Harbour porpoises (*Phocoena phocoena*) in the Marsdiep area, the Netherlands: new investigations in a historical study area

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Abstract: The harbour porpoise (*Phocoena phocoena*) returned in Dutch waters in the late 20th century after a near-absence of approximately three decades. Inspired by historical studies of harbour porpoises in the Marsdiep area (western Wadden Sea), mainly in the 1930s and 1940s, a study was initiated in the same area in 2011 to see if porpoises are now as common as previously recorded and if future, more detailed investigations would be worthwhile. We investigated the current spatial and temporal distribution of harbour porpoises using a combination of visual observations and acoustic recordings. In 2010 and 2011, harbour porpoises were most abundant around mid-March, and disappeared in April. They were most frequently observed off Texel, with slightly lower numbers of visual detections along the dike of Den Helder and at Huisduinen. Relatively high abundances were recorded around high tide at most observation sites, but particularly so off Texel. The observed abundance of porpoises in spring in the Marsdiep area, and the apparent influence of tidal currents on spatial patterns in sightings frequencies, is such that the Marsdiep area could provide rather unique, future study opportunities for harbour porpoises in the wild.

Keywords: Cetacea, *Phocoena phocoena,* Marsdiep, Wadden Sea, tidal rhythm, foraging habitats, sightings, recordings, history, Netherlands.

Introduction

The harbour porpoise (*Phocoena phocoena*) returned as an abundant, indigenous species in Dutch waters in the late 20th century, after a virtual absence of three decades (1960-1990; Camphuysen 2004, Camphuysen & Peet 2006, Camphuysen 2011, Scheidat et al. 2012). Up to the late 1950s, harbour porpoises were common in Dutch coastal waters. The only area where studies were conducted prior to the disappearance from Dutch waters was the Marsdiep, a sea inlet between Den Helder and Texel in the western Wadden Sea. Verwey (1975) reported sightings, documented behaviour and prey preferences and described seasonal patterns of cetaceans in the Marsdiep area between 1931 and the early 1970s.

The Marsdiep area is unique in the sense that the entire area can be overseen from land, and that its complex bathymetry and oceanography offers a rare opportunity to study wild cetaceans, undisturbed, in a variety of marine

habitats. Due to its proximity to the Royal Netherlands Institute of Sea Research (NIOZ), in and around the Marsdiep, several oceanographic and biological sampling programs are established. The historical and detailed dataset on the occurrence of harbour porpoises and common bottlenose dolphins (*Tursiops truncatus*) collected by the Zoological Institute just prior to and following the Second World War served as a reference (Verwey 1975).

Following the return of harbour porpoises in the early 21st century, we felt that a resumption of studies in the Marsdiep area (using modern observation techniques) could yield much needed information on habitat characteristics, seasonality and behaviour of harbour porpoises in Dutch coastal waters. We designed a feasibility study which included a systematic porpoise observation programme. A team of observers manned several, strategically chosen observation sites to assess spatial patterns in harbour porpoise abundance within the tidal inlet (visual observations). The long-term seawatching programme at Huisduinen was continued and intensified to provide a recent background of seasonality in the area. Acoustic techniques were deployed to supplement the information derived from sightings. The objective of this study was to investigate if harbour porpoises within the Marsdiep area are currently abundant enough to warrant a more complete ecological study in future years. We collected sightings (with corrections for observer effort and environmental conditions) during the period of peak abundance in Dutch coastal waters and beyond (February-April 2011), and documented site-specific patterns in abundance together with aspects such as tidal phase, time of day, shipping traffic, presence and abundance of seals, and the occurrence of multi-species feeding frenzies of seabirds and marine mammals.

Historical abundance

Verwey's (1975) studies comprised descriptions of sightings and of the behaviour of the animals observed in the period 1931-1940 and 1945-1973 along the shores of the Marsdiep near Den Helder, with numbers being much higher in the earlier period. Jan Verwey and co-workers from the Zoological Station in Den Helder (now NIOZ, Texel) reconstructed the seasonality in occurrence of harbour porpoises, and described interactions with common bottlenose dolphins and their (presumed shared) prey (Verwey 1975). The animals were observed mostly during bicycle rides along the dike, from the ferry to Texel, or occasionally from the institute's research vessel, i.e. they were opportunistic sightings rather than systematic observations. The last sightings of significance were reported by Dudok van Heel (1960), who recorded 40-50 "*Phocaena*" in Texelstroom, the sea inlet just to the southwest of the Marsdiep area. Since then, few sightings were recorded until the late 1990s (Camphuysen 2004). The information on seasonal trends was only based on data gathered between 1934 and 1939, when porpoises were still abundant. The more systematic observations were made between the harbour of Den Helder and the lighthouse of Huisduinen (along a dike), and were given as "monthly totals", where a month comprised circa twelve observation days (during fine weather). From these historical data and other publications we could summarise the historical abundance of harbour porpoises in Dutch coastal water (with emphasis on the Marsdiep area) as follows:

