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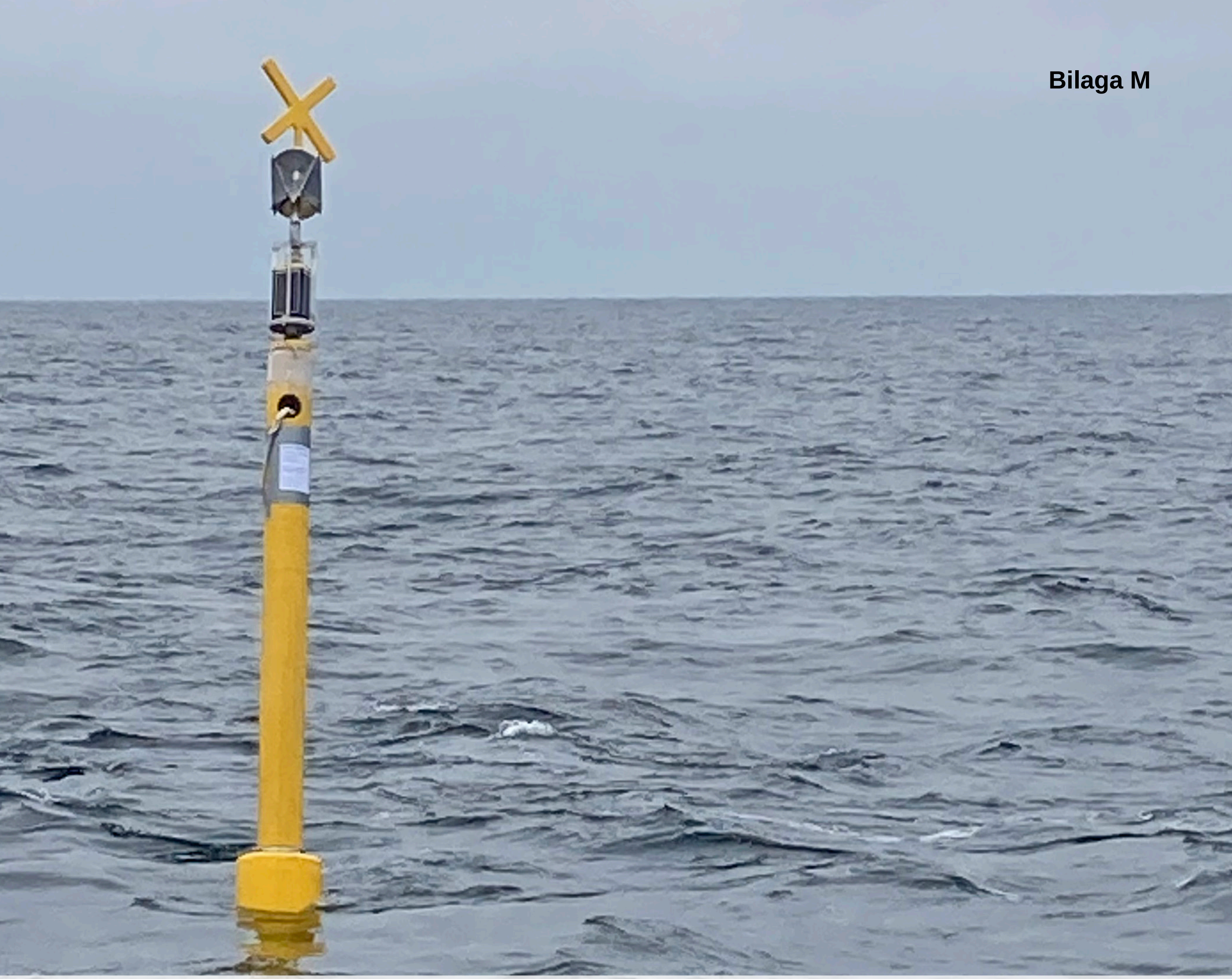

HARBOUR PORPOISE PRESENCE AT KATTEGATT SYD OFFSHORE WIND-FARM SITE FROM MONITORING IN DECEMBER 2020 – DECEMBER 2021

A supplement to the technical report Kattegat Syd Offshore Wind-farm – Effects of pile driving, gravity foundations and sediment spill on marine mammals

Technical Report from DCE – Danish Centre for Environment and Energy No. 234 2022

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Data sheet

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Abstract:	Harbour porpoises were monitored by means of passive acoustic monitoring for one full year at five stations in the potential offshore windfarm Kattegatt Syd. First year's data shows that detection rates in the area is of similar levels as the surrounding areas, as monitored by the Swedish monitoring program, except for the period November through February where the level of porpoise presence is lower. The report is a supplement to the report Kattegat Syd Offshore Windfarm - Effects of pile driving, gravity foundations and sediment spill on marine mammals. The report will be updated following the monitoring in 2022.
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Contents

Preface

The monitoring of harbour porpoises at the potential offshore windfarm site Kattegatt Syd and this report summarizing the first year's results was commissioned by Vattenfall Vind A/B, Sverige. The work was carried out by DCE – Danish Center for Environment and Energy, Aarhus University in the role as a consultant for Vattenfal Vind A/B. The report is a supplement to the technical report *Kattegat Syd Offshore Windfarm -Effects of pile driving, gravity foundations and sediment spill on marine mammals (Kyhn et al., 2021),* wherein all background information and earlier data can be found along with assessments of impact on marine mammals. This report and recommendations herein does not replace the assessements and recommendations in the above mentioned report.

This report contains a description of the temporal presence of harbour porpoises at Kattegatt Syd offshore windfarm (OWF) as recorded over one year (December 2020 - December 2021) and the variation is reported as porpoise presence over monthly and diurnal time-scales. This is relevant with respect to timing of the construction of an offshore windfarm.

Vattenfall Vind A/B was given the opportunity to comment on a draft version of this report. The comments received were all in the form of wishes for justification of statements, not questioning assessments or conclusions, which remains the responsibility of the authors.

Sammenfatning

Marsvin er almindeligt forekommende i det sydlige Kattegat og tilhører Bælthavspopulationen som er listet som *Livskraftig* (LC) på de nationale rødlister i Sverige og Danmark. For at undersøge tilstedeværelsen af marsvin og i hvilken grad marsvin i området vil blive forstyrret af etablering af en vindmøllepark i det udpegede område, under både konstruktion og driftsfase blev der udført passiv akustisk monitering (PAM) af marsvin med fem PAM stationer i området i et år fra december 2020 til december 2021. Overvågningen fortsætter i hele 2022.

Resultaterne fra det første år viser, at marsvin er almindelige i området og forekommer ved samme niveauer som ved de nærmeste svenske moniteringsstationer, på nær i månederne november til og med februar, hvor niveauet var meget lavt med et gennemsnit på mellem 25-125 marsvinepositive minutter (PPM) pr. dag pr. station. Det højeste niveau blev fundet i marts-juni og igen i august-september med et gennemsnit på ca. 100 – 450 PPM pr. dag, med individuelle forskelle mellem de forskellige stationer i området.

Summary

Harbour porpoises are common in the southern part of Kattegat and belong to the Belt Sea Population, which is *Least Concern* on the national red lists of both Sweden and Denmark. In order to understand the temporal presence of porpoises in the area of the planned offshore windfarm and to understand when they would be most disturbed by the construction, passive acoustic monitoring (PAM) of harbour porpoises was conducted at the potential OWF site with five PAM stations in the area for a full year from December 2020 to December 2021. The monitoring continues throughout 2022.

Data from the first years' monitoring shows that porpoises are common in the area and at levels corresponding to the Swedish national monitoring at the nearest monitoring stations. Lowest level of presence was between November and February with an average of app. 25-125 porpoise positive minutes (PPM) per day per station. The highest level of presence was found in March – May and again in August-October with an average of about 100 – 450 PPM per day, with differences between the different stations in the area.

