CHAPTER 15

SEASONAL AND INTERANNUAL PATTERNS IN THE PRESENCE OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN BELGIAN WATERS FROM 2010 TO 2015 AS DERIVED FROM PASSIVE ACOUSTIC MONITORING

*J. Haelters[*1], B. Rumes[2], J. Vanaverbeke[2] & S. Degraer[2]*

[1]Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment, Management Unit of the North Sea Mathematical Models (MUMM), 3de en 23ste Linieregimentsplein, 8400 Ostende, Belgium.

[2]Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature), Aquatic and Terrestrial Ecology (ATECO), Marine Ecology and Management Section (MARECO), Gulledelle 100, 1200 Brussels, Belgium.

[*]Corresponding author: Jan.Haelters@naturalsciences.be

ABSTRACT

The harbour porpoise (*Phocoena phocoena*) is the most abundant cetacean in the Belgian part of the North Sea. We developed a mooring system for static passive acoustic monitoring (PAM) of this species using c-PoDs at locations of opportunity. Data of moorings between 2010 and 2015 at two locations were analysed. They revealed a significant seasonal trend in detections, assessed by month, with peaks in late winter - early spring and late summer, consistent with the results of aerial surveys and with strandings data. At one location there were significant differences in detections between years, with higher detection rates in every year between 2011 and 2014, and the highest detection rates in 2013 and 2014. The experiences gained are used to design a subsequent study strategy to monitor harbour porpoise presence in Belgian waters, including possible effects on their presence due to the construction of offshore windfarms.

15.1. INTRODUCTION

The elusive and highly mobile harbour porpoise (*Phocoena phocoena*) is the most abundant cetacean in the Belgian part of the North Sea (BPNS). Aerial surveys revealed that average densities in these waters range from 0.2 to 4 animals km^{-2} (Haelters et al., 2013; 2015; data RBINS, unpublished), totalling from a few hundred up to more than 10.000 porpoises (or in the latter case more than 3% of the best North Sea population estimate; Hammond et al., 2013). The harbour porpoise should thus be considered as a significant top of the food chain constituent in the BPNS.

Dedicated monitoring of harbour porpoises in Belgian waters started with aerial surveys (Haelters, 2009), with as their main goal to assess the reference situation prior to, and to study the impact of the construction and operation of offshore windfarms. Aerial surveys continue up to date, and demonstrated that porpoise density shows a seasonal pattern in Belgian waters and that concentration areas of porpoises occur (Haelters et al., 2011a; 2013).

As aerial surveys could only be performed with a low temporal resolution (five at the most per year), it is possible that changes in density and distribution in between surveys were missed. Also, due to short daylight time and frequent adverse weather conditions, as of yet no aerial surveys were undertaken between late autumn and late winter. Therefore, a project was set up to complement information generated through aerial surveys with data from continuous passive acoustic monitoring (PAM) as soon as a suitable and affordable PAM system was available. PAM, using autonomous devices that are placed at a fixed location for weeks to months generates data with a high temporal, but low spatial resolution (Au, 1993; Tregenza, 1999; Mellinger et al., 2007).

In this report we describe the results of the PAM study of harbour porpoises in Belgian waters between 2009 and 2015. We first developed and assessed suitable systems for mooring PAM devices on locations of opportunity. Using the data collected, we investigated whether temporal trends in harbour porpoise presence within and between years can be detected. The experiences gained are used to develop a subsequent strategy to monitor harbour porpoise presence in Belgian waters, including possible effects on their presence due to the construction of offshore windfarms.

15.2. MATERIAL AND METHODS

PODS

The only PAM device that was used between 2009 and 2015 was the Continuous Porpoise Detector (C-PoD, further indicated as PoD). PoDs consist of a hydrophone, a processor, batteries and a digital timing and logging system. They continuously monitor sounds between 20 kHz and 160 kHz, and can detect all odontocetes except sperm whales (*Physeter macrocephalus*). A PoD does not record sound itself, but compresses data, generating a raw file with for each click characteristics such as its time of occurrence, duration, dominant frequency, bandwidth and sound pressure level. Using dedicated software, the raw file can be objectively analysed to find click trains and to classify these into a.o. trains produced by odontocetes and trains that originate from other sources such as boat SONAR. Distinction can be made between harbour porpoises, a species producing narrow-band, high-frequency clicks, and dolphins, producing more broadband clicks with a lower frequency. The maximum detection range for porpoises is approximately 400 metres. PoDs have an autonomy of up to 200 days (www.chelonia.co.uk).

