

ENERGINET

## KATTEGAT

OFFSHORE SURVEYS OF BIRDS, BATS AND  
MARINE MAMMALS FOR OFFSHORE WIND  
FARMS IN DANISH WATERS.

TECHNICAL REPORT MARINE MAMMALS

12-07-2024







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### TECHNICAL REPORT MARINE MAMMALS

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<b>Abbreviation</b>	<b>Explanation</b>
<b>CMS</b>	Convention on the Conservation of Migratory Species of Wild Animals
<b>C-POD</b>	Cetacean-Porpoise Detector
<b>CR</b>	Critically endangered
<b>DCE</b>	Danish Center for Environment and Energy
<b>DD</b>	Degree (WGS84 coordinate system)
<b>DP10M</b>	Detection-Positive 10 Minutes
<b>DPD</b>	Detection-Positive Days
<b>EEA</b>	European Environment Agency
<b>EEZ</b>	Exclusive Economic Zone
<b>HELCOM</b>	Helsinki Commission
<b>Ind</b>	Individual
<b>IUCN</b>	International Union for the Conservation of Nature
<b>LC</b>	Least Concern
<b>MM</b>	Minute (WGS84 coordinate system)
<b>NOVANA</b>	Nationwide Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments
<b>ODAS</b>	Offshore Data Acquisition Systems
<b>PAM</b>	Passive Acoustic Monitoring
<b>Pre-investigation area</b>	Gross area for Digital Aerial Survey for marine mammals.
<b>SAC</b>	Special Areas of Conservation
<b>SAMBAH</b>	Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise
<b>SCANS</b>	Small Cetacean Abundance survey in the North Sea and adjacent waters
<b>SCI</b>	Sites of Community Importance
<b>SD</b>	Secure Digital
<b>SPL</b>	Sound Pressure Level
<b>TRL</b>	Target Reference Level
<b>VU</b>	Vulnerable

# 1 SUMMARY

## 1.1 INTRODUCTION

The pre-investigation area for Kattegat is situated between Hesselø Bugt and Anholt in Denmark within the Danish and Swedish EEZ. The pre-investigation area includes two planned offshore wind farm areas (Hesselø and Kattegat). See separate technical report for the pre-investigation at Hesselø. Anholt OWF is located approximately 20 km north of Kattegat.

## 1.2 OBJECTIVES AND METHODOLOGIES

The following monitoring methods were used for the present marine mammal monitoring study:

- Abundance and distribution of marine mammals based on bimonthly digital aerial offshore wildlife surveys (HiDef)
- Spatial and seasonal habitat use of harbour porpoises based on Passive Acoustic Monitoring (PAM) with C-PODs

### 1.2.1 DIGITAL AERIAL SURVEYS

For the assessment of marine mammals in the pre-investigation area for Kattegat digital aerial surveys were conducted using HiDef video technology ([www.hidfsurveying.co.uk](http://www.hidfsurveying.co.uk)), explained in detail in WEIß ET AL. (2016). Transect design for the pre-investigation area consisted of 18 transects aligned from north to south. The transects had a total length of 889 km varying between 240 km and 66 km with a distance between each transect line of 5 km. On average, 11.6% of the 4,125 km<sup>2</sup> pre-investigation area was covered per flight (Table 1.1). Digital aerial surveys were used to determine the spatial distribution and seasonal abundance of marine mammals in both the pre-investigation area from February 2023 to January 2024.

**Table 1.1. Overview of the digital aerial surveys carried out in the survey area between February 2023 and January 2024. Effort is the area covered by the digital aerial flights; coverage is the % area covered relative to the pre-investigation area.**

Survey no.	Date	Distance [km]	Effort [km <sup>2</sup> ]	Coverage [%]
1	04.03.2023	863	463	11.2
2	08.04.2023	891	483	11.7
3	17.06.2023	892	483	11.7
4	27.08.2023	895	479	11.6
5	18.11.2023	895	485	11.8
6	30.12.23	892	483	11.7
		<b>Total: 5,328</b>	<b>Total: 2,876</b>	<b>Average: 11.6</b>

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## 1.2.2 PASSIVE ACOUSTIC MONITORING

The purpose of the passive acoustic monitoring (PAM) survey was to determine the spatial and seasonal habitat use of harbour porpoise occurring in the pre-investigation area from Kattegat during the one-year survey period from February 2023 to January 2024. 8 C-PODs (K-O1 to K-O4 and K-R1 to K-R4) were deployed for passive acoustic monitoring (PAM) of harbour porpoises in the pre-investigation area in the Kattegat.

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## 1.3 RESULTS

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### 1.3.1 HARBOUR SEALS

Out of the 32 seals that were observed during the digital aerial surveys, only 34.4% could be identified to species level. These 11 seals were divided into 90.9% harbour seals (n=10) and 9.1% grey seals (n=1). Harbour seals were the most dominant pinniped species. The highest density for all seals combined was observed in the summer with 0.025 Ind./km<sup>2</sup>. About one third of seals was observed in one of the two Danish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive; *Hesselø med omliggende stenrev* (N128/DK003X202), in which both harbour seal and grey seal are listed as important species respectively, and *Schultz og Hastens Grund samt Briseis Flak* (N204/DK00VA303), which is of no specific importance for seals.

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### 1.3.2 GREY SEALS

Grey seals were only observed during one digital aerial survey (08.04.23). However, as 65.6% of seals could not be identified to species level, results apply to both seal species. About one third of seals was observed in one of the two Danish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive; *Hesselø med omliggende stenrev* (N128/DK003X202), in which both harbour seal and grey seal are listed as important species respectively, and *Schultz og Hastens Grund samt Briseis Flak* (N204/DK00VA303), which is of no specific importance for seals.

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### 1.3.3 HARBOUR PORPOISE

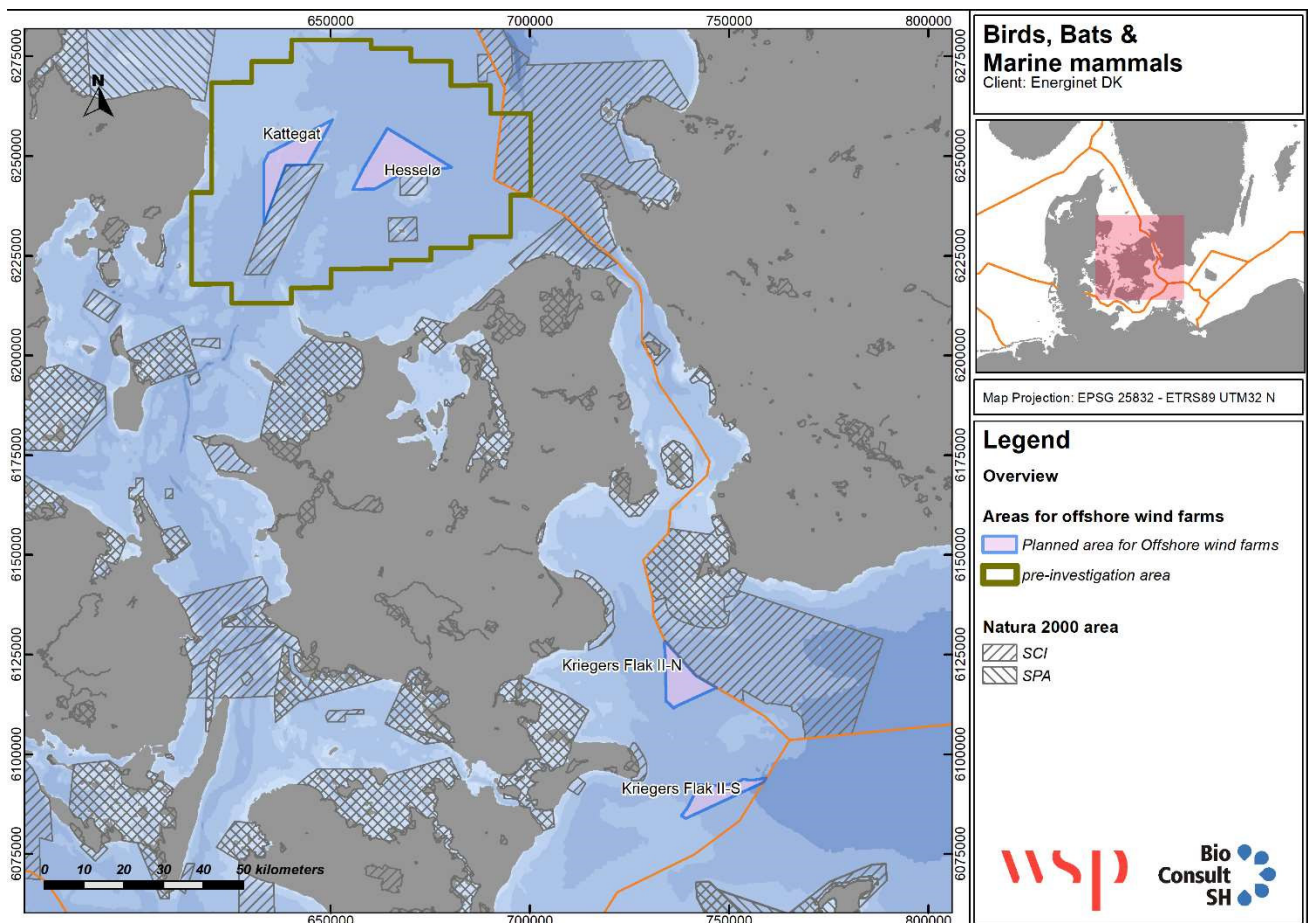
Harbour porpoises were observed during all surveys with the highest densities in summer. Overall, from February 2023 to January 2024 156 individuals were identified as harbour porpoises. The proportion of juveniles was 3.6% (n=4), which is relatively low compared to other areas (e.g., the North Sea). Harbour porpoises were distributed all over the survey area with no clear preference. However, most sightings occurred in the eastern part of the pre-investigation area.

Furthermore, passive acoustic monitoring with a total of 8 C-POD stations was carried out to determine the habitat usage of the area by harbour porpoises. On average, at least one harbour porpoise contact was recorded at each station on 98.4% of all survey days.

## 2 INTRODUCTION

In order to accelerate the expansion of Danish offshore wind production, it was decided with the agreement on the Finance Act for 2022 to offer an additional 2 GW of offshore wind for establishment before the end of 2030. In addition, the parties behind the Climate Agreement on Green Power and Heat 2022 of 25 June 2022 (hereinafter Climate Agreement 2022) decided, that areas that can accommodate an additional 4 GW of offshore wind must be offered for establishment before the end of 2030. Most recently, a political agreement was concluded on 30 May 2023, which establishes the framework for the Climate Agreement 2022 with the development of 9 GW of offshore wind, which potentially can be increased to 14 GW or more if the concession winners – i.e. the tenderers who will set up the offshore wind turbines – use the freedom included in the agreement to establish capacity in addition to the tendered minimum capacity of 1 GW per tendered area.

In order to enable the realization of the political agreements on significantly more energy production from offshore wind before the end of 2030, the Danish Energy Agency has drawn up a plan for the establishment of offshore wind farms in three areas in the North Sea, the Kattegat and the Baltic Sea respectively. The area for Kattegat Offshore Wind Farm (OWF) is located in Kattegat, approximately 20 km east of Djursland and approximately 30 km north of Zealand (Figure 2-1). The area for the OWF is approximately 122 km<sup>2</sup>. The Kattegat OWF will be connected to land via subsea cables making landfall close to Grenaa.



**Figure 2-1** Map showing the location of the investigated offshore wind farm areas Kattegat, Hesselø and Kriegers Flak II (North and South). The present report focuses on Kattegat.



## 3 EXISTING DATA

The purpose of this section is to give a brief overview on the conservation status and biology of the three marine mammal species, regularly occurring in the Kattegat pre-investigation area, namely the harbour porpoise (*Phocoena phocoena*), the harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*). This section is based on publicly available literature (peer-reviewed journals as well as non-peer-reviewed reports) relevant to describe the spatial and seasonal presence of these three marine mammal species in and around the pre-investigation area. Finally, first inferences about the potential importance of the pre-investigation area for each of these three species will be discussed.

### 3.1 HARBOUR SEALS

#### 3.1.1 BIOLOGY, DISTRIBUTION, ABUNDANCE

Harbour seals (*Phoca vitulina*) are the most widely distributed species of all seals ranging from temperate to polar coastal regions all along the Northern Hemisphere. In the Baltic Sea, distribution is limited to Danish, Swedish, German and Polish waters.

Harbour seals can reach a maximum age of 36 years (HÄRKÖNEN & HEIDE-JØRGENSEN 1990). Adult East Atlantic harbour seals were found to show an asymptotic length of 146 cm in females and 156 cm in males (HÄRKÖNEN & HEIDE-JØRGENSEN 1990). Asymptotic weight was 67 kg in females and in 75 kg in males, but strong fluctuations depending on reproductive status and season were observed (HÄRKÖNEN & HEIDE-JØRGENSEN 1990).

Females reach sexual maturity at an average age of 3.7 years and males about a year later (HÄRKÖNEN & HEIDE-JØRGENSEN 1990). The overall pregnancy rate in 3- to 36-year-old females was 92% (HÄRKÖNEN & HEIDE-JØRGENSEN 1990). Females give birth on land, usually once a year, between May and June after an average pregnancy period, or gestation, of 11 months. Pups are usually weaned after four weeks and are then left to fend for themselves. Pups shed their embryonic lanugo fur before birth. They can swim and dive immediately after birth but depend on undisturbed sites on land for suckling and resting. Mating occurs in the water after pups are weaned around July. Males perform an underwater display including specific vocalizations and are sought out by females for mating, a so-called lek-system (VAN PARIJS ET AL. 1997). Moulting occurs between July and September, with a peak in August, and during this time animals also depend on undisturbed sites on land. This is because a good blood perfusion to the outer skin layers is necessary for moulting, which makes animals more prone to heat loss. Therefore, increased perfusion occurs on land, preferably with dry fur (DIETZ ET AL. 2015). Because of the reproduction and moulting period, harbour seals are most sensitive to disturbance at haul-out sites during summer months between May and August.

Harbour seals show no migration movements and instead they display high site fidelity to their haul-out sites, from where they make foraging trips into deeper waters. These trips are mostly confined to a radius of less than 50 km from the coast but can occasionally range as far as 100 km or further offshore (e.g. THOMPSON ET AL. 1994; TOLLIT ET AL. 1998; CUNNINGHAM ET AL. 2009; MCCONNELL ET AL. 2012; DIETZ ET AL. 2013).

Harbour seals are opportunistic predators but show mainly benthic feeding and prefer small to medium sized benthic fish species. As such, they are mainly found to feed in areas with a water depth below 100 m (TOLLIT ET AL. 1998). From two studies in the south-western Baltic Sea, 20 fish species were identified from otoliths

found in 42 harbour seal samples (scat and digestive tracts). Most prey items were made up of lesser sandeel (*Ammodytes tobianus*, 43%), black gobies (*Gobius niger*, 15%) and Atlantic cod (*Gadus morhua*, 12%) (SCHARFF-OLSEN ET AL. 2019). In relation ANDERSEN ET AL. (2007) also found a minimum of 20 different prey species being consumed by harbour seals from Rødsand lagoon (collected 13 scats and 17 digestive tracts). The dominant species was cod, which was found in the diet (42% and 43% of weight consumed) especially in spring and autumn. In the summer period flounder and plaice made up 52% of the weight consumed (cod only 22%).

Harbour seals have probably been present in the Baltic Sea since the last glaciation. Based on molecular data and satellite telemetry studies, it was suggested to split harbour seals in the Baltic region into four different subpopulations or management units (ANDERSEN & OLSEN 2010; BLANCHET ET AL. 2021): one in the Kalmarsund between Øland and the Swedish mainland, one in the south-western Baltic, one in the Kattegat and one in the Limfjord. As tagging studies have shown, there is no or only limited exchange between colonies separated by more than about 100 km due to generally limited movements (DIETZ ET AL. 2013, 2015), and thus at least partial reproductive isolation between these four subpopulations.

The population in the Skagerrak, Kattegat and the Danish Straits exceeded 17,000 animals, but declined to only about 2,500 in 1930 due to intense hunting (HEIDE-JØRGENSEN & HÄRKÖNEN 1988). Following protection in the area, the population recovered in the 1960s. Two severe morbillivirus epidemics in 1988 and 2002 decreased the population size by about 50% on both occasions (HÄRKÖNEN ET AL. 2006), but the population recovered afterwards. Then, a third epidemic caused by an unknown pathogen in 2007 killed about 3,000 harbour seals. However, the recovery rate in the Kattegat has been low ever since the 2002 epidemic (HELCOM 2013a). Latest estimated population sizes of harbour seals were about 2,000 individuals in the SW Baltic and about 12,500 individuals in the Kattegat (HELCOM 2023a). Harbour seal haul-out sites closest to the planned windfarm area of Kattegat, are located in Denmark about 22 km north at Anholt, about 22 km south at Sjællands Rev, about 25 km southeast at Hesselø, about 35 km southwest at Bosserne, and in Sweden about 65 km east at Hallands Väderö. The Haul-out sites at Hesselø, Anholt, and Bosserne, are also used by grey seals.

HELCOM (2023b) states that the harbour seal populations in the Baltic are currently recognized as two official management units consisting of (a) the Kalmarsund and (b) the southwestern (SW) Baltic Sea and the Kattegat. In addition, HELCOM also assessed a third unofficial unit in (c) the Limfjord.

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### 3.1.2 HABITAT USE

As harbour seals show high site fidelity at haul-out sites and aggregate there especially during the lactation and moulting period, estimates of population sizes are based on counts at haul-out sites during the moulting season. Such counts are carried out annually and thus, good knowledge exists on the individual numbers at haul-out sites. In section 5.1.2 location and number of historical haul-out sites are described in further detail. However, much less is known about harbour seal density in the surrounding waters and about harbour seal habitat use there. From tracking studies, it is known that harbour seals usually stay close to shore and make foraging trips that are rarely further than 50 km from their haul-out site (THOMPSON ET AL. 1994; TOLLIT ET AL. 1998; CUNNINGHAM ET AL. 2009; DIETZ ET AL. 2013). Most studies found some seasonal, age- and sex-specific differences in these movement patterns. Juvenile harbour seals seem to have the tendency to travel further distances to up to 200 km to the haul-out site, while adult harbour seals seem to prefer to stay closer to the haul-out sites within the vicinity of 50 km (MCCONNELL ET AL. 2012; DIETZ ET AL. 2015). One reason for these different travel distances may be age depending individual preferences for particular feeding grounds (DIETZ ET AL. 2015).

### 3.1.3 CONSERVATION STATUS

The status of the global population (LOWRY 2016) and the European population (European Mammal Assessment Team 2007) of the harbour seal are classified by the IUCN as least concern (LC). The HELCOM Red List (2013a) classified the Southern Baltic population as LC. The red list of Denmark assessed it as LC (Den Danske Rødliste 2019; AARHUS UNIVERSITET 2019) and the red list of Sweden lists the Baltic population as vulnerable (VU; 2020). Hunting of harbour seals in Sweden is forbidden unless allowed in other parts of the hunting legislation and in Denmark licenses are given to shoot a limited number of individuals each year when seals interfere with fishing gear. Regulation is not allowed between 1st of June and 31st of July and never in seal reserves (HELCOM 2013b).

In EU waters, harbour seals are protected by the EU Habitats Directive and listed in its Annexes II and V (European Commission 2021). They are also covered by the EU Marine Strategy Directive, where distribution, number and bycatch must be reported and evaluated according to descriptor 1. The harbour seal is listed in Appendix II of the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats) and in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as the Bonn Convention (CMS SECRETARIAT 2015). For a summary, see Table 3-1.

The Danish Center for Environment and Energy (DCE) assessed the conservation status of the harbour seals in Habitat Directive Article 17 from 2019 (FREDSHAVN ET AL. 2019) as favorable in both Danish marine regions. It also states that while management units in the Wadden Sea and Kattegat are large and long-term viable, management units in the Limfjord and the Baltic Sea are smaller and more vulnerable. In the DCE Marine areas report from 2021 (HANSEN & HØGSLUND 2021) it is said that the population of harbour seals has shown a substantial increase from 1976 to 2020 as a result of the start of protection measures in 1977 and the establishment of a number of seal reserves with no access. Since 2015, the number of harbour seals in Denmark has decreased by 4% each year in all four management units, indicating that the population is approaching or has reached ecological capacity or is pressured by unknown factors, such as a lack of food, disturbances or competition by grey seals (HANSEN & HØGSLUND 2021).

It is also said that it is uncertain if the Kattegat unit is at or below Target Reference Level or undergoing a decline (HELCOM 2023a). The state of distribution of harbour seals achieves the threshold value for good status in the Kattegat, but when assessed together with the SW Baltic population, good status is not achieved. Thus, the population in the SW Baltic and Kattegat also failed to achieve good status with regards to both key indicators "distribution" as well as "population trends and abundance" (HELCOM 2023a).

**Table 3-1. Listing of the harbour seal in international and regional conservation agreements and international and national Red Lists. LC= Least concern, VU= Vulnerable.**

Species	IUCN (2017)	HELCOM Red List	National Red Lists	Natura 2000 (BfN 2015)	Bern Convention	Bonn Convention
Harbour Seal <i>Phoca vitulina</i>	Global: LC European: LC	Southern Baltic: LC Kalmarsund: VU	DE: threat of unknown extent DK: LC SE: VU (Baltic population)	Appendix II und V	Appendix III	Appendix II

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## 3.2 GREY SEALS

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### 3.2.1 BIOLOGY, DISTRIBUTION, ABUNDANCE

The grey seal (*Halichoerus grypus*) is a large seal species with a cold-temperate to sub-arctic distribution along the coasts of the North Atlantic. Two subspecies of the grey seal are recognized, which are morphologically and genetically (BOSKOVIC ET AL. 1996; GRAVES ET AL. 2009; FIETZ ET AL. 2013) differentiated: the Atlantic grey seal (*Halichoerus grypus atlantica*) inhabiting the Atlantic and the North Sea, and the Baltic grey seal (*Halichoerus grypus grypus*) inhabiting the Baltic Sea (BERTA & CHURCHILL 2012; FIETZ ET AL. 2016; OLSEN ET AL. 2016). However, Atlantic grey seal also occurs in the Kattegat, which is therefore described as a transition area and there is genetic evidence of hybridisation between Atlantic and Baltic grey seals (FIETZ ET AL. 2016; GALATIUS ET AL. 2024). The Baltic grey seal is found throughout the Baltic Sea area with main concentrations in the northern and central parts of the Baltic Sea, but the population is expanding in numbers towards the south-western Baltic and Kattegat area (SCHARFF-OLSEN ET AL. 2019; GALATIUS ET AL. 2020). The two sub-species show different breeding periods and differ in their choice of breeding habitat.

Adult male grey seals can reach a body length of up to 2.5 m and a weight of up to 400 kg, female grey seals are smaller with up to 2.1 m body length and a weight up to 250 kg. (SHIRIHAI ET AL. 2008). Grey seal females reach sexual maturity between 3 and 5 years of age and males between four and six years of age. After a pregnancy of about 11.5 months, grey seal pups are born in winter with a pupping period of February-March in the Baltic and October-December in the northeast Atlantic (GALATIUS ET AL. 2020).

Grey seals in the Baltic Sea breed mainly on drift ice, but where this is not possible, as in the southern Baltic Sea in most winters, they also breed on land. Grey seal pups are born with their lanugo coat, which is not waterproof, so pups are not able to enter the water until they have shed it and attained their adult coat after 2-4 weeks. Nursing lasts about 14 days, during which the females do not feed, and pups undergo substantial weight gain, increasing from a birth weight of about 10 kg to almost 50 kg at the time of weaning. Grey seals therefore highly depend on undisturbed haul-out sites above the high-water line in winter for successful reproduction. Baltic grey seals moult between April and June and during this time, they spend a lot of time hauled out.

Like harbour seals, grey seals are associated with coastal waters, but also make foraging trips at larger distances of the coast with occasional travelling distances of up to 2,000 km (e.g. THOMPSON ET AL. 1991, 1996; MCCONNELL ET AL. 1999; DIETZ ET AL. 2015). Grey seals tagged in the Rødsand lagoon were found to move up to 850 km east into the Baltic (DIETZ ET AL. 2015). Generally, grey seals visit a larger number of haul-out sites than harbour seals and at greater distances (e.g. THOMPSON ET AL. 1996).

Grey seals are generalist and opportunist feeders with a wide range of prey (SCHARFF-OLSEN ET AL. 2019). The fish species consumed include a similar range as that of harbour seals, although grey seals can take larger fish due to their larger size and ability to tear large prey into pieces for consumption. Main contributors to grey seal diet are sand eel (*Ammodytes spec*), flounder (*Platichthys flesus*), herring (*Clupea harengus*) and cod (*Gadus morhua*), depending on location and season (THOMPSON ET AL. 1991, 1996). Additionally, seabirds as well as harbour porpoises and harbour seals may also be preyed upon (JAUNIAUX ET AL. 2014; LEOPOLD 2015; VAN NEER ET AL. 2015; WESTPHAL ET AL. 2023).

The grey seal population in the Baltic Sea suffered from extensive hunting and environmental toxins during the 20th century and was reduced from an original population size of about 80,000 individuals (HELCOM 2023c) to only about 3,000 individuals in the beginning of 1980 (HARDING & HÄRKÖNEN 1999). Following the abandonment of the use of several pollutants and the mitigation of their effects, as well as the introduction of a general culling and hunting ban, the population had increased exponentially since the 1980s (HARDING & HÄRKÖNEN 1999; HÄRKÖNEN ET AL. 2007; HELCOM 2018). In the years 2014–2017, numbers were around 30,000 individuals counted in the Baltic Sea at the haul-outs during the moulting season in late May and early June (ICES 2019), about 38,000 grey seals were counted in 2019, and about 42,000 grey seals were counted in 2021, leading to an estimated population size of about 60,000 animals (HELCOM 2023c).

There are no distinct subpopulations recognized of the Baltic grey seal and it ranges widely within the Baltic Sea, although local differences in their distribution is present. HELCOM (2023c) assessed the grey seal population in the Baltic Sea as a single management unit based on data from 2003-2021. According to this evaluation the grey seal population of the Baltic Sea has failed all four key indicators “trends and abundance”, “distribution”, “nutritional status” and “reproductive status” (HELCOM 2023c).

