HARBOUR PORPOISE PRESENCE AT KATTEGATT SYD OFFSHORE WINDFARM SITE FROM MONITORING IN DECEMBER 2020 – DECEMBER 2022

Second years data

Technical Report from DCE – Danish Centre for Environment and Energy No. 274 2023

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Abstract: Harbour porpoises were monitored by means of passive acoustic monitoring for two full years at five stations in the potential offshore windfarm Kattegat Syd. The monitoring 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 highest level of presence was observed in March-May and August – September. This report includes two years data and supplements 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 2023.

Keywords: Passive acoustic monitoring, Best Environmental Practise, Monthly pattern in presence, diurnality.

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Contents

Preface

The monitoring of harbour porpoises at the potential offshore windfarm site Kattegatt Syd and this report summarizing monitoring results from two full years – December 2020- December 2022, 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 includes the second years data, and thus supplements 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 do not replace the assessments and recommendations in the above-mentioned report. This report is an update of the report *Harbour porpoise presence at Kattegatt Syd Offshore Windfarm site from monitoring in December 2020 – December 2021* and only contains an update of the data collected. This report will be updated again when data from monitoring throughout 2023 is available.

This report contains a description of the temporal presence of harbour porpoises at Kattegatt Syd offshore windfarm (OWF) as recorded over two full years (December 2020 - December 2022) and the variation is reported as porpoise presence over monthly and diurnal timescales. This may be 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 to år fra december 2020 til december 2022. Overvågningen fortsætter i hele 2023, hvorefter denne rapport opdateres.

Resultaterne fra de første to års overvågning viser at marsvin er almindelige i OWF Kattegatt Syd og forekommer ved samme niveauer som ved de nærmeste svenske moniteringsstationer (Figur 1), på nær i månederne november til og med februar, hvor niveauet var højere ved Lilla Middelgrund end ved nogen af de øvrige stationer. Kun i september ved station KAYD4 kom niveauet lige så højt op. Det højeste niveau i OWF Kattegatt Syd begge år blev fundet i marts-maj og igen i august-september med et gennemsnit på ca. 50 – 450 PPM per dag, med individuelle forskelle mellem de forskellige stationer i området. Niveauerne på de enkelte stationer var forholdsvis ens mellem de to år.

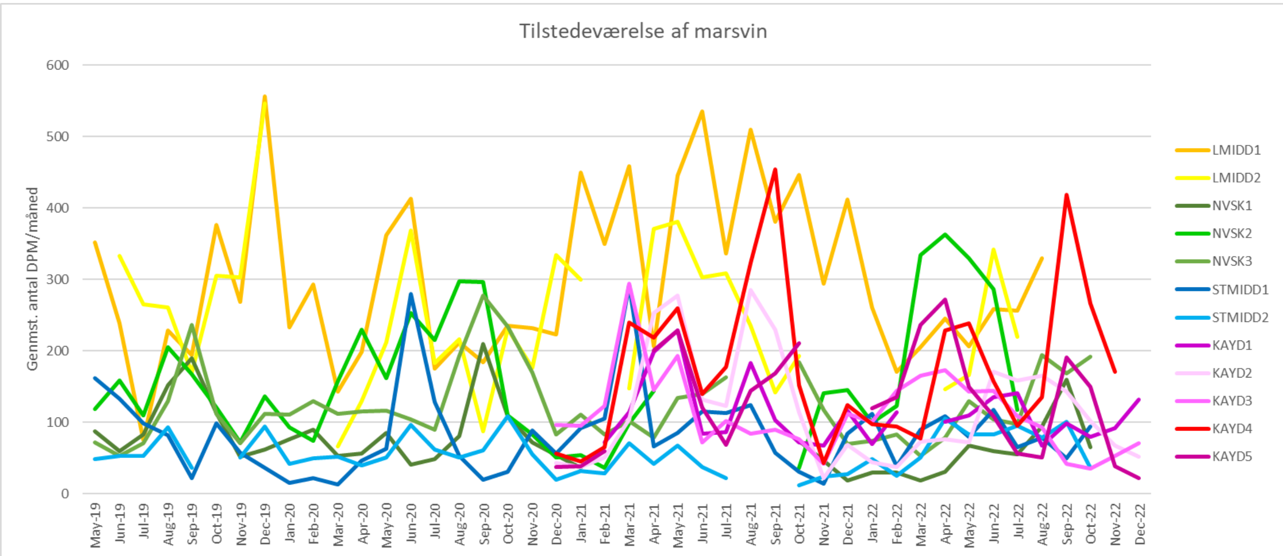


Figure 1. Tilstedeværelse af marsvin i Kattegatt Syd OWF og i omkringliggende svenske overvågningsstationer. LMIDD er Lilla Middelgrund Natura 2000 områdes stationer.STMIDD er Stora Middelgrund og Röda Bank Natura 2000 områdes stationer. NVSK er Nordvest Skånes stationer. KAYD er Kattegatt Syd stationerne.

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. 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 two consecutive years from December 2020 to December 2022. The monitoring continues throughout 2023, whereafter this report will be updated.

Data from the two 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. 50-130 porpoise positive minutes (PPM) per day per station, except for station 4 in 2022, which had higher levels. The highest level of presence was found in March – May and again in August-September with an average of about 50 – 450 PPM per day, with differences between the different stations in the area. The levels at each station were relatively similar between the two years, where station 4 had the most detections.