Before World War II, harbour porpoises were common in Dutch coastal waters (Weber 1922, van Deinse 1925). Numbers in the Marsdiep area were very low from February/March to May, increased in early summer (May or June-July) and rather high numbers were seen in winter (November-December to January-February; once in March; Verwey 1975). Verwey's observations contradict descriptions of the seasonal abundance of harbour porpoises in nearshore waters along the mainland coast of the Netherlands by other authors, who referred to the summer as a period with the

highest numbers (Heinsius 1914, van Deinse 1925). IJsseling & Scheygrond (1943) noted that most strandings in The Netherlands occurred in the summer months (notably in August), and many stranded animals were apparently neonates (newborns; van Deinse 1925). Harbour porpoises in the Marsdiep area were assumed to follow the tidal current (entering during flood, leaving during ebb; Verwey 1975). These suggestions were supported by only two observations. Some porpoises were observed in extremely shallow waters in the Marsdiep area: in small creaks, and over sand banks at high tide that were exposed at low tide. In 1939, the first signs of a decline in numbers were noted (Viergever 1955). During World War II, it was impossible to collect data, but directly following the war numbers seemed to have declined even further. Verwey (1975) stated that this decrease took place around 1945, but the decline became more obvious in the 1960s. Factual data are scarce, unfortunately, and assessments of (effort corrected) trends in relative abundance cannot be reconstructed from this material.

Methods

The Marsdiep forms an inlet between the Wadden Sea and the North Sea, through which half of the total body of water in the Dutch Wadden Sea passes twice a day, equating to one billion m^3 of water (Zimmerman 1978). This movement has an average flow rate of 1 $m.s^{-1}$. This dynamic estuary has a highly variable bathymetry with depths ranging from 1 up to 45 meters (figure 1). The tide in this area can be classified as a semi-diurnal pattern with a cycle of 12.25 hours (Dronkers 1964). The tide is asymmetric in this area with a relatively long-lasting high tide. These high tides can consist of double-headed high tides or a so called "agger", i.e. a high tide in which the water rises to a certain level, recedes slightly, and then rises again. This phenomenon is mainly caused by non-linear effects like friction and self-advection (Zimmerman 1976).

Observations 1981-2010

A recent set of data, uploaded almost daily, was obtained from the database of the Dutch Seabird group (NZG/CVZ; currently managed by www.trektellen.nl). Seawatchers, a highly specialised and well trained group of amateur ornithologists, conducted systematic, year-round observations from vantage points along the Dutch coast (Camphuysen 1985, Camphuysen 2011). Although their main focus was the occurrence of true seabirds and migratory wildfowl and waders, they have always recorded marine mammals. These observations provide a long-term dataset from which long-term trends and seasonal patterns can be analysed (Camphuysen 2011). For this paper, we restrict our review to data collected at the seawatching site at Huisduinen (HD, figure 1) during 1981–2011. Harbour porpoises occur year-round in Dutch coastal waters, but with a distinct peak in January-March (Camphuysen 2011). For the Huisduinen data, only this period has been analysed. Seawatchers recorded the date, weather, and duration of the counts (start- and end-time), and reported sightings per hour of observation (*n*.$hour^{-1}$).

Observations in 2011

Standard seawatches from observation site Huisduinen (HD), following the exact same methods as in previous seasons, were continued to provide comparable data with earlier years. Observation teams were stationed at three additional locations: at Texel on the Wadden Sea dike near the NIOZ (ND), and near the southern tip of the island near a naval base (MB) (figure 1). In addition, observations were conducted from the dike at Den Helder

