Södra Victoria

(former: Södra Midsjöbanken)

C-POD Deployment

Harbour porpoise abundance

(Jan. 2021 – Dec. 2021)

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V.2.1

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AIS	Automatic Identification System
C-POD	Continuous POrpoise Detector
%DPD/month	Percentage of harbour porpoise detection positive days per month.
%DP10M/d	Percentage of harbour porpoise detection positive 10-minutes-units at the 144 available 10-minutes-units of a 24h day.
EEZ	Exclusive economic zone
MW	Megawatt
OWF	Offshore wind farm
PTS	Permanent threshold shift
SMB	Södra Midsjöbanken
TTS	Temporary threshold shift

1 INTRODUCTION

1.1 Study area

RWE Renewables Sweden AB intents to construct the offshore wind farm “Södra Victoria” in the Baltic Sea. An area of 200 km^2 is planned to be covered by the OWF, which will be placed within the area named "the preliminary project area" in this report. The preliminary project area is larger than the actual OWF area and covers an area of 492 km^2. The preliminary project area is situated in the Baltic Sea in the southern part of the Swedish Exclusive Economic Zone (EEZ), close to the border of the Polish EEZ. The area is approximately 80 km away from the southern tip of the island of Öland, Sweden, 100 km from the Polish coast and 250 km from the coast of Lithuania. The area is situated within the Swedish EEZ but outside the territorial border (12 nm zone). The water depths in this area are ranging between 30 and 40 m (Figure 1-1). The preliminary project area is partially overlapping with the Natura 2000 area “Hoburgs bank och Midsjöbankarna (SiteCode: SE0330308)”. As the detailed planning for construction types and final setup has not been finalized until submission of this report, the following information about the planned OWF “Södra Victoria” is preliminary and may change during the planning and consent application process. According to the planning (as of July 2020) the OWF will consist of approximately 120 wind turbines. No final decision has yet been made about the most appropriate foundation type.

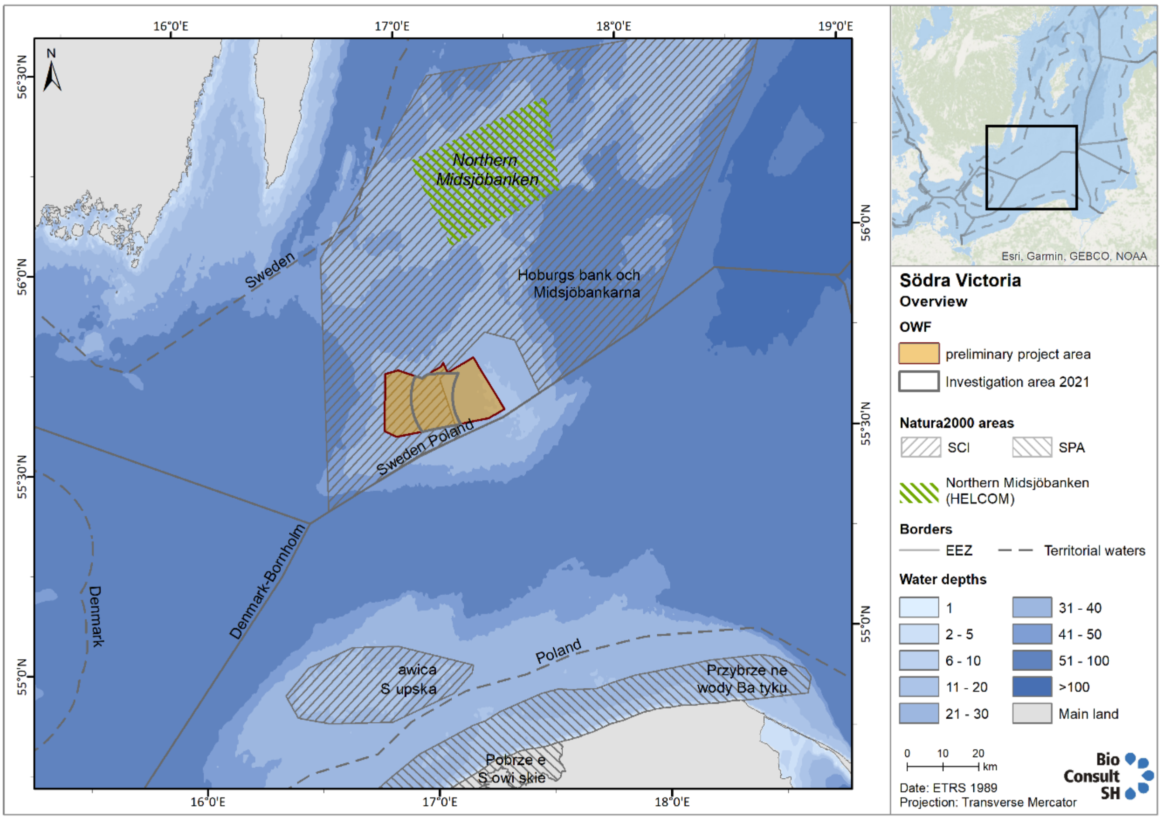

Figure 1-1 Overview of the study area. The preliminary area of the planned OWF is marked in orange. National borders and EEZ borders as well as protected areas are displayed.

1.2 The harbour porpoise (*Phocoena phocoena*)

The harbour porpoise (*Phocoena phocoena*) is widely distributed throughout the entire Northern Hemisphere. It is the only cetacean species reproducing in the Baltic Sea. The life span of harbour porpoises is relatively short compared to other toothed whales, with few animals reaching an age of over 12 years (LOCKYER 2003). Females reach sexual maturity at an age of around five years (KESSELRING ET AL. 2017). Current evaluations of animals reported dead show that the average age at death in the Baltic Sea is about four years only. Harbour porpoises are the smallest cetacean species in Central Europe (BENKE ET AL. 1998). They reach an average length of between 140 and 180 cm and a weight of between 40 and 60 kg. The main reproductive season of harbour porpoises lasts from June to August in the North Sea and Baltic Sea (BENKE ET AL. 1998). Mating and reproductive season may differ between regions. The mating season is between June and August. After a gestation period of eight to ten months (SCHULZE 1996) females give birth to a single calf almost every year between May and July. As the lactation period also spans eight to ten months, most females are pregnant and lactating at the same time, leading to high energetic demand during this period.

Like all toothed cetaceans, harbour porpoises use echolocation for orientation and prey capture. Production and perception of sound is an essential part of different aspects of harbour porpoise life. Harbour porpoise clicks have a main frequency of 130 kHz (RICHARDSON ET AL. 1995).

Harbour porpoises are opportunistic feeders and prey on a wide range of fish species, benthic as well as pelagic fish species. In the western part of the Baltic Sea, the food spectrum of harbour porpoises has been found to mainly consist of Atlantic herring (*Clupea harengus*) and cod (*Gadus morhua*). Especially immature animals also take a large proportion of gobies (Gobiidae). Further fish species like sprat (*Sprattus sprattus*), whiting (*Merlangius merlangus*) and sand laces (Ammodytidae) occur on a regular basis depending on season and location (AAREFJORD et al. 1995; BENKE et al. 1998; BÖRJESSON et al. 2003, ANDREASEN et al. 2017).

The harbour porpoise is listed in the EU habitats directive, annexes II and IV (92/43/EEG). For a species listed in annex IV of the EU habitat directive, Article 12 prohibits “deliberate capture or killing of this species as well as the deliberate disturbance especially during the period of breeding, rearing and migration”. It also prohibits the “deterioration or destruction of breeding and resting habitats”. Furthermore, the Baltic proper population (see below) is listed as “Critically endangered” by the International Union of Nature Conservation, IUCN (BECKER ET AL. 2013).

1.2.1 Harbour porpoise in the Baltic Sea

Historic observations, as well as records of catches of harbour porpoises in the Baltic Sea, show that this species occurred in greater numbers and was much wider distributed across the Baltic Sea than today (KOSCHINSKI 2002). The number of harbour porpoises in the Baltic Sea has been severely reduced during the last century. It is thought that a combination of increased hunting activity in the first half of the 20th century and heavy ice winters as well as the increase in pollution with environmental contaminants are important factors which led to the decline (BERGGREN ET AL. 2002; KOSCHINSKI 2002; LOCKYER & KINZE 2013). The most important factor for the decline in recent decades, however, is probably the increase in fisheries (as well as inventions such as nylon gillnets) from the 1950s onwards and thus the growing by-catch of harbour porpoises (KOSCHINSKI 2002).

Management units in the Baltic Sea

In the Baltic Sea, harbour porpoises can be subdivided into two management units which differ morphologically as well as partly genetically and can therefore be assumed to present two sub-populations (WIEMANN ET AL. 2010; LAH ET AL. 2016; TIEDEMANN ET AL. 2017): The Belt Sea sub-population in the western part and the Baltic Proper sub-population in the eastern part of the Baltic Sea. According to recent findings, the summer delimitation line between the two management units is assumed to be located east of the Odra Bank running from the Swedish mainland north of the island of Bornholm in south-eastern direction at a distance of about 30 km east of the island of Bornholm. Between November and April no clear delimitation can be drawn between the management units since the animals were more dispersed in distribution compared to summer (TEILMANN ET AL. 2017; CARLÉN ET AL. 2018) (Figure 1-2).

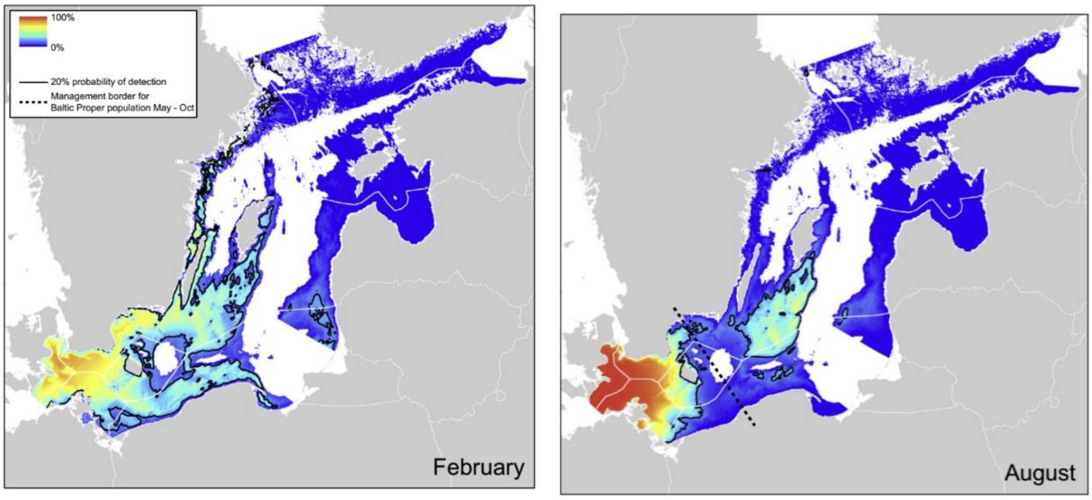

Figure 1-2 Predicted monthly detection probability of harbour porpoises in the study area of the SAMBAH project (2011-2013), examplary shown for February (left panel) and August (right panel). The blue colour indicates 0 % probability and red colour 100 % probability of detection. The black lines indicate the 20 % probability of detection. The dotted line shown for August indicates the seasonal delimination border for the Baltic Proper population. Modified after CARLÉN et al.(2018)

According to the findings of the SAMBAH project, during which 304 C-PODs (Cetacean Porpoise Detectors) were deployed across the Baltic Sea from 2011 – 2013, the number of individuals east of the delimitation line (Baltic Proper population, Figure 1-2) can be estimated at ca. 500 animals (SAMBAH 2016). On the contrary, the abundance of individuals in the south-western Baltic Sea are thought to belong to the Belt Sea population, which was estimated to consist of about 20,000 individuals (SAMBAH 2016). However, a recent survey in 2021, specifically designed to get an update abundance estimate for the Belt Sea population, found lower numbers, resulting in a calculated abundance of 17,301 individuals (UNGER et al. 2021). However, as the authors state themselves, the variance of these new estimates and of especially the earlier ones is high and a dedicated trend analysis is still missing (UNGER ET AL. 2021). Differences have been found in the feeding click activity (feeding buzzes) between the animals from the Baltic proper area and the western Baltic Sea, indicating potential differences in the foraging behaviour of the two sub-populations (KYHN ET AL. 2018). However, in the Baltic proper important areas in terms of feeding and density were identified by KYHN et al.(2018): Hoburgs Bank, as well as Södra and Norra Midsjöbanken.

1.3 Aim of the study

The objective of this C-POD study on harbour porpoises (*Phocoena phocoena*) is to provide information on the seasonal and spatial occurrence of the species in the preliminary project area of "Södra Victoria" during the course of 12 months (January 2021 – December 2021). Specifically, the following information is provided

- presence of harbour porpoises in the study area
- seasonal phenology of harbour porpoise detection rates
- diel patterns of harbour porpoise detection rates
- comparison of the results from 2021 to the results gained in the first year of investigation from February 2020 to December 2020

The results are discussed and assessed in the context of current literature.

2 METHODS

2.1 Study design

Ten C-PODs (SMB01 – SMB10) were deployed for passive acoustic monitoring (PAM) of harbour porpoises in the study area in the south-eastern Baltic Sea in February 2020 (Table 2-1 and Figure 2-1). Table 2-1 shows the coordinates of the respective POD station.

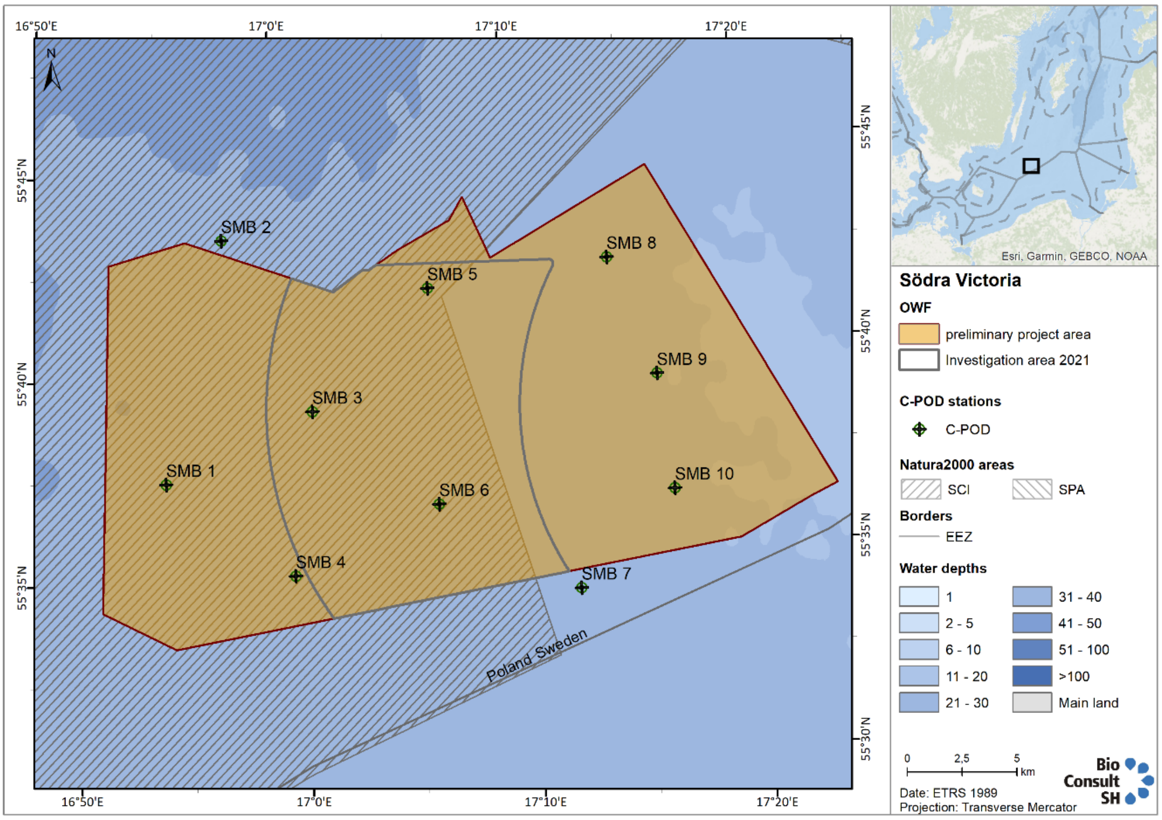

Figure 2-1 C-POD design inside and outside the preliminary project area of the planned OWF "Södra Victoria" (brown). The area investigated 2021 is marked with blue boundaries inside the preliminary project area.