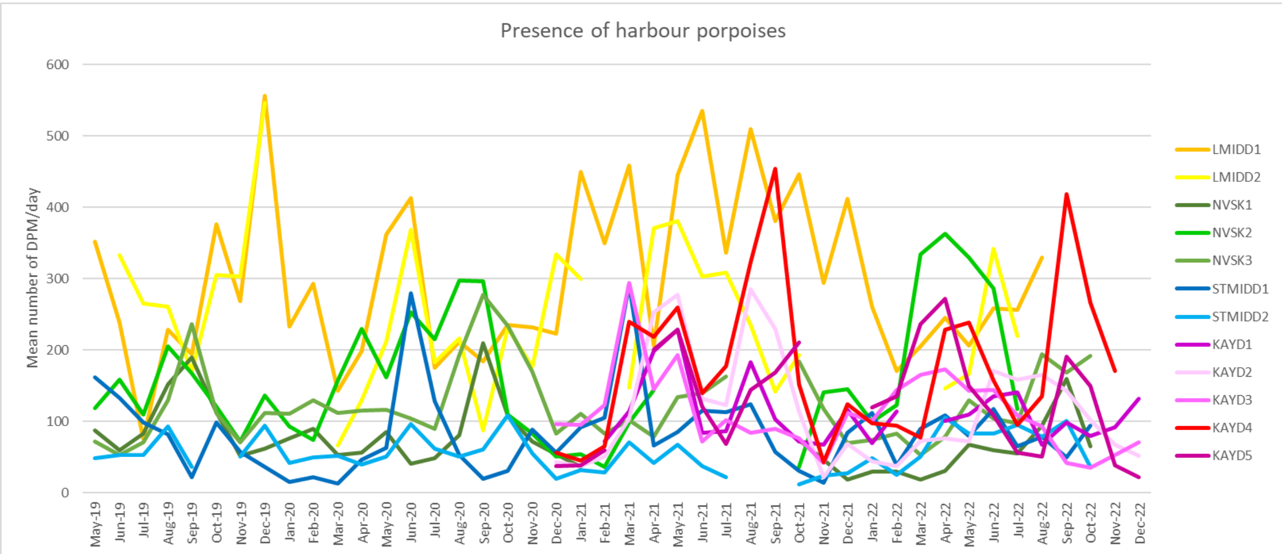


Figure 2. Presence of harbour porpoises at Kattegatt SYD OWF and nearby Swedish monitoring stations. LMIDD is Lilla Middelgrund Natura 2000 site. STMIDD is Stora Middelgrund and Röda Bank Natura 2000 site. NVSK is Northwest Skåne. KAYD is Kattegatt Syd stations.

1 Background

Vattenfall Vind A/B proposes establishing an offshore wind farm between the Natura 2000 sites 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 documented with two years of passive acoustic monitoring in the area. All background information pertaining to harbour 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).

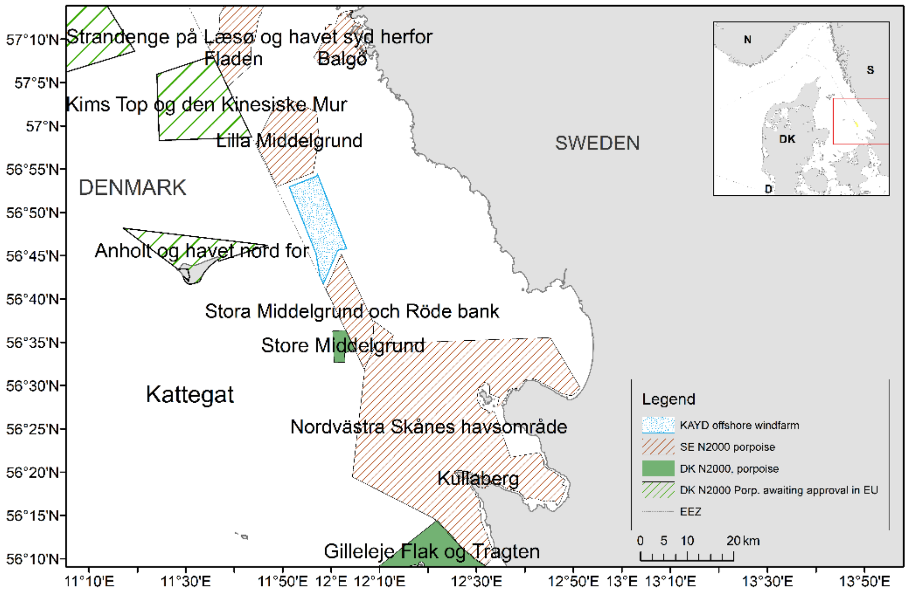


Figure 1.1. Map of Swedish and Danish Natura 2000 sites appointed for harbour porpoises in southern Kattegat. Another two Natura 2000 sites have been appointed in Denmark for harbour porpoises but are awaiting approval by the EU. The proposed offshore wind farm site is shown with blue. KAYD offshore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

1.1 Harbour porpoises in Kattegat

The harbour porpoise is the most common cetacean in Swedish Waters 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, the Belt Sea and Baltic Proper population (Lah et al. 2016, 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 mainly to the Belt Sea Population although individuals from the North Sea population may also be present. 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, 2020 and 2022 (SCANS IV – data not yet available) (Unger et al., 2021). The 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/km² (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.