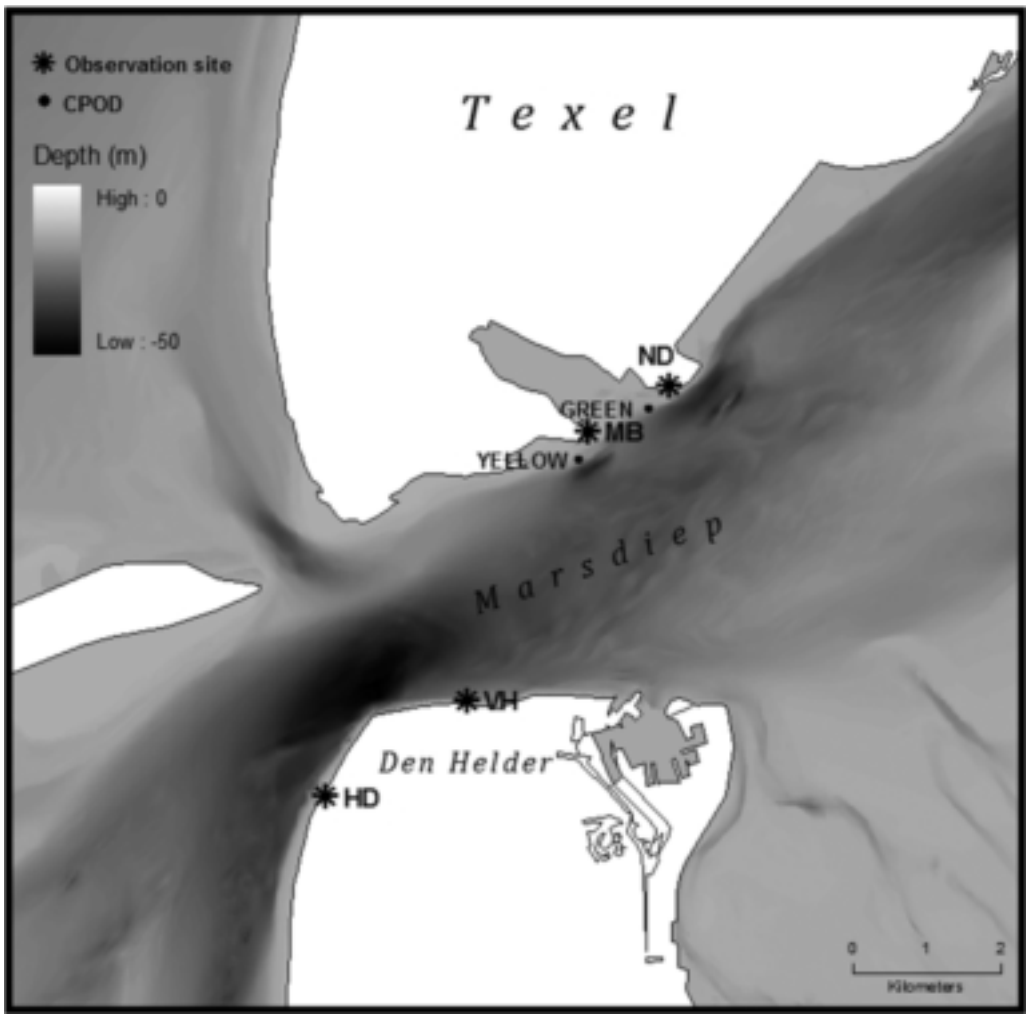

Figure 1. Map of the study area including bathymetry and locations of C-PODs (green and yellow). Standard seawatches were conducted from Huisduinen (HD). Further observation sites included the Wadden Sea dike near NIOZ at Texel (ND), the southern tip of Texel near a naval base (MB), and the dike at Den Helder ("Vlettenhelling"; VH). Green refers to the position of the first C-POD (#1482), attached to a green pole, yellow refers to the position of the second C-POD (#1481) attached to a yellow pole.

(Vlettenhelling; VH), some two km further east into the Wadden Sea relative to the Huisduinen seawatching site. Observations were made between 20 February and 20 April 2011 (516 hours of observation). However, data from April were excluded from the analysis because harbour porpoises were very scarce in that period (81 hours, 5 sightings). Observations were generally done by three observers, with one observer always at Huisduinen and the other two at any of the other observation sites. Effort was logged in 15 minute intervals, recording site, date, time, observer, meteorological conditions (wind direction and speed, cloud cover, visibility, precipitation), sea state, tide and any visual oceanographic features, such as fronts and tidal ripples. For each sighting, real time, distance and

Table 1. Observer effort (h) for visual observations in the Marsdiep area, February-April 2011. For the more detailed analysis of sightings, only the observer effort in bold was used: excluding data collected in April or when visibility was poor (see text); see figure 1 for site locations.

Location	Abbreviation	Feb	Mar	Apr	Total
Huisduinen	HD	**54**	**170**	34	258
Dike Den Helder	VH	**2**	**62**	15	79
NIOZ-dike Texel	ND	**10**	**61**	13	84
Naval base Texel	MB	**0**	**63**	19	82
Poor visibility		3	10	0	13
Total effort (sum)		69	366	81	516

angle were noted. To assess distance to the observer, 7x50 reticle binoculars were used. The reticles were converted to meters following Buckland et al. (1993).

Details about group composition, swimming direction and association with birds or oceanographic features were recorded for each sighting. Apart from harbour porpoises, sightings of seals (Phocidae; not identified to species) and vessels were recorded, under the assumption that high traffic densities and high seal abundances (or the absence of shipping and/or seals as the other extreme) could influence the behaviour and relative abundance of porpoises within the study area.