Table 2-1 Geographical positions of the deployed C-PODs and hydrophones. Water depth (m) and the deployment periods of the devices are given.

Station ID	Latitude (°N)	Longitude (°E)	Water depth (m)	Deployment period C-POD
SMB01	55 37.334	16 54.426	32	09.01.2021 – 16.11.2021
SMB02	55 43.229	16 57.474	36	09.01.2021 – 16.11.2021
SMB03	55 38.907	17 00.959	32	09.01.2021 – 16.11.2021
SMB04	55 34.895	16 59.788	32	09.01.2021 – 16.11.2021
SMB05	55 41.754	17 06.294	32	09.01.2021 – 16.11.2021
SMB06	55 36.440	17 06.211	27	09.01.2021 – 16.11.2021
SMB07	55 34.161	17 12.128	28	09.01.2021 – 16.11.2021
SMB08	55 42.230	17 14.155	25	09.01.2021 – 16.11.2021
SMB09	55 39.301	17 16.008	20	09.01.2021 – 16.11.2021
SMB10	55 36.456	17 16.461	20	09.01.2021 – 16.11.2021

2.2 Harbour porpoise detection devices

2.2.1 The Cetacean Porpoise Detector (C-POD)

A C-POD (**C**etacean **PO**rpoise **D**etector) is a hydrophone, detecting the high-frequency echolocation signals of harbour porpoises up to a distance of about 300 m. Harbour porpoise clicks are directed in a strongly forward direction. They are emitted within a sound beam with a horizontal beam width of 13° and a vertical beam width of 11° (KOBLITZ ET AL. 2012). This means that C-PODs will only be able to detect harbour porpoise presence if these (1) emit click sounds, (2) are located at a suitable distance from the device and (3) have their head pointed towards the hydrophone. Recording of harbour porpoise clicks is therefore highly influenced by the animals' activity as well as distance from and angle of approach towards the C-POD. Applying different pre-set filters, the C-POD converts the sound waves into digital data, which are stored on a SD card. A number of different specific click characteristics is additionally saved. The C-PODs were set to a scan limit of 4,096 clicks/min.

Figure 2-2 Cetacean-POD (http://www.chelonia.co.uk/index.html).

2.2.2 POD calibration

All deployed devices were calibrated by the manufacturer (Chelonia Ltd., UK) to the main frequency of porpoise clicks (130 kHz) and set to the same hearing threshold (± 3 dB). Calibration is carried out in a specifically designed test tank in a standardised acoustic environment indicating possible differences in the sensitivity of the devices. The sensitivity of the units had been standardized when built by rotating the complete instrument in a sound field and adjusted to achieve a radially averaged, temperature corrected, maximum source pressure level (SPL) reading within 5% of the standard at 130 kHz (60.5 dB). The radial values were taken at 5 degree intervals. The calibration and standardization process are described in detail on the manufacturer's website (www.chelonia.co.uk).

2.2.3 POD deployment

The POD is fastened with shackles alongside the Lightweight Release Transponder (LRT, Sonardyne) (Figure 2-3). The hydrophone of the POD points towards the surface. The buoyancy ball (net float 8l buoyancy volume) is connected to the central line of the C-POD and the LRT line. A swivel shackle connects the lid of the rope quiver with the base weight, which consists of 2 chains. The two chains are connected by a non-floating bottom line. This system ensures easy handling, meets the requirements of the approving authority and avoids damages due to e.g. ship traffic.

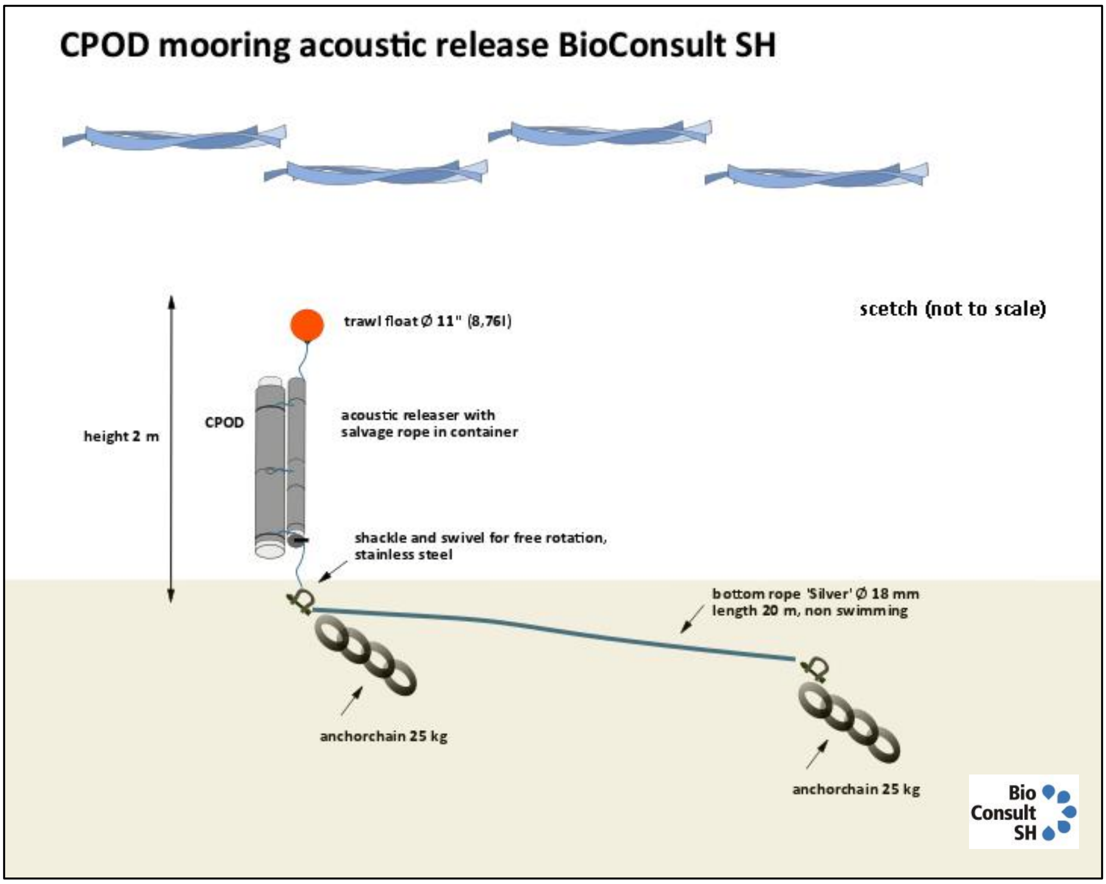

Figure 2-3 POD anchoring system with Lightweight Release Transponder (LRT, Sonardyne)

2.3 C-POD data analysis

Harbour porpoise-positive time units are pre-defined time units (e.g. days/hours/10 minutes or minutes), which are checked for the occurrence of harbour porpoise click trains. In case the chosen time unit contains at least one harbour porpoise signal, this time unit is classified to be harbour porpoise positive. As the number of recorded clicks largely depends on the behaviour of the animals and is very sensitive to possible minor differences in sensitivity between the devices, the parameter "positive time unit" is an indication for harbour porpoise presence, which is independent of the context of the animals' sound emission. Different studies were able to show a clear relation between absolute harbour porpoise density (determined in aerial surveys) and the detection rate within the same period and area in form of harbour porpoise positive time units (SIEBERT & RYE 2008; KYHN ET AL. 2012; WILLIAMSON ET AL. 2016; JACOBSON ET AL. 2017; SCHUBERT ET AL. 2019). It can therefore be assumed that the higher the detection rate the more harbour porpoises will have been present in the respective range of the C-POD on that particular day, although it cannot be completely excluded that in case of a high detection rate only few animals stayed in the area covered by a C-POD for a longer period of time. This parameter therefore only serves as a rough indicator for harbour porpoise density per day. (See formula 1, xt = number of clicks for this time unit).

Formula 1:

$$\text{Harbour porpoise positive time per time unit [\%]} = \frac{\text{N time units with clicks}}{\text{N total time unit}} * 100$$

$$= \frac{\text{N}\,\{\mathrm{x_t} > 0\}}{\text{N total}} * 100$$

The time unit (from minutes up to months or entire study periods) is chosen depending on the specific question and harbour porpoise presence in the study area. The following analyses are based on DPD/month and DP10M/day, focusing on two main questions: 1. What is the monthly presence of porpoises in the study area and 2. How do they use the area during a 24-hour day?

%DPD/time unit (% detection positive days per time unit) gives the percentage of survey days per pre-defined time unit (e.g. month/year/study period, etc.) with at least one harbour porpoise signal. Applying this parameter, it is not differentiated between only one click train recorded that day or hundreds of click trains recorded every minute. This coarse resolution parameter is especially suited for data sets with very few harbour porpoise detections like for the present study area. The parameter is standardised to values between 0 and 100 as %DPD/month, taking the number of recording days per month as 100 %. In areas with low porpoise abundance, e.g. great parts of the eastern Baltic Sea, the daily presence of harbour porpoises has more explanatory power than the (daily) frequency of occurrences (see **%DP10M/d**), as analysis on an hourly or even minute-by-minute basis has a high susceptibility to randomness due to the very infrequent recording and thus only has a low informative value. To meet highest explanatory goals for areas with low porpoise abundance, the reduced temporal resolution is considered an acceptable limitation in data analysis.

%DP10M/time unit (% detection positive 10 minutes per time unit): This parameter gives percentages of the number of 10 minute-units per pre-defined time unit (e.g. days/month/study period, etc.) with at least one harbour porpoise signal. This parameter is usually used in a resolution per day where it describes within how many of the usually available 144 10-minute units of a 24-hour day at least one harbour porpoise signal was recorded. Thus, it is the most appropriate measure in areas with moderate or high porpoise abundance. Based on the complete data set this parameter was used during this study to check for any temporal differences in the presence of porpoises during the course of a 24-hour day. Since the instruments are deployed close to the seabed regular differences in detections during a day can give valuable information about the habitat use.

2.3.1 POD software

Raw data of the C-PODs are processed using the associated software C-POD.exe (Chelonia Ltd., UK). The software is available as a free download under http://www.chelonia.co.uk. C-PODs record signals in real time allowing to identify click trains due to the temporal resolution. Data are processed in two steps. In a first step, harbour porpoise click trains are extracted from the raw data by means of an algorithm of the C-POD.exe software. In a second step, signals are classified by the KERNO classifier into different categories according to the probable source: harbour porpoise, dolphin, boat sonar or unknown source. The software assigns each click train to one of these classes and gives an estimate of the quality of this classification. Four quality classes are available:

- “high”: these click trains are highly probable harbour porpoise signals.
- “moderate”: short click trains, which are probably harbour porpoise signals.
- “low”: click trains with sound patterns which may be harbour porpoise signals but deviate from the ideal and may therefore originate from other sources.
- “doubtful”: series of click trains, which are due to the length or the temporal pattern of rather technical origin. These may still contain harbour porpoise click trains, which were only partly recorded by the hydrophone or from a larger distance or at an unfavourable angle.

For the present analysis standard filtering was applied according to Chelonia including only the two highest quality classes (“high” and “moderate”) to decrease the number of incorrectly classified harbour porpoise click trains. For Baltic Sea conditions, where low detection rates of harbour porpoise are expected and other cetaceans are unlikely, a second encounter classifier (Hel1) is applied analysing the data classified by the KERNO classifier. The Hel1 classifier revises the results from the KERNO classifier in order to further eliminate any click trains, which were eventually falsely identified as of harbour porpoise origin, called “false positive” by the KERNO classifier. Therefore, the Hel1 runs the data with a lower positive predictive value. Even though the more conservative Hel1 classifier may delete a number of positive porpoise click trains in areas of low porpoise abundance, it often becomes important to only include 100 % secure porpoise signals, as any false positive has a strong influence on the assessment of areas. Although it can be assumed that the “false positive”-rate is constant throughout areas and positions, its influence in areas of higher abundance is quite low.

In order to get an estimation on the difference between both algorithms we show the differences per station.

2.3.2 Analysing methods

The C-POD data are analysed in different ways depending on the respective question and the data set used as well as detection parameters. Data from 01.01.2021 to 31.12.2021 were used for the analysis. In most cases, calculations are performed with the software R (version 3.4.0; R CORE TEAM 2017). The basic analysis conducted with the data set are explained in the following:

Seasonality diagrams for each POD station are generated based on harbour porpoise detection rates using the software R (package "stats"; version 3.4.0; R CORE TEAM 2017). Due to the very low abundance of harbour porpoises in the study area, the phenology is represented by the parameter %DPD/month. The number of click trains recorded per day on individual days at a station is not considered. Instead, each day on which at least one click train was recorded is considered a "detection positive day" (DPD). By this procedure, a day with few click train recordings is treated equal to a day on which almost continuous (i.e. many) porpoise click trains are recorded. However, due to the very low porpoise density, days with continuous presence of harbour porpoises in the study area did not occur. Instead, the use of this parameter prevents an overestimation of too large stochastic parameters.

Box-Whiskers plots are generated based on %DPD/month to visualise overall differences in detection rates across all stations between seasons. These plots illustrate particularly well the distribution of detection rates %DPD/month of the total data set, displaying the detection rates above and below the median %DPD/month.

The **spatial distribution** of the harbour porpoises is displayed by overlaying average detection positive days (%DPD/month) as classified circles and the geographical position of the respective C-POD station using the software ArcGIS (Version 10.7).

Based on %DP10M/time unit (% detection positive 10 minutes per time unit) **diel patterns** of harbour porpoises were analysed by pooling all detections [DP10M] for the phases "day" and "night" per C-POD station. It has to be kept in mind, that due to the generally very low detection rate in the study area, the higher time resolution is very susceptible to random values and hence, results need to be discussed carefully.

Furthermore, %DP10M/d was checked for possible differences in the **frequency of occurrence** in the area at a daily time resolution.

2.4 Data recording

Ten C-PODs were deployed on 03.02.2020. Data collected in the period between 01.01.2021 and 31.12.2021 were evaluated for the present report. The deployed devices were exchanged around every two months to extract data and change the batteries. Longer-term data loss occurred at Station SMB10 due to software or technical problems (Figure 2-4). A total of 68 of 3,650 possible days (1.9 %) could not be included in the evaluation due to data loss.

