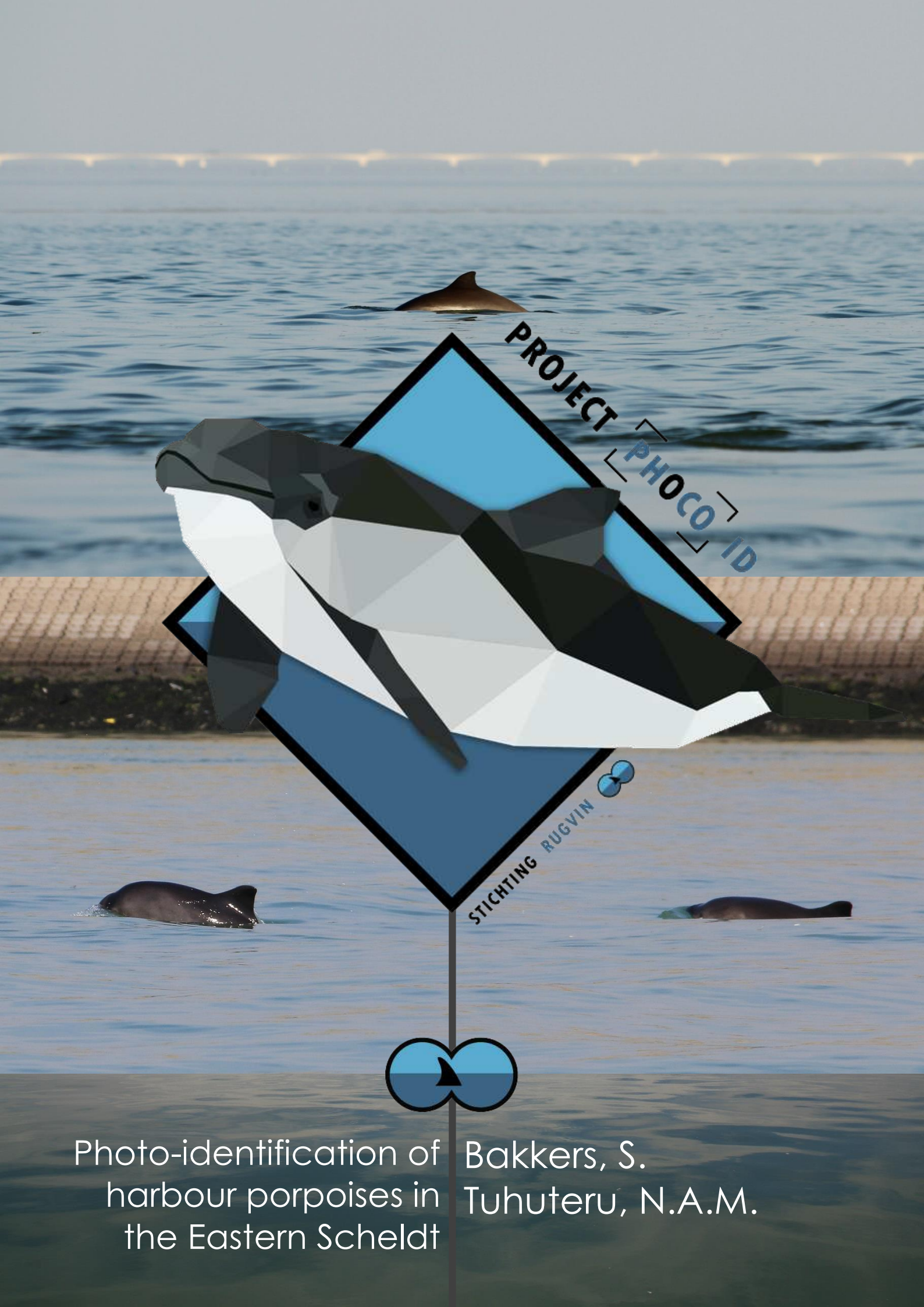

Photo-identification of harbour porpoises in the Eastern Scheldt

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Project [Phoco-id] Photo-identification of harbour porpoises in the Eastern Scheldt

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Abstract

This exploratory report was commissioned to assess the feasibility of a harbour porpoise photo-identification study in the Eastern Scheldt, examine what approaches are (most) effective for collection of the highest possible quantity of photograph suitable for positive identification of harbour porpoise individuals, and to present and discuss possible follow-up strategies for this project in 2016 and beyond. A comparative analysis of fieldwork methodology and results was carried out. The long term aims of the dedicated harbour porpoise photo-identification study in the Eastern Scheldt (henceforth referred to as Project Phoco-ID) is (I.) to increase the general understanding of the harbour porpoise in the Eastern Scheldt and (II.) to shed more light on the cause(s) of the relatively high (starvation-related) mortality among the species in this area.

Fieldwork for the exploratory phase of Project Phoco-ID was carried out between July and September 2015 in the stretch of water between Burghsluis, Kerkwerve and the Roggenplaat, in the province of Zeeland. This area falls within the slightly larger area used previously for opportunistic photo-identification of harbour porpoises between 2010-2015. During the summer season of 2015, sightings data and photo-identification data were collected during a total of 15 land-based and boat-based surveys (two vessel types: a small RIB (dedicated research vessel) and a medium-sized passenger ship (platform of opportunity; PoP)) in weather conditions of up to 4 Beaufort. A programme was set up to collect additional harbour porpoise photographs from public and other external sources, and a fully functional photo-identification catalogue coupled to a sightings database were developed. The catalogue and database include the existing 2010-2015 photo-ID data collected between 2010-2015.

The total number of harbour porpoise sightings during the dedicated surveys for this pilot in 2015 was 27 (average group size of 1.6), with most sightings occurring during the peak of high tide. Public input yielded 18 external sightings. Collectively, these 45 sightings resulted in 18 individuals photographed from the left side and 14 individuals photographed from the right side. Of these 45 sightings, 20 sightings concerned re-sightings spread out over three individuals from the left side catalogue and three individuals from the right side catalogue. The well-known and heavily scarred harbour porpoise nicknamed ‘Willem’, which has been sighted since 2011, was re-sighted six times. Although the data set of the summer field season is too small to draw statistically supported conclusions, the harbour porpoises observed in 2015 seem to occupy the entire study area or travel back and forth between specific parts of it (e.g. the deeper parts in the Eastern Scheldt with strong tidal currents that are likely used as foraging grounds). A further and more comprehensive analysis of the photo-ID data including the data collected between 2010 and 2015 will be part of a follow-up study.

For 2016 and onwards, it is advised to combine the four methods tested in 2010-2015, depending on the possibilities and weather conditions per location. Whenever weather conditions allow (maximum of 2 Beaufort), dedicated boat-based surveys (e.g. with the Zeevarken) should be the prime survey platform. Under worse conditions, up to a sea state of 4 Beaufort, land-based and MS Onrust surveys (or other PoPs) are a valuable alternative. Potential points of thought for 2016 include expansion of the photo-ID catalogue, sightings database, study area, and if necessary to accomplish this, expansion of the project team and fleet. Other questions include whether or not to incorporate

distance sampling and (line) transect surveys in the study design. However, in order to do that the catalogue and sightings database need to get bigger first. The latter would also require a larger dedicated research vessel and most likely a licensed skipper. A larger research vessel may also have benefits for photo-ID work. Important action points for the project in 2016 are to continue data collection and further discuss and investigate the potential points of thoughts and questions stated in this report.

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1. Introduction

1.1 Background & problem statement

The harbour porpoise (*Phocoena phocoena*) is the most commonly found cetacean in Dutch coastal waters with an estimated population of circa 41,299 animals in 2015 (Geelhoed *et al.* 2015). After a decline and near extinction in the 1950s and 1960s, the species made its comeback. Particularly since the mid-1990s with peaks in sightings and strandings in 2006 and 2013 respectively (Camphuysen *et al.* 2008; Scheidat *et al.* 2012; CBS *et al.* 2014). Harbour porpoises have also returned to the Eastern Scheldt, a former estuary located in the south-western part of the Netherlands, where the species used to be frequent visitor. After an absence of several decades following the construction of the storm surge barrier, the harbour porpoise now seems to be more abundant than before in this area (Camphuysen *et al.* 2008; Reijnders *et al.* 2009).

The Rugvin Foundation (Stichting Rugvin), established in 2007, has been studying harbour porpoises in the Eastern Scheldt since 2008, in collaboration with WWF (World Wildlife Fund) Netherlands. The research has so far included acoustical research using C-PODs, annual porpoise surveys and photo-identification (started in 2010). Furthermore, education and awareness related activities have been carried out.

The fairly high starvation-related mortality among harbour porpoises in the Eastern Scheldt and the presence of the storm surge barrier, have raised concerns that the Eastern Scheldt may be functioning as an ecological trap, potentially putting the local 'population' (if at all a discrete unit) in this area at risk (Stichting Rugvin, 2015a). The Rugvin Foundation has therefore set the aim to increase the general understanding of the harbour porpoise in the Eastern Scheldt and to shed more light on the cause(s) of the fairly high mortality rate. In this light, the foundation implemented a dedicated harbour porpoise photo-identification study in the Eastern Scheldt in the summer of 2015. This study continues an earlier photo-identification study carried out between 2010 and 2013 in the same area.

