ENERGINET

KRIEGERS FLAK II

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

TECHNICAL REPORT MARINE MAMMALS

15-10-2025

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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
KF II N	Kriegers Flack II North
KF II S	Kriegers Flack II South
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 the planned Kriegers Flak II Offshore Wind Farm, comprised of two areas, (KF II N and KF II S), is located between Møn in Denmark, Falsterbo in Sweden and Rügen in Germany. This pre-investigation of the planned wind farm is extending across the Danish, Swedish, and German EEZs. Within the pre-investigation area, there are already three operating offshore wind farms, two of which are located within the Danish EEZ.

As part of the offshore baseline surveys in the pre-investigation area, marine mammal abundance and distribution were monitored through bimonthly digital aerial wildlife surveys conducted using HiDef video technology (http://www.hidefsurveying.co.uk). In parallel, the spatial and seasonal habitat use of harbour porpoises was assessed via Passive Acoustic Monitoring (PAM) using C-PODs deployed continuously from February 2023 to February 2025.

Transect design for the pre-investigation area consisted of 13 transects aligned from north to south. The transects had a total length of 831 km varying between 24 km and 84 km with a distance between each transect line of 5 km. On average, 11.4% of the 3,739 km² pre-investigation area was covered per flight.

Out of the 427 seals that were observed during the 12 digital aerial surveys, 43.8% (187 individuals) could be identified to species level. These 187 seals were divided into 47.6% harbour seals (n=89) and 52.4% grey seals (n=98). Grey seals were slightly more dominant than harbour seals and the highest density for grey seals was observed in autumn, while highest densities of all seals combined were observed in winter. While grey seals were only observed during one digital aerial survey in 2023 (04.04.2023), they were recorded in 5 out of 6 surveys in 2024. The highest density for the species was observed in summer 2024. However, as 56.2% of seals could not be identified to species level (n=240), results apply to both seal species. Most seals were observed in the northern part of the pre-investigation area throughout the year with 95.8% of all sightings within one of the two Swedish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive *Falsterbohalvön* (SE0430095) and *Sydvästskånes utsjövatten* (SE0430187), in which both harbour seal and grey seal are listed as important species.

Harbour porpoises were observed during all surveys, with the highest densities recorded in summer. Overall, from February 2023 to January 2025, 155 individuals were identified as harbour porpoises. The proportion of juveniles was 2.7% (n=2), which is relatively low compared to other areas. (for example, in Fehmarn Belt area calves made up 13.04% of all observed individuals (18 calves out of 122 individuals) in 2009, and 5.5% in 2010). Harbour porpoises were distributed all over the pre-investigation area with no clear preference. Most sightings occurred in the middle of the pre-investigation area around and east from Møn and in the southern part of the pre-investigation area.

Furthermore, passive acoustic monitoring with a total of 16 C-POD stations determined that, on average, at least one harbour porpoise contact was recorded at each station on 93% 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 Power and Heat 2022 of 25 June 2022 to enable the expansion of a minimum of 9 GW 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 Kriegers Flak II Offshore Wind Farm (OWF) consists of two sub-areas: North and South. The areas are located 25-50 km off the coast of South Zealand and Møn. Kriegers Flak II North is located approximately 15 km from the east coast of Møn, while Kriegers Flak II South is located approximately 30 km southeast of Møn. The area for the Kriegers Flak II OWF is approximately 175 km^2, divided into 99km^2 for North and 76km^2 for South. The Kriegers Flak II OWF will be connected to land via subsea cables making landfall close to Rødvig on South Zealand see Figure 2-1.

In the agreement on the tender framework, which the Danish Parliament adopted in May 2025, it was decided that the tender for Kriegers Flak II 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 Kriegers Flag OWF for Year 1 (Y1: February 2023 to January 2024) and Year 2 (Y2: February 2024 to January 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 analyzed to study the annual numbers of seals.

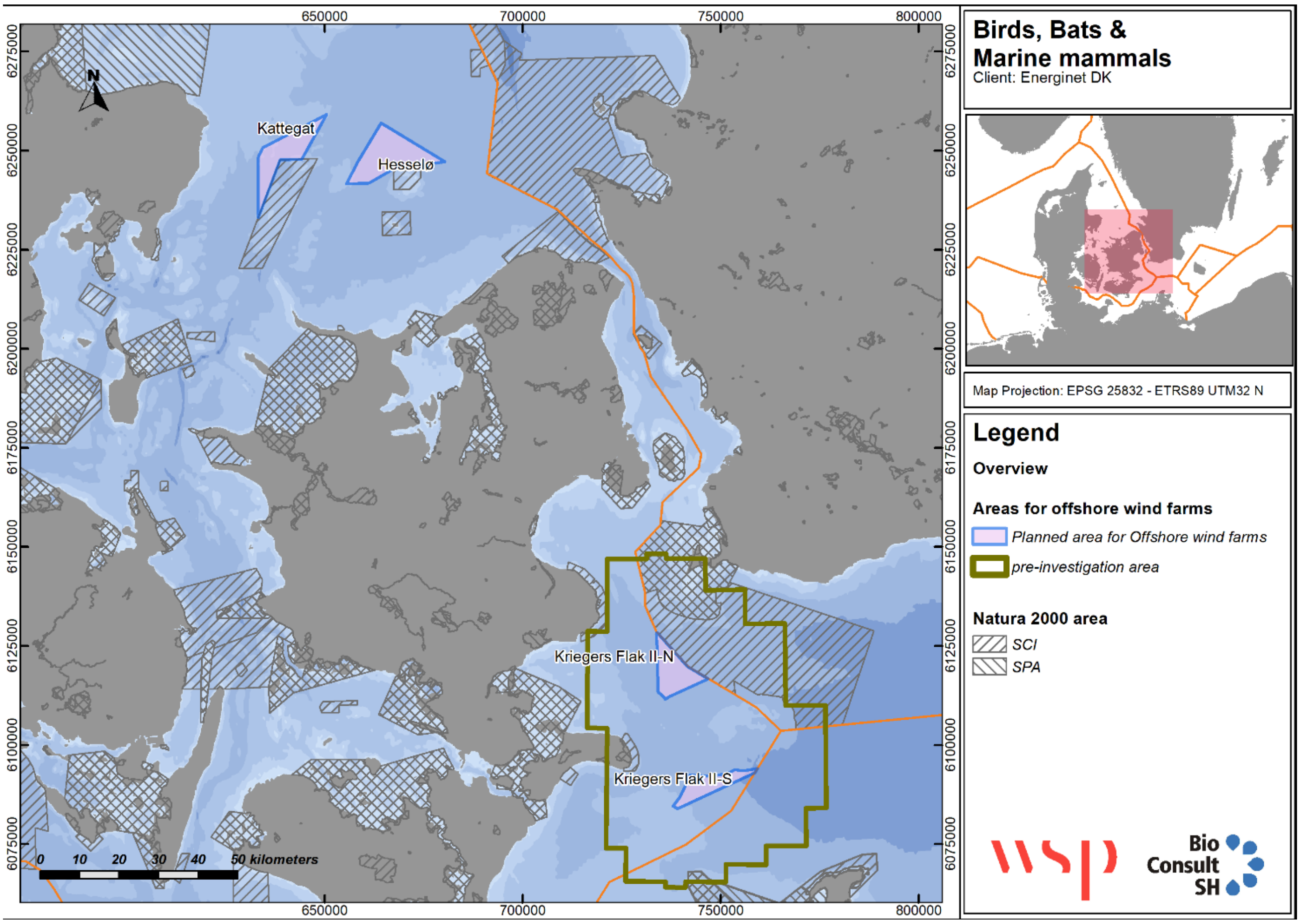

Figure 2-1.Map showing the location of the investigated offshore wind farm areas Kattegat, Hesselø and Kriegers Flak II (KF II N and KF II S). The present report focuses on Kriegers Flak II (KF II N and KF II S).

3 EXISTING DATA

The purpose of this section is to give a brief overview on the conservation status and biology of the three marine mammal species, regularly occurring in the pre-investigation area for Kriegers Flak II (KF II N and KF II S), 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 in 75 kg in males, but strong fluctuations depending on reproductive status and season were observed (HÄRKÖNEN & HEIDE-JØRGENSEN 1990). Females reach sexual maturity at an average age of 3.7 years and males about a year later (HÄRKÖNEN & HEIDE-JØRGENSEN 1990). The overall pregnancy rate 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 since the last glaciation. Based on molecular data and satellite telemetry studies, it was suggested to split harbour seals in the Baltic 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 of 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 whether the Kattegat unit is at or below Target Reference Level or undergoing a decline (HELCOM 2023a). The state of distribution of harbour seals achieves the threshold value for good status in the Kattegat, but when assessed together with the SW Baltic population, good status is not achieved. Thus, the population in the SW Baltic and Kattegat also failed to achieve good status with regards to both key indicators' distribution' and 'population trends and abundance' (HELCOM 2023a).

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). The national red list of Germany lists the harbour seal as being under threat of unknown extent (MEINIG ET AL. 2020).

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 (Berta & Churchill 2012; Fietz et al. 2016; Olsen et al. 2016). 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, 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 males

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 and October-December in the northeast Atlantic (GALATIUS ET AL. 2020).

Grey seals in the Baltic Sea region breed mainly on drift ice, but where this is not possible, as in the southern Baltic Sea region in most winters, they also breed on land. Grey seal pups are born with their lanugo coat, which is not waterproof, so 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 hauling 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 (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 body 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 Ertholomene 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 unfavorable 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 and 2024 (HANSEN & HØGSLUND 2021; 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 Baltic Sea (KINZE 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 three 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 region (defined according to HELCOM; KESSELRING ET AL. 2017). Newborn calves may be seen between April and 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 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.

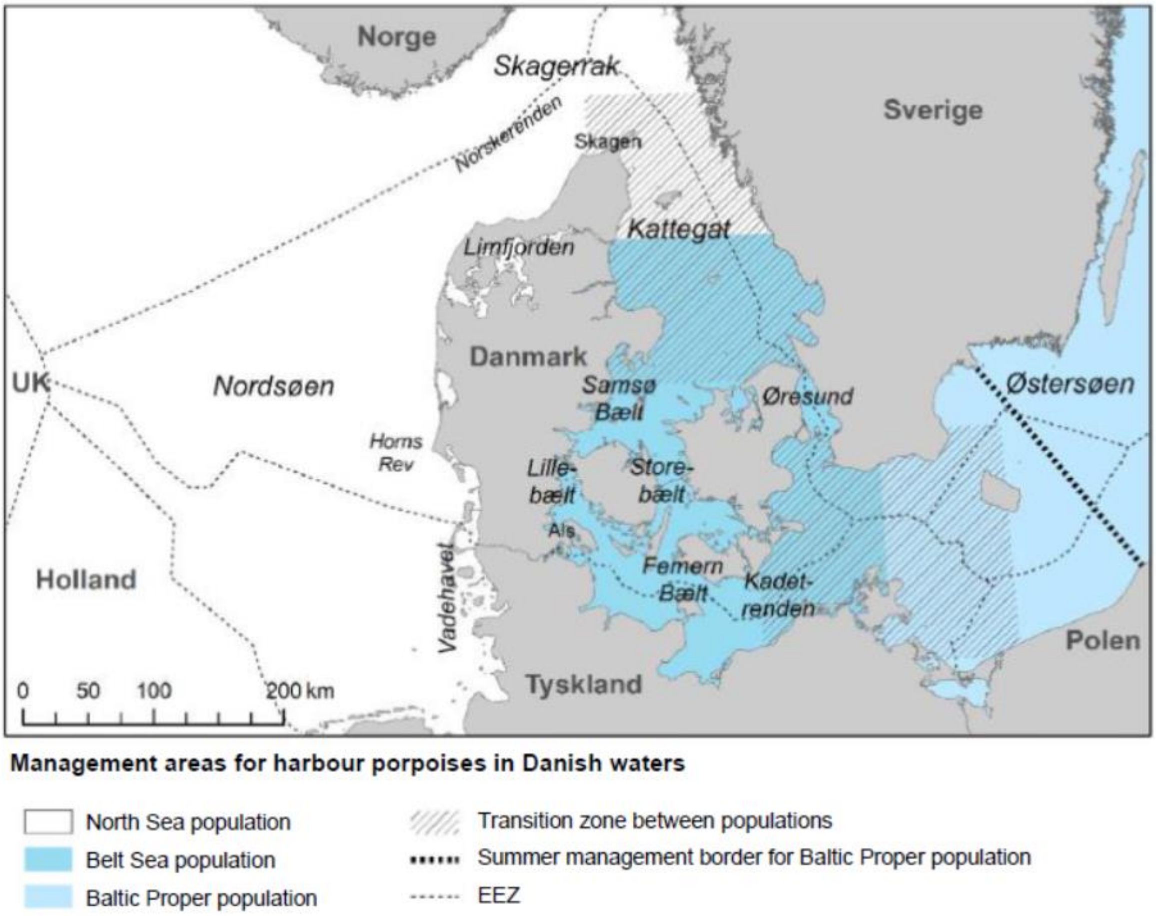

Figure 3-1. Map showing suggested management areas for the three harbour porpoise populations in Danish waters and neighboring countries. Taken from: SVEEGAARD ET AL. 2018.

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 from the 2012 Mini-SCANS-I estimate of 40,475 individuals (VISQUERAT ET AL. 2015), but not significantly different from the 2020 Mini-SCANS-II estimate of 17,301 individuals (UNGER ET AL. 2021). The estimated annual decline between 2012 and 2022 is 1.5% (Figure 3-2). However, the variance in the data is very large, and power analyses showed that the data would only enable to detect a significant decline of at least 4.4% per year. The authors state, that although a significant decline could thus not be determined, this cannot be interpreted as no decline in abundance (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).

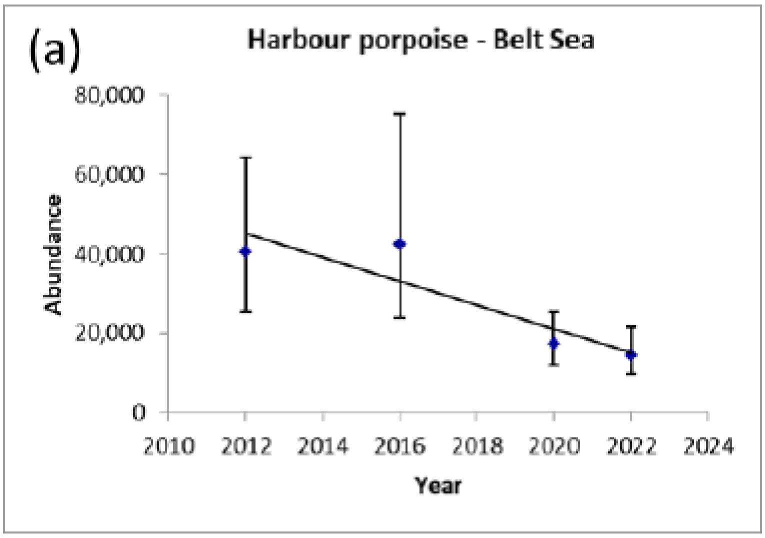

Figure 3-2. Abundance estimates for harbour porpoises of the Belt Sea population with fitted trend line, suggesting an annual decline of 1.5%. Taken from SCANS IV: GILLES ET AL. (2023).

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 (HANSEN ET AL. 2024).

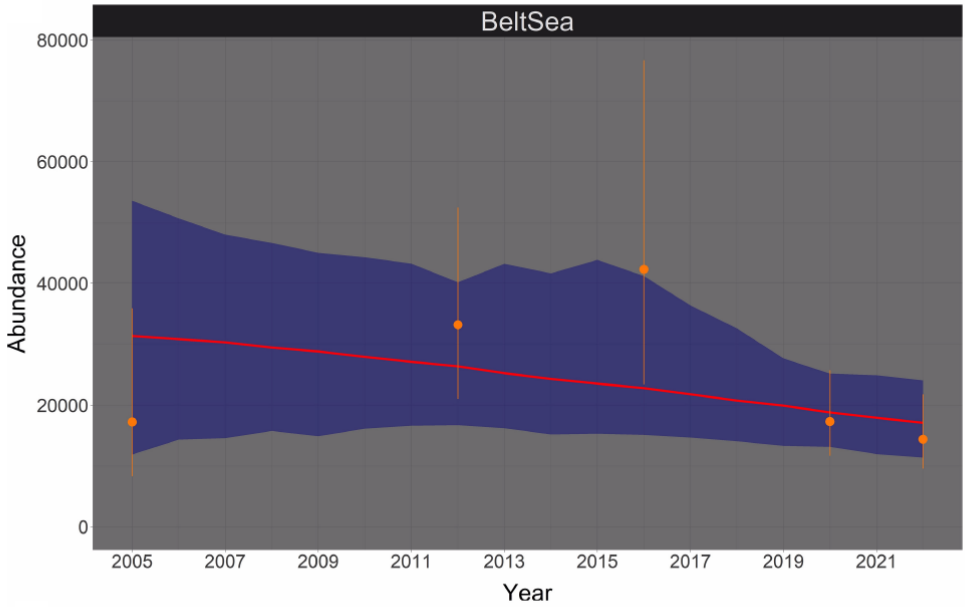

Figure 3-3. Belt Sea harbour porpoise population Bayesian trend, suggesting an annual decline of 2.7%. Taken from: OWEN ET AL. (2024).

National monitoring data, collected in the German part of the Baltic Sea, SCHEIDAT ET AL. (2008) calculated harbour porpoise abundance estimates based on ten aerial surveys (covering between 1,921 km² and 3,400 km and lasting between 2 to 25 days) between 2003 and 2006 during the months March to September. They found harbour porpoise abundance to range from 1,352 harbour porpoises in March-April 2005 to 4,610 harbour porpoises in May 2005, not including one survey in March 2003 yielding an unusual low abundance of only 457 harbour porpoises. For the calculation of harbour porpoise density, they subdivided the study area into three sub-areas (in Figure 3-4). In the west, in sub-area E (Kiel Bight), harbour porpoise density ranged between 0.01 and 0.64 Ind./km² and in the middle, in sub-area F (Mecklenburg Bight), density ranged between 0.04 and 0.35 Ind./km², whereas in the east, in the sub-area G (Pomeranian Bay), the density ranged between 0 to 0.06 Ind./km². Seasonal densities per grid cell corrected for survey effort are shown in Figure 3-5.

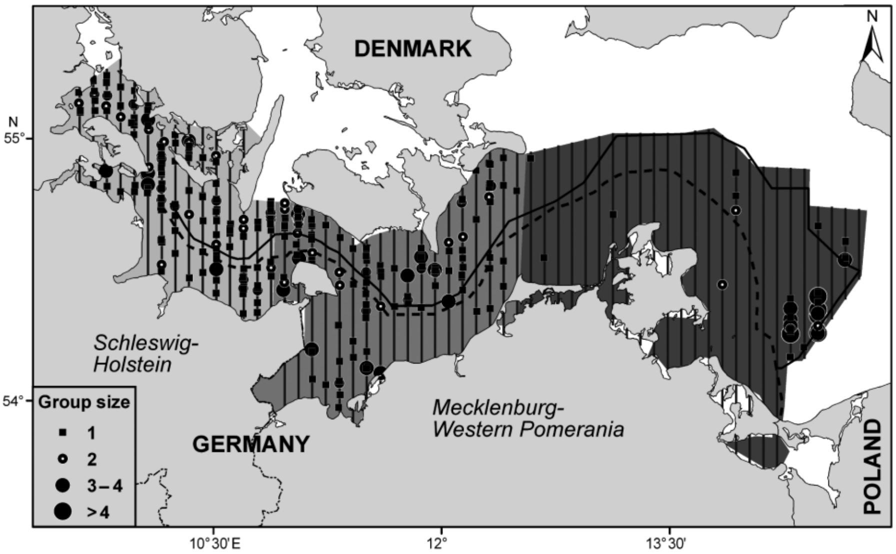

Figure 3-4. Map showing the area in the German Baltic Sea and its division into subareas for calculating harbour porpoise density estimates from aerial surveys between 2003 and 2006. Black squares and points indicate harbour porpoise sightings. From: SCHEIDAT ET AL. (2008).

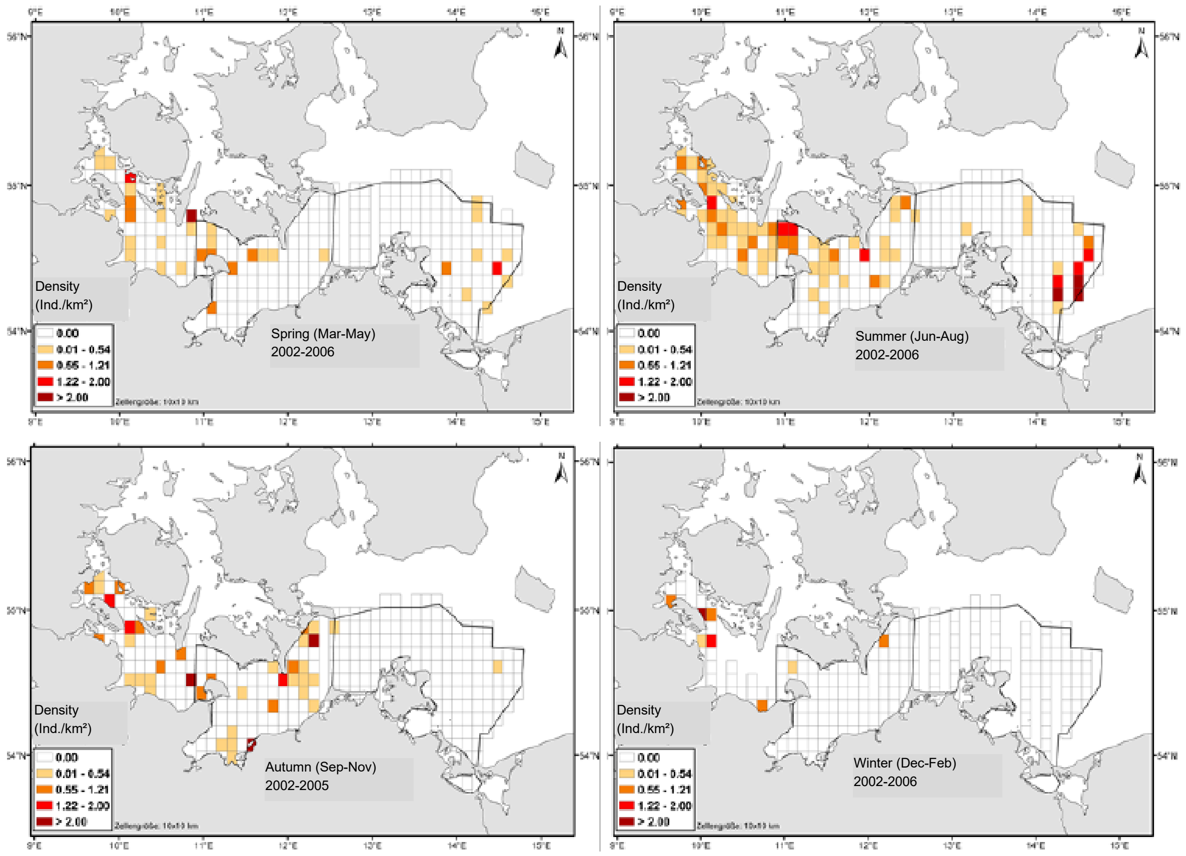

Figure 3-5. Map showing seasonal occurrence of harbour porpoises in the German area of the Baltic Sea based on sightings during aerial surveys between 2002 and 2006. Shown are density estimates per grid cell corrected for survey effort. From: GILLES ET AL. (2007a; b).

Harbour porpoise sightings from ship-based surveys conducted during SCANS-I and II in Polish, Swedish and German waters of the Baltic Proper were so rare that it was not possible to calculate reliable abundance estimates (GILLESPIE ET AL. 2005). Therefore, no more visual surveys were conducted in this region during SCANS III. Instead, it was recommended to conduct passive acoustic monitoring in the Baltic Proper instead.

The SAMBAH (**S**tatic **A**coustic **M**onitoring of the **BA**ltic **H**arbour **P**orpoise) project was launched in 2011 to gain reliable assessments of abundance, distribution and habitat preferences of the harbour porpoise population in the Baltic Proper (SAMBAH 2016). Due to low abundance of harbour porpoises in the area, the generally shy behaviour and thus low visual detectability of animals, the well-established method of passive acoustic monitoring was chosen rather than visual surveys. Over two years, data were collected with 304 C-POD (Cetacean Porpoise Detectors) distributed all over the Baltic Proper between 2011 and 2013. Based on these passive acoustic monitoring data from the SAMBAH study, the number of individuals of the Baltic Proper management unit during summer was estimated at approx. only 500 animals (SAMBAH (STATIC ACOUSTIC MONITORING OF THE BALTIC HARBOUR POROISE) 2016; AMUNDIN ET AL. 2022). In addition, the distribution of harbour porpoise detections showed a strongly decreasing pattern from the south-west to the north-east during the summer months (Figure 3-6).This indicates that in winter, the Baltic Proper population of harbour porpoises shows a widespread distribution across the whole study area, mixing with the Belt Sea population. During the summer breeding season, however, the two populations seem to be separated as the Belt Sea population moves further west and the Baltic Proper population concentrates in Swedish waters around the Hoburg and Midsjö banks south of Gotland and east of Øland (area indicated by a red circle in Figure 3-6). Thus a seasonal population management border that lies east of Bornholm was proposed (Figure 3-6). Harbour porpoise density estimates based on these detections yielded low numbers with about 0.07 ind./km² in the whole study area during winter and with about 0.63 ind./km² in the south-western part of the study area and about 0.004 ind./km² in the north-eastern part of the study area in summer (SAMBAH (STATIC ACOUSTIC MONITORING OF THE BALTIC HARBOUR POROISE) 2016).

Further monitoring data from Swedish waters near the Northern Midsjö Bank south of Øland indicated that the area is probably used by Baltic Proper harbour porpoises during the breeding season (OWEN ET AL. 2021). While this may be indicating the start of population recovery, the rate of increase (2.4%) is still very low relative to what would be expected for this harbour porpoise population in the absence of threats (OWEN ET AL. 2021).

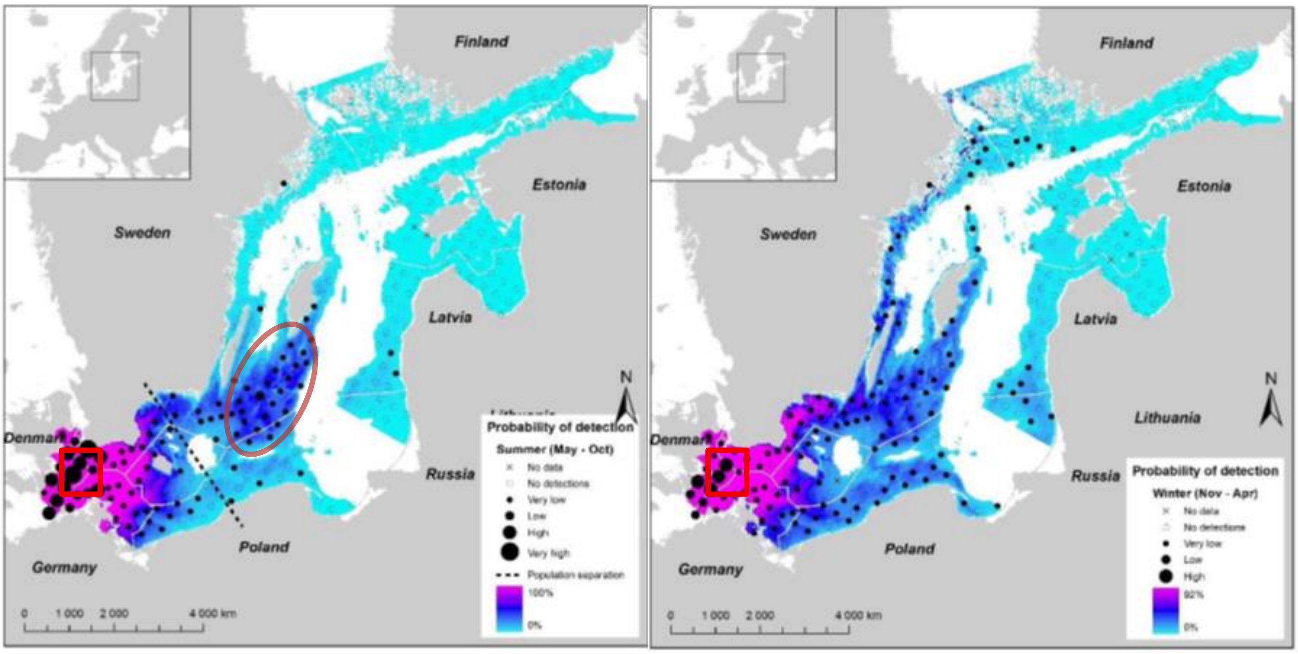

Figure 3-6. Probability of detection of harbour porpoises in the Baltic Sea in summer (May-October) and winter (November-April) as calculated from harbour porpoise detections at 304 C-POD stations deployed during the SAMBAH project between April 2011 and June 2013. The red ellipse indicates the high-density area around the Hoburg and Midsjö banks, which is suggested to be the breeding area of harbour porpoises from the Baltic Proper population. Taken from: SAMBAH (2016). Approximate pre-investigation area is indicated in red.

Using satellite locations from 13 tagged animals of the Belt Sea population, harbour porpoise distribution patterns were modelled in the south-western Baltic Sea and compared to harbour porpoise detections at C-POD stations in the same area during the SAMBAH project (MIKKELSEN ET AL. 2016). As there were only sufficient satellite data for summer (June-August) and autumn (September-November), model results were restricted to these two seasons.