POD MOORING SYSTEMS

The moorings used in this study were mostly moorings of opportunity, using existing platforms: tripods and navigational buoys. Tripods are heavy structures moored on the seafloor. Their presence is indicated by a surface marker buoy, also used to retrieve it. Next to a PoD attached to the central (vertical) column at 1.5 m above the seafloor, the tripods mostly had also other oceanographic instruments attached to them (Van den Eynde et al., 2010) (Figure 1). A mooring system using existing navigational buoys was developed, leading to the concealment of the PoD in a lead-weighted stainless steel container (leaving the hydrophone exposed). This system was hung free from the buoy with a stainless steel chain at approximately 1.5 m below the water surface. The chain was protected with rubber hosing in order to limit chain rattling and prevent damage to the coating of the buoy (Figure 1). In two cases, a PoD was attached to a weight on the seafloor, where it hung free on a rope at around 1.5 m from the seafloor, using its positive buoyancy. These moorings were recovered using divers. Finally, a ‘stealth’ mooring system was tested; it consisted of a stone weight and a Danforth anchor separated by a 40 m long, stretched, bottom rope, and the PoD attached to the weight. While tests in shallow waters to recover the system using a grappling anchor were successful, the only time it was effectively used was unsuccessful, and the PoD was lost.

Figure 1. Prevailing mooring systems used: navigational buoy (left) and tripod, in combination with other oceanographic instruments (right) (images: RBINS).

POD MOORING LOCATIONS

Between 2009 and 2015 we performed 101 moorings of PoDs near the edge of territorial waters in the eastern (Thorntonbank, Gootebank, Bligh Bank) and western part of Belgian waters (Oostdyck Bank), and a few km off the coastal town of Blankenberge (MOW1; Table 1; Figure 2). The goal was to have, continuously, PoDs present at 2 to 3 locations. The locations were predominantly chosen as a function of the availability of a mooring of opportunity, and the distance to an offshore wind farm area. Between 2010 and 2015, mooring locations changed due to shifts in the position or presence of navigational buoys and the deployment of tripods dedicated to other research objectives.

Table 1. Mooring types and location of PoDs ; the locations are precise within a few hundred meters due to tides displacing buoys and the fact that the mooring of the tripods was made within that margin. Distance to the coast was measured to the beach, and does not take account of the harbour of Zeebrugge.

Location	**Type of mooring**	**Lat (°)**	**Lon (°)**	**Water depth vs. MLLWS (m)**	**Distance to the coast (km)**
MOW1	Tripod	51.356667	3.116667	7.3	3.7
Thorntonbank	Buoy	51.590333	3.005083	26.8	32
Thorntonbank	Buoy	51.566667	2.912917	26.7	31
Thorntonbank	Steel weight	51.543333	2.930000	21.5	28
Oostdyck W	Buoy	51.285833	2.438667	24.6	22.4
Gootebank	Buoy	51.449217	2.878717	23.8	21.3
Gootebank	Tripod	51.448100	2.876450	24.5	21.3
Bligh Bank	Stealth	51.711850	2.816533	29.6	49
Bligh Bank	Tripod	51.703333	2.813333	26.6	48