Even though grey seals in the Baltic Sea show increases in their population size, the population growth rate remained under the threshold values (HELCOM 2023c). Because the population is still growing it was assessed as being below Target Reference Level (TRL) and was evaluated against the threshold of 7% annual increase during exponential growth. With an estimated annual growth rate of about 5.1% (80% support for  $\geq 4.7\%$  according to Bayesian analyses) between 2003 and 2021, the population did not reach the growth target. Therefore, the population achieved good status with regards to “abundance” but did not achieve good status with regards to “population trend”.

With regards to “distribution” the Baltic grey seal population achieved good status in the component “area of occupancy” (at sea distribution), but no good status in the components “haul-out sites” and “breeding sites”, because in some subareas some available sites are not occupied (HELCOM 2023c).

Nutritional status of seals is estimated based on blubber thickness of hunted and bycaught seals, which indicates long-term and short-term changes in food supplies and other stressors. Grey seals in the Baltic Sea failed the threshold for good status in the assessment period 2016-2021.

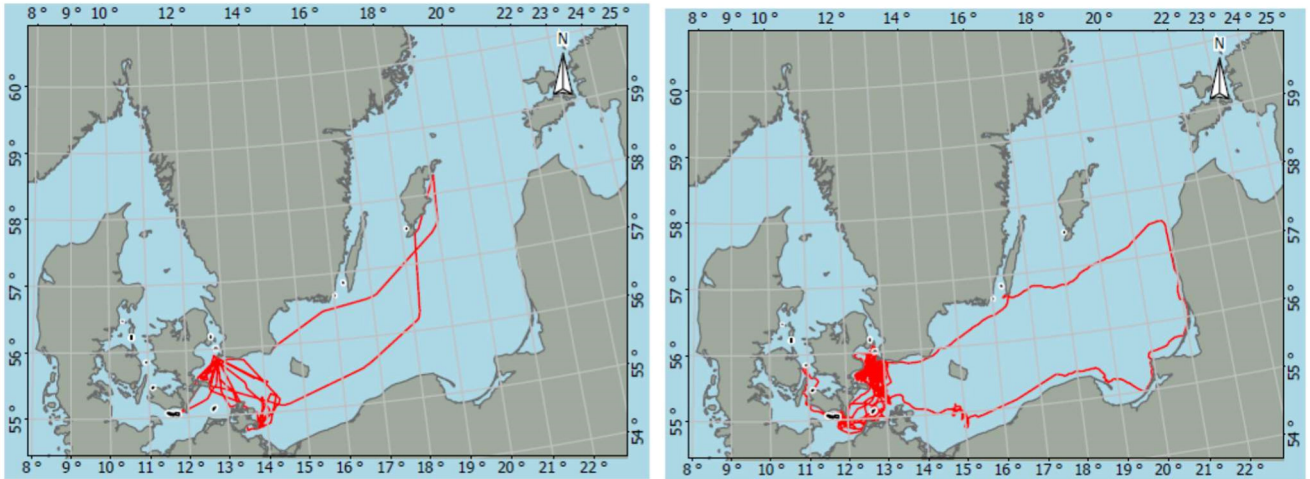
The pregnancy rate in the grey seal population of the Baltic Sea was found to be on average 87% in the period 2016-2021, which is below the threshold value of 90% that would indicate a good status (HELCOM 2023c). Grey seal haul-out sites in the Baltic Sea closest to the planned windfarm area of Kattegat are located in Denmark about 22 km north at Anholt, about 25 km southeast at Hesselø and about 35 km southwest at Bosserne. These haul-out sites are also used by harbour seals.

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### 3.2.2 HABITAT USE

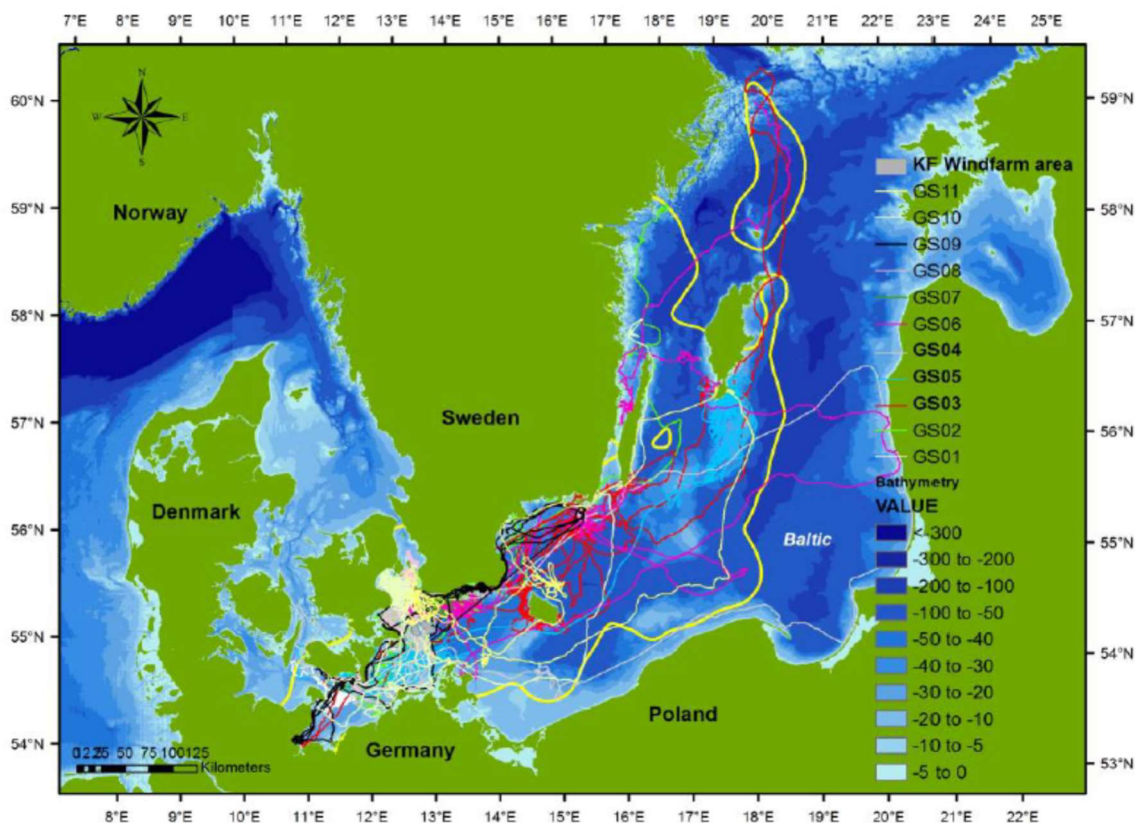
Good knowledge about habitat use of grey seals on the Baltic Sea coastlines exists from observations of the number of animals at haul-out sites, where they are mainly counted during the moulting period (see section 3.2.1). Little is known about grey seal density and habitat use offshore. Some information comes from telemetry studies, which show that grey seals undertake longer foraging trips from their haul-out sites than harbour seals do, and they also show much larger dispersal distances. Grey seals in Scotland for example were reported to show movement patterns on two geographical scales: local, short and repeated trips between haul-out sites and discrete offshore areas about 40 km from the coast, similar to harbour seals, and longer distance travels to areas up to 2,100 km away (MCCONNELL ET AL. 1999). In MCCONNELL ET AL. (2012), five

grey seals in the Rødsand lagoon – one adult and four juveniles – were satellite tracked. These seals also showed similar local movement patterns as well as far distance trips. Two such examples are shown in Figure 3-1. DIETZ ET AL. (2015) tagged five grey seals from Rødsand, five from Falsterbo and one from Ålandsøerne (Figure 3-2). These animals also showed some local movements as well as long distance trips to other haul-out sites. Movement was largely focused on local areas around haul-out sites (Figure 3-2).



**Figure 3-1. Example of tracks from two radio-tracked grey seals, captured and tagged in the Rødsand lagoon. From: McCONNEL ET AL. (2012).**





**Figure 3-2. Map showing the migration routes and the 95% Kernel ranges (yellow polygon) for 11 grey seals tagged between 2009 and 2012 at Falsterbo (5 seals), Rødsand (5 seals) and at Ålandsøerne (1 seals). From: DIETZ ET AL. (2015).**

### 3.2.3 CONSERVATION STATUS

The status of the global population (BOWEN 2016) and the European population (EUROPEAN MAMMAL ASSESSMENT TEAM 2007) of the grey seal are classified by the International Union for the Conservation of Nature (IUCN) as LC, and the status of the Baltic subspecies *Halichoerus grypus grypus* is assessed by the HELCOM Red List (HELCOM 2013a) also as LC. The national Red List of Denmark lists the grey seal as VU (Danske Rødlister 2019; AARHUS UNIVERSITET 2019). The Red List of Germany lists the grey seal as highly threatened in the case of the Baltic grey seal subspecies and as threatened in the case of the Atlantic subspecies (MEINIG ET AL. 2020). The Swedish Red List lists the grey seal as LC (2020). Hunting in Denmark and Germany is forbidden, in Sweden it is allowed but controlled through various regulations and restrictions (HELCOM RED LIST MMEG 2013).

In EU waters, grey seals are protected by the Habitats Directive and listed in its Annexes II and V (European Commission 2021). They are also covered by the EU Marine Strategy Directive, where distribution, number and bycatch must be reported and evaluated according to descriptor 1. Furthermore, grey seals are listed in Appendix III of the Bern Convention, while they are not listed by the Bonn Convention (CMS SECRETARIAT 2015). For a summary, see Table 3-2.

DCE assessed the conservation status of the grey seals in Habitat Directive Article 17 from 2019 (FREDSHAVN ET AL. 2019) as highly unfavorable in both Danish marine regions because breeding activity is assessed to be very far from previous levels. It is also stated, however, that conditions are improving in both regions. In the DCE Marine areas report from 2021 (HANSEN & HØGSLUND 2021) it is stated that the numbers of grey seals in Danish waters have increased over the last ten years. In 2020, 1,098 grey seals were counted in the Danish Baltic Sea. It is expected that the general increase in numbers will continue in all areas in the coming years. However, in the Baltic Sea only six pups were observed at one out of four surveyed sites in 2020, which is a large decline compared to 2017 and worrying for a species of unfavourable conservation status (HANSEN & HØGSLUND 2021).

**Table 3-2. Listing of the grey seal in international and regional conservation agreements and international and national Red Lists. LC= Least concern, VU= vulnerable.**

Species	IUCN (2017)	HELCOM Red List	National Red Lists	Natura2000 (BfN 2015)	Bern Convention	Bonn Convention
<b>Grey seal</b> <i>Halichoerus grypus</i>	Global: LC European: LC	LC	DE: highly threatened (Baltic grey seal) DK: VU SE: LC	Appendix II and V	Appendix III	Not listed

## 3.3 HARBOUR PORPOISES

### 3.3.1 BIOLOGY, DISTRIBUTION, ABUNDANCE

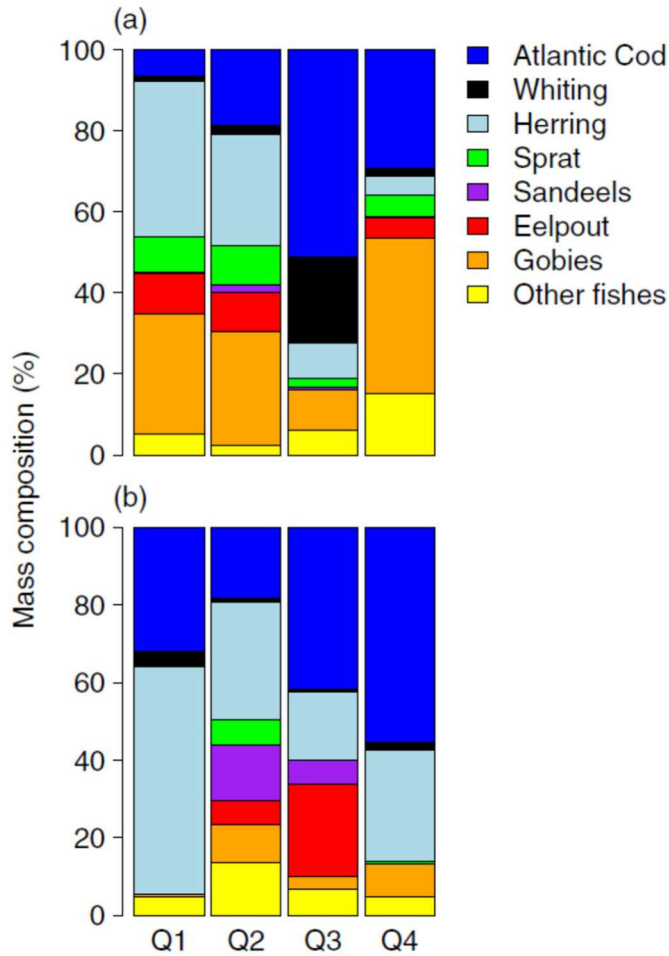
The harbour porpoise (*Phocoena phocoena*) inhabits temperate to cold waters throughout the northern hemisphere and is the only cetacean species resident in the Kattegat (NIETHAMMER & KRAPP 1994; BENKE ET AL. 1998). Harbour porpoise habitat use shows seasonal differences. In general, harbour porpoise habitat use is considered to largely depend on prey availability, and was shown to correlate with strong currents and the occurrence of fronts and eddies (e.g., JOHNSTON ET AL. 2005; PIERPOINT 2008), where prey usually concentrates.

Harbour porpoises in Danish waters (North Sea and Baltic Sea combined) may live up to about 23 years, however, fewer than 5% seem to live longer than 12 years (LOCKYER & KINZE 2003). Based on the study of bycaught and stranded individuals in Danish waters, LOCKYER & KINZE (2003) reported both sexes to reach sexual maturity at about 3 years of age, with corresponding body sizes of about 143 cm in females and 135 cm in males. Ranges of mean body weight of bycaught individuals were 34-47 kg in females and 27-35 kg in males with only little seasonal variation (LOCKYER & KINZE 2003). More recent data from bycaught and stranded harbour porpoises in German waters (North and Baltic Sea), however, showed that female harbour porpoises first show signs of ovulation at a mean age of about 5 years, while average age at death was 5.7 years in the North Sea and only 3.7 years in the Baltic Sea (KESSELRING ET AL. 2017). Newborn calves in the Belt Sea may be seen from April to October. The percentage of calves in the Belt Sea increased from May to June and reached a peak in July and August (LOCKYER & KINZE 2003). The peak in mating seems to occur in July and August (SCHULZE 1996; KOSCHINSKI 2002; LOCKYER & KINZE 2003). The gestation period is about 10 months and the lactation periods spans from 8 to 10 months, such that many harbour porpoise females are pregnant and lactating at the same time (SCHULZE 1996; KOSCHINSKI 2002; LOCKYER & KINZE 2003). The majority of the female



harbour porpoises in the Baltic were found to have a reproduction rate between 0.7 and 0.8, so mature females would produce about two calves in three years (KOSCHINSKI 2002).

The most recent published information on harbour porpoise diet in the Baltic Sea is based on stomach content analysis of 339 harbour porpoises stranded and bycaught in the Danish and German Baltic Sea between 1980 and 2011 (ANDREASEN ET AL. 2017). The authors reported the diet of adult harbour porpoises to consist of mainly Atlantic cod (*Gardus morhua*, 36%) and herring (*Clupea harengus*, 34%), but also of gobies (Gobiidae, 25%), eelpout (*Zoarces viviparus*, 7%), sandeels (Ammodytidae, 5%), sprat (*Sprattus sprattus*, 2%), whiting (*Merlangius merlangus*, 2%) and some other fish species (8%; Figure 3-3). Juveniles were found to take a much higher proportion of gobies than adults (25%), which made up almost as much as cod (26%) and substantially more than herring (18%). Whiting (7%) and sprat (6%) were also taken at a slightly higher proportion than for adults, while sandeels made up only about 1% of juvenile diet. Other fish species contributed about 11% to juvenile diet. There was considerable seasonal variation in the diet composition of adults with cod and herring clearly dominating the winter diet (>80%), while eelpout and sandeel only made up a significant proportion of the adult diet in summer. The more diverse juvenile diet also showed seasonal variation, but less so than in adults. These findings are mainly in line with earlier studies that also found cod, herring and gobies to make up the majority of prey items in Baltic harbour porpoises, however, some found a higher proportion of cod (AAREFJORD ET AL. 1995; BENKE ET AL. 1998; LOCKYER & KINZE 2003). The diet of Baltic Sea harbour porpoises was found to be quite similar to that of harbour porpoises from the North Sea, except for sandeels and whiting appearing more important in the North Sea (BENKE ET AL. 1998; SANTOS & PIERCE 2003; LEOPOLD 2015). In summary, harbour porpoises mainly live of pelagic fish species like herring and whiting and of semi-pelagic living cod. However, during the summer and especially for juvenile harbour porpoises, demersal fish species such as gobies and sandeels also play a significant role as prey.



**Figure 3-3. Quarterly prey mass composition in the diet of juvenile (a) and adult (b) harbour porpoises in the western Baltic Sea in the period 1980-2011. From: ANDREASEN ET AL. (2017).**

According to KOSCHINSKI (2002), many studies and even a crude examination of sighting and stranding data support the general view that the number of harbour porpoises have declined and their distributional range in the Baltic has narrowed extensively. Danish catch statistics reviewed by KINZE (1995) showed that in the Belt Sea region a consistently increased take occurred in the second half of the 19th century when the catch rate doubled in the Little Belt area. This may have led to an overexploitation initiating the decline of the Baltic harbour porpoise population. Mean annual catch rates in the Little Belt finally decreased from 1,195 harbour porpoises between 1871 and 1892 to only about 327 harbour porpoises during the second world war KINZE (1995).

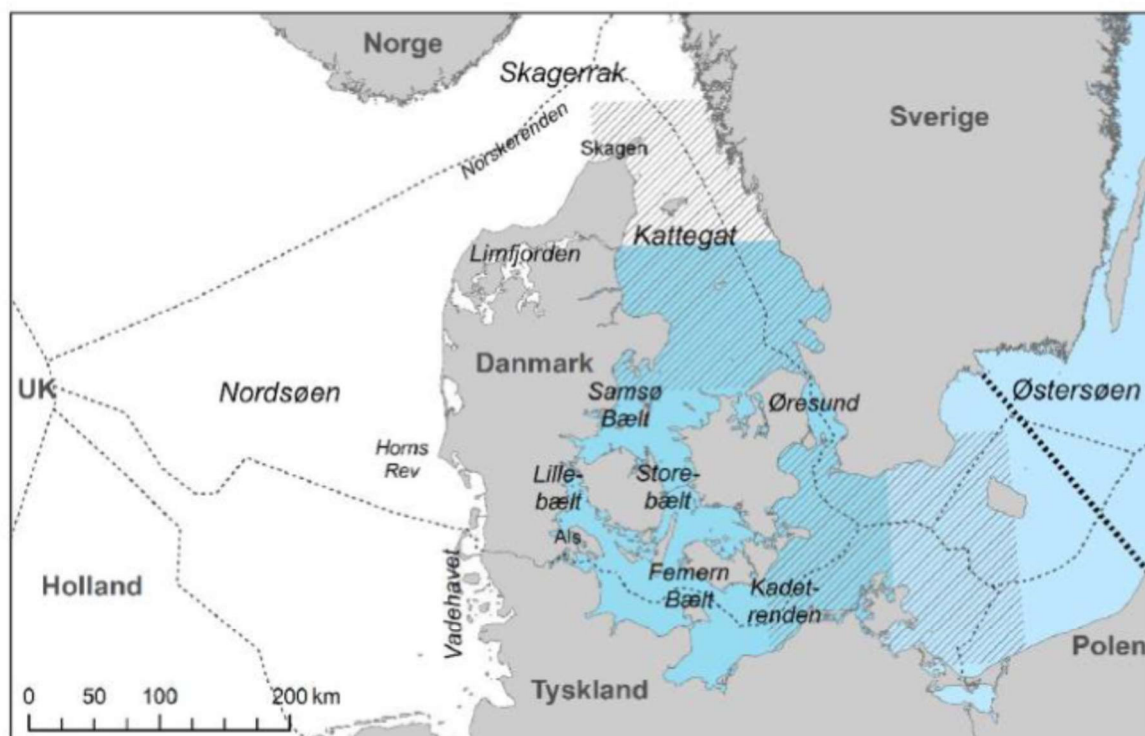
Catch statistics suggest that harbour porpoises in the Baltic Sea used to show strong migration patterns from the Baltic Proper into the Belt and Kattegat area during autumn and back into the Baltic Proper in spring (see KOSCHINSKI 2002 for review). Such strong migration patterns are no longer evident today, possibly because the present population in the Baltic Proper is so much smaller.

Harbour porpoises occurring in the Baltic Sea are thought to belong to three different (sub)populations (Skagerrak/North Sea, Belt Sea and Baltic Proper). Genetic and morphological evidence suggest that harbour porpoises inhabiting the Baltic Proper belong to a different (sub)population than harbour porpoises in the




Skagerrak (which probably belong to the North Sea population of harbour porpoises) and harbour porpoises from the Belt Sea (sub)population, inhabiting the Kattegat, Sound, Belt Sea and western Baltic Sea (WIEMANN ET AL. 2010; BENKE ET AL. 2014; LAH ET AL. 2016; TIEDEMANN ET AL. 2017). Based on survey and acoustic monitoring data, BENKE ET AL. (2014) suggested a management border for the Baltic Proper population around the Darss ridge. SVEEGAARD ET AL. (2015) provide a map with suggested overlapping zones between these populations based on survey and telemetry data. More recently, based on the distribution of harbour porpoise detections in the Baltic region, it was suggested that animals from the Belt Sea and Baltic Proper are separated during the summer from May to October (so including the breeding season) but have overlapping distribution patterns from November to April (CARLÉN ET AL. 2018). The seasonal management border proposed for the Baltic Proper population of harbour porpoises by CARLÉN ET AL. (2018) lies 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) and is thus further east than the one suggested by Benke et al. (2014). Figure 3-4 taken from SVEEGAARD ET AL. (2018) shows the suggested management areas for the separate populations as well as their transition areas.

From passive acoustic monitoring data collected during the SAMBAH project, the number of individuals of the Baltic Proper population was estimated at approx. only 500 animals (AMUNDIN ET AL. 2022). Regardless of the special protection status, any disturbance or even removal of animals from this small population can lead to severe consequences for the well-being of this population. The Belt Sea population of harbour porpoises is estimated to consist of about 17,300 individuals (HANSEN & HØGSLUND 2021).

While the southern Kattegat, in which the pre-investigation area is located, is mostly important for the Belt Sea (sub)population, it is also thought as a transition zone for the North Sea harbour porpoise (SVEEGAARD ET AL. 2018; SCANS-IV 2023). The population size of the North Sea harbour porpoise was last estimated in 2022 with an abundance of 338,918 individuals and has been stable since 1994 (SCANS-IV 2023). TEILMANN ET AL. (2013) has shown that satellite tracked harbour porpoise from the Belt Sea migrate into the North Sea. However, it is not completely understood, to what extent harbour porpoises from the North Sea enter the Baltic Sea and, more specifically, the southern Kattegat.



**Management areas for harbour porpoises in Danish waters**

- |   |                          |   |   |
|---|--------------------------|---|---|
|  | North Sea population     |  | Transition zone between populations                   |
|  | Belt Sea population      |  | Summer management border for Baltic Proper population |
|  | Baltic Proper population |  | EEZ   |

**Figure 3-4. Map showing suggested management areas for the three harbour porpoise populations in Danish waters and neighbouring countries. Taken from: SVEEGAARD ET AL. 2018.**

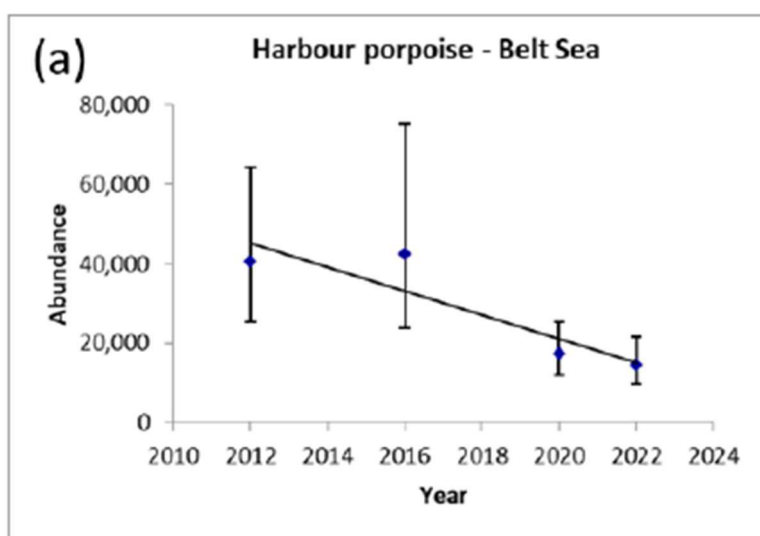
### 3.3.2 HABITAT USE

Information on density and abundance of harbour porpoises in the inner Danish waters (also including Kattegat) exists from different sources: visual and acoustic surveys covering different parts of the Inner Danish waters. Because of differences in methodology and in the area covered by these surveys, it is difficult to compare estimates of abundance and densities between the surveys. This is especially the case for visual aerial-based and ship-based surveys.