A summary of the SAMBAH C-POD data is shown in Figure 3-7, which clearly shows a decrease in harbour porpoise detections from west to east, confirming results from the model used by MIKKELSEN ET AL. (2016), based on satellite data from the Belt Sea harbour porpoises; these confirm high habitat suitability in the south-western part of the study area in summer and the western areas in autumn (Figure 3-8).

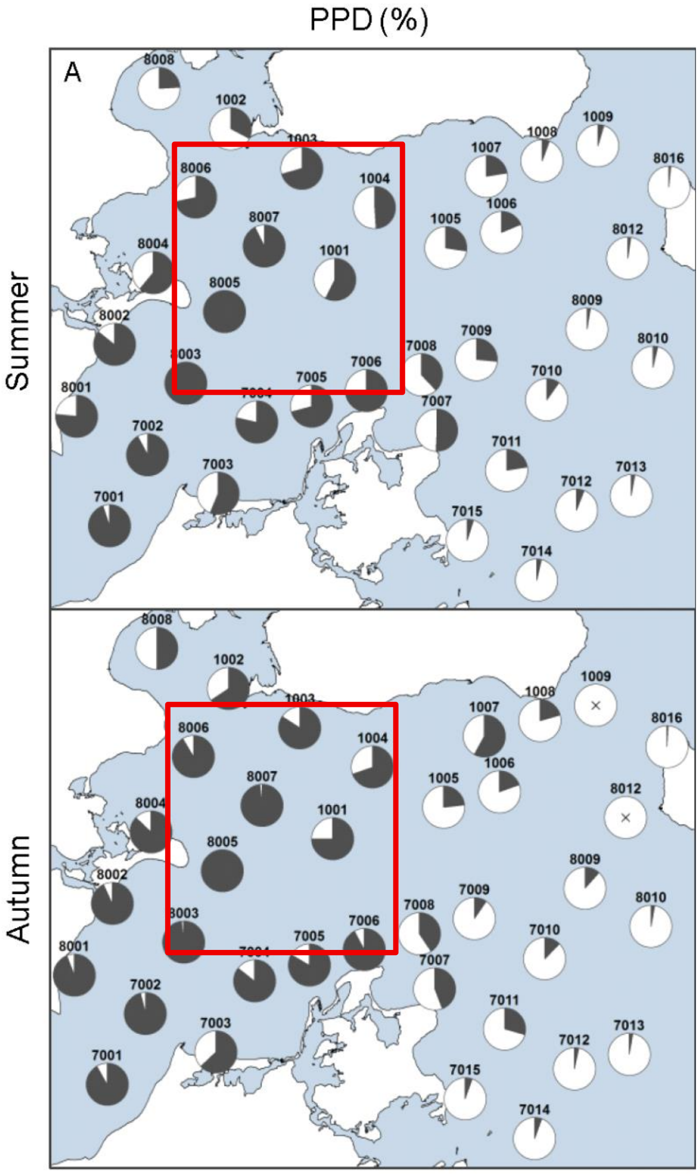

Figure 3-7. Percentage of harbour porpoise positive days (PPD %) by season (summer: June-August, autumn: September-November) at the C-POD stations used during the SAMBAH project between 2011 and 2013. Stations with an x mark indicate that no clicks were recorded at that station. From: MIKKELSEN ET AL. (2016). Approximate pre-investigation area is indicated in red.

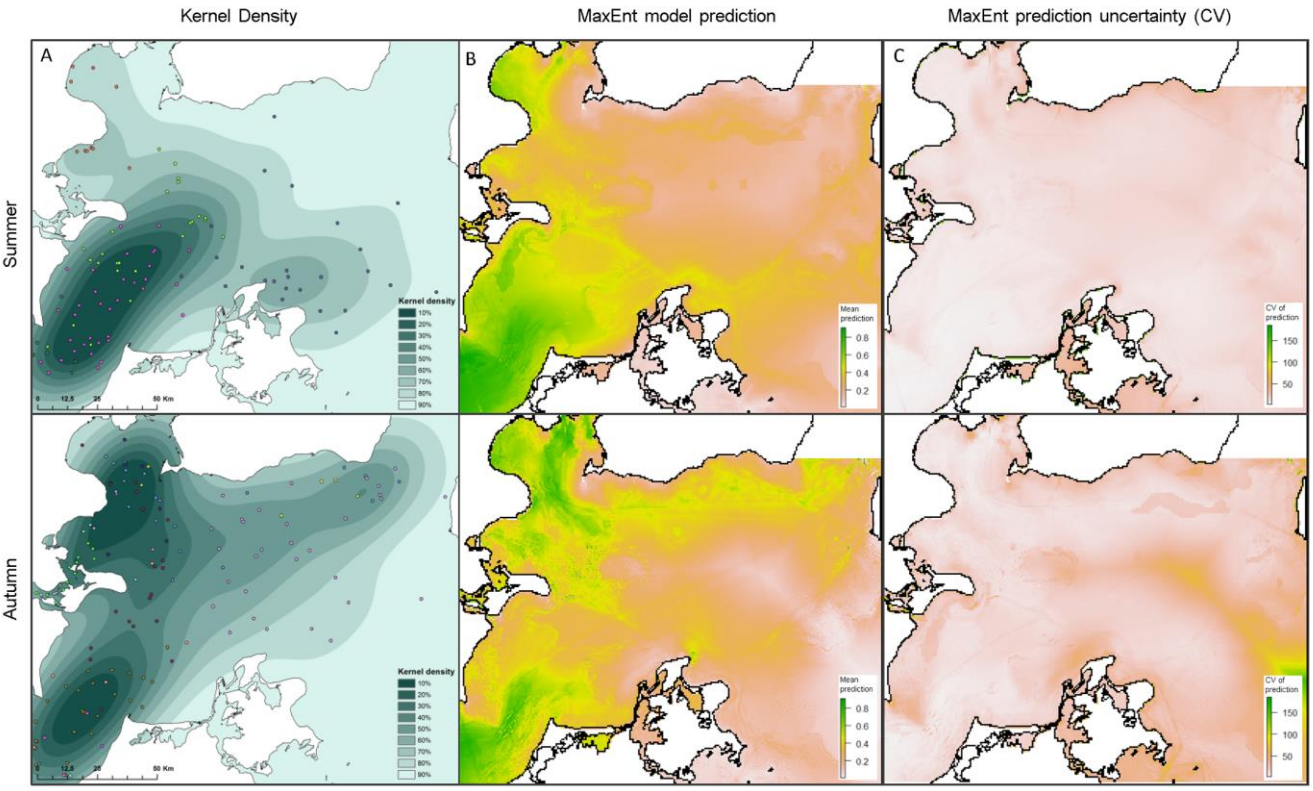

Figure 3-8. Kernel and MaxEnt results. (A) Kernel density results for summer (June-August, top row) and autumn (September-November, bottom row). (B) Mean prediction of the probability of presence of harbour porpoises based on 100 bootstrap models. The scale of the colouring can be interpreted as the relative probability of presence of harbour porpoises given the environment. (C) The uncertainty of the prediction expressed by the coefficient of variation (CV). From: Mikkelsen et al. (2016).

In a recent HOLAS III report (Sveegaard et al. 2022) data from porpoise telemetry in the Belt Sea, SCANS, SAMBAH and other national data were revisited with the aim to create a map showing the importance of areas in the Baltic Sea for harbour porpoises. As a map based exclusively on density estimates would fail to highlight the areas that may be important for the Baltic Proper population of harbour porpoises 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 Prober population of harbour porpoises, before joining it in a single map.

The importance of areas in the Baltic Sea for the Belt Sea population was estimated using telemetry data from 2007-2021, separately for summer and winter. With the Kernel Density tool in ArcGIS, contour lines (called isopleths) were created that encompassed 10, 50, 75% and 100% of harbour porpoise locations. The 50% isopleth was then used to identify areas of high importance, the 75% isopleth areas of medium importance, and areas outside these were categorized as being of lower importance. Then seasonal maps were merged, and this map was then compared with data from SCANS III (Lacey et al. 2022), the Belt Sea density surface model (period 2002-2016, ITAW / unpublished) and MiniSCANS II (Unger et al. 2021), after which some areas of importance were added to the map in the Kattegat and Little Belt / Kiel Bight, giving the map shown in Figure 3-9.

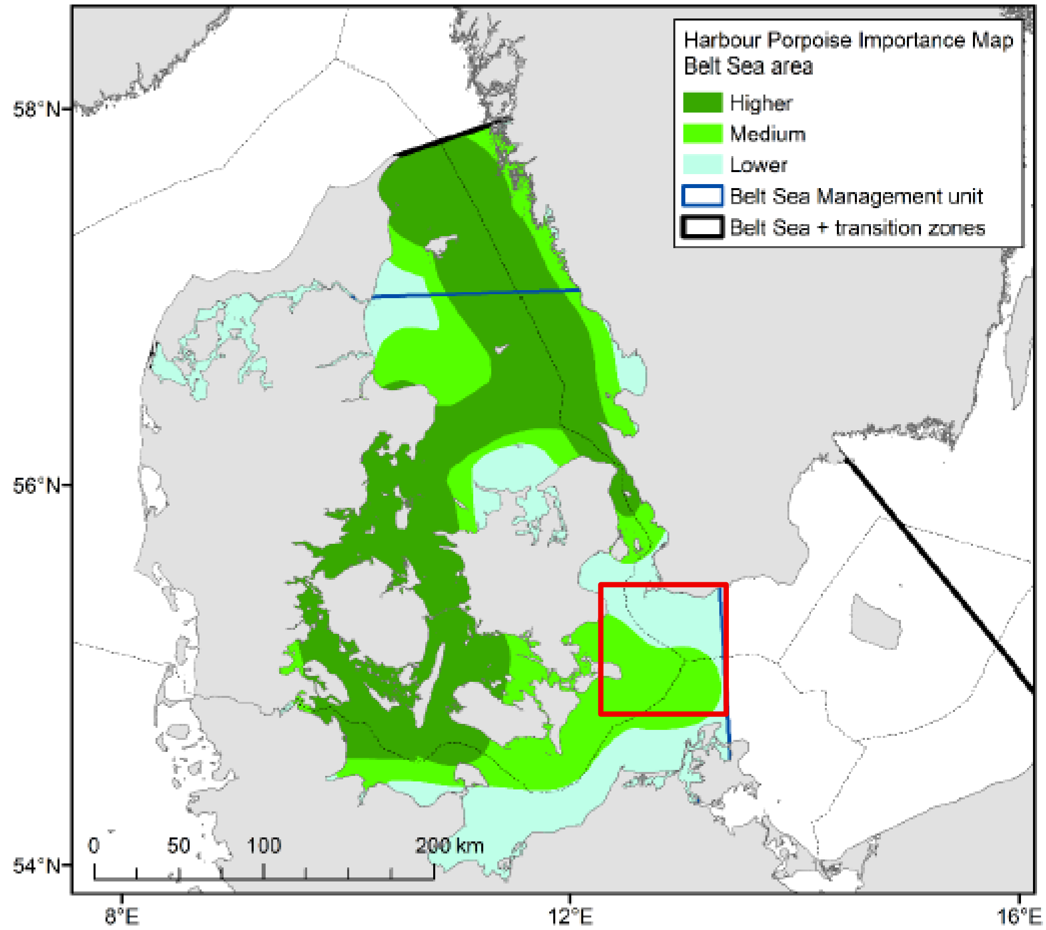

Figure 3-9. Map of the importance of different areas for the Belt Sea population of harbour porpoises. From: SVEEGAARD ET AL. (2022). Approximate pre-investigation area is indicated in red.

The importance map for the Baltic Proper population was based on probability of detection from SAMBAH, also first created separately for winter and summer and then merged. Areas of ≥ 20% probability of detection were chosen to represent areas of higher importance, and areas between 10% - 20% probability of detection were chosen to present areas of medium importance. A convex hull (smallest polygon containing all the 20% (and then 10%) detection probability areas was drawn to present the area of higher (≥ 20%) and medium (10-20%) importance for harbour porpoises of the Baltic Proper population. An area of high importance was added in Polish waters based on assessment of local PAM data and also an area of medium importance was added in Finnish waters, where national monitoring data indicated regular presence of harbour porpoises. Furthermore, information was added showing in what areas data are deficient, because no or only very little monitoring took place, giving the map shown in Figure 3-10. Note the summer and winter management borders that are also included in Figure 3-10.

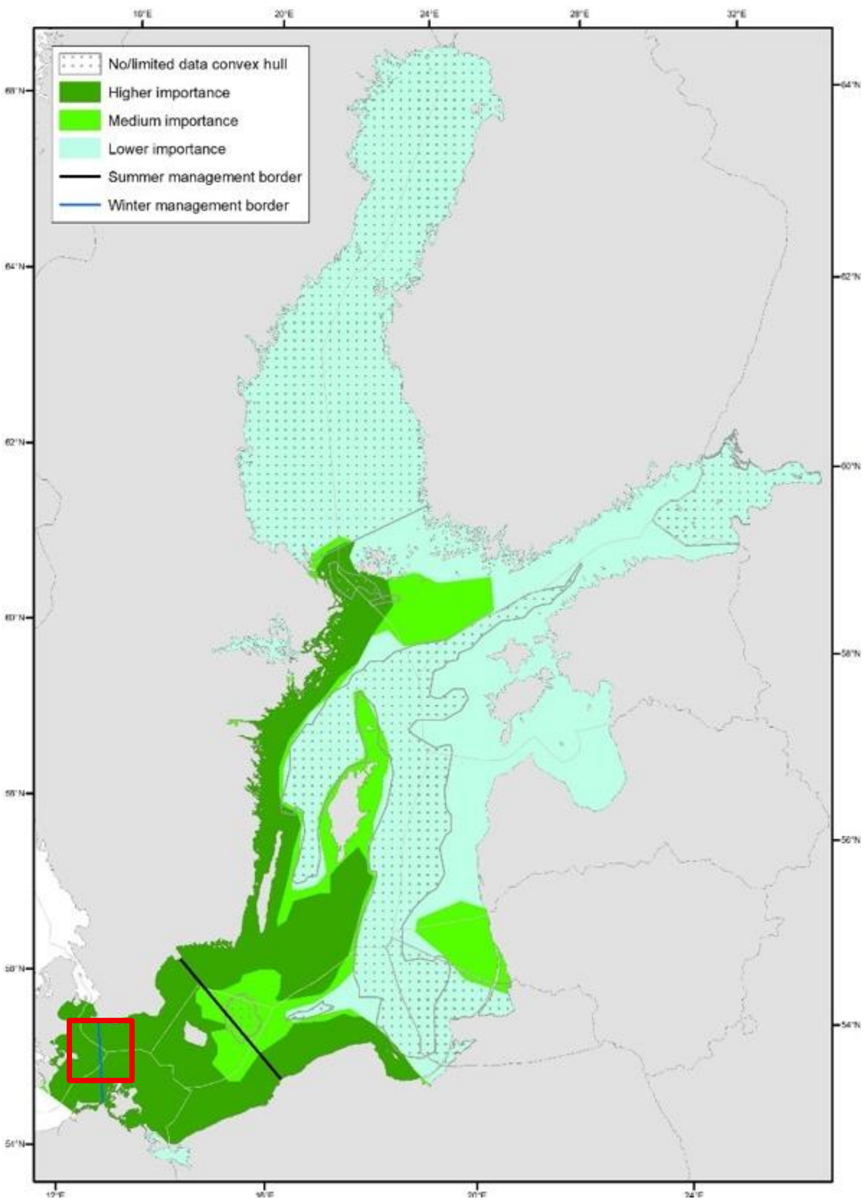

Figure 3-10. Map of the importance of different areas for the Baltic Proper population of harbour porpoises. From: SVEEGAARD ET AL. (2022). Approximate pre-investigation area is indicated in red.

These two maps were finally joined to gain one harbour porpoise importance map for the Baltic Sea, which is shown in Figure 3-11.

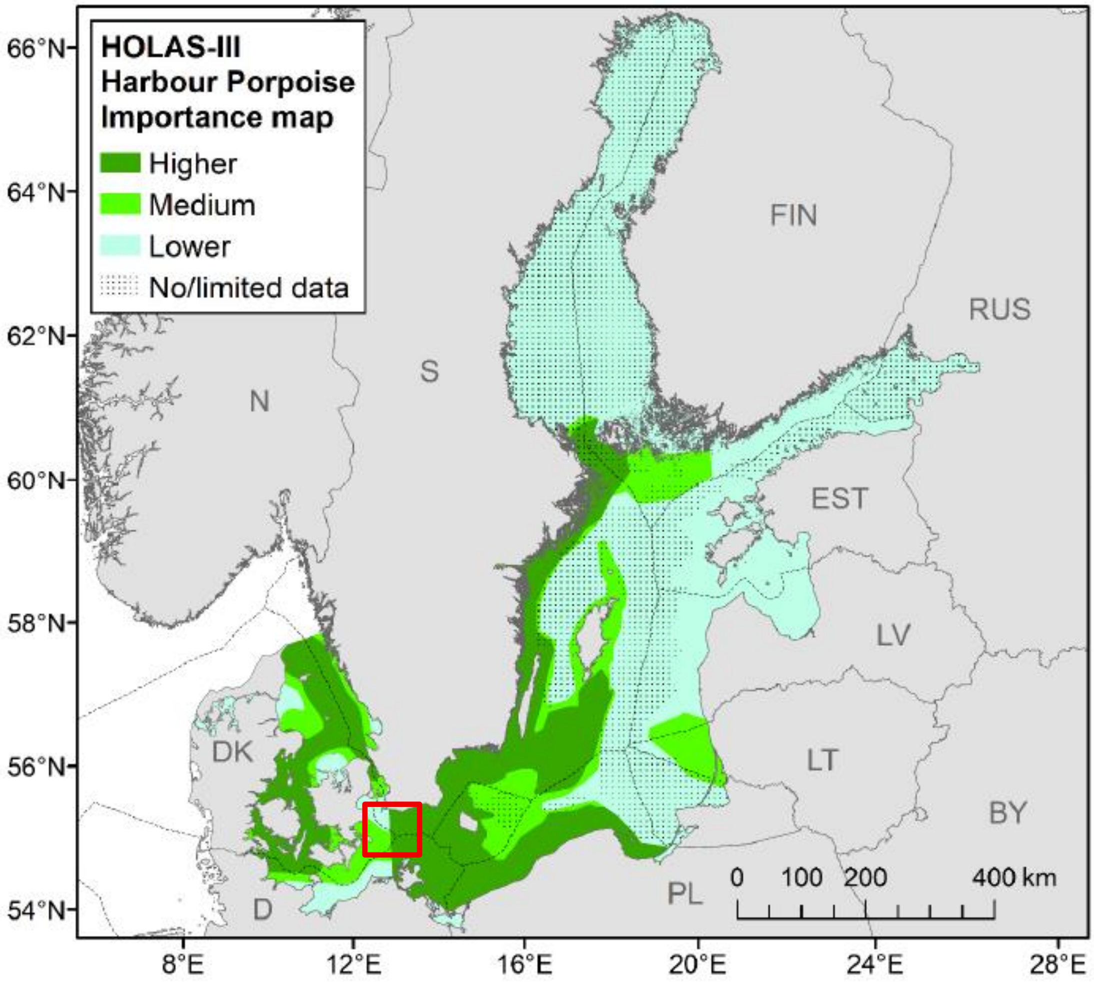

Figure 3-11. HOLAS III map of importance for harbour porpoises within the HELCOM area. From: SVEEGAARD ET AL. (2022). Approximate pre-investigation area is indicated in red.

Whilst the status of the global population (BRAULIK ET AL. 2020) and the European population (SHARPE & BERGGREN 2023) of the harbour porpoise is classified by the IUCN as least concern (LC), the Baltic Proper subpopulation is classified as critically endangered (CR; CARLSTRÖM ET AL. 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 Baltic Sea subpopulation is considered decreasing. The HELCOM Red List lists the Baltic Sea subpopulation as CR and the Belt Sea subpopulation as VU (HELCOM 2013c). The national Danish Red List classified the harbour porpoise as LC (AARHUS UNIVERSITET 2019), the German as highly threatened (MEINIG ET AL. 2020), and the Swedish lists the Baltic Sea subpopulation as CR (SLU SWEDISH SPECIES INFORMATION CENTRE 2023).

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 recovery plan for the Baltic harbour porpoise and a conservation plan for the harbour porpoise in the Western Baltic, Belt Sea and Kattegat (www.ascobans.org/en/documents/action-plans). Furthermore, the Baltic Sea states have agreed in HELCOM Recommendation 17/2 to protect the harbour porpoise in the Baltic Sea. For a summary see Table 3-3.

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

The Danish National 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).

Within Danish marine territory in the Baltic region, two distinct populations are present: one inhabiting the inner Danish waters and another located in the central Baltic Sea, including the marine area surrounding Bornholm. These populations are collectively assessed as having a severely 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 3-3. Listing of the harbour porpoise in international and regional conservation agreements and international and national Red Lists. * The population in the inner Danish waters.

Species	IUCN	HELCOM Red List	National Red Lists	Natura 2000 (BfN 2015)	Bern Convention	Bonn Convention
Harbour Porpoise *Phocoena phocoena*	Global: LC Europe: LC Baltic Sea 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 January 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 January 2025) will be shown. Data for 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 KF II N and KF II S.

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 surveys flights from February 2023 to January 2025. 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 KF II N and KF II S, digital aerial surveys were conducted using HiDef video technology (www.hidefsurveying.co.uk). Transect design for the pre-investigation area consisted of 13 transects aligned from north to south (Figure 4-1). The transects had a total length of 831 km varying between 24 km and 84 km with a distance between each transect line of 5 km (Table 4-1). On average, 11.4% of the 3,739 km² pre-investigation area was covered per flight (Table 4-1).

Table 4-1. Overview of the digital aerial surveys carried out in the pre-investigation area between February 2023 and January 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 [km²]	Coverage [%]
1	27.02.2023	833	431	11.5
2	04.04.2023	787	417	11.1
3	22.06.2023	790	421	11.2
4	16.08.2023	834	340	9.1
5	18.10.2023	796	415	11.1
6	23.12.2023	834	445	11.9
7	29.02.2024	835	445	11.9
8	15.04.2024	835	443	11.9
9	21.06.2024	836	446	11.9
10	13.08.2024	835	445	11.9
11	12.10.2024	834	445	11.9
12	01.12.2024	832	432	11.6
		Total: 9,881	**Total: 5,125**	**Average: 11.4**

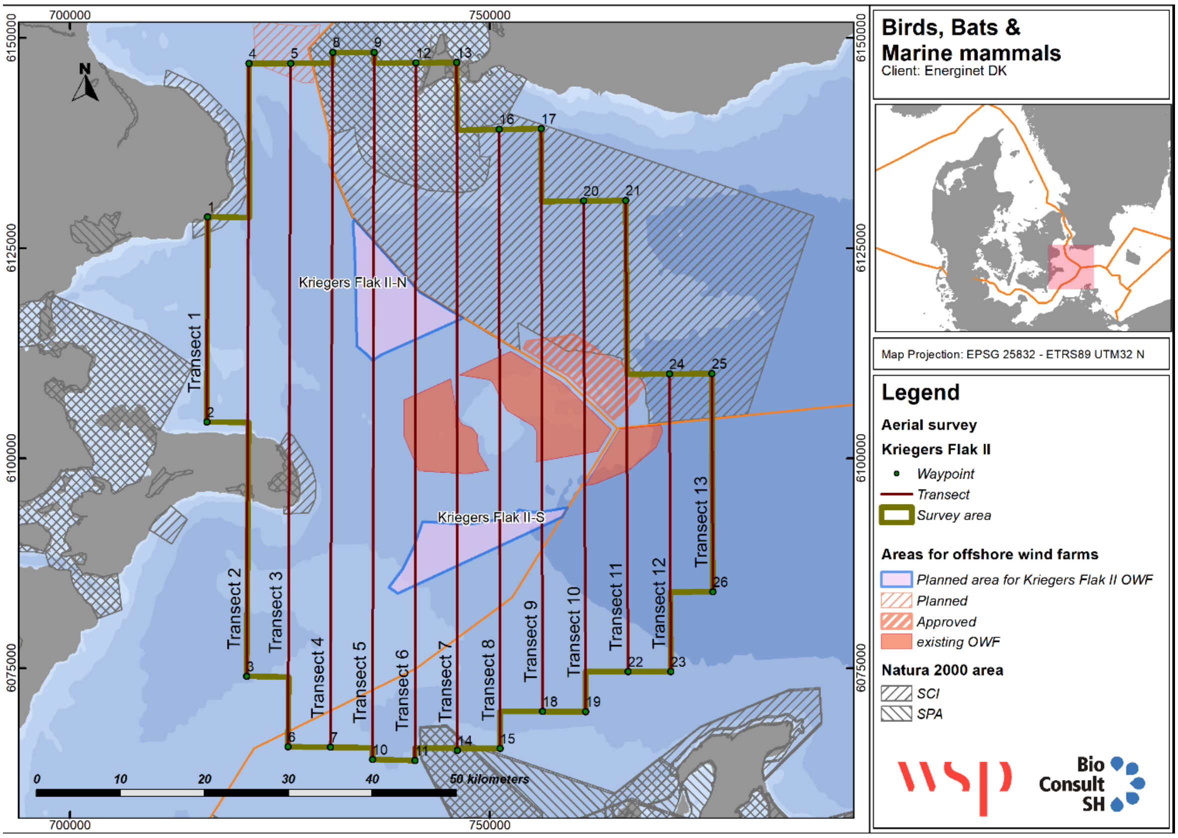

Figure 4-1. Transect design for aerial marine mammals' surveys in the pre-investigation area for KF II N and KF II S.

Table 4-2. Waypoints (WP) and Transects coordinates and lengths for aerial marine mammal surveys in the pre-investigation area for Kriegers Flak II N and KF II S.

Transect	Start Transektt	End Transekt	Length [km]
1	WP1: 55.25736°N; 12.40568°E	WP2: 55.03848°N; 12.38576°E	20.5
2	WP3: 54.76499°N; 12.43648°E	WP4: 55.41892°N; 12.49748°E	30.9
3	WP5: 55.41678°N; 12.57595°E	WP6: 54.68753°N; 12.50645°E	37.9
4	WP7: 54.68479°N; 12.58426°E	WP8: 55.42622°N; 12.65561°E	40.7
5	WP9: 55.42399°N; 12.73385°E	WP10: 54.66939°N; 12.6609°E	46.8
6	WP11: 54.66589°N; 12.73898°E	WP12: 55.41029°N; 12.81078°E	49.9
7	WP13: 55.40829°N; 12.88752°E	WP14: 54.67413°N; 12.81805°E	53.1
8	WP15: 54.67378°N; 12.8972°E	WP16: 55.33462°N; 12.95984°E	55.2
9	WP17: 55.33248°N; 13.03839°E	WP18: 54.71077°N; 12.97924°E	57.3
10	WP19: 54.70801°N; 13.05826°E	WP20: 55.25289°N; 13.10999°E	57.3
11	WP21: 55.25074°N; 13.18862°E	WP22: 54.74793°N; 13.14068°E	62.0
12	WP23: 54.74524°N; 13.21973°E	WP24: 55.06281°N; 13.2507°E	62.0
13	WP25: 55.06031°N; 13.32938°E	WP26: 54.82762°N; 13.30673°E	65.9

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 the sea surface. Since the camera system is not directed vertically downwards (depending on the position of the sun, 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 in width, while the internal ones cover a width of 129 m each, resulting effectively in 544 m 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, enabling precise geographic assignment of locations to both the captured images and the animals identified within them. The collected data were stored on mobile hard drives for subsequent review and analysis.

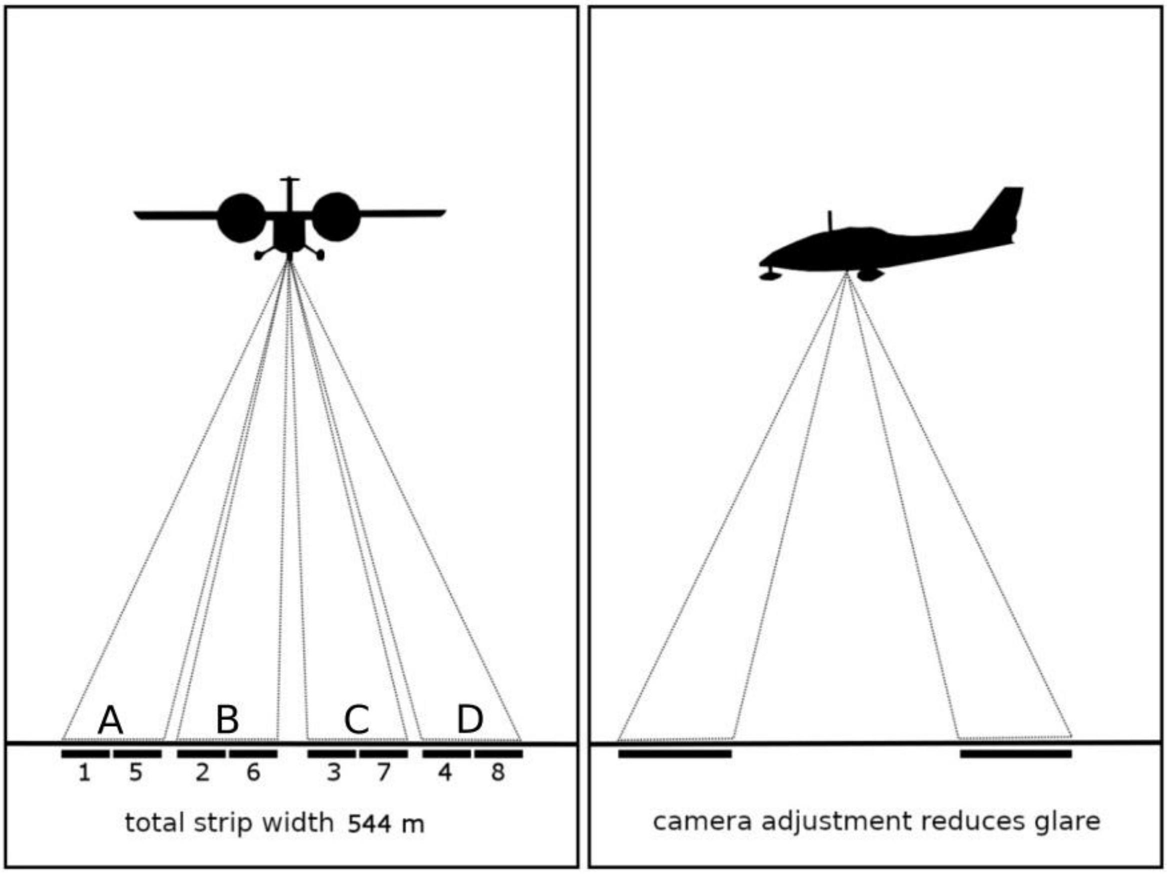

Figure 4-2. The HiDef Camera System. The four cameras (A to D) cover an effective strip width of 544 m of the sea surface at a flight altitude of 549 m (left: frontal view; right: side view). The numbering indicates the camera images as they are used in the evaluation (the images from each camera are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

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 about 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 can be multiplied by a factor that takes into account the probability of harbour porpoises being present in the upper level of the water column (0-2 m, TEILMANN ET AL. 2013). This likelihood was determined by means of tagged animals in the North- and Baltic Sea while considering seasonal fluctuations (Table 4-3).