Weather permitting, six hours of observation per day were planned, with observer effort being equally distributed over the time of day and over the tide, to account for obvious factors that may affect the abundance and behaviour of harbour porpoises. During rough weather (high sea state), scheduled visual observations were cancelled. Data of observations conducted in poor visibility (less than 1000 m) were excluded from the analysis (effort and sightings; in total 13 h observation and six sightings; table 1). Data collected in April, when harbour porpoises appeared to be very scarce, were excluded from the analysis of factors associated with high abundances (a removal of 81 hours of observation, resulting into only five sightings). Information on tide and water level were obtained from the DONAR (Data Opslag Natte Rijkswaterstaatdatabase) made available by the Dutch Ministry of Infrastructure and the Environment at www.waterbase.nl. Time to high-tide was classified into four classes, with break points at high and low tide and exactly in between low and high tide. This was used to analyse the relation between porpoise abundance, behaviour and tide.

Passive acoustic monitoring

Because of their elusive nature, harbour porpoises are easily overlooked, particularly in windier conditions with rough seas. Therefore we used, in addition to our visual observations, passive acoustic monitoring devices, so-called Continuous Porpoise Detectors (hereafter called C-PODs) at two sites; one situated close to the NIOZ dike (53°00'N, 04°47'E) and the other one on the other side of the bay, close to the naval base (52°99'N, 04°77'E; figure 1). C-PODs record frequencies of 20 to 160 kHz and pick up harbour porpoise clicks. The click train filter developed by Tregenza (2011) was used to extract click trains from background noise. Porpoise click frequency is very high, between 100 and 160 kHz, which means that the sound propagation range is relatively small (Au 2000). Hence, the range of a C-POD is only around 250 meters horizontally, depending on

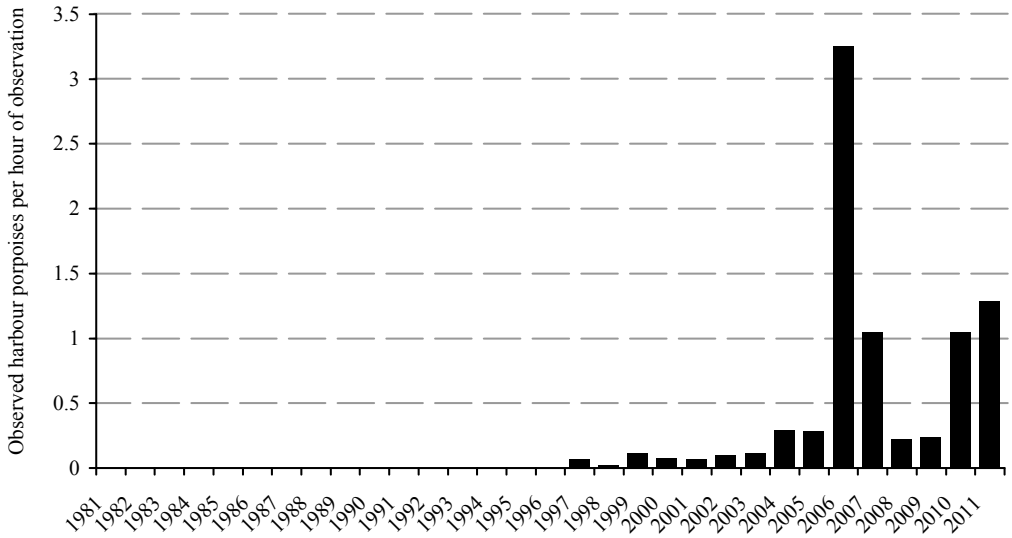

Figure 2. Harbour porpoises (*n*.h-1) in spring (January-March) at Huisduinen, based on systematic seawatching data, 1981-2011 (database NZG/Club van Zeetrekwaarnemers, www.trektellen.nl and unpublished annual reports Vogelwerkgroep Den Helder, 1996-2005).

sea conditions, but also on characteristics of the harbour porpoise clicks and orientation of the individual relative to the C-POD. The beam width of the sound emitted by porpoises is only about 12° (Au et al. 1999), hence a substantial number of porpoises in proximity of the C-POD may remain undetected.

To increase buoyancy, a buoy was glued to the C-POD. The C-POD was attached to an anchor with a 1 m long rope, so that the device was not in contact with the sea floor, in order to minimize the influence of sediment noise as much as possible. Once every few weeks, the SD memory cards of the C-PODs were replaced. The data on the memory cards was processed in the computer programme CPOD.exe, V2.012 (Tregenza 2011). From 8 February 2011 onwards, CPOD #1482 ("green pole") was deployed, and from the 17 February 2011 onwards a second CPOD (#1481, "yellow pole") was used (figure 1). Deployment depth during low tide was at approximately 9 and 14 m, respectively. Data recorded between 22 February and 7 April were used for comparison with our visual observations.

In the software programme the trains of clicks were classified as low, moderate or high quality clicks on the basis of their probability to be a porpoise click (Tregenza 2011). In the analysis, only click trains of high and moderate quality were used. Low quality click trains were left out, because these were considered to include many false positive detections. The input high pass filter was kept at the normal setting (20 kHz) and the train filter was set on detecting only NBHF cetaceans (thus 'other cetacean' was not ticked). For the data analysis, the range was set at 117 to 155 kHz. The number of minutes per day during which porpoise clicks where detected (porpoise positive minutes – PPM) was used to describe the temporal trend in porpoise occurrence.

