Observations of harbour porpoises in offshore wind farms

Final report

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WAARDEN BURG Ecology

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Preface

In this study, we collected and analysed all sightings of harbour porpoises in offshore wind farms in the North Sea that are present in the databases of Waardenburg Ecology originating from various projects over the past decades.

This report was realised by:

Jacco Leemans	field work, analyses, report writing
Ruben Fijn	field work, project management
Jeroen Kwakkel	project start up
Rob van Bemmelen	field work, quality control analyses
Camiel Heunks	second reader

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Summary

With the ongoing development of offshore wind energy in the North Sea, a substantial part of the distribution of harbour porpoises (*Phocoena phocoena*) will overlap with offshore wind farms (OWFs) in the near future. Effects of the construction of OWFs on the distribution and ecology of harbour porpoises has received a lot of attention in research and impact assessments for many years, however, data on the presence of harbour porpoises in and around operational OWFs are relatively scarce. Gaining more knowledge on the spatial and temporal occurrence of harbour porpoises in OWFs is a prerequisite for adequate impact management. As part of ornithological monitoring programmes, 174 visits to multiple OWFs in the North Sea were carried out between 2007 and 2023. Following standardized observation protocols for birds, marine mammal observations were also recorded during these visits. Additionally, harbour porpoises were recorded during Digital Aerial Surveys (DAS) in and around the operational wind farm Borssele in 2021. We combined all harbour porpoise observations from these studies with the aim to study temporal and spatial use of operational OWFs. Harbour porpoises were seen year-round inside OWFs with highest abundances in winter. We found additional (smaller) peaks in autumn (September and October), which, to our knowledge, has not yet been reported before. A comparison of observations in two nearby OWFs separated by a decade suggests an increase in the abundance of harbour porpoises in the area over time. Behaviour was not systematically recorded but foraging behaviour inside the wind farm area was observed on a small number of occasions. Harbour porpoises were occassionally observed at close distances to operational wind turbines, even foraging. However, data of DAS shows that the probability of observing a harbour porpoise significantly decreases closer to wind turbines, which strongly suggests that harbour porpoises avoid close distances to operational wind turbines. Their numbers stabilise at distances of around 500m to wind turbines. Furthermore, we found that harbour porpoise densities do not significantly differ inside a wind farm corridor compared to the wind farm border or inside the wind farm area.

1 Introduction

Several programmes, such as the Dutch Governmental Offshore Wind Ecological Programme (*Wind op Zee Ecologisch Programma* (Wozep)), the Harbour Porpoise Conservation Plan (LNV 2020) and the *Monitoring-Onderzoek-Natuurversterking-Soortbescherming* (MONS) programme, indicate the importance of gaining more knowledge on the habitat quality and prey availability for harbour porpoises (*Phocoena phocoena*) in the North Sea. Considering the ongoing development of offshore wind energy on the North Sea, a substantial part of the distribution of harbour porpoises will overlap with offshore wind farms (OWFs) in the near future. Potentially, this can lead to disturbance and habitat loss for porpoises, but the artificial habitat in and around OWFs potentially also influences the food availability for harbour porpoises. Whether this latter effect is positive or negative is yet unknown.

Effects of (the construction of) offshore wind farms on the distribution and ecology of harbour porpoises have been researched for years. However, many knowledge gaps remain on the presence of harbour porpoises in and around operational offshore wind farms, how they use these areas and whether these aspects change over time. Gaining more knowledge on the spatial and temporal occurrence of harbour porpoises in operational OWFs is a prerequisite for adequate impact management.

Recently, Rijkswaterstaat has commissioned a project within the Wozep framework focussing on the presence of harbour porpoises in offshore wind farm Borssele using passive acoustic monitoring (Porpoise Network Borssele, PNB). This methodology has some specific limitations and parameters such as behaviour of porpoises, the use of corridors in the wind farm and the number of specific individuals during detections cannot be determined using the PNB. There are however possibilities to gather this information from additional data. Over the past decades, Waardenburg Ecology carried out regular visits to several offshore wind farms and platforms in the North Sea. These visits were always done as part of bird studies (Fijn *et al.* 2012). Nonetheless, sightings of harbour porpoises were also recorded. In this study, we collected and analysed all these sightings with the aim to answer the following research questions:

1. When and how do harbour porpoises use offshore wind farms?
2. Do harbour porpoises forage inside offshore wind farms or do they merely commute through them?
3. If harbour porpoises show foraging behaviour, what is their distance to wind turbines?
4. To what extent do harbour porpoises use corridors inside offshore wind farms?

An earlier report of Leemans *et al.* (2023), which includes data up to the end of 2022, forms the base of the report at hand. In 2023, we have collected additional data in wind farm Borssele, amongst others during trips with the Porpoise Network Borssele. This report will therefore update the report of Leemans *et al.* (2023) by including data of all offshore field visits up to November 2023. Furthermore, this report contains a more profound analysis of aerial survey data, compared to Leemans *et al.* (2023).

2 Methods

This report includes all harbour porpoise observations recorded during visual observations from different observation locations (Figure 2.1) as part of bird studies in Offshore Wind farm Egmond aan Zee (OWEZ), Luchterduinen, Borssele and Gemini (Table 2.1, Figure 2.2) up to November 2023**.** Additionally, we present data of Digital Aerial Surveys (DAS) carried out in and around wind farm Borssele between February 2021 until February 2022. For this, two surveys were carried out in each month, with the exception of February (three surveys). Most visual observations were carried with generally favourable weather conditions with a maximum seastate of 4. An exception on this were three field visits to Gemini, as transfers to the platform were done via helicopter. Digital Aerial Surveys were carried out with a maximum seastate of 6.

Table 2.1 Overview of the study period, starting year of construction of the wind farm, number of visits and type of observation location of the visual bird surveys carried out in the four different wind farms.

Wind farm (start of construction)	Study period	Number of visits	Observation location
OWEZ (2006)	2007-2009	58	Metmast
Luchterduinen (2013)	2018-2021	59	Wind turbine
Gemini (2015)	2020-2021	7	Platform
Borssele (2019)	2019-2021	9	Platform
	2021-2023	37	Ship
	2023	4	Wind turbine

Figure 2.1 Impression of the locations from which observations were carried out: the Metmast in OWEZ (left), the Transition Piece (TP) of a wind turbine in Luchterduinen (middle) and the platforms in Borssele and Gemini (right). Photos credits (from left to right): H. Waardenburg, D. Beuker, J. Leemans.

