersal species, it can be seen that some sightings are at the same location or around the same location of demersal species. This does not conclude that where the demersal species are, the porpoises are as well. First, a distribution map of pelagic species should be made and then the sightings and fish species should be compared again. Also, a list of present species on which place could give more information.

6.2 ERROR ANALYSIS

During this study it was quite difficult to obtain relevant information that made it possible to draw conclusions. Because of the low amount of different fishermen, it made it very difficult to make the information representative. Therefore, the conclusions taken in this study, should be considered as weak due to the amount of data that was too low.

While the study was already in an advanced state, the amount of data was not enough due to too less fishermen, what made the data to focused on certain areas. The best was of many fishermen to get an overview of the Oosterschelde instead of data that is focused on a few spots. So the choice was made for another approach. To reach more fishermen, the internet was not going to be enough, so the fishermen were visited in the harbor. The harbors included were Zierikzee, Yerseke and Colijnsplaat. These harbors are “fishermen” harbors, in most other places the harbors were marinas. The fishermen were approached while on the boat. The forms were left behind and it could only be hoped that the fishermen sent them back. Resources were not available to carry out a more extensive research. Starting with nothing, obtain contacts and lots of travelling costs too much time. But also tools such as GPS, hydrophone etc. were available but not for this study.

Due to the lack of information about the distribution of pelagic species, no figure about these fish could be given, so therefore no conclusion can be given about the location of pelagic fish species and Harbour porpoises.

7. CONCLUSION

- What kind of fish species are present at the Oosterschelde?

In the results it can clearly be seen that a lot of different fish species are present in the Oosterschelde. Also, the Oosterschelde is a very important place for species to spawn and for young individuals to grow and then leave the protected area.

Fish species that are common are Common sole, Common dab, European Lobster and Whiting. The complete list can be found in Appendix 4.

- Where do Harbour Porpoises occur?

From the combination map of the distribution and depth chart it can be concluded that the Harbour porpoises occur in the most deeply parts of the Oosterschelde. These parts are for instance the Harbour of Zierikzee, Near the shore of “Zuid-Beveland” and “Noord Beveland” and around the “Zeelandsbrug”. These parts are also considered to be the deepest parts of the Oosterschelde. But also, Northwesterly of the Oosterschelde some sightings of porpoises occurred.

- What kind of fish species are found in the stomach contents of the Harbour porpoise?

A unique species found in the stomach of the Harbour porpoise present in the Oosterschelde is the Black Goby. Furthermore the porpoises in the Oosterschelde also feed on *Nereis longissima*, European Common squid, Common Goby and the Common Bobtail, while other populations do not consume these species. Juveniles consume a quite high amount of Common Gobies, about 13% in total.

It can be concluded that the diet of the Harbour porpoise population in the Oosterschelde is slightly different from the other populations. Especially the goby and the two cephalopod species are quite remarkable.

- What is the relationship between fish species and the sightings of Harbour porpoises?

From the data that has been given from the demersal fish species and the sightings of the porpoises, it can be said that some of the locations have the porpoises and demersal species in common. But at this moment, more research should be done to confirm any assumptions. It may be possible that there is a relationship between certain demersal fish species and sightings of porpoises.