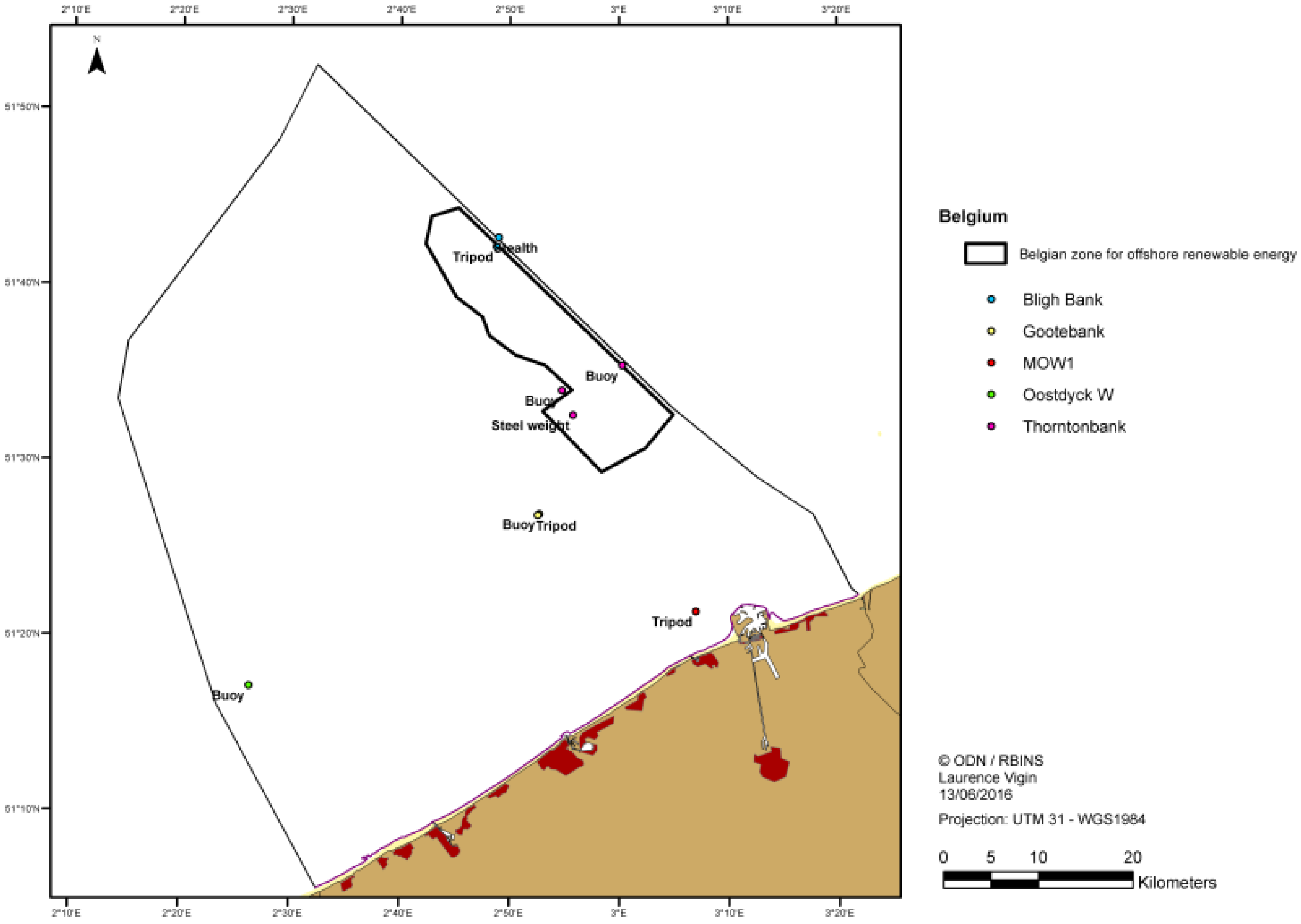

Figure 2. Location of PoD moorings

DATA ANALYSIS

The data were analysed using CPOD.exe software version 2.043. Of the four levels of confidence (quality) of the data, only high and moderate train quality was used, with the species filter set to harbour porpoises. Data were exported and further analysed using Excel and R-software (R Development Core Team, 2016). Different measures were initially used to describe harbour porpoise presence:

- Detection Positive Minutes per day (DPM day^{-1}): the number of minutes in a day in which harbour porpoises were detected;
- Time Present per day (TP day^{-1}; in seconds): cumulative duration of trains per day.

Both measures have their value: in case animals move quickly, and stay at one location for only a short time, more encounters (~DPM) would be recorded than if they would move slowly. The cumulative duration of trains (TP) would however remain more constant at different swimming speeds.

Data were treated per mooring, which lasted from two weeks to more than five months, yielding useful data for up to 143 days.

High levels of ambient noise interfere with the ability of a PoD to detect odontocetes in two ways: they mask clicks, and they use up the limited amount of data that can be stored per minute (resulting in % of time lost). In comparing data of 82 moorings, on average 95.2% of the minutes could be used for moorings on tripods, while 83.8% of the minutes could be used for moorings on buoys. This figure increased to 95.7%, respectively 87.4% when including minutes with up to 20% saturation. The minimum number of minutes that showed no saturation in a tripod system was 74.6%, while it was 55.3% in a PoD moored on a buoy (Figure 3).

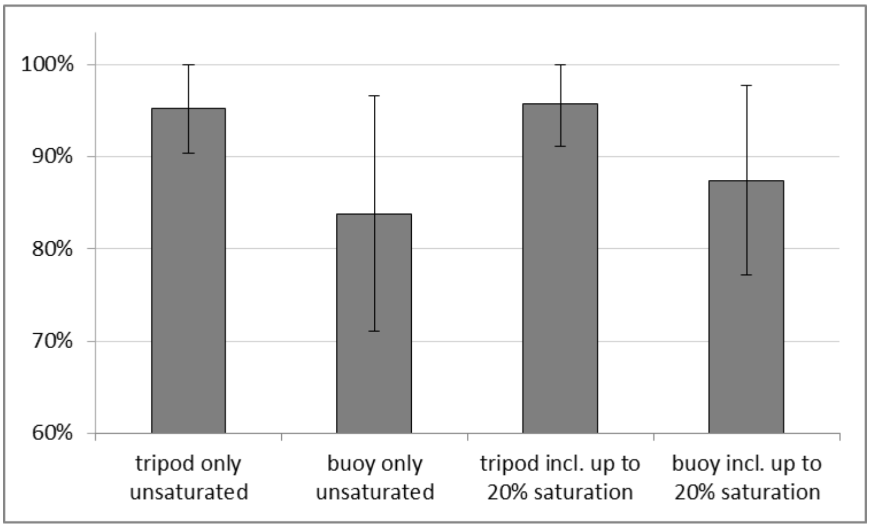

Figure 3. The percentage of minutes without saturation and those including saturation up to 20% that could be used differed between the two main mooring systems (including Standard Deviation).

