ENERGINET

KATTEGAT

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

TECHNICAL REPORT MARINE MAMMALS

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PREPARED BY: WSP AND BIOCONSULT SH
PROJECT MANAGER: JAN NICOLAISEN
REPORT MANAGER: ALEXANDER SCHUBERT AND SANNE KJELLERUP
CHECKED BY: SANNE KJELLERUP AND CECILIE KJER ELKJÆR
APPROVED BY: LEA B. SCHMIDT
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INDHOLD

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

1 SUMMARY

The pre-investigation area for planned Kattegat Offshore Wind Farm is situated between Hesselø Bugt and the island of Anholt in the Danish part of the Kattegat. The pre-investigation area includes the areas for the two planned offshore wind farms (Hesselø and Kattegat). See separate technical report for the pre-investigation for Hesselø OWF. For the offshore baseline surveys of marine mammals in the pre-investigation area the abundance and distribution of marine mammals was monitored using bimonthly digital aerial offshore wildlife surveys using HiDef video technology (www.hidefsurveying.co.uk) and the spatial and seasonal habitat use of harbour porpoises was investigated using Passive Acoustic Monitoring (PAM) with C-PODs between February 2023 and February 2025.

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 km² pre-investigation area was covered per flight.

Out of the 54 seals that were observed during the digital aerial surveys, only 22.2% could be identified to species level. These 12 seals were divided into 83.3% harbour seals (n=10) and 16.7% grey seals (n=2). Harbour seals were the most dominant pinneped species. The highest density for all seals combined was observed in the winter (February 2024) with 0.028 Ind./km², followed by 0.025 Ind./km² in summer (June 2023). About one third of the observed seals were registered within one of the two Danish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive: *Hesselø med omliggende stenrev* (N128/DK003X202) and *Schultz og Hastens Grund samt Briseis Flak* (N204/DK00VA303).

Grey seals were only observed during two digital aerial surveys (08.04.23 and 23.10.2024). However, as 77.8% of seals could not be identified to species level, results apply to both seal species. About one third of the observed seals were registered within one of the two Danish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive: *Hesselø med omliggende stenrev* (N128/DK003X202) and *Schultz og Hastens Grund samt Briseis Flak* (N204/DK00VA303). Both harbour seals and grey seals are listed as important species in the area *Hesselø med omliggende stenrev* (N128/DK003X202), whereas none of the seal species are listed as important in the area *Schultz og Hastens Grund samt Briseis Flak* (N204/DK00VA303).

Harbour porpoises were observed during all digital aerial surveys with the highest densities in summer. Overall, from February 2023 to February 2025, 246 individuals were identified as harbour porpoises and generally the results showed a similar pattern in both years. The proportion of juveniles was 4.6% (n=6), which is relatively low compared to 6.4% for a larger study area consisting of the Western Baltic and the Kattegat (Unger et al., 2021). Harbour porpoises were distributed all over the pre-investigation 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 determined that, on average, at least one harbour porpoise contact was recorded at each station on 98.8% of all survey days.

In conclusion, the data collected within the pre-investigation area between February 2023, and February 2025 (Y1+Y2) highlight the importance of temporal and spatial resolution in ecological datasets and the two-year study period (February 2023 to February 2025; Y1+ Y2) has helped reduce the influence of interannual variability.

2 INTRODUCTION

In order to accelerate the expansion of Danish offshore wind production, it was politically decided with the agreement on the Finance Act for 2022 and the subsequent Climate Agreement on Green Electricity and Heat 2022 of 25 June 2022 to enable the expansion of a minimum of 9 GW of offshore wind in Danish waters.

In order to enable the realization of the political agreements on significantly more energy production from offshore wind, the Danish Energy Agency has prepared a plan for the establishment of offshore wind farms in three areas in the North Sea, the Kattegat and the Baltic Sea respectively, and has initiated a large number of feasibility studies in the areas, some of which are reported in this report.

The area for Kattegat Offshore Wind Farm (OWF) is located in Kattegat, approximately 20 kilometers east of Djursland and approximately 30 kilometers north of Zealand se Figure 2-1. The area for the OWF is approximately 122 km^2. The Kattegat OWF will be connected to land via subsea cables making landfall close to Grenaa.
In the agreement on the tender framework, which the Danish Parliament adopted in May 2025, it was decided that the tender for Kattegat OWF will be included in the pool of development areas that will be tendered at a later, not yet decided, date.

The present report outlines the surveys, data and analyses undertaken in the pre-investigation area for the planned Kattegat OWF for Year 1 (Y1: February 2023 to January 2024) and Year 2 (Y2: February 2024 to February 2025). Data from Y1 and Y2 are presented combined unless specified otherwise. In addition, data from seal haul-out sites in the vicinity of the planned OWF area were obtained and analysed to study the annual numbers of seals.

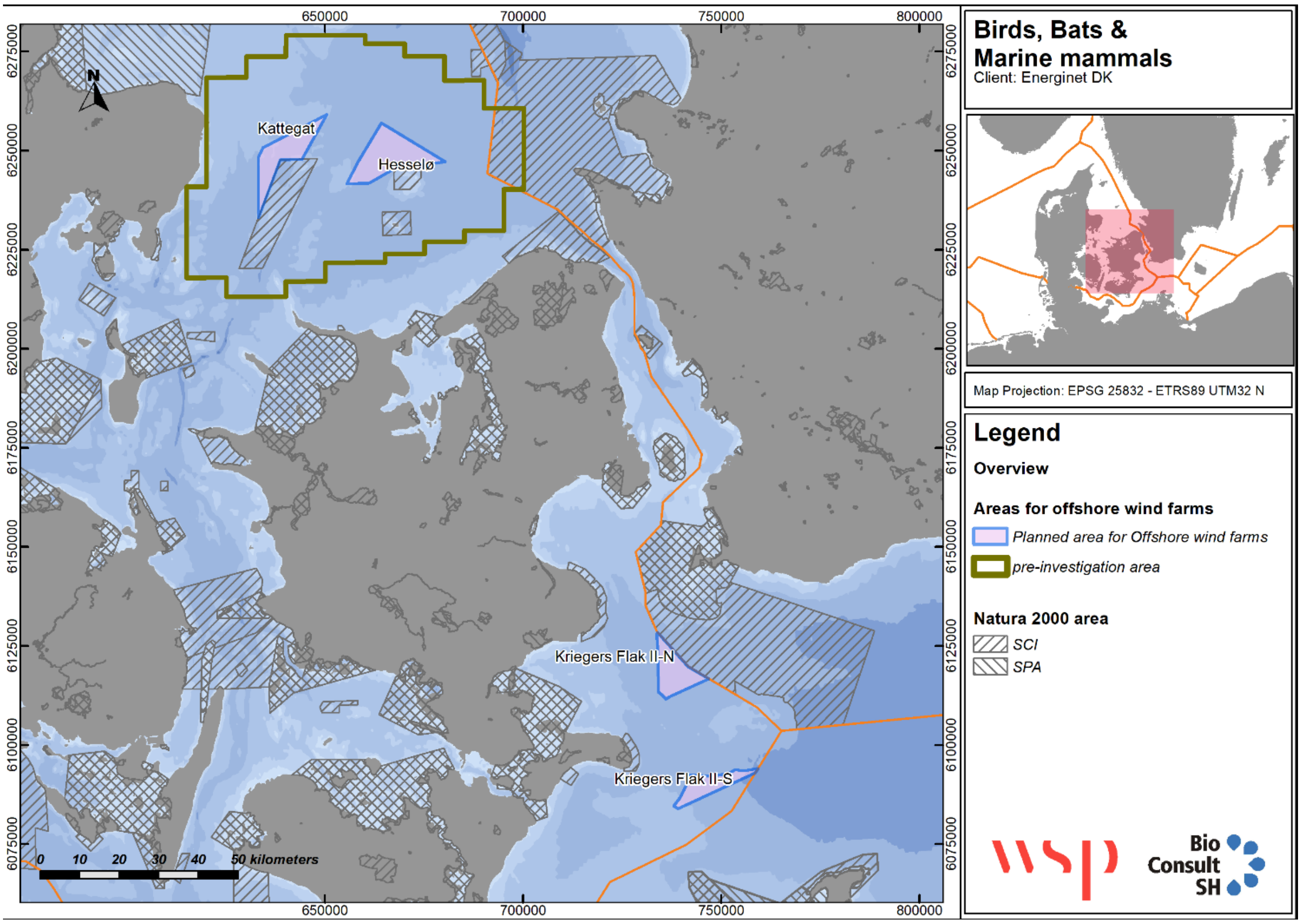

Figure 2-1. Map showing the location of the investigated offshore wind farm areas Kattegat, Hesselø and Kriegers Flak II (North and South). The present report focuses on Kattegat.

3 EXISTING DATA

The purpose of this section is to provide 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, the potential importance of the pre-investigation area for each of these three species will be discussed.

3.1 HARBOUR SEALS

3.1.1 DISTRIBUTION, BIOLOGY, HABITAT USE

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 region, 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 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 is 92% (Härkönen & Heide-Jørgensen 1990) and females give birth on land, usually once a year, between May and June after a gestation of 11 months. Pups are usually weaned after four weeks and are then left to fend for themselves. They can swim and dive immediately after birth but depend on undisturbed sites on land for suckling and resting. Mating occurs post-partum 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. Generally, good blood perfusion to the outer skin layers is necessary for moulting and increased perfusion occurs on land, preferably with dry fur (Dietz et al. 2015), thus animals depend on undisturbed sites on land during the moult. Due to 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 are opportunistic predators but prefer small to medium sized benthic fish species. As such, they are mainly benthic foragers found in waters below 100 m depth (Tollit et al. 1998). From two studies in the south-western Baltic Sea, 20 fish species were found in 42 harbour seal samples (scat and digestive tracts), identified from otoliths. 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). 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 main species was cod, which dominated spring and autumn diet (42% and 43% of weight consumed). During the summer period flounder (*Platichthys flesus*) and plaice (*Pleuronectes platessa*) together made up 52% of the weight consumed (cod only 22%).

Harbour seals do not migrate but show high site fidelity to their haul-out sites and aggregate there especially during the lactation and moulting period. However, much less is known about harbour seal density and habitat use in the waters surrounding the haul-out sites

Foraging trips into deeper waters are mostly confined to a radius of less than 50 km from the coast, but can occasionally range as far as 100 km from shore (e.g. THOMPSON ET AL. 1994; TOLLIT ET AL. 1998; CUNNINGHAM ET AL. 2009; MCCONNELL ET AL. 2012; 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 distances of up to 200 km from the haul-out site, while adult harbour seals seem to prefer to stay within 50 km from the haul-out sites (MCCONNELL ET AL. 2012; DIETZ ET AL. 2015), possibly due to age-dependent individual preferences for particular feeding grounds (DIETZ ET AL. 2015).

3.1.2 POPULATIONS, ABUNDANCE, CONSERVATION STATUS

Harbour seals have probably been present in the Baltic Sea region (defined according to HELCOM) since the last glaciation. Based on molecular data and satellite telemetry studies, it was suggested to split harbour seals in the Baltic Sea region (defined according to HELCOM) into four different subpopulations (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. Tagging studies showed none or only limited exchange between colonies separated by more than about 100 km due to limited migration movements (DIETZ ET AL. 2013, 2015), and thus at least partial reproductive isolation between these four subpopulations. Harbour seal haul-out sites in the Kattegat closest to the planned windfarm area of Hesselø are located in Denmark about 11 km south at Hesselø, about 27 km north at Anholt, about 35 km south at Sjællands Rev, about 56 km southwest at Bosserne, and in Sweden about 38 km East at Hallands Väderö. The haul-out sites at Hesselø, Anholt, and Bosserne, are also used by grey seals.

HELCOM (2023a) states that the harbour seal populations in the Kattegat 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 (c) in the Limfjord. Latest estimated population sizes are about 2,000 individuals in the SW Baltic and about 12,500 individuals in the Kattegat (HELCOM 2023b); counts at haul-out sites indicate 9,250 animals in Danish waters in 2023 (HANSEN ET AL. 2024).

The status assessment of the individual populations under HELCOM (2023a) shows that the SW Baltic population alone is below Limit Reference Level, but when assessed together with Kattegat, the combined abundance exceeds the Limit Reference Level. However, growth rates in the SW Baltic and the Kattegat population are still below the threshold value for good status. Furthermore, it is uncertain if the Kattegat unit is at or below Target Reference Level or undergoing a decline (HELCOM 2023b). 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' and 'population trends and abundance' (HELCOM 2023b).

The status of both the global population of harbour seals (LOWRY 2016) and the European population (European Mammal Assessment Team 2007) are classified by the IUCN as least concern (LC; Table 3-1). The HELCOM Red List (2013a) classified the Southern Baltic population as LC. The red list of Denmark assessed it as LC (Den Danske Rødliste2019; AARHUS UNIVERSITET 2019) and the red list of Sweden lists the Baltic population as vulnerable (VU; SLU SWEDISH SPECIES INFORMATION CENTRE 2023).

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 (CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS (CMS) 2015). For a summary, see Table 3-1.

The Danish Centre for Environment and Energy (DCE) assessed the conservation status of the harbour seals in Habitat Directive Article 17 from 2025 (FREDSHAVN ET AL. 2025b) 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).

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 ***Phoca vitulina***	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

3.2 GREY SEALS

3.2.1 DISTRIBUTION, BIOLOGY, HABITAT USE

The grey seal (*Halichoerus grypus*) is a large seal species with a cold-temperate to sub-artic distribution along the coasts of the North Atlantic. Two subspecies of grey seal are recognized, which differ both morphologically and genetically (BOSKOVIC ET AL. 1996; GRAVES ET AL. 2009; FIETZ ET AL. 2013): the Atlantic grey seal (*Halichoerus grypus atlantica*) inhabits the Atlantic and the North Sea, and the Baltic grey seal (*Halichoerus grypus grypus*) inhabits the Baltic Sea region (defined according to HELCOM; BERTA & CHURCHILL 2012; FIETZ ET AL. 2016; OLSEN ET AL. 2016). However, the 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 region (defined according to HELCOM), with main concentrations in the northern and central parts of the Baltic Sea region (defined according to HELCOM), 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 & JARRETT 2008). Grey seal females reach sexual maturity between 4 and 6 years of age and females between 3 and 5 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 region (defined according to HELCOM), and October-December in the northeast Atlantic (GALATIUS ET AL. 2020).

Grey seals in the Baltic Sea region (defined according to HELCOM) breed mainly on drift ice, but where this is not possible, as in the southern Baltic Sea region (defined according to HELCOM) in most winters, they also breed on land. Grey seal pups are born with a lanugo coat, which is not waterproof, so they are unable to enter the water until they have 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 are therefore highly dependent on undisturbed haul-out sites above the high-water mark 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.

Little is known about grey seal density and habitat use offshore, but telemetry studies show that grey seals undertake longer foraging trips from their haul-out sites than harbour seals do,with occasional travelling distances of up to 2,100 km (e.g. THOMPSON ET AL. 1991, 1996; MCCONNELL ET AL. 1999; DIETZ ET AL. 2015); they also show much larger dispersal distances. Grey seals tagged in the Rødsand lagoon were found to move up to 850 km east into the Baltic proper (DIETZ ET AL. 2015). Generally, grey seals visit a larger number of haul-out sites than harbour seals and travel greater distances (e.g. THOMPSON ET AL. 1996).

Grey seals are generalist opportunistic feeders with a wide range of prey (SCHARFF-OLSEN ET AL. 2019). 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 nutritional status of seals is usually estimated based on blubber thickness of hunted and bycaught seals, which indicates long-term and short-term changes in food supplies and other stressors (KYHN ET AL. 2022). However, grey seals in the Baltic Sea failed the threshold for good status in the HELCOM assessment period 2016-2021 (KYHN ET AL. 2022).

3.2.2 POPULATIONS, ABUNDANCE, CONSERVATION STATUS

There are no distinct subpopulations of the Baltic grey seal recognized and it ranges widely within the Baltic Sea region, although there are local differences in their distribution. HELCOM (2023c) assessed the grey seal population in the Baltic Sea region as a single management unit based on data from 2003-2021. Grey seal haul-out sites in the Kattegat closest to the planned windfarm area of Hesselø, are located about 11 km south at Hesselø, about 27 km north at Anholt and about 56 km southwest at Bosserne. These haul-out sites are also used by harbour seals.

Between 2014 and 2017, grey seal numbers were around 30,000 individuals in the Baltic Sea region, based on haul-out counts during the moulting season in late May and early June (ICES 2019). In 2019, about 38,000 grey seals were counted, and about 42,000 grey seals were counted in 2021, leading to an estimated population size of about 60,000 animals (HELCOM 2023c). The number of grey seal sightings has generally been increasing over the past decade and in 2023, up to 182 grey seals were recorded at Danish locations in

the Kattegat, 213 in the Wadden Sea and 1456 in the Danish part of the Baltic Sea. In 2023, 1456 grey seals were counted in the Danish part of the Baltic Sea (including 914 at Ærteholmene and 539 at Rødsand), the highest number on record so far (HANSEN ET AL. 2024). In the Kattegat, 123 grey seals were counted in 2023 and 213 animals in the Wadden Sea (HANSEN ET AL. 2024). 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 unfavorable conservation status (HANSEN & HØGSLUND 2021). In the 2023-2024 season, two pups were observed in January in the Wadden Sea in the outer Knude Deep and two at Galgedyp. In December 2023 and January 2024, aerial surveys were carried out in the Kattegat for the third time during the North Sea grey seal breeding season and no pups were recorded, unlike the first two seasons when two grey seal pups were observed at Læsø in both cases (HANSEN ET AL. 2024). Despite this, it is expected that the general increase in the number of grey seals will continue in the coming years (HANSEN ET AL. 2024).

Even though grey seals in the Baltic Sea region 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 >=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). According to this evaluation, the grey seal population of the Baltic Sea region has failed all four key indicators "trends and abundance", "distribution", "nutritional status" and "reproductive status" (HELCOM 2023c). The pregnancy rate in the grey seal population of the Baltic Sea region (defined according to HELCOM) was on average 87% between 2016-2021, which is below the threshold value of 90% that would indicate a good status (HELCOM 2023c).

The status of the global population (BOWEN 2016) and the European population (EUROPEAN MAMMAL ASSESSMENT TEAM 2007) of the grey seal are both classified by the International Union for the Conservation of Nature (IUCN) as LC, and the status of the Baltic subspecies *Halichoerus grypus grypus* is also assessed as LC by the HELCOM Red List (HELCOM 2013a). The national Red List of Denmark lists the grey seal as VU (Danske Rødliste 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 (SLU SWEDISH SPECIES INFORMATION CENTRE 2023). Hunting in Denmark and Germany is forbidden, in Sweden it is allowed, but controlled through various regulations and restrictions (HELCOM 2013b).

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 (CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS (CMS) 2015). For a summary, see Table 3-2.

DCE assessed the conservation status of the grey seals in Habitat Directive Article 17 from 2025 (FREDSHAVN ET AL. 2025b) as highly unfavourable but improving in both Danish marine regions. Since 2003, the grey seal has established itself as a breeding species at certain locations and is occurring in increasing numbers in Danish waters. In the DCE Marine areas report from 2021 (Hansen & Høgslund 2021) and 2024 (Hansen et al. 2024), it is stated that the numbers of grey seals in Danish waters have increased over the last ten years.

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
Grey seal ***Halichoerus grypus***	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 DISTRIBUTION, BIOLOGY, HABITAT USE

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). Numerous studies and a crude examination of sighting and stranding data support the general view that the number of harbour porpoises have declined during the second half of the 20th century and their distributional range in the Baltic Sea region (according to HELCOM) has narrowed extensively (Koschinski 2002).

Harbour porpoises in Danish waters (North Sea, Inner Danish waters/Kattegat 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). Both sexes attain sexual maturity at about 3 years of age, with corresponding body sizes of about 143 cm in females and 135 cm in males (Lockyer & Kinze 2003). 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) showed that female harbour porpoises start ovulating 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 (defined according to HELCOM; Kesselring et al. 2017). Newborn calves may be seen from April to October in the Belt Sea and the percentage of calves 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 period spans between 8 and 10 months, thus many harbour porpoise females are simultaneously pregnant and lactating (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 per annum, so mature females would produce about two calves in three years (Koschinski 2002).

Baltic harbour porpoises mainly feed on pelagic fish species, like herring and whiting, and on semi-pelagic 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 (Aarefjord et al. 1995; Benke et al. 1998; Lockyer & Kinze

2003; SANTOS & PIERCE 2003; LEOPOLD 2015; ANDREASEN ET AL. 2017). The diet of Belt Sea harbour porpoises was found to be quite similar to that of harbour porpoises from the North Sea, except for sandeels and whiting being more important in the North Sea (BENKE ET AL. 1998; SANTOS & PIERCE 2003; LEOPOLD 2015).

Harbour porpoise habitat use shows seasonal differences and is considered to largely depend on prey availability, as well as correlate with strong currents and the occurrence of fronts and eddies (e.g., JOHNSTON ET AL. 2005; PIERPOINT 2008), where prey usually concentrates.

Catch statistics suggest that harbour porpoises in the Baltic Sea region 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. TEILMANN ET AL. (2013) have shown that satellite tracked harbour porpoises from the Belt Sea migrate into the North Sea, but it is not completely understood to what extend harbour porpoises from the North Sea enter the Baltic Sea and, more specifically, the southern Kattegat.

3.3.2 POPULATIONS, ABUNDANCE, CONSERVATION STATUS

Harbour porpoises occurring in Danish waters belong to three different (sub)populations: Skagerrak/North Sea, Belt Sea (including the Kattegat, Sound, Belt Sea and western Baltic Sea) and Baltic Proper based on genetic and morphological evidence (WIEMANN ET AL. 2010; BENKE ET AL. 2014; LAH ET AL. 2016; TIEDEMANN ET AL. 2017). A management border for the Baltic Proper population was suggested to occur around the Darss ridge following survey and acoustic monitoring data (BENKE ET AL. 2014). Sveegaard et al. (2015) provide a map with suggested overlapping zones between the three populations based on survey and telemetry data. More recently, it was suggested that animals from the Belt Sea and Baltic Proper are separated during the summer from May to October (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 3-1 taken from Sveegaard et al. (2018) shows the suggested management areas for the separate populations as well as their transition areas based on passive acoustic monitoring (PAM) data.

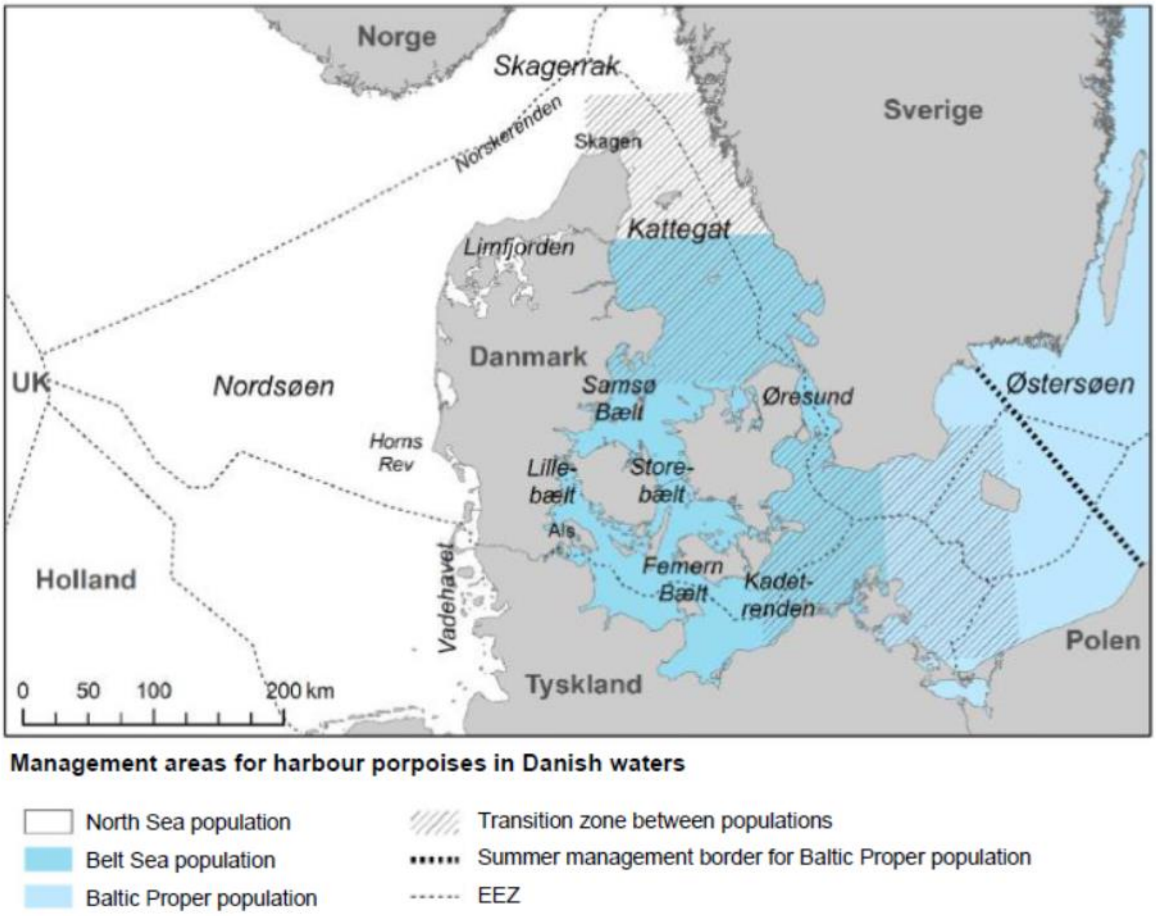

Figure 3-1. Map showing suggested management areas for the three harbour porpoise populations in Danish waters and neighbouring countries. Taken from: SVEEGAARD ET AL. 2018.