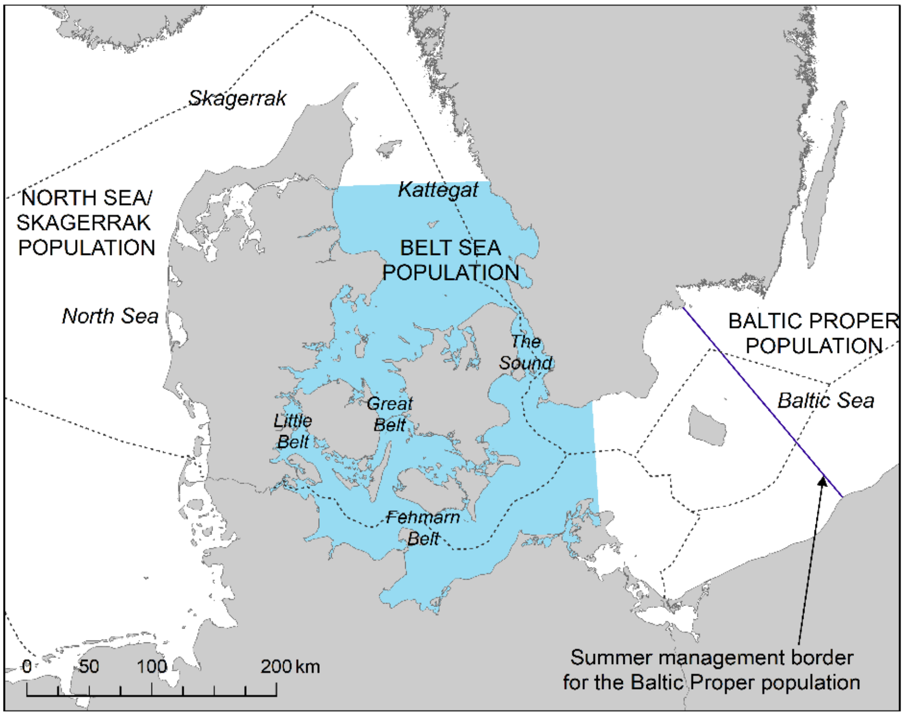


Figure 1.2. Map of management areas for the three populations of harbour porpoises. The North Sea population (white) overlaps with the Belt Seas population (blue) in southern Kattegat.

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 at 1 km distance, Lilla Middelgrund (SE0510126) of 17840.2 ha and to the south at 1 km distance, 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). There are also Natura 2000 sites appointed for harbour porpoises in Danish waters. The Natura 2000 site *Store Middelgrund* (No. DK00VA250) comprises a 2,094 ha area south of the OWF area. To the west hereof there are *Kims Top & the Chinese Wall* and *Anholt og havet nord for* (see Figure 1.1).

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

To quantify 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 during construction in order to provide information for assessing the principle of *Best Environmental Practice*.

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 national 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 or several years. 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.

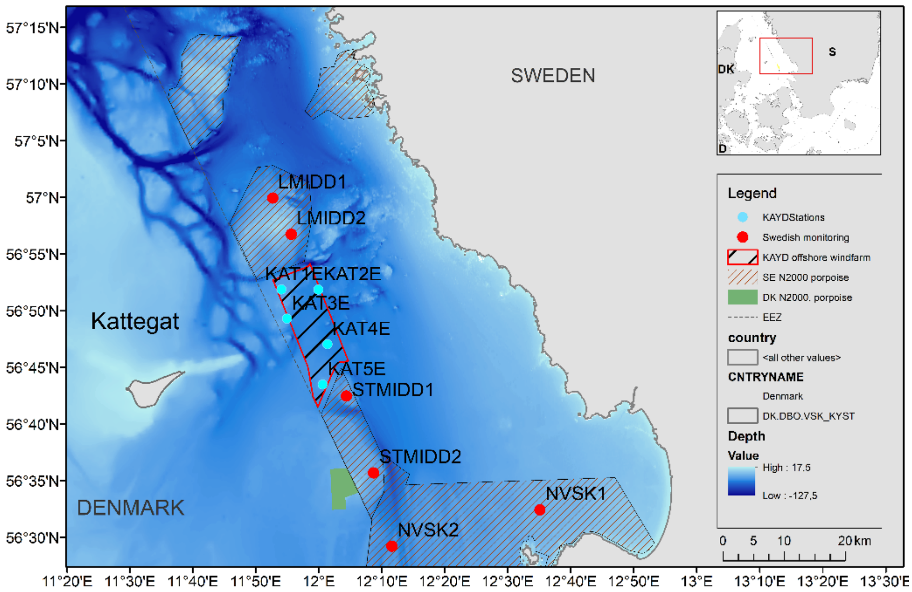


Figure 2.1. Position of monitoring PAM stations in the Kattegatt Syd OWF. Also, Swedish monitoring stations are shown in red.

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 its sensitivity may be affected by the rather brutal treatment during trawling and later stranding. Only units living up to 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. From 2023, all units are equipped with a satellite transmitter in order to be able to track and collect trawled stations. The satellite transmitters are followed via the ARGOS system.

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 for the last service trip in 2021 and all service trips in 2022. Permission to sail within 12 nm of the Swedish coast was applied for at the Swedish maritime authorities, but they deemed it not necessary to have as only one station was at the boarder of the 12 nm zone.

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 CP3 files are 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. Harbour porpoise is the only narrow-band high-frequency species in Kattegat. 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, 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 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

To quantify variation in diurnal presence of harbour porpoises, 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 smoothing 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 modelled by fitting a continuous time covariate autocorrelation structure of order 1 (corCAR1) using hour as the time covariate and julian day as grouping variable.

To quantify differences in harbour porpoise presence between months, data collected by the five PAM stations were analysed using linear mixed-effects models (LME). In the LME, DPM per day was fitted as the response variable and month and year as well as their interaction were fitted as fixed effects. Station ID was fitted as a random variable to account for unbalanced data. Temporal autocorrelation in the data was modelled by fitting a continuous time covariate autocorrelation structure of order 1 (corCAR1) using julian day as the time covariate and station ID as grouping variable. Based on the results of the LME, a *post hoc* Tukey Honest Significance Difference test was used to determine differences in the mean DPM/day between all months across 2 years of monitoring.