The literature does not provide any information about the proportion of seals in the upper 2 m of the water column. Telemetry studies 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 porpoise 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 areas from KF II N and KF II S during the one-year survey period from February 2023 to January 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. Detection rates were positively correlated with the number of tagged animals present in a given area, indicating that areas with higher porpoise activity yielded more frequent acoustic detections. One of the advantages of PAM is the very high temporal resolution. Therefore, even short-term patterns can be investigated. Furthermore, C-PODs are capable of continuously recording data, a major advantage in comparison to other survey methods like aerial or ship-based surveys. This produces large quantities of data, allowing for robust statistical analyses. Furthermore, C-PODs also record harbour porpoises at night, whereas aerial and ship-based surveys are limited to daylight hours. A disadvantage of the PAM method is the small spatial coverage. The detection range of a C-POD reaches only up to about appr. 300 meters, and it depends on the direction into which the harbour porpoise click was sent out by the animal. Only deployment of several C-PODs at different locations, like in the present study, allows for analysis of the spatial distribution of harbour porpoises.

4.2.1 STUDY DESIGN

A total of 16 C-PODs (F-O1 to F-O8 and F-R1 to F-R8) were deployed for PAM of harbour porpoises in the pre-investigation area in the Western Baltic Sea (Figure 4-3; Table 4-4).

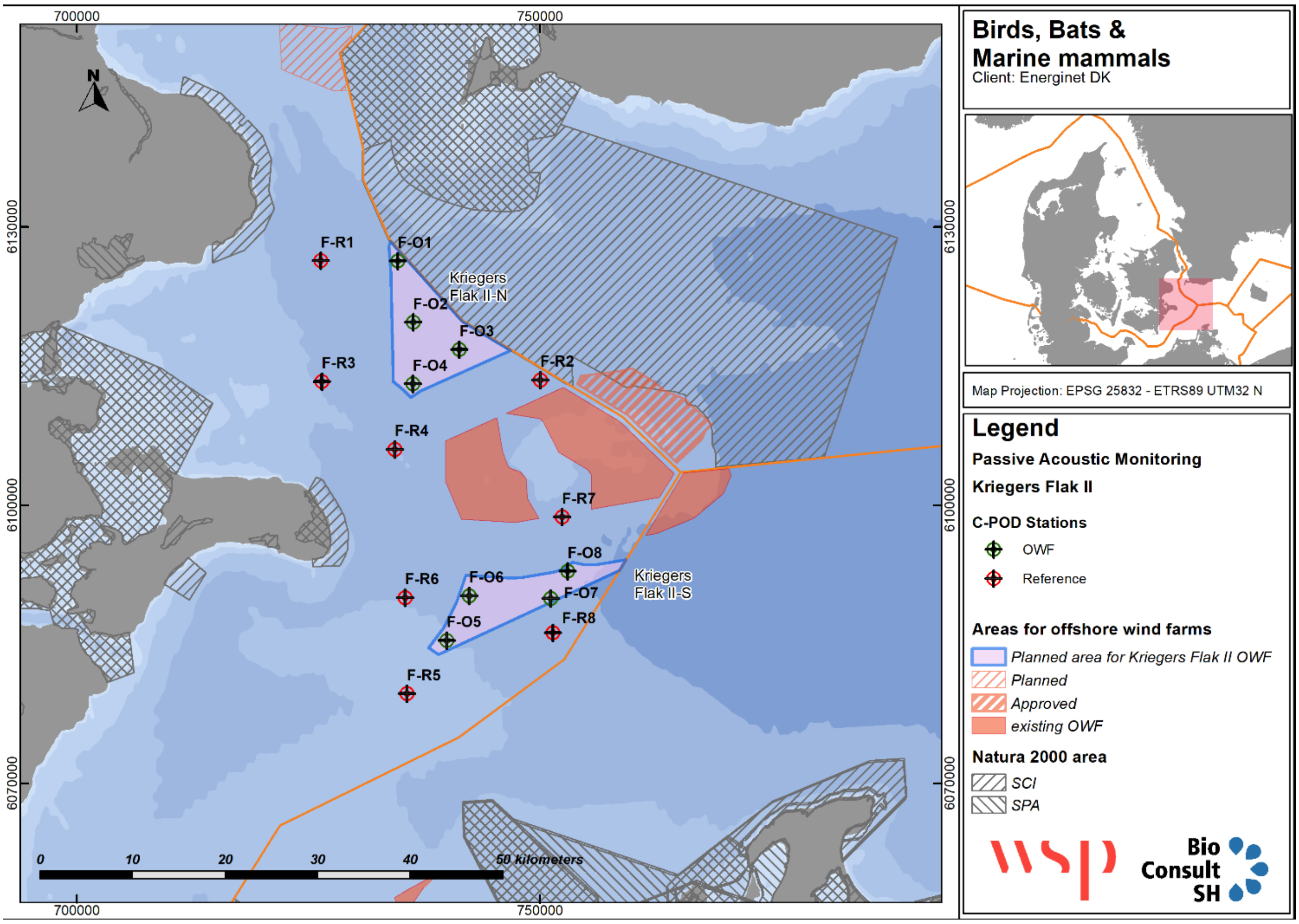

Figure 4-3. C-POD design inside and outside the planned windfarm areas of KF II N and KF II S.

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)
F-O1	55.227677	12.690192	55° 13' 39.64'' N	12° 41' 24.69'' E
F-O2	55.167744	12.710919	55° 10' 03.88'' N	12° 42' 39.31'' E
F-O3	55.138938	12.786561	55° 08' 20.18'' N	12° 47' 11.62'' E
F-O4	55.108120	12.704763	55° 06' 29.23'' N	12° 42' 17.15'' E
F-O5	54.858534	12.738946	54° 51' 30.72'' N	12° 44' 20.21'' E
F-O6	54.900388	12.780795	54° 54' 01.40'' N	12° 46' 50.86'' E
F-O7	54.893524	12.917329	54° 53' 36.69'' N	12° 55' 02.38'' E
F-O8	54.918788	12.948089	54° 55' 07.64'' N	12° 56' 53.12'' E
F-R1	55.232059	12.559632	55° 13' 55.41'' N	12° 33' 34.68'' E
F-R2	55.105177	12.920309	55° 06' 18.64'' N	12° 55' 13.11'' E
F-R3	55.115174	12.551529	55° 06' 54.63'' N	12° 33' 05.50'' E
F-R4	55.045845	12.668195	55° 02' 45.04'' N	12° 40' 05.50'' E
F-R5	54.809000	12.667616	54° 48' 32.40'' N	12° 40' 03.42'' E
F-R6	54.901906	12.672705	54° 54' 06.86'' N	12° 40' 21.74'' E
F-R7	54.971533	12.943873	54° 58' 17.52'' N	12° 56' 37.94'' E
F-R8	54.860297	12.917251	54° 51' 37.07'' N	12° 55' 02.10'' E

All 16 C-POD stations were deployed from 7th and 8th of February 2023 to 4th and 5th of February 2025 (Y1+Y2) with the permission from the Danish Maritime Authority. Only data until 31st of January was analysed in order to ensure that the dataset clearly represents the two complete years and is not biased by partial data from February 2025. The maintenance of C-PODs at sea (e.g. extract data and change the batteries) was done every two months to avoid potential data gaps due to losses or malfunctions.

The deployment and recording periods of the C-PODs for all monitoring stations are shown in Figure 4-4. There were varying degrees of data loss at eight stations at different times during the study period: F-O1 in February-March 2024, F-O8 in February-March 2023, F-R2 in May 2024, F-R3 in June-July 2024, F-R4 in April-May 2023 and December 2024-January 2025, F-R5 in February-March and October 2024, F-R7 in June-July 2024, and F-R8 in October-November 2024 (Figure 4-4).

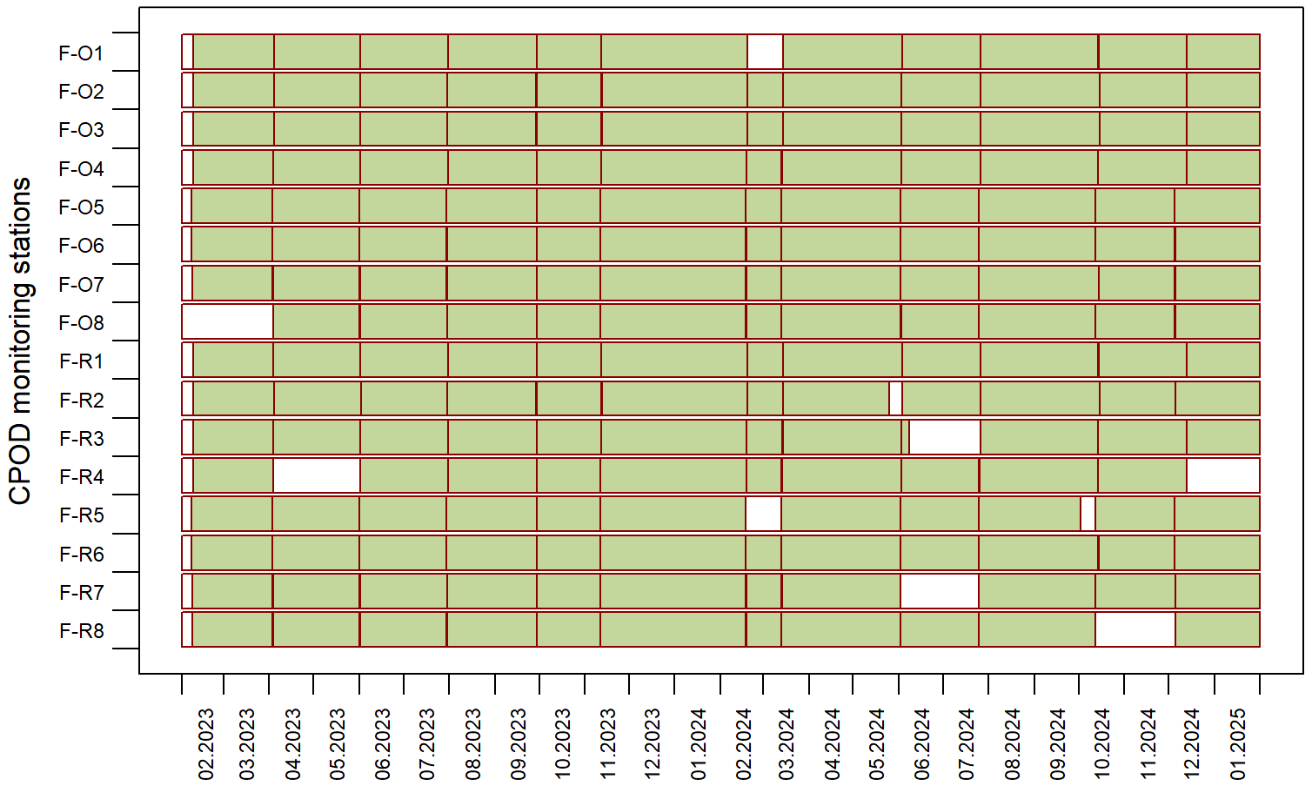

Figure 4-4. Bar chart, indicating the duration of deployment of C-PODs within the pre-investigation area for the two-year survey period (February 2023 to January 2025; Y1+Y2). Green: C-POD recorded data, white: no data. The x-axis shows the date, the y-axis the C-POD station. Vertical lines indicate the time of exchange/service 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 (Timing POrpoise Detector) 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.

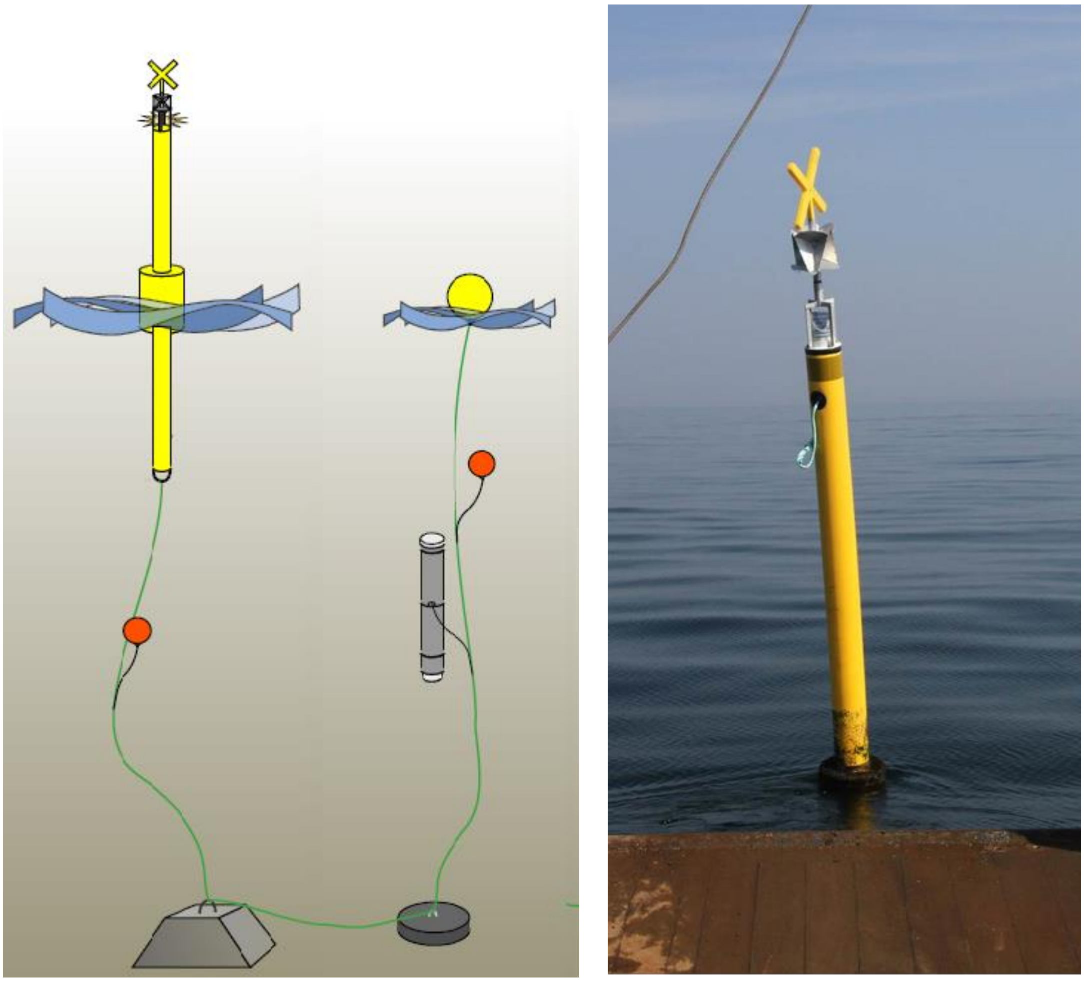

Figure 4-6. C-POD mooring system with spar buoys.

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 behavior 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; SCHUBERT ET AL. 2019). It can therefore be assumed that a higher detection rate indicates a higher presence of harbour porpoise 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 harbor porpoise detections, as observed in the current pre-investigation area. The parameter is standardized to values between 0 and 100 as %DPD/month, taking the number of recording days per month as 100%. In areas with low porpoise abundance, i. e., great parts of the eastern Baltic Sea, the daily presence of harbour porpoises has more explanatory power than the (daily) frequency of occurrences (see %DP10M/day). That is because analyses based on an hourly or even minute-by-minute basis have a high susceptibility to randomness due to very infrequent recording and thus only have a low informative value. To meet 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 (ROSE 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 378 days of 11,592 possible monitoring days (3.3%) for Y1 and Y2 combined for all 16 C-PODs combined could not be included in the evaluation due to data loss (Figure 4-4); 11,214 C-POD monitoring days remained for further consideration. About 3.1% of all C-POD monitoring days did not meet the noise criteria described above and were therefore discarded. Hence, 10,863 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. No data were available for the German grey seal haul-out sites at Rügen and Poel as there was no breeding recorded in recent years (only historically, GALATIUS ET AL. 2020). These data will be used to study the annual numbers of seals in the vicinity of the proposed offshore 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 & HØGSLUND (2021). In contrast to HANSEN & HØGSLUND (2021), data was not corrected for seals at sea during haul-out counts. Therefore, the true abundance may be much higher as in some areas, around 60% of seals may be at sea during counts (HANSEN & HØGSLUND 2021; HANSEN ET AL. 2024).

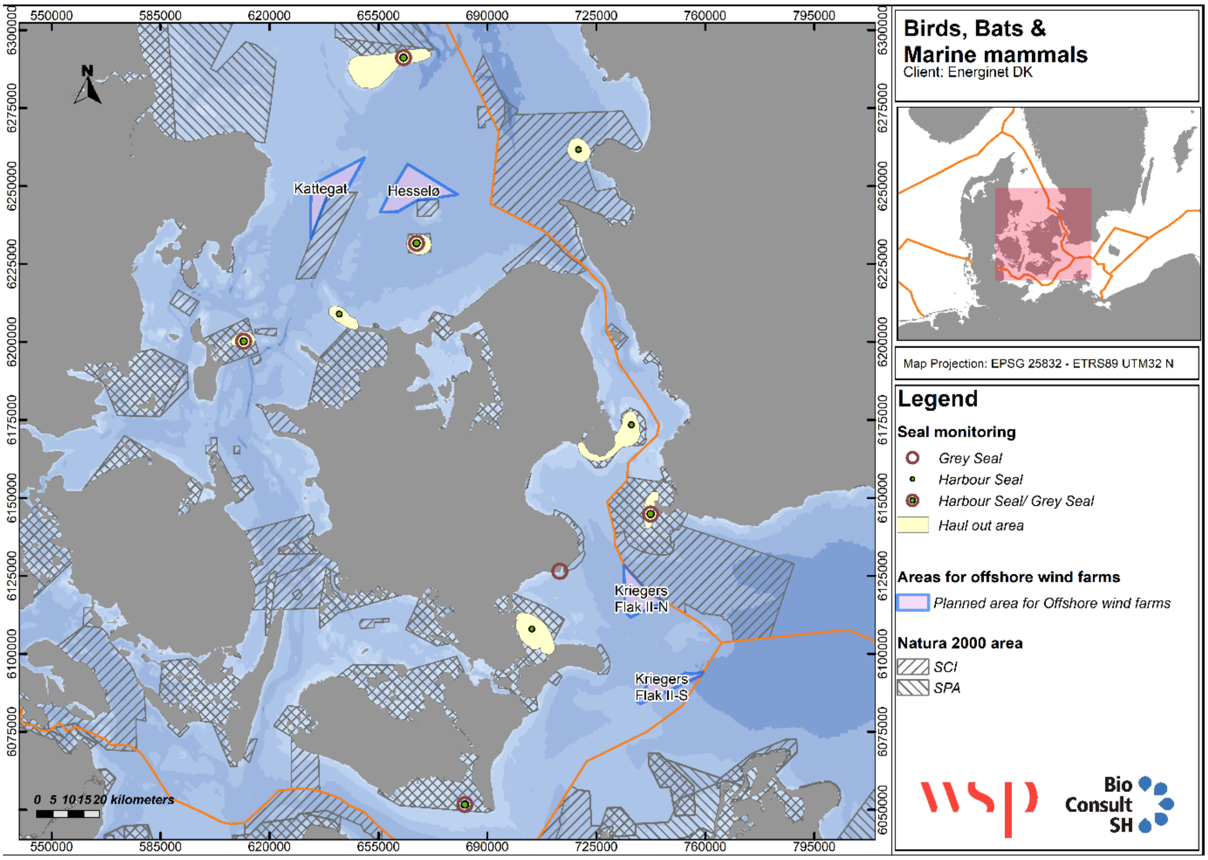

Figure 4-7. Haul-out sites of Harbour Seals and Grey Seals in the vicinity of the windfarm areas Kattegat II, Hesselø Syd, Kriegers Flak II N and Kriegers Flak II S. The distribution of seals and prey on beaches and sandbanks shown is adapted from Hansen & Høgslund (2021) and Søndergaard et al. (1976).

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

ID	Name	Type	Lat	Long	Seal Spec.	Natura 2000 EU	Natura 2000 DK
1	Bosserne	Haul out	55.93373151	10.78840203	both	DK00DX155	N55
2	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 January 2025 (Y1 + Y2), a total of 594 marine mammals (Figure 5-1 and Table 5-1) 427 seals (89 harbour seals, 98 grey seals, 240 seals), 155 harbour porpoises and 12 unidentified marine mammals) were observed during the 12 digital aerial surveys. The 12 unidentified marine mammals most likely belong to one of the two categories of harbour porpoise or unidentified seal.

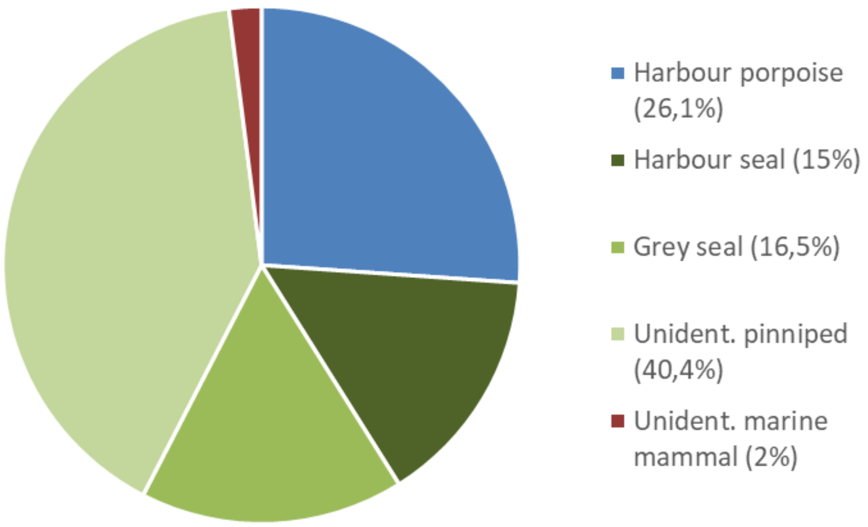

Figure 5-1. Proportion of different marine mammal observations in the pre-investigation area during aerial surveys between February 2023 and January 2025 (Y1+Y2).

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

Survey no.	Date	Effort [km²]	Harbour seal [Ind.]	Grey Seal [Ind.]	Unidentified seal [Ind.]	Seals (total)	Harbour porpoises [Ind.]	unidentified marine mammal [Ind.]
1	27.02.23	431	1	0	9	10	5	2
2	04.04.23	417	1	5	10	16	9	0
3	22.06.23	421	23	0	4	27	34	0
4	16.08.23	340	1	0	0	1	12	0
5	18.10.23	415	41	0	2	43	10	1
6	23.12.23	445	0	0	3	3	4	4
7	29.02.24	445	0	1	37	38	3	0
8	15.04.24	443	2	7	22	31	28	4
9	21.06.24	446	19	9	11	39	25	1
10	13.08.24	445	0	42	48	90	3	0
11	12.10.24	445	0	0	0	0	17	0
12	01.12.24	432	1	34	94	129	5	0
	Total	**5,125**	**89**	**98**	**240**	**427**	**155**	**12**

Furthermore, passive acoustic monitoring with a total of 16 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 93% 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 427 seals that were observed during the 12 digital aerial surveys, 43.8% could be identified to species level (Figure 5-2 and Table 5-1). These were divided into 20.8% harbour seals (n=89) and 23% grey seals (n=98). Considering that 56.2% of the observed seals could not be identified to species level (n=240), all observed seals will in the following be analysed together as seals wherever relevant.

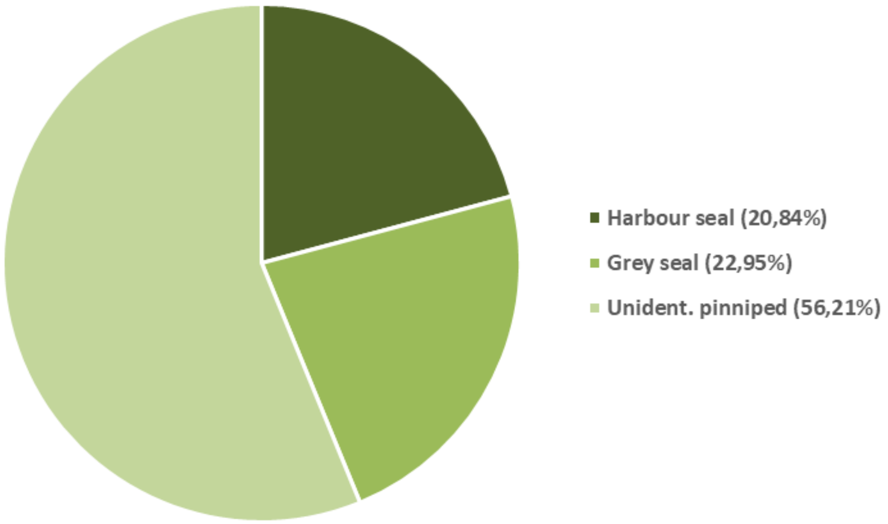

Figure 5-2. Proportion of harbour seal, grey seal and unidentified seal observations in the pre-investigation area during aerial surveys between February 2023 and January 2025 (Y1+Y2).

SEASONAL DISTRIBUTION

In 2023, grey seals were observed only once, on April 4th. By contrast, in 2024, they were detected during five of the six aerial survey flights—specifically in February, April, June, August, and December (see

and Figure 5-3). Harbour seals showed the opposite pattern: they were recorded on five flights in 2023 (every flight except December) but appeared in only half of the surveys in 2024-namely April, June, and December. When combining data from both years, grey seals reached their highest densities in August and December 2024, with 0.094 and 0.079 Ind./km², respectively. Harbour seals had the highest recorded density in October 2023 with 0.099 Ind./km² (Table 5-2).

Table 5-2. Seal densities in the pre-investigation area during aerial surveys between February 2023 and January 2025 (Y1+Y2). Harbour seal, grey seal and unidentified seal. All observed seals are summarised 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	27.02.23	431	0.002	0	0.021	0.023
2	04.04.23	417	0.002	0.012	0.024	0.038
3	22.06.23	421	0.055	0	0.010	0.064
4	16.08.23	340	0.003	0	0	0.003
5	18.10.23	415	0.099	0	0.005	0.104
6	23.12.23	445	0	0	0.007	0.007
7	29.02.24	445	0	0.002	0.083	0.085
8	15.04.24	443	0.005	0.016	0.050	0.07
9	21.06.24	446	0.043	0.020	0.025	0.087
10	13.08.24	445	0	0.094	0.108	0.202
11	12.10.24	445	0	0	0	0
12	01.12.24	432	0.002	0.079	0.217	0.298
		Total: 5,125	**Avg: 0.0176**	**Avg: 0.0186**	**Avg: 0.0458**	**Avg:0.0818**

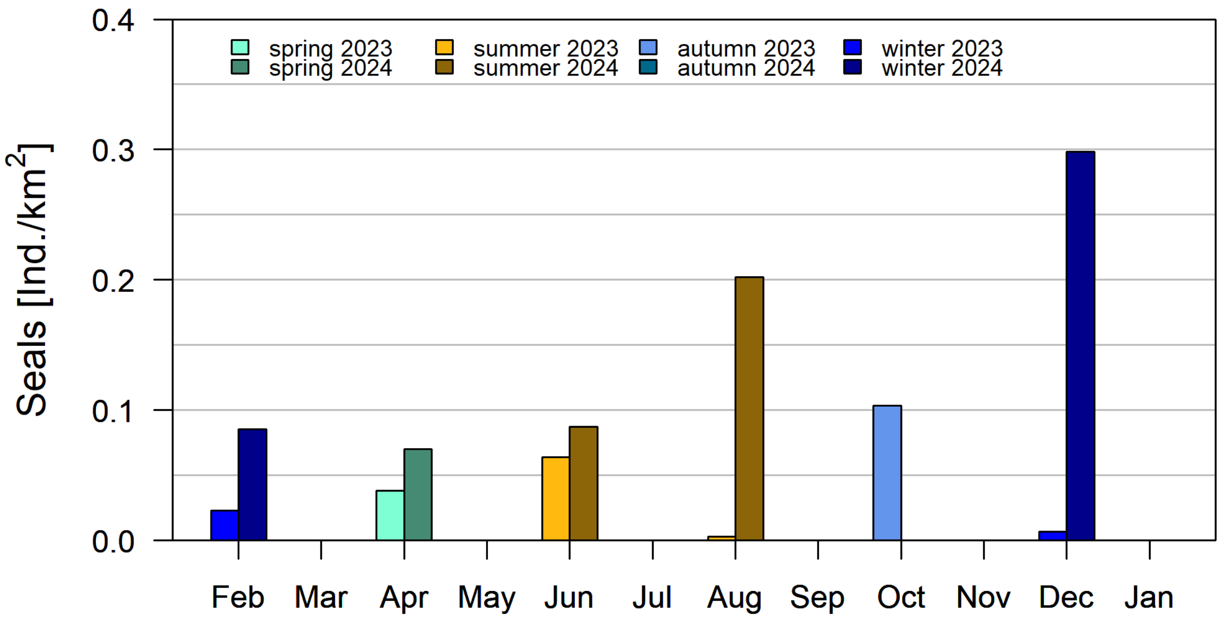

Figure 5-3. Mean seal density (Ind./km²) per month (harbour seal, grey seal and unidentified seals) during the study period (February 2023 – January 2025; Y1+Y2). In months without a bar, no surveys were carried out. The seasons are colour-coded.

