Hotspot determination of harbour porpoises *(Phocoena phocoena)* in the Oosterschelde

Stichting Rugvin
HAS Den Bosch
31/01/2012

Hotspot determination of harbour porpoises *(Phocoena phocoena)* in the Oosterschelde

29th of August 2011 – 27th of January2012

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With special thanks to Stichting ANEMOON, for their maps with the density of fish species
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19th January 2012
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Photograph: Sophie Neitzel

Foreword

This report is the result of a twenty-week research involving the observation of harbour porpoises in the Oosterschelde estuary, The Netherlands. The study was conducted in the period from August 29th 2011 until January 27th 2012 as an internship at Stichting Rugvin. During these twenty weeks an investigation was carried out whether harbour porpoises prefer occurring on certain locations in the Oosterschelde (hotspots) and which factors are of influence (occurrence of certain fish species, depth and currents). National Park Oosterschelde would like to bring out the information of hotspots in the Oosterschelde so that not only local people but also tourists get to know more about the occurrence of harbour porpoises in the Oosterschelde.

The inspiration for conducting this study originated from our interest in nature, animals and the relationship of these animals in an ecosystem, with particular interest in marine mammals.

This research report is written by Sophie Neitzel and Lotte Niemeijer, two third-year Applied Biology students from HAS Den Bosch.

Our special thanks to Frank Zanderink, founder and coordinator of Stichting Rugvin, for his support and guidance throughout this research project. Also, our thanks to Huub van Osch, supervisor from HAS Den Bosch, for his constructive criticism and help during our internship. Geert Peeters (HAS Den Bosch) spend a lot of time helping us with Arc GIS. We thank Mardik Leopold (IMARES) for his help choosing fish species. Jaap van de Hiele (EHBZ) brought us in contact with a lot of people and we thank him for his help. We thank Niels Schrieken (Stichting ANEMOON) and Arjan Gittenberger (GiMaRIS) for their feedback, distribution maps of fish species and enthusiasm. Finally, we thank Osama Almalik, (HAS Den Bosch) who helped with the statistics.

Lisanne Korpelshoek (Stichting Rugvin), Willem van het Anker (captain), Peter Koppenaal (captain MS Hammen), Ilse Hoekstra (Stichting Rugvin), Wouter-Jan Strietman (Stichting Rugvin), Nynke Osinga (Stichting Rugvin), Bas Beekmans (Stichting Rugvin), Kees Goudswaard (IMARES), Eligius Everaarts (SOS Dolfijn) and volunteers from Stichting Rugvin for the landscan: Marret Noordewier, Karin van Schieveen, Els de Jong, Rob Vroom, Ernst Schrijver, Rosanne van Oudheusden, Michelle Geers, Yvonne Kemp, and Jennifer Koch.

’s Hertogenbosch, January 2012

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Samenvatting

In opdracht van Stichting Rugvin heeft een onderzoek van twintig weken naar de observatie van bruinvissen plaatsgevonden in de Oosterschelde. De Oosterschelde is een uniek Nationaal park dat gekenmerkt wordt door de stormvloedkering. De stormvloedkering is een onderdeel van de deltawerken dat bij een zeeniveau van +3m NAP zijn deuren sluit [Stichting Deltawerken Online, 2004]. Om te weten te komen op welke plekken in de Oosterschelde de bruinvissen het meest voorkomen, is er rekening gehouden met de invloed van het getij en verschillende vissoorten. Deze aspecten zijn onderzocht voor het beantwoorden van de hoofdvraag: ***'Waar liggen de hotspots voor bruinvissen in de Oosterschelde?'***

Bruinvissen werden in twintig veldwerkdagen, zes uur per dag geobserveerd. Het aantal waarnemingen werd genoteerd in de waarnemingstabel, evenals weersveranderingen, gebiedskenmerken en kalfjes als die werden waargenomen. Een totaal van 174 bruinvissen is waargenomen in de Oosterschelde, waarvan de meeste bruinvissen voorkwamen op locatie A3. Veertien van de 174 bruinvissen waren kalfjes. Een kaart van de hotspots, mogelijke hotspots en geen hotspots is gemaakt om weer te geven waar de hotspots van bruinvissen gelokaliseerd zijn. De hotspot voor bruinvissen in de Oosterschelde is locatie A3. De mogelijke hotspots zijn locaties A1, A2 en A5. Alle andere locaties zijn geen hotspots omdat het niet diep genoeg is, niet veel bruinvissen zijn waargenomen, niet alle vissoorten voorkomen en de dichtheden van de soorten die er voorkomen ook erg laag zijn.

Bij elke observatie is het getij bij aankomst genoteerd in de waarnemingstabel. Het getij is verdeeld in zes verschillende fasen van laagtij tot laagtij (twee uur per fase). Een chi-kwadraat toets is uitgevoerd om aan te tonen of er een significant verschil is tussen de verschillende fasen in het aantal bruinvissen. De meeste bruinvissen kwamen voor in fase 1 en fase 6. De uitkomst van de chi-kwadraat toets was 0,000 ($\alpha = 0.05$). De chi-kwadraat toets toont dus aan dat er een significant verschil is ($0.000 < 0.05$) in de verschillende fasen. Er kan dus geconcludeerd worden dat bruinvissen het meest voorkomen in fase 1 en 6, wat betekent dat ze het meest voorkomen bij afgaand tij.

Vier kaarten met de verspreiding en dichtheid van de vissoorten (grondels (*Pomatoschistus*), zwarte grondels (*Gobius niger*), haring en sprot (*Clupea harengus* en *Sprattus sprattus*) en wijting (Merlangius merlangus) van Stichting ANEMOON zijn vergeleken met het aantal waargenomen bruinvissen in de Oosterschelde. Een hoge dichtheid van deze vissoorten in dat gebied kunnen het voorkomen van bruinvissen op diezelfde plaats verklaren. Alle vier de vissoorten komen voor op locaties A1, A2, A3 en A5. Op locatie A1 zijn zes bruinvissen waargenomen wat duidt op een mogelijke hotspot, net als locaties A2 en A5. Locatie A3 is gedefinieerd als een hotspot door het grote aantal waargenomen bruinvissen, het voorkomen van alle vier de vissoorten en de grote diepte op die locatie. Op locatie A3 komen de vissoorten in grote aantallen voor. Er kan geconcludeerd worden dat de vissoorten invloed hebben op het vormen van een hotspot voor bruinvissen.
Een ARC GIS kaart met daarop de locaties van waargenomen kalveren in de Oosterschelde is gemaakt om zo een overzicht te geven van het voorkomen van kalveren. Deze kaart is vergeleken met de kaart met het voorkomen van grondels in de Oosterschelde. Kalveren komen het meest voor op locaties A2 A3 en A5. Deze locaties komen overeen met waar grondels voorkomen. Er kan geconcludeerd worden dat kalveren voorkomen op locaties waar grondels ook voorkomen, wat voorgaand onderzoek bevestigd waarin gezegd wordt dat grondels als hoofdvoedsel voor kalveren wordt beschouwd.

Het antwoord op de onderzoeksvraag "Waar zijn de hotspots voor bruinvissen in de Oosterschelde?" is dat er een hotspots is voor bruinvissen is in de Oosterschelde: locatie A3. Sommige locaties zijn mogelijke hotspot: dit zijn locaties A1, A2 en A5. Dit kan verklaard worden door het voorkomen van de vier vissoorten (wijting, (zwarte) grondels, haring en sprot) en de diepte van de Oosterschelde. Ook is de hotspot A3 en de mogelijke hotspots A1, A2 en A5 voor toeristen makkelijk bereikbaar met de auto, fiets of te voet wat een belangrijke factor is voor Nationaal Park Oosterschelde.

Voor verder onderzoek wordt aanbevolen om minimaal drie observaties per locatie uit te voeren om meer betrouwbaardere statistiek uit te voeren. Ook kan de landscan gecombineerd worden met de jaarlijkse boten scan van Stichting Rugvin om zo een groter oppervlakte van de Oosterschelde te dekken. Ook wordt aanbevolen om de start tijd van de observaties gelijk te stellen aan de fasen van het tij en niet alleen data van het voorkomen van vissoorten langs de kustlijn te gebruiken maar ook gebruik te maken van data over het voorkomen van vissoorten voor de diepere delen van de Oosterschelde.

Summary

A twenty-week research involving the observation of harbour porpoises has been done as a research project of Stichting Rugvin in the Oosterschelde, the Netherlands. The Oosterschelde is a unique national park, which has a storm surge barrier that can be closed when the sea level reaches a height of 3m +NAP [Stichting Deltawerken Online, 2004]. To find out if harbour porpoises do actually occur most frequently on 'hotspots' in the Oosterschelde, the influence of the tide and several fish species had been taken into account to answer the research question ***"Where are the hotspots for harbour porpoises in the Oosterschelde?"***

Harbour porpoises were observed and listed in a fieldform in twenty fieldwork days, six hours a day. Also weather conditions, characteristics of the area and a sighted calf were listed on the fieldform. A total of 174 harbour porpoises were sighted in the Oosterschelde area and most porpoises are sighted on location A3. Fourteen of the 174 porpoises were calves. A map with hotspots, potential hotspots and no hotspots was made to show which locations are important for the occurrence of porpoises. The hotspot of harbour porpoises in the Oosterschelde is location A3. Potential hotspots are locations A1, A2 and A5. All other locations are no hotspots because of the low amount of fish species, low depth and low number of sighted porpoises.

At each observation the water level was documented at the arrival time and was listed on the field form. Tide was divided into six different phases from low tide to low tide (two hours per phase). A chi-square test was done to show if there was a significant difference between the different phases in amount of porpoises. Compared to the tide most porpoises occur in phase 1 and 6 at low tide. The result of the related chi-square test is 0,000 ($\alpha = 0.05$). The chi-square test shows that there is a significant difference ($0.000 < 0.05$) in the different phases. It can be concluded that porpoises mostly occur in phase 1 and 6, which means they mostly occur at falling tide.

Four maps with the occurrence of the fish species (gobies *(Pomatoschistus*), black gobies (*Gobius niger*), herring and sprat *(Clupea harengus* and *Sprattus sprattus)* and whiting (*Merlangius merlangus*)) from Stichting ANEMOON was compared to the amount of sightings of harbour porpoises in the Oosterschelde. A high density of fish species in those specific areas can explain the amount of harbour porpoise sightings in those areas. All four fish species occur on locations A1, A2, A3 and A5. On location A1 only six harbour porpoises are sighted which means that it is a potential hotspot. Locations A2 and A5 are also potential hotspots. Location A3 is defined as a hotspot because of the high number of sighted porpoises, occurrence of all four fish species and a great depth. On location A3, all fish species occur in large numbers. It can be concluded that the fish species have influence on the hotspots of harbour porpoises.

An ArcGIS map with the locations of sighted calves in the Oosterschelde was made to give a view of the occurrence of calves. This map was compared to the map with the occurrence of gobies to show if the sighted calves match with a high density of gobies in the Oosterschelde. Calves mostly occur on locations A2, A3 and A5. These locations match with the locations where gobies occur. It can be concluded that calves occur on locations where gobies also occur, which confirms previous research saying that gobies form the main diet of calves in the Oosterschelde.

The answer on the research question *"Where are the hotspots for harbour porpoises in the Oosterschelde?"* is that there is a hotspot for harbour porpoises in the Oosterschelde: location A3. Some of the locations are potential hotspots; these are the locations A1, A2 and A5. This can be explained by the occurrence of four fish species (whiting, (black) gobies, herring and sprat) and the depth of the Oosterschelde. Also the hotspot A3 and potential hotspots A1, A2 and A5 are for tourists easily accessible by car and bicycle, which are important factors for Nationaal Park Oosterschelde.

For further research it is recommended to carry out at least three observations per location for obtaining more reliable statistics. Also the land scan could be combined with the annual boat scan from Stichting Rugvin to cover a bigger surface of the Oosterschelde. It is also recommended to match the starting time of the observations with the tide phases and not only to use data of occurrence of fish species along the coastline, but also use data of occurrence of fish species on the deeper parts of the Oosterschelde (which are not available yet).

