ENERGINET

# ENVIRONMENTAL NOTE - CRANE AND BIRDS OF PREY AVOIDANCE RESPONSE TO OFFSHORE WIND FARMS

03-05-2024

# ENVIRONMENTAL NOTE - CRANE AND BIRDS OF PREY AVOIDANCE RESPONSE TO OFFSHORE WIND FARMS

ENERGINET

| | |
|---|---|
| Project name | **ENVIRONMENTAL NOTE - CRANE AND BIRDS OF PREY AVOIDANCE RESPONSE TO OFFSHORE WIND FARMS** |
| Project no. | **22003772** |
| Recipient | **Energinet** |
| Document type | **Note** |
| Version | **Version 2** |
| Date | **03-05-2024** |
| Prepared by | **Mikkel Friborg Mortensen, Rune Skjold Tjørnløv, Rasmus Velling and Jannis Liedtke.** |
| Checked by | **Jan Frydensberg Nicolaisen and Erik Mandrup Jacobsen** |
| Approved by | **Client: Bent Sømod** |
| Description | **Environmental Note - Crane and birds of prey avoidance response to Offshore wind farms** |
| Frontpage picture | **Common cranes (*Grus grus*) flying at the GPS marking site, Sweden 2022.** |

WSP.COM
BIOCONSULT SH GMBH & CO. KG

# CONTENTS

| Abbreviation | Explanation |
|---|---|
| **AEWA** | African-Eurasian Migratory Waterbird Agreement |
| **BSH** | Federal Maritime and Hydrographic Agency of Germany (Bundesamt für Seeschifffahrt und Hydrographie) |
| **CITES** | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| **CPUE** | Catch per unit effort |
| **CRM** | Collision Risk Model |
| **DEA** | Danish Energy Agency |
| **EIA** | Environmental Impact Assessment |
| **EIB** | Energy Island Bornholm |
| **FHD** | Flight Height Distribution |
| **GPS** | Global Positioning System |
| **GW** | Gigawatt |
| **IUCN** | International Union for Conservation of Nature and Natural Resources |
| **LRF** | Laser-rangefinder |
| **LT** | Local time |
| **MTR** | Migration Traffic Rate |
| **OWF** | Offshore Wind Farm |
| **SLU** | Sveriges lantbruksuniversitet |

# SUMMARY

The Energy Islands mark a new era in offshore wind energy generation, aimed at providing renewable power to Danish and foreign grids. These offshore renewable power plants will help phase out fossil fuels in Denmark and Europe. The establishment of an Offshore Wind Farm (OWF) of this magnitude will most likely have different environmental impacts, but the effect on long-distance migratory birds like cranes and birds of prey is not well-documented.

To prevent or minimize the risk of collision, it is crucial to gain knowledge of species-specific avoidance behaviour in migrating flocks of birds. Macro-avoidance occurs outside the OWF, meso-avoidance within the array, and micro-avoidance involves last-second manoeuvres to avoid rotor blades. Unfortunately, detailed data on avoidance behaviour, especially on migrating cranes, is limited, often resulting in conservative assumptions about the risk of collision being made in Environmental Impact Assessments (EIAs), due to a precautionary principle. This study used radar and laser-rangefinder methods from a vessel anchored in front of the existing offshore wind farms Kriegers Flak (Denmark) and Baltic 2 (Germany), to observe avoidance behaviour of cranes and birds of prey at different spatial scales (macro-, meso-, and micro) in relation to the OWFs and thereby assist in filling in the knowledge gap.

During the survey period, autumn 2022 and spring 2023, a total of 3,425 cranes, occurring in 47 flocks were observed in autumn 2022 and 1,041 cranes, distributed in 37 flocks, were observed in spring 2023. Adding up to a total of 4,466 cranes, distributed in 84 flocks, observed within in the survey period. In total, 49 % of all cranes distributed in 40 flocks, showed detectable avoidance behaviour on either macro scale, macro-, meso-, micro scale or at meso-, and micro scale. The avoidance behaviour observed was quite equally distributed between avoidance expressed on the macro scale, 36 %, avoidance expressed as a combination at the macro-, meso-, and micro- scale, 28 % and avoidance expressed on the meso-, and micro- scale, 36 %. The flocks of birds, that expressed avoidance behaviour, appeared to be able to react both at macro scale, performing either vertical or horizontal avoidance behaviour from a faraway distance, and at meso-, and micro- scale avoidance manoeuvring in-between the rotor swept area without colliding. Additionally, ten sparrowhawks, one marsh harrier, and one red kite was also observed, some expressing signs of avoidance behaviour.
In general, the flocks recorded during the vessel surveys showed to avoid strong winds when migrating and preferred lower wind speeds. However, the wind direction showed less important, with most of the flocks recorded during headwinds in autumn 2022 and during tailwinds in spring 2023, as well as a third of the observed flocks, both during autumn 2022 and spring 2023, recorded migrating in crosswinds.

Results from the Band collision model predicted roughly 1-2 collisions for cranes per year for the same migration passage, conditional on commonly applied avoidance rates (0.98 – 0.99). This suggests that common cranes exhibit a high level of avoidance towards offshore wind farms. The true average rate might be as high as 0.99 – 1. However, in that case, our modelling results show that a much larger number of cranes would have to be observed passing through the wind farm in order to have a fair chance of detecting just a single collision.

Secondly, this study fitted GPS transmitters to track 11 juvenile cranes in southern Sweden in 2022 and six cranes in northern Sweden in 2023, gathering real-time data on their migration across the Baltic Sea, Kattegat, the Sound Gulf of Bothnia, the Gulf of Finland, and the Gulf of Riga during autumn 2022, spring 2023 and autumn 2023. The cranes flew at varying altitudes from near the sea surface to above one kilometre. Some cranes exhibited soaring behaviour when approaching the coast to benefit from thermal upwinds, however, this behaviour was also observed over open water without thermals and while approaching offshore wind farms.
No collisions between migrating birds and wind turbines were observed throughout the survey periods during the vessel surveys, nor did the GPS transmissions indicate any evidence of collision incidents.

However, further analyses are required in order to investigate, whether this pattern of avoidance persist in adverse weather conditions.

# 1 INTRODUCTION

The Energy Islands mark the beginning of a new era for the generation of energy from offshore wind, aimed at creating a renewable energy supply for Danish and foreign electricity grids. Operating as renewable energy power plants at sea, the islands are expected to play a major role in the phasing-out of fossil fuel energy sources in Denmark and Europe.

After political agreement on the energy islands has been reached, the Danish Energy Agency (DEA) plays a key role in leading the project that will transform energy islands from a vision to reality. The Energy Island projects are pioneer projects that will necessitate the deployment of existing knowledge into an entirely new context.

In the Baltic Sea, the electrotechnical equipment will be placed on the island of Bornholm, where electricity from offshore wind farms will be routed to electricity grids on Zealand and neighbouring countries. The turbines off the coast of Bornholm will have a capacity of up to 3.8 GW.

The establishment of an Offshore Wind Farm (OWF) of this magnitude will most likely have different environmental impacts, especially on the ecosystem of the area in close proximity to the OWF, but the effect on long distant migrants such as the common crane (*Grus grus*), hereafter crane, is only incompletely described in the literature. The migration of cranes across the Baltic Sea is known to be distributed over a broad front. Although migration intensity can be higher at specific departure points on land, migrating cranes tend to disperse over a wide area when crossing the open sea. Given the ongoing development of offshore wind farms in the southern Baltic Sea region, it has become more and more likely that migrating cranes will encounter wind farms offshore during their passage between breeding and wintering sites. Therefore, cranes risk to collide with the spinning blades of offshore wind turbines during their bi-annual passage. Inevitably, a collision between a crane and a spinning rotor offshore is most likely to have a fatal outcome. Thus, knowledge of the species-specific migratory behaviour of cranes and on their ability to avoid collision with turbines in the offshore environment is critical, in order to minimise the negative impact on survival of migration flocks.

### *1.1.1 OFFSHORE WIND FARMS AND FLIGHT BEHAVIOUR*

Since one of the projects main goals was to observe the avoidance behaviour of cranes approaching an OWF, investigations of flight behaviour near existing wind farms can provide valuable information about impacts from already commissioned as well as future offshore wind farms.

Avoidance behaviour will depend on multiple factors. First, there are site independent factors such as weather conditions in particular wind (wind speed, direction) and visibility. It is therefore expected that avoidance behaviour will be affected by weather independently from the exact location/wind farm site. Secondly, avoidance behaviour will crucially depend on the flight height of birds. Only if birds fly at certain altitudes they are at risk of colliding with the turbine and thus will only show avoidance at specific flight heights and potentially show different avoidance types (macro- versus meso- avoidance and vertical versus horizontal movements) depending on the exact flight height.

Flight heights in turn are influenced by location. Depending on season flight height of cranes near to the starting point of migration will be higher and slowly decrease over the course of crossing the sea. Thus, to accurately predict avoidance behaviour we need season- and site-specific flight height distributions (FHDs).

This note has proposed methods to investigate the near wind farm flight behaviour of common crane – in particular FHDs and avoidance behaviour. This was achieved using vessel-based surveys, that investigated FHD and avoidance behaviour of cranes near OWFs during their migration over the Baltic Sea. By a combination of radar and laser-rangefinder methods, avoidance behaviour was specified on different scales. Horizontal radar allowed tracking of cranes up to 20 km distance and thus to observe large distance (macro-) avoidance. Whereas the usage of the laser-rangefinder obtained three-dimensional data on flying birds close to and even within the OWFs if the birds flew in between the turbines, which allowed the capturing of meso-, and possible micro- scale avoidance behaviour, further explained in section 4 Methodology.

In combination, these methods contributed to determine avoidance behaviour of cranes towards OWFs, on the macro-, meso-, and micro- scale.

Avoidance rates are a crucial factor in collision risk models (CRMs; Band 2012, May 2015). For example, a change in assumed avoidance rate from 95 % to 99.5 % can result in a 10-fold change of estimated collisions (compare Chamberlain et al., 2006). Unfortunately, precise, and data-based estimates of avoidance behaviour towards OWFs and FHD of migrating cranes are very limited. This lack of knowledge leads to the practice of assuming rather low avoidance rates in collision risk models during EIAs, due to a precaution principle.

Consequently, German authorities are considering demanding wind farms to be shut down if specific threshold of mean migration traffic rates (MTR) are exceeded. However, recent investigations of crane flight behaviour towards onshore wind farms shows significant higher avoidance rates than typically used in CRMs ranging from 99.88 % to 100 % (Drachmann et al., 2021). This stresses the importance of assessing cranes' avoidance behaviour in an offshore setting. Identifying accurate avoidance rates of cranes towards offshore OWFs are therefore of utmost importance to correctly estimate the number of collisions using CRMs. The same holds true for FHD (Johnston et al. 2014b) which we aimed to identify in this project. The aim of the note was to provide data on the avoidance behaviour of cranes and birds of prey towards operating offshore wind farms, which is essential for assessment of the impacts of OWFs on these bird species in future EIA's.

### *1.1.2 VESSEL BASED SURVEYS OF MIRGATING CRANES AND BIRDS OF PREY*

A vessel, Skoven (IMO: 8621408, 41.87 x 8.41 meters), anchored in front of the existing offshore wind farms, Kriegers flak (Denmark) and Baltic 2 (Germany), facing the cranes and birds of prey as they migrated through the survey area, providing some of the best observation opportunities possible. Since migration directions changes with season, the best observation spots changed accordingly. Using a vessel, it was possible to freely choose where exactly to anchor and observe depending on the season: north or south of a particular wind farm facing the approaching birds (Figure 1). Additionally, the anchor site was changed during an observation trip, if it turned out that, on a specific day, cranes mainly crossed the Baltic Sea some distance further west or east of the current location. While the main migration corridor generally is known, unpredictable conditions such as weather may affect the migratory patterns.

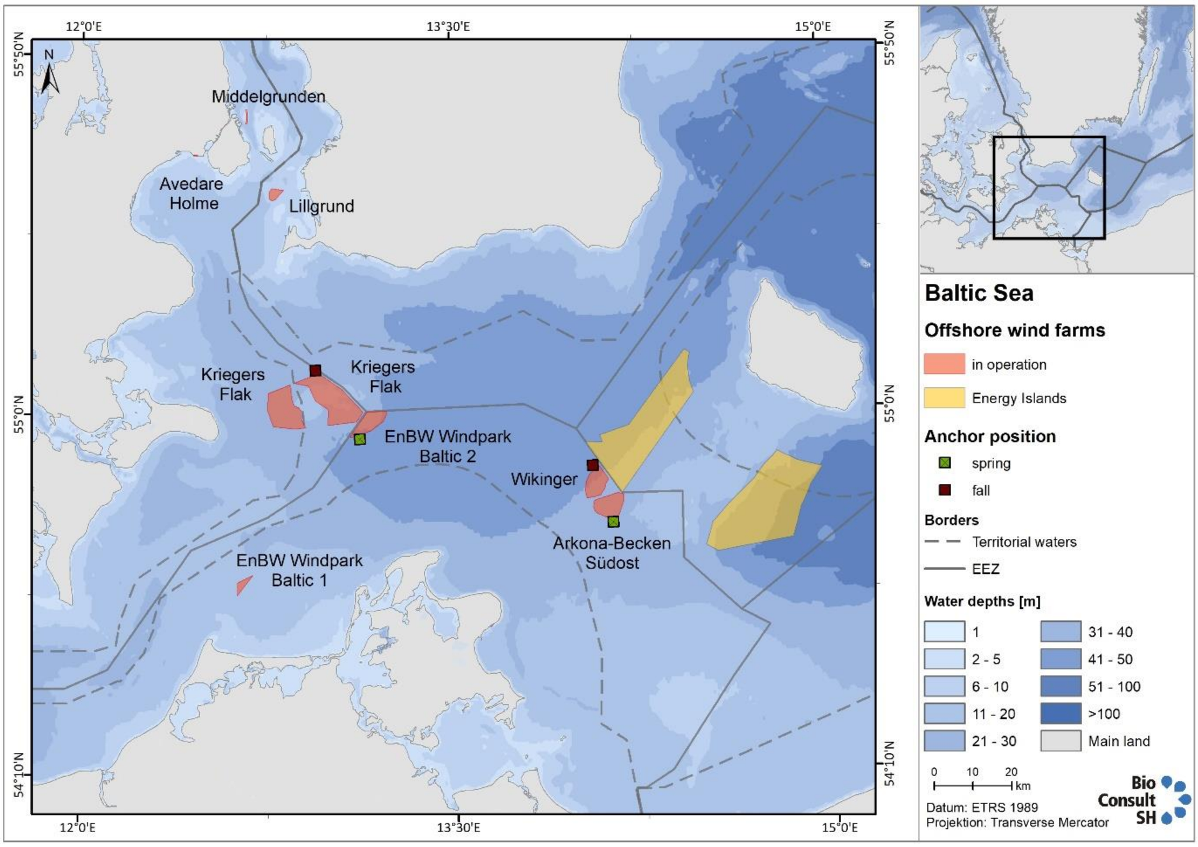



**Figure 1. Overview of the survey area, Kriegers Flak and Baltic 2, alongside the other operational wind farms in the Baltic Sea between the Danish, Swedish and German bodies of water, as well as the proposed area of the Energy Islands. Potential anchor positions are given in green for spring migration and in dark brown during fall migration.**

To observe enough migrating cranes and to generate a sufficient database (sample size) for statistical analysis seven observation days were accomplished. To produce enough data, the field trips needed to match with the migration peak. Information from local observers and online bird observation databases helped determine the onset of migration. Together with weather forecasts indicating good migration conditions, this aided narrowing down to the most likely periods of crane migration over the Baltic Sea and when to start field observations accordingly. The vessel used for the observations was available on short notice, which allowed full flexibility and the possibility to mobilise with very short notice. Nevertheless, due to stochastic events and local conditions at migration starting sites, the main days on which cranes will cross the Baltic Sea are impossible to predict precisely. Therefore, the risk of spending observation days out at sea without any or just a few sightings of cranes cannot be eliminated completely.

### 1.1.3 SUPPORTING DATA FROM CRANES WITH SATELITTE TRANSMITTERS

To obtain migratory flight and avoidance behaviour on a fine scale, 11 juvenile cranes were tagged with GPS transmitters (OrniTrack-R19 3G solar powered GPS-GSM transmitter) in southern Sweden in 2022. To supplement these and to investigate the migration route of birds from a more northerly breeding population, another 6 juvenile cranes were tagged in northern Sweden in 2023. Juveniles are most frequently selected for tagging, because they are easier to catch than adults and because the risk of harming individuals during capturing is smaller. It is possible to capture adult cranes using canon-nets, snares, and other highly invasive methods. However, these methods imply a higher risk of injury, lower chances of success and increased logistical cost regarding planning and execution of field activities.

Juvenile cranes have high survival rates, follow the same migration routes as their parents and tend to join larger groups of other migrating cranes. It is therefore most likely, that the generated tracks represent typical migration routes of cranes, rather than random routes taken by inexperienced individuals.

Flight behaviour data derived from the GPS tracks was analysed using adequate models incorporating weather data.

# 2 BIRDS AND OFFSHORE WIND FARMS

Birds making use of the survey area can be roughly divided into two groups; resting seabirds that utilize the area for a pro-longed period of time and migrating birds that may cross the area temporarily while alternating between different distant regions (e.g., cranes and birds of prey).

Potentially, offshore wind farms pose a variety of direct and indirect impacts to migrating birds, most notably:

- Risk of collision with turbines, which most often results in direct mortality
- Barrier effects where the wind farm constitutes an obstacle to migrating birds forcing birds to find alternative routes or adjust their flight altitude
- Displacement effects on resting seabirds

The degree to which these birds may be affected by any of these potential risks associated with the operation of offshore wind farms varies strongly with respect to the species. Moreover, impacts from offshore wind farms cannot be seen in isolation, because they are additive to other existing anthropogenic effects, such as agricultural monocultures and large-scale solar fields, which reduce the available space for either breeding and/-or roosting habitats (Dwyer et al., 2018).

### 2.1.1 BIRD MIGRATION

Migrating birds alternate between breeding and non-breeding regions. They can disperse very long distances twice a year in order to optimize feeding and climate conditions. Although it is a regular yearly repeating phenomenon, the magnitude and timing of migration can vary strongly from year to year and is subject to great variation. Moreover, some species migrate long distances, others only comparatively shorter distances, while for other species, only parts of the populations may migrate, and the rest remain in the area.

Despite the great variability, estimates suggest that about half a billion birds of about 200 species cross the western Baltic Sea during autumn, and half of this number (~ 250 million birds) crosses the area in spring (BSH, 2021). The great majority of them (> 95 %) are songbirds. The rest is composed of sea- and waterbirds such as divers, grebes, ducks, geese, waders, gulls, terns and auks and by thermal gliders such as birds of prey and cranes (BSH, 2021).

As already mentioned, bird migration is very variable and thus hard to predict. However, birds adapt the timing of their migration to weather conditions such as temperature, precipitation, fog, wind speed and direction, because energetic costs are related to the presence and magnitude of these parameters (BSH, 2021). Thus, migration does not occur regularly but most of it takes place during certain days of the migration period.

For many Scandinavian and Siberian breeding bird species, the Baltic Sea is part of their annual migration routes (Figure 2). Numerous night-migrating songbirds are thought to cross the Baltic offshore area in a broad front movement mostly with a south-western orientation, but local aggregations and deviating directions are also possible. Most day-migrating land birds follow landmarks from Falsterbo in Sweden over Danish islands such as Zealand and Lolland and German Fehmarn to the mainland of Europe, but fractions of those populations also directly cross the open water. Waterfowl like geese, ducks or divers mainly move through the area in an east-west direction (Bellebaum et al., 2010a).

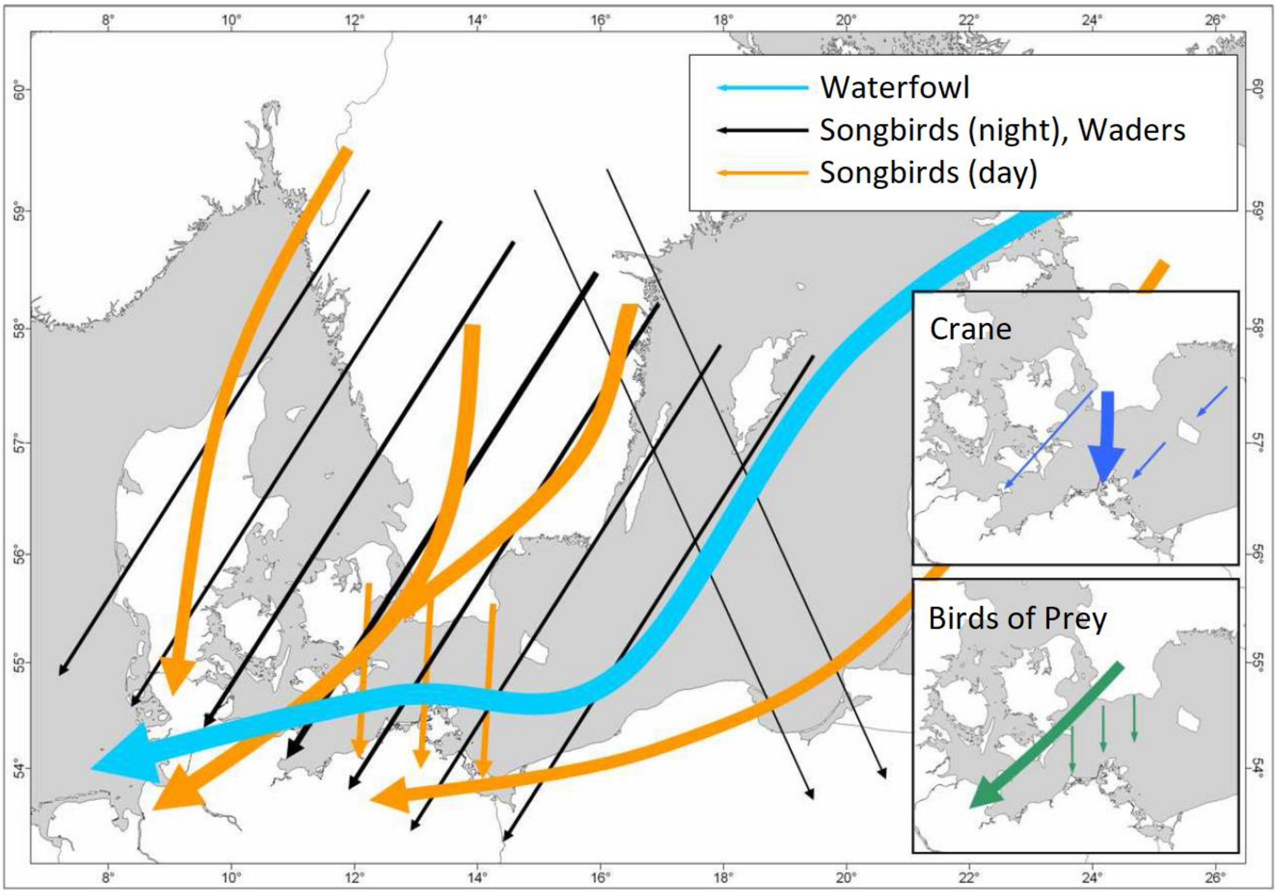



**Figure 2. Most important migration routes in the Baltic Sea during autumn. Arrow thickness reflects migration intensity. From Bellebaum et al., (2010a).**

# 3 RELEVANT SPECIES AND SPECIES GROUPS

In this section, an overview of the most relevant species groups of migrating birds potentially present at the survey area, the area around the OWS's Kriegers Flak and Baltic 2, is provided.

## 3.1 CRANES

### *3.1.1 BIOLOGY, DISTRIBUTION AND ABUNDANCE*

The population of cranes breeding in Northwest Europe and Scandinavia increased in size and is estimated to be 350,000 individuals (WETLANDS INTERNATIONAL 2022, AEWA CSR 8, retrieved on 25.02.2022). Especially for cranes of Finland and Sweden, the Southwestern Baltic Sea is an integral part of their migration route to and from wintering quarters in Southwestern Europe. The Rügen-Bock region in Germany is an important resting area, hosting temporarily up to 40,000 cranes (BSH, 2021). A huge part of these birds crosses the Arkona basin in a 1–2-hour flight. Especially in autumn, a proportion of cranes will also move in a southwestern direction over the area of Bornholm (Figure 3). The exact number of birds crossing the survey area is not known and will be highly dependent on the weather conditions each year.

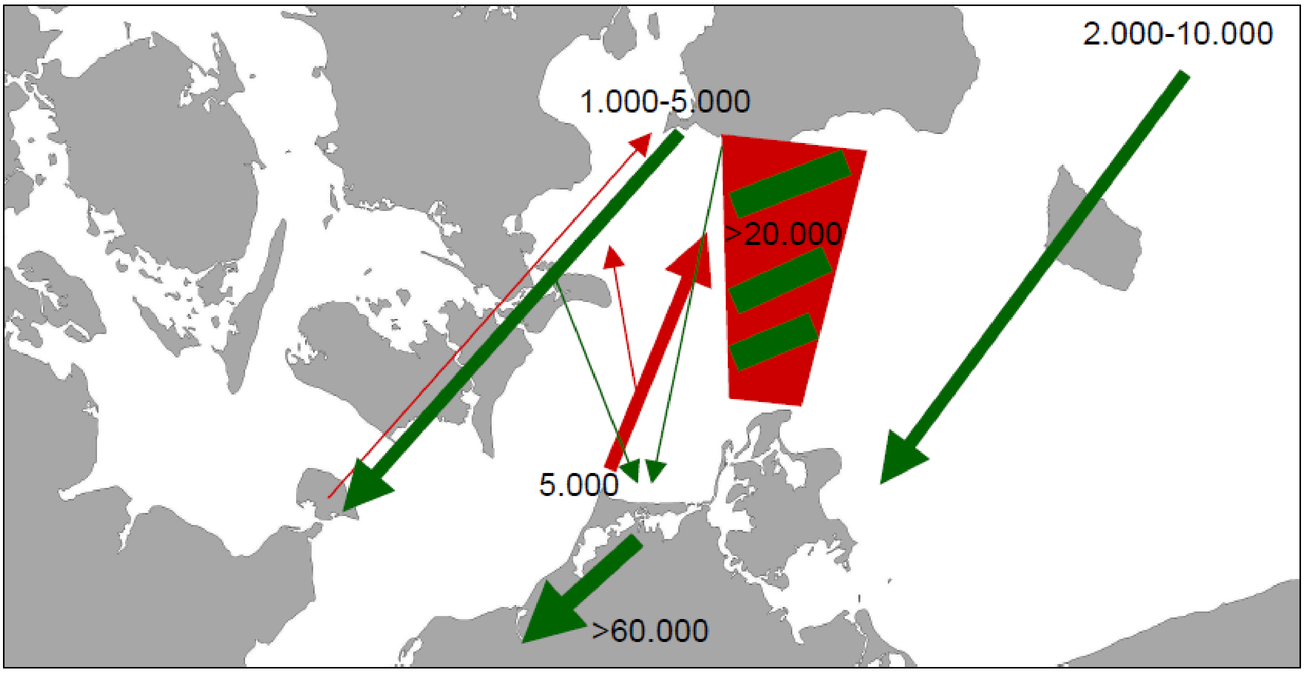



**Figure 3. Migration routes of common cranes in the southern Baltic area (BSH, 2021, based on Falsterbo, Bornholm and other observation data). Estimated numbers may be higher today due to an increasing population trend. Red arrows mark spring migration routes and green arrows autumn migration. The thickness of the lines indicates the assumed magnitude of migration and for the central route between southern Sweden and Rügen the approximate spatial extension of this migration corridor.**

At Bornholm, the crane is a relatively common breeding bird, and the island probably holds the densest population of breeding in the country. During the latest Danish breeding bird atlas, at least 70 pairs were breeding at the island, and the population is still increasing (Vikstrøm & Moshøj, 2020).

The number of migrating cranes passing Bornholm is highly dependent on wind conditions, with the highest number during periods with westerly winds (BSH, 2021) and generally more birds during autumn compared to spring (Table 1).

**Table 1. Monthly distribution of the number of cranes observed at Bornholm 2010-2023. The numbers are "max numbers", i.e. the highest number of birds observed on a single day each month (DOF-basen, 2023).**

| Month | Max number |
|---|---|
| January | 14 |
| February | 55 |
| March | 200 |
| April | 282 |
| May | 82 |
| June | 42 |
| July | 91 |
| August | 288 |
| September | 3,814 |
| October | 6,250 |
| November | 395 |
| December | 9 |

### *3.1.2 CONSERVATION STATUS AND POTENTIAL THREATS*

Due to its increasing population trend, the crane currently has a Red List status of "least concern" (BirdLife International, 2021). However, its susceptibility to increasing offshore wind power generation remains not completely clear. One important behavioural trait in this regard might be the flight height of cranes crossing the Baltic Sea. Cranes tend to use soaring flight over land, but due to the lack of thermal updrafts over the open water, they have to gain or hold their altitude in powered flight after leaving the coasts (Alerstam, 1990). Studies of flight altitudes of cranes in the Baltic offshore region so far reveal a certain variety, with cranes observed flying clearly below 200 meters height as well as far above (Schulz et al., 2013; Skov et al., 2015). Also, a dependency on wind directions has been observed.

## 3.2 BIRDS OF PREY

### *3.2.1 BIOLOGY, DISTRIBUTION AND ABUNDANCE*

Birds of prey, also known as raptors, are all top predators. More than half of the known world species (at least 62 % or 183 species) undertake seasonal migrations, many of them are long-distance migrants undertaking sometimes intercontinental flights (Bildstein, 2006). Most birds of prey can soar, which is why they are able to maintain flight without flapping their wings and making use of the rising air currents and thereby reducing energetic costs. Soaring is an efficient form of transport, both during and outside of long-distance migration (Bildstein, 2017). Especially, long-distance migrants such as the European Honey buzzard or Montagu's Harrier, are strongly dependent on soaring flight to complete their migration routes. Whereas many species use soaring during their migration routes, others do migrate with powered flight (flapping their wings; examples are ospreys, harriers, most accipiters and falcons). Most raptors are day migrants, but few species such as peregrine falcons, ospreys, and merlins also migrate during nights. Migrating raptors travel over well-known corridors and often in flocks (Bildstein, 2006).

The most important flyway for raptors in Europe is the western European-western Africa flyway (Bildstein, 2017). A comparative study of satellite tracking and ring recoveries for four common raptor species show detailed information on the routes taken by these migrants (Strandberg et al., 2009). In Europe, there are about 39 species of breeding diurnal birds of prey (Stroud, 2003).

Relatively close to the survey area, at the Falsterbo peninsula in south Sweden, raptor autumn migration has been studied since the early 1940s (Kjellén & Roos, 2000) whereas standardized counts of raptors and other migratory birds have been conducted since 1973 (Kjellén, 2019). It has then been estimated that an average of 46,000 migrating raptors and falcons are observed annually. The most common species there are Eurasian sparrowhawk *Accipiter nisus*, common buzzard *Buteo buteo* and the red kite *Milvus milvus* (Kjellén, 2019). Species with more southerly distribution, which breeds close to Falsterbo, are more easily observed than species with northerly distribution (Kjellén, 2019). Similarly, thermal migrants tend to be more concentrated than active flyers at Falsterbo and also since raptors tend to fly at lower altitudes there, the censuses at Falsterbo have been particularly important for studies of raptors (e.g., Kjellén, 1997).

The numbers of most common birds of prey seem to have increased or maintained stable within the last decades of the censuses (cf. Kjellén, 2019). Three species however show negative trends in their censuses numbers in Falsterbo: the European honey buzzard *Pernis apivorus,* the rough-legged buzzard *Buteo lagopus* and the northern goshawk *Accipiter gentilis* (Kjellén, 2019). In comparison to a previous study on the trends of raptors from 1940s to the late 1990s in the same area, there seems to be a slight recovery in the numbers of raptors currently migrating through Falsterbo (Kjellén & Roos, 2000; Kjellén, 2019).

There is, however, a large variation in the number of raptors being observed during the autumn migration every year. This may not only be linked to more birds being counted under favourable weather conditions (for example, when birds fly against the wind, they tend to fly at lower altitudes, and may be easily observed and counted), but also to real changes in the populations due to changes in productivity. For example, species like the Eurasian honey buzzard *Pernis apivorus* and the rough-legged buzzard *Buteo lagopus* are known to produce varying numbers of juveniles in relation to the availability of prey during the breeding season (e.g., wasps and rodents respectively, Kjellén, 2019).

**Table 2. Population size estimates, trends, average numbers seen at Falsterbo in Sweden (between 1942-1960 and between 1973-2019) and conservation status for the most common raptor species expected to migrate over the survey area. Population trends: INC = increasing, DEC = declining, STA = stable. See 9.1.4 for explanation of EU's bird directive.**

| Species | Most recent population estimate (Trend)[1] | Annual average numbers at Falsterbo (1942-1960)[2] | Average autumn migration numbers at Falsterbo[3] | Conservation status | | |
|---|---|---|---|---|---|---|
| | | | | European Birds Directive | CITES | Red List Birdlife 2021 |
| Eurasian Sparrowhawk (*Accipiter nisus*) | 728,000-1,150,000 (STA) | 5,944 | 20,364 | I (only ssp *granti*) | II | LC |
| Common Buzzard (*Buteo buteo*) | 1,760,000-2,460,000 (INC) | 17,086 | 14,383 | | II | LC |
| European Honey Buzzard (*Pernis apivorus*) | 241,000-350,000 (STA) | 7,979 | 6,491 | I | II | LC |
| Red Kite (*Milvus milvus*) | 65,100-76,600 (INC) | 51 | 1,305 | I | II | LC |
| Rough-legged buzzard (*Buteo lagopus*) | 57,600-11,700 (STA) | 139 | 889 | | II | LC |
| Common Kestrel (*Falco tinnunculus*) | 823,000-1,270,000 (DEC) | 271 | 690 | | II | LC |
| Western Marsh Harrier (*Circus aeruginosus*) | 303,000-485,000 (STA) | 28 | 659 | I | II | LC |
| Osprey (*Pandion haliaetus*) | 19,200-27,100 (INC) | 68 | 270 | I | II | LC |
| Hen Harrier (*Circus cyaneus*) | 112,000-174,000 (DEC) | 46 | 264 | I | II | LC |
| Merlin (*Falco columbiarius*) | 40,100-83,400 (DEC) | 128 | 236 | I | II | VU |

[1] Population sizes and trends taken from Birdlife International (2021). INC: Increasing, STA: stable, DEC: decreasing. In cases where the trend is less certain a "?" may be appended.
[2] Average numbers observed at Falsterbo between 1942-1960 from (Bijleveld, 1974)
[3] Average numbers observed at Falsterbo between 1973-2019 from (Kjellén, 2019)
[4] Conservation status categories are explained in the appendix.

Bornholm is generally not known as an important migration site for migrating raptors. However, a variety of species, some of them in considerable numbers, are observed at Dueodde, the southern tip of the island during autumn. Especially, the number of rough-legged buzzard is noteworthy in some years (Table 2 and 3).
With more than 82.000 observations of more than 300 species of migrating birds 2000-2023, the island of Bornholm is relatively well covered by bird observers (DOF-basen, 2022).

It is therefore most likely that the relatively few observations and low number of birds of prey entered into DOF-basen (2022) reflects the fact that only few birds of prey migrate over Bornholm, when compared to e. g. Falsterbo, which is one of the most important locations for migratory birds in Europe.

Since the OFW's, Kriegers Flak and Baltic 2, are placed relatively close to Falsterbo and in between Falsterbo and Bornholm, in the western part of the Baltic Sea, some of the migrating birds of prey may migrate in close proximity to the OWF's. However, Both birds of prey and cranes tend to avoid crossing open sea during their migration. Instead, they follow land areas for as long as possible and therefore concentrate at peninsulas or other narrow stretches of land in order to reduce the energy expenditure associated with active flight over the sea. The Falsterbo peninsula constitutes just such a bottleneck for these species, whereas Bornholm and the OWF's are far more isolated and surrounded by bodies of water.

**Table 3. Numbers of migrating raptors at Dueodde at Bornholm 2010-2023. The numbers are "max numbers", i.e. the highest number of raptors observed on a single day in the period. Data from DOF-basen (2023).**

| Species | Max number 2010-2023 |
|---|---|
| Eurasian sparrowhawk (*Accipiter nisus*) | 214 |
| Goshawk *(Accipiter gentilis)* | 3 |
| Common buzzard (*Buteo buteo*) | 370 |
| European honey buzzard (*Pernis apivorus*) | 54 |
| Rough-legged buzzard *(Buteo lagopus)* | 485 |
| Red kite (*Milvus milvus*) | 27 |
| Hobby *(Falco subbuteo)* | 27 |
| Red-footed falcon *(Falco vespertinus)* | 25 |
| Merlin (*Falco columbiarius*) | 15 |
| Common kestrel (*Falco tinnunculus*) | 128 |
| Peregrine *(Falco peregrinus)* | 3 |
| Hen harrier (*Circus cyaneus*) | 4 |
| Marsh harrier (*Circus aerginosus*) | 11 |
| Pallid harrier *(Circus macrourus)* | 2 |
| Osprey (*Pandion haliaetus*) | 9 |
| White-tailed eagle (*Haliaeetus albicilla)* | 4 |
| Bonelli's eagle (*Aquila fasciata*) | 1 |
| Golden eagle (*Aquila chrysaetos*) | 1 |

### 3.2.2 CONSERVATION STATUS AND POTENTIAL IMPACTS FROM OWFS

As top predators, most birds of prey are slowly reproducing species with a relatively little annual reproduction and their young require many years to mature before breeding takes place (Dwyer et al., 2018). Thus, they have naturally low densities. In fact, the population sizes of raptor species are relatively small compared to other breeding birds. Their life-history traits and their high trophic level make them extremely susceptible to anthropogenic threats (such as land use change, direct killing, poisoning and environmental contaminants, electrocution and climate change) and are thus among the most threatened group of birds in the world (McClure et al., 2018). In Europe, the most important impacts affecting the populations of the most vulnerable diurnal raptor species include habitat loss, intensification of agriculture, direct persecution (e.g. shooting, poisoning), pesticide contamination, disturbance of nest sites, among many others (Stroud, 2003).

