Assessment of the Effects of the Offshore Wind Farm Egmond aan Zee (OWEZ) for Harbour Porpoise (T_1)

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Interim Report

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Contents

Summary

In order to evaluate the environmental impacts of the Off Shore Wind farm Egmond aan Zee (OWEZ), a series of baseline studies have been carried out in 2003 and 2004 to provide a thorough description of the ecological reference situation (T_0). In 2007 this work continued to investigate the potential effect of the wind farm on harbour porpoise after the completion of the construction. This interim report describes the first results and preliminary analyses of the T-POD data collected. Field work will continue in 2008. A final report will be presented after results of the 2008 research are available as well.

Harbour porpoise seasonal presence and activity in the study area were measured by acoustic monitoring of echolocation sounds. The monitoring of echolocation sounds consisted of stationary passive acoustic porpoise detectors (T-PODs) which were distributed over eight stations. Three positions of the T-PODs were north of the wind farm, two positions within the wind farm and three positions south of the wind farm.

To facilitate the handling and reduce the boat time, for each position two T-PODs were calibrated by deploying them together. This allows the calibration of the detection rates between those T-PODs. The majority of the time the T-PODs functioned well, although some problems with battery time were encountered. A total of six T-PODs were lost from their mooring, of which three were recovered at a later time and redeployed. The highest loss rate was in the month of November 2007 during a time of severe storms. To reduce the T-POD losses, a new design of the attachment was developed and is tested at the moment.

The first analyses of the data indicates that a strong seasonal variation in the use of the area is apparent. There were more recordings of harbour porpoises in the fall and spring period compared to the summer months. Spatial variation was also observed, with a slightly higher activity in the northern site of the study area. The overall seasonal pattern is very similar to the one observed during the T_0 with some indication that the small scale habitat use differs within and outside the wind farm. A thorough statistical analysis will be done in 2008 and 2009 when the data sets are complete.

1 Introduction

1.1 Goal of this study

The aim of this study is to investigate possible effects of presence of an Offshore Wind Farm (OWEZ) on the habitat use of harbour porpoises. The data collected now (T_1) will be compared to the baseline data collected prior to the construction (T_0). This project is carried out on behalf of NoordzeeWind, through a sub contract with WageningenImares

To describe seasonal presence, density and activity of harbour porpoise in the area acoustic monitoring as well as visual surveys were conducted (see report Brasseur *et al*. 2004). Acoustic monitoring, of echolocation sounds, was used to measure harbour porpoise activity and presence This was done with eight permanently deployed acoustic porpoise detectors (T-PODs) operating on a 24 hour basis. The T-POD deployment followed the same method as during the T_0 study. This interim report describes the current status of the study as well as some preliminary results. Field work will continue in 2008. A final report will be presented after results of the 2008 research are available as well.

1.2 Status of the harbour porpoise in the Netherlands

The Harbour porpoise (*Phocoena phocoena*) used to be a common appearance in Dutch coastal waters. Before the 1950s, it was not uncommon to spot porpoises off the coast, in harbours and even up rivers. The observed numbers started to decline in the second half of the century (van Deinse, 1952, Smeenk, 1987) to such an extent that by the 1970s/1980s porpoise became a rare visitor to the Dutch coast. However, since the early 1990s, live sightings as well as dead strandings started to increase and continue to increase until now (Camphuysen, 1994, Reijnders *et al*., 1996, Witte *et al*., 1998, Smeenk, 2003).
In the last decade, increased numbers of sightings from land (http://home.planet.nl /~camphuys/Cetacea.html) as well as increased stranding rates along the Dutch, Belgian and French coast indicated a return of the porpoise (Camphuysen 2004). A recent large scale survey, SCANS II, confirms that there is a shift of porpoise density from the northern part of the North Sea to the southern part, including Dutch waters (pers. comm. Hammond).

The reasons for the noted decline and subsequent increase remain unclear. For the decrease, possible explanations include changes in prey availability, mortality due to fishing gear, disturbance and pollution. Reijnders has suggested that decreased prey availability leading to a shift in distribution and the cumulative effect of accidental catches of porpoises by fisheries may have been the main factors (Reijnders *et al*., 1996; Reijnders, 1992).

2 Methods

2.1 Site description

The study site is located in the North Sea, west of the province of North Holland (The Netherlands), where the offshore wind farm, (OWEZ Offshore Windfarm Egmond aan Zee) is constructed (Figure 1). A total of 8 fixed stations are used for acoustic monitoring of harbour porpoises; three control stations north, three control stations south and two stations within the wind farm area.

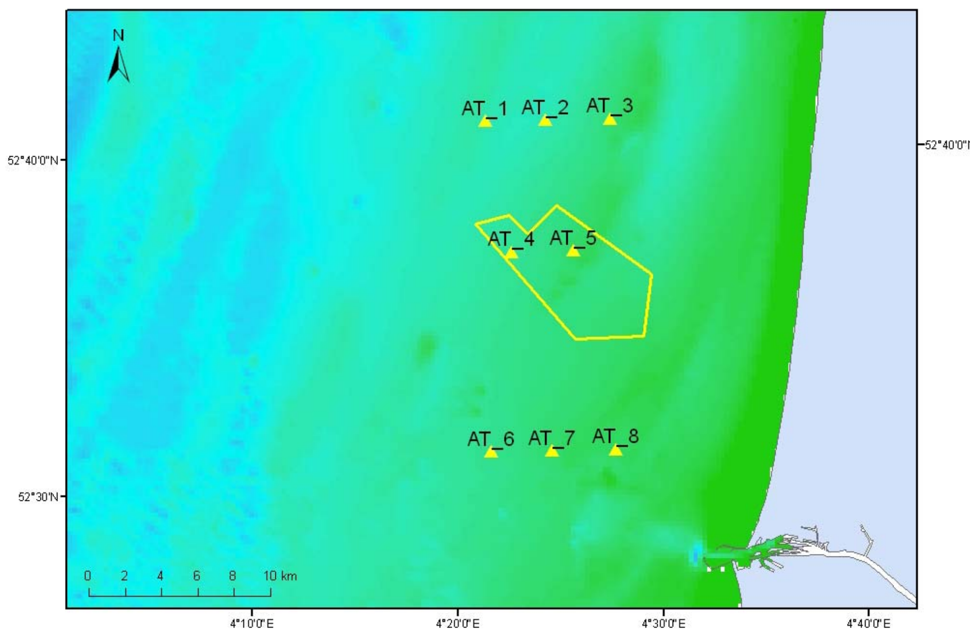

Figure 1. Positions of the 8 monitoring stations (AT1 –AT8), northwest of the harbour of IJmuiden (NL). The yellow line shows the outline of the OWEZ area. Geographic system: ED-50; Projection: UTM zone 31N.

2.2 T-PODS

In order to observe and quantify the occurrence of porpoises, known to occur in relatively low densities in the study area, it is most suitable to use permanent recording stations such as anchored T-PODs, as well as visual observations which could yield density estimates. T-PODs enable us to record every porpoise encounter within a radius of some hundred meters and, as the stations were permanently monitored for a whole year, diurnal variation, seasonality and other variations in occurrence were analysed.

2.2.1 Technical description of T-PODs

The T-POD or POrpoise Detector is a small self-contained data-logger that logs echolocation clicks of harbour porpoises and other cetaceans. It was developed by Nick Tregenza (Chelonia, UK). It is programmable and can be set to specifically detect and record the echolocation signals of harbour porpoises. The T-POD consists of a hydrophone, an amplifier, a number of band-pass filters and a data-logger that logs echolocation click-activity. It processes the recorded signals in real-time and only logs time and duration sounds fulfilling a number of acoustic criteria set by the user. These criteria relate to click-length (duration), frequency distribution and intensity, and are set to match the specific characteristics of echolocation-clicks. The T-POD operates with six separate and individually programmable channels. This allows for e.g. one channel to log low frequency boat activity while the remaining channels log porpoise echolocation activity. All channels had identical settings in this study (Table 1).

The T-POD relies on the highly stereotypical nature of porpoise sonar signals (Au 1993, Au *et al.* 1999, Diederichs *et al.* 2003). These are unique in being very short (50-150 microseconds) and containing virtually no energy below 100 kHz. The main part of the energy is in a narrow band 120-150 kHz, which makes the signals ideal for automatic detection. Most other sounds in the sea, with the important exception of echo sounders and boat sonars, are characterised by being more broadband (energy distributed over a wider frequency range), being longer in duration, having peak energy at lower frequencies or combinations of the three.

The actual detection of porpoise signals is performed by comparing signal energy in a narrow filter centred at 130 kHz with another narrow filter centred at 90 kHz. Any signal that has substantially more energy in the high compared to the low filter and is below 200 microseconds in duration, is highly likely to be either a porpoise or a man-made sound (echosounder or boat sonar). This fundamental logic of detection is identical to what is used in the towed array, described in the appendix. Although the hardware implementation is different, the fundamental idea is still a comparison between narrow band filters, one low and one high for the T-POD, two low and one high for the towed array. The selectivity of the array for porpoises has been documented in the field by Gillespie and Chappell (2002).

Some spurious clicks of undetermined origin (e.g. background noise, cavitation sounds from high-speed propellers) may also be recorded. These, as well as boat sonars and echo sounders are filtered out by analysing intervals between subsequent clicks. Porpoise click trains are recognisable by a gradual change of click intervals throughout a click sequence, whereas boat sonars and echo sounders have highly regular repetition rates (almost constant click intervals). Clicks of other origin tend to occur at random, thus with highly irregular intervals.

No other cetacean regularly found in the North Sea has sonar signals that can be confused with porpoise signals. Dolphins (with the exception of the genus *Cephalorhynchus*, which does not occur in the North Sea) use broadband sonar clicks, i.e. energy distributed over a wide frequency range, from below 20 kHz to above 200 kHz in some cases. It is thus highly unlikely that they will trigger the T-POD.