BIBLIOGRAPHY

- American Cetacean Society** (2004) Species description Harbour porpoise, found on 20/04/10 accessed on www.acsonline.org
- Cetacean Research and Rescue Unit** (2010) Harbour Porpoise Cetacean factsheet, found on 20/04/10 accessed on www.crru.org.uk
- Convention on Migratory Species** (2010) Species Description Harbour porpoise, found on 20/04/10 accessed on www.cms.int/
- Deltares** (2010) Bekken: Oosterschelde, karakteristieken. Found on 18/05/10
- Deltawerken** (2004) Informatie over de biodiversiteit in de Oosterschelde. Found on 25/05/10
- Fisheries and Oceans Canada** (2008) Harbour porpoise image Found on 18/05/10. Accessed on www.dfo-mpo.gc.ca
- Gemeente Vlissingen** (2010) Kaart van Zeeland. Found on 20/04/10. Accessed on www.vlissingen.nl
- Geschiedenis Zeeland**, (2010) De stormvloedkering Oosterschelde, Zeeland 1986. found on 26/04/10 accessed on geschiedenis.vpro.nl/
- Gubby, S.** (2006) Marine nature conservation in the pelagic environment: a case for pelagic Marine Protected Areas? WWF. Found on 29/06/10
- IUCN** (2010) Harbour porpoise, *Phocoena Phocoena*. Found on: 06/05/10 accessed on <http://www.iucnredlist.org/>
- Koschinski, S.** (2002) Current knowledge on Harbour porpoises (*Phocoena phocoena*) in the Baltic Sea , *Ophelia* Vol. 55, no. 3, pp. 167-198. Feb 2002. Found on 16/05/10
- Leopold, M.F and Camphuysen, C.J.** (2006) Bruinvisstrandingen in Nederland in 2006, Achtergronden, leeftijdsverdeling, sexratio, voedselkeuze en mogelijke oorzaken. IMARES Rapport C083/06, NIOZ Report 2006-5, Wageningen IMARES en Koninklijk Nederlands Instituut voor Onderzoek der Zee, Texel. Found on 26/05/10
- Maandag, H.** (1999) Densiteit van demersale vissoorten in de Oosterschelde, Hogeschool Zeeland, Found on 07/05/2010
- Maandag, H.** (1999) Visstand in de Oosterschelde; Augustus 1999, Hogeschool Zeeland Found on 07/05/2010
- Ministerie van Verkeer en Waterstaat** (2003) Verandering van de morfologie van de Oosterschelde door de aanleg van de Deltawerken. Found on 16/07/10
- Nationaal Park Oosterschelde**, Diersoorten en wetgeving Oosterschelde, found on 24/05/10 accessed on www.nationaalpark.org
- Nationaal Park Oosterschelde** (2010) Informatie over de Oosterschelde, found on 24/05/10 accessed on www.np-oosterschelde.nl/
- Okka Jansen and Mardik Leopold** (2010) Stomach contents of Harbour porpoises found in the Oosterschelde. Accessed 1/7/10
- Osinga, N.; Berends, D.J.; 't Hart, P.; Morick, D.** (2007) *Bruinvissen in Nederland; Populatie, pathologie en visserij* found on 20/04/10

Santos, M.B. and Pierce , G.J. (2003) *The diet of the Harbour porpoise (Phocoena phocoena) in the North East Atlantic.* *Oceanography and Marine Biology: an annual review* 2003. **41** pp 355-390. Found on 28/05/2010

Seamasters, duikschool vzw (2010) *Borstelwormen in de Oosterschelde.* Found on 12/05/10 accessed on www.seamasters.be

Seamasters, duikschool vzw (2010) *Beenvissen en kraakbeenvissen in de Oosterschelde.* Found on 02/06/10 accessed on www.seamasters.be

APPENDIX 2 CETACEAN SHEET

Naam.....		Datum:			Stichting De Rugvin				
num mer	Tijd	Latitude	Longitude	Soort	Aantal	Weer	Windkracht	Windrichting	Opmerkingen

Soort: BR = Bruinvis; T= Tuimelaar; WD= Witsnuitdolfijn; GD = Gewone dolfin

Weer: M= mist; B= bewolkt; Z= Zonnig; R=Regen

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APPENDIX 3 STOMACH CONTENTS HARBOUR PORPOISES 2006

Table 1 Stomach contents of beached Harbour porpoises in 2006. Copyright C.J Camphuysen and M.F. Leopold