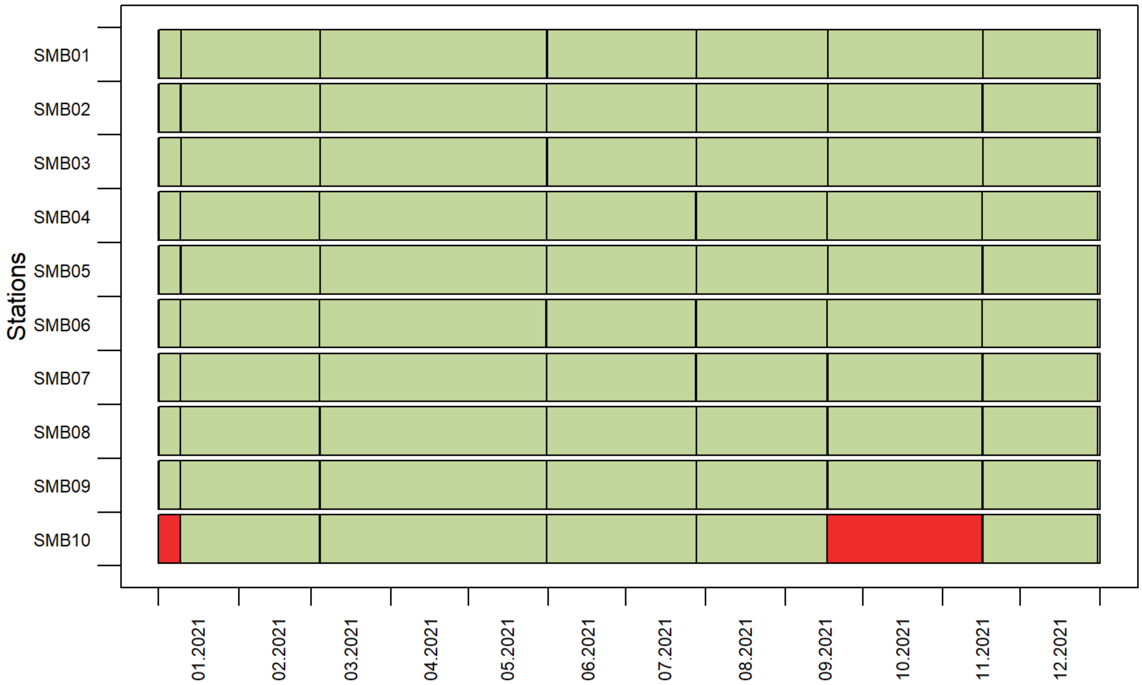

Figure 2-4 *Bar chart, indicating the duration of deployment of the PODs for the survey period (January to December 2021). Green: POD recorded data, red: POD was deployed but did not record data. The x-axis shows the date, the y-axis the POD station. Vertical black lines indicate the time of exchange of the devices.*

2.4.1 Clicks of unknown origin

To avoid possible impacts of many clicks of unknown sources on the registration of harbour porpoise clicks, the quality of C-POD records was checked. In addition to echolocation sounds of harbour porpoises, C-PODs record all impulse sound events in a frequency band of between 20 kHz and 150 kHz. Among these are the sounds of boat sonars and sediment movement. If a C-POD is deployed in a noisy environment, the pre-set click limit of 4,096 clicks per minute will quickly be exceeded and the C-POD will then record no further data for the rest of this particular minute. In such a case, harbour porpoise clicks may be missed. But even when the limit is not reached it cannot be excluded that porpoise clicks may be missed due to masking. To avoid that too many clicks of unknown origin influence the data too strongly, a dual criterion was defined in order to clean the data for further analysis: The two criteria were defined based on experience gained in the analysis of different projects in the North Sea and Baltic Sea (ROSE ET AL. 2019). All complete days with C-POD recordings were removed that recorded either more than three million clicks (the maximum possible number is > 5.89 million clicks) or had more than 200 minutes during which the click limit of 4,096 clicks was exceeded. Furthermore, only days with records for half of the 1,440 minutes were included in the evaluation. Duplicate or incomplete records due to for example exchanges of the POD were thus excluded. About 4.8 % (175 days) of all possible POD days (3,650 days) met these criteria and were therefore excluded from the analysis.

3 RESULTS

3.1 Harbour porpoise presence in the study area

In comparison to the western areas of the Baltic Sea, the occurrence of harbour porpoises in the waters of Södra Midsjöbanken is very low (Figure 3-1 and Table 3-1). Except for stations SMB04 the average rate of harbour porpoise positive days was below 5 %DPD. The lowest detection rate was recorded at station SMB10 on the south-eastern tip of the study area with 0.36 % DPD, which equals 1 day during the analysis period, where detections were recorded (20.07.2021). As in 2020 in less than 50% of all 120 station months harbour porpoise clicks were recorded. In 86 % of all station months only 2 or less days (85 % in 2020) with at least one porpoise signal were measured, showing that porpoises are rare in the study area. On 123 days at least one porpoise detection was recorded. Overall, the frequency of occurrence (with a resolution of ten-minute units) was very low with 0.05 %DP10M/d (averaged over all stations and the entire study period). Nevertheless, on 97 out of the 123 days with positive detections, more than one minute with positive detection was measured. Maximum value was reached with on average 9.3 %DPD at position SMB04. The highest detection rates in harbour porpoise positive days (%DPD/analysis period) were recorded in the Natura 2000 area “Hoburgs bank och Midsjöbankarna” at stations SMB02, SMB03 and SMB04. Of the 3,475 days with recordings, on average about 3.5% were harbour porpoise positive days with at least one harbour porpoise detection indicating a very low harbour porpoise presence in the survey area. This is comparable to the 3% detection positive days (DPD) measured in 2020 (Figure 3-1). As in 2020, in less than 50% of all 120 station months harbour porpoise clicks were recorded. Across all stations no statistically significant difference between the detection rates in 2020 and 2021 could be found (Mann-Whitney-U-Test, $p > 0.05$).

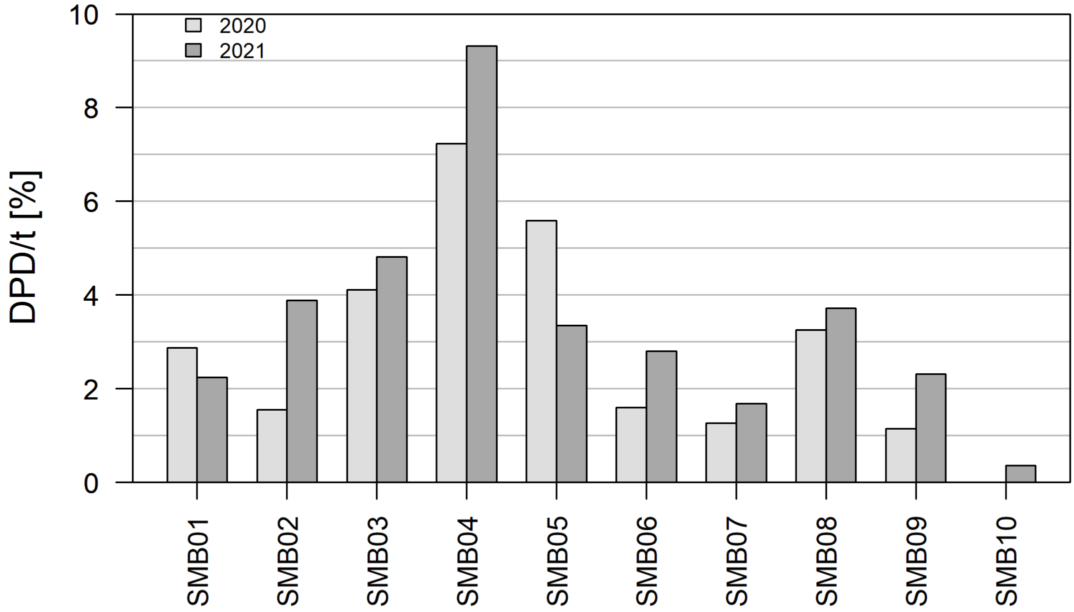

Figure 3-1 Mean detection positive days (%DPD/t) over the course of the study period 2020 (light grey) and 2021 (dark grey) for each C-POD station. At SMB10 no harbour porpoise was detected in the study period 2020.

Table 3-1 Number of days with POD data suitable for evaluation, total number of harbour porpoise positive days and detection rates as harbour porpoise positive days, hours and 10 minute-units. Given is the respective mean proportion (%) of the total data suitable for evaluation.

POD station	Recording days (N)	Harbour porpoise positive days (N)	Harbour porpoise positive days per study period [%DPD]	Harbour porpoise positive hours per study period [%DPH]	Harbour porpoise positive 10-minute units per study period [%DP10M]
SMB01	357	8	2.24	0.14	0.04
SMB02	360	14	3.89	0.19	0.05
SMB03	353	17	4.82	0.25	0.06
SMB04	365	34	9.32	0.62	0.16
SMB05	358	12	3.35	0.15	0.03
SMB06	357	10	2.80	0.13	0.03
SMB07	355	6	1.69	0.07	0.02
SMB08	349	13	3.72	0.19	0.04
SMB09	347	8	2.31	0.11	0.03
SMB10	274	1	0.36	0.02	0.00
Total	**3,475**	**123**			
Average			**3.45**	**0.19**	**0.05**

Spatial distribution

Since all stations had on average less than 10 %DPD/month, the differences between the single stations were in general very low. Still, the detections of harbour porpoises were not evenly distributed across the study area during the course of the 12 months investigated. Stations with low average porpoise detection rates (in %DPD) were located in the south-eastern part of the study area (SMB07 and SMB09, Figure 3-2), as seen in 2020 as well, and unlike 2020, station SMB01 located in the west of the study area exhibited low average porpoise abundance (2.24 %DPD) compared to the other stations. The highest %DPD on average were detected at stations SMB02, SMB03 and SMB04. These stations also exhibited the highest average %DP10M/study period.

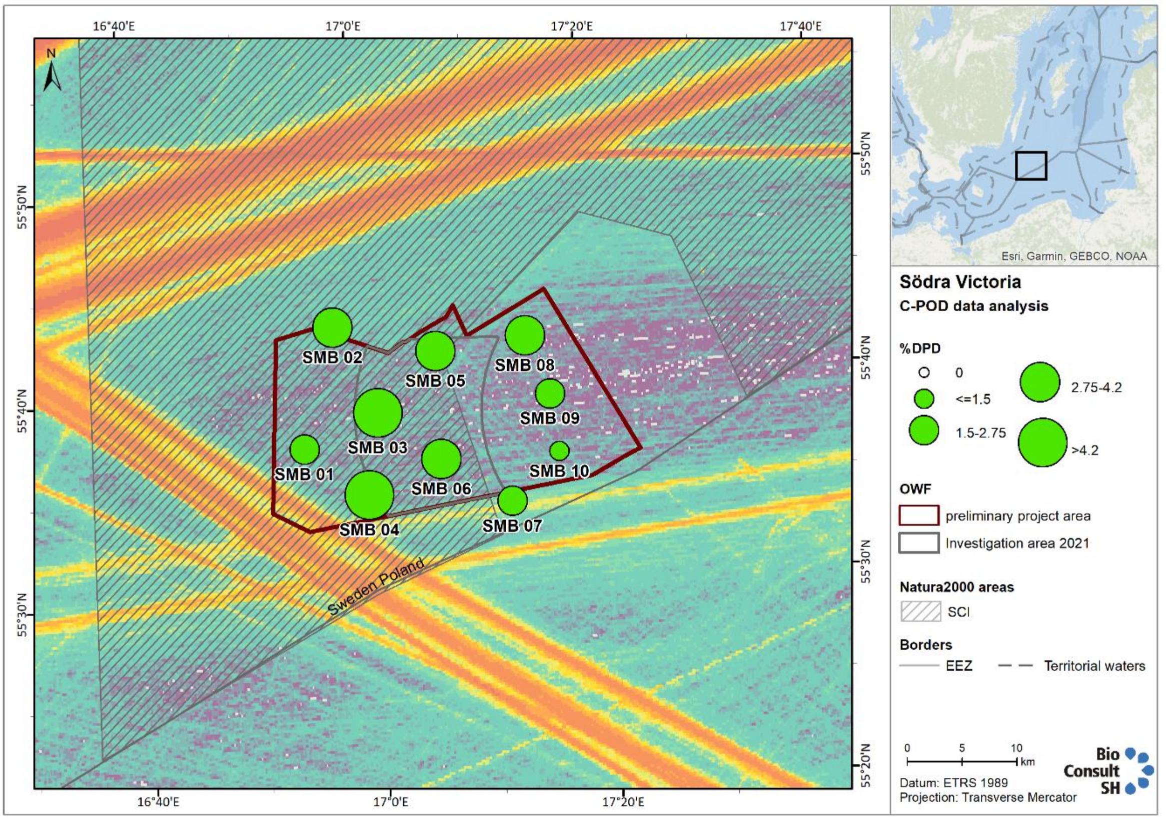

Figure 3-2 Average rate of harbour porpoise positive days (%DPD) per station in 2021 in form of classified circles. In the background ship traffic is accumulated for 2020 (2021 not available yet) to display the major shipping routes (www.marinetraffic.com) where the colours represent the intensity of the ship traffic. The colours ranging from blue (no or low ship traffic) over green, yellow and orange to red (high ship traffic).

3.1.1 Harbour porpoise phenology

The observed seasonal pattern of harbour porpoise positive days (%DPD/month) between January and December 2021 across all 10 C-POD stations was similar to the seasonal pattern observed in 2020 (Figure 3-3), with maximum detection rates between July and September. It slightly differed between single C-POD stations, however (Table 3-2). The average detection rates (%DPD/month) stayed below 4 %DPD/month from January 2021 to June 2021 and in November and December 2021. The number of days with harbour porpoise detections started increasing in July 2021 across the survey area and reached the maximum in August 2021. The peaks in August and September 2021 were generally higher than in 2020. When comparing single stations, the maximum was detected at position SMB04 with 38.71 %DPD/month in August, corresponding to 12 days with at least one harbour porpoise detection.

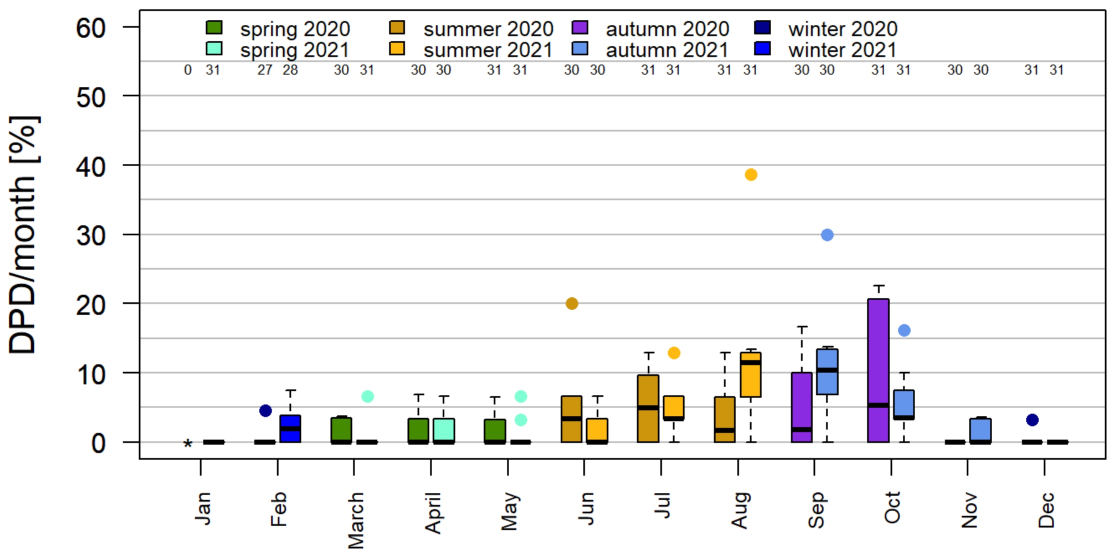

Figure 3-3 Mean monthly detection positive days (%DPD/month) averaged over all ten stations in the study period 2020 and the study period 2021. Seasons are colour coded. Number of days, where one of the C-PODs recorded data are given above the Box-Whisker plots.

Five of the 10 C-POD stations exhibited a maximum number of harbour porpoise detections in August 2021 (SMB03, SMB04, SMB05, SMB08 and SMB09) (Figure 3-4 to Figure 3-13, Table 3-2, Figure 3-14). At the remaining stations, maximum values were recorded in September, except for Station SMB10, which only recorded harbour porpoise detections in July 2021. In winter and spring, harbour porpoise signals were only rarely recorded at most of the stations, while it has to be noted that the average detection rates were higher in February 2021 than in June 2021. No harbour porpoises were detected on any day in January and December 2021; in March 2021 no detections were recorded at nine of the 10 stations.

Table 3-2 Average rate of harbour porpoise positive days (%DPD/month) in the study area per month and station. Maximum detection rates per station are printed in bold.