Table of contents

1. Introduction

1.1 Hotspots

In this research a hotspot is a location where harbour porpoises occur throughout the entire day (>20 individuals per six hours). Occurrence of fish species and depth are also factors that define a hotspot. During this research the occurrence of fish species, which will be discussed further on this chapter, have been taken into account. When all four fish species occur on one observation location it is more likely that harbour porpoises would choose that location to feed. This because when a location has more fish species available, the chance to catch a fish is probably bigger than when a harbour porpoise would look for food on a location where less fish species occur. The depth of the location is important because harbour porpoises will not occur on areas where the sea is not that deep (< 20m NAP). On locations where the water level is not high, harbour porpoises are not able to make enough speed to catch their prey.

1.2 The Oosterschelde

The Oosterschelde is located in Zeeland, between Schouwen Duiveland and Noord and Zuid Beveland (Figure 1.1) [Nationaal Park Oosterschelde, n.d.]. In and around on this water there are fish, birds and other species such as crustaceans and shellfish. During this research project fish species are especially of interest. Species such as cod, herring, sprat, gobies and bass thrive very well in the Oosterschelde. Flatfish such as plaice, flounder, sole and dab are found at the bottom of the Oosterschelde [Stichting Deltawerken Online, 2004, Ho et al., 1986]. The Oosterschelde is connected to Natura 2000 law on the 23rd of December, 2009 by the Ministry of Economic Affairs, Agriculture and Innovation. The Oosterschelde is managed by Ministry of Infrastructure and the Environment, Natuurmonumenten, Staatsbosbeheer and Stichting het Zeeuwse landschap [Ministerie van Economische Zaken,Landbouw en Innovatie, n.d.].The Oosterschelde has a unique history. Until the middle ages it was a small river arm and has in time become the present Oosterschelde. In 1953 the flood took place which brought serious consequences. The flood led to the construction of the Oosterschelde barrier, which was completed in 1986. By building this barrier Zeeland is better protected against the force of the water. The gates of the Oosterschelde barrier close when the sea level reaches a height of 3m +NAP [Stichting Deltawerken Online, 2004].

Figure 1.1: Location of the Oosterschelde ©RB-DESKKART

1.3 Harbour porpoise

The harbour porpoise (*Phocoena phocoena*) is a member of the suborder of toothed whales (*Odontoceti*) and is also one of the smallest cetaceans (Figure 1.2) [Rice, 1998]. They are between 150 and 190 centimeters and weigh between 45 and 60 kilograms. The characteristics are a bulging forehead, blunt snout, the length and the small triangular dorsal fin with a blunt tip [Shirihai, 2006]. The harbour porpoise is found in the North Sea, the North Atlantic and since several years in the Oosterschelde [Nowak, 1999, Dollinger, 1988]. In 2009 Stichting Rugvin counted 37 harbour porpoises in the Oosterschelde during an annual boat scan. In 2011 they counted 61 individuals [Stichting Rugvin, 2011]. A map with the boat route for the boat scan is included in the appendix (Appendix 1).

Figure 1.2: Harbour porpoise (*Phocoena phocoena*)
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The first sightings of harbour porpoises in the Oosterschelde date from the mid-90s. It appears that they are present year round [Osinga et. al, 2009; Nationaal Park Oosterschelde, n.d.]. During the annual scan in the Oosterschelde of Stichting Rugvin of June 29 2011, 61 harbour porpoises were counted. This number can change due to mortality and migration through the Oosterschelde barrier. When these animals migrate to the North Sea they diffuse into the main population of harbour porpoises from the North Sea. Due to lack of data it cannot be said how many individuals consist in the main population. Research is still too young to tell how this main population relates to the population of the Oosterschelde. [Stichting Rugvin, 2011]. To maintain the population in the Oosterschelde it is important to know where the hotspots are and why these are so attractive to them (for example: the occurrence of certain fish species, depth and currents.

A couple of years ago Stichting Rugvin placed three C-pods near the storm surge barrier. C-pods uses digital waveform characterisation to select cetacean clicks and logs the time, centre frequency, sound pressure level, duration and bandwidth of each click [Chelonia Limited, n.d.].

During the project fish species that occur in different parts of the Oosterschelde have been taken into account. Those species are: gobies *(Pomatoschistus*), black gobies (*Gobius niger*), herring and sprat *(Clupea harengus* and *Sprattus sprattus)* and whiting (*Merlangius merlangus*) [Leopold et al., 2011].

1.4 Research question

To find out if harbour porpoises do actually occur most frequently on 'hotspots' in the Oosterschelde, the following research question has been drawn:

"Where are the hotspots for harbour porpoises in the Oosterschelde?"

To answer this research question a main question has been formulated:
"Which factors are of influence for a hotspot?"

The main question is divided into two sub questions:

- *Are there more harbour porpoises present at rising tide than at falling tide?*
- *Is the presence of certain fish species of influence for a hotspot?*
    - *Do harbour porpoises especially occur in areas with gobies (Pomatoschistus)?*
    - *Do harbour porpoises especially occur in areas with black gobies (G. niger)?*
    - *Do harbour porpoises especially occur in areas with herring and sprat (C. harengus and S. sprattus)?*
    - *Do harbour porpoises especially occur in areas with Whiting (M. merlangus)?*

Expected is that there are hotspots for harbour porpoises. These hotspots are probably in areas with gobies, black gobies, herring/sprat and whiting. Depth could be an important factor (occurrence of fish species) as well as current regarding to the tide.

The following hypothesis has been drawn:
'There are locations, called 'hotspots', in the Oosterschelde where harbour porpoises do occur most frequently.'

2. Materials and Methods

In this research project the hotspots of the harbour porpoise in the Oosterschelde were localized.
Ten locations were observed twice for six hours each (n=120). On The 14th of October 2011 Stichting Rugvin organized a land scan (Appendix 2). During this scan a group of twelve volunteers observed in pairs on six different locations (A1, A3, A4, A5, B3 and B5). The other fourteen observations were carried out without the help of volunteers. This resulted in twenty observations of which six came from the land scan.

2.1 Research area

The selection of the observation locations was based on a map with the amount of sightings during the annual scans of Stichting Rugvin from 2009 until 2011 (Appendix 3). Five observation locations were chosen based on the largest number of sightings of harbour porpoises in that area. Those locations were called “Potential hotspots”. Another five locations were chosen based on the smallest number of sightings in that area. Those locations were called “non potential hotspots”. All locations can be seen in figure 2.1 where the black dots show the “non potential hotspots” and the red dots show the “potential hotspots”. The “potential hotspot” locations start with the letter A and followed by a digit (1-5). The “non potential hotspot” locations all start with a letter B followed by a digit (1-5). Those digits are only used to differentiate between the different locations and are distributed randomly.

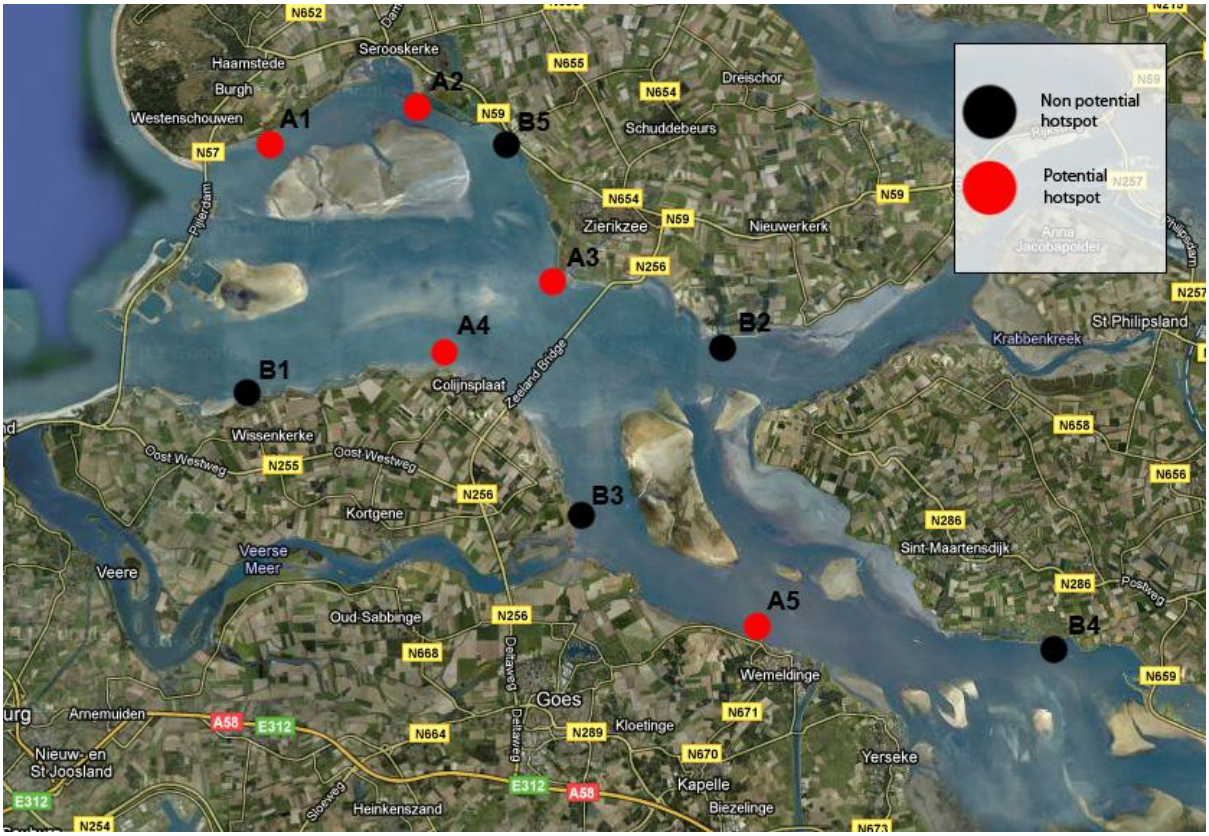


Figure 2.1: Satellite map of the Oosterschelde with ten observation locations.

2.2 Observations

Each location was observed between ±08.00 hrs and ±18.00 hrs (Greenwich Mean Time +1). These times were chosen because tide, fog and wind must be taken into account. A six-hour observation was chosen because if, for example, a one-hour observation is carried out, there is a possibility that at that time harbour porpoises are seen while they normally do not visit that location. While observing two people were present: one person observed and one person filled in the field form, wrote down all sightings and where needed helped with observing. These shifts were alternated every 20 minutes so at least one person was uninterruptedly observing freshly during the six hours. In this way the chance to see porpoises was higher than if two people were continuously observing and after a while lose their concentration. During each observation, a number of conditions were monitored and processed on a list; like the weather conditions, wind (Appendix 5), starting time, tide (Appendix 5), behavior of the harbour porpoise, swimming direction of the harbour porpoise, distance to the water level and height of the observing site with respect to the sea level. These aspects were listed at the time of arrival. Any changes in the weather were also recorded. The sightings were listed in the same field form as the conditions described above. If with certainty a calf (Figure 2.2) was sighted it was listed. The field form that was used to record the sightings can be found in the appendix (Appendix 4). The definitions of, for example the swimming directions and the behaviour of the harbour porpoise, can also be found in the field form. A filled in example can also be found in the appendix (Appendix 5). Circumstances of the observation site were also taken into account. It was also made sure that no obstacles such as streetlights or lighthouses were in the way during the observations. Passing boats could not be avoided. During this study binoculars with magnification 10x50 and 8x25 were used for observation.

Figure 2.2: Adult harbour porpoise (bottom right) with calf (top left).
©Steve Hinton Wildlife Photography

For the results of the observations only descriptive statistics were used because the ten locations are not independent from each other therefore inductive statistics could not be used. The sightings per observation were incorporated in a table. The sightings per location (the sum of the two observations not the mean because of too many variables) were integrated in a graph. The reason for both the table and the graph is that the table shows the amount of sightings within each location (first and second observation separate) while the graph shows on which location the most harbour porpoises have been seen.

To give a view of the exact location where harbour porpoises were sighted an Arc GIS map was made. Behaviour and swimming direction were also translated into Arc GIS maps to see if they are related to each other. If there is a high amount of sightings in one area but the individuals all tend to “pass by” it is possible that the location is not a hotspot (for example because fish species that harbour porpoise prefer to feed on do not occur in that are). The same applies to locations with a small amount of sightings: if they all tend to be “foraging” (which means that the animal is looking for food, uses a lot of energy by chasing them and therefore comes to the surface more often to breathe), that location could be a hotspot. An ArcGIS map was also made of the sighted calves to give a view of the occurrence of calves in the Oosterschelde. This map will not be used to answer the research question because it is not always possible to classify a sighting as a calf, juvenile or an adult. This map was made to give an impression of where calves occur in the Oosterschelde and if the occurrence of fish species has an influence.