<i>Clupidae</i>	<i>Gadidae</i>	<i>Ammodytes</i>	<i>Gobiidae</i>	<i>Syngnathus</i>	<i>Other roundfish</i>	Pleuronecti- formes	invertebrates
Herring (<i>Clupea harengus</i>)	Cod (<i>Gadus morhua</i>)	Raitt's sand eel (<i>Ammodytes marinus</i>)	Lozano's goby (<i>Pomatoschistus lozanoi</i>)	Greater Pipefish (<i>Syngnathus acus</i>)	Sand Smelt (<i>Atherina Presbyter</i>)	European flounder (<i>Platichthys flesus</i>)	Atlantic Bobtail (<i>Sepiola atlantica</i>)
European Sprat (<i>Sprattus sprattus</i>)	Whiting (<i>Merlangius merlangus</i>)	Lesser sand eel (<i>Ammodytes tobianus</i>)	Sand Goby (<i>Pomatoschistus minutes</i>)	Lesser Pipefish (<i>Syngnathus rostellatus</i>)	Dragonnet lyre (<i>Callionymus lyra</i>)	Common sole (<i>Solea solea</i>)	Veined Squid (<i>Loligo forbesii</i>)
Twait Shad (<i>Alosa fallax</i>)	Poor Cod (<i>Trisopterus minutus</i>)	Great Sandeel (<i>Hyperoplus lanceolatus</i>)			European Seabass (<i>Dicentrarchus Labrax</i>)	European Plaice (<i>Pleuronectus platessa</i>)	Common Shrimp (<i>Crangon crangon</i>)
	Pouting (<i>Trisopterus luscus</i>)				Atlantic Horse Mackerel (<i>Trachurus trachurus</i>)	Common dab (<i>Limanda limanda</i>)	King ragworm (<i>Nereis virens</i>)
					Atlantic Mackerel (<i>Scomber scombrus</i>)		<i>Nereis diversicolor</i>
					European Smelt (<i>Osmerus eperlanus</i>)		(<i>Hydrobia ulvae</i>)
					European Perch (<i>Perca fluviatilis</i>)		Mollusca

APPENDIX 4 FISH SPECIES

Flatfish species

Table 2 Flatfish Species

Latin name	English	Dutch
<i>Solea solea</i>	Common sole	Tong
<i>Buglossidium luteum</i>	Solenette	Dwergtong
<i>Scophthalmus rhombus</i>	Brill	Griet
<i>Limanda limanda</i>	Common dab	Schar
<i>Platichthys flesus</i>	European flounder, butt	Bot
<i>Microstomus kitt</i>	Lemon sole	Tongschar
<i>Psetta maxima</i>	Turbot	Tarbot
<i>Pleuronectus platessa</i>	European plaice	Schol

[Maandag, 1990]

Goby species

Table 3 Goby Species

Latin name	English	Dutch
<i>Gobius niger</i>	Black Goby	Zwarte grondel
<i>Aphia minuta</i>	Transparent goby	Glasgrondel
<i>Pomatoschistus minutus</i>	Sand Goby	Dikkopje
<i>Pomatoschistus lozanoi</i>	Lozano's goby	Lozano's grondel
<i>Pomatoschistus microps</i>	Common Goby	Brakwatergrondel
<i>Pomatoschistus pictus</i>	Painted Goby	Kleurige Grondel

[Maandag, 1990]

Cod Species

Latin name	English	Dutch
<i>Trisopterus luscus</i>	Pouting	Steenbolk
<i>Raniceps raninus</i>	Tadpole fish	Vorskwab
<i>Merlangius merlangus</i>	Whiting	Wijting
<i>Ciliata mustela</i>	Five bearded Rockling	Vijfdradige Meun
<i>Trisopterus minutus</i>	Poor Cod	Dwergbolk

Demersal Scorpaeniformes

Latin name	English	Dutch
<i>Eutrigla gurnardus</i>	Grey Gurnard	Grauwe Poon
<i>Myoxocephalus scorpius</i>	Short-spined Bullhead/ sea scorpion	Gewone zeedonderpad
<i>Agonus cataphractus</i>	Armed Bullhead	Harnasmannetje
<i>Liparus liparus</i>	Atlantic Bearded Brotula	Slakdolf
<i>Trigla lucerna</i>	Tub Gurnard	Rode Poon
<i>Taurulus bubalis</i>	Long-spined Bullhead	Groene zeedonderpad