1 Background

Vattenfall Vind A/B proposes establishing an offshore wind farm between Lilla Middelgrund and Stora Middelgrund in Swedish Kattegat (Figure 1.1). The OWF site is called Kattegatt Syd. This report provides information on the monthly and diurnal pattern of porpoise presence in the area as found by one year of passive acustic monitoring in the area. All background information pertaining to harbor porpoises and the windfarm, including assessment of disturbance effects, can be found in the report *Kattegat Syd Offshore Windfarm -Effects of pile driving, gravity foundations and sediment spill on marine mammals* (Kyhn et al., 2021).

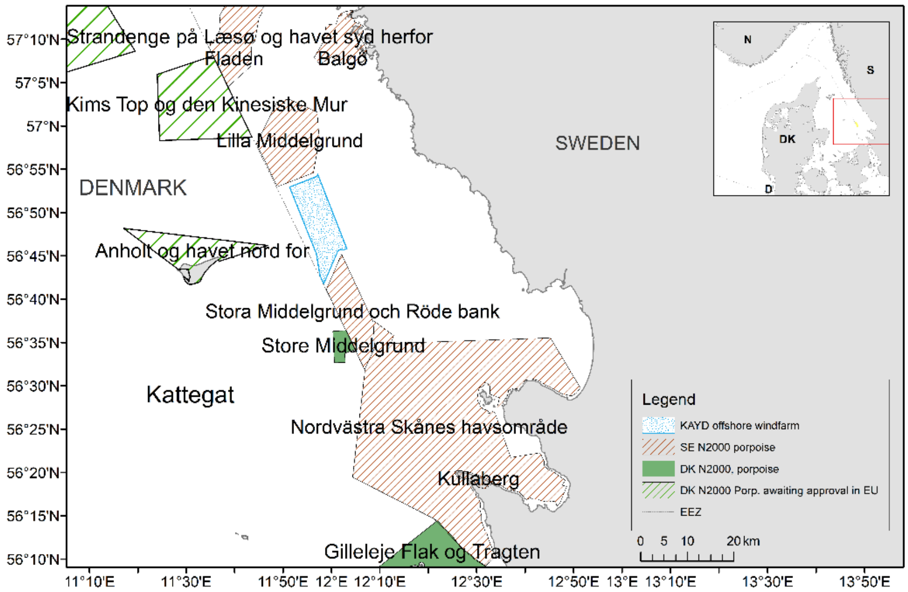


Figure 1.1. Map of Swedish and Danish Natura 2000 sites appointed for harbour porpoises in southern Kattegat. Another two Natura 2000 sites have been appointed in Denmark for harbour porpoises, but are awaiting approval by the EU. The proposed offshore wind farm site is shown with blue.

1.1 Harbour porpoises in Kattegat

The harbour porpoise is the most common cetacean and is present throughout Kattegat. It is listed in Annex II and IV of the EU Habitats Directive (92/43/EEC), Annex II of the Bern convention, Annex II of the Bonn convention and Annex II of the Convention on the International Trade in Endangered Species (CITES). Furthermore, it is included in descriptor 1 “Biodiversity” of the Marine Framework Strategy Directive (European Commission, 2008/56/EY) aiming for a good environmental status. Harbour porpoises are also covered by the terms of the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS, a regional agreement under the Bonn Convention) and by HELCOM (The Helsinki Commission; protection of the marine environment of the Baltic Sea from all sources of pollution). The EU Habitats Directive requires habitat protection for a range of habitat types and species listed in Annexes I and II respectively, and strict protection for a range of species listed in Annex IV. The harbour porpoise is listed in both Annex II and IV, which means that it is protected throughout its range, as well as with additional protection within special areas of conservation that has been designated for harbour porpoises (Natura 2000 sites).

There are three different populations of harbour porpoises inhabiting Swedish Waters: The North Sea, Belt Sea and Baltic Proper population (Galatius et al., 2012; Wiemann et al., 2010). Management areas have been suggested for the Belt Sea population (Sveegaard et al., 2015) and the Baltic Proper population (Carlén et al., 2018) (**Figure 1.2**). The porpoises inhabiting the southern Kattegat, relevant to the proposed Kattegatt Syd OWF, belongs to the Belt Sea Population. The management area of the Belt Sea population includes the Belt Sea, the Sound, southern Kattegat and the western Baltic Sea. The abundance of the Belt Sea population has been estimated in 1994, 2005, 2012, 2016 and 2020 (Unger et al., 2021). The latest survey in 2020 estimated 17,301 harbour porpoises (95% CI = 11,695-25,688; CV = 0.20), with an average density of 0.41 individuals / km^2 (95% CI = 0.28-0.61). The densities of the population have varied over the years, with the 2005 and the 2020 estimates as the lowest (Unger et al., 2021). The national red list status of the Belt Sea population of harbour porpoises is Least Concern (LC) in both Sweden and Denmark.

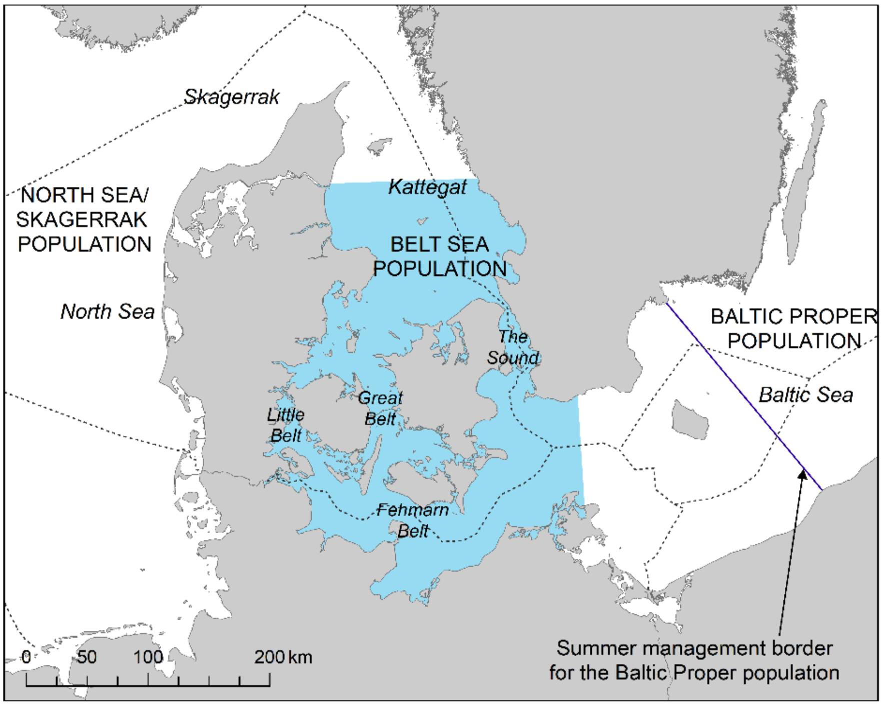


Figure 1.2. Map of management areas for the three populations of harbour porpoises. The North Sea population (white) overlaps with the Belt Seas population (blue) in southern Kattegat.

The density of porpoises varies within the Belt Sea population area (Sveegaard et al., 2011) and protected Special Areas of Conservation (or Natura 2000 sites) have been designated in high density areas. Within Swedish Waters there are three Natura 2000 sites appointed for harbour porpoises close to the Kattegatt Syd OWF; to the north, Lilla Middelgrund (SE0510126) of 17840.2 ha and to the south, Stora Middelgrund & Röda Bank (SE0510186) with a combined area of 11,410 ha. Further to the southeast, there is another large area ‘Nordvästra Skånes havsområde’ (SE0420360) of 134,240.8 ha also appointed for harbour porpoises (Figure 1.1). In Danish waters, the Natura 2000 site Store Middelgrund (No. DK00VA250) comprises a 2,094 ha area. Other new Danish Natura 2000 sites have been appointed for harbour porpoises west of the wind farm area: Kims Top & the Chinese Wall and Anholt (see **Figure 1.1**). However, these are waiting for approval by the EU.