Given the relatively high level of minutes showing saturation a a number of moorings, data were further treated as follows:

- All minutes with SONAR risk and/or continuous noise detected with the software, were omitted from the analysis.
- All minutes were included, except those with more than 20% time lost. While in theory not necessary to include minutes with up to 20% time lost for most of the files, this was done in order to treat all files in a standardised way.
- Days in which data for less than 50% of the total number of minutes/day were available, were omitted from the analysis.

When using minutes with time lost, the TP for each minute was corrected proportionally. Also when presenting DPM day^{-1} and TP day^{-1}, data were corrected proportionally with the minutes that were considered. As the temperature recording in the PoDs had not been calibrated, it was not used further. Instead, reliable sea surface temperatures were used for the Oostdyck W location and MOW1 (data extracted from http://marine.copernicus.eu).

For the two stations with data available from a sufficiently long period over multiple years (MOW1 and Oostdyck W), statistical modelling was performed on the DPM day^{-1} to describe seasonal trends in porpoise detection. TP day^{-1} was not used further for the statistical analysis, as there did not seem to be important deviations from a parallel track between TP day^{-1} and DPM day^{-1} (Annex 4). Preliminary data analyses revealed, as could be expected, strong autocorrelation when using total DPM day^{-1} as response variable. Therefore observations per day were pooled per month, providing a proxy for harbour porpoise detections per month at each station. Available predictors included ‘year’, ‘month’ and ‘temperature’. As ‘temperature’ was strongly collinear with ‘month’, only month and year were used for the final analysis.

The continuous variable *month* was used to model seasonal fluctuations by fitting a cyclic sine curve, described by a linear sum of sinus and cosinus terms (Stewart-Oaten & Bence, 2001, Onkelinx et al. 2008, Vanermen et al. 2015). In order to allow multiple peaks in detections per year, several start formulations of the model were tested:

- TotalDPM~offset(days) +
  sin(2*pi*(Month/12)) +
  cos(2*pi*(Month/12)) + factor(Year)
- TotalDPM~offset(days) +
  sin(2*pi*(Month/12)) +
  cos(2*pi*(Month/12)) +
  sin(2*pi*(Month/6)) +
  cos(2*pi*(Month/6)) + factor(Year)
- TotalDPM~offset(days) +
  sin(2*pi*(Month/12)) +
  cos(2*pi*(Month/12)) +
  sin(2*pi*(Month/4)) +
  cos(2*pi*(Month/4)) + factor(Year)

The ‘offset(days)’ term takes into account the different length of the months and the number of mooring days per month. Based on AIC, the best model was determined, and further model selection was performed based on a backward selection with AIC as decision criterion. However, plots of residuals versus fitted values clearly indicated heterogeneity of variances. Therefore, we adopted a linear regression with generalized least-square extension (Zuur et al., 2009), which allows unequal variances among treatment combinations to be modeled as a variance-covariance matrix (West et al., 2006; Pinheiro & Bates, 2009).

Following West et al. (2006) and Zuur et al. (2009), the most appropriate variance-covariate matrix was determined using AIC scores in conjunction with plots of fitted values versus residuals with different variance-covariate terms relating to the independent variables, using restricted maximum-likelihood (ML) (REML, West et al., 2006). This procedure resulted in the use of a variance structure that allowed for different variances per stratum for 'year' or 'month' for the analysis of the data for MOW1 and Oostdyck W respectively (varIdent function, R package nlme). Once the appropriate random component had been determined, the fixed component of the model was refined by manual backwards stepwise selection using ML to remove insignificant variable terms.

No account was taken of windfarm construction activities during the period of the study. Effects on the presence of harbour porpoises during pile driving could have been present at all sites, and with a high level of certainty negative effects occurred at the mooring locations closest to the pile driving sites (Haelters et al., 2015). It has been demonstrated that piling can have effects on harbour porpoise presence up to distances of more than 20 km away from pile driving sites (Nedwell et al., 2003; Carstensen et al., 2006; Tougaard et al., 2009; Brandt et al., 2011; Murphy et al., 2012; Dähne et al., 2013; 2014; Haelters et al., 2015). However, possible negative or positive effects were not considered for Oostdyck W and MOW1 as these locations were respectively 40 and 23 km away from the nearest pile driving site and as piling was limited in time vs. the total PoD mooring time.

15.3. RESULTS

MOORING SYSTEMS AND DURATION

When only including periods yielding useful information (excluding lost PoDs or the periods with no data collected, e.g. due to batteries that ran out), PoDs yielded data for a total duration of 4,575 days between 2009 and 2015. The total number of days of moorings yielding useful information varied between locations (from 208 days at the Bligh Bank to 1,912 days at MOW1) and between years (Figure 4). Excluding 19 PoD moorings that did not yield data, the 47 PoD moorings on tripods yielded on average 46 days of data (10-143), while the 35 PoD moorings on buoys yielded on average 68 days of data (15-139).