2.3 Data analyses

Are there more harbour porpoises present at rising tide than at falling tide?

This question has been answered by documenting the water level (in meters) at the time of arrival. The time of high tide and low tide on that day (along with the height in meters of the water regarding to +NAP) was logged on the field form (Appendix 4). Tide was divided into six different phases from low tide to low tide (Figure 2.3) where phase 1 defines the two hours after the moment of low tide. Phase 2 defines the two hours after phase 1. Phase 4 defines the two hours after the moment of high tide and phase 5 defines the two hours after phase 4 etcetera. After phase 6 phase 1 starts again. It does not take twelve hours from the moment of high tide until high tide but it takes twelve hours and 25 minutes [RIKZ, 1998]. This figure shows a cycle of twelve hours to make it less complex. The nunmber of harbour porpoises sighted per observation were put in a table where the six phases were integrated. This table shows an overview of the total amount of harbour porpoises sighted per phase. A chi-square test was done (α=0.05) to determine if there was a difference between the separate phases.

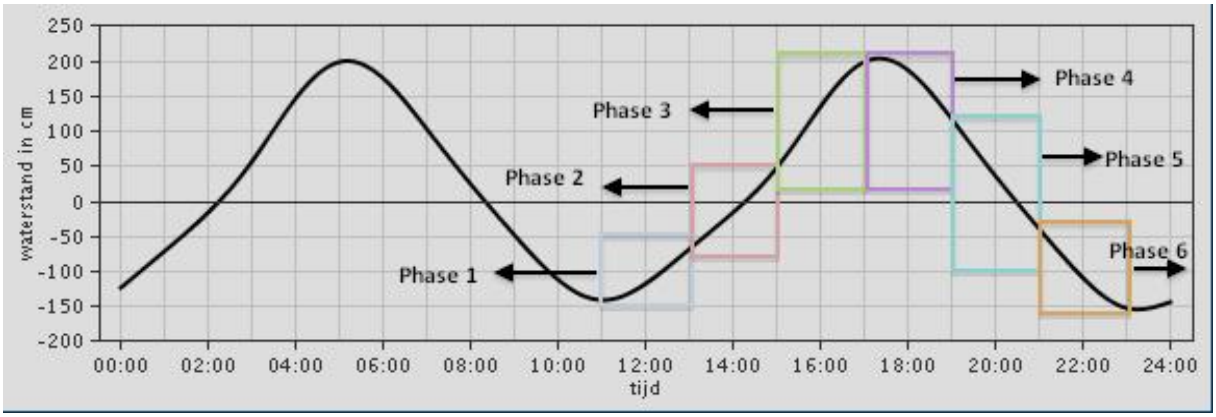


Figure 2.3: Tide graph with six different phases.

Is the presence of certain fish species of influence for a hotspot?

- *Do harbour porpoises especially occur in areas with gobies (Pomatoschistus)?*
- *Do harbour porpoises especially occur in areas with black gobies (G. niger)?*
- *Do harbour porpoises especially occur in areas with herring and sprat (C. harengus and S. sprattus)?*
- *Do harbour porpoises especially occur in areas with Whiting (M. merlangus)?*

This question is divided in to four sub questions. The fish species have been chosen because previous research has shown that these species form are a big part of harbour porpoises' main diet [Leopold et al., 2011 & Korpelshoek, 2011]. General information about the five fish species can be found in the appendix (Appendix 6). Especially adults eat black gobies so therefore this species has been used [Korpelshoek, 2011]. The group of other gobies has not been divided into species because individual difference is not that big. Whiting belongs within the group of gadoids and 90% of the gadoids in harbour porpoises stomachs are whiting. [Leopold et al., 2011 & personal communication] Herring and sprat are both fatty fish and are therefore combined. Each question is answered by looking at previous research projects about the diet of the harbour porpoise in the Oosterschelde. In addition, data of the "Monitoringsproject Onderwater Oever" (MOO) project have been used. MOO is a project from ANalyse, Educatie en Marien Oecologisch ONderzoek (ANEMOON) where volunteers write down their observations while diving in the Oosterschelde. These data are translated into charts to create trend lines of different kinds of crabs, mollusks, polyps and fish species. Of each map with the dispersion of the fish species the locations with the highest density were compared to the amount of sightings of harbour porpoises (from the ten locations). This way a high density of fish could explain the amount of harbour porpoise sightings in that area.

An ARC GIS map with the locations of the sighted calves was made to give a view of the occurrence of calves in the Oosterschelde. Gobies are numerically important for calves as well as in terms of prey mass [Leopold et al., 2011]. The occurrence of calves was therefore compared to the occurrence of gobies (Appendix 6).

When all the research questions have been answered the main question *"Which factors are of influence for a hotspot?"* can also be answered. Therefore depth, occurrence of certain fish species and the number of porpoises per location were incorporated in a table.

To answer the research question, ***"Where are the hotspots for harbour porpoises in the Oosterschelde?"*** all locations were classified in a map as "hotspot", "potential hotspot" or "no hotspot", where hotspot defines locations where all four fish species occur, the amount of sightings is more than 20 individuals per six hours and where the depth of the water is more than 25 meters below NAP.

3. Results

3.1 Observations

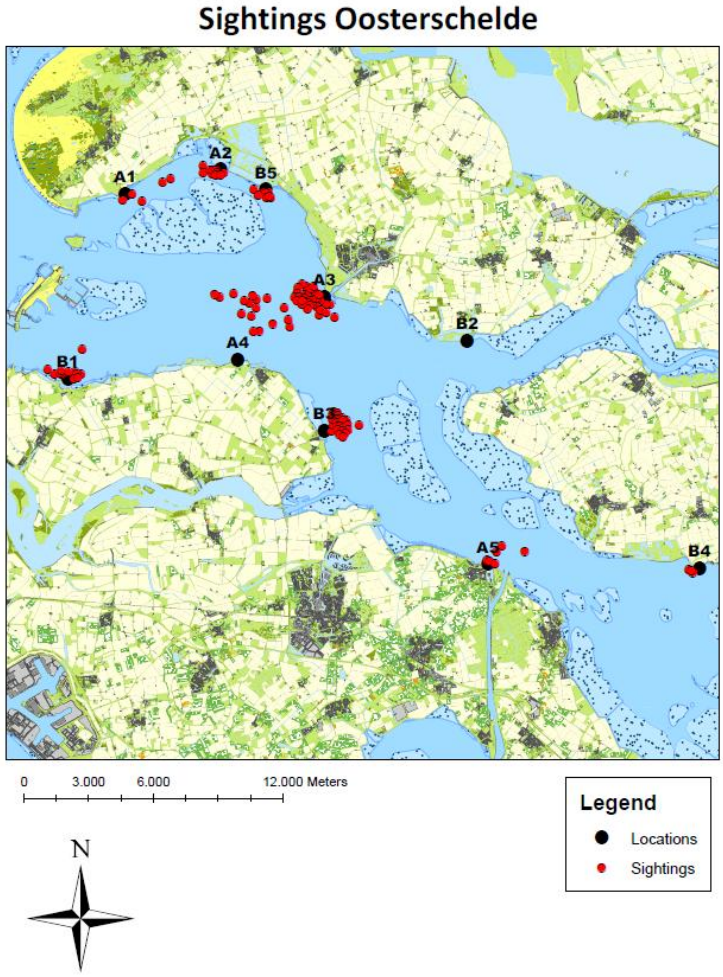


Figure 3.1: Map of all 174 sightings (calves included) on all ten locations in the Oosterschelde.

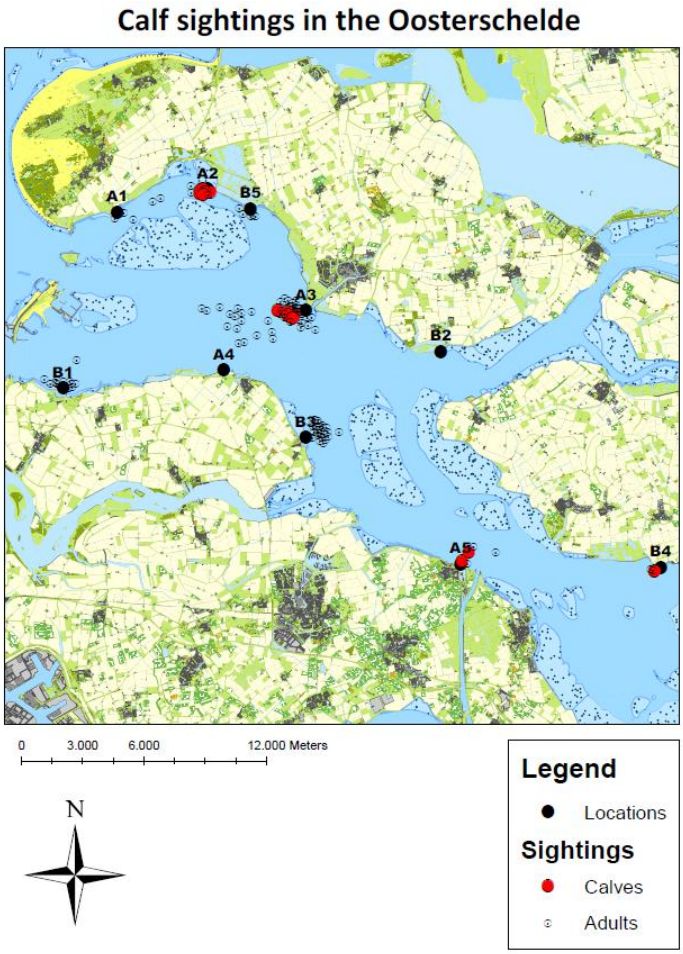
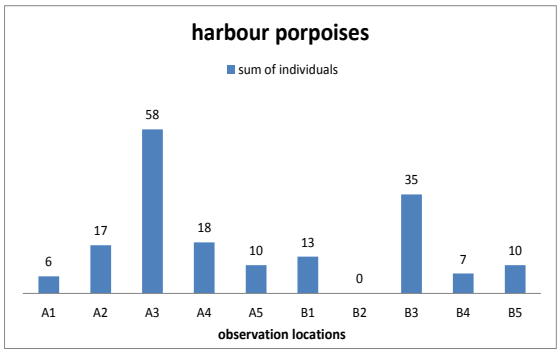


Figure 3.2: Calf sightings in the Oosterschelde. From the 174 harbour porpoises that were sighted in the Oosterschelde fourteen could be defined as calves.

Table 3.1: Individuals per observation of harbour porpoises in the Oosterschelde.

Individuals per location			
A1	5	B1	9
A1	1	B1	4
A2	17	B2	0
A2	-	B2	0
A3	33	B3	1
A3	25	B3	34
A4	18	B4	7
A4	0	B4	0
A5	10	B5	1
A5	0	B5	9
Total	109		65

In table 3.1 the number of individuals per observation is shown. The total of individuals per group (A of B) can also be seen. Notable is that the total of individuals from group A is almost twice as big as the total of group B. The second observation of location A2 resulted in a missing value due to poor visibility. Remarkable is the large number of sightings on the second observation of location B3 unlike the sighted individuals on the first observation.



*The sightings of one observation.

Figure 3.3: Sum of harbour porpoises sighted per location. Location A3 has with 55 the highest number of animals sighted and B2 has with zero individuals the least amount of individuals sighted.

3.2 Tide

3.2.1 Tables

Table 3.2: Tide table

	low tide			high tide			low tide			high tide		
A1	3	1										1
A1	1											
A2		5	10	2								
A2												
A3					4	15	14					
A3						9	5	5	6			
A4					2	4	9	3				
A4												
A5					6	4						
A5												
B1				1	3	5						
B1						2			2			
B2												
B2												
B3		1										
B3	18											16
B4	4	3										
B4												
B5			1									
B5	6	2										1
total	32	12	11	3	15	39	28	8	8	0	0	18

In table 3.2 a tide table with all ten locations is shown. “Low tide” defines the period from low tide until high tide (six hours). For every two hours the numbers of individuals are listed. For example: The first observation on location A1 shows that three individuals were seen in the first two hours after “low tide”. For the second observation one individual was seen in the first two hours after low tide.

Table 3.3: Tide divided into phases

Low tide	**phase 1**	60
	phase 2	20
	phase 3	19
High tide	**phase 4**	3
	phase 5	15
	phase 6	57

Table 3.3 shows low and high tide each divided into six separate phases.