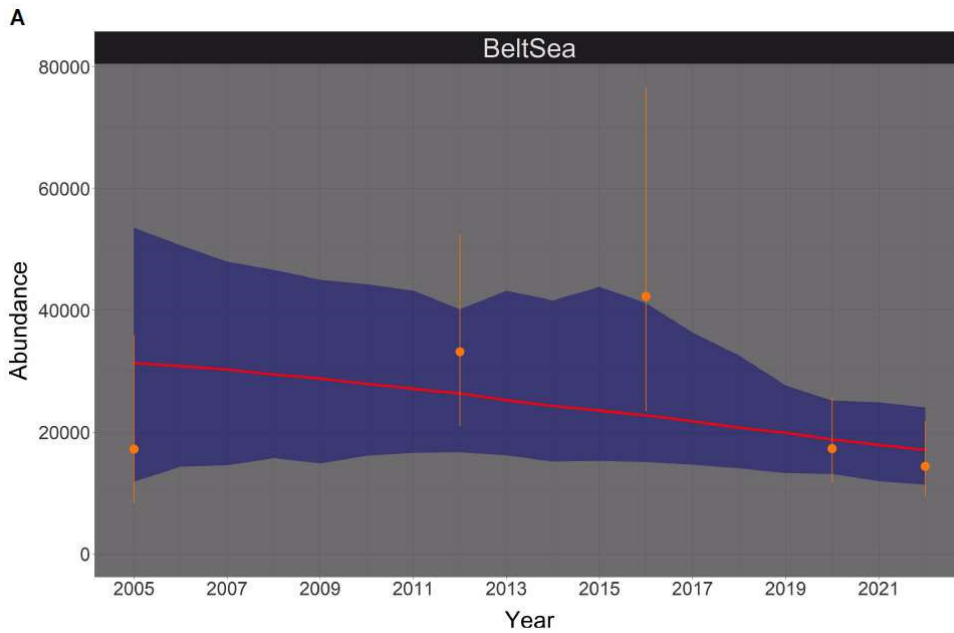
The first systematic survey for harbour porpoise density in the inner Danish waters was the “Small Cetacean Abundance survey in the North Sea and adjacent waters” (SCANS-I survey) in July 1994 (HAMMOND ET AL. 2002), followed by the SCANS-II survey in July 2005 (HAMMOND ET AL. 2013), SCANS III in 2016 (HAMMOND ET AL. 2017) and SCANS IV in 2022 (SCANS-IV 2023). During the SCANS I, II and III surveys, the inner Danish waters was covered from the Skagerrak in the north to Rügen in the east with ship-based surveys, during the SCANS IV survey it was covered by aerial surveys. Density and abundance estimates, of harbour porpoises, in the inner Danish waters (covering the Skagerrak, Kattegat and Belt Sea area) based on the 2016 survey were 73,573 individuals with a density of 1.15 Ind./km<sup>2</sup>. Estimates for 2005 and 1994 were lower but considering the large confidence intervals associated with these calculations, no clear changes in abundance could be detected (HAMMOND ET AL. 2017).

The area for which these estimates were calculated also includes the Skagerrak region and is therefore not only focused on the Belt Sea population. However, due to ongoing discussions about different populations of harbour porpoises in the Baltic Sea it is important to define a discrete management unit for each population. This means that the area that is used by animals from one population needs to be carefully defined and abundance estimates need to be calculated for this management unit (in this management area) and their development monitored over time to assess the populations conservation status. Therefore, the SCANS III and IV surveys redefined a porpoise management unit for only the Belt Sea population of harbour porpoises and in-between these large-scale SCANS surveys, two Mini-SCANS surveys were conducted in 2012 and 2020, especially focusing on the Belt Sea population of harbour porpoise (VIQUERAT ET AL. 2014; UNGER ET AL. 2021).

Because of the methodological differences in survey methods and the area that was covered only estimates from 2016 onwards can be used to assess the Belt Sea population, as it is now defined. The latest 2022 SCANS IV resulted in estimate for the Belt Sea harbour porpoise population of 14,403 individuals (SCANS-IV 2023), which is considerably lower than the 2016 estimate of 42,324 individuals (SCANS III) and from the 2012 Mini-SCANS-I estimate of 40,475 individuals (VISQUERAT ET AL. 2015), but not significantly different from the 2020 Mini-SCANS-II estimate of 17,301 individuals (UNGER ET AL. 2021). The estimated annual decline between 2012 and 2022 is 1.5% (Figure 3-5). However, the variance in the data is very large and power analyses showed that the data would only enable to detect a significant decline of at least 4.4% per year. The authors state, that although a significant decline could thus not be determined, this cannot be interpreted as no decline in abundance (SCANS-IV 2023). A more robust Bayesian approach revealed a strong negative trend of 2.7% per year with a 90.5% probability since 2005 (OWEN ET AL. 2024).



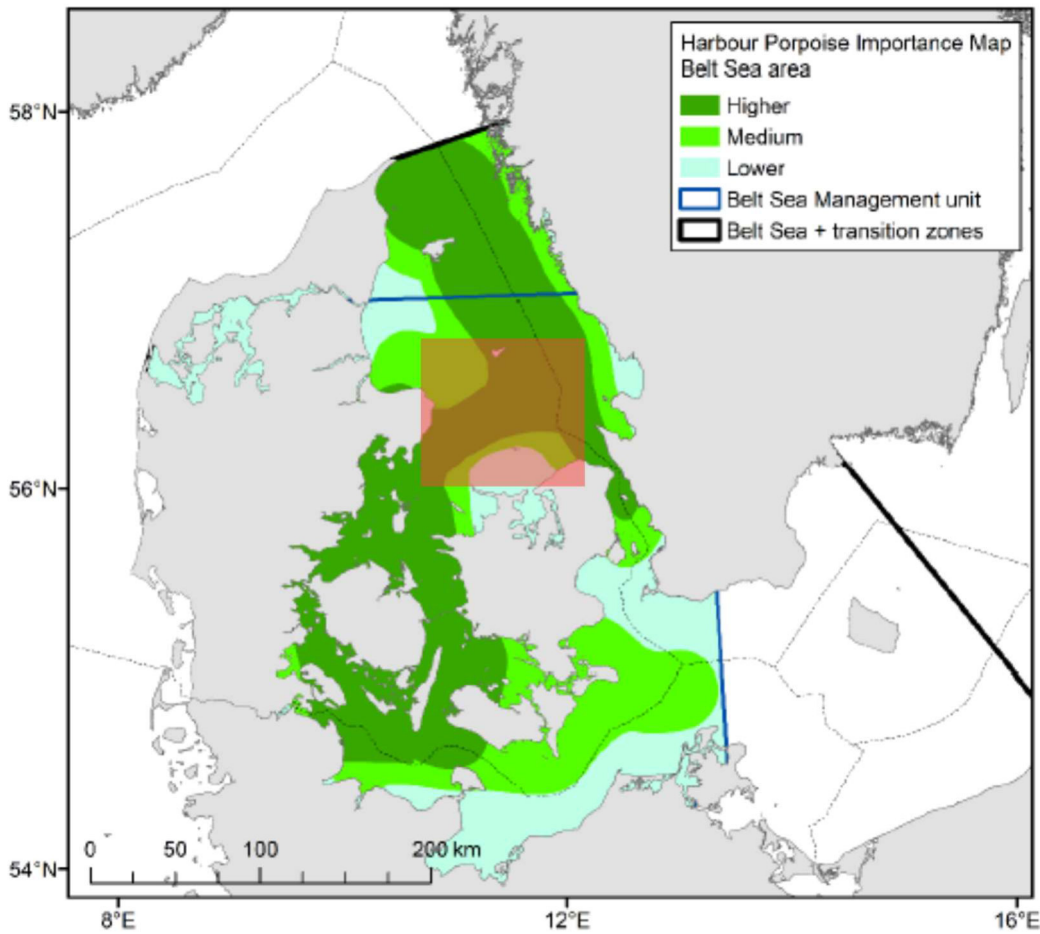
**Figure 3-5. Abundance estimates for harbour porpoises of the Belt Sea population with fitted trend line, suggesting an annual decline of 1.5%. Taken from SCANS IV: GILLES ET AL. (2023).**



**Figure 3-6. Belt Sea harbour porpoise population Bayesian trend, suggesting an annual decline of 2.7%. Taken from: OWEN ET AL. (2024).**

In a recent HOLAS III report (SVEEGAARD ET AL. 2022) data from porpoise telemetry in the Belt Sea, SCANS, SAMBAH and other national data were revisited with the aim to create a map showing the importance of areas in the Baltic Sea for harbour porpoises. Not being solely based on density estimates, which would fail to highlight the areas that may be important for the Baltic Proper population of harbour porpoises, which only consists of about 500 individuals, it was created using several steps: Importance was estimated separately for the Belt Sea population and the Baltic Proper population of harbour porpoises, before joining it for a single map.

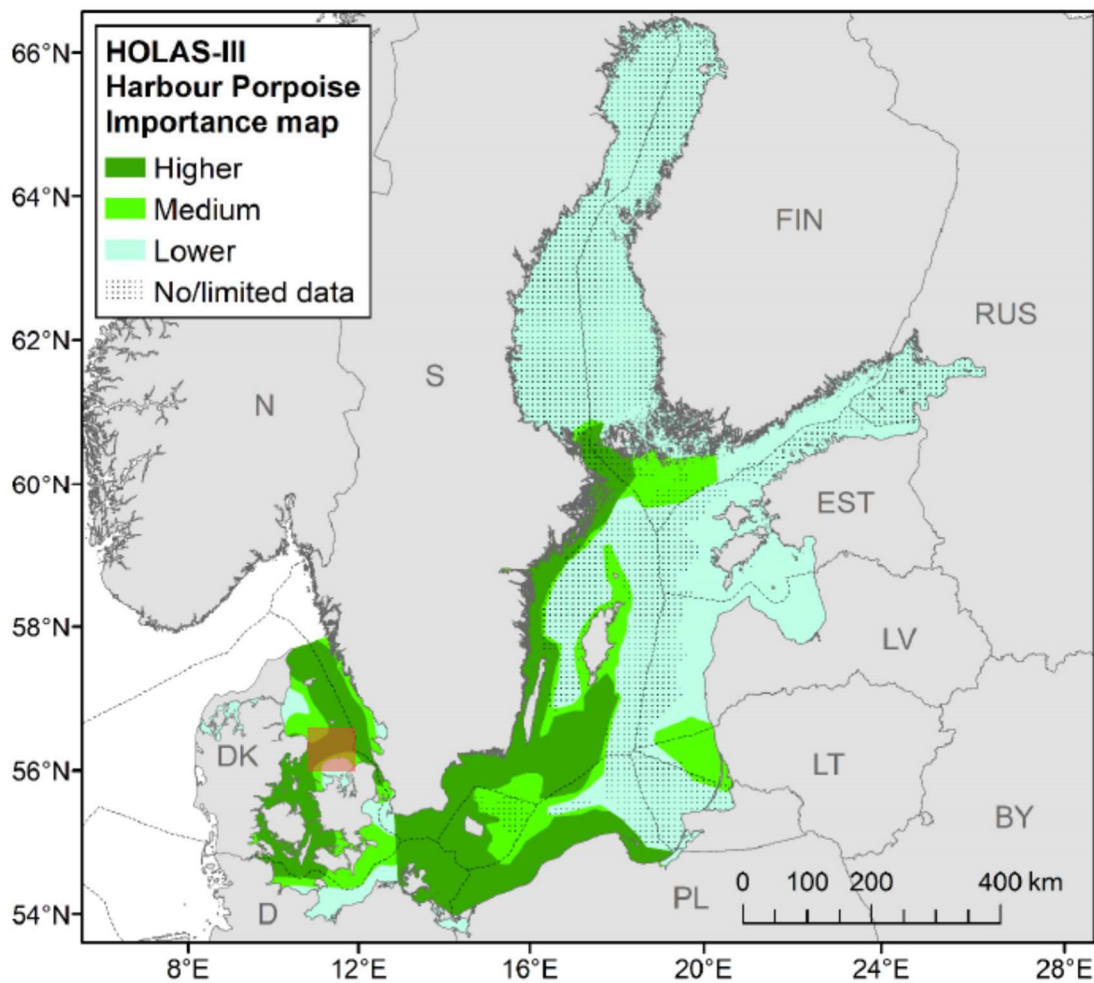
Importance of areas in the Baltic Sea for the Belt Sea population was estimated using telemetry data from 2007-2021, separately for summer and winter. With the Kernel Density tool in ArcGIS, contour lines (called isopleths) were created that encompassed 10, 50, 75% and 100% of harbour porpoise locations. The 50% isopleth was then used to identify areas of high importance, the 75% isopleth areas of medium importance, and areas outside these were categorized as being of lower importance. Then seasonal maps were merged, and this map was then compared with data from SCANS III (LACEY ET AL. 2022), the Belt Sea density surface model (period 2002-2016, ITAW / unpublished) and MiniSCANS II (UNGER ET AL. 2021), after which some areas of importance were added to the map in the Kattegat and Little Belt / Kiel Bight, giving the map shown in Figure 3-7.



**Figure 3-7. Map of the importance of different areas for the Belt Sea population of harbour porpoises. From: SVEEGAARD ET AL. (2022). Approximate pre-investigation area is indicated in red.**

The importance map for the Baltic Proper population was based on probability of detection from SAMBAH, also first created separately for winter and summer and then merged. Areas of  $\geq 20\%$  probability of detection were chosen to represent areas of higher importance, and areas between  $10\% - 20\%$  of probability of detection were chosen to present areas of medium importance. A convex hull (smallest polygon containing all the  $20\%$  (and then  $10\%$ ) detection probability areas) was drawn to present the area of higher ( $\geq 20\%$ ) and medium ( $10\% - 20\%$ ) importance for harbour porpoises of the Baltic Proper population. An area of high importance was added in Polish waters based on assessment of local PAM data and also an area of medium importance was added in Finnish waters, where national monitoring data indicated regular presence of harbour porpoises. These data were joined with the map shown in Figure 3-7 to gain one harbour porpoise importance map for the entire Baltic region (The HELCOM area), which is shown in Figure 3-8.





**Figure 3-8. HOLAS III map of importance for harbour porpoises within the HELCOM area. From: SVEEGAARD ET AL. (2022). Approximate pre-investigation area is indicated in red.**

### 3.3.3 CONSERVATION STATUS

Whilst the status of the global population (BRAULIK ET AL. 2020) and the European population (SHARPE & BERGGREN 2023) of the harbour porpoise is classified by the IUCN as least concern (LC), the Baltic Proper subpopulation is classified as critically endangered (CR; CARLSTRÖM ET AL. 2023), which is the highest threatened status (SPECIES ACCOUNT BY IUCN SSC CETACEAN SPECIALIST GROUP; REGIONAL ASSESSMENT BY EUROPEAN MAMMAL ASSESSMENT TEAM 2007; HAMMOND ET AL. 2008). The Baltic Proper subpopulation is considered decreasing. The HELCOM Red List lists the Baltic Proper subpopulation as CR and the Belt Sea subpopulation as VU (HELCOM 2013c). The national Danish Red List classified the harbour porpoise as LC (AARHUS UNIVERSITET 2019), the German as highly threatened (MEINIG ET AL. 2020), and the Swedish lists the Baltic Proper subpopulation as CR (2020).

Like all cetacean species, the harbour porpoise is included in Annex II and IV of the EU Habitats Directive (92/43/EEG), meaning that it requires strict protection, including the designation of Special Areas of Conservation (SACs) by the European member states. EU member states are required to maintain a



“favorable conservation status” of harbour porpoises. All whale species are also covered by the EU Marine Strategy Directive, where distribution, number and bycatch must be reported and evaluated according to descriptor 1.

The harbour porpoise is listed in Appendix II of the Bern Convention, meaning that it is strictly protected in member states. The harbour porpoise populations of the North and Baltic Seas are further included in Appendix II of the Bonn Convention (CMS SECRETARIAT 2015). The CMS daughter agreement ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas) hosts a recovery plan for the Baltic harbour porpoise and a conservation plan for the harbour porpoise in the Western Baltic, Belt Sea and Kattegat ([www.ascobans.org/en/documents/action-plans](http://www.ascobans.org/en/documents/action-plans)). Furthermore, the Baltic Sea states have agreed in HELCOM Recommendation 17/2 to protect the harbour porpoise in the Baltic Sea. For summary see Table 3-3.

HELCOM (2023d; e) pre-core indicators both (abundance and distribution) failed for the Baltic Proper harbour porpoise population. Due to a lack of sufficient scientific data, a quantitative evaluation could not be implemented and instead a qualitative expert-based evaluation was conducted based on the SAMBAH results from passive acoustic monitoring (PAM) in 2011-2013 (CARLÉN ET AL. 2018; AMUNDIN ET AL. 2022) and historic records. The qualitative evaluation shows that the abundance and the distribution of the Baltic Proper harbour porpoise population does not achieve good environmental status HELCOM (2023d; e). This is due to the very small population size of only about 500 individuals estimated (CARLÉN ET AL. 2018; AMUNDIN ET AL. 2022) and a decline in abundance and distribution over the last century when the current situation is compared to historic records.

The Danish National Center for Environment and Energy (DCE) assessed the conservation status of the harbour porpoise in Habitat Directive Article 17 from 2019 (FREDSHAVN ET AL. 2019) as follows: The population in the marine Atlantic region is considered as being of favorable conservation status. In the Baltic area the Belt Sea population is considered as having a favorable conservation status whereas the Baltic Proper population has a highly unfavorable conservation status. However, in the DCE Marine areas report from 2021 (HANSEN & HØGSLUND 2021) it is stated that the entire Belt Sea population of harbour porpoises has halved since previous counts in 2012 and 2016 to only about 17,300 individuals. On the other hand, acoustic monitoring in the Flensborg Fjord, Bedgrund and the waters around Als and Lillebælt revealed an increase in acoustic detections of harbour porpoises from 2013 to 2020 (HANSEN & HØGSLUND 2021).

**Table 3-3. Listing of the harbour porpoise in international and regional conservation agreements and international and national Red Lists. \* The population in the inner Danish waters.**

Species	IUCN	HELCOM Red List	National Red Lists	Natura 2000 (BfN 2015)	Bern Convention	Bonn Convention
Harbour Porpoise <i>Phocoena phocoena</i>	Global: LC Europe: LC Baltic Proper subpopulation: CR	Baltic Sea: CR Western Baltic*: VU	DE: Highly threatened DK: LC SE: CR (Baltic Sea population)	Appendix II und IV	Appendix II	Appendix II

# 4 METHODOLOGY

This chapter outlines the data collection methods, and analytical approaches applied for the investigations of marine mammals within and around the pre-investigation area of Kattegat.

## 4.1 DIGITAL AERIAL SURVEYS

Digital aerial surveys were used to determine the spatial distribution and seasonal abundance of marine mammals in the pre-investigation area from February 2023 to January 2024.

### 4.1.1 STUDY DESIGN

For the assessment of marine mammals in the pre-investigation area for Kattegat digital aerial surveys were conducted using HiDef video technology ([www.hidefsurveying.co.uk](http://www.hidefsurveying.co.uk)). Transect design for the pre-investigation area consisted of 18 transects aligned from north to south (Figure 4-1). The transects had a total length of 889 km varying between 240 km and 66 km with a distance between each transect line of 5 km (Table 4.2). On average, 11.6% of the 4,125 km<sup>2</sup> survey area was covered per flight (Table 4.1).

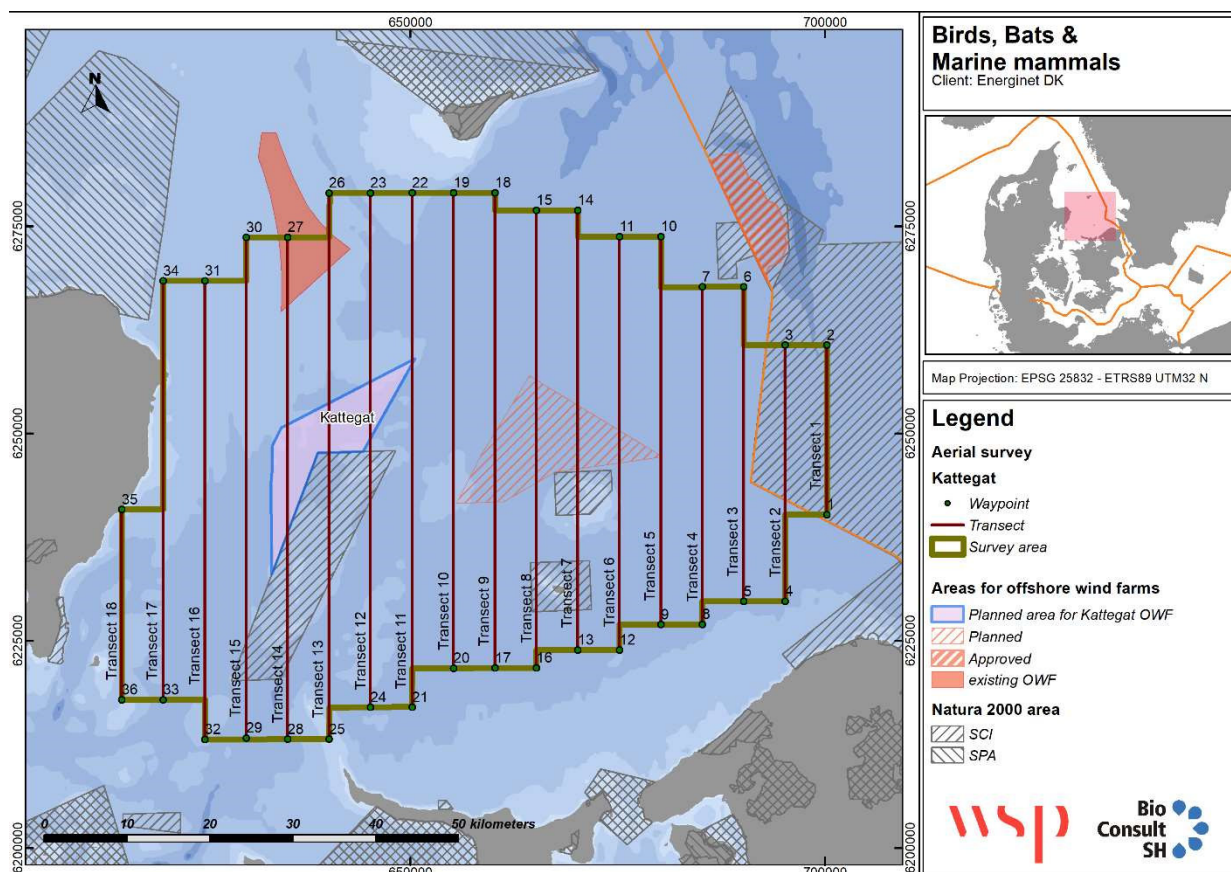


Figure 4-1. Transect design for aerial marine mammals' surveys in the pre-investigation area for Kattegat.

**Table 4.1. Overview of the digital aerial surveys carried out in the pre-investigation area between February 2023 and January 2024. Effort is the area covered by the digital aerial flights; coverage is the % area covered relative to the pre-investigation area.**

Survey no.	Date	Distance [km]	Effort [km <sup>2</sup> ]	Coverage [%]
1	04.03.2023	863	463	11.2
2	08.04.2023	891	483	11.7
3	17.06.2023	892	483	11.7
4	27.08.2023	895	479	11.6
5	18.11.2023	895	485	11.8
6	30.12.2023	892	483	11.7
		<b>Total: 5,328</b>	<b>Total: 2,876</b>	<b>Average: 11.6</b>

**Table 4.2. Waypoints (WP) and Transects coordinates and lengths for aerial marine mammal surveys in the pre-investigation area for Kattegat.**

Transect	Start Transekt	End Transekt	Length [km]
1	WP01: 56.26473°N; 12.23245°E	WP02: 56.44831°N; 12.24803°E	20.5
2	WP03: 56.45031°N; 12.16704°E	WP04: 56.17310°N; 12.14416°E	30.9
3	WP05: 56.17503°N; 12.06374°E	WP06: 56.51548°N; 12.09118°E	37.9
4	WP07: 56.51738°N; 12.01003°E	WP08: 56.15204°N; 11.98138°E	40.7
5	WP09: 56.15386°N; 11.90099°E	WP10: 56.57385°N; 11.93309°E	46.8
6	WP11: 56.57565°N; 11.85181°E	WP12: 56.12816°N; 11.81858°E	49.9
7	WP13: 56.12987°N; 11.73823°E	WP14: 56.60606°N; 11.77261°E	53.1
8	WP15: 56.60775°N; 11.69125°E	WP16: 56.11229°N; 11.65655°E	55.2
9	WP17: 56.11389°N; 11.57622°E	WP18: 56.62851°N; 11.61120°E	57.3
10	WP19: 56.63010°N; 11.52977°E	WP20: 56.11545°N; 11.49588°E	57.3
11	WP21: 56.07468°N; 11.41289°E	WP22: 56.63163°N; 11.44834°E	62.0
12	WP23: 56.63312°N; 11.36690°E	WP24: 56.07613°N; 11.33263°E	62.0
13	WP25: 56.04313°N; 11.25036°E	WP26: 56.63455°N; 11.28545°E	65.9
14	WP27: 56.58813°N; 11.20122°E	WP28: 56.04447°N; 11.17015°E	60.6
15	WP29: 56.04719°N; 11.09001°E	WP30: 56.58944°N; 11.11986°E	60.4
16	WP31: 56.54375°N; 11.03597°E	WP32: 56.04700°N; 11.00972°E	55.3
17	WP33: 56.09135°N; 10.93165°E	WP34: 56.54496°N; 10.95470°E	50.5
18	WP35: 56.29859°N; 10.86128°E	WP36: 56.09249°N; 10.85133°E	23.0

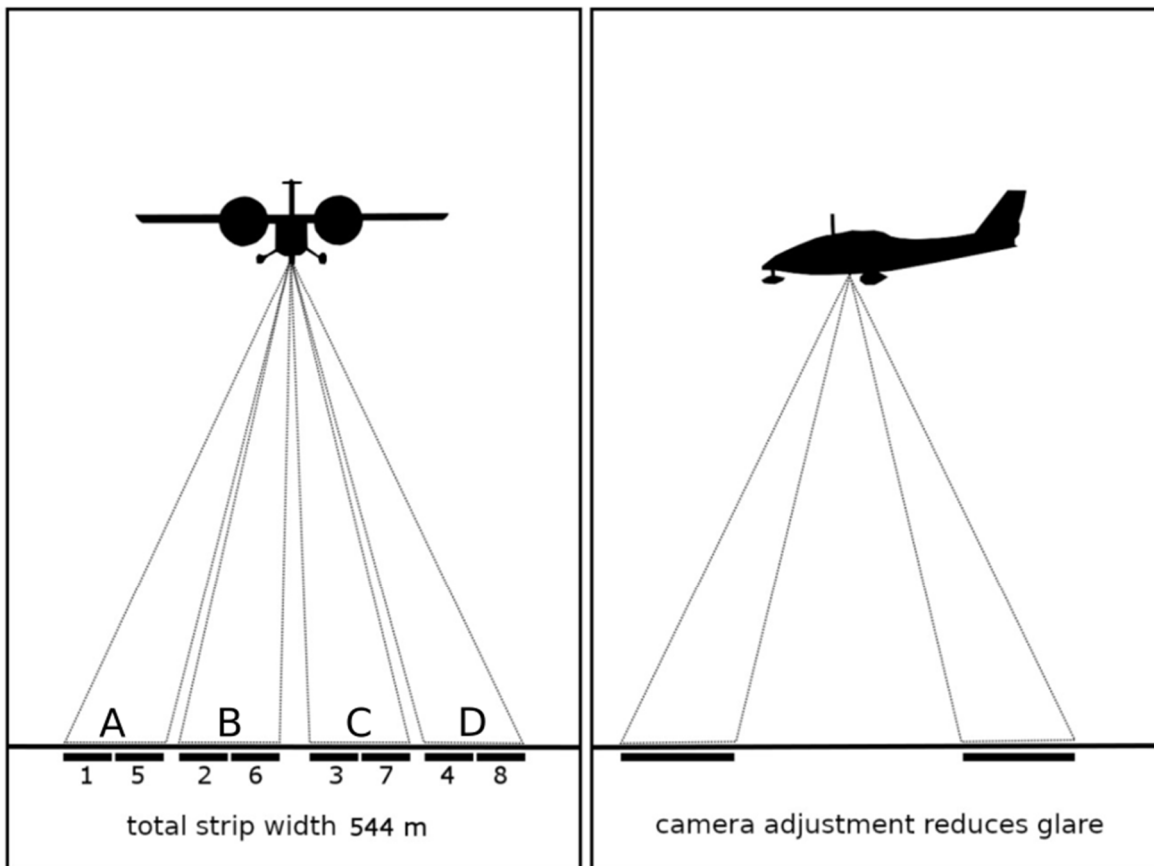
#### 4.1.2 DATA COLLECTION

The recording of marine mammals was performed using the digital video technology developed by the company HiDef surveying Ltd. ([www.hidefsurveying.co.uk](http://www.hidefsurveying.co.uk)), explained in detail in WEIB ET AL. (2016) and summarized in the following paragraphs.