3 Results

3.1 Servicing and data loss

The five stations were monitored throughout 2021 and 2022. The monitoring continues throughout 2023. At first servicing on 11th February 2021, two PAM units were lost and a third CPOD had malfunctioned (i.e. not recorded). Upon evaluation it was decided to move station 3 and 5 to locations with less trawling activity, as deemed by evaluation of VMS data obtained from the Danish authorities (Figure 3.1). Later on, the borders of the OWF were 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 the second servicing on 11th April 2021, three PAM units were gone along with two surface buoys. Hereafter, all stations were generally in place, however, see Figure 3.3 for a full overview. At three servicings, the CPOD had malfunctioned; KAYD1A, KAYD5F and KAYD4L.

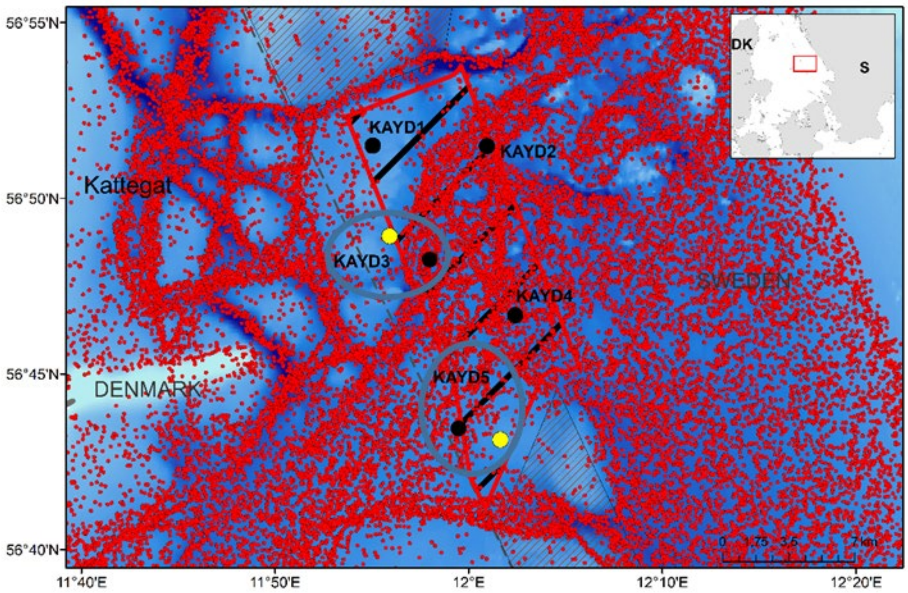


Figure 3.1. Station KAYD3 and KAYD5 were moved as they were trawled during the first two deployments. Original stations are in black and moved stations are in yellow. See inside the blue circles. The red dots are VMS data from 2020 signifying trawling.

All, but one lost PAM unit, 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 three deployment periods KAYD1A, KAYD5F and KAYD4L contained no data as the deployed CPODs malfunctioned. In KAYD4L one battery had corroded and there was no data.

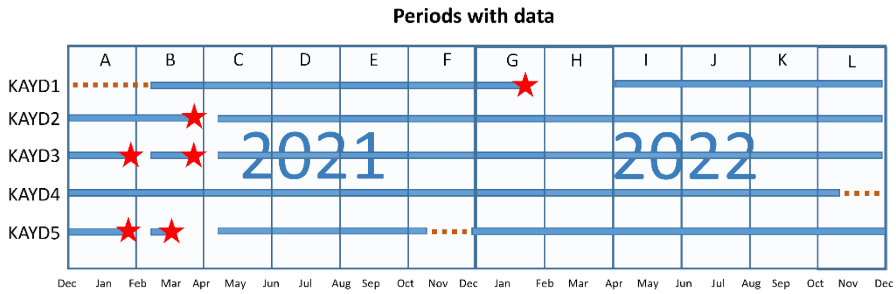


Figure 3.3. Periods with data during consecutive two-months deployments between December 2020 to 3rd January 2023. The PAM stations were trawled multiple times causing loss of data as shown with the empty periods following red stars. On three occasions the CPODs had not recorded (KAYD1A, KAYD5F and KAYD4L). This is shown with broken red lines. The day of deployment/retrieval is omitted from the analysis. The deployment periods are signified by the letters A-L.

3.3 Diurnal and monthly patterns in presence

Monthly pattern in presence across all five stations are shown in Figure 3. 4. For each monthly mean, the 95 % confidence interval is shown. Here data are shown as mean number of DPM per day for each month. Data from both years are shown. Generally, there were a higher level of DPMs per day in 2021 with less pronounced monthly peaks than in 2022, however only significantly so for May. Overall, the yearly pattern is rather similar for the two years, with highest level of in March to May and in August-September. The lowest level of presence was from November to February, but these months were not significantly different from June-July in 2021 or June-August in 2022 when statistically compared as averages across all stations (figure 3.4).

Figure 3 4. Monthly pattern in presence across the five monitoring stations at Kattegatt Syd OWF calculated as means (95%CI) of DPM per day per months across all stations. Identical letters signify that the particular months are not significantly different. Months within and between years with dissimilar letters are significantly different.

Detection positive minutes (DPM) per hour were analysed to examine daily pattern in presence across months of the year at the five PAM stations in Kattegatt Syd OWF. The results are shown in Figure 3.5 and the statistical results of the GAMMs model is shown in appendix 1 in Table 8.1. 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 almost all months of the year, which is unusual, and must be related to activity at this station – either in terms of prey or animal behaviour other than foraging. It is the same pattern for both monitoring years. 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. 4, where mean numbers of DPM per day per month are shown for the five stations in both years.