1.2 Monitoring of harbour porpoises in the potential offshore windfarm Kattegatt Syd

In order to be informed on the use of the OWF site for harbour porpoises and to obtain data on temporal monthly pattern of presence of porpoises in the potential OWF Kattegatt Syd, Vattenfall Vind A/B decided to conduct a monitoring study to inform the EIA. The collected data were to be compared with data from the Swedish monitoring to get an impression of the importance of the area for harbour porpoises with respect to the nearby Natura 2000 sites. Because the monitoring data also provides data on the monthly pattern of presence in the area, the data are also relevant for finding the period where the fewest porpoises will be affected in the area in order to provide information for assessing the principle of *Best Environmental Practice*. This will be assessed when data from the second year of monitoring is available.

2 Methods

Harbour porpoises emit characteristic and distinct high frequency narrow band clicks during echolocation and communication (Kyhn et al., 2013; Møhl and Andersen, 1973), which no other living being in the Belt Sea region emits. Moreover, porpoises emit clicks almost constantly (Wisniewska et al., 2016) and they are therefore ideal to study via passive acoustic monitoring (PAM) (Kyhn, 2010). In PAM acoustic dataloggers are deployed to detect and record clicks and noise from the surroundings. For this study, the CPOD (Chelonia Ltd.) was chosen as it is used in both the Swedish and Danish monitoring of harbour porpoises, which makes comparisons straight forward.

The Kattegatt Syd OWF site is comparable in size to the Danish Natura 2000 sites, where five stations has proven to be enough to statistically establish differences between monitoring years. For this study, the aim was to find differences between months, and because the expected level of porpoise activity was likely to be similar to the other areas of the Belt Sea population, five stations were deemed sufficient to analyse for variation between months of a full year. The positions of the PAM stations were chosen randomly in a specific grid with respect to environmental parameters influencing porpoise presence. This approach was chosen in order not to bias the data collection, but to get the actual level of presence in the area. The distribution of dataloggers is shown in **Figure 2.1**.

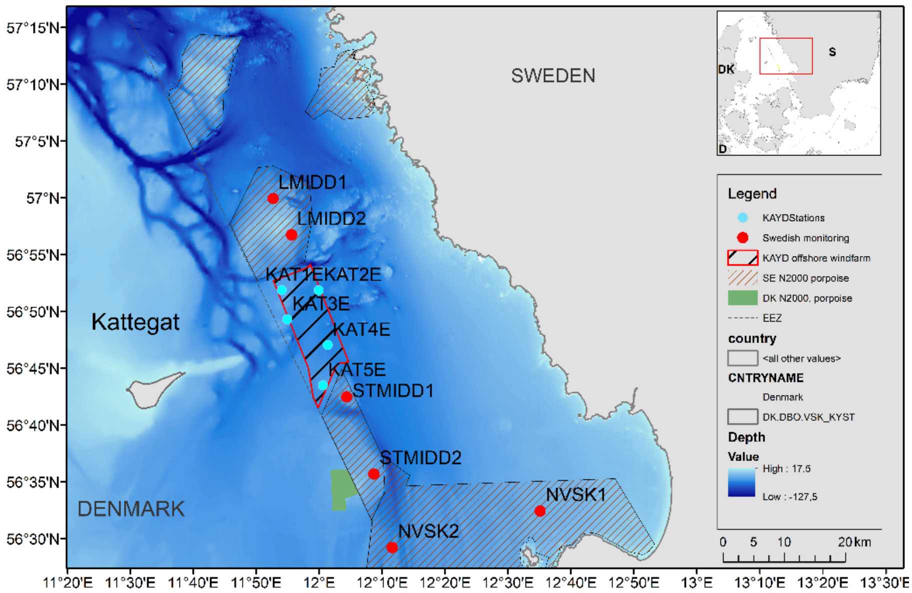


Figure 2.1. Position of monitoring PAM stations in the Kattegatt Syd OWF. Also, Swedish monitoring stations are shown in red.

The CPODs were new and factory calibrated prior to the fieldwork. This makes it possible to compare data from the different stations directly and to move individual CPODs among the five stations during servicing. If a CPOD was trawled, it was not reused in the study before it had been re-calibrated, as their sensitivity may be affected by the rather brutal treatment during trawling and later stranding. Only units living up to the the factory standard were used in the study.

The CPODs were deployed using an acoustic releaser (Sub Sea Sonics AR-60, type, San Diego) attached to two hessian bags filled with stones as an anchor. Upon an acoustic signal send through a hydrophone submerged from the service vessel, two iron links melt via electrolytic erosion, and the releaser and CPOD float to the surface, where they are caught from the vessel. Two trawl floats are attached above the CPOD to ensure positive buoyancy and hence flotation in case the station is trawled.

As protection against trawling, a large surface buoy was placed next to each PAM station within some 50 meters. Permission for deployment of the buoys were obtained from the Swedish authorities.

The service vessel was *R/V Aurora* owned by Aarhus University or *Skoven*, privately owned and used only for the last service trip. Permission to sail within 12 nm of the Swedish coast was obtained from the Swedish authorities.

2.1 Data analysis

The CPOD stores so called CP1 files, which is analysed in the custom made software CPOD.exe v 2.044 (Chelonia Ltd., 29th July 2014). With this software so called CP3 files were extracted with the Kerno classifier (unpublished algorithm) to find click trains. Click trains are grouped into narrow band high frequency origin, e.g. harbour porpoises, dolphins or boat sonars. For each origin category, click trains are categorised into either '*high*', '*medium*' or '*low*' probability of arriving from the stated source. For this study only narrow band high frequency click trains were selected and only when categorized with a *high* or *moderate* probability of arriving from a narrow band high frequency species. This is the same methodology as used in the Swedish and Danish monitoring of harbour porpoises. Since the harbour porpoise is the only species emitting this click types in the Baltic region, it is safe to assume that the narrow band high frequency click trains in the CP3 files arrived from harbour porpoises. The Swedish and Danish monitoring data is further analysed with an extra algorithm (Hel1) that was developed for extreme low density areas such as the Baltic Proper, with which this monitoring data is compared. Hel1 reduces the likelihood of false positives. This is important in areas of very low density area, sich as the Baltcic Proper. In high density areas, such as Kattegat and the Danish Straits there is hardly any difference in data analysed with the Hel1 classifier or only with the Kerno classifier. In a test dataset from this study at Kattegatt Syd OWF, the Hel1 classifier removed app. 0.16% of the minutes with harbour porpoise clicks, which means that it has no effect when analysed on a daily basis. The data from Kattegatt Syd are thus fully comparable to Swedish and Danish monitoring data.

Following extraction of the click trains from harbour porpoises in the high and moderate categories, number of minutes with these click trains were exported from CPOD. exe on an hourly basis. The unit *detection positive minutes (DPM) per hour* was then analysed in R to obtain daily and monthly patterns of porpoise presence at the five stations.

2.2 Statistical analysis

Data collected by the five PAM stations were analysed using Generalized Additive Mixed Models (GAMMs). DPM per hour was fitted as the response variable using a log function (Poisson family). Hour and month were fitted as fixed effects as well as interactive smooting terms to assess diurnal variation in porpoise presence for each month of the year. Here we used a cyclic cubic regression spline to ensure that DPMs at hour 01:00 matched with hour 00:00. Month was also fitted as a random variable to account for unbalanced data over time. A separate model was constructed for each listening station to avoid any spatial autocorrelation in the data and to avoid use of overly complex models with 3 way interactions. Temporal autocorrelation in the data was incorporated by fitting a continuous time covariate autocorrelation structure of order 1 (corCAR1) using hour as the time covariate and julian day as grouping variable.