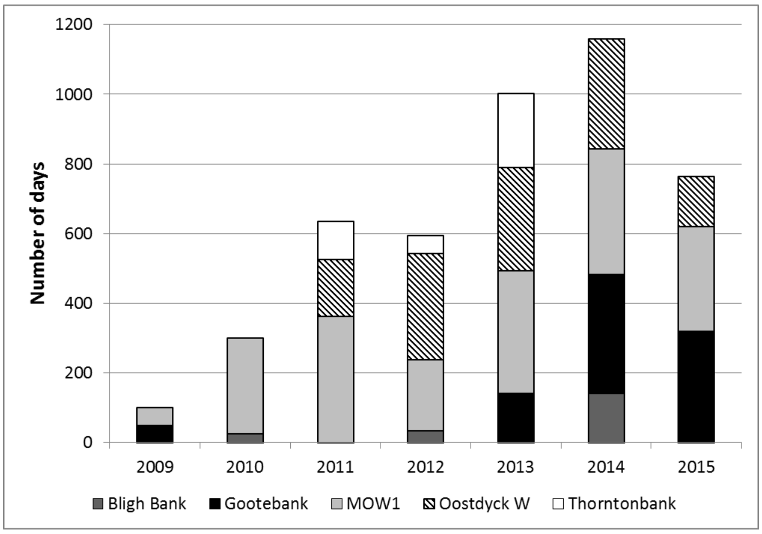

Figure 4. Moorings of pods (days) per location and per year; only days yielding useful information are included.

During the study, 7 PoDs were lost (including a buoy moored PoD that was later recovered in Denmark, and that still contained data) on a total of 101 moorings: 1 from a tripod (the whole tripod was lost), 5 from buoys and 1 from the stealth mooring system. The highest loss rate occurred in buoy moored PoDs: 5 losses out of 40 moorings (12.5%), vs. 1 out of 58 moorings (1.7%) in PoDs mounted on tripods. After the loss of PoDs that were fastened to buoys with a stainless steel wire, the wire was replaced by a stainless steel chain, but a few losses still occurred. Data collection without the PoD getting lost was unsuccessful in 13 moorings, including in the PoDs moored on the steel anchor weight (2).

TEMPORAL CHANGES IN DETECTION RATE

An overview of the raw data (average corrected DPM and TP per week and per month, and average DPM and TP per month split up into years are taken up in Annex 4 (Figures a-d).

For the statistical analysis, only DPM data from 2010 to 2015 were used, given the limited data available for 2009. At both mooring locations for which the PAM data were analysed (Oostdyck W and MOW1), there was a significant seasonal trend in DPM day^{-1}, assessed by month, with a peak in the detection rate in late winter – early spring and a smaller one in late summer (Figure 5). Only at MOW1 there were significant differences in DPM day^{-1} (aggregated per month) between years, compared to 2010, with higher detection rates in every year between 2011 and 2014 (Figure 6). The highest detection rates occurred in 2013 and 2014.

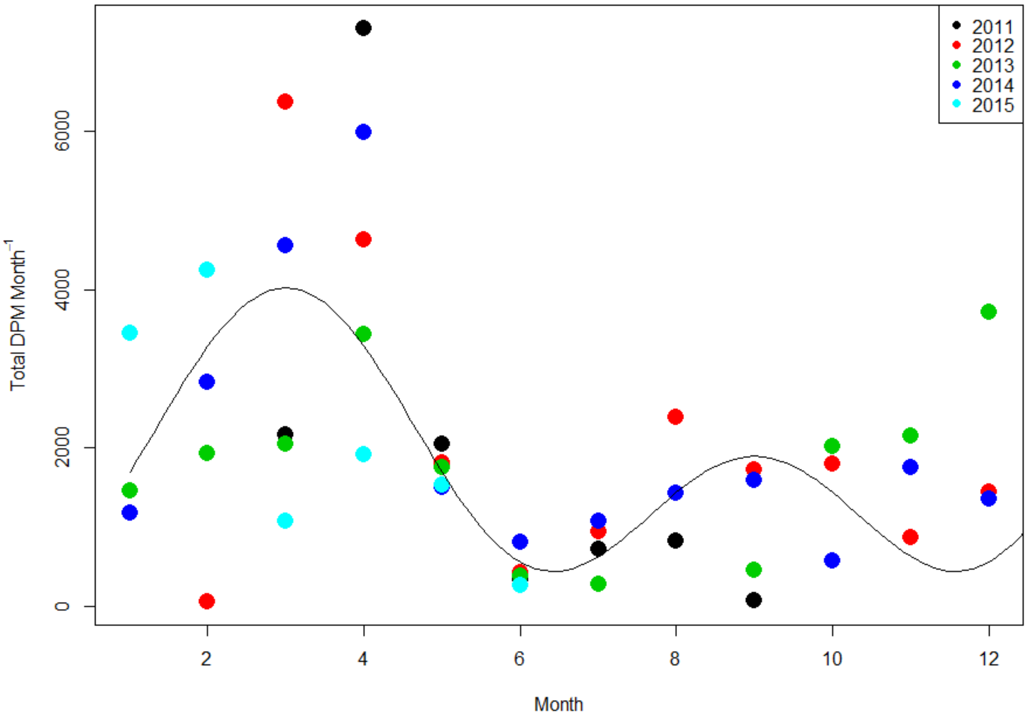

Figure 5. Model output (DPM month^{-1}) of seasonal trend at Oostdyck W.