3.2.2 Data analysis

Table 3.4: SPSS Output of the Chi-square test.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
total	174	45,08	19,509	3	60

Test Statistics

			total
Chi-Square			96,483[a]
df			5
Asymp. Sig.			,000
Monte Carlo Sig.	Sig.		,000
	95% Confidence Interval	Lower Bound	,000
		Upper Bound	,000

a. 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 29,0.

Table 3.4 shows the output of the chi-square test with a significance of 0.000 (α=0.05).

3.3 Fish species

Table 3.5: Table with general information of each location.

	fish species				porpoises	depth (m) compared to NAP
	goby	black goby	herring&sprat	whiting		
A1	X	X	X	X	6	25 to 35
A2	X	X	X	X	17	35 to 45
A3	X	X	X	X	58	< 45
A4					18	25 to 35
A5	X	X	X	X	10	25 to 35
B1	X		X		13	< 45
B2					0	7.5 to 10
B3		X			35	35 to 45
B4	X	X	X		7	10 to 15
B5	X	X	X		10	35 to 45

Table 3.5 shows the occurrence of fish species and maximum depth (derived from the figure in appendix 7) along with the number of harbour porpoises of each location. When the specific fish species occurs in that area a cross is listed in the table. Noticeable are the results for location B2: there were zero porpoises sighted, none of the fish species occur in that area and the maximum depth is seven and a half to ten meters. The results for location A4 are also noticeable: eighteen porpoises sighted but none of the fish species seem to occur in that area. For location A5 is it noticeable that eleven harbour porpoises have been sighted while all four fish species occur in that area. Also for location A1 is noticeable that six porpoises have been seen while all four fish species occur.

3.4 Behaviour and swimming direction

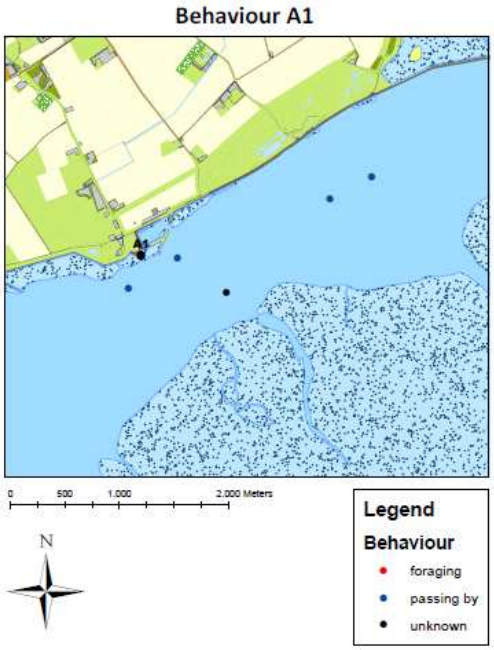


Figure 3.4: Behaviour of harbour porpoises on location A1. From a total of five sightings the individuals of four sightings were passing by and the behaviour of one was unknown.

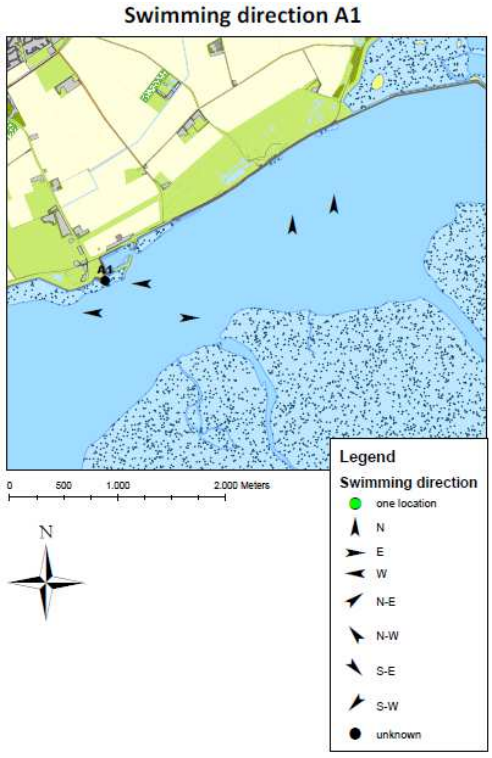


Figure 3.5: Swimming direction of harbour porpoises on location A1. From a total of five sightings the individuals of two sightings swam north, two swam west and one swam east.

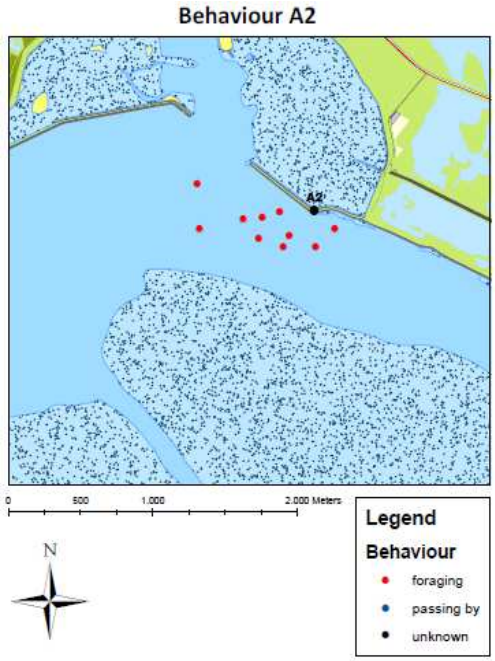


Figure 3.6: Behaviour of harbour porpoises on location A2. From a total of ten sightings the individuals of all sightings were foraging.

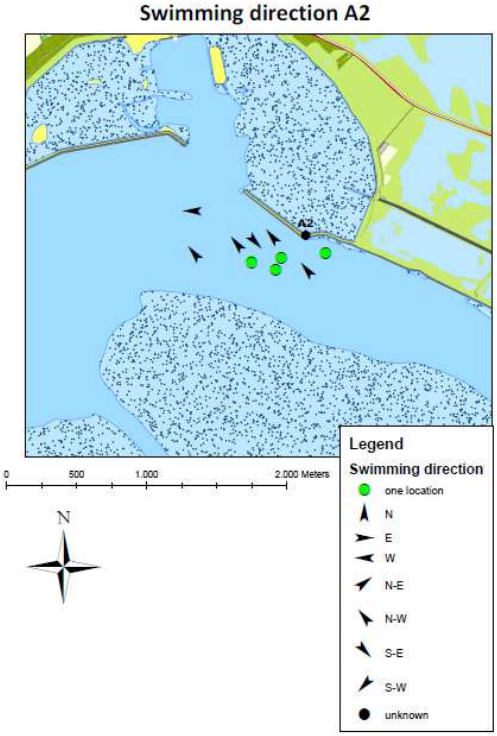


Figure 3.7: Swimming direction of harbour porpoises on location A2. From a total of ten sightings the individuals of four sightings swam north-west, one swam south-east and one swam west.

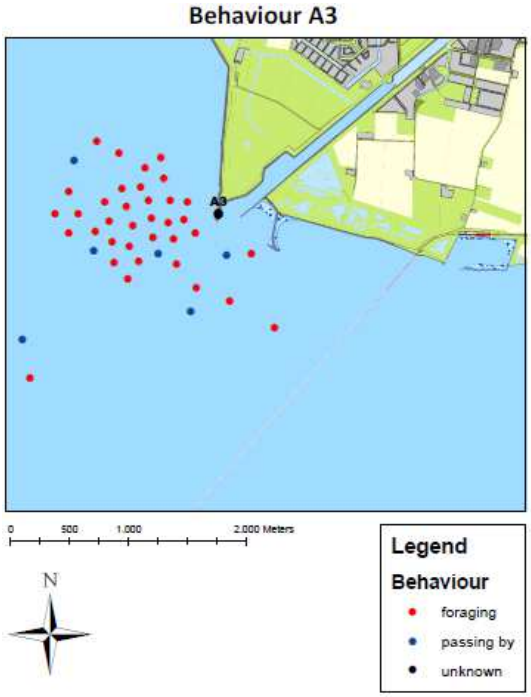


Figure 3.8: Behaviour of harbour porpoises on location A3. From a total of 38 sightings the individuals of five sightings were passing and the rest were foraging.

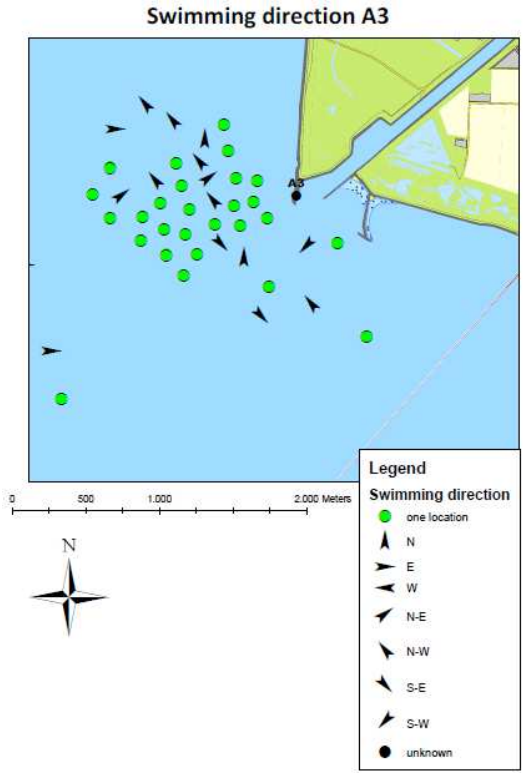


Figure 3.9: Swimming direction of harbour porpoises on location A3. From a total of 38 sightings the individuals of 24 sightings swam on one location. The individuals of six sightings swam north-west

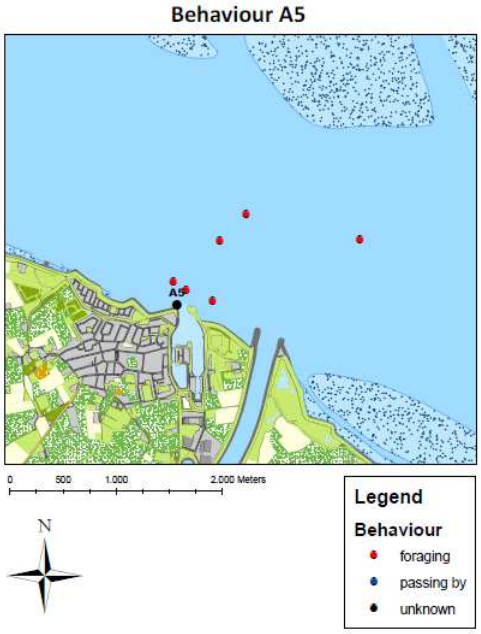


Figure 3.10: Behaviour of harbour porpoises on location A5. From a total of five sightings the individuals of all sightings were foraging.

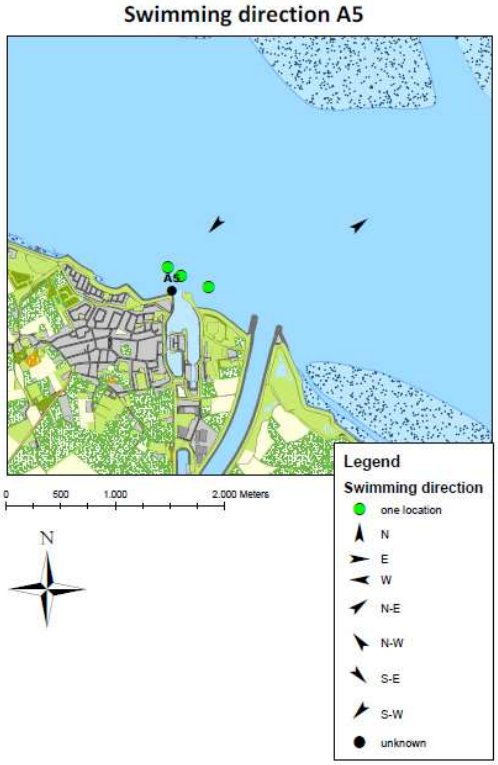


Figure 3.11: Swimming direction of harbour porpoises on location A5. From a total of five sightings the individuals of three sightings swam on one location, one swam south-west and one swam north-east.