1.2 Harbour porpoise in the Eastern Scheldt

The number of harbour porpoises found in the Eastern Scheldt is small with annual population counts in the Eastern Scheldt ranging from 15 to 61 animals between 2010 and 2015. In 2014 and 2015, 35 and 29 animals were counted respectively. Casual sightings and survey results indicate a year-round presence in the area. (Zanderink & Osinga, 2010; Osinga & Zanderink, 2015; Stichting Rugvin, 2015b; W.J. Strietman, pers. comm., 26 January 2016).

The Eastern Scheldt – once an estuary, now considered a tidal bay – has been greatly altered in the past by the construction of the Deltaworks between 1950 and 1997. The construction of two large auxiliary compartment dams in the rear ends (Oesterdam and Philipsdam, 1977-1987), for instance, has isolated the Eastern Scheldt from the nutrient-rich, freshwater input from the rivers Scheldt and Rhine. This led to a higher water salinity and lower nutrient conditions (Nienhuis & Smaal, 1994). Between 1979 and 1986, a storm surge barrier with sluices was constructed to protect the Netherlands from North Sea flooding (Nienhuis & Smaal, 1994; Stichting Deltawerken Online, 2009). Although the tidal influence and direct connection with the North Sea have been retained through the sluices, the construction reduced the tidal exchange with the North Sea, creating more sheltered conditions. The collective change in abiotic conditions led to alterations in habitats, phytoplankton community structure and species distribution (Nienhuis & Smaal, 1994).

After the construction of the storm surge barrier, the harbour porpoise had not been observed in the Eastern Scheldt for a few decades. Their return to this area was noted only approximately 10-15 years ago, at the beginning of the 21st century (Zanderink & Osinga, 2010; Jansen *et al.* 2013). It is now suspected that the small and narrow sluice openings have reduced migration options for harbour porpoises between the North Sea and the Eastern Scheldt (W.J. Strietman, pers. comm., 26 January 2016). With the storm surge barrier forming a potential impediment for harbour porpoises migrating back into the North Sea, it is thought that the Eastern Scheldt may function as an ecological trap (Stichting Rugvin, 2015a). This hypothesis is supported by a stable isotope analysis of stranded harbour porpoises carried out by Jansen *et al.* 2013. This study showed that individuals in the Eastern Scheldt likely do not leave the basin to forage in the North Sea and that a continuous influx of animals from the North Sea is probable. At the same time, the study found no indications for a life-long residency within the Eastern Scheldt. Mothers with young calves and neonates (most likely born in the Eastern Scheldt) have, however, been observed in the basin on multiple occasions (Zanderink & Osinga, 2010; Jansen *et al.* 2013; personal observations of the authors). This includes individuals which have been recorded within the Eastern Scheldt for longer time periods (WJ Strietman, pers. comm., 28 April 2016. An acoustic study with C-PODs suggests that migration to the North Sea through the storm surge barrier does take place, but scantily (Rodrigues, 2014).

Knowledge of habitat use in the Eastern Scheldt is lacking, apart from the information obtained from the photo-identification work carried out by Strietman (2010-2014) and the 'hotspots' that have been identified by Neitzel & Niemeijer (2012). In this latter study, hotspots were defined as locations where harbour porpoises occurred throughout the entire day and at least 20 individuals were sighted per six hours. Applying findings from other study areas to the harbour porpoise in the Eastern Scheldt may be inappropriate as habitat use of harbour porpoises seems to differ greatly among places in the North Atlantic. However, the species is often associated with habitats characterised by complex bathymetry and a high diversity of substrates and fish communities (BjØrge, 2003; Camphuysen & Siemensma, 2011). There is some evidence for seasonal or temporary sexual segregation in habitat use between adult males and mother-calf pairs in the Baltic Sea, North Sea and the north-western Atlantic Ocean. This is most likely related to differences in dietary requirements resulting from pregnancy and lactation (MØhl-Hansen, 1954; Neave & Wright, 1968; Verwey, 1975; Smith & Gaskin, 1983; Recchia & Read, 1989).

1.3 Photo-identification of harbour porpoises

Photo-identification studies rely on images of individuals bearing sufficient, unique and long-lasting marks or other distinguishing features (Hammond, 1986; Würsig & Jefferson, 1990). Harbour porpoises are dark (sometimes light brownish) grey on the dorsal side, contrastingly white on the ventral side with a whitish colouration sweeping up to the mid flanks in a mottled pattern (referred to as the flank pattern). This pattern seems to be unique to individuals, much like a human finger print, and can be used to distinguish between individuals (WJ Strietman, pers. comm., 26 January 2016). Other than the flank pattern, individuals often lack obvious natural markings that can be used for photo-identification (BjØrge & Tolley, 2002; Shirihai & Jarrett, 2006).

Additionally, their small size and typically timid behaviour makes them difficult to observe. During surfacing bouts, the water surface is broken only briefly with a rolling motion ('wheeling') and, generally, merely the top of the head, dorsal fin and a small part of the back become visible (Amundin, 1974; Schulze, 1987). Bow-riding and breaching is rarely observed in the species and they tend to avoid (especially loud) motor boats. Sailing vessels, surfboards and kayaks, on the other hand, may occasionally be approached (Camphuysen & Van der Avoirt, 2008; Camphuysen & Heijboer, 2008). Harbour porpoises are usually found solitary or in small groups of 2-4 animals, though from time to time larger groups may be observed. Congregating for foraging activities rather than for social reasons, they are thought to be fairly solitary animals (Pinnell *et al.* 2004). All in all,

social organisation of the harbour porpoise remains poorly understood (Lockyer & Kinze, 2000; Andersen *et al.* 2001).

Due to the lack of obvious natural markings and their timid behaviour, the number of photo-identification studies of harbour porpoises has been limited. The first photo-identification study carried out in the Eastern Scheldt started by coincidence. Since little was known about the harbour porpoises in the Eastern Scheldt, along with the annual harbour porpoise surveys, a dedicated field research was started and pioneered in 2010 by Wouter Jan Strietman (Rugvin Foundation). By photographing the individuals encountered during opportunistic trips, it was noticed that individual porpoises could be individually recognised by their unique flank patterns (along with nicks and scratches). Based on this experience, a photo-ID catalogue was developed in 2010.

In 2010, photo-identification research on harbour porpoises was rather unique. The few other studies proving that photo-identification based studies can be successfully applied to this species, include projects run by Golden Gate Cetacean Research in San Francisco Bay (Keener *et al.* 2013) and Pacific Mammal Research in the Salish Sea (PacMam, 2015).

The photo-identification research carried out between 2010 and 2014 showed that this kind of research is feasible in the Eastern Scheldt as the animals are found close to land, tend to feed at certain hotspots for longer time periods, and are relatively easy to find within this area. In addition, it concerns a small group of harbour porpoises (Osinga & Zanderink, 2015; Stichting Rugvin, 2015b). More importantly, the (semi-)enclosed nature of the Eastern Scheldt makes for an interesting study area to pioneer with harbour porpoise photo-identification, since the chances of encountering the same individuals are likely to be much higher than in other (more) open study areas. Based on these experiences, a plan was made by the Rugvin Foundation to initiate a pilot study investigating whether a dedicated photo-identification study of the harbour porpoises in the Eastern Scheldt was feasible.

1.4 Research Objectives

The follow up to the 2010-2014 photo-identification study, henceforth referred to as Project Phoco-ID, took place between July and September 2015. The main objectives of the exploratory phase of this project were:

- To develop a photo-identification catalogue coupled to a sightings database for harbour porpoises in the Eastern Scheldt (2010-2014 sightings and 'public' (external) sightings included). ;
- To analyse data collected in 2015 in context of Project Phoco-ID and present preliminary results;
- To examine what approaches are (most) effective for collection of the highest possible quantity of photographs suitable for positive identification of harbour porpoise individuals;
- To develop manuals on photo-identification, data(base) management and boat handling procedures;
- To present and discuss possible follow-up strategies for Project Phoco-ID in 2016 and beyond.

This report describes the steps taken since the start of the follow up in 2015, including the development of a harbour porpoise photo-identification catalogue, a sightings database and accompanying manuals. It also examines which of the research methods tested in 2015 were (most) effective for the photo-identification study of harbour porpoises in the Eastern Scheldt and how this relates to possible follow-up strategies for Project Phoco-ID in 2016 and beyond.

2. Methods

2.1 Study area

The study area consisted of a 10 km stretch of water within the Eastern Scheldt (Figure 1 a/b). This narrow body of water is 300-800 meter wide, with depths varying from 25-45 meter. The study area is located within the slightly larger are where a photo-ID surveys have been taking place since 2010. Within the research area the focus has been on the potential hotspots (henceforth referred to as hotspots) near the harbour of Burghsluis and coast of Schelphoek. Both hotspots are known to feature prey species and have appropriate depths for foraging with one located near the opening of the harbour of Burghsluis and the other located nect to the dike at Weversinlaag.