3 Results

3.1 Servicing and data loss

Error! Reference source not found.(Figure 3.1). Later on, the borders of the OWF moved to have a 1 km distance to the nearest Natura 2000 sites, which is why the new stations are placed on the boarder of the OWF. On second servicing on 11th April 2021, three PAM units were gone along with two surface buoys. Hereafter, all stations were in place at servicings, however at the last servicing 30th December 2021, one CPOD had not recorded.

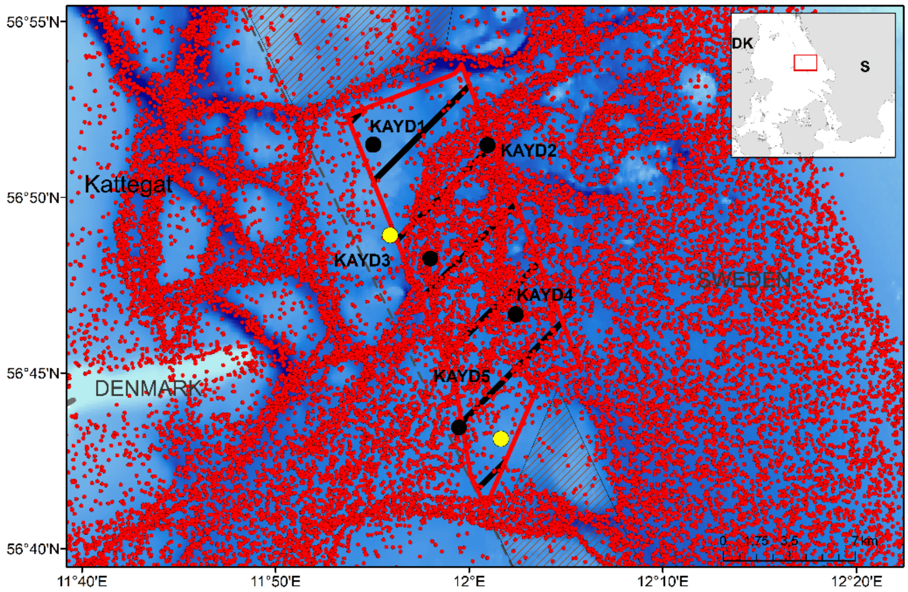


Figure 3.1. Station KAYD3 and KAYD5 were moved as they were trawled during the first two deployments. Original stations are in black and moved stations are in yellow. See inside the blue circles. The red dots are VMS data from 2020 signifying trawling.

All the lost PAM units were eventually recovered and data could be retrieved. Trawling events are clear from the data analysis as the angle of the CPOD changes markedly along with an immense increase in and saturation of background noise (Figure 3.2). Data are cut, so that only entire days are included in the statistical analysis. For example, on the day of deployment on 1st December, only data from 2nd December at 00:01 onwards is used. The same for the date of retrieval on 30th December, only data from 29th December until 00:00 is included. The same goes for trawling events. This means that a full day per servicing is lost as well as the days following trawling

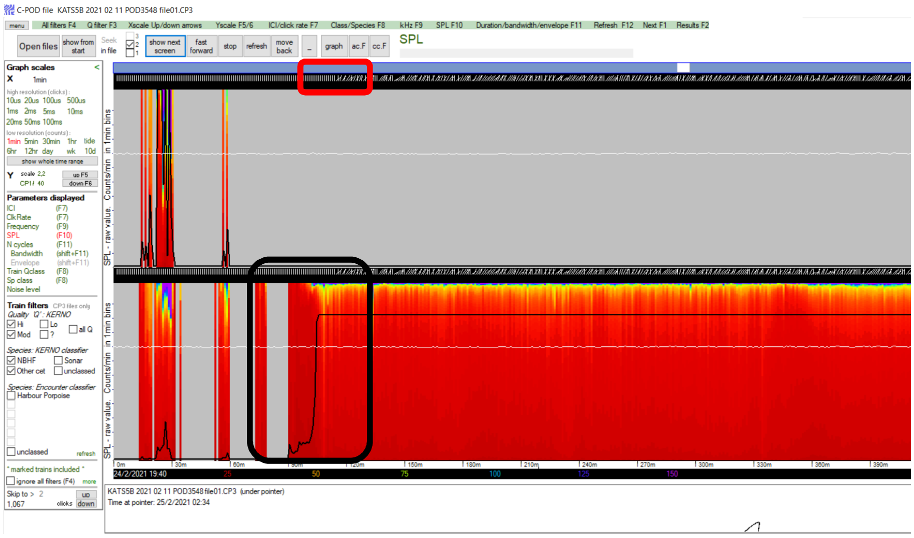


Figure 3.2. Example of a CPOD that has been trawled. Deployment KAYD 2B. Notice how the background noise increases and saturates (red colour in lower graph inside the black rectangle) along with a change in angle (red rectangle in upper graph).

3.2 Data

A summary of the covered periods is shown in Figure 3.3. One day of data is lost for each day of deployment / retrieval, i.e. one day per deployment period, unless the PAM station was trawled, in which case it was more days. Also two deployment periods KAYD1A and KAYD5F contained no data as the deployed CPODs malfunctioned.

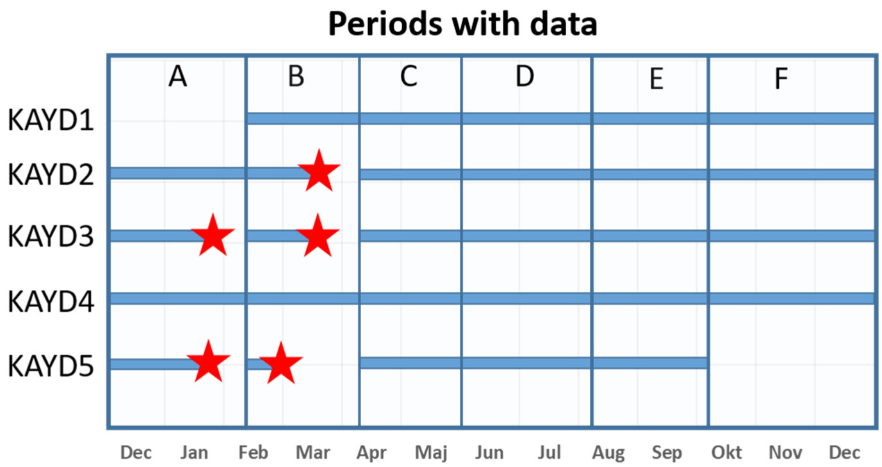


Figure 3.3. Periods with data from the first year of data collection (2021). The PAM stations were trawled multiple times causing loss of data as shown with the empty periods following red stars. During the first deployment at station KAYD1 and the last deployment at station KAYD5, the CPOD malfunctioned and resulted in data loss. The day of deployment/retrieval is omitted from the analysis. The deployment periods are signified by the letters A-F.

3.3 Diurnal and monthly patterns in presence

Detection positive minutes (DPM) per hour were analysed to examine daily pattern in presence across the months of the year at the five PAM stations in Kattegatt Syd OWF. The results are shown in Figure 3.4 and the statistical results of the GAMMs model is shown in appendix 1 in Table . Two things are evident from the figure: First, the highest level of presence or echolocation activity is during the dark hours, except at KAYD5, where the highest level is during daytime in April, May, June, August, September and October, which is unusual. Secondly, it is clear that the winter months (November through February) show the lowest level of porpoise presence at all five stations. This is also shown in Figure 3.5 where mean numbers of DPM per month are shown for the five stations. Here, the monthly pattern in presence is more clear with a minimum during November to February. There is also a low in presence in June-July, but not as low as in winter.