Results

Seawatching data Huisduinen 1981-2011

During systematic seawatching observations in Jan-Mar at Huisduinen between 1997 and 2011,

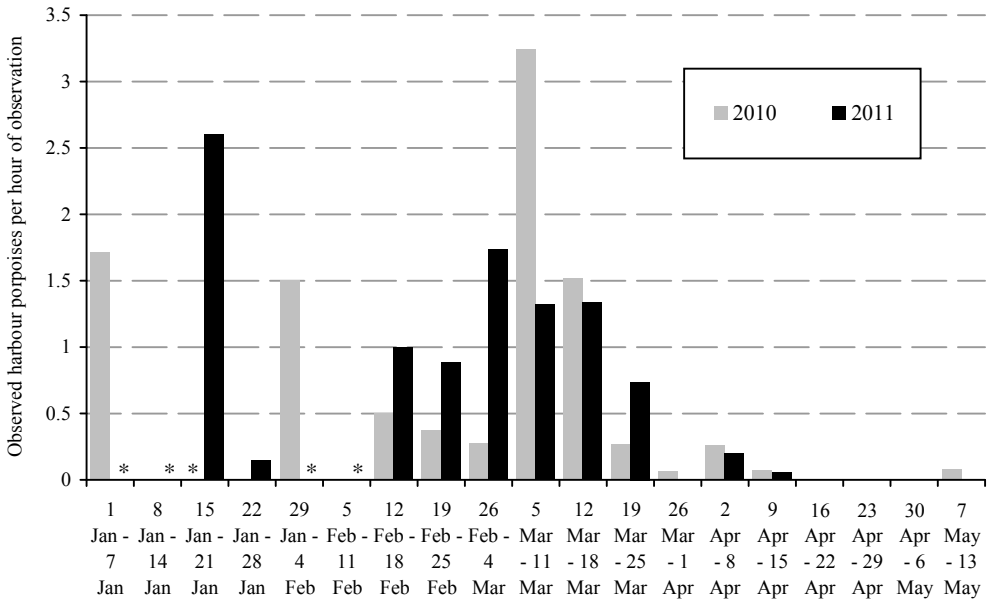

Figure 3. Weekly observed harbour porpoises (*n*.h^{-1}) at Huisduinen, January to mid-May, 2010 and 2011 (www.trektellen.nl). * no observation effort

1458 porpoises were recorded in 2400 hours of observation (mean 0.61 porpoises.h^{-1}); while none were seen and recorded in earlier years (1981-96; figure 2). The overall mean sighting frequencies in late winter did not exceed 0.20.h^{-1} until 2004. In 2006, sightings peaked at 3.25.h^{-1}, and from then on did not drop below 1.h^{-1}, with the exception of 2008 and 2009, when 0.25.h^{-1} were recorded. Spring 2011 was the season with the second most observations ever, with slightly higher numbers than in 2007 and 2010, but less than half the number of porpoises per hour as in 2006. In the first five months of both 2010 and 2011, sightings (*n*.h^{-1}) were most regular between late February and late March (figure 3). In both years, numbers declined markedly in April.

Marsdiep visual observations in 2011

Between 20 February and the end of March 2011, 605 harbour porpoises were recorded during more than 400 hours of observation (poor visibility conditions excluded; 1.53.h^{-1}). A first peak in sighting frequencies was recorded on 23 February, a second peak on 5-7 March, and a third period of relatively high numbers of sightings lasted from 12-30 March (figure 4). Very few animals were observed in April, after a marked decline in sighting frequencies during the last week of March. Harbour porpoises were most abundant off the naval base at Texel (MB, 2.4.h^{-1}), followed by the Wadden Sea dike at Texel (ND, 1.8.h^{-1}), seawatching site Huisduinen (HD, 1.3.h^{-1}), and the dike at Den Helder (VH, 0.75.h^{-1}). The mean pod size (±sd) was 1.31±0.59 per sighting (range=1-5).