Table 1. T-POD filter settings used during deployments

Setting parameters	Version 3	Version 5
A filter: frequency (kHz)	130	130
B filter: frequency (kHz)	90	92
Ratio: A/B	5	-
A filter: Q (kHz) / integration time	short	-
B filter: Q (kHz) / integration time	long	-
Click bandwidth	-	5
Noise adaptation	-	+
Sensitivity:	6	10
Max number of clicks / scan:	160	160
Minimum click duration: (μS)	30	30
Angle sensor	120	120

Each of the six channels of the T-POD records sequentially for 9 seconds, with 6 seconds per minute assigned for change between channels. This gives an overall duty cycle of 90% (54 seconds per minute), with 15% for individual channels (9 seconds per minute). In order to minimise data storage requirements, only the onset time of clicks and their duration are logged. This is done with a resolution of 10 μs. The absolute accuracy of the timing (time since deployment) is much less, due to drift in the T-PODs' clock during deployment (a few minutes per month). This drift however, is only of concern when comparing records from two T-PODs deployed simultaneously. Clicks shorter than 10 μs and sounds longer than 2550 μs are discarded.

The hydrophone of the T-POD is cylindrical and thus omni-directional in the horizontal plane. Resonance frequency is 120 kHz. T-PODs are insensitive to temperature changes within the normal operating range between 3ºC and 25ºC, except for a reduction in battery life at lower temperatures. Battery voltage does not influence sensitivity as the electronics in the T-POD receive a stable voltage until the battery is drained to 5.1 V, below which the electronics turn off.

The hydrophone, and thus T-POD sensitivity, is insensitive to changes in hydrostatic pressure down to depths of 120 m. The hydrophone ceramics are not expected to lose sensitivity with age beyond a few percent per decade, so for all practical purposes, the sensitivity of a T-POD should not change within its expected lifetime.

Data from the T-POD can be downloaded in the field with a parallel cable for storage on a PC. Data was downloaded with the T-POD.exe program designed for communication with the T-POD and subsequent analyses of data. Figure 2 shows an example of downloaded data. Harbour porpoise echolocation clicks were extracted from the background noise using a filtering algorithm that filters out non-porpoise clicks such as cavitation noise from boat propellers, echo sounder signals and similar high frequency noise. This filter has several classes of confidence of which both the highest and second highest class ("cetaceans all") was used. Data were exported in ASCII format for statistical analysis after filtering.

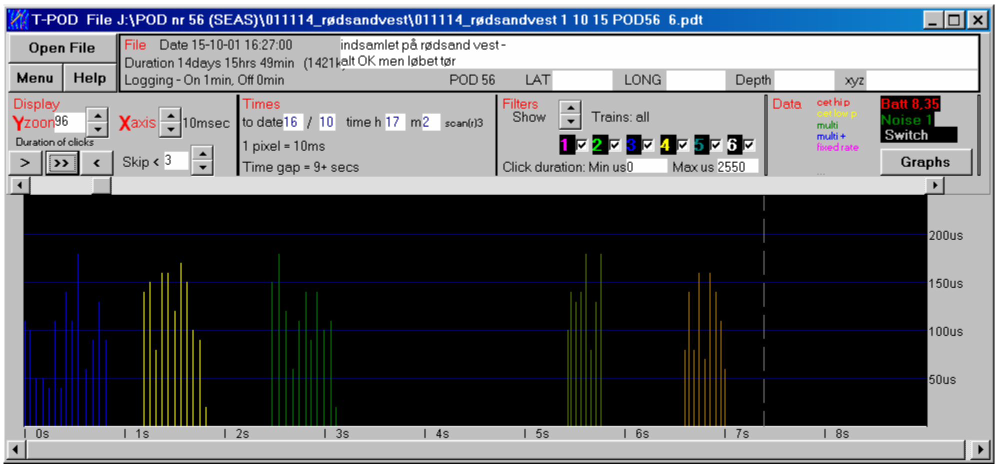

Figure 2. Screen snapshot from the T-POD.exe program. Five series of porpoise clicks can be seen as vertical bars. Time in seconds is shown on the X-axis, and the duration of each click is shown on the Y-axis.

2.2.2 Mooring technique

The mooring used for the T-PODs/ in the Dutch coastal waters was designed using robust material. Where in other areas T-PODs are usually attached to small anchor blocks and small buoys, this study uses very heavy equipment for anchoring the T-PODs/s due to the risk of collision with trawlers in the area. Approximately 15 tonnes of buoys, chain and concrete were used for securely anchoring a single T-POD (Figure 3 and 4).

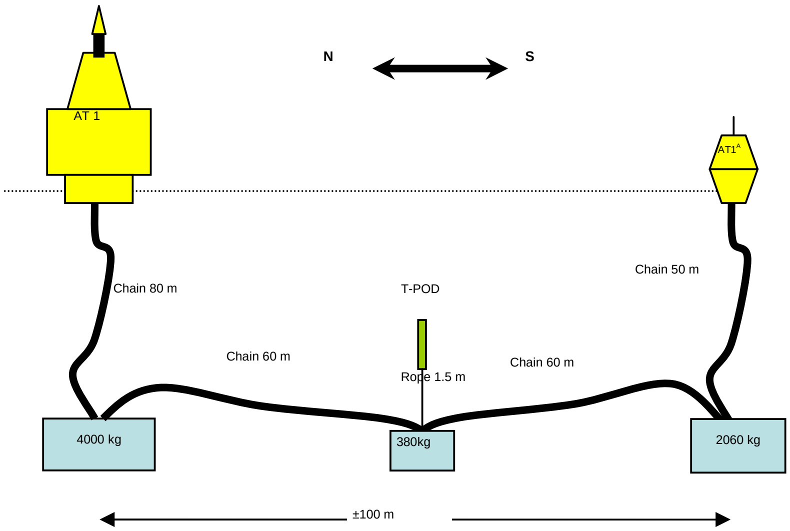

Figure 3. Schematic setup of the T-POD mooring. The large buoy is lighted at night.

Each T-POD is deployed between two large buoys, the larger being equipped with a yellow warning lantern.

Figure 4. Set-up of the anchoring. View above water (photo Saskia Mulder, RIKZ)

Due to a number of losses, probably because of some heavy storms, the actual attachments of the T-PODs were changed during the December survey. Figure 5 shows a picture of the new design. The attachment is made of a Kevlar cable surrounded with rubber tubing. To add buoyancy a buoy is attached to the upper part of the T-POD.

Figure 5. The new T-POD attachment. Kevlar cable with rubber tubing (1) and buoy (2) for additional buoyancy.

2.2.3 Analysis of T-POD data

Porpoise clicks were recorded using all channels of the deployed T-PODs (1-6, each monitoring 9 seconds every minute) and the average click intensity per minute was calculated as the sum of these 6 channels, adjusted by a factor of 60/54 corresponding to the active "listening" period of the T-PODs. Data retrieved from the T-PODs were stored in a database as 1-minute counts for the 6 separate channels. During the final statistical analyses of the datasets results might still change. Thus for the results presented here, we applied the quite robust measurement encounter rate.

A new porpoise encounter is typical defined by click recordings separated by a silent period of more than 10 minutes. The preliminary analysis presented here used encounter rate per day per position. If more than one T-POD were stationed on one position the mean encounter rate was calculated for that position.

Encounter rate = Number of encounters /day

To investigate potential impacts of boat activities, boat sonar's were also analysed using the same measurement unit.

3 Results and Discussion

3.1.1 Fieldwork

The T-PODs deployed at the 8 stations were regularly serviced. This included cleaning, downloading the data and changing the batteries (Brasseur *et al*, 2003). Table 2 shows an overview of the fieldwork related to the project.
In 2007, four trips were conducted to the wind park to deploy and/or recover T-PODs: April 17, June 21, October 2, December 13. Additionally in May one T-POD was deployed that had not been working previously. T-PODs were exchanged according to the calibration scheme (Table 2). Due to the successful calibrations in October, the exchange of T-PODs in December was much more time efficient.

Table 2. Deployment and recovery of T-PODs during the 2007 field season. The numbers indicate the identification numbers of each T-POD. Coloured field indicate T-PODs that had been lost.

	17 April 2007	**21 June 2007**		**2 October 2007**		**13 December**	
Loca-tion	Deploy -ment	Reco-very	Deploy-ment	Recovery	Deploy-ment	Recovery	Deploy-ment
AT_1	**701**	**701**	**701 238**	**701 238**	**238**	**238**	**701**
AT_2	**-**	**707***	**707 730**	**-**	**707 730**	**-**	**730**
AT_3	**700**	**700**	**700 233**	**700 233**	**233**	**233**	**700**
AT_4	**702**	**702**	**702 240**	**702 240**	**240**	**-**	**702**
AT_5	**706**	**706**	**234**	**-**	**706**	**706**	**706 749**
AT_6	**705**	**705**	**705 230**	**705 230**	**230**	**230**	**705 230**
AT_7	**704**	**704**	**276**	**276**	**704 276**	**704 276**	**276**
AT_8	**703**	**703**	**232**	**232**	**232 703**	**-**	**703**

* T-POD was not working on April 17, it was repaired and deployed in May but did not record

lost and recovered
lost and not recovered

3.1.2 Performance of T-PODs

Servicing periods were set originally to 2-3 months to ensure that batteries were changed before drained (according to the manufacturer about every 100 days). During the deployment the batteries lasted substantially less than the assumed 100 days. The maximum endurance was 74 days which led to some gaps in the data collection. Additionally, in September 2007 the T-PODs did not work as long as planned and in combination with a postponed survey due to bad weather conditions this lead to a data gap for that month. Because expected battery power was lower than originally anticipated, future servicing intervals should not exceed 2 months. Figure 6 shows an overview of how long the different T-PODs worked in days. Changing the memory chip in the T-PODS of the new version was thought to reduce battery drainage, however, this could not be confirmed by our observations.