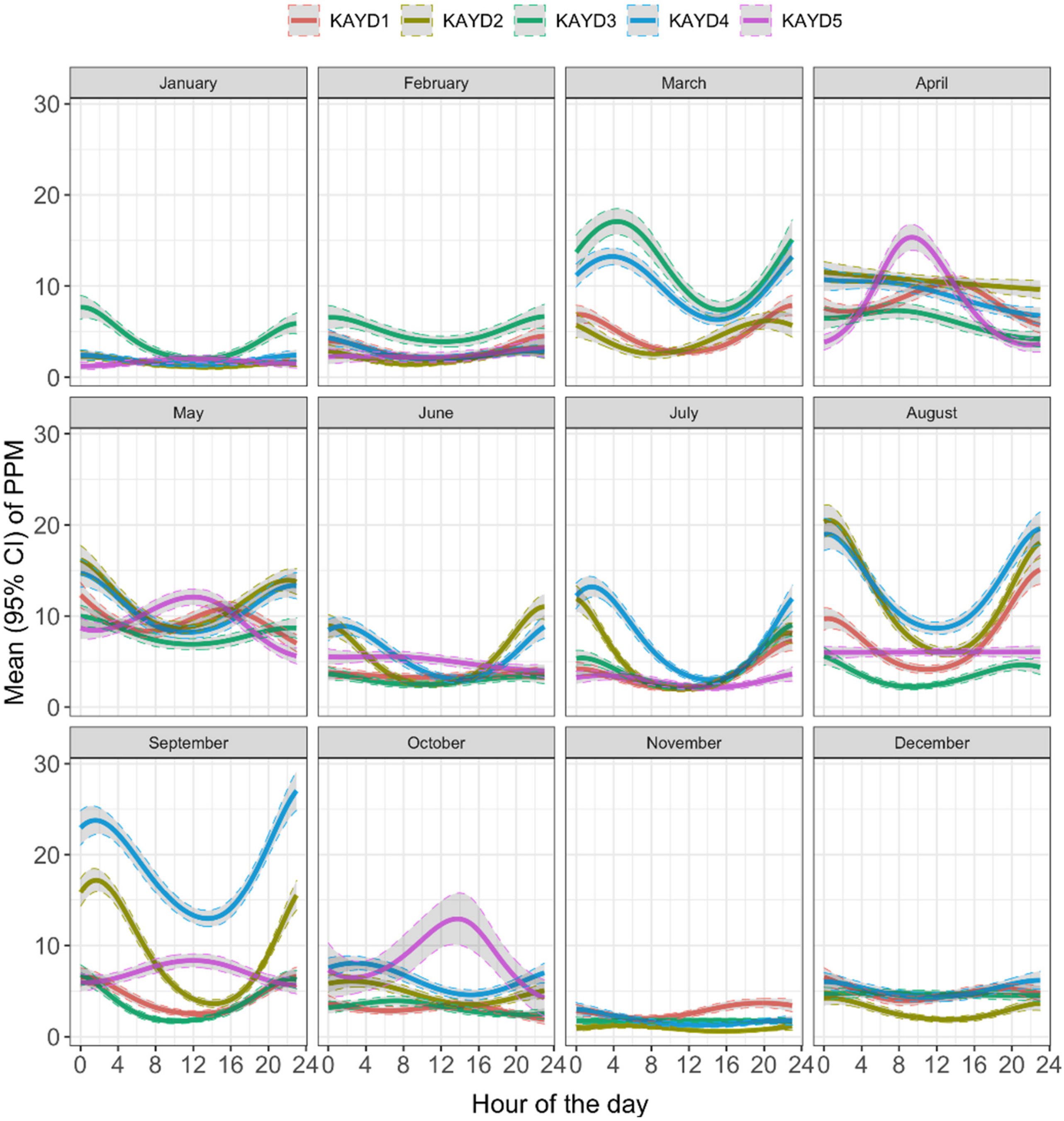


Figure 3.4. Diurnal and monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF. The y-axis shows mean number of detection positive minutes per hour as a function of time of the day (x-axis) across the twelve months of monitoring. Note that station KAYD3 and KAYD5 was moved to more trawl-safe locations on 11th April 2021.

Figure 3.5. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF. The y-axis shows mean number of detection positive minutes per day per station as a function of month (x-axis) across the twelve months of monitoring.

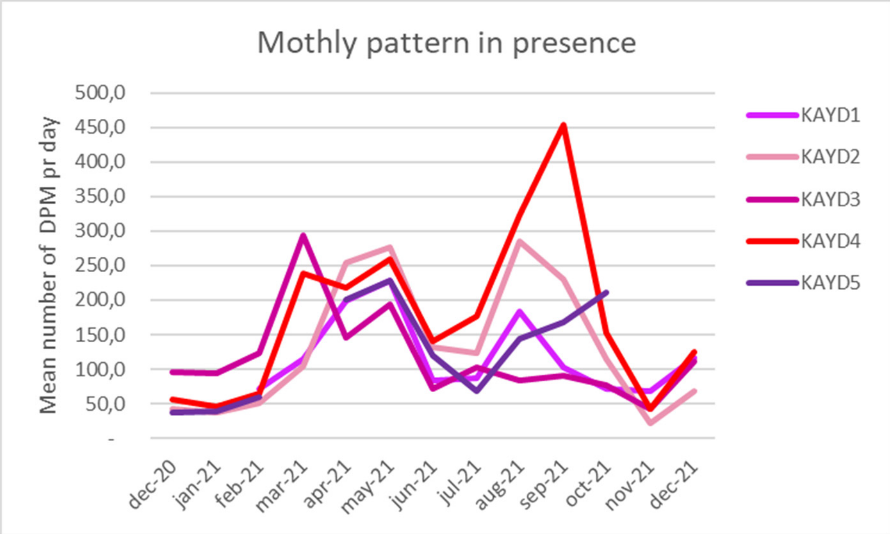
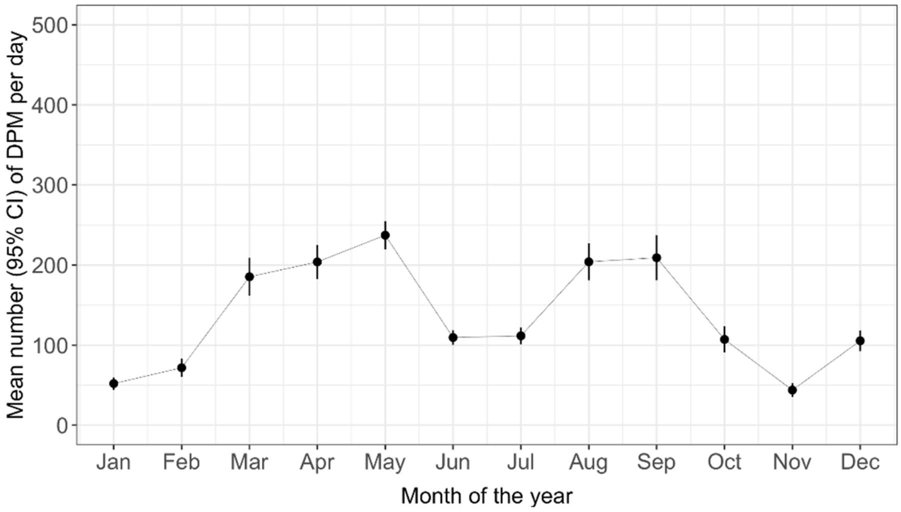