An overview of different population surveys for harbour porpoises in the North and Baltic Sea is given in Table 3-3. Please note that due to the methodological differences in survey methods and areas covered, only estimates from 2016 onwards can be used to assess the Belt Sea population as it is now defined. 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 population's conservation status. Therefore, the SCANS III and IV surveys redefined a porpoise management unit for only the Belt Sea population; 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 porpoises (VIQUERAT ET AL. 2014; UNGER ET AL. 2021).

Table 3-3. Overview of surveys undertaken on harbour porpoise populations in the Baltic Sea region.

Survey name	Survey year	Survey method	Survey area/ (Sub)population examined	Population estimate	Reference
SCANS-I	1994	Ship-based and aerial combined	Skagerrak, Kattegat and western Baltic (according to HELCOM)	n/a	(HAMMOND ET AL. 2002)
SCANS-II	2005	Ship-based	Inner Danish waters (Skagerrak, Kattegat and western Baltic (according to HELCOM))	23,227	(HAMMOND ET AL. 2013)
SAMBAH	2011-2013	PAM	Baltic Proper	500	(AMUNDIN ET AL. 2022)
*SCANS-III	2016	Ship-based	Skagerrak in the north to Rügen in the east (Skagerrak, Kattegat and the Belt Sea area) -Belt Sea	73,573 42,324	(HAMMOND ET AL. 2017)
*SCANS-IV	2022	Aerial survey	-Belt Sea -North Sea	14,403 338,918	(GILLES ET AL. 2023)
MiniSCANS-I	2012	Aerial survey	Belt Sea	40,475	(VIQUERAT ET AL. 2014)
MiniSCANS-II	2020	Aerial survey	Belt Sea	17,301	(UNGER ET AL. 2021)
NOVANA monitoring program	2023	Aerial survey	-Skagerrak -Southern North Sea -Kattegat -Belt Sea	2,675 1,244 3,251 1,953	(HANSEN ET AL. 2024)

* SCANS III and IV surveys redefined a porpoise management unit for the Belt Sea population only

The latest 2022 SCANS IV resulted in an estimate for the Belt Sea harbour porpoise population of 14,403 individuals (GILLES ET AL. 2023), which is considerably lower than the 2016 estimate of 42,324 individuals (SCANS III) and 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 3-2). However, the variance in the data is very large, and power analyses showed that the data would only allow detection of 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 (GILLES ET AL. 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).

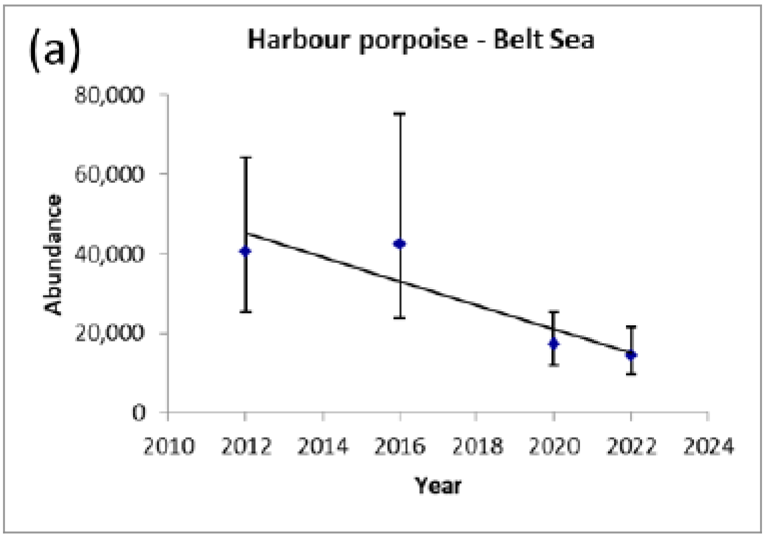

Figure 3-2. Abundance estimates for harbour porpoises of the Belt Sea population with fitted trend line, suggesting an annual decline of 1.5%. Taken from SCANS IV: GILLES ET AL. (2023).

The estimated numbers of harbour porpoises in the monitoring areas in the Southern North Sea (2011-2023), Skagerrak (2017-2023) and Belt Sea (2022-2023) indicated more or less stable numbers in the Southern North Sea (1.244 animals counted in 2023 with 95% CI: 484-2.361; HANSEN ET AL. 2024). In contrast, numbers for the Skagerrak (2.675 animals counted in 2023 with 95% CI:1.454-4.381) and the Belt Sea (1.953 animals counted in 2023 with 95% CI 1.134-3.130) showed a continuous decline (HANSEN ET AL. 2024). This should be cause for concern and is in line with the large decline in harbour porpoises in the Belt Sea population (OWEN ET AL. 2024).

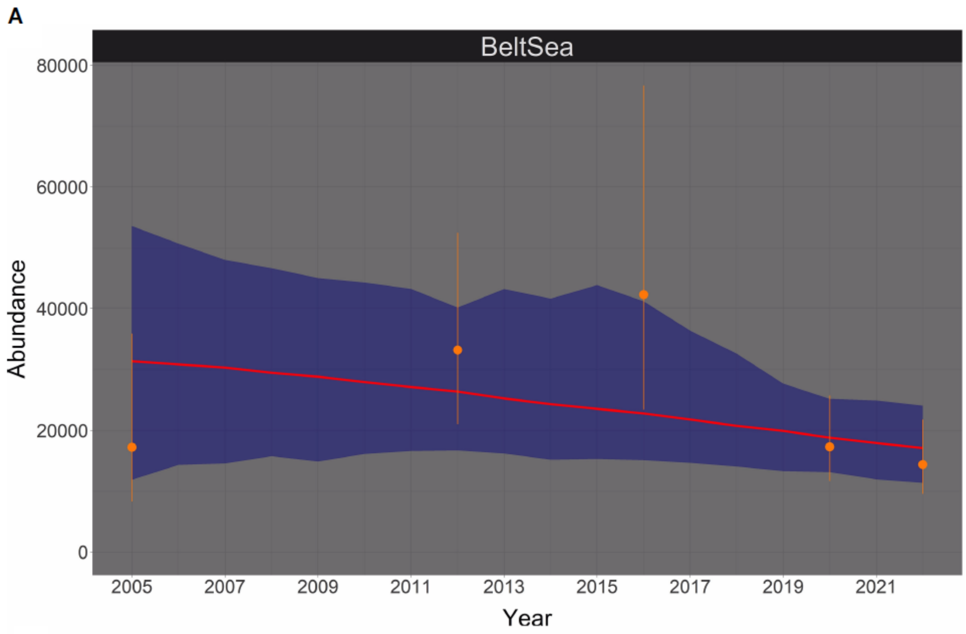

Figure 3-3. Belt Sea harbour porpoise population Bayesian trend, suggesting an annual decline of 2.7%. Taken from: OWEN ET AL. (2024).

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 region for harbour porpoises. As a map based exclusively on density estimates would fail to highlight the areas that may be important for the Baltic Proper population of only about 500 individuals, the HOLAS III map 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 in a single map.

The importance of areas 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 (Figure 3-4).

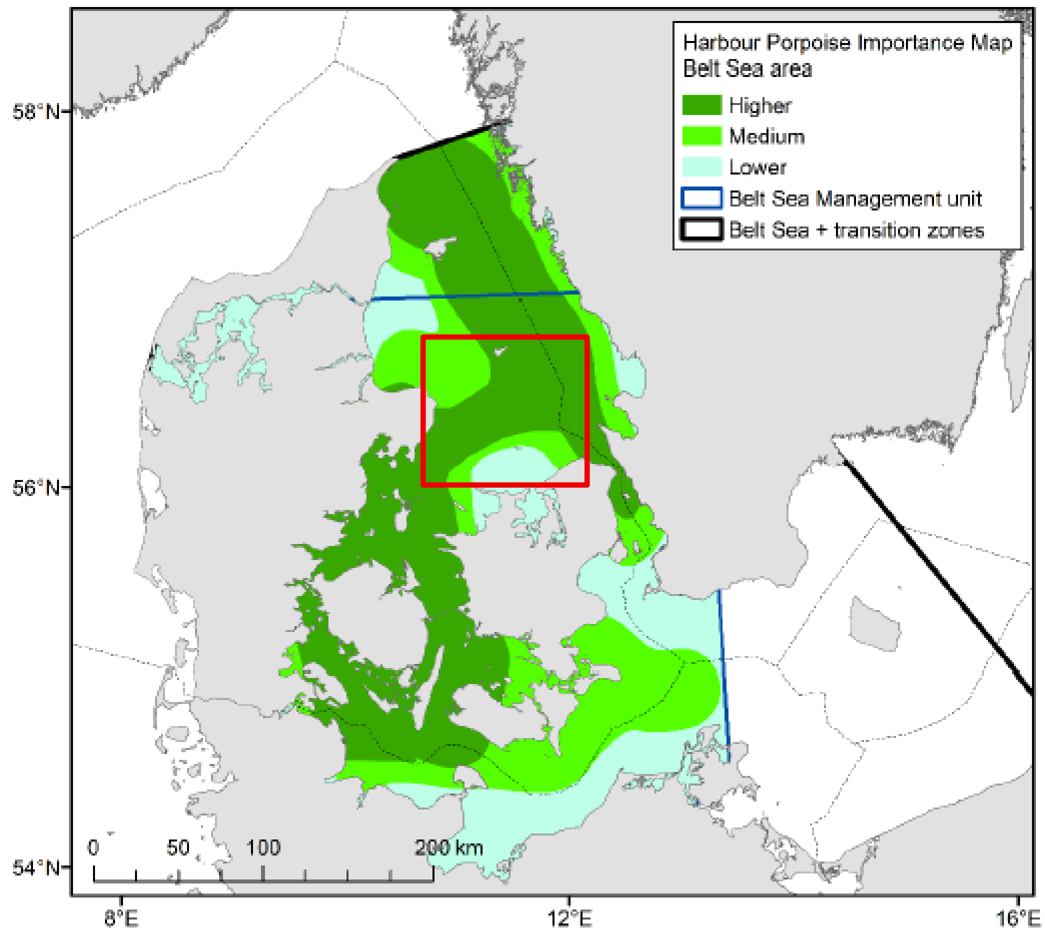

Figure 3-4. Map of the importance of different areas for the Belt Sea population of harbour porpoises. From: SVEEGAARD ET AL. (2022). Approximate pre-investigation area is indicated in red.

The 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) and the HELCOM Red List lists the Belt Sea subpopulation as VU (HELCOM 2013c).

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 by member states. The harbour porpoise populations of the North and Baltic Seas are further included in Appendix II of the Bonn Convention (CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS (CMS) 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 conservation plan for the harbour porpoise in the Western Baltic, Belt Sea and Kattegat (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 region. For a summary see Table 3-4.

The Danish National Centre for Environment and Energy (DCE) assessed the conservation status of the harbour porpoise in Habitat Directive Article 17 from 2025 (FREDSHAVN ET AL. 2025b) as follows: In the Baltic region, two distinct populations inhabit Danish waters: one in the inner Danish waters and another in the central Baltic Sea, including the waters surrounding Bornholm. These two populations are collectively assessed as having a severely unfavorable conservation status. The Baltic Sea population is very small and classified as critically endangered by the IUCN, while the population in the inner Danish waters undergone a significant decline between 2005 and 2022, indicating a marked deterioration in its conservation condition. The population in the marine Atlantic region is considered as being of favorable conservation status. The DCE Marine areas report from 2021 (HANSEN & HØGSLUND 2021) it is stated that the entire Belt Sea population of harbour porpoises has declined to 14,403 individuals since previous counts in 2012 and 2016 (GILLES ET AL. 2023) a trend which also was confirmed in the DCE Marine areas report from 2023 (HANSEN ET AL. 2024). 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).

From May 2022 to April 2023, acoustic monitoring was conducted in the N2000 areas ‘Central Great Belt and Vresen’ and ‘Flensburg Fjord, Bredgrund and the waters around Als’ (HANSEN ET AL. 2024). Previously, more harbour porpoises were generally detected in the Great Belt than in Kalundborg Fjord, but in the fourth, most recent monitoring period, the average detection level in the two areas was approximately the same (±6 PPM/day/month). Although this seems to indicate an increase in Kalundborg Fjord, there is no statistically significant difference between monitoring periods (n=4; HANSEN ET AL. 2024). In the Great Belt, the number of porpoise detections increased during the first three monitoring periods, but decreased in the most recent monitoring period (HANSEN ET AL. 2024).

In contrast to the Belt Sea population, the Baltic Proper subpopulation is classified as critically endangered (CR; CARLSTRÖM ET AL. 2023a), which is the highest threatened status (SPECIES ACCOUNT BY IUCN SSC CETACEAN SPECIALIST GROUP; REGIONAL ASSESSMENT BY EUROPEAN MAMMAL ASSESSMENT TEAM 2007; CARLSTRÖM ET AL. 2023b). 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 (SLU SWEDISH SPECIES INFORMATION CENTRE 2023; Table 3-4). The Danish National Centre for Environment and Energy (DCE) assessed the conservation status of the Baltic Proper harbour porpoise in Habitat Directive Article 17 from 2025 (FREDSHAVN ET AL. 2025b) to have a highly unfavorable conservation status. The Baltic Sea population is critically small and classified as Critically Endangered by the International Union for Conservation of Nature (IUCN). In addition, the population in the inner Danish waters has undergone a significant decline between 2005 and 2022, indicating a marked deterioration in its conservation condition (FREDSHAVN ET AL. 2025a; b).

Table 3-4. 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 *Phocoena phocoena*	Global: LC Europe: LC Baltic Proper subpopulation: CR	Baltic Sea: CR Western Baltic*: VU	DE: Highly threatened DK: CR SE: CR (Baltic Sea population)	Appendix II und IV	Appendix II	Appendix II

4 METHODOLOGY

In order to obtain baseline data on the abundance and distribution of marine mammals and the spatial and seasonal habitat use of harbour porpoises for the pre-investigation area, different survey methods, such as digital aerial surveys and passive acoustic monitoring (PAM), were used. This report incorporates data from Y1 (February 2023 to January 2024) and Y2 (February 2024 to February 2025) and focuses on the general distribution and abundance of marine mammals during this period. Please note that data from Y1 and Y2 will be combined, except in the case of major differences between years, which will be stated and data for Y2 (February 2024 to February 2025) will be shown. Data from Y1 can be found in the report (BioConsult SH & WSP Denmark 2024).

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 during 12 digital aerial survey flights from February 2023 to February 2025 (Y1+Y2). 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.

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). 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 km² pre-investigation area was covered per flight (Table 4-1).

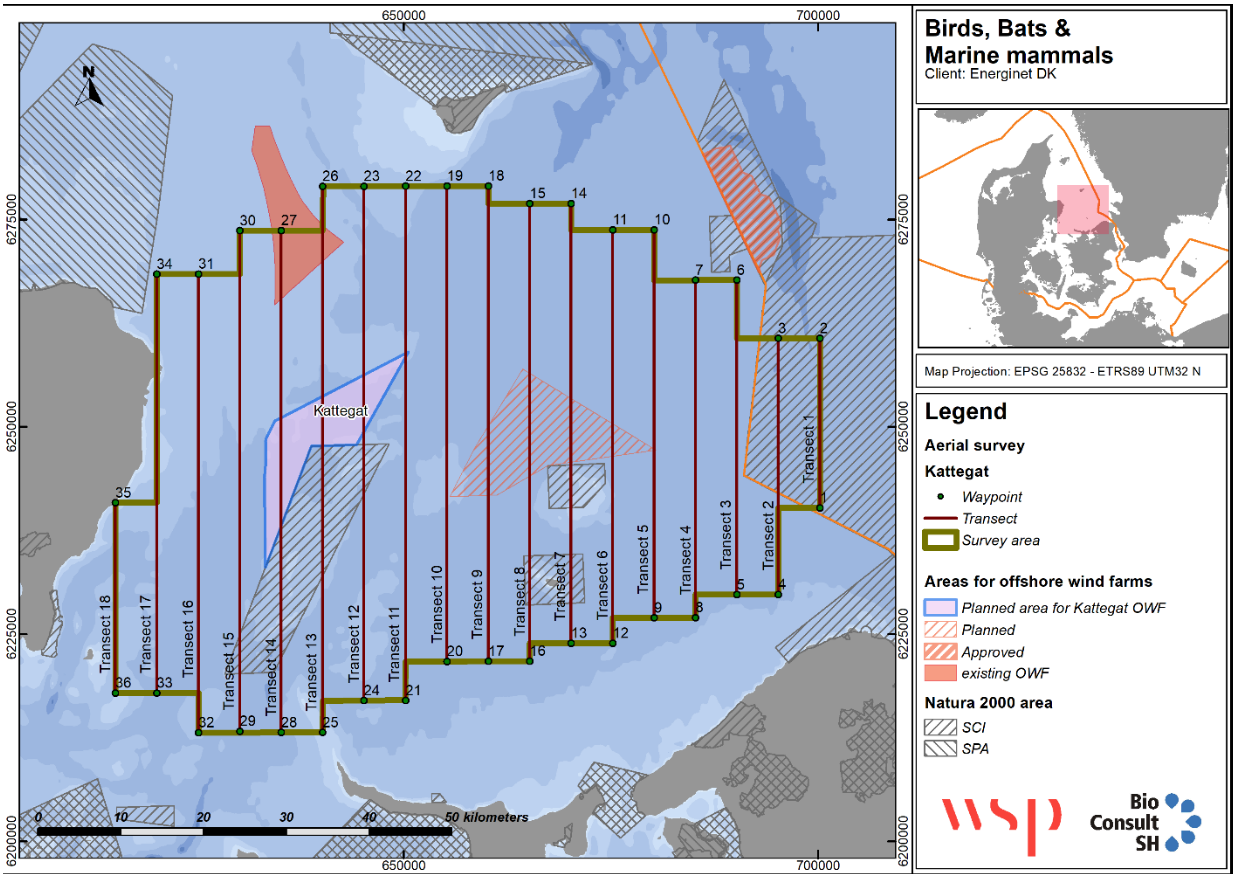

Figure 4-1. Transect design for aerial marine mammals' surveys in the pre-investigation area for Kattegat.

Table 4-1. Overview of the digital aerial surveys carried out in the pre-investigation area between February 2023 and February 2025 (Y1+Y2). 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^2]	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
7	17.02.2024	871	472	11.4
8	06.04.2024	892	483	11.7
9	18.06.2024	892	475	11.5
10	07.08.2024	894	484	11.7
11	23.10.2024	893	484	11.7
12	17.12.2024	893	484	11.7
		Total: 10,663	**Total: 5,758**	**Average: 11.6**

Table 4-2. Waypoints (WP) and Transects coordinates and lengths for aerial marine mammal surveys in the pre-investigation area for Kattegat.

Transect	Start Transektt	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), explained in detail in WEIß 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, a distance of about 20 m 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.

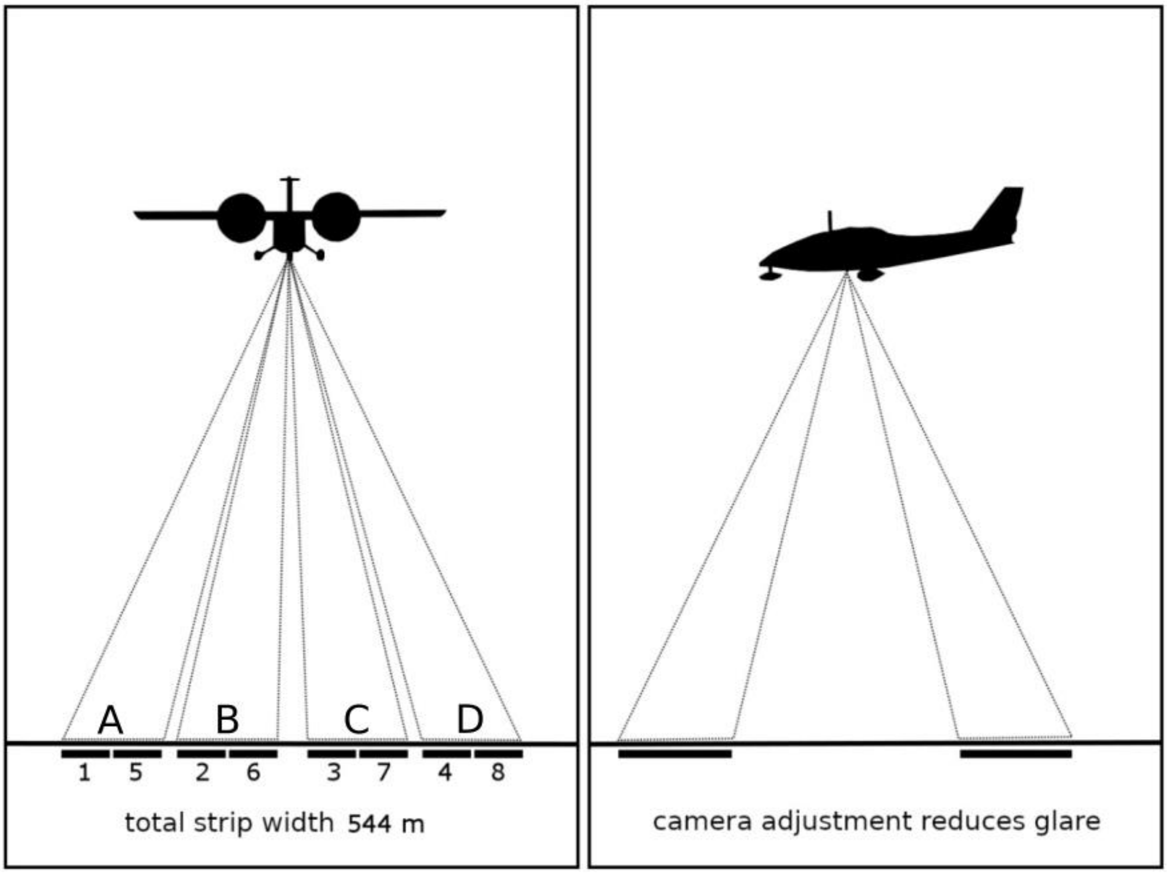

Figure 4-2. The HiDef Camera System. The four cameras (A to D) cover an effective strip width of 544 m of the sea surface at a flight altitude of 549 m (left: frontal view; right: side view). The numbering indicates the camera images as they are used in the evaluation (the images from each camera are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

4.1.4 DATA ANALYSIS

Densities of individuals (individuals/km²) 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-investigation 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 km² was reached.

Certain correction factors were included in the calculation and analysis since marine mammals located more than 2 m below the water surface may escape detection from the air. This correction allows for these animals to be included in the abundance and density estimates. To correct for this so-called availability error (BORCHERS 2003), the number of animals sighted is 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 made 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 metres 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 two-year survey period from February 2023 to February 2025 (Y1+Y2).

Studies comparing C-POD PAM results to simultaneous visual observations (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 were 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 approx. 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.

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).