Particular phases of the tidal cycle produced more sightings than others. Relatively high abundances were recorded around high tide (late flood and early ebb; figure 5). When a distinction is made between ebb and flood, higher abundances were found during flood. This pattern was found at most sites, but most clearly at the naval base. Along the dike of Den Helder near VH, however, a complete different pattern was found: here the highest abundance was observed directly after

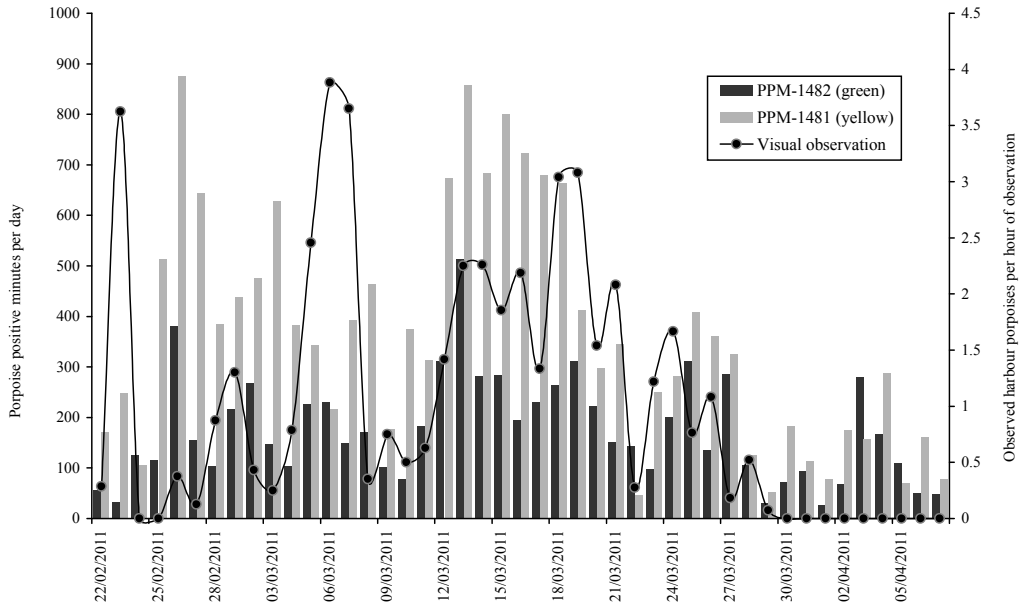

Figure 4. Acoustic detections of harbour porpoises (porpoise positive minutes per day; PPM) based on continuous recordings of two C-PODs in the Marsdiep area and visual detections during daytime (mean $n.h^{-1}$, indicated by ●) at all observation sites combined (animals per hour of observation). Estimates of porpoise sighting rates on days during which no observations were possible (bad weather or otherwise), are based on linear interpolations between the observation days.

low tide, during early flood, after which it decreased until the next early flood. The visual observations included impressions of the behaviour of porpoises. Some porpoises were accompanied with searching and plunge diving gulls, but by far most animals were seen away from the most prominent feeding frenzies of seabirds.

Acoustic observations in 2011

The number of porpoise positive minutes recorded per day by the C-PODs during the study period show a similar seasonal pattern as that obtained by visual observations (figure 4), but some disagreements in recordings (high peak in sightings with few acoustic recordings or vice versa) occurred on 23 February (many sightings), 26-27 February (frequent acoustic recordings) and around 6 March (many sightings). Daily activity indices derived from both C-PODs (using days that visual observations were conducted in the Marsdiep area) were positively correlated (Pearson's correlation based on log PPM per day: r^2= 0.67, df=43, t=5.9, P<0.00001). Also, the frequency of sightings and acoustic recordings for both C-PODs were positively correlated (mean log of PPM of C-POD 1481 ("yellow") per day versus log of daily sightings rate; r^2= 0.58, df=43, t=4.72, P=0.000025, mean log of PPM of C-POD 1482 ("green") per day versus log of daily sightings rate; r^2= 0.48, df=43, t=3.6, P=0.00079). Acoustic detections and visual detections were scarce in April.

Discussion

During this pilot study, a substantial data-set could be obtained and especially in March porpoises were observed on a regular basis, particularly near the coast of Texel. Although