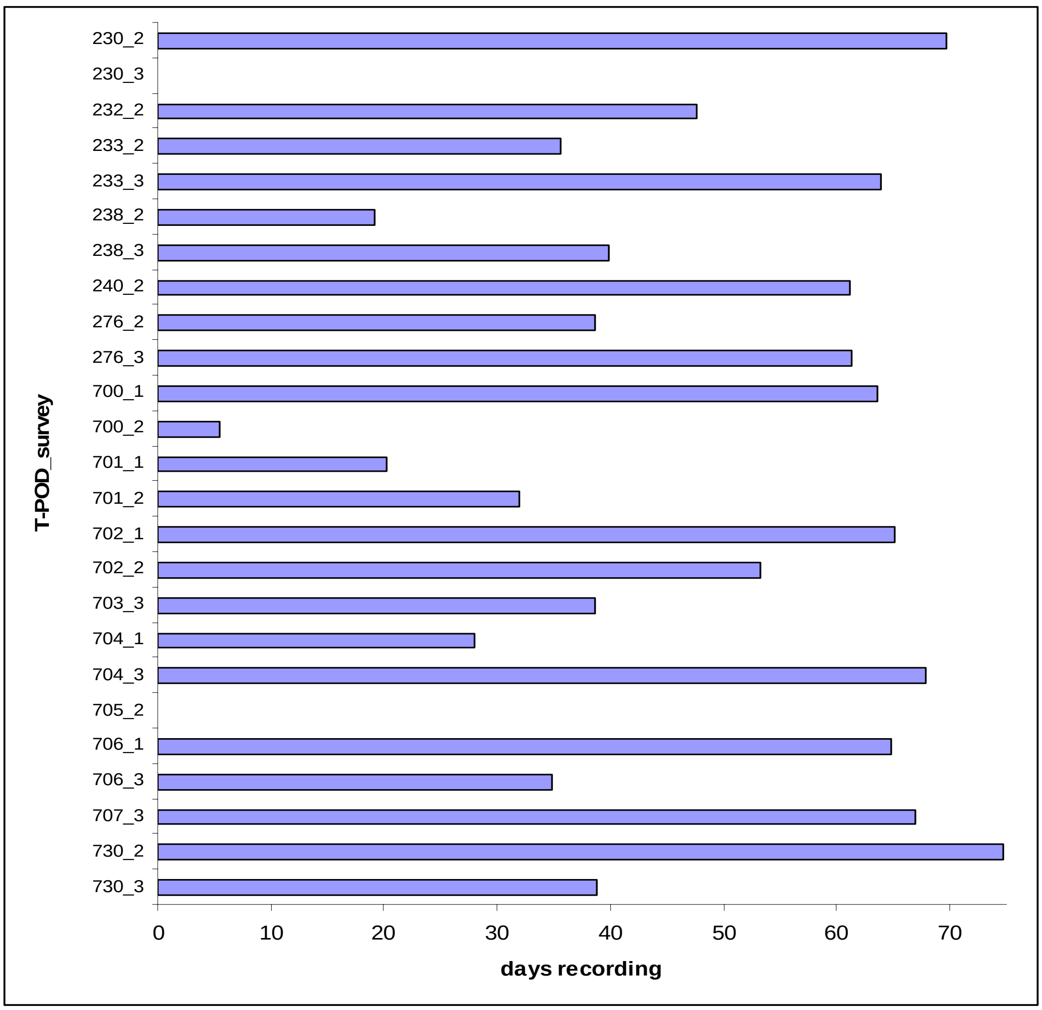

Figure 6. T-POD recording time. On the y axis the T-POD ID Number and the survey (1- June, 2 – October, 3 – December) are given.

The time series contains some gaps resulting from technical problems with the T-PODs, detachment from the mooring and loss of T-PODs. Figure 7 shows an overview of the data collection for the different stations.

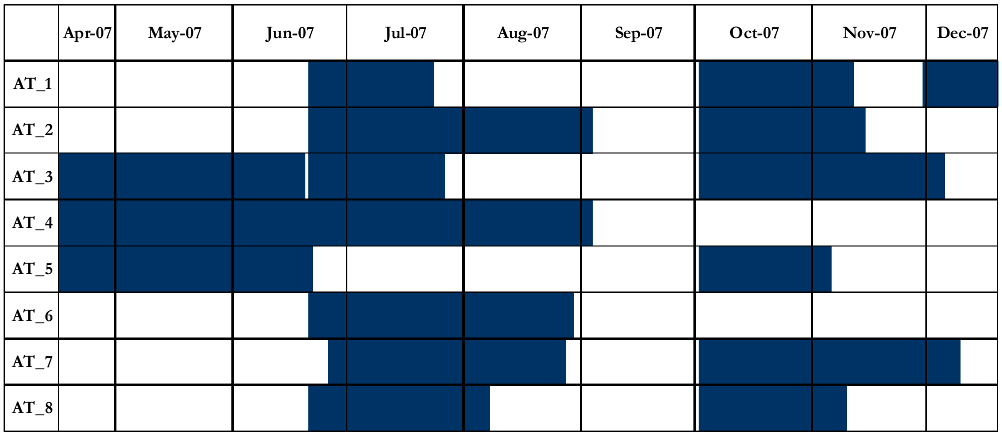

Figure 7. Functioning of the T-PODs (blue). Lack of data (white) was mainly due to the loss of battery power.

3.1.3 Encounter rate of porpoises

To obtain an overview of the data, first of all the encounter rate per day was calculated as an average for all stations combined. Figure 8 shows the encounter range from April 2007 until December 2007. Fewest encounters were noted in spring and early summer. A steady increase in the use of the area was seen in late summer and fall into the early winter months. The highest encounter rate recorded by a single T-POD was 28 encounters in a day.

The seasonal pattern indicated during the T_1 study is similar to what was observed during T_0. Figure 9 shows the same data analyses for the years 2003 and 2004 prior to the construction of the wind farm. The increase in encounter rate starts in autumn of 2004 and reaches its height in the winter months. By May 2004 this has dropped again.

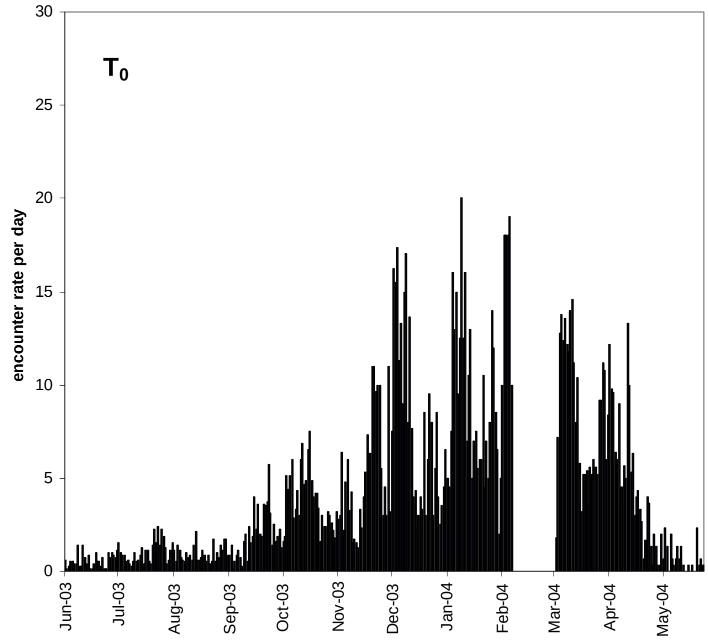

Figure 8. Encounter rate per day for harbour porpoises in stations AT_1 to AT_8 during the ***T_0*** *project* ***2003/2004*** *(taken from Brasseur et al. 2004).*

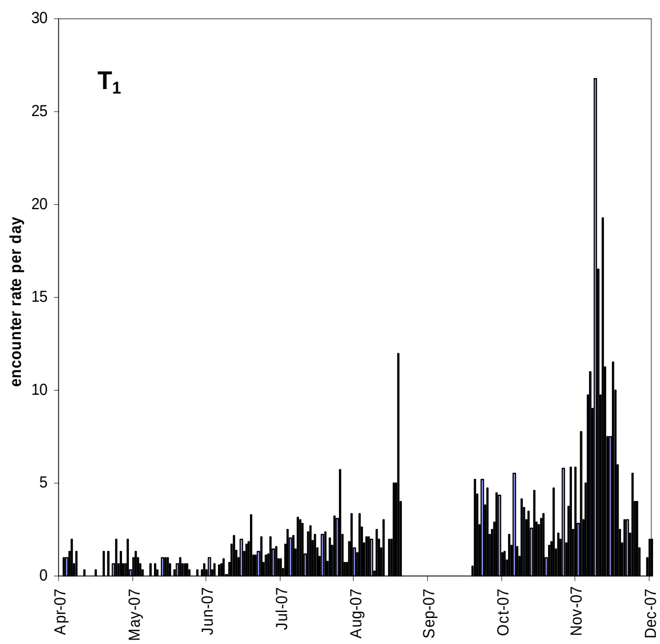

Figure 9. Uncorrected encounter rate per day for harbour porpoises in stations AT_1 to AT_8 during the ***T_1*** *project* ***2007****.*

To get an indication how the activities varied between the reference stations and the stations in the wind farm, a mean encounter rate per month was calculated for each station. Figure 10 shows the results for the stations in the north (orange), reference stations (green) and the southern stations (blue).
There is some indication of difference in how porpoises used the three areas. During the summer months, the southern stations show the typical low encounter rate that would be expected from the T_0 study. The northern station as well as the wind farm station show an encounter rate similar to what is observed in the winter months. Additionally, in November harbour porpoises used the northern and southern station frequently, but this was less in the wind farm itself. Further statistical analyses is needed to determine if this is a true effect. This analyses will be carried out end of 2008 to beginning of 2009 when all datasets are collected. As a comparison with the T_0 dataset the same representation of the data is given in figure 11. Here the seasonal patterns are very similar between the three different areas.