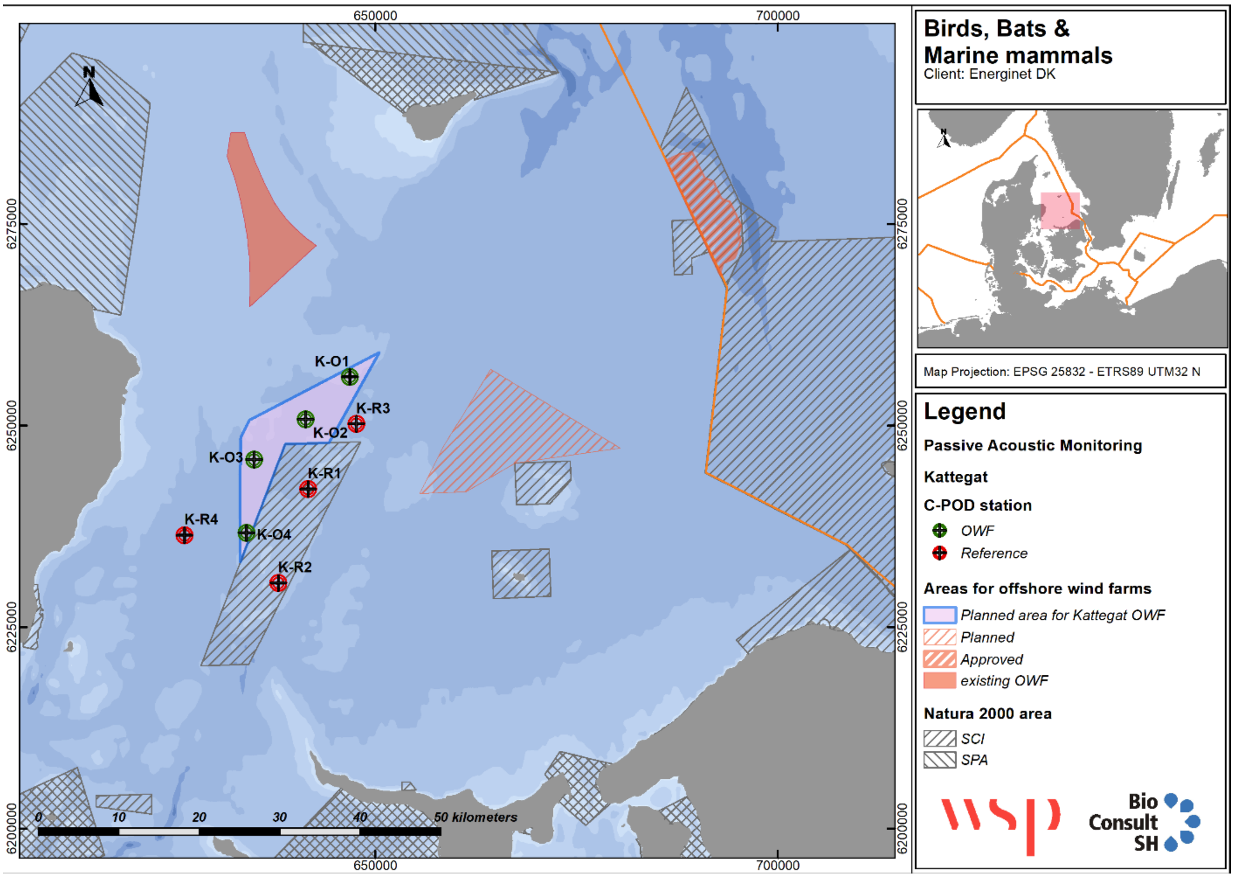

Figure 4-3. C-POD design inside and outside the planned windfarm area of Kattegat.

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 from 23rd of February 2023 to 26th of February 2025 (Y1+Y2) with the permission from the Danish Maritime Authority. 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

. There was minimal data loss at three stations: one deployment period in winter 2024-2025 at station K-O2, a short period of time in June 2023 at station K-O4 and in May-June 2024 at station K-R2.

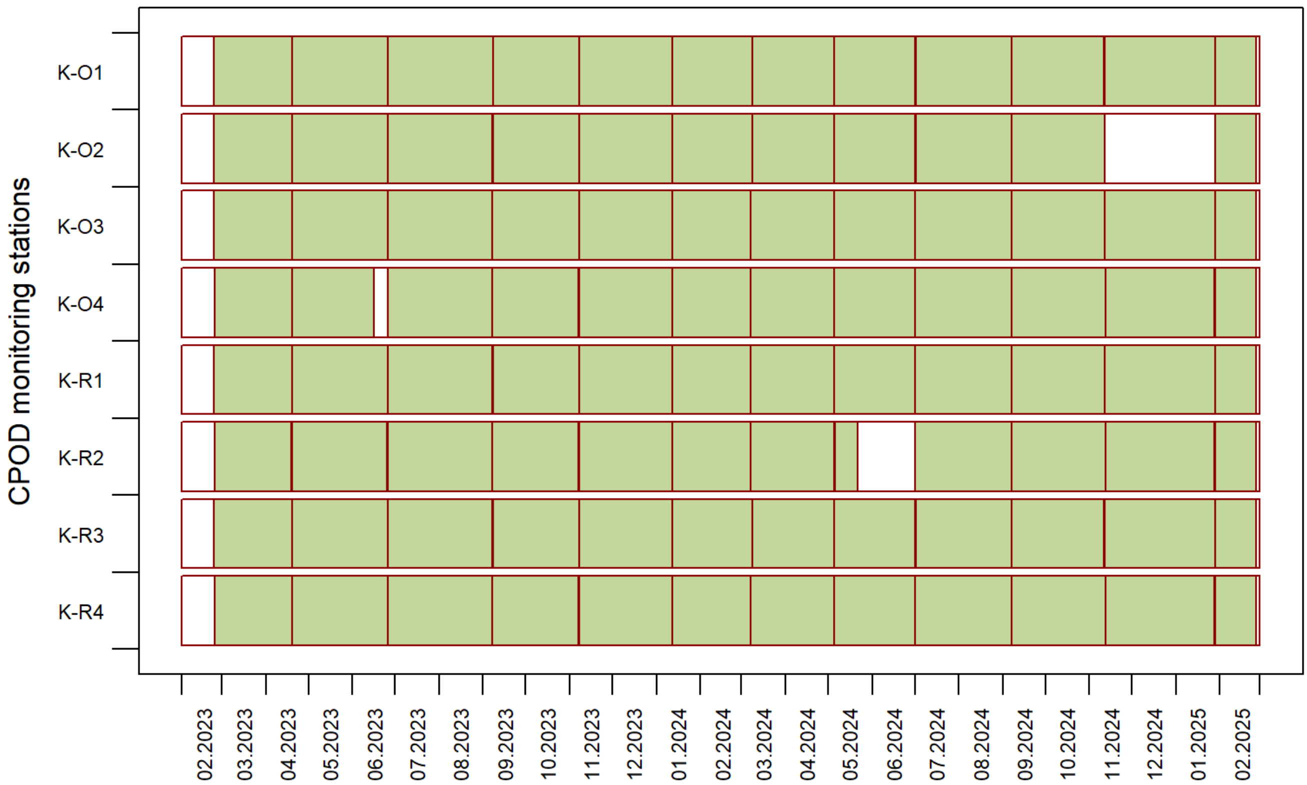

Figure 4-4. Bar chart, indicating the duration of deployment of C-PODs within the pre-investigation area for the two-year survey period (February 2023 to February 2025; Y1+Y2). Green: C-POD recorded data, white: no data. The x-axis shows the date, the y-axis the C-POD station. Vertical lines indicate 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° (KOBLITZ ET AL. 2012). This means that C-PODs will only be able to detect harbour porpoise presence if these (1) emit click sounds, (2) 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 2024), 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 all 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. Additionally, a number of different specific click characteristics is 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).

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 (±3 dB). The calibration and standardization process are described in detail on the manufacturer's website (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.

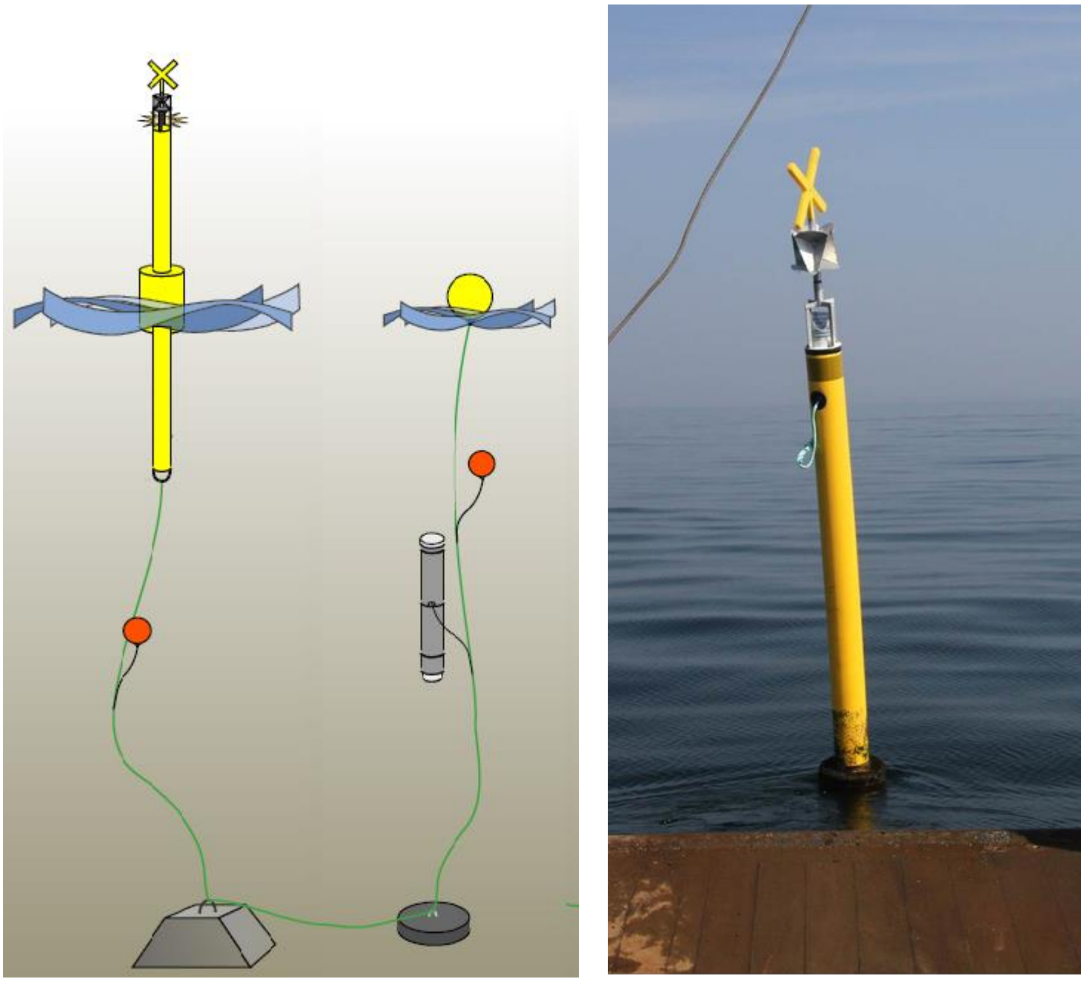

Figure 4-6. C-POD mooring system with spar buoys.

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 of harbour porpoise presence. Different studies have shown 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 a higher detection rate indicates a higher presence of harbour porpoises in the respective range of the C-POD and the respective timeframe, although it cannot be excluded that a high detection rate could be caused by a few animals staying in the area covered by a C-POD for a longer period of time. This parameter therefore only serves as a rough indicator of harbour porpoise density per time unit. See formula 1, xt = number of clicks for this time unit.

Formula 1:

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

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 harbour 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 the 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, describing the number of 10-minute units within a 24-hour day (144 in total), where 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 for the identification of 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. First, harbour porpoise click trains were extracted from the raw data by means of an algorithm of the CPOD.exe software. Secondly, 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 with high probability 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 criterions 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 124 days of 5,880 possible monitoring days (2.1%) for Y1 and Y2 combined could not be included in the evaluation due to data loss (Figure 4-4). 5,756 C-POD monitoring days remained for further consideration. About 3.6% of all C-POD monitoring days did not meet the noise criteria described above and were therefore discarded. Hence, 5,550 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.

4.3 SEAL COUNTS AT HAUL-OUT SITES

Data from seal counts under the Danish national monitoring programme NOVANA during the moulting and pupping seasons of harbour seals and grey seals, respectively, were analysed according to HANSEN ET AL. (2024). 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 each year will be considered. Based on historical (SØNDERGAARD ET AL. 1976) and current distribution of seals (HANSEN & HØGSLUND 2021; HANSEN ET AL. 2024) and their haul-outs on beaches and sand banks in the Baltic Sea and Kattegat, haul-out sites were selected for further analyses. The data was provided by DCE – Nationalt Center for Miljø og Energi and Swedish Museum of Natural History.

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, the haul-out sites count data for May and June and for grey seals, the haul-out sites count data for August were used according to HANSEN ET AL. (2024). In contrast to HANSEN ET AL. (2024) data was not corrected for seals at sea during haul-out counts. Therefore, the true abundance may be much higher as in some areas, around 60% of seals may be at sea during counts (HANSEN & HØGSLUND 2021; HANSEN ET AL. 2024).

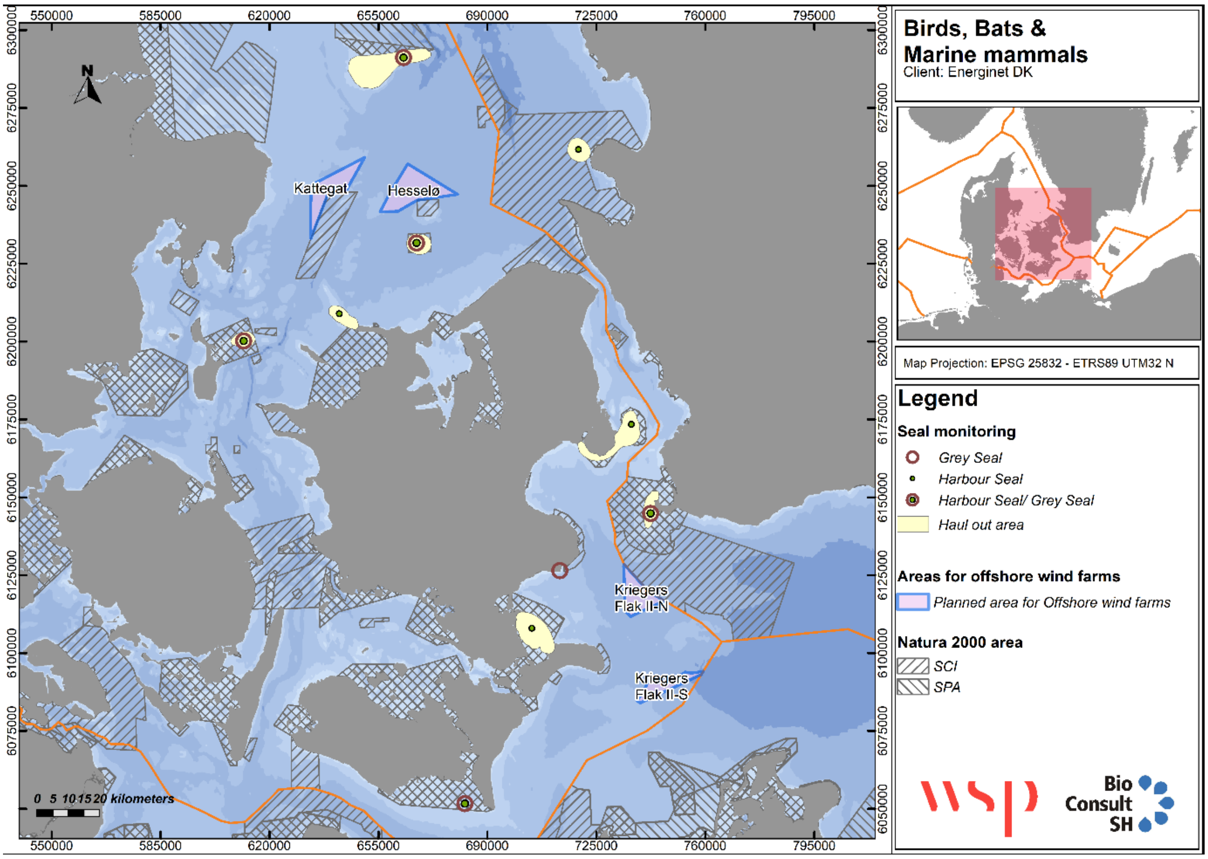

Figure 4-7. Haul-out sites of Harbour Seals and Grey Seals in the vicinity of the windfarm areas Kattegat, Hesselø, Kriegers Flak II N and Kriegers Flak II S. The distribution of seals and prey on beaches and sandbanks shown is adapted from HANSEN ET AL. (2024) and SØNDERGAARD ET AL. (1976).

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	Sjaelland 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 February 2025 (Y1+Y2), a total of 314 marine mammals (Figure 5-1 and Table 5-1; 54 seals (10 harbour seals, 2 grey seals, 42 unidentified seals), 246 harbour porpoises and 14 unidentified marine mammals) were observed during the 12 digital aerial surveys. The 14 unidentified marine mammals most likely belong to one of the two categories harbour porpoise or unidentified seal.

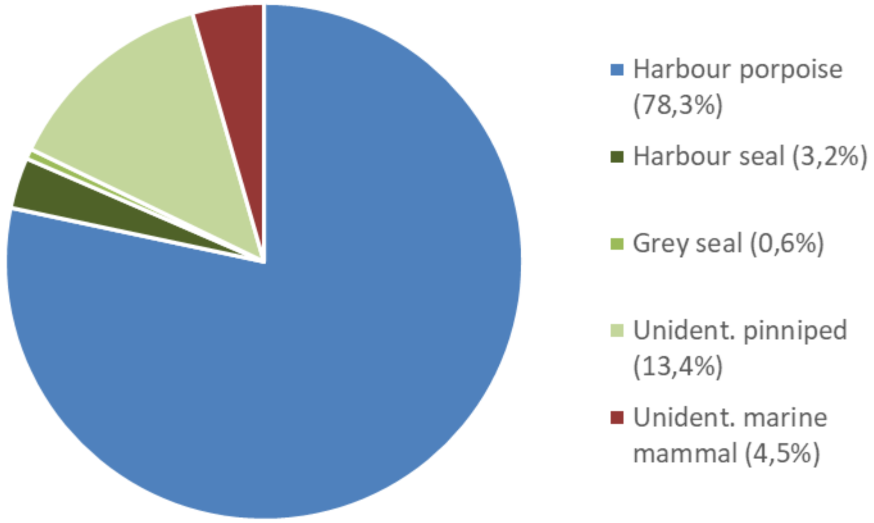

Figure 5-1. Proportion of different marine mammal observations in the pre-investigation area during aerial surveys between February 2023 and February 2025 (Y1+Y2).

Table 5-1. Observations of marine mammals in the pre-investigation area during aerial surveys between February 2023 and February 2025 (Y1+Y2). Harbour seal, grey seal and unidentified seal are summarised under the term seals.

Survey no.	Date	Effort [km^2]	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
7	17.02.24	472	0	0	13	13	21	3
8	06.04.24	483	0	0	2	2	40	1
9	18.06.24	475	0	0	2	2	12	0
10	07.08.24	484	0	0	0	0	8	0
11	23.10.24	484	0	1	3	4	5	0
12	17.12.24	484	0	0	1	1	2	0
	Total	**5,758**	**10**	**2**	**42**	**54**	**246**	**14**

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

5.1 SEALS

5.1.1 DIGITAL AERIAL SURVEYS

Out of the 54 seals that were observed during the 12 digital aerial surveys, only 22.2% could be identified to species level (Figure 5-2 and Table 5-1). These 12 seals consisted of 83.3% harbour seals (n=10) and 16.7% grey seals (n=2). Considering that 77.8% of the observed seals could not be identified to species level (n=42), all observed seals will in the following be analysed together as seals where relevant.

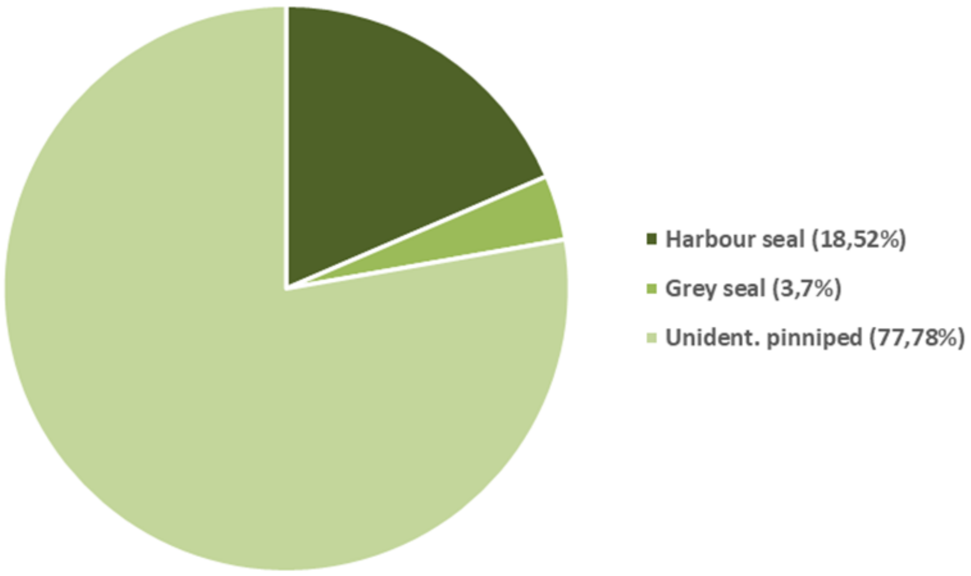

Figure 5-2. Proportion of harbour seal, grey seal and unidentified seal observations in the pre-investigation area during aerial surveys between February 2023 and February 2025 (Y1+Y2).

SEASONAL DISTRIBUTION

Regarding seals identified to species level, only two grey seals were observed during the digital aerial surveys on 08.04.2023 and 23.10.24 combined, while harbour seals were observed during the 2 surveys in June and August 2023 (5 animals on each survey). Including unidentified animals, seals were observed during 10 of the 12 surveys (Table 5-2). Overall, the highest combined seal density was recorded in winter (February 2024) at 0.028 Ind./km², followed by a slightly lower density of 0.025 Ind./km² in summer (June 2023; Table 5-2 and Figure 5-3). Out of all surveys, the lowest density was observed in December 2024 with 0.002 Ind./km² and no seals were observed in December 2023 and August 2024 (Table 5-2 and Figure 5-3).

Table 5-2. Seal densities in the pre-investigation area during aerial surveys between February 2023 and February 2025 (Y1+Y2). Harbour seal, grey seal and unidentified seal are summarized under the term seals.

Survey no.	Date	Effort [km²]	Harbour seal [Ind./km²]	Grey Seal [Ind./km²]	Unidentified seal [Ind./km²]	Seals [Ind./km²]
1	04.03.23	463	0	0	0.004	0.004
2	08.04.23	483	0	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	0	0.010	0.010
6	30.12.23	483	0	0	0	0
7	17.02.24	472	0	0	0.028	0.028
8	06.04.24	483	0	0	0.004	0.004
9	18.06.24	475	0	0	0.004	0.004
10	07.08.24	484	0	0	0	0
11	23.10.24	484	0	0.002	0.006	0.008
12	17.12.24	484	0	0	0.002	0.002
		Total: 5,758	**Avg: 0.0017**	**Avg: 0.0003**	**Avg: 0.0072**	**Avg: 0.0093**

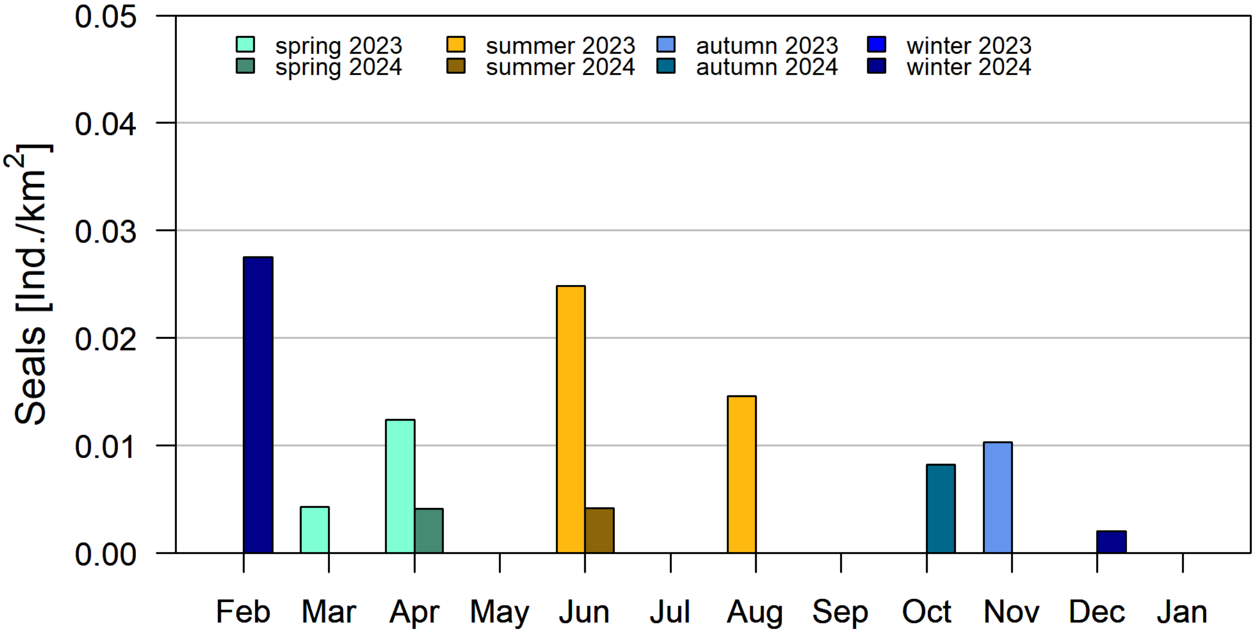

Figure 5-3. Mean seal density (Ind./km²) per month (harbour seal, grey seal and unidentified seals) in the study period (February 2023 – February 2025; Y1+Y2). In months without bars, no surveys were carried out. The seasons are colour-coded.