Figure 3.5. Diurnal and monthly pattern in presence (DPM per hour) at the five monitoring stations at Kattegatt Syd OWF in 2021 and 2022. 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. The same station has a nuance of the same colour in the two years, e.g. red nuances for station KAYD1

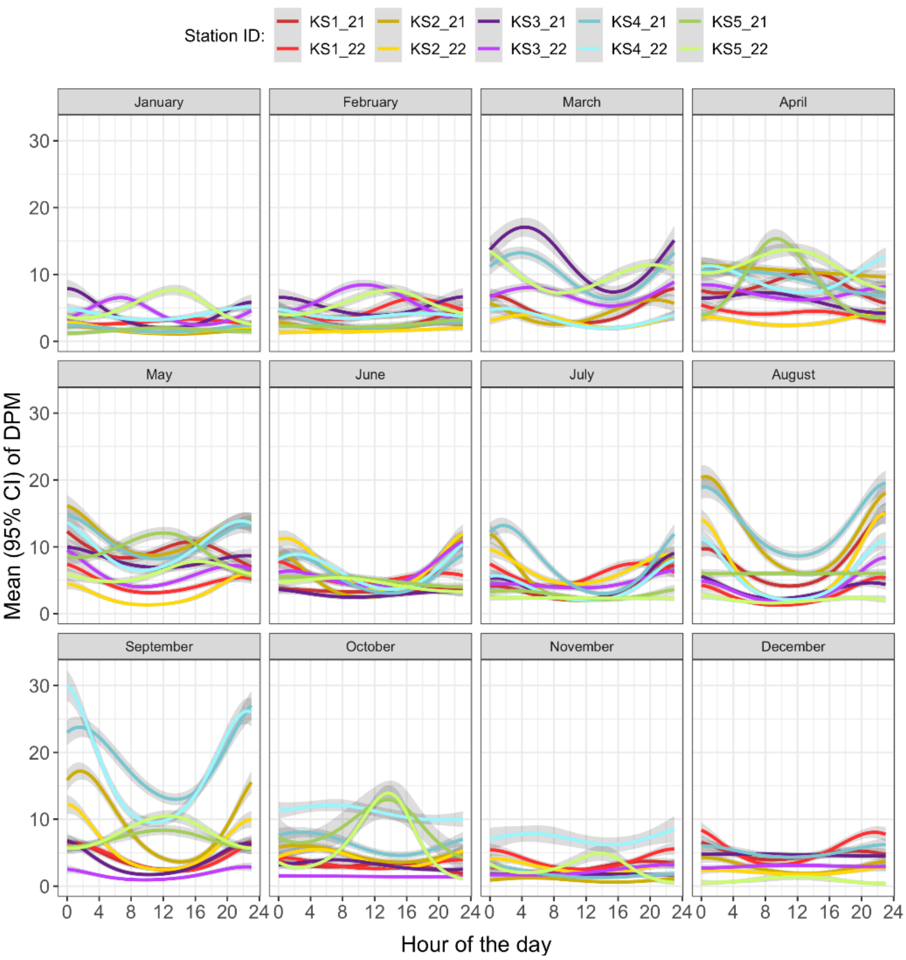
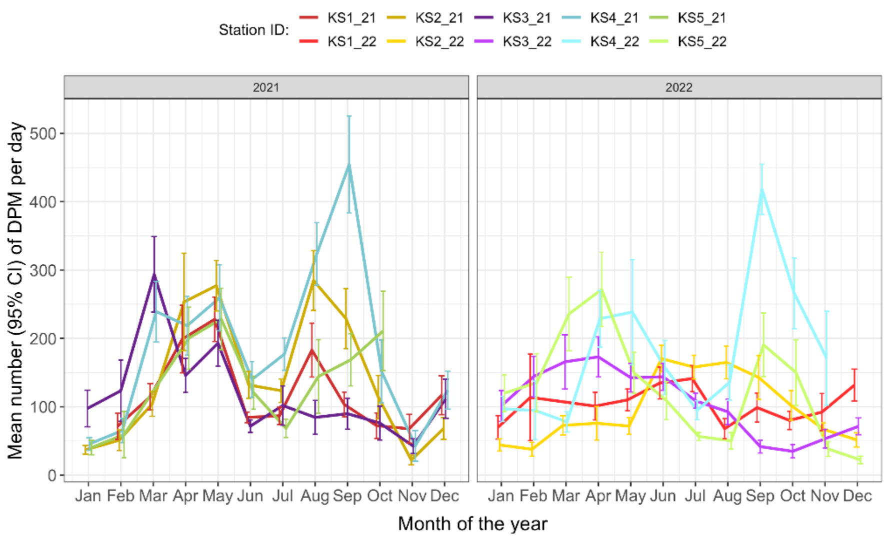


Figure 3.6. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF in 2021 and 2022. The y-axis shows mean number of detection positive minutes per day per station as a function of month (x-axis) across the two years of monitoring. Identical stations have similar colours across the years.



In Figure 3.7, the data is shown as box plots to visualize the variation better. Here, each month can be compared within and across years. It is again clear that May 2021 saw statistically higher levels of DPM than May 2022.