Due to the particular vulnerability of birds of prey and the reduction of their population sizes because of the numerous threats they have already faced by the first half of the last century (Bijleveld, 1974; Bildstein, 2017), birds of prey are among the rarest birds in Europe: 46 % of European birds with less than 1,000 breeding pairs are birds of prey (Stroud, 2003). Thus, many of the species are protected by European legislation and have also been included in other conventions (see table 3) for the most common species likely crossing through the Baltic Sea).

Direct mortality from collisions with wind turbines are relatively common in birds of prey. The killing of hundreds of birds of prey by wind turbines were already seen with the first large wind farms placed in Altamont Pass in California and have been documented in many other places ever since. In Germany, in March 2013, at least 37 % of all reported birds collisions corresponded to birds of prey confirming that they made up a disproportionately large part of all collisions (Hötker, 2017). Some species were especially susceptible, among them red kites, whose breeding populations in Germany have been rapidly declining since 1991 (Mammen et al., 2017).

Despite estimates of collision rates of birds of prey with wind turbines are very variable and the difficulty of obtaining reliable data, some overall findings and conclusions have been achieved from the German database in Brandenburg (Rasran & Dürr, 2017). Most frequently killed birds were red kite and common buzzard, but other species such as white-tailed eagle, common kestrel and black kite were also often reported as victims. Most collision victims were adult birds and mainly occurred in spring and late summer (Rasran & Dürr, 2017). The collision risk directly depends on the rotor swept area, thus the flight height at which the species most commonly fly. Red kites often flew at heights within the rotor swept area. In fact, it was found that up to 50 % of all recorded red kite flights led into the risk area of wind turbines (Mammen et al., 2017).

Whereas collisions have been documented for at least 34 species of birds of prey, the effect they may have on population level have been explored for comparatively fewer species. For example, a modelling study of the population of red kites in Germany has predicted a further decline due to additional mortality from collisions with wind turbines (Bellebaum et al., 2013). Indirect effects such as modifying flight altitudes to avoid wind farm collision and displacement and effective habitat loss have also been studied for different species. For example, golden eagles are apparently able to detect and avoid turbines during migration after the construction of wind farms (Johnston et al., 2014a) or black kites reduced the use of areas up to 674 meters away from turbines with an estimated loss of 3-14 % of the suitable areas at the migratory bottleneck of the Strait of Gibraltar (Marques et al. 2019). Further examples of study cases of the effects of wind turbines on different birds of prey are reviewed by Watson and colleagues (2018).

# 4 METHODOLOGY

In this section, the fieldwork related to GPS tagging of juvenile cranes, the survey methods to investigate flight height distributions collected from the survey vessel “Skoven” and Band collision risk model, is explained.

## 4.1 CRANE TAGGING PROJECT

### 4.1.1 OUTLINE AND PURPOSE

At Grimsö Wildlife Research Station, Sveriges lantbruksuniversitet (SLU), Västmanland Sweden, there is an ongoing crane survey project, and an established expertise of capturing juvenile cranes for GPS-tagging. WSP Denmark has successfully established a collaboration with the research station for a tagging-project. This collaboration, and the expertise provided by SLU, ensured the highest possible chances of success.

While managing expectations, it became clear that no more than 10 to 12 tagged juvenile cranes could be expected under the already running survey project – yielding a catch per unit of effort (CPUE) of approximately 1 crane/day. This CPUE is obtained only under optimal conditions with good weather and after a successful breeding season, where good numbers of young cranes are available for tagging.

To reach the goal of 20 tagged cranes the only option is an increase in effort. The optimal time period for tagging was approximately 10-14 days, during which juvenile cranes had grown large enough to carry the GPS-transmitter but were still unable to fly. During this time period it was possible to catch the birds with a method abiding to the ethical standards. Using two tagging teams at the same time it was therefore necessary to increase the effort. Not every catching attempt was successful and each territory holding a pair of cranes with offspring, was only approached once.

In order to compare migration tactics of different breeding populations of cranes, tagging was also performed in Västerbotten, Northern Sweden. This area was selected in order to benefit from an ongoing color ringing scheme project on cranes in this area and because resightings suggest that cranes from this more northern part of the breeding population migrate south along the Swedish east coast and cross the Baltic Sea near the island of Bornholm. Moreover, high-resolution data on flight heights will also be generated from the GPS-tracks, potentially also around the island of Bornholm, if any of the tagged cranes cross this area, which would be data of novel information.

Tagging effort invested in two geographically distant areas made it possible to get behavioral data on cranes from both the western and eastern part of the migration route – covering both existing wind farms.

#### METHOD OF THE FIELDWORK

To abide to animal welfare ethical standards, minimizing the risk of injuring birds, the best practice is to capture and GPS-tag juvenile cranes. It is possible to capture adult cranes using canon-nets, snares, and other highly invasive methods. However, these methods imply a higher risk of injury, lower chances of success and increased logistical cost regarding planning and execution of field activities.

The fieldwork within each tagging area consisted of two parts. First a survey and mapping of territory holding a crane pair with offsprings, followed by the actual tagging efforts.

The survey and mapping of territories was carried out just before the tagging. It is done opportunistically by driving around and observing areas with reasonable accessibility. Having two areas with already established survey and ringing schemes, benefitted from the local knowledge and experience of the crane's whereabouts. This reduced the number of field days considerably. Observations from the survey were used to plan the tagging efforts.

Capturing was done by localizing juvenile cranes and carried out optimally in dry fields with good access. The best chance is during early morning, before the cranes retreat into the more wet/ unassailable habitats. When a juvenile crane was singled out, an approach was made. Because of the fact that the juvenile cranes are not yet able to fly, it was possible to catch them by hand after a short sprint. After capture, the juvenile crane was leg-fitted with an OrniTrack-R19 4G transmitter (Figure 4.1). The transmitter uploads data continuously to a database through the GSM/GPRS network.

**Figure 4.1. Fieldwork during late summer 2023, in the area around Umeå, Sweden, showing the mounted GPS transmitter (223701) and the specific color ring combination for that individual. Photo: Mikkel Friborg Mortensen, 2023.**

The logging frequency was set to 900 seconds in general, with some designated geofences in the Baltic Sea, in which the logging frequency has been increased to 1 and 60 seconds intervals to record the fine scale behavioral data during migration across the sea The spatial extent of the geofences were targeted main departure areas along coasts (60 second interval) and open water of the Baltic Sea (1 second) over which migration of Cranes was likely to occur. The geo-fencing was monitored on a regular basis and adjusted manually from time to time to prevent drainage of the GPS battery. (Figure 4.2).

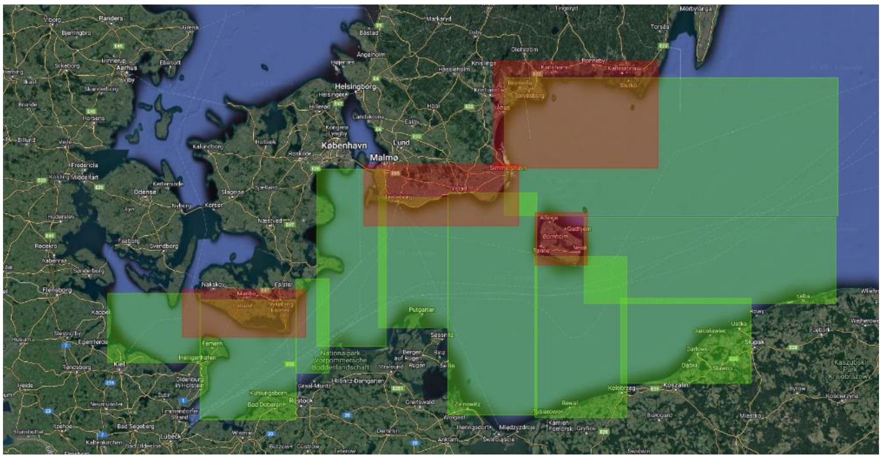


**Figure 4.2 A map showing the selected Geo-fencing on the 20-09-2023, with the red areas showing the 60 second intervals and the green areas showing the 1 second intervals. Ornitela.com, Limited access, 2023.**

### ETHICAL STATEMENT

Capturing and tagging activities of common cranes was approved by the local animal ethics authority in Uppsala, Sweden (Dnr. 5.8.18 – 09841/2022). The ethical application was targeted and submitted under the project "Ecology, migration strategies and disease transmission in common cranes, in relation to agriculture and development of offshore wind power". The submitted application contained a detailed description of the planned field activities and applied procedures as well as an animal risk hazard assessment. Exemption was granted to perform tagging of cranes in the field (rather than in a laboratory) to reduce handling time and animal stress load. It was assessed that the animal stress and suffering resulting from the project activities were at a low and acceptable level and could be well justified by the expected knowledge gain of the tagging project. The field work was coordinated and undertaken by a small, dedicated team of experts experienced in capturing, handling and tagging of large birds such as cranes. Prior to the field activities, all participants had completed relevant courses in laboratory animal science and Swedish legislation & Ethics, animal welfare and "3R" (replacement, reduction, and refinement) offered by SLU.

### METHOD OF THE SPATIAL MAPS

The spatial maps presented, showing the migratory routes of the juvenile cranes, are the raw data from the GPS transmitters mounted on the various cranes, with all available tracks during the crossing of open water included as well as the altitude of each known location. The start and end of each track is chosen as the approximate start and end of the crane's movement within the Geo-fence.

## 4.2 MEASURING AVOIDANCE BEHAVIOUR AND FLIGHT HEIGHT OF MIGRATING CRANES

The main aim of this study was to identify avoidance behaviour of cranes towards offshore wind farms (OWFs). We differentiated avoidance behaviour at the macro-, meso-, and micro scale. Macro-avoidance is an avoidance response towards the wind farm array occurring outside the wind farm perimeter. Meso- avoidance is any avoidance behaviour occurring towards individual turbines inside the wind farm array, whereas micro-avoidance is the last second evasive movements performed by a bird to avoid collision with rotor blades (Figure 5). While a macro-avoidance response can be triggered relatively close to the OWF, it is often initiated at distances of several kilometres away from the wind farm perimeter. Evidence of avoidance behaviour on these different spatial scales were collected using two principal techniques: Radar observation for assessments of macro- and meso- avoidance, and laser-rangefinder (LRF) measurements for all three levels of avoidance: macro-, meso-, and micro-avoidance. The LRF was also used to measure the flight height of migrating cranes.

The wind turbines at Kriegers Flak impose a vertical zone of collision risk within altitudes of 25 - 189 meters, with 82-meter rotor blades and a hub height of 107 meters. Whereas the wind turbines of Baltic 2 impose a vertical zone of collision risk within altitudes of 18 – 138 meters, with 60-meter rotor blades and a hub height of 78 meters.

Assessments of avoidance behaviour were performed either directly in the field by visual observations of changes in the flight behaviour of migrating cranes or by judgement of the spatial pattern of collected radar and laser-rangefinder tracks. For tracks that were not visually assessed, only the spatial pattern of track marks relative to turbine positions were used to infer the behavioural response of migrating cranes.

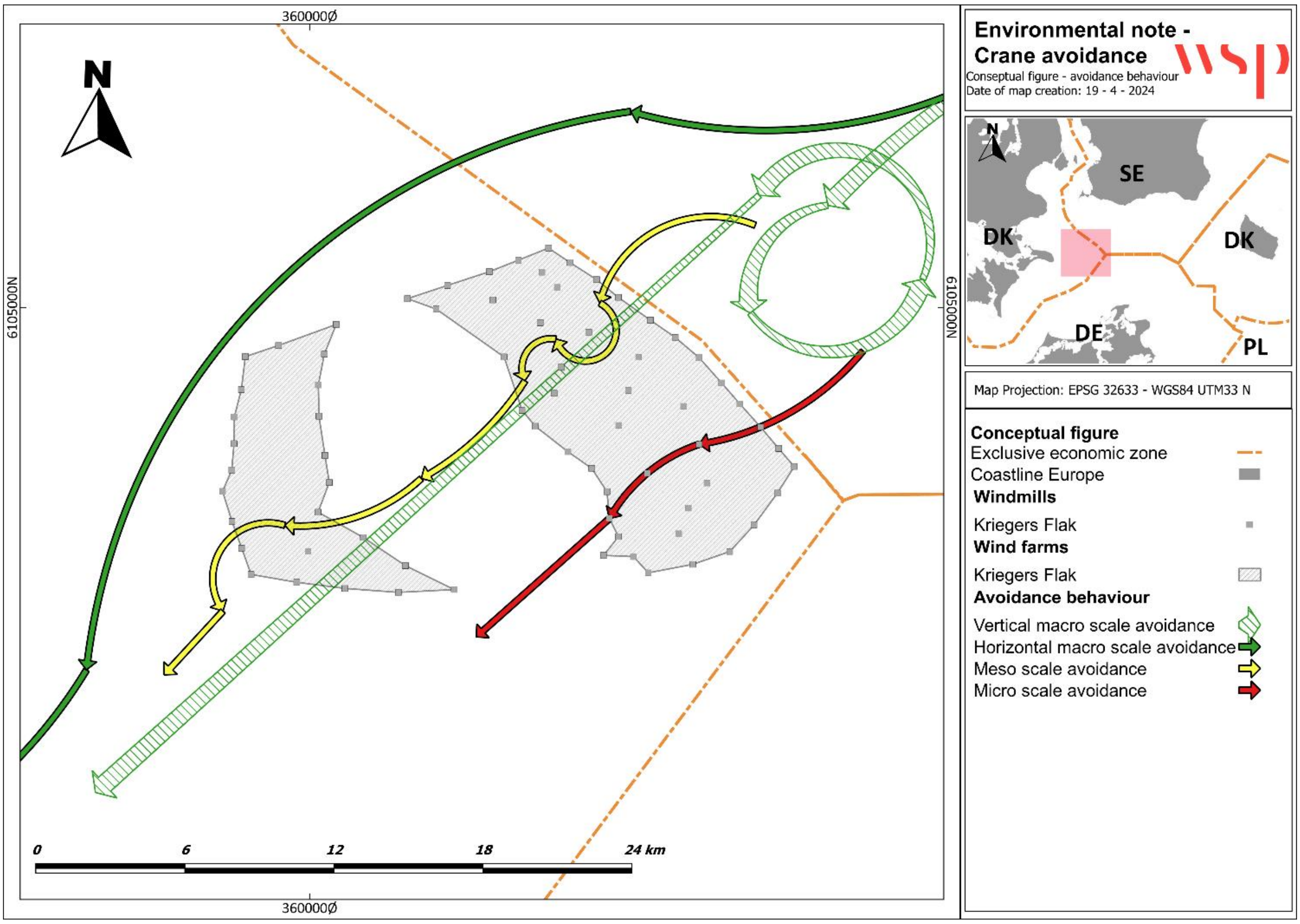



**Figure 5. A conceptual map showing different scales of avoidance behaviour; Macro-, (vertical and horizontal), meso-, and micro- scale which may be expressed by birds encountering an offshore wind farm during migration passage. The green arrows illustrate avoidance behaviour at the macro scale, with solid fill as horizontal macro avoidance (flying around the wind farm array) and the dashed fill as vertical macro avoidance (flying above the wind farm array, outside the reach of the rotors). The yellow arrows illustrate horizontal avoidance behaviour at the meso-scale, with a flock of birds entering the wind farm at rotor height but circumventing in the horizontal plane at some distance of the reach of the rotors. The red arrows illustrate avoidance behaviour at the micro scale, illustrated by a flock of birds entering the wind farm array by flight through several rotor swept zones, while avoiding colliding with the spinning blades by adjusting their flight, either vertically or horizontally.**

### 4.2.1 GENERAL PROCEDURE OF VESSEL BASED SURVEYS

Two observers were positioned on the deck facing towards the expected migration direction while scouting for cranes migrating over the Baltic Sea. Monitoring was performed according to the agreed methods (document: `Methods: Vessel-based LRF migration monitoring´ and radar `document Method: radar tracing´, which can be provided if desired).

#### BEGIN AND END OF SURVEY

Previous data indicate that cranes may arrive at the anchoring site early in the morning but not earlier than 1.5 hours after civil twilight. Thus, observers started 1.5 hours after civil twilight. During mid-September the civil twilight is approximately 6:00 am local time and during mid-October it takes place around 7:00 am.
Observations were stopped approximately one hour before sunset – but the observations continued if migratory behaviour of cranes was still prominent and detectable.

If no cranes were observed for two consecutive days and there were no clear signs of migration on the following day the survey trip was stopped, and the vessel returned to harbour.

#### OTHER SPECIES

The main objective of this study is to detect avoidance behaviour of cranes. However, in cases of low or no activity of migrating cranes, observers detected and recorded avoidance behaviour and FHDs of birds of prey. However, radar tracking of birds of prey was not included, to not overlook any cranes.

### 4.2.1 WIND CONDITIONS AND CRANE MIGRATION DURING THE VESSEL BASED SURVEYS IN AUTUMN 2022 AND SPRING 2023

Wind measurements from the 2022 and 2023 migration seasons were derived from one of the turbines at Kriegers Flak (kindly provided by Vattenfall). Wind conditions were matched with the visual observations of cranes and classified into head-, tail- and crosswind, while taking account of the recorded flight directions. The wind conditions (direction and speed) relative to the observed migration direction of the cranes was plotted as season-specific histograms.

### 4.2.2 COLLISION RISK MODELLING

The risk of collision for migrating cranes with the Kriegers Flak offshore wind farm was estimated by means of the ‘Extended’ version of the Band Model (Band, 2012). This version of the model considers a species-specific flight height distribution, when estimating the proportion of birds flying at rotor height. Season-specific flight height distributions of migrating cranes were estimated based on the laser-rangefinder measurements collected during the surveys as well as the flight heights estimated visually. Although the visual observation and GPS data constitute interesting examples of crane avoidance behaviour, they cannot be used to accurately estimate empirical avoidance rates, partly due to the relatively limited sample size (number of observed flocks or individuals carrying GPS) and due to the difficulty for the observers to detect avoidance behaviour and collisions occurring at the posterior part of the wind farm. Moreover, the radar is unable to detect birds flying behind or in the vicinity of the turbines (blind zones) making it difficult to assess flight behaviour at the micro scale based on the radar tracks. Ideally, calculations of empirical avoidance rates require much larger data sets of the spatial distribution and behavioural patterns of bird movements in 2D and 3D outside as well as inside offshore wind farms, such as data generated by long-term monitoring studies using radar and cameras (Tjørnløv et al., 2023, Skov et al., 2018).

The Band collision model relies on several critical assumptions. One of them is, that the model computes the risk of collision for a single bird transit and then scales up to the total passage of birds through the wind farm array. In theory, it is probably correct that birds flying in flocks, such as cranes, may be able to perform a kind of aversive flight in order to avoid collision (Skov et al. 2015). However, a correction factor for aversive flight cannot be accurately estimated and has therefore not been included in the models of collision risk.

The number of collisions was estimated for the migration passage (number of migrating individuals) observed during the surveys in spring and autumn, respectively, and for a range of realistic avoidance rates between 0.980 – 0.999 (Drachmann et al., 2021). For each of these avoidance rates, a model was used to estimate the required passage of cranes to result in one collision per year, given otherwise same input parameters. This analysis was undertaken in order to relate the observed passage and number of collisions to those estimated by the model.

# 5 RESULTS

## 5.1 CRANE TAGGING PROJECT

In this section, the migratory behaviors of the tagged cranes are presented by GPS transmissions of their very first migration south, during autumn 2022, the return north during spring 2023 and the migration south during autumn 2023, the very first time for six individuals and the second time for the rest, is presented.

Secondly, the observational results from the vessel survey, which describe the migratory behavior of cranes, flying above or in close proximity to Kriegers Flak or Baltic II wind farms during the study period in autumn 2022 and spring 2023, together with the results of Band collisions risk model, is presented.

### *5.1.1 GPS TRANSMISSIONS OF THE TAGGED JUVENILE CRANES DURING AUTUMN 2022, SPRING 2023 AND AUTUMN 2023*

In total, 17 cranes were successfully fitted with GPS transmitters (No. ID. Between 223691 – 223711) during late summer 2022 and late summer 2023. As 20 transmitters were acquired for the project, that leaves three unused GPS transmitters. Of the remaining 3 transmitters, two were fitted onto juvenile birds that succumbed some weeks after they had been fitted the GPS transmitters, one in France and one in Sweden, and the last transmitter was malfunctioning at project start. For the cranes that had successfully been fitted GPS transmitters, the transmitters have afterwards provided real time transmissions of the cranes movements and migration, including the altitude at each position. The transmitters received a GPS location every 900 seconds outside the pre-set geo-fences, every 60 seconds inside the red pre-set geo-fences and every second inside the green pre-set geo-fences, that covered the bodies of water between Denmark, Sweden and the other counties in the southwestern part of the Baltic Sea. The resulting tracks illustrated that migrating Cranes tended to increase their flight altitude over land before initiation of departure over the open sea (Figure 6-8). Some of the GPS transmissions lacked data points in the figures. This was due to different technical elements, such as unfortunate calibration updates, and battery level of zero power, though with the crane migrating in sunny weather conditions, causing sporadic transmissions from the transmitter before power drainage occurred again.

Interestingly, the GPS tracks also unveiled that cranes are able to increase their flight altitude over the open sea and that this can be used as a strategy to avoid collision with wind farms offshore.

#### AUTUMN MIGRATION OF CRANES 2022

Within the period from 18$^{th}$ of September – 19$^{th}$ of October 2022, 11 tagged cranes migrated south. The migratory routes and flight altitudes of the 11 birds are presented in Figure 6. A summary for each bird, presented by the number of the attached GPS transmitters is given in Table 4, including weather data for the days of passage.

Two of the GPS trails crossed in between the wind farm arrays Kriegers Flak and Baltic 2, no. 223695, and above the wind farm array Nysted, no. 223697, during their migration southward (Figure 6, Table 4).

**Table 4. Migration data for cranes migrating in the autumn 2022. Wind direction in () indicates a change in the wind direction during the day. The times mentioned refers to the beginning and end of the migration routes visualized in Figure 6. Wind data is from Falsterbo (SMHI, 2023).**

| Date and time (LT) | No. | Wind direction | Mean wind speed (m/s) | Altitude (m) | Flight characteristics |
|---|---|---|---|---|---|
| **18-09-2022 11:00 – 15:00** | 223710 | West | 3.8 | 150 – 650 | Ascending in the middle of the crossing and afterwards descending for the remaining of the crossing |
| **19-09-2022 07:00 – 12:00** | 223697 | Northwest | 7.9 | 200 – 700 | Ascending several times when approaching land and descending above the sea, crossing above the wind farm array Nysted. |
| **19-09-2022 12:00 – 15:00** | 223693 | Northwest | 7.9 | 600-700 | Descending above the sea. |
| **19-09-2022 14:00 – 17:00** | 223700 | Northwest | 7.9 | 500 – 800 | Descending over the sea, with a single increase in altitude north of the established wind farms Arcadis Ost 1 and Wikinger |
| **21-09-2022 07:00 – 11:00** | 223695 | North (northwest) | 2.5 | 300 – 700 | Descending above the sea, flying through the corridor between Kriegers Flak and Baltic 2. |
| **21-09-2022 08:00 – 12:00** | 223709 | North (northwest) | 2.5 | 250 – 900 | Descending above the sea |
| **30-09-2022 09:00 – 15:00** | 223692 | South | 8.0 | 100 – 300 | Descending above the sea with a few intervals of flying closer than 10 meters from the surface. |
| **30-09-2022 13:00 – 17:00** | 223698 | South | 8.0 | 10 – 200 | Descending above the sea, with a few intervals of flying closer than 10 meters from the surface |
| **30-09-2022 13:00 – 17:00** | 223707 | South | 8.0 | 10 – 250 | Shifting in altitude while crossing the sea |
| **01-10-2022 to 02-10-2022 23:00 – 07:00** | 223704 | West | 10.1 | 10 – 100 | Descending above the sea, though the transmissions of the GPS on this individual are very limited during the crossing |
| **02-10-2022 05:00 – 13:00** | 223711 | West (northwest) | 10.3 | 10 – 150 | Descending above the sea, with a several intervals of flying closer than 10 meters from the surface. |

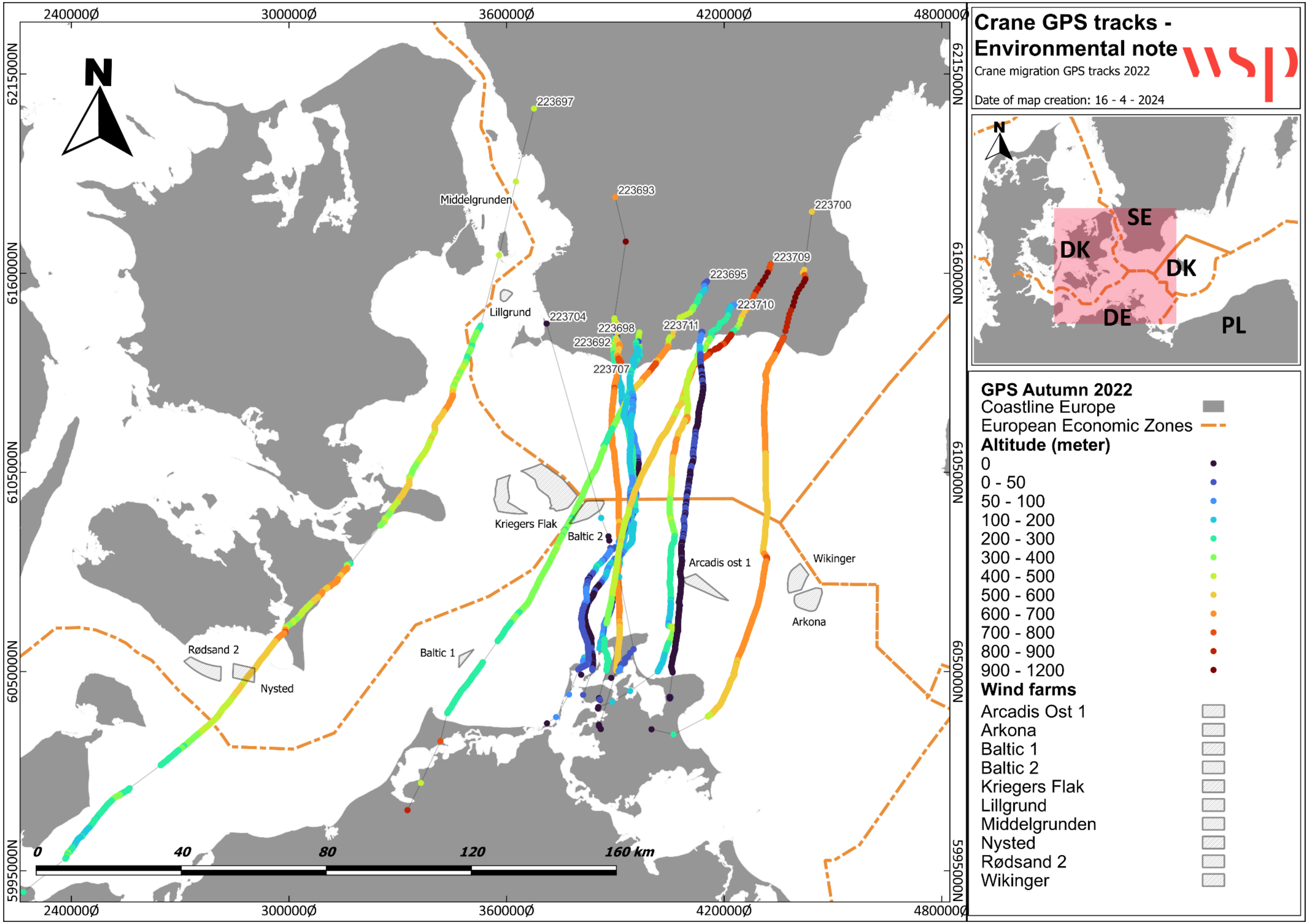



**Figure 6.**
**Displays a map over the western parts of the Baltic Sea, with the outline of the bordering countries, as well as the established wind farms, and the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 11 tagged common cranes on their migration south, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223692 – 223711.**

**All tracks are displayed individually in the appendix 9.1.5.**

## SPRING MIGRATION OF CRANES 2023

Within the period from 23rd of April – 3rd of June 2023, seven of the 11 cranes migrated all the way back to Sweden while four of the cranes stopped their migration in the northern parts of Germany. Of the seven cranes that migrated northward back to Sweden, six crossed the Baltic Sea, while one crossed Kattegat (Figure 7-8). A summary for each bird, presented by the number of the attached GPS transmitters and weather data is given in Table 5 for cranes crossing the Baltic Sea and Table 6 for the crane crossing Kattegat.

One of the GPS trails, no. 223709, crossed close to the wind farm array Rødsand 2, during its migration northward (Figure 7, Table 5).

**Table 5. Migration data for cranes migrating across the Baltic Sea in the spring 2023. Wind direction in () indicates a change in the wind direction during the day. The times mentioned refers to the beginning and end of the migration routes visualized in Figure 7. Wind data is from Falsterbo (SMHI, 2023).**

| Date and time (LT) | No. | Wind direction | Mean wind speed (m/s) | Altitude (m) | Flight characteristics |
|---|---|---|---|---|---|
| **23-04-2023 09:00 –14:00** | 223709 | West | 4.3 | 150 – 300 | Ascending several times when approaching land and descending above the sea, migrating close to the wind farm array Rødsand 2. |
| **01-05-2023 03:00 – 07:00** | 223698 | South (southeast) | 5.5 | 50 – 100 | Descending above the sea |
| **01-05-2023 09:00 – 12:00** | 223711 | South (southeast) | 5.5 | 50 – 850 | Descending above the sea |
| **18-05-2023 11:00 – 15:00** | 223707 | West (southwest) | 3.9 | 150 – 500 | Descending above the sea |
| **27-05-2023 04:00 – 11:00** | 223693 | Northwest (south) | 3.8 | 50 – 500 | Descending over the sea, with a few intervals of flying closer than 10 meters from the surface, before ascending again when approaching shore |
| **02-06-2023 (07:00) to 03-06-2023 (11:00)** | 223704 | North | 7.1 | 50 – 700 | Ascending several times when approaching land and descending above the sea, then had a stopover on Zealand before migrating to Sweden, across the Sound, on the 3rd of May |

**Table 6. Migration data for crane migrating Kattegat in the spring 2023. The time mentioned refers to the beginning and end of the migration route visualized in Figure 8. Wind data is from Læsø (DMI, 2023).**

| Date and time (LT) | No. | Wind direction | Mean wind speed (m/s) | Altitude (m) | Flight characteristics |
|---|---|---|---|---|---|
| **09-05-2023 07:00 – 10:00** | 223710 | Southwest | 10.4 | 50 – 300 | Descending above the sea |

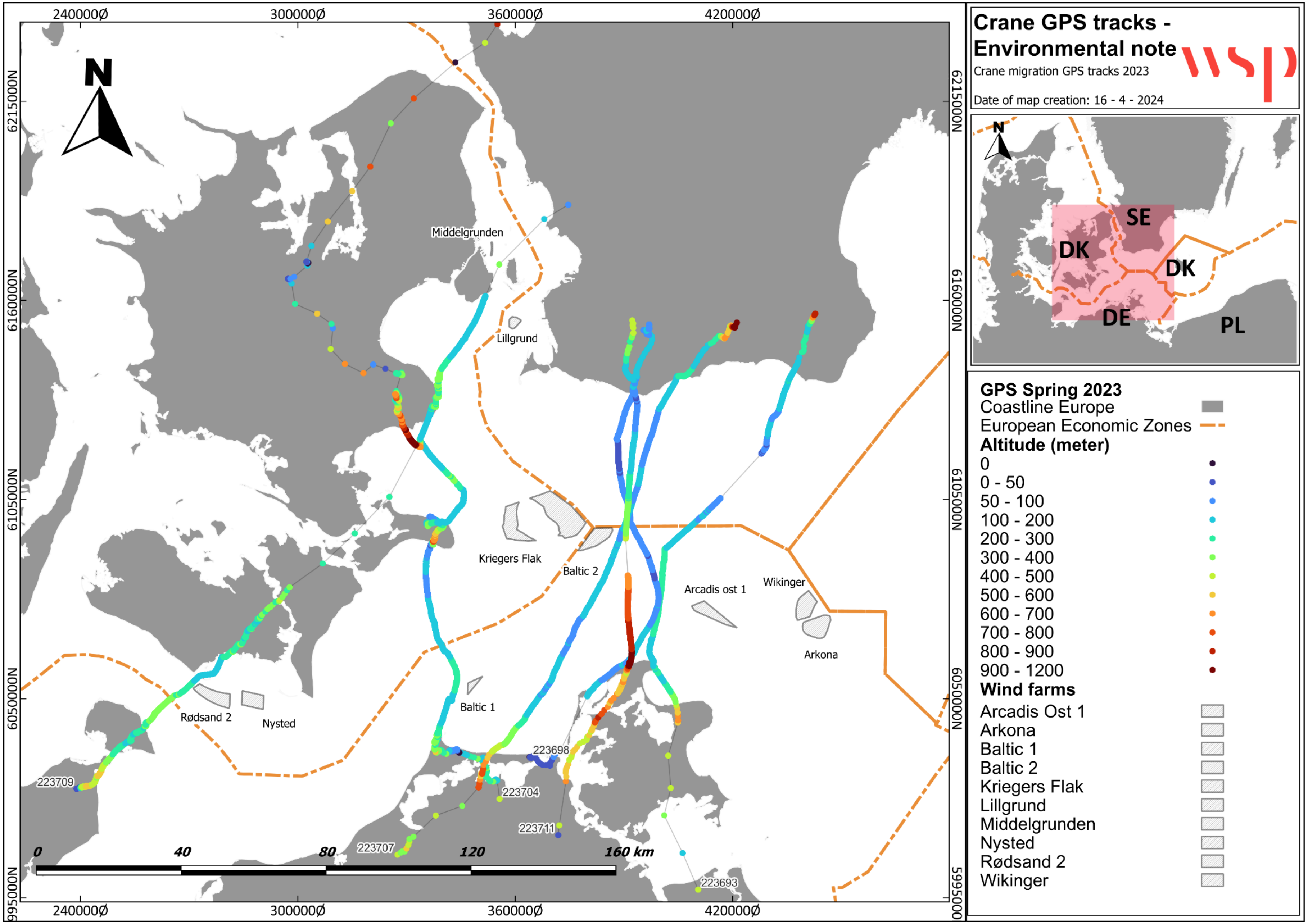



**Figure 7.**
**Displays a map over the western parts of the Baltic Sea, with the outline of the bordering countries, as well as the established wind farms, and the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 6 tagged common cranes on their migration north, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223692 – 223711.**

**All tracks are displayed individually in the appendix 9.1.5.**

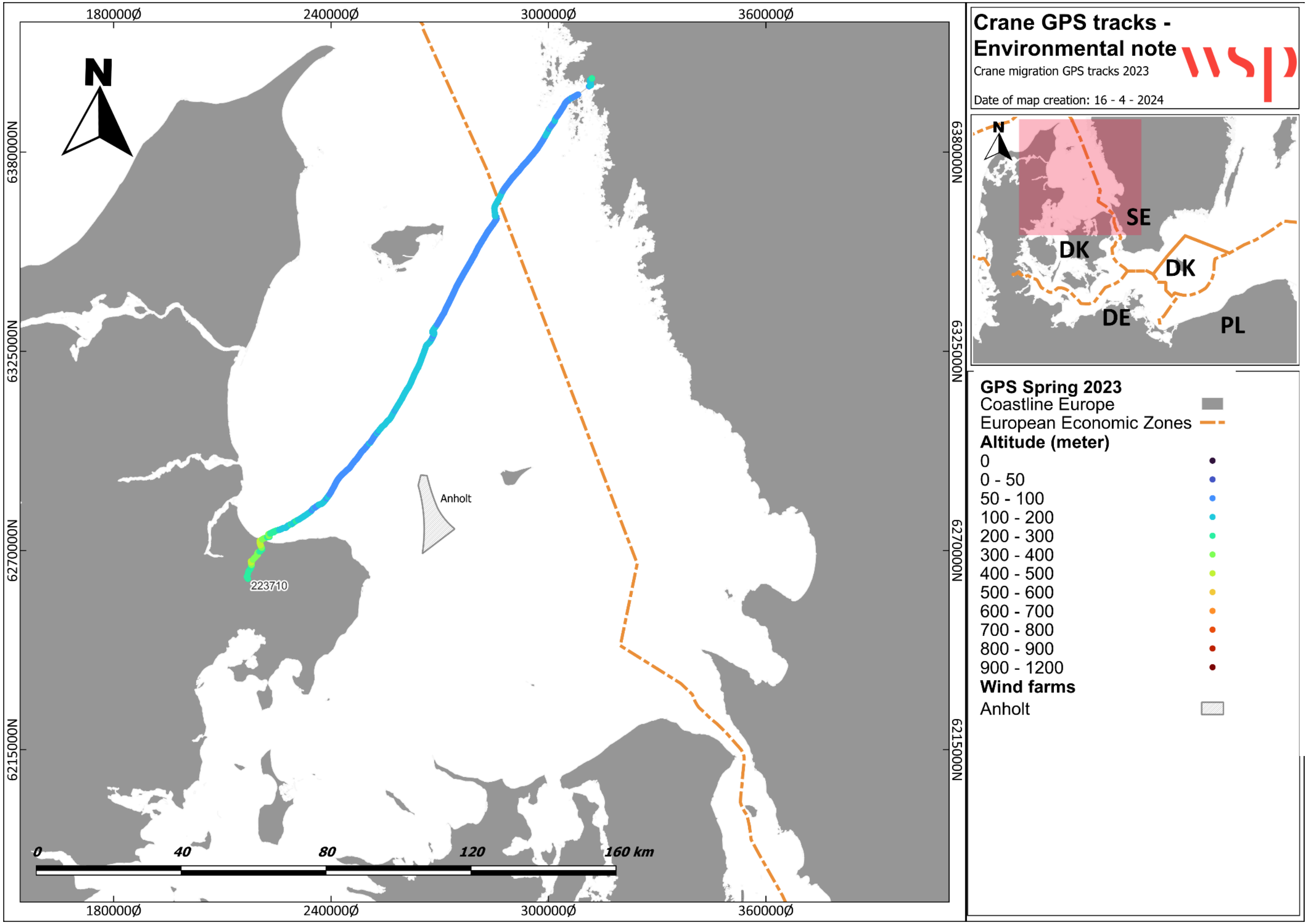



**Figure 8.**
**Displays a map over the Kattegat, with the outline of the bordering countries, as well as the established wind farms, and the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of one of the tagged common cranes on their migration north, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**The crane is presented by the number of the GPS transmitter, no. 223710.**

## AUTUMN MIGRATION OF CRANES 2023

A total of 17 cranes were fitted with GPS transmitters by autumn 2023, the 11 tagged cranes from 2022 and 6 newly mounted tags from July 2023. Of the 11 tagged cranes from 2022, four never made a migration all the way to Sweden and spent the summer in Northen Germany, while the remaining seven spent the summer in Sweden. All of which migrated southward during autumn 2023. The new six juvenile cranes that were tagged during July 2023, in the Umeå region of Sweden, also migrated southward during autumn 2023 and therefore performed their first migration ever. Of the 13 cranes that migrated southward from Sweden during autumn 2023, nine crossed the Baltic Sea, while four crossed both the Gulf of Bothnia, Gulf of Finland and the Gulf of Riga. The autumn migration in 2023 spanned from the $14^{th}$ of September – $12^{th}$ of November (Figure 9 to 13). A summary for each bird, presented by the number of the attached GPS transmitters and weather data is given in Table 7 for cranes crossing the Baltic Sea and Table 8 for the cranes crossing the Gulf of Bothnia, Gulf of Finland and the Gulf of Riga.