3.5 Classification

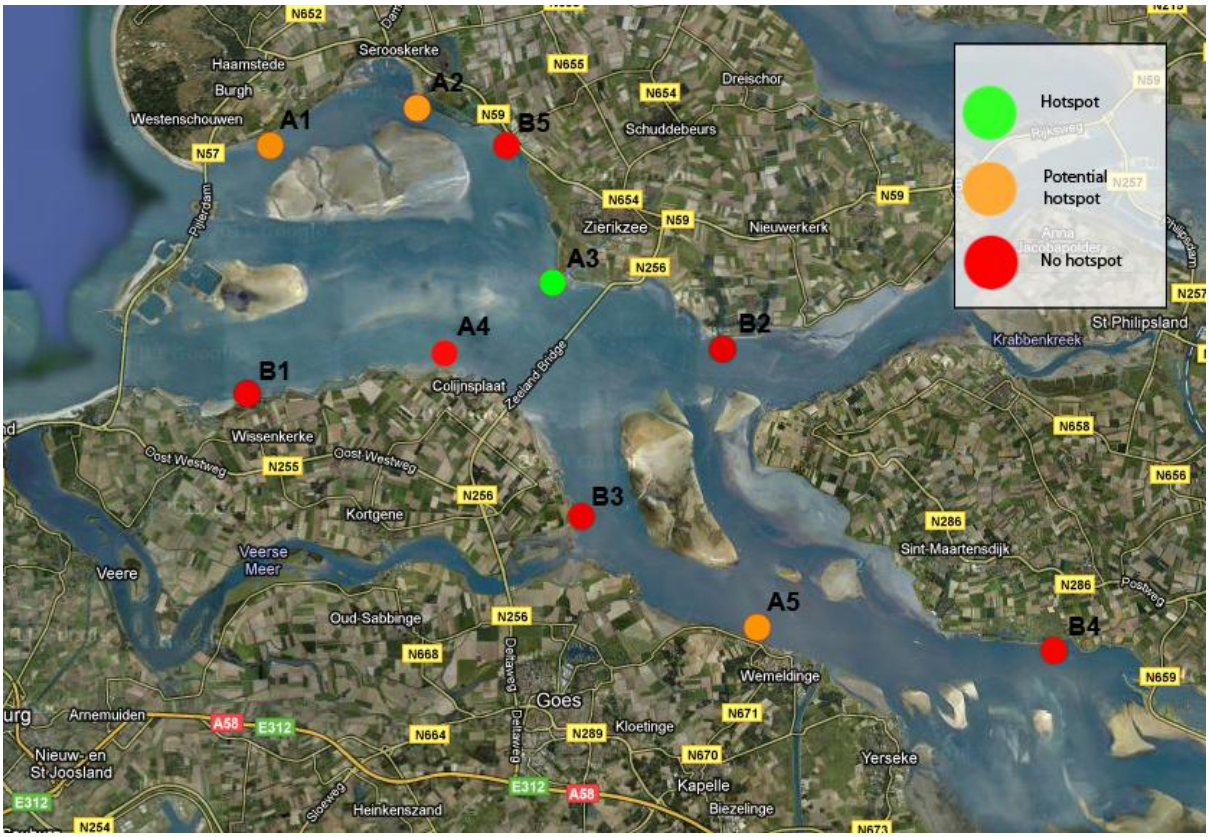


Figure 3.12: Classification (hotspot, potential hotspot and no hotspot of all ten locations. Out of ten locations three are potential hotspots (A1, A2 and A5) and one is a hotspot (A3) for harbour porpoises in the Oosterschelde.

4. Discussion and conclusion

4.1 Locations

A total of 174 individuals were sighted during this research. This does not mean that the population consists of 174 individuals. All the sightings were put into an Arc GIS map, figure 3.1, to give an overview of all the sightings in the Oosterschelde. Table 3.1 shows that on all B locations a sum of 65 individuals were sighted. The sum of individuals for the A locations was 109 animals. This is almost twice as much as for the B locations. This means that there could be a difference between the A and the B locations, which was expected. Unfortunately inductive statistics could not be used because all locations are not independent from each other. In figure 3.3 the sum of harbour porpoises in per location is shown. Location B3 and A3 have the highest amount of individuals. Location A3 is a location where an "ammunition depot" is situated [Eck et al., 2001]. The depth on that location can be an explanation for harbour porpoises to occur so close to the shore. Unfortunately only one observation could be done for location A2. This was due to bad weather conditions. Two results from the land scan were striking: the second observation on location A4 (where zero harbour porpoises were sighted after eighteen on the first observation) and the second observation on location B3 (34 harbour porpoises sighted while during the first observation only one individual was sighted). Different weather conditions can be the explanation of these unexpected results. It is also a fact that different people have participated in this research, which means that each individual had their own way of observing during the landscan. This can lead to different results. It is not excluded that two observations per location are enough to give a good impression of each location.

The most harbour porpoises were sighted on location A3. Also some harbour porpoises were constantly present on that location. Location A2 is probably a hotspot for harbour porpoises. Location B2 where zero harbour porpoises were sighted is probably not a hotspot. Most calves were also sighted on location A3. This could mean that there are more calves present on that location or on that location it is more likely to see the difference between an adult and a calf. Location A3 is a location where all four fish species occur which can also mean that harbour porpoises with calves choose location A3 as a feeding location.

4.2 Tide

Are there more harbour porpoises present at rising tide than at falling tide?

Table 3.2 shows the amount of harbour porpoises per tide phase. Most harbour porpoises were sighted in phase 1 (60 individuals) and phase 6 (57 individuals) (Table 3.3). During phase 4 only three individuals were observed. The output of the chi-square test was 0.000 which means that there is a significant difference between the six separate phases. Previous research shows that porpoises use strong tidal currents during foraging [Watts & Gaskin, 1985] because these currents concentrate fish, which is funnelled towards the waiting porpoises [Pierpoint, 2008]. They also use their echolocation more often when the tide is falling because it costs more energy for them to catch fish when the tide is falling [Korpelshoek, 2011] which could mean that they have to come to the surface more often to breathe. This could be an explanation for why harbour porpoises were sighted more often during falling tide.

This research shows that harbour porpoises are more present during falling tide.

4.3 Fish species

***Is the presence of certain** fish **species of influence for a hotspot**?*

The locations where the four chosen fish species occur most of the time (gobies, black bogies, whiting and herring & sprat) can change throughout the year because of their life cycle (mating) or the season. There can also be other factors that have influence on the relation of harbour porpoises to these four fish species.

- *Do harbour porpoises especially occur in areas with gobies (Pomatoschistus)?*
- *Do harbour porpoises especially occur in areas with black gobies (G. niger)?*

Research from the MOO-Project (Appendix 6, Figure 9 and Figure 10) by Stichting ANEMOON shows where gobies occur in the Oosterschelde. These locations where gobies occur match with the locations where harbour porpoises occur. So by looking at the research from the MOO-project, it can be concluded that harbour porpoises choose for a location where gobies occur. This also confirms previous research saying that they consume gobies [Leopold et al., 2011 & Stichting ANEMOON, n.d.]. The spots where these gobies occur can change throughout the years, because harbour porpoises have to eat smaller gobies in autumn then in the winter or spring, because the gobies are in an early stage of their life cycle [Korpelshoek, 2011]. Gobies and black gobies mate during the winter, which may mean that they relocate themselves in the Oosterschelde [Goudswaard, 2011]. They also protect their eggs very intensively and will be very careful and hide themselves, which means that the harbour porpoise may have a hard time finding and catching the (black) gobies [Stichting ANEMOON, n.d.].

- *Do harbour porpoises especially occur in areas with Whiting (M. merlangus)?*

Research from the MOO-Project (Appendix 6 Figure 12) by Stichting ANEMOON shows where whiting occur in the Oosterschelde. These 'hotspots' where whiting occur, match the harbour porpoise hotspots. So by looking at the research from the MOO-project, we can conclude that harbour porpoises choose for a location where whiting occurs. This also confirms previous research saying that they consume whiting [Leopold et al., 2011 & Stichting ANEMOON, n.d.]. The population of whiting in the Oosterschelde is not healthy and often parasitized, whereby the whiting is probably an easy prey for harbour porpoises [Goudswaard, 2011].
For all fish species counts that there is only data available from the coastline along the Oosterschelde. Data from the inner part of the Oosterschelde is still absent, which means that the hotspot of the fish species may have looked different when there is such information available. It is also known that harbour porpoises sporadically started to eat pelagic round fish like sea bass, mackerel and Atlantic horse mackerel [Leopold, 2011]. These fish are not included in this research, but are nevertheless very important in the diet of a harbour porpoise. The harbour porpoise will have to do more effort to capture a sea bass then he needs to do, when he captures seven herring. A harbour porpoise will have to eat less sea bass to get the same amount of nutrition while eating more herring. This is probably the reason why there is more goby, herring and sprat, black goby and whiting found in the harbour porpoise stomachs, then sea bass or mackerel.

- *Do harbour porpoises especially occur in areas with herring and sprat (C. harengus and S. sprattus)?*

Research from the MOO-Project (Appendix 6 Figure 11) by Stichting ANEMOON shows where herring and sprat occur in the Oosterschelde. These 'hotspots' where herring and sprat occur, match the harbour porpoise hotspots. So by looking at the research from the MOO-project, we can conclude that harbour porpoises choose for a location where herring and sprat occur. This also confirms previous research saying that they consume herring and sprat [Leopold et al., 2011 & Stichting ANEMOON, n.d.]. That herring and sprat are commonly found in harbour porpoise stomachs has to do with the fact that these fish are an easy prey to the harbour porpoise, because the populations of herring and sprat of the Oosterschelde are young animals [Stichting ANEMOON, n.d.].

Figure 3.2 shows that calves especially occur on locations A2, A3 and A5. The map of the occurrence of gobies shows that gobies also occur on these three locations (especially locations A3 and A5). This confirms the results of previous research [Leopold et al., 2011].

From the results and the discussion can be concluded that the fish species have influence on the hotspots of harbour porpoises. On location A3, these four fish species all occur in large numbers, which has been shown in earlier research [Korpelshoek, 2011].

4.4 Main question

Where are the hotspots for harbour porpoises in the Oosterschelde?

Table 3.5 shows an overview per location of the fish species that occur on that location, the maximum depth and the amount of harbour porpoises sighted during this research. Location A4 and B2 have no fish species that occur in that area. Therefore these locations are no hotspots. Locations B4 has three fish species that occur in that area but it has a small maximum depth and is therefore also not a hotspot. Location B5 also has three fish species that occur in that area and the depth is between 35 and 45 meters that is attractive for harbour porpoises. Although the location has a great depth, the location probably is not a hotspot because the location is situated between shore and a sandbank. Harbour porpoises only use that location to pass by. Two fish species occur in the area of location B1 and in this research the occurrence of fish species is important. Therefore is location B1 not a potential hotspot even though the maximum depth is 45 meters and thirteen harbour porpoises were sighted. On location B3 a total of 35 harbour porpoises were sighted. The most harbour porpoises (34) were sighted on the second observation (during the land scan) due to possible difference in observation and lack of fish species in that area this location is not a potential hotspot. Locations A1, A2, A3 and A5 are the only four locations where all four fish species occur and also have a maximum depth between 25 and 45 meters.

For each of these four locations two Arc GIS maps were made: one with the behaviour of the harbour porpoise and one of the swimming directions of the harbour porpoise. The map of the behavior of the harbour porpoises on location A1 shows that the individuals of four of the five sightings of harbour porpoises are passing by (Figure 3.4). The map with the swimming direction (Figure 3.5) shows that the individuals of two sightings of harbour porpoises are swimming towards the storm surge barrier, which can mean that they are swimming towards incoming fish (tide on that moment is about to rise which means that fish are funneled into the Oosterschelde). The individuals of two other sightings of harbour porpoises are swimming north. They are probably on their way into the Oosterschelde. Because of the sand bank they will automatically pass location A2. The map with the behavior for the harbour porpoises sighted on location A2 (Figure 3.6) show that all the animals sighted on that location are foraging. The map with the swimming direction for location A2 (Figure 3.7) shows that not all harbour porpoises are staying on one location. The individuals of six sightings are actually swimming into a specific direction. This could mean that there are a lot of fish on that location and the harbour porpoises are chasing them. The harbour porpoises that are swimming into a specific direction do not all swim into the same direction. This could mean that the harbour porpoises are not swimming towards another hotspot. Figure 3.8 (Behaviour map for location A3) show that almost all harbour porpoises are foraging. The maps with the swimming direction for these harbour porpoises (Figure 3.9) show that most harbour porpoises are swimming on one location. The harbour porpoises that are swimming into a specific direction are, like the harbour porpoises on location A2, not all swimming into the same direction. This could mean the same as for location A2: harbour porpoises are chasing fish. The behavior of the harbour porpoises from location A5 (Figure 3.10) is for all individuals the same, they are all foraging. The individuals of two sightings of the harbour porpoises are swimming into a specific direction (Figure 3.11). the individuals of one sighting are swimming North-East (away from the shore) and the individuals of one sighting are swimming south-west (towards the shore). The individuals of three sightings of harbour porpoises that are foraging were swimming very close to the shore. This means that fish probably occurs close to the shore on that location.