Neitzel & Niemeijer (2012) studied the existence of potential hotspots for harbour porpoises in the Eastern Scheldt. A hotspot is defined as a place where more than 20 harbour porpoises occur throughout the day per six hours, whilst also taking into account the occurrence of certain prey fish species (gobies (*Pomatoschistus*), black gobies (*Gobius niger*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and whiting (*Merlangius merlangus*); Santos & Pierce, 2003) and location depth. Out of the ten locations studied, Neitzel & Niemeijer found one clear hotspot, located near the harbour of Zierikzee. Three other potential hotspots were defined where both the offer of prey fish species present and the depth (25-45 m) was considered favourable.

2.2 Fieldwork

Fieldwork for this study took place in the summer of 2015 starting in July and continuing until September. Boat-based surveys were conducted with a small rubber zodiac, named Zeevarken. This low-lying vessel seats three people. Due to the size and height of the research vessel, and the possibility to safely and effectively conduct photo-ID surveys, fieldwork was highly weather dependent and only conducted when weather conditions were considered favourable (Beaufort Sea State (BSS) ranging between 0 and 2, visibility of at least 1 km; Appendix 1). Therefore, weather conditions were checked every day using different online sources such as Windguru, Windfinder and Weeronline. If weather conditions were not good enough for fieldwork with the Zeevarken, boat-based surveys utilising the MS Onrust or land-based surveys were considered. Surveys aboard the medium-sized passenger ship MS Onrust were conducting if the BSS ranged between 3 and 4, land-based surveys were carried out if the BSS ranged between 2 and 3.

At the start and end of each survey (both boat- and land-based), time and weather conditions were noted on a **survey form** (Appendix 2). Weather changes during a survey were also noted on this form. When harbour porpoises were encountered within a 100 m radius, an **encounter form** (Appendix 3) was filled in (Appendix 3). This form features weather conditions (including BSS, sunny/cloudy, visibility etc.), start and end time of the encounter, coordinates, number of individuals, behaviour(s) and if possible the age class(es) of the individual(s). Two observers attempted to take as many pictures as possible during encounters using SLR cameras with 300 mm optic zoom lenses.

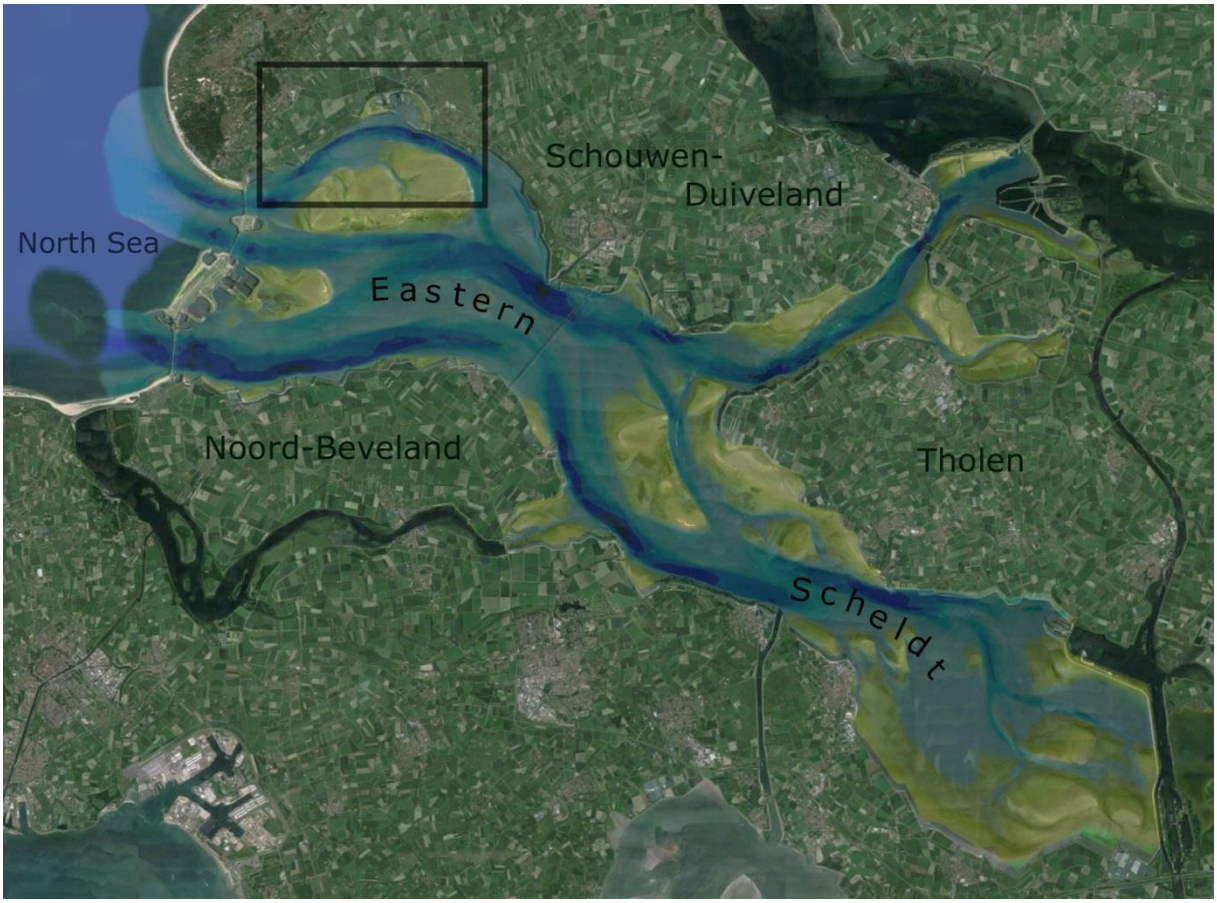

Figure 1 (a). Geographical map of the Eastern Scheldt with the study area outlined in black. (b). Study area zoomed-in; line = Route of the MS Onrust passenger ship, circle = hotspot, triangle = viewpoint for land-based surveys.

2.2.1 Boat-based

Zeevarken

The Zeevarken is a small 3.3 m long, motor operated (dedicated) research vessel. In 2015, it was temporarily docked at the harbour of Burghsluis. To operate the vessel properly, a vessel protocol was made and carefully followed (Bakkers & Tuhuteru, 2016c). A survey started when the boat left the harbour. At this point, a survey form was filled in and the GPS was set to track the survey route. Each survey followed a different route, sailing toward one of the hotpots and sailing around the hotspot location. The three observers on the boat continuously scanned the water for harbour porpoises using binoculars and the naked eye. Each observer covered a different section around the boat, making sure the whole 360° view around the boat was covered. Every now and then the engine was turned off to enable picking up sounds of surfacing harbour porpoises.

MS Onrust

In cooperation with the recreational vessel the MS Onrust, boat-based fieldwork was conducted under less favourable weather conditions. Observers were allowed on board for free on non-busy days. Caution was taken to ensure observers did not interrupt any of the tourists on the boat. The MS Onrust is a medium-sized (39 m in length), motor operated passenger ship (recreational touring vessel) docked at the harbour of Burghsluis. In the summer of 2015, the boat carried out daily tours around the Eastern Scheldt at 11:00-12:30h and 13:30-15:00h. To book a trip, the staff of the MS Onrust was called an hour before departure at 10:00h. A survey started when the boat left the harbor. At this point, a survey form was filled in and the GPS was set to track the survey route. Observers were arranged on the front of the upper deck where the view was most optimal. Because of the height of the boat, harbour porpoises could still be spotted in sea states of 3-4 bft. Each time a harbour porpoise was spotted the skipper was notified and the encounter sheet was filled in, whilst the other observers were taking pictures.

Stern

Between 2010 and 2015, the vessel Stern was used for a total of 22 dedicated photo-ID trips. Most of these trips took place in 2011 and 2012. Although it was not used during the summer field season of 2015, it will be included in the comparison of research methods (Zeevarken, MS Onrust and land-based). The Stern is approximately 10m long and 3m wide. Departing from the harbour of Burghsluis, the Stern would sail to Zierikzee and back. Harbour porpoises were slowly approached to obtain photos. Photo-ID approaches of very skittish or unapproachable animals were often abandoned. Sighting data, including sighting time, location and proximity to other individuals, were recorded. On average, 11 harbour porpoises were spotted per trip. This number might, however, include double counted animals. Over the years, 60 individuals were photographed from the left side and 38 from the right side.

2.2.2 Land-based

If weather conditions did not allow for a boat-based survey with the Zeevarken, but BSS was between 2-3 bft, a land-based survey was carried out at the viewpoint Schelphoek (Figure 1b). The best time frame for land-based surveys seemed to be from 15:00-18:00h. Harbour porpoises seemed to be attracted to this location in relation to the strong currents that were most prevalent during this time frame.

2.2.2 Method comparison

In order compare the different survey platforms, the following aspects were analysed: the number of surveys per survey platform, the number of catalogued individuals per survey platform and the photo-identification success per survey platform (percentage of individuals of a sighting that was successfully photographed, one value for left sides and one value for right sides).

2.3 Public Input

In order to gather as many pictures as possible, the public was asked through social media to participate in the project by sending in their pictures from harbour porpoises taken in the Eastern Scheldt, accompanied with as much information as possible about e.g. time and location. To make it more interesting for people to send in their photos and information, the photographer was given the opportunity to name the individual if it could be added to the photo-ID catalogue as a new individual or a resighting (only if it was the first resighting), based on the photo that was submitted.