A twin-engine, high-wing propeller-driven aircraft (Partenavia P 68) was used for the acquisition of digital videos, see Figure 4-2. This aircraft is equipped with four high-resolution video camera systems, which take approximately seven images per second and can achieve a resolution of two cm at sea surface. Since the

camera system is not directed vertically downwards (depending on the sun position, it can be slightly inclined or even set against the flight direction), interferences arising from solar reflections (glare) can be effectively reduced. The external cameras (indicated by A and D, Figure 4-2) cover a strip of 143 m width while the internal ones cover a width of 129 m each, resulting in 544 m effectively covered. There is however about 20 m distance between each strip to avoid double counting of individuals detected by the cameras. Thus, the total recorded strip of 544 m is distributed over a width of 604 m.

The aircraft flew at an average speed of approx. 220 km/h (120 knots) at an altitude of 549 m. A GPS device (Garmin GPSMap 296) recorded the position every second, which permitted to geographically assign a location to the images and the animals registered on them. The collected data were stored on mobile hard disks for subsequent review and analysis.



**Figure 4-2. The HiDef Camera System. The four cameras (A to D) cover an effective strip width of 544 m of the sea surface at a flight altitude of 549 m (left: frontal view; right: side view). The numbering indicates the camera images as they are used in the evaluation (the images from each camera are divided into two halves).**

### 4.1.3 DATA PROCESSING

To facilitate the detection of objects, the video sequences taken from each camera were split into two halves, so that each half of the picture fitted the width of a large monitor. The video files were then processed using an image capture and management software (StreamPix). First, the images were examined and all the detected objects (marine mammals, ships, etc.) were marked and pre-sorted for subsequent

identification. To guarantee a consistent high quality, 20% of each film was randomly selected and processed again by another reviewer. If both reviewers reached a consensus of 90% regarding object identification, discrepancies were rechecked, and the film afterwards approved for further analysis. If the consensus was below 90%, the film was reanalyzed entirely. Sections of the footage that could not be assessed due to backlight or the presence of clouds were not considered for further analysis.

The next step involved the identification of the previously marked objects (marine mammals). This was done by experienced observers. Often marine mammals can be identified on the images to species level. Due to strong similarities between some species (e.g., harbour seals and grey seals), an identification on species level is not always possible. However, it is usually possible to identify individuals as belonging to a species group formed by two (or few) closely related species. In addition to the identification, other information such as position, age, behavior and swim direction were determined whenever possible. Environmental parameters (air turbidity, sea state, solar reflection, and water turbidity) were recorded every 500 images (approx. covering 4 km). To assure quality control, 20% of the objects identified were re-assessed by a second reviewer. All discrepancies between the first and second identification process were checked again by a third expert. If there was a consensus of at least 90%, the data collected was released for further analysis. If the consensus was below 90%, systematic errors (e.g., problems in determining specific species groups) were corrected and all objects were re-identified.

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#### 4.1.4 DATA ANALYSIS

Densities of individuals (individuals/km<sup>2</sup>) were calculated for all species or species groups. All seal taxa (grey seal, harbour seal and unidentified seal) were evaluated together as seals.

The density per survey and the seasonal densities were calculated for seals and harbour porpoises. In addition, the seasonal distribution was analysed. To illustrate the spatial distribution, a grid was laid across the pre-investigations area, and the grid cells were aligned with the European Environment Agency grid (EEA 2019). The edge length of the single cells consists of squares with 5 km edge lengths. Densities per grid cell are only shown if a minimum survey effort of 0.5 km<sup>2</sup> was reached.

Certain correction factors are included in the calculation and analysis since marine mammals located more than about 2 m below the water surface may escape detection from the air. Thus, these animals could also be taken into account to determine abundance and densities. To correct for this so-called availability error (BORCHERS 2003), the number of animals sighted can be multiplied by a factor that takes into account the probability of harbour porpoises being present in the upper level of the water column (0-2 m, TEILMANN ET AL. 2013). This likelihood was determined by means of tagged animals in the North- and Baltic Sea while considering seasonal fluctuations (Table 4.3).

The literature does not provide any information about the proportion of seals in the upper 2 m of the water column. Telemetry studies make it clear that the animals mainly remain close to the seafloor and only briefly come to the surface to breathe (ADELUNG ET AL. 2004). Consequently, the density of seals presented here can only be taken as a minimum density and not as an average.

**Table 4.3 Seasonal residence probability (%) of harbour porpoises in the top two meters of the water column, separated by month; according to Teilmann et al. (2013).**

ID	Month	Residence probability [%] (0-2 m)
1	January	49.2
2	February	42.5
3	March	52.5
4	April	61.5
5	May	57.3
6	June	55.3
7	July	57.0
8	August	51.7
9	September	45.0
10	Oktober	45.3
11	November	46.3
12	December	49.9

## 4.2 PASSIVE ACOUSTIC MONITORING SURVEY

The purpose of the passive acoustic monitoring (PAM) survey was to determine the spatial and seasonal habitat use of harbour porpoise occurring in the pre-investigation area from Kattegat during the one-year survey period from February 2023 to January 2024.

### 4.2.1 STUDY DESIGN

A total of 8 C-PODs (K-O1 to K-O4 and K-R1 to K-R4) were deployed for PAM of harbour porpoises in the pre-investigation area in the southern Kattegat (Figure 4-3; Table 4-4).



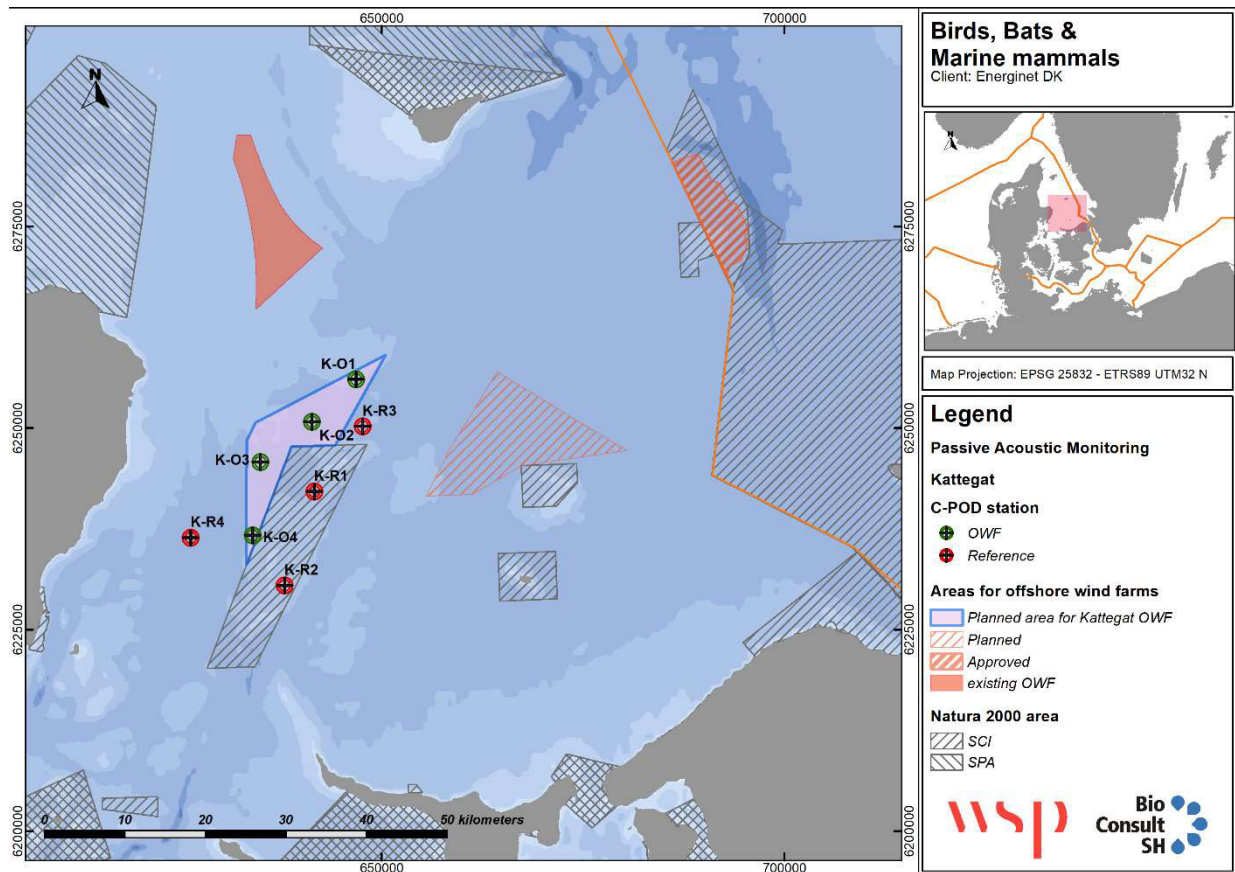


Figure 4-3. C-POD design inside and outside the planned windfarm area of Kattegat.

Table 4-4. Geographical positions of the deployed C-PODs. C-PODs were deployed at all stations.

Station	(WGS 84, DD)	(WGS 84, DD)	(WGS 84, DD°MM)	(WGS 84, DD°MM)
K-O1	56.426117	11.380518	56° 25.567' N	11° 22.831' E
K-O2	56.380633	11.289414	56° 22.838' N	11° 17.365' E
K-O3	56.337628	11.183250	56° 20.258' N	11° 10.995' E
K-O4	56.256335	11.162913	56° 15.380' N	11° 09.775' E
K-R1	56.302726	11.289738	56° 18.164' N	11° 17.384' E
K-R3	56.373581	11.391245	56° 22.415' N	11° 23.475' E
K-R2	56.199228	11.223871	56° 11.954' N	11° 13.432' E
K-R4	56.255706	11.038729	56° 15.342' N	11° 02.324' E

All eight C-POD stations were deployed on the 23<sup>rd</sup> of February 2023. The devices were replaced approximately every two months to extract data and change the batteries. The deployment and recording periods of the C-PODs for all monitoring stations are shown in Figure 4-4. There was no data loss at a majority of stations, except for a short period of time at stations K-O4.

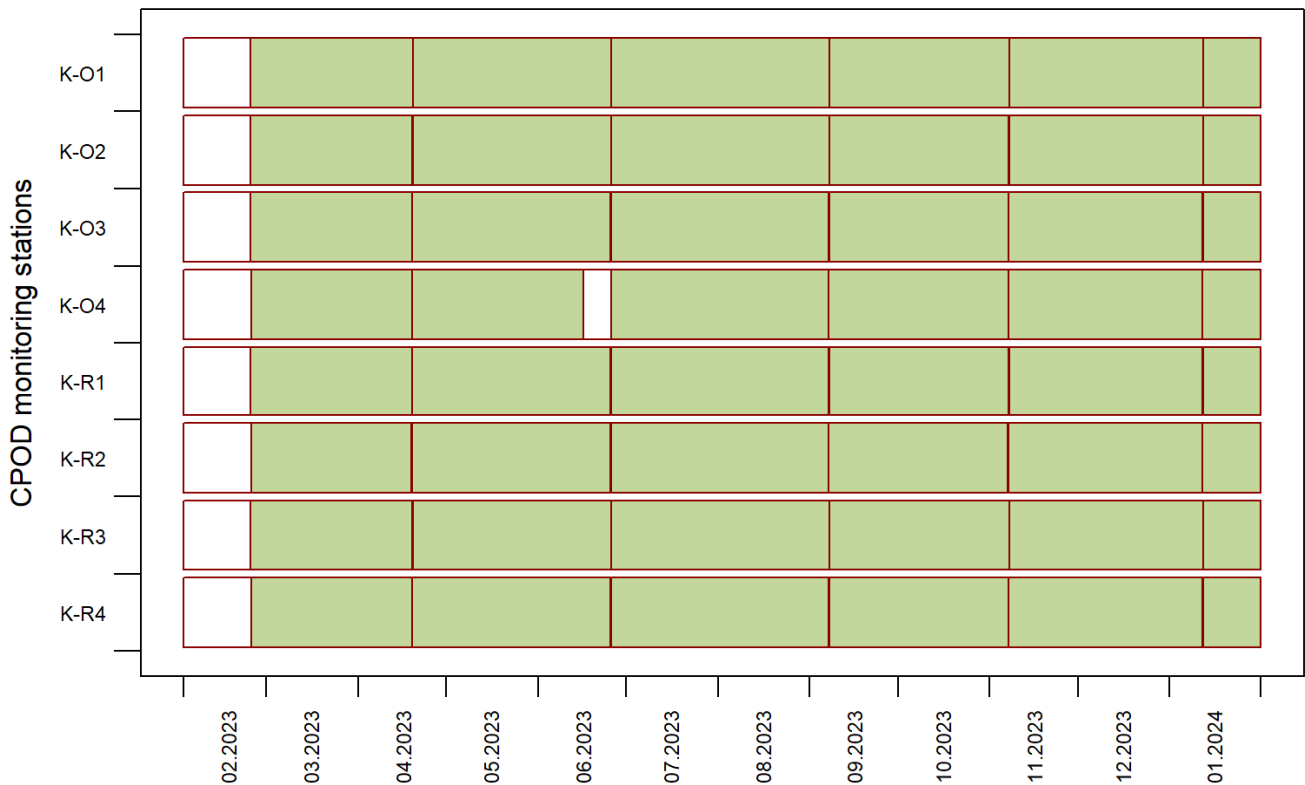


Figure 4-4. Bar chart, indicating the duration of deployment of C-PODs within the pre-investigation area for the survey period (February 2023 to January 2024). Green: C-POD recorded data, white: no data. The x-axis shows the date, the y-axis the C-POD station. Vertical lines indicate the time of exchange of the devices.

#### 4.2.2 DATA COLLECTION

##### THE CETACEAN PORPOISE DETECTOR (C-POD)

C-PODS were used to conduct passive acoustic monitoring of marine mammals. A C-POD (Cetacean Porpoise Detector; Figure 4-5) 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° (KOBLOITZ ET AL. 2012). This means that C-PODs will only be able to detect harbour porpoise presence if these (1) emit click sounds, (2) have their head pointed towards the hydrophone, and (3) are located at a suitable distance from the device. Even though the manufacturer of the C-POD states that these data loggers can record clicks of harbour porpoises up to a range of 400 m (CHELONIA LIMITED 2023), the effective detection radius is smaller. For example, in a field study with the predecessor model, the T-POD, only clicks up to a distance between 22 and 104 m were effectively recorded (KYHN ET AL. 2012), while in another field study a detection range of about 170 m was observed (KOSCHINSKI ET AL. 2003). The respective detection radius depends on the C-POD type, C-POD sensitivity, train classification settings and duration of snapshots, as well as sea state, wind, current speed and sediment type which affect the background noise level.

The 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 an 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.



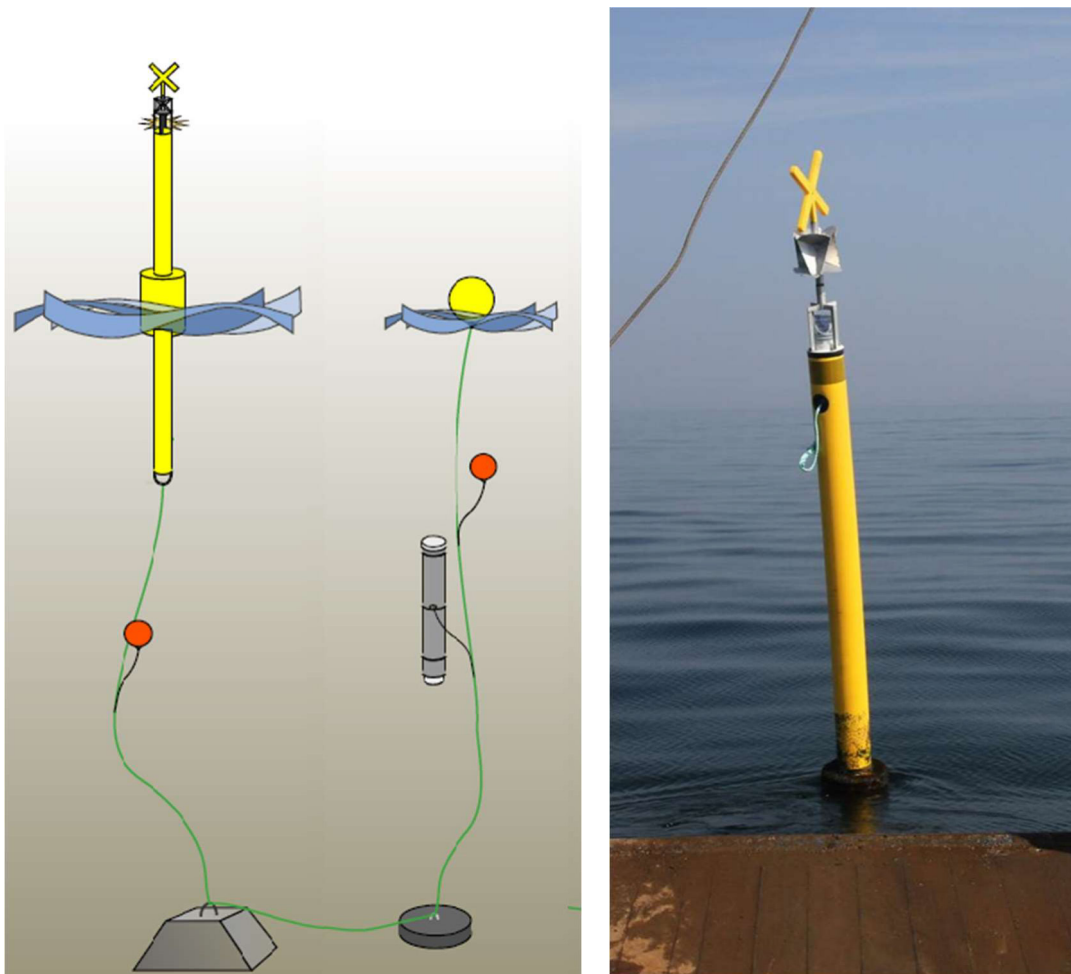
Figure 4-5. C-POD ([www.chelonia.co.uk/index.html](http://www.chelonia.co.uk/index.html)).

### C-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 ( $\pm 3$  dB). Calibration is carried out in a specifically designed test tank in a standardized 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°-intervals. The calibration and standardization process are described in detail on the manufacturer's website ([www.chelonia.co.uk](http://www.chelonia.co.uk)).

### C-POD DEPLOYMENT

According to the international guideline for offshore data acquisition systems (ODAS) all C-PODs were marked by a yellow rubber marker buoy as well as a 6 m sparbuoy, equipped with a yellow 3NM flashlight, a radar-reflector and a yellow top-cross (Figure 4-6). Two surface markers are connected via a rope on the sea floor.



**Figure 4-6. C-POD mooring system with spar buoys.**

C-PODs were deployed starting February 2023 after the permission from the Danish Maritime Authority for deployment was acquired. The maintenance of C-PODs at sea was done every 6-10 weeks to avoid potential data gaps due to losses or malfunctions as short as possible.

### 4.2.3 DATA ANALYSIS

#### MEASUREMENT UNITS

Harbour porpoise-positive time units are pre-defined periods (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 click train, this time unit is rated to be harbour porpoise positive. As the number of recorded click trains 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. 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; BIOCONSULT SH 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 timeframe. 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 time unit. See formula 1,  $x_t$  = number of clicks for this time unit.

Formula 1:

$$\text{Harbour porpoise positive time per time unit [\%]} = \frac{\text{N time units with clicks } (x_t > 0)}{\text{N total time unit}} * 100$$

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 pre-investigation area.

The following analyses are based on DPD/month and DP10M/day (see below), focusing on two main questions:

1. What is the monthly presence of porpoises in the preliminary project area?
2. How do animals utilize 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, no difference is made if only one click train was recorded that day or if every minute hundreds of click trains occurred. The coarse resolution parameter is particularly well-suited for datasets characterized by a limited number of harbor porpoise detections, as observed in the current pre-investigation area. The parameter is standardized 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, i. e., 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/day). That is because analyses based on an hourly or even minute-by-minute basis have a high susceptibility to randomness due to very infrequent recording and thus only have 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. This parameter can be used to check for any temporal differences in the presence of harbour 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 habitat use.

## CALCULATIONS

**Seasonality diagrams** for each C-POD station were generated based on harbour porpoise detection rates using the software R (package “stats”; version 3.4.0; R CORE TEAM 2017). The phenology is represented by the parameter %DPD/month and %DP10M/d. With the former parameter, 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 as equal to a day on which almost continuous (i. e. many) porpoise click trains are recorded. The use of this parameter prevents an overestimation of too large stochastic parameters. The other parameter %DP10M/d provides a finer temporal resolution but is more prone to stochasticity.

The **spatial distribution** of the harbour porpoises is displayed by overlaying the average of detection positive 10-minute units per day (%DP10M/d) as classified circles and the geographical position of the respective C-POD station using the software ArcGIS (Version 10.8).

**Dial patterns** of harbour porpoises were analysed based on the daytime-phase-length-weighted proportion of %DP10M/t relative to all phases (sum of all four phases day, night, dusk, and dawn = 100 %; dusk and dawn not shown in plots). This was done per C-POD station.

## DATA QUALITY

C-PODs record signals in real time allowing to identify click trains due to the temporal resolution. Raw data of C-PODs were processed using the associated software CPOD.exe (Chelonia Ltd., UK). Data was processed in two steps. In a first step, harbour porpoise click trains were extracted from the raw data by means of an algorithm of the CPOD.exe software. In a second step, signals were classified by the KERNO classifier into different categories according to the probable source: harbour porpoise, dolphin, boat sonar or unknown source. The software assigned each click train to one of these classes and gave 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 Ltd., including only the two highest quality classes (“high” and “moderate”) to decrease the number of incorrectly classified harbour porpoise click trains.

To avoid possible masking effects of too 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 minute. In such a case, harbour porpoise clicks may be missed. However, even if the limit is not reached it cannot be excluded that porpoise clicks may be missed due to masking. A double quality criterion was defined in order to prevent too much data of unknown origin from being included in the further analysis and causing a bias in the outcome: The two criteria were defined based on experience gained in the analysis of different projects in the North Sea and Baltic Sea (BIOCONSULT SH ET AL. 2019). All complete days with C-POD recordings that registered either more than three million clicks (the maximum possible number is > 5.89 million clicks) or had more than 200 minutes reaching the click limit of 4,096 clicks were removed. Furthermore, only whole days with records of 1,440 minutes were included in the evaluation. Duplicate or incomplete records due to e.g. exchanges of C-PODs were excluded.

A total of 8 days of 2,744 possible monitoring days (0.3%) could not be included in the evaluation due to data loss. 2,736 C-POD monitoring days remained for further consideration. About 3,8% of all C-POD monitoring days did not meet the above described noise criteria and were therefore discarded. Hence, 2,633 C-POD days remained for further analysis. The dual noise criterion was not applied to sonar analyses, as ship noise was of special interest here.