Figure 3.12 shows a map of the Oosterschelde with hotspots, potential hotspots and no hotspots. The answer on the research question ***"Where are the hotspots for harbour porpoises in the Oosterschelde?"*** is that there is a hotspot for harbour porpoises in the Oosterschelde: location A3. Some of the locations are potential hotspots; these are the locations A1, A2 and A5. This can be explained by four fish species (whiting, (black) gobies, herring and sprat) and the depth of the bottom of the Oosterschelde. Also the hotspot A3 and potential hotspots A1, A2 and A5 are easily accessible by car and bicycle for tourists, which are important factors for Nationaal Park Oosterschelde.

5. Recommendations

This sort of research has never been done in the Oosterschelde and this is a good base for further research. The land scan can be combined with the boat scan from Stichting Rugvin for the best results because people cover a bigger surface [Laake et al., 1997]. It can be attractive for tourists to participate in the boat scan (maybe not as a real observer but so join the observers on the boat). For Stichting Rugvin it could be interesting to place a C-pod near location A3.

For further research on the influence of tide on the occurrence of harbour porpoises, observations should match the tide (for example: first observations in phase 1, 2 and 3 and the next observations during phase 4, 5 and 6). Also satellite-linked transmitters are available that can be used for porpoises [Read et al., 1997].

It is also recommended not to take only the data of all fish species along the coastline, but also from the inner part of the Oosterschelde. This way there will be a view on the whole Oosterschelde for a better view about the hotspots of fish in relation with the harbour porpoise. There can be carry out more research on the content of harbour porpoise stomachs, so there will be known more about what fish species from the Oosterschelde, the harbour porpoise eat the most.

Further research on the influence of occurrence of harbour porpoises is necessary because of getting a better impression the harbour porpoises in the Oosterschelde. Therefore observing should be carried out three times per location for obtaining more reliable statistics.

For tourists location A3 is the most attractive location because it is a hotspot and therefore the best on-shore location to spot harbour porpoises. The location is accessible by car (parking space is available) and from then it is a short walk over a dike to get there. The dike does not have a bicycle path but this will be an idea for the near future. Because harbour porpoises come very close to the shore, the chance to see calves is bigger. It is recommended to keep distance (>20 meters) from the harbour porpoises.

6. References

Chelonia Limited Cetacean Monitoring Systems (2004). 'About the C-POD'. http://www.chelonia.co.uk/about_the_cpod.htm. Consulted 16 January 2012.

Dollinger, P. (1988). *Convention on International Trade in Endangered Species of Wild Fauna and Flora; Identification Manual Vol I. Mammalia*, Switzerland: Secretariat of the Convention.

Eck, G. Th. M. van & Holland, A. M. B. M. & Pagee, ir. J. A. van (RIKZ) (2001). 'Risicobeoordeling Munitiestort Oosterschelde'.

Goudswaard, K. (2011) Personal communication.

Ho, H. & Jürgen Fügel E. & Möhn, H. & Naglschmid, F. (n.d.).*Vissen en andere waterdieren van West- en Midden Europa*, Amsterdam: Readers Digest NV Amsterdam (1986)

Korpelshoek, L. D. (2011). Resident harbour porpoises *Phocoena phocoeas* in the Oosterschelde (Netherlands): their behaviour compared to the behaviour of migratory harbour porpoises in the southern Noth Sea. Unpublished

Leopold M. F. & Jansen O.E. & Beerman, A. S. (2011). *Small prey for big beasts: why do gobies dominate the diet of Dutch harbour porpoises?* unpublished.

Leopold M. F. (2011), Personal communication.

Laake, J. L & Calambokidis, J. & Osmek, S. D. & Rugh, D. J. (1997). 'Probability of detecting harbor porpoise from aerial surveys: estimating g(0)´ in: *Journal of Wildlife Management* , 61(1) 63 75

Ministerie van Economische Zaken, Landbouw en Innovatie (n.d.). Gebiedsdatabase, Natura 2000 'Oosterschelde'. http://www.synbiosys.alterra.nl/natura2000/gebiedendatabase.aspx?subj=n2k&groep=10&id=n2k118. Consulted 30 August 2011.

Nationaal Park Oosterschelde (n.d.). http://www.np-oosterschelde.nl. Consulted 30 August 2011.

Nowak, R. (1999). *Walker's Mammals of the World, 6th Ed. Vol II*, Baltimore: John Hopkins University Press.

Osinga, N. & Zanderink, F. (2009). '*Annual Report 2009*'.

Pierpoint, C. (2008). 'Harbour porpoise (*Phocoena phocoena*) foraging strategy at a high energy, near-shore site in south-west Wales, UK.' in: *Journal of the Marine Biological Association of the United Kingdom,* 88(6): 1167 – 1173.

Read, A. J. & Westgate, A. J. (1997). '' in: *Marine Biology* 130: 315-322

Rice D. W. (1998). *Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy, Special Publication Number 4*, Lawrence, KS. USA.

RIKZ (Rijksinstituus voor Kunst en Zee) (1998). 'Hoe ontstaan getijden?'

Shirihai H. & Jarrett, B. (2006). *Whales, dolphins and seals*, England: A&C Black publishers Limited (2006)

Stichting Deltawerken Online (2004). 'De Deltawerken'. http://www.deltawerken.com/De-Oosterschelde. Consulted 30 August 2011.

Stichting Rugvin (2011). Derde Bruinvisscan Oosterschelde groot succes. http://www.rugvin.nl. Consulted 2 September 2011.

Sportvisserij Nederland (Vissengids) (n.d.), Application.

Watts, P. & Gaskin, D.E. (1985). 'Habitat index analysis of the harbour porpoise (*Phocoena phocoena*) in the southern coastal Bay of Fundy, Canada' in: *Journal of Mammalogy*, 66: 733 – 744.

7. Appendix

Appendix 1: Map with route for the boat scan.

Figure 1: Map with eight routes used for the boat scan.

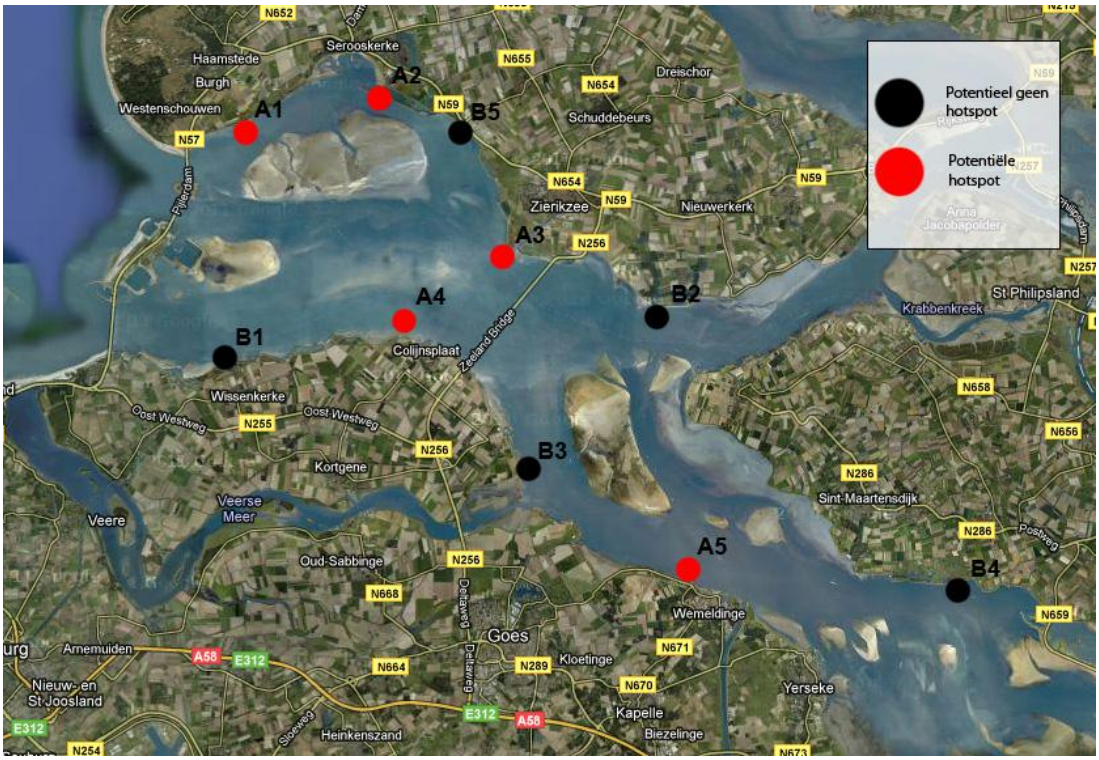
Appendix 2: Information of the land scan Stichting Rugvin 2011

In dit document staan alle tien de observatielocaties weergeven met indien bekend hun coördinaten, gebiedsbeschrijving, foto's van de observatieplek en een screen print uit Google Maps van de locatie met daarop een rode pijl om de exacte zitplek aan te geven.

Tijdens de landscan zal, als het mogelijk is, op elke locatie met twee personen geobserveerd worden met een verrekijker. De observatie duurt acht uur, waarbij de twee personen elkaar om de 20 minuten afwisselen. Ook eten, drinken en eventueel stoelen zijn wel gemakkelijk. Niet bij elke locatie is een toilet beschikbaar!

U heeft een invulformulier gekregen dat ingevuld dient te worden tijdens de landscan (Appendix 4). Wij willen jullie vragen om dit formulier voorafgaand aan de landscan een of twee keer uit te printen (aangezien we jullie niet meer treffen en dus jullie niet zelf de formulieren kunnen overhandigen). Op dit formulier worden de weersomstandigheden, aantal bruinviswaarnemingen e.d. ingevuld.
Belangrijk: Het invullen van de windkracht en de getijden zijn niet nodig, dat zullen wij later zelf invullen. Mochten er nog vragen of onduidelijkheden zijn m.b.t. het invulformulier of iets dergelijks dan horen we dat graag zodat we eventueel nog iets kunnen aanpassen. Onze mobiele nummers staan onderaan dit document.

In het figuur hieronder staan alle tien de observatielocaties globaal weergegeven. Het nummer van de locatie dient ook op het formulier ingevuld te worden.
Tijdens de landscan zullen we maximaal 8 plaatsen kunnen observeren. Dat betekend dat twee locaties niet aan bod komen. Dit zijn locaties A2 en B2.



Figuur 1: Observatielocaties rond de gehele Oosterschelde

Observatielocatie A1

Coördinaten:
Latitude: 51.673432
Longitude: 3.755250

Navigeer naar “nieuwe havenweg”. Bij de haven van Burgsluis kunt u uw auto gratis parkeren. Elke locatie op de kaart aangegeven met een rode pijl. Via Google Maps hebben wij een afdruk gemaakt zodat de straatnamen ook bekend zijn.

Toilet: aanwezig, achter het Restaurant ’t Oliegeultje.

Observatielocatie A2

Coördinaten:
Latitude: 51.684457
Longitude: 3.818584

LET OP: wij hebben deze locatie nog niet bezocht dus we weten niet in hoeverre dit punt bereikbaar is met de auto!
Navigeer naar de “hoosjesweg” in Serooskerke Schouwen. Als u deze helemaal af rijdt kun u (hopelijk) u auto parkeren en een stuk de arm op lopen.
Toilet: onbekend (waarschijnlijk niet)

Observatielocatie A3

Coördinaten:
Latitude: 51.657360
Longitude: 3.919912

U rijdt via de Levensstrijdweg (Zierikzee) de Weldamseweg op, waar zich achter de boerderij een parkeerplaats bevindt. Vanaf de parkeerplaats kunt u via de trap de dijk oversteken. Ga bovenop de dijk links en loop deze uit tot het havenlicht (kleine vuurtoren) zichtbaar is. Let op: u moet door het hek gaan waar op staat; 'Schapen. Honden aan de lijn'. Op de punt waar de vuurtoren staat wordt geobserveerd (zie foto).
Toilet: niet aanwezig.