Other demersal species

Latin Name	English	Dutch
<i>Ammodytes tobianus</i>	Small Sandeel	Kleine Zandspiering
<i>Atherina presbyter</i>	Sand smelt	Koornaarsvis
<i>Blennius gattorugine</i>	Tompot Blenny	Gehoornde Slijmvis
<i>Callionymus lyra</i>	Dragonnet lyre	Gewone Pitvis
<i>Anguilla anguilla</i>	European Eel	Paling
<i>Symphodus melops</i>	Corkwing wrasse	Zwartlipvis/Gewone lipvis
<i>Labrus bergylta</i>	Ballan Wrasse	Gevlekte Lipvis
<i>Lipophrys pholis</i>	Smooth Blenny	Steenslijmvis
<i>Mullus barbatus</i>	Red Mullet	Gewone Zeebarbeel
<i>Mullus surmuletus</i>	Striped Red Mullet	Koning van de Poon; Mul
<i>Pholis gunnellus</i>	Butterfish; Rock Gunnel	Botervis
<i>Zoarces viviparus</i>	Viviparous Eelpout	Puitaal

7.1.1.1 Pelagic Fish Species

The Oosterschelde is, in particular for the Sprat and Herring, a spawning area where the young will grow to adults and leave the area.

Pelagic Cod Species

Latin name	English	Dutch
<i>Gadus morhua</i>	Atlantic Cod	Atlantische Kabeljauw
<i>Pollachius pollachius</i>	European – or Atlantic Pollock	Witte Koolvis / Pollak

Syngnathus (Pipefish and Seahorse family)

Table 5 Pipefish and seahorse species present in Oosterschelde

Latin name	English	Dutch
<i>Syngnathus acus</i>	Greater Pipefish	Grote zeenaald
<i>Syngnathus rostellatus</i>	Lesser Pipefish	Kleine zeenaald
<i>Entelurus aequoreus</i>	Snake Pipefish	Adder zeenaald
<i>Hippocampus ramulosus</i>	Long Snouted Seahorse	Langsnuit Zeepaardje

Other pelagic species

Latin name	English	Dutch
<i>Belone belone</i>	Garfish	Gewone Geep
<i>Clupea harengus</i>	Atlantic Herring	Haring
<i>Sprattus sprattus</i>	European Sprat	Sprot
<i>Chelon labrosus</i>	Thick-lipped grey mullet	Diklipharder
<i>Liza ramada</i>	Thin-lipped grey mullet	Dunlipharder
<i>Cyclopterus lumpus</i>	Lumpfish	Snotolf
<i>Trachurus trachurus</i>	Atlantic horse Mackerel	Horsmakreel
<i>Labrus bergylta</i>	Ballan Wrasse	Gevlekte lipvis
<i>Gasterosteus aculeatus</i>	Three-spined stickleback	Driedoornige Stekelbaars

1.1.1.1 Other species

Polychaetes (worms)

Latin name	English	Dutch
<i>Arenicola marina</i>	Lugworm	Zeepier
<i>Harmothoë impar</i>	-	Schubworm
<i>Lanice conchilega</i>	Sand mason worm	Schelpkokerworm
<i>Nereis diversicolor</i>	-	Veelkleurige Duizendpoot, zager
<i>Pectinaria koreni</i>	Trumpet worm	Goudkammetje
<i>Phyllodoce (Anaitides) maculata (Lin.)</i>	-	Gestippelde Dieseltreinworm
<i>Amphitrite gracilis</i>	Polychaete worm	Slijmkokerworm
<i>Aphrodite aculeata</i>	Sea Mouse	Zeemuis