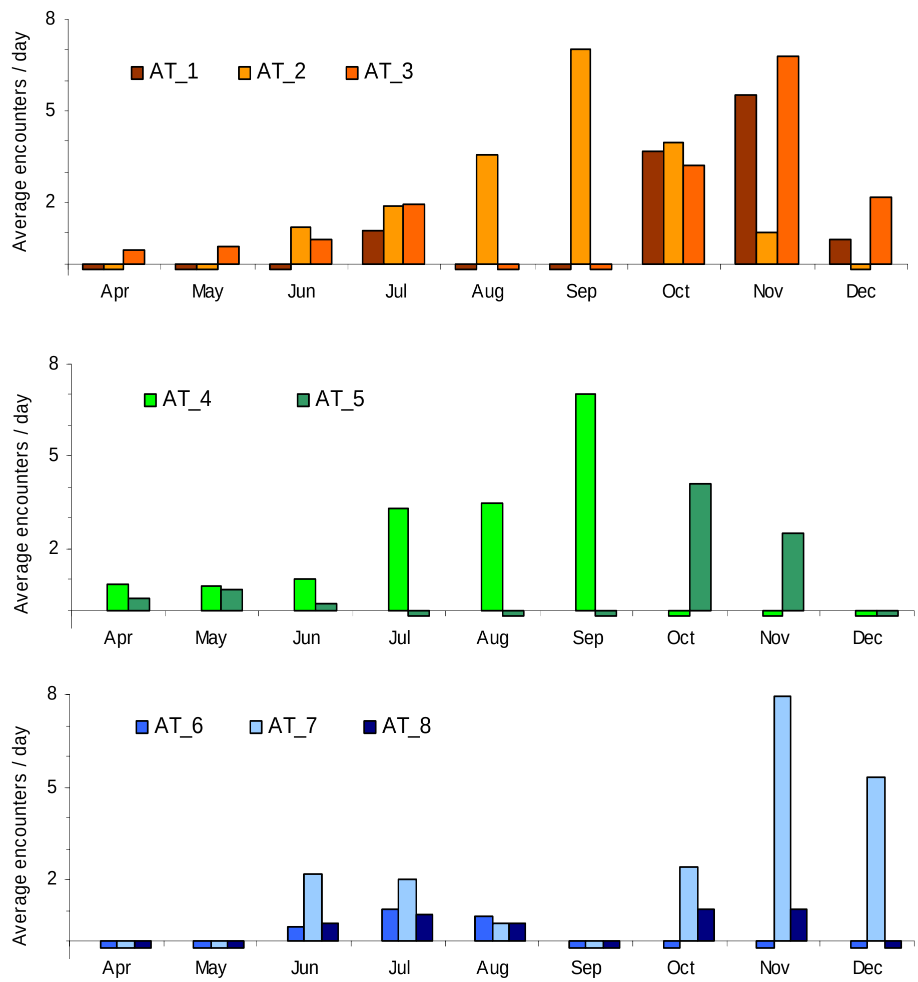

Figure 10. T_1 results: Monthly average of ***uncorrected*** *encounters per day for each T-Pod location (orange – northern stations, green – wind farm stations, blue – southern stations). Columns below the x-axis indicate when no T-Pod recordings were taking place.*

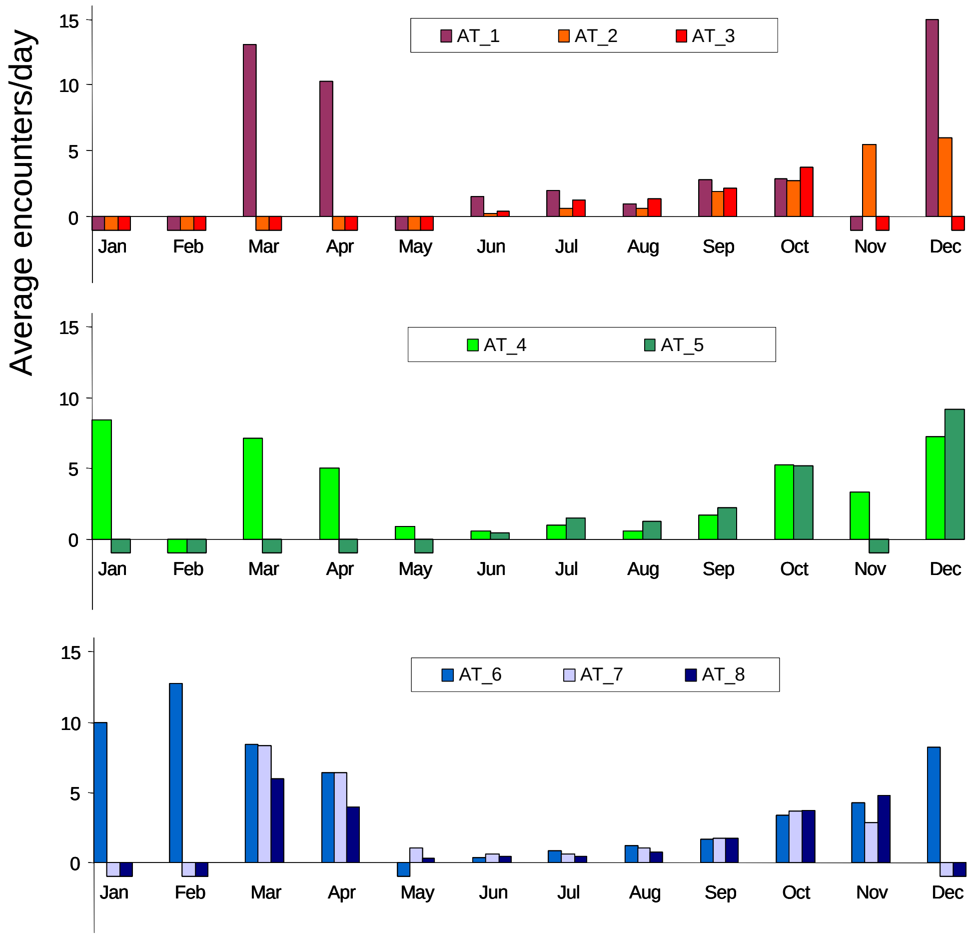

Figure 11. T_0 results: Monthly average of encounters per day for each T-Pod location (orange – northern stations, green – wind farm stations, blue – southern stations). Columns below the x-axis indicate when no T-Pod recordings were taking place (taken from Brasseur et al. 2004).

3.1.4 Encounter rate of boat sonar

As a rough indication of how much boat activity took place in the study area (also as a potential effect on porpoises) the acoustic data categorised as "boat sonar" were analysed in this respect. To do this they were analysed as encounters per day as a proxy for boat activity close to the T-PODs. Figure 12 shows the boat sonar encounters per day for the study time period. The highest activity was in the summer months. The two very high peaks were both recorded at AT_8 on July 23rd and July 25th 2007. Another period of boat activity was in October and November.

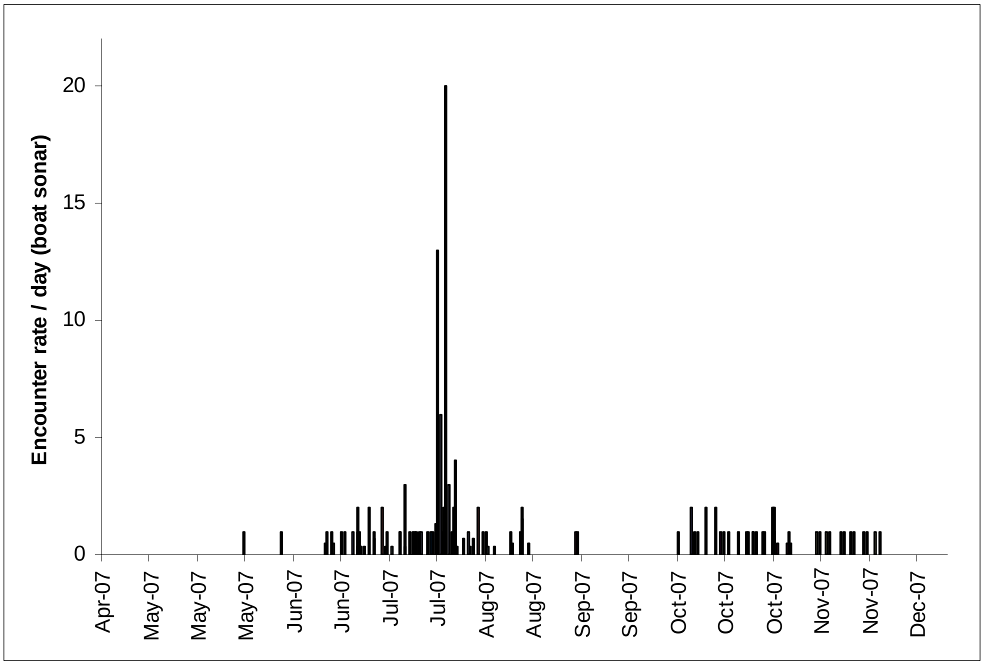

Figure 12 Average uncorrected encounter rate per day for boat sonars in the study area. All stations are combined..

When separating this pattern for the different stations it becomes obvious that all of the high summer encounter rates are from station AT_8 in the south (note the different scale in figure 15 for AT_8). Recorded sonar activities in autumn mainly took place in the northern reference area (figure 13) as well as in the wind farm (figure 14). The boat sonar can only give a minimum occurrence of activities of vessels. First of all not all vessels that are present in the area come close enough to the T-PODs to be recorded, and secondly not all vessels use sonar. Further more detailed analyses of what research and building activities were occurring in this time period might allow a better interpretation of the observed data.

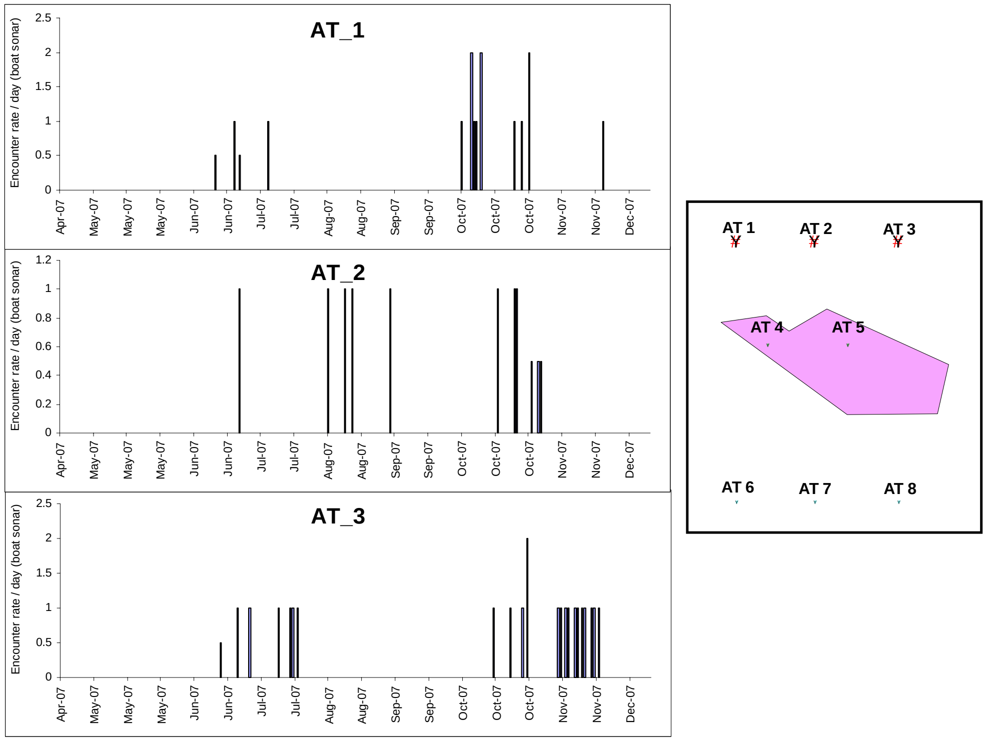

Figure 13 Average *<u>uncorrected</u>* *encounter rate per day for boat sonars in the northern study area, separated by station. Note different y scales. The small map indicates the position of the T-PODs in relation to the wind farm (pink).*