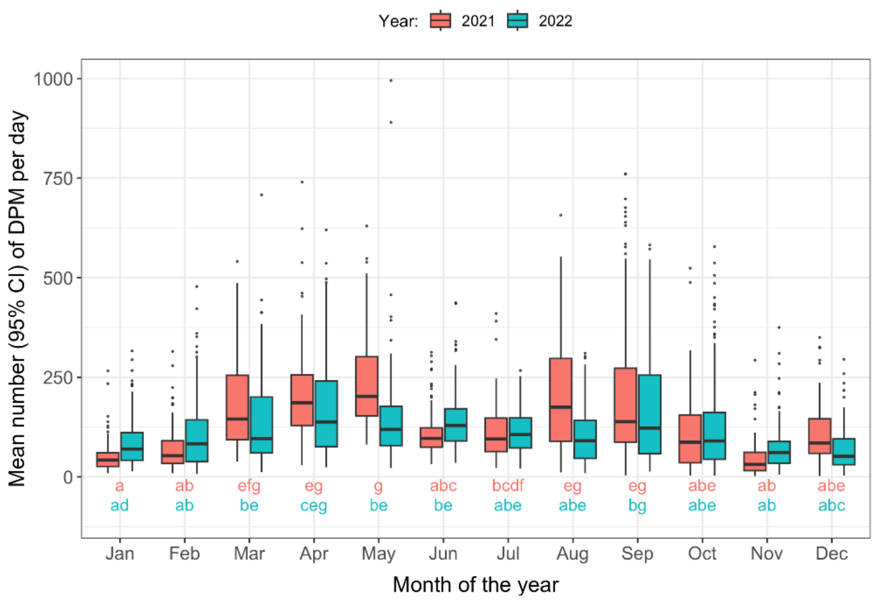


Figure 3.7. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF. The plot shows mean number of detection positive minutes per day per month across all stations. The figure can be used to statistically compare between months and years. The box contains 50 % of DPM. The box and whiskers are 95% of the DPM. The individual dots is the remaining 5% of DPM. The letters on the bottom signify whether months are statistically similar (0.05 level) or different, between or within years. Months with the same letter are statistically similar.

The combined analyses of the passive acoustic monitoring data from 2021 and 2022 at hourly and monthly scales (Figure 3.4 to Figure 3.7 and stats in appendix 1) suggests that porpoise presence in the area was highest between March-September with a temporary significant decline during the summer months: June-July. 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. In 2021, a simultaneous temporal and spatial monitoring study 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. The overlap began in December, so the period August-November was not overlapping in 2020.

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 3.8. 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. The data from this study is compared to the national monitoring in Figure 3.8.

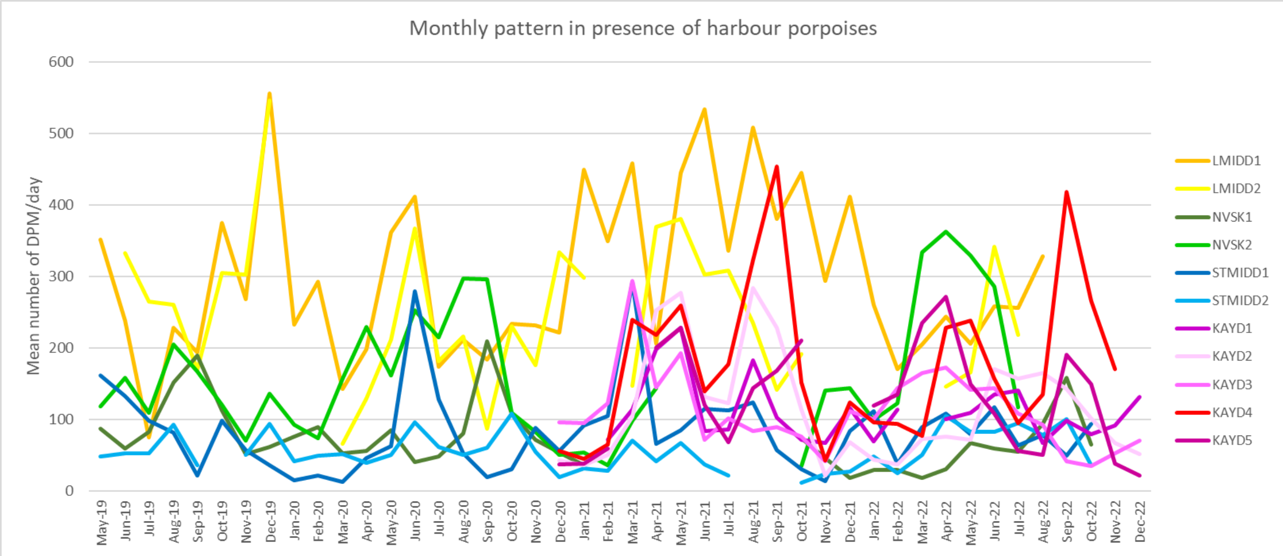


Figure 3.8. Monthly pattern in presence at the five monitoring stations at Kattegatt Syd OWF in 2021-2022 compared with the six closest Swedish monitoring stations from May 2019 to October 2022. Yellow colours signify Lilla Middalgrund. Blue colours signify Stora Middelgrund and Röda Bank. Green colours signify Nordvästra Skånes Havsområde. Red colours signify Kattegatt Syd monitoring. Please see figure 2. 1 for position of the Swedish national monitoring stations. Data from 2019 onwards are shown to visualize the annual pattern in presence. The Swedish data is available from Havs- och vattenmyndigheten och SMHI at Sharkweb free of charge.

There are three years of national monitoring data available; from May 2019 to October 2022. All are included in figure 3.8 to show the annual variantion in presence of porpoises. In general, the level of presence is highest at Lilla Middelgrund, Nordvästra Skånes Havsområde station NVSK6 and at Kattegat Syd station KAYD4 in all years. There are, however, some variation between the years for the two stations at Lilla Middelgrund, where there was a large number of DPM in all of 2021, with a pattern of annual changes across months in the other years. Only at KAYD4 did the mean number of DPM/month reach as high as at Lilla Middelgrund and at Nordvästra Skånes Havsområde. The other KAYD stations have much lower mean level of DPM/month. The lowest level of detection across all years was observed at Stora Middelgrund, especially in winter months.

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 2023 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. Therefore, all PAM loggers have been equipped with satellite transmitters for the 2023 season. The satellite transmitter will send only when it comes to the surface. Therefore, we can follow and retrieve units, if they are trawled to the surface between servicings.