Six of the GPS trails crossed above wind farm arrays on their migration southward. No. 223707 crossed above the wind farm array Baltic 2. No. 223710, 223704, 223711 and 223701 crossed above the wind farm array Arcadis Ost 1. While no. 223691 crossed above the wind farm array Kriegers Flak (Figure 9 - 10, Table 7).

**Table 7. Migration data for cranes migrating across the Baltic Sea in the autumn 2023. The times mentioned refers to the beginning and end of the migration routes visualized in Figure 9-10. Wind data is from Falsterbo (SMHI, 2023).**

| No. | Date and time (LT) | Wind direction | Mean wind speed (m/s) | Altitude (m) | Flight characteristics |
|---|---|---|---|---|---|
| 223693 | 04-10-2023 07:04 – 10:59 | West | 12.1 | < 50 - 400 | Descending above the sea |
| 223707 | 07-10-2023 04:00 – 05:59 | Northwest | 11.2* | < 50 - 400 | Descending above the sea, then ascending before crossing the wind farm Baltic 2, then descending again approaching the shore |
| 223709 | 07-10-2023 04:01 – 07:47 | Northwest | 11.2* | 50 - 200 | Flying within the same altitude when leaving and approaching the shore, most of the crossing unfortunately lack datapoints. |
| 223710 | 07-10-2023 04:11 – 07:39 | Northwest | 11.2* | < 50 - 200 | Descending above the sea, crossing the wind farm Arcadis Ost 1 at low altitude and starts ascending once reaching the shore. |
| 223698 | 07-10-2023 05:00 – 06:58 | Northwest | 11.2* | 50 - 400 | Descending above the sea, ascending in the middle of the crossing, approaching shore in a higher altitude. |
| 223704 | 07-10-2023 11:00 – 13:59 | Northwest | 11.2* | 200 - 1200 | Descending above the sea, with a slight ascending before crossing the wind farm Arcadis Ost 1, then descending again once reaching the shore. |
| 223711 | 16-10-2023 09:01 – 11:59 | Northwest | 9.3 | 300 - 1200 | Descending above the sea, ascending again before |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | crossing the wind farm Arcadis Ost 1, then descending once again upon reaching the shore. |
| **223691** | 19-10-2023 03:34 – 12:59 | East | 11.4 | 100 - 800 | Descending and ascending above the sea several times, also just before and while crossing the wind farm Kriegers Flak, ascending again upon reaching the shore. |
| **223701** | 12-11-2023 (07:09) to 13-11-2023 (09:54) | East | 3.1 | 100 - 600 | Descending above the sea, ascending after crossing the wind farm Arcadis Ost 1, approaching shore in a higher altitude. |

***In the night at 3 am the wind blew 17 m/s and decreased to around 8.5 m/s from 9 am an on.**

**Table 8: Migration data for cranes migrating across the Gulf of Bothnia, the Gulf of Finland, and the Gulf of Riga in the autumn 2023. Wind direction in () indicates a change in the wind direction during the day. Upper and lower rows for each number refers to the beginning and end of the visualized migration route in Figure 11-13, respectively. Wind data is from Umeå, Sweden (SMHI, 2023) and Ruhnu, Estonia (EEA, 2023).**

| No. | Date and time (LT) | Wind direction | Mean wind speed (m/s) | Altitude (m) | Flight characteristics |
|---|---|---|---|---|---|
| **223702** | 14-09-2023 05:11 | North (southeast) | 3.2 | 50 - 500 | Descending above the sea. |
| | 11-10-2023 08:51 | South-southwest | 10.7 | < 50 - 300 | Crossing at the narrowest straits within the Gulf of Riga. |
| **223703** | 17-09-2023 06:13 | North-northwest | 6.5 | 300 - 700 | Ascending in the middle of the crossing |
| | 02-10-2023 09:00 | West (southwest) | 2.9 | < 50 - 200 | Crossing at low altitude, ascending upon reaching the shore |
| **223694** | 28-09-2023 05:08 | Calm (south) | (1.6) | < 50 - 400 | Descending above the sea |
| | 02-10-2023 11:59 | West (southwest) | 3.6 | < 50 - 400 | Ascending and descending several times above the sea |
| **223696** | 28-09-2023 05:10 | Calm (south) | (1.6) | 50 - 200 | Descending above the sea. |
| | 02-10-2023 08:46 | West (southwest) | 3.6 | < 50 - 500 | Descending above the sea and ascending when approaching the shore. |

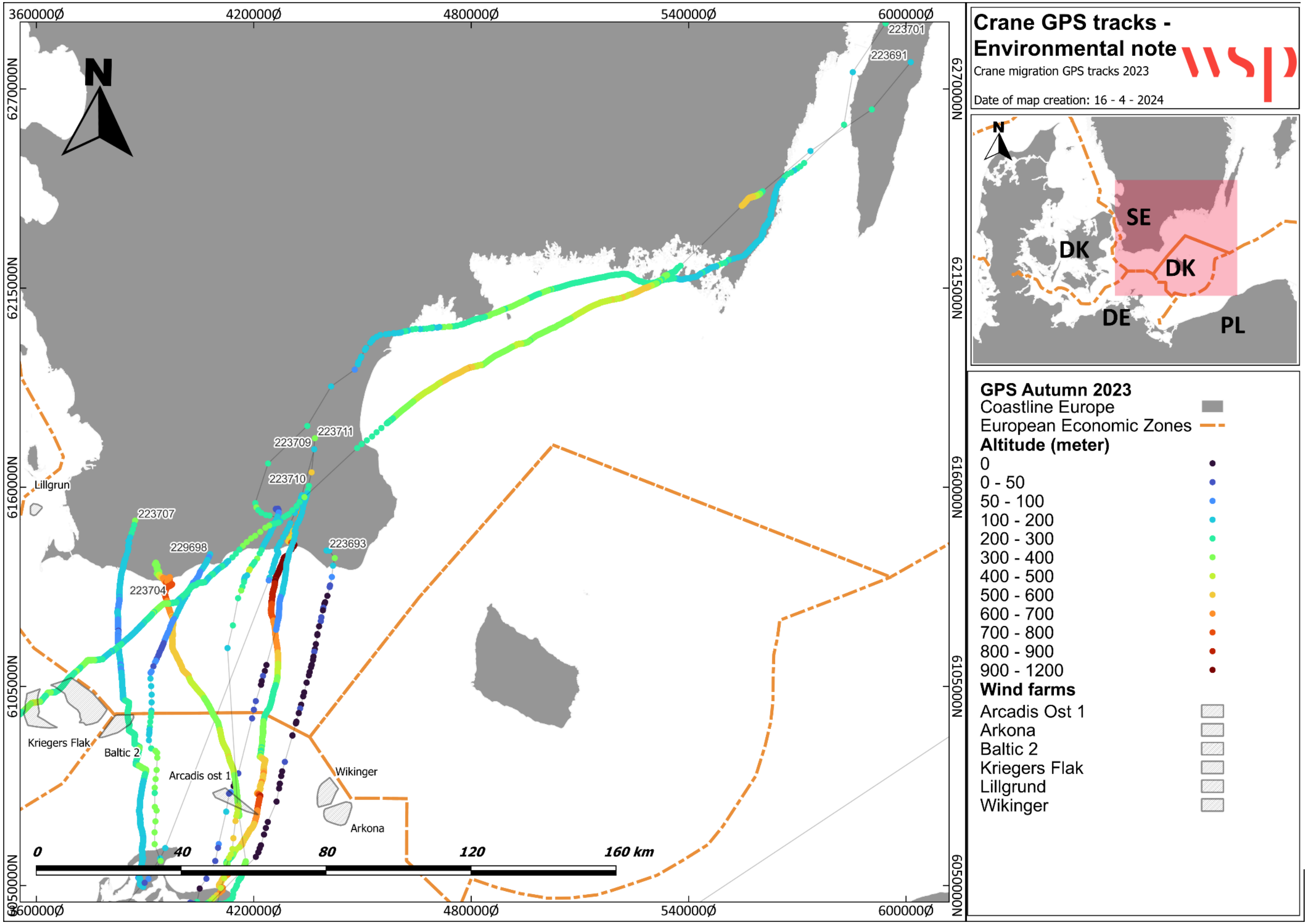



**Figure 9.**
**Displays a map over the western parts of the Baltic Sea, with the outline of the bordering countries, as well as the established wind farms, and the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 9 tagged common cranes on their migration south, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223692 – 223711.**

**All tracks are displayed individually in the appendix 9.1.5.**

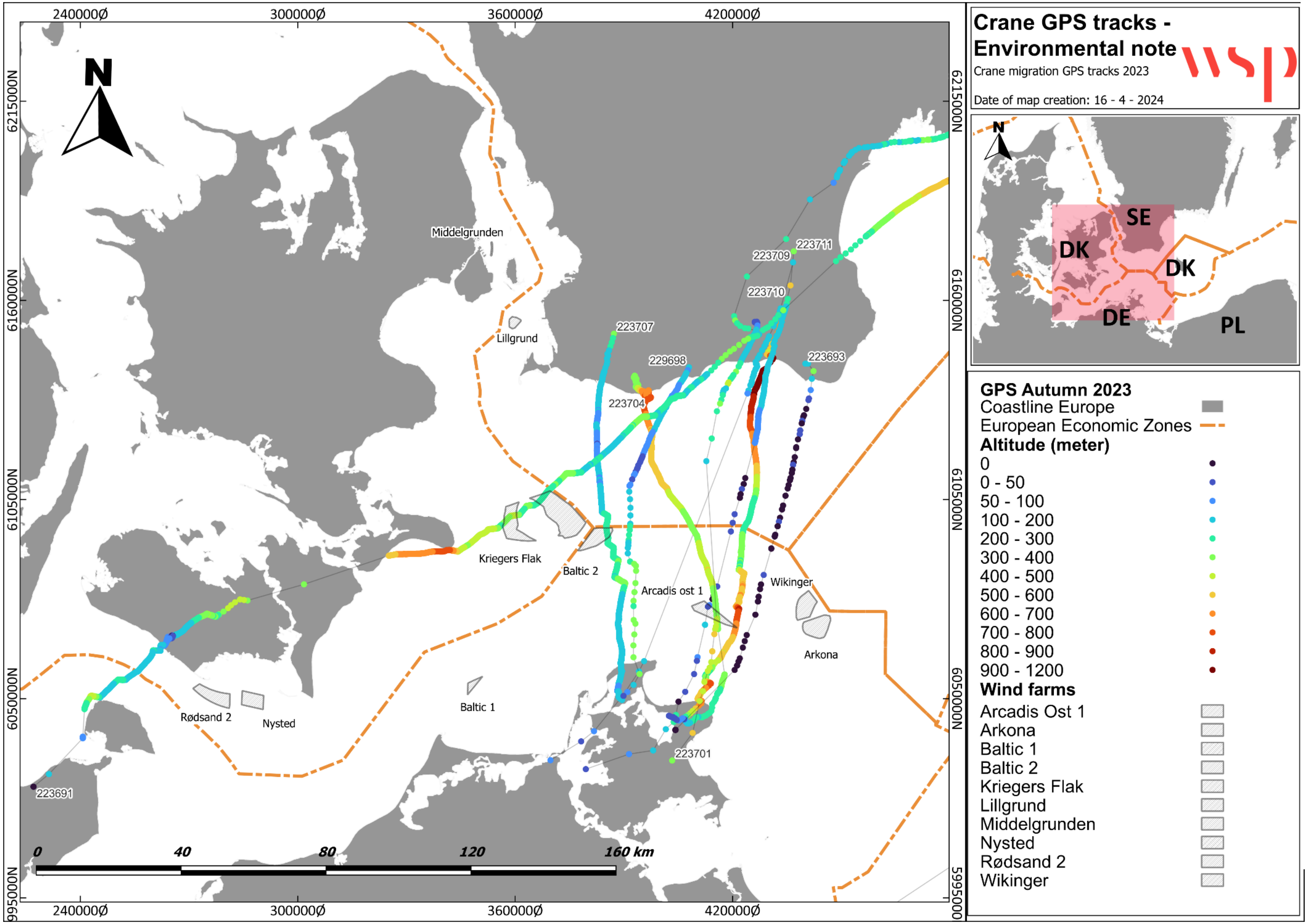



**Figure 10.**
**Displays a map over the western parts of the Baltic Sea, with the outline of the bordering countries, as well as the established wind farms, and the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 9 tagged common cranes on their migration south, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223692 – 223711.**

**All tracks are displayed individually in the appendix 9.1.5.**

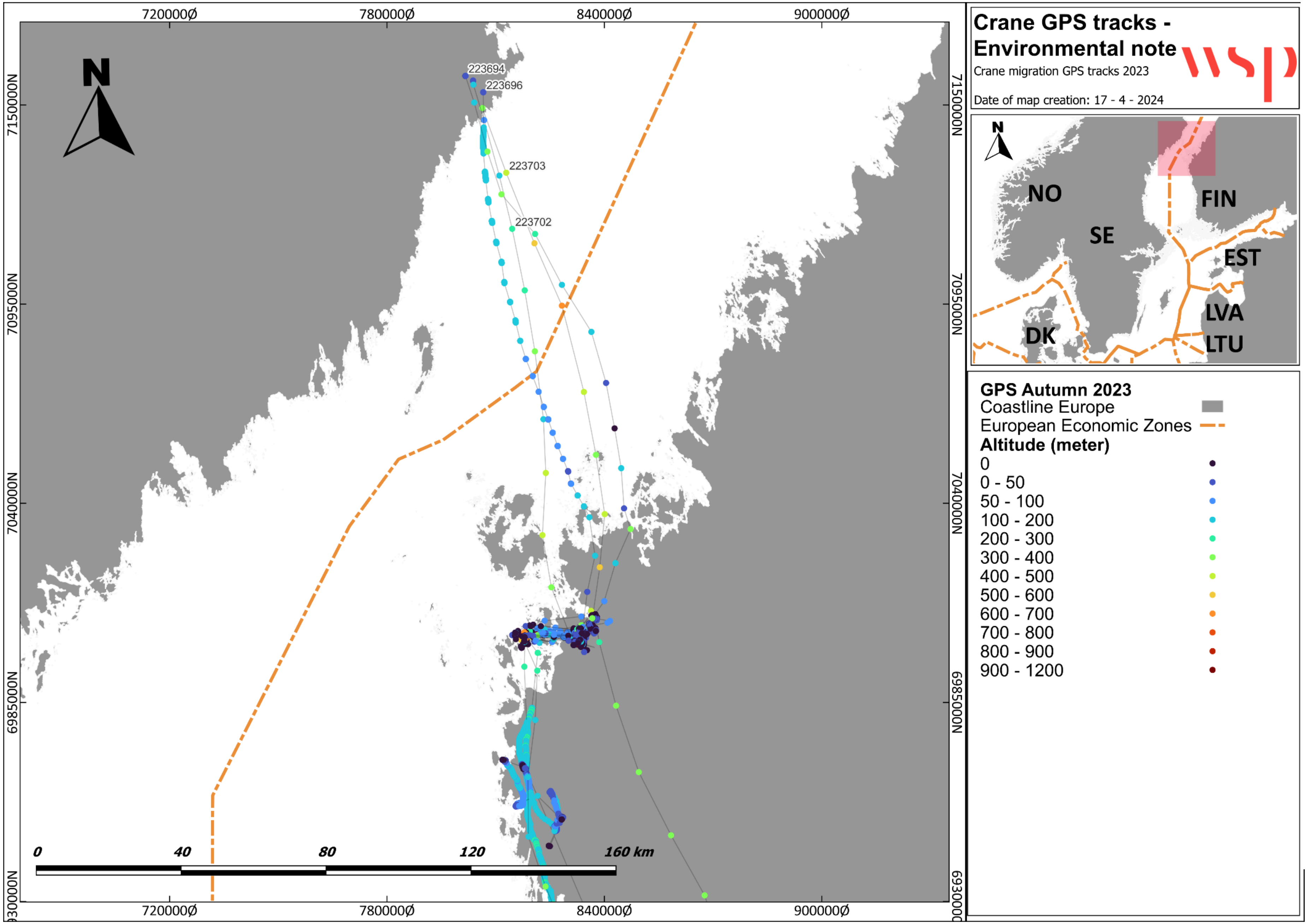



**Figure 11.**

**Displays a map of the Gulf of Bothnia, with the outline of the bordering countries, as well as the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 4 tagged common cranes on their migration south, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223694, 223696, 223702 and 223703.**

**All tracks are displayed individually in the appendix 9.1.5.**

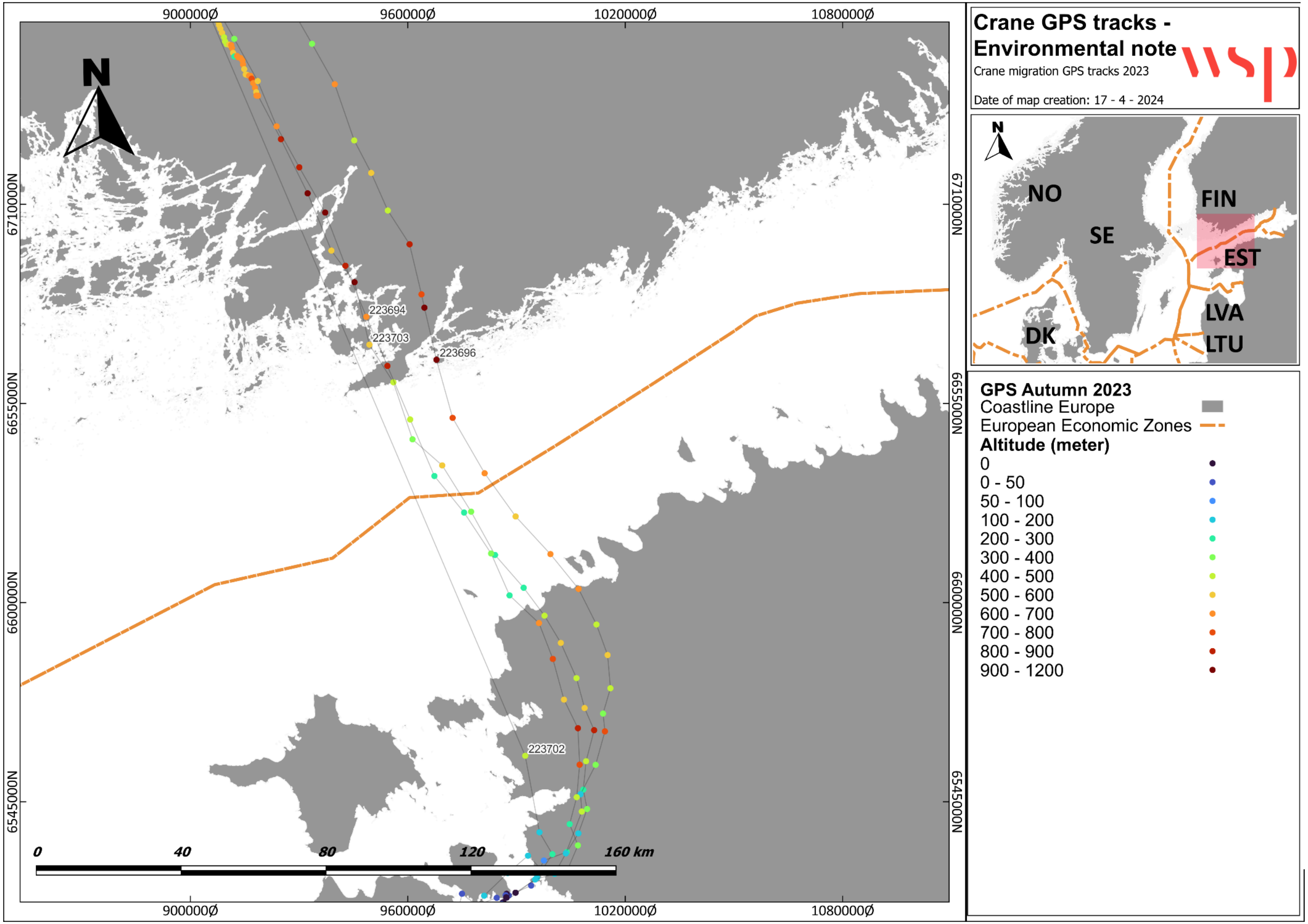



**Figure 12.**
**Displays a map of the Gulf of Finland, with the outline of the bordering countries, as well as the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 4 tagged common cranes on their migration south, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223694, 223696, 223702 and 223703.**

**All tracks are displayed individually in the appendix 9.1.5.**

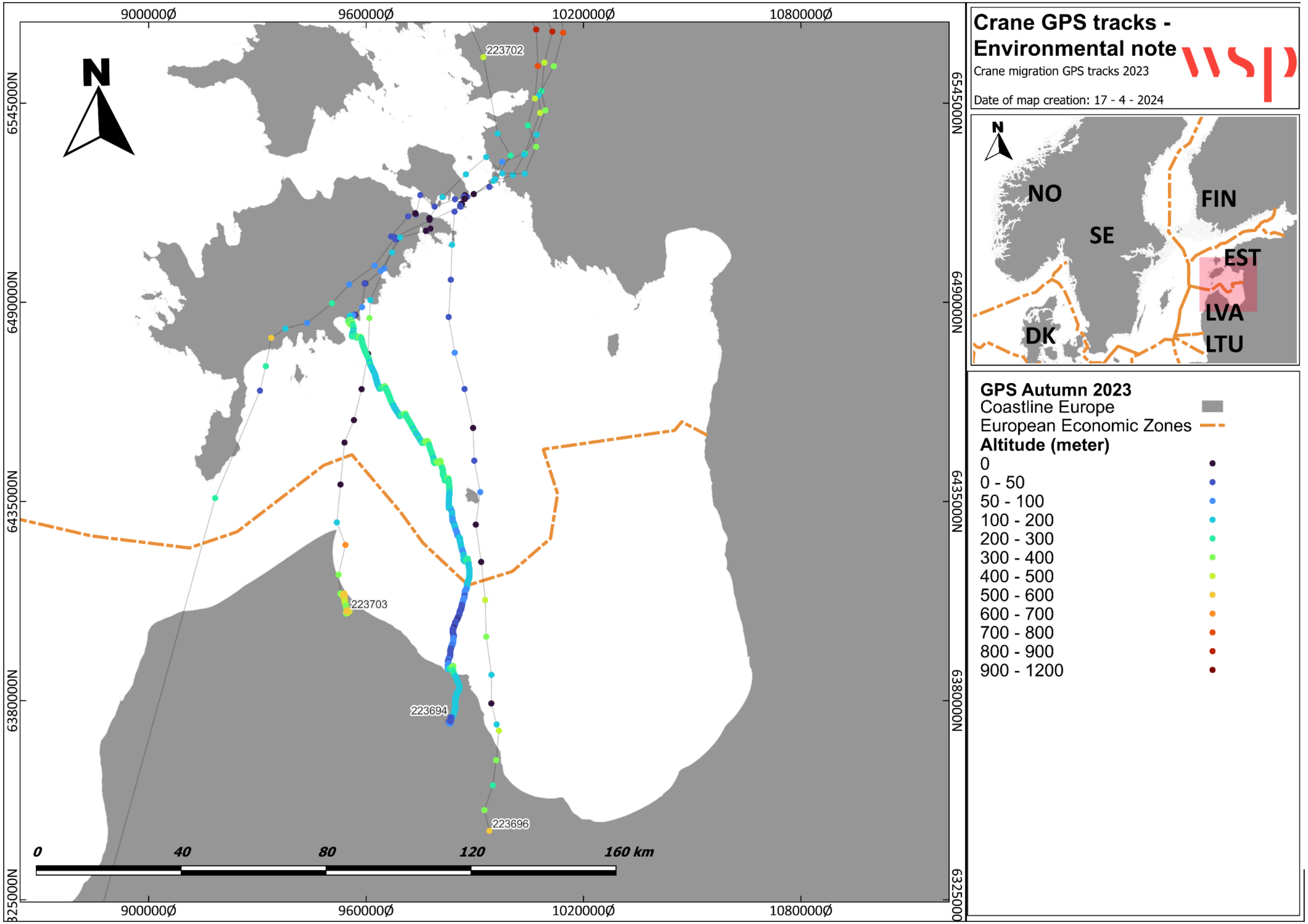



**Figure 13.**
**Displays a map of the Gulf of Riga, with the outline of the bordering countries, as well as the Exclusive Economic Zone (EEZ) between the countries.**

**The GPS positions of each of the 4 tagged common cranes on their migration south, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available.**

**Each crane is presented by the number of the GPS transmitter, ranging within no. 223694, 223696, 223702 and 223703.**

**All tracks are displayed individually in the appendix 9.1.5.**

## EXAMPLE OF VERTICAL MACRO AVOIDANCE FROM GPS DATA

During autumn 2023 on the 19th of October, one of the juvenile cranes, tagged during summer 2023 in the Umeå region (No. 223691), migrated through the area of Kriegers Flak, see Figure 14. While migrating southward, the crane displayed vertical avoidance behaviour, on several occasions, when approaching the two parts of the wind farm Kriegers Flak (Zone of rotor swept area 25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2).

The track shows that, coming from the north and heading south in an altitude between 100 – 200 meters, the juvenile crane start ascending to an altitude between 400 – 500 meters. Afterwards, the crane descends, probably gliding past the first part of the wind farm and start ascending in between the two parts once again. Then after gliding once more, it starts ascending once more above the wind farm and finally glides past the second part of the wind farm.

The transmitted GPS positions clearly illustrate the fine scale movement of the migratory behaviour on this occasion, of both the juvenile and the behaviour of the flock it was most likely migrating together with. Based on the flock sizes counted during the vessel surveys 2022/2023, listed in this note, the mean +/- SD flock of cranes consisted of 53 (+/- 44.2) individuals. Therefore, this GPS track could represent, based on average assumptions from data collect for this note, the avoidance behaviour for a flock of 53 cranes passing through the Kriegers Flak wind farm on their southward migration (Figure 14). On the same assumption we can, based on our collected data, with a total of 17 GPS transmitters assume that the observed tracks represent at least 901 cranes, probably even more.

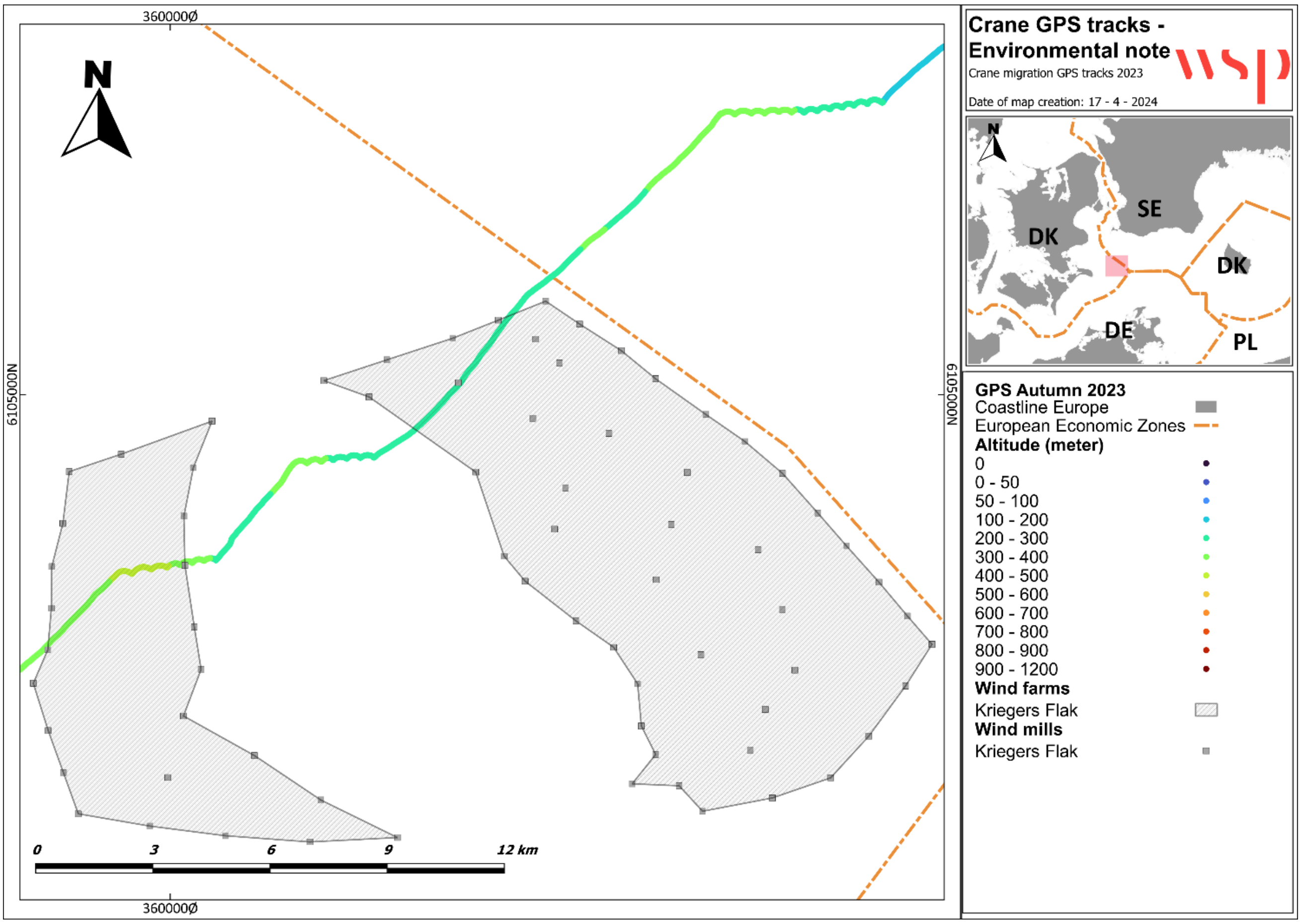



**Figure 14. Displays a map over the Kriegers Flak wind farm array in the western parts of the Baltic Sea, with the outline of the boarding countries and the Exclusive Economic Zone (EEZ) between the countries. The GPS positions of the tagged common crane no. 223691 on its migration south, while crossing the sea are shown, with the altitude of each GPS position displayed by colour (from blue – light green).**

# 5.2 MEASURING AVOIDANCE BEHAVIOUR AND FLIGHT HEIGHT OF MIGRATING CRANES

## 5.2.1 VESSEL SURVEY DURING AUTUMN 2022

A total of 3,425 migrating cranes distributed over 47 different flocks were observed during autumn 2022. Of these, 23 flocks of 1,752 cranes displayed avoidance behaviour in relation to the wind turbines in either Kriegers Flak or Baltic 2. This is equivalent to 51 % of all the migrating cranes and 48 % of the observed flocks (Appendix 9.1.1, Figure 15–19).

### AVOIDANCE BEHAVIOUR MEASURED BY RADAR TRACKS

Out of the total numbers of observed cranes, 743 cranes, distributed in 10 flocks, showed avoidance behaviour at the macro scale only, whereas 422 cranes, distributed in 5 flocks, reacted at the meso-, and micro- scale only, equivalent to 22 % and 12 %, respectively. Additionally, 587 cranes, distributed in 24 flocks, showed a combination of macro-, meso-, and micro- scale avoidance, equivalent to 17 %. Estimated flight heights was in the range of 2 – 900 meters. No collisions between cranes and wind turbines were observed within the study period.

The remaining 1,673 migrating cranes, distributed in 24 flocks, showed no avoidance behaviour towards the OWF, equivalent to 48 % of all the cranes observed, with the cranes flying either far above or far away from the OWF (Appendix 9.1.1, Figure 15–19).

Based on a total of 14 individuals of birds of prey, distributed between three species, sparrowhawk, marsh harrier and red kite, one sparrowhawk showed avoidance behaviour at the macro scale, 4 individuals showed avoidance behaviour on the meso-, and micro- scale and the red kite was detected expressing micro avoidance behaviour (Appendix 9.1.1). Equivalent to 43 % of the total amount of birds of prey observed, whereas the remaining eight individuals showed no detectable response to the OWF.

### FLIGHT HEIGHT MEASURED BY LRF

Based on the collected laser-rangefinder (LRF) data (Table 9), it was also possible to estimate an average flight height of the migrating cranes within and outside the OWF, together with an estimated flight height in four different scenarios of turbine activity: Operative (OP); Idle (IDL); Not Operative (NO); No information (NA).
The difference in the average altitude of the migrating cranes outside and inside the OWF were 223 and 308 meters, respectively, equivalent to an average increase of altitude by 28 % above the OWF. The flight height also varied with the activity of the wind turbines. With an average flight height of 354 meters and 583 meters above the OWF while the wind turbines were operating at operative speed and while idling, respectively. The average flight height while the wind turbines were not operative was down to 136 meters. This is equivalent to a percentwise difference between operative and not operative of 62 % and a percentwise difference between idling and not operative of 77 %. However, the sample size did not allow for a statistical analysis for the activity of the windmills and the difference found between inside and outside the borders of the wind farm array, was not significant when applying a student’s t-test ($p = 0.62$).

**Table 9. Average flight height in meters (m) of migrating common cranes (*Grus grus*) during autumn 2022, based on data points collected by laser-rangefinder (Number of data points from LRF (n), with the given Standard deviation). OWF=Offshore wind farm. The number of individuals and flocks, of which the datapoints are based on, have been noted, as well as the range of flight height distribution. Secondly, an average flight height in meters (m) in four different scenarios of wind turbine movement: Operative (OP), Idle (IDL), Not operative (NO), No information (NA) has been calculated. The zone of rotor swept area is 25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2. For details on each flock see appendix 9.1.2.**

| Within OWF | Number of datapoints from LRF (n) | Individuals (n) | Flocks (n) | Average flight height (m) | Standard Deviation | Minimum height (m) | Maximum height (m) |
|---|---|---|---|---|---|---|---|
| Not within or above the OWF | 157 | 1,215 | 18 | 222.5 | 216.7 | 0 | 1,034 |
| Within or above the OWF | 39 | 881 | 10 | 308.2 | 332.7 | 0 | 1,329 |
| **Turbine rotation** | **Number of datapoints from LRF (n)** | **Individuals (n)** | | **Average flight height (m)** | **Standard Deviation** | **Minimum height (m)** | **Maximum height (m)** |
| Operative (OP) | 14 | 1,095 | - | 353.6 | 312.1 | 0 | 1,034 |
| Idle (IDL) | 2 | 145 | - | 583.4 | 582.1 | 145 | 1,329 |
| Not Operative (NO) | 2 | 88 | - | 135.7 | 20.8 | 82 | 202 |
| No information (NA) | 2 | 20 | - | 45 | 42.9 | 0 | 79 |

## MIGRATORY BEHAVIOUR AND WIND TURBINE ACTIVITY DURING AUTUMN 2022

Weather data was recorded in the field per hour during the active observation periods by a weather recording radar based on the vessel, from 06:30 at the earliest – 17:00 being the latest time recorded within the study period.

The **20-09-2022** the wind came from the north with a mean wind speed of 6.7 m/s (n = 10), at that date 12 flocks of migrating cranes were recorded, heading south or southwest, five of which showed tracks on the radar (Appendix 9.1.1, Figure 15). The flocks were recorded throughout the day, in a time spectrum from 09:25 – 16:33. Of the 12 flocks, 4 flocks showed avoidance behaviour at the macro scale, one of which was tracked on the radar while showing avoidance behaviour (Appendix 9.1.1; Track 1, Figure 15). The remaining flocks, tracked on the radar, showed no signs of detectable avoidance behaviour, flying either far above or at a faraway distance of the OWFs (Appendix 9.1.1; track 2 – 5, Figure 15).

Besides the recorded flocks of cranes, two sparrowhawks were recorded heading southwest, at the time 13:17, expressing meso-, and micro- avoidance behaviour flying low in between the turbines (Appendix 9.1.1).
The turbines were recorded being operative, when the flocks of cranes and the two sparrowhawks migrated past the area (Appendix 9.1.1).

The **21-09-2022** the wind came from northeast and turned northwest during the day, with a mean wind speed of 4.5 m/s (n = 11), at that date 10 flocks of migrating cranes were recorded, heading south or southwest, which all showed tracks on the radar (Appendix 9.1.1; Figure 16). The flocks were recorded in the morning, in a time range from 08:53 – 10:50. Of the 10 tracks, two flocks showed avoidance behaviour at the macro scale (Track 6 and 10, Figure 16; Appendix 9.1.1), while the remaining flocks showed no signs of detectable avoidance behaviour, flying either far above or at a faraway distance of the OWFs (Appendix 9.1.1, Figure 16).
The turbines were recorded being operative, while the flocks recorded as track no. 6; 9-11 and 13 passed through the wind farm, with the flocks recorded as track no. 6 and 10 showing avoidance behaviour on the macro scale (Appendix 9.1.1).