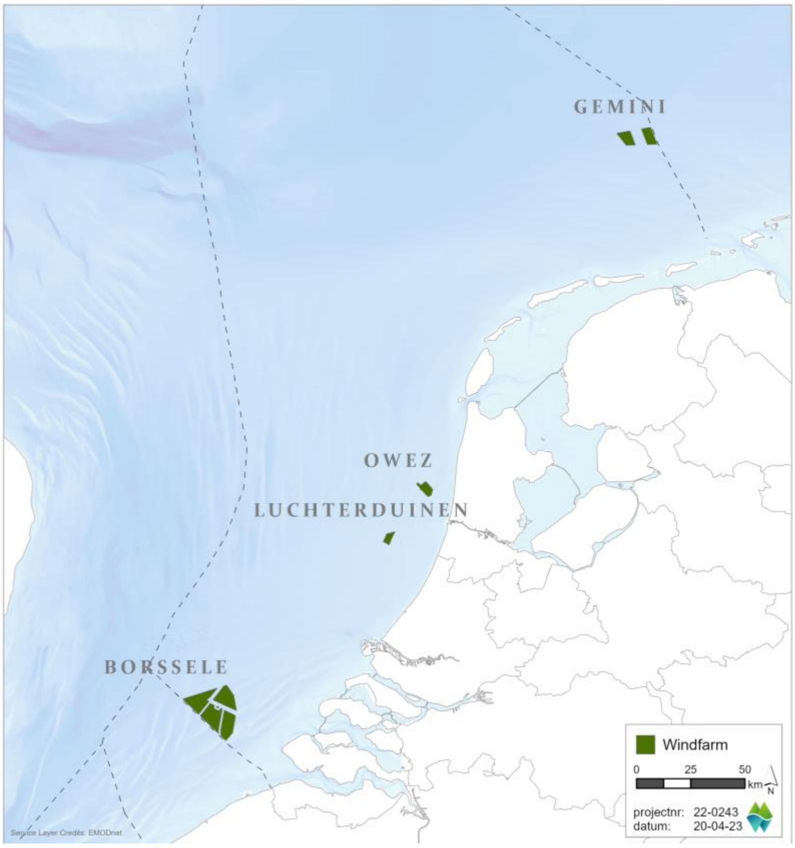

Figure 2.2 *Overview of the locations of the four offshore wind farms included in this study.*

Based on visual observations and DAS, we describe temporal and spatial patterns in the presence of harbour porpoises in these offshore wind farms (Table 2.2). The spatial patterns based on DAS were analysed using binomial logistic regression with the R-package 'lme4' (Bates *et al.* 2015). We modelled the presence/absence of harbour porpoises in a 25x25m grid in relation to the distance the nearest wind turbines or platform, with each separate survey day as a random effect. Furthermore, we use ship-based counts in Borssele following ESAS (European Seabirds at Sea) protocols (Vanermen *et al.* 2022) to analyse the corridor use of harbour porpoise in this wind farm (Figure 2.3). Lastly, we summarise the recorded behaviors of harbour porpoise based on the visual observations.

Table 2.2 *Overview of the sources of all data included in this analysis.*

Wind farm	Chapter	Data source
Temporal patterns – visual obs.	§3.1.1	Visual observations
Temporal patterns – DAS	§3.1.2	Digital Aerial Surveys
Spatial patterns – visual obs.	§3.2.1	Visual observations
Spatial patterns – DAS	§3.2.2	Digital Aerial Surveys
Spatial patterns – corridor use	§0	Ship counts in Borssele
Behavior in OWFs	§3.3	Visual observations

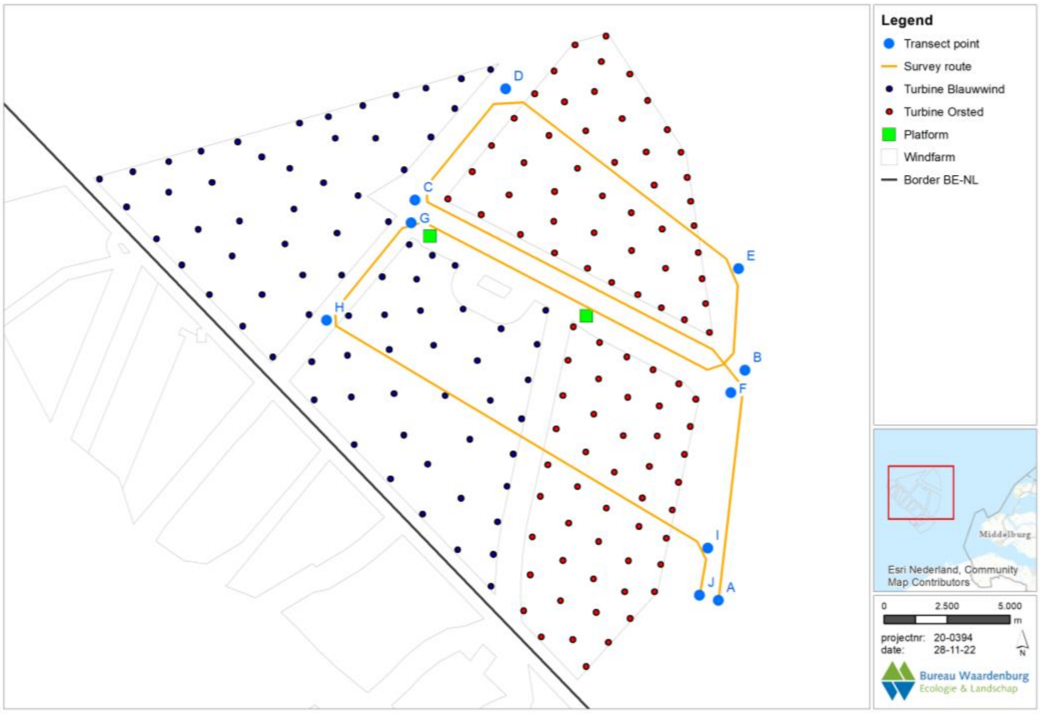

Figure 2.3 *Sailed transects of the ship-based ESAS counts in wind farm Borssele. Transects B-C, C-D and G-F were located inside the corridor (Heida et al. 2022).*

3 Results

3.1 Temporal patterns

3.1.1 Visual observations

During seabird surveys in offshore wind farms OWEZ, Luchterduinen, Borssele and Gemini from 2007 to 2009 and from 2018 to 2023, a total of 377 harbour porpoises were observed (Table 3.1). Most animals were observed in Luchterduinen, both in absolute numbers as in the number of individuals per visit. The percentage of visits in which at least one harbour porpoise was observed (referred to as 'frequency of occurrence') was highest in Gemini, where harbour porpoises were seen during 4 out of 7 visits (57%).