Cephalopods

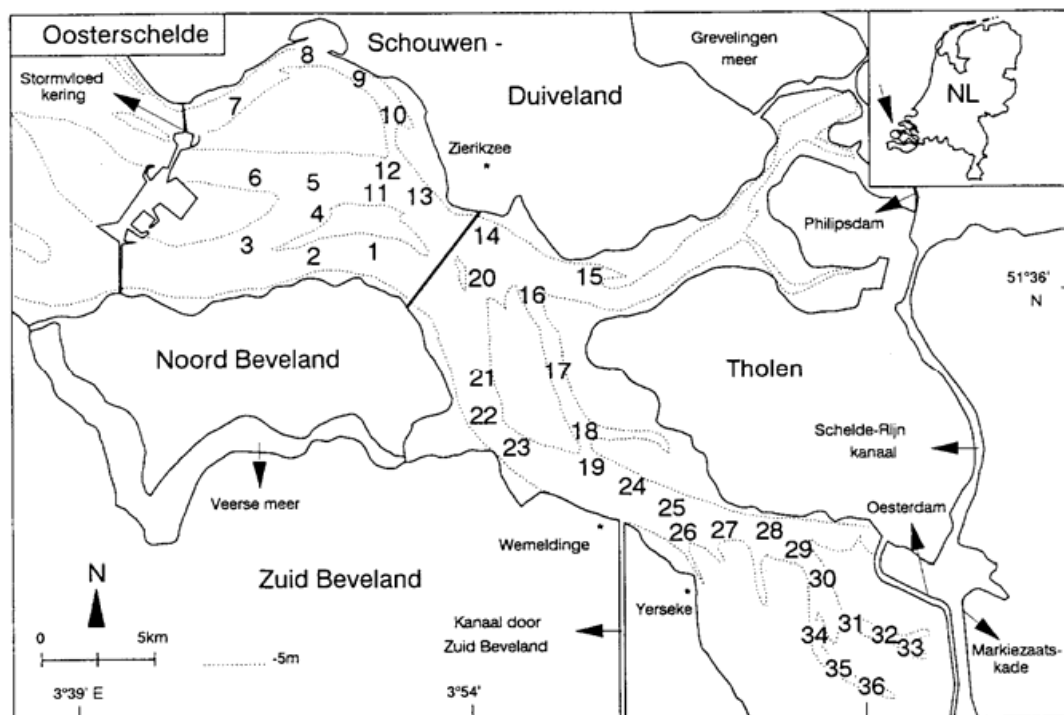
Latin name	English	Dutch
<i>Alloteuthis subulata</i>	European Common Squid	Dwergpijlinktvis
<i>Sepia officinalis</i>	Common Cuttlefish	Gewone Zeekat
<i>Loligo vulgaris</i>	European Squid	Gewone Pijlinktvis
<i>Sepiola atlantica</i>	Atlantic Bobtail	Dwerginktvis

[seamasters.be]