Observatielocatie A4

Coördinaten:
Latitude: 51.605107
Longitude: 3.83306

Navigeer naar ‘west zeedijk’ in Colijnsplaat. U komt uit bij camping ‘Orisant’ waar u uw auto kunt parkeren. Loop recht over de camping (houdt bij het informatiehuisje rechts aan) tot u uitkomt bij de dijk met een trap. Neem de trap over de dijk en u ziet een picknicktafel in het gras (zie foto).
Toilet: aanwezig, op de camping. (5 min. lopen)

Observatielocatie A5

Coördinaten:
Latitude: 51.574339
Longitude: 3.889286

Stel op uw navigatie ‘promenade Wemeldinge’ in. Eenmaal aangekomen bij de promenade kunt u parkeren aan de dijk of in de woonwijk. Loop nadat u geparkeerd heeft richting water (haven), waarna u doorloopt tot het puntje van de havenarm (nabij een klein huisje met schilderijen van boten e.d.). Op dit puntje loopt een fietspad en links van dit punt ligt een klein strandje zichtbaar bij eb. In de bocht van het fietspad is de beste plek om plaats te nemen. (zie foto)
Toilet: als ze er zijn, vriendelijk vragen bij de mensen in het “boten” huisje.

Observatielocatie B1

Coördinaten:
Latitude: 51.592579
Longitude: 3.718664

Navigeer naar Sophia Boulevard in Kamperland. U komt aan in de Roompot Marina haven en kunt hier gemakkelijk uw auto parkeren. Loop vervolgens links via de dijk naar de linkerarm van de haven, tot op de punt. Vanaf hier heeft u goed zicht op de passerende bruinvissen. (zie foto)
Toilet: aanwezig, tegenover de parkeerplaats in hetzelfde gebouw als de winkel met boot onderdelen e.d. (10 min lopen)

Observatielocatie B2

Coördinaten:
Latitude: 51.615437
Longitude: 3.986499

LET OP: op deze locatie hebben we ook nog niet bezocht.
Nagiveer naar: restaurant “de vierbannen” in Ouwerkerk. U kunt daar waarschijnlijk uw auto parkeren. Daarna loopt u de we van de buitenlandse pers af en dan komt u uit op een hoek. Het is onbekend of u daar een prettige zitplaats zult hebben.
Toilet: onbekend (Misschien bij het restaurant)

Observatielocatie B3

Coördinaten:
Latitude: 51.576400
Longitude: 3.891549

Navigeer naar bestemming ‘veerhaven’ in Kats. U kunt parkeren bij restaurant ‘De Katse Kaai’ in de haven (u moet door een automatisch sluitend hek). Vanaf daar loopt u het hek weer uit, de trap op en daarna naar rechts. U moet door twee hekken heen die daar staan i.v.m. schapen. Loop het grindpad uit en vervolg uw weg over het gras naar het water. U komt uit op een hoek waar u goed zicht heeft over een groot deel van de Oosterschelde. (zie foto)
Toilet: aanwezig, in het restaurant in de haven (5 min. lopen)

Observatielocatie B4

Coördinaten:
Latitude: 51.521693
Longitude: 4.144206

Navigeer naar de bestemming ‘scheldestraat’ in Strijenham. U kunt hier uw auto parkeren. U loopt vanaf de parkeerplaats richting dijk waar u via de trap de dijk oversteekt. Loop daarna rechts en blijf rechts aanhouden langs het kleine vuurtorentje tot u op een hoek bij een bankje uitkomt (ongeveer 10 minuten lopen). Indien de werkzaamheden aan de dijk nog bezig zijn is het niet aan te raden om plaats te nemen op dit bankje, maar enkele meters ervoor. U heeft hier goed zicht op de Oosterschelde.
Toilet: niet aanwezig.

Observatielocatie B5

Coördinaten:
Latitude: 51.473006
Longitude: 3.849317

Navigeer naar ‘boogerdweg’ nabij Serooskerke en Zierikzee. U kunt parkeren bij restaurant ‘de Heerenkeet’. Loop vanaf de Heerenkeet de dijk op (nogsteeds Boogerdweg) en blijf deze volgen tot u een bord tegenkomt ‘dijk niet toegankelijk i.v.m. dijkversteviging’. Loop hier ook recht door (dus niet rechtsaf de inlaagweg op). Loop door tot het puntje van deze dijk (linkerarm van een bekken). Op de andere arm tegenover u ziet u een vuurtoren/havenlicht staan. Als u dan naar rechts kijkt zie u wat op de foto staat.
Toilet: aanwezig is het restaurant (10 min. lopen)

Wij, Sophie en Lotte, wensen jullie veel plezier bij het observeren en we hopen op (mooi weer en) een mooi resultaat!

Maak bij het vinden van een gestrande bruinvis (dood of levend) melding bij de EHBZ: 06 537 636 28

Mobiele nummers:
Sophie: 06 10 53 76 83
Lotte: 06 38 21 50 31

Appendix 3: Map with route for boat scan.

Figure 2: Annual boat scan Stichting Rugvin 2009

Figure 3: Annual boat scan Stichting Rugvin 2010

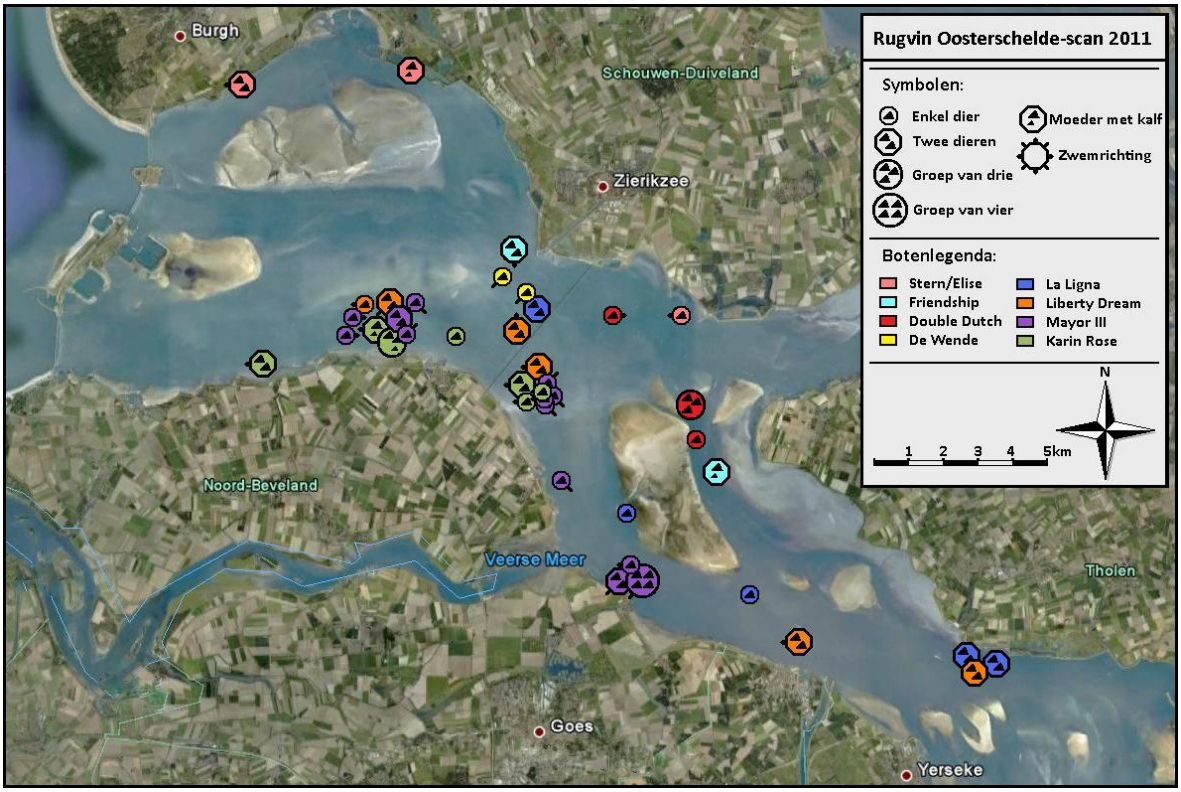
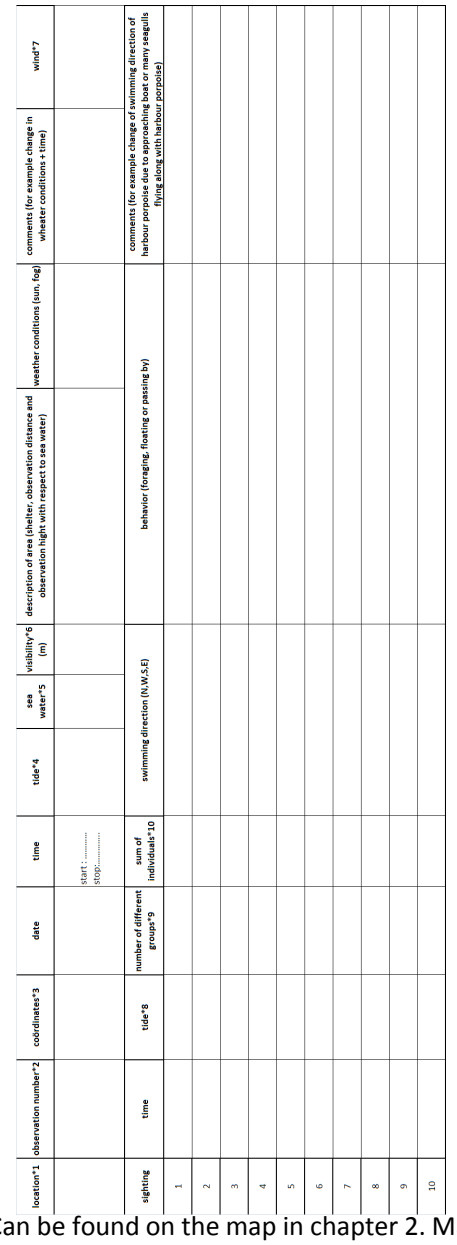


Figure 5: Annual boat scan Stichting Rugvin 2011

Appendix 4: Field form



location*1	observation number*2	coördinates*3	date	time	tide*4	sea water*5	visibility*6 (m)	description of area (shelter, observation distance and observation hight with respect to sea water)	weather conditions (sun, fog)	comments (for example change in wheater conditions + time)	wind*7
				start : ..... stop:.....							

sighting	time	tide*8	number of different groups*9	sum of individuals*10	swimming direction (N,W,S,E)	behavior (foraging, floating or passing by)	comments (for example change of swimming direction of harbour porpoise due to approaching boat or many seagulls flying along with harbour porpoise)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

*1= name of observation location. Can be found on the map in chapter 2. Materials and Methods
*2=the number is 1 when it is the first observation and 2 when it is the second observation (on that specific location)
*4= time on that day when it will be high tide and low tide (along with water level in meters)

*5= scale from 1 to 5 with 1=no wrinkles on the water, 2=light wrinkles, 3=small waves of plus minus 10 cm high, 4=waves of plus minus 30cm high and 5= waves higher than 50 cm.
*6= distance of visibility in meters

*7= wind (knots) noted on the day of the observation [Source : http://www.windfinder.com/forecasts/]

*8= height of sea water on that moment [Source : http://www.getijvoorspellingen.nl/index.cfm?page=getijvoorspellingen2]
*9= an observation may consist of several groups of harbour porpoises

*10= number of animals per group. For example, there are 3 groups of respectively 3, 2 and 1 harbour porpoise (sum of harbor porpoise is 6) write down as followed: 3-2-1

Appendix 5: Example observation

Lokale datum	Zondag, nov 13							
Lokale tijd	01h	04h	07h	10h	13h	16h	19h	22h
Windrichting								
Windsnelheid (Knots)	9	10	9	11	11	10	10	9
Windvlaag (Knots)	10	12	11	13	14	14	12	10
Wolkendek								
Neerslag (mm/3h)	0	0	0	0	0	0	0	0
Luchtdruk (hPa)	1031	1031	1031	1031	1030	1029	1029	1028
Luchttemperatuur (°C)	11	10	9	9	11	11	9	9