Table 3.1 Summary of the number of harbour porpoises, the number of visits, the number of individuals per visit and the percentage of visits in which at least 1 harbour porpoise was observed ('frequency of occurrence') in OWEZ, Luchterduinen, Borssele and Gemini.

Wind farm	Number of harbour porpoises	Number of visits	Individuals per visit	Frequency of occurrence
OWEZ	74	58	1.3	24%
Luchterduinen	169	59	2.9	49%
Borssele	121	50	2.4	24%
Gemini	13	7	1.9	57%

Among all wind farms, the frequency of occurrence was lowest in April (16%), followed by July (17%), and June and August (25%) (Table 3.2, Figure 3.1). The highest frequency of occurrence was in January (60%), while the number of individuals per visit was highest in February (4.7 individuals). Generally, the number of individuals per visit was higher (>2 individuals) from December to May and in September. In the summer months (June to August) the number of individuals per visit was relatively constant at a low level (0.4-0.6 individuals), while this number was slightly higher in October and November (0.8-0.9 individuals). In absolute numbers, most harbour porpoises were seen in September (81 individuals).

In OWEZ, the highest number of harbour porpoises (in absolute terms and per visit) were observed in February and September (Figure 3.2). No harbour porpoises were seen in OWEZ from March to July and November, despite several visits in these months. On the contrary, in Luchterduinen, harbour porpoises were observed in each month, with highest numbers (in absolute terms and per visit) in January and September. The frequency of occurrence in Luchterduinen was highest from December to February. In Borssele, the frequency of occurrence was highest from October to March, with exceptions of December and February. In absolute numbers most harbour porpoises were seen in Borssele in April (52), which were all observed on the same day. No harbour porpoises were seen in Borssele in July and August, despite 10 visits in these months. Lastly, the monthly number of visits to wind farm Gemini is generally too low to draw any conclusions on the monthly abundance of harbour porpoises in this wind farm.

Table 3.2 Total (all wind farms together) monthly number of harbour porpoises, the number of visits, the number of individuals per visit and the percentage of visits in which at least 1 harbour porpoise was observed ('frequency of occurrence').

Month	Number of harbour porpoises	Number of visits	Individuals per visit	Frequency of occurrence
January	41	10	4.1	60%
February	66	14	4.7	57%
March	27	12	2.3	33%
April	57	19	3.0	16%
May	29	14	2.1	36%
June	5	12	0.4	25%
July	11	18	0.6	17%
August	8	16	0.5	25%
September	81	19	4.3	53%
October	10	12	0.8	33%
November	13	14	0.9	29%
December	29	14	2.1	36%

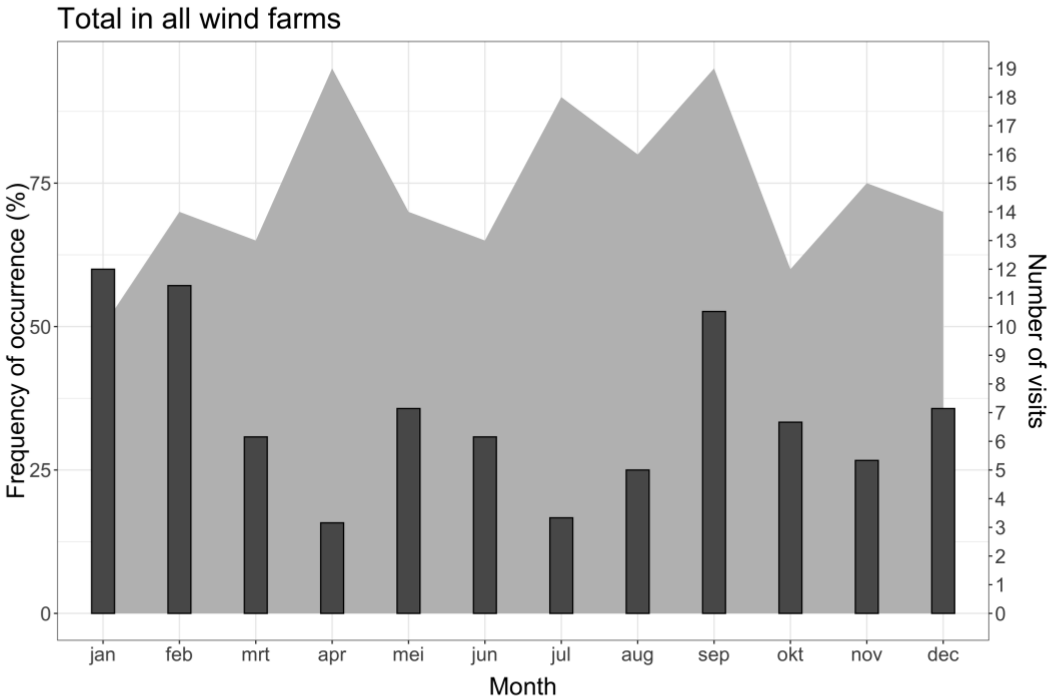

Figure 3.1 *Total (all wind farms together) monthly frequency of occurrence (bars) and the number of visits (grey shading).*