SPATIAL DISTRIBUTION

Fifteen of the 54 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).

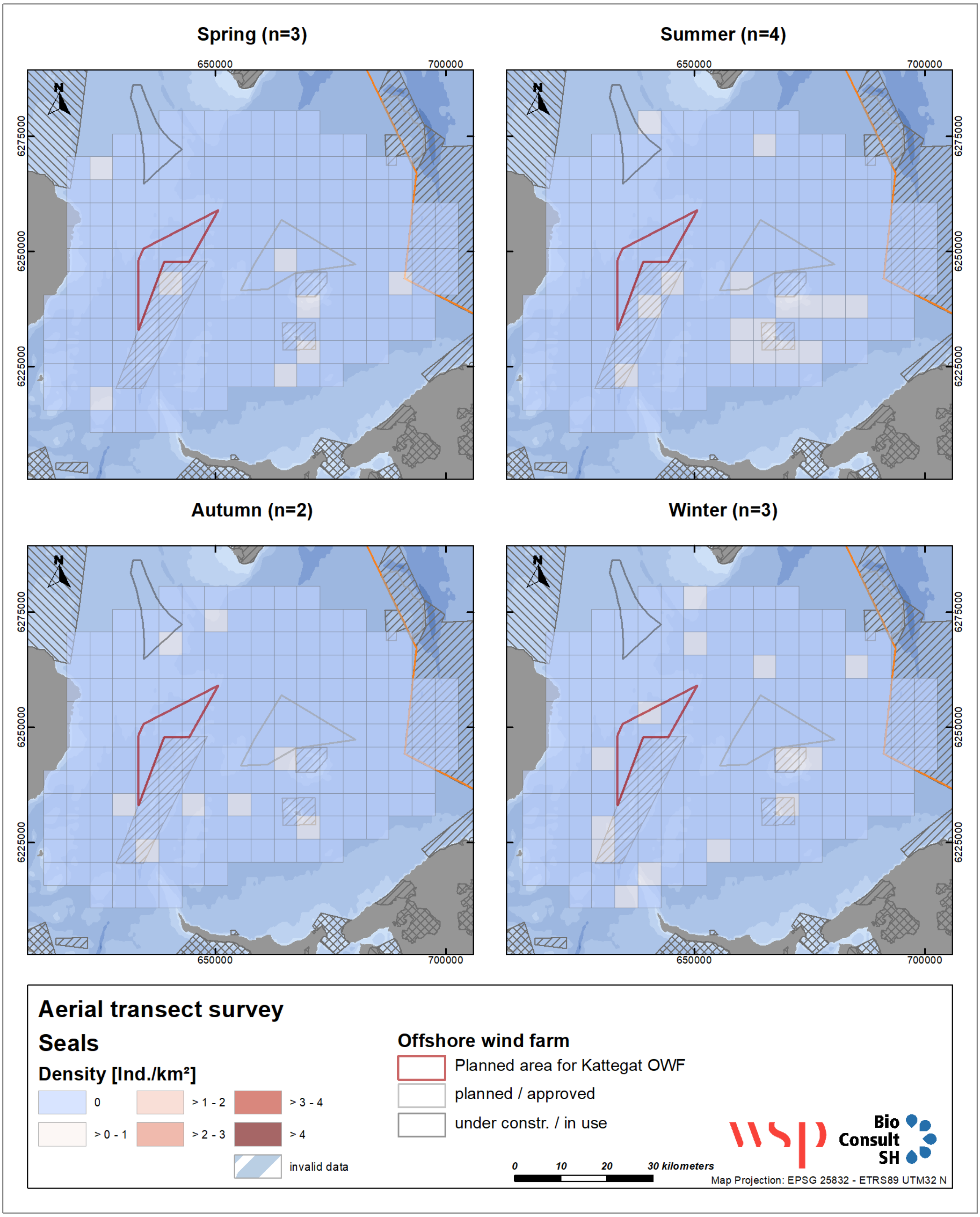

Figure 5-4. Spatial distribution of seals during digital aerial surveys between February 2023 and February 2025 (Y1+Y2). The number (n) of digital aerial surveys included to calculate seasonal densities is given in the title of the respective panel.

5.1.2 SEAL COUNTS AT HAUL-OUT SITES

HARBOUR SEALS

Within the Kattegat and southwestern Baltic area, nine haul-out sites are taken into account in the analysis for harbour seals (Figure 5-6). Four of the nine haul-out sites contribute with about 90% of all harbour seals counted during the different monitoring programs: Hesselø, Anholt, Bosserne and Hallands Väderö. The haul-out site at Hesselø was the most important for harbour seals, 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 Sjællands Rev (0.8%), Bøgestrøm (0.8%) and Rødsand (0.1%) were visited much less frequently by harbour seals (Figure 5-5). Out of these haul-out sites, Måkläppen and Bøgestrøm, which account for approximately 5% of harbour seals in the Kattegat/Western Baltic area, are outside the regular foraging distance from the planned windfarm areas. However, exchange between haul-out sites is possible to some extent and not completely understood. Therefore, a general overview of the wider population area is important.

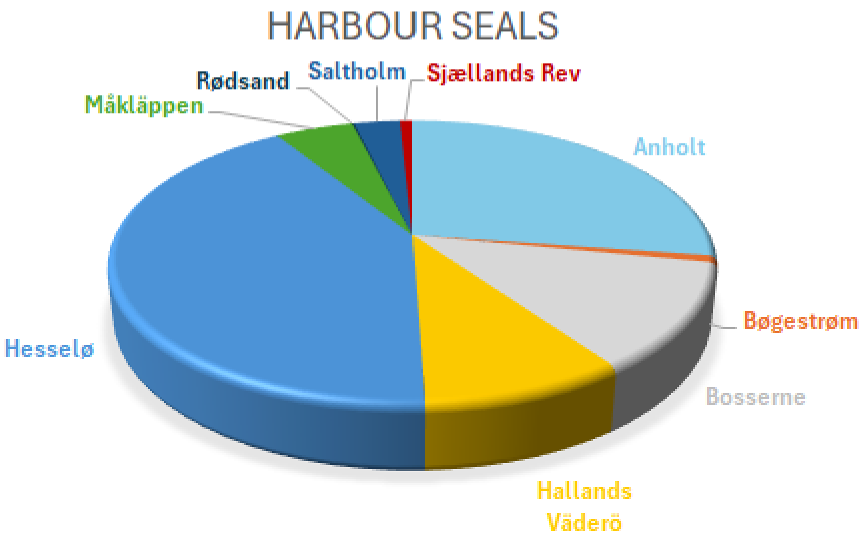

Figure 5-5. Composition (percentage of total counted individuals) of the harbour seal haul-out sites to the abundance in the Kattegat and southwestern Baltic area between 2013 and 2023.

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).

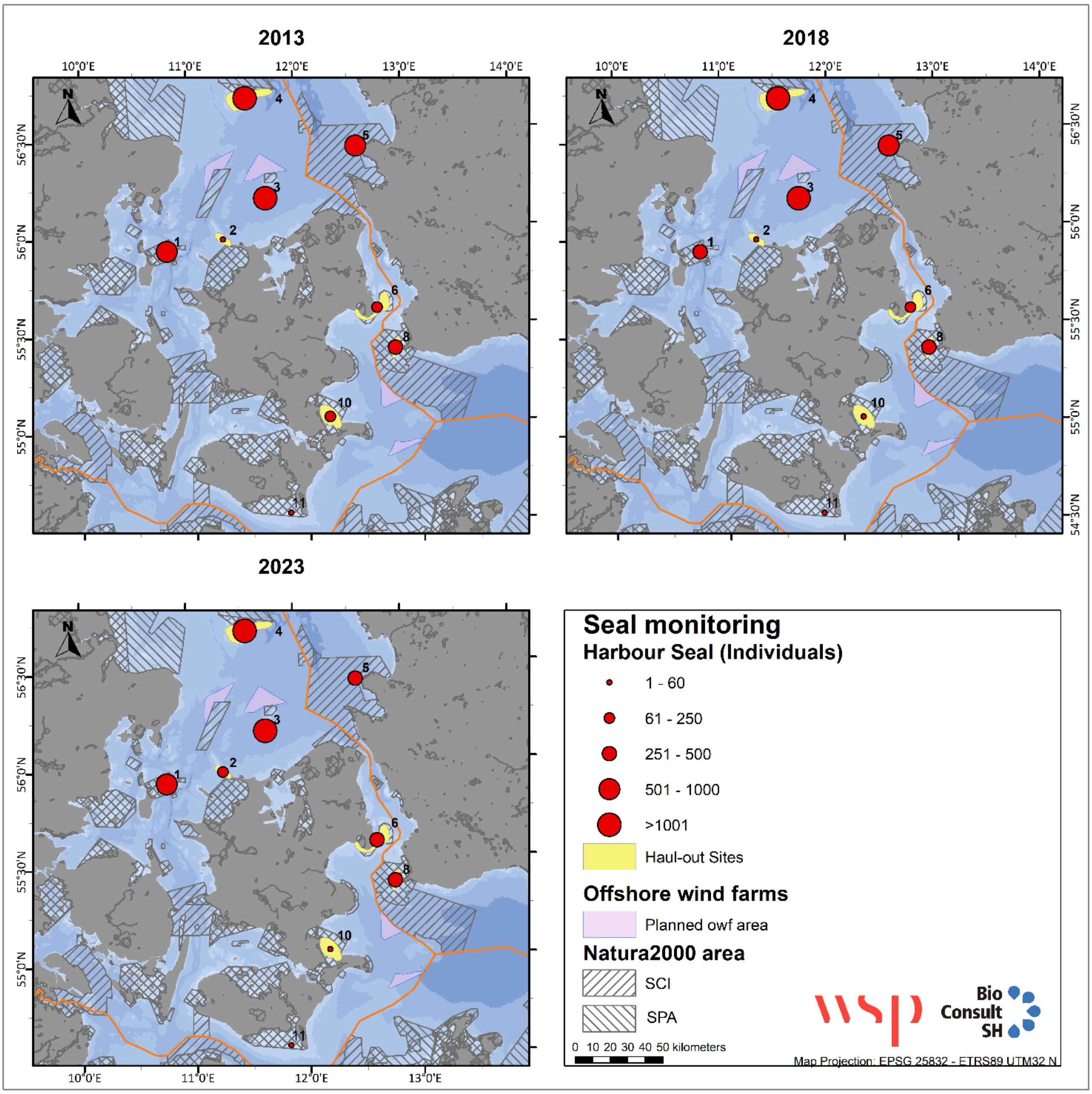

Figure 5-6. Counts of harbour seals at haul-out sites in the Kattegat and southwestern Baltic area in 2013, 2018 and 2023(data provided by DCE – Nationalt Center for Miljø og Energi and Swedish Museum of Natural History).

The abundance of seals at the nine haul-out sites has decreased over the past 10 years, from about 9,600 harbour seals in 2013 to about 5,900 harbour seals in 2023 (Figure 5-7). However, especially in the last six years, there has also been 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 the second highest 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.

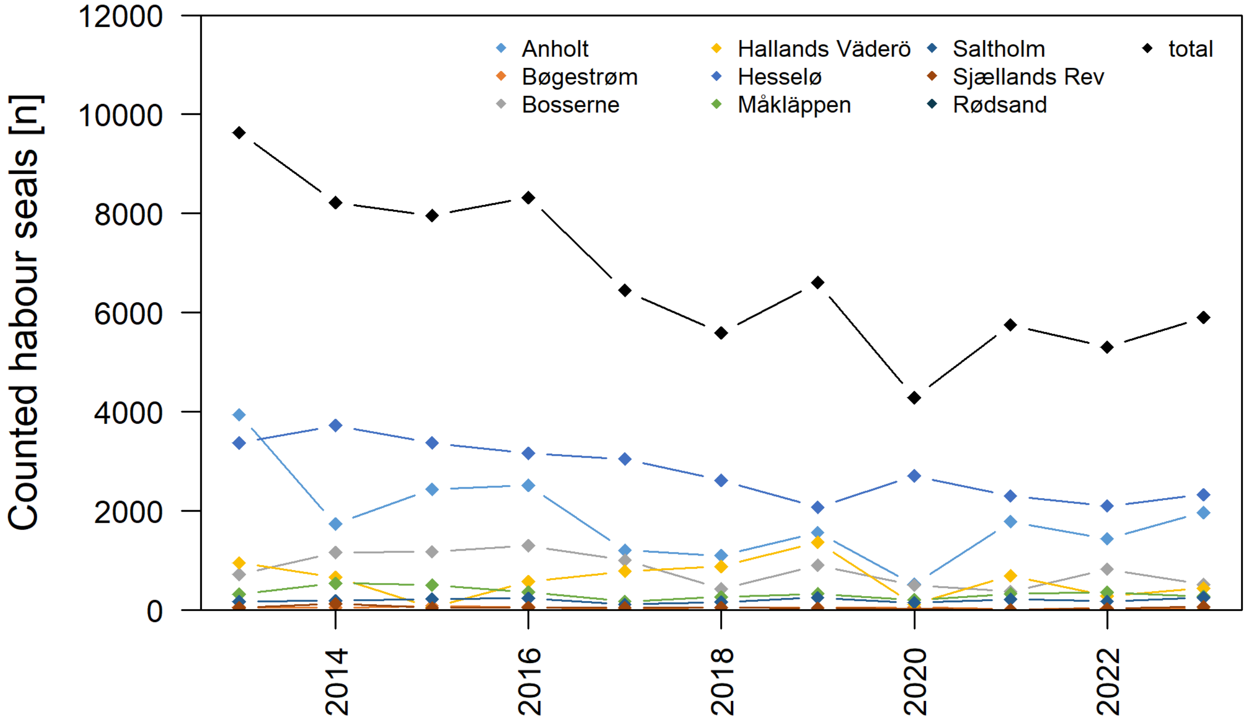

Figure 5-7. Development of the harbour seal abundance at certain haul-out sites in the Kattegat and southwestern Baltic area between 2013 and 2023.

GREY SEALS

Within the Kattegat and southwestern Baltic area, four haul-out sites are included in the analysis for grey seals, of which the majority reside at 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 four 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, from 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 shown the same variability in 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 in comparison to harbour seals (Figure 5-8). Out of these haul-out sites, Måkläppen, which is the most important grey seal haul-out site in the Kattegat/Western Baltic area, is outside the regular foraging distance from the planned windfarm areas.

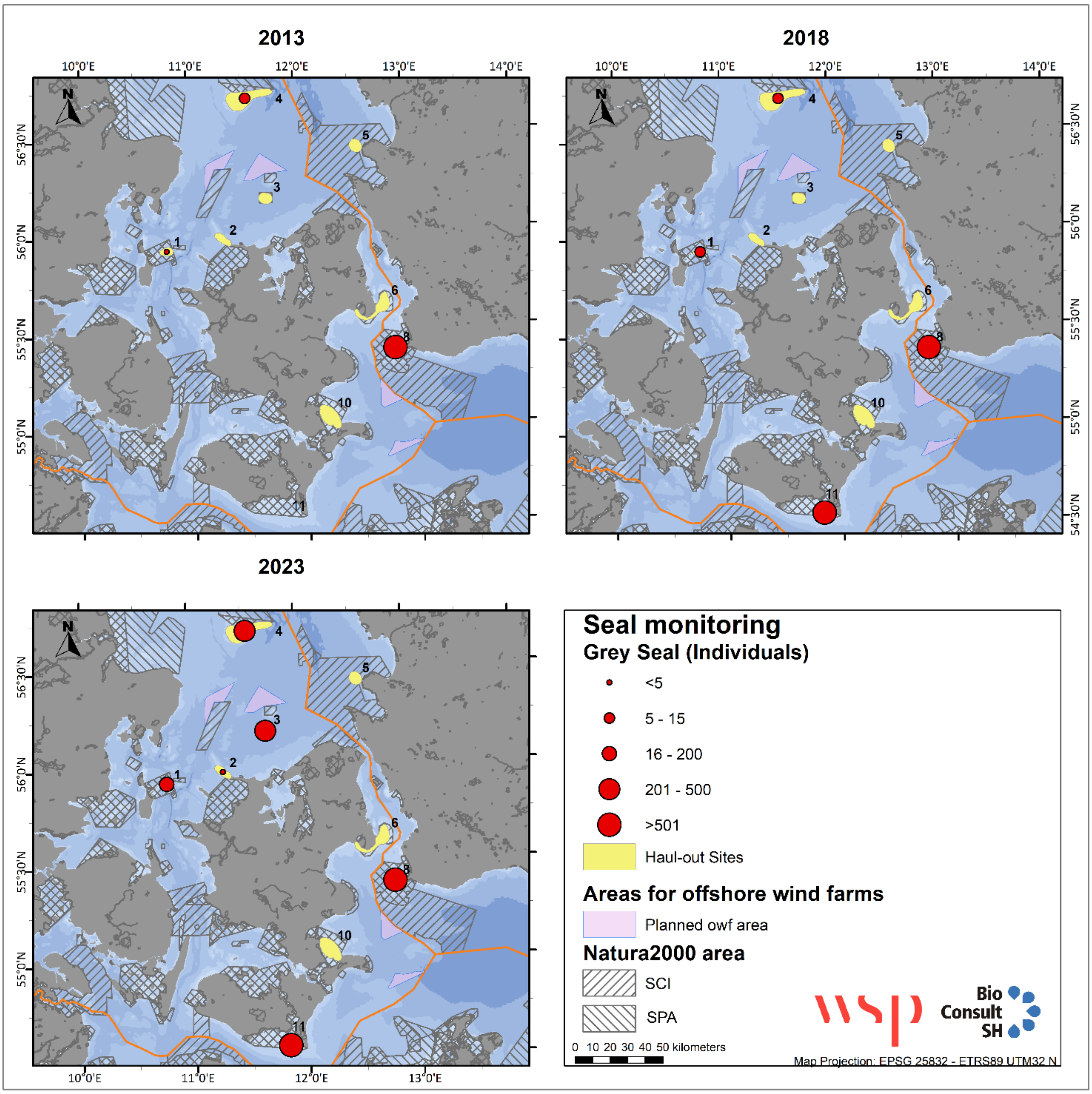

Figure 5-8. Counts of grey seals at haul-out sites in the Kattegat and southwestern Baltic area in 2013, 2018 and 2023 (data provided by DCE – Nationalt Center for Miljø og Energi and Swedish Museum of Natural History).

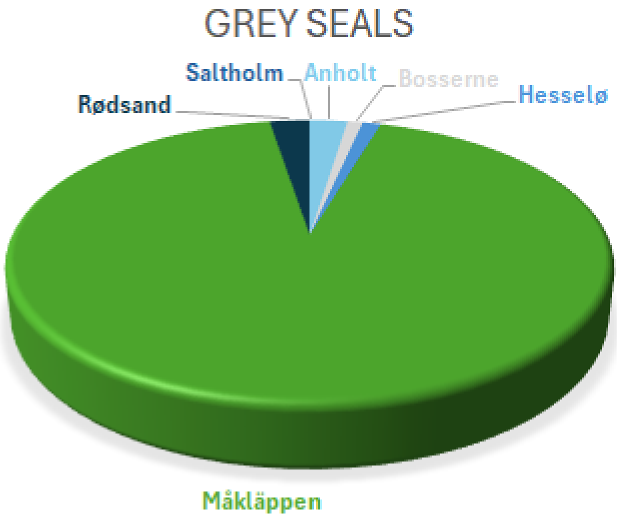

Figure 5-9. Composition (percentage of total counted individuals) of the grey seal haul-out sites to the abundance in the Kattegat and southwestern Baltic area between 2013 and 2023.

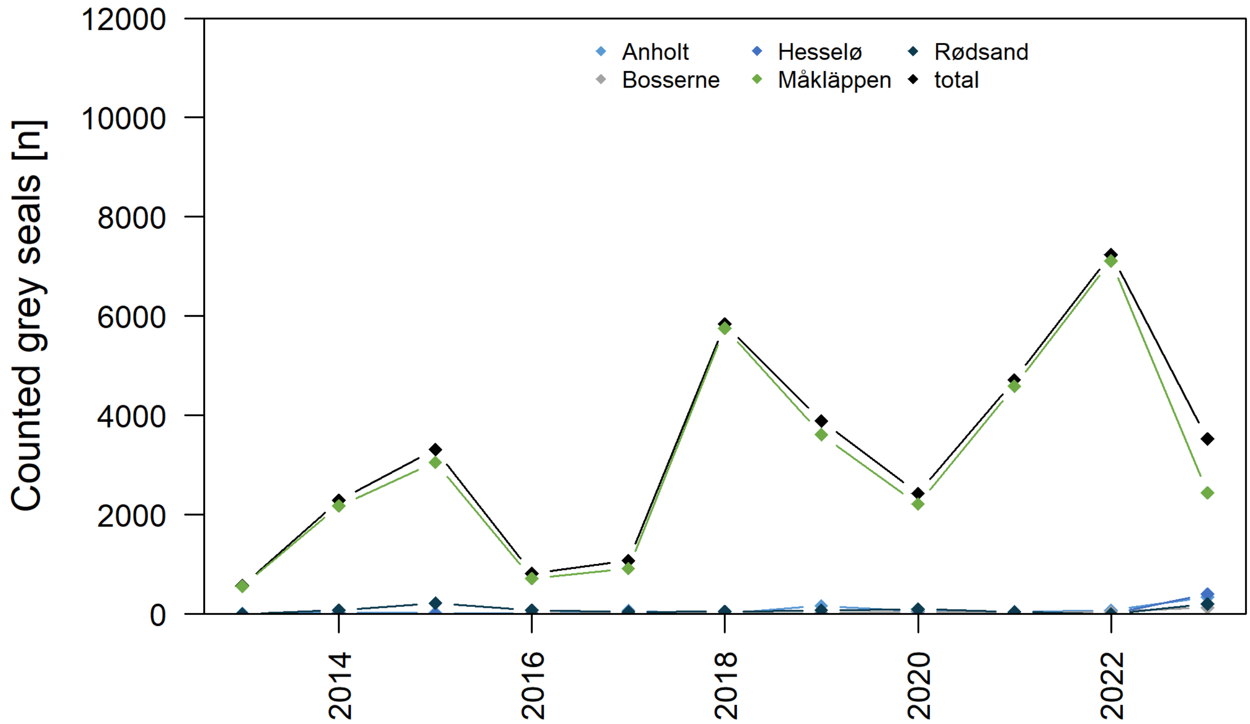

Figure 5-10. Development of the grey seal abundance at certain haul-out sites in the Kattegat and southwestern Baltic area between 2013 and 2023.

5.2 HARBOUR PORPOISES

The harbour porpoise was, with 246 individual sightings the most abundant marine mammal species during the 12 digital aerial surveys between February 2023 and February 2025 (Y1+Y2). Detection rates were relatively high, ranging from 97.4%DPD/t to 99.4%DPD/t among stations, with a mean value of 98.8%DPD/t across all stations.

5.2.1 DIGITAL AERIAL SURVEYS

SEASONAL DISTRIBUTION

Harbour porpoises were observed during all 12 surveys in 2023 and 2024. The highest seal densities were observed during summer, with 0.269 Ind./km² in June 2023 (Figure 5-11) and 0.153 Ind./km² in August 2023 (Table 5-3 and Figure 5-12). During February and April 2024, densities were still above 0.1 Ind./km² (namely 0.105 and 0.135 Ind./km², respectively), while they were below that value in all other surveys (Table 5-3 and Figure 5-12). The lowest densities were observed during the winter surveys (December 2023 and 2024) with 0.008 Ind./km² in both months (Table 5-3 and Figure 5-12). During the four surveys conducted in the calving season, six juveniles were observed, representing 4.6% of all individuals recorded during that period (Table 5-3). The calving season of harbour porpoises typically spans from Mid-May to September.

Table 5-3. Harbour porpoise densities in the survey area during aerial surveys between February 2023 and February 2025 (Y1+Y2).