The **22-09-2022** the wind came from west and turned southwest during the day, with a mean wind speed of 3.4 m/s (n = 11), at that date zero flocks of migrating cranes were recorded. One sparrowhawk was recorded heading west, at the time 09:07, expressing meso-, and micro- avoidance behaviour flying low in between the turbines (Appendix 9.1.1).

The turbines were recorded being operative when the sparrowhawk was recorded, which showed avoidance behaviour at the meso-, and micro- scale (Appendix 9.1.1).

The **04-10-2022** the wind came from northwest and turned southwest during the day, with a mean wind speed of 6 m/s (n = 11), at that date six flocks of migrating cranes were recorded, heading south or southwest, which all showed tracks on the radar (Appendix 9.1.1; Figure 17). The flocks were recorded in the morning and in the early afternoon, in a time range from 08:32 – 12:53. Of the six tracks, two flocks showed a combination of avoidance behaviour at the macro-, meso-, and micro- scale (Track 17 and 21, Figure 17; Appendix 9.1.1), while one flock showed avoidance behaviour at the meso-, and micro- scale (Track 16, Figure 17; Appendix 9.1.1). The remaining flocks showed no signs of detectable avoidance behaviour, flying either far above or at a faraway distance of the OWFs (Appendix 9.1.1, Figure 17).

Besides the recorded flocks of cranes, five sparrowhawks were recorded heading southwest, in a time range from 08:22 – 10:36, two of which expressed meso-, and micro- avoidance behaviour flying low in between the turbines, the rest showed no detectable avoidance behaviour (Appendix 9.1.1).

In the time where track 17 was recorded showing a combination of avoidance behaviour on the macro-, meso-, and micro- scale, the wind turbines were recorded operative (Appendix 9.1.1). While when the two sparrowhawks, that showed avoidance behaviour on the meso-, and micro- scale the wind turbines were both operational and, for the one at 08:22, not operational.

The **05-10-2022** the wind came from southwest, with a mean wind speed of 9 m/s (n = 12), at that date only one flock of migrating cranes were recorded, heading south (Appendix 9.1.1). The flock was recorded in the early afternoon, at 13:19 and showed avoidance behaviour at the macro-, meso-, and micro- scale but did not get detected by the radar.

The **12-10-2022** the wind came from south, with a mean wind speed of 4 m/s (n = 9), at that date 14 flocks of migrating cranes were recorded, heading south or southwest, which all showed tracks on the radar (Appendix 9.1.1; Figure 18). The flocks were recorded in the morning and in the afternoon, in a time range from 07:52 – 14:33. Of the 14 flocks, three flocks showed avoidance behaviour at the macro scale only (Track 23, 29 and 32, Figure 18; Appendix 9.1.1), three flocks showed avoidance behaviour at the meso-, and micro- scale only (Track 25, 31 and 33, Figure 18; Appendix 9.1.1), while five flocks showed a combination of avoidance behaviour at the macro/- meso-, and micro- scale (Track 22, 26, 28, 30 and 34, Figure 18; Appendix 9.1.1). The remaining flocks were not recorded expressing any avoidance behaviour (Track 24, 27 and 35, Figure 18; Appendix 9.1.1). Besides the recorded flocks of cranes, four sparrowhawks were recorded heading southwest, in a time range from 08:14 – 08:40, not expressing any avoidance behaviour. Similarly, a marsh harrier recorded heading southwest at 08:19, no avoidance behaviour was detected. A red kite however, recorded heading southwest at 08:04, expressed avoidance behaviour on the micro scale flying close to the rotor blades (Appendix 9.1.1).
In the cases of the tracks: 22, 28, 30 and 34, the flocks showing a combination of avoidance behaviour at the macro-, meso-, and micro- scale, the wind turbines were not operative. In the cases of the tracks: 23, 29 and 32, the flocks showing avoidance behaviour at the macro scale, the wind turbines were operative. In the tracks: 24 and 26, the flocks that showed a combination of avoidance behaviour at the macro-, meso-, and micro- scale, tracks 26, and no avoidance behaviour, track 24, the wind turbines were idling (Appendix 9.1.1). In the cases of one of the sparrowhawks, the marsh harrier and the red kite, the wind turbines were not operative.

The **13-10-2022** the wind came from south, with a mean wind speed of 6.6 m/s (n = 10), at that date four flocks of migrating cranes were recorded, heading south, with two of the flocks showed tracks on the radar while displaying avoidance behaviour (Track 36 and 37, Figure 19; Appendix 9.1.1). The flocks were recorded in the morning and in the afternoon, in a time spectrum from 09:16 – 14:20. Track 36 showed avoidance behaviour at the macro scale, while track 37 showed avoidance behaviour on the meso-, and micro- scale (Track 36 and 37, Figure 19; Appendix 9.1.1). The remaining two flocks was not recorded expressing and avoidance behaviour (Appendix 9.1.1).

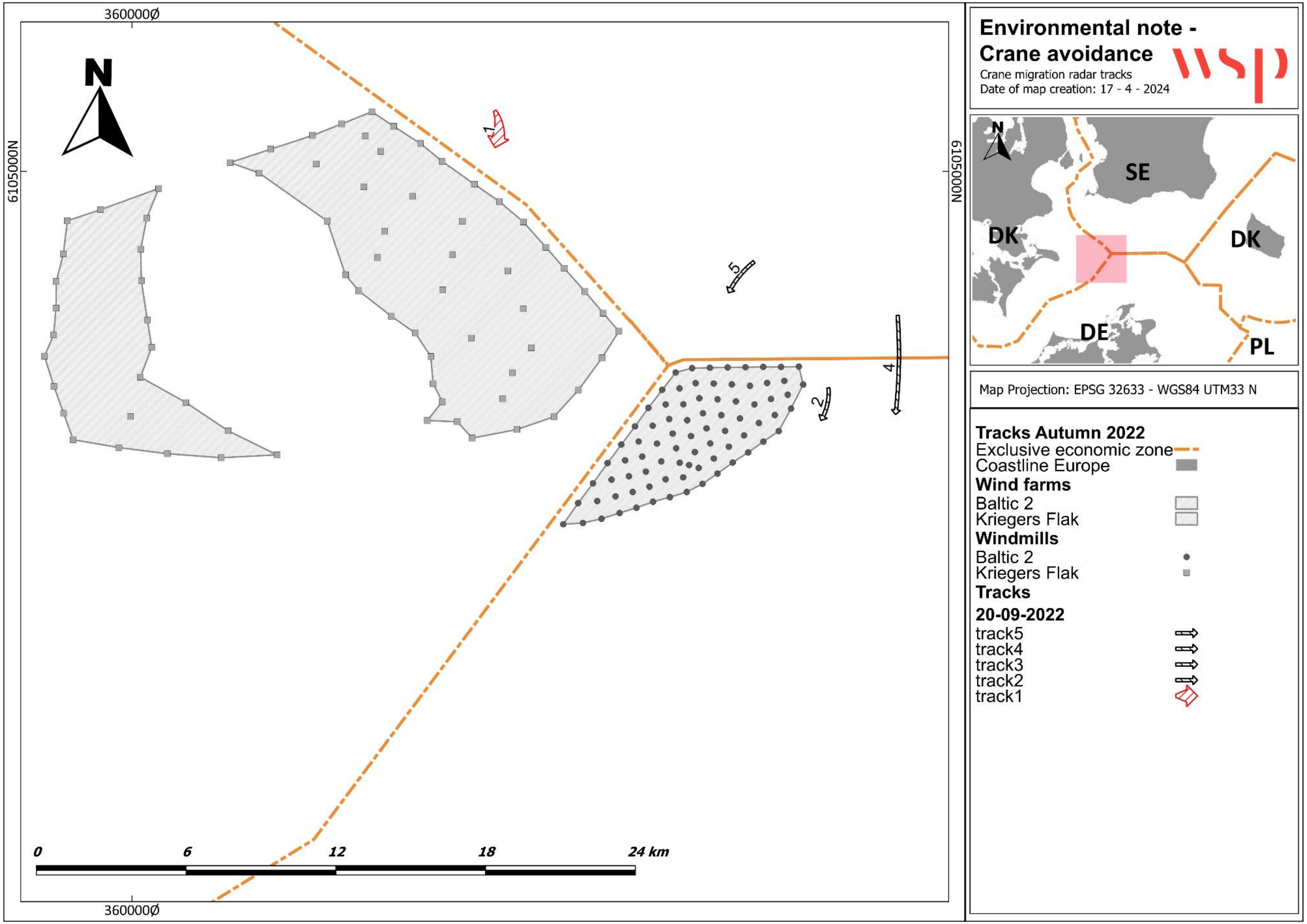



**Figure 15.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 20-09-2022.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 20-09-2022 the wind came from the north with a mean wind speed of 6.7 m/s.**

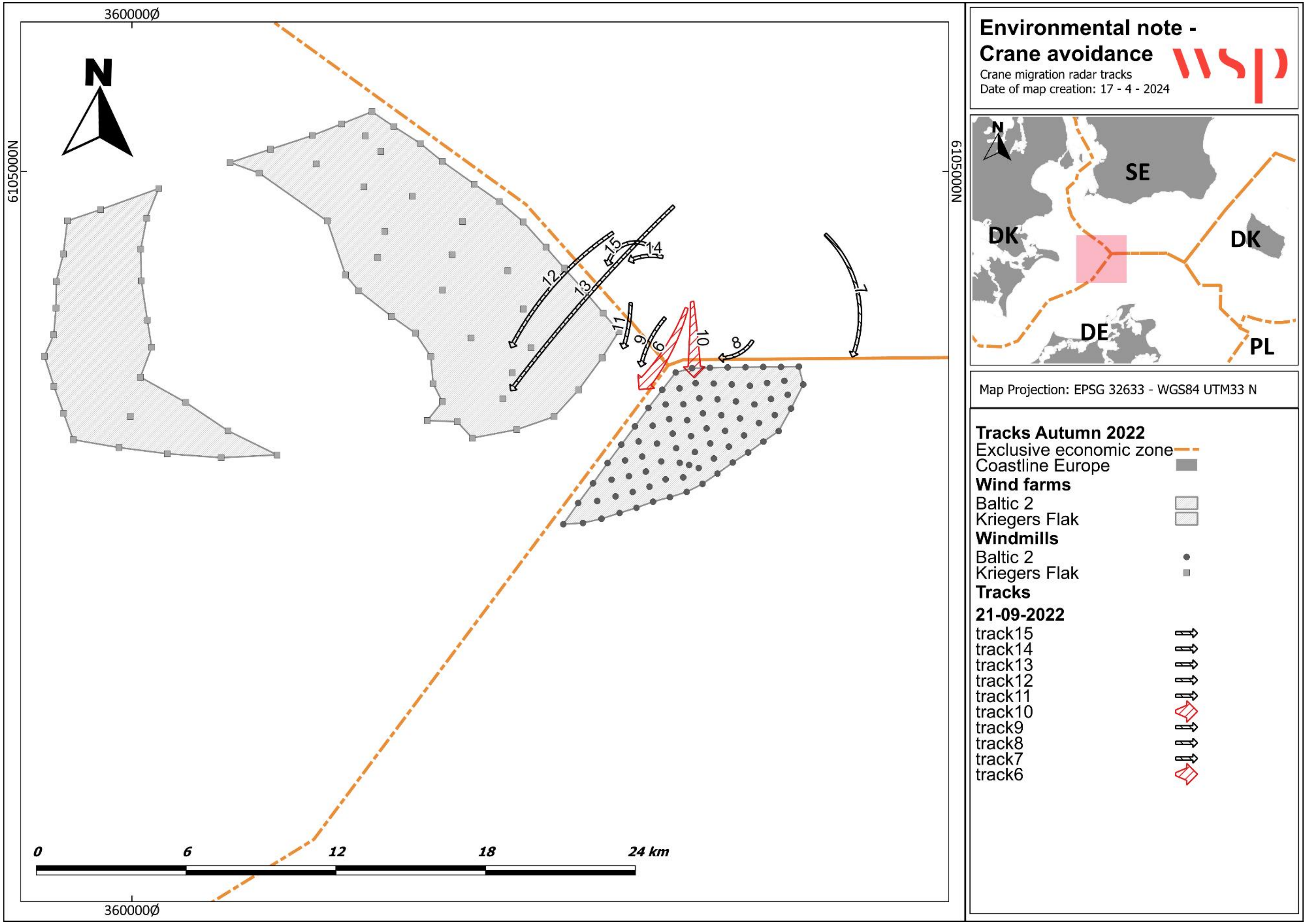



**Figure 16.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 21-09-2022.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 21-09-2022 the wind came from northeast and turned northwest during the day, with a mean wind speed of 4.5 m/s.**

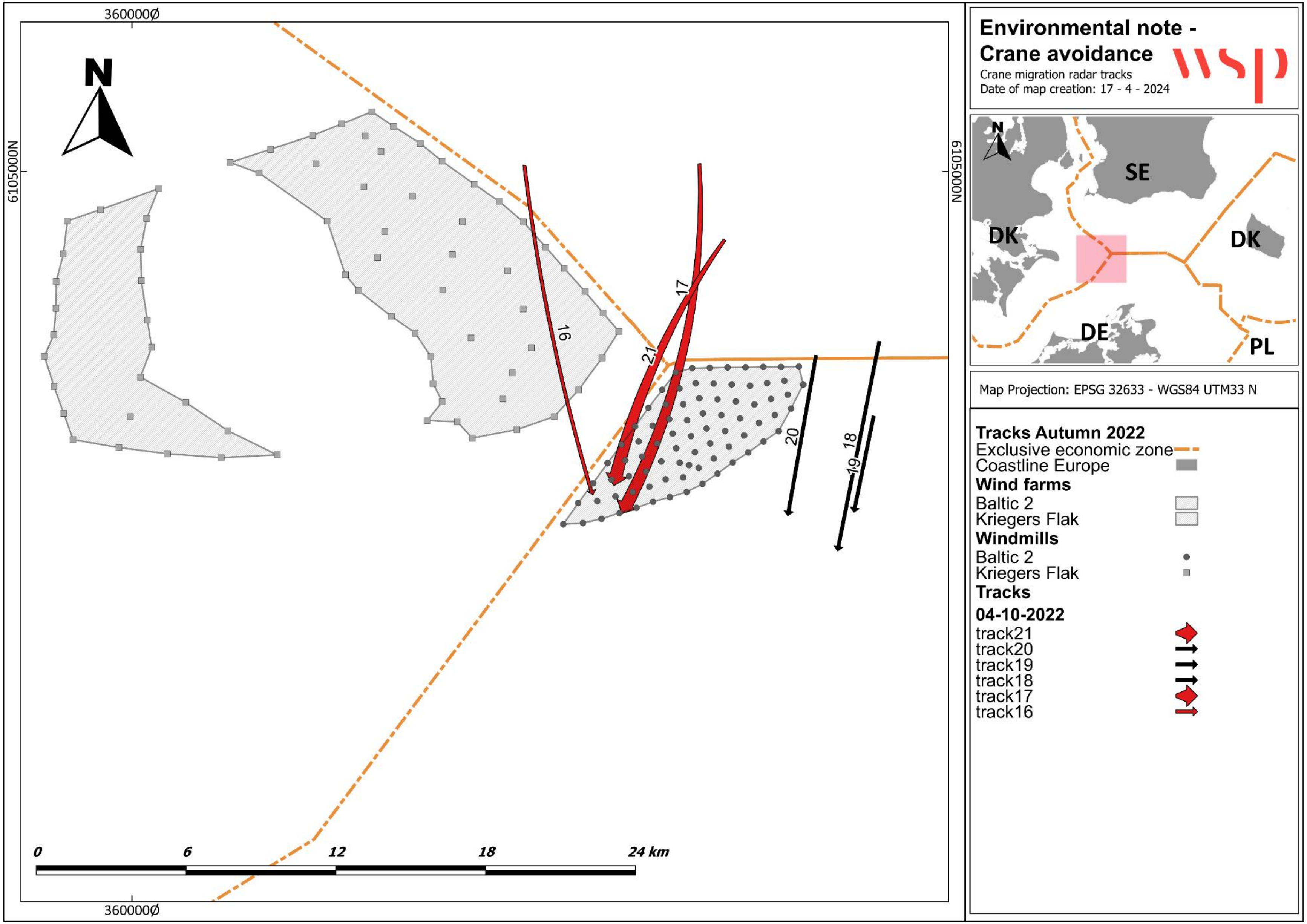



**Figure 17.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 04-10-2022.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 04-10-2022 the wind came from northwest and turned southwest during the day, with a mean wind speed of 6 m/s.**

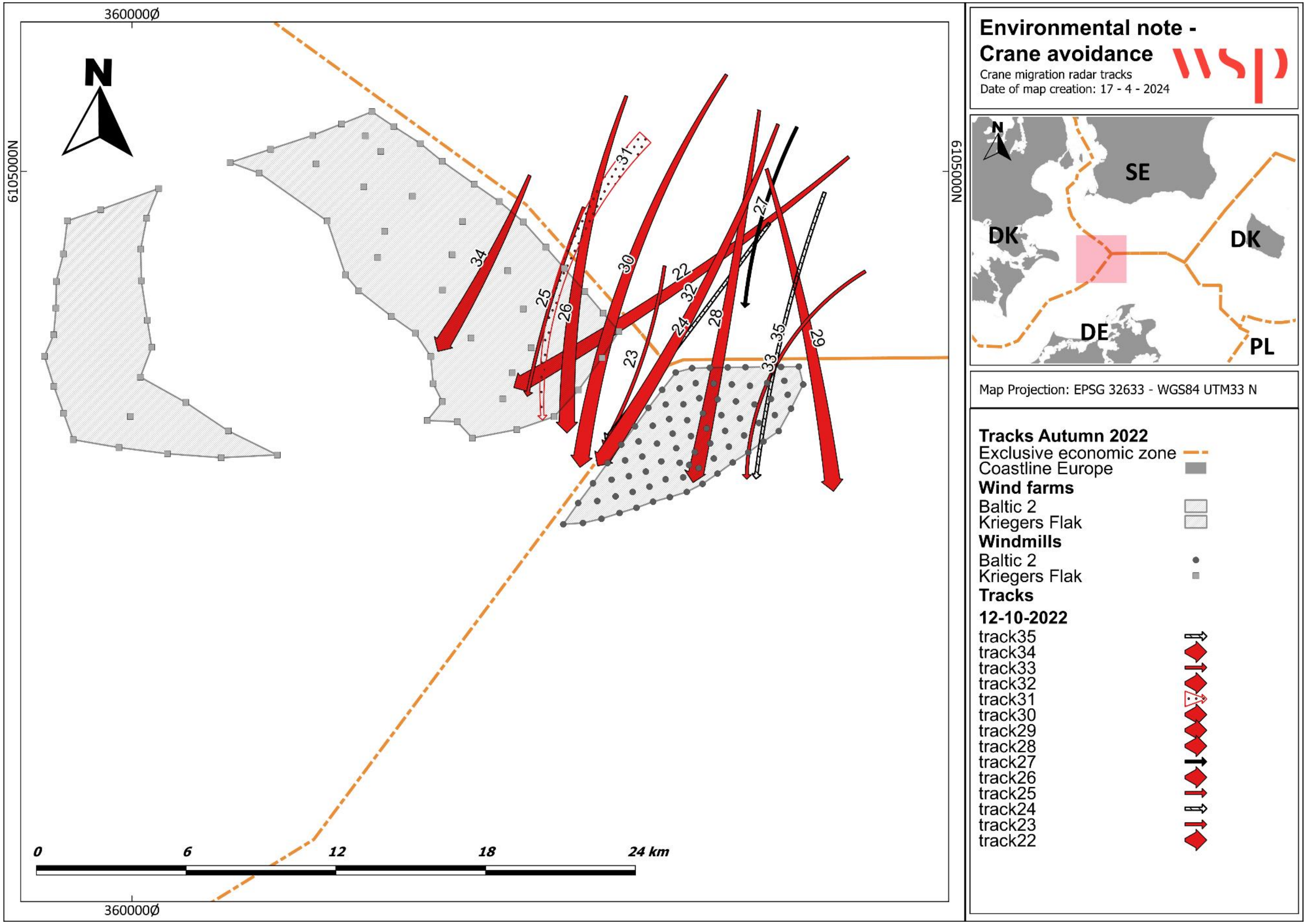



**Figure 18.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 12-10-2022.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 12-10-2022 the wind came from south, with a mean wind speed of 4 m/s.**

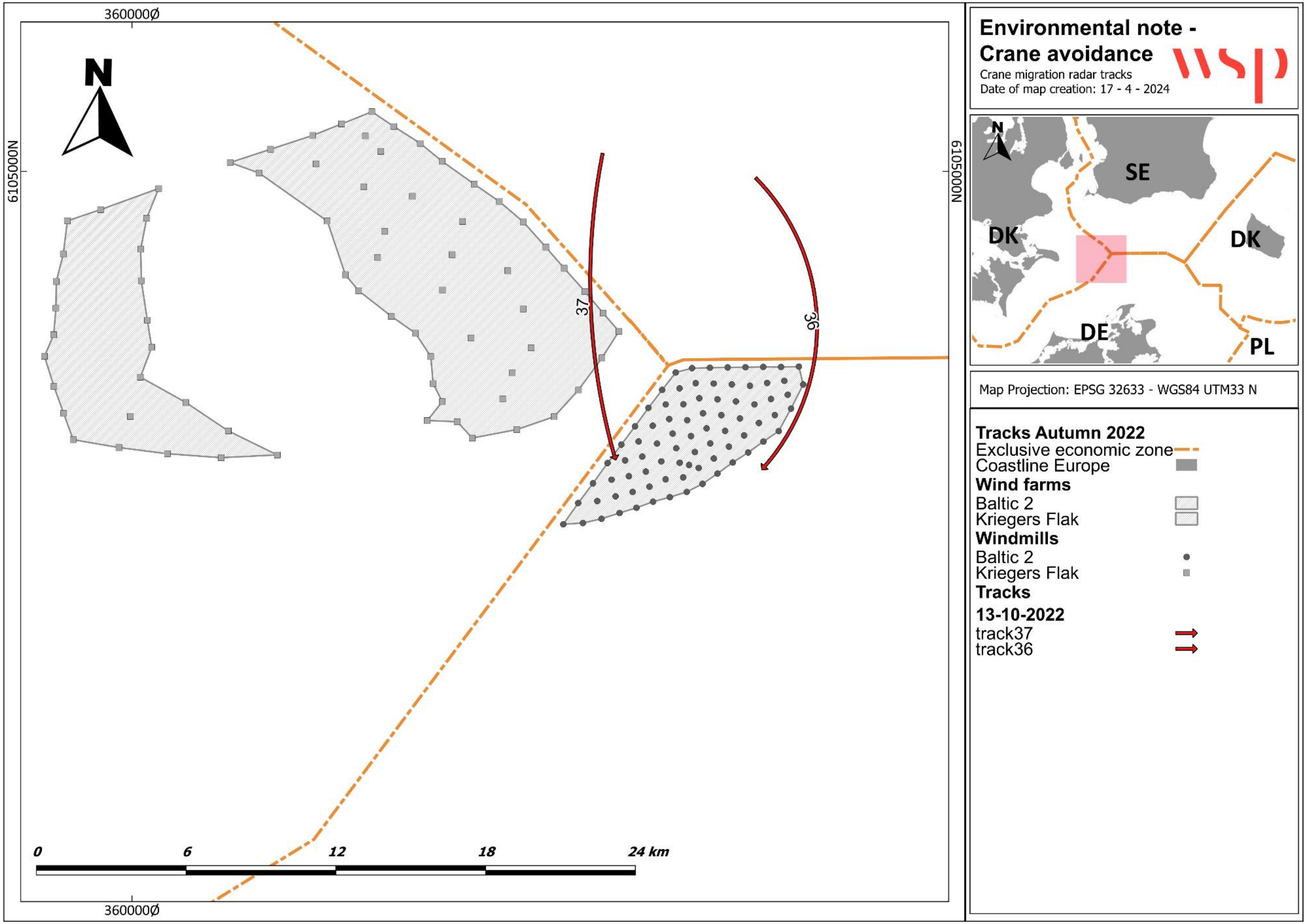



**Figure 19.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 13-10-2022.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 13-10-2022 the wind came from south, with a mean wind speed of 6.6 m/s.**

### 5.2.2 VESSEL SURVEY DURING SPRING 2023

A total of 1,041 migrating cranes distributed over 37 different flocks were observed during spring 2023. Of these, 17 flocks of 438 cranes displayed avoidance behaviour in relation to the wind turbines in either Kriegers Flak or Baltic 2. This is equivalent to 42 % of all the migrating cranes and 46 % of the observed flocks (Appendix 9.1.1, Figure 20-23).

#### AVOIDANCE BEHAVIOUR MEASURED BY RADAR TRACKS

Out of the total numbers of observed cranes, 45 cranes, distributed in 2 flocks, showed avoidance behaviour at the macro scale only, whereas 377 cranes, distributed in 14 flocks, reacted at the meso-, and micro- scale only, equivalent to 4 % and 36 %, respectively. Additionally, 16 cranes, distributed in 1 flock, showed a combination of avoidance behaviour at the macro-, meso-, and micro- scale, equivalent to 2 %. Estimated flight heights during spring 2023 were in the range of 50 – 400 meters. No collisions were observed within the study period.
The remaining 603 migrating cranes, distributed in 20 flocks, showed no avoidance behaviour towards the OWF, equivalent to 58 % of all the cranes observed, with the cranes flying either far above or far away from the OWF (Appendix 9.1.1, Figure 20-23).

#### FLIGHT HEIGHT MEASURED BY LRF

Based on the collected laser-rangefinder (LRF) data (Table 10), it was also possible to estimate an average flight height of the migrating cranes within and outside the OWF. The difference in the altitude of the migrating cranes outside versus inside the OWF were 123 and 125 meters, respectively, equivalent to an average increase of altitude by 1.4 % above the OWF. During spring 2023 measurements were recorded only during operative (OP) mode.

**Table 10. Average flight height in meters (m) of migrating common cranes (*Grus grus*) during spring 2023, based on data points collected by laser-rangefinder (Number of data points from LRF (n), with the given Standard deviation). OWF= Offshore wind farm. The number of individuals and flocks, of which the datapoints are based on, have been noted. During spring 2023 measurements were recorded only during operative (OP) mode of the wind turbines. The zone of rotor swept area is 25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2. For details of each flock see appendix 9.1.3.**

| Within OWF | Number of datapoints from LRF (n) | Individuals (n) | Flocks (n) | Average flight height (m) | Standard Deviation | Minimum height (m) | Maximum height (m) |
|---|---|---|---|---|---|---|---|
| Not within or above the OWF | 74 | 201 | 8 | 123.3 | 51.2 | 52 | 265 |
| Within or above the OWF | 4 | 50 | 2 | 125.0 | 88.4 | 73 | 257 |

## MIGRATORY BEHAVIOUR AND WIND TURBINE ACTIVITY DURING SPRING 2023

Since no weather data was recorded in the field during the spring survey 2023, weather data from Falsterbo in southern Sweden is applied in the following section (SMHI, 2023).

The **10-03-2023** the wind came from east with a mean wind speed of 5.8 m/s. One flock of cranes were recorded migrating north, showing tracks on the radar (Appendix 9.1.1; Track 38, Figure 20). The flock was recorded at 12:31 far from the OWFs, no avoidance behaviour was detected. No data about the activity of the wind turbines was available for this day.

The **16-03-2023** the wind came from southwest and turned southeast during the day, with a mean wind speed of 4.5 m/s. At that date 17 flocks of migrating cranes were recorded, heading north, where all the flocks showed tracks on the radar (Track 39 – 55, Figure 21; Appendix 9.1.1). The flocks were recorded in the morning and in the afternoon, in a time range from 08:53 – 14:23. Of the 14 tracks, one flock showed avoidance behaviour at the macro scale only (Track 50, Figure 21; Appendix 9.1.1), five flocks showed avoidance behaviour at the meso-, and micro- scale (Track 47, 48, 51, 54 and 55, Figure 21; Appendix 9.1.1), while one flock showed a combination of avoidance behaviour at the macro-, meso-, and micro- scale (Track 39, Figure 21; Appendix 9.1.1). The remaining flocks was not recorded expressing any sort of avoidance behaviour (Track 40 – 46, 49, 52 and 53, Figure 21; Appendix 9.1.1).

In the cases of track 39 and 40, showing a combination of avoidance behaviour at the macro-, meso-, and micro- scale and expressing no avoidance behaviour, respectively, the wind turbines were recorded operative (Appendix 9.1.1), for the rest of the tracks, on the 16th of march, the wind turbines were idle.

The **18-03-2023** the wind came from southeast and turned southwest during the day, with a mean wind speed of 4.8 m/s. At that date eight flocks of migrating cranes were recorded, heading north, where all the flocks showed tracks on the radar (Track 56 – 63, Figure 22; Appendix 9.1.1). The flocks were recorded before noon and in the afternoon, in a time range from 10:47 – 12:43. Of the eight tracks, three flocks showed avoidance behaviour at the meso-, and micro- scale (Track 56, 58 and 63, Figure 22; Appendix 9.1.1). The remaining flocks was not recorded expressing any avoidance behaviour (Track 57 and 59- 62, Figure 22; Appendix 9.1.1). No data about the activity of the wind turbines was available for this day.

The **19-03-2023** the wind came from south-southeast with a mean wind speed of 7.1 m/s. At that date 11 flocks of migrating cranes were recorded, heading north, nice of which showed tracks on the radar (Track 64, 65, 66 and 67 – 74, Figure 23; Appendix 9.1.1). The flocks were recorded from before noon and into the afternoon, in a time range from 10:34 – 14:12. Of the 11 tracks, one flock showed avoidance behaviour at the macro scale (Track 71, Figure 23; Appendix 9.1.1), while six flocks showed avoidance behaviour at the meso-, and micro- scale (Track 64, 65, 66, 67, 69 and 70, Figure 23; Appendix 9.1.1). The remaining flocks were not recorded expressing any avoidance behaviour (Track 68 and 72, Figure 23; Appendix 9.1.1). No data about the activity of the wind turbines was available for this day.

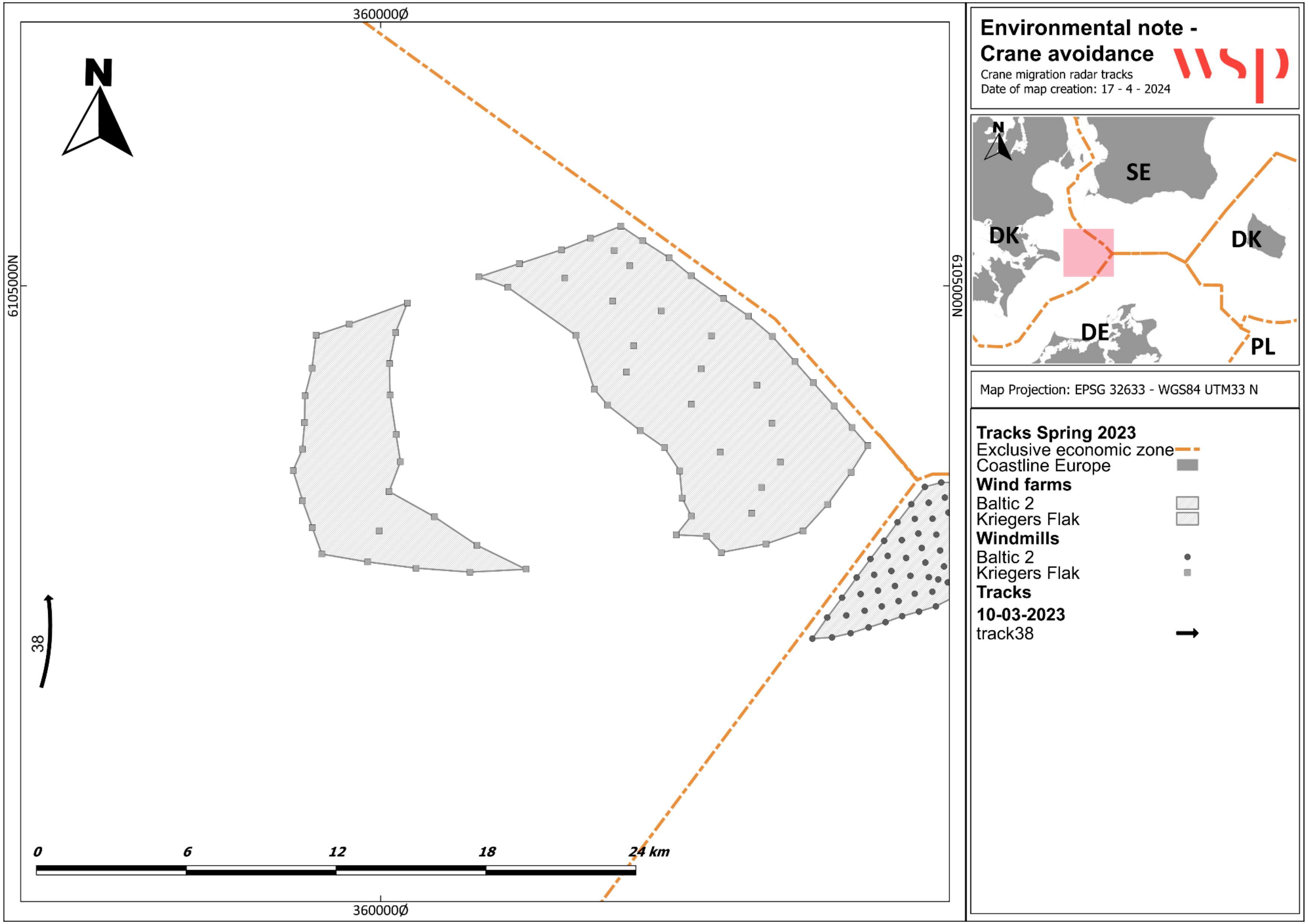



**Figure 20.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 10-03-2023.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 10-03-2023 the wind came from east with a mean wind speed of 5.8 m/s.**

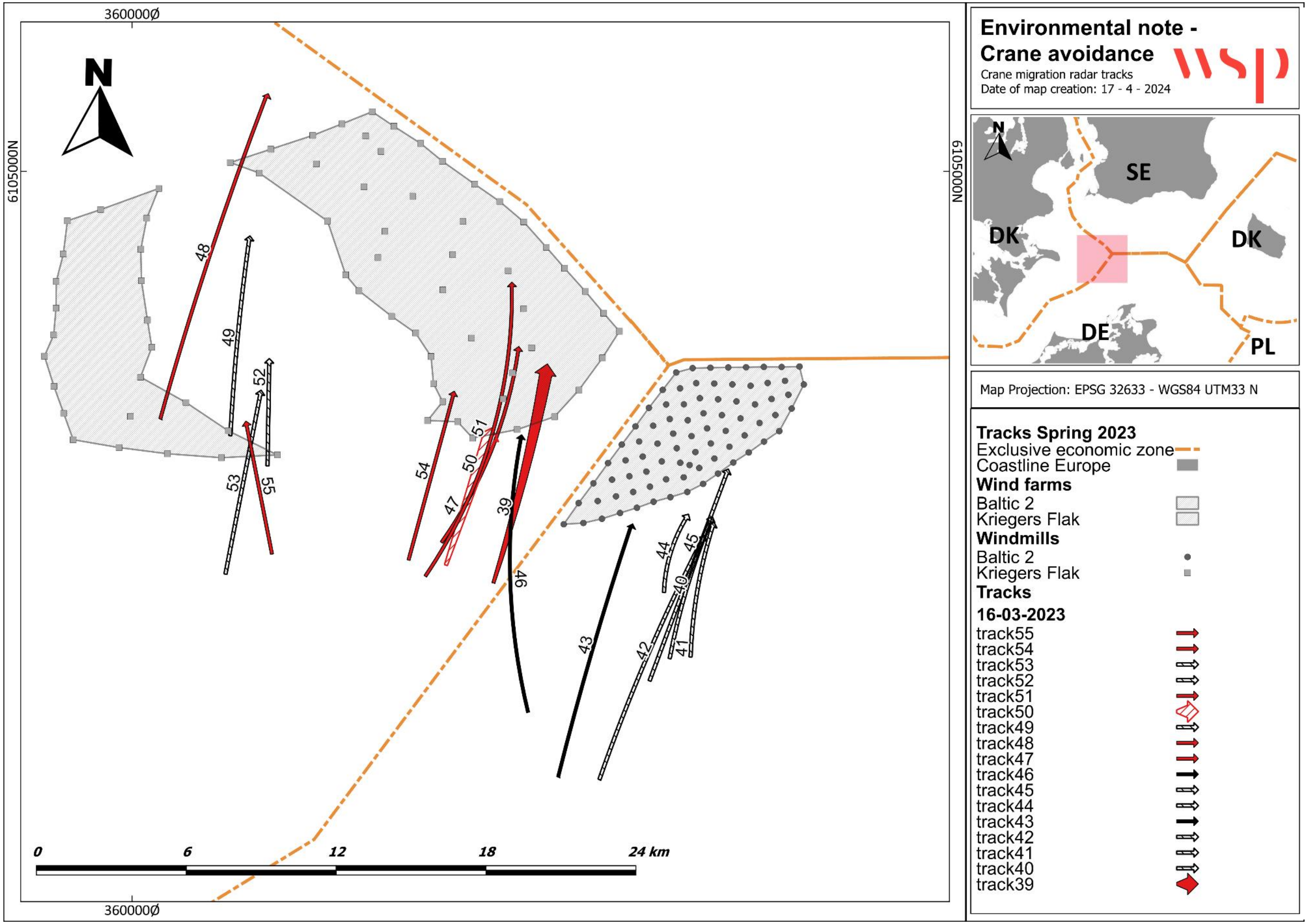



**Figure 21.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 16-03-2023.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 16-03-2023 the wind came from southwest and turned southeast during the day, with a mean wind speed of 4.5 m/s.**