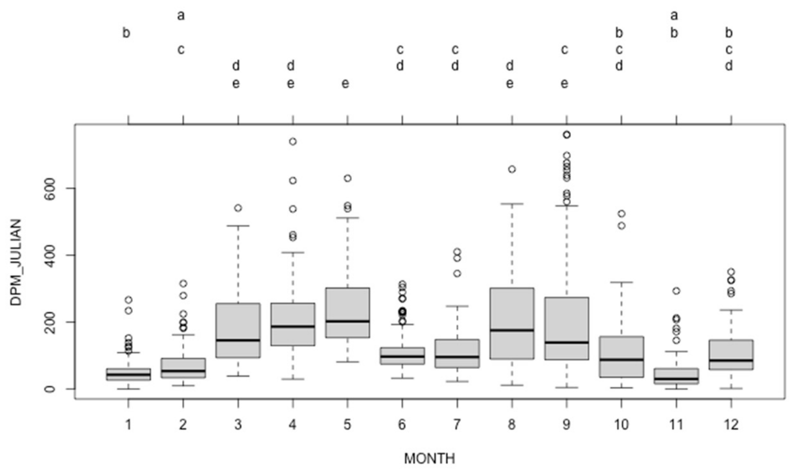
Figure 3.6 show mean DPM per hour across the five monitoring stations for each months through the year. For each monthly mean, the 95 % confidence interval is shown.

Figure 3.6. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF calculated as means (95%CI) of DPM per months across the five stations. This figure is therefore not directly comparable to figure 4.5 above..



The combined analyses of the passive acoustic monitoring data at hourly and monthly scales (Figure 3.4, Figure 3.6, Figure 3.7 and stats in appendix 1) suggests that porpoise presence in the area was highest between March-September with a temporary decline during the summer months: Jun-Jul. Porpoise presence appeared to be lowest in Jan-Feb and Nov, while porpoise presence during October and December were of similar levels as recorded during Jun-Jul.. A simultaneous monitoring study in the same area was conducted for a different potential windfarm, namely Galatea (OX2 AB) by AquaBiota. The data was collected at four stations inside an area a little larger than Kattegat Syd OWF and directly bordering the two nearby Natura 2000 sites. The data was collected from August 2020 to September 2021 and showed monthly means in DPM across the four stations (Stensland et al., 2021). The monthly level in detections was lower than in this study but with a similar peak in March, however with lower levels in August-September and the level during winter was not as low. Bare in mind that the overlap began in December, so the period August-November was not overlapping in 2020.

Figure 3.7. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF. The plot shows mean number of detection positive minutes per day per month across all stations. The box contains 50% of DPM. The box and whiskers are 95% of the DPM. The individual dots is the remaining 5% of DPM. The letters on top signify whether months are statistically similar (0.05 level) or different. Months with the same letter are statistically similar. January, February, November are significantly lower than the rest of the year.



In order to examine whether Kattegatt Syd is an area of higher or lower importance for harbour porpoises in Kattegat, data from this study was also compared to Swedish monitoring data from the nearest stations, i.e. the PAM stations at Stora Middelgrund, Lilla Middelgrund and in the Nordvästra Skånes Havsområde, station 1-4. The location of these stations are shown in Figure 2.1. Swedish monitoring data is made available by Havs- och vattenmyndigheten och SMHI, and can be downloaded and used free of charge from a webpage (https://sharkweb.smhi.se/hamta-data/) even for commercial use as in this study. Unfortunately, there was no data available from 2021 at the time of writing this report, so data was compared to the previous year in Figure 3.8.

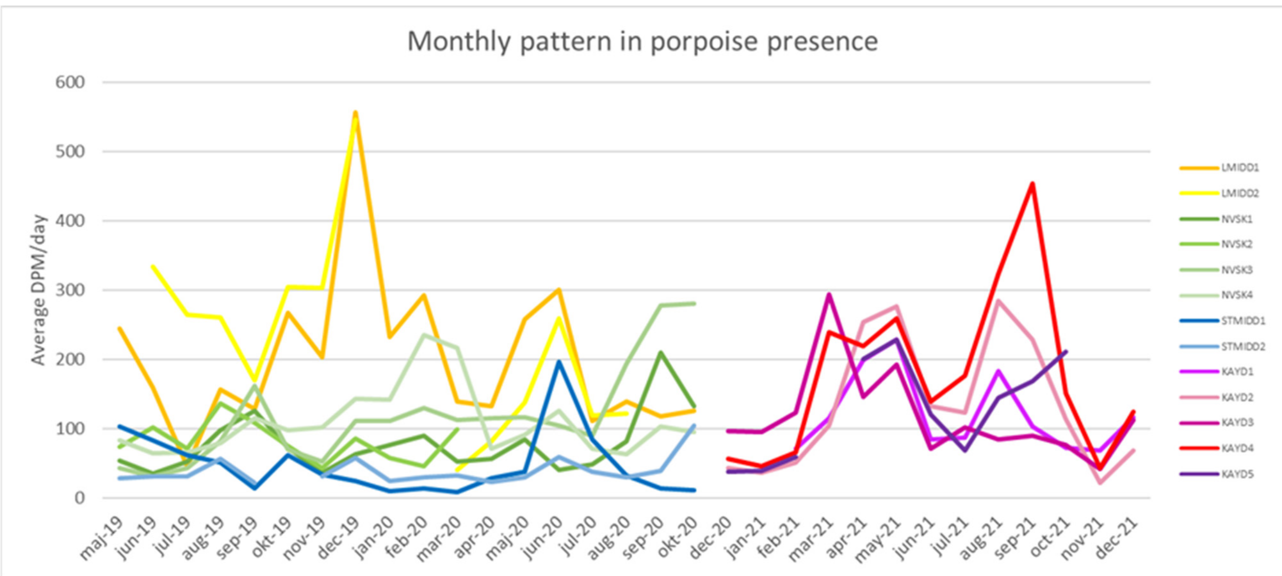


Figure 3.8. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF in 2021 compared with the eight closest Swedish monitoring stations in 2020. **Yellow colours signify Lilla Middalgrund**. **Blue colours signify Stora Middelgrund and Röda Bank**. **Green colours signify Nordvästra Skånes Havsområde.** **Red colours signify Kattegatt Syd monitoring**. The Swedish data is available from Havs- och vattenmyndigheten och SMHI at Sharkweb free of charge**.**

Comparing the 2020 data with the 2021 data (Figure 3.7), there is some similarity in the patterns between the two monitoring years in the different areas, except for the Lilla Middelgrund stations (yellow colours). It is striking, that the periods of least porpoise activity at Kattegatt Syd (November through February) was the periods of highest porpoise activity at Lilla Middelgrund the previous year, with a rather high level of DPM. Except for the two stations at Lilla Middelgrund, there is consistency in the winter months being of lowest porpoise activity in the area. Future Swedish monitoring data, as well as data from Kattegatt Syd from 2022 will show whether this is a general trend.

4 Discussion

4.1 Data loss

The period from late winter to spring, where the PAM stations were lost, coincides with the period of bottom trawling for lobsters. After this period, no stations were lost. It is unfortunately expected, that PAM stations will be lost again in the lobster season 2022 despite that all stations are clearly marked with a large surface buoy, as well as the position of each of the five buoys have the required permits and have been informed by the Swedish authorities to the fishery community.