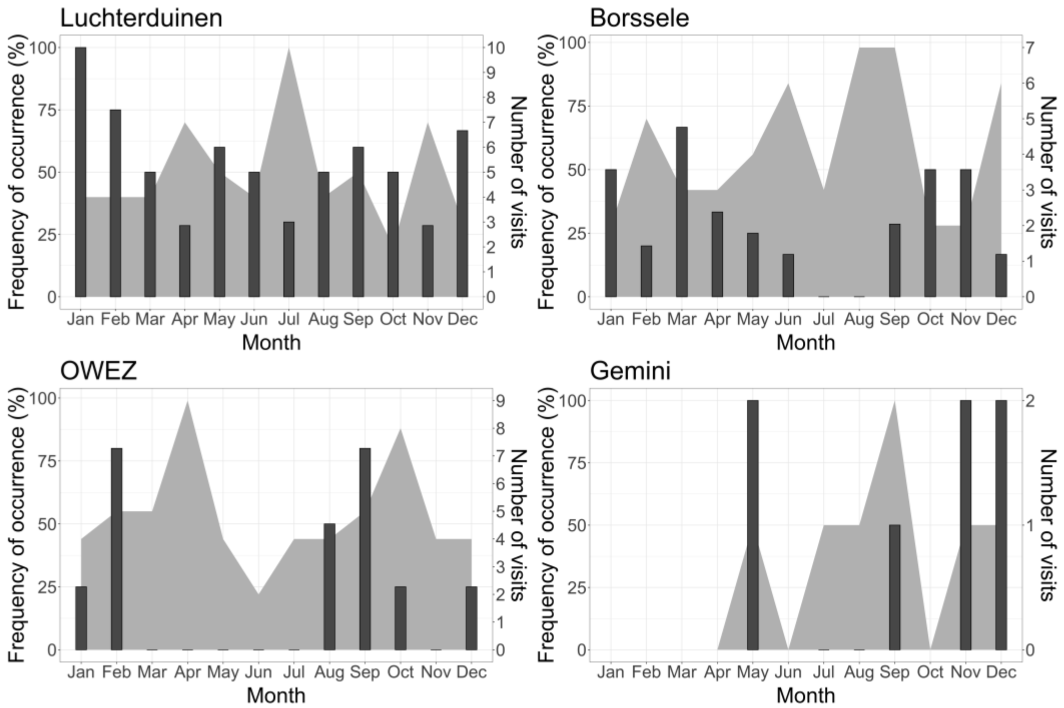

Figure 3.2 *Monthly frequency of occurrence (bars) and the number of visits (grey shading) per wind farm.*

3.1.2 **Digital Aerial Surveys**

During Digital Aerial Surveys, a total of 896 harbour porpoises were observed in and around wind farm Borssele during surveys from February 2021 until February 2022. Most animals were seen in March, followed by January and February (Figure 3.3). The lowest numbers of harbour porpoise were found in August, September and November. However, note that the surveyed strip width in November and December surveys was approximately three-quarters of that in other months due to the inclusion of data from three instead of four cameras as in other months (Collier *et al.* 2022). Also, the data of February includes one extra survey compared to other months. The pattern in the monthly number of harbour porpoises observed during Digital Aerial Surveys corresponds well with the pattern of monthly frequency of occurrence based on visual observations in Borssele (Figure 3.2).

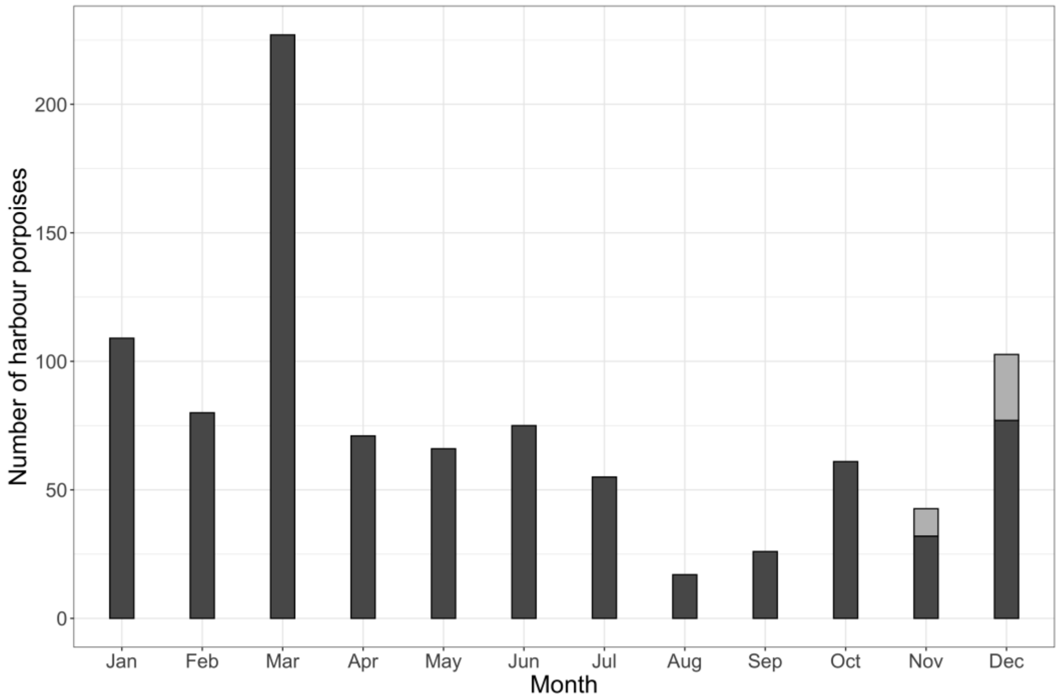

Figure 3.3 *Monthly number of harbour porpoise found in and around wind farm Borssele during Digital Aerial Surveys. In November and December linearly interpolated numbers for the missed camera are given in light grey bars on top of the counted numbers.*

3.2 Spatial patterns

3.2.1 **Visual observations**

During visual observations, the locations of harbour porpoises were not systematically recorded, resulting in 67% of observations with information on their position or on their distance to observers. Harbour porpoises were occasionally seen at close distance within 50m to wind turbines or platforms. In total, five individuals were recorded within 50m from a wind turbine in Luchterduinen (Figure 3.4), another 11 observations were done within

50m from the Metmast in OWEZ, and 2 observations within 50m from the platform in Gemini.