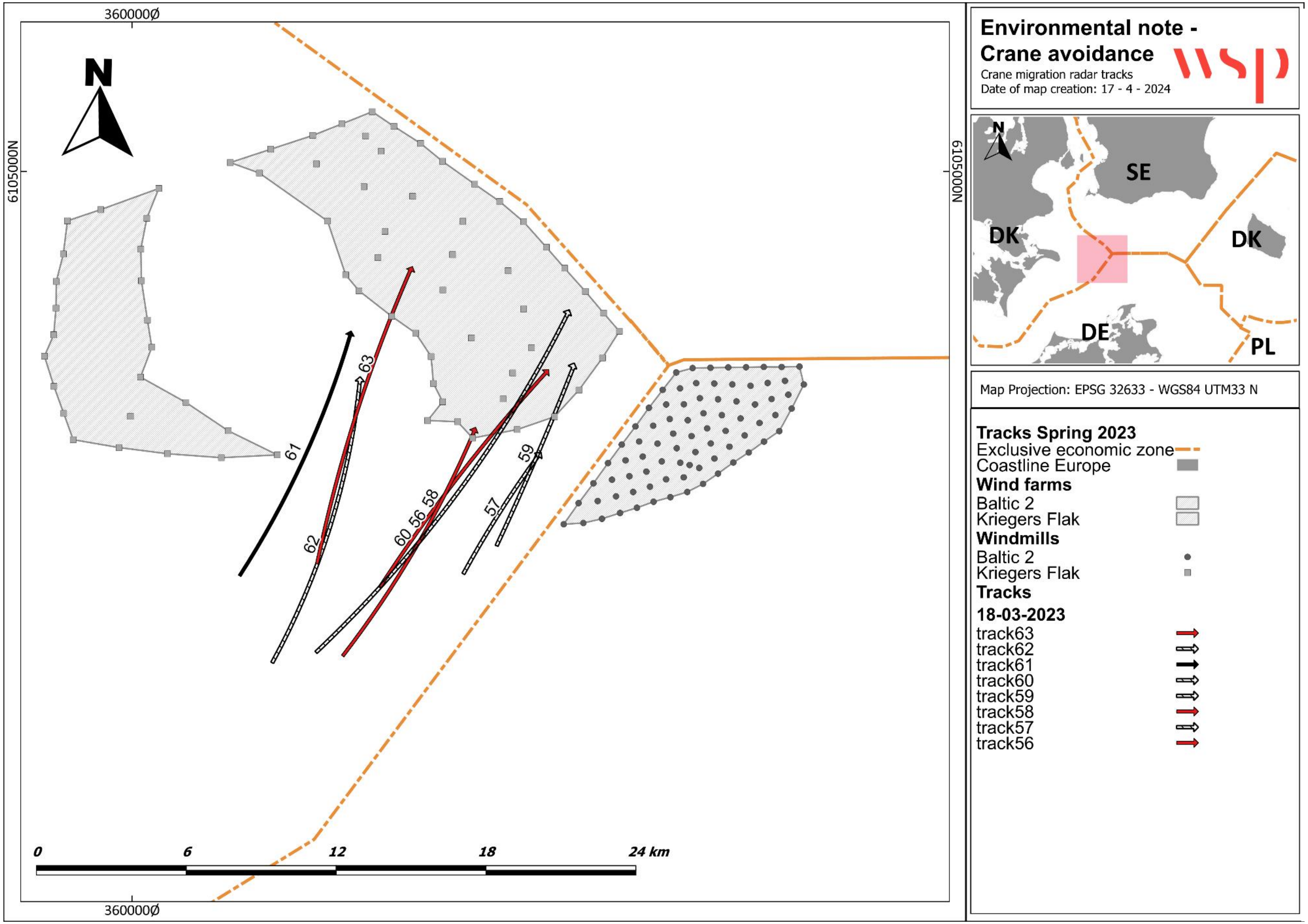



**Figure 22.**
**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 18-03-2023.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 18-03-2023 the wind came from southeast and turned southwest during the day, with a mean wind speed of 4.8 m/s.**

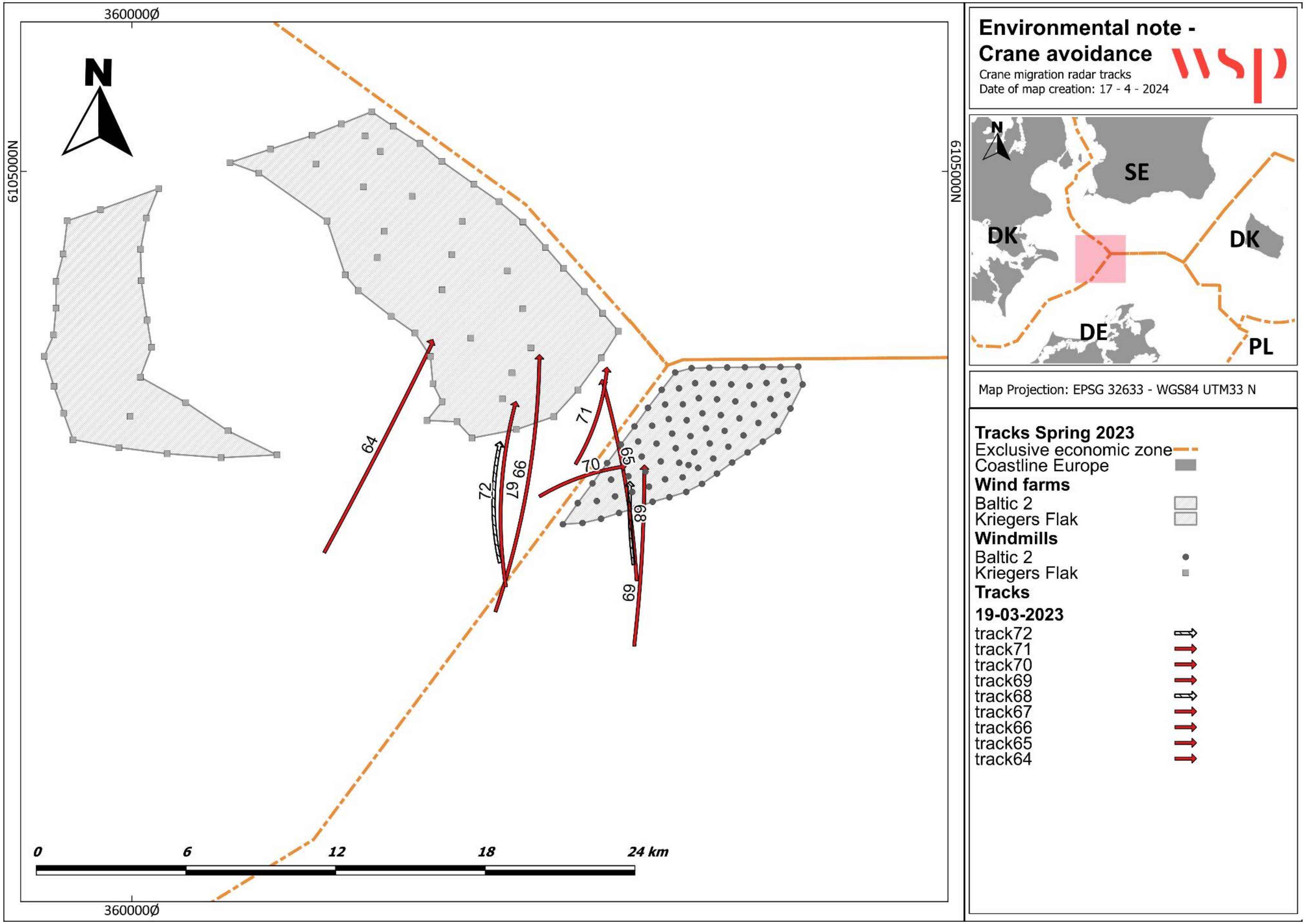



**Figure 23.**

**Displays a map of the offshore wind farm arrays Kriegers Flak and Baltic 2 on the 19-03-2023.**

**The arrows indicate flocks of cranes and their direction of flight.**

**The color and filling of the arrow indicate whether avoidance behavior was recorded (red) or not (black) and if the altitude of the flock was within the interval of the swept area of the rotor blades (full filling) or not (dashed filling).**
**(25 - 189 m for Kriegers Flak and 18 – 138 m for Baltic 2)**

**A broad end in the direction of an arrow indicates an incline in altitude, whereas a simple arrow indicates no change in altitude. A dotted arrow indicates a decline in altitude.**

**Specific details on each track are found in Appendix 9.1.1.**

**The 19-03-2023 the wind came from south-southeast with a mean wind speed of 7.1 m/s.**

### 5.2.3 WIND CONDITIONS AND CRANE MIGRATION DURING THE VESSEL BASED SURVEYS IN AUTUMN 2022 AND SPRING 2023

#### AUTUMN 2022

Of the total 3,425 migrating cranes distributed over 47 different flocks, that were observed during autumn 2022, 22 flocks migrated in headwind, equivalent to 47 % of the flocks, 11 flocks migrated in tailwind, equivalent to 23 % of the flocks and 14 flocks migrated in crosswind, equivalent to 30 % of the flocks recorded.

Of that, 30 flocks migrated during wind speeds between 0-6 m/s, equivalent to 64 % of the observed flocks, additionally 16 flocks migrated during wind speeds between 6-10 m/s, equivalent to 34 % of the observed flocks and only 1 flock migrated during wind speeds above >10 m/s, equivalent to 2 % of the observed flocks recorded during the survey. The distribution of the observed patterns for autumn 2022 has been illustrated on Figure 24.

The flight height distributions also varied in relation to the wind direction. Of the observed flocks of cranes, 21 flocks migrated in altitudes within the interval of 0 – 250 m, equivalent to 45 % and one flock migrated in altitudes within the interval of 250 – 500 m, equivalent to 2 %, in headwind conditions.

In tailwind conditions, 5 flocks migrated in altitudes within the interval of 250 – 500 m, equivalent to 11 %, while 3 flocks migrated in altitudes within the interval of 0 – 250 m, equivalent to 6 %, two flocks migrated in altitudes within the interval of 500 – 750 m, equivalent to 4 %, and one flock was observed migrating within the interval of 750 – 1000 m, equivalent to 2 %.

During crosswinds, 5 flocks migrated in altitudes within the interval of 0 – 250 m, equivalent to 11 %, and another 5 flocks in altitudes within the interval of 250 – 500 m also equivalent to 11 %, while three flocks migrated in altitudes within the interval of 500 – 750 m, equivalent to 6 % and one flock was observed migrating within the interval of 750 – 1000 m, equivalent to 2 % of the flight height distribution observed during autumn 2022.

The results of the flight height distribution for autumn 2022 have been illustrated in Figure 25.

#### SPRING 2023

Of the total 1,041 migrating cranes distributed over 37 different flocks, that were observed during spring 2023, only 1 flock migrated in headwind, equivalent to 3 % of the flocks, 25 flocks migrated in tailwind, equivalent to 68 % of the flocks and 11 flocks migrated in crosswind, equivalent to 30 % of the flocks recorded.

Of that, 27 flocks migrated during wind speeds between 0-6 m/s, equivalent to 73 % of the observed flocks, additionally 7 flocks migrated during wind speeds between 6-10 m/s, equivalent to 19 % of the observed flocks and three flocks migrated during wind speeds above >10 m/s, equivalent to 8 % of the observed flocks recorded during the survey. The distribution of the observed patterns for spring 2023 has been illustrated in Figure 24.

The flight height distributions also varied in relation to the wind direction. Of the observed flocks of cranes, one flock migrated in altitudes within the interval of 0 – 250 m, equivalent to 3 %, in headwind conditions.
In tailwind conditions, 21 flocks migrated in altitudes within the interval of 0– 250 m, equivalent to 57 % and 3 flocks migrated in altitudes within the interval of 250 – 500 m, equivalent to 8 %.

During crosswinds, 11 flocks migrated in altitudes within the interval of 0 – 250 m, equivalent to 29 %, and one flock in altitudes within the interval of 250 – 500 m equivalent to 3 % of the flight height distribution observed during spring 2023.

The results of the flight height distribution for spring 2023 have been illustrated in Figure 25.

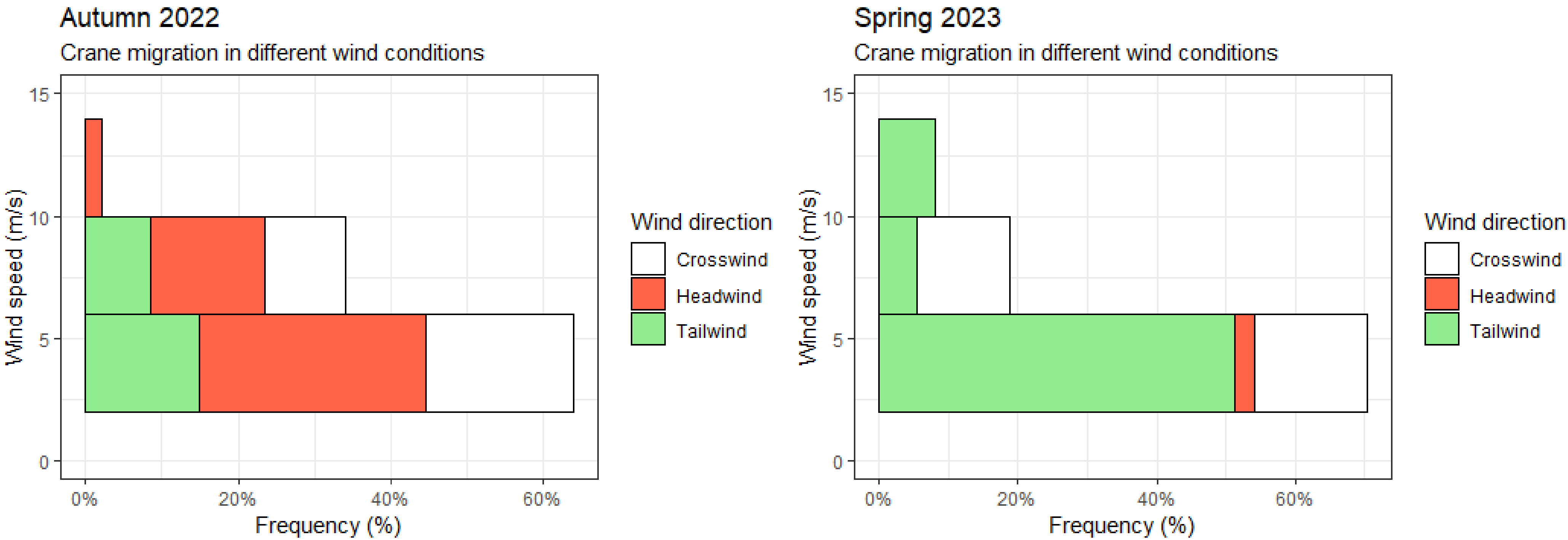



**Figure 24.**
**Displays frequency distributions of the flocks of cranes that migrated during the vessel-based surveys in autumn 2022 (left) and in spring 2023 (right), displayed in relation to wind direction (head, tail, and crosswind) and wind speed divided into three categories 0-6 m/s, 6-10 m/s and 10 - 15 m/s.**

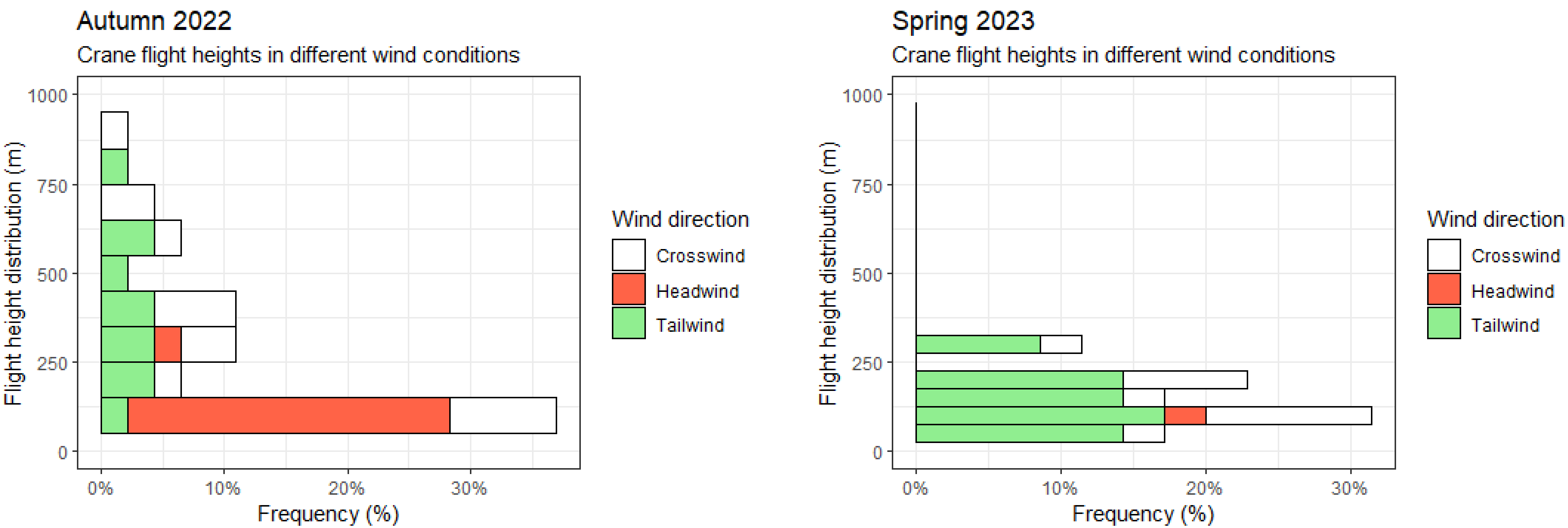



**Figure 25.**
**Displays the frequency of the flight height distributions of flocks of cranes that migrated during the vessel-based surveys in autumn 2022 (left) and in spring 2023 (right), displayed in relation to wind direction (head, tail, and crosswind) and flight height distributions into four categories 0-250 m, 250-500 m, 500-750 m and 750-1000 m.**

### 5.2.4 COLLISION RISK MODELLING

Modelling of collision risk revealed that even small changes in avoidance rate had a large impact on the number of estimated collisions. For the observed number of common cranes passing through the Kriegers Flak wind farm, the model predicted almost 2 collisions per year for an avoidance rate of 0.980, and less than one collision per year for avoidance rates of 0.99 or higher (Table 11). Since no collisions were observed during the surveys, this supports that migrating cranes have a high level of avoidance towards offshore wind farms. Given the assumption that migrating cranes have an avoidance rate of 0.995 or higher, the model estimates that a much larger passage of birds is likely to be required for detection of just one collision (Table 11).

**Table 11. Results from Band collision models given different avoidance rates in the range between 0.98 – 0.999 and the observed passage of cranes as well as the required passage to obtain one collision per year, according to the model.**

| | Avoidance rate | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Season** | **Passage** | **Passage/Km** | **0.980** | **0.985** | **0.990** | **0.995** | **0.9975** | **0.999** |
| **Spring passage** | 1,041 | 45 | 0.76 | 0.57 | 0.38 | 0.19 | 0.10 | 0.04 |
| **Autumn passage** | 3,425 | 149 | 1.20 | 0.90 | 0.60 | 0.30 | 0.15 | 0.01 |
| **Total passage** | 4,466 | 194 | 1.96 | 1.47 | 0.98 | 0.49 | 0.25 | 0.05 |
| **Required passage** | 1,845 | 80 | 1 | | | | | |
| - | 2,460 | 107 | | 1 | | | | |
| - | 3,690 | 160 | | | 1 | | | |
| - | 7,380 | 321 | | | | 1 | | |
| - | 14,760 | 642 | | | | | 1 | |
| - | 36,900 | 1,604 | | | | | | 1 |

# 6 DISCUSSION

The surveys at Kriegers Flak and Baltic 2 monitored the response pattern of migrating cranes and birds of prey towards commissioned offshore wind farms in the Baltic Sea area. The analysis has been based on visual field observations, as well as radar and laser rangefinder tracks collected in autumn 2022 and spring 2023. During these surveys, a total of 4,466 cranes flying in 84 flocks were observed migrating across or in the vicinity of the Kriegers Flak and Baltic 2 offshore wind farms. During the same period, 12 sparrowhawks, one marsh harrier and one red kite, also migrated through the same area. By combining radar and laser rangefinder methods, the large distance (macro-) avoidance behaviour could be determined, as well as the flight behaviour of birds flying inside the turbine arrays, at the meso- and micro- scale. Weather conditions and the mode of turbine operation were noted to allow for investigations of how the flight behaviour of the migrating cranes depended on these parameters. Overall, the avoidance behaviour observed was quite equally distributed between avoidance expressed on the macro- and meso and micro- scales with both horizontal as well as vertical adjustments in flight.

The tagged cranes have generated real time data on migration routes and flight behaviour over the open sea as well as detailed flight behavioural patterns in relation to offshore wind farms. The generated data has been presented together with an overall description of the migration routes and variation in flight altitudes of the tagged individuals. Since cranes tend to migrate in flocks, the flight characteristics inferred from the tags is likely represented by flocks of cranes rather than single individuals. Based on the observed flock sizes and proportional scaling, the 17 tagged cranes could in theory represent as many as 901 individuals, possibly even more.

The cranes migrated in a timespan from early morning to late afternoon, and in a wide range of heights from just above the sea surface and up to more than one kilometre. Several flocks displayed soaring behaviour at land departure points, presumably to benefit from thermal up-winds but surprisingly, a similar behaviour was observed over the open sea, where thermal up-winds are more reduced. In addition, some GPS tracks showed that the cranes reacted to the OWFs Kriegers Flak (Denmark), and Baltic 2, Arcadis Ost 1 and Wikinger (Germany), expressing signs of vertical macro avoidance by soaring behavior before crossing above or in the vicinity of the OWFs.

GPS tagging and studies of avoidance behaviour of cranes migrating over the Kriegers Flak area were also undertaken as part of the baseline investigations for Kriegers Flak offshore wind farm (Skov et al. 2015). In the study by Skov et al., GPS tracks and flight altitudes of six cranes were successfully recorded during migration over the open parts of the Baltic Sea area and under different meteorological conditions. In addition, laser rangefinders were used to collect species-specific data on migrating birds both from the FINO 2 platform, from the Falsterbo Rev Lighthouse and from the coasts of eastern Denmark and southern Sweden. In the study by Skov et al. (2015), the patterns of flight altitude displayed by migrating common cranes were very similar to those observed for raptors, but with a higher proportion of the cranes crossing Kriegers Flak at altitudes above 200 m. According to the study by Skov et al. (2015) cranes crossed the Arkona Basin at lower altitudes during tailwind than during headwind in autumn (Skov et al. 2015). This finding contrasts with the results obtained in this study, which indicate that during autumn cranes tend to fly at lower altitudes during headwind than during tailwind conditions, whereas crane flocks in spring were primarily seen in tailwind condition. In both seasons, most of the crane flocks were observed in light wind conditions. However, since the vessel-based surveys did not cover the entire migration season and only under circumstances where it was possible to maintain safety precautions at sea e.g. no survey conducted in harsh weather conditions, it remains uncertain whether cranes selected for specific wind conditions to ease migration, or these patterns is a result of coincidence.

Interestingly, laser rangefinder measurements from autumn 2022 indicated higher flight altitudes inside or above the turbine arrays (308 meters) compared to flocks outside (223 meters), however, this difference was not statistically significant. Likewise, the rangefinder measurements also suggested a potential difference between the operating mode of the turbines, with a higher average flight height recorded during idling mode (583m) compared to operating mode (354 meters) and non-operating mode (136 meters). Unfortunately, the sample sizes of the measurements collected in the different modes of operation were too small to infer general tendencies.

With respect to collisions, Skov et al. 2015 estimated the annual number of colliding cranes between 216 and 296 (depending on turbine type) for Kriegers Flak alone and between 366 and 446 for Kriegers Flak in combination with Baltic 1 and Baltic 2. This contrasts with the findings of the present study, which suggests very few collisions to occur annually, both for cranes and for birds of prey, however, very few birds of prey were observed during this study.

In comparison, results from the Band collision model predicted roughly 1-2 common crane collisions per year for the same migration passage, conditional on avoidance rates of 0.98 – 0.99. This suggests that common cranes exhibit a high level of avoidance towards offshore wind farms. The true average rate may be as high as 0.99 – 1. However, in that case, our modelling results show that a much larger number of cranes would have to be observed passing through the wind farm in order to have a fair chance of detecting just one collision.

Despite these results, it remains to be investigated how avoidance behaviour of cranes is influenced by adverse weather conditions such as precipitation, fog, and longer periods of strong winds, etc. This may be achieved by coupling spatial data from GPS-tagged cranes with real-time weather data e.g. from local offshore weather stations.

# 7 CONCLUDING REMARKS

The purpose of this note was to describe the response pattern of migrating cranes and birds of prey towards commissioned offshore wind farms in the Baltic Sea area. The analysis has been based on visual field observations, radar tracks and laser-rangefinder measurements collected in autumn 2022 and spring 2023. This information was supplemented with satellite transmissions of juvenile cranes tagged with a GPS transmitter during summer 2022 and 2023. Apart from the spatial and behavioural patterns, the Band collision model ('Extended' version, including measured and visually assessed flight heights of migrating cranes from the vessel-based surveys) has been used to compare the observed collision rate with standard model predictions.

No collisions between wind turbines and migrating cranes or birds of prey were observed throughout the survey period, supporting that these species express a high level of collision avoidance towards offshore wind farms. The vast majority of the flocks of cranes were spotted in low altitudes and light tailwind conditions in spring, whereas a more diverse pattern in relation to wind and flight height was observed in autumn.

Both the spatial tracks (radar) and the visual observations indicated that migrating flocks of cranes that entered the close vicinity of Kriegers Flak or Baltic 2 were able to recognise the OWF at a faraway distance and take the necessary precaution by performing vertical and/or horizontal adjustments in their flight at the macro-, meso- or micro- scale. Band collision models confirmed very few crane collisions per year for the observed passage conditional on avoidance rates and highlighted that a much larger sample of flocks would have to be observed to have a fair chance of detecting just a single collision.

Overall, interesting patterns of flight and avoidance behaviour of cranes have emerged from this study, based on field observations and analysis of GPS-tracks, all indicating a high level of collision avoidance. The behavioural response pattern revealed by this study, is likely transferable to other offshore wind farms located on a migration corridor for common cranes. However, further analyses are required in order to investigate, whether this pattern of avoidance persist in adverse weather conditions.

# 8 REFERENCES


Alerstam, T. (1990) Bird Migration. Publ. Cambridge University Press, Cambridge, New York, Melbourne, pp. 420.

Band, B. (2012) Using a collision risk model to assess bird collision risks for offshore wind farms. Final Report, The Nunnery, Thetford (GBR), p. 62.

Bellebaum, J., C. Grieger, R. Klein, U. Köppen, J. Kube, R. Neumann, A. Schulz, H. Sordyl & H. Wendeln (2010a) Ermittlung artbezogener Erheblichkeitsschwellen von Zugvögeln für das Seegebiet der südwestlichen Ostsee bezüglich der Gefährdung des Vogelzuges im Zusammenhang mit dem Kollisionsrisiko an Windenergieanlagen. Abschlussbericht. Forschungsvorhaben des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit (FKZ 0329948), Neu Broderstorf (DEU), p. 333.

Bellebaum, J., F. Korner-Nievergelt, T. Dürr & U. Mammen (2013b) Wind turbine fatalities approach a level of concern in a raptor population. Journal for Nature Conservation (6, vol. 21), pp. 394–400.

Bijleveld, M. (1974) Birds of prey in Europe. publ. The MacMillan Press Ltd.

Bildstein, K. L. (2006) Migrating raptors of the world: their ecology & conservation. publ. Cornell University Press.

Bildstein, K. L. (2017) Raptors: The Curious Nature of Diurnal Birds of Prey. publ. Cornell University Press, pp. 336.

BirdLife International (ed.) (2021) European Red List of Birds. publ. Publications Office of the European Union, Luxembourg (LUX), pp. 51.

BSH (2021) Umweltbericht zum Entwurf des Raumordnungsplans für die deutsche ausschließliche Wirtschaftszone in der Ostsee. (aut. Bundesamt für Seeschifffahrt und Hydrographie).

Chamberlain, D. E., M. R. Rehfisch, A. D. Fox, M. Desholm & S. J. Anthony (2006) The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. Ibis (s1, vol. 148), pp. 198–202.

DOF-basen (2023) Data from the Danish Bird Observation Database. DOF-basen - af Dansk Ornitologisk Forening. https://dofbasen.dk/. Reviewed on 20th December, 2023.

DMI (2023) Danmarks Meteorologiske Institut. Available at: https://www.dmi.dk/vejrarkiv (Accessed: 15 December 2023).

Drachmann, J., S. R. Waagner & H. Haaning Nielsen (2021) Pink-footed Goose and Common Crane exhibit high levels of collision avoidance at a Danish onshore wind farm. Dansk Ornitologisk Forenings Tidsskrift (vol. 115), pp. 253–271.

Dwyer, J. F., M. A. Landon & E. K. Mojica (2018) Impact of renewable energy sources on birds of prey. in Birds of prey, publ. Springer, pp. 303–321.

EEA (2023) Estonian Environment Agency. Available at: https://www.ilmateenistus.ee/ilm/ilmavaatlused/vaatlusandmed/?lang=en (Accessed: 20 December 2023).

Hötker, H. (2017) Research Issues and Aims of the Study. in Birds of prey and wind farms, publ. Springer, pp. 1–4.

Johnston, N. N., J. E. Bradley & K. A. Otter (2014a) Increased flight altitudes among migrating Golden Eagles suggest turbine avoidance at a Rocky Mountain wind installation. PLOS ONE (3, vol. 9), p. e93030.

Johnston, A., A. S. C. P. Cook, L. J. Wright, E. M. Humphreys & N. H. K. Burton (2014b) Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology (1, vol. 51), pp. 31–41.

Kjellén, N. (1997) Importance of a bird migration hot spot: proportion of the Swedish population of various raptors observed on autumn migration at Falsterbo 1986-1995 and population changes reflected by the migration figures. Ornis Svecica (1, vol. 7), pp. 21–34.

Kjellén, N. (2019) Migration counts at Falsterbo, Sweden. Birds Census News (1–2, vol. 32), pp. 27–37.

Kjellén, N. & G. Roos (2000) Population trends in Swedish raptors demonstrated by migration counts at Falsterbo, Sweden 1942–97. Bird Study (2, vol. 47), pp. 195–211.

Mammen, K., U. Mammen & A. Resetariz (2017) Red Kites. in Birds of Prey and Wind Farms, publ. Springer, pp. 13–95.

Marques, A. T., C. D. Santos, F. Hanssen, A.-R. Muñoz, A. Onrubia, M. Wikelski, F. Moreira, J. M. Palmeirim & J. P. Silva (2019) Wind turbines cause functional habitat loss for migratory soaring birds. Journal of Animal Ecology (vol. 89), pp. 93–103.

May, R. F. (2015) A unifying framework for the underlying mechanisms of avian avoidance of wind turbines. Biological Conservation (vol. 190), pp. 179–187.

McClure, C. J. W., J. R. S. Westrip, J. A. Johnson, S. E. Schulwitz, M. Z. Virani, R. Davies, A. Symes, H. Wheatley, R. Thorstrom, A. Amar, R. Buij, V. R. Jones, N. P. Williams, E. R. Buechley & S. H. M. Butchart (2018) State of the world’s raptors: Distributions, threats, and conservation recommendations. Biological Conservation (vol. 227), pp. 390–402.

Rasran, L. & T. Dürr (2017) Collisions of Birds of Prey with Wind Turbines — Analysis of the Circumstances. in Birs of Prey and Wind Farms, publ. Springer, pp. 259–282.

Schulz, A., T. Dittmann, A. Weidauer, M. Kilian, T. Löffler, V. Röhrbein & K. Schleicher (2013) Weiterentwicklung der Technik für Langzeituntersuchungen der Vögel mittels Radars und automatischer Kamerabeobachtung am Standort FINO 2 und Durchfühung von Langzeitmessungen am Standort für den Zeitraum 2010 bis 2012. Abschlussbericht, Neu Brodersdorf (DEU), Teilprojekt Vogelzug. Bestandteil des Forschungsvorhabens “Betrieb für Forschungsplattform FINO 2” (BMU; FKZ 0329905D), p. 103.

Skov, H., M. Desholm, S. Heinänen, T. W. Johansen & O. R. Therkildsen (2015) Kriegers Flak Offshore Wind Farm Environmental Impact Assessment. Technical background report Birds and bats Prepared for Energinet.dk by Aarhus University DCE – Danish Centre for Environment and Energy & DHI. p. 196.

Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S. & Ellis, I. 2018. ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. United Kingdom. 247 pp.

SMHI (2023) Sveriges meteorologiska och hydrologiska institut. Available at: https://www.smhi.se/data/meteorologi/ladda-ner-meteorologiska-observationer#param=airtemperatureInstant,stations=core (Accessed: 15 December 2023).

Strandberg, R., R. H. G. Klaassen & K. Thorup (2009) Spatio-temporal distribution of migrating raptors: a comparison of ringing and satellite tracking. Journal of Avian Biology (5, vol. 40), pp. 500–510.

Stroud, D. A. (2003) The status and legislative protection of birds of prey and their habitats in Europe. in Birds of prey in a changing environment, publ. The Stationary Office, pp. 51–84.

Tjørnløv, R.; Skov, H.; Armitage, M.; Barker, M.; Jørgensen, J.; Mortensen, L.; Thomas, K.; Uhrenholdt, T. (2023). Resolving Key Uncertainties of Seabird Flight and Avoidance Behaviours at Offshore Wind Farms: Final Report for the study period 2020-2021. Report by Danish Hydraulic Institute (DHI). Report for Vattenfall

UNEP/AEWA Secretariat (ed.) (2019) Agreement text and annexes. As amended by MOP7. Agreement on the conservation of African-Eurasian Migratory Waterbirds (AEWA). As amended at the 7th Session of the Meeting of the Parties to AEWA 4 - 8 December 2018, Durban, South Africa. Bonn (DEU), p. 62.

Vikstrøm, T. & C. Moshøj (eds.) (2020) Fugleatlas: de danske ynglefugles udbredelse 2014–2017. publ. Dansk Ornitologisk Forening & Lindhardt og Ringhof., pp. 839.

Watson, R. T., P. S. Kolar, M. Ferrer, T. Nygård, N. Johnston, W. G. Hunt, H. A. Smit-Robinson, C. J. Farmer, M. Huso & T. E. Katzner (2018) Raptor interactions with wind energy: Case studies from around the world. Journal of Raptor Research (1, vol. 52), pp. 1–18.

Wetlands International (2022) “Waterbird Populations Portal”. Retrieved from wpp.wetlands.org.