2.4 Phoco-ID manuals

2.4.1 Boat set-up and handling

Rugvin Foundation utilizes a small 3 meter, foldable BRIG DINGO rubber boat for fieldwork. To set-up and handle the boat for fieldwork a manual was made. It gives detailed instructions on how to assemble, use and handle boat and engine properly (Bakkers & Tuhuteru, 2016c).

2.4.2 Catalogue, photo sorting & matching

The photo-identification catalogue of harbour porpoises of the Eastern Scheldt consists of a left and right side catalogue: L_Catalogue (PP) and R_Catalogue (PP). Photos taken in the field are sorted and edited using Windows Explorer/Adobe Bridge and Picasa (free downloadable software; Google Inc.)/Adobe Photoshop respectively. For detailed instructions on the usage of the catalogue a manual was made and followed (Bakkers &Tuhuteru, 2016a).

2.4.3 Sightings database

The survey and encounter sheets were entered into a Microsoft Access database. The sightings database was initially designed with and for Microsoft Access. However, to ensure access to the database for everyone working on Project Phoco-ID, the same data was made available through PostgreSQL, a (free) open-source database. The database consists of 11 different tables named accordingly: surveys, sightings, PPID_observations, PPID_catalogue, associated_species, tracks, weather, observers, platforms, species and project_contributors. Each table contains general and detailed information about the concerning subject. More information about the structure and use of the sightings database can be found in the sightings database manual (Bakkers & Tuhuteru, 2016b).

2.5 Data Analyses

A descriptive analysis was carried out to present basic sightings data (e.g. number of sightings, number of resightings a group size). The harbour porpoise sightings were also illustrated in a geographical map of the study area (Open Street Maps) using QGIS, a free and open-source geographic information system (GIS). Each survey, both boat- and land-based, was colour coordinated in the map to distinguish between the three different survey platforms that were used.

3. Results

3.1 Chapter overview

This chapter describes the five products of the work conducted in context of the 2015 follow-up of Project Phoco-ID, the photo-identification study of harbour porpoises in the Eastern Scheldt (ES). These products are a boat handling manual for the Rugvin Foundation's research vessel Zeevarken (I), a harbour porpoise photo-identification catalogue (II) and a sightings database (III) focused on ES harbour porpoises, including accompanying manuals (IV & V) The results are shown of the three research methods tested for the harbour porpoise photo-identification study: land-based survey, boat-based surveys with the Zeevarken (small dedicated RIB) and boat-based surveys on board the MS Onrust (medium-sized passenger ship; Platform of Opportunity (PoP) providing Eastern Scheldt tours). The given results provide a basis for evaluation and comparison of the three methods in chapter 4 (Discussion).

3.2 Product 1: boat handling manual

The boat handling manual describes and illustrates how to set up and use the Zeevarken and the engine (Mercury FourStroke) properly. The manual explains boat handling in a chronological order, starting with preparatory actions before dealing with boat operation instructions. The manual concludes with necessary actions required to safely and neatly end the survey.

3.3 Product 2 & 4: photo-identification catalogue & manual

During the field season of 2015, a photo-identification catalogue for ES harbour porpoises was developed. This catalogue facilitates matching between individuals photographed over an extended period of time. The photo-ID catalogue consists of a left and right sided catalogue. Both sub catalogues are a combination of the best photographs of the anterior, middle, posterior part and/or full body of an individual animal. It also includes the best photographs for every new re-sighting. The photo-identification catalogue manual functions as a guide and protocol on sorting pictures, naming pictures, matching individuals and adding (new) individuals to the catalogue.

3.4 Product 3 & 5: sightings database & manual

Along with the photo-identification catalogue, a sightings database was developed. The Phoco-ID sightings database was designed and implemented in 2015 to archive and manage sightings data and other related data associated with Project Phoco-ID. The sightings database can be accessed through the programs PostgreSQL and Microsoft Access. The most important tables of the database are:

- SURVEYS: contains all survey information, such as survey date, start and end times;
- SIGHTINGS: contains information on cetacean sightings, for example group size, group structure and behaviour (does not contain data on individual animals);
- PPID_OBSERVATIONS: contains information on which harbour porpoise individuals were sighted where, when and what types of behaviour were displayed. This table has a strong link with the SIGHTINGS table and provides more detailed information on the individuals. In contrast to the SIGHTINGS table, the PPID_OBSERVATIONS table does not focus on overall group information of a sighting. It specifically focuses on sighting data of individual animals.
- PPID_CATALOGUE: This table focuses on individual animals, with an emphasis on the characteristics of harbour porpoise individuals, such as age class, sex and scarring. The table can be used in the photo-identification matching process as it provides the option to search on the number of markings visible on the anterior, middle and posterior part of the body and other

identifying characteristics. The table therefore has a strong link with the photo-identification catalogue.

The sightings database manual describes the way the database is structured and functions as a guide on how to manage the sightings database and transfer data from PostgreSQL to Microsoft Access and vice versa.

3.5 Overview of surveys 2015

In the field season of 2015, a total of 15 surveys were carried out between July and September. Three different types of platforms were used: land-based (n=3 surveys), Zeevarken (n=9) and MS Onrust (n=2). A fourth platform, the Balena (large RIB) was used for an opportunistic survey (n=1); an official survey organised annually by the Rugvin Foundation to count harbour porpoises in the Eastern Scheldt. Sea states recorded ranged from a minimum of 0 bft to a maximum of 3 bft.

Survey effort was highest around the Burghsluis harbour and Schelphoek. Most of the dedicated surveys (n=10) took place in Burghsluis, the main focus of the project in 2015 (table 3.1). Two vessels were used in this area: Zeevarken and MS Onrust. In the Schelphoek area, land-based surveys and surveys on the MS Onrust and Zeevarken amounted to a total of seven surveys. No official surveys were conducted in Zierikzee as it fell outside the project scope in 2015. However, one training survey with the RIB Zeevarken resulted in harbour porpoise ID photos being added to the photo-ID catalogue. This training survey was therefore included in the database. During training surveys, attempts were made to photograph harbour porpoises as practice for later surveys, but no survey and encounter data were collected for these sightings.

3.6 Overview of sightings per method 2015

The total number of harbour porpoise sightings in 2015 was 28 (land-based n=4, MS Onrust n=3, Zeevarken n=20, Balena n=1). In addition to the sightings from the surveys mentioned in paragraph 3.2, nine opportunistic sightings in the Eastern Scheldt from external sources were selected from Waarneming.nl based on the quality of accompanying photographs. Photographs of sufficient quality for identification purposes were added to the photo-ID catalogue. The total of 37 sightings resulted in 14 individuals photographed from the left side and 11 individuals from the right side.

The average group size of sightings made during surveys was 1.6 (min.-max. range = 1 - 4), not taking into account external sightings. The average photo-ID success was 22% for the left-catalogue and 14% for the right-catalogue. The average ID success per platform is shown in table 3.2. The average ID success was highest for boat-based surveys on the Zeevarken (27% left, 16% right), followed by land-based surveys (13% left, 13% right). The two MS Onrust surveys were least successful with a photo-ID success of 0%. A series of land-based training surveys was carried out in July 2015 from the viewpoints in front of the Burghsluis harbour; the ID success was equal to 0.

Table 3.2. Average photo-ID success, photo-ID success ranges and the number of individuals added to the catalogue per sighting for left and right body sides of harbour porpoise individuals per research method (land-based and boat-based – Zeevarken and MS Onrust).

		Survey types (Research methods)		
		Zeevarken	*MS Onrust*	*Land-based*
Body side	*Left*	27%	0%	13%
	Right	16%	0%	13%
No. of photographed individuals added to catalogue (new individuals & re-sightings of individuals)		14	4	0

4. Discussion

The objective of this study was to develop a photo-identification catalogue and database for harbour porpoises of the Eastern Scheldt (ES), examine three different research methods using a small RIB, a medium-sized passenger ship and a land-based survey platform, determine the most successful of the three methods tested, and develop manuals for the catalogue, database and the small RIB. At the end of the 2015 field season, the ES harbour porpoise catalogue and database were established and the manuals were made accordingly. In this chapter, field experiences and the results of the three different research platforms are compared and thoroughly discussed.

4.1 Method evaluation

4.1.1 Comparison of methods 2010-2015

In 2015, three research methods based on the boat-based platforms Zeevarken (small RIB) and MS Onrust (medium-sized passenger ship) and a land-based platform ("Schelphoek") were applied to assess the feasibility of harbour porpoise photo-identification in the Eastern Scheldt and to determine which method or combination of methods would be most successful in doing so. Finally, a third vessel "Stern", used between 2010-2015 for photo-ID trips, will be discussed. During the summer field season of 2015, most surveys were carried out on board the Zeevarken, followed by the MS Onrust and land-based surveys. No special attention was given to carrying out an equal number of surveys per survey platform. The number of surveys per platform depended only on weather conditions. The number of harbour porpoise sightings and photo-ID success was highest for the Zeevarken surveys, followed by the MS Onrust surveys, and the least successful method land-based surveys at the Schelphoek viewpoint.