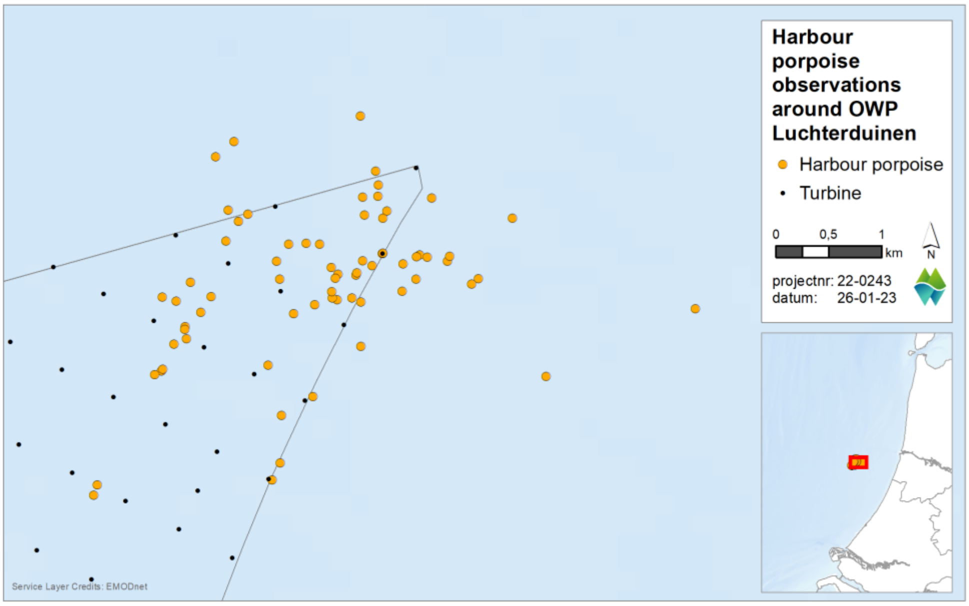

Figure 3.4 All recorded locations of harbour porpoises during visual observations in wind farm Luchterduinen.

3.2.2 Digital Aerial Surveys

All observations of harbour porpoises recorded during the digital aerial surveys (Figure 3.5) show that harbour porpoise generally prefered some distance to wind turbines or platforms. When correcting for differing detection probabilities of harbour porpoises at different distances to the nearest wind turbine or platform, due to differences in the sampled area, also the number of harbour porpoises generally increased up to around 500m from wind turbines or platforms (Figure 3.5). Binomial logistic regression shows that this effect is statistically significant, meaning that with increasing distance to a wind turbine of platform, the probability of observing a harbour porpoise significantly increases ($\beta = 0.13$, $p < 0.05$). During the digital aerial surveys, the closest recorded distance of a harbour porpoise to a wind turbine was 57m, while two harbour porpoises together were recorded at 40m from a platform.

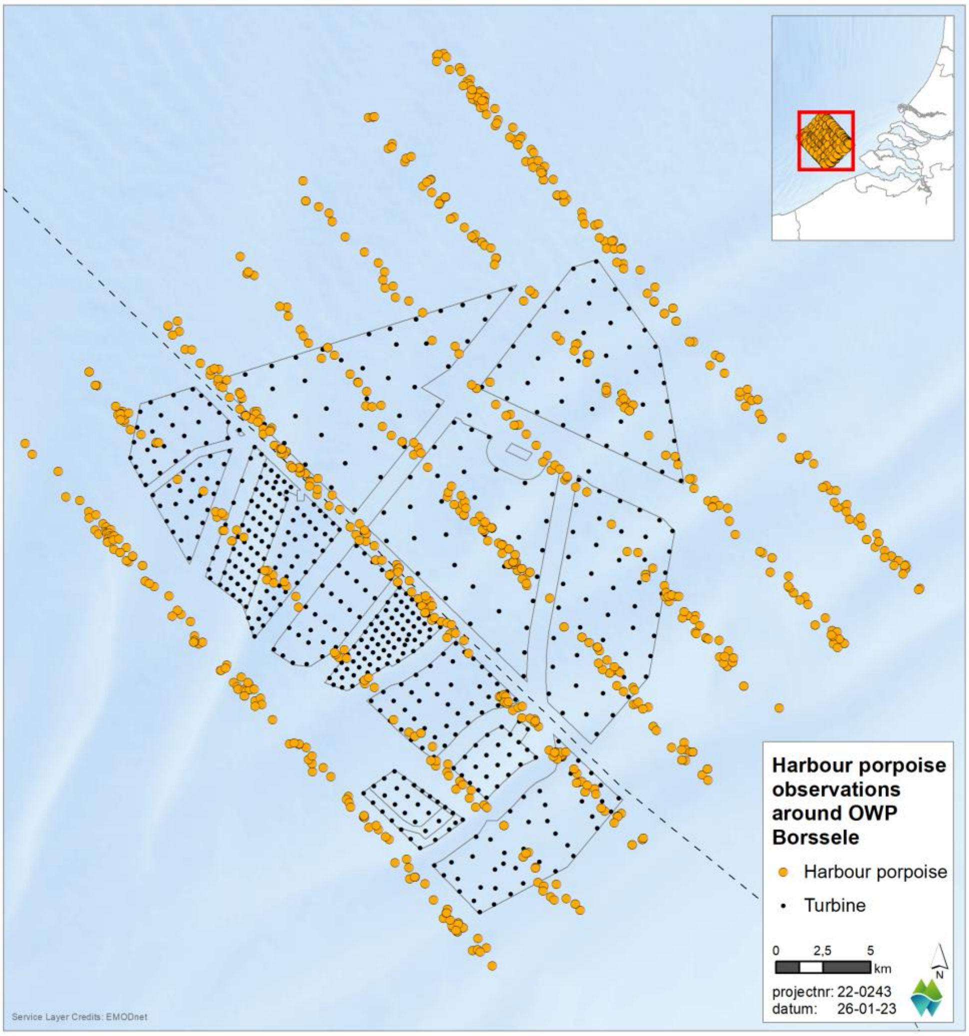

Figure 3.5 *All recorded locations of harbour porpoises during Digital Aerial Surveys in wind farm Borssele and adjoining Belgium wind farms. Note that the areas between the seven transect routes were not surveyed.*