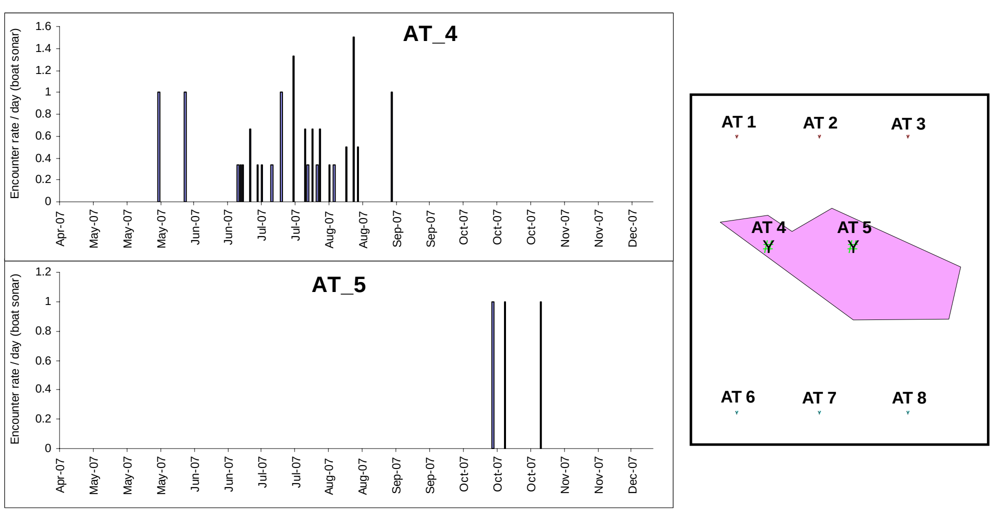

Figure 14 Average *<u>uncorrected</u>* *encounter rate per day for boat sonars in the wind mill farm area, separated by station. Note different y scales. The small map indicates the position of the T-PODs in relation to the wind farm (pink).*

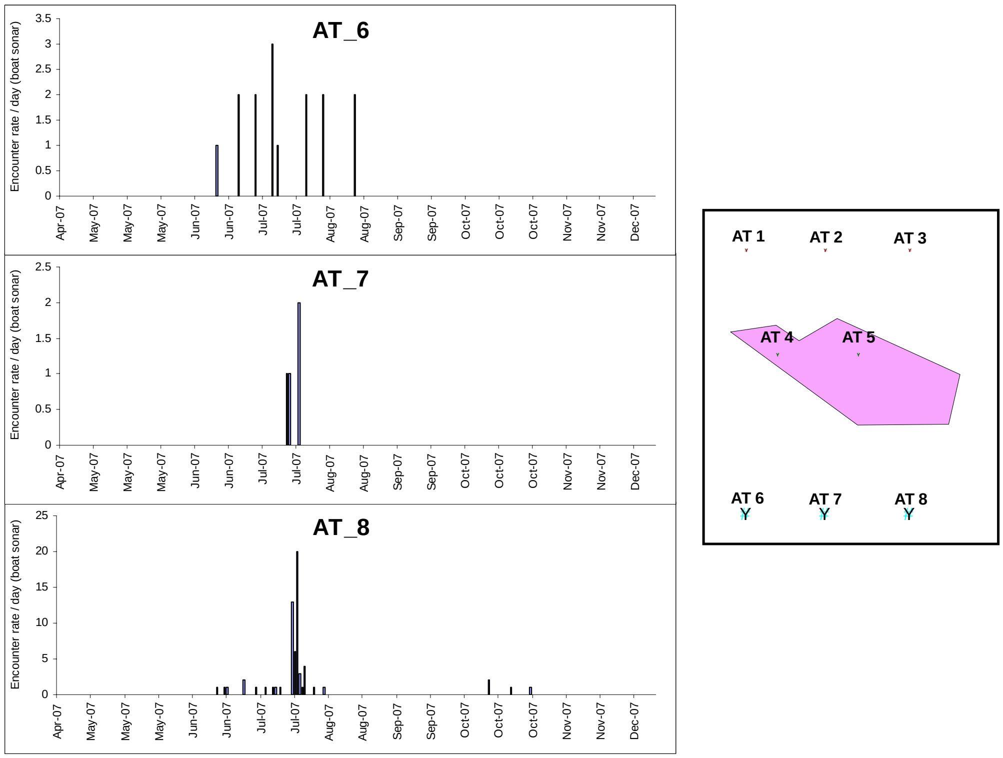

Figure 15 Average *__uncorrected__* *encounter rate per day for boat sonars in the southern reference area, separated by station. Note different y scales. The small map indicates the position of the T-PODs in relation to the wind farm (pink).*

4 Conclusion

This interim report gives an overview of the data collected so far and a preliminary analyses and interpretation of this data. One of the conclusions is that the area continues to be used by harbour porpoises. If and to what degree the usage has changed between the T_0 and the T_1 phase will need to be determined by more detailed statistical analyses. These analysis will be part of the preparation work for the final report. There is some indication that the habitat use differed between the reference areas and the area of the wind mill farm. The continuing study will hopefully provide some more information on this.

Technical problems have led to some data gaps, specifically in September 2007. The memory capacity of the T-PODs is related to the amount of porpoises in the vicinity, filling up faster if many animals are recorded. As the "normal" pattern of the T_1 study seems to differ slightly from what was observed previously, the data volume has increased in the summer months. Thus, for the future months of data collection we will shorten the time between surveys to a maximum of 2 months to avoid data loss on some of the stations.

The effectiveness of the new T-POD attachments needs to be evaluated after the next recovery surveys. Hopefully this will reduce future losses.

5 Acknowledgements

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6 References

Au, W.W.L., 1993. The sonar of dolphins. Springer-Verlag, New York.

Au, W.W.L., R. Kastelein, T. Rippe & N. Schooneman, 1999. The transmission beam pattern and echolocation signal of the harbour porpoise (*Phocoena phocoena*). J. Acoust. Soc. America 105:1261-

Borchers, D.L., W. Zuchini & R.M. Fewster, 1998. Mark-recapture models for line transect surveys. Biometrics 54: 1207-1220.

Brasseur S.M.J.M, O.D. Henriksen & P.J.H. Reijnders, 2003. First field rapport on the project "Assessment of the Reference Situation of the Near Shore Windfarm (NSW) for Harbour porpoise". Report to RIKZ, 12pp.

Brasseur, S., Reijnders, P., Henriksen, O.D., Carstensen, J., Tougaard, J., Teilmann, J., Leopold, M., Camphuysen K. & J. Gordon, 2004. Baseline data on the harbour porpoise, *Phocoena phocoena*, in relation to the intended wind farm site NSW, in the Netherlands Wageningen, Alterra, Alterra-rapport 1043. 80 blz.; .32 figs.; 11 tables.; 50 refs.

Camphuysen, C.J, 1994. The Harbour porpoise *Phocoena phocoena* in the southern North Sea. II: A comeback in Dutch waters? Lutra 37: 54-61.

Camphuysen C.J. 2004. The return of the harbour porpoise (*Phocoena phocoena*) in Dutch coastal waters. Lutra 47(2): 113-122.

Camphuysen C.J., http://home.planet.nl/~camphuys/Bruinvis.html

Deinse, A.B. van, 1952. De walvisachtige dieren in Nederland waargenomen in 1951, alsmede bijzonderheden omtrent onze oude en moderne walvisvaart. Het Zeepaard 12: 19-29.

Diederichs, A., T. Grünkorn & G. Nehls, 2003. Do porpoise detectors detect porpoises? Poster presented at the 17th conference of the European Cetacean Society, Las Palmas de Gran Canaria. Spain.

Gillespie, D. & O. Chappell, 2002. An automated system for detecting and classifying the vocalisations of harbour porpoises. Bioacoustics 13: 37-61.

Hammond, P.S., H. Benke, P. Berggren, D.L. Borchers, S.T. Buckland, A. Collet, M.P. Heide-Jørgensen, S. Heimlich Boran, A.R. Hiby, M.F. Leopold & N. Øien 1995. Distribution and abundance of harbour porpoises and other small cetaceans in the North Sea and adjacent waters. Final Report to the European Commission. LIFE 92-2/UK/O27.

Hammond, P.S., P. Berggren, H. Benke, D.L. Borchers, A. Collet, M.P. Heide-Jørgensen, S.Heimlich, A.R. Hiby, M.F. Leopold & N. Øien, 2002. Abundance of Harbour Porpoise and other small cetaceans in the North Sea and adjacent waters. J. Appl. Ecol. 39: 361-376.

Reijnders, P.J.H., 1992. Harbour porpoises *Phocoena phocoena* in the North Sea: numerical responses to changes in environmental conditions. Neth. J. Aquat. Ecol. 26: 75-86.

Reijnders, P.J.H., M.F. Leopold, C.J. Camphuysen, H.J.L. Heessen & R.A. Kastelein, 1996. The Status of the Harbour Porpoise Phocoena phocoena, in Dutch Waters and the State of Related research in the Netherlands: An Overview. Rep. Int. Whal. Commn. 46: 607-611.

Smeenk, C., 1987. The harbour porpoise *Phocoena phocoena* (L., 1758) in The Netherlands: stranding records and decline. Lutra 30: 77-90.