Zeevarken

The success of the Zeevarken method may be linked to its versatility and freedom of movement. This method allows the observers to deliberately survey a specific location and routes within the study area for a self-determined time period, follow and stay with animals for a prolonged time if necessary, approach animals more closely and take on ideal positions to obtain high quality photographs for photo-identification (e.g. light behind the photographer, camera perpendicular to the flank of the animal). Additionally, the low height of this survey vessel provides in most cases, a good vantage point for taking photographs of the flanks. Although, it must be said that waves may cover part of the flanks (including the flank pattern) when the sea state is higher than 3 bft. A disadvantage of the Zeevarken is its small size as it can only fit three people; room for motion and storage of equipment is very limited. Because of its small size and lack of an anchor that can be deployed in case of an emergency, the Zeevarken makes for a risky vessel in terms of safety. Especially because of the strong tidal currents in the research area. Finally, the number of days that the Zeevarken could be used for surveys turned out to be very limited. In 2015, only nine surveys were conducted between July-September.

MS Onrust

The MS Onrust and land-based methods lack the versatility of the Zeevarken and freedom of movement. The MS Onrust is considered a platform of opportunity (PoP) and is used for daily tours around the north-western part of the Eastern Scheldt. In 2015, these daily tours involved round trips: 'Burghsluis-Roggenplaat-Kerkwerve-Schelphoek-Plompe Toren (Koudekerke)-Burghsluis' and 'Burghsluis-Colijnsplaat-Zierikzee-Burghsluis' (the latter also including the locations Roggenplaat, Kerkwerve, Schelphoek and Plompe Toren). Harbour porpoises are observed regularly from the MS Onrust and have been spotted during surveys. However, the observers have no influence on the (survey) route and whether or not the animals will be approached (if not, distance depends solely on the animal's behaviour: approaching, evasive or indifferent). The MS Onrust method does not allow the observers to follow and stay with animals for a prolonged time, offers limited influence on lighting for photography and provides a very high vantage point. The probability of obtaining high quality photographs with the right angle is therefore much lower. The very high vantage point, however, strongly increases the chances of spotting harbour porpoises in sea states higher than 2 and 3. In other words, a huge advantage of MS Onrust surveys is the flexibility in respect to weather conditions. Where Zeevarken surveys are limited to a sea state of 2-3 bft, MS Onrust surveys can occur in sea states of 1-4 bft. The real value of MS Onrust surveys in respect to photo quality for photo-ID could not be assessed in 2015 as none of the encounters lasted long enough to take photographs of the harbour porpoise individual(s).

Land-based

The situation of land-based surveys at the Schelphoek viewpoint is slightly different, but is comparable to that of the MS Onrust. Like MS Onrust surveys, it is not possible to actively approach or follow the animal when it moves away; the vantage point is lower and more suitable for photo-ID purposes. Ideally, photographs are taken of the left and right sides of individuals with the sunlight coming from behind the photographer. However, in land-based surveys, light conditions strongly depend on the survey location. At the Schelphoek viewpoint, observers always face the same direction. Light conditions thus depend solely on the natural course of the sun (time of the day and time of the year) and weather conditions. As a result, most land-based photo-ID surveys near Schelphoek are disadvantaged by backlight conditions, producing photographs with a darkened subject, very often concealing important details such as scarring and the flank pattern. This problem is most likely not or less prevalent when land-based surveys are carried out on the south side of the Eastern Scheldt.

Stern

The Stern is a relatively fast and stable vessel with plenty of space to move around. It provides an excellent platform for spotting harbour porpoises in sea conditions up to 2-3 bft. Surveys with the Stern can take place in sea conditions of 4 bft. However, this is not recommended. Compared to the Zeevarken, it is much easier to follow harbour porpoise when they are moving in an erratic pattern (which is often the case) due to the height of the deck. The Stern provides both low and high vantage points making it easier to obtain high quality photographs with the right angle. Furthermore, the

vessel allows for a maximum of eight passengers. During the 2010-2015 trips on the Stern, the team typically consisted of one or two photographers (also observing), at least two other observers and the captain (because of his age the current captain of the Stern (Willem) may not be available for future trips; it is preferred to have a second skipper on the vessel for safety reasons. In this way, the chance that animals surfacing within viewing range of the observers were actually spotted was high. Finally, compared to the Zeevarken, the Stern is suitable for longer trips covering a larger distance.

4.1.2 Follow-up strategy 2016 & onwards

Taking into account the benefits and disadvantages of the four methods mentioned above, the advice is to combine the four methods depending on the possibilities per location, the availability of observers and the weather conditions. Whenever weather conditions allow (maximum of 3 bft, no white caps on waves), the Stern or a similar vessel, should be the prime focus of the investigators. In sea conditions of 0-1 bft, the Zeevarken is comparable to the Stern, but still has its disadvantages in terms of e.g. freedom of movement for the team (observes, photographers and data recorder(s)) and lack of height. Under worse conditions, up to a sea state of 4-5 bft, MS Onrust or land-based surveys are a good alternative. MS Onrust and land-based methods still need to be tested further to reliably assess their effectiveness. Even though these survey types may not always result in useful photo-ID data, they may still be valuable for research. Coupling behavioural data to locations, for example, might eventually increase the understanding of habitat use of harbour porpoises in the Eastern Scheldt and may point out foraging areas.

Focal points of Project Phoco-ID in 2016 should be the expansion of the photo-ID catalogue and the sightings database, expansion of the study area (including at least Zierikzee and, if possible, locations in the southern and eastern parts of the Eastern Scheldt) and an even distribution of survey effort across the study area. Points of interest that should be considered include:

- *Expansion of the study area by adding locations other than the research area of the last couple of years.* The first step towards expanding the study area would be to assign new areas of interest where photo-ID surveys could be productive. The Rugvin Foundation has access to a large amount of sightings data derived from the annual Eastern Scheldt harbour porpoise counts (boat scans), a land scan and previous studies. A selection of this data is shown in the figures in Appendix 4. Comparing the data displayed on these sighting maps and the depth chart, areas of interest could be the stretch of water between Neeltje Jans and Roompot Beach Resort (Wissenkerke), Colijnsplaat, Kats, Het Sas and possibly Wemeldinge and possibly Westkerke. Harbour porpoises have been sighted as far east as Yerseke. Supporting the recommendation of Neitzel & Niemeijer (2012), the final advice regarding this topic would be to organise at least three to five trial surveys (either land-based or boat-based) per location to determine, for example, the number of sightings per unit of time or effort, the distance from the animals to the observation point (is it possible to photograph animals from land?) and thus the value of a particular location for Project Phoco-ID. It is also important to identify places suitable for storing or docking the research vessel(s) and other ways to get on the water.

Expansion of the study area may require a larger and mobile team to make sure all locations are covered and regularly surveyed. Finding the right survey methods for new locations will depend on local and financial possibilities and requires some creativity: is it possible to enlarge Rugvin Foundation's fleet with new research vessels? Is it possible and efficient to transport the Zeevarken between locations? How effective are land-based surveys per location with respect to photo-identification purposes and would it be sufficient to concentrate on land-based surveys only in these areas? Is it possible to integrate the aid of local skippers and their vessels (collaborating with observers from the Rugvin Foundation)? These questions need to be further investigated.

- *Introduction of a new dedicated research vessel in order to maximise photo-ID success.* The research vessel Zeevarken that has been used during the summer of 2015 is in certain conditions suitable for photo-ID purposes but inconvenient due to its small size, lack of space, height and safety equipment. A larger vessel, e.g. a vessel similar to the Stern, a larger RIB or other type of motorboat with a more powerful yet quiet engine (to limit the possibility of underwater noise affecting harbour porpoise behaviour) has several advantages. In the first place, there would be more space for observers to move around the boat and follow the animals while they move from one side to the other side of the boat. Secondly, there would be more room to store equipment. Thirdly, the possibility arises to conduct transects or routes between multiple locations and cover more areas within a smaller time frame. With the right study design, transects (in combination with photo-ID work as main purpose) can be used for abundance estimates. Finally, a larger vessel will also allow the observers to stand up while searching for animals or photographing individuals. The slightly higher vantage point would be advantageous in the sense of (I.) being able to look past small waves that potentially hide a surfacing harbour porpoise, (II.) to follow animals swimming just below the surface, and (III.) predicting where animals will surface (and thus be more prepared to capture the entire surfacing on camera). It should be noted that a larger research vessel with a more powerful engine would require a licensed skipper (a certificate is necessary for all motorboats smaller than 15 m capable of reaching speeds faster than 20 km/h, recreational crafts with a length between 15-25 m, and commercial vessels with a length between 15-20 m; CWO-vaarschool, 2015).

- *Gathering and matching pictures of stranded harbour porpoises in and around the Easter Scheldt.* Now that a catalogue is established with individuals, it will be very interesting to see if any of the photographed individuals have been or will be found dead or live stranded. By collaborating with the first responders (from rescue organisations) and the University of Utrecht, pictures can be gathered from stranded individuals in and around the Eastern Scheldt. These pictures can then be compared to the individuals in the catalogue. If there is a match, the individual can be marked in the catalogue as deceased. In this manner, it is possible to keep track of mortality and keep the catalogue as up to date as possible. This is important when calculating re-sighting rates and can make a significant difference over the years.