# 9 APPENDIX

### 9.1.1 VESSEL BASED OBSERVATIONS OF MIGRATING CRANES

**Appendix 9.1.1. Vessel based visual observations of migrating Common cranes (*Grus grus*) and three species of raptor: Eurasian sparrowhawk (*Accipiter nisus*), red kite (*Milvus milvus*) and western marsh harrier (*Circus aeruginosus*) in the autumn period 2022 and spring period 2023. The observed migratory behavior was noted with date, time, species of bird, flock size (number of individuals), flight direction, height of flight (start, mid and end of visual observation), average flight height in meters (m) based on data points collected by laser-rangefinder (mean LRF height outside OWF and mean LRF height inside OWF), whether the wind turbines were operational and to what degree (Operative (OP), Idle (IDL), Not operative (NO), No information (NA)), The track number identical to the tracks displayed on Figure 15 – 23 and additional comment of e.g., avoidance behavior. Comments relate to the whole flock.**

| Date | Time in UTC (hh:mm:ss) | Species | Flock size (Number of individuals) | Flight direction | Flight Height (m) Start | Flight Height (m) Middle | Flight Height (m) End | Mean LRF height outside OWF | Mean LRF height inside OWF | Windmills operating (OP: NO: IDL) | Track number | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-09-2022 | 09:25:00 | Common crane *(Grus grus)* | 60 | S | 150 | - | 500 | - | - | - | 1 | **Macro** avoidance detected outside of OWF, soaring from 150 m to 500 m height. |
| 20-09-2022 | 10:34:25 | Common crane *(Grus grus)* | 72 | SW | 300 | - | 300 | - | - | - | - | Above OWF, no avoidance behavior detected. |
| 20-09-2022 | 11:28:30 | Common crane *(Grus grus)* | 90 | S | 600 | - | 600 | - | - | - | - | Above OWF, no avoidance behavior detected. |
| 20-09-2022 | 11:51:00 | Common crane *(Grus grus)* | 60 | S | 400 | - | 400 | - | - | - | - | Passing east of Baltic 2, no avoidance behavior detected. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-09-2022 | 12:00:00 | Common crane *(Grus grus)* | 28 | S | 300 | - | 300 | - | - | - | 2 | Passing east of Baltic 2, no avoidance behavior detected. |
| 20-09-2022 | 12:31:00 | Common crane *(Grus grus)* | 15 | S | 500 | - | 500 | - | - | - | - | 4 km distance, passing above Kriegers Flak, no avoidance behavior detected. |
| 20-09-2022 | 12:46:00 | Common crane *(Grus grus)* | 80 | S | 800 | - | 800 | - | - | - | 3 | Passing east of Baltic 2, no avoidance behavior detected. |
| 20-09-2022 | 15:56:12 | Common crane *(Grus grus)* | 120 | SW | 600 | - | 600 | 714.2 | - | OP | - | Gaining height 2 km North of Baltic 2, then passing above the OWF in the East. **Macro avoidance behavior detected.** |
| 20-09-2022 | 15:57:52 | Common crane *(Grus grus)* | 130 | SW | 700 | - | 700 | - | 735,2 | OP | - | Gaining height 2 km North of Baltic 2, then passing above the OWF in the East. **Macro avoidance behavior detected.** |
| 20-09-2022 | 15:59:51 | Common crane *(Grus grus)* | 12 | SW | 700 | - | 700 | 762.2 | 751 | OP | - | Gaining height 2 km North of Baltic 2, then passing above the OWF in the East. **Macro avoidance behavior detected.** |
| 20-09-2022 | 16:19:00 | Common crane *(Grus grus)* | 35 | S | 300 | - | 300 | - | - | - | 4 | Passing east of Baltic 2, no avoidance behavior detected. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-09-2022 | 16:33:16 | Common crane *(Grus grus)* | 80 | SW | 900 | - | 900 | 939.7 | - | OP | 5 | Passing above OWF, no avoidance behavior detected. |
| 21-09-2022 | 08:53:41 | Common crane *(Grus grus)* | 7 | SW | 150 | - | 200 | 184.6 | - | OP | 6 | Passing between Baltic 2 and Kriegers Flak, briefly soaring in the distance. **Macro avoidance behavior detected.** |
| 21-09-2022 | 09:28:00 | Common crane *(Grus grus)* | 120 | S | 200 | - | 200 | - | - | - | 7 | Passing east of Baltic 2, no avoidance behavior detected. |
| 21-09-2022 | 09:32:00 | Common crane *(Grus grus)* | 70 | SW | 200 | - | 200 | - | - | - | 8 | Passing east of Baltic 2, no avoidance behavior detected. |
| 21-09-2022 | 10:00:52 | Common crane *(Grus grus)* | 48 | SW | 350 | - | 350 | 336.8 | - | OP | 9 | No avoidance behavior detected. |
| 21-09-2022 | 10:15:40 | Common crane *(Grus grus)* | 40 | S | 180 | - | 200 | 182.1 | - | OP | 10 | **Macro avoidance behavior detected.** |
| 21-09-2022 | 10:19:34 | Common crane *(Grus grus)* | 110 | SW | 400 | - | 400 | 405.4 | - | OP | 11 | No avoidance behavior detected. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-09-2022 | 10:35:00 | Common crane *(Grus grus)* | 100 | SW | 400 | - | 400 | - | - | - | 12 | No avoidance behavior detected. |
| 21-09-2022 | 10:38:14 | Common crane *(Grus grus)* | 130 | SW | 400 | - | 400 | 361.5 | 388 | OP | 13 | No avoidance behavior detected. |
| 21-09-2022 | 10:50:00 | Common crane *(Grus grus)* | 60 | S | 400 | - | 400 | - | - | - | 14 | No avoidance behavior detected. |
| 21-09-2022 | 10:50:00 | Common crane *(Grus grus)* | 60 | S | 600 | - | 600 | - | - | - | 15 | No avoidance behavior detected. |
| 04-10-2022 | 08:32:00 | Common crane *(Grus grus)* | 47 | S | 80 | - | 80 | - | - | - | 16 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 04-10-2022 | 09:25:00 | Common crane *(Grus grus)* | 183 | SW | 10 | 50 | 150 | 62.4 | (114) | OP | 17 | **Macro-, meso-, and micro-avoidance behavior detected** (gaining height) 2 km before reaching Baltic 2, splitting up in 3 flocks while passing through the gap between Kriegers Flak and Baltic 2. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04-10-2022 | 10:49:00 | Common crane *(Grus grus)* | 200 | SW | 10 | - | 80 | - | - | - | 18 | Passing SE of Baltic 2, gaining height when approaching OWF, not entering Baltic 2. No avoidance behavior detected. |
| 04-10-2022 | 10:49:00 | Common crane *(Grus grus)* | 20 | SW | 10 | - | 80 | - | - | - | 19 | Passing SE of Baltic 2, gaining height when approaching OWF, not entering Baltic 2. No avoidance behavior detected. |
| 04-10-2022 | 11:38:00 | Common crane *(Grus grus)* | 95 | S | 100 | - | 100 | - | - | - | 20 | Passing SE of Baltic 2, No avoidance behavior detected. |
| 04-10-2022 | 12:53:00 | Common crane *(Grus grus)* | 38 | SW | 30 | 70 | 100 | 18.9 | - | - | 21 | Aiming for gap between Kriegers Flak and Baltic 2, flying into Baltic 2 in SW corner, gaining height up to 100m. **Macro-, meso-, and micro- avoidance behavior detected.** |
| 05-10-2022 | 13:19:02 | Common crane *(Grus grus)* | 13 | S | 2 | 50 | 150 | 15.5 | 45.8 | - | - | Flock disintegrated and rejoined while gaining height (from 2 – 150 m) while passing Baltic 2. **Macro-, meso-, and micro- avoidance behavior detected.** |
| 12-10-2022 | 07:52:00 | Common crane *(Grus grus)* | 3 | SW | 40 | 80 | 130 | - | (121) | NO | 22 | **Macro-, meso-, and micro- avoidance behavior detected.** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-10-2022 | 07:58:00 | Common crane *(Grus grus)* | 4 | S | 130 | 130 | 130 | 128.2 | - | OP | 23 | **Macro avoidance behavior detected.** |
| 12-10-2022 | 08:24:00 | Common crane *(Grus grus)* | 35 | SW | 300 | 300 | 300 | 661 | 1329 | IDL | 24 | No additional comment. |
| 12-10-2022 | 08:42:00 | Common crane *(Grus grus)* | 140 | SW | 150 | 150 | 150 | - | - | - | 25 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 12-10-2022 | 09:50:00 | Common crane *(Grus grus)* | 110 | SW | 150 | 170 | 200 | 166 | 175.7 | IDL | 26 | **Macro-, meso-, and micro-avoidance behavior detected.** |
| 12-10-2022 | 10:20:00 | Common crane *(Grus grus)* | 95 | S | 100 | 100 | 100 | - | - | - | 27 | No additional comment. |
| 12-10-2022 | 10:22:00 | Common crane *(Grus grus)* | 55 | S | 100 | 150 | 200 | - | - | - | 28 | **Macro-, meso-, and micro-avoidance behavior detected.** |
| 12-10-2022 | 10:55:00 | Common crane *(Grus grus)* | 60 | S | 20 | 30 | 40 | - | - | - | 29 | **Macro avoidance behavior detected.** |
| 12-10-2022 | 11:10:00 | Common crane *(Grus grus)* | 85 | S | 100 | 150 | 200 | 157.2 | 138.2 | NO | 30 | **Macro-, meso-, and micro-avoidance behavior detected.** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-10-2022 | 11:35:00 | Common crane *(Grus grus)* | 85 | SW | 5 | 15 | 10 | - | - | - | 31 | **Meso-, and micro-avoidance behavior detected.** |
| 12-10-2022 | 12:00:00 | Common crane *(Grus grus)* | 180 | S | 100 | 120 | 150 | 100.9 | 110.5 | OP | 32 | **Macro avoidance behavior detected.** |
| 12-10-2022 | 12:24:00 | Common crane *(Grus grus)* | 55 | S | 120 | 120 | 120 | - | - | - | 33 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 12-10-2022 | 12:46:00 | Common crane *(Grus grus)* | 100 | SW | 100 | 120 | 140 | - | - | - | 34 | **Macro-, meso-, and micro-avoidance behavior detected.** |
| 12-10-2022 | 14:33:00 | Common crane *(Grus grus)* | 50 | S | 150 | 150 | 150 | - | - | - | 35 | No avoidance behavior detected. |
| 13-10-2022 | 09:16:00 | Common crane *(Grus grus)* | 2 | S | 79 | 71 | 76 | 75.3 | - | - | - | No additional comment. |
| 13-10-2022 | 12:13:00 | Common crane *(Grus grus)* | 18 | S | - | - | - | 25.4 | - | - | - | No additional comment. |
| 13-10-2022 | 13:59:00 | Common crane *(Grus grus)* | 95 | S | 120 | 120 | 120 | - | - | - | 37 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13-10-2022 | 14:20:00 | Common crane *(Grus grus)* | 130 | S | 120 | 120 | 120 | - | - | - | 36 | Passing east of OWF, **Macro avoidance behavior detected.** |
| | | | | | | | | | | | | |
| 20-09-2022 | 13:17:09 | Eurasian sparrowhawk *(Accipiter nisus)* | 2 | SW | 30 | 30 | 30 | 24.8 | - | OP | - | Flying towards and through OWF. **Meso-, and micro-avoidance behavior detected.** |
| 22-09-2022 | 09:51:22 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | W | 20 | - | 20 | 17 | - | OP | - | Flying into Kriegers flak. **Meso avoidance behavior detected.** |
| 04-10-2022 | 08:22:19 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | SW | 1 | - | 1 | 1 | - | NO | - | With prey, passing low between Kriegers Flak and Baltic 2. **meso-, and micro-avoidance behavior detected.** |
| 04-10-2022 | 09:07:11 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | SW | 10 | - | 2 | 17 | - | OP | - | No additional comment. |
| 04-10-2022 | 10:03:54 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | SW | 20 | - | 20 | 19.4 | - | OP | - | Aiming for gap between Kriegers Flak and Baltic 2. **Macro avoidance behavior detected.** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04-10-2022 | 10:23:51 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | SW | 5 | - | 10 | 20.5 | - | OP | - | No additional comment. |
| 04-10-2022 | 10:36:30 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | SW | 20 | - | 20 | - | - | - | - | No additional comment. |
| 12-10-2022 | 08:04:00 | Red kite *(Milvus milvus)* | 1 | SW | 40 | 50 | 40 | 82.5 | - | NO | - | **Micro avoidance behavior detected**, "slipped" around windmill blades. |
| 12-10-2022 | 08:14:00 | Eurasian sparrowhawk *(Accipiter nisus)* | 1 | SW | 40 | 60 | 80 | 79.3 | - | - | - | No additional comment. |
| 12-10-2022 | 08:19:00 | Western marsh harrier *(Circus aeruginosus)* | 1 | SW | 100 | 100 | 100 | 4.5 | - | NO | - | No additional comment. |
| 12-10-2022 | 08:40:00 | Eurasian sparrowhawk *(Accipiter nisus)* | 3 | SW | 1 | 3 | 1 | 2 | - | NO | - | No additional comment. |
| **Date** | **Time in UTC (hh:mm:ss)** | **Species** | **Flock size (Number of individuals)** | **Flight direction** | **Flight Height (m) Start** | **Flight Height (m) Middle** | **Flight Height (m) End** | **Mean LRF height outside OWF** | **Mean LRF height inside OWF** | **Windmills operating (OP: NO: IDL)** | **Track number** | **Comment** |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-03-2023 | 12:31:18 | Common crane *(Grus grus)* | 7 | N | 100 | 100 | 100 | - | - | - | 38 | No additional comment. |
| 16-03-2023 | 08:53:40 | Common crane *(Grus grus)* | 16 | N | 50 | - | 100 | - | - | OP | 39 | **Macro-, meso-, and micro-avoidance behavior detected.** |
| 16-03-2023 | 09:19:02 | Common crane *(Grus grus)* | 40 | N | 150 | 150 | 150 | - | - | OP | 40 | No additional comment. |
| 16-03-2023 | 09:36:43 | Common crane *(Grus grus)* | 24 | N | 200 | 200 | 200 | - | - | IDL | 41 | No additional comment. |
| 16-03-2023 | 10:10:33 | Common crane *(Grus grus)* | 45 | N | 150 | 150 | 150 | - | - | IDL | 42 | No additional comment. |
| 16-03-2023 | 10:16:22 | Common crane *(Grus grus)* | 5 | N | 100 | 100 | 100 | - | - | IDL | 43 | No additional comment. |
| 16-03-2023 | 10:36:53 | Common crane *(Grus grus)* | 12 | N | 200 | 200 | 200 | - | - | IDL | 44 | No additional comment. |
| 16-03-2023 | 10:43:44 | Common crane *(Grus grus)* | 20 | N | 150 | 150 | 150 | - | - | IDL | 45 | No additional comment. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16-03-2023 | 10:50:33 | Common crane *(Grus grus)* | 25 | N | 100 | 100 | 100 | - | - | IDL | 46 | No additional comment. |
| 16-03-2023 | 10:52:30 | Common crane *(Grus grus)* | 12 | N | 150 | 150 | 150 | - | - | IDL | 47 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 16-03-2023 | 12:41:59 | Common crane *(Grus grus)* | 80 | N | 100 | 100 | 100 | - | - | IDL | 48 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 16-03-2023 | 13:07:28 | Common crane *(Grus grus)* | 25 | N | 300 | 300 | 300 | - | - | IDL | 49 | No additional comment. |
| 16-03-2023 | 13:27:20 | Common crane *(Grus grus)* | 25 | N | 300 | 400 | 400 | - | - | IDL | 50 | **Macro avoidance behavior detected.** |
| 16-03-2023 | 13:32:27 | Common crane *(Grus grus)* | 20 | N | 75 | 75 | 75 | - | - | IDL | 51 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 16-03-2023 | 13:32:05 | Common crane *(Grus grus)* | 15 | N | 200 | 200 | 200 | - | - | IDL | 52 | Passing above OWF, No additional comment. |
| 16-03-2023 | 13:40:50 | Common crane *(Grus grus)* | 35 | N | 300 | 300 | 300 | - | - | IDL | 53 | No additional comment. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16-03-2023 | 13:50:25 | Common crane *(Grus grus)* | 8 | N | 50 | 50 | 50 | - | - | IDL | 54 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 16-03-2023 | 14:23:24 | Common crane *(Grus grus)* | 15 | N | 80 | 80 | 80 | - | - | IDL | 55 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 18-03-2023 | 10:47:32 | Common crane *(Grus grus)* | 16 | N | 50 | 50 | 50 | - | - | - | 56 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 18-03-2023 | 11:50:05 | Common crane *(Grus grus)* | 40 | N | 200 | 200 | 200 | - | - | - | 57 | No additional comment. |
| 18-03-2023 | 11:57:34 | Common crane *(Grus grus)* | 45 | N | 150 | 150 | 150 | - | - | - | 58 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 18-03-2023 | 12:02:37 | Common crane *(Grus grus)* | 45 | N | 200 | 200 | 200 | - | - | - | 59 | Passing above OWF, no additional comment. |
| 18-03-2023 | 12:10:00 | Common crane *(Grus grus)* | 35 | N | 200 | 200 | 200 | - | - | - | 60 | Passing above OWF, no additional comment. |
| 18-03-2023 | 12:16:23 | Common crane *(Grus grus)* | 20 | N | 100 | 100 | 100 | - | - | - | 61 | No additional comment. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-03-2023 | 12:26:45 | Common crane *(Grus grus)* | 70 | N | 200 | 200 | 200 | - | - | - | 62 | No additional comment. |
| 18-03-2023 | 12:43:20 | Common crane *(Grus grus)* | 25 | N | 100 | 100 | 100 | - | - | - | 63 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 19-03-2023 | 10:34:11 | Common crane *(Grus grus)* | 26 | N | 50 | 50 | 50 | - | - | - | 64 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 19-03-2023 | 12:41:48 | Common crane *(Grus grus)* | 20 | N | 120 | 120 | 120 | - | - | - | 65 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 19-03-2023 | 12:56:34 | Common crane *(Grus grus)* | 30 | N | - | - | - | - | - | - | - | No additional comment. |
| 19-03-2023 | 13:01:25 | Common crane *(Grus grus)* | 25 | N | 100 | 100 | 100 | - | - | - | 66 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 19-03-2023 | 13:14:53 | Common crane *(Grus grus)* | 35 | N | - | - | - | - | - | - | - | No additional comment. |
| 19-03-2023 | 13:15:57 | Common crane *(Grus grus)* | 30 | N | 100 | 100 | 100 | - | - | - | 67 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19-03-2023 | 13:24:13 | Common crane *(Grus grus)* | 15 | N | 200 | 200 | 200 | - | - | - | 68 | Passing above OWF, no additional comment. |
| 19-03-2023 | 13:45:32 | Common crane *(Grus grus)* | 20 | N | 70 | 70 | 70 | - | - | - | 69 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 19-03-2023 | 13:47:08 | Common crane *(Grus grus)* | 35 | E | 100 | 100 | 100 | - | - | - | 70 | Passing through OWF, **meso-, and micro-avoidance behavior detected.** |
| 19-03-2023 | 14:05:19 | Common crane *(Grus grus)* | 20 | N | 150 | 150 | 150 | - | - | - | 71 | **Macro avoidance behavior detected.** |
| 19-03-2023 | 14:12:22 | Common crane *(Grus grus)* | 60 | N | 300 | 300 | 300 | - | - | - | 72 | No additional comment. |

### 9.1.2 LASER-RANGEFINDER DATA AUTUMN 2022

**Average flight height in meters (m) of migrating common cranes (*Grus grus*) during autumn 2022, based on data points collected by laser-rangefinder (Number of data points from LRF (n), with the given Standard deviation). The number of individuals, of which the datapoints are based on, have been noted, as well as the range of flight height distribution. Secondly, an average flight height in meters (m) in four different scenarios of wind turbine movement: Operative (OP), Idle (IDL), Not operative (NO), No information (NA) has been calculated.**

| Number of datapoints from LRF (n) | Individuals (n) | Average flight height (m) | Standard Deviation | Minimum height (m) | Maximum Height (m) | Turbine Rotation |
|---|---|---|---|---|---|---|
| 5 | 120 | 714.2 | 18.6 | 699 | 736 | Op |
| 6 | 130 | 735.2 | 9.7 | 721 | 748 | Op |
| 9 | 12 | 757.2 | 13.3 | 741 | 781 | Op |
| 3 | 80 | 939.7 | 106.7 | 824 | 1034 | Op |
| 7 | 7 | 184.6 | 15.7 | 164 | 204 | Op |
| 17 | 48 | 336.8 | 9.5 | 322 | 357 | Op |
| 14 | 40 | 182.1 | 16.6 | 162 | 220 | Op |
| 10 | 110 | 405.4 | 7.7 | 394 | 414 | Op |
| 13 | 130 | 365.6 | 20.9 | 330 | 409 | Op |
| 16 | 183 | 61.7 | 46.7 | 0 | 150 | Op |
| 14 | 38 | 12.1 | 12.1 | 0 | 36 | Op |
| 12 | 13 | 25.5 | 35.3 | 0 | 118 | Op |
| 1 | 3 | 121.0 | NA | 121 | 121 | No |
| 5 | 4 | 128.2 | 4.8 | 122 | 135 | Op |
| 2 | 35 | 995.0 | 472.3 | 661 | 1329 | idl |
| 5 | 110 | 171.8 | 16.3 | 145 | 187 | idl |
| 25 | 85 | 150.4 | 29.7 | 82 | 202 | No |
| 17 | 180 | 102.0 | 13.5 | 79 | 137 | Op |
| 3 | 2 | 75.3 | 4.0 | 71 | 79 | NA |
| 12 | 18 | 14.7 | 20.9 | 0 | 60 | NA |

### 9.1.3 LASER-RANGEFINDER DATA SPRING 2023

**The average flight height in meters (m) of migrating common cranes (*Grus grus*) during spring 2023, based on data points collected by laser-rangefinder (Number of data points from LRF (n), with the given Standard deviation). The number of individuals, of which the datapoints are based on, have been noted, as well as the range of flight height distribution.**

**During spring 2023 measurements were recorded only during operative (OP) mode of the wind turbines.**

| Number of datapoints from LRF (n) | Individuals (n) | Average flight height (m) | Standard Deviation | Minimum height (m) | Maximum Height (m) | Turbine Rotation |
|---|---|---|---|---|---|---|
| 3 | 5 | 135.7 | 3.1 | 133 | 139 | Op |
| 6 | 3 | 112.7 | 8.1 | 100 | 123 | Op |
| 1 | 8 | 71.0 | NA | 71 | 71 | Op |
| 13 | 80 | 134.7 | 7.3 | 121 | 148 | Op |
| 8 | 25 | 112.8 | 14.8 | 100 | 141 | Op |
| 28 | 42 | 79.8 | 9.8 | 52 | 100 | Op |
| 11 | 30 | 137.0 | 3.2 | 133 | 143 | Op |
| 8 | 8 | 259.4 | 3.2 | 256 | 265 | Op |

### 9.1.4 EU BIRDS DIRECTIVE

(EUR-Lex - 02009L0147-20190626 - EN - EUR-Lex (europa.eu))

EU Birds Directive:

| | | |
|---|---|---|
| Annex I | Annex I of the EU Birds Directive includes a total of 194 species. These are species threatened with extinction, rare due to low populations or small distribution areas or particularly in need of protection due to their habitat requirements. | |
| Annex II | It includes 82 species that can be hunted. However, the hunting periods are limited, and hunting is forbidden when birds are at their most vulnerable: during their return migration to nesting areas, reproduction and the raising of their chicks. | The difference between Part A and B lies in the geographical area where this hunting applies. Species listed in Part A may be hunted in the geographical sea and land area where this Directive applies, whereas species listed in Part B may be hunted only in the Member States in respect of which they are indicated. |
| Annex III | activities that directly threaten birds, such as their deliberate | Again, species listed in Part A includes species that have been |

| | | |
|---|---|---|
| | killing, capture or trade, or the destruction of their nests, are banned. Nonetheless, the Member States can allow these activities for the species listed in this annex. | legally killed or captured or otherwise legally acquired. Part B includes the same but for some of the Member States as indicated in the EU Birds Directive. |

European Red List of Birds (Birdlife International, 2021)

| | |
|---|---|
| R – Critically Endangered: | "Critically Endangered". A taxon is Critically Endangered when, according to the best available data, there is an extremely high risk that the taxon will become extinct in the wild in the immediate future. |
| EN – Endangered: | "Endangered". A taxon is Endangered when, according to the best available data, there is a very high risk that the taxon will become extinct in the wild in the immediate future. |
| VU – Vulnerable: | "Vulnerable". A taxon is Vulnerable if, according to the best available data, it is considered to be facing a high risk of extinction in the wild is a high risk that the taxon will become extinct in nature in the immediate future. |
| NT - Near Threatened | "Near Threatened". A taxon is Near Threatened if the assessment does not result in being classified as CR, EN, or VU, but is expected to be classified in one of the categories in the near future |
| LC - Least Concern | "Least Concern". A taxon is Least Concern if the assessment does not lead to its classification as CR, EN, VU or NT. Widespread species and those with large numbers of individuals are listed here. |
| NE - Not evaluated | "Not Evaluated". |

Population status according to the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (**AEWA**)

| | |
|---|---|
| A 1b: | Species that are listed as "Threatened" in the current IUCN Red List |
| A 1c: | Populations of fewer than approx.10,000 individuals. |

| | |
|---|---|
| A 2: | Populations of approx. 10,000 to 25,000 individuals. |
| A 3b: | Populations of approx. 25,000 to 100,000 individuals that are considered endangered due to their reliance on a critically endangered habitat type. |
| A 3c: | Populations of approx. 25,000 to 100,000 individuals that are considered endangered due to a significant long-term decline. |
| A 4: | Species that are listed as "Near Threatened" in the IUCN Red List, but which do not meet the criteria for classification in categories A 1, A 2 or A 3, |
| B 1: | Populations of approx. 25,000 to 100,000 individuals that do not meet the requirements for column A. |
| B 2a: | Populations of more than approx. 100,000 individuals for which special attention appears to be necessary due to the concentration on a small number of sites at each stage of their annual cycle. |
| B 2b: | Populations of more than approx. 100,000 individuals, for which special attention appears to be necessary due to the reliance on a critically endangered habitat type. |
| B 2c: | Populations of more than approx. 100,000 individuals for which special attention appears to be necessary due to a significant long-term decline. |
| B 2d: | Populations of more than approx. 100,000 individuals for which special attention appears to be necessary due to large fluctuations in population size or trends. |
| C 1: | Populations of more than approx.100,000 individuals for which international cooperation could be of considerable benefit and that do not meet the conditions for column A or B. |
| ( ): | Population situation unknown, endangerment status estimated. |
| *: | Populations marked with an asterisk may exceptionally continue to be hunted on the basis of sustainable use, provided that the hunting of these populations corresponds to a long cultural |

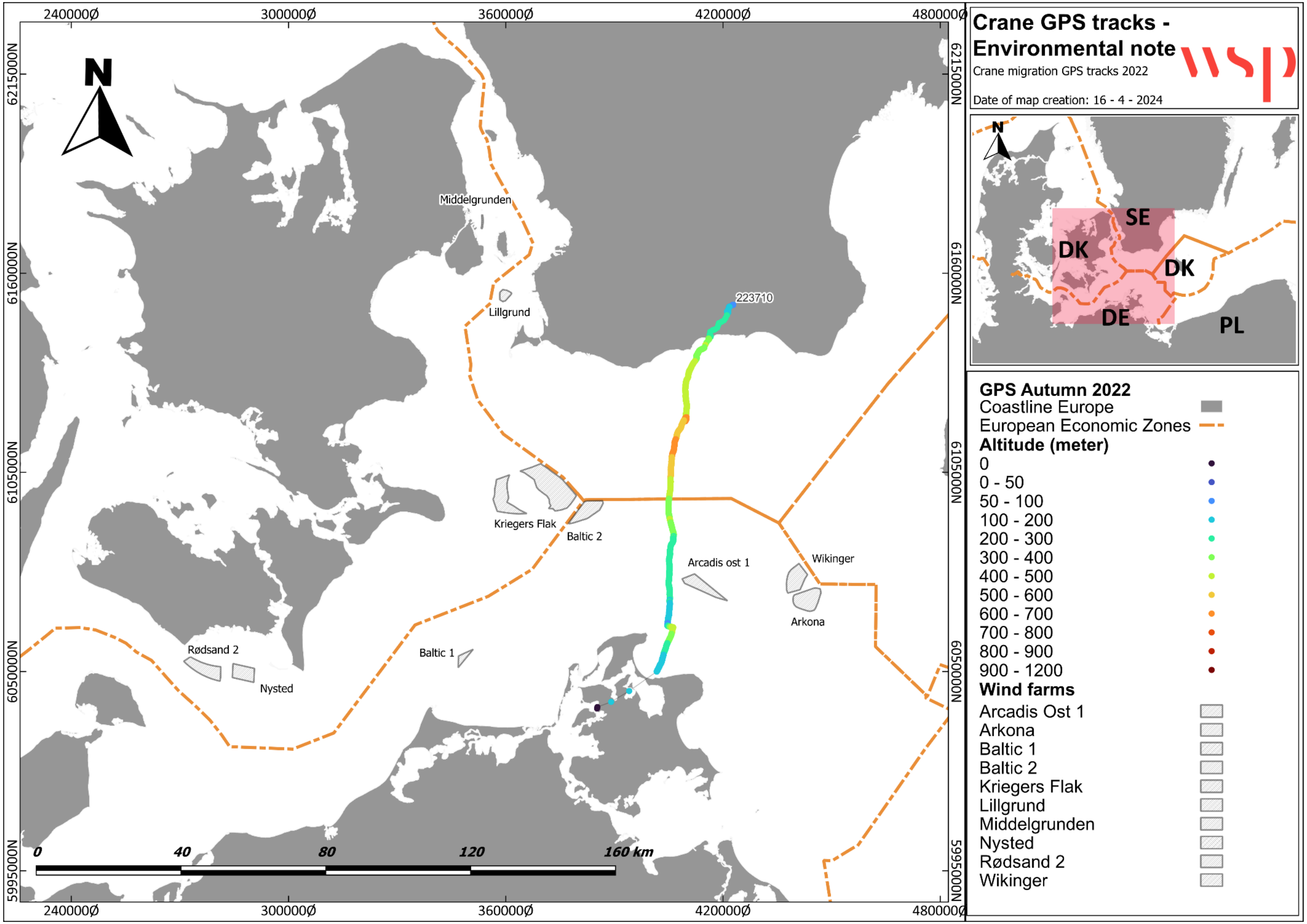
| | |
|---|---|
| | tradition (see Annex 3, paragraph 2.2.1). |
| [N]: | Type of AEWA agreement for which Germany is not a range state. |

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

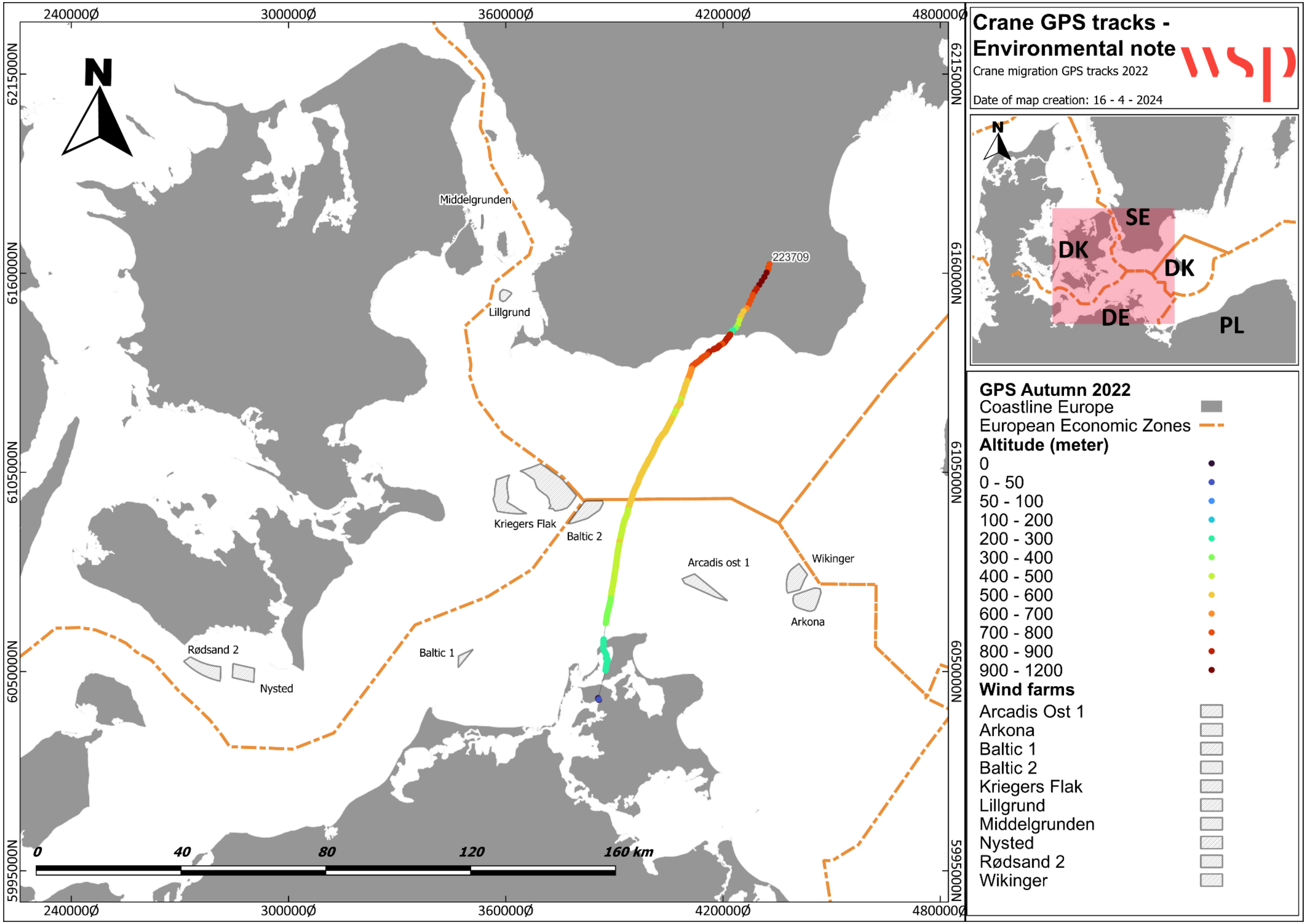
| | |
|---|---|
| Appendix I | includes all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances |
| Appendix II/A | Includes all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival; |
| Appendix II/B | Includes other species which must be subject to regulation in order that trade in specimens of certain species referred to in sub-paragraph (a) of this paragraph may be brought under effective control |
| Appendix III | includes all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the co-operation of other Parties in the control of trade. |

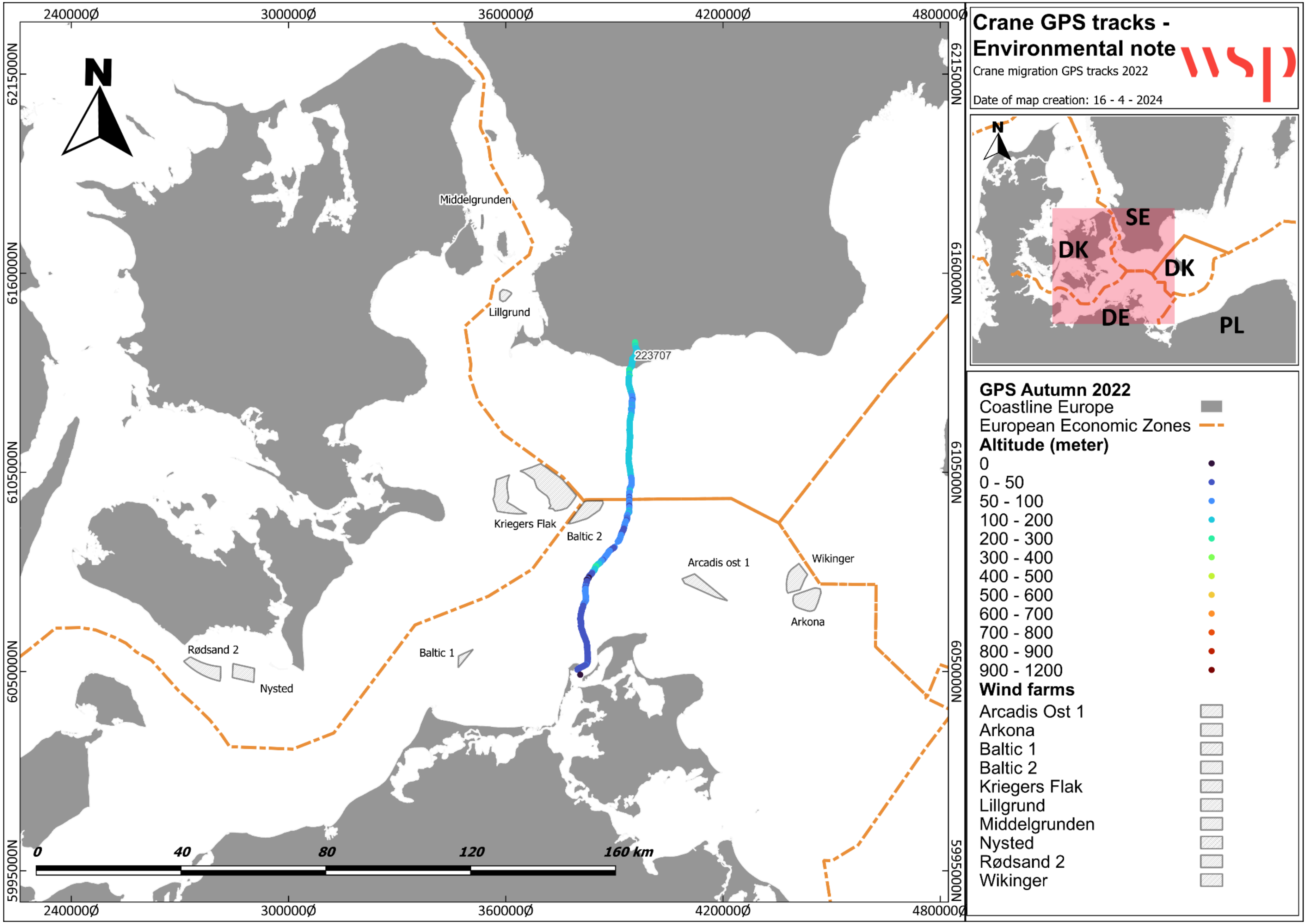
### 9.1.5 MAPS DISPLAYING INDIVIDUAL GPS TRACKS 2022 -2023

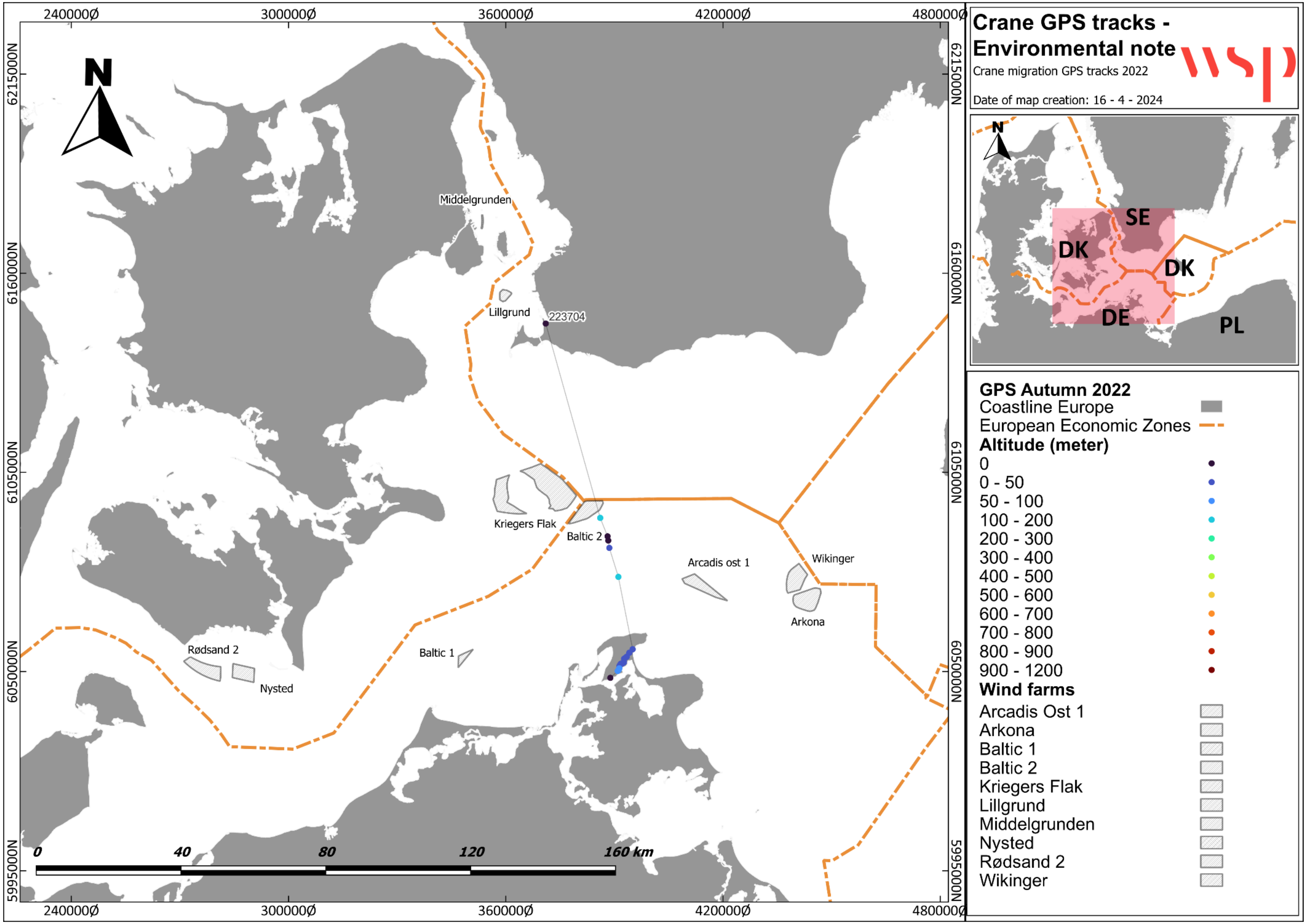
**The following maps displays the individual tracks of each GPS transmitter crossing the Baltic Sea, with the outline of the boarding countries, as well as the established wind farms, and the Exclusive Economic Zone (EEZ) between the countries. The GPS positions of each tagged Common crane on their migration north or south during 2022 - 2023, while crossing the sea, are shown. With the altitude of each GPS position displayed by color (from blue – red) and with a line drawn between two datapoints if there were no GPS positions available. Each crane is presented by the number of the GPS transmitter, ranging within no. 223692 – 223711.**