Smeenk, C., 2003. Strandingen van Cetacea op de Nederlandse kust in 1993-1997. Cetacea stranded on the Dutch coast in 1993-1997. Lutra-. 2003; 46(1): 45-64

Witte, R.H., H.J.M. Baptist & P.V.M. Bot, 1998. Increase of the harbour porpoise *Phocoena phocoena* in the Dutch sector of the North Sea. Lutra 40: 33-40.

ANNEX - Report of the towed hydrophone array

Pilot study to investigate the use of a towed hydrophone array for monitoring of porpoises in Dutch waters

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Contents

1 Introduction

Cetaceans are almost always difficult subjects to view at sea. This is particularly the case when sea conditions are sub-optimal, when visibility is poor, and at night. However, many species make loud and distinctive vocalisations and can often be detected more readily using passive acoustic systems rather than by visual means.

The advantages of using acoustic survey are multiples. They are generally less expensive (as you do not need as many fieldworkers), you can collect data whatever the visibility, the time of the day and the survey is not as much restricted by weather conditions as visual surveys are. For some species, it is difficult or impossible to determine which species, distance and number of animals you are recording. But this problem is minimized with harbour porpoise. This species is producing high frequency, narrow-band signal easily identifiable and they are usually travelling in small groups (Hang *et al*. 2003; Perrin *et al*. 2002). With the automatic acoustic detector Rainbowclick (IFAW), it is simple to detect them from the ambient noise, in some case it is possible to track the animals and to have an idea about the group size encountered. Porpoises are considered shy and generally tend to avoid vessels, supporting the idea that acoustic survey techniques can be very useful and more efficient than visual survey techniques to study harbour porpoise population.

The aim of this pilot study was to investigate the value of using a towed hydrophone array during a bird and marine mammal visual survey.

2 Methods

2.1 Hydrophone deployment

The equipment of the towed hydrophone array and computers were borrowed from the Sea Mammal Research Unit (SMRU) in St. Andrews, UK. The hydrophone was deployed during two surveys conducted within an ongoing environmental impact study in and around an offshore windmill farm located in the North Sea, west of the province of North Holland. The system was based on the equipment and software developed by Chappell *et al*. (1996) and further refined by Gillespie & Chappell (2002).

The towed hydrophone equipment was deployed from the *Vos Baltica* which was conducting bird and cetacean visual surveys. The hydrophone was run via the aft starboard side of the vessel. The buffer box and computer setup was done in an office on an upper level of the vessel. The retrieval of the hydrophone was done using a capstan winch. Generally, the speed of the vessel was reduced to 5 knots during deployment and retrieval. During data collection the ship speed was kept at approximately 10 knots. In general the hydrophone was deployed up to a sea state of 5-6. The towing depth of the hydrophone was monitored during the trip. It was generally 7m, depending on the speed of the vessel. Because of the low water depth close to shore and (during the first trip) ship speeds of less than 9knots the hydrophone was only reeled out to 180m length.

Two surveys were conducted: The first trip was from November 5th to 6th 2007. The second survey was conducted from November 20th to 25th 2007. Data were collected continuously whenever the hydrophone was in the water. Candidate clicks from harbour porpoises were archived for later analyses.

2.2 Data Analyses of towed hydrophone array

The analysis was conducted in two phases through the automatic detector *Rainbowclick*. The default value of the detector classified the clicks in 6 different categories: Harbour porpoise (HP), echo sounder (100, 115, 150 and 200 kHz) and low frequency noise. During the first phase, all the clicks within a minute before and after a click were automatically classifed as harbour porpoise were selected, highlighted as HP event and stored in an Microsoft Access database table. During the second phase, clicks within HP event where individually re-assessed as harbour porpoise or not. For that a careful observation of the waveform and spectrum (figure 1), following by the detection of the echoes (low amplitude and inter-click interval in comparison to its nearest neighbours) (figure 1) was necessary. Each event was then classified by: the number of porpoise clicks that it contained, if they showed a clearly definable track past the sensor array, and by the number of animals thought to be associated with each detection (figure 2).

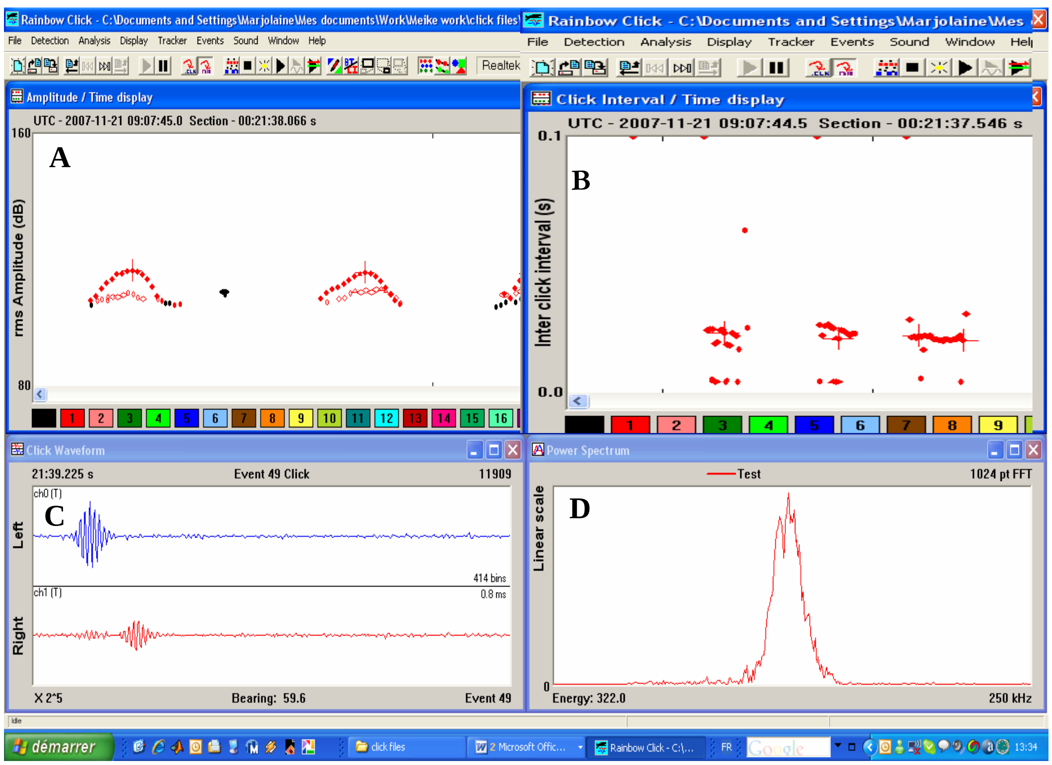

Figure 16. *Different view of HP track (A,B) and click (C, D) with Rainbowclick: A: Amplitude versus time, echoes have a lower amplitude (open points); B: Inter Click Interval versus time; echoes are the clicks with very low ICI; C: Classical waveform of a harbour porpoise click; D: Classical spectrogram of a harbour porpoise click*

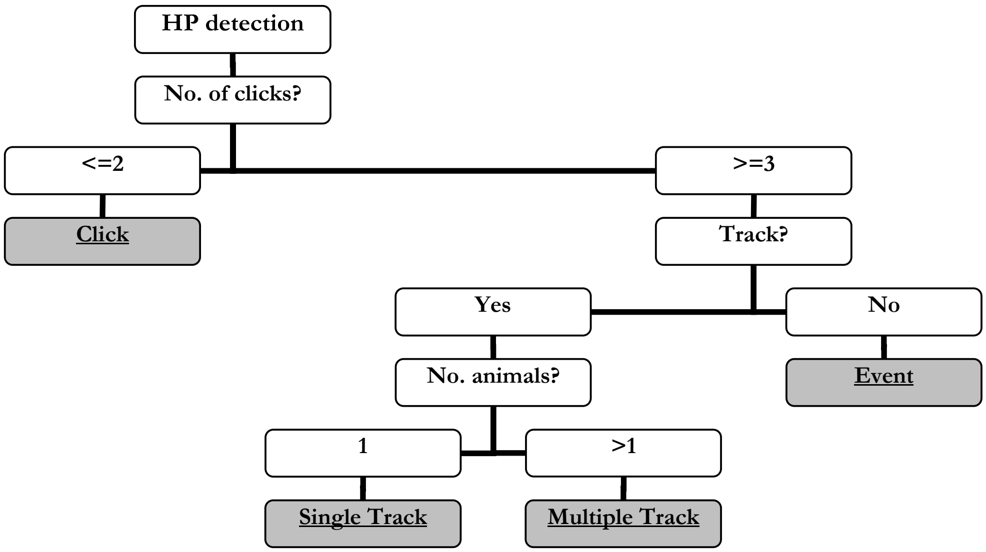

Figure 17: *Harbour porpoise detection classification tree. Detections are classified as single porpoise clicks, events (multiple porpoise clicks with no definable track), as well as single or multiple animals with a definable track.*

3 Results

3.1 Acoustic detections of the towed hydrophone array

The first trip started November 5th from Den Helder. The hydrophone was deployed for 6 hours and 85 km. Sea state was increasing from a 4 Bft to 5 Bft and the swell height increased from 2m to 3m. After a change in course with the wave direction perpendicular to the hydrophone the background noise level on the hydrophone increased substantially. The buffer was overflowing and it was decided to stop the recording. On November 6th the weather conditions deteriorated and the acoustic as well as visual survey had to be stopped.

The second trip started November 20th, again from Den Helder and the hydrophone could be deployed on the 20th to 22nd as well as on the 24th of November. During those days 700 km of acoustic data was collected. Some of this was done additionally to the visual survey, e.g. during night time. In total of 47hours of recording within 787 km of survey were made.

A total of 35 harbour porpoise were detected acoustically with a high certainty. These comprised of 8 single clicks (16%), 12 single track (24%), 2 multiple tracks (4%) and 21 events (40%). Additionally to these detections 10 clicks were identified as possible harbour porpoises (16%). An overview of the different identification categories is given in figure 3.