4.2 Porpoise activity level at Kattegatt Syd OWF

The levels of porpoise presence in the Kattegatt Syd OWF, measured as average DPM per hour per month per station at Kattegatt Syd, is only a little lower than at the nearest Natura 2000 site Lilla Middelgrund, however it is station KAYD4 that drives this pattern. The other four stations show lower levels of presence than at Lilla Middelgrund (Figure 3. 8). At the southern Natura 2000 site Stora Middelgrund and Röda Bank the level of presence is lower than at Kattegat Syd OWF and lower than at any of the other national monitoring stations (Figure 3. 8). 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 PAM positions following a random but 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 Steensland et al. unintentionally 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 two years of monitoring show that the period with the fewest animals present could be from November until February (Figure 3.4 - 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 in the same area 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 level of presence with an average more than 200 DPM/day/month in March, Kattegat Syd OWF saw levels above 200 DPM/day/station/month in March, April, May, August and September in both years, but for fewer stations in 2022. This lends weight to a negative bias in the Steensland 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), and more than 3-400 DPM/day in 2021 at LMIDD 1 (except April). In 2022 the levels were lower at Lilla Middelgrund with a max of 329 DPM in July, which is where the data record ends. There was a tendency for lower levels of detections at all stations in 2022. The Kattegat Syd data show that the periods March through May and August through September on average had highest levels of DPM over the two years of monitoring, despite August being lower in 2022. For the overall area as such (Lilla Middelgrund, Kattegatt Syd and Stora Middegrund) there does not appear to be a general seasonal pattern in presence for the monitored years. This suggests that more data is needed to assess the seasonal pattern in the area.

The observed periods with the fewest porpoises present at the Kattegatt Syd OWF was in November-February. 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 total 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. For a ballpark estimation, there is about 2 times as many DPM/month in Summer (April-September) as in Winter (October-March). If we assume, unjustified, that this corresponds to a doubling of the amount of individuals, this means that more individuals will be affected in the Winter season where the noise spreads a factor four further than in Summer. This calculation is based on the maximum sound velocity in Winter. In reality the difference is smaller between the seasons, as the sound velocity changes gradually across the seasons with temperature and changes in the salinity.

5 Conclusion

The presence and activity level of harbour porpoises in the Kattegat Syd OWF was monitored during two full years (Dec. 2020 – Dec. 2022) with five PAM stations.

The monthly pattern in presence shows that porpoises had the highest level of activity 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 Lilla Middelgrund that have higher levels.

The level of Detection Positive Minutes (DPM) with porpoises was lower at all stations (Kattegatt Syd stations and national monitoring) in 2022 than in other years.

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), suggest that fewer individuals will be disturbed by construction of the Windfarn in Summer than in Winter.

The monitoring at Kattegatt Syd is continued throughout 2023, following which, this report will be updated.

6 Referencer

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Appendix 1

Table 8.1. . Output of the statistical analysis performed with Generalized Additive Mixed Models (GAMMs) for 2021 data. 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
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
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
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
	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
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

Table 8.2. Output of the statistical analysis performed with Generalized Additive Mixed Models (GAMMs) for 2022 data. 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**
KS1_22	(Intercept)	1.078	0.064	16.948	<0.001
	HOUR	-0.001	0.005	-0.218	0.828
	MONTH2	0.439	0.106	4.141	<0.001
	MONTH4	0.658	0.084	7.856	<0.001
	MONTH5	0.576	0.078	7.379	<0.001
	MONTH6	0.797	0.077	10.332	<0.001
	MONTH7	0.769	0.076	10.057	<0.001
	MONTH8	-0.271	0.086	-3.142	0.002
	MONTH9	0.231	0.081	2.868	0.004
	MONTH10	0.144	0.084	1.714	0.087
	MONTH11	0.213	0.082	2.595	0.009
	MONTH12	0.608	0.076	8.012	<0.001
	Smoothing term	edf	Ref.df	F	p-value
	s(HOUR):MONTH1	1.674	2	5.294	0.002
	s(HOUR):MONTH2	1.882	2	12.156	0.000
	s(HOUR):MONTH4	1.808	2	7.529	0.000
	s(HOUR):MONTH5	1.961	2	72.45	<0.001
	s(HOUR):MONTH6	1.921	2	31.14	<0.001
	s(HOUR):MONTH7	1.968	2	53.346	<0.001
	s(HOUR):MONTH8	1.979	2	125.322	<0.001
	s(HOUR):MONTH9	1.978	2	112.73	<0.001
	s(HOUR):MONTH10	1.874	2	22.24	<0.001
	s(HOUR):MONTH11	1.958	2	69.004	<0.001
	s(HOUR):MONTH12	1.982	2	138.539	<0.001
KS2_22	(Intercept)	0.720	0.071	10.171	<0.001
	HOUR	-0.012	0.006	-2.226	0.026
	MONTH2	-0.491	0.109	-4.507	<0.001
	MONTH3	0.249	0.093	2.669	0.008
	MONTH4	0.317	0.092	3.444	0.001
	MONTH5	0.103	0.090	1.146	0.252
	MONTH6	1.116	0.080	13.953	<0.001
	MONTH7	1.174	0.080	14.625	<0.001
	MONTH8	0.933	0.079	11.760	<0.001
	MONTH9	1.019	0.081	12.650	<0.001
	MONTH10	0.600	0.087	6.853	<0.001
	MONTH11	0.388	0.093	4.169	<0.001
	MONTH12	-0.051	0.099	-0.517	0.605
	Smoothing term	edf	Ref.df	F	p-value
	s(HOUR):MONTH1	1.889	2	25.452	<0.001
	s(HOUR):MONTH2	0.762	2	0.811	0.121
	s(HOUR):MONTH3	1.954	2	34.708	<0.001