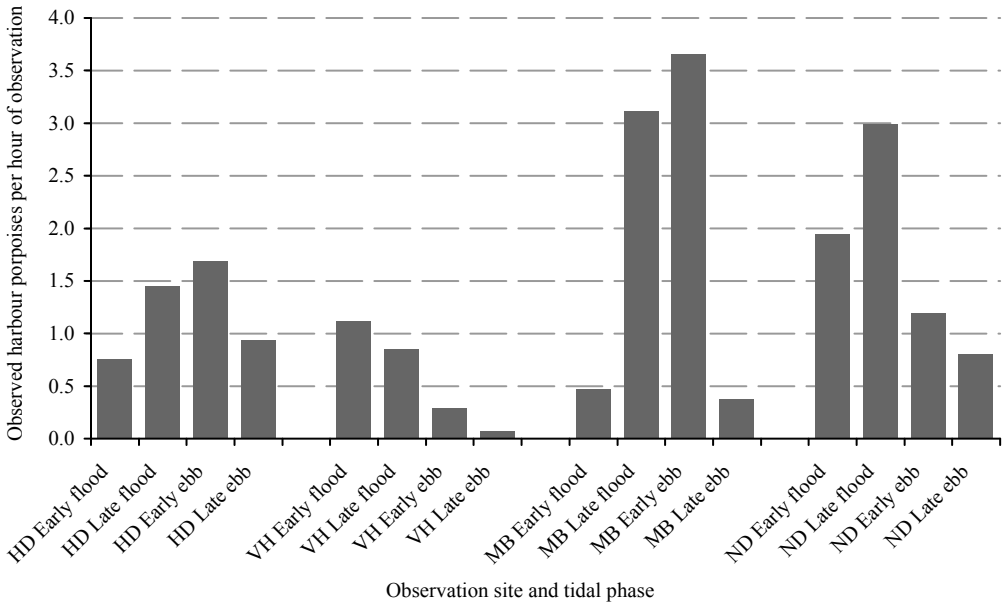

Figure 5. Visual detections of harbour porpoises ($n.h^{-1}$) at each observation site relative to the tidal phase.

at almost every location a relation between abundance and tide was found, the effect was most clear off the naval base (MB), where the abundance was highest around high tide. At the constant effort-site Huisduinen, the abundance of porpoises in spring 2011 ($1.53.h^{-1}$) was similar to 2007 and 2010, but higher than in 2008 and 2009 (mean $1.6.h^{-1}$ for the same observation period at Huisduinen, 2006-2010). From the perspective of our feasibility study, harbour porpoises were certainly numerous enough in early spring to have the Marsdiep serve as a study area for harbour porpoises in future years.

The higher sighting frequencies at the Texel side, particularly near the naval base, suggest that porpoises have a preference for this side of the Marsdiep. Alternatively, the more frequent sightings may have been caused by larger numbers of semi-resident animals (temporarily present on the spot; numerous re-sightings; movements within a particular area). Along the dike of Den Helder, more animals may have been just passing by and would have a lower chance to be recorded over and over again. Directed movements (all animals moving in the same direction) are common at Huisduinen, but on days with particularly high numbers of sightings, local movements (producing double-counts) prevailed.

Visual vs. acoustic observations

The abundance of harbour porpoises in the Marsdiep area during our study period was highly variable (figure 4), and the causes of fluctuations in numerical abundance are currently not well understood. The peak in sightings on 6-7 March consisted mainly of sightings at one observation site. The abrupt end of sightings in April was, like in other years, very distinct, and seems to point at a general departure towards deeper waters of the North Sea (cf. Camphuysen 2011). In contrast, recent coastal observations in 2013 suggest a high abundance of harbour porpoises in April (www.trektellen.nl).

Some peaks in sightings were not reflected in the acoustic data. Because acoustic recording were deployed during the same period in the same area, we were able to compare the

acoustic recordings with indices of abundance recorded during visual observations. The acoustic data was expressed in porpoise positive minutes recorded per day. Porpoises use echolocation clicks to locate prey and to navigate, but when travelling, less clicks per minute are produced than when searching and hunting prey (Verfuβ et al. 2009). Hence, fluctuations in numbers of clicks does not necessarily represent variations in number of porpoises. However, PPM does not differentiate between variations in click frequency, and is therefore a more robust estimate of local occurrence. The relative strong and significant correlation between the visual sightings and C-POD recordings indicates that the acoustic recordings can indeed be used as a proxy of local porpoise abundance.

Both the acoustic and visual observations reveal a sudden disappearance in April. The historical seasonal pattern in abundance (Verwey 1975) was compared with the seasonality observed today (Camphuysen 2011). Verwey did not describe a sudden disappearance of porpoises in spring, nor a distinct peak season in late winter. In the old days, numbers gradually declined through May, June, and July. Interestingly, most recent observations in 2013 suggest a high abundance in April. This may be a single year event caused by cold weather conditions in March, or may be a first sign of a forward seasonal shift.

Competition and prey

The decline in numbers of porpoises in late winter described by Verwey (1975) may have been linked with the arrival of common bottlenose dolphins. Common bottlenose dolphins entered the Wadden Sea in early spring and in considerable numbers (ter Pelkwijk 1937, Viergever 1940), chasing the migrating Zuiderzee herring (*Clupea harengus*) (Verwey 1975). This annual event coincided with a seasonal decline in porpoise numbers. Bottlenose dolphins can be aggressive towards and even kill harbour porpoises (Ross & Wilson 1996), and their arrival could have been the main reason for porpoises to avoid the area during this period. The bottlenose dolphins have disappeared from the Marsdiep area and did so far not return (Camphuysen & Peet 2006). The abrupt decline in numbers in April as observed during this study can therefore not be explained by (aggressive) encounters with larger cetaceans.