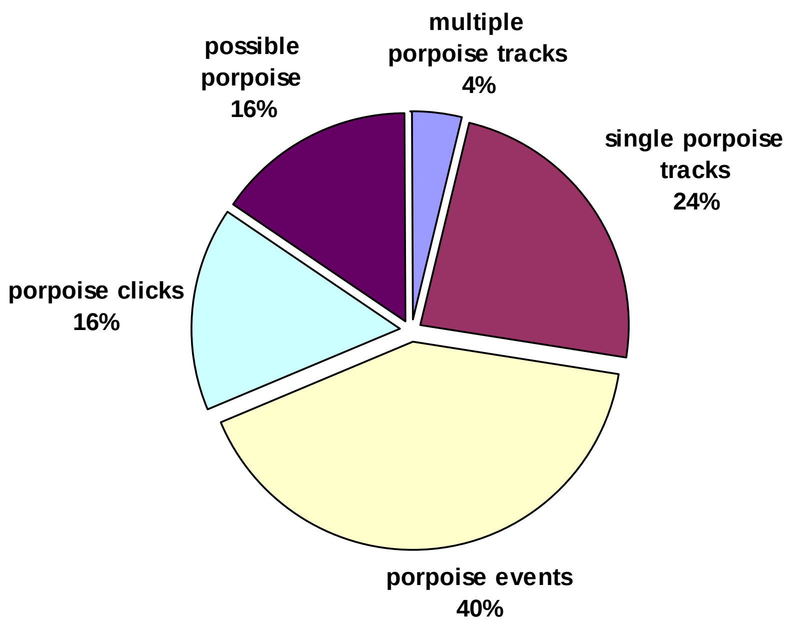

Figure 18. *Frequency distribution of the different categories of porpoise click identification.*

The hydrophone was successfully deployed on the way from the starting harbour Den Helder to the study area and back, as well as during all of the visual tracklines (figure 4). Some tracklines were covered more than once, including some additional night surveys. Acoustical detections of harbour porpoises were not uniform over the study area. Most detections concentrated on the transit to the study area, the western edge of the study area, as well as on the northern and southern tracklines (figure 4). The only vessel detection was made in the windfarm area of the Offshore windfarm

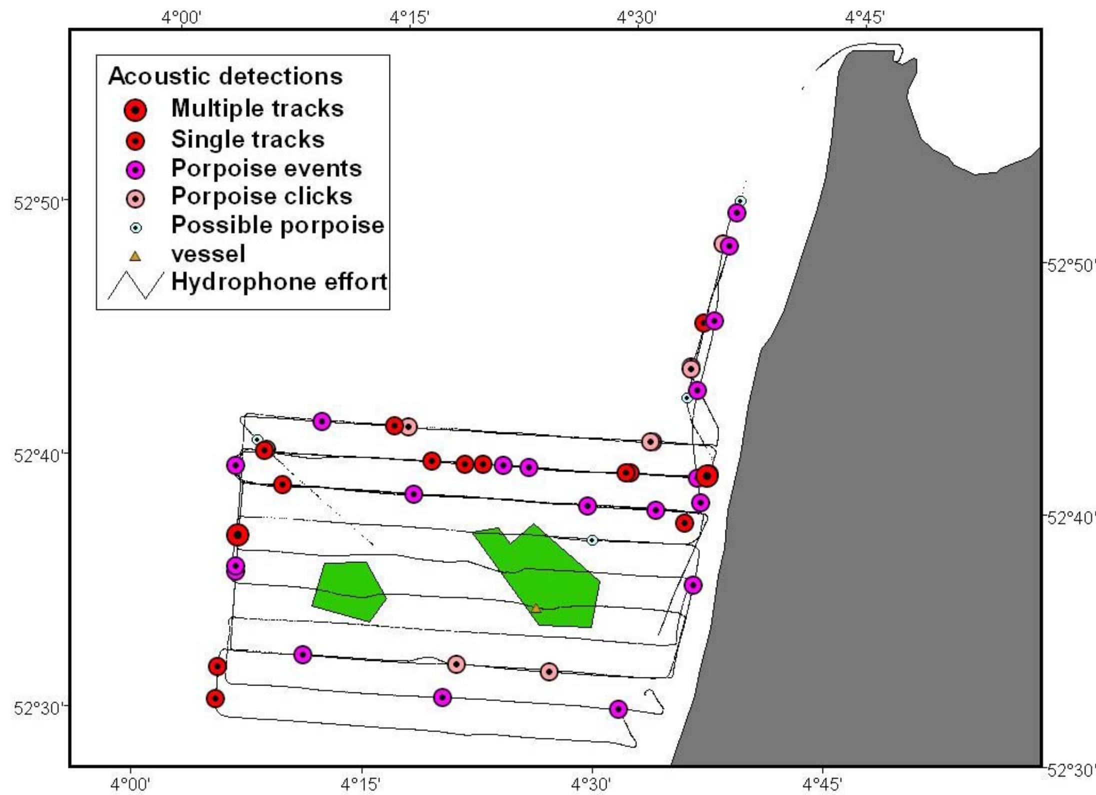

Figure 19. *Design of the survey with the acoustic detections. The green areas are the positions of offshore wind farms. Note that effort was higher on the northern tracklines.*

A tracking algorithm written for sperm whales and implemented in Matlab, was adapted for tracking porpoise events. This directly queries Click, Event and GPSData tables in an MS Access Logger2000 database, plots the ships course and heading, and bearings to individual clicks within an event. The algorithm estimates a location for the vocalising animal using target motion analysis by minimising the difference between observed and expected (predicted) bearings using a Chi Square test, and assuming a stationary animal and moving survey platform.

Two possible positions are calculated on either side of the track-line and position with smallest Chi Square value is assumed to be the location of the vocalising animal. The products of this algorithm are a position from which range to the first click (bearing), perpendicular distance (m), and the time abeam can be calculated.

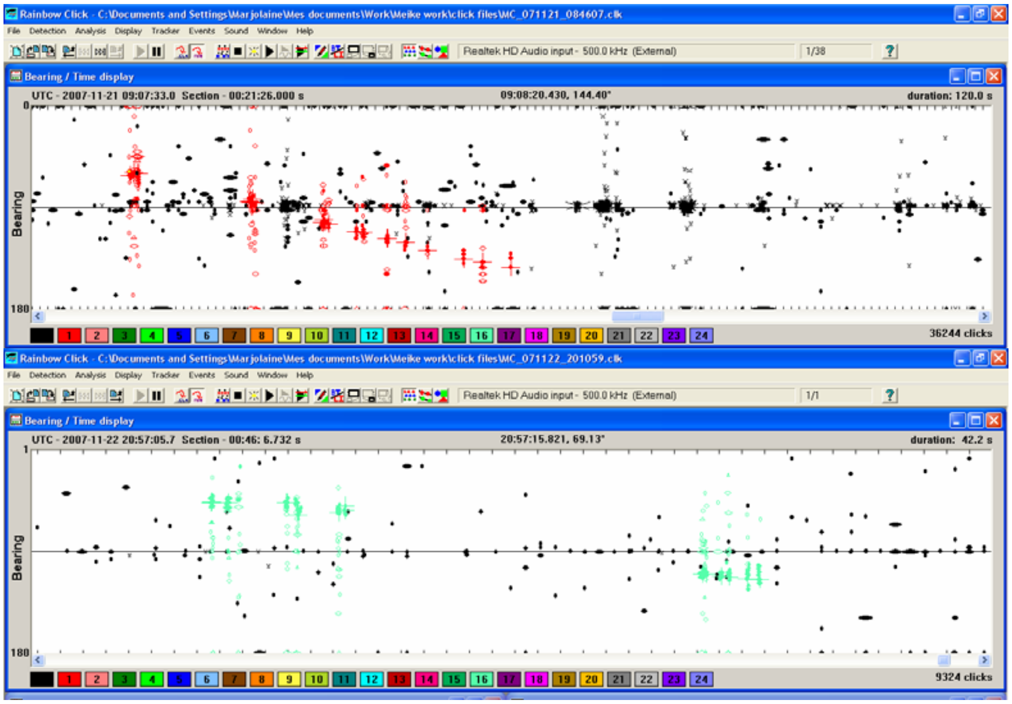

Figure 20. *Two harbour porpoise single Track recorded the 21st and 22nd of November 2007.*

The perpendicular distance has been calculated only on the ST (single track) events (figure 5). A histogram of all detection distances is given in figure 6.

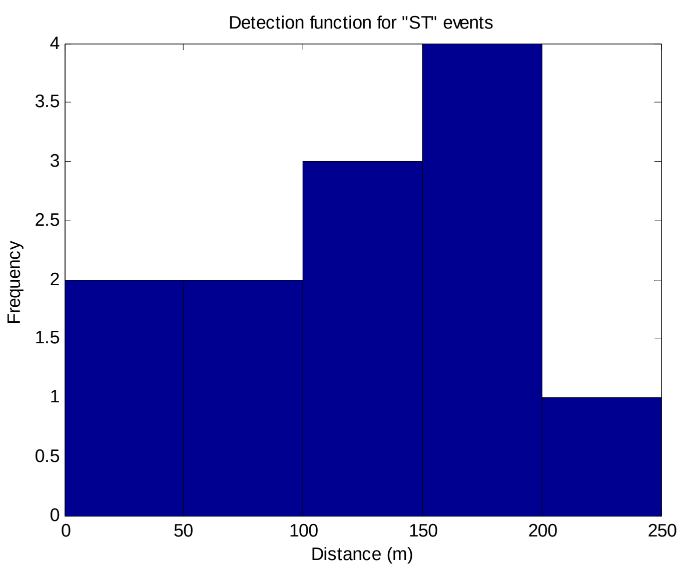

Figure 21. *Detection function for the "ST" events.*

4 Discussion and Conclusion

This pilot study showed that the towed hydrophone array could be deployed successfully from the *Vos Baltica* during the normal visual survey operations. After some initial problems during the set up, the hydrophone could be deployed and recovered without disturbing the ongoing research activities. Additionally, because of the automated system, only little effort and thus man power was needed for the actual monitoring of the data collection. The hydrophone could be deployed without problems up to sea state 6 and a swell of about 2m. In worse weather conditions the array picked up a lot of noise and the program was frequently overloading. The sea states of the two surveys analysed for this study were normally above 3. This makes effective visual surveys for porpoises more difficult and allowed fairly high detection rates for porpoises with the towed array.