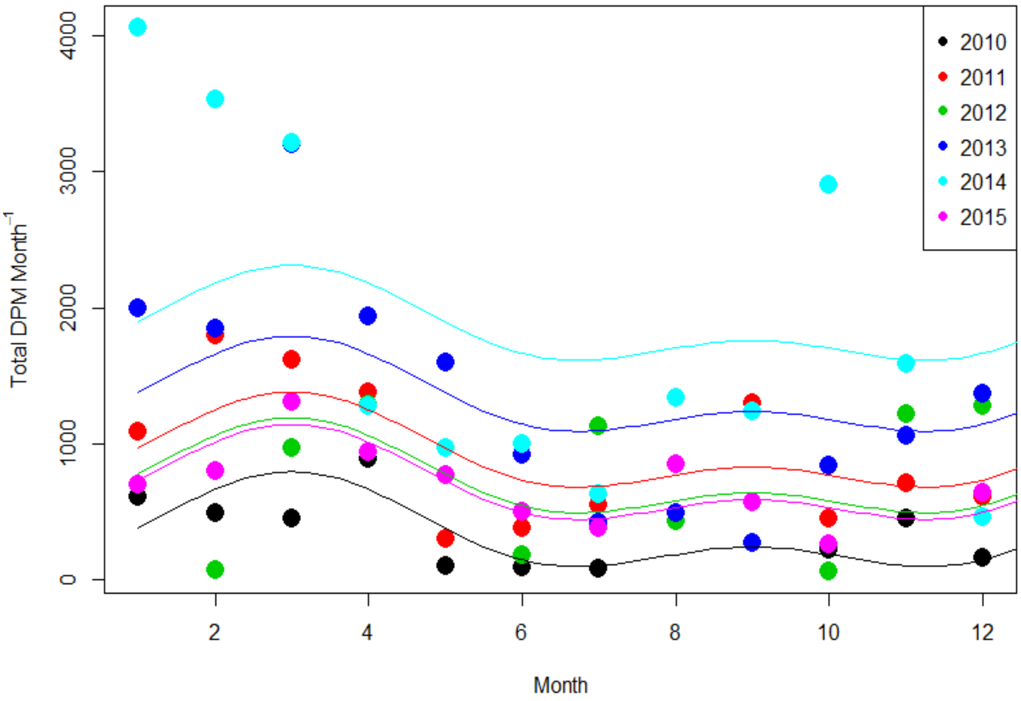

Figure 6. Model output (DPM month^{-1} year^{-1}) of seasonal trend at MOW1.

DIFFERENCES IN DETECTION RATE PER LOCATION

The detection rates at the Oostdyck W location were in general higher than at MOW1, with per month on average more than twice as many DPM day^{-1} and seconds TP day^{-1} (Figure 7; Annex 4).

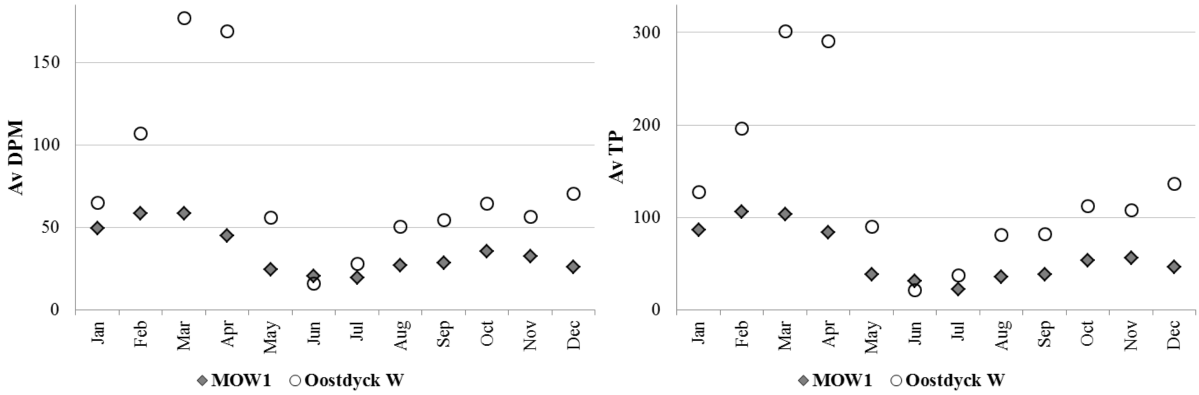

Figure 7. Average DPM/d (left) and TP/d (seconds; right) per month for MOW1 vs. Oostdyck W.