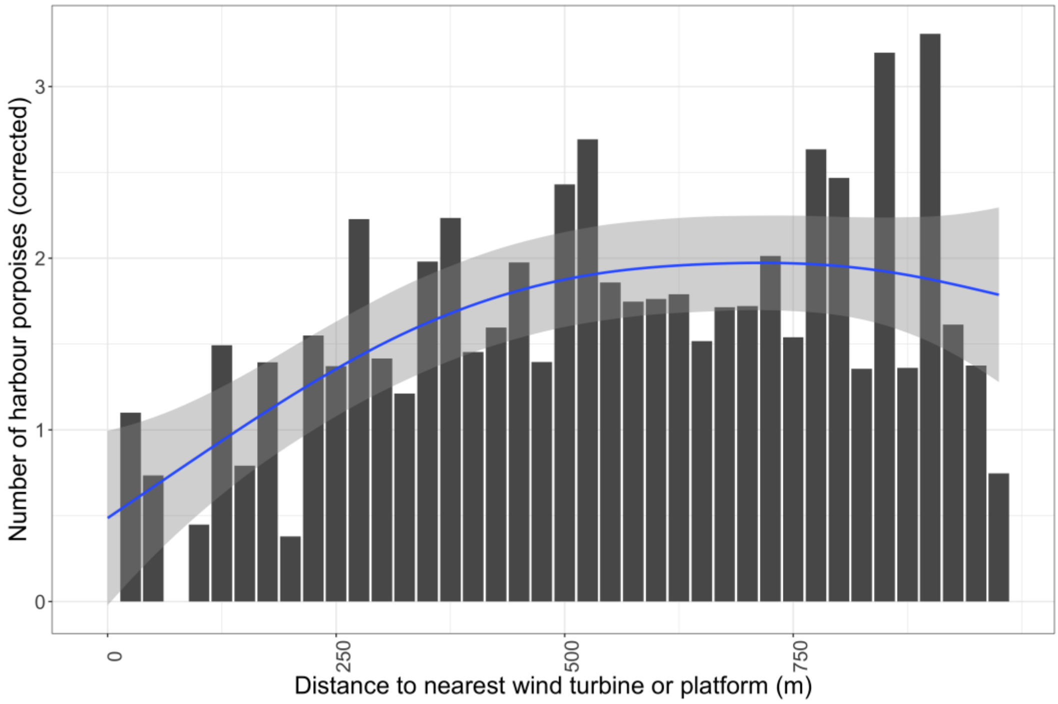

Figure 3.6 *Number of harbour porpoises versus the distance to the nearest wind turbine or platform up to 1km distance. The number of harbour porpoises is corrected for the differing dectection probability at different distances to the nearest wind turbine or platform.*

3.2.3 Corridor use

In total, 42 harbour porpoise were recorded during ship-based ESAS counts carried out in wind farm Borssele (Table 3.3). Most of these observations were done inside the wind farm perimeter, both in absolute numbers and per kilometer transect. The number of harbour porpoises per kilometer transect suggests that their densities are lower in the corridor compared to the wind farm border or inside the wind farm. However, the difference in their numbers between the transects is not statistically significant (Kruskal-Wallis H(2) = 0.16781, p = 0.92). Additionally, the transects of the Digital Aerial Surveys only covered a small part of the corridor (Figure 3.5), and thus these data are not useful to examine the corridor use of harbour porpoises.

Table 3.3 *Number of recorded harbour porpoises (per km transect) in wind farm Borssele during ship-based ESAS counts, separated for transects in the corridor, inside and along the border of the wind farm*

Location	Length of transects (km)	Number of harbour porpoises	Per km transect
border	16.0	9	0.56
corridor	34.8	13	0.37
owf	34.4	20	0.58

3.3 Behavior inside offshore wind farms

The behavior of harbour porpoises in offshore wind farms was not systematically recorded during the surveys, with only 28% of observations containing information on their behavior. Swimming/commuting was most commonly recorded (46 times), while foraging behavior was recorded three times (Table 3.4). Additionally, anecdotally we know that foraging behavior was also observed on a small number of occasions in OWEZ and Luchterduinen, although these observations were not structurally recorded as such.

Table 3.4 Summary of the recorded behaviors of harbour porpoises in offshore wind farms.

Behavior	Times recorded
swimming/commuting	46
foraging	3
resting/sun bathing	7
breaching	1
no behavior recorded	203

3.4 Photo-identification of harbour porpoises

In this study, we have collected all images of harbour porpoises that we took inside offshore wind farms during the surveys. In total 176 images were collected, which are stored in the WOZEP repository. These images may be used for the purpose of photo-identification of different individuals, which is also done in the Oosterschelde by Stichting Rugvin (Podt & Zanderink 2018).

4 Discussion

In this report, we present the temporal and spatial patterns of harbour porpoises recorded during visual observations or Digital Aerial Surveys in offshore wind farms OWEZ, Luchterduinen, Borssele and Gemini and summarise their behaviors inside these wind farms, with the aim to answer the following questions:

1. When and how do harbour porpoise use offshore wind farms?
2. Do harbour porpoise forage inside offshore wind farms or do they merely commute through it?
3. If harbour porpoise show foraging behavior, what is their distance to wind turbines?
4. To what extent use harbour porpoise corridors inside offshore wind farm?

Harbour porpoises were seen year-round in offshore wind farms. Generally, the highest numbers were found in January, February and September and the lowest in April and June to August. However, in absolute terms April had one the highest numbers, due to one day in Borssele on which with 52 harbour porpoises were observed. In general, the density of harbour porpoises in the Dutch southern part of the North Sea is thought to be highest in winter and spring, while in summer individuals tend to distribute to areas further offshore (Gilles *et al.* 2016, Geelhoed & Scheidat 2018, Bouveroux *et al.* 2020). We thus mostly found similar patterns, with elevated numbers in winter from December to February, and in spring in March and May.

In both OWEZ and Luchterduinen, we found an additional peak in September, while in Borssele, both the visual observations and the DAS data show a peak in October. These peaks in autumn were not found by Gilles *et al.* (2016). Instead, they predicted in autumn the highest densities in more north(west)ern parts of the North Sea. The authors, however, stress that they could not thoroughly assess the autumn distribution of harbour porpoises, and mention this as an essential knowledge gap. Also, another study that presents year-round harbour porpoise strandings and near-shore (<2km) sightings in the Netherlands, did not find peaks in September/October (IJsseldijk *et al.* 2021). However, all sightings in our study were done at least 10km offshore, which may confound the comparison with this study. In the large-scale monitoring program MWTL, aerial surveys of birds and marine mammals in the Dutch North Sea are carried out six times a year (Van Bemmelen *et al.* 2022), but not in September and October, thus any peaks in these months will be missed. Similarly, the latest SCANS surveys that study the distribution and abundance of cetaceans in European Atlantic waters were carried out in July (Gilles *et al.* 2023). Thus to our knowledge, the present study is the first to report on these autumn peaks in harbour porpoises densities in the Dutch North Sea.