DPD/month	Jan 21	Feb 21	Mar21	Apr 21	May21	Jun 21
SMB01	0	0	0	0	0	0
SMB02	0	7.14	0	0	0	0
SMB03	0	0	0	6.67	6.67	6.67
SMB04	0	0	0	3.33	3.23	3.33
SMB05	0	7.41	6.67	0	0	0
SMB06	0	0	0	3.33	0	0
SMB07	0	3.85	0	0	0	3.33
SMB08	0	3.85	0	0	0	0
SMB09	0	3.85	0	3.57	0	0
SMB10	0	0	0	0	0	0
Average	0.00	2.61	0.67	1.69	0.99	1.33

DPD/month	Jul 21	Aug 21	Sep 21	Oct21	Nov 21	Dec 2021
SMB01	0	6.45	**13.79**	3.45	3.45	0
SMB02	3.33	12.9	**13.33**	10	0.00	0
SMB03	6.67	**12.9**	10.34	6.9	0.00	0
SMB04	12.9	**38.71**	30	16.13	3.33	0
SMB05	0	**12.9**	10	3.45	0.00	0
SMB06	3.33	10	**13.33**	3.33	0.00	0
SMB07	6.67	0	**6.9**	0	0.00	0
SMB08	6.67	**13.33**	10.34	7.41	3.57	0
SMB09	3.33	**10**	6.67	0	0.00	0
SMB10	**3.45**	0	0	NA	0.00	0
Average	4.64	**11.72**	11.47	5.63	1.04	0.00

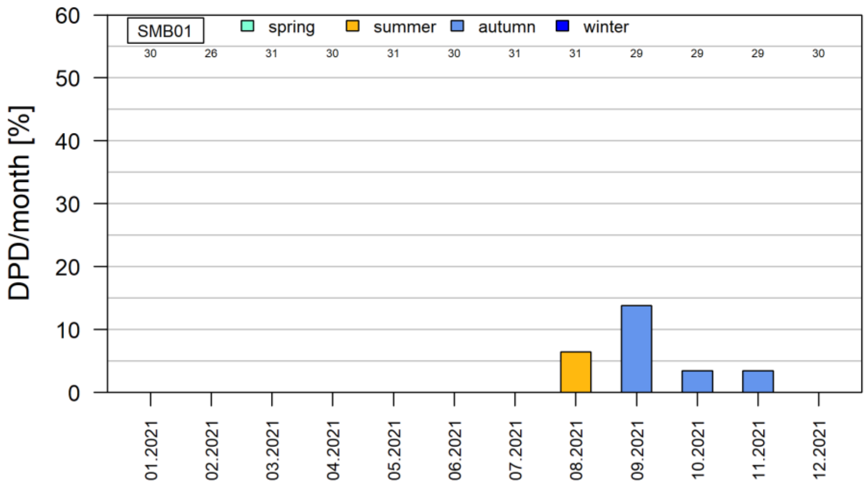

*Figure 3-4 Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB01. Number of days, where the C-POD recorded data are given above the bars. *no data*

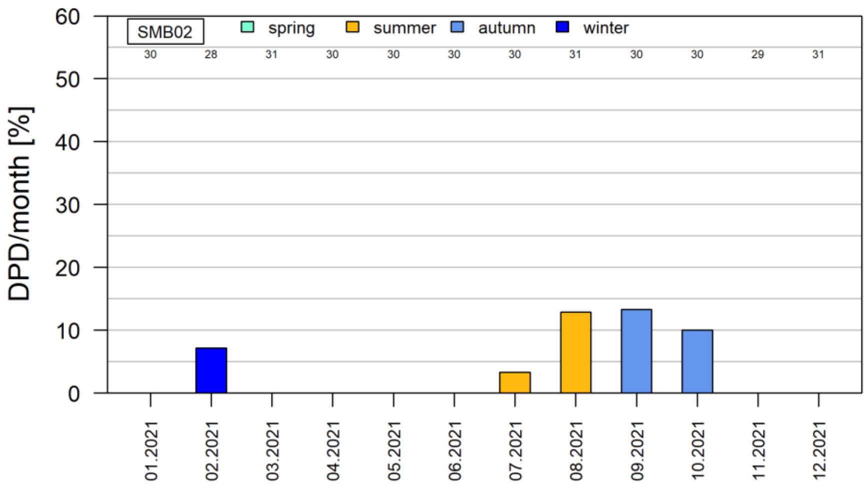

*Figure 3-5 Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB02. Number of days, where the C-POD recorded data are given above the bars. *no data*

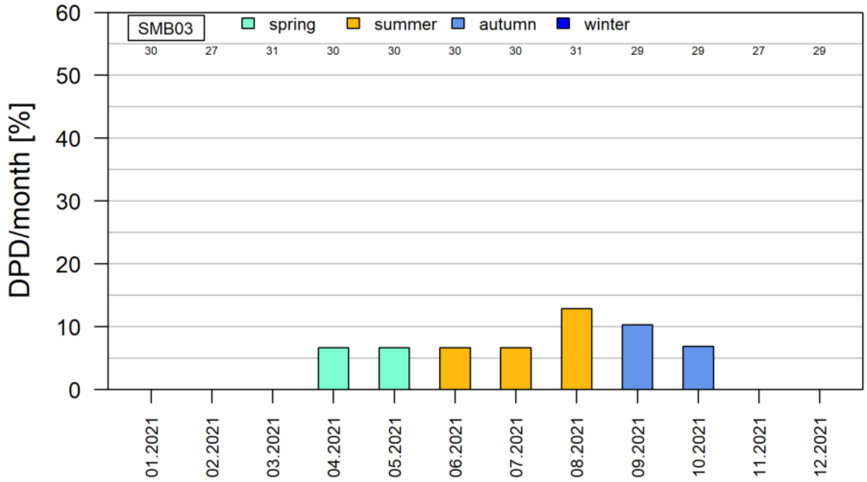

Figure 3-6 *Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB03. Number of days, where the C-POD recorded data are given above the bars. *no data*

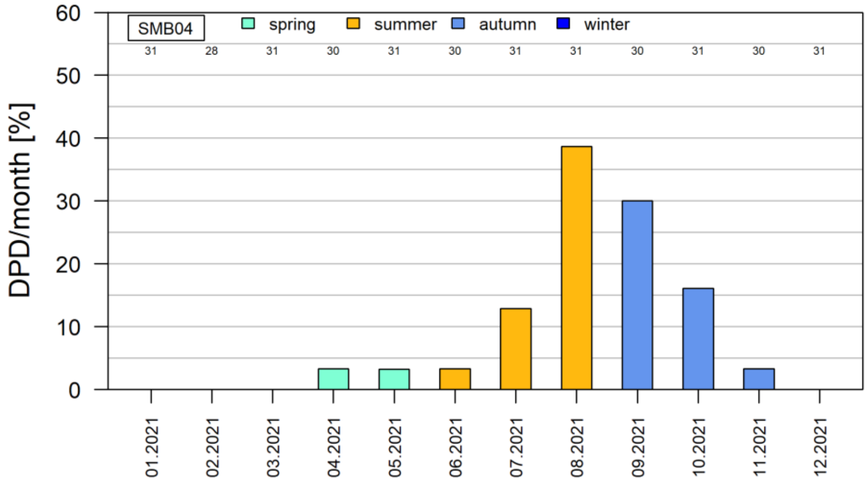

Figure 3-7 *Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB04. Number of days, where the C-POD recorded data are given above the bars. *no data*

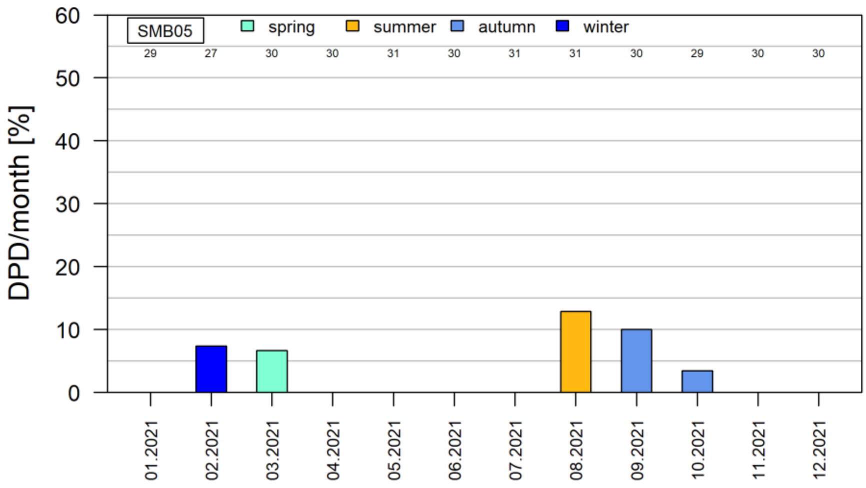

*Figure 3-8 Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB05. Number of days, where the C-POD recorded data are given above the bars. *no data*

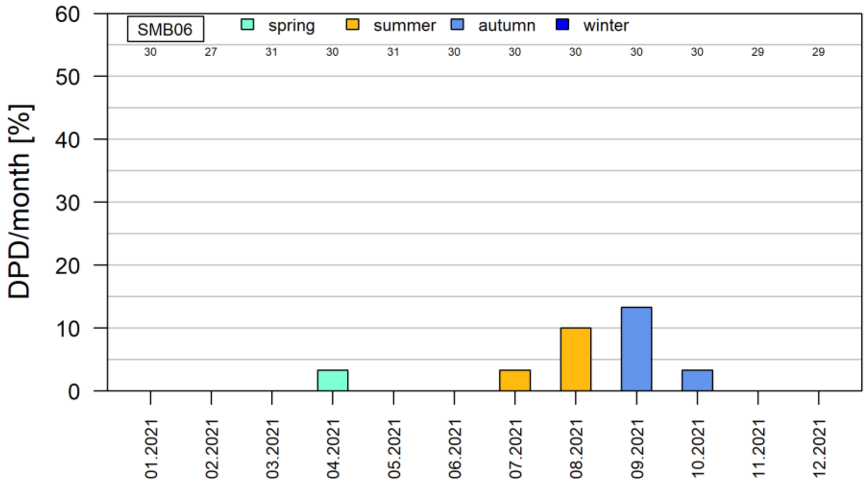

*Figure 3-9 Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB06. Number of days, where the C-POD recorded data are given above the bars. *no data*

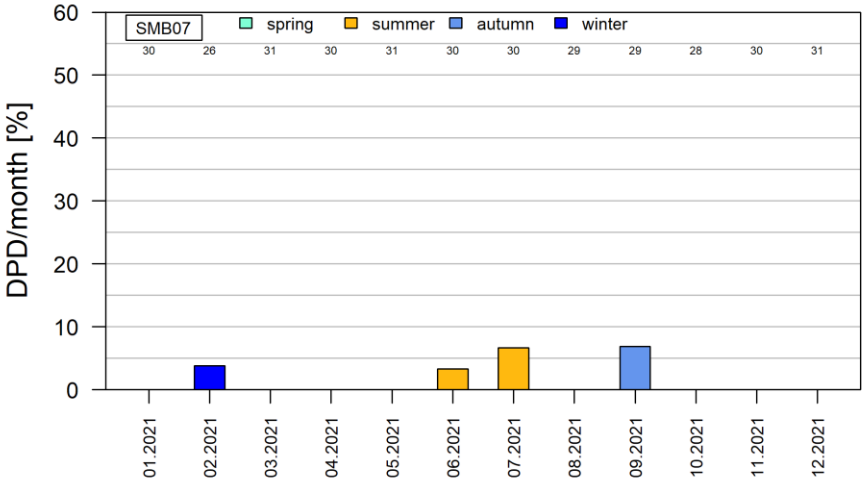

Figure 3-10 *Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB07. Number of days, where the C-POD recorded data are given above the bars. *no data*

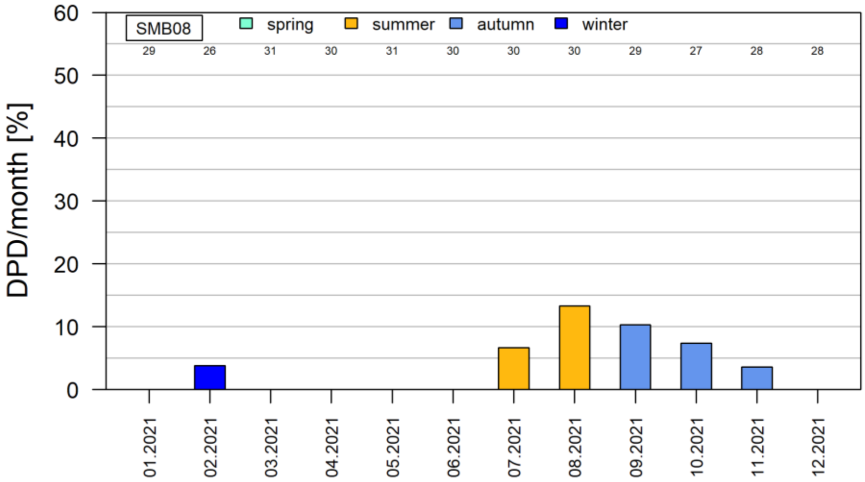

Figure 3-11 *Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB08. Number of days, where the C-POD recorded data are given above the bars. *no data*

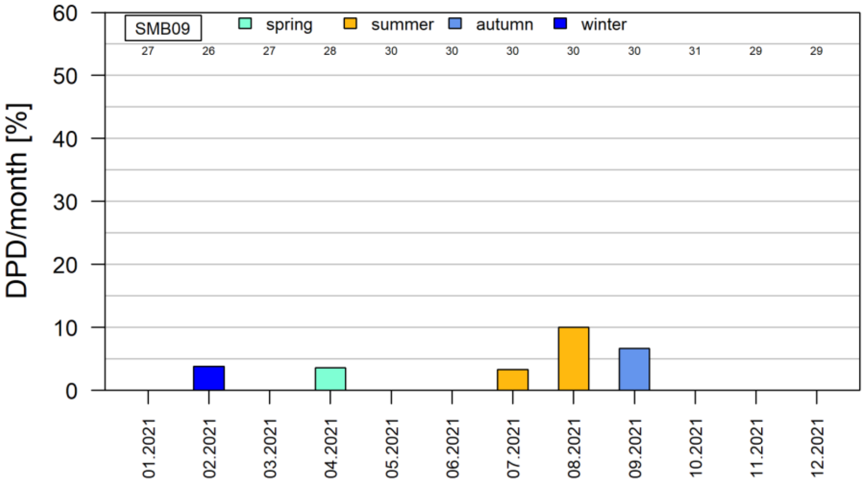

*Figure 3-12 Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB09. Number of days, where the C-POD recorded data are given above the bars. *no data*

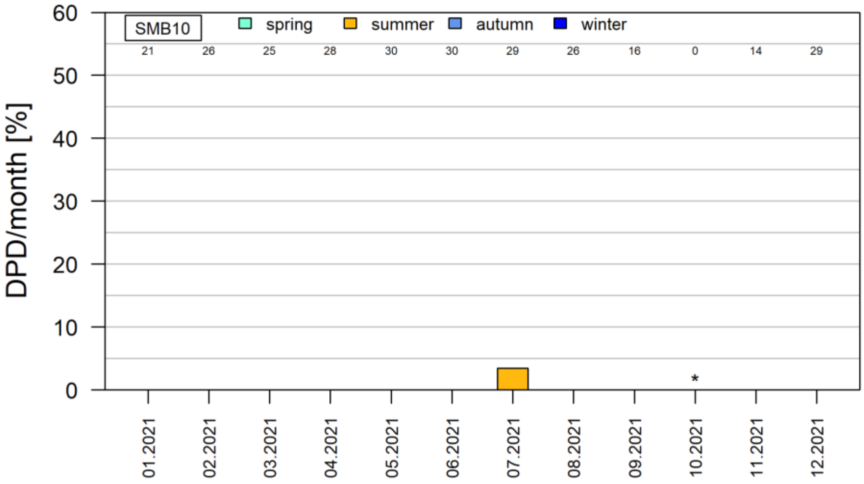

*Figure 3-13 Mean detection positive days (% DPD/month) at each month of the study period (January 2021 – December 2021) for C-POD stations SMB10. Number of days, where the C-POD recorded data are given above the bars. *no data*

At all stations there was a time period of several days without any porpoise detections. The number of minutes per day with harbour porpoise signals show, that in 49.6 % (49.5 % in 2020) of all days with positive porpoise detections, porpoises were only recorded within one of the 144 10-minute units per day. As in 2020 only at few days of the study period (in summer and autumn) more than 5 % DP10M/d were recorded at single stations: Four days in 2020 at stations SMB02 and SMB04, and three days in 2021 at stations SMB01 and SMB04.