Survey no.	Date	Effort [km²]	Harbour porpoise [Ind.]	Juveniles [Ind.]	Harbour porpoise [Ind./km²]
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
7	17.02.24	472	21	0	0.105
8	06.04.24	483	40	1	0.135
9	18.06.24	475	12	2	0.046
10	07.08.24	484	8	0	0.032
11	23.10.24	484	5	0	0.023
12	17.12.24	484	2	0	0.008
		Total: 5,758	Total: 246	Total: 6	Avg: 0.0093

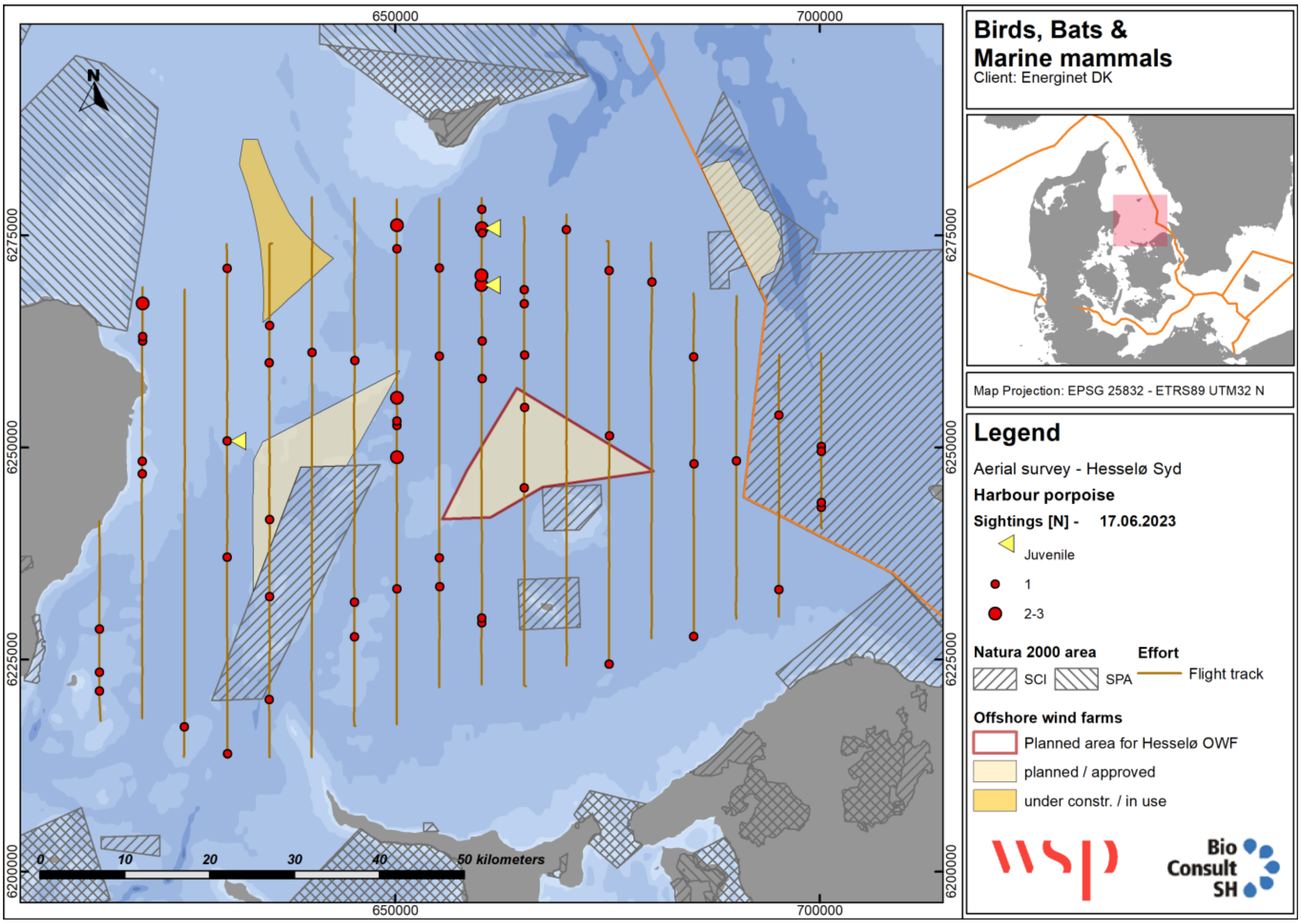

Figure 5-11. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 17.06.2023.

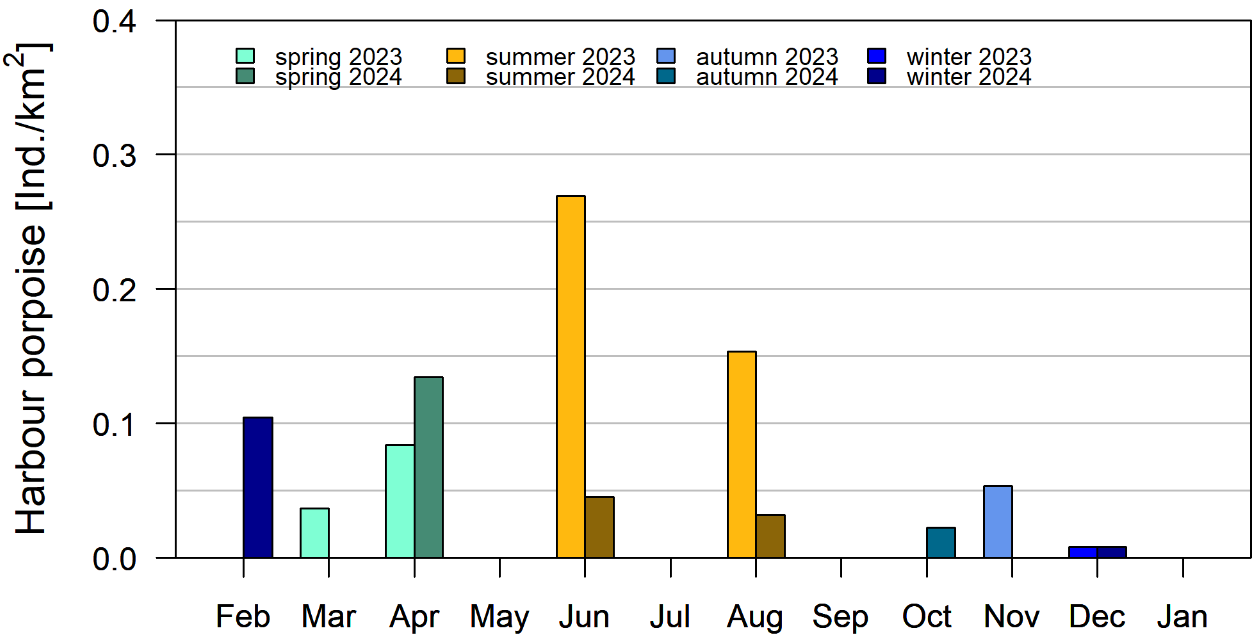

Figure 5-12. Mean harbour porpoise density (Ind./km²) per month in the study period (February 2023 – February 2025; Y1+Y2). In months without bars, no surveys were carried out. The seasons are colour-coded.

SPATIAL DISTRIBUTION

Harbour porpoises were distributed throughout the pre-investigation area with no clear preference, although slightly higher densities were observed in the northeastern part of the pre-investigations area (Figure 5-11and Appendix Figure 9-6 to Figure 9-10). This was particularly true for observations during summer, when most harbour porpoises were observed in the pre-investigation area. Overall, 32 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 (22) were observed in the latter, which, like the others, has the harbour porpoise listed as an important species.

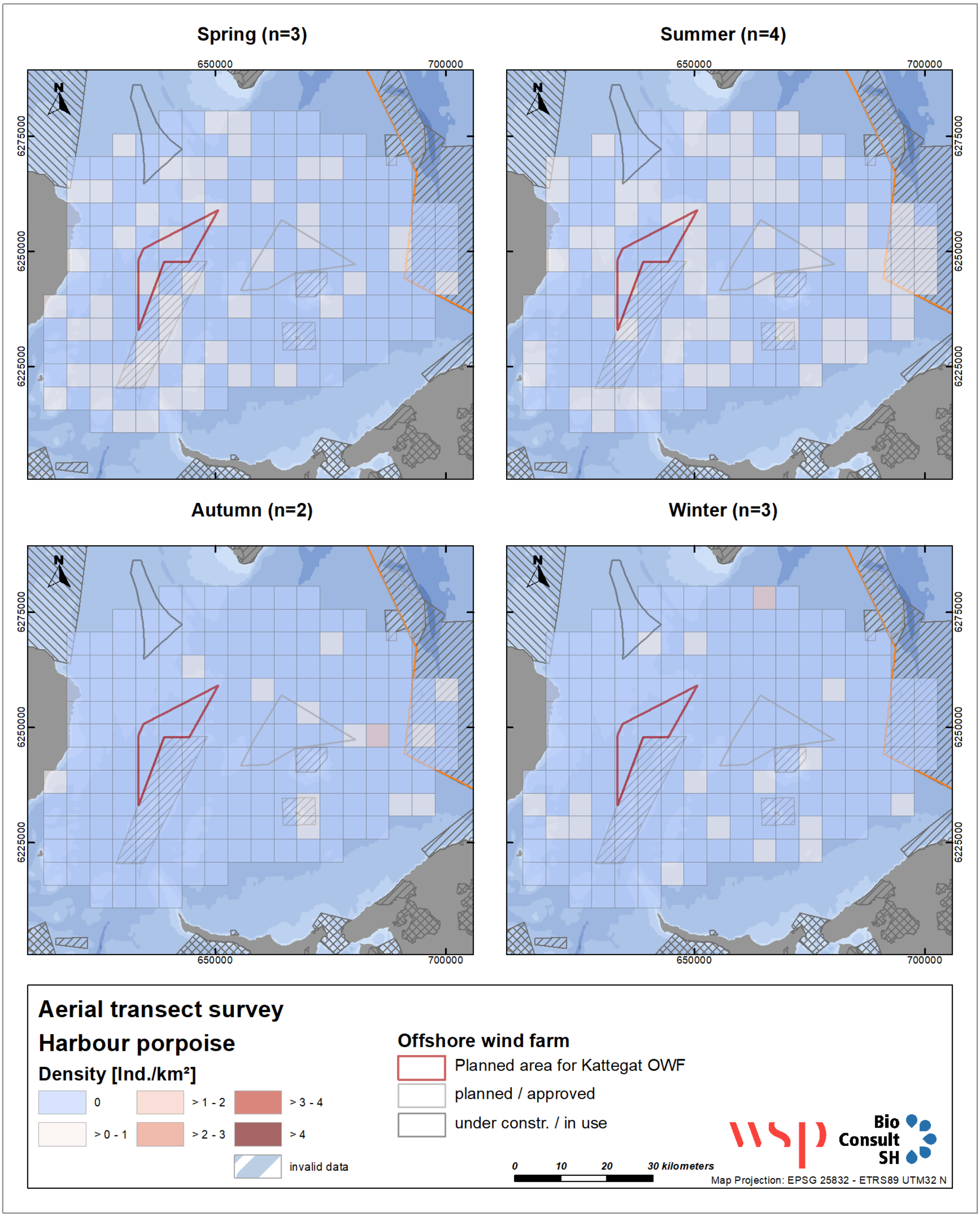

Figure 5-13. Spatial distribution of harbour porpoises during digital aerial surveys between February 2023 and February 2025 (Y1+Y2). The number (n) of digital aerial surveys included to calculate seasonal densities is given in the title of the respective panel.

5.2.2 PASSIVE ACOUSTIC MONITORING

PHENOLOGY/ SEASONALITY

During the survey period (February 2023 – February 2025; Y1+Y2), harbour porpoises were detected almost daily at all 8 C-POD stations. Detection rates throughout the entire survey period (expressed as %DPD/t) were close to 100%, ranging from 97.4% at station K-R3 to 99.4% at station K-R4, with a mean value of 98.8% across all stations (Figure 5-14 and Table 5-4). This suggests that harbour porpoises are generally present 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 mean %DP10M/d was at station K-R2 (15.4%), followed by station K-O2 (15.2%), with lowest mean %DP10M/d at station K-R3 (5.6%) (Table 5-4). Mean %DP10M/d was very similar at four stations K-R4 (12.4%), K-O3 (11.7%), K- R1 (11.7%) and K-O1 (11.2%). There is no clear pattern in the spatial distribution of porpoise presence within the pre-investigation area (Figure 5-15). Of the two stations with relatively lower %DP10M/d (<10%), station K-R3 was located in the north-eastern side of the pre-investigation area while station K-O4 was located further south. Meanwhile, the remaining stations with relatively higher %DP10M/d (>10%) were spread out across the pre-investigation area. One of the two stations with the highest %DP10M/d (>15%), station K-R2 was located within the SCI site (Natura 2000 area) *Schultz og Hastens Grund samt Briseis Flak* (DK00VA303), while the other, station K-O2, was located outside the SCI site, within the OWF area.

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 February 2025; Y1+Y2). d refers to a day.

C-POD	Days with positive detections	Days deployed	DPD/t [%]	DP10M/d [%]
K-O1	684	692	98.8	11.2
K-O2	628	638	98.4	15.2
K-O3	701	709	98.9	11.7
K-O4	677	686	98.7	9.4
K-R1	714	719	99.3	11.7
K-R2	666	671	99.3	15.4
K-R3	698	717	97.4	5.6
K-R4	714	718	99.4	12.4

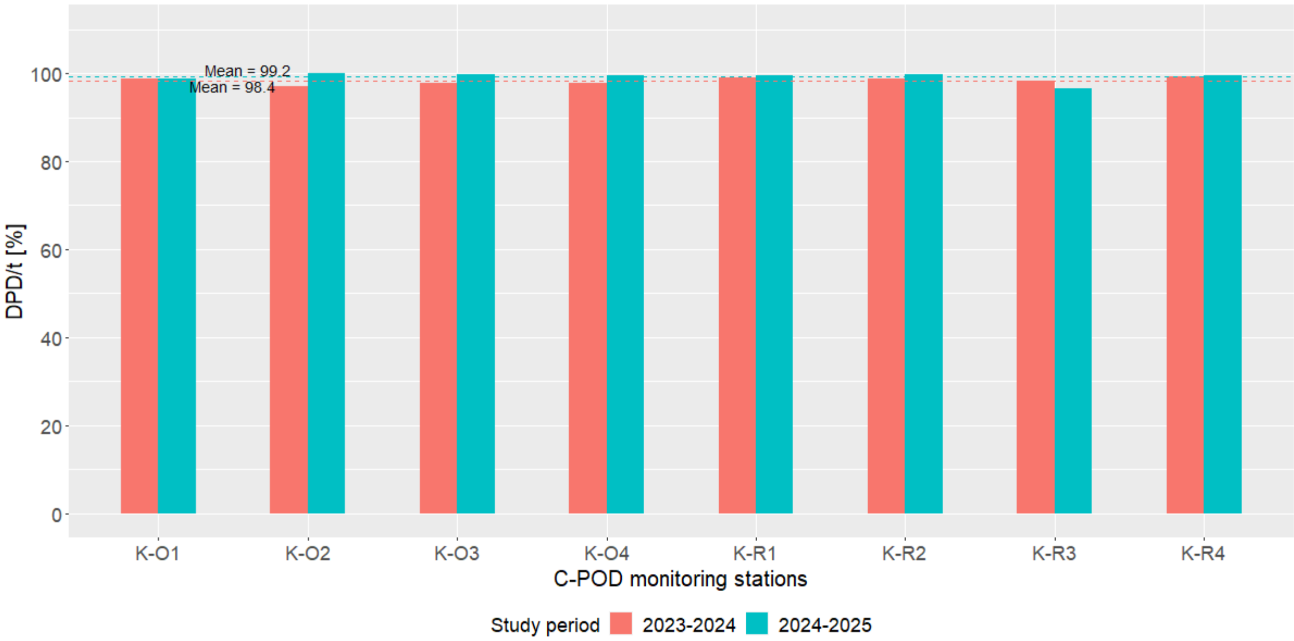

Figure 5-14. The proportion of days with positive harbour porpoise detections over the entire survey period (red: February 2023 – January 2024 (Y1); blue: February 2024 – February 2025 (Y2), expressed as Detection Positive Days (DPD/t), at the 8 C-POD stations deployed within the investigation area. The red and blue dashed lines show the mean values across all stations for Y1 and Y2, respectively.

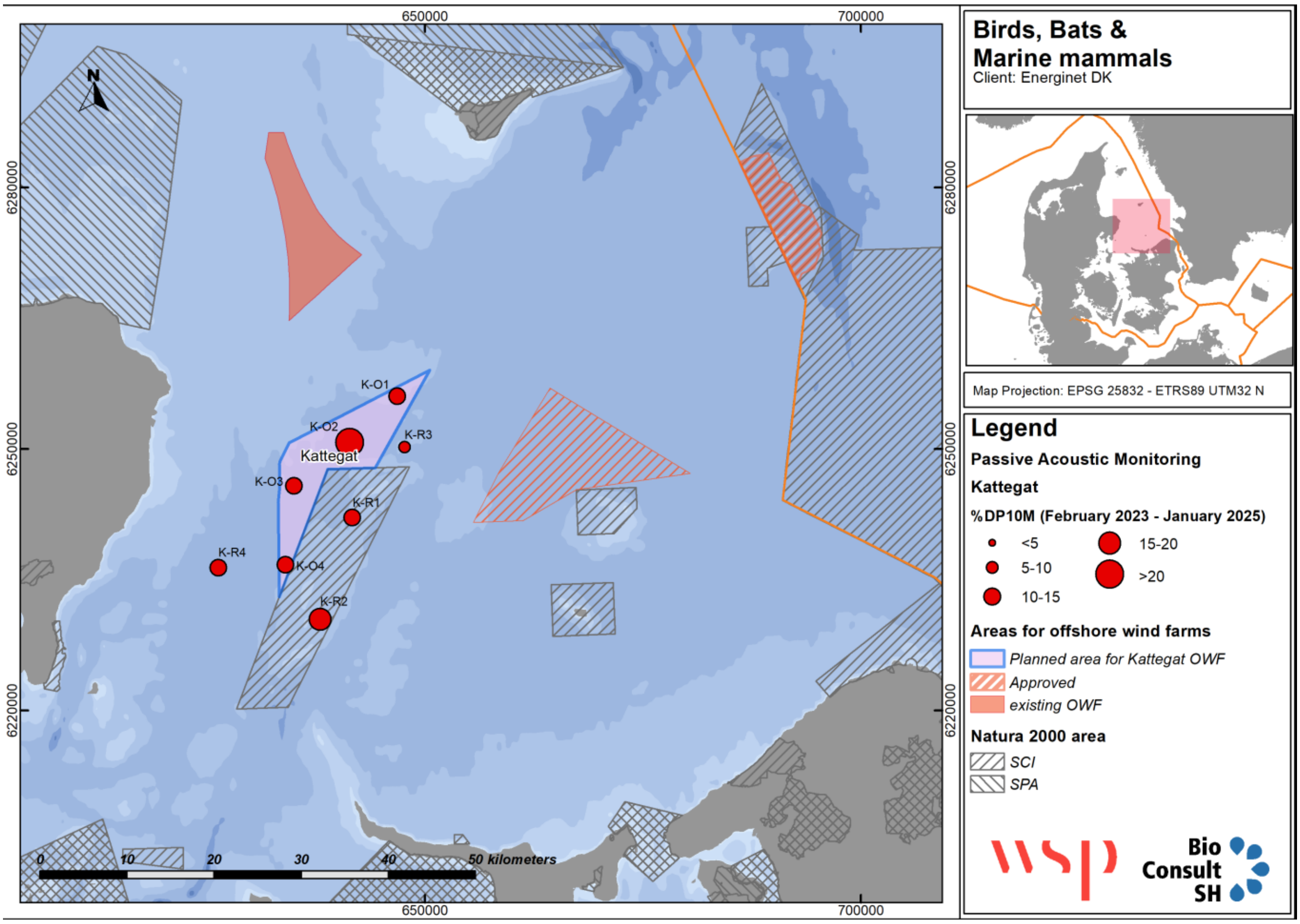

Figure 5-15. Harbour porpoise detection rates, expressed as mean Detection Positive 10-Minutes per day (%DP10M/d), at the 8 C-POD stations deployed within the investigation area for the entire survey period (February 2023 – February 2025; Y1+Y2).

Monthly mean %DP10M/d (averaged over all 8 stations) showed the temporal variation (seasonal trend) in harbour porpoise presence within the entire pre-investigation area across the survey period (Figure 5-16). There was little seasonal variation during Y1 (February 2023 – January 2024), with similar detection rates in the area were comparable from month to month, being only slightly higher in summer (June and July 2023). In Y2 (February 2024 – February 2025), however, there was a strong peak during late spring (May 2024) and early summer (June 2024). When comparing Y1 and Y2, detection rates were much higher in January-February 2025 and March-June 2024 compared to the same time period in the previous year (January-February 2024 and March-June 2023). Detection rates during the other months were either in the same order of magnitude or slightly lower in Y2.

A closer examination of individual C-POD stations revealed stark differences between stations, with no general seasonal pattern among stations. There is no clear seasonal pattern at station K-O1: detection rates were low (ca. 10 %DP10M/d) throughout most of 2023 before increasing in December 2023 and remaining at around 20 %DP10M/d until a decrease again from July 2024 to ca. 10 %DP10M/d for the rest of the Y2 survey period (Figure 5-18). Strong peaks in detection rates were observed at station K-O2 during summer and winter, with peaks in 2024 being of a higher magnitude (Figure 5-18). At station K-O3, a strong peak in detection rates was observed in late spring/summer during both Y1 and Y2 (Figure 5-19). The seasonal variation at station K-O4 differed between Y1 and Y2: a bimodal pattern was present in 2024 (Y2), but little seasonal variation was observed in 2023 (Y1; Figure 5-20). At station K-R1, a strong peak was observed in late spring/early summer for both Y1 and Y2 (2023 and 2024), but a second smaller peak observed in autumn
2023

was absent in autumn 2024 (Figure 5-21). A bimodal pattern can be observed at station K-R2, with peaks in late spring/early summer and in autumn (Figure 5-22). There was little seasonal variation at station K-R3, where detection rates were low throughout the year (Figure 5-23). Detection rates at station K-R4 were strongest during the winter months (December – February) and lowest in late summer and autumn periods (Figure 5-24).

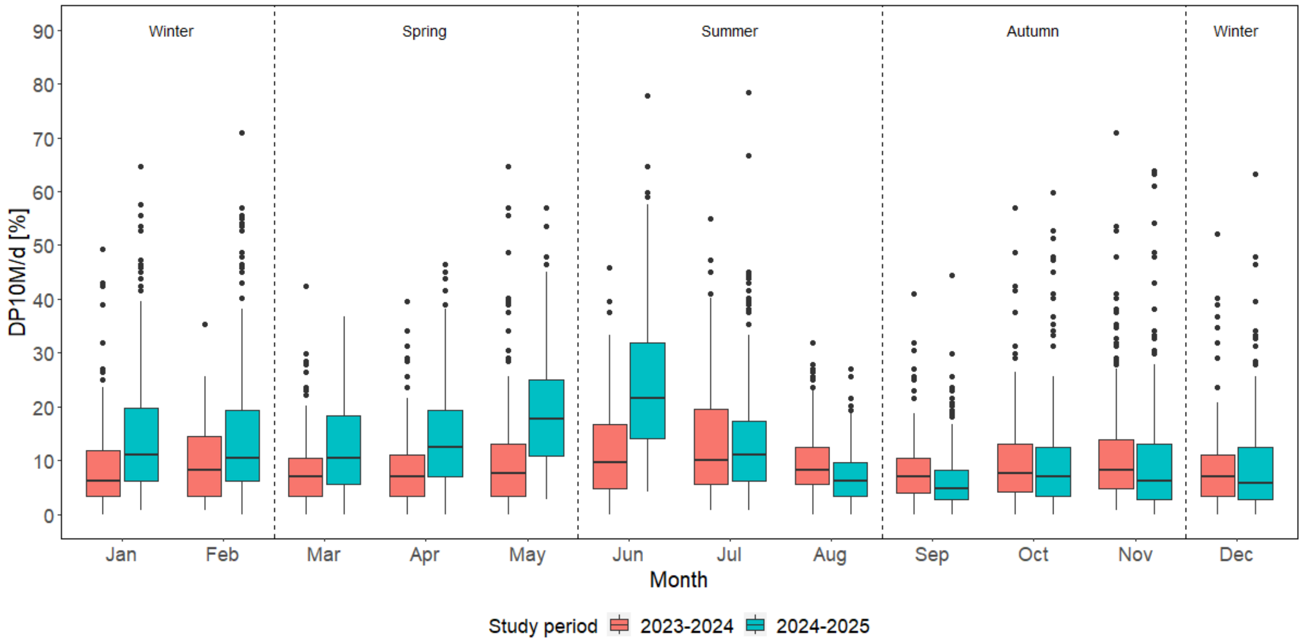

Figure 5-16. Mean monthly Detection Positive 10-Minutes per day (% DP10M/d) averaged over all 8 C-POD stations. Red: February 2023 – January 2024 (Y1); blue: February 2024 – February 2025 (Y2). Seasons were defined as spring (March – May), summer (June – August), autumn (September – November) and winter (December – February).