Overall, harbour seals only had a mariginally higher abundance than grey seals with 23% vs 20.8% of all individuals (Figure 5-2). The difference in abundance between the two species is primarily based on 2024 (Y2) data, as harbour seals were the more dominant species in 2023 (Y1), with more than 85% of all individuals. However, 56.2% of all sightings were still made up of unidentified seals (Table 5-2).

In general, the highest density for all seals combined was observed in winter 2024, with 0.298 Ind./km² (December 2024), followed by late summer 2024 with 0.202 Ind./km² (August 2024) and autumn 2023 with 0.104 Ind./km² (October 2023; Table 5-2). The remainder of the surveys showed some variability in densities; all had densities below 0.1 Ind./km², with the lowest densities encountered in August and December 2023 (0.003 Ind./km² and 0.007 Ind./km², respectively; Figure 4-2).

SPATIAL DISTRIBUTION

Most seal sightings during the study period occurred in the northern part of the pre-investigation area. Notably, 95.8% of all observations took place within one of two Swedish Sites of Community Importance (SCIs) designated under the EU Natura 2000 Habitats Directive: *Falsterbohalvön* (SE0430095) and *Sydvästskånes utsjövatten* (SE0430187), where both harbour and grey seals are considered important species.
In contrast, only 13 individual sightings were recorded in the western or southern sections of the pre-investigation area (Figure 5-5; Appendix Figure 9-1). Most detections involved single individuals, but some groupings were observed: 19 groups contained between 2 and 10 seals, and 10 groups exceeded 10 individuals. The highest aggregation of 41 harbour seals was recorded at the *Måkläppen/Falsterbo* site.

Seal densities surpassed 4 Ind./km² in the relevant grid cell during summer, autumn, and winter. In comparison, most other grid cells showed densities below 1 Ind./km² (Figure 5-4).

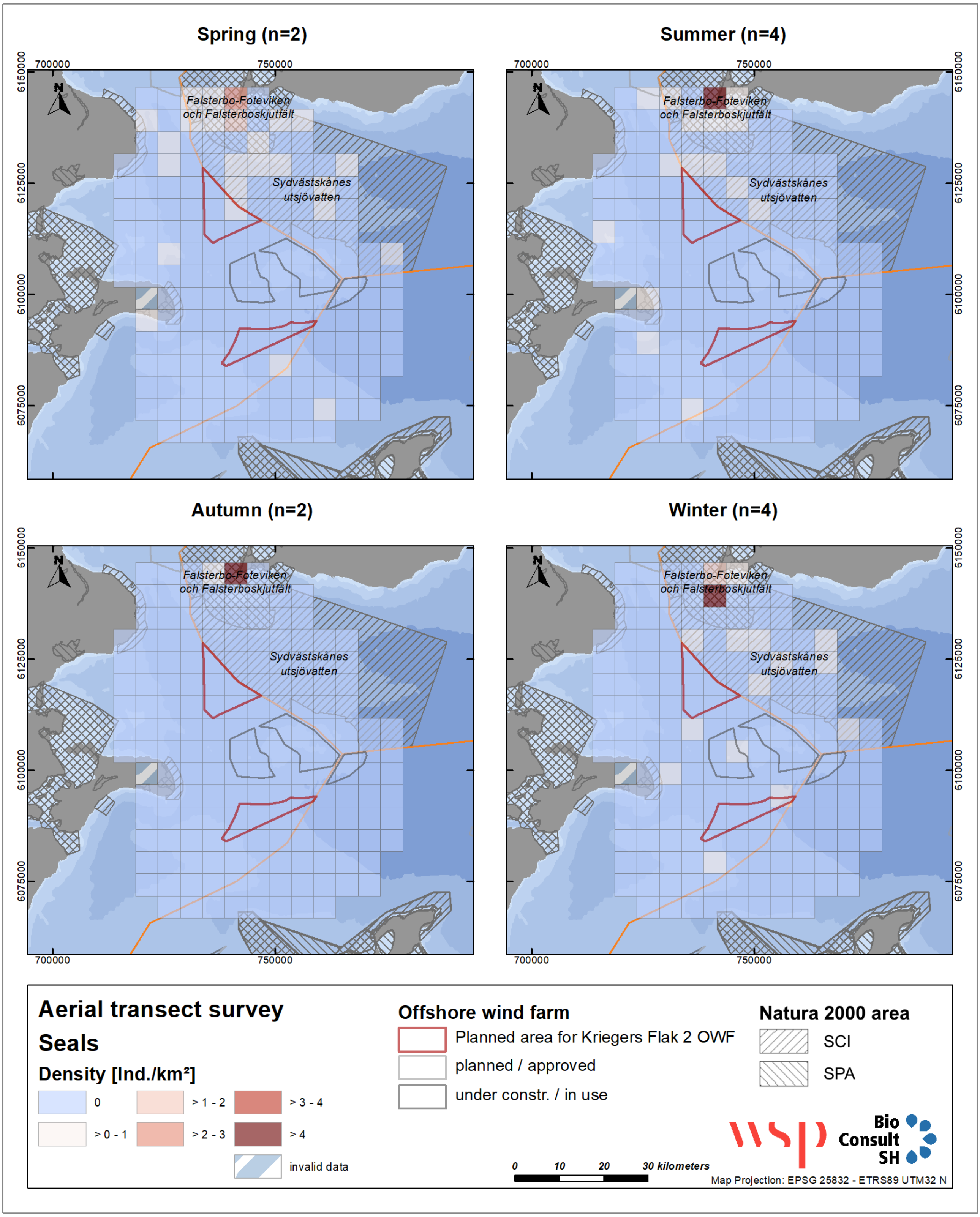

Figure 5-4. Spatial distribution of seals during aerial surveys between February 2023 and January 2025 (Y1+Y2). The number (n) of digital aerial surveys included to calculate seasonal densities is given in the title of the respective panel.

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 (namely Hesselø, Anholt, Bosserne and Hallands Väderö) contribute with about 90% of all harbour seals counted during the different monitoring programs. The haul-out site at Hesselø was the most important one 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, only Måkläppen and Bøgestrøm, which account for approximately 5% of harbour seals in the Kattegat/Western Baltic area, are within 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.

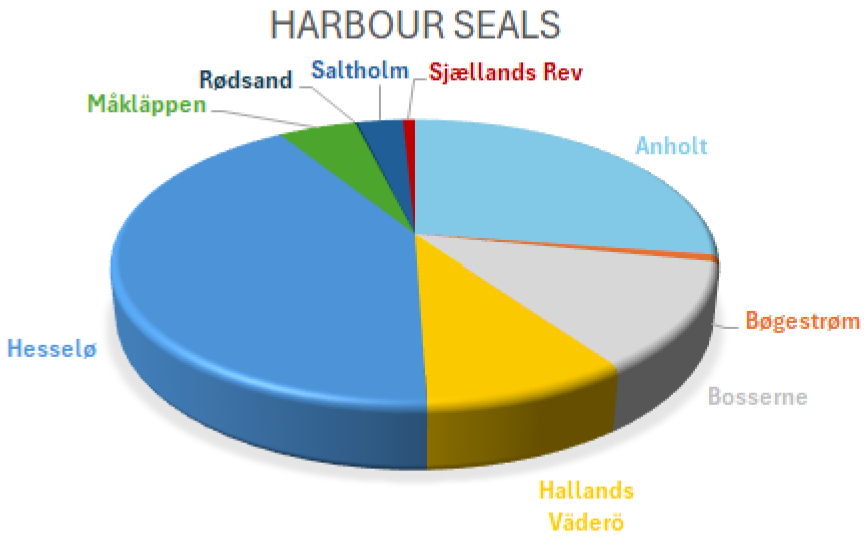

Figure 5-5. Composition (percentage of total counted individuals) of the harbour seal haul-out sites to the abundance in the Kattegat and southwestern Baltic area between 2013 and 2023.

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).

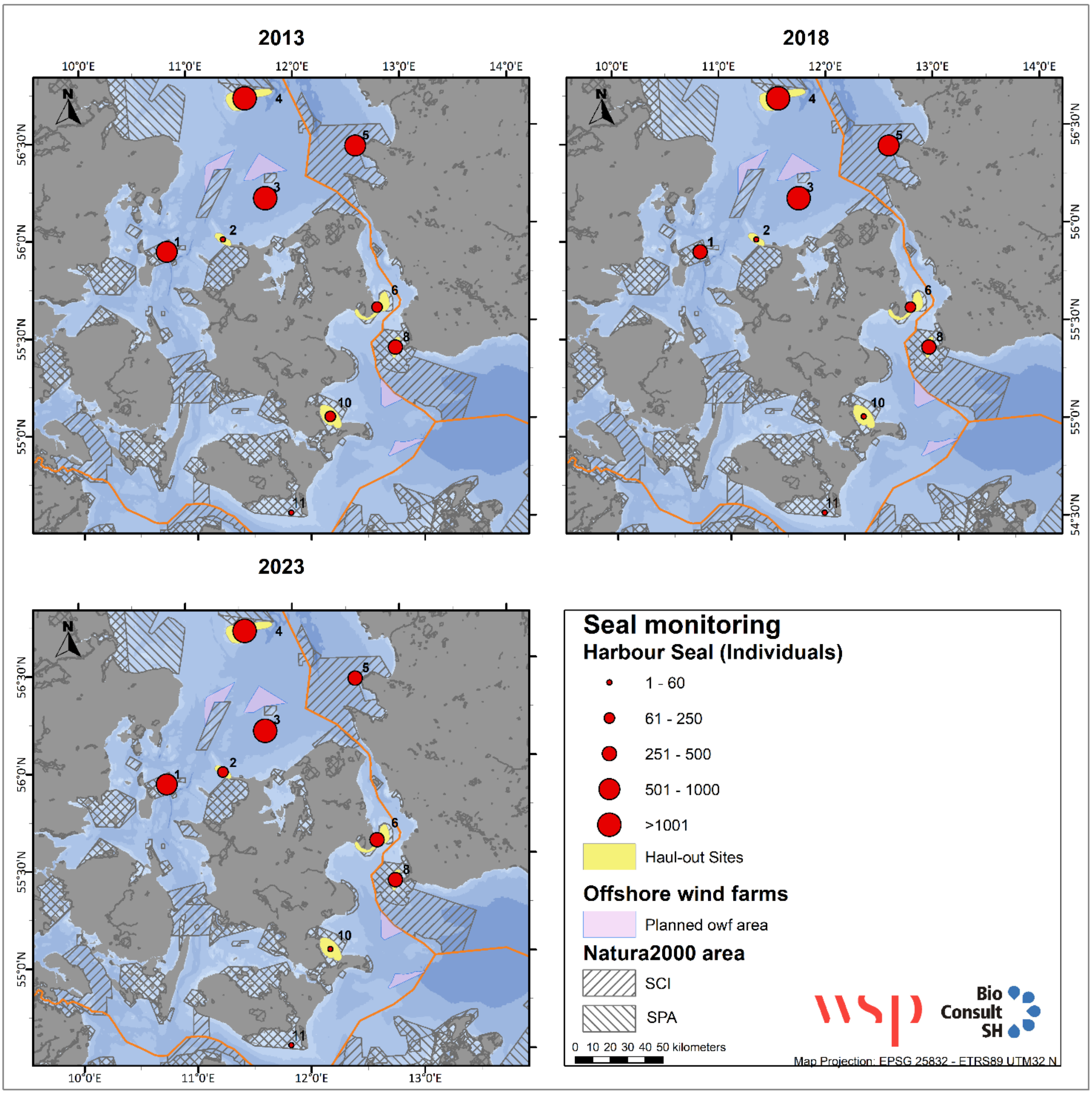

Figure 5-6. Counts of harbour seals at haul-out sites in the Kattegat and southwestern Baltic area in 2013, 2018 and 2023 (data provided by DCE – Nationalt Center for Miljø og Energi and Swedish Museum of Natural History.

Overall, 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.

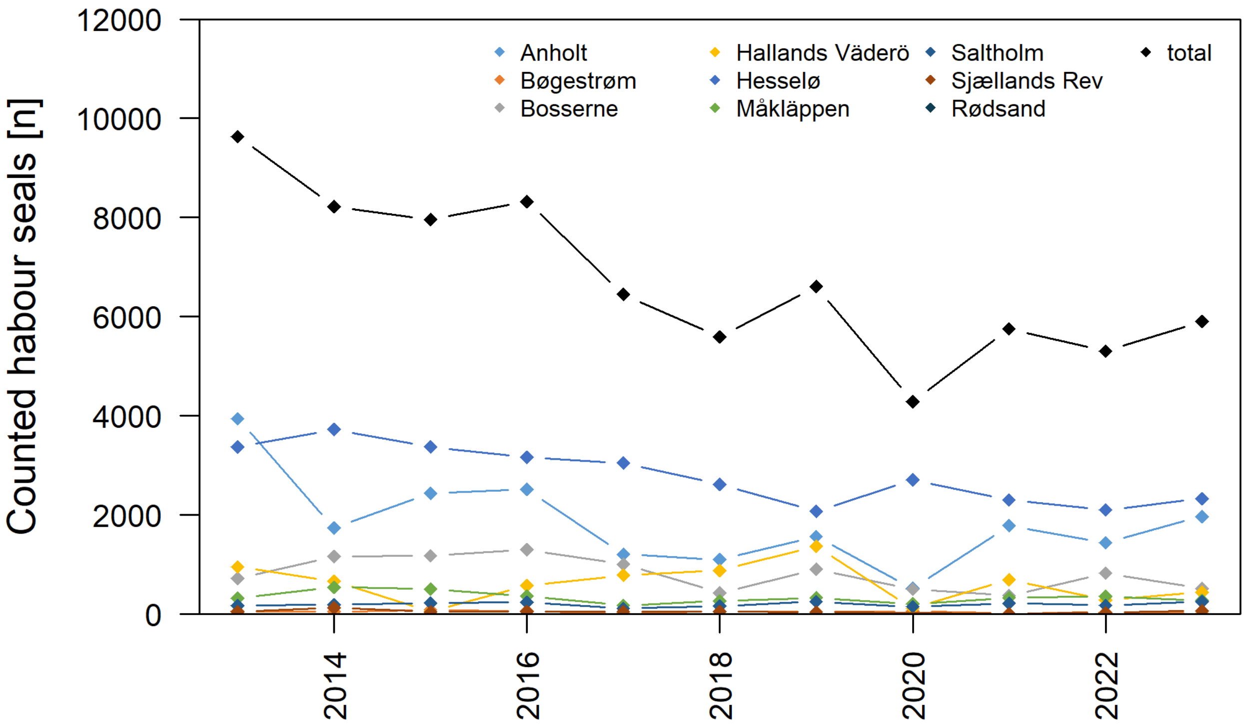

Figure 5-7. Development of the harbour seal abundance at certain haul-out sites in the Kattegat and southwestern Baltic area between 2013 and 2023.

GREY SEALS

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

The abundance at the five 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, only Måkläppen, which is the most important grey seal haul-out site in the Kattegat/Western Baltic area, is within regular foraging distance from the planned windfarm areas.

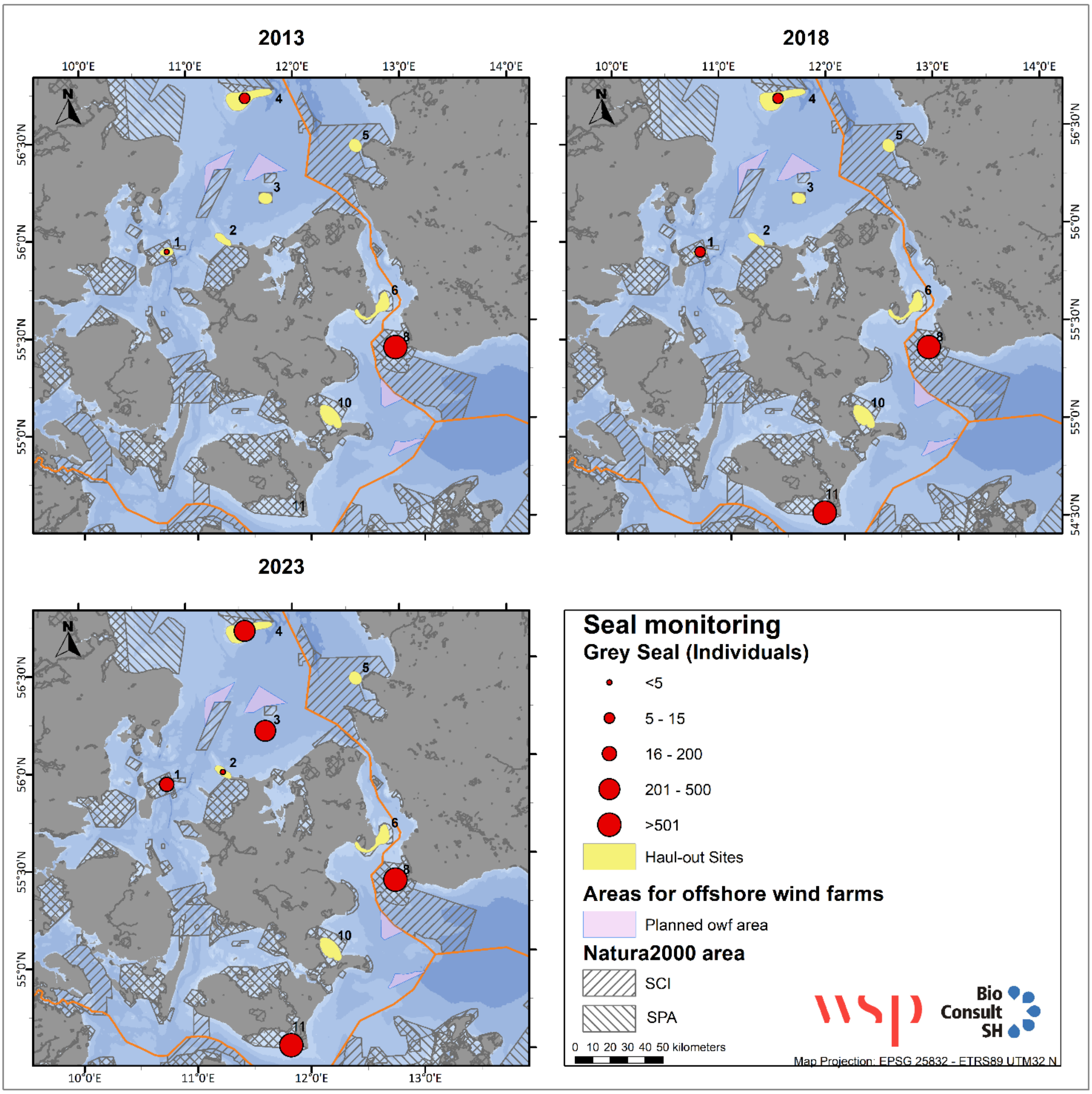

Figure 5-8. Counts of grey seals at haul-out sites in the Kattegat and southwestern Baltic area in 2013, 2018 and 2023 (data provided by DCE – Nationalt Center for Miljø og Energi and Swedish Museum of Natural History).

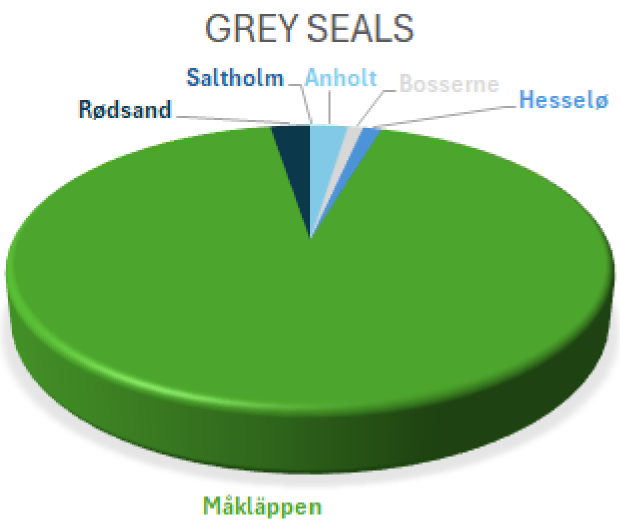

Figure 5-9. Composition (percentage of total counted individuals) of the grey seal haul-out sites to the abundance in the Kattegat and southwestern Baltic area between 2013 and 2023.

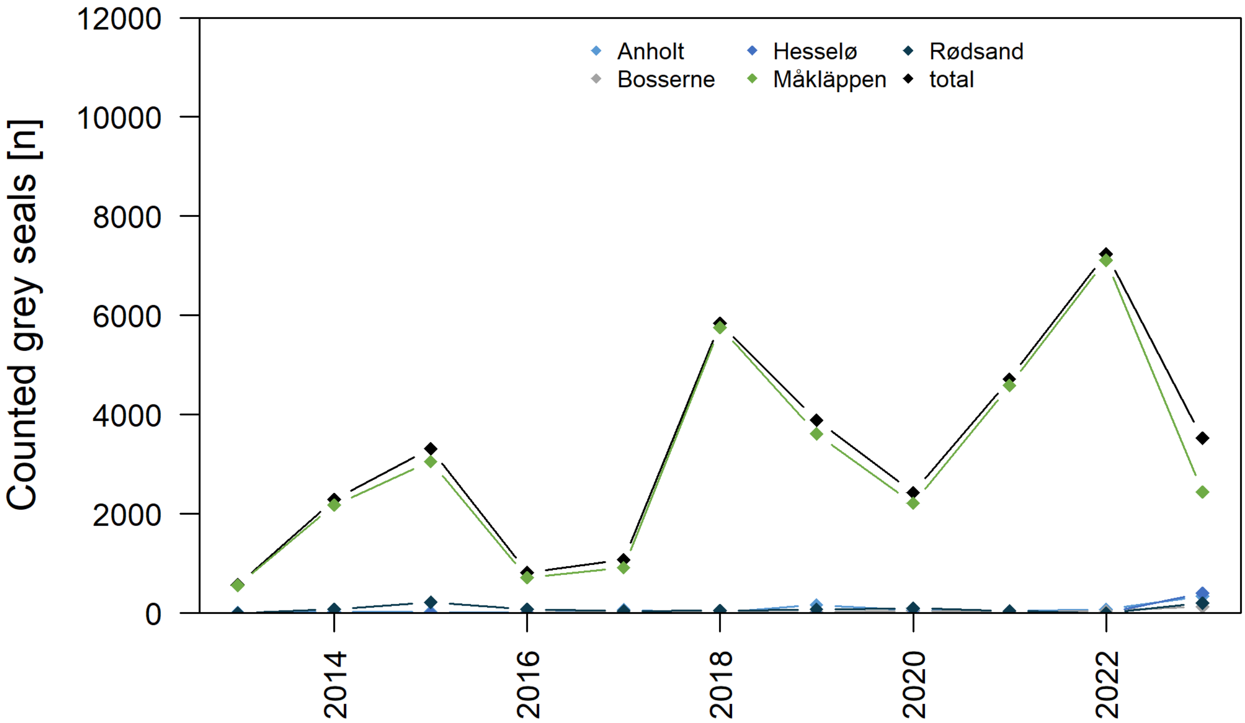

Figure 5-10. Development of the grey seal abundance at certain haul-out sites in the Kattegat and southwestern Baltic area between 2013 and 2023.

5.2 HARBOUR PORPOISES

The harbour porpoise was with 155 individual sightings the most abundant marine mammal species during the 12 digital aerial surveys between February 2023 and January 2025 (Y1+Y2). Detection rates were relatively high, ranging from 79.5%DPD/t to 99.3%DPD/t among stations, with a mean value of 93% across all stations.

5.2.1 DIGITAL AERIAL SURVEYS

SEASONAL DISTRIBUTION

Harbour porpoises were observed during all 12 surveys. The highest densities were observed during summer 2023 and 2024 and spring 2024, with 0.146 Ind./km² for June 2023 and 0.103 Ind./km² and 0.101 Ind./km² for April and June 2024, respectively (Table 5-3 and Figure 5-11). Densities during the August 2023 survey and October 2023 and 2024 surveys were 0.068 Ind./km², 0.053 Ind./km² and 0.084 Ind./km², respectively (Table 5-3

and Figure 5-11). Densities during the remaining surveys (February, April and December 2023; February, August, December 2024) were all below 0.05 Ind./km² (Table 5-3 and Figure 5-12). Four aerial surveys were conducted during the calving period from mid-May until September in 2023 and 2024. During one of these surveys (June 2023), 2 juveniles were observed, which results in a proportion of juveniles of 2.7% during the summer (Table 5-3).

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

Survey no.	Date	Effort [km²]	Harbour porpoise [Ind.]	Juveniles [Ind.]	Harbour porpoise [Ind./km²]
1	27.02.23	431	5	0	0.027
2	04.04.23	417	9	0	0.035
3	22.06.23	421	34	2	0.146
4	16.08.23	340	12	0	0.068
5	18.10.23	415	10	0	0.053
6	23.12.23	445	4	0	0.018
7	29.02.24	445	3	0	0.016
8	15.04.24	443	28	0	0.103
9	21.06.24	446	25	0	0.101
10	13.08.24	445	3	0	0.013
11	12.10.24	445	17	0	0.084
12	01.12.24	432	5	0	0.023
		Total: 5,125	**Total: 155**	**Total: 2**	**Avg: 0.0573**

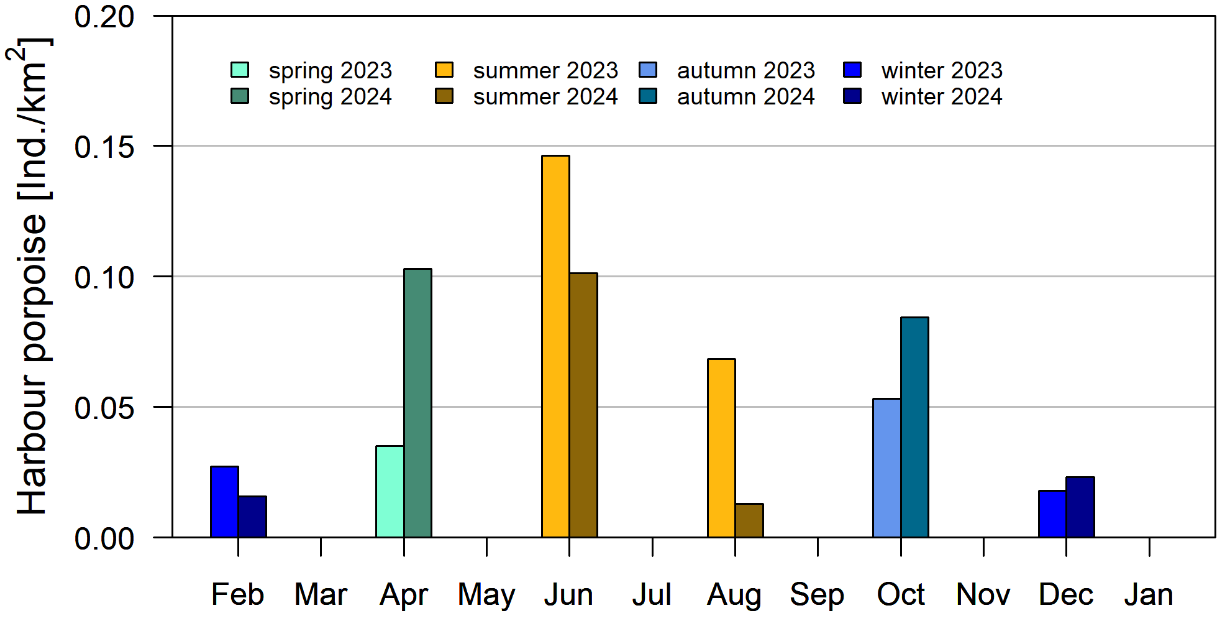

Figure 5-11. Mean harbour porpoise density (Ind./km²) per month in the study period (February 2023 – January 2025; Y1+Y2). In months without a bar, no surveys were carried out. The seasons are colour-coded.

SPATIAL DISTRIBUTION

Harbour porpoises were distributed throughout the pre-investigation area with no clear preference. However, the majority of sightings were concentrated in the central part of the pre-investigation area during summer, and in the southern part during spring. Additionally, the sightings were concentrated in the vicinity of the operational Kriegers Flak windfarm, as well as in the central to western sections of the pre-investigation area near Møn (Figure 5-12, Figure 5-13 and in the Appendix).