4.2 Harbour porpoise photo-identification

4.2.1 Global comparison

In the past, photo-identification of harbour porpoises has been attempted multiple times before succeeding (Watson & Gaskin, 1983; Watson, 1976). The first successful harbour porpoise catalogue, a catalogue developed by William Keener in the San Francisco Bay area, was not initiated until 2009 (Keener, 2011). Like the Phoco-ID project the San Francisco catalogue project also uses multiple platforms in the form of boat- and land-based surveys and calls the public to submit sightings. It has grown to include 600 individuals in 2013, an impressive number for this difficult to observe species (Keener *et al.* 2013).

It is not yet clear whether the sighted individuals form a resident community, but the photo-identification project has made it possible to determine birth rate of certain individuals. This is critical in understanding the resilience of the population in case of food shortages or a catastrophe, such as an oil spill.

Continuing photo-ID research on the population in the Eastern Scheldt can yield the same type of analysis as is being used in San Francisco plausible. Population size, birth rate and social structure are some examples of what could be studied with a successful catalogue. Broadening the study area to include parts of the Dutch North Sea coast could also shine light on the question if the harbour porpoises move back and forth (regularly) between the storm surge barrier. IJmuiden, for example, would be an interesting place to start both land- and/or boat-based surveys.

4.2.2 Photo-id methodology

The method of photo-identification is a commonly used tool and has successfully been used in numerous cetacean studies, including species such as bottlenose dolphins (*Tursiops truncatus*; O'Brien *et al.* 2009; Karczmarski & Cockcroft, 1998), rough-toothed dolphins (*Steno bredanensis*; Mayr & Ritter, 2005) and humpback dolphins (*Sousa chinensis*; Weir, 2009; Karczmarski & Cockcroft, 1998). It has also been used in porpoise studies, including species as the vaquita (*Phocoena sinus*; Jefferson et al. 2009) and the Dall's porpoise (*Phocoenoides dalli*; Miller, 1990). The trailing edge of the dorsal fin has found to be the most distinctive feature in many species and is the identifying feature most often used in photo-ID (Würsig &Jefferson, 1990).

The harbour porpoises encountered in this study had an ID-success of 14-22% (right-left side). Compared to the ID-success of 19.4%- 29.1% (right-left side) found by Wouter Jan Strietman, for surveys conducted between 2010-2015, this season yielded a slightly lower result. However, when making this comparison it has to be taking into account that Wouter Jan Strietman calculated ID-success per survey instead of per encounter. Therefore, his ID-success is an underestimation compared to the ID-success found in 2015. Furthermore, compared to other small cetaceans the overall ID-success of the harbour porpoise in the Eastern Scheldt is promising. Photo-ID research studying other small cetaceans found similar ID-success rates such as 17-21% for the Dall's porpoise

(Miller, 1990) and 24-31% for the vaquita (Jefferson et al., 2009). The 14-22% found in 2015 shows a promising result, considering marks on the dorsal fin of the harbour porpoise could not be used because of their rarity and the photo-identification was therefore dependant on markings throughout the body, which is more difficult to photograph.

Assessment of the longevity and changeability of distinctive marks used for identification is very important. The harbour porpoise catalogue is reliable only if the individuals stay recognisable and documented over longer periods of time. There is no evidence yet about the longevity and changeability of markings on harbour porpoises. However, the development in the physical appearance of the scars and markings of one individual in the Phoco-ID project give an indication. Markings on this individual, nicknamed Willem, have been documented since 2011 and stayed stable (enough) throughout the years for positive identification. Studies into the use of (natural) markings have been conducted for other cetaceans, such as the Irrawaddy dolphin (*Orcaella brevirostris*; Parra & Corkeron, 2001) and the bottlenose dolphin (Lockyer & Morris, 1990). Both these studies found that the use of photo-ID is feasible and could continue to be used for research on the ecology and conservation biology of the dolphins. Studies have found that even large open wounds heal within a matter of months, but the scars resulting from those wounds seem to last for a significant amount of time. For example, Risso's dolphins (*Grampus griseus*) are well known for having bodies covered in scars that have been accumulating for a life-time (McCann, 1974). Continuing project Phoco-ID could shed light on the longevity and changeability of markings on harbour porpoises.

5. Conclusion

Project Phoco-ID now has a left and right catalogue with a corresponding database and dedicated manuals, to ensure this research can be followed through in the future. The most effective fieldwork method turned out to be the small RIB boat-based surveys. However, it is advised to combine the three methods depending on the possibilities considering factors like weather conditions and local conditions.

The main recommendations are:

- Expand the research area to cover multiple parts of the Eastern Scheldt. Inherently linked to this recommendation is that the research team needs to be larger and mobile.
- Invest in a new and bigger dedicated research vessel.
- Gather pictures from stranded harbour porpoises in and around the Eastern Scheldt to compare and possibly match them to the catalogue.

By continuing project Phoco-ID and expanding the research effort, the catalogue can grow and more light can be shed on the ecology of the harbour porpoises of the Eastern Scheldt.

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Appendix 1Definitions of weather conditions

Definitions of the different weather states, the Beaufort Sea States and the visibility according to Rankmore et al. (2012).

Weather		Definition
	Sunny	Predominantly sunny, no/few clouds.
	Sunny with clouds	Predominantly sunny, many clouds.
	Overcast	Cloudy/grey with nog visible sunshine.
	Showers	Light rain on and off with limited visibility.
	Rain	Heavy/continuous rain with dark skies.
H	Hail	Hail showers/storms.
F	Fog	Fog and mist.
BSS*	Knots	Definition
0	0-1	Smooth and mirror-like, wind calm.
1	1-3	Light ripple, light air.
2	4-6	Small wavelets, not breaking, light breeze.
3	7-10	Scattered whitecaps, gentle breeze.
4	11-16	Small waves, frequent whitecaps, moderate breezes.
5	17-21	Moderate waves, many whitecaps, fresh breeze.
6	22-27	All whitecaps, some spray, strong breeze.
7	28-33	Breaking waves, spindrift begins, near gale.
8	34-40	Medium high waves, foamy gale.
		*colors represent the color code used by windguru.nl
Visibility		Definition
Excellent		Water is still and calm, very easy to sight animals.
Very good		May be slightly uneven lighting or light chop
Good		Light chop/scattered whitecaps (BSS 0-3), swell (2-4 meters) or some sun glare or other impediment (e.g. haze) in < or equal to 10% of the study area, sighting animals is still fairly easily.
Fair		Choppy waves with fairly frequent whitecaps, low-light conditions (e.g. heavy overcast, dawn, dusk), swell 4-6 meters or sun glare in, or equal to 50% of stufy area, animals are likely to be missed.
Poor		Numerous whitecaps (BSS 5), sun glare or haze in > or equal to 50% of study area, or swell > 6 meters, impeding ability to sight animals, many animals are likely to be missed.

Appendix 2 Survey data sheet

Date of survey.

Box is checked when form digitalized in Access.

Name of the observer completing the survey form.

Weather conditions and tidal state according to predictions.

Camera and binocular type and the operating observers initials.

Definitions weather pictograms Appendix X.

Definitions Beaufort sea state Appendix X.

Definitions visibility types Appendix X.

When there are significant changes in the weather they are noted here.

Fuel state: F(ull), H(alf), E(mpty) is noted here.

Anything significant unrelated to the subjects covered can be noted in general remarks.

Survey Data Sheet

Processed: ☐

Date (dd/mm/yy): ..... / ..... / ..... **Completed by** (name):

Weather & tide predictions

Weather:	Observers:
H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks: Tide: *Low tide* *High tide*	Equipment (type & observer *abbr.*): *Camera 1* *Binocular 1* *Camera 2* *Binocular 2* *Camera 3* *Binocular 3* *Other*

Departure information	**Return information**
Time (start survey):	Time (end of survey):
Location (incl. coordinates): Lat/long. 51 ..... 3	Location (incl. coordinates): Lat/long. 51 ..... 3 .....
Weather conditions: H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks:	Weather conditions: H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks:
Tidal state: *high falling low rising*	Tidal state: *high falling low rising*

Change in weather during survey (optional)

Time:	Time:
H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks:	H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks:
Tidal state: *high falling low rising*	Tidal state: *high falling low rising*

Platform information + fuel consumption

Vessel type:	Remarks:
Fuel state (departure): ..... extern. tank (± 12 L)	Fuel state (return): ..... extern. tank (± 12 L)

General remarks:

Appendix 3 Encounter data sheet

Initials of observer whom spotted the harbour porpoise(s).

Encounter Data Sheet

Processed: ☐

Date (dd/mm/yy): ..... / ..... / ..... **Completed by** (name):

Encounter no.: **Sighted by:** **Cue:** **Encounter code:**

????

Thing that indicates the presence and location of the harbour porpoise(s): fin or hunting associated species like birds or seals.