Figure 6: Observation A1 – 1

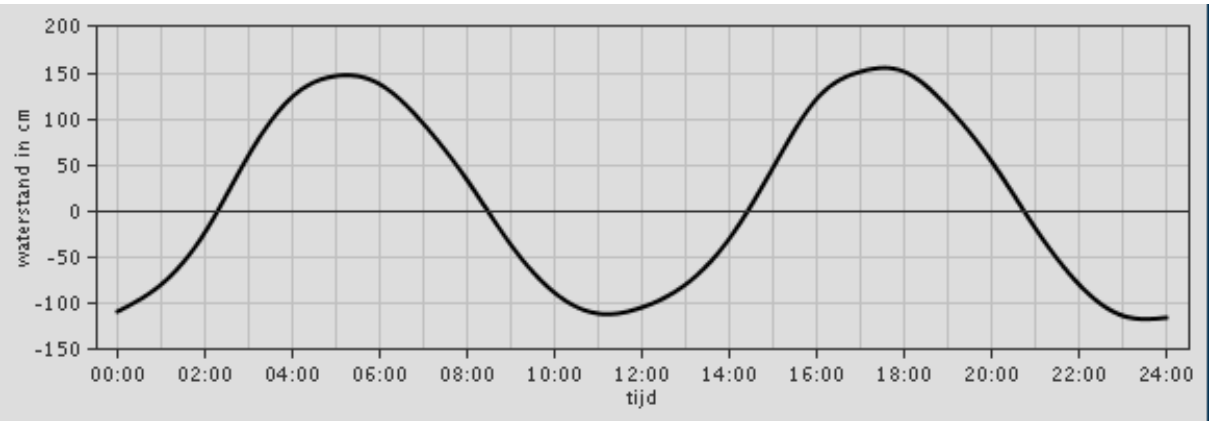


Figure 7: Observation A1 – 1

location*1	observation number*2	coördinates*3	date	time	tide*4	sea water*5	visibility*6 (m)	description of area (shelter, observation distance and observation hight with respect to sea water)	weather conditions (sun, fog)	comments (for example change in wheater conditions + time)	wind*7
A1	1	/	14 october 2011	start : 10:25 stop: 16:25	High: 05:26 (149cm) and 17:35 (155cm) Low: 11:10 (-111cm) and 23:30 (-117cm) (ROOMPOT BINNEN)	2 to 3	4 kilometers		sunny, cold, glare.		08:00: 10, 11:00: 10, 14:00: 10, 17:00: 11, 20:00: 13.

sighting	time	tide*8	number of different groups*9	sum of individuals*10	swimming direction (N,W,S,E or one location)*11	behavior (foraging, floating or passing by)*11	comments (for example change of swimming direction of harbour porpoise due to approaching boat or many seagulls flying along with harbour porpoise)
1	10:35	-110	1	1	W	Passing by	Lost in glare
2	11:05	-120	1	1	N	Passing by	Far away
3	11:25	-115	1	2	N	Passing by	Far away
4	14:25	5	1	1	W	Passing by	Seen under water

Figure 8: Fieldform A1 – 1

Appendix 6: Fish species

Gobies (*Pomatoschistus*)
Gobies are members of the family Gobiidae, which exist of more than 2000 species and are one of the largest families of fish. Most gobies grow up to ten centimeters. Gobies such as black goby, sand goby and common goby are found in the North Sea, Atlantic Ocean and East Sea [Sportvisserij Nederland, n.d.].

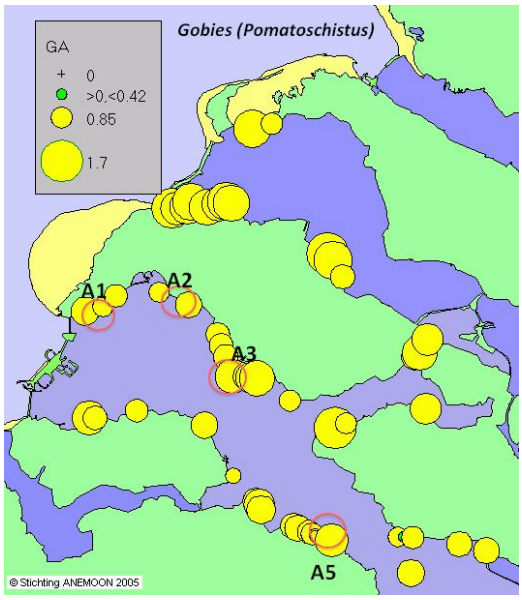


Figure 9: Dispersion in numbers of gobies in the the Oosterschelde where locations A1, A2, A3 and are highlighted.

Black goby (*G. niger*)
The black goby is a member of the Gobiidae family. It can reach a length of 18 centimeters. A female black goby is spotted and a male black goby has large dorsal fins. The black goby is the largest native goby with its large head and swollen lips and it can be found in the North Atlantic Ocean, North Sea and East Sea. On the Dutch coastline it is very rare, but it can be found in large numbers in Zeeland in the Oosterschelde. Their main diets consist of worms and small crustaceans [Sportvisserij Nederland, n.d.].

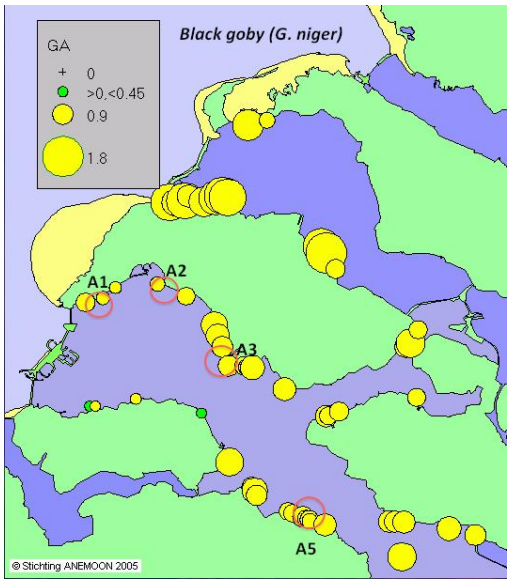


Figure 10: Dispersion in numbers of gobies in the the Oosterschelde where locations A1, A2, A3 and are highlighted.

Herring *(C. harengus)*
The herring is a member of the Clupeidae family and can be found in the Atlantic Ocean, North Sea and East Sea. Not far from the Dutch coastline live a lot of juvenile herring. They live in large schools up to 200 meters depth and feed on krill, copepods and smaller fish. They can grow up to 54 centimeters and have 51 to 6 scales between the head and tailfin [Sportvisserij Nederland, n.d.]

Sprat *(S. sprattus)*
Sprat is also a member of the Clupeidae family. Sprat can be found in most European waters like the North Sea, Atlantic Ocean and East Sea. They mainly feed on krill. Sprat lives in schools up to a depth of 150 meters and can also be found in brackish waters [Sportvisserij Nederland, n.d.].

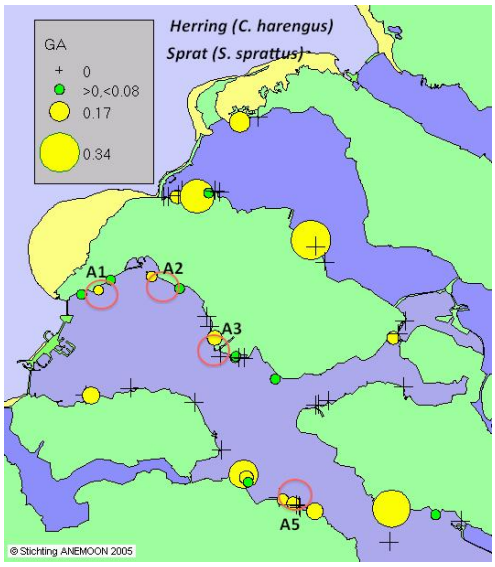


Figure 11: Dispersion in numbers of gobies in the Oosterschelde where locations A1, A2, A3 and are highlighted.

Whiting (*M. merlangus*)
Whiting can reach a length of 70cm and has three dorsal fins and two anal fins with a dark side line. It has an inferior mouth with pointed snout without chin threads and long pointy teeth. There is a dark stain above the base of the pectoral fins. The whiting is found in the Northeast Atlantic, North Sea and the Baltic Sea. He is fairly common along the Dutch coast and lives mainly on shrimp and other fish. The whiting is found on the bottom at depths from the coastal zone up to 300 meters. Reproduction takes place from spring well into summer [Sportvisserij Nederland, n.d.].

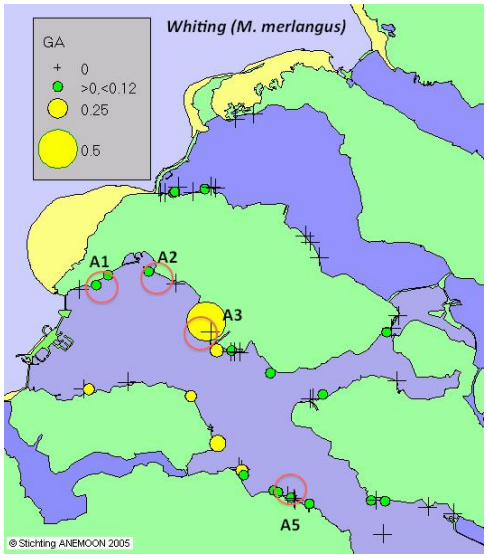


Figure 12: Dispersion in numbers of gobies in the the Oosterschelde where locations A1, A2, A3 and are highlighted.

Appendix 7: Depth chart of the Oosterschelde

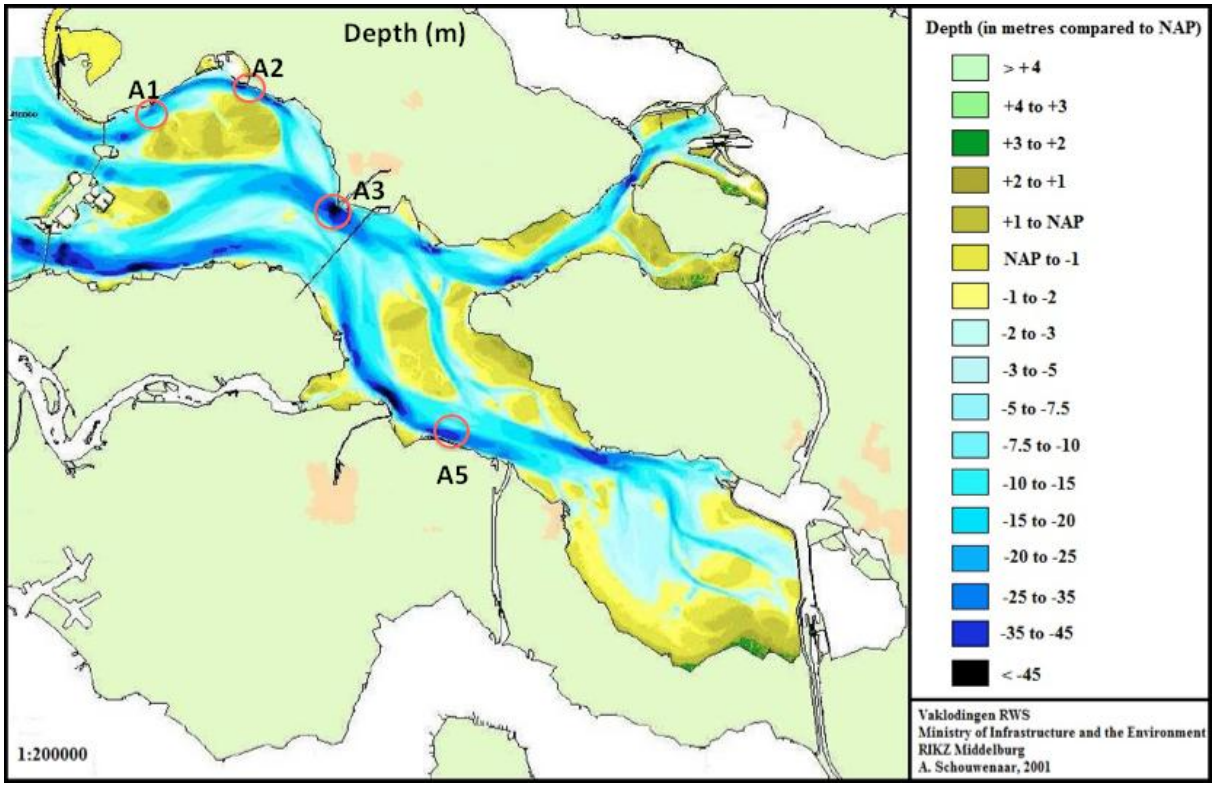


Figure 13: Depth chart of the Oosterschelde in meters compared to NAP where observation locations A1, A2, A3 and A5 are highlighted.