During summer counts, harbour porpoises were more widely distributed across the pre-investigation area compared to seals. Notably, 80% of sightings occurred outside the two Swedish Sites of Community Importance (SCIs) designated under the Natura 2000 Habitats Directive: *Falsterbohalvön* (SE0430095) and *Sydvästskånes utsjövatten* (SE0430187). Only 28 individuals were observed within *Sydvästskånes utsjövatten* (SE0430187), where harbour porpoises are listed as important species.

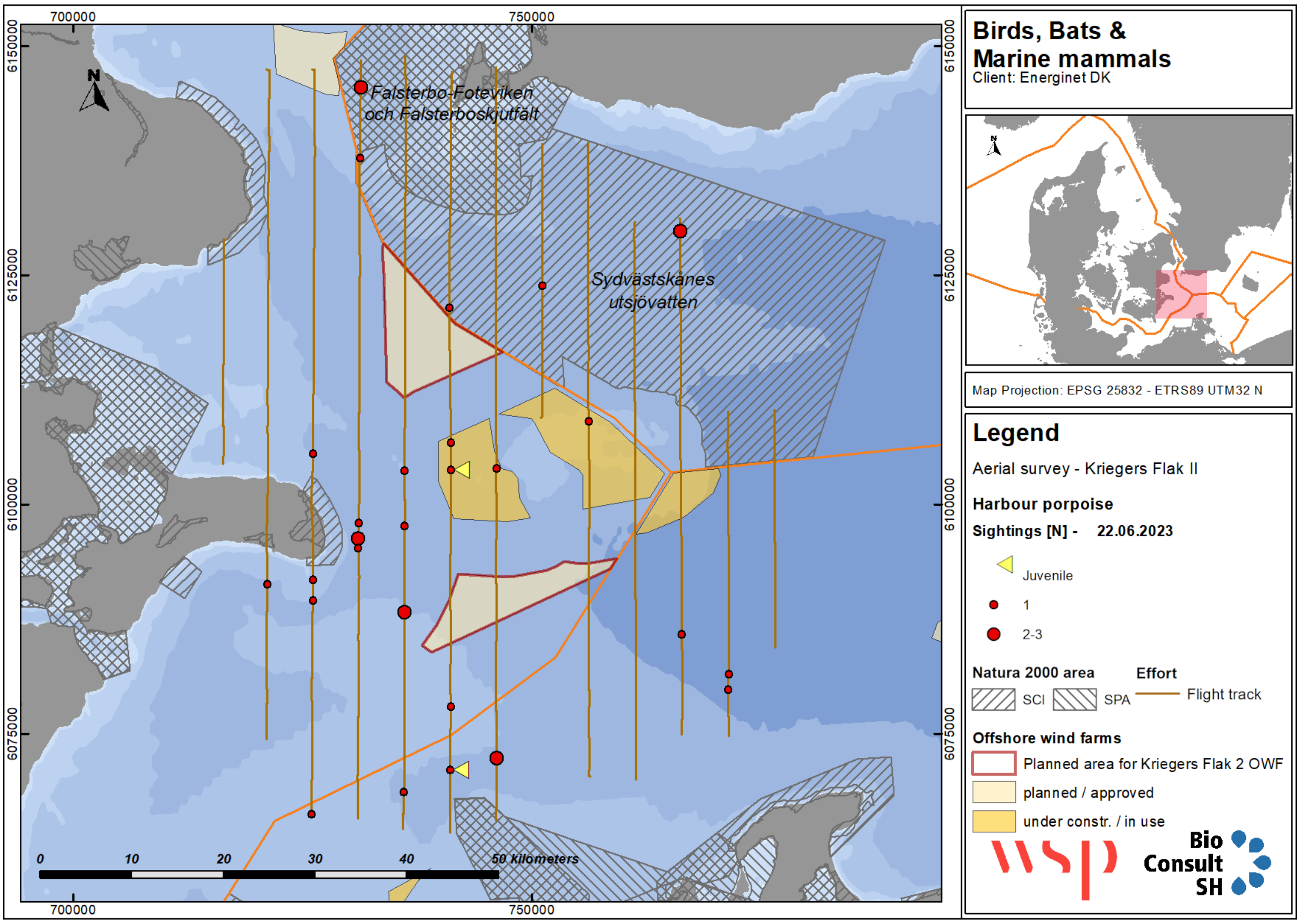

Figure 5-12. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 22.06.2023.

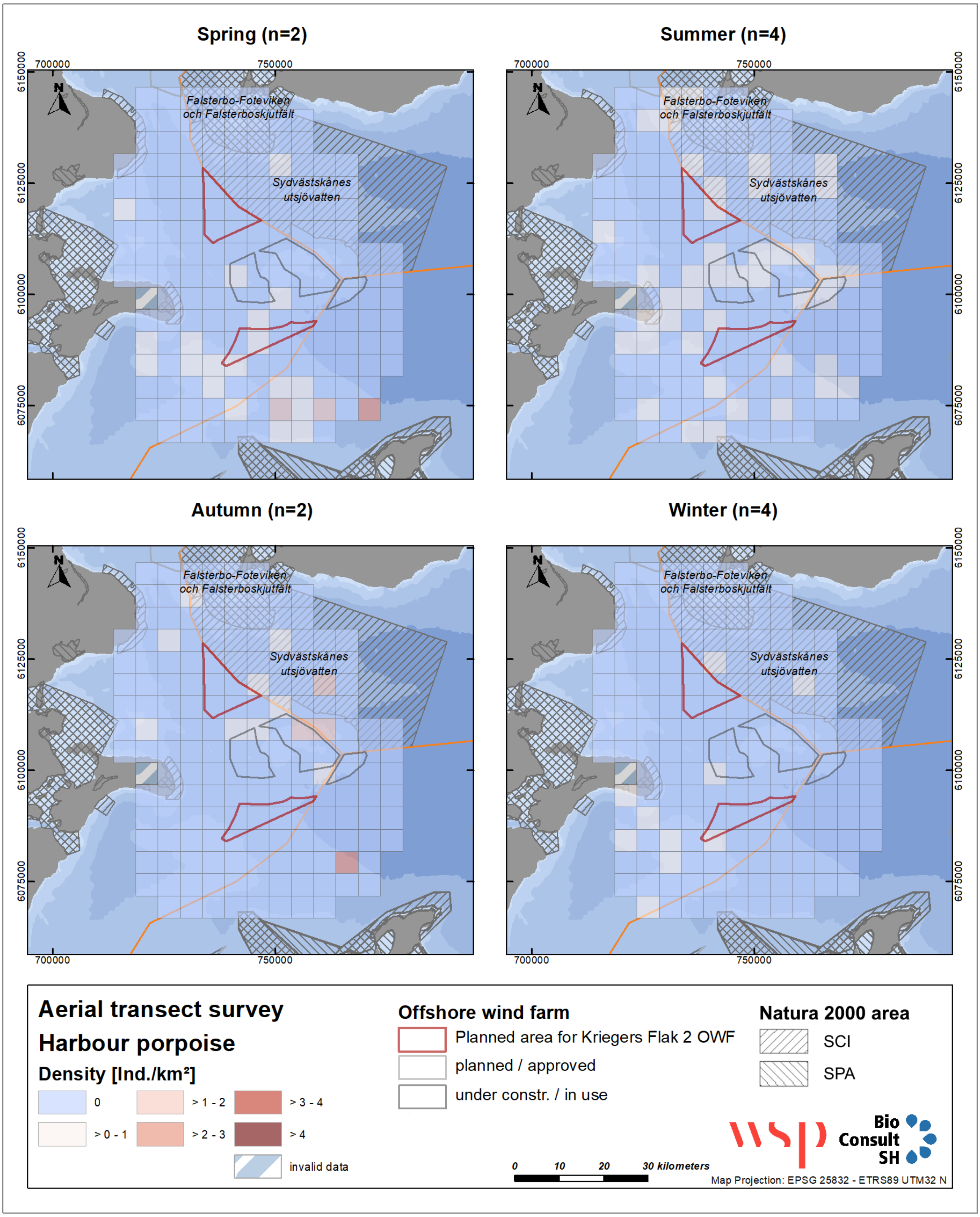

Figure 5-13. Spatial distribution of harbour porpoises during digital aerial surveys between February 2023 and January 2025 (Y1+Y2). The number (n) of digital aerial surveys included to calculate seasonal densities is given in the title of the respective panel.

5.2.2 PASSIVE ACOUSTIC MONITORING

PHENOLOGY/ SEASONALITY

During the survey period (February 2023 – January 2025; Y1+Y2), harbour porpoises were detected almost daily at all 16 C-POD stations. Detection rates throughout the entire survey period (expressed as %DPD/t) were relatively high, ranging from 79.5% at station F-R3 to 99.3% at station F-O7, with a mean value of 93% 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), showed detection rates on a daily scale at a very fine temporal resolution of 10-minute blocks 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). Mean %DP10M/d was highest at station F-O8 (27.2%), followed by station F-O7 (22.5%) and lowest at stations F-R3 (4.1%) and F-R4 (4.6%). Detection rates at all stations, except F-R3 and F-R3, were generally >10%DP10M/d (Figure 5-15). The two stations with the highest %DP10M/d, F-O7 (22.5%) and F-O8 (27.2%), are located close together in the southern part of the pre-investigation area. In the northern part of the pre-investigation area detection rates showed an increasing gradient from north to south, from 12.8% at station F-O1 to 19.2 %DP10M/d at station F-O4. The remaining stations exhibited a broad range of detection rates, without any clear spatial pattern. The lowest rates were recorded at stations F-R3 and F-R4 (<5 %DP10M/d), situated in the southwest of the pre-investigation area. In contrast, the highest detection rate was observed at station F-R7 (17 %), located slightly north of stations F-O7 and F-O8.

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 16 C-POD stations deployed within the pre-investigation area. %DPD/t and mean %DP10M/d were calculated over all available recording days. t refers to the entire survey period (February 2023 to January 2025; Y1+Y2). d refers to a day.

C-POD	Days with positive detections	Days deployed	DPD/t [%]	DP10M/d [%]
F-O1	566	672	84.2	12.8
F-O2	641	702	91.3	13.0
F-O3	662	700	94.6	14.6
F-O4	676	705	95.9	19.2
F-O5	688	698	98.6	10.4
F-O6	691	701	98.6	13.1
F-O7	699	704	99.3	22.5
F-O8	644	649	99.2	27.2
F-R1	611	712	85.8	10.3
F-R2	607	703	86.3	10.7
F-R3	515	648	79.5	4.1
F-R4	497	603	82.4	4.6
F-R5	654	670	97.6	10.6
F-R6	672	677	99.3	15.0
F-R7	639	660	96.8	17.0
F-R8	652	659	98.9	11.6

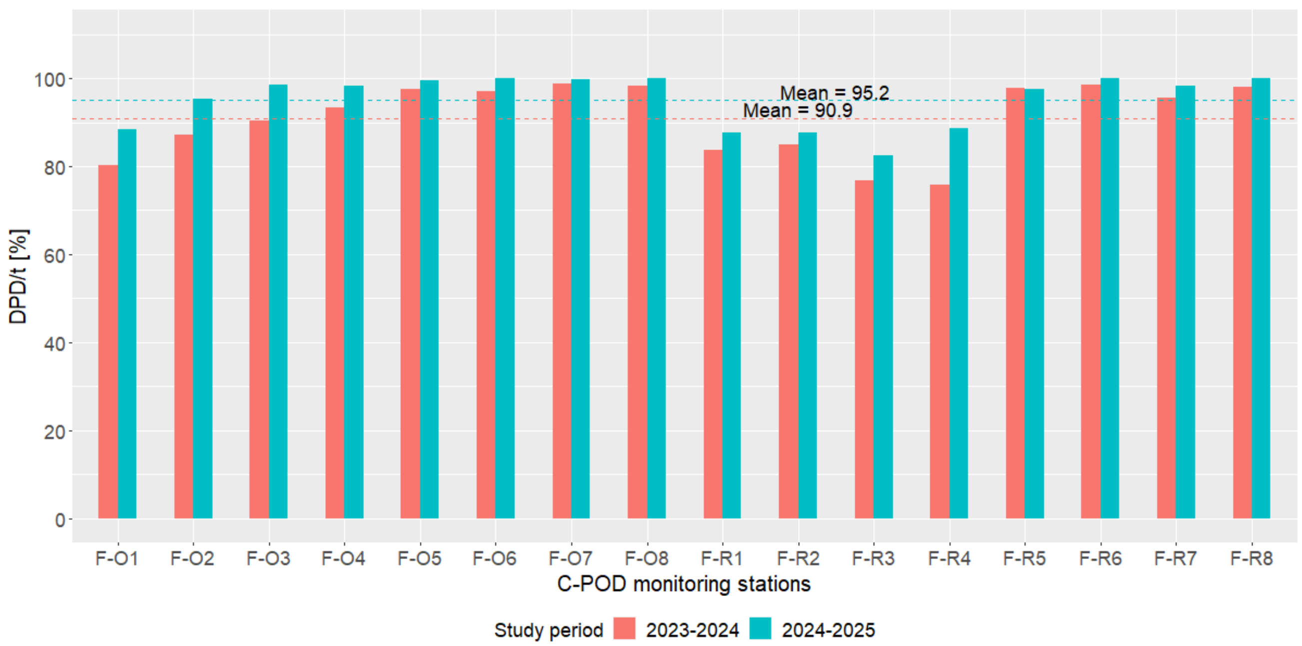

Figure 5-14. The proportion of days with positive harbour porpoise detections over the entire survey period (red: February 2023 – January 2024 (Y1); blue: February 2024 – January 2025 (Y2)), expressed as Detection Positive Days (DPD/t), at the 16 C-POD stations deployed within the pre-investigation area. The red and blue dashed lines show the mean values across all stations for Y1 and Y2, respectively.

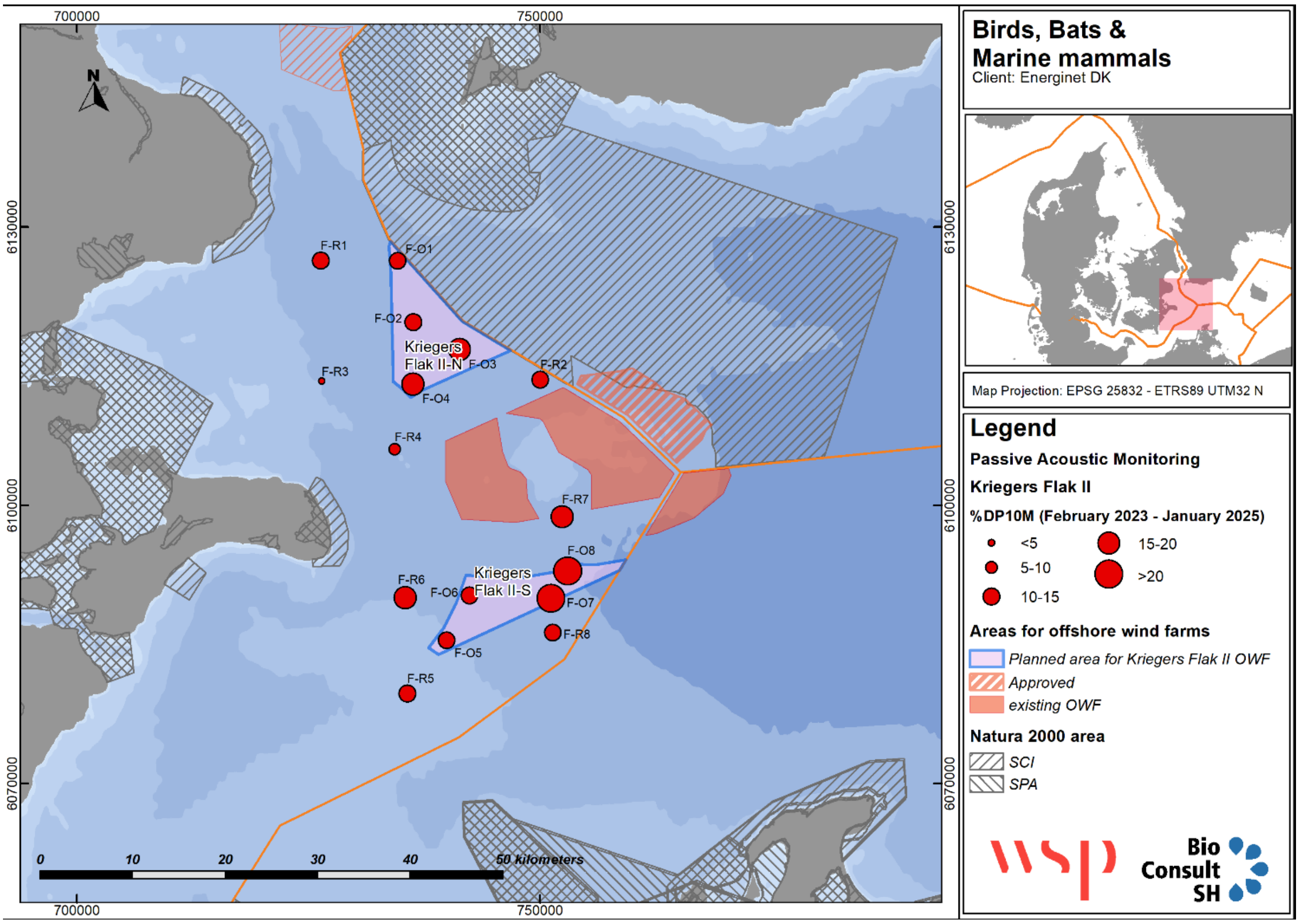

Figure 5-15. Harbour porpoise detection rates, expressed as mean Detection Positive 10-Minutes per day (%DP10M/d), at the 16 C-POD stations deployed within the investigation area for the entire survey period (February 2023 – January 2025; Y1+Y2).

Monthly mean %DP10M/d (averaged over all 16 stations) showed the temporal variation (seasonal trend) in harbour porpoise presence within the entire pre-investigation area across the survey period (Figure 5-16). In general, detection rates in the winter months (December – February) were much lower compared to spring (March – May), summer (June – August) and autumn (September – October). A bimodal pattern can be observed, with a first peak in detection rates occurring either in spring or early summer and a second peak in autumn. Comparing Y1 and Y2, a larger difference in monthly mean %DP10M/d was observed in the months of January, February, March, October and December, with detection rates slightly higher in these months during Y2 (February 2024 – January 2025) than Y1 (February 2023 – January 2024). The remaining months showed detection rates in the same order of magnitude for both Y1 and y2.

The timing and magnitude of both the spring/summer peak and autumn peak differ slightly between C-POD stations (Figure 5-17 - Figure 5-32). At stations F-O1, F-O2 and F-R7, for example, the first peak in late spring/early summer was much weaker than the autumn peak. However, at other stations (e.g., F-O4, F-O7, F-R1), the magnitude of the first peak was comparable to that of the second peak. Interannual differences were minor at the majority of the stations, with similar phenology between the years of pre-investigations. Station F-O8, on the other hand, showed very different seasonal variations between 2023 (Y1) and 2024 (Y2): a bimodal pattern with spring/summer and autumn peaks was observed in Y1, but not in Y2. Instead, in Y2, the detection rates at this station increased from late spring and remained high throughout summer and autumn with a peak in August 2024. In contrast, there were no apparent seasonal variation at stations F-R3 and

F-R4 where detection rates were constantly low throughout most of the survey period (Figure 5-27 and Figure 5-28).

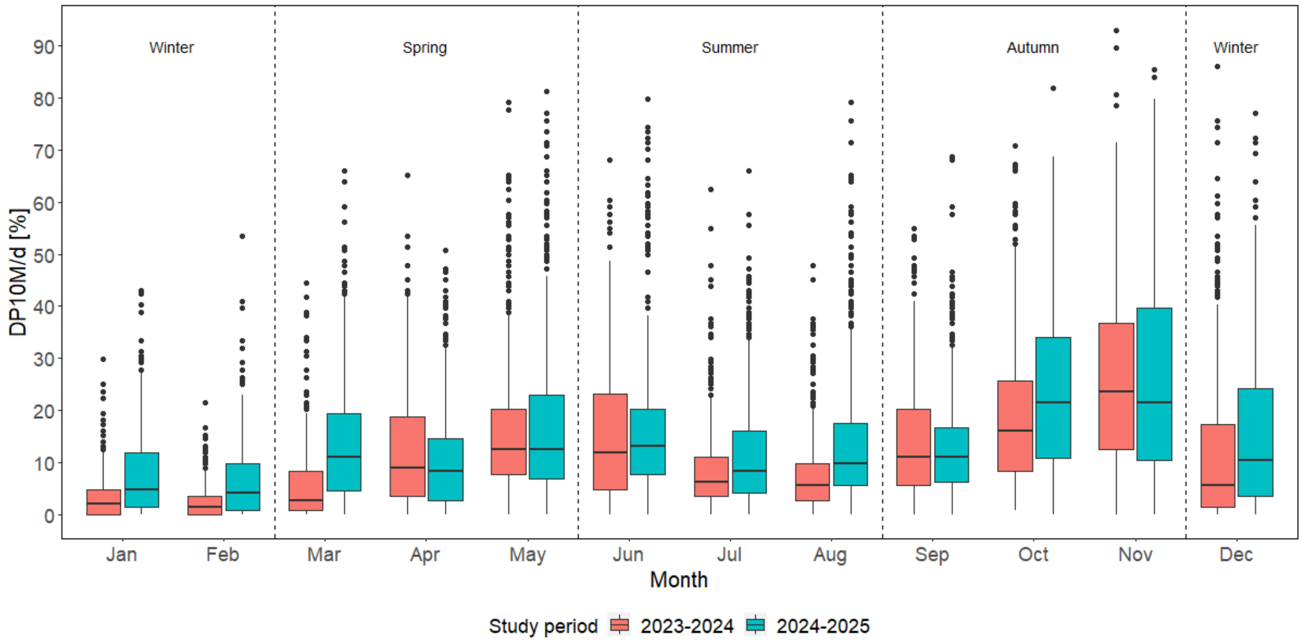

Figure 5-16. Mean monthly Detection Positive 10-Minutes per day (% DP10M/d) averaged over all 16 C-POD stations. Red: February 2023 – January 2024 (Y1); blue: February 2024 – January 2025 (Y2). Seasons were defined as spring (March – May), summer (June – August), autumn (September – November) and winter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

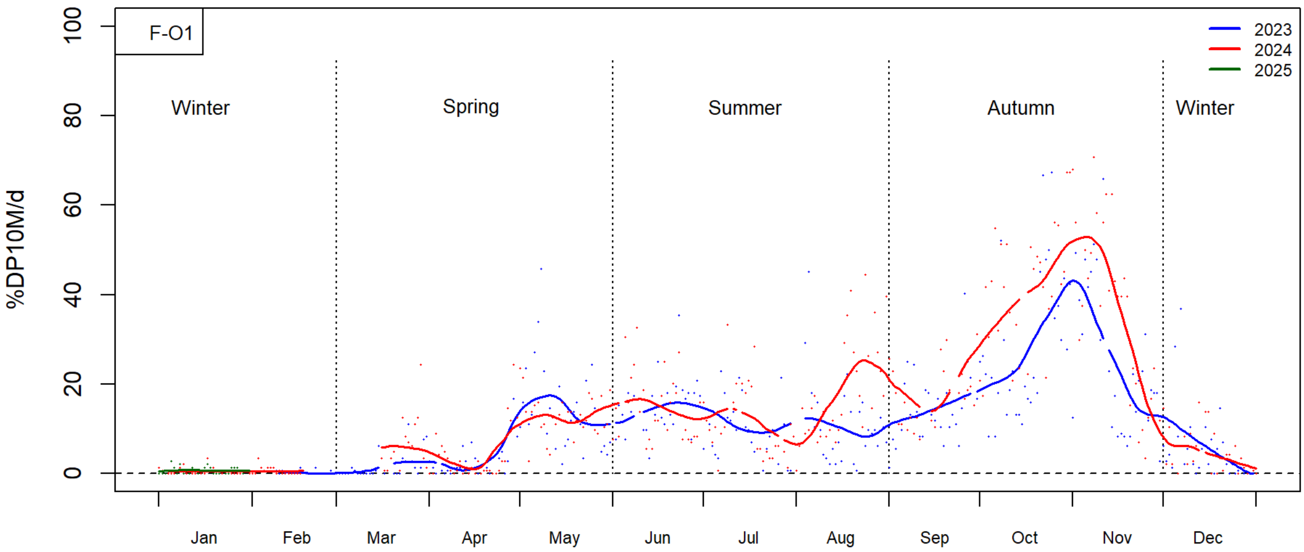

Figure 5-17. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O1 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

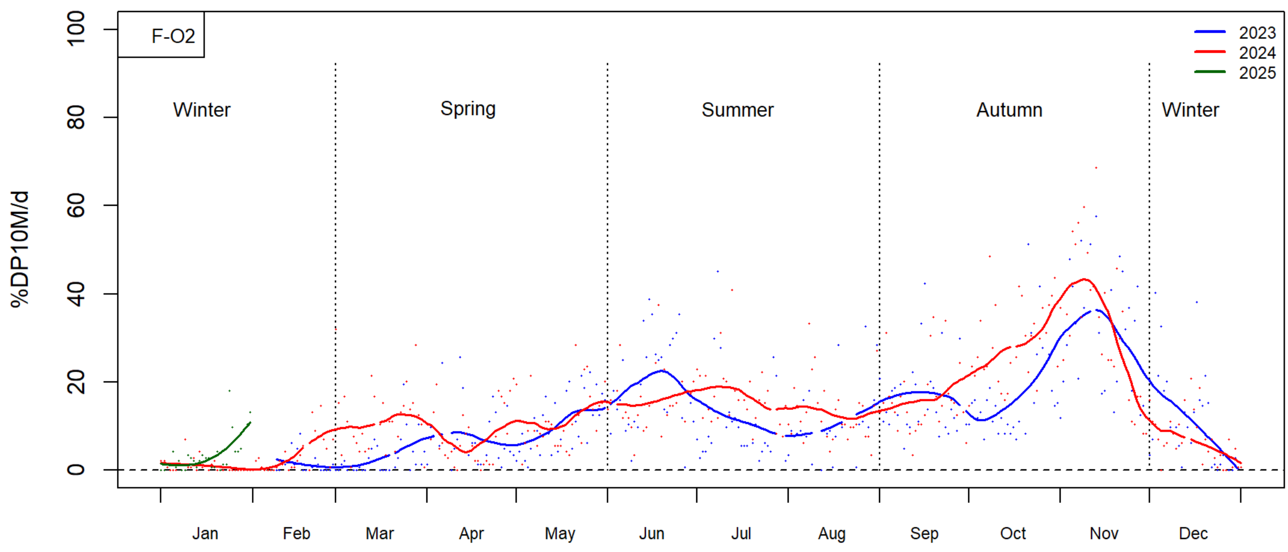

Figure 5-18. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O2 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

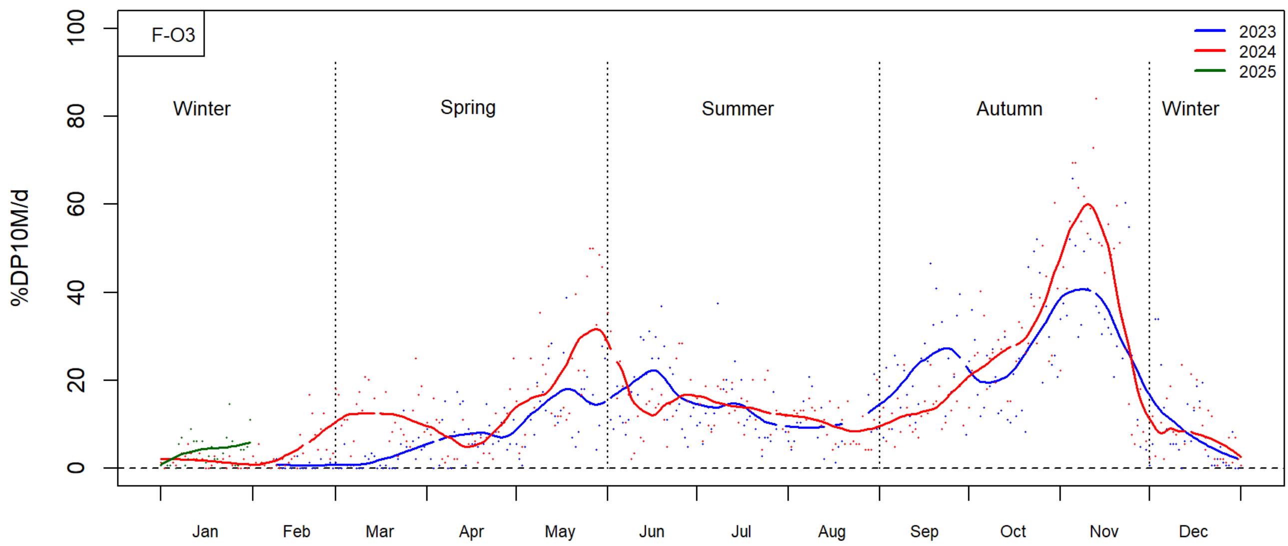

Figure 5-19. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O3 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