	s(HOUR):MONTH4	1.892	2	26.327	<0.001
	s(HOUR):MONTH5	1.982	2	151.439	<0.001
	s(HOUR):MONTH6	1.990	2	259.653	<0.001
	s(HOUR):MONTH7	1.975	2	113.473	<0.001
	s(HOUR):MONTH8	1.996	2	609.485	<0.001
	s(HOUR):MONTH9	1.992	2	359.117	<0.001
	s(HOUR):MONTH10	1.963	2	44.098	<0.001
	s(HOUR):MONTH11	1.914	2	31.376	<0.001
	s(HOUR):MONTH12	1.777	2	10.930	<0.001
KS3_22	(Intercept)	1.228	0.057	21.628	<0.001
	HOUR	0.014	0.004	3.172	0.002
	MONTH2	0.658	0.079	8.321	<0.001
	MONTH3	0.549	0.070	7.811	<0.001
	MONTH4	0.765	0.069	11.032	<0.001
	MONTH5	0.705	0.069	10.151	<0.001
	MONTH6	0.246	0.072	3.423	0.001
	MONTH7	0.083	0.076	1.094	0.274
	MONTH8	-0.275	0.077	-3.579	<0.001
	MONTH9	-0.812	0.094	-8.616	<0.001
	MONTH10	-0.796	0.091	-8.703	<0.001
	MONTH11	-0.791	0.095	-8.306	<0.001
	MONTH12	-0.186	0.082	-2.270	0.023
	Smoothing term	edf	Ref.df	F	p-value
	s(HOUR):MONTH1	1.981	2	77.777	<0.001
	s(HOUR):MONTH2	1.968	2	93.044	<0.001
	s(HOUR):MONTH3	1.957	2	39.500	<0.001
	s(HOUR):MONTH4	1.854	2	18.795	<0.001
	s(HOUR):MONTH5	1.973	2	91.759	<0.001
	s(HOUR):MONTH6	1.967	2	87.536	<0.001
	s(HOUR):MONTH7	1.843	2	17.454	<0.001
	s(HOUR):MONTH8	1.982	2	157.455	<0.001
	s(HOUR):MONTH9	1.949	2	51.831	<0.001
	s(HOUR):MONTH10	0.000	2	0.000	0.461
	s(HOUR):MONTH11	1.484	2	3.065	0.017
	s(HOUR):MONTH12	1.131	2	1.776	0.045
KS4_22	(Intercept)	1.351	0.053	25.421	<0.001
	HOUR	0.003	0.004	0.700	0.484
	MONTH2	0.147	0.079	1.877	0.061
	MONTH3	-0.126	0.079	-1.595	0.111
	MONTH4	0.820	0.064	12.752	<0.001
	MONTH5	0.915	0.063	14.632	<0.001
	MONTH6	0.335	0.068	4.885	<0.001
	MONTH7	-0.241	0.074	-3.268	0.001
	MONTH8	0.222	0.068	3.282	0.001
	MONTH9	1.502	0.058	25.729	<0.001
	MONTH10	1.110	0.063	17.725	<0.001

	MONTH11	0.522	0.090	5.813	<0.001
	Smoothing term	edf	Ref.df	F	p-value
	s(HOUR):MONTH1	1.886	2	23.897	<0.001
	s(HOUR):MONTH2	1.759	2	7.065	<0.001
	s(HOUR):MONTH3	1.951	2	44.139	<0.001
	s(HOUR):MONTH4	1.954	2	60.886	<0.001
	s(HOUR):MONTH5	1.982	2	141.130	<0.001
	s(HOUR):MONTH6	1.983	2	133.372	<0.001
	s(HOUR):MONTH7	1.982	2	154.307	<0.001
	s(HOUR):MONTH8	1.992	2	343.735	<0.001
	s(HOUR):MONTH9	1.995	2	520.585	<0.001
	s(HOUR):MONTH10	1.635	2	4.481	0.004
	s(HOUR):MONTH11	1.694	2	5.163	0.002
KS5_22	(Intercept)	1.743	0.060	28.924	<0.001
	HOUR	-0.015	0.005	-3.085	0.002
	MONTH2	-0.057	0.084	-0.676	0.499
	MONTH3	0.638	0.069	9.223	<0.001
	MONTH4	0.808	0.071	11.366	<0.001
	MONTH5	0.070	0.077	0.916	0.360
	MONTH6	-0.067	0.082	-0.815	0.415
	MONTH7	-0.876	0.086	-10.215	<0.001
	MONTH8	-0.883	0.096	-9.228	<0.001
	MONTH9	0.302	0.077	3.949	<0.001
	MONTH10	0.443	0.089	4.970	<0.001
	MONTH11	0.070	0.146	0.481	0.630
	MONTH12	-1.782	0.248	-7.196	<0.001
	Smoothing term	edf	Ref.df	F	p-value
	s(HOUR):MONTH1	1.977	2	111.360	<0.001
	s(HOUR):MONTH2	1.946	2	49.037	<0.001
	s(HOUR):MONTH3	1.968	2	71.685	<0.001
	s(HOUR):MONTH4	1.946	2	53.444	<0.001
	s(HOUR):MONTH5	1.933	2	22.650	<0.001
	s(HOUR):MONTH6	1.706	2	7.809	<0.001
	s(HOUR):MONTH7	0.000	2	0.000	0.555
	s(HOUR):MONTH8	1.829	2	11.785	<0.001
	s(HOUR):MONTH9	1.964	2	79.839	<0.001
	s(HOUR):MONTH10	1.995	2	450.390	<0.001
	s(HOUR):MONTH11	1.959	2	40.507	<0.001
	s(HOUR):MONTH12	1.787	2	11.956	<0.001

HARBOUR PORPOISE PRESENCE AT KATTEGATT SYD OFFSHORE WINDFARM SITE FROM MONITORING IN DECEMBER 2020 – DECEMBER 2022

Second years data

Harbour porpoises were monitored by means of passive acoustic monitoring for two full years at five stations in the potential offshore windfarm Kattegat Syd. The monitoring 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 highest level of presence was observed in March-May and August – September. This report includes two years data and supplements 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 2023.

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