4.2 Porpoise activity level at Kattegatt Syd OWF

The levels of porpoise presence in the Kattegatt Syd OWF, measured as average DPM per day per month across all stations at Kattegatt Syd, is a little higher than at the surrounding stations, except for the Natura 2000 site Lilla Middelgrund at both its two monitoring stations (Figure 3.). At the southern Natura 2000 site Stora Middelgrund and Röda Bank there is only one station with a similar high level and only in September-October (Figure 3.7). As discussed in the results' section above, OX2 AB, conducted a similar monitoring study in the same area, which they call Galatea (Stensland et al., 2021). The study overlapped in time from December 2020 to September 2021. The data was collected with the same methodology, however the Galatea CPOD positions were deliberately chosen to be on hard-bottom substrate, whereas this study chose CPOD positions following a fixed grid in order for the data to be sampled at random with respect to various environmental drivers, which may bias the data. The level of detections at Galatea is lower than in this study, which suggest that the hard-bottom substrate is not preferred by porpoises or their prey and that they unintentionally have biased their data negatively.

4.3 Seasonal pattern of presence

Harbour porpoises move around throughout the year and their temporal presence and abundance is important to consider in relation to establishment of offshore wind farms in order to disturb as few individuals as possible. Following the principle of *Best Environmental Practice*, application of the most appropriate combination of environmental control measures and strategies must be considered when disturbing the environment (OSPAR Convention). One leg in this is minimizing the disturbance of harbour porpoises, but many other aspects must be considered as well. Considering harbour porpoises alone, this means that construction of the OWF should be carried out at the time of the year when the fewest animals will be disturbed and / or when the effect will be lowest. The 'fewest animals disturbed' can be achieved in two ways: 1) at the time of the year where sound propagation properties are least favourable for long-range transmission in order to disturb as small an area as possible and thereby as few animals as possible, and / or 2) when naturally the fewest porpoises are present in the disturbed area. The impact on the animals will be lowest in the period where the affected animals are least sensitive. The impact on the porpoise population in the OWF following Best Available Technology (BAT) was assessed as minor (Kyhn et al., 2021) and adding a layer of mitigation in terms of BEP is therefore unlikely to further reduce the assessment for porpoises, and it may be deemed that other environmental aspects will be more important than lowering the effect on porpoises in order to live up to the BEP principle. Nevertheless, this aspect is considered in the following.

At Kattegatt Syd OWF data from the first year of monitoring show that the period with the fewest animals present could be from November until February (**Figure 3 - Figure 3.7**), where the level of detection positive minutes (DPM) is lowest. A seasonal pattern can only be obtained with several years of data. Stensland et al. (2021) however also found a decline in porpoise presence during winter months, and a surge in March. Stensland et al. (2021) did not show confidence intervals and it is thus unclear what the varation was between their different stations per month, and they conclude that there is no clear seasonal pattern in their data. Where Stensland et al., 2021 only saw a high with on average more than 200 DPM / day / month in March, we found levels above 200 DPM / day / month in March, April, May, August and September, which lends weight to a negative bias in their data. The general pattern for the area covered by both monitoring studies thus, was lowest porpoise activity in the winter months, however with a Summer low in June-July. The overall highest level of presence in the surrounding area was found at the Lilla Middelgrund stations, just north of Kattegatt Syd OWF, with up to 550 DPM / day / month in December 2019 (**Figure 3.7**). In contrast, the first year's data from this study show that the periods March through May and August through September on average had highest levels of DPM. The present data is therefore contradictory when it comes to seasonal presence since the levels in December 2019 at Lilla Middelgrund saw highest levels of presence and just south of here in Kattegat Syd OWF had lowest levels of presence in December 2020 and 2021. This further suggest that more data is needed to assess sesonal patterns in the area.

Data from the second year of monitoring at Kattegatt Syd OWF will hopefully provide an impression of the level of annual variation. When this report is updated in January 2023 it is also expected that more data will be available from the Swedish monitoring program which will also inform on the annunal presence of porpoises in the surrounding area.

The observed period with the fewest porpoises present at the Kattegatt Syd OWF in 2021 for this study was in November-February and this is also the time of year where sound propagation properties are most favourable for long-range transmission, as was evident in the sound modelling performed for the Environmental Impact Assessment (EIA) conducted for the Kattegatt Syd offshore windfarm (Kyhn et al., 2021). In the EIA, the Summer period was therefore recommended as construction period, as fewest porpoises was expected to be affected due to shorter noise transmission distances, and since porpoises are evaluated as being equally sensitive all year. In the EIA, noise propagation for construction of the windfarm by piling was modelled with use of Best Available Technology (BAT) noise abatement with Double Big Bubble Curtains and Hydrosound Dampeners. The difference between worst case (December) and best case (July) was a factor 4 in area. The question then is: If winter turns out to be the period with the fewest porpoises present, will construction in the winter period then result in more porpoises being affected than during the summer period, because noise spreads to four times the area? Since the data obtained with PAM only provides a relative estimate of abundance, it is not possible to calculate the difference in number of affected animals. However, it can be approximated by differences in number of DPM per day / month for the summer and winter periods. Since the construction period is deemed to last up to six months it is relevant to evaluate across seasons, Winter and Summer. The sound propagation changes within each season, which makes the approach imprecise. Since we only have one year of data, and therefore don't know whether there is a general pattern in presence or not, we will examine which period would be best for construction according to BEP following the data collection in 2022.

5 Conclusion

The presence and activity level of harbour porpoises in the Kattegat Syd OWF was monitored during 13 months (Dec 2020 – Dec 2021) with five PAM stations.

The monthly pattern in presence shows that porpoises had the highest level of presence in the Kattegat Syd OWF in the periods March through May and August through September.

The level of presence in the Kattegat Syd OWF is similar to the surrounding areas as measured by the Swedish PAM monitoring program, except for the period November through February, where the level is lower.

The diurnal pattern in the Kattegat Syd OWF shows that porpoises are more active in the dark hours, except at one station.

Combining monthly pattern in presence measured as average DPM across all five stations with the results of the bi-seasonal modelling of piling noise propagation performed by Niras for the EIA (Kyhn et al., 2021), can be used to examine which season would disturb the fewest porpoises during construction of the OWF with respect to Best Environmental Practice. This will be done following data collection in 2022.

The monitoring at Kattegatt Syd is continued throughout 2022, following which, this report will be updated.

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Appendix 1

Table A.1. Output of the statistical analysis performed with Generalized Additive Mixed Models (GAMMs). For each station diurnal and monthly patterns were compared using Detection Positive Minutes (DPM). A p-value less than 0.001 signifies that the hour or month is significantly different from the other hours/months.

Station	Parameter	Estimate	Std. Error	t value	p-value
KAYD1	(Intercept)	0,977	0,078	12,49	<0.001
	HOUR	0,006	0,006	1,017	0,309
	MONTH3	0,454	0,090	5,022	0,000
	MONTH4	1,264	0,089	14,232	<0.001
	MONTH5	1,546	0,086	18,068	<0.001
	MONTH6	0,286	0,096	2,983	0,003
	MONTH7	-0,047	0,095	-0,492	0,623
	MONTH8	0,747	0,087	8,627	<0.001
	MONTH9	0,416	0,092	4,526	<0.001
	MONTH10	0,456	0,101	4,531	<0.001
	MONTH11	-0,052	0,102	-0,51	<0.001
	MONTH12	0,750	0,092	8,164	<0.001
	Smoothing term	**edf**	**Ref.df**	**F**	**p-value**
	s(HOUR):MONTH2	1,908	2	30,741	<0.001
	s(HOUR):MONTH3	1,978	2	135,44	<0.001
	s(HOUR):MONTH4	1,952	2	50,668	<0.001
	s(HOUR):MONTH5	1,957	2	34,266	<0.001
	s(HOUR):MONTH6	1,35	2	2,737	0,018
	s(HOUR):MONTH7	1,971	2	99,115	<0.001
	s(HOUR):MONTH8	1,988	2	244,068	<0.001
	s(HOUR):MONTH9	1,975	2	112,728	<0.001
	s(HOUR):MONTH10	1,869	2	12,236	<0.001
	s(HOUR):MONTH11	1,881	2	13,895	<0.001
	s(HOUR):MONTH12	1,902	2	21,269	<0.001