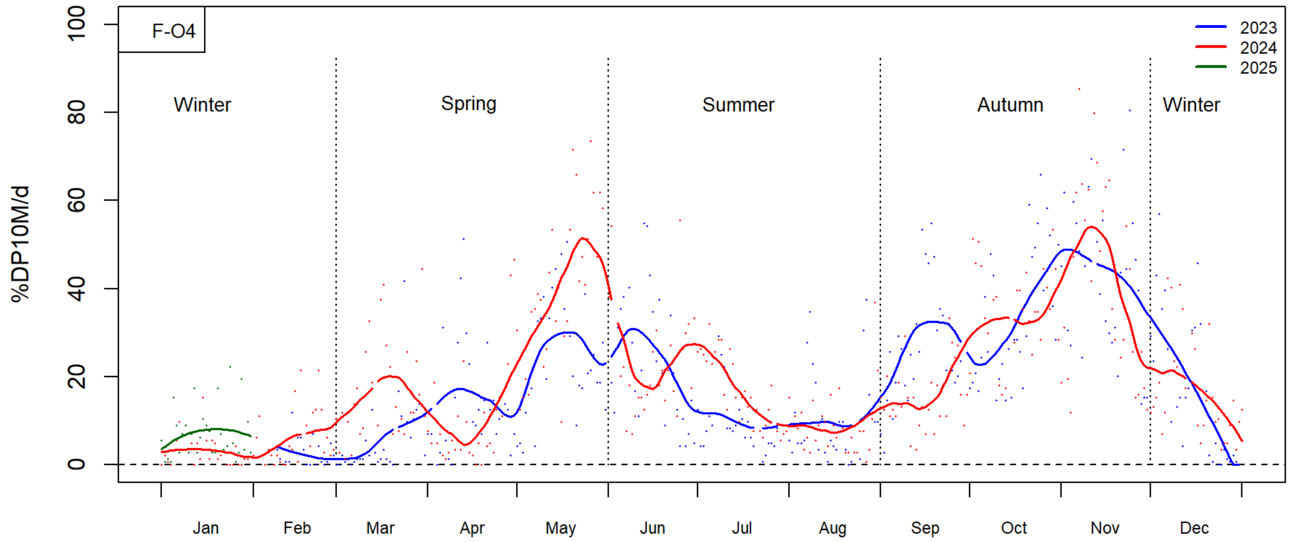

Figure 5-20. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O4 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

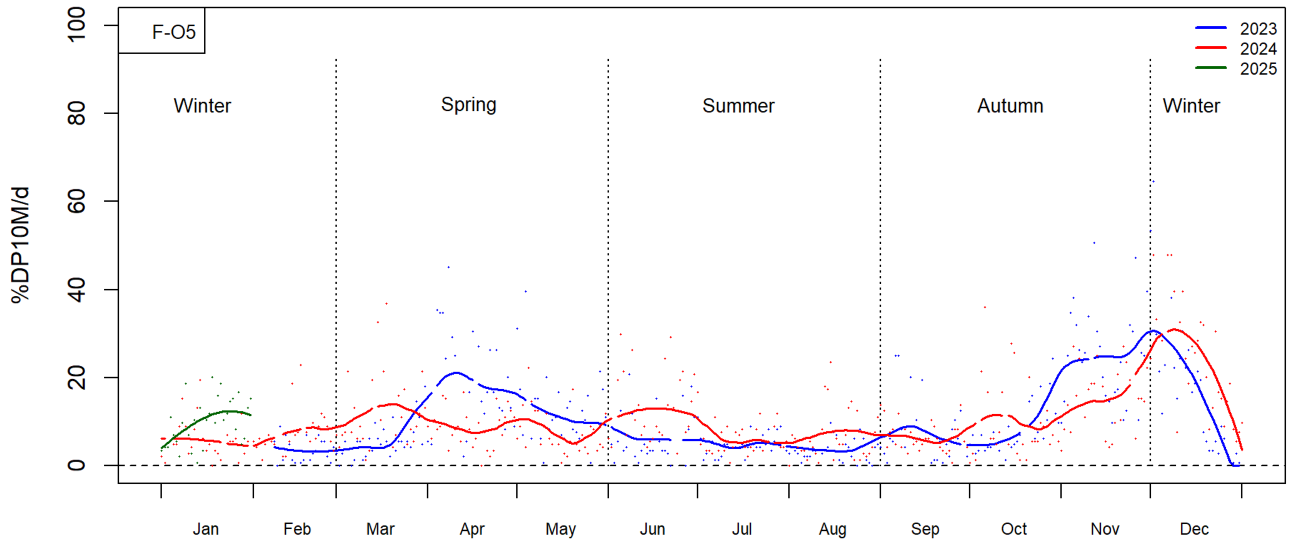

Figure 5-21. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O5 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

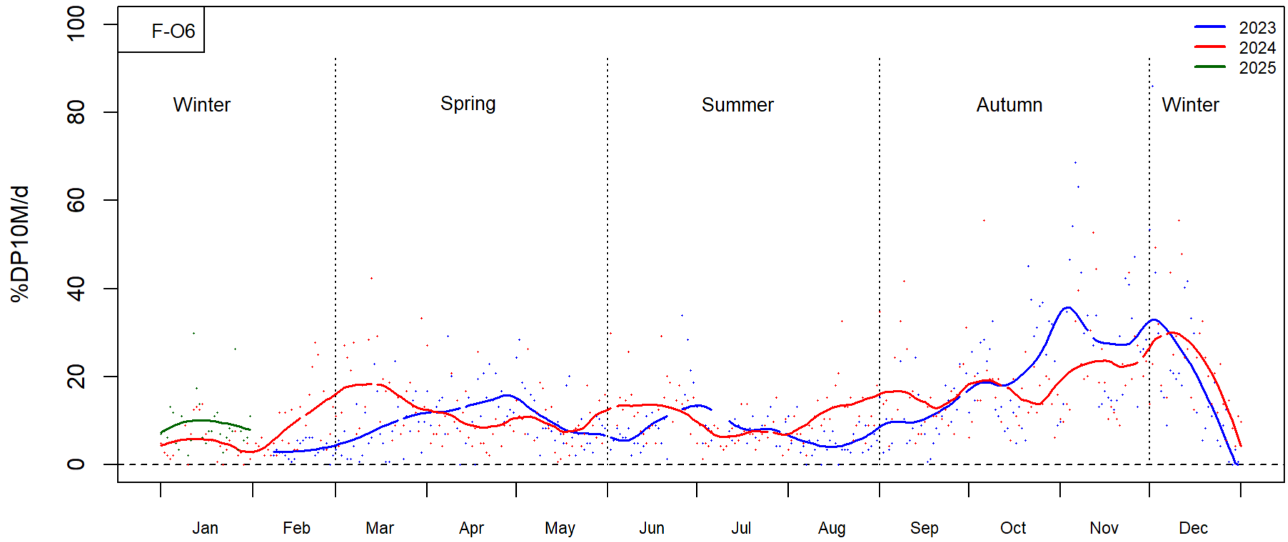

Figure 5-22. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O6 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

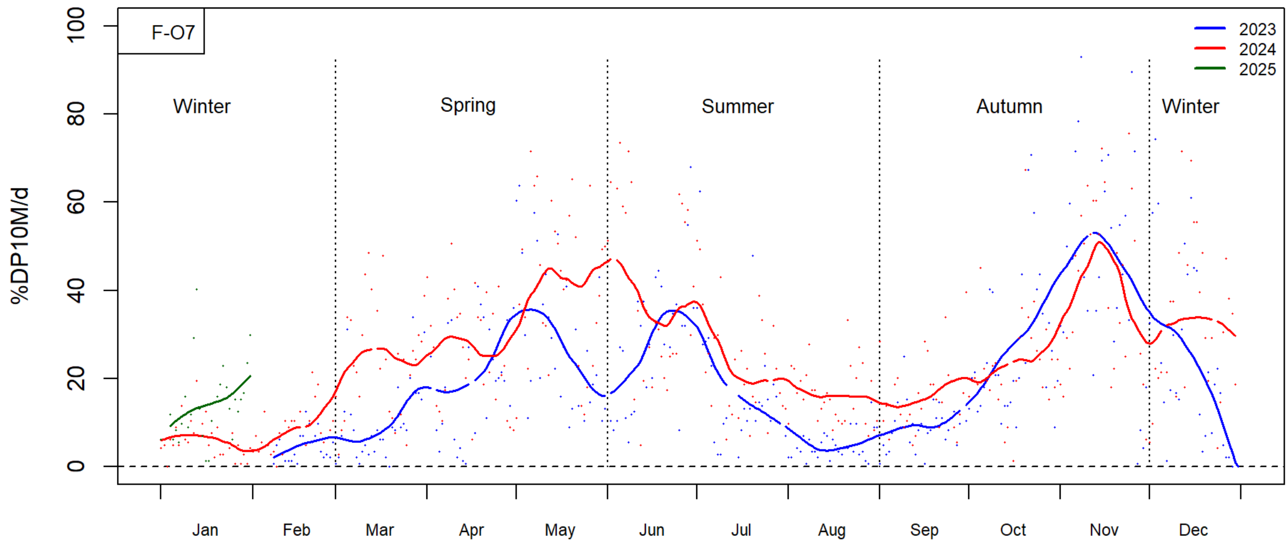

Figure 5-23. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O7 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

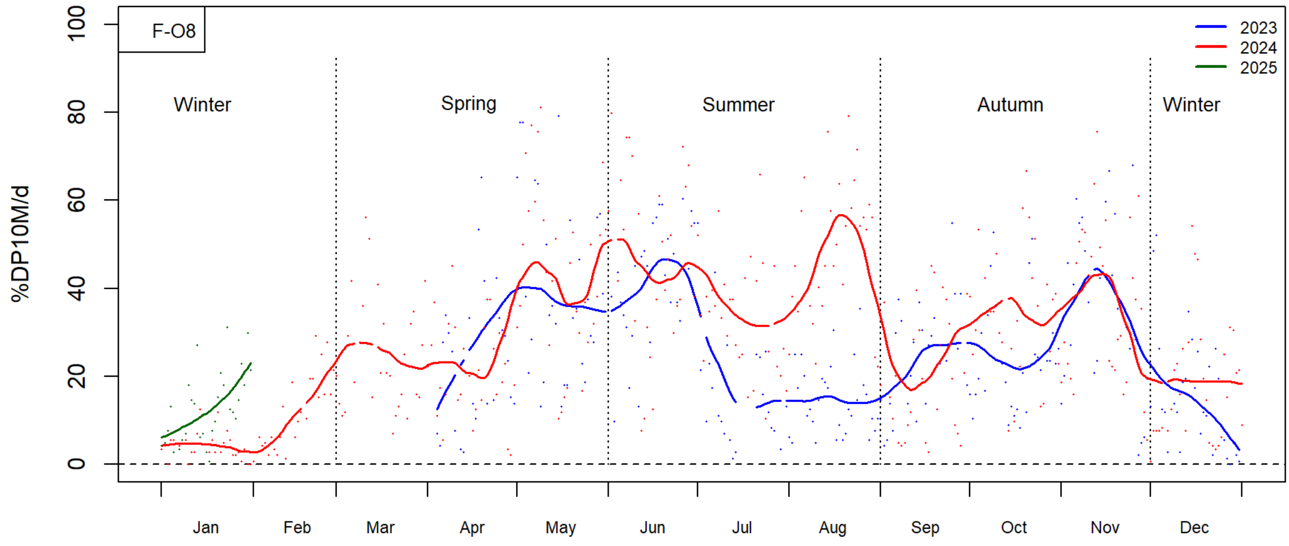

Figure 5-24. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at station F-O8 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

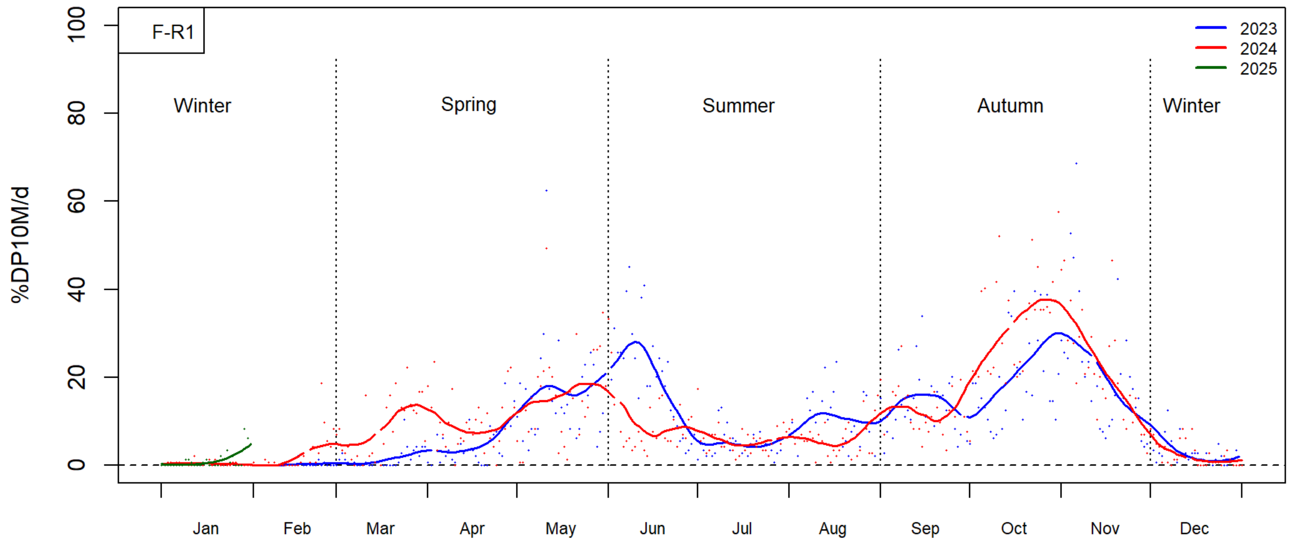

Figure 5-25. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R1 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

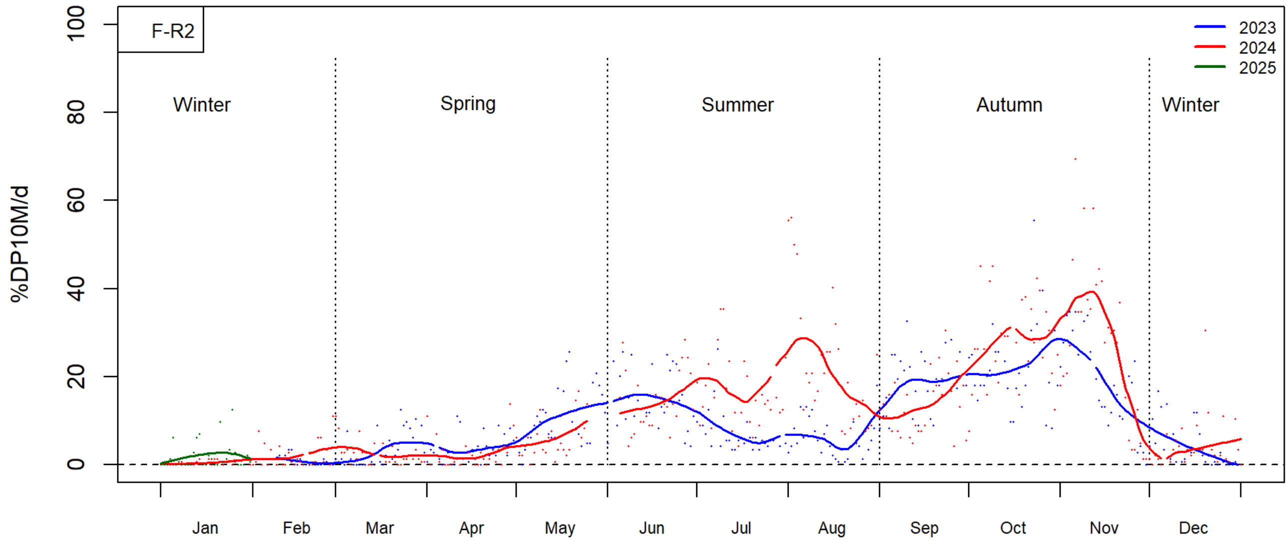

Figure 5-26. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R2 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

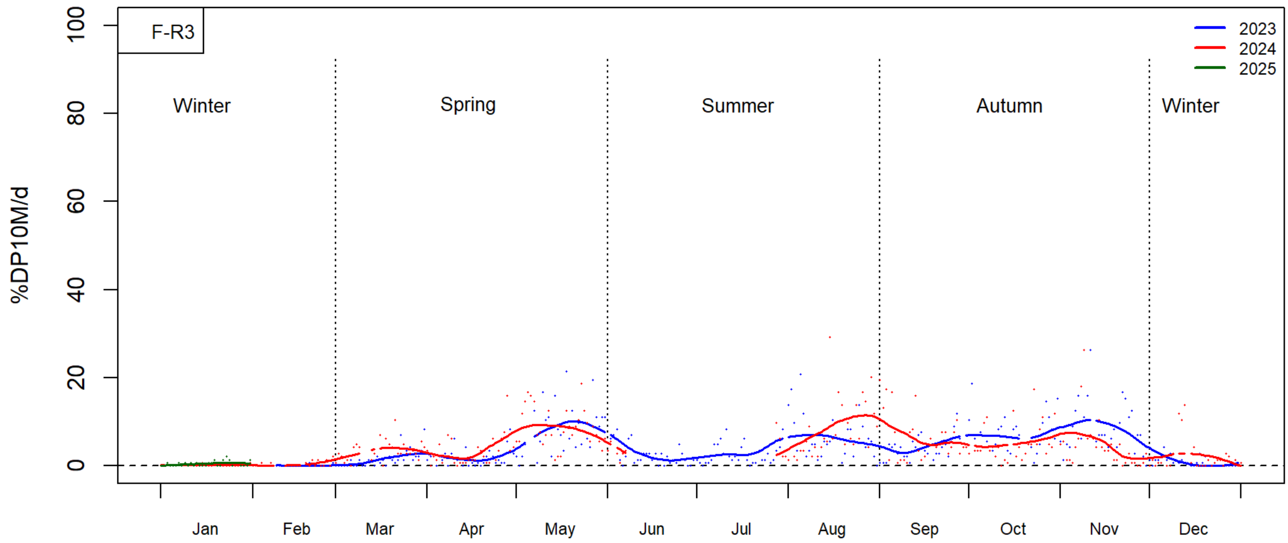

Figure 5-27. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R3 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

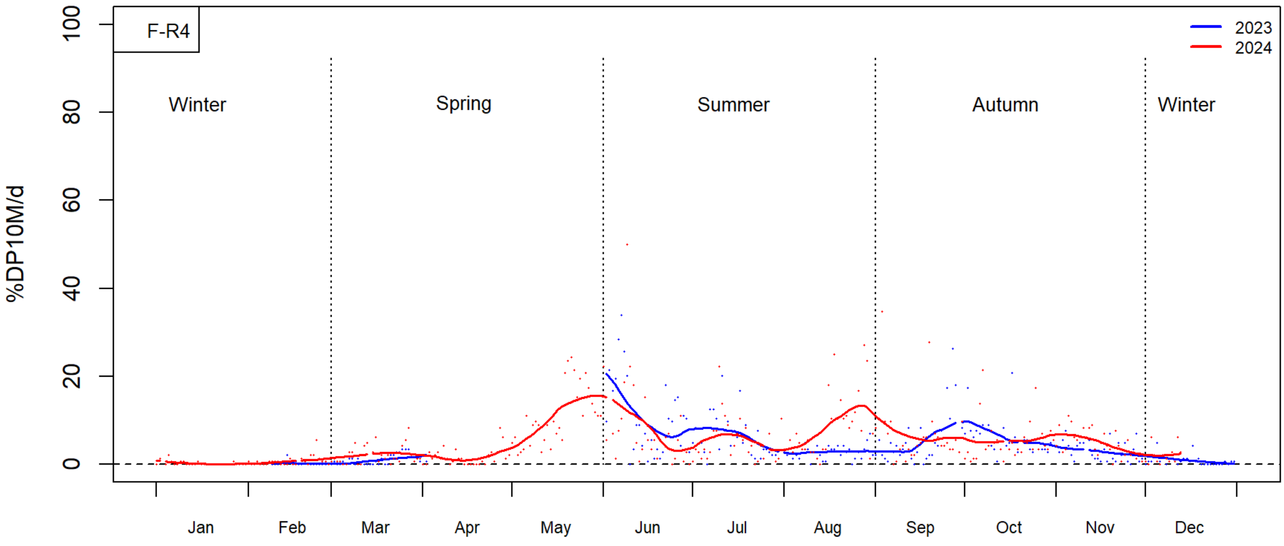

Figure 5-28. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R4 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

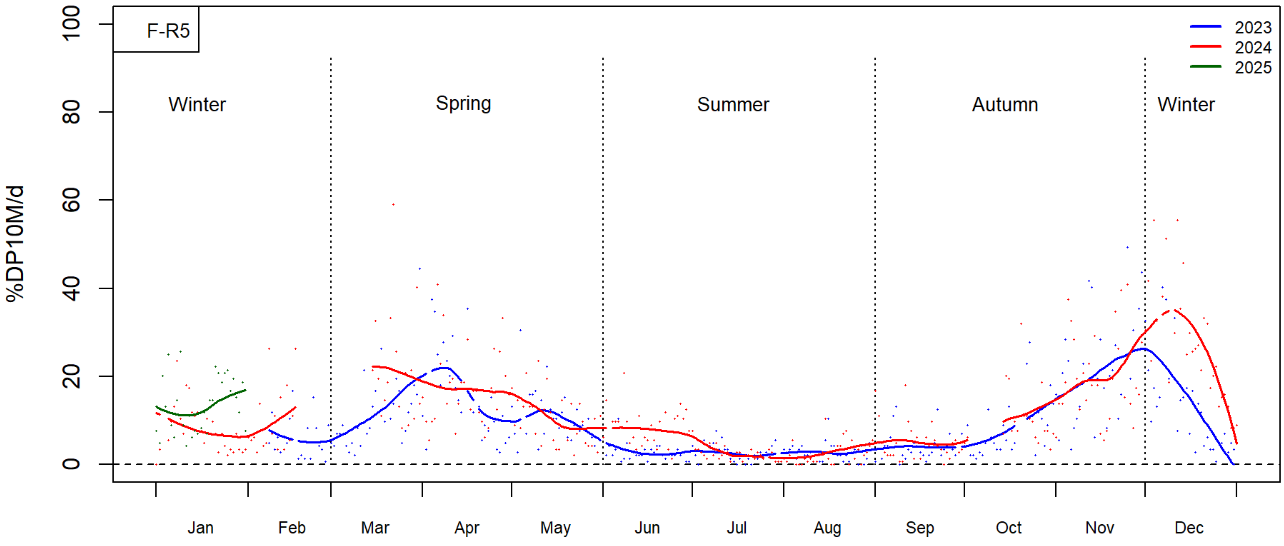

Figure 5-29. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R5 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

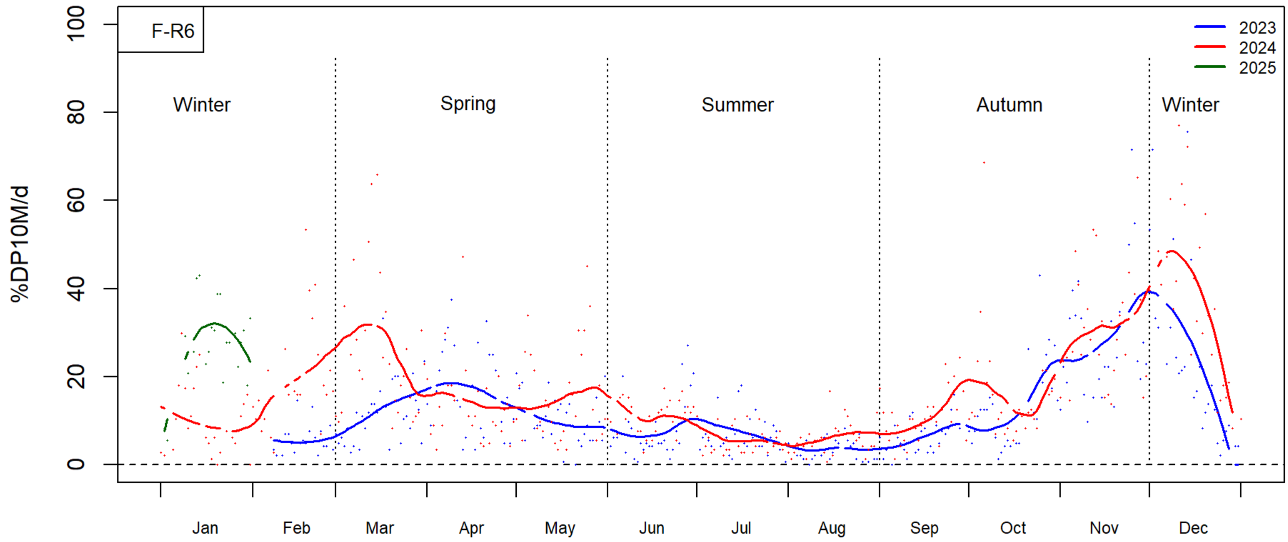

Figure 5-30. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R6 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

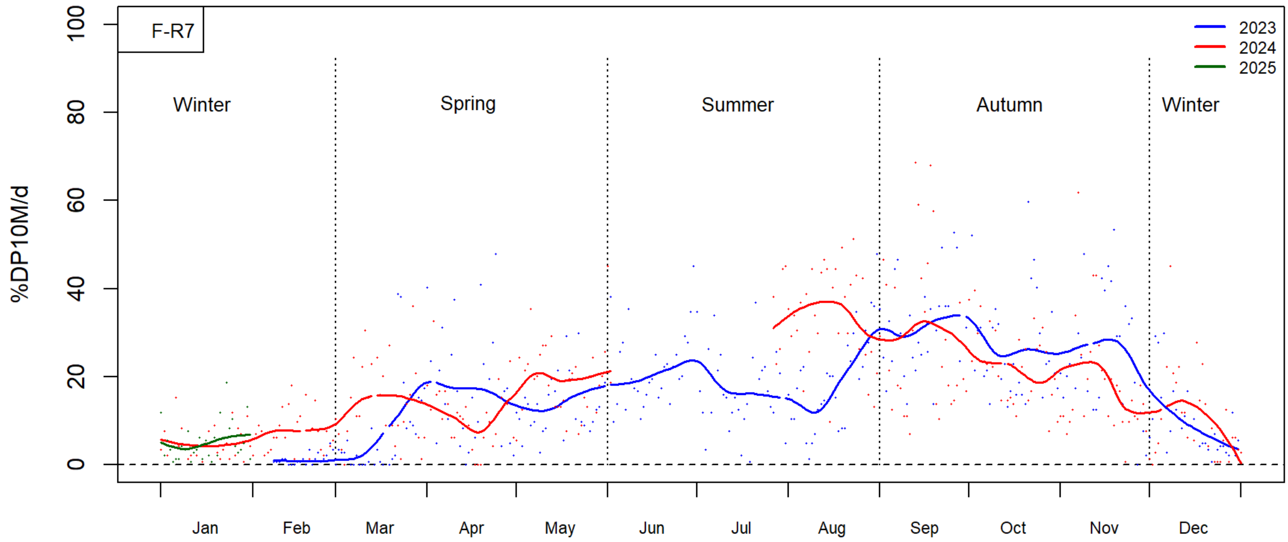

Figure 5-31. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R7 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

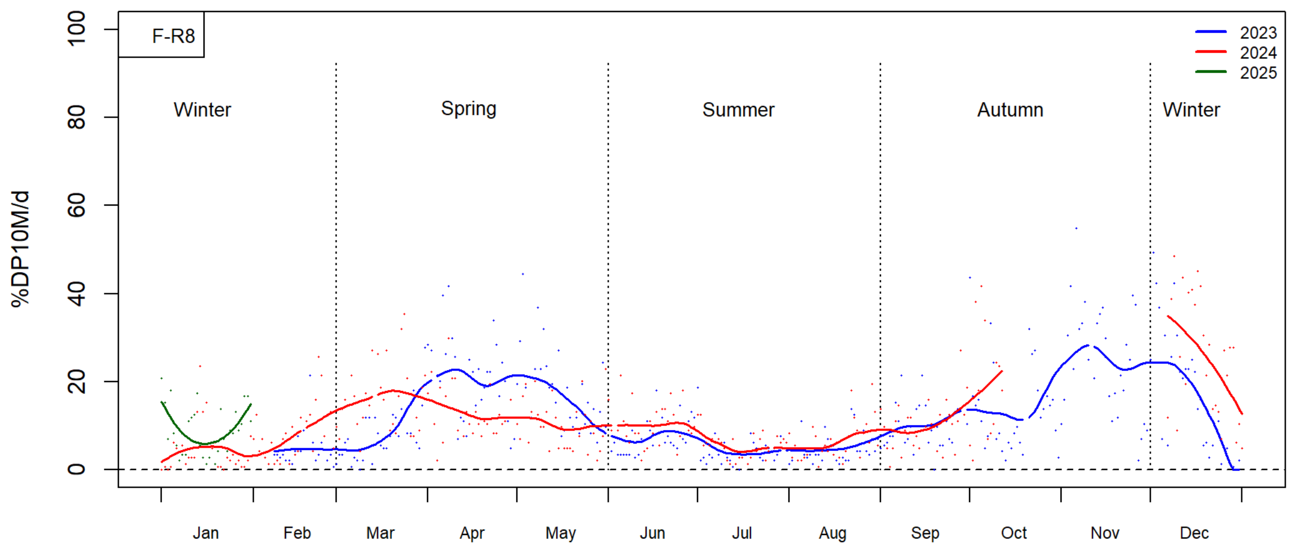

Figure 5-32. Phenology of Detection Positive 10-Minutes per day (%DP10M/d) at stations F-R8 across the entire survey period (February 2023 – January 2025; Y1+Y2). Gaps in the loess regression curves represent periods with no data.

Diel pattern analysis revealed differences in daylight and nighttime activity of harbour porpoises at each C-POD station (Figure 5-33). Harbour porpoises were detected more frequently during daylight hours at 6 stations (F-O4, F-O5, F-R3, F-R5, F-R6 and F-R8), while nighttime activity prevailed at the remaining 10 C-POD stations (F-O1, F-O2, F-O3, F-O6, F-O7, F-O8, F-R1, F-R2, F-R4 and F-R7).