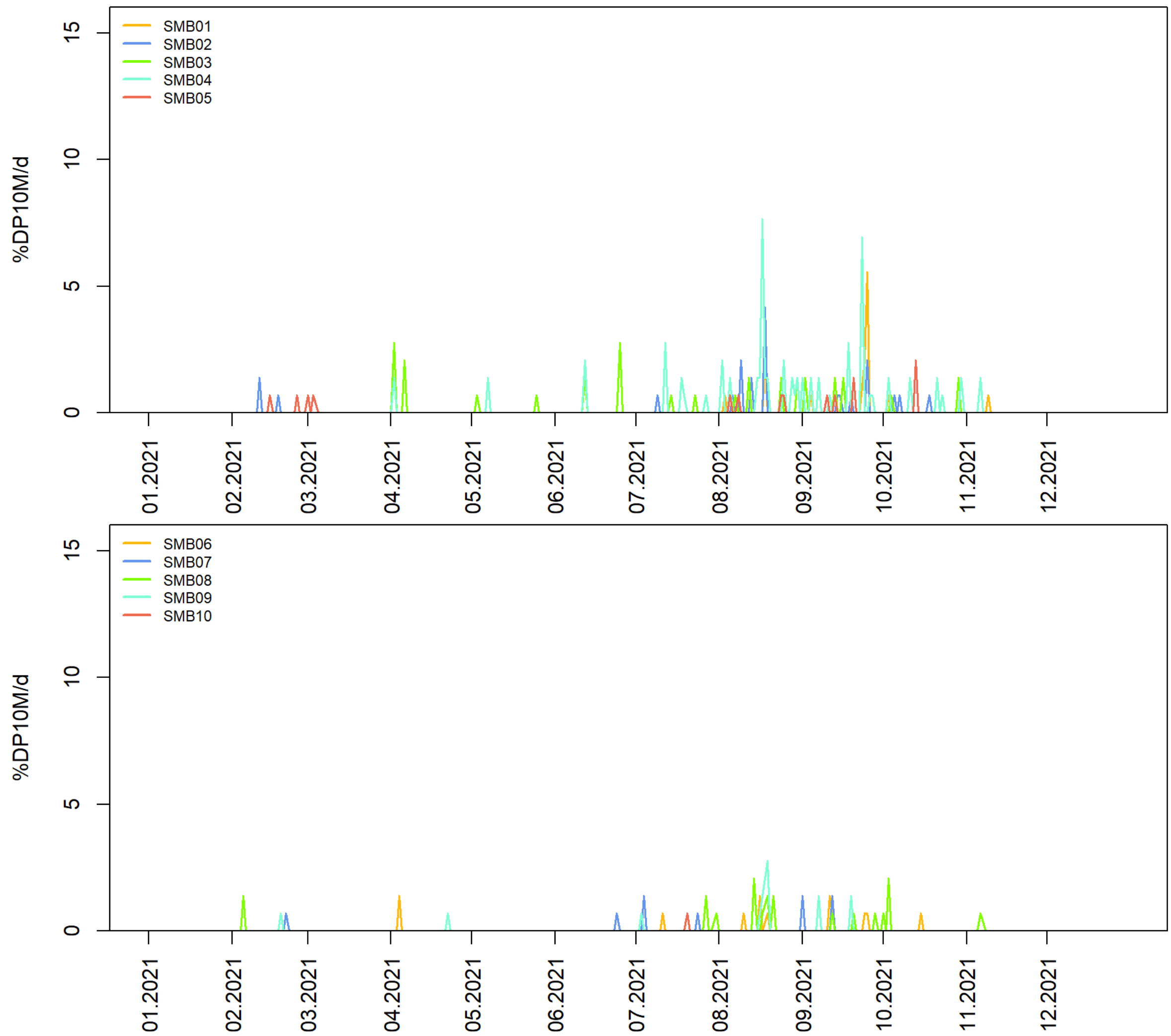

Figure 3-14 Development of the number of %DP10M/d at the C-POD stations. Given are moving averages over the entire period between 01.01. and 31.12.2021 (loess regression). Stations SMB01 to SMB05 are shown in the upper panel, SMB06 to SMB10 in the lower panel.

3.1.2 Day-night activity of harbour porpoises

Harbour porpoise detections at the respective POD stations over the study period of the survey year 2021 were investigated in order to check for a diel pattern (Figure 3-15). For this purpose, the DP10M/d harbour porpoise detection rates for the phases “day” and “night” were calculated per station. “Night” was defined as the time between civil twilight and civil dawn when the sun is at an angle of > 6° under the horizon. Consequently “day” was defined as the time between civil dawn and civil dusk when the sun is at < 6° under the horizon.

Out of all stations, where harbour porpoises were detected, three stations, SMB03, SMB04 and SMB08, showed slightly higher mean porpoise activity during daytime compared to night-time. At the other stations detection rates (%DP10M/d) were slightly higher during night. However, due to the generally very low detection rates at all stations, confidence intervals are very high, such that potential differences need to be treated carefully.

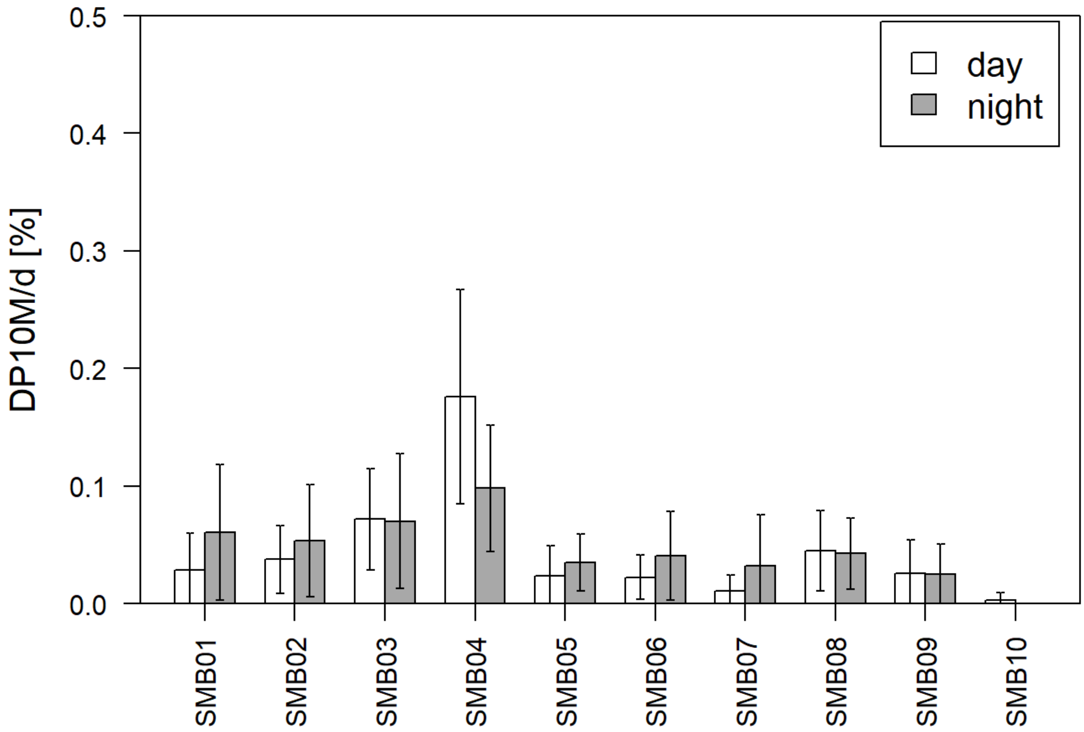

Figure 3-15 *Pattern of harbour detections according to time of day at all POD stations over the entire study period (January 2021 to December 2021). Detection rates (%DP10M/d) at each station of SMB during daylight hours (white bars) and during night-time (grey bars) with confidence interval are given.*

3.2 Comparison of the C-POD classifiers KERNO and Hel1

As expected, porpoise detections were reduced by the Hel1 classifier as compared to the KERNO classifier at all ten stations (Figure 3-16). On average 38 % of the detections (DPD) were classified as “false positives” by the Hel1-classifier, but the overall pattern across stations remains the same, except for SMB01, where the KERNO classifier identified more harbour porpoise positive days than at station SMB02, whereas by applying the Hel1-classifier the numbers of DPD at the two stations are equal.

The application of the Hel1-classifier enables a better comparison with the results of the SAMBAH study where this classifier was used, but for showing seasonal patterns, it does not matter which classifier is used, since it can be assumed that the error is equal at all stations at all time (Figure 3-16). As the difference in DPD between the two classifiers at station SMB01 was proportionally higher than at the other stations, click trains were visually verified at this station, resulting in the identification of some “false positives” in the KERNO classifier, which reduces the actual difference in DPD between the two classifier at SMB01.

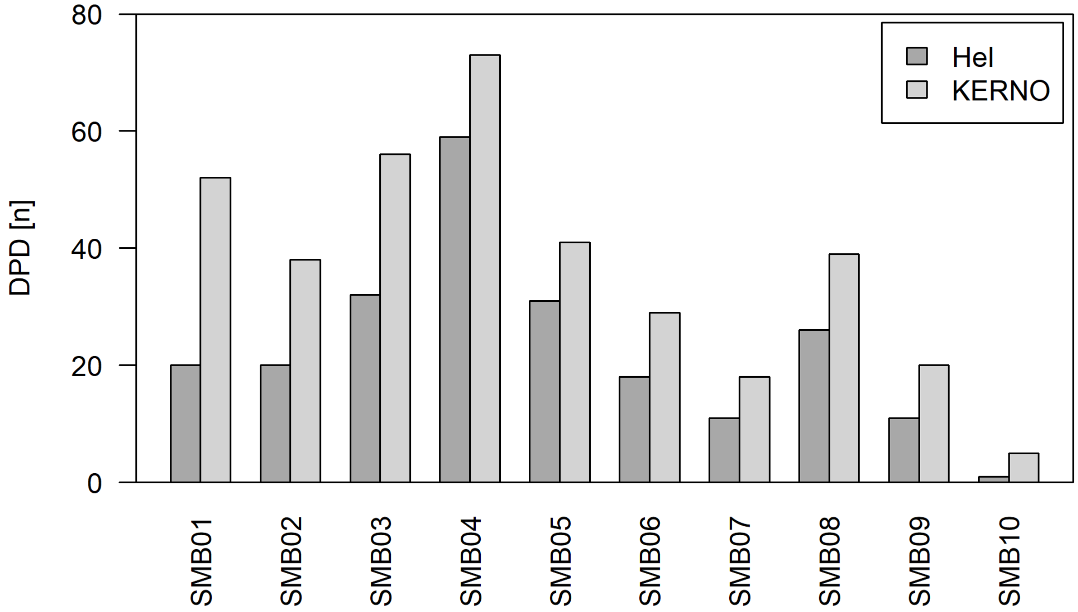

Figure 3-16 Number of detection positive days (DPD) at each Station from January 2021 – December 2021 classified according to the KERNO (light grey) and the HEL1- classifier (dark grey).

4 DISCUSSION

4.1 Survey method passive acoustic monitoring (PAM)

Harbour porpoises almost continually use echolocation for orientation and target location (AKAMATSU ET AL. 2007; WISNIEWSKA ET AL. 2016). Studies comparing the C-POD PAM results to visual observations at the same time (KYHN ET AL. 2012; WILLIAMSON ET AL. 2016; JACOBSON ET AL. 2017; SCHUBERT ET AL. 2018) were able to show that the results of acoustic monitoring correspond to absolute densities. Based on a comparison of telemetric data of harbour porpoises and C-POD recordings in the Baltic Sea around the island of Rügen, Germany, a study of MIKKELSEN et al. (2016) showed that both data sets correlated with each other. The more tagged animals were present in an area, the higher were the detection rates recorded in this area. In the past, PAM data recorded using C-PODs have proven to be informative in terms of habitat use of harbour porpoises (TOUGAARD ET AL. 2009; BIOCONSULT SH & BIOLA 2010; BRANDT ET AL. 2011, 2018; DÄHNE ET AL. 2013; WOLLHEIM ET AL. 2013; DIEDERICHS ET AL. 2014). One of the advantages of this method is the very high temporal resolution. Data are recorded exact to the millisecond. Therefore, even temporally small-scale patterns can be investigated. Furthermore, C-PODs can continually record data, a major advantage in comparison to other survey methods like aerial or ship-based surveys. This produces quantities of data, which allow for robust statistical analyses. In areas with a low presence of harbour porpoises like the study area of the present study, recordings of echolocation signals are the only method to obtain a sufficiently large amount of data to allow for statements about the distribution and presence of harbour porpoises. Furthermore, C-PODs also record harbour porpoises at night whereas aerial and ship-based surveys are limited to daylight. A disadvantage of the PAM method is the small spatial coverage. The detection range of a C-POD is only about appr. 300 metres, and the probability of recording a porpoise present depends on the direction of the harbour porpoise click. Only deployment of several C-PODs at different locations, like in the present study, allows for statements about the spatial distribution of harbour porpoises.

The comparison of the KERNO and HEL1 classifier could show that the HEL1 classifier is more sensitive and thus classified more detections as “false positives” than the KERNO classifier. Using the data classified by the HEL1 classifier enables a more appropriate comparison between data generated in the present study and results from other studies in this area of the Baltic Sea (e.g. data from the SAMBAH project), which generally used the HEL1 classifier.

4.2 Harbour porpoises in the study area

Presence and distribution in the study area

Harbour porpoise detection rates (%DPD) recorded at the ten stations in the study area were generally very low, which is in line with the results gained in 2020. It has to be kept in mind that in the North Sea in the German Bight, detection rates of up to 100 %DPD/study period or 10 to 40 %DP10M/study period were usually found (BIOCONSULT SH & BIOLA 2010; ROSE ET AL. 2014, 2019; BRANDT ET AL. 2018), i.e. harbour porpoise detections there are considerably higher than in the study area of the present study. Also in the more westerly parts of the Baltic Sea higher porpoise detection rates of up to 100 %DPD/month were reported (e.g. GALLUS & BENKE 2014; MIKKELSEN ET AL. 2016;

SAMBAH 2016; SCHULTZE ET AL. 2017). The maximum detection rate was measured at SMB04 with 38.74 %DPD/month in August 2021. Detection rates generated from the C-POD data cannot directly be transferred into absolute densities. However, comparisons between data derived from T-PODs (earlier version of the C-PODs) and aerial data in the German Baltic Sea indicate that DPD below 35 % correspond to a density less than 0.1 Ind./km^2 (SIEBERT & RYE 2008). Thus, the detection rates measured in August 2021 at Station SMB04 could indicate a density of around 0.1 Ind./km^2. However, the comparison of SIEBERT & RYE (2008) is based on mean values of several C-POD stations. During the present study the mean %DPD in August across all stations was 11.72 %DPD/month, which therefore suggests a lower density than 0.1 Ind./km^2 within the present study area.

Also, the detection positive 10-minute blocks only differed hardly between the study period in 2020 and the present time frame (0.04 %DP10M in 2020 and 0.05 %DP10M in 2021) as well as the % hours with positive detections (%DPH), which was also slightly higher in the measurement period 2021 (0.19 %DPH) than 2020 (0.16 %DPH), but with negligible differences. Thus, the data analysis conducted so far suggests that the general presence of harbour porpoises in the area was at comparable levels in 2020 and 2021.

Generally, as in 2020 harbour porpoise presence was not evenly distributed across the study area in 2021 and differed slightly between positions. Compared to detection rates measured in the eastern Baltic Sea (CARLÉN ET AL. 2018), the differences within the project area are on a rather minor scale. As in 2020 the highest detection rates were measured at station SMB04, while they were slightly higher in 2021 than in 2020: 9.32 %DPD and 7.23 %DPD, respectively. This equals 34 days with at least one positive porpoise detection in 2021 and 24 days in 2020.

Due to the generally low harbour porpoise detection rate and a rather short investigation period of only two seasonal cycles (February 2020 to January 2022), no further assumptions can be made about preferences of harbour porpoises within the study area.