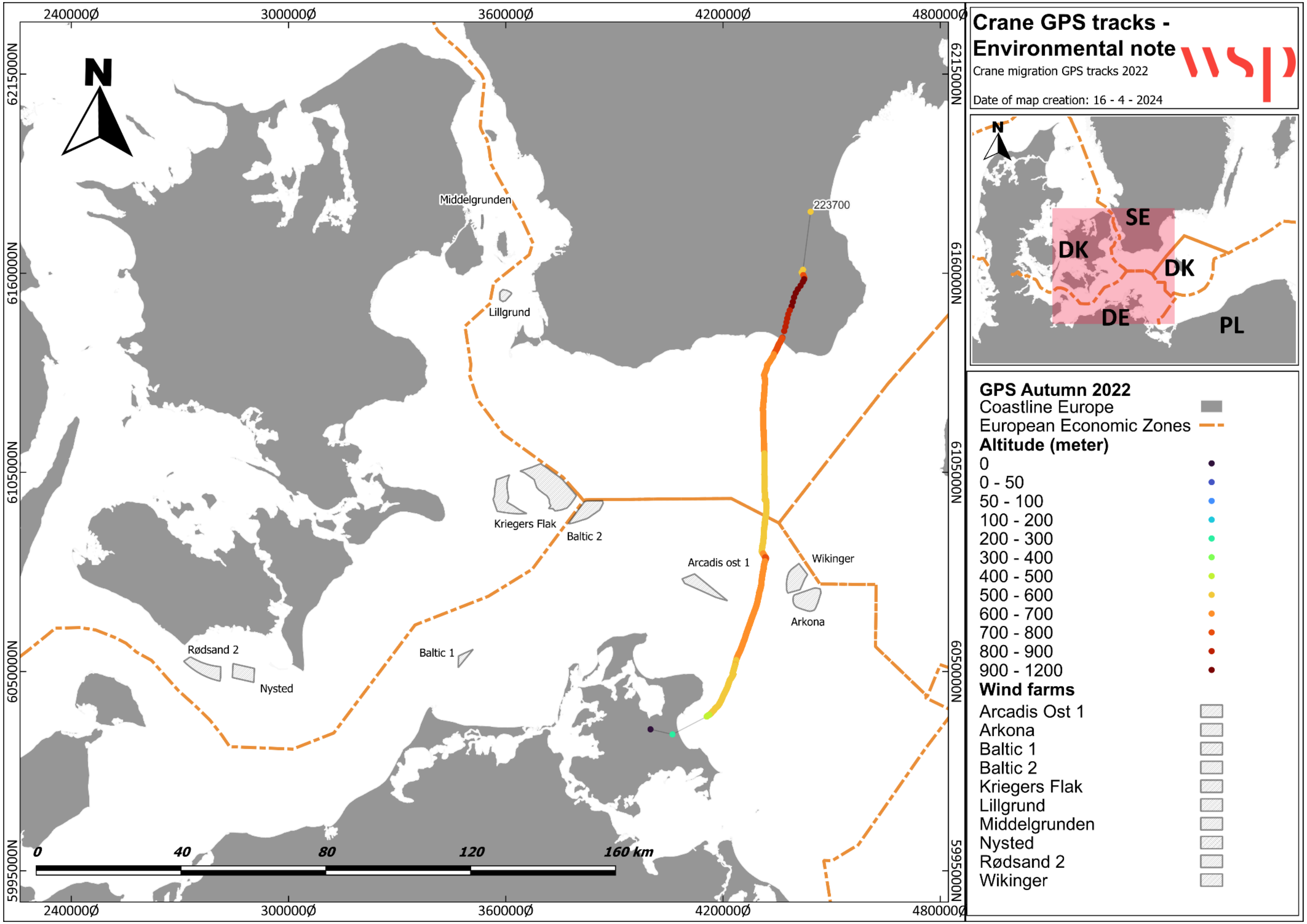


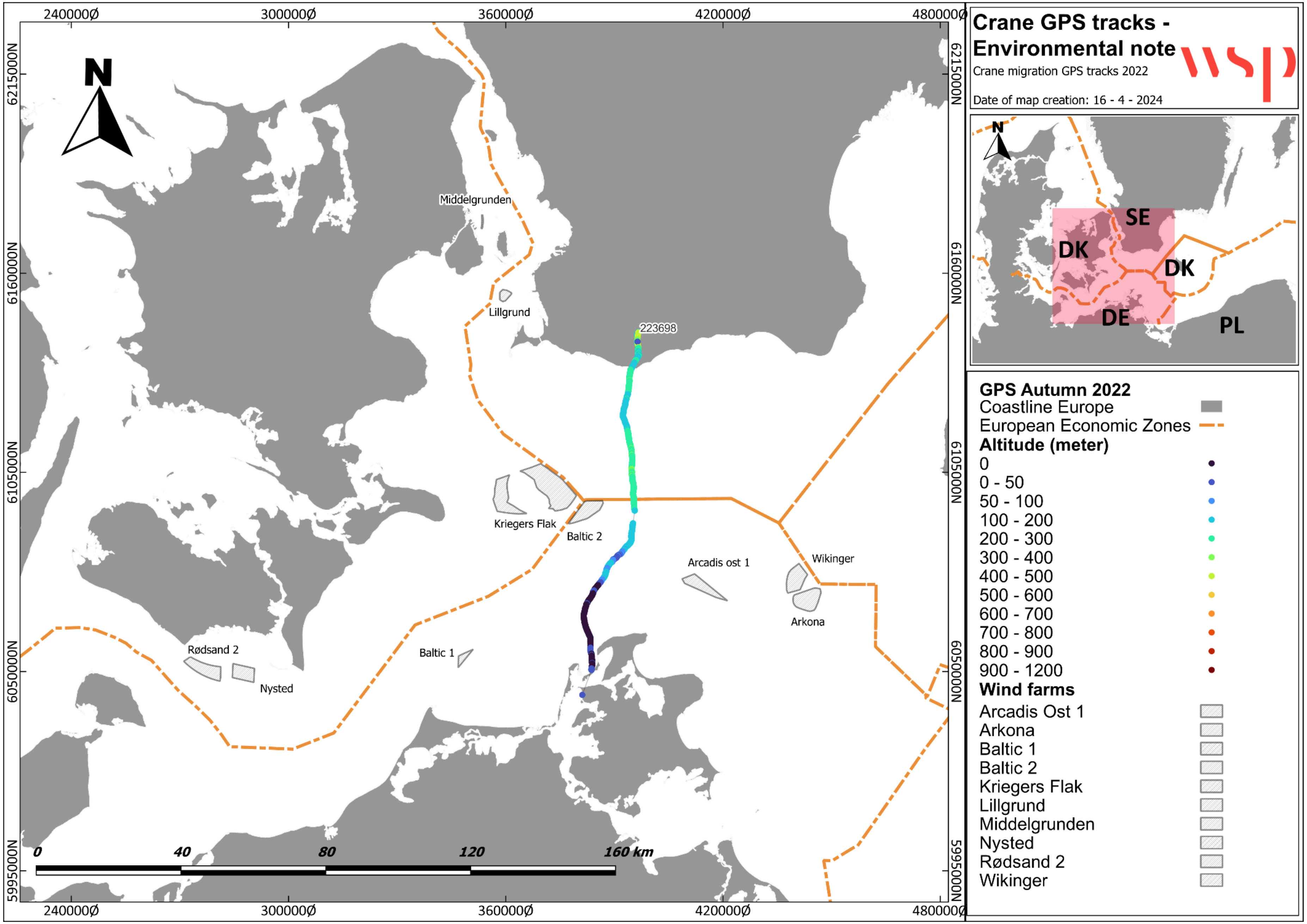
Crane GPS tracks - Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
SE
DK
DK
DE
PL
N
N
Middelgrunden
Lillgrund
223710
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
0
40
80
120
160 km
2400000
3000000
3600000
4200000
4800000
6215000N
6160000N
6105000N
6050000N
5995000N

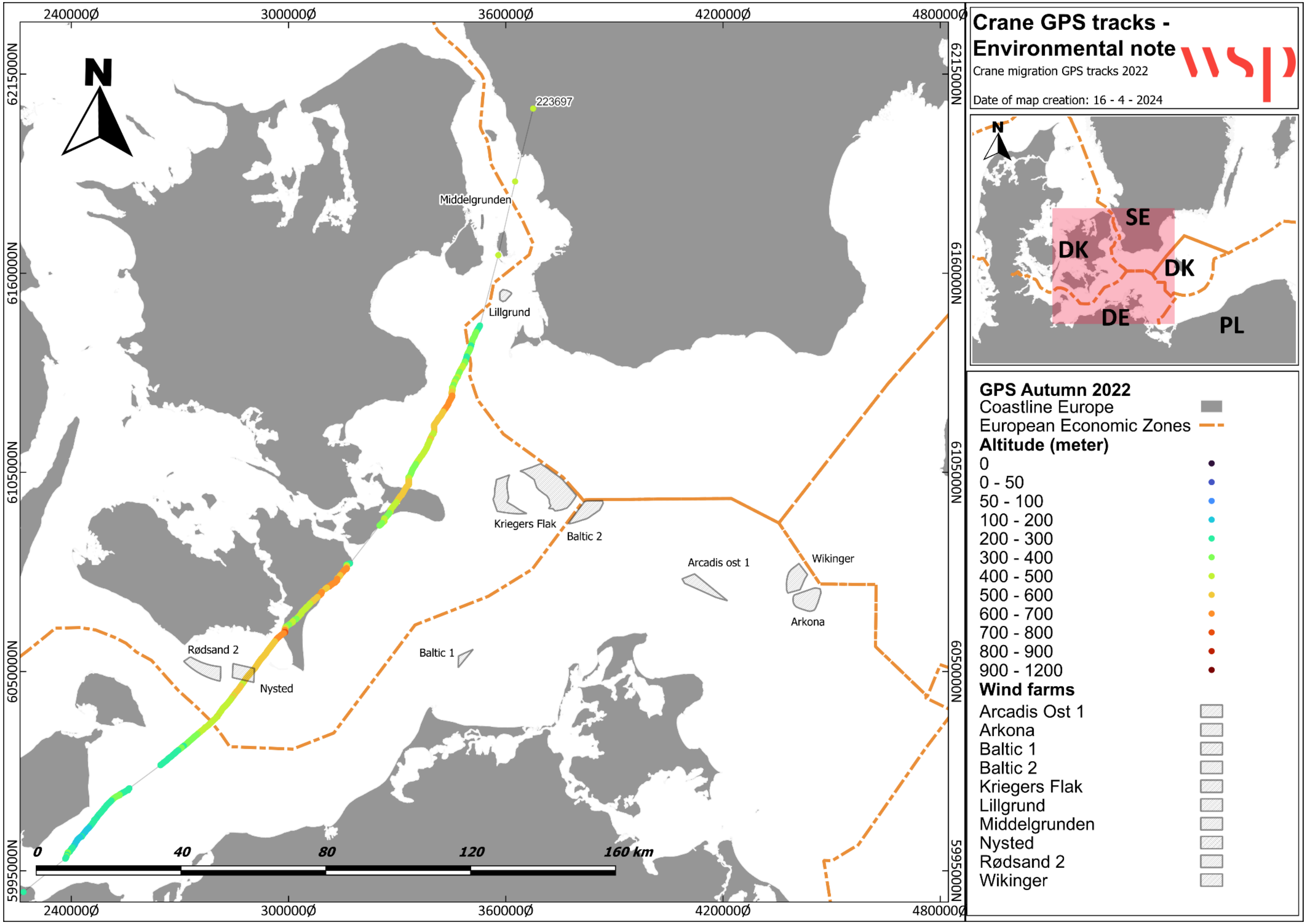

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
Middelgrunden
Lillgrund
223709
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
SE
DK
DK
DE
PL
N
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N


Crane GPS tracks - Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
wsp
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
SE
DK
DK
DE
PL
N
Middelgrunden
Lillgrund
223707
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0 40 80 120 160 km
2400000Ø 3000000Ø 3600000Ø 4200000Ø 4800000Ø
6215000N 6160000N 6105000N 6050000N 5995000N

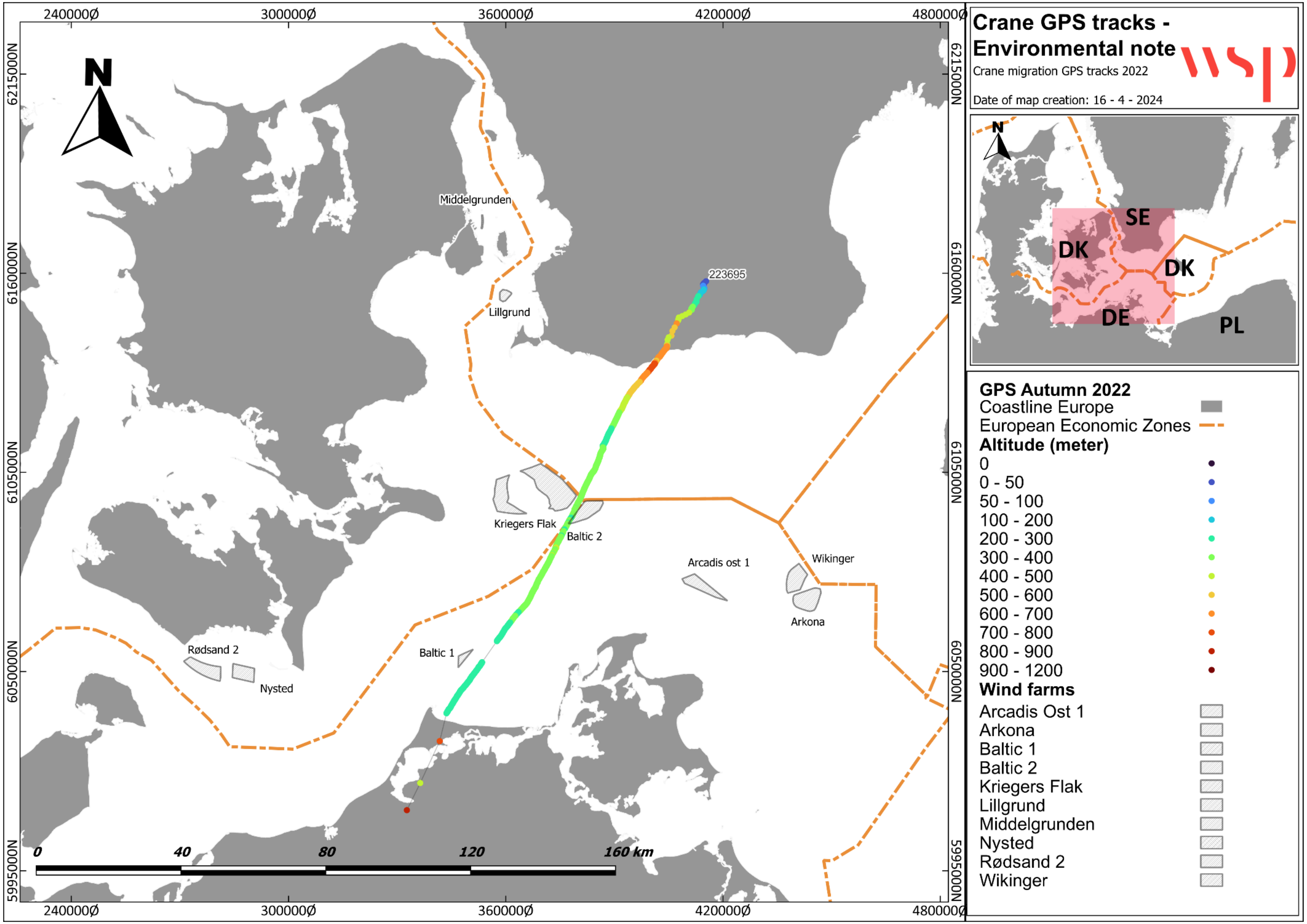

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
Middelgrunden
Lillgrund
223704
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
SE
DK
DK
DE
PL
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
223700
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
0
40
80
120
160 km
SE
DK
DK
DE
PL
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger

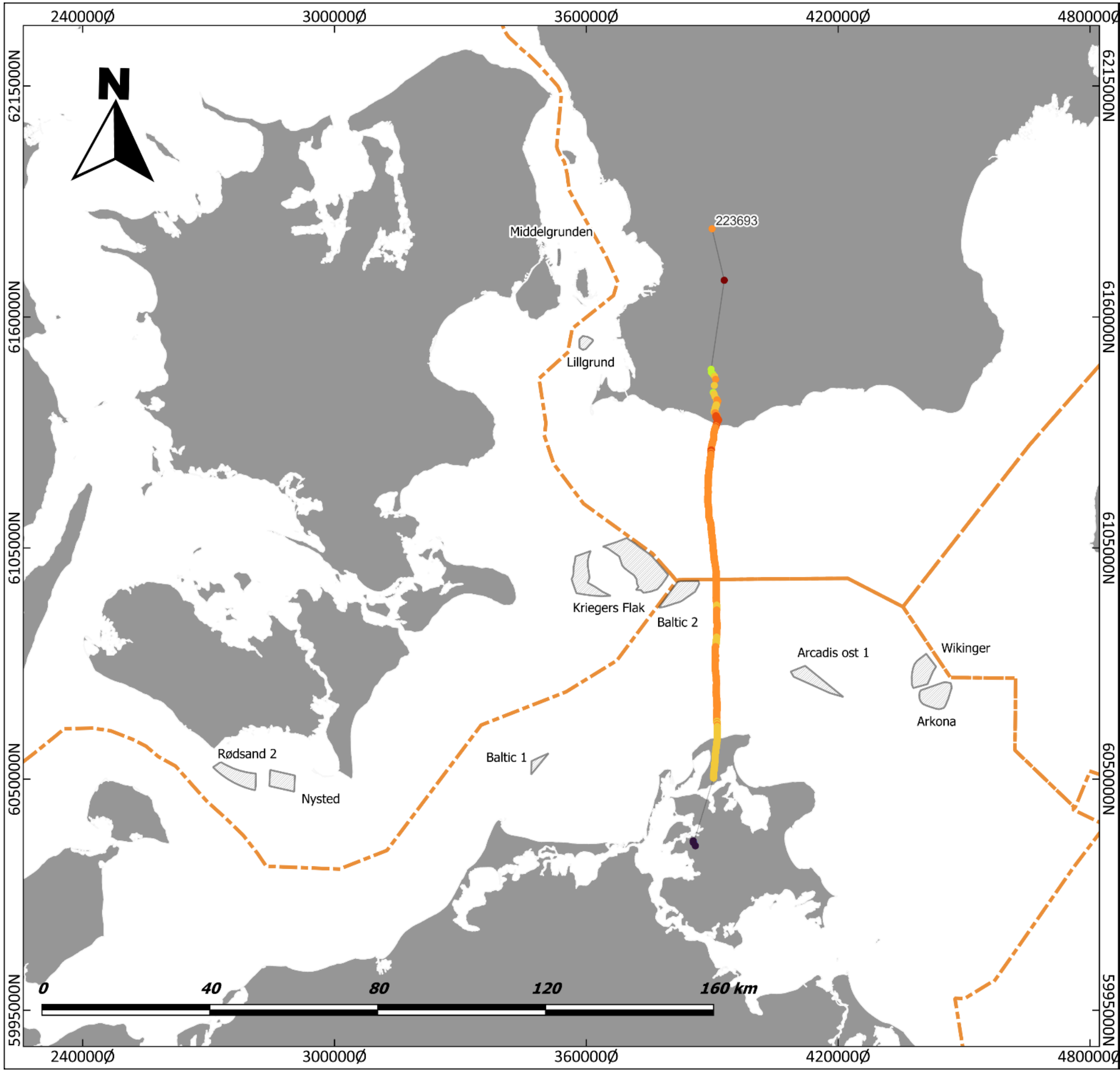

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
223698
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km
SE
DK
DK
DE
PL
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger



Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
N
SE
DK
DK
DE
PL
223697
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N



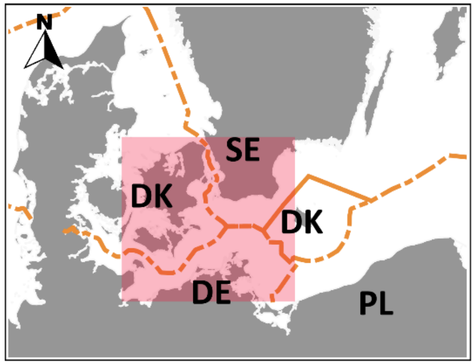
Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
wsp
N
SE
DK
DK
DE
PL
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
N
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
Middelgrunden
Lillgrund
223695
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km




**Crane GPS tracks - Environmental note**

Crane migration GPS tracks 2022

Date of map creation: 16 - 4 - 2024




**GPS Autumn 2022**

Coastline Europe

European Economic Zones

**Altitude (meter)**

0

0 - 50

50 - 100

100 - 200

200 - 300

300 - 400

400 - 500

500 - 600

600 - 700

700 - 800

800 - 900

900 - 1200

**Wind farms**

Arcadis Ost 1

Arkona

Baltic 1

Baltic 2

Kriegers Flak

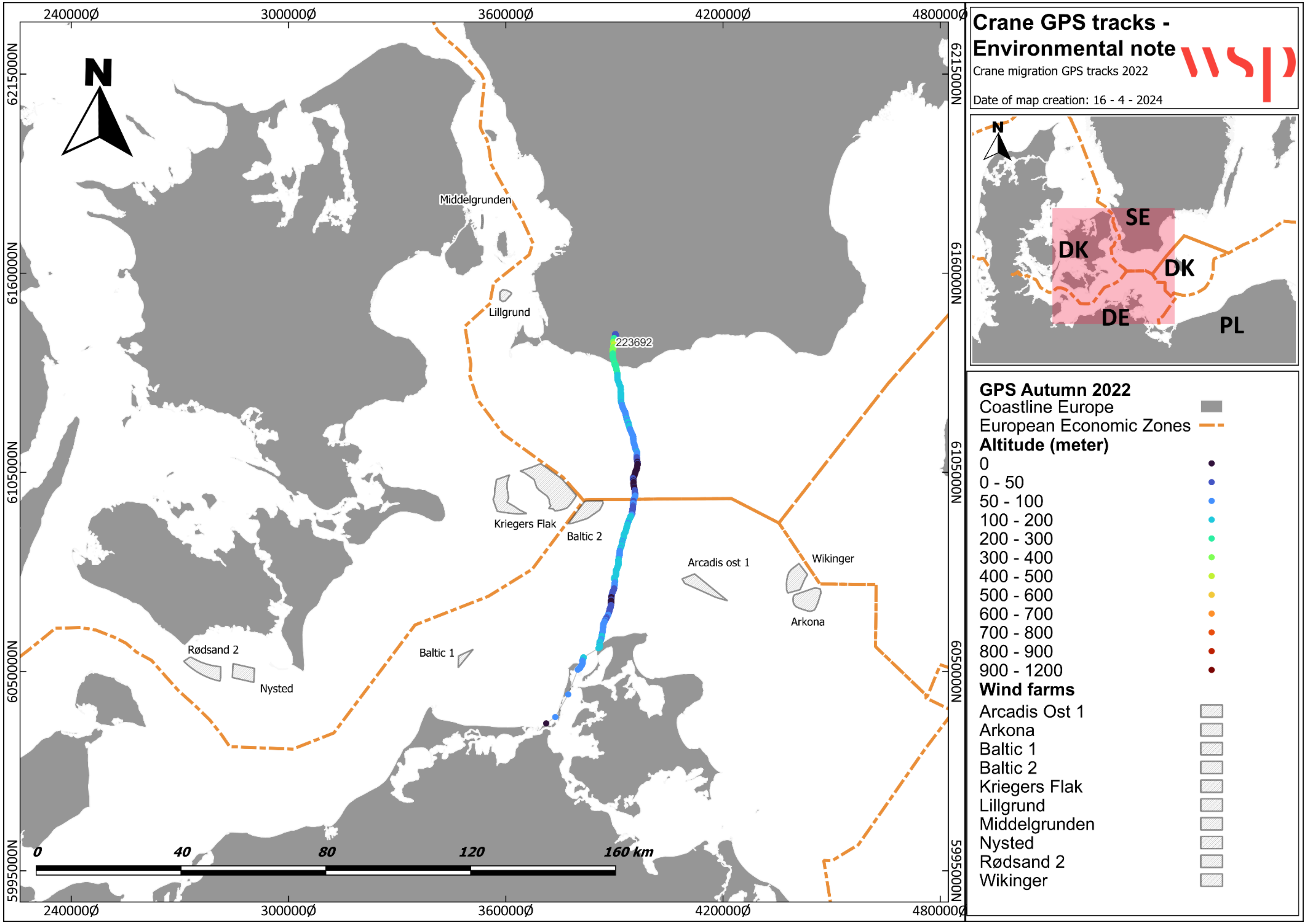
Lillgrund

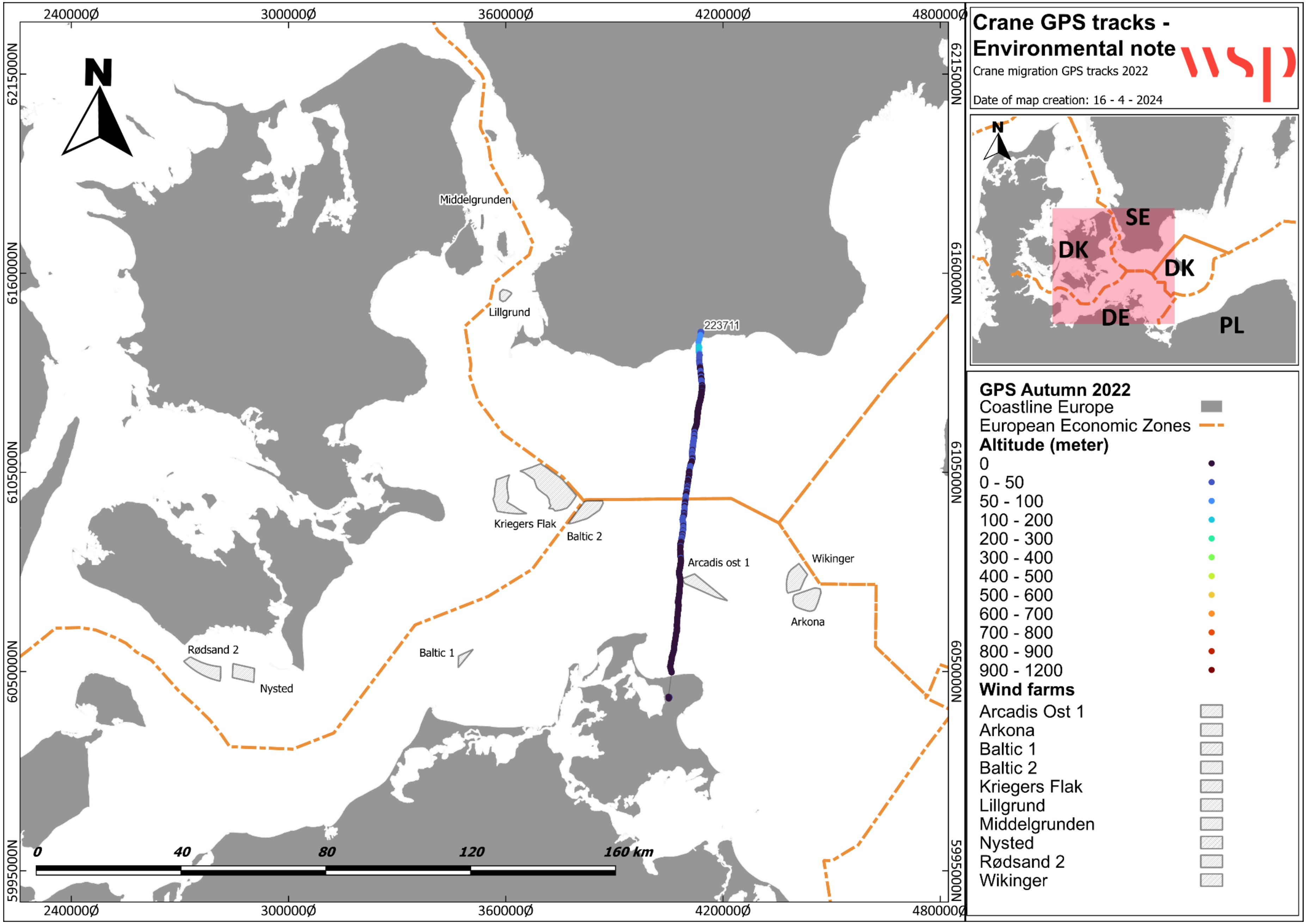
Middelgrunden

Nysted

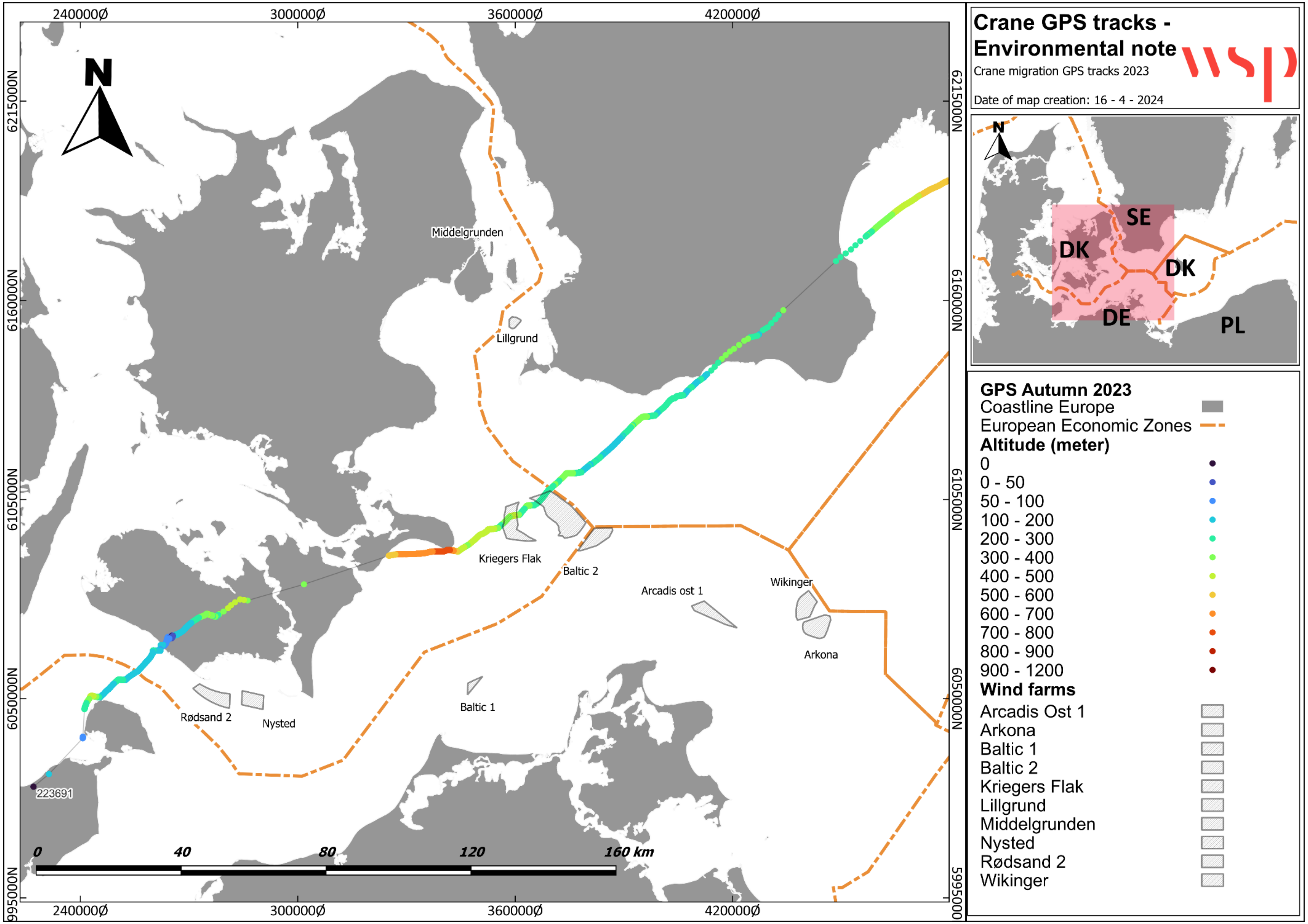
Rødsand 2

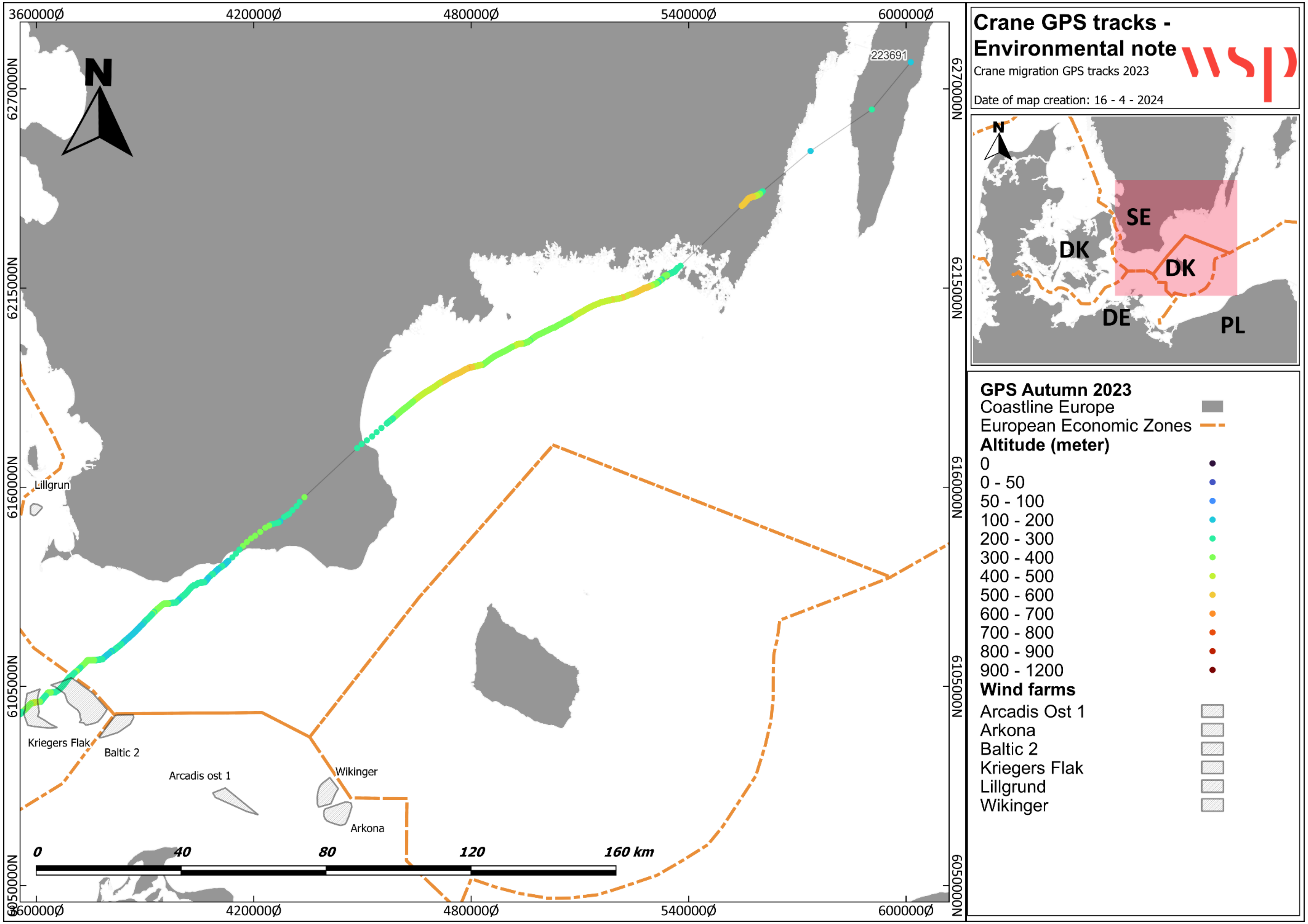
Wikinger

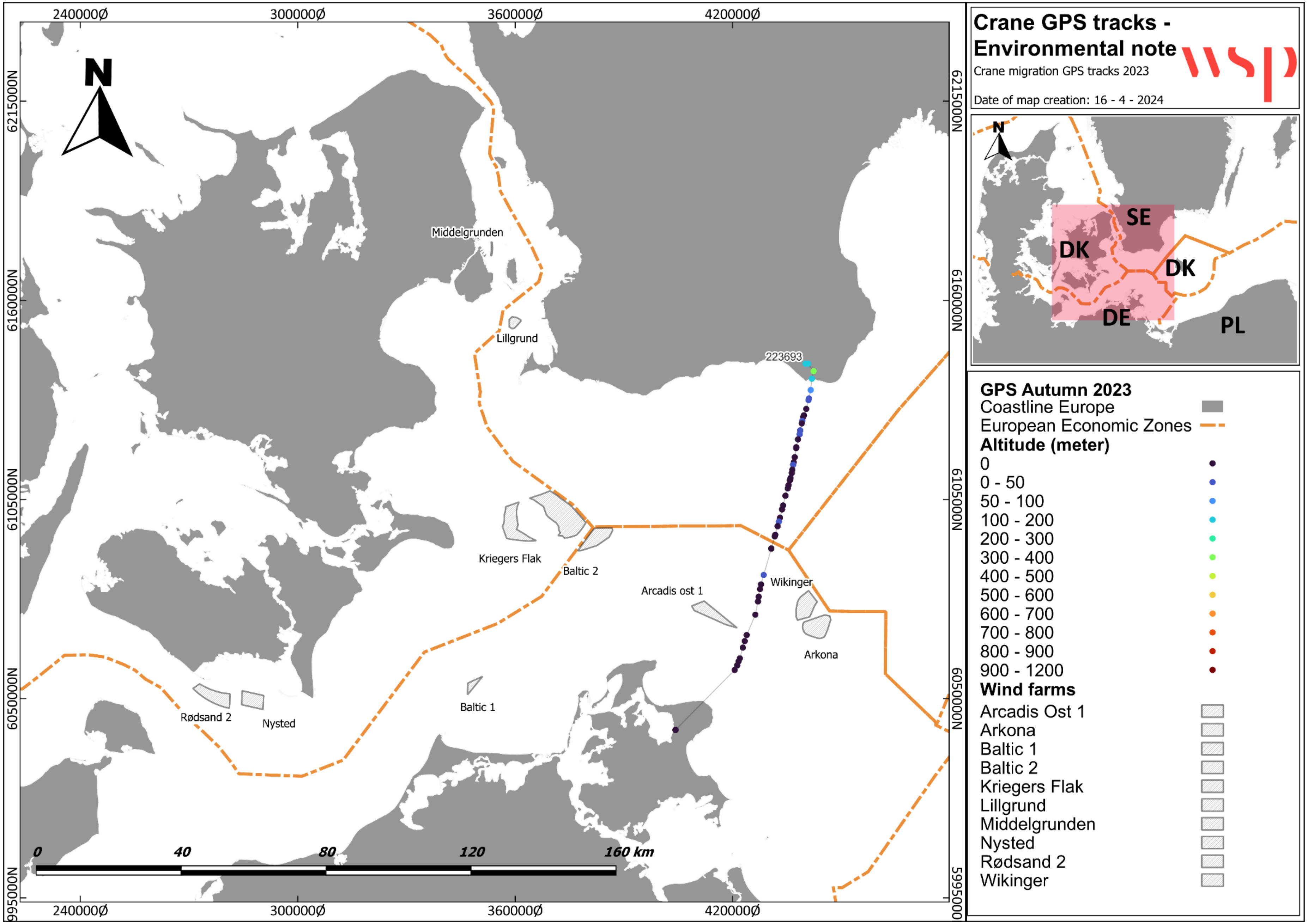

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
223692
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
0
40
80
120
160 km
SE
DK
DK
DE
PL
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger