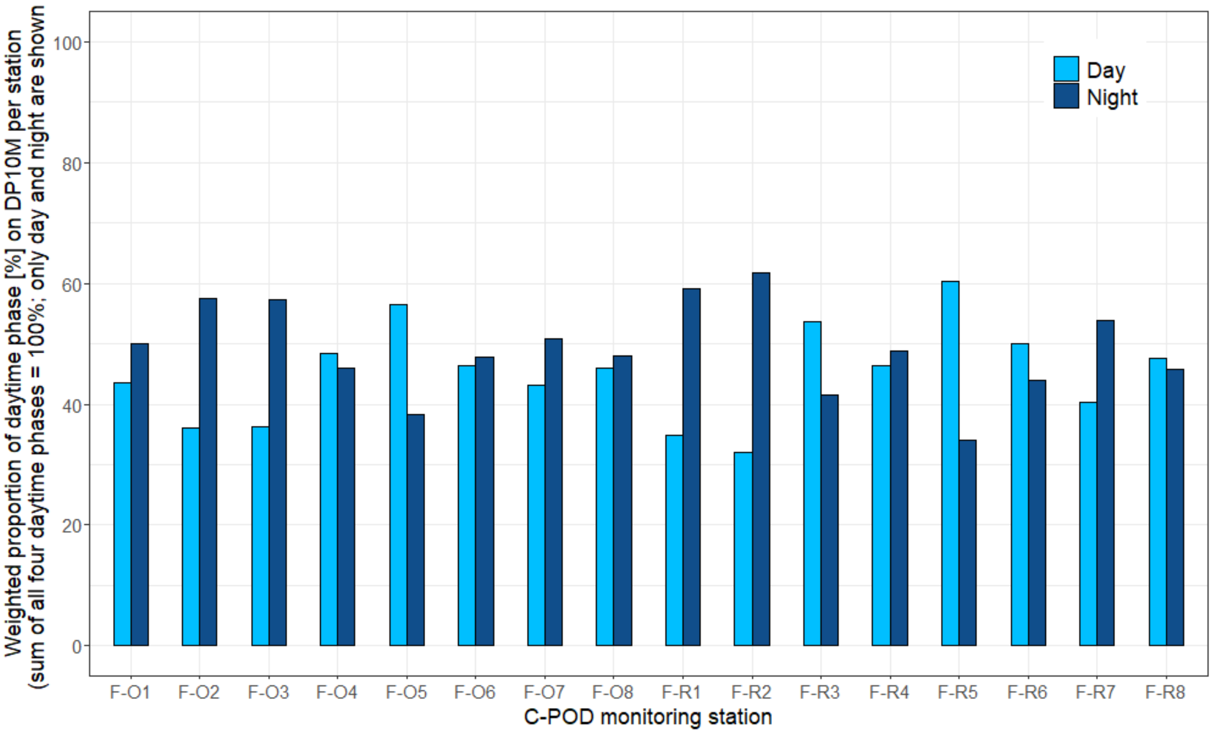

Figure 5-33. Diel pattern of harbour porpoise detection rates at the 16 C-POD stations deployed within the pre-investigation area. Detection rates for each station were averaged across the entire survey period (February 2023 – January 2025; Y1+Y2). Each 24-hour period is divided into four phases (day, night, dusk, dawn) for analysis. Only day and night phases are shown here (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 KF II N and KF II S OWF.

Three marine mammal species regularly occur within the pre-investigation area of KF II N and KF II S. These are the harbour seal, the grey seal and, as the only cetacean species occurring in the Baltic Sea region, the harbour porpoise. The basis of this study is comprised of 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 the Baltic Sea closest to the planned windfarm area of KF II N and KF II S are located about 13 km northeast at Falsterbo (Måkläppen) in Sweden, and about 25 km to the west in Bøgestrøm (Denmark). Måkläppen is by far the most important haul-out site in this part of the Baltic Sea. 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 in the northern part of the pre-investigation area throughout the year with 95.8% of all sightings within one of the two Swedish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive *Falsterbohalvön* (SE0430095) and *Sydvästskånes utsjövatten* (SE0430187), in which harbour seals are listed as important species, respectively. 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).

In 2023, an average of 1,600 harbour seals were counted in the Western Baltic Sea, which is the highest number recorded so far. The PDV epidemic affected the number of seals less than in the other areas and the population has apparently grown exponentially since the epidemic in 2002, with an average annual growth rate of 6.5%. The number of harbour seals at the haul-out sites modelled based on the development since 2003 was 1,428 in 2023 (95% CI: 1,296-1,574). There were very few seals in the area when the harbour seal was protected in 1976 and the reason for the continued growth is likely that the population in the area, compared to other areas, was much more severely affected by hunting, but not particularly hard hit by the PDV epidemic. Harbour seal pups are not counted in the Western Baltic Sea, because the pups cannot be reliably counted from aircraft at the scattered rocky sites at Saltholm, Jungshoved, Vitten-Skrollen, Avnø Fjord and Dyrefod (HANSEN ET AL. 2024). The South Funen Archipelago and the Little Belt are the only areas where harbour seals largely disappeared from their resting places due to previous hunting. In recent years, there have been reports of more seals in these areas, so in 2021, the first count was conducted in these areas. A total of 229 harbour seals were counted, 186 of which were in southern Lillebælt, while the rest were counted at Strynø Kalv and Drejø in the South Funen Archipelago. In 2023, 161 harbour seals were counted, 149 of which were in southern Lillebælt. Thus, the last area where harbour seals were exterminated in Denmark is once again part of the species' distribution area, also at resting sites. These seals probably came from the populations in the western Baltic Sea and/or Kattegat, which has since then been confirmed with genetic studies (HANSEN ET AL. 2024).

6.2 GREY SEALS

The only grey seal haul-out sites in the Baltic Sea close to the planned windfarm area of KF II N and KF II S is located about 13 km northeast at Falsterbo (Måkläppen) in Sweden. At Stevns Rev in Denmark about 16 km west, findings have also been reported. However, the population of the south-western Baltic grey seal management unit is dominated by animals from Måkläppen. 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 in the northern part of the pre-investigation area throughout the year, with 95.8% of all sightings within one of the two Swedish Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive *Falsterbohalvön* (SE0430095) and *Sydvästskånes utsjövatten* (SE0430187), in which grey seals are listed as important species, respectively. In contrast to the harbour seal counts, grey seal counts have increased over the past 10 years (HANSEN & HØGSLUND 2021). 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 region (HELCOM 2023c).

6.3 HARBOUR PORPOISES

Harbour porpoises in the pre-investigation area of KF II N and KF II S are attributed to the Belt Sea population as the area is located in the western part of the transition zone according to SVEEGAARD ET AL. (2018). While SVEEGAARD ET AL. (2018) indicates that the three Natura2000-areas *Havet og kysten mellem Præstø Fjord og Grønsund* (DK006X233), *Stevns Rev* (DK00VA305), and *Saltholm and surrounding sea* (DK002X110) may be important for the Baltic Proper harbour population in winter, the occurrence of individuals from the Baltic Proper population is not very likely. In the present survey, harbour porpoises were most abundant in summer and spring. In the summer of the first survey year, 2 juveniles were observed, which resulted in a proportion of juveniles of 2.7%, 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 region and the Kattegat (UNGER ET AL. 2021) and a proportion of juveniles of 9.1% was observed 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, observations of harbour porpoises showed no clear pattern, but most sightings occurred in the central part of the pre-investigation area around and east from Møn and in the Southern part of the pre-investigation area. Only few observations occurred within the Sites of Community Importance (SCI) under the Natura 2000 Habitats Directive *Sydvästskånes utsjövatten* (SE0430187), where harbour porpoises are listed as an important species. Recent studies show 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 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 January 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 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 January 2025; Y1+ Y2) has helped reduce the influence of interannual variability.

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9 APPENDIX

9.1 SEALS – AERIAL SURVEY SIGHTINGS

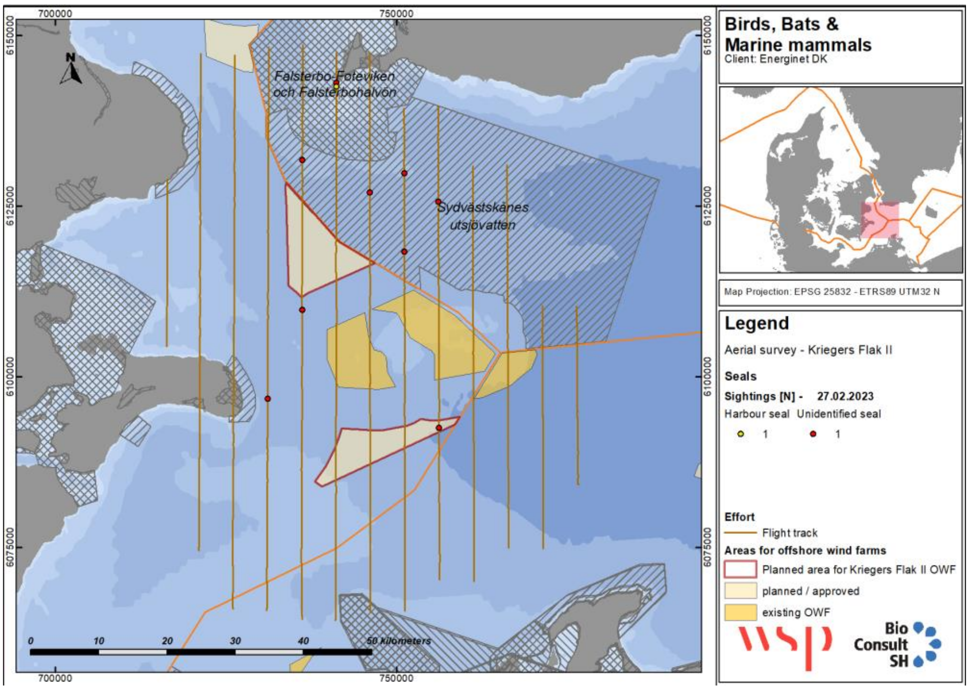

Figure 9-1. Seal observations in the pre-investigation area during the digital aerial survey on 27.02.2023.

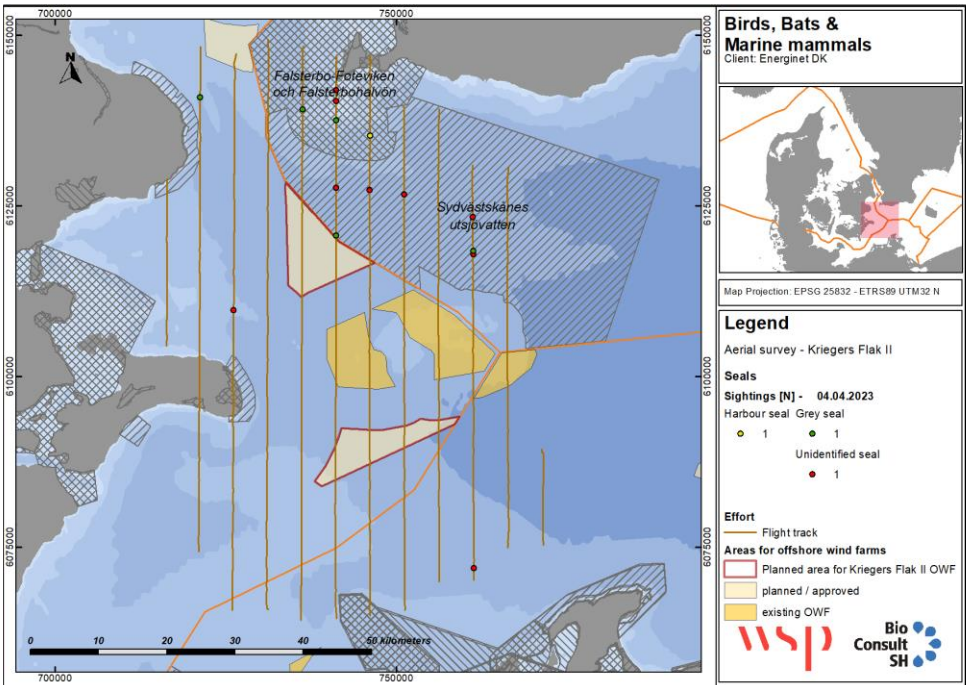

Figure 9-2. Seal observations in the pre-investigation area during the digital aerial survey on 04.04.2023.

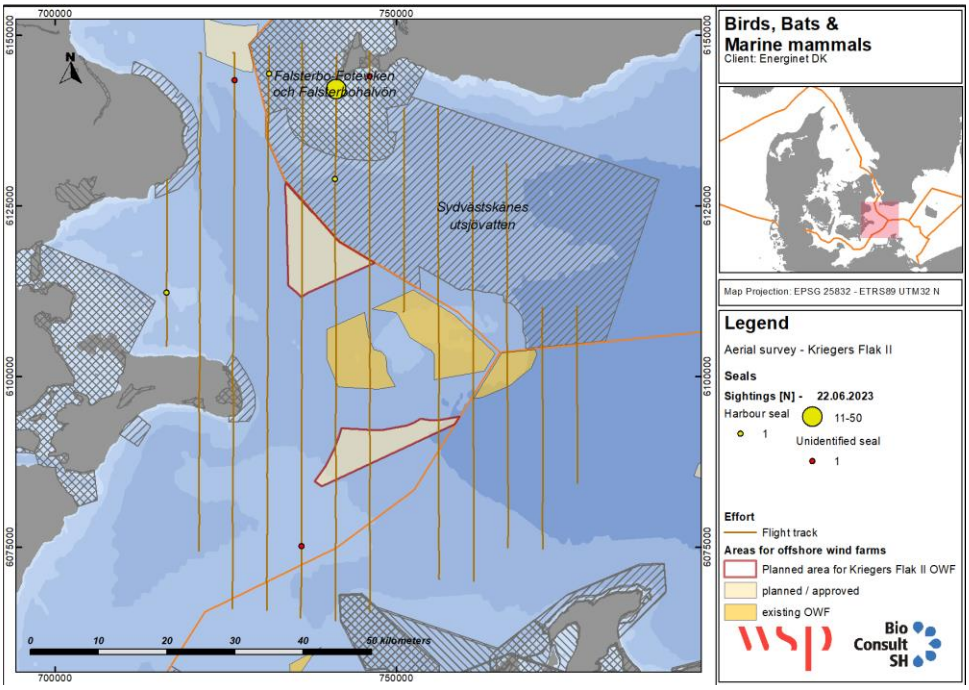

Figure 9-3. Seal observations in the pre-investigation area during the digital aerial survey on 22.06.2023.

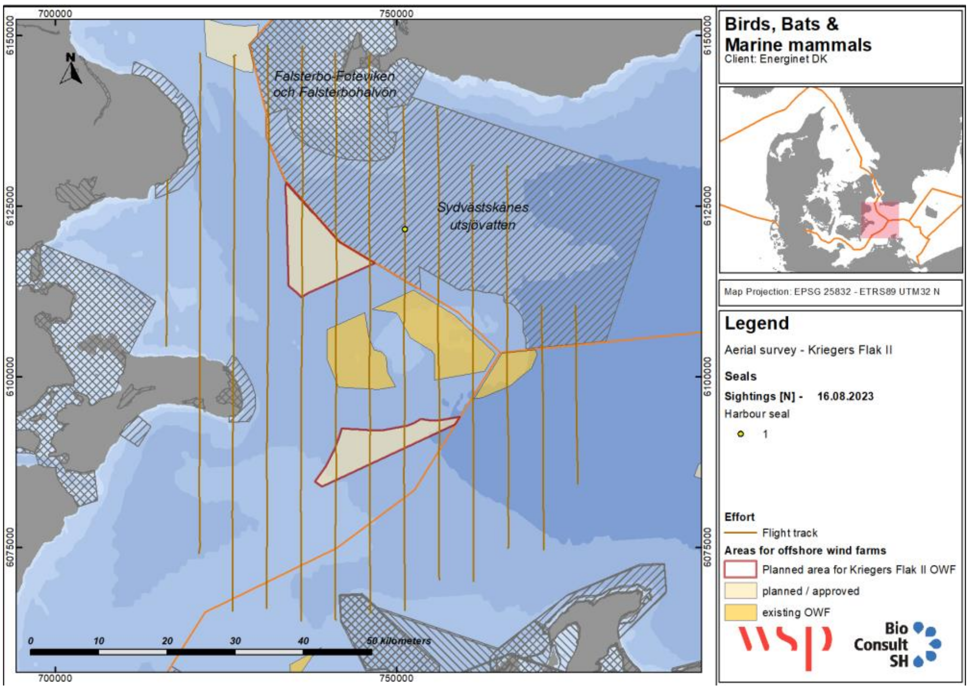

Figure 9-4. Seal observations in the pre-investigation area during the digital aerial survey on 16.08.2023.

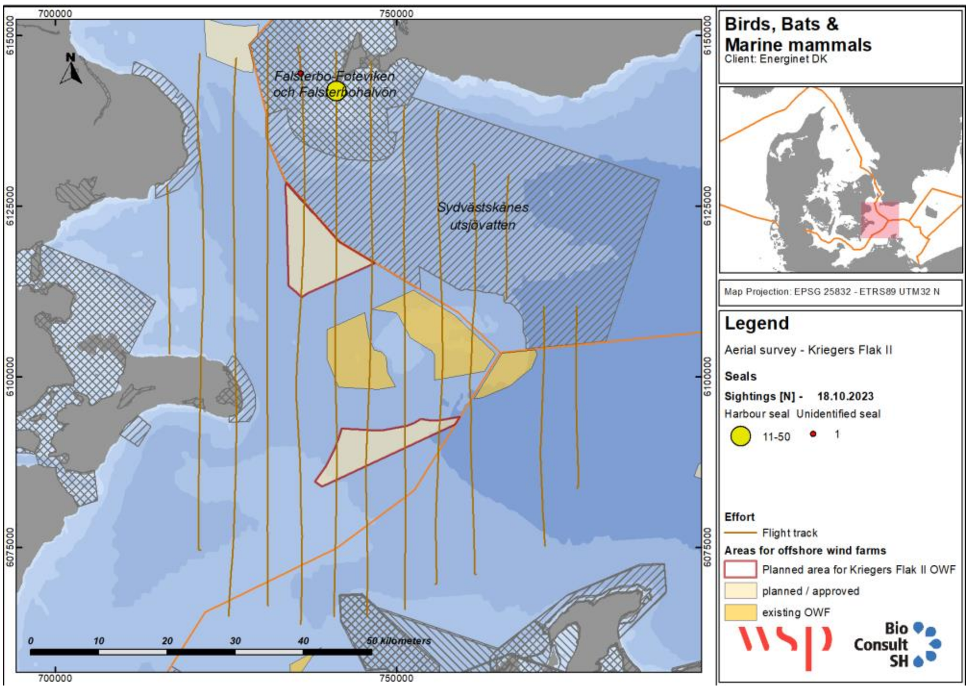

Figure 9-5. Seal observations in the pre-investigation area during the digital aerial survey on 18.10.2023.

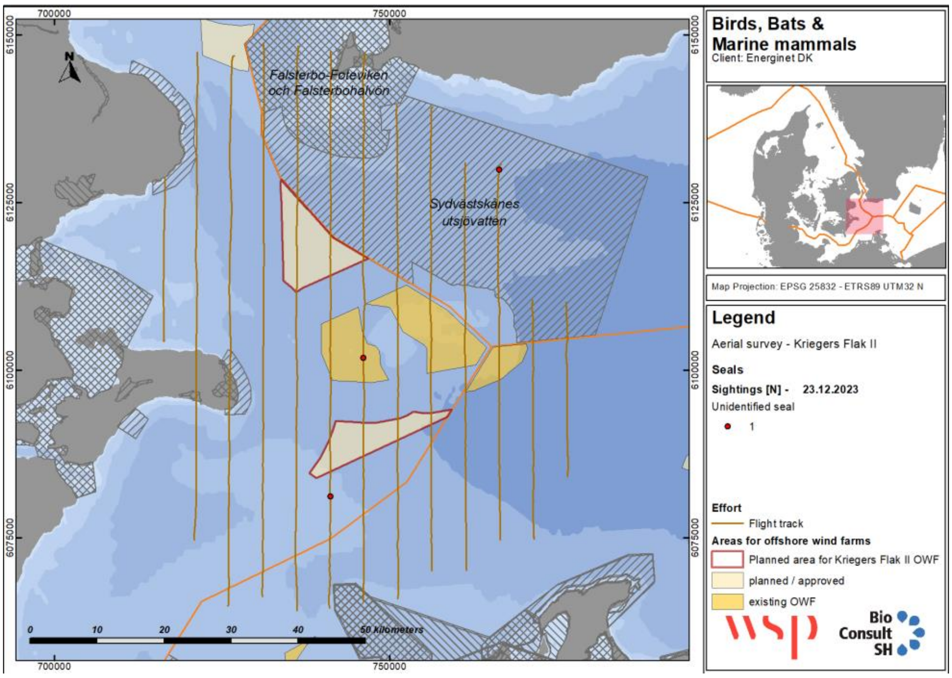

Figure 9-6. Seal observations in the pre-investigation area during the digital aerial survey on 23.12.2023.

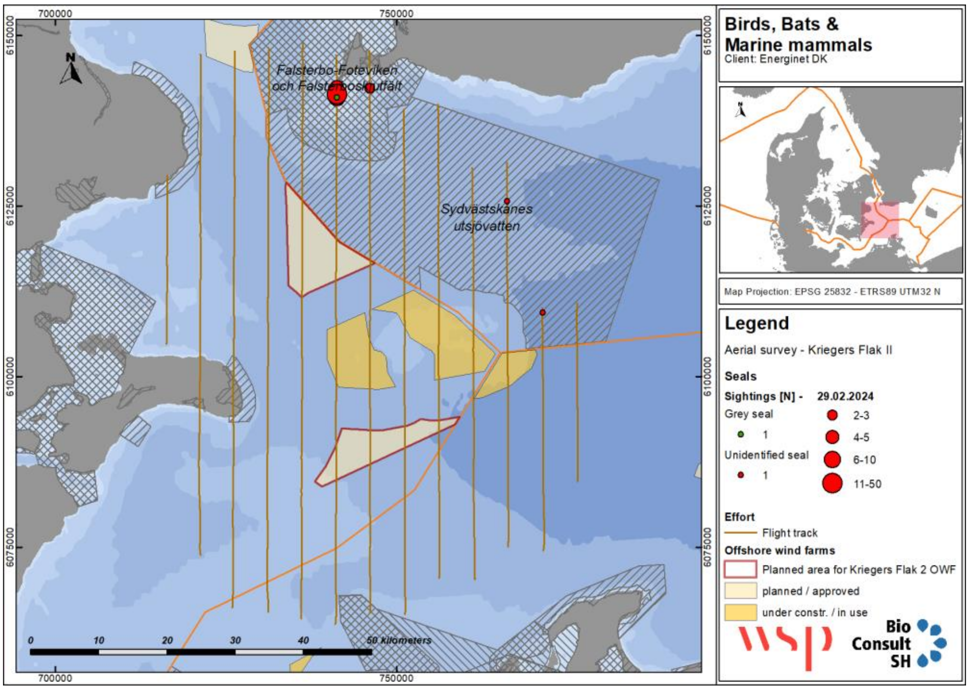

Figure 9-7. Seal observations in the pre-investigation area during the digital aerial survey on 29.02.2024.

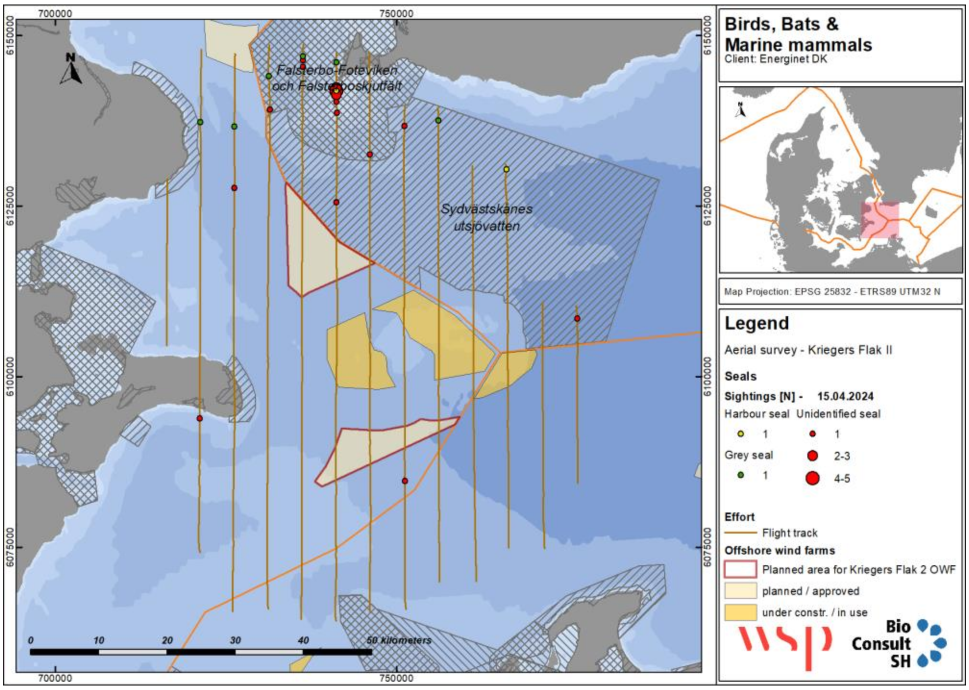

Figure 9-8. Seal observations in the pre-investigation area during the digital aerial survey on 15.04.2024.

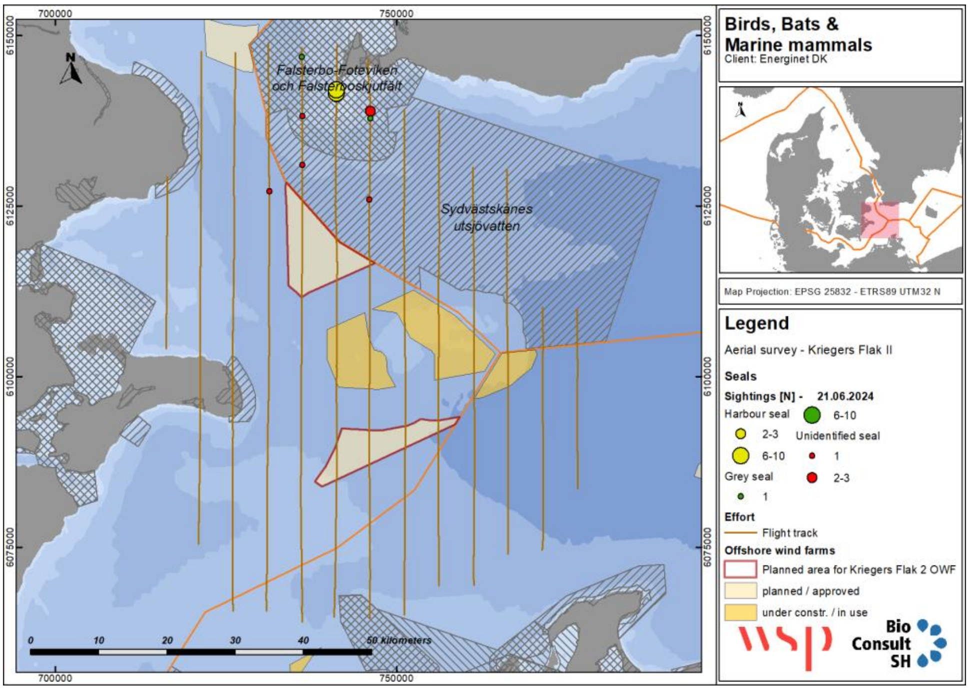

Figure 9-9. Seal observations in the pre-investigation area during the digital aerial survey on 21.06.2024.

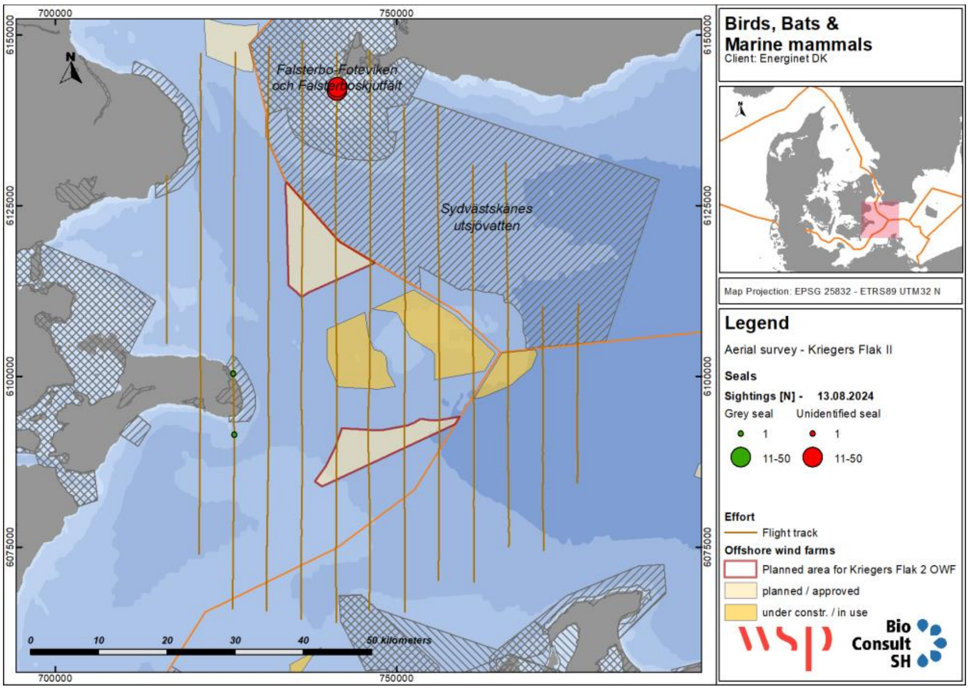

Figure 9-10. Seal observations in the pre-investigation area during the digital aerial survey on 13.08.2024.