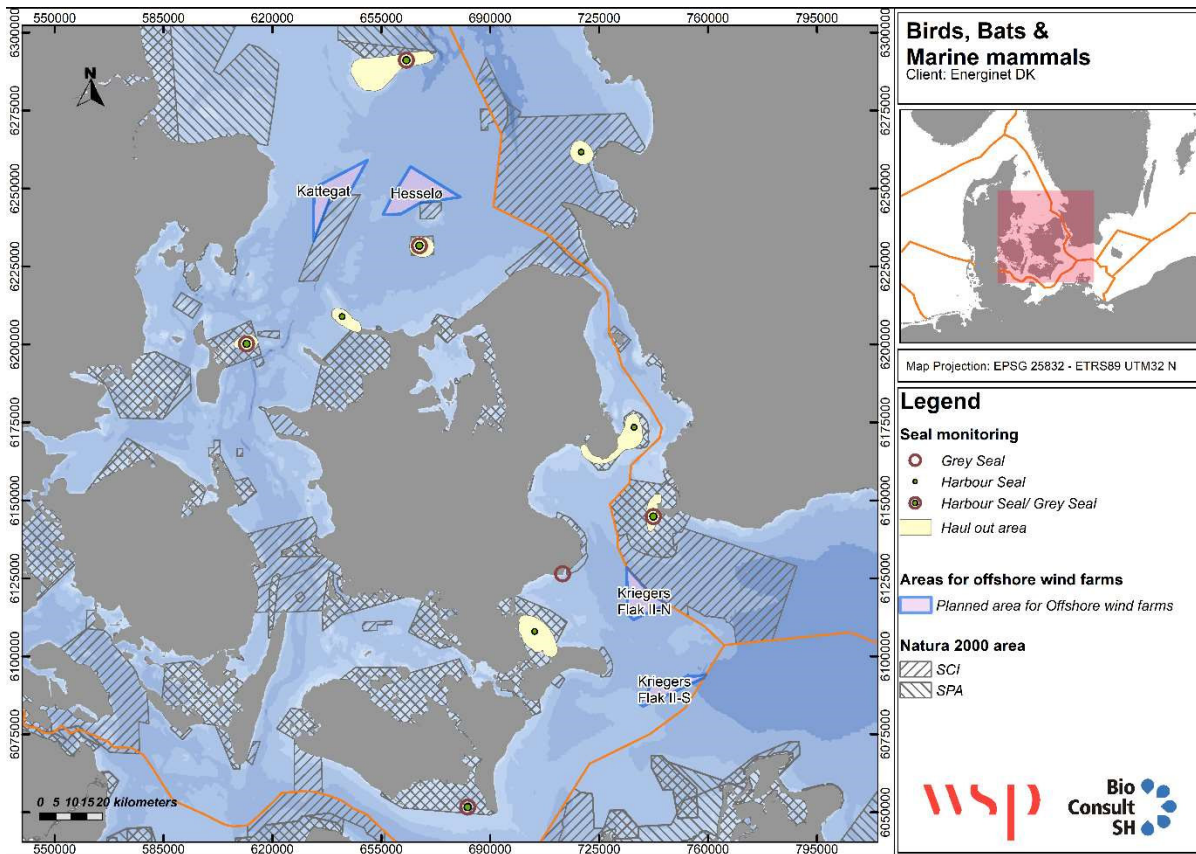
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### 4.3 SEAL COUNTINGS AT HAUL-OUT SITES

Data from seal countings under the Danish national monitoring programme NOVANA during the moulting and pupping seasons of harbour seals and grey seals, respectively were analyses according to HANSEN & HØGSLUND (2021). In addition to the NOVANA data, also publicly available data for seals from Sweden through the pan-Baltic grey seal moult survey, organised by HELCOM, between late May and early June will be considered. Based on historical (SØNDERGAARD ET AL. 1976) and current distribution of seals (HANSEN & HØGSLUND 2021) and their haul-outs on beaches and sand banks in the Baltic Sea and Kattegat, haul-out sites were selected for further analyses.

These data will be used to study the annual numbers of seals in the vicinity of the planned windfarm areas Kattegat, Hesselø and Kriegers Flak II, which are included in the ongoing tender for offshore wind (Figure 4-7 and Table 4-5).

For harbour seals May and June haul-out sites count data and for grey seal August haul-out sites count data were used according to HANSEN & HØGSLUND (2021). In contrast to HANSEN & HØGSLUND (2021) data was not corrected for seals at sea during haul-out counts. Therefore, the true abundance may be much higher as at some areas around 60% of seals may be at sea during counts (HANSEN & HØGSLUND 2021).



**Figure 4-7. Haul-out sites of Harbour Seals and Grey Seals in the vicinity of the windfarm areas Kattegat, Hesselø, Kriegers Flak II N and Kriegers Flak II S. The distribution of seals and prey on beaches and sandbanks shown is adapted from HANSEN & HØGSLUND (2021) and SØNDERGAARD ET AL. (1976).**

**Table 4-5. Haul-out sites in Kattegat and around Kriegers Flak from which publicly available data will be analysed.**

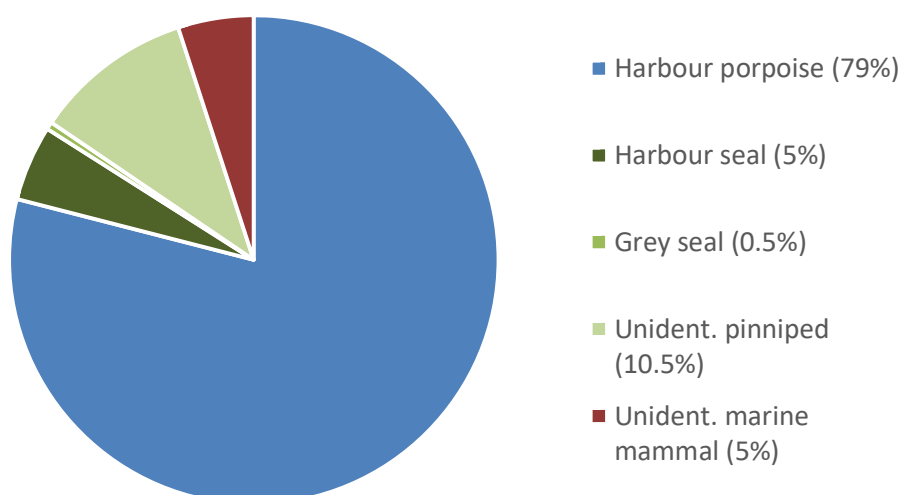
ID	Name	Type	Lat	Long	Seal Spec.	Natura 2000 EU	Natura 2000 DK
1	Bosserne	Haul out	55,93373151	10,78840203	both	DK00DX155	N55
2	Sjælland Rev	Haul out	56,00391878	11,28404046	Harbour Seals	DK005X221	N154
3	Hesselø	Haul out	56,19966196	11,69505519	both	DK003X202	N128
4	Anholt	Haul out	56,73561799	11,66533395	both	DK00DX146	N46
5	Hallands Väderö	Haul out	56,44814246	12,5576291	Harbour Seals	SE0420002	
6	Saltholm	Haul out	55,60638302	12,75682771	Harbour Seals	DK002X110	N142
7	Vestamager	Haul out	55,55455963	12,59122218	Harbour Seals	DK002X111	N143



8	Måkläppen	Haul out	55,38954768	12,82751999	both	SE0430095	
9	Stevns Rev	Finding	55,23813505	12,35443397	Grey Seals	DK00VA305	N206
10	Bøgestrøm	Haul out	55,07619534	12,20003145	Harbour Seals	DK006X233	N168
11	Rødsand	Haul out	54.57861100	11.82838900	both	DK006X238	

## 5 DATA AND RESULTS

During the survey period from February 2023 to January 2024, a total of 200 marine mammals (Figure 5-1 and Table 5-1; 32 seals (10 harbour seals, 1 grey seal, 21 seals), 158 harbour porpoises and 10 unidentified marine mammals) were observed during the six digital aerial surveys. The 10 unidentified marine mammals belong most likely to one of the categories harbour porpoise or unidentified seal.



**Figure 5-1. Proportion of different marine mammal observations in the pre-investigation area during aerial surveys between February 2023 and January 2024.**

**Table 5-1. Observations of marine mammals in the pre-investigation area during aerial surveys between February 2023 and January 2024. Harbour seal, grey seal and unidentified seal are summarised under the term seals.**

Survey no.	Date	Effort [km <sup>2</sup> ]	Harbour seal [Ind.]	Grey Seal [Ind.]	unidentified seal [Ind.]	Seals (Total)	Harbour porpoises [Ind.]	Unidentified marine mammal [Ind.]
1	04.03.23	463	0	0	2	2	9	1
2	08.04.23	483	0	1	5	6	25	2
3	17.06.23	483	5	0	7	12	72	3
4	27.08.23	479	5	0	2	7	38	1
5	18.11.23	485	0	0	5	5	12	3
6	30.12.23	483	0	0	0	0	2	0
	<b>Total</b>	<b>2,876</b>	<b>10</b>	<b>1</b>	<b>21</b>	<b>32</b>	<b>158</b>	<b>10</b>

Furthermore, passive acoustic monitoring with a total of 8 C-POD stations was carried out to determine the habitat usage of the area by harbour porpoises. On average, at least one harbour porpoise contact was recorded at each station on 98.4% of all survey days.



Details on harbour seals, grey seals and harbour porpoises in the pre-investigation area are described in the following sections.

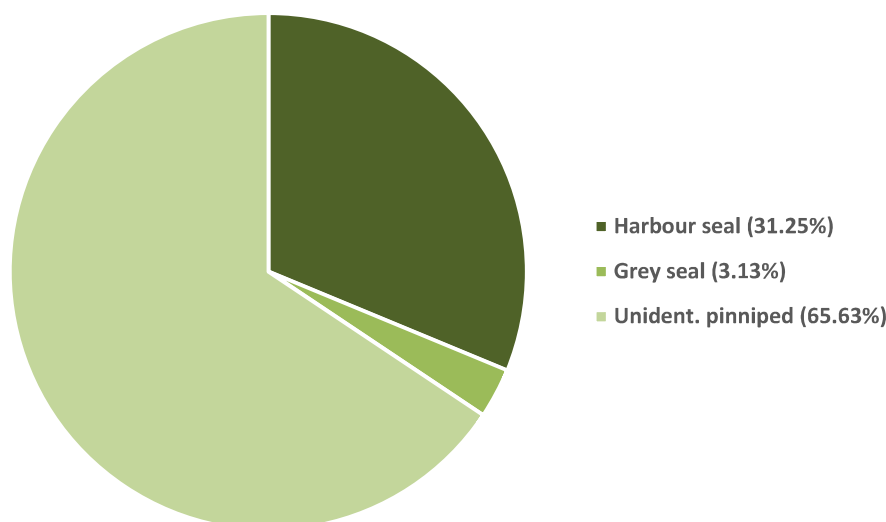
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## 5.1 SEALS

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### 5.1.1 DIGITAL AERIAL SURVEYS

Out of the 32 seals that were observed during the digital aerial surveys, only 34.4% could be identified to species level (Figure 5-2 and Table 5-1). These 11 seals consisted of 90.9% harbour seals (n=10) and 9.1% grey seals (n=1). In order to consider that 65.6% of the observed seals could not be identified to species level (n=21), all overserved seals will in the following be analysed together as seals when relevant.



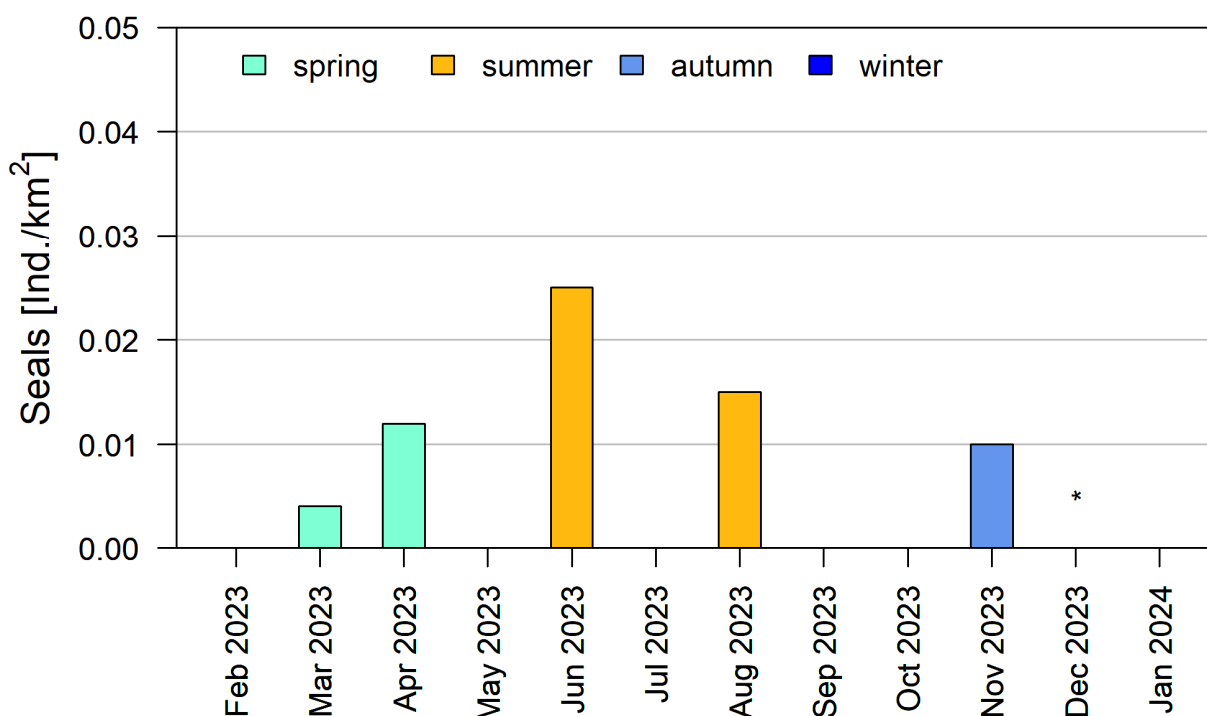
**Figure 5-2. Proportion of harbour seal, grey seal and unidentified seals observations in the pre-investigation area during aerial surveys between February 2023 and January 2024.**

### SEASONAL DISTRIBUTION

Regarding seals identified on species level, only one grey seal was observed during the digital aerial survey on 08.04.23, while harbour seals were observed during the 2 surveys in June and August. Taking into account also unidentified animals, seals were observed during 5 of 6 surveys. In general, highest density for all seals combined with 0.025 Ind./km<sup>2</sup> was observed in summer (June 2023; Table 5-2 and Figure 5-3). The second highest density of 0.015 Ind./km<sup>2</sup> was observed in August 2023. Of all the surveys the lowest density was observed in December 2023 with 0 Ind./km<sup>2</sup>.

**Table 5-2. Seal densities in the pre-investigation area during aerial surveys between February 2023 and January 2024. Harbour seal, grey seal and unidentified seal are summarized under the term seals.**

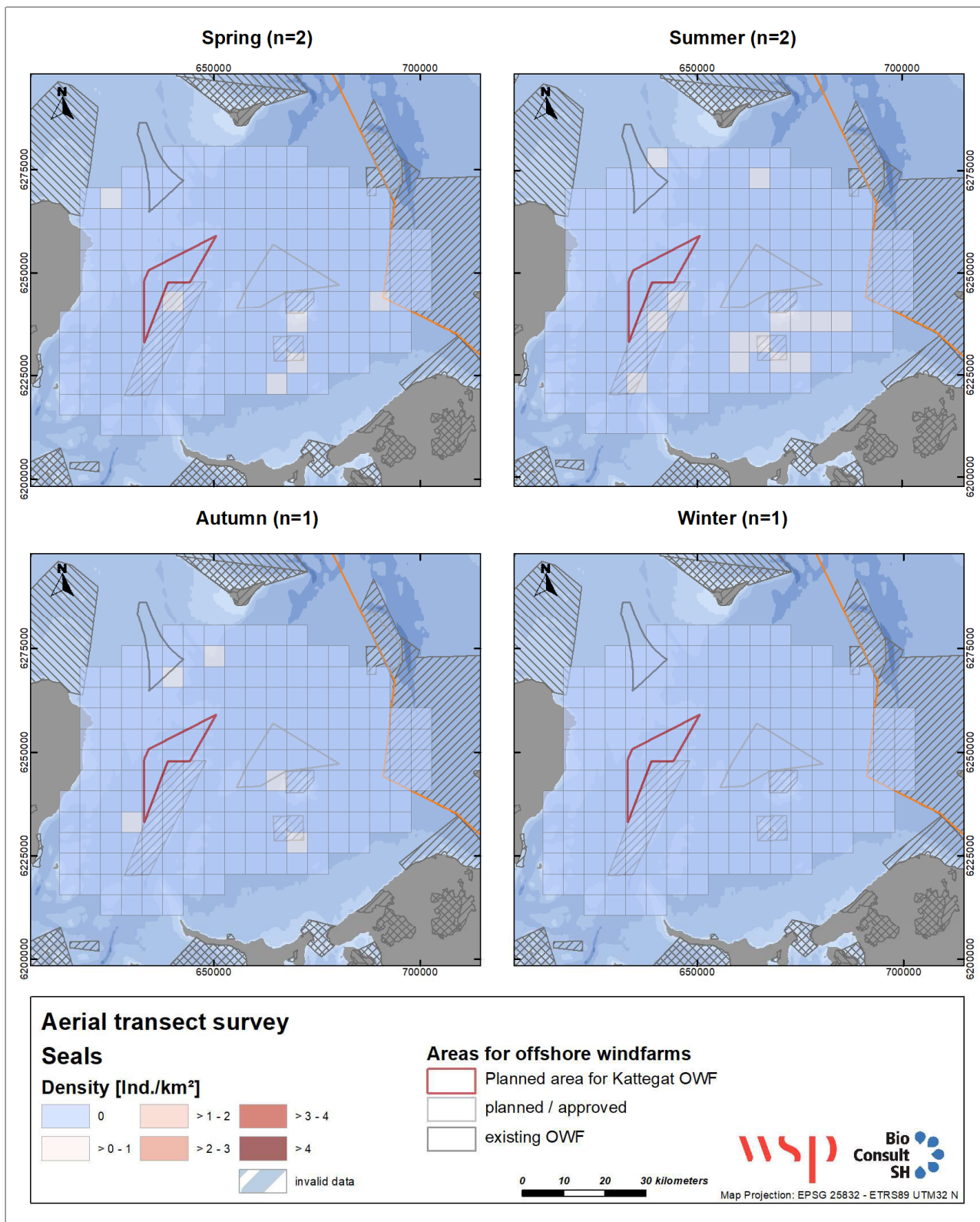
Survey no.	Date	Effort [km <sup>2</sup> ]	Harbour seal [Ind./km <sup>2</sup> ]	Grey Seal [Ind./km <sup>2</sup> ]	Unidentified seal [Ind./km <sup>2</sup> ]	Seals [Ind./km <sup>2</sup> ]
1	04.03.23	463	0	0	0.004	0.004
2	08.04.23	483	0.000	0.002	0.010	0.012
3	17.06.23	483	0.010	0	0.014	0.025
4	27.08.23	479	0.010	0	0.004	0.015
5	18.11.23	485	0.000	0	0.010	0.010
6	30.12.23	483	0	0	0	0
	Total	<b>2,876</b>	<b>0.003</b>	<b>0.0003</b>	<b>0.007</b>	<b>0.011</b>



**Figure 5-3. Mean seal density (Ind./km<sup>2</sup>) per month (harbour seal, grey seal and unidentified seals) in the study period (February 2023 – January 2024). In months without bars, no surveys were carried out. The seasons are colour coded. \*) no seal sightings**

## SPATIAL DISTRIBUTION

Eleven of the 32 identified individuals were observed within the Natura 2000 sites *Hesselø med omliggende stenrev* (DK003X202) and *Schultz og Hastens Grund samt Briseis Flak* (DK00VA303). However, it is only the *Hesselø med omliggende stenrev* which has harbour seal and grey seal listed as important species (Figure 5-4 and Appendix Figure 9-1 to Figure 9-4).



**Figure 5-4. Spatial distribution of seals during digital aerial surveys between February 2023 and January 2024. The number (n) of digital aerial surveys taken into account to calculate seasonal densities is given in the title of the respective panel.**

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## 5.1.2 SEAL COUNTINGS AT HAUL-OUT SITES

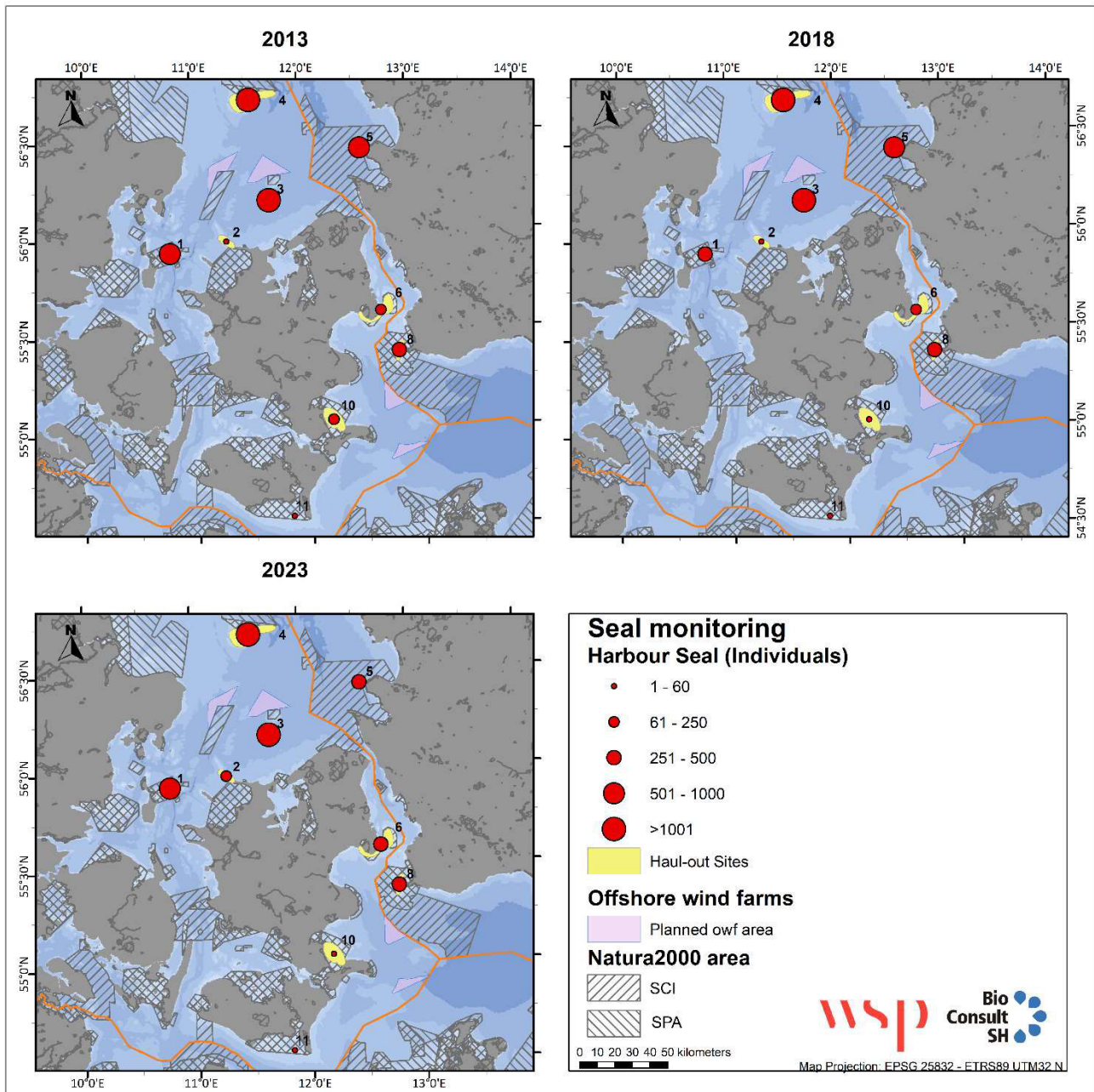
### HARBOUR SEALS

Within the Kattegat and southwestern Baltic area eight haul-out sites are taken into account in the analysis for harbour seals (Figure 5-6). Four of the eight haul-out sites contributes with about 90% of all harbour seals counted during the different monitoring programs. The haul-out site at Hesselø was the most important haul-out site for harbour with about 42% of all counted seals between 2013 and 2023, followed by Anholt (27%), Bosserne (12%) and Hallands Väderö (9%). The haul-out sites Måkläppen (5%), Saltholm (3%) as well as Sjøllands Rev (0.8%), Bøgestrøm (0.8%) and Rødsand (0.1%) were much less frequent visited by harbour seals (Figure 5-5). Out of these haul-out sites Måkläppen and Bøgestrøm, which account to approximately 5% of harbour seals in the Kattegat/Western Baltic area, are outside the regular foraging distance to the planned windfarm areas. However, exchange to some extent between haul-out sites is possible and not totally understood. Therefore, a general overview of the wider population area is important.



**Figure 5-5. Composition (percentage of total counted individuals) of the harbour seal haul-out sites to the abundance in the Kattegat and southwestern Baltic area between 2013 and 2023.**

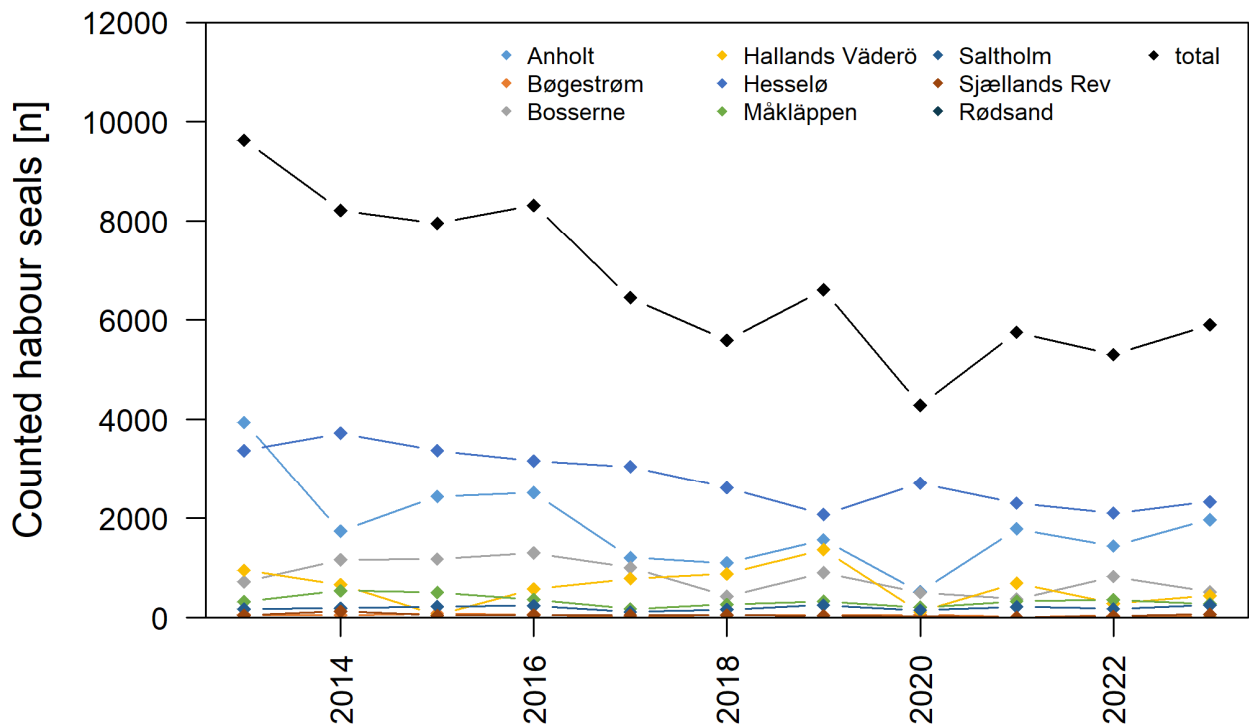
Counts of harbour seals at the different haul-out sites in the years 2013, 2018 and 2023 show a similar distribution of harbour seals counted at the different haul-out sites despite the interannual variation (Figure 5-6).