According to Johnston et al. (2005), a strong relation with the distribution of their main prey species is an essential part of the harbour porpoise life-history. A link between the abundance of whiting (*Merlangius merlangus*) in the North Sea and the abundance of porpoises in late winter, as proposed by Verwey (1975), may still be valid today. Whiting, and also gobies (*Pomatoschistus* spp. - a common prey of immature porpoises in late winter), form the major part of adult harbour porpoise's diet in terms of mass and energy (M.F. Leopold, personal communication). The movements of harbour porpoises in this part of the North Sea can be related to the migration of some important prey species and a relation between the presence of porpoises in the Marsdiep area and the spring abundance of gobies has been suggested. The annual migration of gobies was described by Fonds (1973). The harbour porpoise is a relatively small, endothermic predator with limited energy storage capacity, dependent on foraging throughout the year without prolonged periods of fasting (Kastelein et al. 1997, Bjørge 2003). Future work in the Marsdiep area will need to focus at the foraging ecology of porpoises entering this tidal inlet to find a potential link with seasonal fluctuations of available prey.

Tide and foraging opportunities

The bathymetric composition of the site interacting with the tidal current could induce upwelling or relative high vorticity, enhanc-

ing particle transports and food availability in the water column (Mann & Lazier 1996). Such features could enhance the foraging opportunities for harbour porpoises (Jovallanos & Gaskin 1983, Johnston et al. 2005). If foraging opportunities off the naval basis did increase around high tide, movements of porpoises should be directed towards the area during flooding. Porpoises were in fact rarely seen to join these feeding frenzies in the turbulent areas around the shallows off the naval base. Their frequent occurrence in the area suggests other foraging opportunities that must receive more attention in future studies. Our results suggest that individual porpoises do not stay in the Marsdiep for long periods, but rather move in and out on a more or less daily basis.

Conclusions

In conclusion, the Marsdiep and its spring harbour porpoise population, provide excellent opportunities to study these elusive cetaceans in their natural habitat in the wild. During this pilot study, with relatively simple techniques, a considerable amount of new information on temporal and spatial aspects of the occurrence of porpoises in one of the most spectacular tidal inlets in the Wadden Sea was collected. The study opportunities off the naval basis at Texel are the most promising. The area is complex in its oceanography and bathymetry, and serves as a foraging area for several piscivorous top-predators. Advanced observation techniques may have to be deployed to pinpoint the exact positions of porpoises in that area. Such exact locations of sightings will then be combined with high resolution data on local bathymetry, currents and vorticity, water properties such as salinity, turbidity and temperature, and hopefully also with the availability of suitable prey, in order to achieve a better understanding of the ecology of harbour porpoises in this dynamic sea area.

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Samenvatting

Bruinvissen (*Phocoena phocoena*) in het Marsdiep: nieuw onderzoek in een historisch onderzoeksgebied

De bruinvis (*Phocoena phocoena*) keerde na een periode van afwezigheid van ongeveer drie decennia aan het eind van de vorige eeuw terug in de Nederlandse kustwateren. Bruinvissen zijn hier momenteel het meest aanwezig in de winter en het vroege voorjaar (december-maart). In het Marsdiep, de doorgang van de Noordzee naar de westelijke Waddenzee tussen Den Helder en het eiland Texel, werd de bruinvis in het midden van de 20ste eeuw bestudeerd. Dit onderzoek moest echter wor-

den gestopt wegens het verdwijnen van de bruinvis. Na de terugkeer van bruinvissen in de Nederlandse kustwateren is er in 2011 een haalbaarheidsonderzoek uitgevoerd om na te gaan of het opnieuw de moeite waard zou kunnen zijn om bruinvissen in het Marsdiep te bestuderen. De aantallen bruinvissen die in het voorjaar van 2011 werden gezien waren groot, maar weken niet wezenlijk af van wat er, op basis van zeetrektellingen bij Huisduinen, aan aantallen bruinvissen in de afgelopen vier seizoenen werd gezien. De meeste dieren werden waargenomen rond middenmaart en ze verdwenen in april. In vergelijking met het historische voorkomen lijkt deze piek in voorkomen twee tot drie maanden verschoven in de tijd. Waargenomen aantallen waren het hoogst aan de Texelse kant van het Marsdiep, vooral in de monding van de Mokbaai ter hoogte van de marinebasis op de zuidpunt van Texel. Op bijna alle observatieposten werden relatief veel waarnemingen gedaan rondom hoog water, bij de marinebasis was dat het meest uitgesproken. De waarnemingen suggereren dat, vooral tijdens hoogwater, deze plaats zuidelijk van de Mokbaai een voor bruinvissen aantrekkelijk gebied vormt, wellicht om te foerageren of om hydrodynamische redenen. De door Verwey waargenomen verplaatsing van bruinvissen "met het getijde mee" kon tijdens ons onderzoek niet worden bevestigd. Wij concluderen dat bij gelijkblijvende (of toenemende) aantallen bruinvissen in het gebied, het Marsdiep een uniek en zeer geschikt studiegebied zou kunnen zijn om bruinvissen ongestoord en in het wild te onderzoeken.

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