A hypothesis that might explain the peaks in September in Luchterduinen and October in Borssele and subsequent lower numbers in the following month(s) is that a population of harbour porpoises migrates through these areas to spend the winter in more southern areas. Then in December a (potentially different) population might arrive at Luchterduinen and further south in Borssele in January. Following this hypothesis, harbour porpoises migrate north again in spring with first a peak in Borssele in March and later in

Luchterduinen and surroundings in May. Scheidat *et al.* (2012) suggested similar migration patterns in spring as peak abundances of harbour porpoise in German waters (April) were one month later than in Dutch waters (March). Also, they found another peak in German waters in June, which, as they argue, may suggest that some individuals directly move northwards, while others slowly disperse north. The existence of different populations of harbour porpoise has also been suggested before, although the porpoises of the Dutch waters are thought to belong to the same population (Evans *et al.* 2009, Geelhoed & Scheidat 2018). If indeed different populations of harbour porpoise use the Dutch part of the North Sea, this may have substantial consequences on, for example, the assessment of the effects of offshore wind farms on harbour porpoises.

Remarkable is the absence of harbour porpoise observations in OWEZ from March to July, while in the nearby located Luchterduinen wind farm animals were seen in all of these months, sometimes even in high numbers throughout the day. The study in Luchterduinen is carried out more than 10 years later than in OWEZ, which could explain these differences. Potentially, the number of harbour porpoises in the area might have increased or their distribution might have further shifted throughout these years, similar to their distribution shift from the northern to the southern North Sea over the last 25 years (Bouveroux *et al.* 2020, Gilles *et al.* 2023). Another hypothesis is that the harbour porpoises present in the area in these months might have habituated to the presence of offshore wind farms, as OWEZ was the first offshore wind farm in that area of the North Sea.

Also notable are the low numbers that we found in April, as Dutch waters are generally thought to support substantial denstities of harbour porpoises in spring. In 19 visits to offshore wind farms in April in seven different years, harbour porpoises were only seen during three visits. However, nine of these visits were to OWEZ, where harbour porpoises were not seen from March to July (see above). Of the remaining ten visits, three visits were carried out in unfavourable weather conditions with relatively high waves which hampers the detection of harbour porpoises. Therefore, the low numbers in April might be slightly biased. The visit to wind farm Borssele in April, on which 52 harbour porpoises were seen, shows that they could occur in high numbers during this month.

In this study, we did not correct for any effects of weather circumstances on the capability of observers to detect harbour porpoises during visual observations. One reason for this is that we cannot objectively determine the relationship between weather circumstances (such as wave height) and the probability that observers detect a harbour porpoise, which should form the basis for such correction. Moreover, most field visits were carried out in favourable weather circumstances. Field visits on days with relatively high waves were scarce, as safety restrictions generally do not allow transfers from boat to wind turbines or platforms above certain wave height thresholds. An exception on this were the field visits to Gemini, as transfers to the platform were done via helicopter. Therefore, three of the seven visits to Gemini (those of July, August and November) were accompanied by high waves, which thus likely reduced the detection of harbour porpoises on those days.

As the visual observations were primarily carried out as part of bird studies, the behavior of harbour porpoises in offshore wind farms was not systematically recorded during the surveys. Therefore, most of the study questions related to behavior cannot be readily answered yet. Foraging behavior inside offshore wind farms was recorded on a small number of occassions. However, it may be difficult to determine the behavior of harbour porpoise as they may brake the surface a few times before submerging again. It is thus likely that foraging behavior occurs more often than recorded. Within this project, we have developed a new protocol to better record the behaviour of harbour porpoises in the future. Furthermore, resightings of individuals (by photo-identifcation of harbour porpoises) inside offshore wind farms could provide further insights into the purpose of offshore wind farms for harbour porpoises, for example by analysing the residence time of individuals in the area. However, this will require substantial effort to collect enough images of sufficient quality over time. Other methods, such as tagging of harbour porpoises, may therefore be more suitable.

Harbour porpoises that were recorded foraging did so at distances between 50 and 1.250m to the nearest wind turbine. The data of the Digital Aerial Surveys show that most harbour porpoises in and around wind farm Borssele and adjoining Belgium wind farms were recorded at similar distances of around 500m to wind turbines. The probability of recording a harbour porpoise significantly decreased at closer distances to wind turbines, which suggests that either harbour porpoises or their prey may experience suboptimal conditions close to wind turbines, and therefore avoid these areas. However, as harbour porpoises can usually only be observed at or very close to the sea surface, we cannot exclude that further below the surface harbour porpoises approach wind turbines at closer distances. Furthermore, the statistical analysis that we performed to test the effect of distance to the nearest turbine on the presence of harbour porpoises did not (yet) correct for any spatial autocorrelation that may exist in the data. Due to time limitations, such a more sophisticated analysis could not be carried out for the report at hand, but it is recommended to do in the future. Nonetheless, the results of this analysis strongly suggest that harbour porpoises avoid close distances to operational wind turbines, which - as far as we know - has not yet been described in literature before.

The above-mentioned analyses show that harbour porpoise densities are lower within 500m from wind turbines or platforms, but stabilise at larger distances. It thus seems that harbour porpoises only avoid the direct surroundings of wind turbines. Therefore, one might not necessarily find higher densities inside a wind farm corridor or outside the wind farm perimeter, which is also supported by our ship-based survey data. The analysis of corridor use in wind farm Borssele based on ship-based counts shows no significant differences in their densities in the corridor compared to the wind farm border or inside the wind farm. Furthermore, the density of harbour porpoises in and around Borssele did not differ from their densities in a reference area approximately 20-50km north of Borssele (Collier *et al.* 2022). Nonetheless, avoidance of close distances to wind turbines potentially affects the density of harbour porpoises inside offshore wind farms if the spacing between wind turbines is smaller (*i.e.* if turbine density within a wind farm is higher), as is shown for Sandwich terns (Van Bemmelen *et al.* 2023).