**Figure 5-6. Counts of harbour seals at haul-out sites in the Kattegat and southwestern Baltic area between in 2013, 2018 and 2023.**

The abundance at the 8 haul-out sites has overall decreased over the last 10 years, with about 9,600 harbour seals in 2013 to about 5,900 harbour seals in 2023 (Figure 5-7). However, especially in the last 6 years, there has been also a high interannual variability within the data. In 2013 Anholt was the haul-out site with the highest counts of harbour seals whereas most harbour seals have been counted at the haul-out site at Hesselø since 2014 with Anholt having second most of the counts until 2023. The other haul-out sites showed an even higher variability with counts below 1,500 individuals. The lowest number was counted at Sjællands Rev with 12 individuals in 2021.





**Figure 5-7. Development of the harbour seal abundance at certain haul-out sites in the Kattegat and southwestern Baltic area between 2013 and 2023.**

## GREY SEALS

Within the Kattegat and southwestern Baltic area four haul-out sites are taken into account in the analysis for grey seals, of which the vast majority of grey seals reside on one of the haul-out sites. Måkläppen contributed to about 93% of all grey seals counted during the different monitoring programs (Figure 5-8). The other 4 haul-out sites, Anholt, Hesselø, Bosserne and Rødsand contributed to about 1%-3% (Figure 5-9).

The abundance at the four haul-out sites has increased over the last 10 years, with about 572 grey seals in 2013 to about 3,500 grey seals in 2023 (Figure 5-10). The highest count was achieved in 2022, with about 7,200 individuals. However, there has been a high interannual variability within the data in relation to the haul-out site at Måkläppen. All other haul-out sites have not influenced the overall grey seal abundance.

Counts of grey seals at the different haul-out sites in the years 2013, 2018 and 2023 show that the distribution of grey seals was spread wider over different haul-out sites over the years (Figure 5-8). Out of these haul-out sites Måkläppen, which is the most important grey seals haul-out site in the Kattegat/Western Baltic area, is outside the regular foraging distance to the planned windfarm areas. However, it is not only important for the Western Baltic, but also for a wider region.

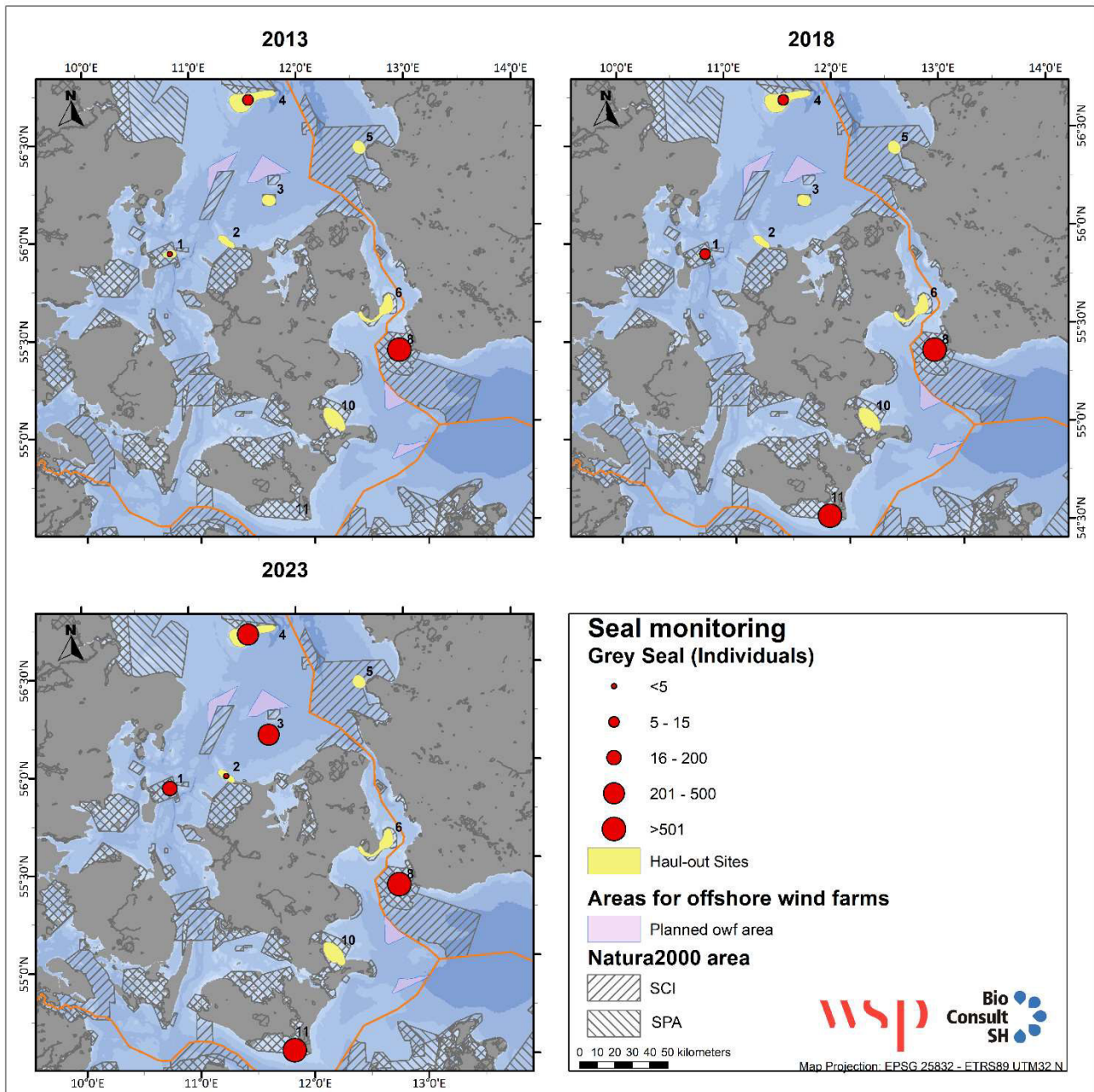


Figure 5-8. Counts of grey seals at haul-out sites in the Kattegat and southwestern Baltic area between in 2013, 2018 and 2023.





Figure 5-9. Composition (percentage of total counted individuals) of the grey seal haul-out sites to the abundance in the Kattegat and southwestern Baltic area between 2013 and 2023.

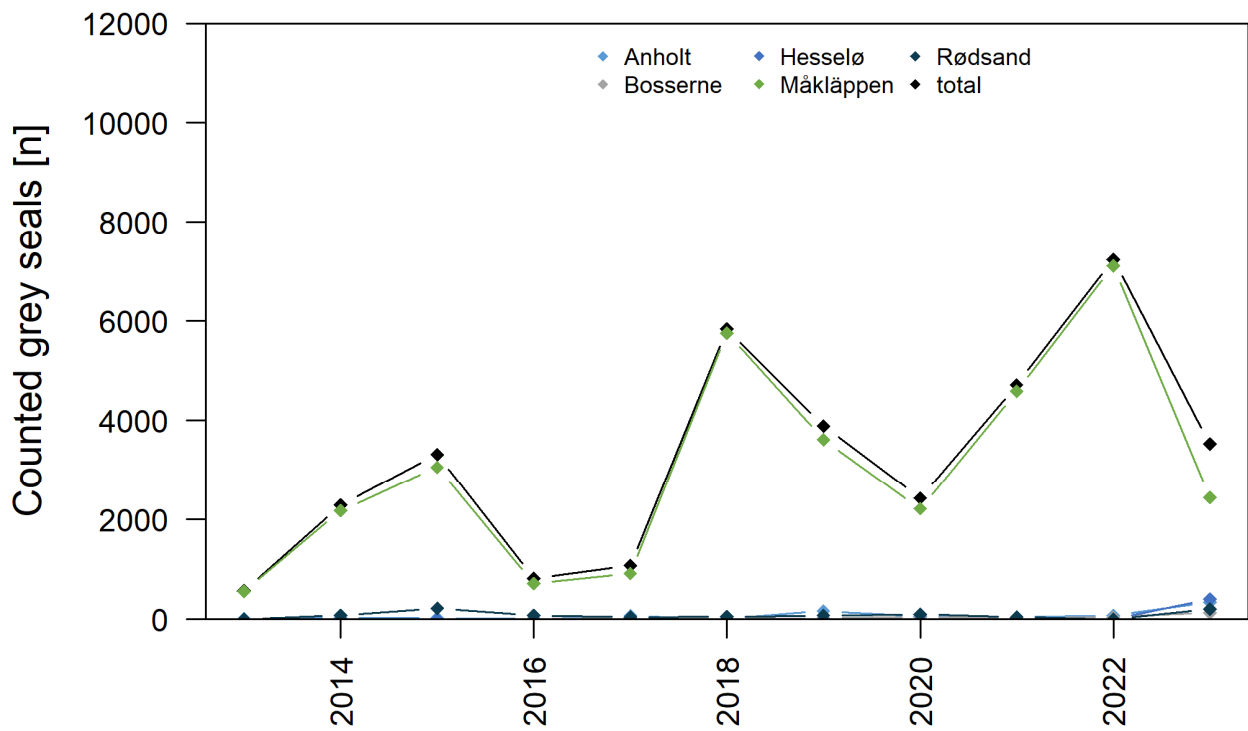


Figure 5-10. Development of the grey seal abundance at certain haul-out sites in the Kattegat and southwestern Baltic area between 2013 and 2023.

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## 5.2 HARBOUR PORPOISES

The harbour porpoise was, with 110 individual, sightings the most abundant marine mammal species during the 6 digital aerial surveys between February 2023 and January 2024. Detection rates were relatively high, ranging from 97.0%DPD/t to 99.4%DPD/t among stations, with a mean value of 98.4%DPD/t across all stations.

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### 5.2.1 DIGITAL AERIAL SURVEYS

#### SEASONAL DISTRIBUTION

Harbour porpoises were observed during all 6 surveys. The highest densities were observed in the summer, with 0.269 Ind./km<sup>2</sup> (Figure 5-11) and 0.153 Ind./km<sup>2</sup> in June and August, respectively (Table 5-3 and Figure 5-12). The density during the autumn survey (October 2023) was in the same order of magnitude compared to the two spring surveys (March 2023 and April 2023) with densities observed about one third of summer densities. The lowest densities were observed during the winter survey (December 2023) with 0.008 Ind./km. Two aerial surveys were conducted during the calving period from mid-May until September. During these surveys 4 juveniles were observed, which results in a proportion of juveniles of 3.6% during that period of time (Table 5-3).

**Table 5-3. Harbour porpoise densities in the survey area during aerial surveys between February 2023 and January 2024.**

Survey no.	Date	Effort [km <sup>2</sup> ]	Harbour porpoise [Ind.]	Juveniles [Ind.]	Harbour porpoise [Ind./km <sup>2</sup> ]
1	04.03.23	463	9	0	0.037
2	08.04.23	483	25	0	0.084
3	17.06.23	483	72	3	0.269
4	27.08.23	479	38	1	0.153
5	18.11.23	485	12	0	0.053
6	30.12.23	483	2	0	0.008
	Total	<b>2,876</b>	<b>158</b>	<b>4</b>	<b>0.101</b>

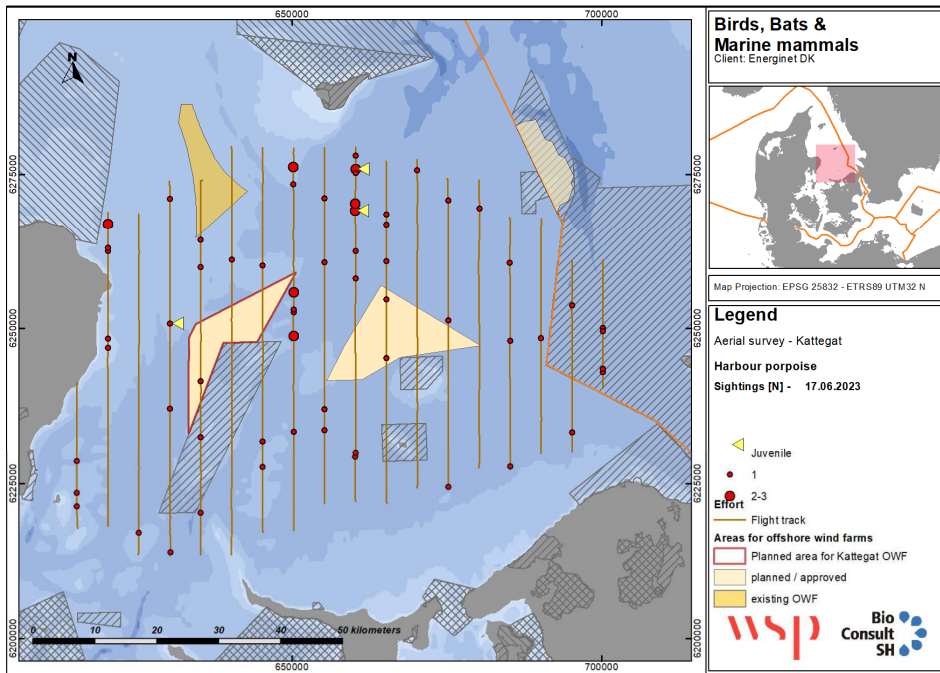


Figure 5-11. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 17.06.2023.

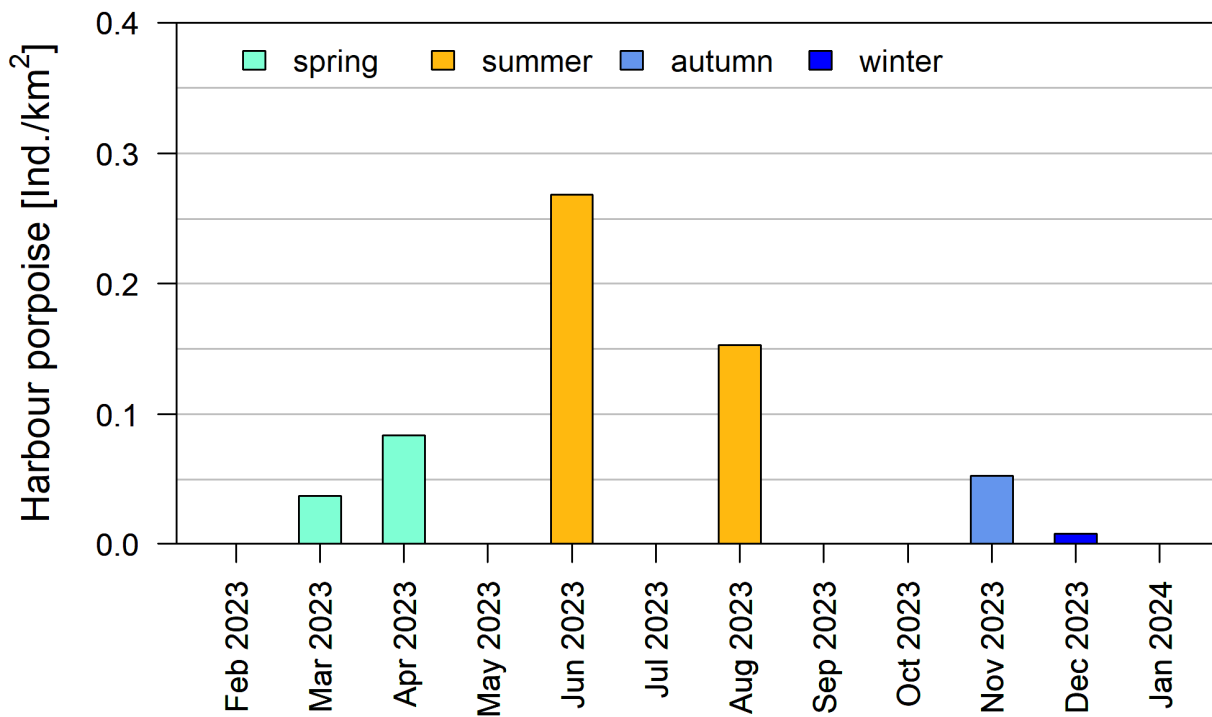
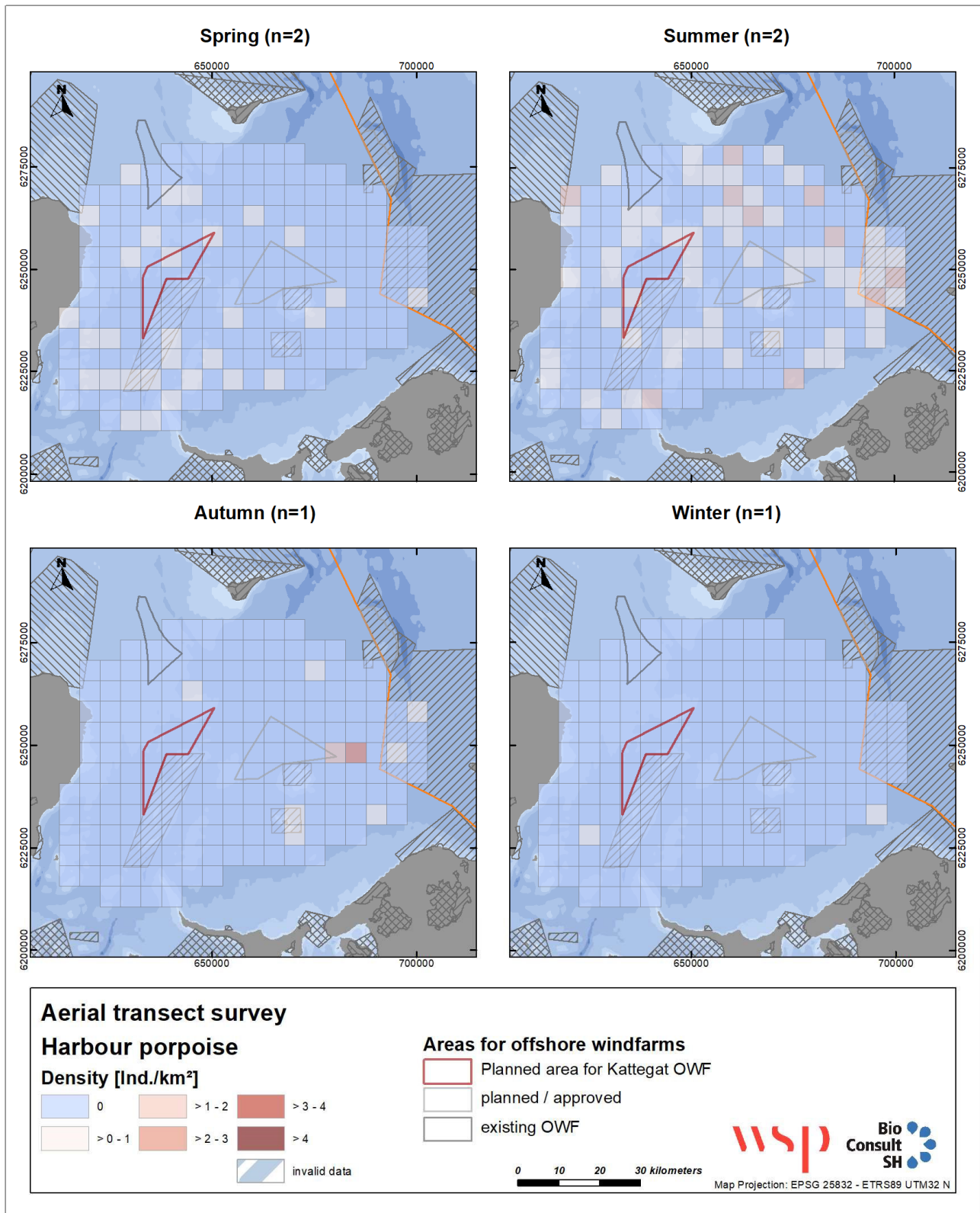


Figure 5-12. Mean harbour porpoises density (Ind./km<sup>2</sup>) per month in the study period (February 2023 – January 2024). In months without bars, no surveys were carried out. The seasons are colour coded.

## SPATIAL DISTRIBUTION

Harbour porpoise were distributed all over the pre-investigations area with no clear preference, but slightly higher densities in the northeast of the pre-investigations area (Figure 5-11 and Figure 9-6 to Figure 9-10). This was in particular true for summer observations. Most harbour porpoises were also observed during summer surveys. Overall 24 harbour porpoises were observed inside one of the three Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive including the areas *Hesselø med omliggende stenrev* (DK003X202), *Schultz og Hastens Grund samt Briseis Flak* (DK00VA303) and *Nordvästra Skånes havsområde* (SE0420360). Most individuals (18) were observed in the latter, which, like the others, lists the harbour porpoise as an important species.



**Figure 5-13. Spatial distribution of harbour porpoises during digital aerial surveys between February 2023 and January 2024. The number (n) of digital aerial surveys taken into account to calculate seasonal densities is given in the title of the respective panel.**

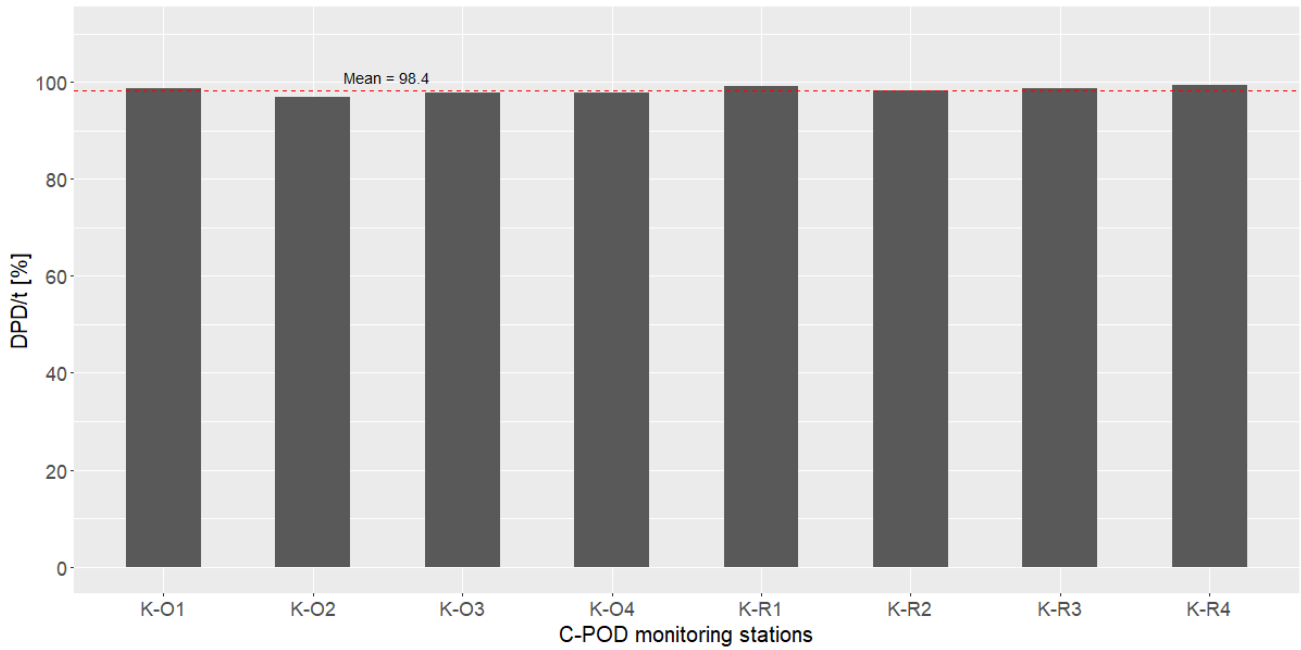
## 5.2.2 PASSIVE ACOUSTIC MONITORING

### PHENOLOGY/ SEASONALITY

During the survey period (February 2023 – January 2024), harbour porpoises were detected almost daily at all 8 C-POD stations. Detection rates (expressed as %DPD/t) were close to 100%, ranging from 97.0% at station K-O2 to 99.4% at station K-R4, with a mean value of 98.4% across all stations (Figure 5-14 and Table 5-4). This suggests that harbour porpoises are generally present all year-round within the pre-investigation area. Mean Detection Positive 10-Minutes per day (%DP10M/d), which showed detection rates on a daily scale at a very fine temporal resolution of 10-minutes block per day, varied between stations. Therefore, the pre-investigation area showed a heterogenous spatial distribution of harbour porpoise presence, which may be driven by habitat preference (Figure 5-15 and Table 5-4). The highest and lowest mean %DP10M/d were at stations K-R2 (14.5%) and K-R3 (5.7%) respectively (Table 5-4). Mean %DP10M/d was very similar at four stations K-R4 (10.7%), K-O2 (10.3%), K-O3 (10.2%) and K-R1 (10.2%). There is no clear pattern in the spatial distribution of porpoise presence within the pre-investigation area (Figure 5-15). Of the three stations with relatively lower %DP10M/d (<10%), two (K-O1 and K-R3) were located in the north-eastern side of the pre-investigation area while one (K-O4) was located further south. Meanwhile, the remaining stations with relatively higher %DP10M/d (>10%) were spread out across the pre-investigation area, with two of them (K-R1 and K-R2) located within the SCI *Schultz og Hastens Grund samt Briseis Flak* (DK00VA303).