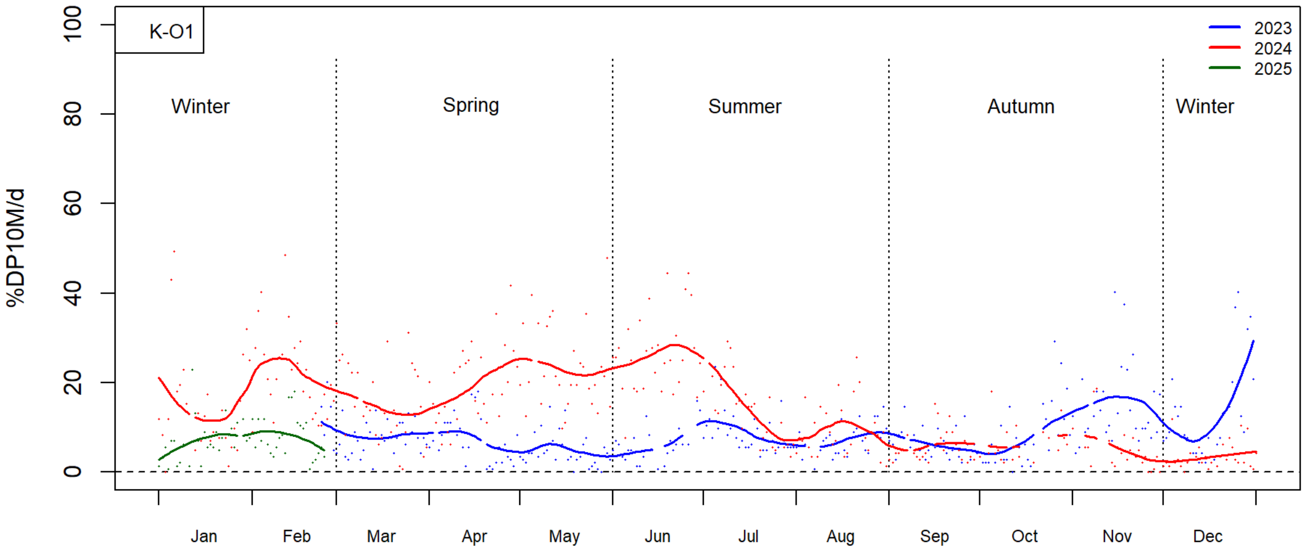

Figure 5-17. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-O1 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

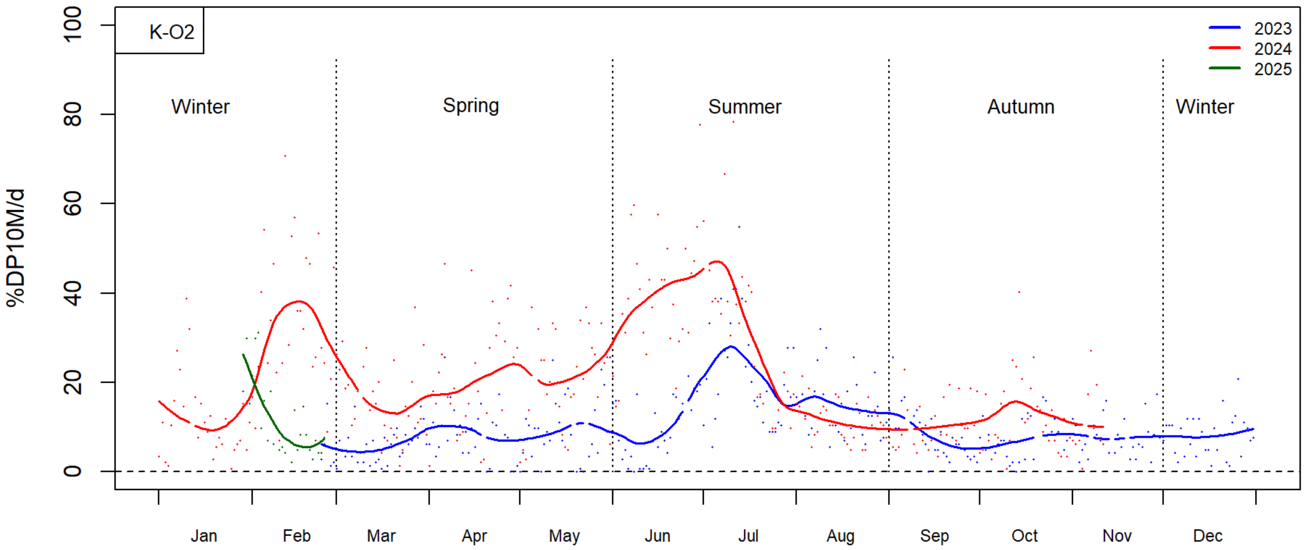

Figure 5-18. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-O2 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

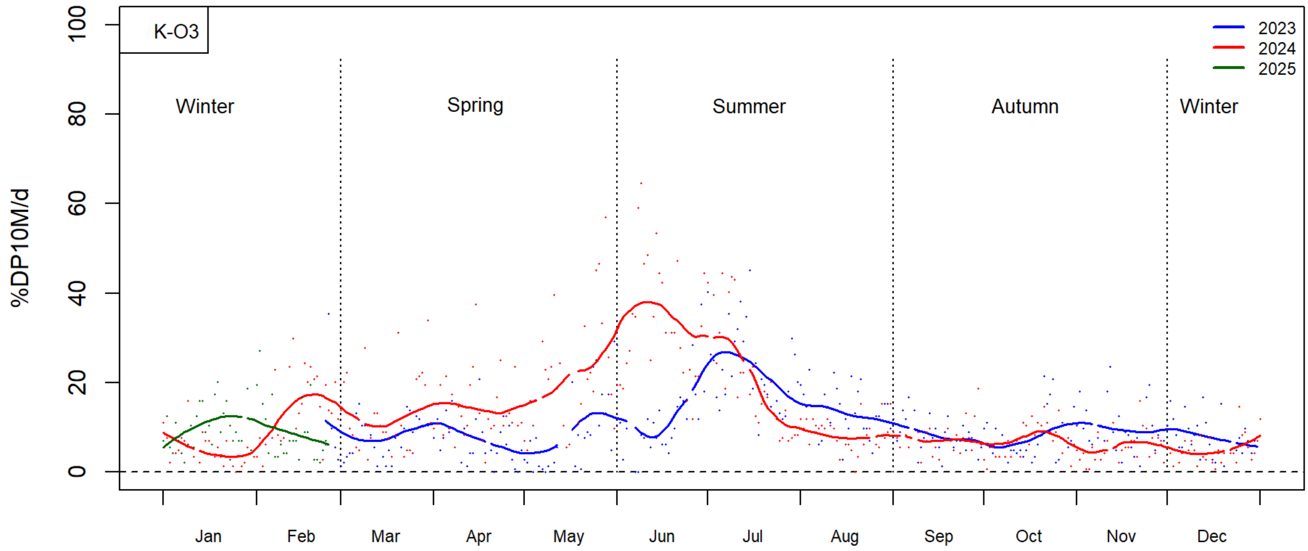

Figure 5-19. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-O3 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

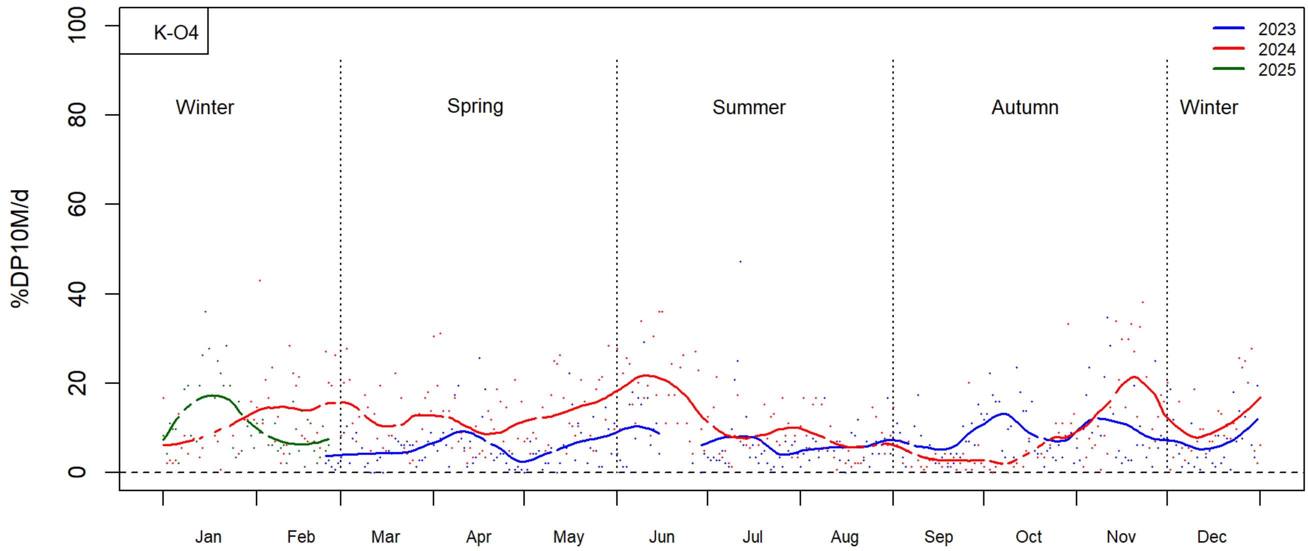

Figure 5-20. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-O4 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

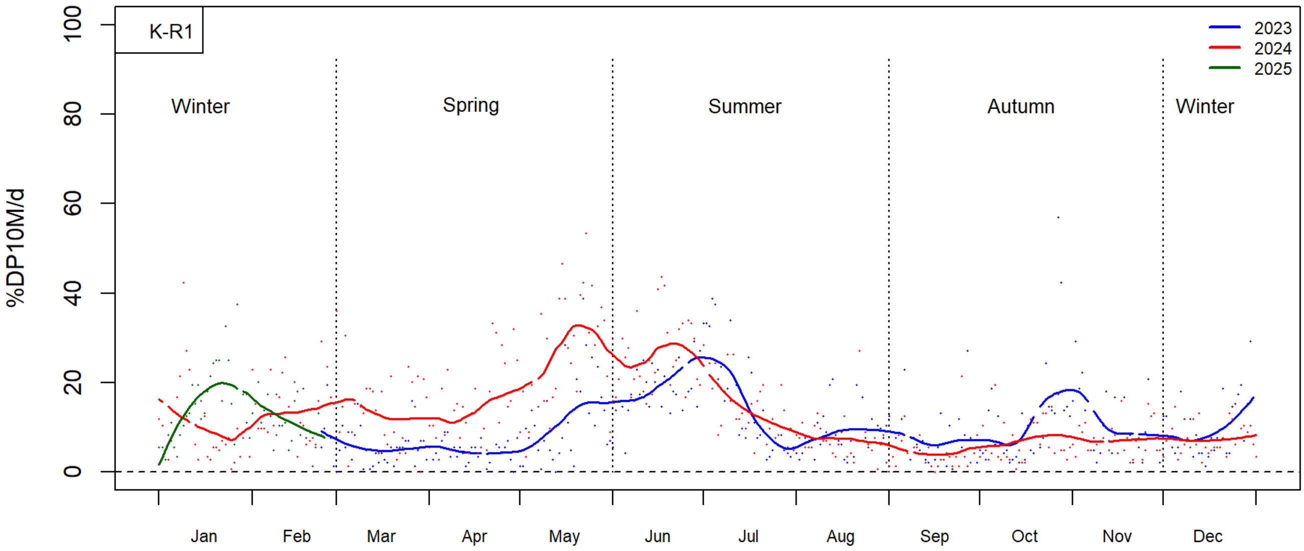

Figure 5-21. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-R1 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

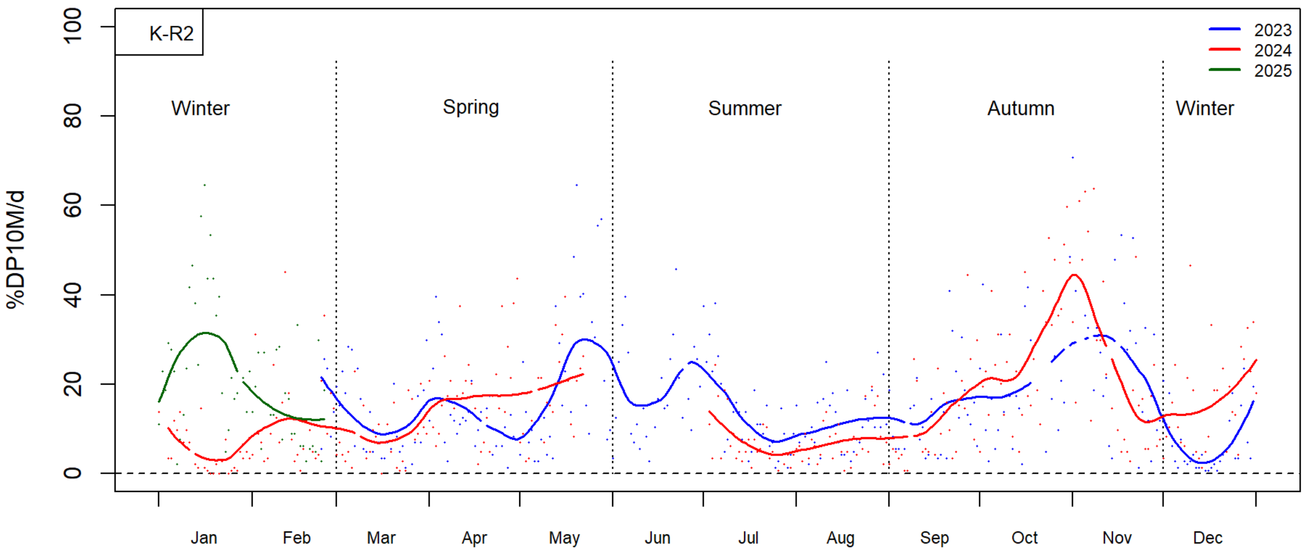

Figure 5-22. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-R2 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

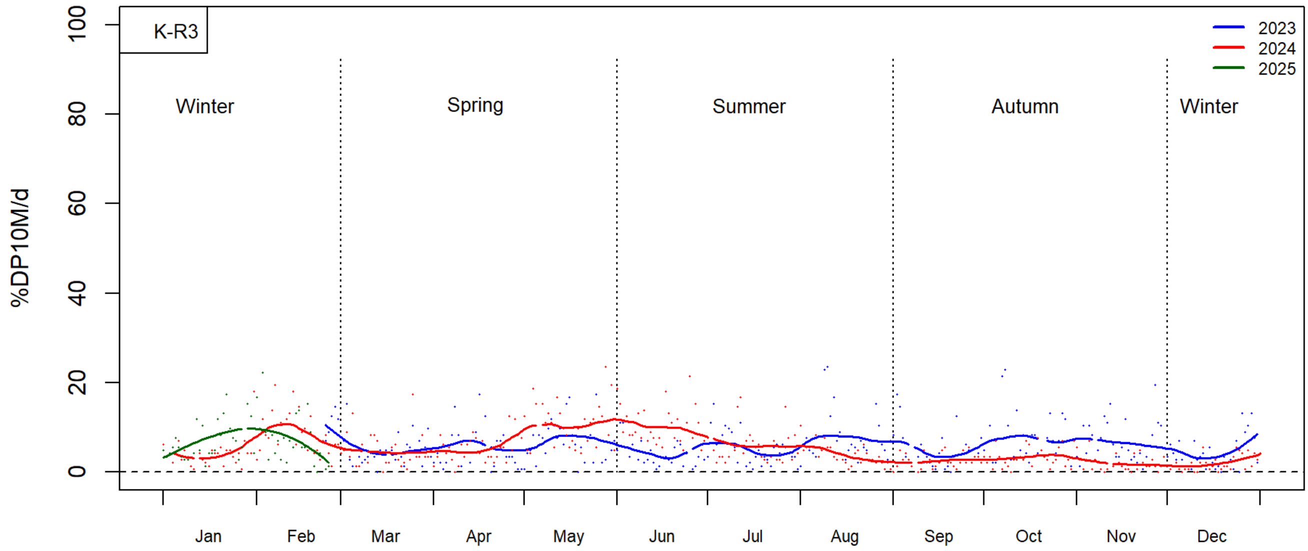

Figure 5-23. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-R3 across the entire survey period (February 2023 – February 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

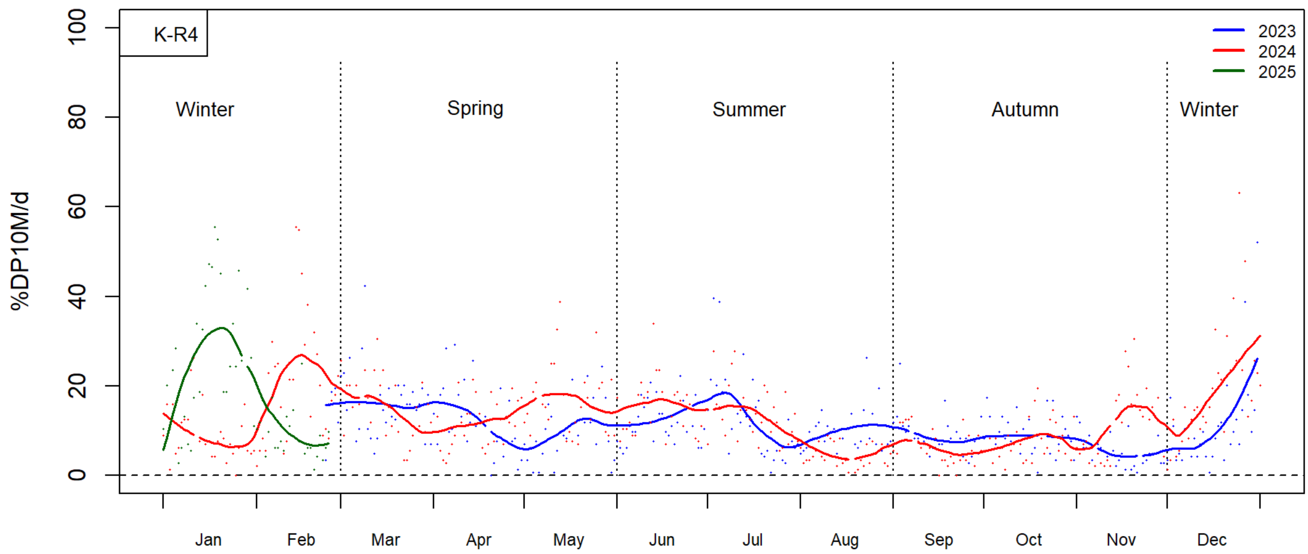

Figure 5-24. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station K-R4 across the entire survey period (February 2023 – February 2025). Gaps in the loess regression curves represent periods with no data.

Diel pattern analysis revealed differences in daylight and nighttime activity of harbour porpoises at each C-POD station (Figure 5-25). Harbour porpoises were detected more frequently during daylight hours at three stations (K-O2, K-R2 and K-R4), while nighttime detection rates were higher in the remaining five stations. In general, the difference between daylight and nighttime activity was relatively small at the majority of stations.

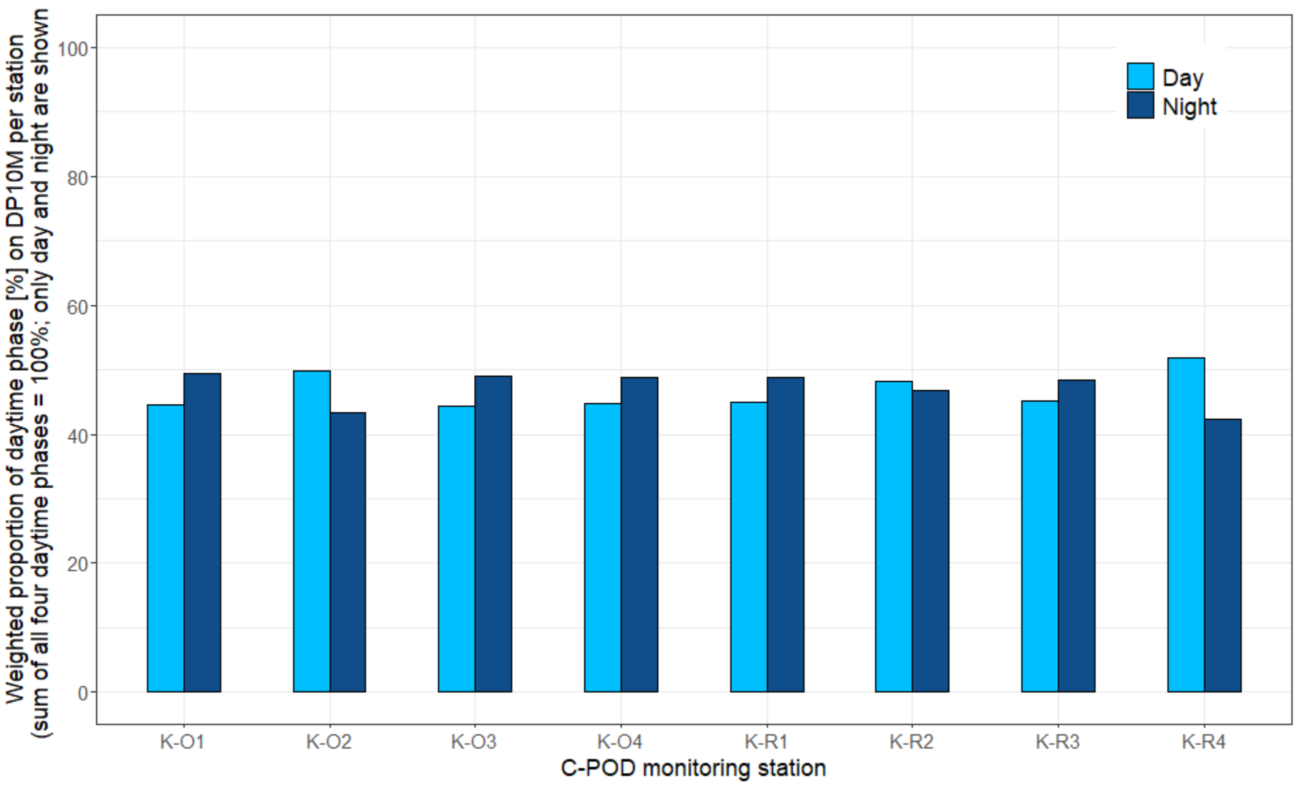

Figure 5-25. Diel pattern of harbour porpoise detection rates at the 8 C-POD stations deployed within the investigation area. Detection rates for each station were averaged across the entire survey period (February 2023 – February 2025; Y1+Y2). Each 24-hour period is divided into four phases (day, night, dusk, dawn) during analysis. Only day and night phases are shown (dusk and dawn phases are not considered). A weighting factor based on day length proportion is applied due to different lengths of phases at different dates throughout the year. The sum of all phases equals 100% but is not reached here since dusk and dawn phases are not shown.

6 DISCUSSION

The surveys, data analysis and report provide a comprehensive and detailed baseline study for marine mammals present in the pre-investigation area for the planned Kattegat OWF.

Three marine mammal species regularly occur within the pre-investigation area. 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.

6.1 HARBOUR SEALS

Harbour seal haul-out sites in Kattegat closest to the planned Kattegat OWF 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. Among these Hesselø accounts for 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 pattern is also reflected in the results of digital aerial surveys, where most seals were observed inside and 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. Although harbour seal counts have declined over the past decade, this trend should be interpreted with caution, as the population may be nearing or has reached ecological carrying capacity- estimated at approximately 2,000 individuals in the southwestern Baltic and around 12,500 in the Kattegat (HANSEN & HØGSLUND 2021; HELCOM 2023a).

The population of harbour seals in Kattegat is shared with Sweden. In 2023, an average of 4,500 harbour seals were counted in the Danish part, which is on par with the last ten years. From the epidemic in 2002 to 2011, the average annual growth rate in the Danish part was 11%. Since then, growth has slowed, and in the last ten years the number has remained stable. However, there is great variability in the counts, suggesting that the population has reached the ecological carrying capacity of the environment, with the survival of the pups fluctuating from year to year, depending on the amount of food, disturbances and diseases. A stabilisation of the population around the current level can thus be expected if conditions for the seals do not change. The number of harbour seals at resting sites modelled based on the development since 2003 was 4,270 in 2023 (95% CI: 3,728-4,890). Harbour seals breed throughout the Danish part of the Kattegat, and in 2023, 1,900 pups were counted. This corresponds to 44% of the estimate of moulting seals on land, which is an average proportion since pup counts began in 2011, when the pup proportion has fluctuated between 30 and 70%.

6.2 GREY SEALS

Grey seal haul-out sites in Kattegat 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. In contrast to the harbour seal counts, grey seal counts have increased over the past 10 years. In 2021, the first count of grey seals of the North Sea population during the moulting period was conducted in the Kattegat, where 182 grey seals were recorded at resting sites (HANSEN & HØGSLUND 2021) and in 2023, 123 grey seals were counted (HANSEN ET AL. 2024). The estimated population size is 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 (5.1.2).