Position & weather conditions

Start time Encounter (24h):	End time Encounter (24h):
First sighted at: *Vessel position (lat/long.):* 51 ..... 3 ..... **Vessel direction:* ..... ° **Sighting direction:* ..... ° Estimated distance from vessel: .....m	Last sighted at: *Vessel position (lat/long.):* 51 ..... 3 ..... **Vessel direction:* ..... ° **Sighting direction:* ..... ° Estimated distance from vessel: .....m
Weather conditions: H F Visibility: *excellent very good fair poor* Tidal state: *high falling low rising*	Cloud coverage: .....% Beaufort (sea state): 0 1 2 3 4 Remarks:

When there are significant changes in the weather during the encounter, they are noted here.

Change in weather during encounter (optional)

Time:	Time:
H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks: Tidal state: *high falling low rising*	H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks: Tidal state: *high falling low rising*
Time:	**Time:**
H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks: Tidal state: *high falling low rising*	H F Beaufort (sea state): 0 1 2 3 4 Visibility: *excellent very good fair poor* Cloud coverage: .....% Remarks: Tidal state: *high falling low rising*

To estimate group size a minimum, maximum and a best estimate is noted.

Encounter details

Definitions and initials of associated species Appendix X.

Definitions dispersion Appendix X.

Definitions behaviour Appendix X.

Focus species: harbour porpoise (PP)	Assoc. species: SH PV HG

Group size:	Min.	Max.	Best.

Legend: **x** absent, **?** unknown, **I** present (no. tally)

Age class:	Neonate	Calf	(Sub)adult

Definitions of age classes Appendix X.

PP behaviour		Dispersion
Initial	*Secondary*	Tight
Foraging	Foraging	Grouped
Travelling	Travelling	Loose
Resting	Resting	Sub grouped
_____	_____	Dispersed
Remarks:		

Group heading: ..... ° / no clear heading	All captured: yes no
Behavioural signs of disturbance: yes no	Possible source(s):

If all individuals are successfully photographed, yes is checked in all captured.

Appendix 4 Sightings data

Appendix 4 contains a selection of sightings data and other data derived from the annual boat scans (Eastern Scheldt harbour porpoise counts) and the report of Neitzel & Niemeijer (2012).

Figure 4.1. Harbour porpoise sightings made during the annual boat scan (Eastern Scheldt harbour porpoise counts) of the Rugvin Foundation in 2009 (Rugvin.nl, 15 January 2016).

Figure 4.2. Harbour porpoise sightings made during the annual boat scan (Eastern Scheldt harbour porpoise counts) of the Rugvin Foundation in 2010 (Rugvin.nl, 15 January 2016).

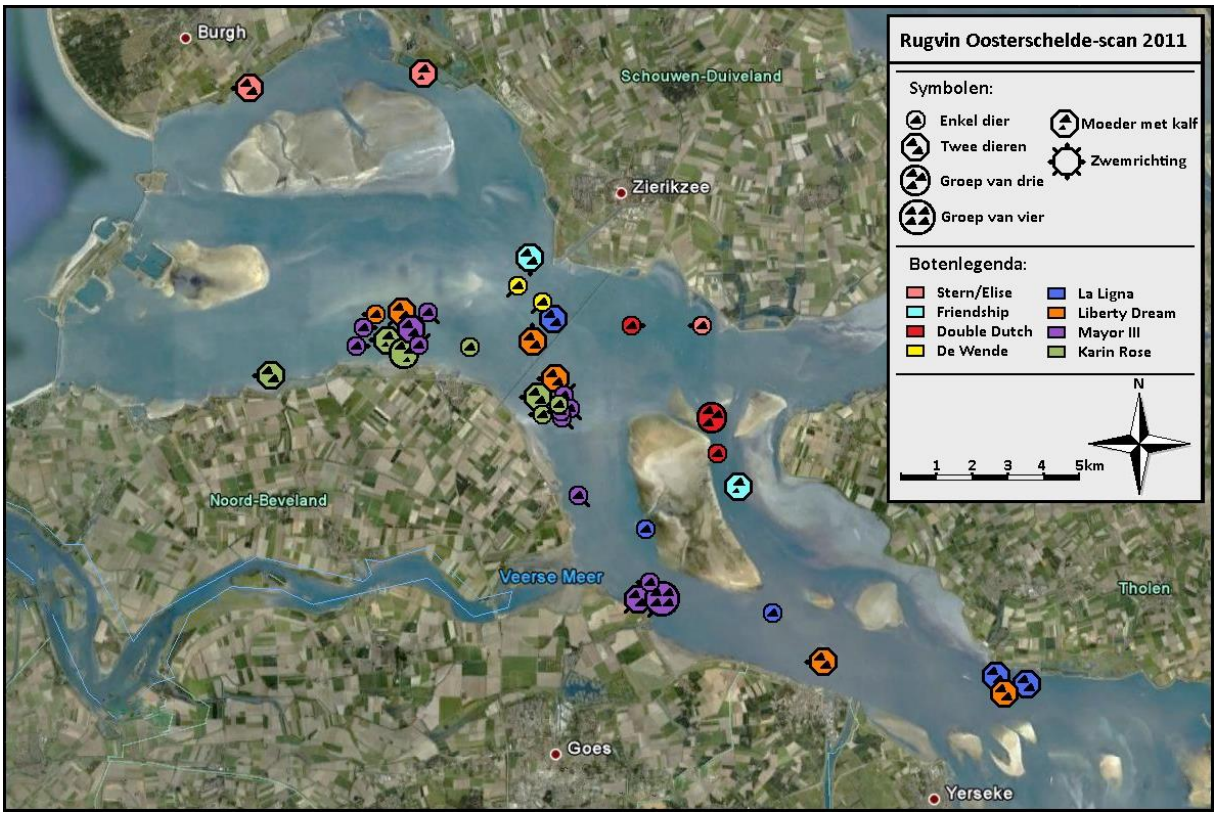

Figure 4.3. Harbour porpoise sightings made during the annual boat scan (Eastern Scheldt harbour porpoise counts) of the Rugvin Foundation in 2011 (Rugvin.nl, 15 January 2016).

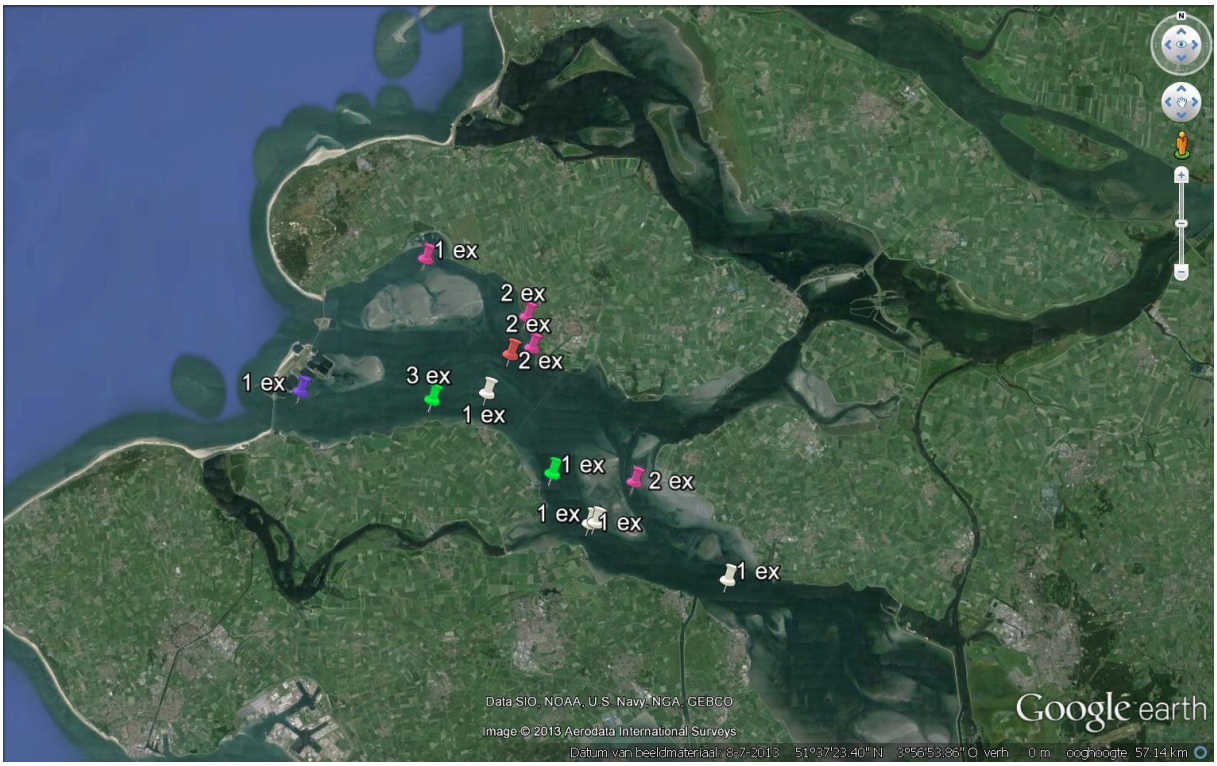

Figure 4.4. Harbour porpoise sightings made during the annual boat scan (Eastern Scheldt harbour porpoise counts) of the Rugvin Foundation in 2013 (Rugvin.nl, 15 January 2016).