15.4. DISCUSSION

ISSUES IN MOORING PODS

As Belgian waters are characterized by predominantly soft sediments, experiencing a high level of bottom trawling, and given budgetary constraints, moorings were tested at locations of opportunity by developing mooring systems adapted to such locations. Both main used mooring techniques have their advantages and disadvantages. A large ship is needed for mooring (expensive) tripods, while for mooring PoDs on existing navigational buoys a small RHIB type vessel is sufficient. Especially with the PoDs hanging from the buoys, there were issues to be resolved with orientation (the PoD needs to be kept as vertical as possible) and robustness; this was eventually achieved using a relatively heavy system (with a lead weight at the bottom of the steel container).

PoD losses can occur even with robust mooring systems (e.g. Brasseur et al., 2004; Diederichs et al., 2009). In our study, losses in PoDs moored on buoys were higher than in tripod mounted PoDs. This is probably due to a combination of factors. Buoy moored PoDs are more vulnerable to damage during adverse weather conditions, as they are much more exposed than tripod mounted PoDs. After the replacement of stainless steel wire with a chain in buoy moored PoDs, a few losses still occurred due to the whole mooring system getting lost. In one case of a buoy moored PoD, the mooring system remained in place, while the PoD had disappeared, probably due to a broken 8 mm stainless steel screw keeping it fastened. Theft of buoy mooring systems or vandalism could not be excluded, as they were within easy reach. The loss of the tripod could have been the consequence of displacement to an unknown location by bottom trawl fisheries. In 2016 (not in this study) a tripod mounted PoD got detached (and lost) from a tipped tripod due to unknown reasons.

Saturation in PoDs hanging from buoys occurred on average more frequently than in PoDs mounted on tripod systems, as could be expected given higher underwater sound levels around buoys and the unavoidable continuous movement of the PoDs in this mooring system. Particularly in the data obtained from such moorings, broadband background noise can interfere with porpoise detections, by leading to an overload in the detection capabilities of PoDs, or by masking porpoise clicks. This is especially the case during periods with strong tidal currents and adverse weather conditions.

The unsuccessful data collection in a number of moorings was due to unknown reasons (3; including possibly a wrong initialisation of the PoD), loose SD cards (2) and the tipping over of tripods, automatically switching off the PoD (6). Data from the PoDs moored on the steel anchor weight (2) could not be used due to a pinger nearby, saturating the data with a 69 kHz sound.

A NEED FOR STANDARDISATION OF MOORING METHODS?

It is likely that the variation in the detection rate at different locations is not solely the consequence of a difference in the presence of porpoises, but also of the use of different mooring systems. It has been demonstrated for instance that detection rates can vary according to the deployment depth of C-PoDs (Sostres Alonso & Nuuttila, 2015). There could also be a different attraction of harbour porpoises to a tripod mounted PoD vs. a buoy moored PoD, resulting in a different detection rate, and there could be different false detection rates. Given the use of moorings of opportunity in our study, we could not assess the possible effects of this, but as the MOW1 (tripod) location was very shallow, we estimate that the effect of at least mooring depth would be minimal. However, possible differences in detections due to the use of different mooring systems should be avoided through a high level of standardisation, such as in the SAMBAH project (Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise project; www.sambah.org). In this way, PAM data (generated by a similar PAM device) could be better compared over larger areas than is currently the case within the North Sea. This may however be difficult to achieve, given wide ranges in current velocity, depth, bottom type, etc.

STUDY DESIGN

In impact assessment of human activities, no firm conclusions can be drawn when using a small number of PoDs, as in this study. For a meaningful statistical analysis, more replicates and more locations with simultaneous PoD deployments are needed. For impact assessment of pile driving, PoDs should be placed along a gradient from the piling location, up to more than 20 km away (as in Brandt et al., 2011; 2012; Dähne et al., 2013), before piling starts up to weeks after the end of piling operations. For impact assessment of operational wind farms, PoDs need to be placed both within a windfarm, and at a location with similar environmental variables outside it, at a short distance (eg. at least two locations with 3 PoDs each) (Scheidat et al, 2011).

However mooring fewer PoDs, such as in this study, can yield useful information. They provide the basis for the analysis of technical aspects in the mooring of PAM devices, generate information about what PAM studies can achieve locally, and as such form the basis of further studies. Additionally, they provide information for the assessment of seasonal differences in harbour porpoise presence and migratory/foraging movements and in differences in the presence of porpoises in between years. The information obtained from a relatively small number of PoDs can thus contribute to other studies, such as of stranded animals and other studies providing information useful for managing activities possibly adversely affecting porpoises, such as piling and fisheries.