As part of the EU LIFE+ project SAMBAH C-PODs were deployed at more than 300 stations covering a big part of the Baltic Sea and collecting data from April 2011 until June 2013 (AMUNDIN ET AL. 2022). The data of eight of the C-POD stations located in the wider vicinity of the preliminary project area (Figure 4-2) were provided by the SAMBAH representatives for being able to compare the results gained in the present report with harbour porpoise detections from 2011 – 2013. Two of the C-POD positions used for the present study match with two former SAMBAH locations (SMB02 = 1027 and SMB10 = 1028). Furthermore, there is an ongoing Swedish national monitoring program for harbour porpoises in the Baltic Sea, where a subset of previous C-POD stations of the SAMBAH project is recording harbour porpoise detections. Depending on the station, data are available for download at SHARKweb (https://sharkweb.smhi.se), run by the Swedish meteorological and hydrological institute (SMHI), from March 2017 to September 2020, respectively (Figure 4-3 to Figure 4-6). However, the data is not directly comparable, as no information about background noise, click limit and recording duration per day is available.

The mean %DPD/month at station 1027 (2.28 %DPD, Figure A-3) from the SAMBAH project (2011-2013) is in the same scale as the detection rates measured during the present study at station SMB02 (1.55% DPD in 2020 and 3.89 %DPD in 2021). Detection rates at station 1028 (SMB10, respectively) are on a lower scale during the study period 2011-2013 (0.98 %DPD/month, Figure A-4) as well as during the present study period in 2020-2021 (0.00 % and 0.36 %DPD/month respectively). According to the results from the eight SAMBAH stations, the presence in the wider area is at a comparable level to the results gained in the present project (2020-2021) (Figure 4-6), with only station 1036 being an exception, which will be described and discussed in the subsequent paragraph. The average detection rate of the eight SAMBAH stations of 1.74 %DPD is somewhat lower than the average detection rate measured in the present study (3.45 %DPD), but in both cases harbour porpoises were detected on a rather low level compared to areas in the western Baltic Sea (e.g. GALLUS & BENKE 2014; MIKKELSEN ET AL. 2016; SAMBAH 2016; SCHULTZE ET AL. 2017), indicating that the detection rates observed in the present study are typical for the area. However, it has to be noted that during the recordings for the SAMBAH project, many months without recordings occurred. Therefore, and due to the low detection rates and the high number of months without any detection (in SAMBAH as well as in the present study), only assumptions can be made and no further statement about phenology can be provided.

Compared to the other seven SAMBAH stations (Figure A-1 to Figure A-8) and the stations of the previous report, station 1036 (appr. 40 km north of the present study area) showed exceptionally high detection rates up to almost 90 %DPD/month from spring to late autumn in 2011 and 2012. This pattern also continues during the Swedish national monitoring program between 2017 and 2020 (Figure 4-5), when detection rates at position 1036 were again quite high with on average 52.54 % DPD/month (Figure 4-4 and Figure 4-5). In contrast, at position 1026 further south (appr. 25 km north of the present study area), detection rates were on average only 2.46 % DPD/month, which is in the same range as average detection rates found in the present study (3.45 %DPD/month).

Our results and the detection rates at the single stations of the SAMBAH project and the Swedish national monitoring program display certain distribution patterns and give slight indications that in summer areas with higher densities and more frequent use might be located further north than the study area. The study area is located within the approximate distribution area of the Baltic Proper management unit east of the suggested delimitation border to the Belt Sea management unit. Recent research, however, suggest a transition area around the delimitation border, where the distribution of the two management units is thought to overlap, which reaches from around the island of Rügen to the east of the island of Bornholm (CARLÉN ET AL. 2021; Figure 4-1) and results from satellite tracked individuals showed that single animals from the Belt Sea may enter the area east of the island of Bornholm (SVEEGARD 2011). Thus, it cannot be excluded that individuals detected in the survey area are belonging to the Belt Sea management unit.

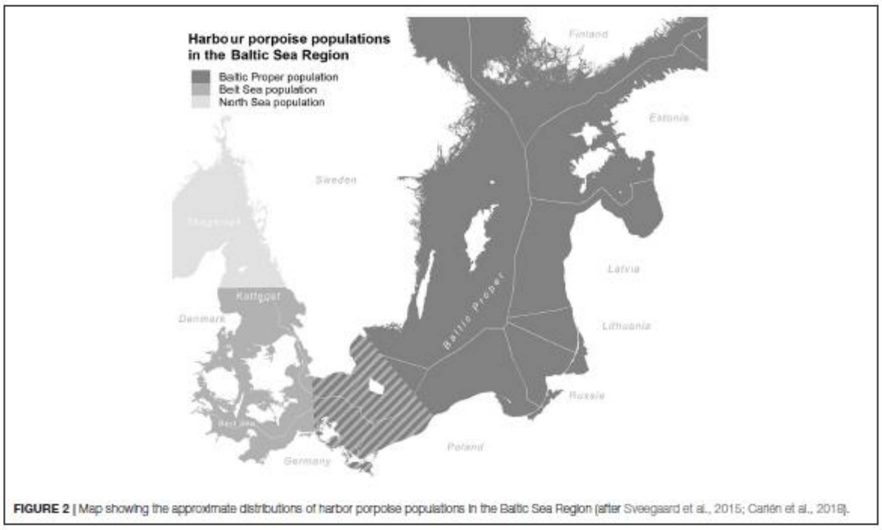

Figure 4-1 Area of approximate distribution of harbour porpoise management units in the Baltic Sea. The dashed grey area represents the area where the distribution of the Baltic proper management unit and Belt Sea management unit are thought to overlap. Source: (CARLÉN ET AL. 2021)

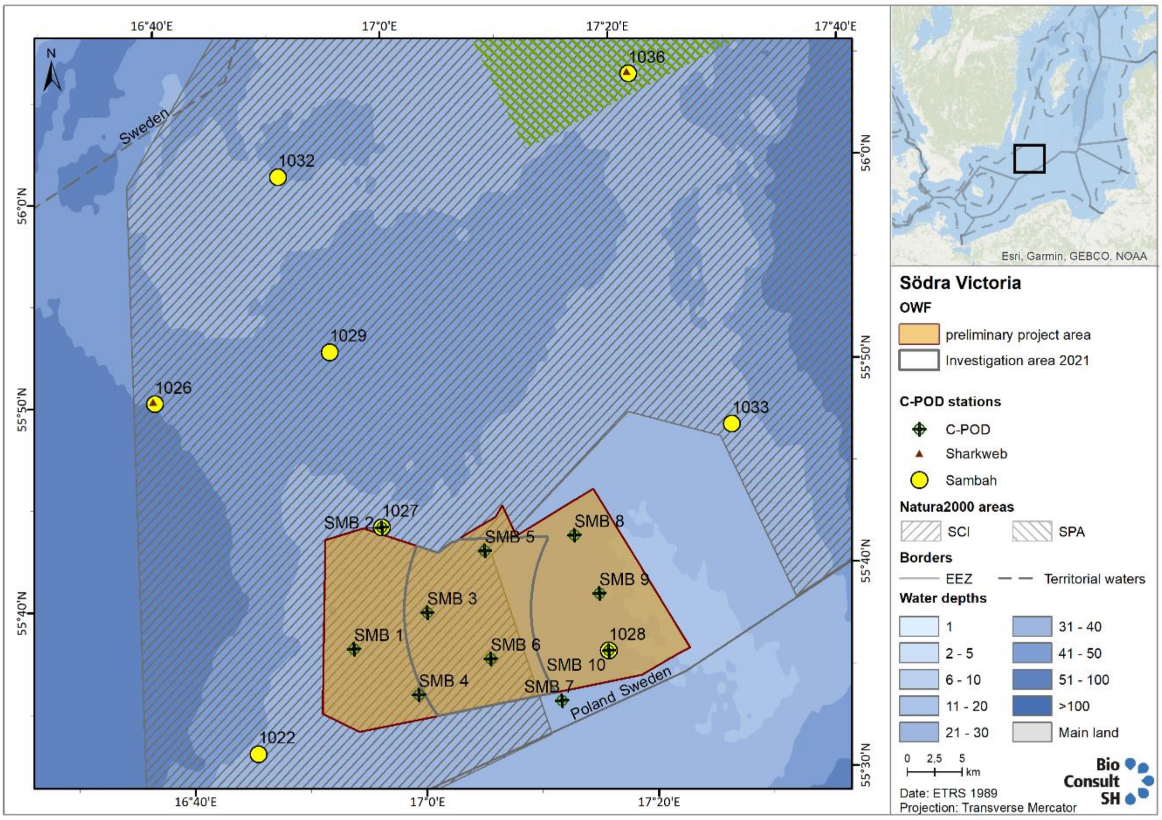

Figure 4-2 Positions of former SAMBAH stations from 2011 - 2013 (yellow dots), stations from the Swedish national monitoring program 2017 - 2020 (red triangles) and C-POD stations of the present project (green crosses).

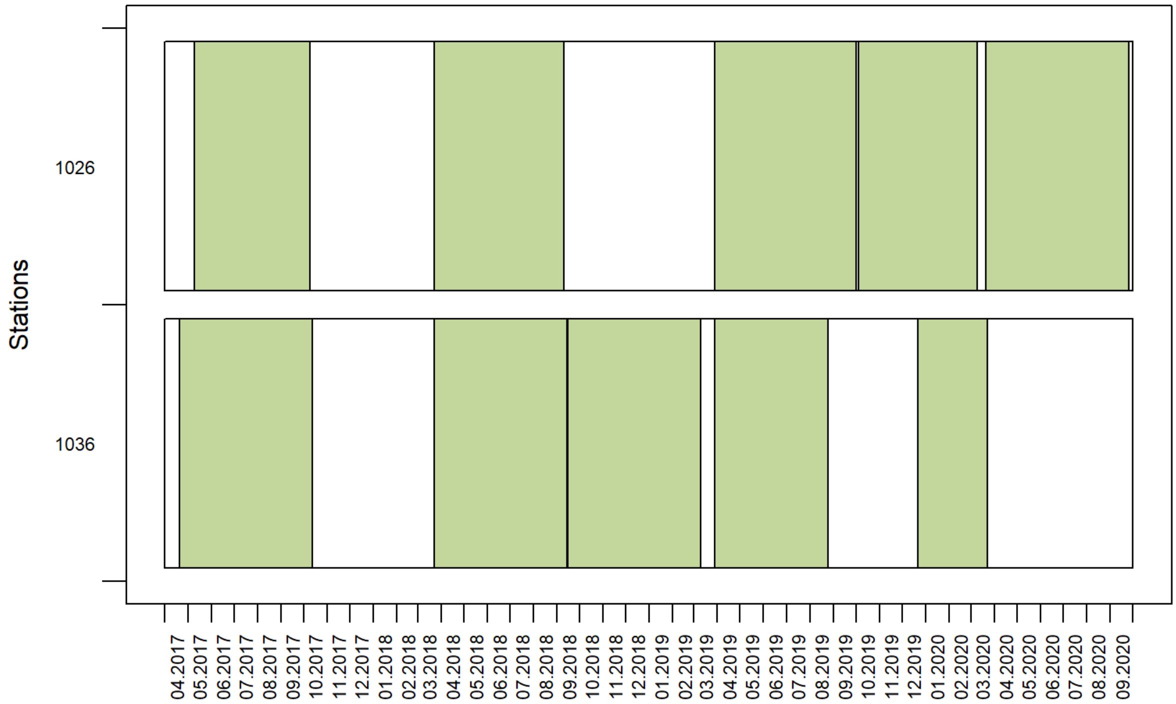

Figure 4-3 *Bar chart, indicating the duration of deployment of the C-PODs of the Swedish national monitoring program for the time period available at the database (April 2017 to November 2020). Green: POD recorded data, white: POD was deployed but did not record data or C-POD was not deployed. The x-axis shows the date, the y-axis the POD station.*

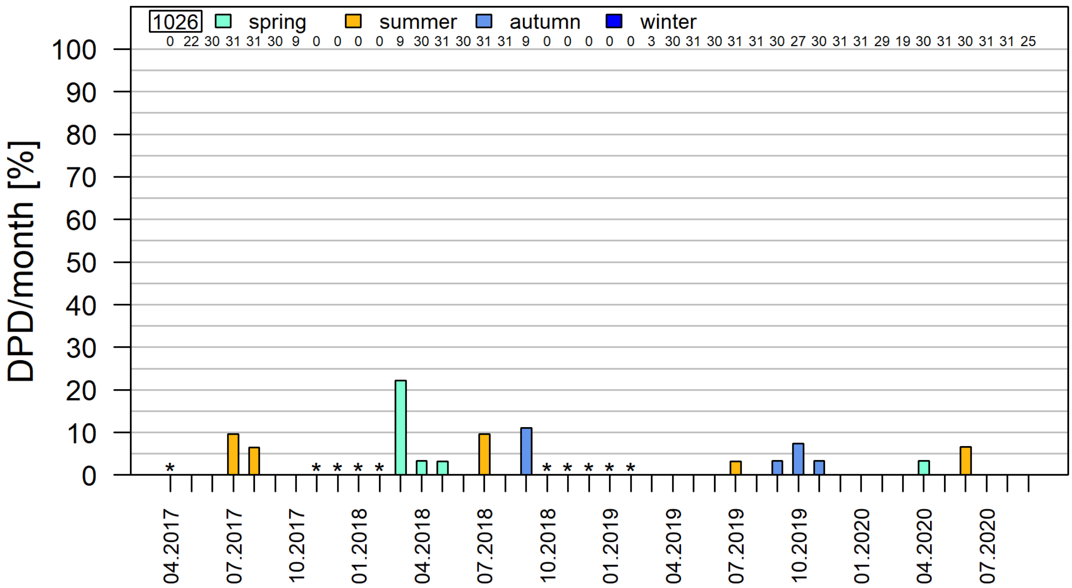

Figure 4-4 *Monthly detection rates (%DPD/month) at station 1026 from the Swedish national monitoring program from April 2017 to October 2020 (the time frame of available data from the database). Seasons are colour coded. These values show rawdata and are not corrected for noise as the C-POD data from the current study.*

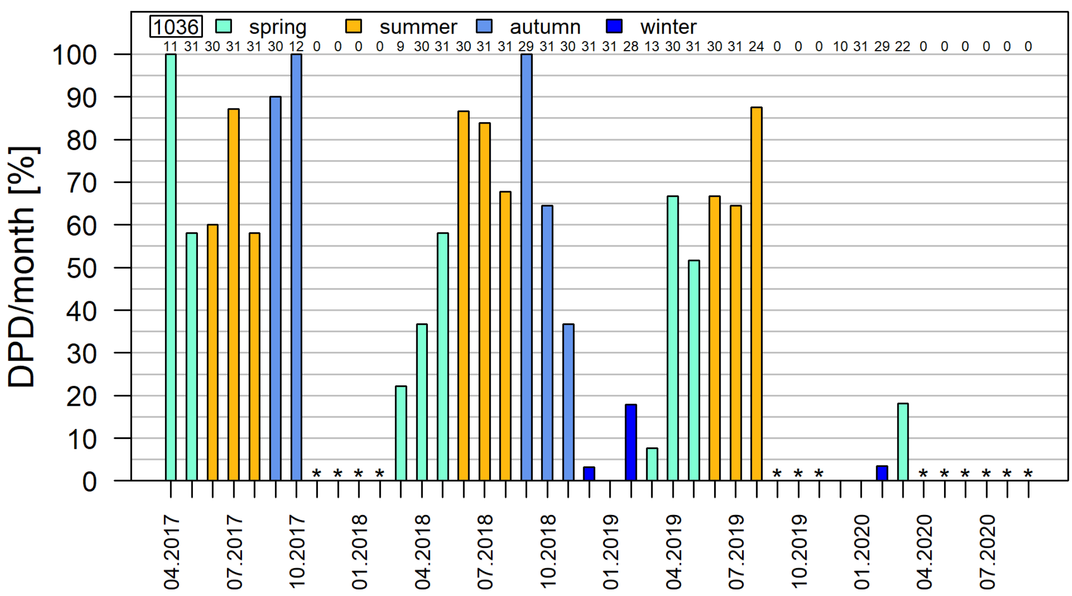

Figure 4-5 *Monthly detection rates (%DPD/month) at station 1036 from the Swedish national monitoring program from April 2017 to October 2020 (the time frame of available data from the database). Seasons are colour coded. These values show rawdata and are not corrected for noise as the C-POD data from the current study.*