Divers

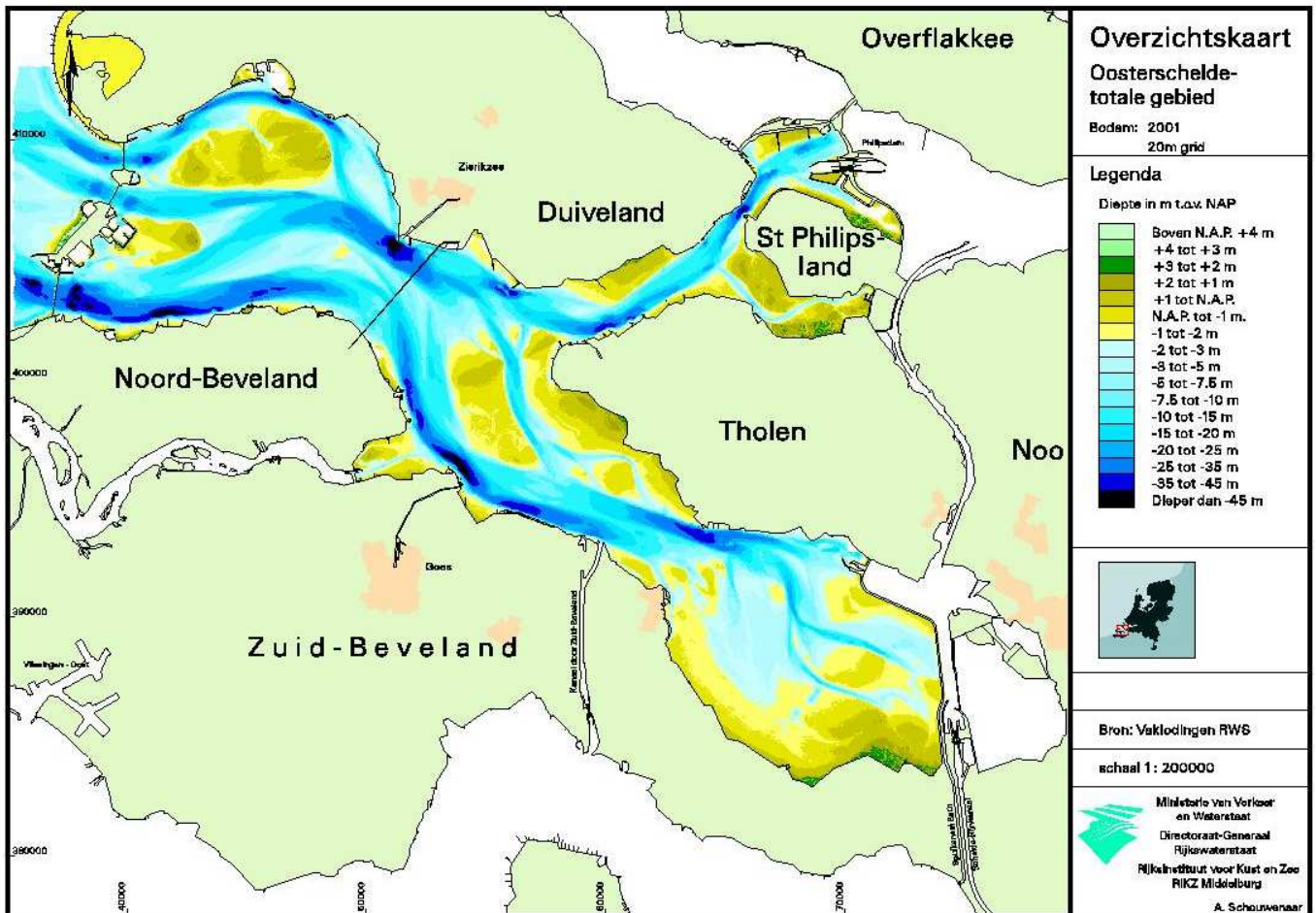
Latin name	English	Dutch
<i>Homarus gammarus</i>	European Lobster	Europese Zeekreeft
<i>Dasyatis pastinaca</i>	Common Stingray	Pijlstaartrog
<i>Raja batis</i>	Common Skate	Vleet
<i>Raja clavata</i>	Thornback Ray	Stekelrog
<i>Scyliorhinus canicula</i>	Small-spotted Catshark	Hondshaai

APPENDIX 5 FISH NUMBERS AND DENSITY



Number	Density	Number of species	Number	Density	Number of species
1	110	21	19	190	19
2	200	17	20	360	19
3	120	22	21	290	18
4	480	16	22	190	20
5	105	17	23	350	18
6	140	23	24	205	21
7	255	20	25	150	23
8	500	17	26	140	26
9	390	20	27	80	20
10	850	15	28	190	22
11	290	19	29	60	11
12	280	17	30	115	22
13	230	20	31	590	19
14	150	22	32	280	21
15	360	22	33	350	20
16	170	22	34	160	23
17	220	20	35	190	22
18	225	21	36	360	18

APPENDIX 6 DEPTH CHART OF THE OOSTERSCHELDE



Depth Map of the Oosterschelde 2001, Source: Ministerie van Verkeer en Waterstaat 2003