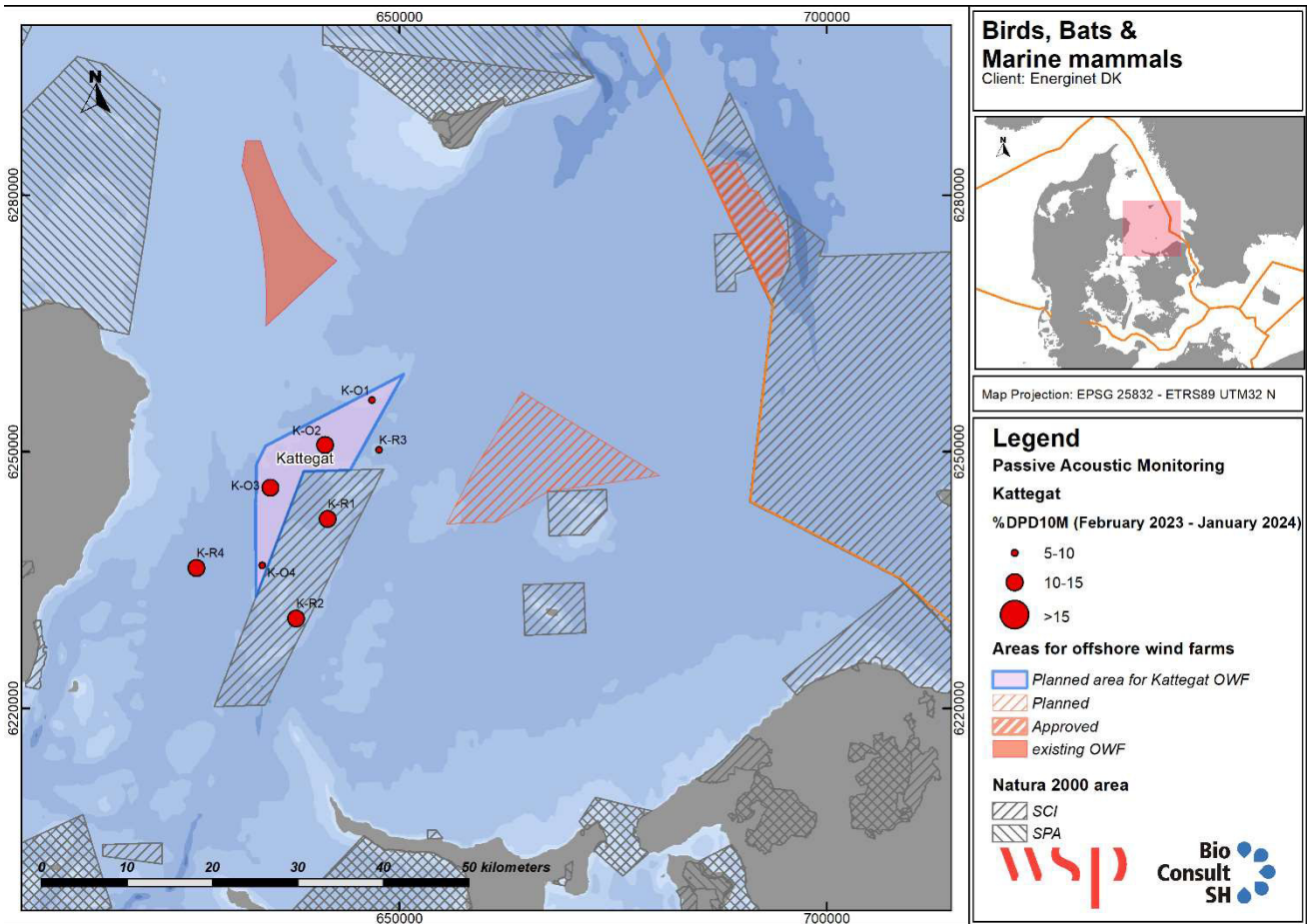
**Table 5-4. Harbour porpoise detection rates at different temporal resolution, Detection Positive Days over the entire survey period (DPD/t) and mean Detection Positive 10-Minutes per day (DP10M/d), at the 8 C-POD stations deployed within the pre-investigation area. %DPD/t and mean %DP10M/d were calculated over all available recording days. t refers to the entire survey period (February 2023 to January 2024). d refers to a day.**

C-POD	Days with positive detections	Days deployed	DPD/t [%]	DP10M/d [%]
K-O1	323	327	98.8	9.0
K-O2	321	331	97.0	10.3
K-O3	323	330	97.9	10.2
K-O4	312	319	97.8	7.2
K-R1	331	334	99.1	10.2
K-R2	322	326	98.8	14.5
K-R3	326	332	98.2	5.7
K-R4	332	334	99.4	10.7



**Figure 5-14.** The proportion of days with positive harbour porpoise detections over the entire survey period (February 2023 – January 2024), expressed as Detection Positive Days (DPD/t), at the 8 C-POD stations deployed within the investigation area. The red dashed line shows the mean value across all stations.





**Figure 5-15. Harbour porpoise detection rates, expressed as mean Detection Positive 10-Minutes per day (%DP10M/d), at the 8 C-POD stations deployed within the investigation area for the entire survey period (February 2023 – January 2024).**

Monthly mean %DP10M/d (averaged over all 8 stations) showed the temporal variation (seasonal trend) in harbour porpoise presence within the entire investigation area across the survey period (Figure 5-16). In general, there was little seasonal variation throughout the year. Detection rates in the area were comparable from month to month, being only slightly higher in summer (June and July 2023). However, a closer examination of individual C-POD stations revealed stark differences between stations. Detection rates at stations K-O1 and K-O2 were comparable throughout most of the year, but a strong peak can be observed at station K-O1 in summer (July 2023) while detection rates at K-O2 remained constantly low, increasing slightly only towards end of autumn (Figure 5-17). A similar difference in seasonal trend can also be observed between stations K-O4 and K-O5 (Figure 5-18), and also stations K-R3 and K-R4 (Figure 5-20). On the other hand, a bimodal pattern can be observed at stations K-R1 and K-R2, with a first peak in detection rates occurring in late spring or early summer and a second peak in autumn (Figure 5-19).

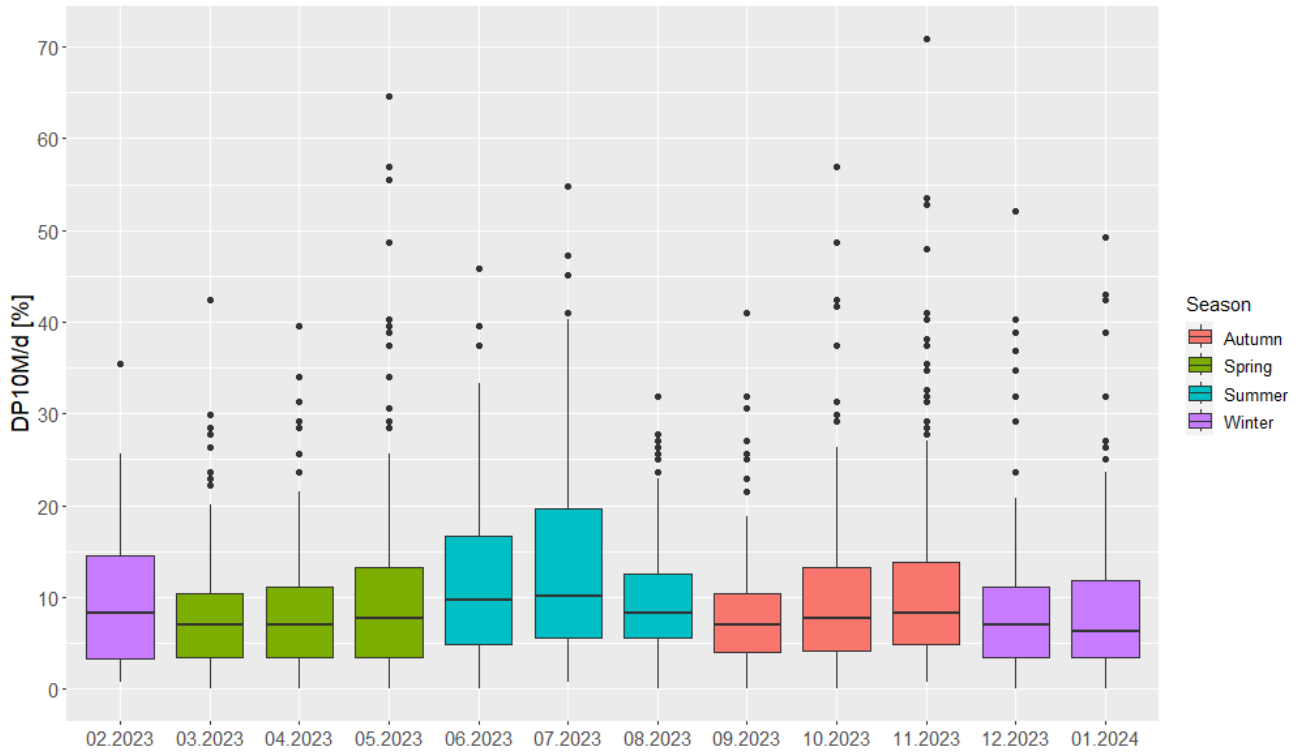


Figure 5-16. Mean monthly Detection Positive 10-Minutes per day (% DP10M/d) averaged over all 8 C-POD stations.

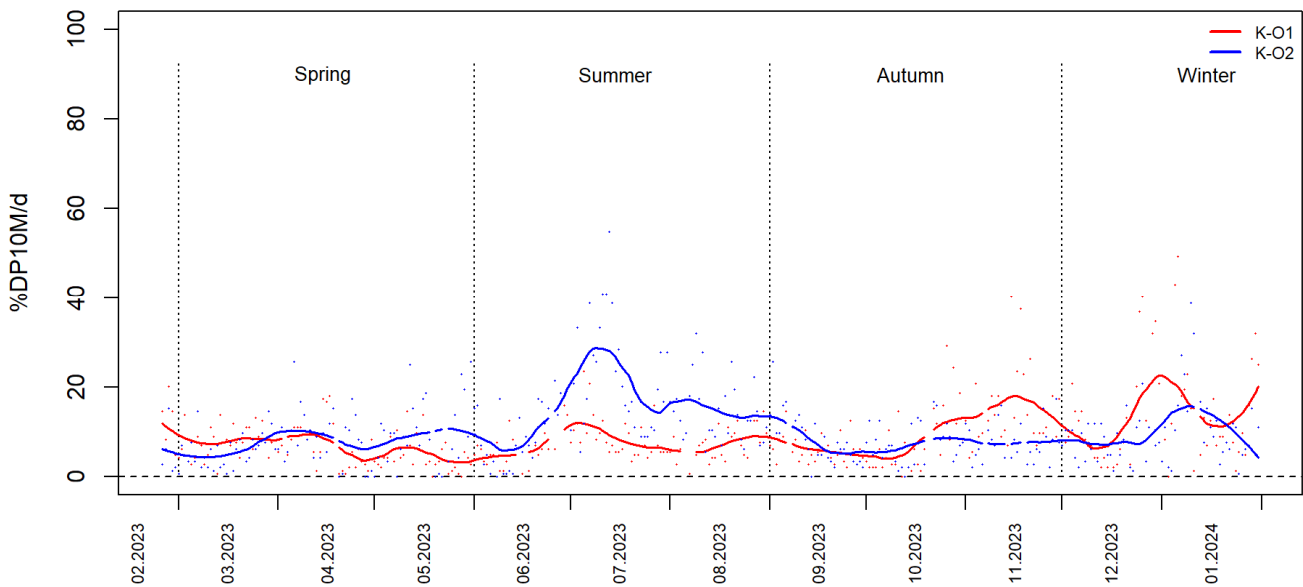
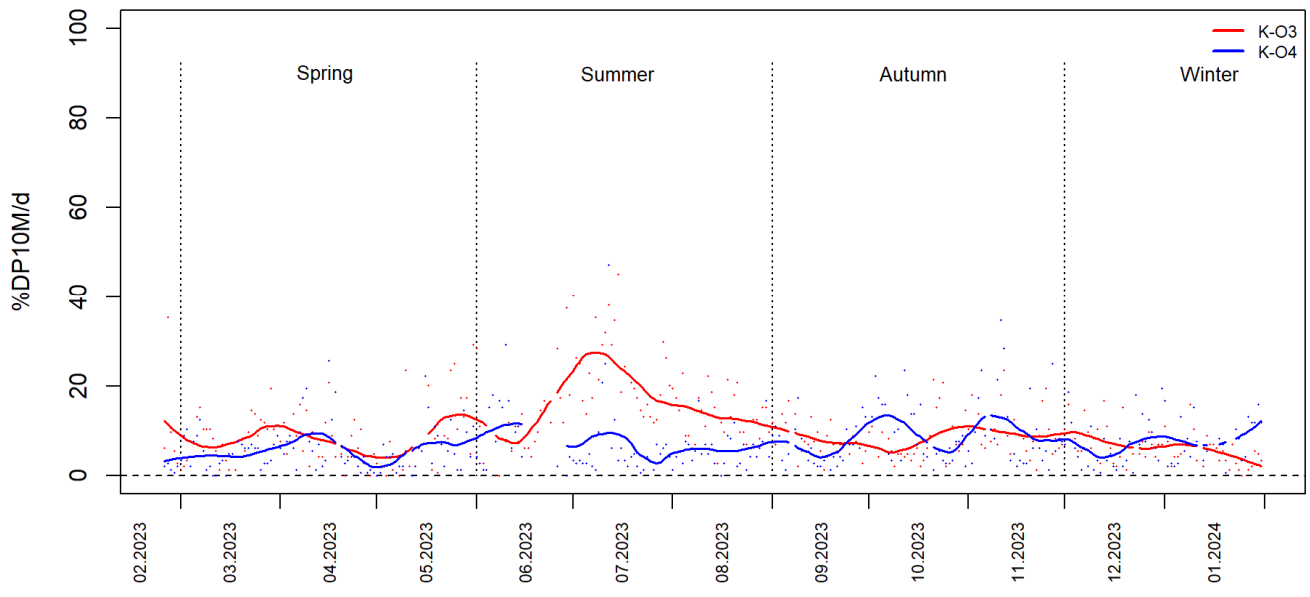
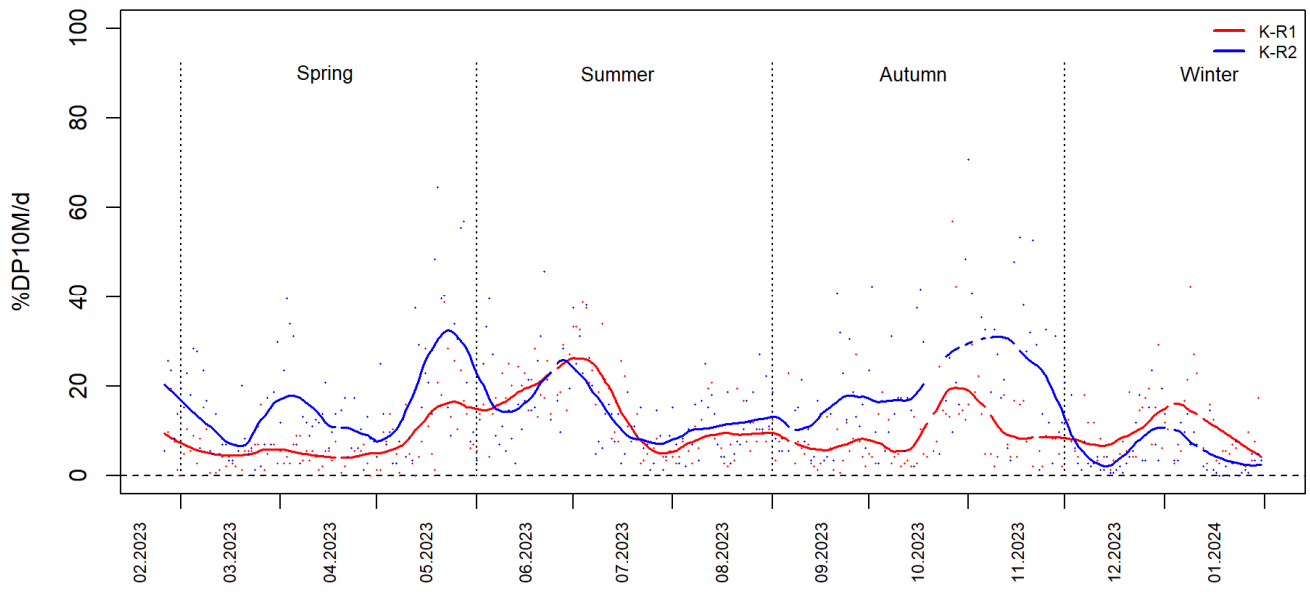


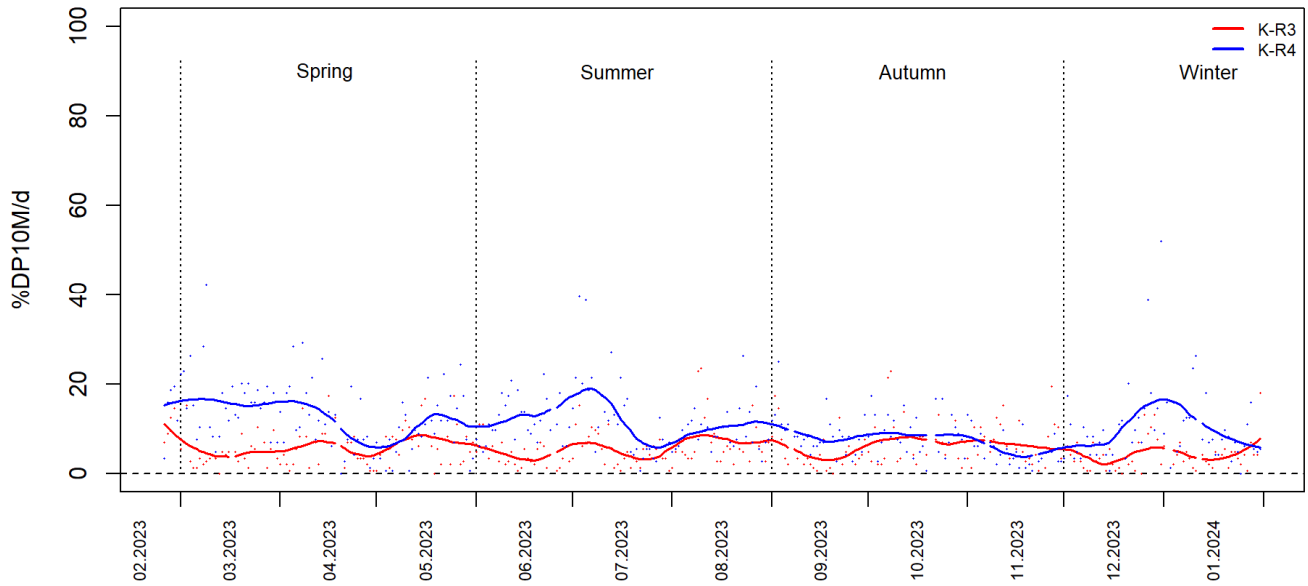
Figure 5-17. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations K-O1 and K-O2 across the entire survey period (February 2023 – January 2024). Gaps in the loess regression curves represent periods with no data.



**Figure 5-18. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations K-O3 and K-O4 across the entire survey period (February 2023 – January 2024). Gaps in the loess regression curves represent periods with no data.**

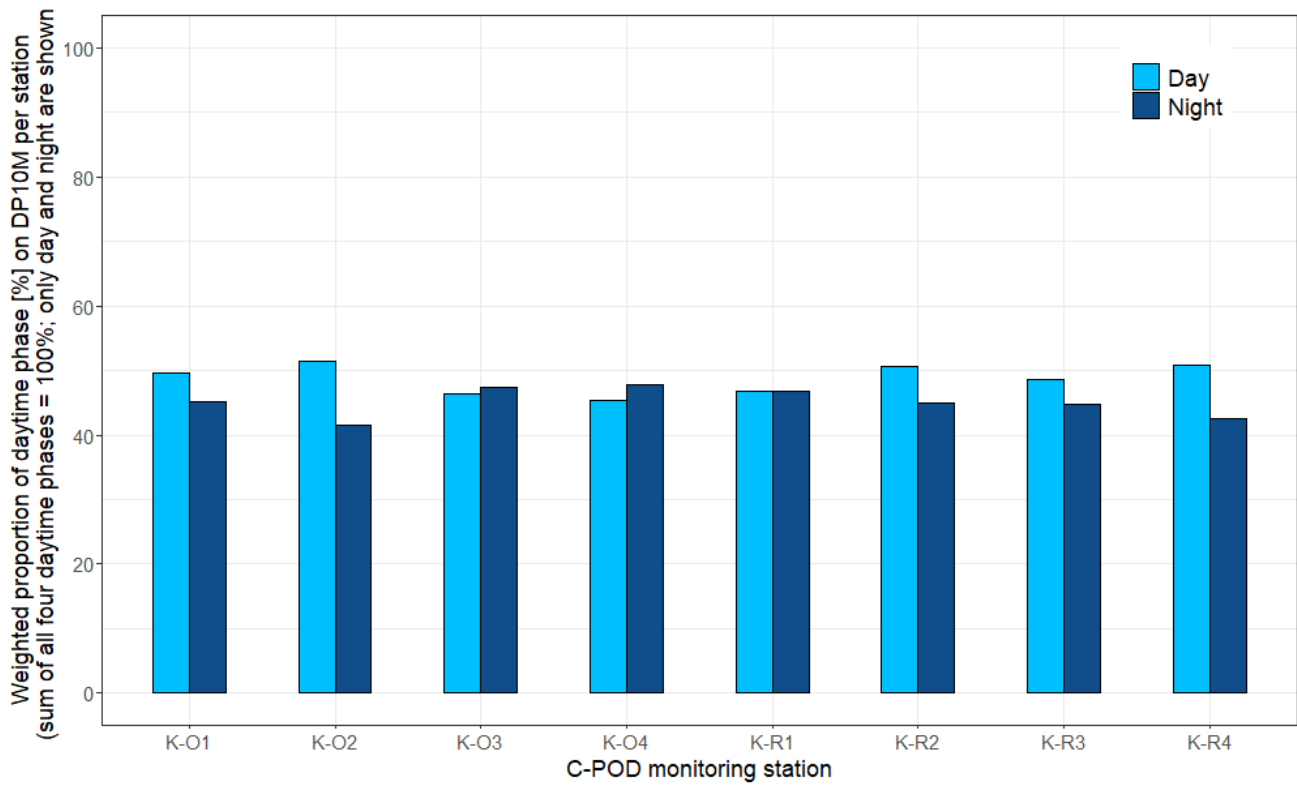


**Figure 5-19. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations K-R1 and K-R2 across the entire survey period (February 2023 – January 2024). Gaps in the loess regression curves represent periods with no data.**



**Figure 5-20. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations K-R3 and K-R4 across the entire survey period (February 2023 – January 2024). Gaps in the loess regression curves represent periods with no data.**

Diel pattern analysis revealed differences in daylight and nighttime activity of harbour porpoises at each C-POD station (Figure 5-21). Harbour porpoises were detected more frequently during daylight hours at 5 stations (K-O1, K-O2, K-R2, K-R3 and K-R4). The difference between daylight and nighttime activity was very small at 2 C-POD stations (K-O3 and K-O4), with nighttime activity being only slightly higher than daylight activity. Meanwhile, there was no difference in daylight and nighttime activity at station K-R1.



**Figure 5-21. Diel pattern of harbour porpoise detection rates at the 8 C-POD stations deployed within the investigation area. Each 24-hour period is divided into four phases (Day, Night, Dusk, Dawn) during analysis. Only Day and Night phases are shown (Dusk and Dawn phases are not considered). A weighing factor based on daylength proportion is applied due to different lengths of phases at different dates throughout the year. Sum of all phases equals to 100% but is not reached here since Dusk and Dawn phases are not shown.**

# 6 CONCLUSION

This report provides a comprehensive and detailed baseline study for marine mammals in the pre-investigation area for the planned Kattegat OWF.

Three marine mammal species regularly occur within the pre-investigation area of Kattegat. These are the harbour seal, the grey seal and, as the only cetacean species occurring in the southern part of Kattegat, the harbour porpoise. The basis of this study is comprised by digital aerial surveys for all marine mammal species and passive acoustic monitoring using C-PODs to monitor harbour porpoises in more detail, as well as data from the national seal monitoring programs from Denmark and Sweden. In addition, existing data from peer-reviewed literature and other monitoring programs have been considered.

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## 6.1 HARBOUR SEALS

Harbour seal haul-out sites in Kattegat closest to the planned windfarm area of Kattegat area are located in Denmark about 22 km north at Anholt, about 22 km south at Sjællands Rev, about 25 km southwest at Hesselø, about 35 km southwest at Bosserne, and in Sweden about 65 km east at Hallands Väderö, whereas Hesselø experiences about 40% of all harbour seal counts, followed by Anholt (26%), Bosserne (12%) and Hallands Väderö (9%) of all haul-out site in this part of the Kattegat. At these distances, the planned windfarm area is within regular foraging trip distance (e.g. THOMPSON ET AL. 1994; TOLLIT ET AL. 1998; CUNNINGHAM ET AL. 2009; DIETZ ET AL. 2013). This is also shown by the results of the digital aerial surveys, where most seals were observed inside as well as in the vicinity of the Site of Community Importance (SCI) under the Natura 2000 Habitats Directive *Hesselø med omliggende stenrev* (DK003X202), in which harbour seals are listed as important species. While the harbour seal counts decrease over the past 10 years, it has to be considered that the population may be approaching or has reached ecological capacity (HANSEN & HØGSLUND 2021) with about 2,000 individuals in the SW Baltic and about 12,500 individuals in the Kattegat (HELCOM 2023a).

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## 6.2 GREY SEALS

Grey seal haul-out sites in Kattegat close to the planned windfarm area of Kattegat area are located about 22 km north of the planned windfarm area, at Anholt, about 25 km southwest at Hesselø and about 35 km southwest at Bosserne. At this distance, the planned windfarm area is within regular foraging trip distance (e.g. THOMPSON ET AL. 1991, 1996; MCCONNELL ET AL. 1999; DIETZ ET AL. 2015). This is also shown by the results of the digital aerial surveys, where most seals were observed inside as well as in the vicinity of the Site of Community Importance (SCI) under the Natura 2000 Habitats Directive *Hesselø med omliggende stenrev* (DK003X202), in which grey seals are listed as important species respectively. In contrast to the harbour seal counts, grey seal counts have increased over the past 10 years (HANSEN & HØGSLUND 2021) with an estimated population size of about 60,000 animals for the Baltic Sea (HELCOM 2023c). However, counts at these haul-out sites are relatively low and numbers are not in the order of magnitude as for example Måkläppen and hence of lesser importance, but may reach a few hundred in some years.