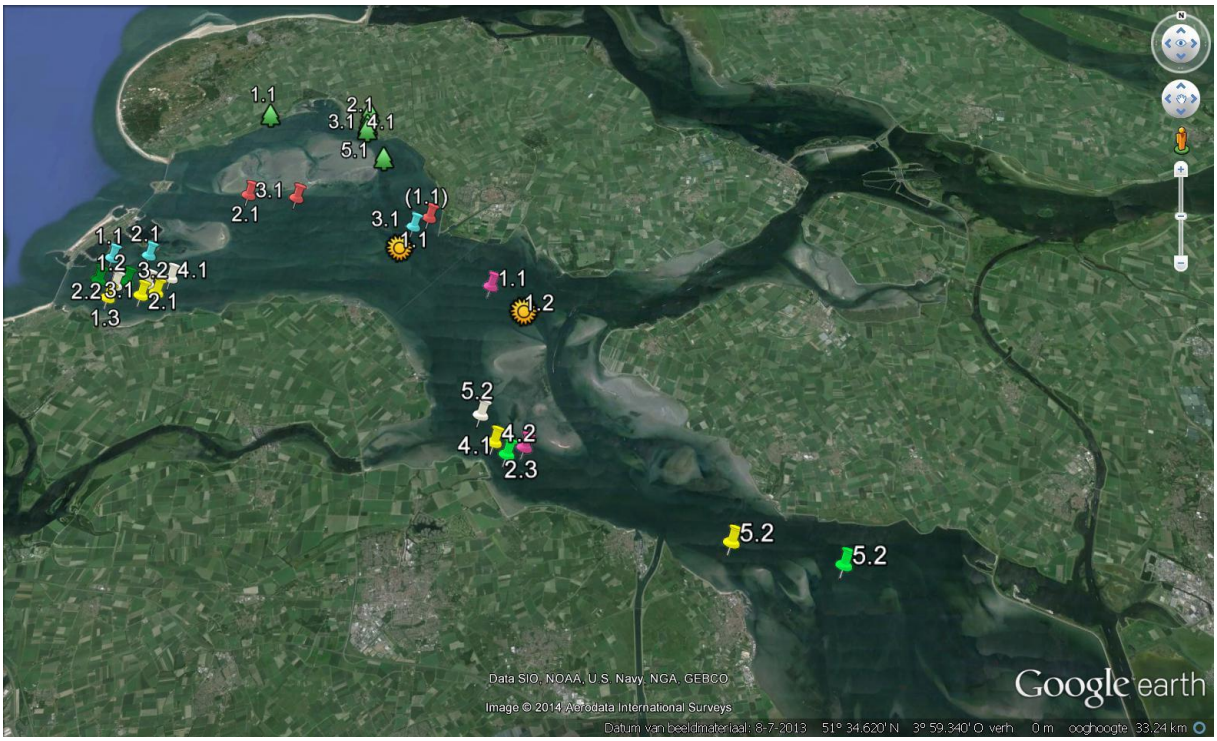

Figure 4.5. Harbour porpoise sightings made during the annual boat scan (Eastern Scheldt harbour porpoise counts) of the Rugvin Foundation in 2014 (Rugvin.nl, 15 January 2016).

Figure 4.6. Harbour porpoise sightings made during the annual boat scan (Eastern Scheldt harbour porpoise counts) of the Rugvin Foundation in 2015 (Rugvin.nl, 15 January 2016).

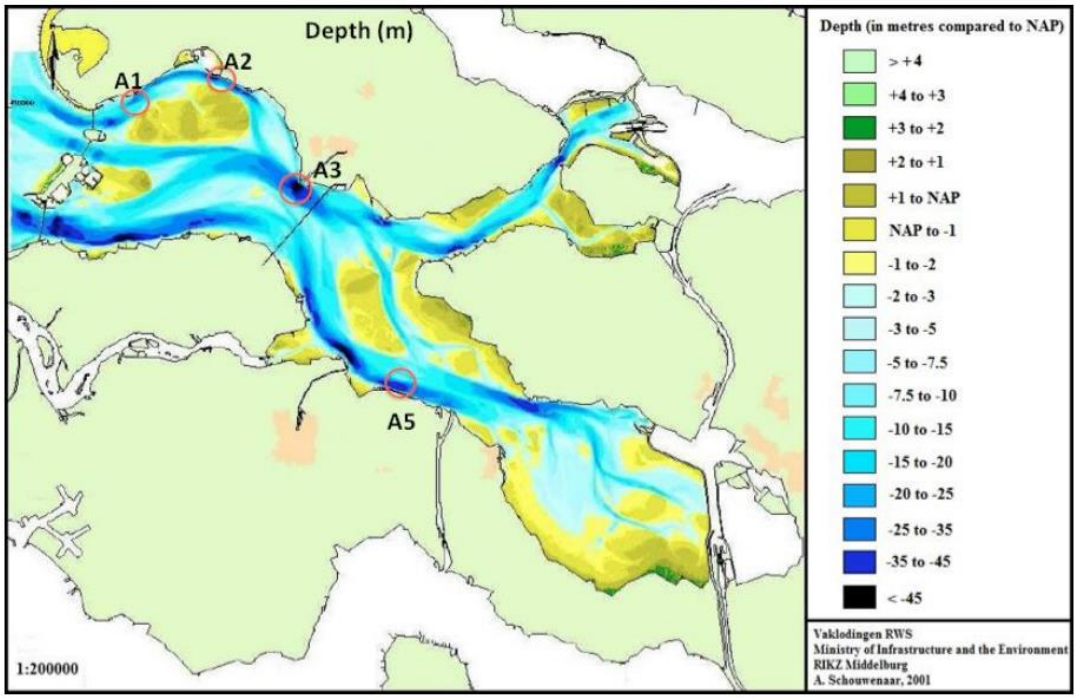

Figure 4.7. Depth chart of the Eastern Scheldt. Depth is displayed in meters compared to NAP. *NAP is a Dutch reference height: Normal Level of Amsterdam (NAP)(Neitzel & Niemeijer, 2012).*

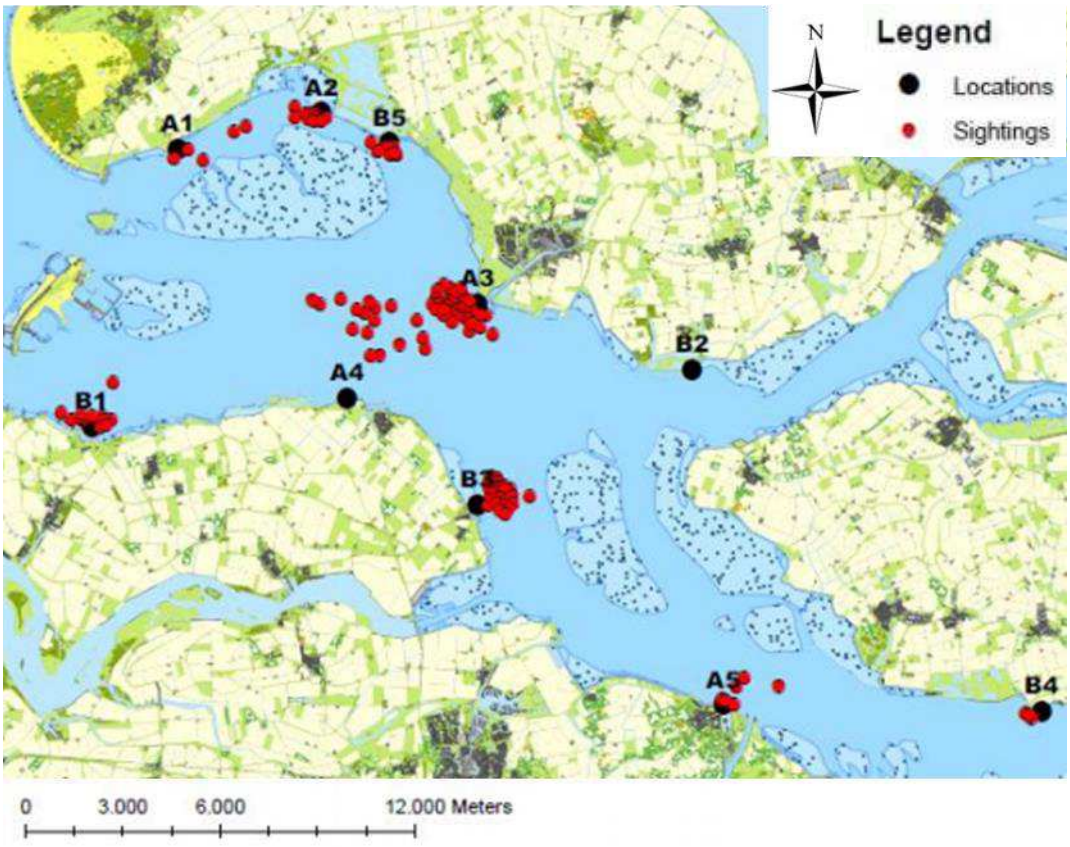

Figure 4.8. Harbour porpoise sightings made by Neitzel & Niemeijer (2012).