Station	Parameter	Estimate	Std. Error	t value	p-value
KAYD2	(Intercept)	0,559	0,079	7,034	<0.001
	HOUR	-0,014	0,006	-2,219	0,03
	MONTH2	0,198	0,108	1,834	0,07
	MONTH3	0,860	0,106	8,127	<0.001
	MONTH4	1,885	0,086	21,823	<0.001
	MONTH5	1,954	0,085	23,046	<0.001
	MONTH6	0,923	0,090	10,256	<0.001
	MONTH7	1,098	0,089	12,273	<0.001
	MONTH8	1,883	0,084	22,292	<0.001
	MONTH9	1,555	0,086	18,071	<0.001
	MONTH10	1,051	0,093	11,28	<0.001
	MONTH11	-0,780	0,139	-5,629	<0.001
	MONTH12	0,522	0,100	5,223	<0.001

Smoothing term	edf	Ref.df	F	p-value
s(HOUR):MONTH1	1,82	2	14,61	<0.001
s(HOUR):MONTH2	1,91	2	25,17	<0.001
s(HOUR):MONTH3	1,94	2	35,62	<0.001
s(HOUR):MONTH4	0,00	2	0	0,696
s(HOUR):MONTH5	1,97	2	108	<0.001
s(HOUR):MONTH6	1,99	2	271,83	<0.001
s(HOUR):MONTH7	1,99	2	344,55	<0.001
s(HOUR):MONTH8	1,99	2	418,28	<0.001
s(HOUR):MONTH9	2,00	2	447,02	<0.001
s(HOUR):MONTH10	1,91	2	21,4	<0.001
s(HOUR):MONTH11	1,86	2	10,75	<0.001
s(HOUR):MONTH12	1,94	2	42,46	<0.001

Station	Parameter	Estimate	Std. Error	t value	p-value
KAYD3	(Intercept)	1,436	0,056	25,635	<0.001
	HOUR	-0,011	0,004	-2,748	0,006
	MONTH2	0,177	0,083	2,146	0,032
	MONTH3	0,979	0,071	13,885	<0.001
	MONTH4	0,565	0,079	7,143	<0.001
	MONTH5	0,712	0,067	10,635	<0.001
	MONTH6	-0,293	0,082	-3,559	<0.001
	MONTH7	-0,340	0,074	-4,566	<0.001
	MONTH8	-0,083	0,077	-1,082	0,279
	MONTH9	-0,184	0,075	-2,451	0,014
	MONTH10	-0,174	0,084	-2,066	0,039
	MONTH11	-0,851	0,091	-9,393	<0.001
	MONTH12	0,130	0,071	1,822	0,068
	Smoothing term	**edf**	**Ref.df**	**F**	**p-value**
	s(HOUR):MONTH1	1,98	2	113,25	<0.001
	s(HOUR):MONTH2	1,89	2	24,97	<0.001
	s(HOUR):MONTH3	1,98	2	82,17	<0.001
	s(HOUR):MONTH4	1,76	2	10,36	<0.001
	s(HOUR):MONTH5	1,88	2	23,39	<0.001
	s(HOUR):MONTH6	1,78	2	10,48	<0.001
	s(HOUR):MONTH7	1,98	2	156,78	<0.001
	s(HOUR):MONTH8	1,96	2	64,33	<0.001
	s(HOUR):MONTH9	1,98	2	172,64	<0.001
	s(HOUR):MONTH10	1,78	2	8,82	<0.001
	s(HOUR):MONTH11	0,43	2	0,35	0,195
	s(HOUR):MONTH12	0,43	2	0,32	0,223

Station	Parameter	Estimate	Std. Error	t value	p-value
KAYD4	(Intercept)	0,598	0,076	7,858	<0.001
	HOUR	0,000	0,006	0,071	0,943
	MONTH2	0,588	0,101	5,844	<0.001

Station	Parameter	Estimate	Std. Error	t value	p-value
	MONTH3	1,584	0,084	18,940	<0.001
	MONTH4	1,829	0,084	21,691	<0.001
	MONTH5	1,817	0,082	22,043	<0.001
	MONTH6	1,065	0,088	12,100	<0.001
	MONTH7	1,288	0,085	15,171	<0.001
	MONTH8	1,937	0,081	23,832	<0.001
	MONTH9	2,225	0,080	27,795	<0.001
	MONTH10	1,262	0,088	14,371	<0.001
	MONTH11	0,222	0,108	2,062	0,039
	MONTH12	1,024	0,090	11,340	<0.001
	Smoothing term	**edf**	**Ref.df**	**F**	**p-value**
	s(HOUR):MONTH1	1,84	2	16,595	<0.001
	s(HOUR):MONTH2	1,88	2	22,789	<0.001
	s(HOUR):MONTH3	1,99	2	118,699	<0.001
	s(HOUR):MONTH4	1,52	2	4,342	0,004
	s(HOUR):MONTH5	1,97	2	91,025	<0.001
	s(HOUR):MONTH6	1,98	2	142,033	<0.001
	s(HOUR):MONTH7	1,99	2	307,605	<0.001
	s(HOUR):MONTH8	1,99	2	233,953	<0.001
	s(HOUR):MONTH9	1,99	2	219,289	<0.001
	s(HOUR):MONTH10	1,94	2	31,93	<0.001
	s(HOUR):MONTH11	1,84	2	16,529	<0.001
	s(HOUR):MONTH12	1,85	2	17,921	<0.001

Station	Parameter	Estimate	Std. Error	t value	p-value
KAYD5	(Intercept)	0,386	0,106	3,631	<0.001
	HOUR	0,010	0,008	1,220	0,222
	MONTH2	0,317	0,152	2,088	0,037
	MONTH4	1,624	0,126	12,932	<0.001
	MONTH5	2,053	0,114	18,040	<0.001
	MONTH6	1,376	0,117	11,752	<0.001
	MONTH7	0,595	0,124	4,788	<0.001
	MONTH8	1,406	0,113	12,418	<0.001
	MONTH9	1,586	0,116	13,650	<0.001
	MONTH10	1,993	0,162	12,326	<0.001
	Smoothing term	**edf**	**Ref.df**	**F**	**p-value**
	s(HOUR):MONTH1	1,65	2	6,787	<0.001
	s(HOUR):MONTH2	1,12	2	1,791	0,043
	s(HOUR):MONTH4	1,99	2	248,224	<0.001
	s(HOUR):MONTH5	1,97	2	80,609	<0.001
	s(HOUR):MONTH6	1,31	2	2,551	0,021
	s(HOUR):MONTH7	1,89	2	17,903	<0.001
	s(HOUR):MONTH8	0,00	2	0	0,618
	s(HOUR):MONTH9	1,90	2	27,17	<0.001
	s(HOUR):MONTH10	1,90	2	22,387	<0.001

HARBOUR PORPOISE PRESENCE AT KATTEGATT SYD OFFSHORE WIND-FARM SITE FROM MONITORING IN DECEMBER 2020 – DECEMBER 2021

A supplement to the technical report Kattegat Syd Offshore Windfarm – Effects of pile driving, gravity foundations and sediment spill on marine mammals

Harbour porpoises were monitored by means of passive acoustic monitoring for one full year at five stations in the potential offshore windfarm Kattegatt Syd. First year's data shows that detection rates in the area is of similar levels as the surrounding areas, as monitored by the Swedish monitoring program, except for the period November through February where the level of porpoise presence is lower. The report is a supplement to the report Kattegat Syd Offshore Windfarm - Effects of pile driving, gravity foundations and sediment spill on marine mammals. The report will be updated following the monitoring in 2022.

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