The detection function showed a dip close to the trackline. Harbour porpoises need to avoid an approaching vessel and thus it is to be expected that at about 200m behind the vessel they are still at a distance to the original trackline. The maximum detection range of about 250 m is probably similar to what you would expect from visual surveys in good to moderate weather conditions.

Visual surveys for harbour porpoise are most reliable in fine weather conditions (sea state 3 or less); such conditions are relatively rare at sea, especially in the winter months. Thus passive acoustic monitoring can be a useful addition to a visual survey without too much of an additional effort in terms of work load. Potentially it can provide independent detection data to calibrate sighting rates and it allows surveys to continue during periods of darkness and poor sighting conditions.

A wide range of platforms of opportunity are potentially available for the deployment of the towed hydrophone array in Dutch waters. This includes for example fishery research vessels which cover large areas and thus the costs of the deployment would be minimal. Although the difference between vessels in terms of data quality need to be considered at the analysis stage of the data, the amount of data that could be collected cost-effectively is considerable. A collation of the analysed data in a common database, collected over long time periods and covering large areas, would provide valuable information on distribution patterns of harbour porpoises and possible changes within these patterns.

5 Acknowledgements

We would like to thank Henk Kouwenhoven and Martin Dekker for the assistance during the planning stage of this project and for helping us get the clearance for using the array in the wind farm. A special thanks goes to the crew of the *Vos Baltica* during the two survey trips. Thanks to Viola Kimmel for her review of the report.

6 References

Au, W.W.L., 1993. The sonar of dolphins. Springer-Verlag, New York.

Au, W.W.L., R. Kastelein, T. Rippe & N. Schooneman, 1999. The transmission beam pattern and echolocation signal of the harbour porpoise (Phocoena phocoena). J. Acoust. Soc. America 105:1261-

Berggren P., S. Brown, D. Gillespie, I. Kuklik, T. Lewis, J. Matthews, R. McLanaghan, A. Moscrop, & N. Tregenza, 2002. Passive acoustic and visual survey of Harbour Porpoises (Phocoena phocoena) in Polish coastal waters confirms endangered status of Baltic population. IWC, SC54/SM3, 6pp.

Buckland, S.T., D.R. Anderson, K.P. Burnham & J.L. Laake, 1993. Distance sampling: estimating abundance of biological populations. Chapman & Hall, London.

Buckland, S.T., 1996. The potential role of acoustic surveys in estimating the abundance of cetacean populations. In: Report of the Cetacean Acoustic Assessment Workshop, 1996. Hobart, Tasmania.

Camphuysen, C.J, 1994. The Harbour porpoise Phocoena phocoena in the southern North Sea. II: A comeback in Dutch waters? Lutra 37: 54-61.

Chappell, O., R. Leaper & J. Gordon, 1996. Development and performance of an automated harbour porpoise click detector. Rep. Intern. Whal. Commn. 46: 587-594.

Chatfield, C., 1984. The analysis of time series – An introduction. Third edition. Chapman and Hall, London

Gillespie, D. & O. Chappell, 2002. An automated system for detecting and classifying the vocalisations of harbour porpoises. Bioacoustics 13: 37-61.

Hammond, P.S., H. Benke, P. Berggren, D.L. Borchers, S.T. Buckland, A. Collet, M.P. Heide-Jørgensen, S. Heimlich Boran, A.R. Hiby, M.F. Leopold & N. Øien 1995. Distribution and abundance of harbour porpoises and other small cetaceans in the North Sea and adjacent waters. Final Report to the European Commission. LIFE 92-2/UK/O27.

Hammond, P.S., P. Berggren, H. Benke, D.L. Borchers, A. Collet, M.P. Heide-Jørgensen, S.Heimlich, A.R. Hiby, M.F. Leopold & N. Øien, 2002. Abundance of Harbour Porpoise and other small cetaceans in the North Sea and adjacent waters. J. Appl. Ecol. 39: 361-376.

Hang, T., Desportes, G., Vikingson, G.A. & Witting, L. 2003. Harbour porpoises in the North Atlantic. NAMMCO scientific publications (Volume 5).

Koschinski, S., B.M. Culik, O.D. Henriksen, N. Tregenza, G. Ellis, C. Jansen & G. Kathe, 2003. Behavioural reactions of free-ranging porpoises and seals to the noise of a simulated 2 MW windpower generator . Mar. Ecol. Progr. Ser. 265: 263-273

Leopold, M.F. & C.J. Camphuysen, 2002. T-zero seabirds and cetaceans surveys in the wind farm sites NSW and Q7. Cruise report of the second survey, carried out by Alterra, CSR, Bureau Waardenburg and Ecologic. Unpubl. Report to RIKZ.

Perrin, W.F., Würsig. & Thewissen, J.G.M. 2002. Encyclopedia of marine mammals. San Diego, CA Academic Press.

Tougaard, J., J. Carstensen, O.D. Henriksen, H. Skov & J. Teilmann, 2003. Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef. Report request. Commissioned by Techwise A/S. Hedeselskabet, Roskilde. 71 pp.

Tougaard, J., J. Carstensen, O.D. Henriksen, J. Teilmann & J.R. Hansen, 2004. Harbour Porpoises on Horns Reef - Effects of the Horns Reef Wind Farm. Technical Report for Elsam Engeneering A/S by National Environmental Research Institute, Roskilde, Denmark.

Appendix to report: OWEZ_R_253_ T1_20080219

To whom it may concern

Within the framework of the Off shore Wind farm Egmond aan Zee project, on the order of Dutch Government and with their financial support, an extensive environmental monitoring program is carried out. Research area's are birds, marine mammals, fish, benthos, solid substrate and public opinion.

The report at hand is written within the framework of the monitoring program and reports the work done in 2007 on one of the research topics. Before publication, the reports were reviewed by Dutch energy agency SenterNovem and the Waterdienst, a department of the Dutch water authority Rijkswaterstaat. The questions raised and comments of the researchers can be found in this appendix, however the text is available only in Dutch.

Aan de lezer van dit rapport

In het kader van het project Off shore Windpark Egmond aan Zee wordt, in opdracht van en met financiële ondersteuning van de Nederlandse rijksoverheid, een milieu monitoring programma uitgevoerd. Onderwerpen van onderzoek zijn vogels, zeezoogdieren, vis, benthos, hard substraat en publieke opinie.

Het rapport dat voor u ligt is gemaakt in het kader van dat programma en doet verslag van het werk dat in 2007 aan één van deze onderwerpen is uitgevoerd. Voorafgaand aan publicatie is dit concept rapport voorgelegd aan SenterNovem en de Waterdienst van Rijkswaterstaat die namens de overheid het monitoringprogramma begeleiden. Hun vragen bij dit rapport en de reactie van de onderzoekers treft u aan in deze bijlage bij het rapport.

Vragen en opmerkingen van de overheid op dit rapport:

De opzet van het onderzoek en de locatie van de T-pods komt overeen met die van de T0 en is dus vergelijkbaar. Wat mist is de vergelijking met hydrographische data dmv CTD's op de Tpods, en de vergelijking met visuele data. Het is niet duidelijk welke zaken allemaal in de T1 gaan worden berekend en met welke statistische methoden, dus hoe de data worden geanalyseerd. In de T1 wordt enkel gesproken van de encounter rate, terwijl in de T0 daarnaast ook ingaat op clickfrequency, click intensity, encounter duration, waiting time. Daarnaast worden in de T0 bepaalde correctiefactoren toegepast die in de T1 (nog?) niet worden toegepast. Ook mist de link tussen het hydrophone onderzoek en de T-pod data. Door het (tijdelijk) uitvallen van verschillende T-pods is het op dit moment voor SenterNovem en de waterdienst niet duidelijk of er voldoende gegevens zijn verzameld om iets te kunnen zeggen over het effect van OWEZ.

Opmerkelijk is dat in de T1 in figuur 7 staat dat er in september geen data zijn verzameld (blz 13 T1), terwijl in de grafieken op blz 15 in figuur 10 in september juist de hoogste aantallen zijn waargenomen. Bijvoorbeeld bij AT_4, terwijl die volgens tabel 7 na begin september 2007 niet meer operationeel is geweest. Ook figuur 14 blz 18 geeft aan dat er na begin september 2007 geen encounters meer zijn geregistreerd. Het wordt niet duidelijk hoe dan wel voor september en verder gegevens kunnen zijn opgenomen in figuur 10.

<u>Reactie van de onderzoekers:</u>
Uit de T0 bleek dat de CTD geen extra informatie geeft over het voorkomen van bruinvissen. In de T1 zijn daarom geen CTD metingen uitgevoerd.
Tijdens de T0 en T1 zijn verschillende types TPOD gebruikt. Om de data te kunnen vergelijken moet een correctiefactor tussen beide types worden vast gesteld. Nadat de correctiefactor is bepaald kan de statische vergelijking tussen T0 en T1 worden gemaakt.
Op het moment van schrijven van het rapport was de correctiefactor nog niet berekend. Daarom is alleen ingegaan op de "encounter rate". Die data zijn robuust genoeg om zonder correctiefactor goed geïnterpreteerd te kunnen worden. Voor het eindrapport zal de correctiefactor wel beschikbaar zijn en daarin zullen de clickfrequency, click intensity, encounter duration, waiting time wel aan de orde komen.

Er zijn inderdaad periodes waarin TPOD's ofwel niet hebben gewerkt, ofwel verloren zijn gegaan. Er zijn over de meetperiode van inmiddels twee jaar (de TPOD's zijn recent opgehaald) echter ruim voldoende data om de gevraagde analyses te doen.

In september 2007 zijn door TPOD's AT2 en AT4 wel data verzameld, maar slechts weinig, zoals blijkt uit figuur 7. Deze data zijn gebruikt voor de figuren 10, 13 en 14.

De opmerking dat er geen link is tussen het hydrophone onderzoek en de TPOD data is correct. Beide onderzoeken hebben geen relatie en het towed hydrophone experiment maakt geen deel uit van het monitoringprogramma van OWEZ. Imares heeft de gelegenheid gebruikt die geboden werd door een vaartocht in het kader van het werk aan lokale vogels om het experiment uit te voeren. De resultaten werden interessant geacht en daarom is een verslag van het experiment in een bijlage toegevoegd.