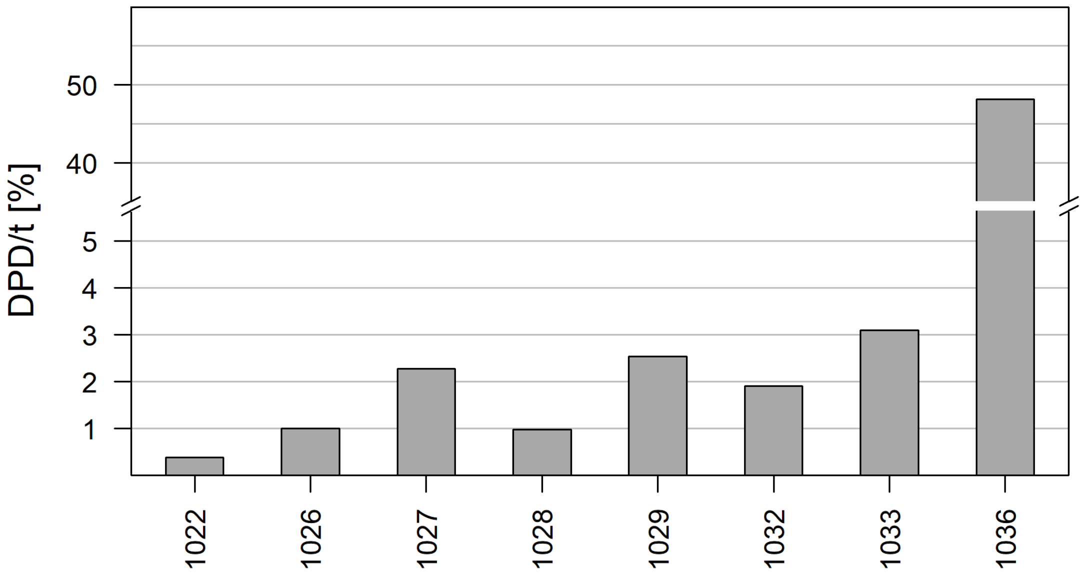

Figure 4-6 *Mean detection rates (%DPD/month) at the former SAMBAH stations in the wider vicinity of the preliminary project area from April 2011 to July 2013.*

Seasonal and diel patterns

In the study area harbour porpoises showed the highest presence in late summer and/or autumn, which is in line with the results of the SAMBAH study (Figure A-1 to Figure A-8) (CARLÉN ET AL. 2018), only in 2011 at station 1036 the detection rates reached comparably high values in spring. As detection rates were generally very low (Figure 3-1) no station specific phenological pattern could be defined, but when averaged over all stations the seasonal pattern becomes visible. Since porpoise detections at different positions did not match in time and detections mostly occurred only within one 10-minute period of a day, it can be suggested that the animals entered the area rather sporadically, either passing the area or staying for only a short period of. While there were only few or almost no detections in late autumn and winter, which could also be seen in the data from the single SAMBAH stations, it can be assumed that harbour porpoises leave the area at least to an extent to reduce the detection possibility close to zero. This may be triggered by food resources of seasonally differing quality or availability (VAN BEEST ET AL. 2018) and/or locally occurring hydrological factors (which in fact also governs food availability). The area is known as a spawning area for Baltic cod and sprat (2017), both species being prey for harbour porpoise (AAREFJORD ET AL. 1995; ANDREASEN ET AL. 2017). Sprat and cod usually spawn from April to August and over the summer months, respectively (VOSS ET AL. 2011). In the adjacent Bornholm basin sprat aggregations could be identified in other seasons as well e.g. in October (VOSS ET AL. 2011), which could be one possible reason for the elevated harbour porpoise abundance from summer until October in the present study.

Although the survey area of the present study was found to have very low harbour porpoise presence, harbour porpoises were detected every month at least at one station, except January and December 2021. During the survey year from February 2020 to December 2020, no harbour porpoises were detected in November, indicating that the area is not highly frequented in late autumn and early winter. Despite the overall very low density, the results from 2020 and 2021 indicate regular presence of harbour porpoises in this area. Even though there are higher detection rates also in Polish and Lithuanian waters during some months (DHI 2015), the highest abundance of individuals of the Baltic Proper population seems to occur in Swedish waters around the banks south of the islands of Öland and Gotland (CARLSTRÖM & CARLÉN 2016; CARLÉN ET AL. 2018). Results of the SAMBAH project show a shift in the seasonal harbour porpoise presence west of the study area. The authors of the study recommend the summer population delimitation line towards the east of the island of Bornholm (SAMBAH 2016; CARLÉN ET AL. 2018). It is assumed that at least the animals present in the study area from May to October are part of the Baltic proper sub-population (management unit), whereas the management units cannot be clearly separated during the rest of the year, according to the findings of the SAMBAH project (CARLÉN ET AL. 2018). A seasonal migration of harbour porpoises of the Baltic Proper management unit may occur as harbour porpoises leave areas with a high risk of ice formation returning as soon as the risk had passed (TEILMANN & LOWRY 1996). This will probably not be the only factor leading to seasonal migration of harbour porpoises, but so far, no further factors have been identified. This is of importance as the Baltic Proper population is critically endangered according to the IUCN (HAMMOND ET AL. 2008), prohibiting any additional disturbance, which may threaten this population any further.

The probability maps from the SAMBAH project show that highest probability of detection in the wider area around "Södra Victoria" occurs in February, from April on until August, and in October (CARLÉN ET AL. 2018, Fig. 3), which is partly reflected by the results of the single SAMBAH stations in the area (Figure A-1 to Figure A-8). The present study partially confirms these findings, with higher detection rates in February than March to June and increasing detection rates until September 2021, which are then decreasing towards winter. The pattern showed only slight differences to the observations from 2020. A major difference between the phenology of the present study and the results of the SAMBAH project (2011 – 2013) is displayed in the detection rates measured in September. There was a high data loss during the SAMBAH project at the stations analysed for the present study in September, still the C-PODs recording in September, detected only few or no harbour porpoises between 2011 and 2013 (Figure A-1 to Figure A-8) and the modelled results by CARLÉN et al. (2018) thus show a low detection probability in September in the area. This contrasts with the detection rates in the present study in 2020 and 2021, as well as with the data obtained within the framework of the Swedish national monitoring program at the two stations considered in this study, where also during September comparably high detection rates occurred, assuming that during this month the presence of harbour porpoises is very likely in the area. According to the modelled results of the SAMBAH project, a low probability of detection was found from November to January (CARLÉN ET AL. 2018), a pattern, which is supported by the data of the Swedish national monitoring program and the results of 2020 and 2021, gained during this project.

Furthermore, the seasonal pattern is similar further north-east (Station 1036 SAMBAH and national Swedish monitoring program), but constantly high detection rates of >30% DPD/month between May and October 2011 to 2012 and >50 %DPD/month were recorded between April/May and October from 2017 to 2019 (no data available for this time period in 2020). This suggests that porpoise abundance is clearly higher further north in the area of Northern Midsea Bank, reaching maximum values of nearly 100 % DPD/month, which is known from areas in the North Sea and from the western Baltic Sea.

There was only a weak indication of a diel rhythm of harbour porpoise detections throughout the study area. Most of the stations showed tendency towards higher detection rates at night or an approximate equilibrium between day and night activity. Only at station SMB04, the station with the highest overall detection rates, the majority of detections were recorded during daytime, as in 2020. Overall, this pattern may suggest that the distribution and occurrence of the animals is caused by site-specific parameters. As the detection rates in the present study were on an overall very low level (with a high confidence interval), these are indications only and do not provide strong scientific evidence. The presence of suitable food resources (i.e. fish, WISNIEWSKA ET AL. 2016; VAN BEEST ET AL. 2018; ZEIN ET AL. 2019) as well as hydrographical parameters and sediment types (WILLIAMSON ET AL. 2017) can be assumed to be the most important parameters. However, since recent findings from a laboratory study suggest, that the higher activity during night time is not triggered by food-availability (OSIECKA ET AL. 2020), there is to date no single factor identified to fully understand diel patterns of harbour porpoises.

5 SUMMARY AND CONCLUSION

The present study was conducted on behalf of RWE Renewables Sweden AB in the preliminary project area of the OWF “Södra Victoria” to investigate the abundance of harbour porpoises in this area. Harbour porpoises were detected through Passive Acoustic Monitoring (PAM) at 10 C-POD stations, covering a time frame of 12 months in 2021 (January to December). The area is thought to be part of the habitat for the Baltic Proper management unit of harbour porpoises, which is estimated to consist of approx. 500 individuals and is classified as “critically endangered” by the IUCN.

As expected, the detection rates were low compared to the North Sea or more westerly areas of the Baltic Sea, which are inhabited by the Belt Sea management unit, which is estimated to consist of approx. 20,000 individuals. On only 3.45% of the possible detection days, harbour porpoise clicks were recorded at one of the C-POD stations. The highest yearly average of 9.3 %DPD/t was recorded at station SMB04, as also seen in the results from 2020 (7.2 %DPD/t). In general, across all stations no statistically significant difference between the detection rates in 2020 and 2021 could be found.

At all stations the majority of days with positive detections (%DPD/month) occurred during summer or autumn, while in winter (January and December 2021) harbour porpoises were not recorded at any station. Since in about 50 % of the detections, only one detection positive 10-minute block was recorded per day, harbour porpoises seem to use (or pass) the area sporadically rather than staying there for a longer period of time, which is supported by results gained in the previous report for 2020. This indicates that the area is used by porpoises as a transit area rather than as an important feeding ground. Furthermore, it could be shown that harbour porpoises were not present in the area all year round but visited this region during specific times of the year. Due to the scarcity of data, no clear statements about increased day or night activity could be made. These findings are in line with the overall picture generated in the SAMBAH project, where it was suggested that harbour porpoise abundance in the area of the Södra Midsjöbanken is shifted further to the southwest during winter, assuming that the animals leave the area at least to an extent to reduce the detection possibility close to zero due to the risk of sea ice formation.

It can be assumed that by far the availability of food is the main trigger for the distribution of harbour porpoises (SVEEGAARD ET AL. 2012; NABE-NIELSEN ET AL. 2013). The results from the previous report (February to December 2020), data from 2017 to 2020 of one station from the Swedish National Monitoring Program (available at https://sharkweb.smhi.se) in the vicinity of the preliminary project area and the average of seven stations from the SAMBAH project (2011 to 2013) located in the wider vicinity of the preliminary project area, show detection rates on a similar scale as investigated in the present study in 2021. On the other hand, one station located approx. 40 km to the Northeast of the study area, where data were collected during the SAMBAH project as well as in the ongoing Swedish national monitoring program, showed much higher detection rates over the course of the years 2011 to 2013 and 2017 to 2020, up to almost 100 % DPD/month, while in the present study the maximum detection rates did not exceed 38.71 %DPD/month. However, detection rates in the current study area are not in the lower range compared to other areas investigated within the SAMBAH project. Therefore, it can be assumed that the presence of harbour porpoises in the area varies strongly between seasons, yet on a lower scale than at station 1036 that was found to have higher porpoise abundance especially in summer.

6 SAMMANFATTNING OCH SLUTSATSER PÅ SVENSKA

Denna studie genomfördes på uppdrag av RWE Renewables Sweden AB i det preliminära projektområdet för vindkraftsparken "Södra Victoria" för att undersöka förekomsten av tumlare i området. Tumlare inventerades genom passiv akustisk övervakning (PAM) vid 10 C-POD-stationer, inom en tidsram på 12 månader 2021 (januari till december). Området tros vara en del av livsmiljön för Östersjötumlaren, som uppskattas bestå av cirka 500 individer och klassificeras som "kritiskt hotad" av IUCN.

Som förväntat var detektionsgraden låg jämfört med Nordsjön eller mer västliga områden i Östersjön, som är hemvist för Bälthavspopulationen, vilken beräknas bestå av cirka 20 000 individer. På endast 3,45 % av de möjliga detekteringsdagarna registrerades tumlareklick på någon av C-POD-stationerna.

Det högsta årliga genomsnittet var 9,3 %DPD/t (andel dagar med positiv detektion) vid station SMB04, vilket överensstämmer med resultaten från 2020 (7,2 % DPD/t). Sammantaget för alla 10 stationerna hittades ingen statistiskt signifikant skillnad i detektionsfrekvensen mellan 2020 och 2021.

På alla stationer inträffade de flesta dagar med positiva upptäckter (%DPD/månad, andel dagar med positiv detektion under en månad) under sommaren eller hösten, medan tumlare inte registrerades på någon station under vintern (januari och december 2021). Eftersom endast ett detekteringspositivt 10-minutersblock registrerades per dag i cirka 50 % av upptäckterna, verkar tumlare använda (eller passera) området sporadiskt snarare än att de stannar där under en längre tid, vilket stöds av resultaten i den tidigare rapporten för 2020.

Resultatet indikerar att området används av tumlare som transitområde snarare än som en viktig födosöksplats. Dessutom kunde det visas att tumlare inte fanns i området året runt utan besökte denna region under vissa tider på året. På grund av bristen på data kunde inga tydliga uttalanden om ökad dag- eller nattaktivitet göras. Dessa resultat ligger i linje med den helhetsbild som framgick av SAMBAH-projektet, där det föreslogs att förekomsten av tumlare i Södra Midsjöbankens område flyttas längre åt sydväst under vintern, troligen för att djuren lämnar området på grund av risken för havsisbildning.

Den överlägset viktigaste faktorn bakom närvaron av tumlare kan antas vara tillgången på föda (SVEEGAARD et al. 2012; NABE-NIELSEN et al. 2013). Resultaten från den tidigare rapporten (februari–december 2020), uppgifter från 2017 till 2020 från en station inom det nationella övervakningsprogrammet (tillgänglig vid https://sharkweb.smhi.se) i närheten av det preliminära projektområdet och genomsnittet av sju stationer från SAMBAH-projektet (2011–2013) som ligger lite längre bort från det preliminära projektområdet, visar alla detektionsfrekvenser i liknande skala som undersökningarna i denna studie 2021. Å andra sidan visade en station som ligger ca 40 km nordost om studieområdet, där data samlades in under SAMBAH-projektet samt i det pågående svenska nationella övervakningsprogrammet, mycket högre detektionsfrekvens under åren 2011–2013 och 2017–2020, upp till nästan 100 % DPD/månad medan den maximala detektionsfrekvensen i denna studie inte överskred 38.71 %DPD/månad.

Jämfört med andra områden som undersökts i SAMBAH-projektet är dock detektionsfrekvenserna i det aktuella undersökningsområdet inte i det nedre spannet. Därför kan man anta att närvaron av tumlare i området varierar kraftigt mellan olika säsonger, om än på en lägre nivå än station 1036 som visat sig ha en högre tumlartäthet, speciellt under sommaren.

7 LITERATURE

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A APPENDIX

A.1 Monthly detection rates at stations deployed during the SAMBAH project

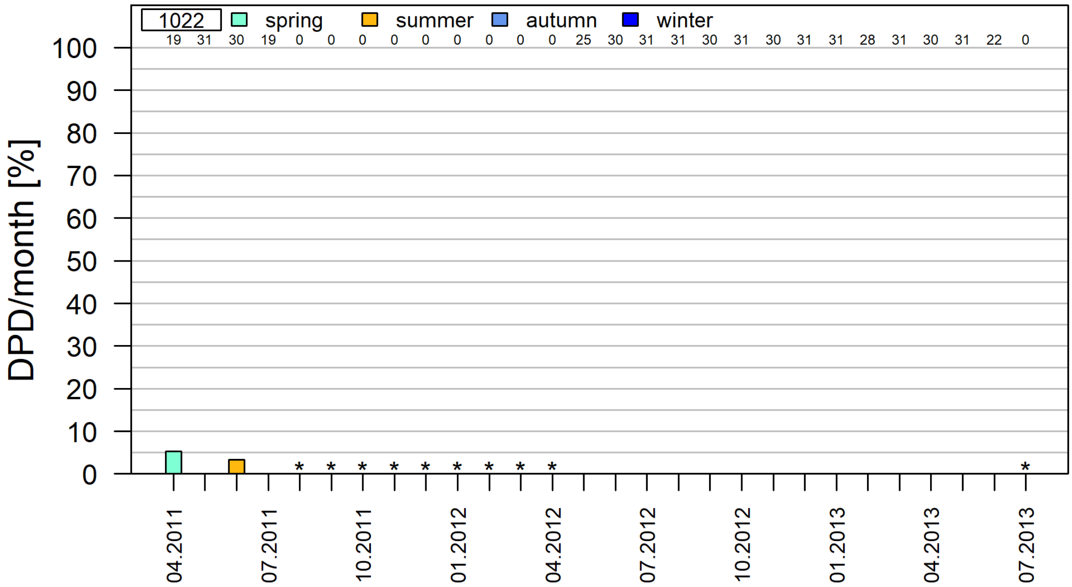

Figure A-1 Monthly detection rates (%DPD/month) at the SAMBAH station 1022 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).