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Appendix I Protocol to record sightings of harbour porpoise in offshore wind farms

The goal of this protocol is to record sightings of harbour porpoises in offshore wind farms in a consistent way. Data on the numbers of harbour porpoises, their behaviour and their exact position in an offshore wind farm can provide relevant information about the use of offshore wind farms by these marine mammals. Also, it is important to record the effort of the observations to determine absences of harbour porpoises.

The protocol can be carried out from vessels as well as from wind turbines (WTG).

Observations from a WTG

Record at the start of each period

- Date and time
- Name of observers
- Position of observers (which WTG)
- In which area the observations are carried out
    - For example, in an area between observers and certain nearby WTGs (record which WTGs)
- Sea state
- Temperature
- Wind force and direction
- Precipitation

Record any changes in these data during the day.

Record for every harbour porpoise sighting

- Date and time
- Number of porpoises
- Behaviour
    - see Table 1; use the codes provided for each behaviour
- Direction
    - The direction the harbour porpoise is moving to. If the harbour porpoise is not moving in one clear direction, then record as 'local'.
- Their position (as accurate as possible)
    - Ideally, measure the position (coordinates) of the harbour porpoise directly with a Laser Range Finder (LRF), although this will be quite hard.
    - Otherwise record *as accurate as possible*:
        - Compass angle between observers and harbour porpoise
        - Distance between observers and harbour porpoise, for example by:
            - directly measuring with the LRF
            - using the number of reticles from the horizon to the harbour porpoise with the LRF.
            - using an inclinometer; only if the harbour porpoise is close by
            - estimating as accurate as possible
- If applicable, mention in the comments any additional information which could be relevant for the interpretation of the behaviour of the harbour porpoise, for example associations/interactions with other species.

Record at the end of each period

- End time
- Percentage of time that the area was scanned for harbour porpoises.
- Subjective circumstances for observations (bad, moderate, good)

Observations from a vessel

Harbour porpoises can be recorded from both sailing and stationary vessels.

Counts from vessels are ideally performed by an observer from an observation box on the top of the bridge or at least 10 meters above the waterline. Observations are carried out on one side of the vessel (the side with the best (light) conditions). The method of counting harbour porpoises from a vessel depends on the sea state. The chance of detecting harbour porpoises is higher with lower sea states. Also, harbour porpoises can be detected up to larger distances with lower sea states. Determine at the start of the observations up to which distance harbour porpoise can reliably be detected. Recommended for sea states one and two is to count the porpoises in a strip of *at least* 500 meters wide, divided into eight distance bands: A (0-50m), B (50-100m), C (100-200m), D (200-300m), E (300-500m), F (500-750m), G (750-1000m) and H (>1000m). For the sea states three and four, recommended is to count the porpoises in a strip of *at most* 500 meters wide, divided into five distance bands: A (0-50m), B (50-100m), C (100-200m), D (200-300m) and E (300-500m). If the sea state is five or higher, the chances in detecting harbour porpoises are very small and therefore counting with sea state five or higher is not recommended.

Record at the start of each period

- Date and time
- Name of observers
- Whether vessel is sailing of stationary
- In which area the observations are carried out
    - At what side of the vessel
    - Up to which distance from the vessel
- Sea state
- Temperature
- Wind force and direction
- Precipitation

Record any changes in these data during the day.

Make sure a GPS track of the trip is made. It is important to accurately synchronize the time of GPS with the time used to record sightings.

Record with every harbour porpoise sighting

- Date and time (HH:MM:SS => record also the seconds to match with GPS track of trip)
- Number of porpoises
- Behaviour
    - see Table 1; use the codes provided for each behaviour
- Direction

    - The direction the harbour porpoise is moving to. If the harbour porpoise is not moving in one clear direction, then record as 'local'.
- Distance from the vessel
    - A = 0-50 m
    - B = 50-100 m
    - C = 100-200 m
    - D = 200-300 m
    - E = 300-500 m
    - F = 500-750 m
    - G = 750-1000 m
    - H = >1000 m
- Only if conditions allow, try to collect additional information on their position (as accurate as possible)
    - Measure the position (coordinates) of the harbour porpoise directly with a Laser Range Finder (LRF)
    - Compass angle between observers and harbour porpoise
    - Distance between observers and harbour porpoise
        - Measure the distance with the LRF.
        - Measure the number of reticles from the horizon to the harbour porpoise with the LRF.
        - Measure with an inclinometer; only if the harbour porpoise is close by.
        - Estimate as accurate as possible.
- If applicable, mention in the comments any additional information which could be relevant for the interpretation of the behaviour of the harbour porpoise, for example associations/interactions with other species.

Record at the end of each period

- End time
- Percentage of time that the area was scanned for harbour porpoises
- Subjective circumstances for observations (bad, moderate, good)

Table 1 Overview of different behaviours of harbour porpoise that are most likely to be recorded, given by a behavioural code, short description and explanation. Adapted from Camphuysen & Garthe (2004)[1].

Code	Description in short	Explanation
W	Wheeling or swimming slowly	Slow movement, no white crests, at least dorsal fin visible above water
SF	Swimming fast	Fast movements, splashes, at least dorsal fin visible above water
UW	Swimming under water	Moving animal completely under water
D	Diving	Diving away into the deep, becoming invisible
F	Apparently feeding	Animal (apparently) feeding on or chasing prey, indications of foraging could be quick movements in different directions, fish leaping out of the water, association with/attraction of other species (like foraging birds)
C	Calf at the tail of adult	Immature animal constantly staying close to the side of an adult
BK	Basking, afloat	Constantly visible animal, often with dorsal fin exposed, floating at the sea surface
SH	Spy-hopping	Head sticks out the water (including the eyes), apparently to look around
B	Breaching clear out of the water	Vertical leap, sometimes clear of the water
SB	Sexual behaviour	Any sexual behaviour (copulations) observed
P	Play	Any behaviour observed that could be play, such as interactions with floating material (driftwood or seaweed)
#O	Other	Any behaviour that cannot be assigned to one of the above classifications; clearly describe what is observed

[1] Camphuysen, C.J. & S. Garthe, 2004. Recording foraging seabirds at sea: standardised recording and coding of foraging behaviour and multi-species foraging associations. Atlantic Seabirds 6(1): 1-32.