6.3 HARBOUR PORPOISES

Harbour porpoises in the pre-investigation area of Kattegat are attributed to the Belt Sea population, but animals from the North Sea population may be visiting the area as it is located in the southern part of the transition zone according to SVEEGAARD ET AL. (2018). In the present study, harbour porpoises were most abundant in summer in the survey area. Most juveniles were observed during surveys in June (5 animals in total for 2023 and 2024 combined) and the total proportion of juveniles sighted is 4.6%, indicating that the pre-investigation area may be used for breeding, although surveys in other areas have yielded higher numbers. 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 9.1% for the Skagerrak in 2020 (HANSEN & HØGSLUND 2021), while it was 0% for the Skagerrak, 5.56% for the Kattegat and 7.69% for the Belt Sea in 2023 (HANSEN ET AL. 2024). Within the pre-investigation area, harbour porpoises showed no clear site preference, but slightly higher densities in the northeast of the pre-investigation area. About 13% of 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 the harbour porpoise is listed as an important species. Recent studies showed a decrease of the Belt Sea population (GILLES ET AL. 2023; OWEN ET AL. 2024), which is currently estimated to be about 14,000 to 17,000 individuals (HANSEN & HØGSLUND 2021; GILLES ET AL. 2023). However, these negative trends are not significant and may be biased by different survey methods used and a small sample size (GILLES ET AL. 2023). Determining whether this apparent decline represents a statistically significant trend will require further long-term studies and comprehensive population monitoring.

7 CONCLUSION

A review of existing literature (see Chapter 3), along with an analysis of count data from seal haul-out sites near the planned windfarm area, provides a solid overview of the abundance and distribution of the three marine mammal species present in the region. These findings complement the digital aerial survey data and passive acoustic monitoring data collected within the pre-investigation area between February 2023 and February 2025 (Y1+Y2). However, the analysis also highlights the importance of temporal and spatial resolution in ecological datasets, which often present limiting factors. As demonstrated by the seasonal trends and spatial distribution analyses in this report, combining focused investigations within the pre-investigation area with existing datasets is essential. Moreover, the two-year study period (February 2023 to February 2025; Y1+ Y2) has helped reduce the influence of interannual variability.

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9 APPENDIX

9.1 SEALS – AERIAL SURVEY SIGHTINGS

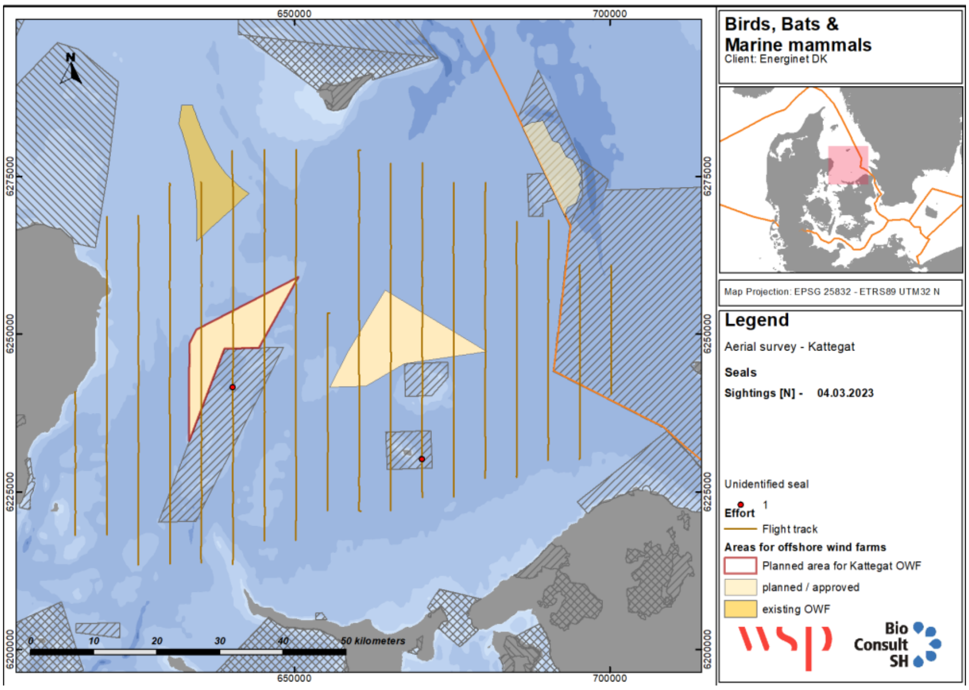

Figure 9-1. Seal observations in the pre-investigation area during the digital aerial survey on 04.03.2023.

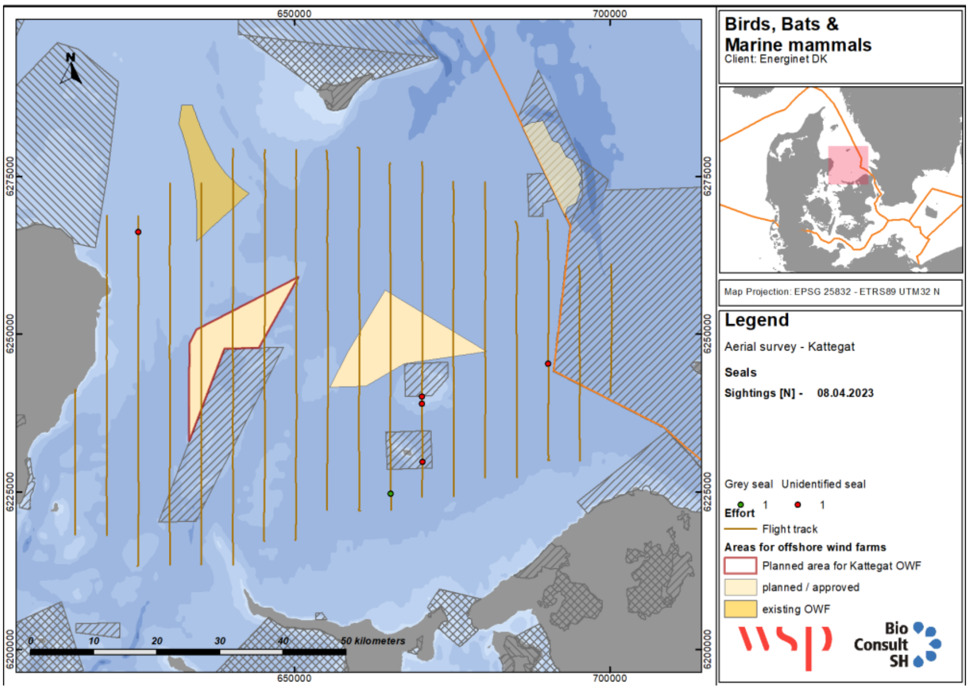

Figure 9-2. Seal observations in the pre-investigation area during the digital aerial survey on 08.04.2023.

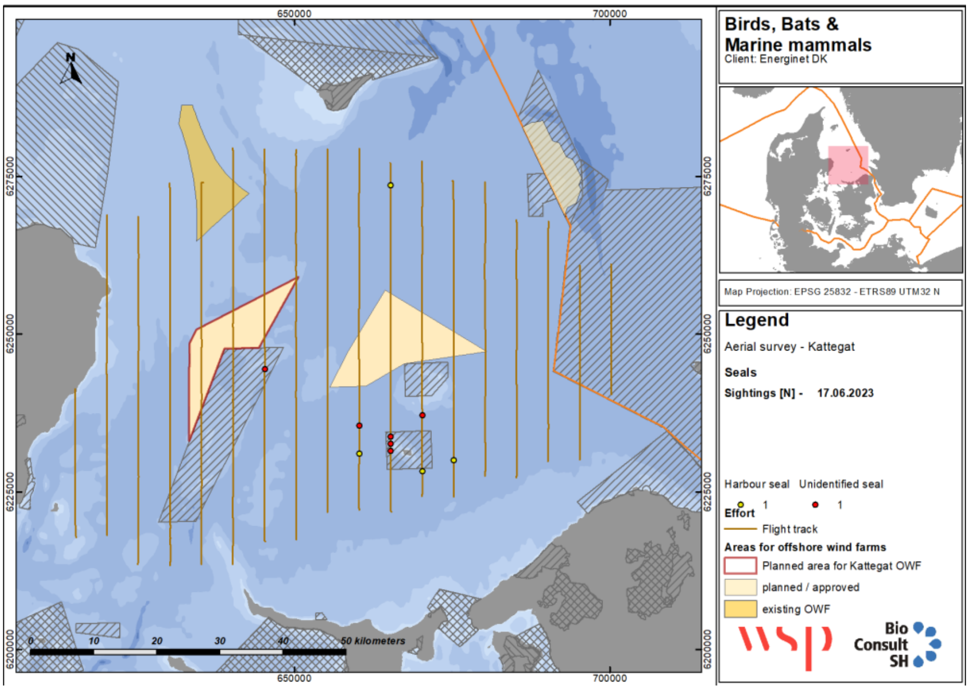

Figure 9-3. Seal observations in the pre-investigation area during the digital aerial survey on 17.06.2023.

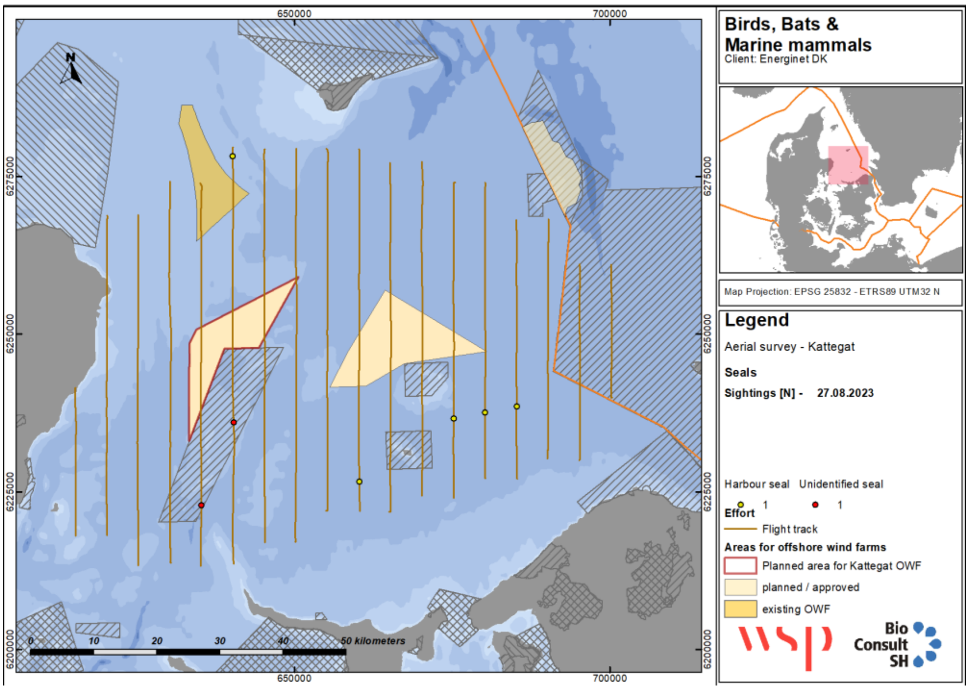

Figure 9-4. Seal observations in the pre-investigation area during the digital aerial survey on 27.08.2023.

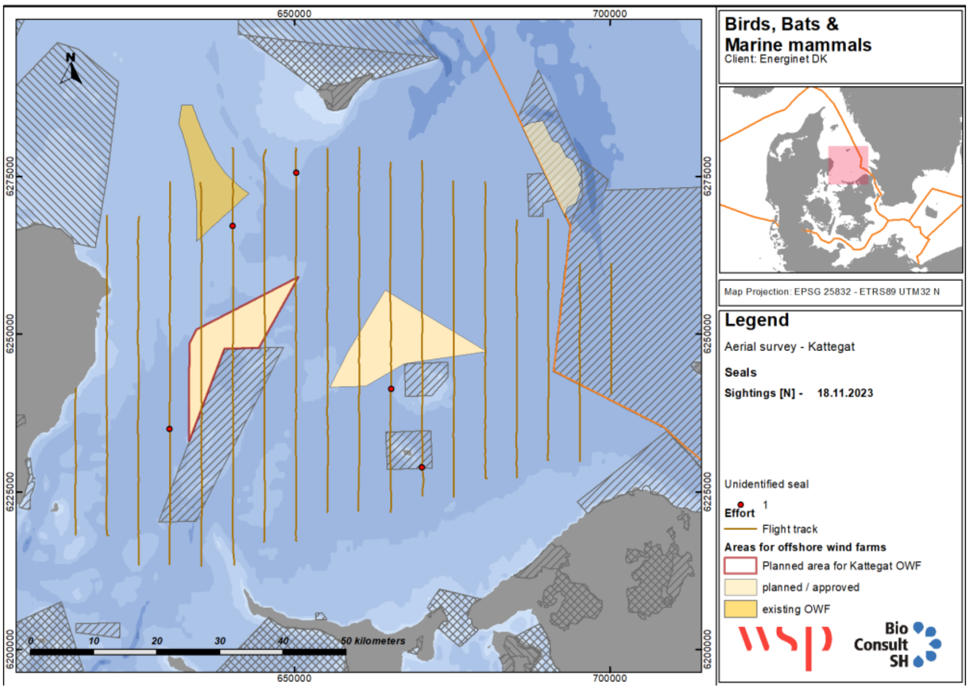

Figure 9-5. Seal observations in the pre-investigation area during the digital aerial survey on 18.11.2023.

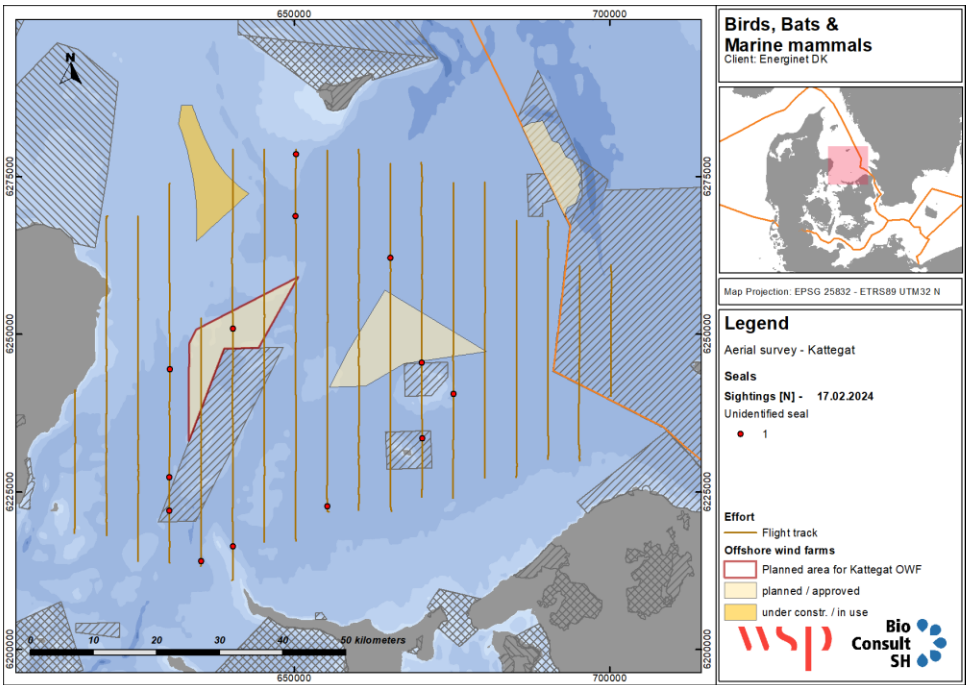

Figure 9-6. Seal observations in the pre-investigation area during the digital aerial survey on 17.02.2024.

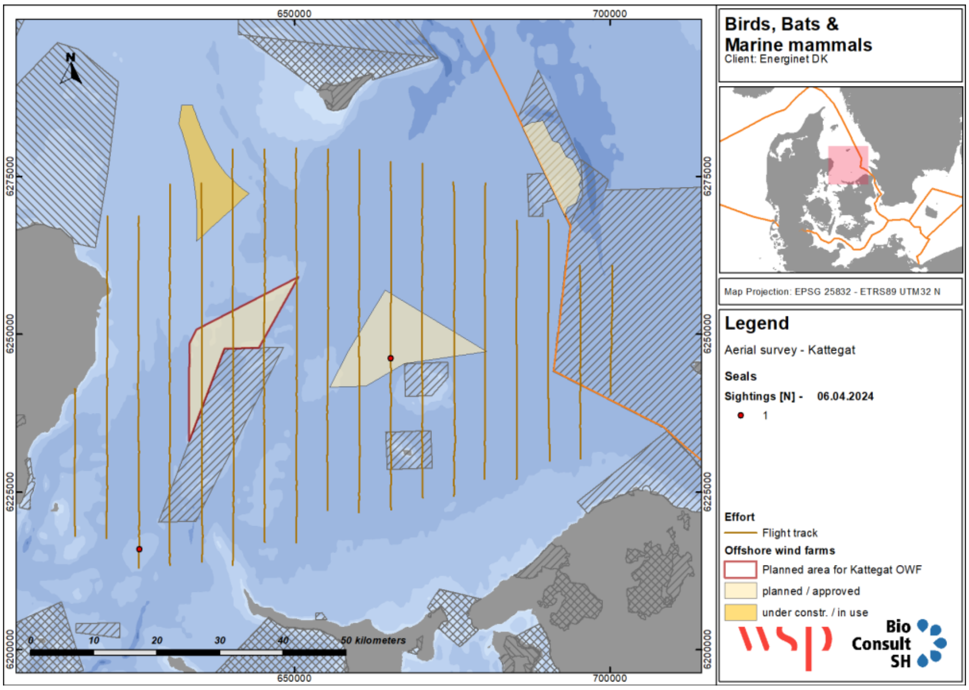

Figure 9-7. Seal observations in the pre-investigation area during the digital aerial survey on 06.04.2024.

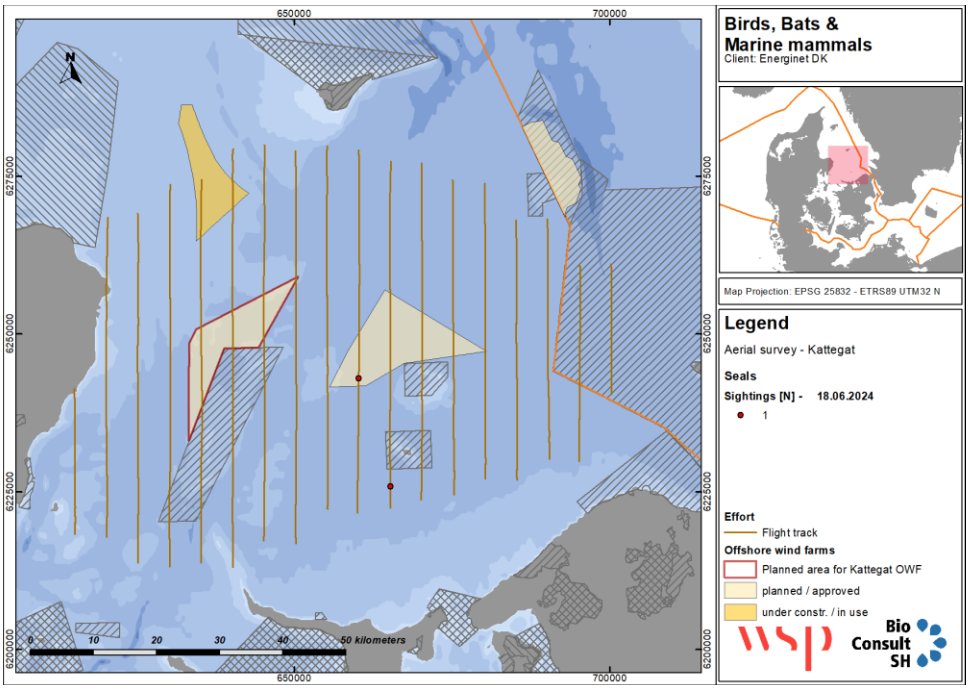

Figure 9-8. Seal observations in the pre-investigation area during the digital aerial survey on 18.06.2024.

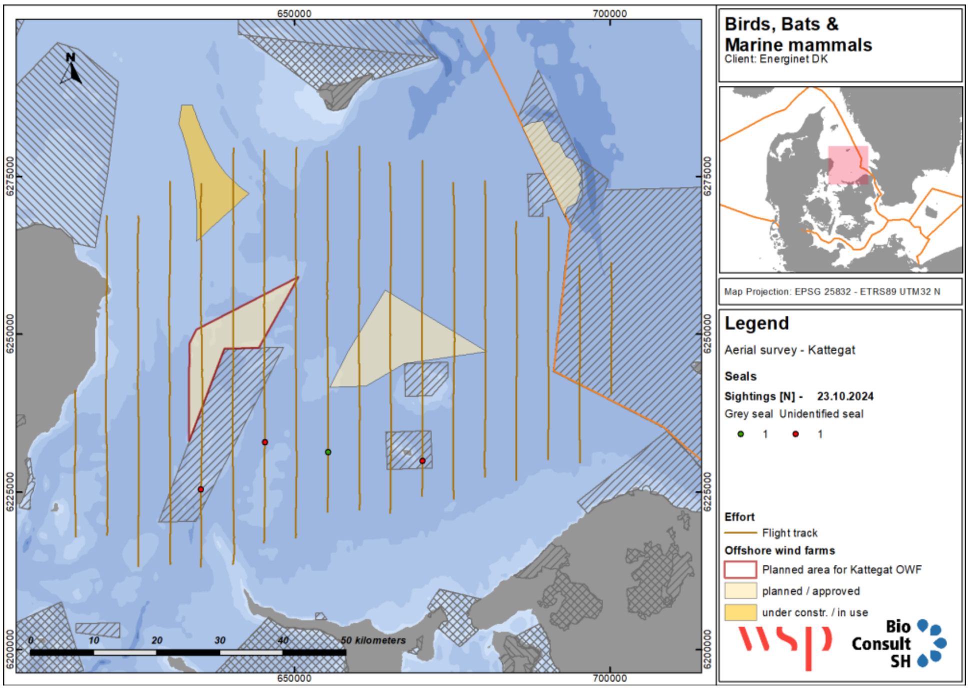

Figure 9-9. Seal observations in the pre-investigation area during the digital aerial survey on 23.10.2024.

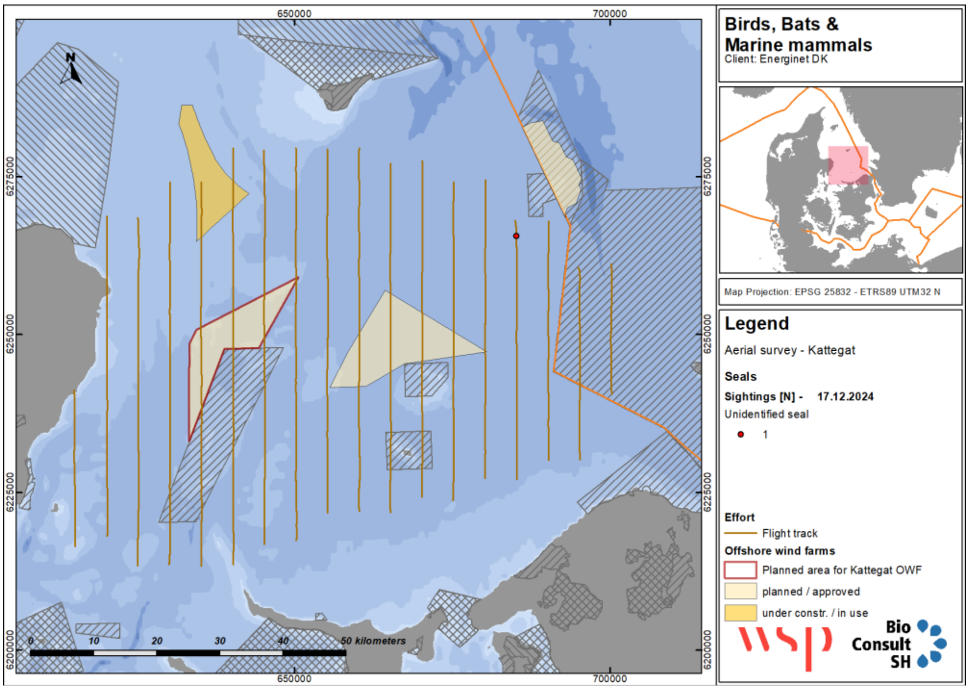

Figure 9-10. Seal observations in the pre-investigation area during the digital aerial survey on 17.12.2024.

9.2 HARBOUR PORPOISE – AERIAL SURVEY SIGHTINGS

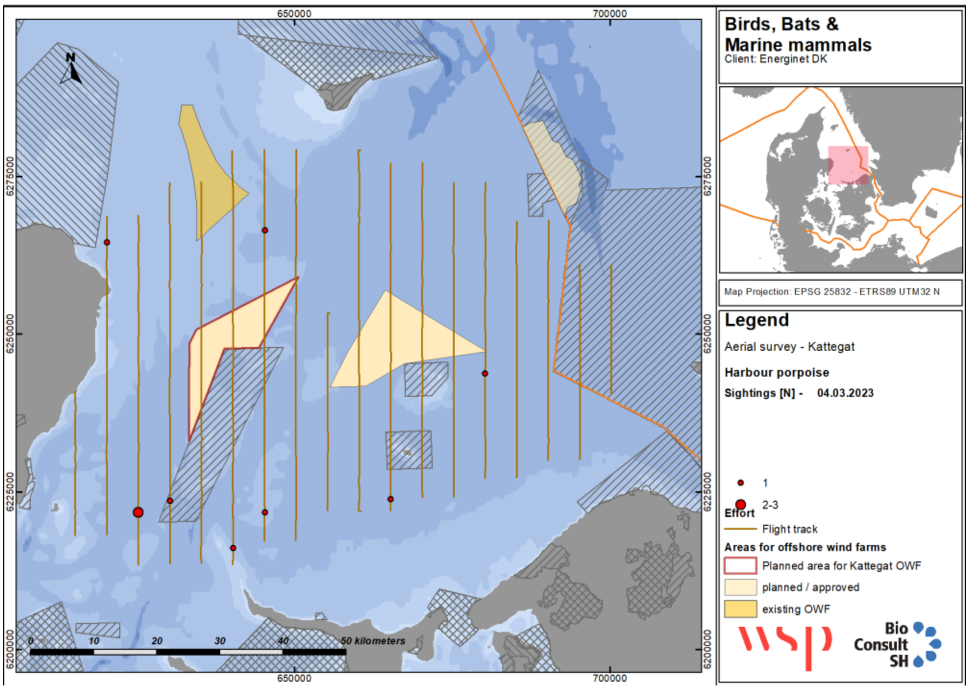

Figure 9-11. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 04.03.2023.