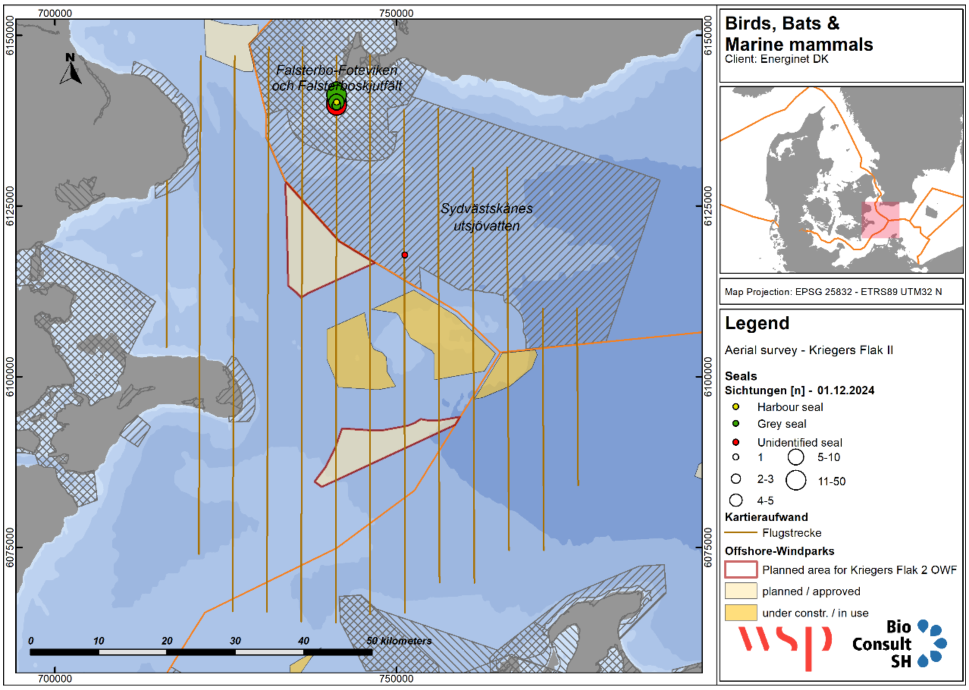

Figure 9-11. Seal observations in the pre-investigation area during the digital aerial survey on 01.12.2024.

9.2 HARBOUR PORPOISE – AERIAL SURVEY SIGHTINGS

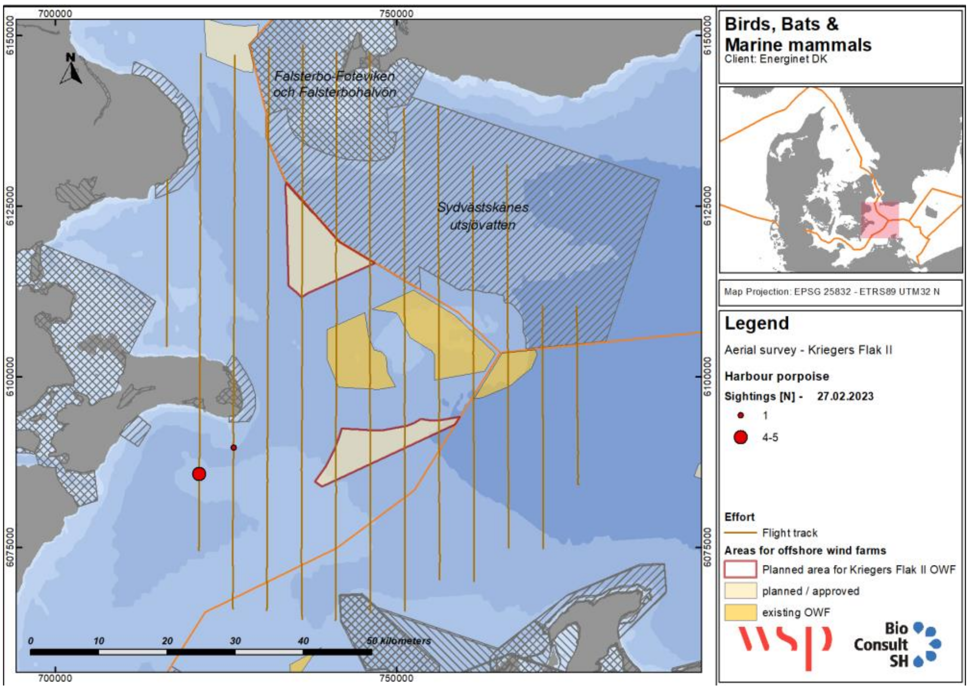

Figure 9-12. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 27.02.2023.

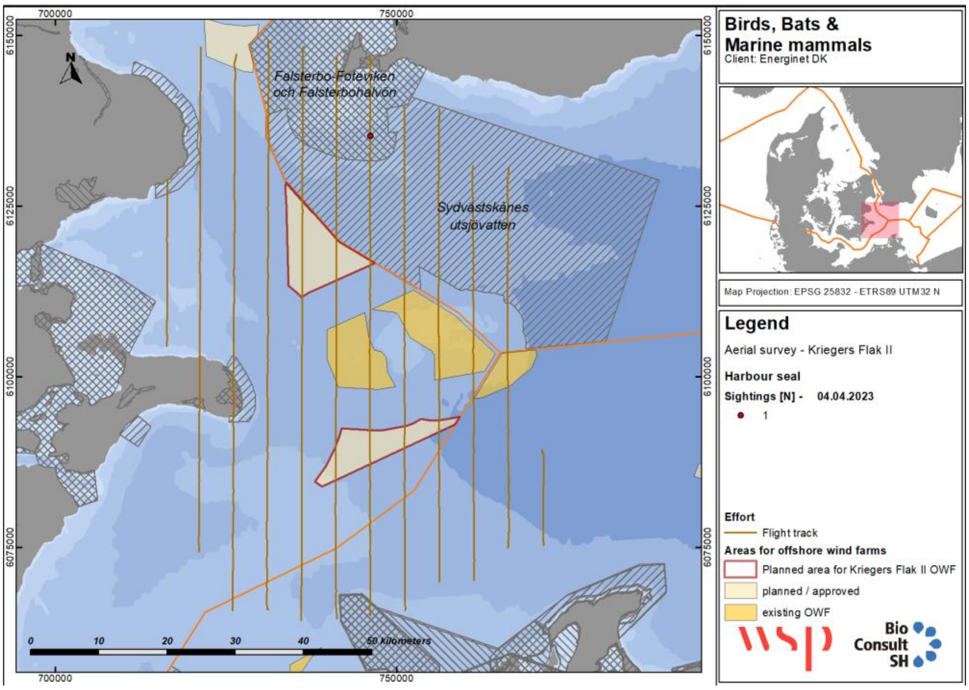

Figure 9-13. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 04.04.2023.

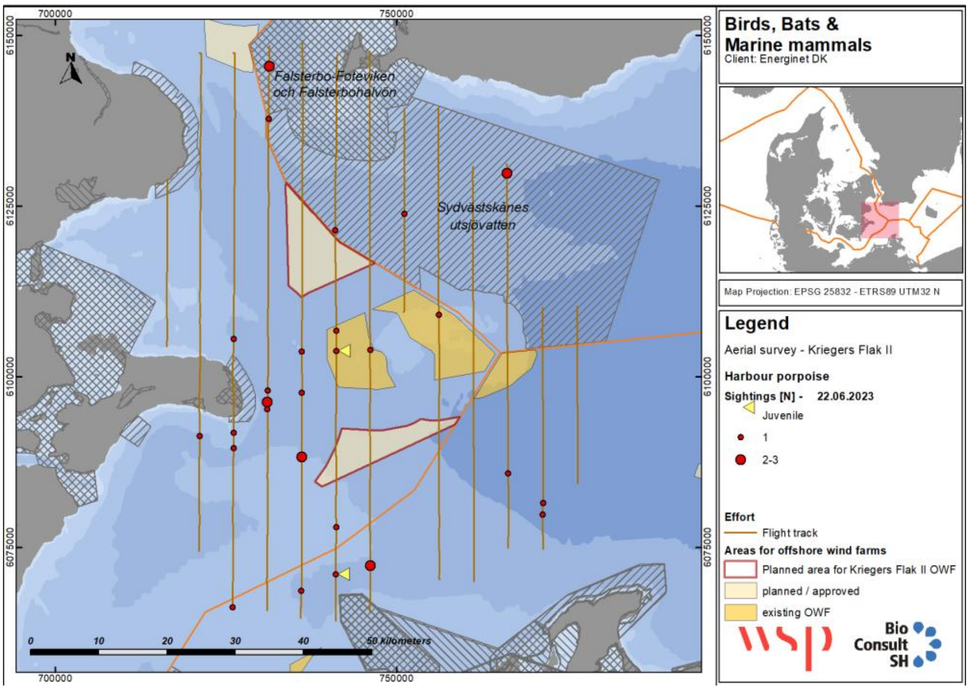

Figure 9-14. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 22.06.2023.

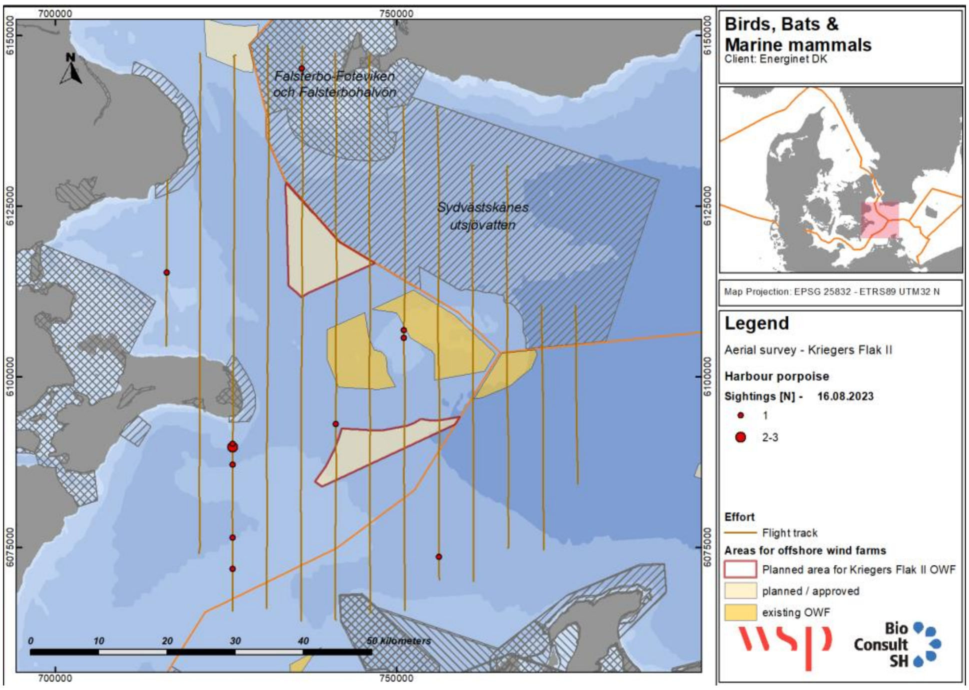

Figure 9-15. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 16.08.2023.

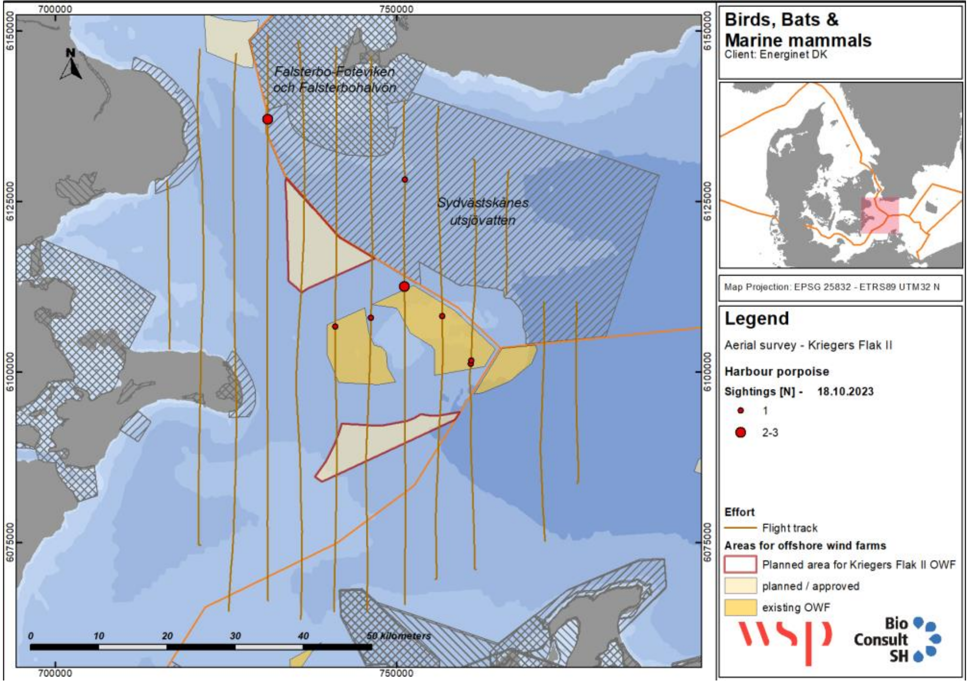

Figure 9-16. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 18.10.2023.

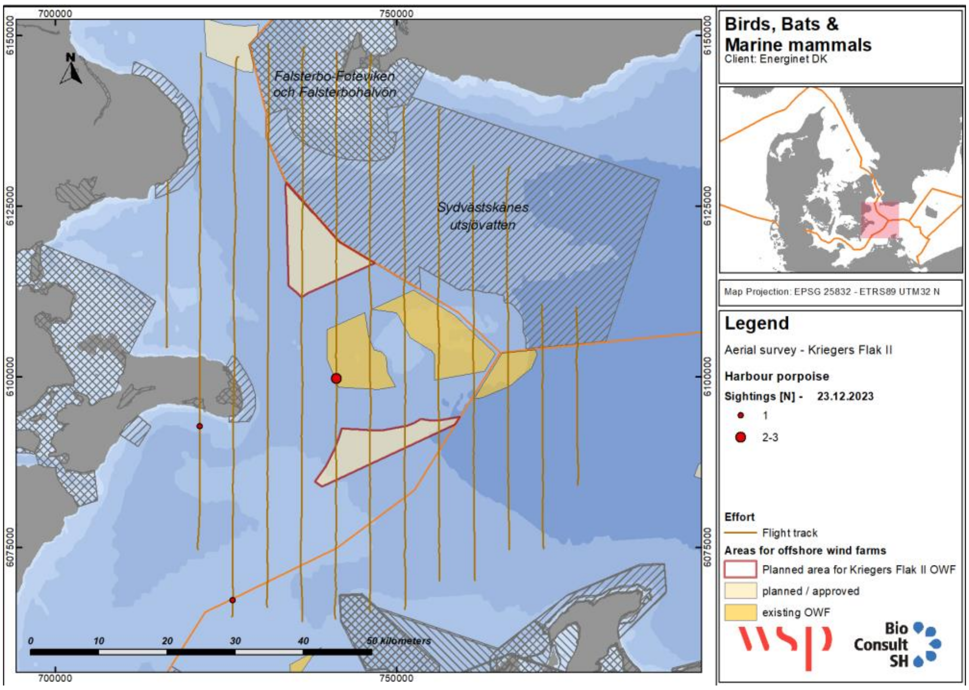

Figure 9-17. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 23.12.2023.

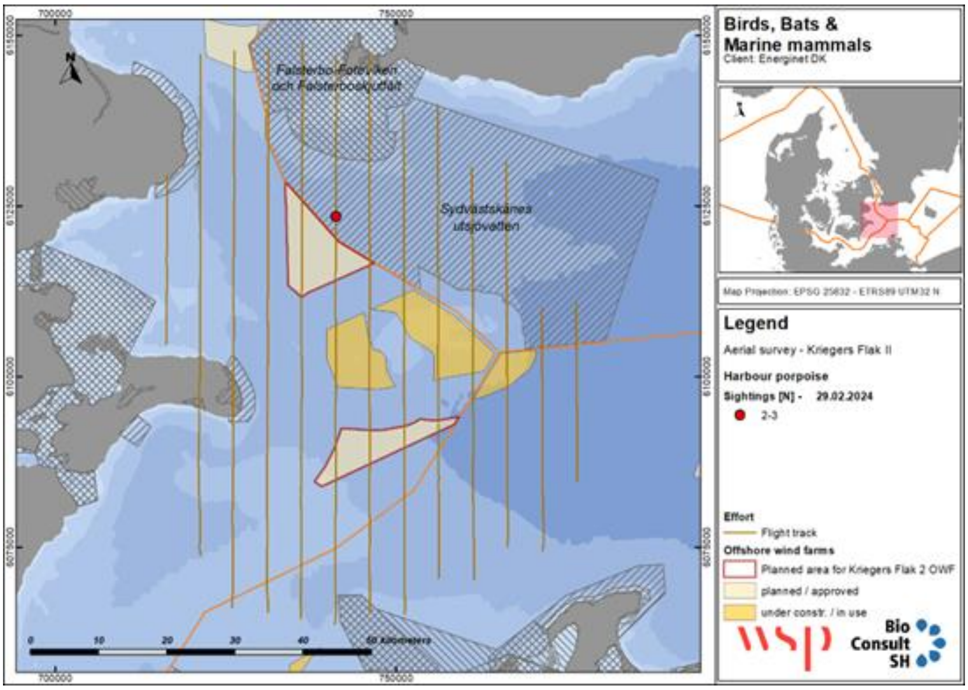

Figure 9-18. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 29.02.2024.

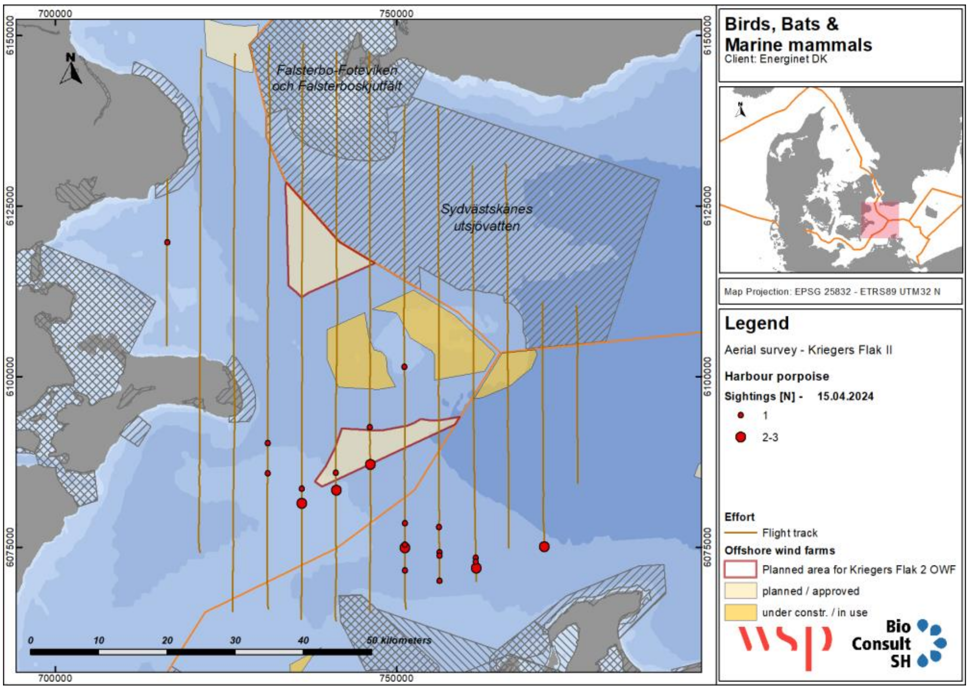

Figure 9-19. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 15.04.2024.

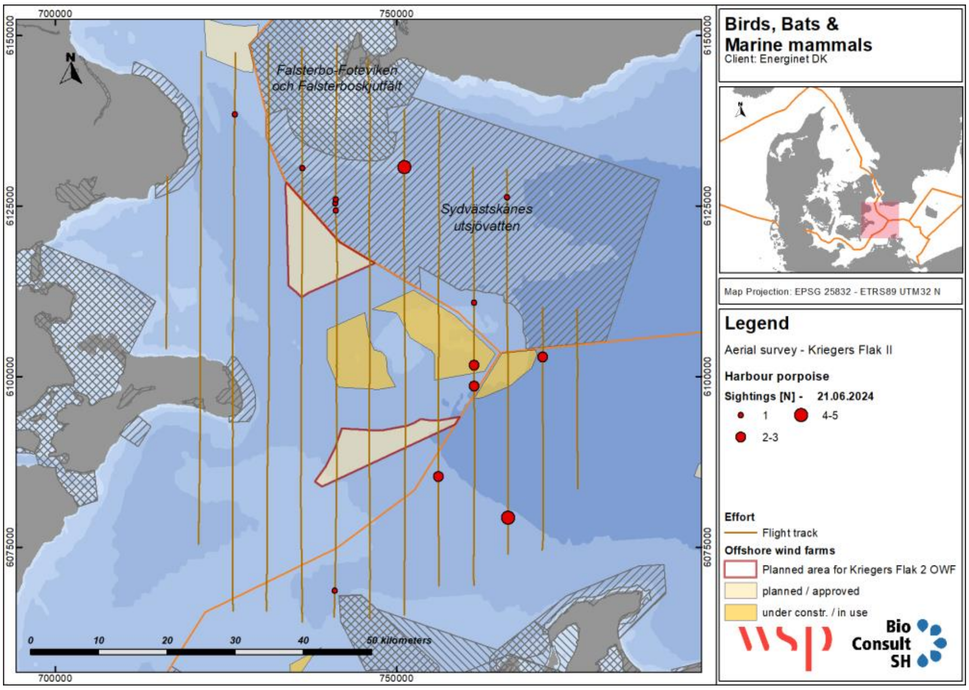

Figure 9-20. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 21.06.2024.

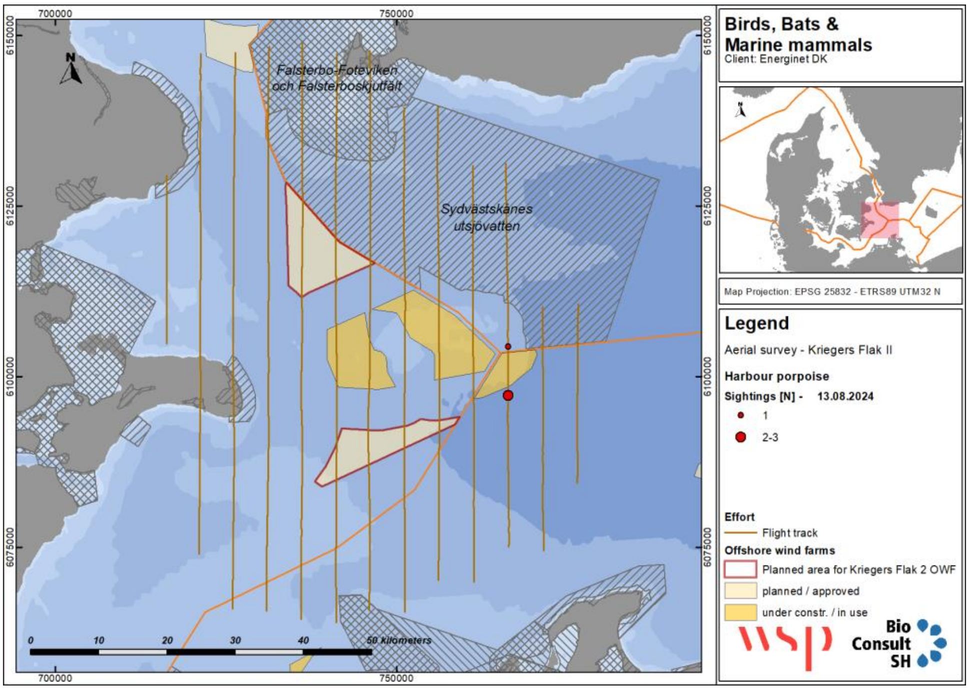

Figure 9-21. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 13.08.2024.

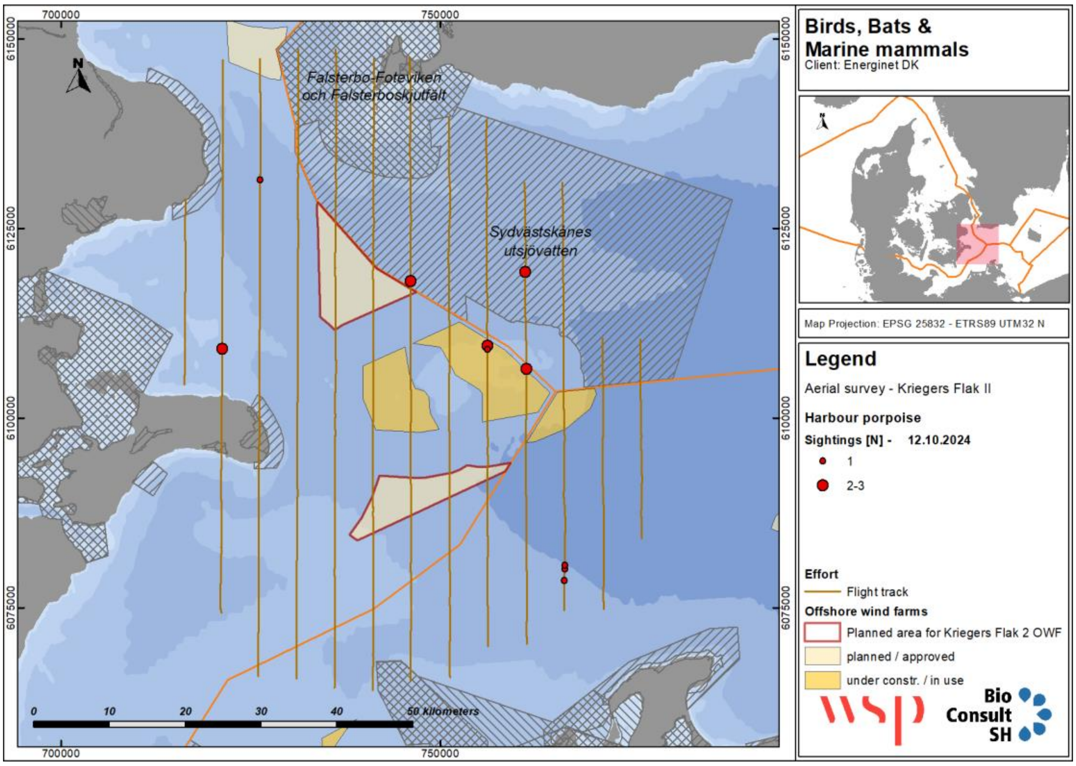

Figure 9-22. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 12.10.2024.

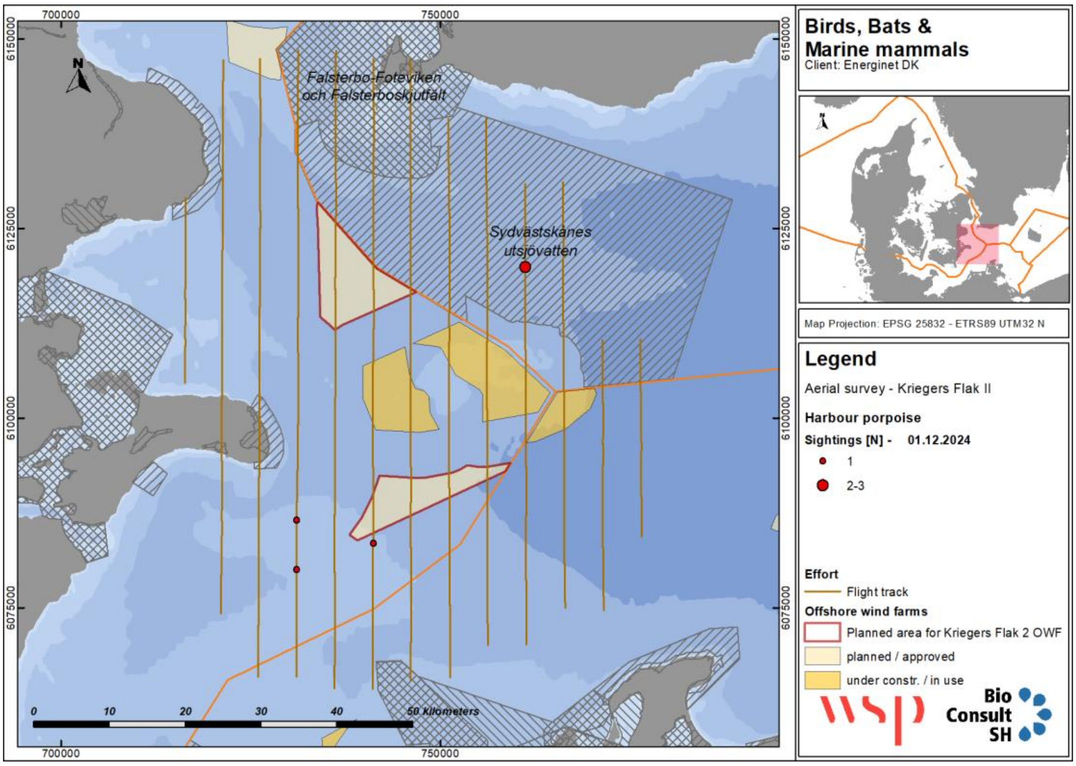

Figure 9-23. Harbour porpoise observations in the pre-investigation area during the digital aerial survey on 01.12.2024.