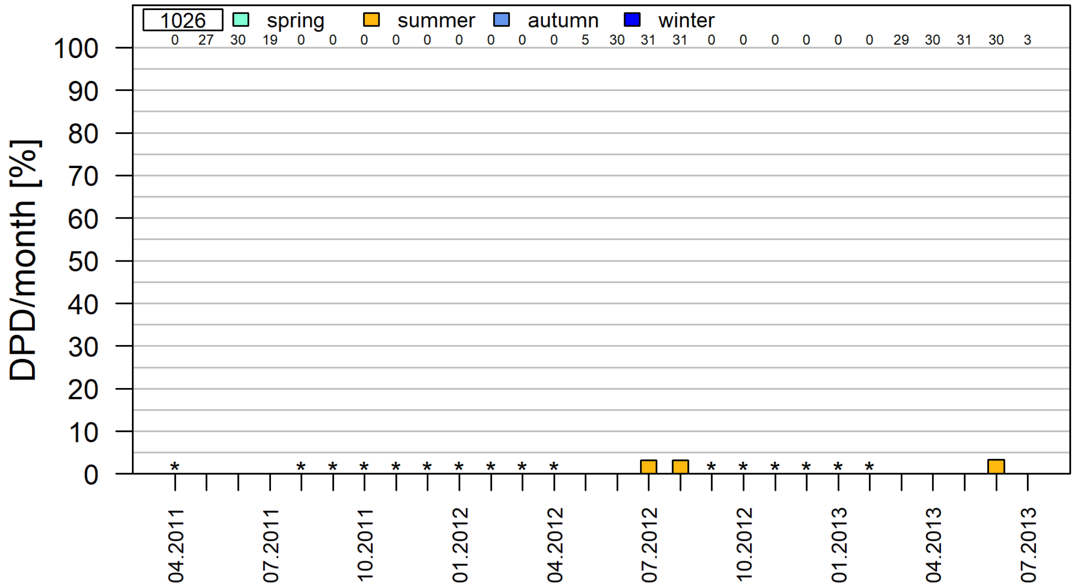

Figure A-2 *Monthly detection rates (%DPD/month) at the SAMBAH station 1026 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).*

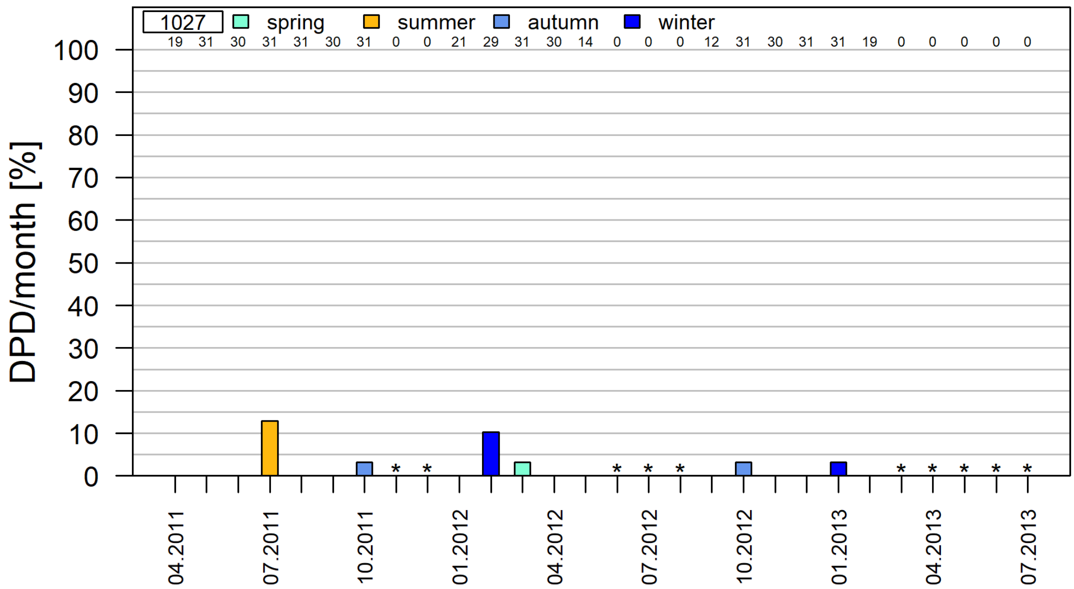

Figure A-3 *Monthly detection rates (%DPD/month) at the SAMBAH station 1027 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).*

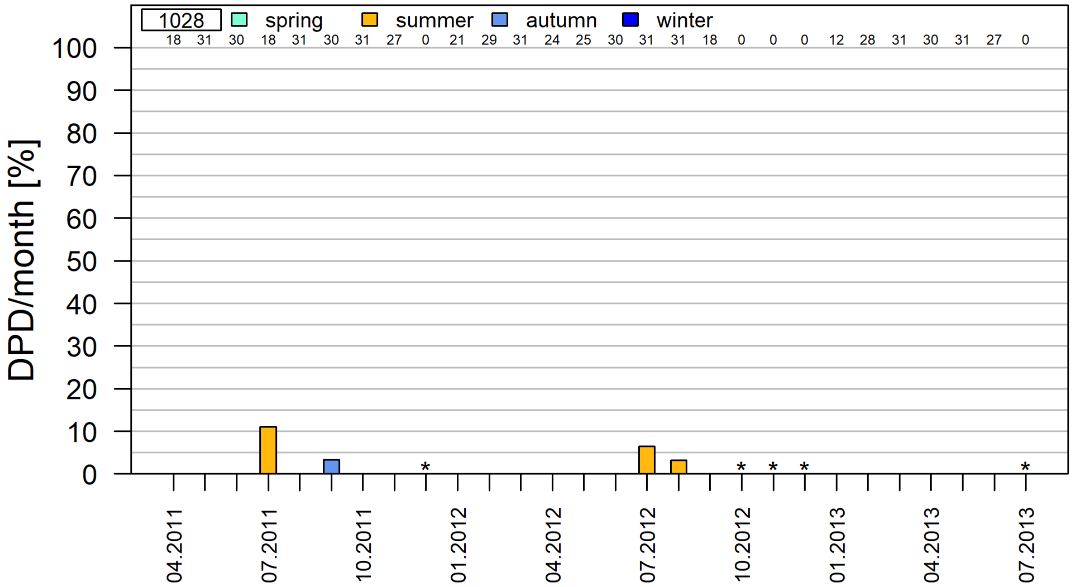

Figure A-4 Monthly detection rates (%DPD/month) at the SAMBAH station 1028 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).

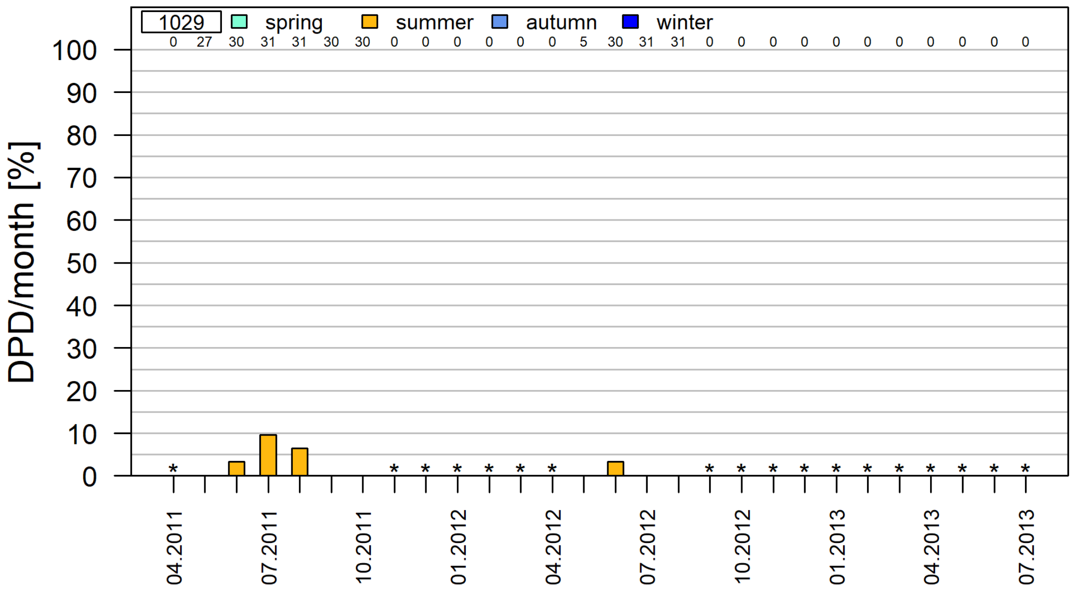

Figure A-5 Monthly detection rates (%DPD/month) at the SAMBAH station 1029 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).

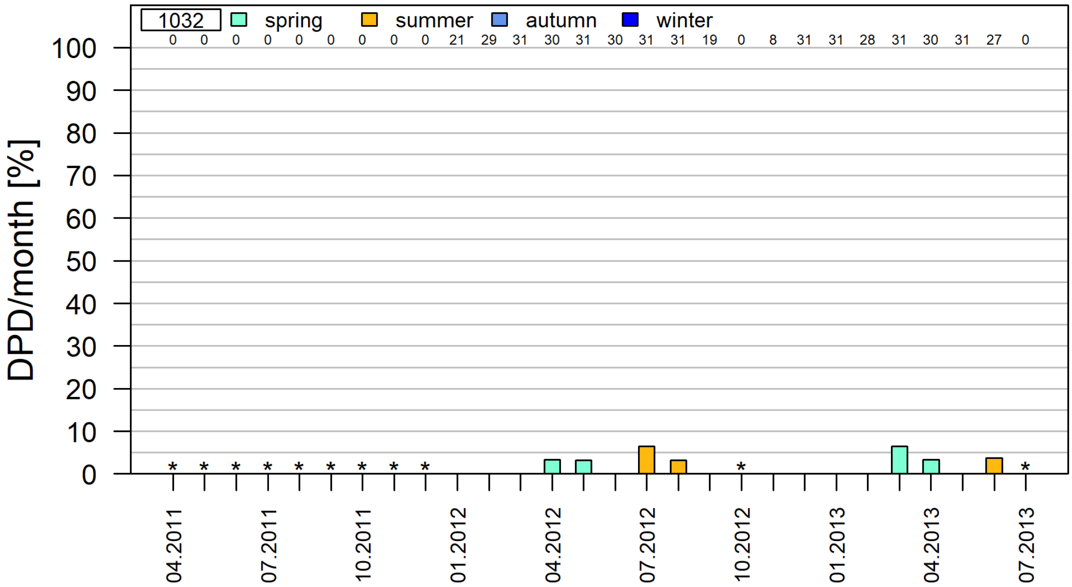

Figure A-6 *Monthly detection rates (%DPD/month) at the SAMBAH station 1032 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).*

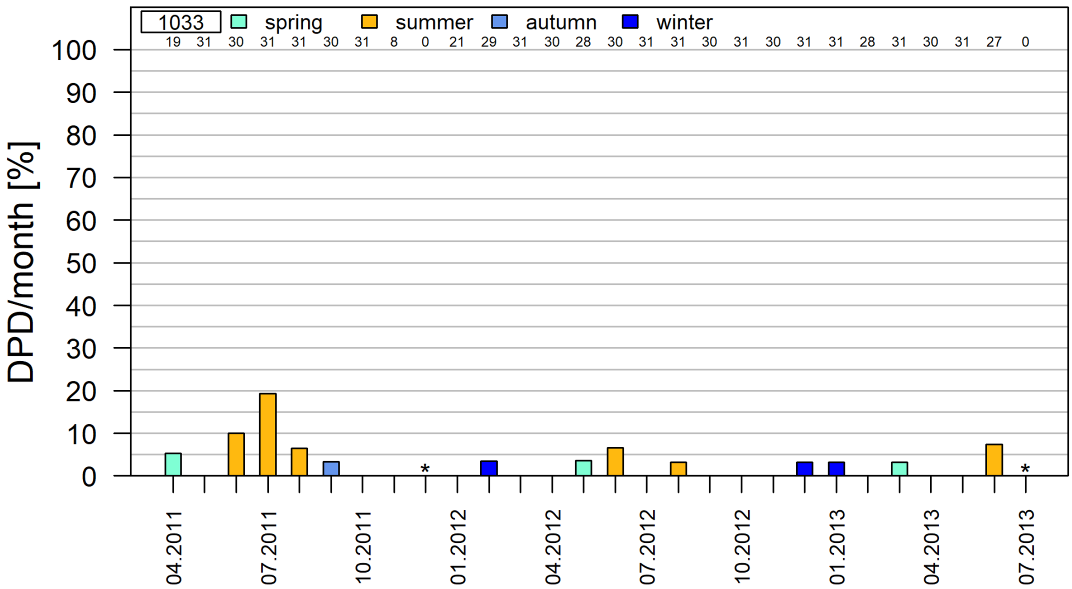

Figure A-7 *Monthly detection rates (%DPD/month) at the SAMBAH station 1033 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).*

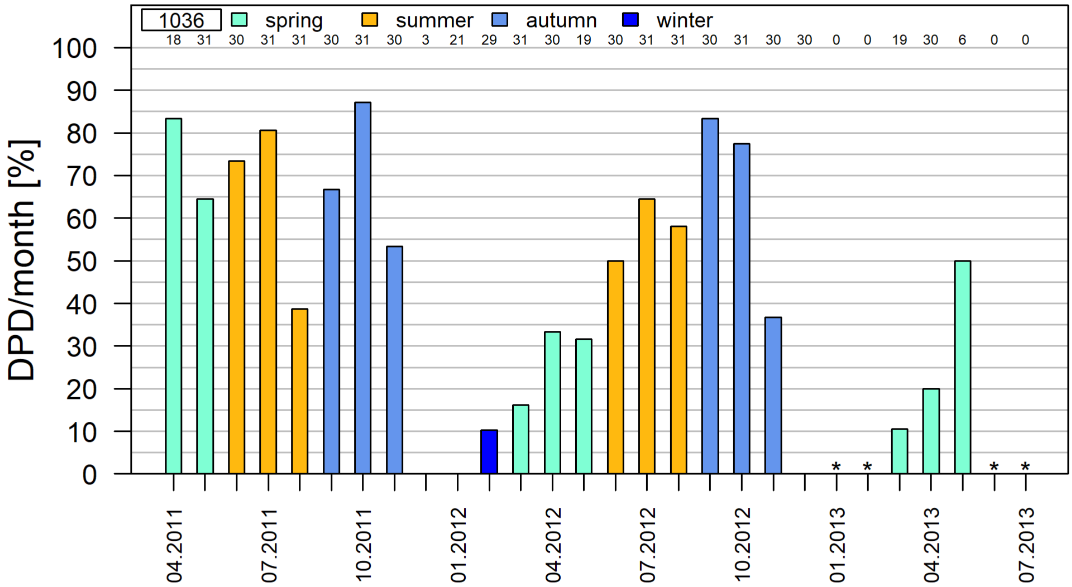

Figure A-8 *Monthly detection rates (%DPD/month) at the SAMBAH station 1036 from April 2011 to July 2013. Seasons are colour coded. Number of day/month with recordings are given above each bar. Months without recording are marked (*).*