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## 6.3 HARBOUR PORPOISES

Harbour porpoises in the pre-investigation area of Kattegat area are attributed to the Belt Sea population but may have visitors from the North Sea population as the area is located in the southern part of the transition zone according to SVEEGAARD ET AL. (2018). Harbour porpoises were most frequently abundant in the beginning of summer and in autumn. In summer, 4 juveniles were observed, which results in a proportion of juveniles of 3.6%, indicating that the pre-investigation area is used for breeding, but to a smaller extent compared to other areas. For example a proportion of juveniles of 6.4% was observed for a larger study area consisting of the Western Baltic Sea and the Kattegat (UNGER ET AL. 2021) and a proportion of juveniles of 9.1% was observed for the Skagerrak both in 2020 (HANSEN & HØGSLUND 2021). Within the pre-investigation area, harbour porpoise showed no clear preference, but slightly higher densities in the northeast of the pre-investigation area. About 15% observations occurred within the Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive one of the three Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive *Hesselø med omliggende stenrev* (DK003X202), *Schultz og Hastens Grund samt Briseis Flak* (DK00VA303) and *Nordvästra Skånes havsområde* (SE0420360), where harbour porpoises are listed as an important species. Recent studies showed a decrease of the Belt Sea population (SCANS-IV 2023; OWEN ET AL. 2024), which is currently estimated to be about 14,000 to 17,000 individuals (HANSEN & HØGSLUND 2021; SCANS-IV 2023). However, these negative trends are not significant and may be biased by different methods used and a small sample size (SCANS-IV 2023).



## 7 DATA AND KNOWLEDGE GAPS

In this study, aerial survey data was collected during 6 digital aerial surveys. The advantage of digital aerial data collection is that densities of marine mammals can be assessed quickly and with a uniform collection effort on a large spatial scale, e.g. compared to ship-based surveys and observer-based aerial surveys (ŽYDELIS ET AL. 2019). This method is considered as a “snap-shot”-method since the distribution of marine mammals is only observed during the specific time frame of a flight and not continuously. Therefore, the results only show the abundance on the specific survey date and during daylight hours.

Studies comparing 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) showed that the results of PAM roughly 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 datasets correlated. The more tagged animals being present in an area the higher were the detection rates recorded in this area. One of the advantages of PAM is the very high temporal resolution. Therefore, even short-term patterns can be investigated. Furthermore, C-PODs are capable of continuously recording data, a major advantage in comparison to other survey methods like aerial or ship-based surveys. This produces large quantities of data, allowing for robust statistical analyses. Furthermore, C-PODs also record harbour porpoises at night, whereas aerial and ship-based surveys are limited to daylight hours. A disadvantage of the PAM method is the small spatial coverage. The detection range of a C-POD reaches only up to about appr. 300 meters, and it depends on the direction into which the harbour porpoise click was sent out by the animal. Only deployment of several C-PODs at different locations, like in the present study, allows for analysis of the spatial distribution of harbour porpoises.

A literature research on existing data (see chapter 3) and an analyses of the count data at seal haul-out sides in the vicinity of the planned windfarm area, gives a good general overview of abundance and distribution on the three marine mammal species present in the area and complements the data from February 2023 to January 2024 in the pre-investigation area. However, it also reveals that temporal and geographical resolution of data is important, but often a limiting factor. A focus on the pre-investigation area in combination with existing results, as it has been shown in this report, is therefore crucial and an upcoming additional study period from February 2024 to January 2025 will decrease the impact of annual variability.

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# 9 APPENDIX

## SEALS – AERIAL SURVEYS SIGHTINGS

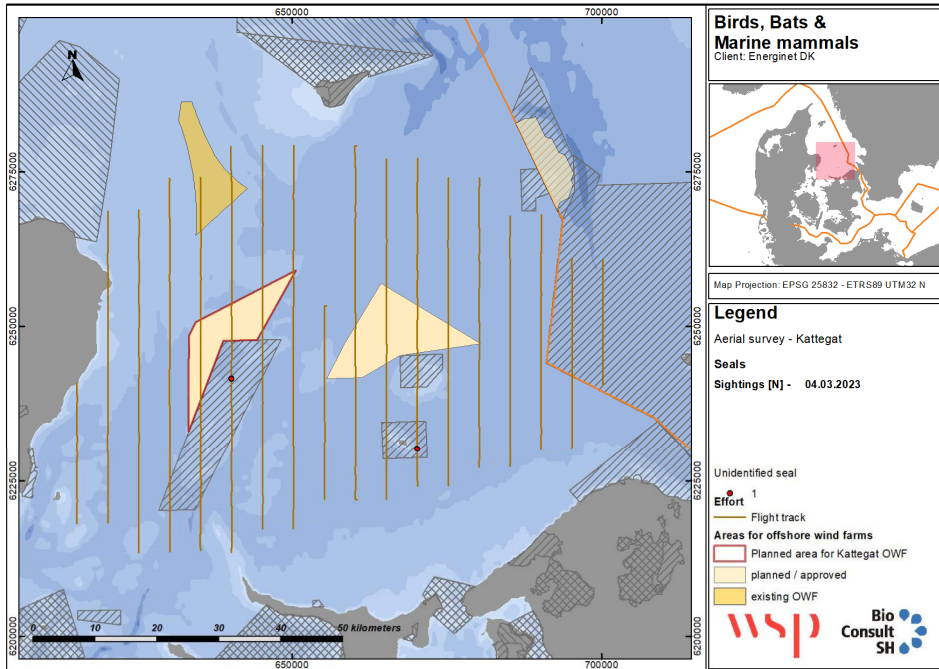


Figure 9-1. Seal observations in the pre-investigation area during the digital aerial survey on 04.03.2023.

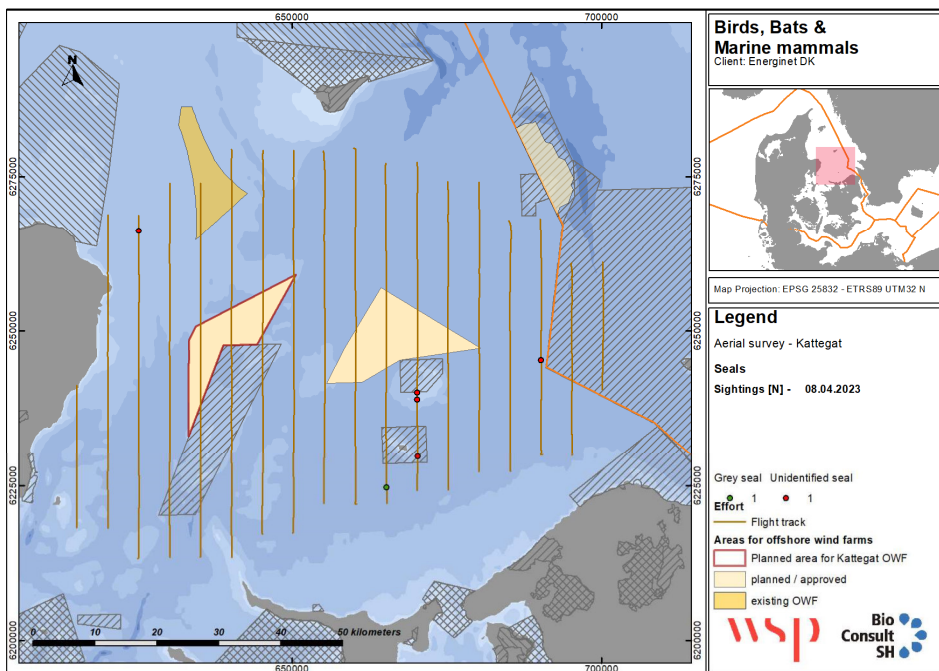


Figure 9-2. Seal observations in the pre-investigation area during the digital aerial survey on 08.04.2023

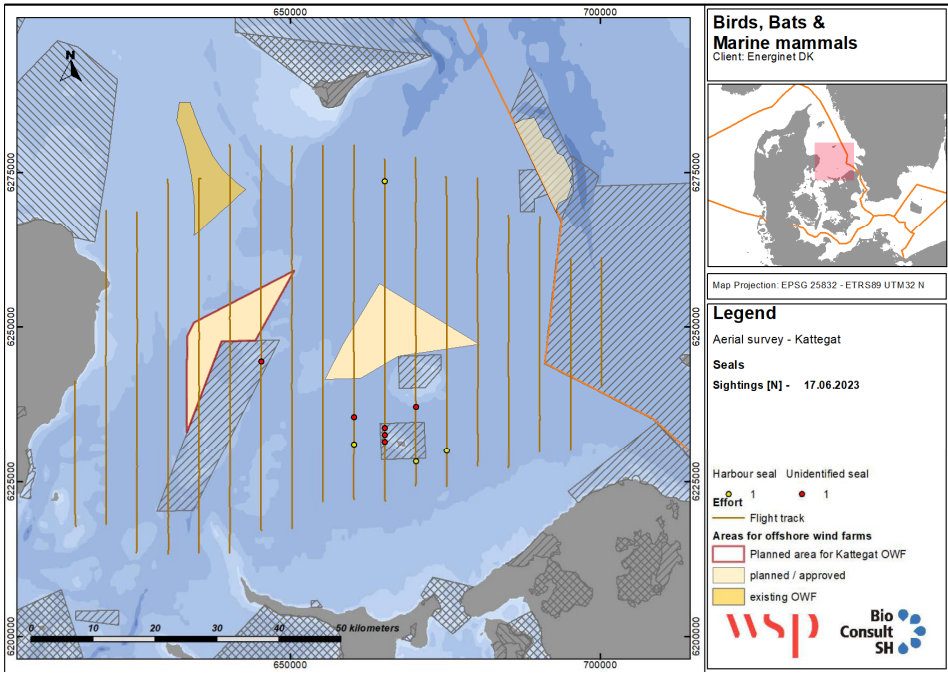


Figure 9-3. Seal observations in the pre-investigation area during the digital aerial survey on 17.06.2023.

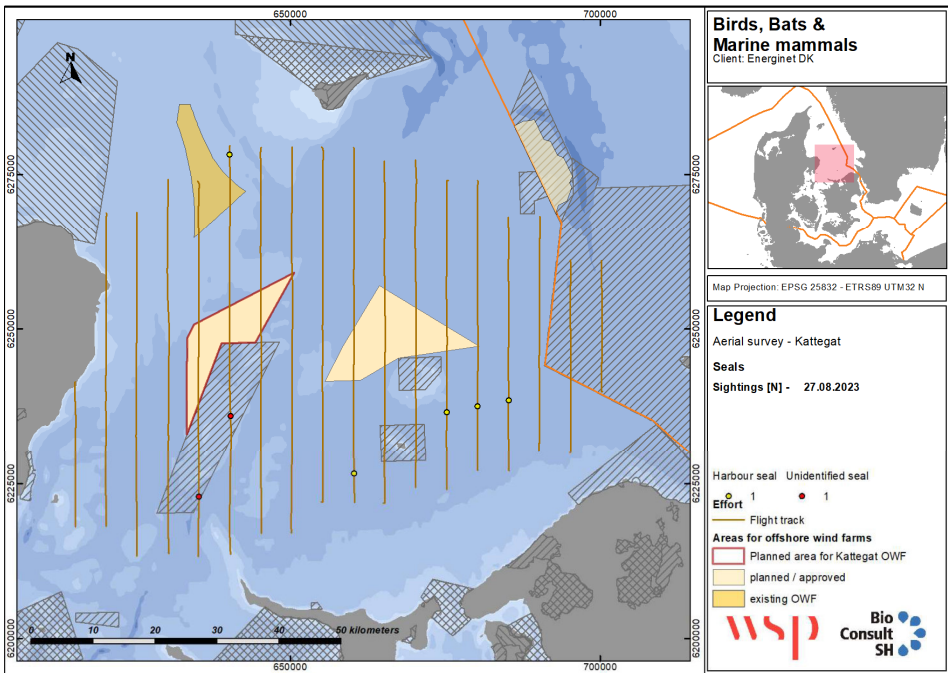


Figure 9-4. Seal observations in the pre-investigation area during the digital aerial survey on 27.08.2023.

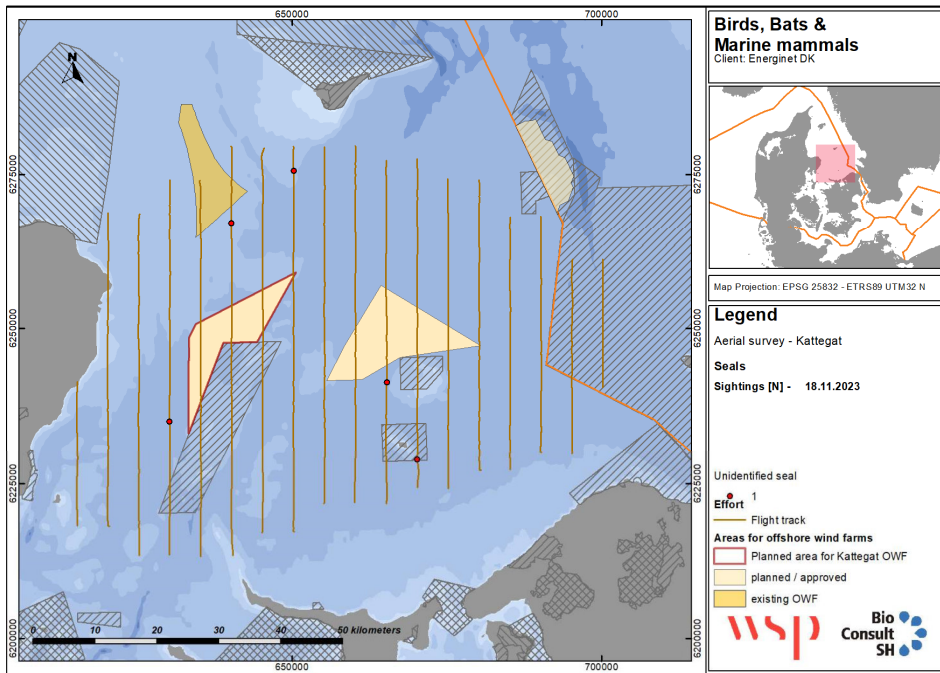


Figure 9-5. Seal observations in the pre-investigation area during the digital aerial survey on 18.11.2023.

## 9.1 HARBOUR PORPOISE – AERIAL SURVEYS SIGHTINGS

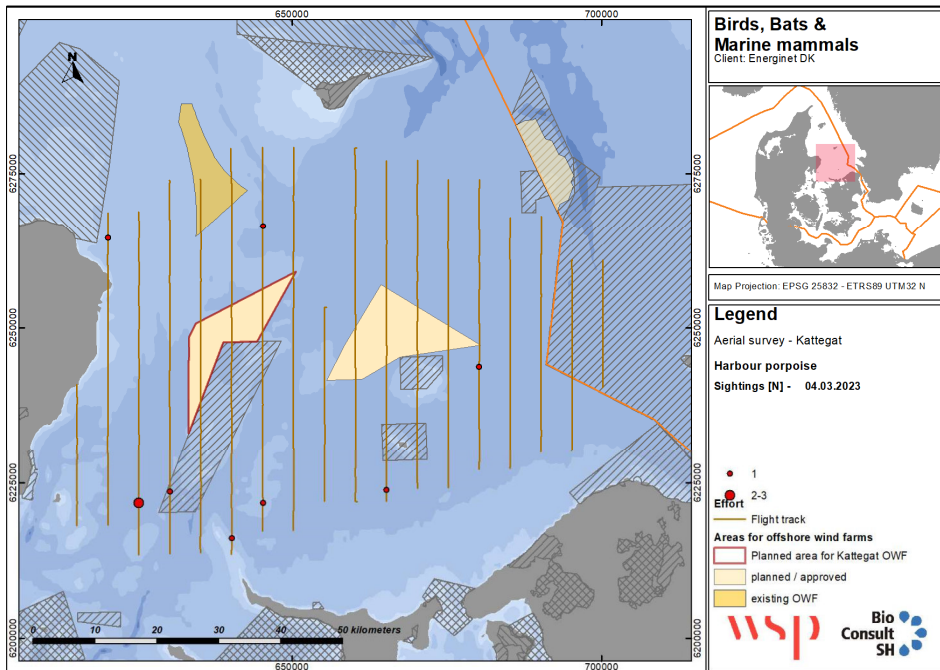


Figure 9-6. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 04.03.2023.

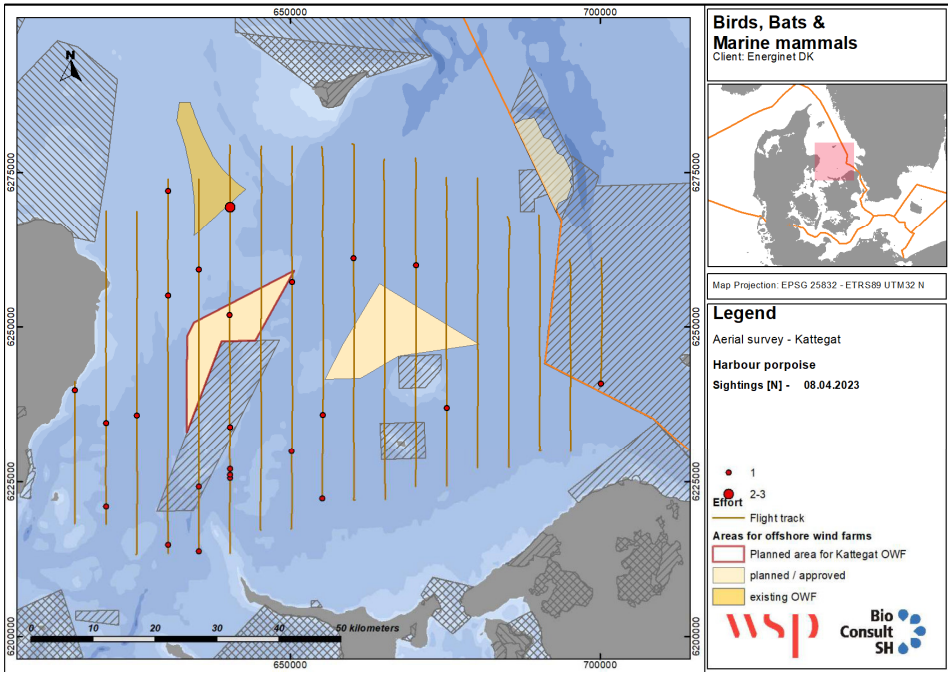


Figure 9-7. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 08.04.2023

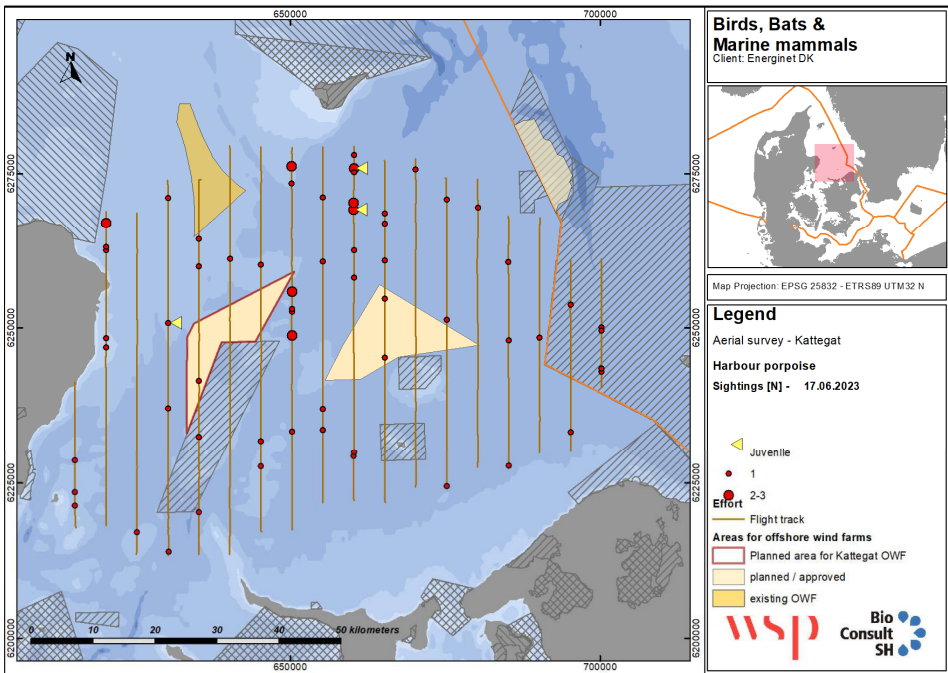


Figure 9-8. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 17.06.2023.



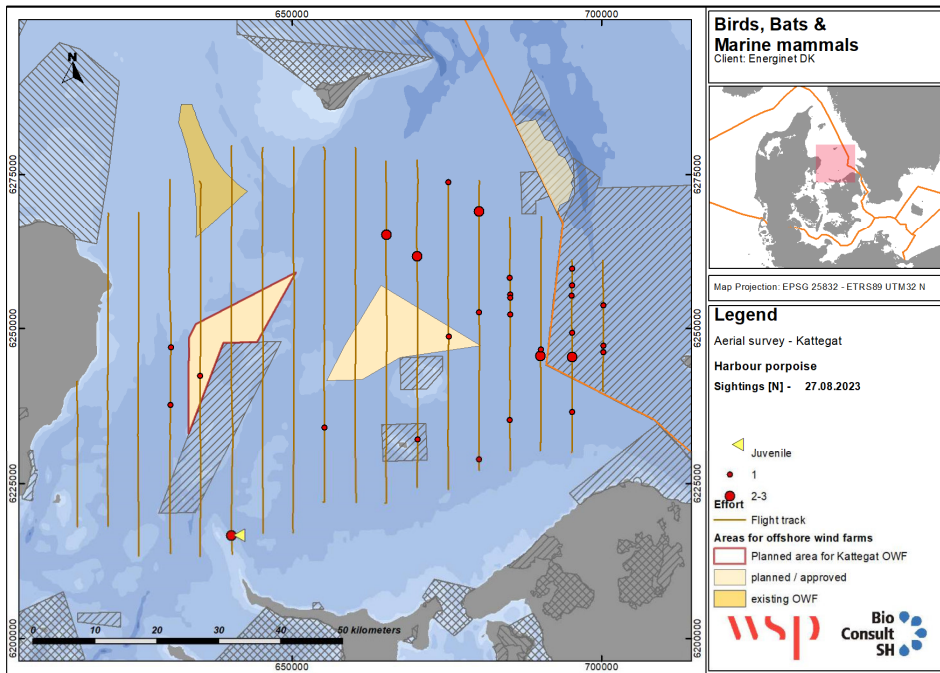


Figure 9-9. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 27.08.2023.

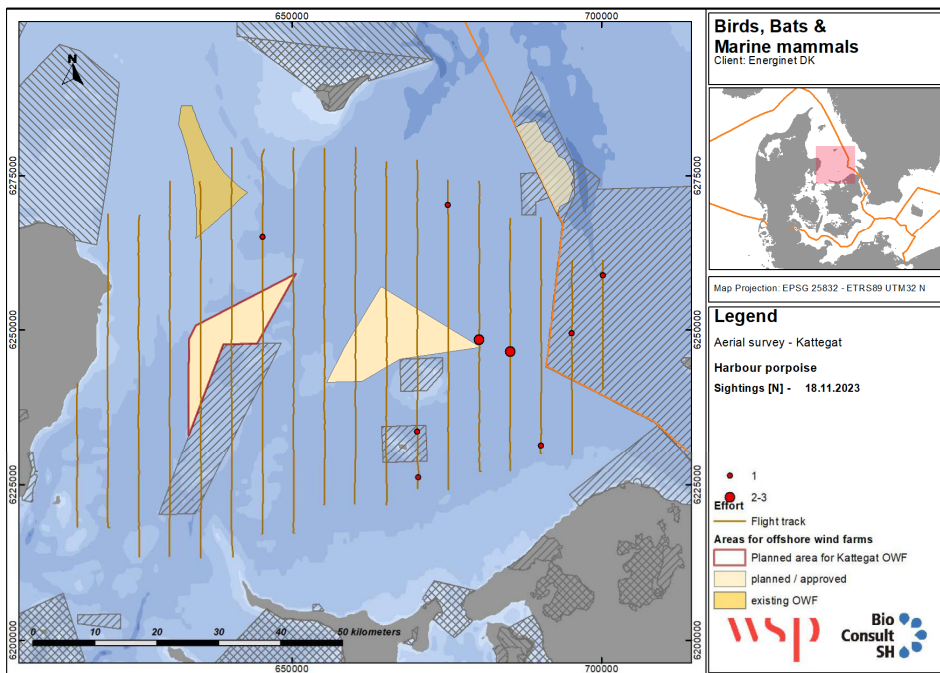


Figure 9-10. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 18.11.2023.

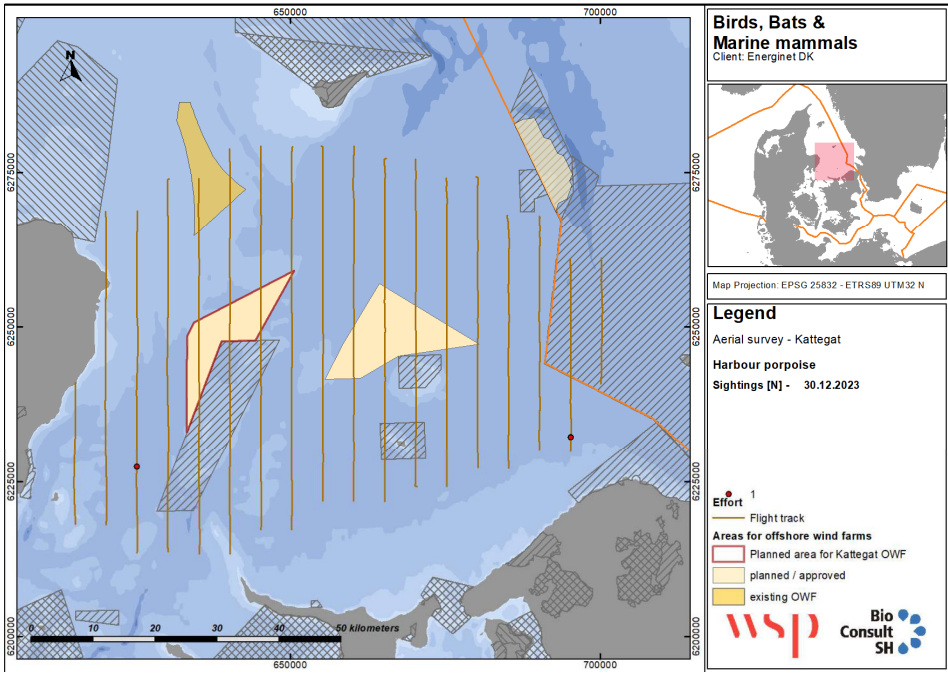


Figure 9-11. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 30.12.2023.