PAM VS. STRANDINGS AND AERIAL SURVEY DATA

In contrast to visual line transect methods (Buckland et al., 2001), PAM is a cue counting method, and it cannot usually directly provide an estimate of absolute density, a value often requested for in for instance environmental impact assessment studies. PoDs only measure the time during which animals are detected, and the number of clicks detected. Complicating factors in efforts to correlate detection rate with density of animals include the following:

- There may be a varying false positive detection rate in PoDs (although it is probably low), and it could be different between different mooring systems.
- The detection probability as a function of the distance around the PAM device is usually unknown.
- Vocalisations of harbour porpoises are directional, possibly leading to different detection rates in for instance benthic vs. pelagic feeding animals.
- Differences in group sizes, not detected through PAM, may be related to a combination of a seasonal variation in prey species and different social stages in the life cycle of harbour porpoises, with distinct periods of mating, breeding and lactation (Addink et al., 1995; Gaskin et al., 1984; Haelters et al., 2011b; Lockyer, 2003).
- While porpoises echolocate almost continuously (Verfuß et al., 2005; Akamatsu et al., 2007), there are diurnal rhythms (likely to reflect differences in prey choice and hunting behaviour) and perhaps also seasonal differences in echolocation (Stedt et al., 2015; Brandt et al., 2016).
- Tidal noise and noise originating from adverse meteorological conditions could affect the echolocation capabilities of harbour porpoises, which may during running tides adapt their echolocation activities.

All these factors lead to the conclusion that there is no straightforward correlation between detection rate, as a result from acoustic activity, and the density of porpoises (Brandt et al., 2016; Kyhn et al., 2008; Kyhn & Tougaard, 2009). Specific scaling factors would be needed to convert PAM data into absolute densities of animals over a given area and time period. Estimating such multipliers constitutes a complex and challenging analytical problem that has been approached through tracking individual animals in the proximity of PAM devices (Kyhn et al., 2012a; 2012b; Tougaard, 2008; Thomas & Marques, 2012; Marques et al., 2013). Tougaard (2008) converted 2.7 detection positive minutes per hour in a T-POD type PAM device into a density estimate of 0.69 porpoises/km². A more pragmatic way to provide an empirical estimate of absolute density from PAM data would be to correlate density estimates from aerial line transect surveys to PAM data (Haelters et al., 2013).

The results of the PAM at Oostdyck W and MOW1 are consistent with the results of aerial surveys (Haelters et al., 2013; 2015) and with strandings data (Haelters et al., 2016), both revealing a seasonal pattern, with in general the highest detection rates in late winter and early spring. Strandings also showed a peak in late summer and early autumn, consistent with a peak in PAM detections. However, strandings data are heavily biased due to meteorological conditions and changes in mortality throughout the year. PAM yielded in general higher detection rates at the Oostdyck W location than at MOW1, which would also be consistent with the results of aerial surveys, although the use of a different mooring system might have some influence. Significant year-to year differences in detection rate were apparent in one of the mooring locations; the lowest detection rates in PAM at MOW1 occurred in 2010 and 2015, also the years with the lowest number of stranded animals (Haelters et al., 2016).

Erratic peaks in the detection rate, possibly due to erratic invasions of harbour porpoises in the BPNS, were present. Peaks in harbour porpoise density are probably the consequence of changes in local prey availability in combination with higher density areas nearby (Haelters et al., 2011a; Gilles et al., 2016; Haelters & Geelhoed, 2015), and the fact that only a small part of the distribution area of the North Sea harbour porpoise population is covered in this study (Hammond et al., 2015; ICES, 2014).

15.5. CONCLUSION

For this PAM study, the detection rate was analysed at the locations MOW1 and Oostdyck W. At both locations it showed a peak in late winter - early spring, and a smaller peak in late summer - early autumn. This is consistent with data obtained from aerial surveys and strandings. At MOW1, there were significant differences from year to year.

The research conducted until now should be considered as a trial phase: mooring systems needed to be developed and tested, moorings were not possible at any location, there were only a limited number of locations and no replicates. Issues encountered during this study are, however, considered in the monitoring programme starting in 2016.

In order to avoid different detection rates due to the use of different mooring systems, such systems should be standardised. In general, the number of saturated minutes, leading to time lost, was higher in buoy moored PoDs than in PoDs mounted on tripods. PoDs moored on buoys had a higher loss rate than those mounted on tripods. Therefore, it is advised to use a system that places PoDs at a reference height from the seafloor (eg. at around 1.5 m above the seafloor), by using tripods or weights equipped with an acoustic release and no surface marker buoy. The number and placement of the PoDs should not be at random, but should be chosen as a function of the objectives of the study.

While keeping in mind that there are inherent issues in PAM (as is the case in other cetacean monitoring methods) that cannot be resolved, PAM has demonstrated its potential to add to the information obtained through aerial surveys. Although many difficulties and uncertainties remain, it provides useful data, certainly if combined with data originating from other research. Density estimation from PAM will gain importance in the future. The use of PAM is increasingly popular for short- to long-term (i.e. weeks to years) monitoring of cetaceans, both for basic ecological research and for impact assessment of human activities and will become a standard way of monitoring cetaceans (Marques et al., 2011).

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