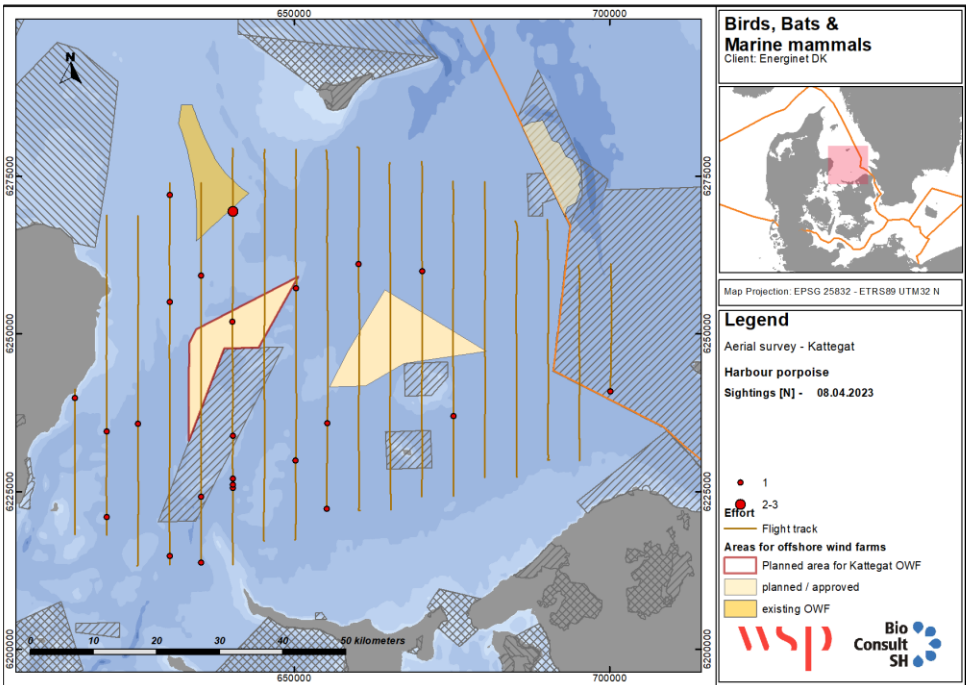

Figure 9-12. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 08.04.2023.

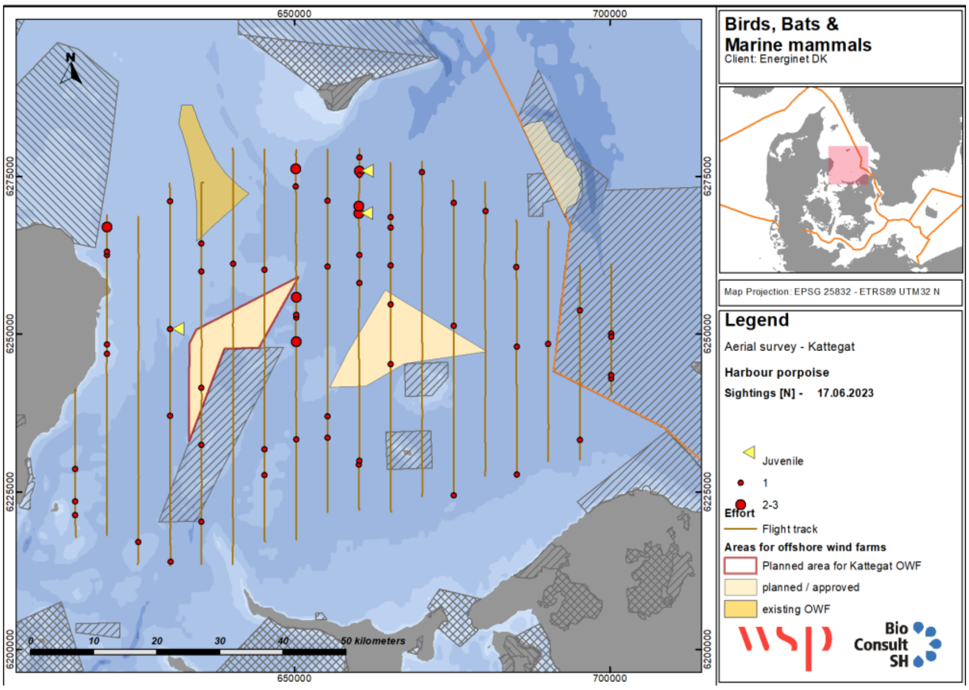

Figure 9-13. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 17.06.2023.

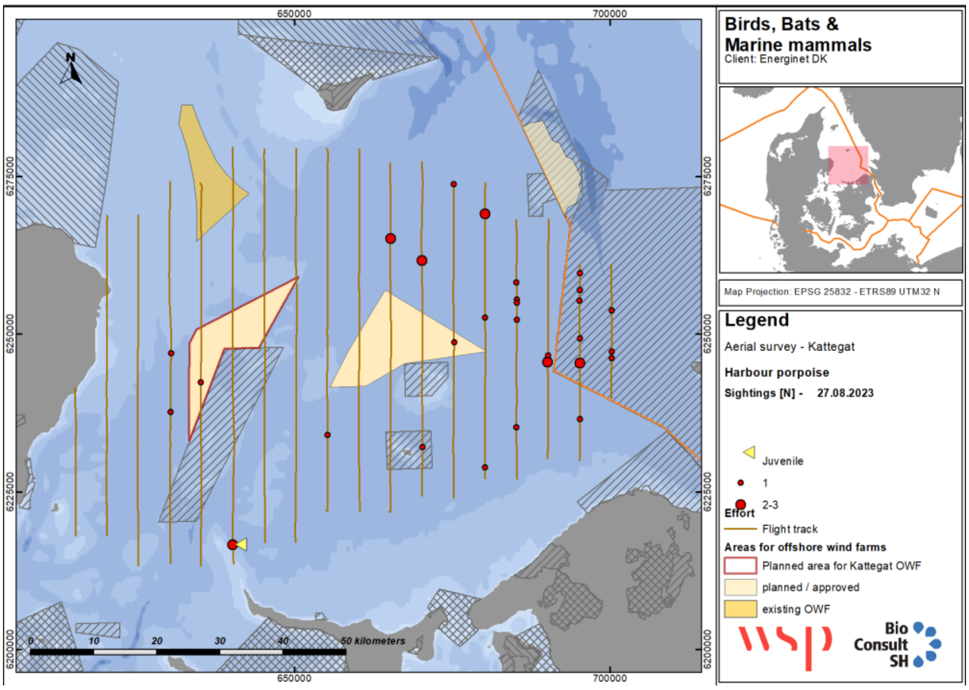

Figure 9-14. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 27.08.2023.

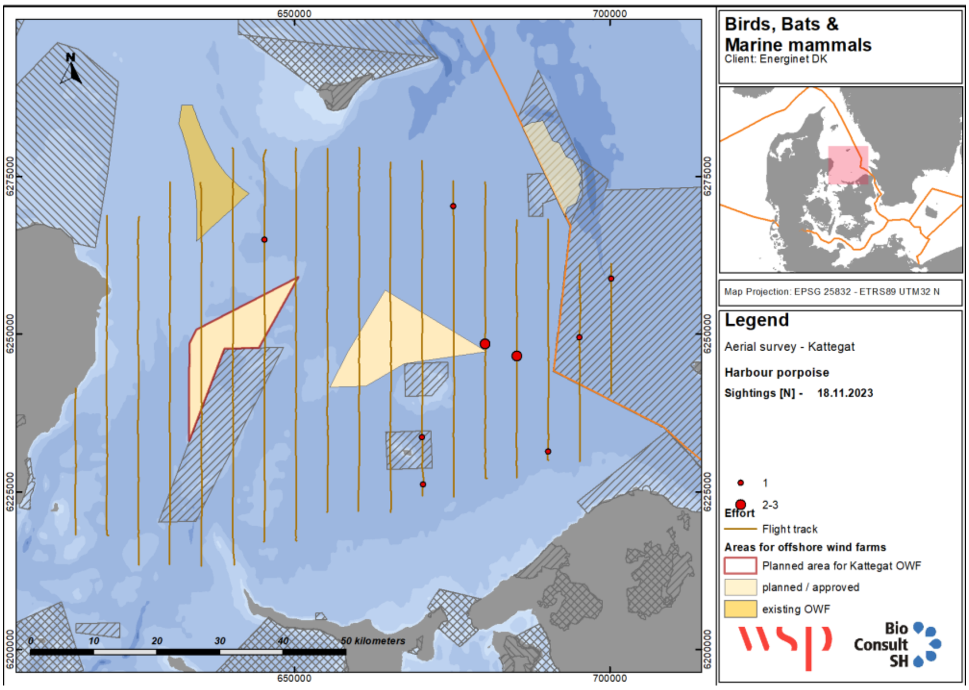

Figure 9-15. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 18.11.2023.

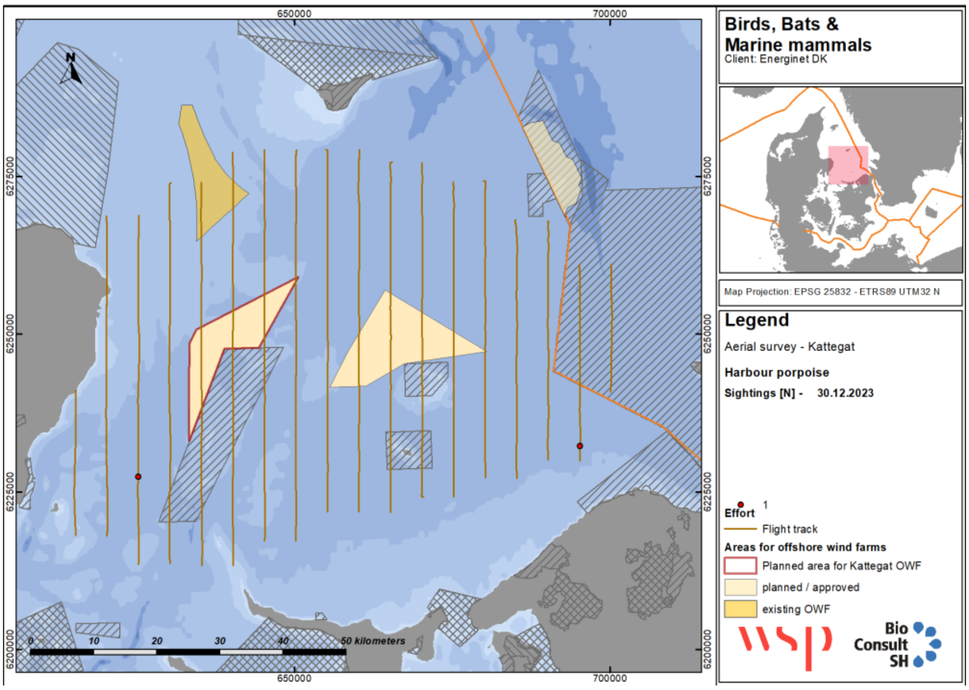

Figure 9-16. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 30.12.2023.

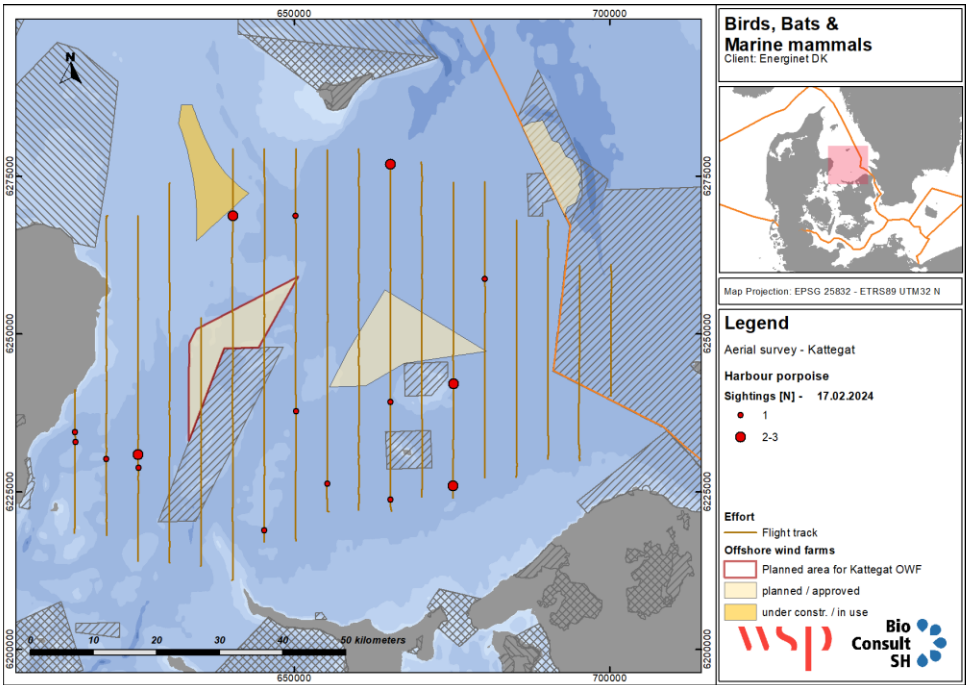

Figure 9-17. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 17.02.2024.

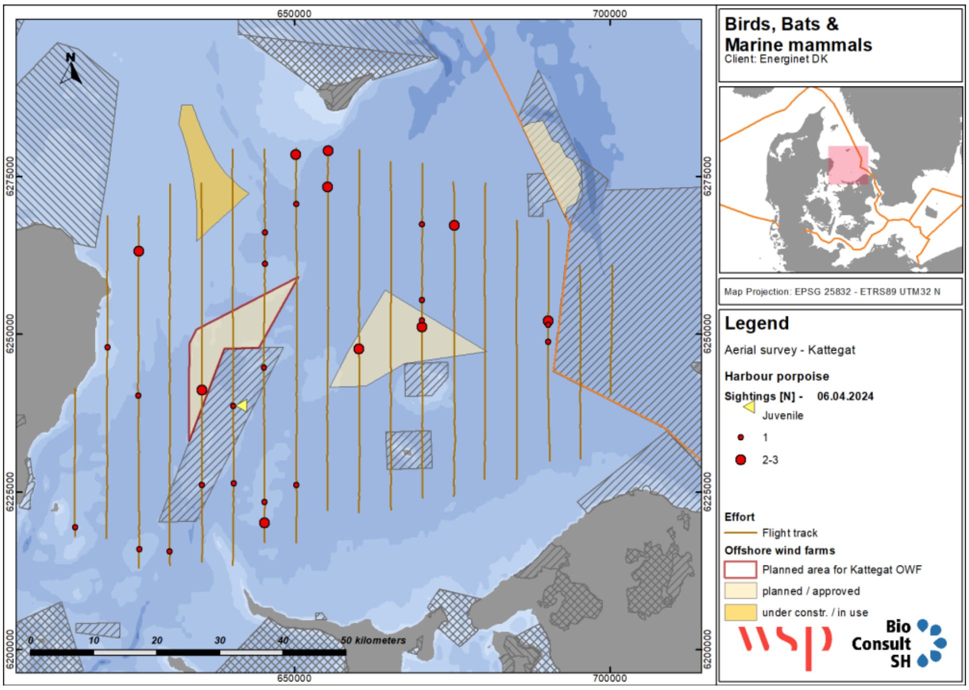

Figure 9-18. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 16.04.2024.

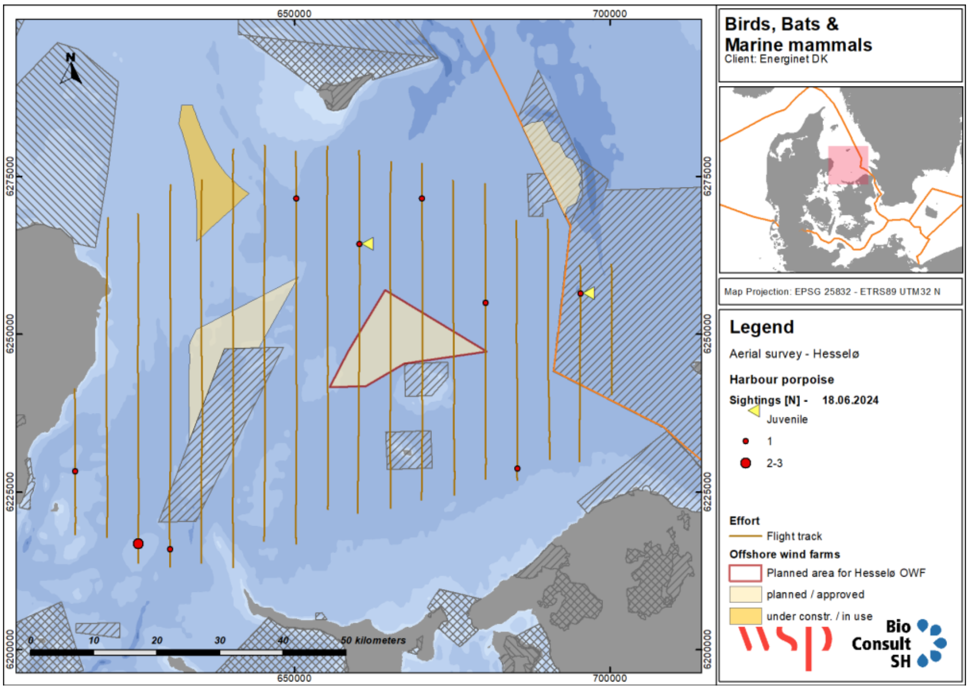

Figure 9-19. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 18.06.2024.

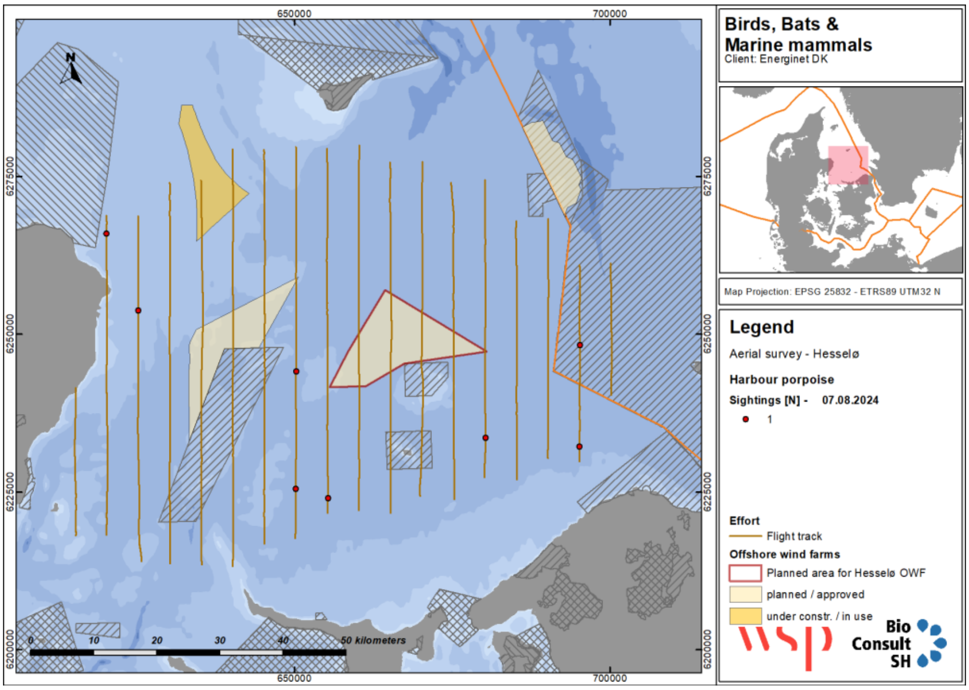

Figure 9-20. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 07.08.2024.

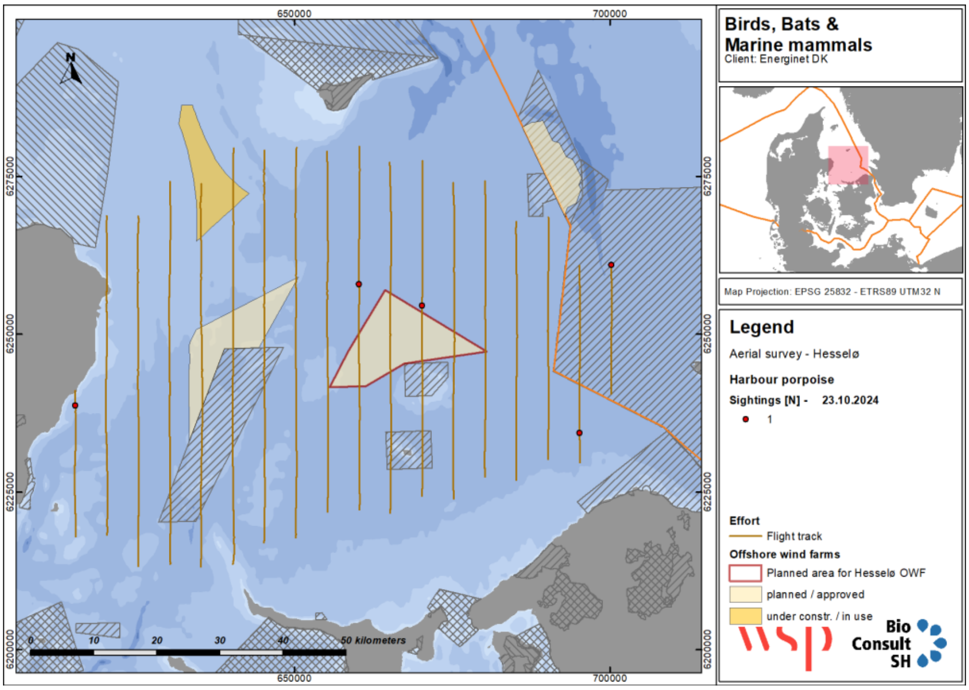

Figure 9-21. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 23.10.2024.

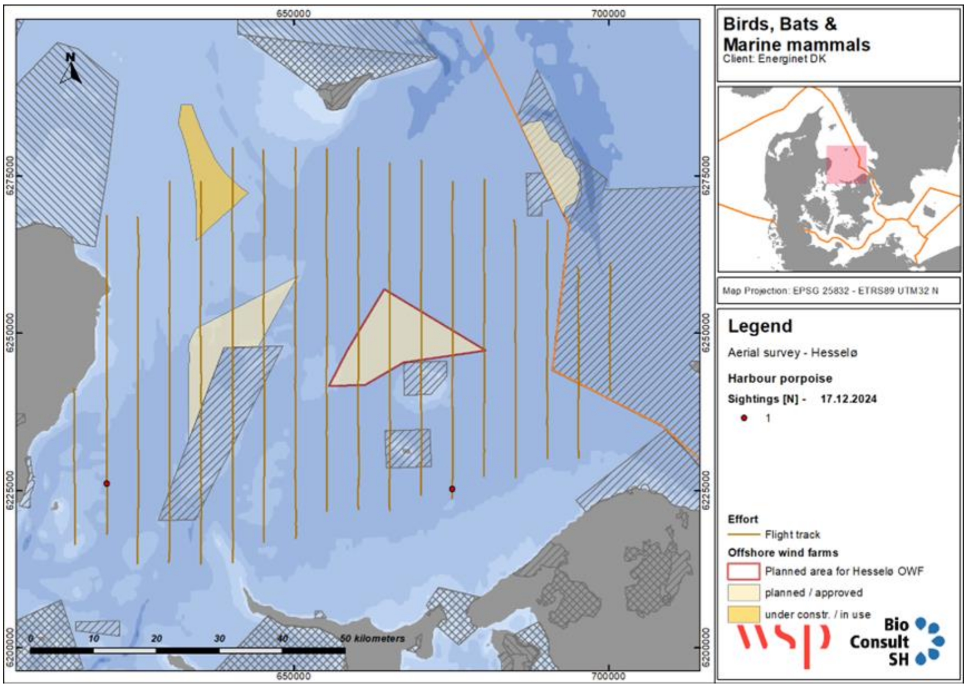

Figure 9-22. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 17.12.2024.