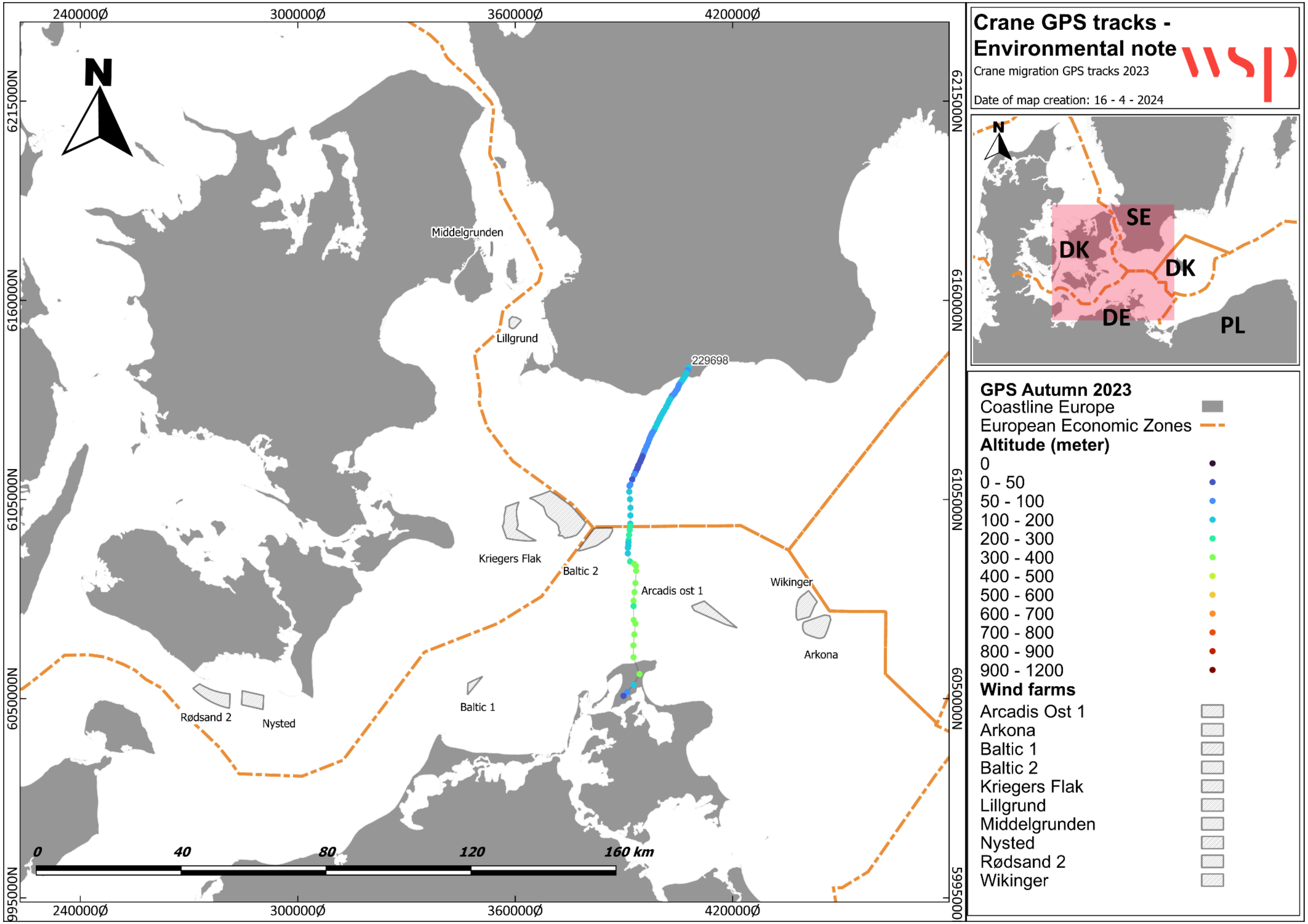


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2022
Date of map creation: 16 - 4 - 2024
wsp
2400000Ø
3000000Ø
3600000Ø
4200000Ø
4800000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
223711
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
0
40
80
120
160 km
SE
DK
DK
DE
PL
GPS Autumn 2022
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger

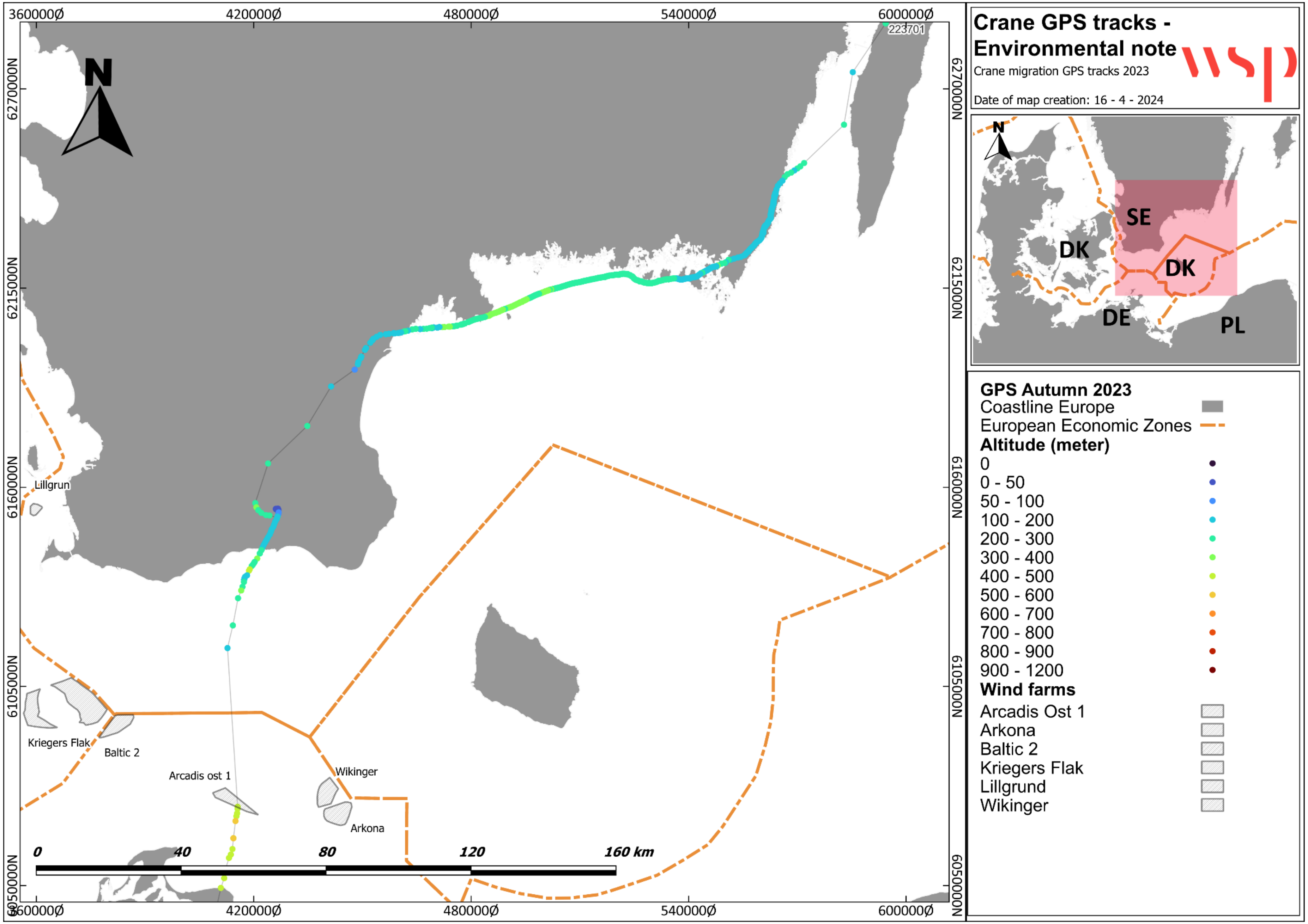

Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
wsp
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
N
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223691
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N

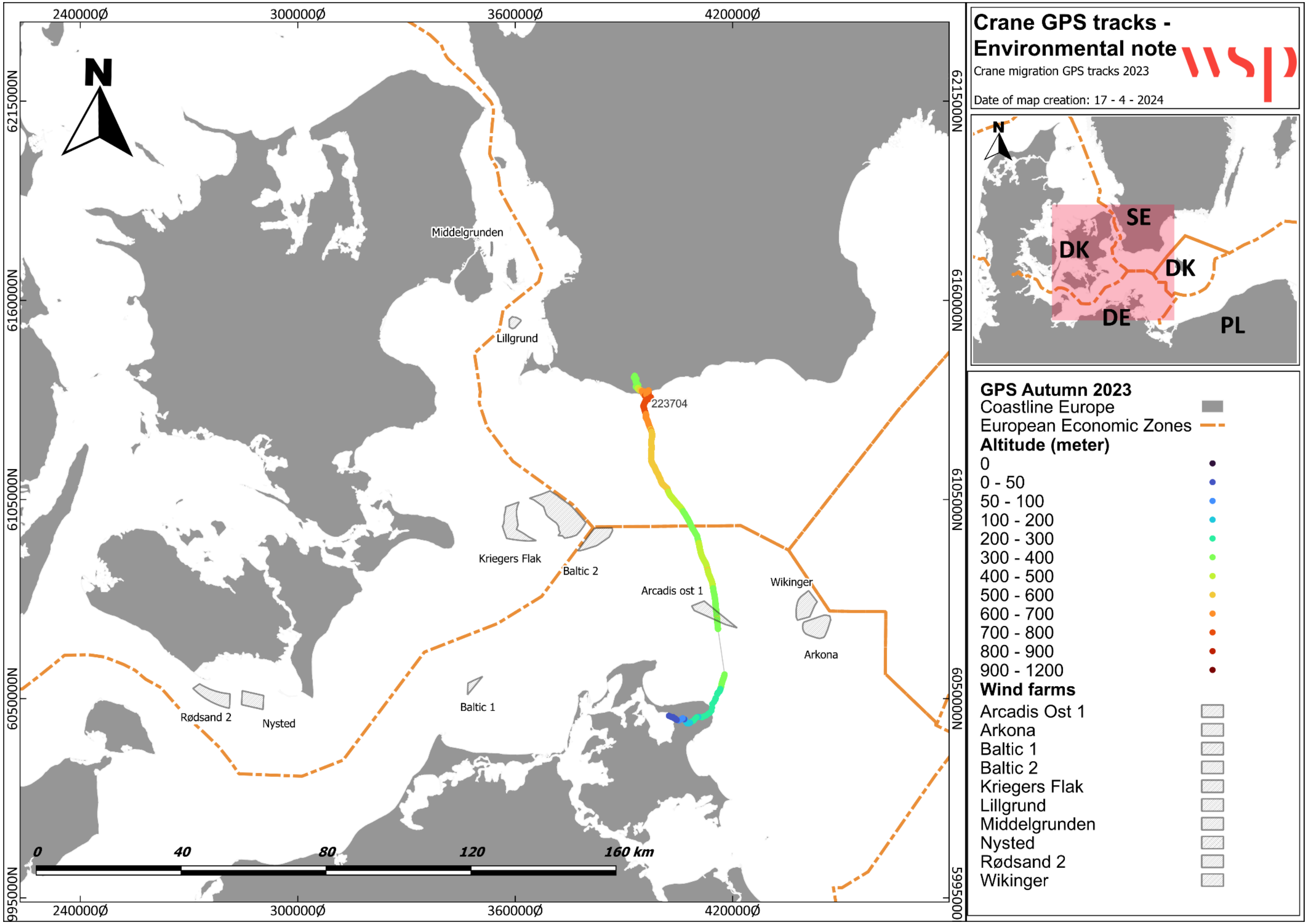

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
SE
DK
DK
DE
PL
N
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 2
Kriegers Flak
Lillgrund
Wikinger
N
223691
Lillgrun
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
0
40
80
120
160 km
3600000
4200000
4800000
5400000
6000000
6270000N
6215000N
6160000N
6105000N
6050000N

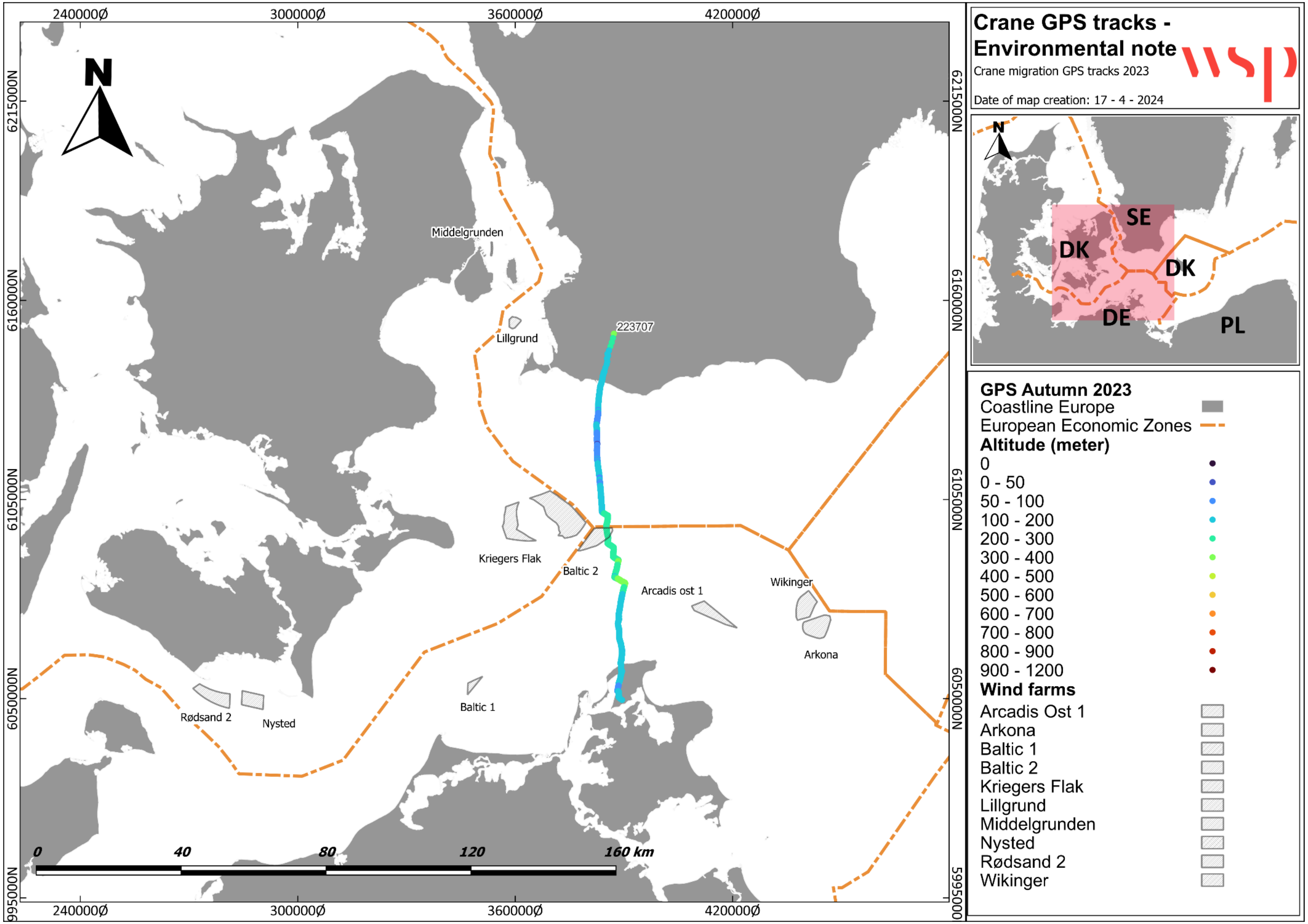

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
N
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
2400000
3000000
3600000
4200000
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
223693
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km

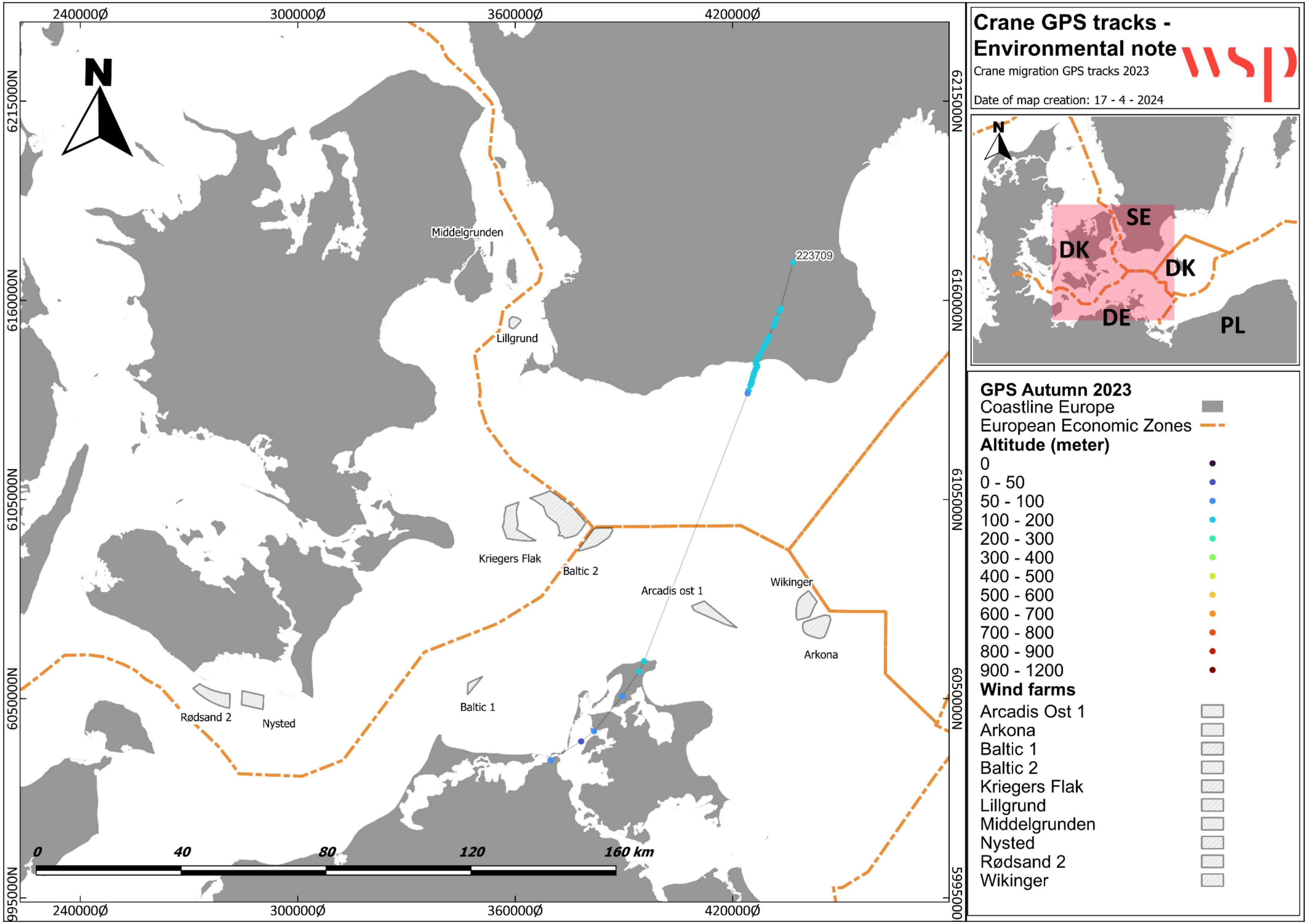


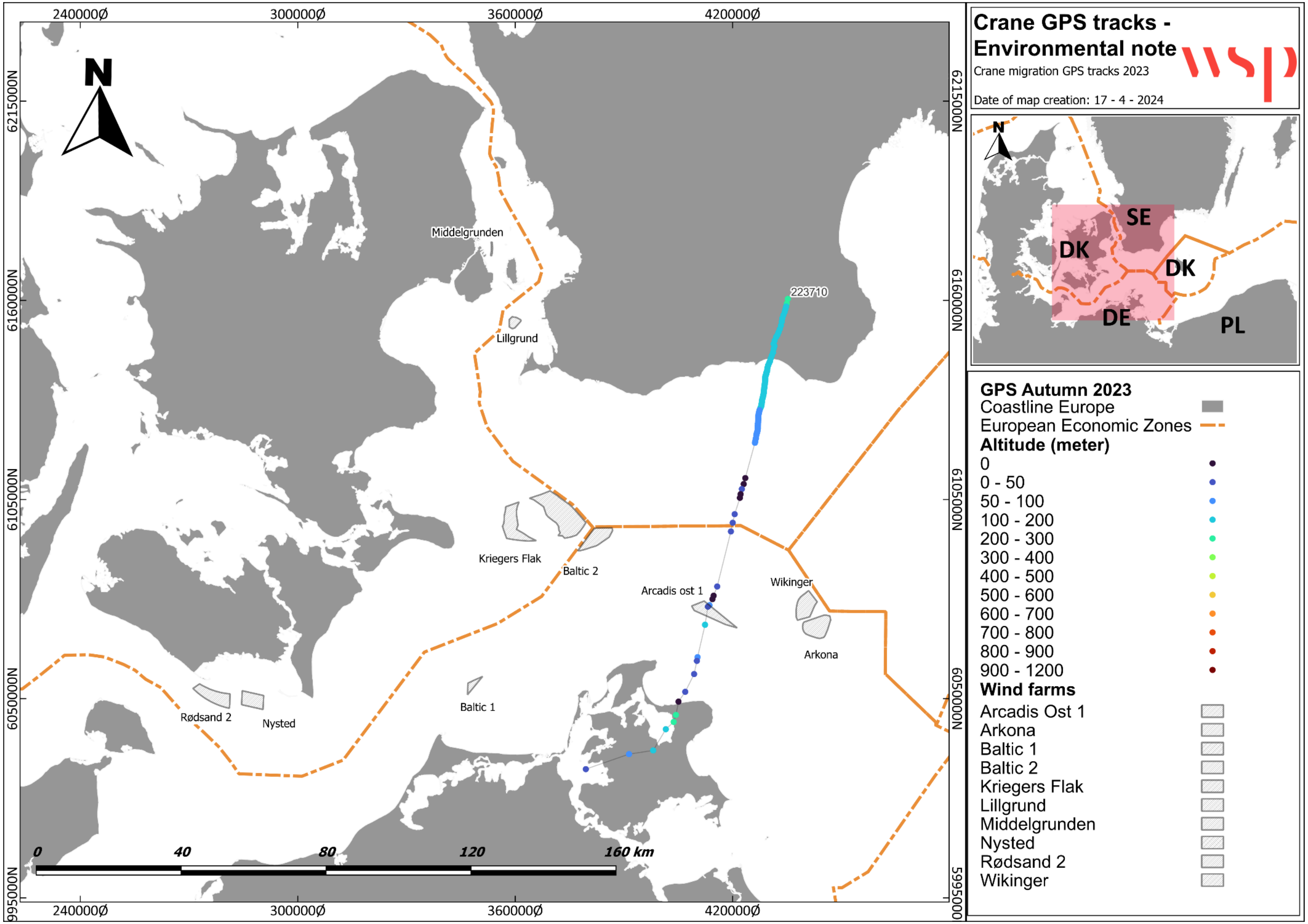
Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
wsp
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
N
Middelgrunden
Lillgrund
229698
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Rødsand 2
Nysted
Baltic 1
0 40 80 120 160 km
2400000
3000000
3600000
4200000
6215000N
6160000N
6105000N
6050000N
5995000N

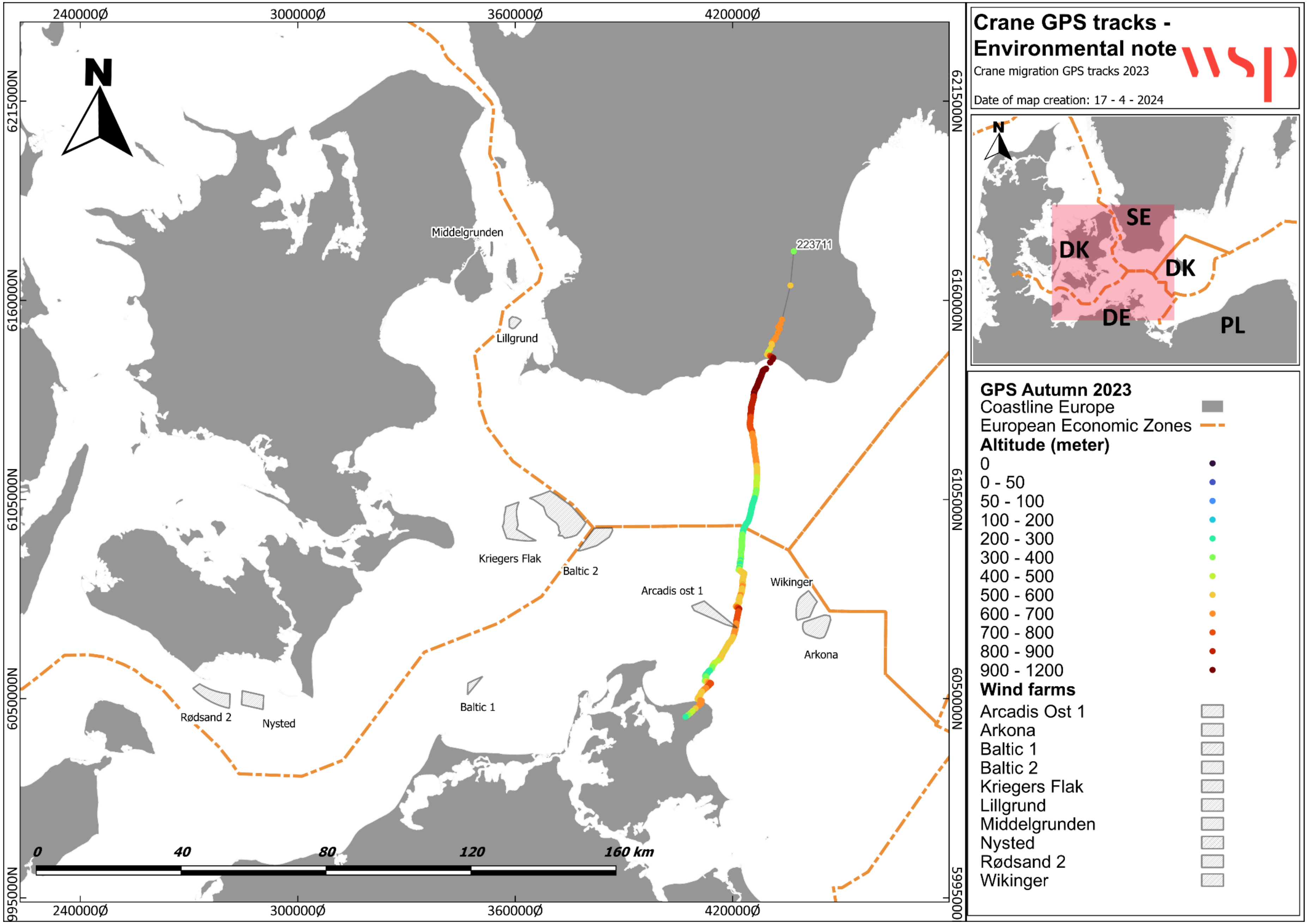

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
N
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 2
Kriegers Flak
Lillgrund
Wikinger
N
223701
Lillgrun
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
0
40
80
120
160 km
3600000
4200000
4800000
5400000
6000000
6270000N
6215000N
6160000N
6105000N
6050000N

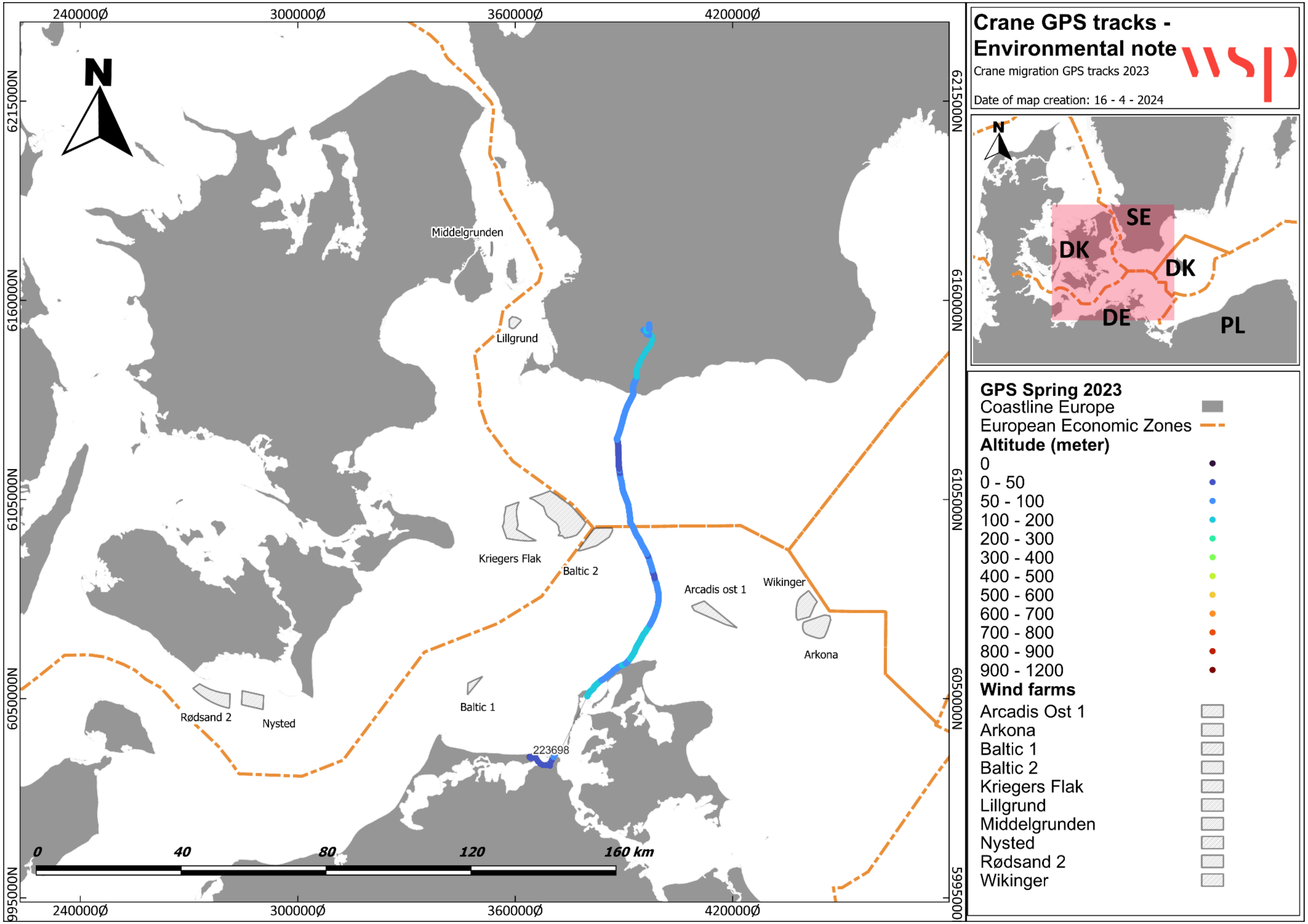

Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
N
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
Middelgrunden
Lillgrund
223704
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km
2400000
3000000
3600000
4200000
6215000N
6160000N
6105000N
6050000N
5995000N

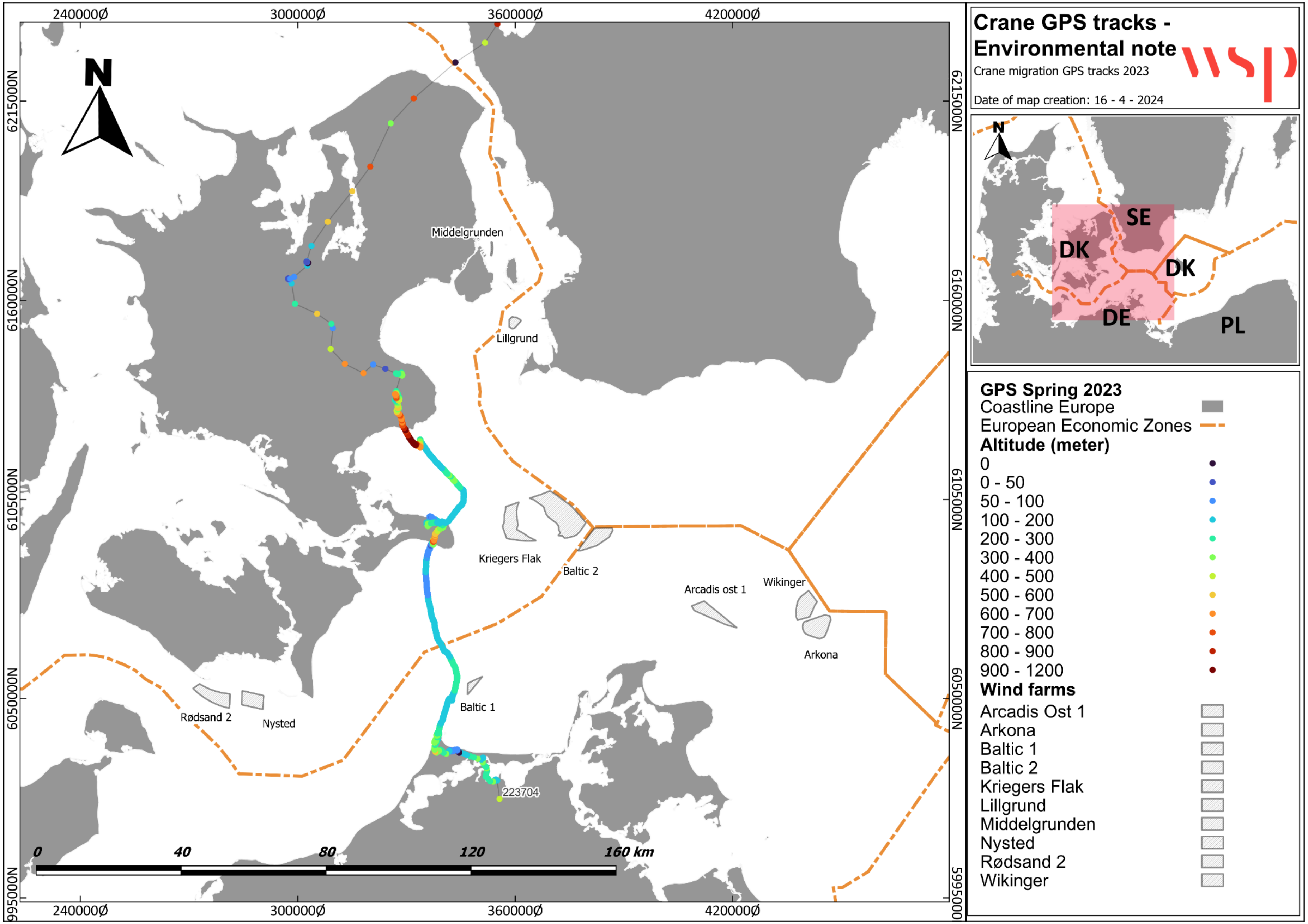

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
N
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
N
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
Middelgrunden
Lillgrund
223707
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km

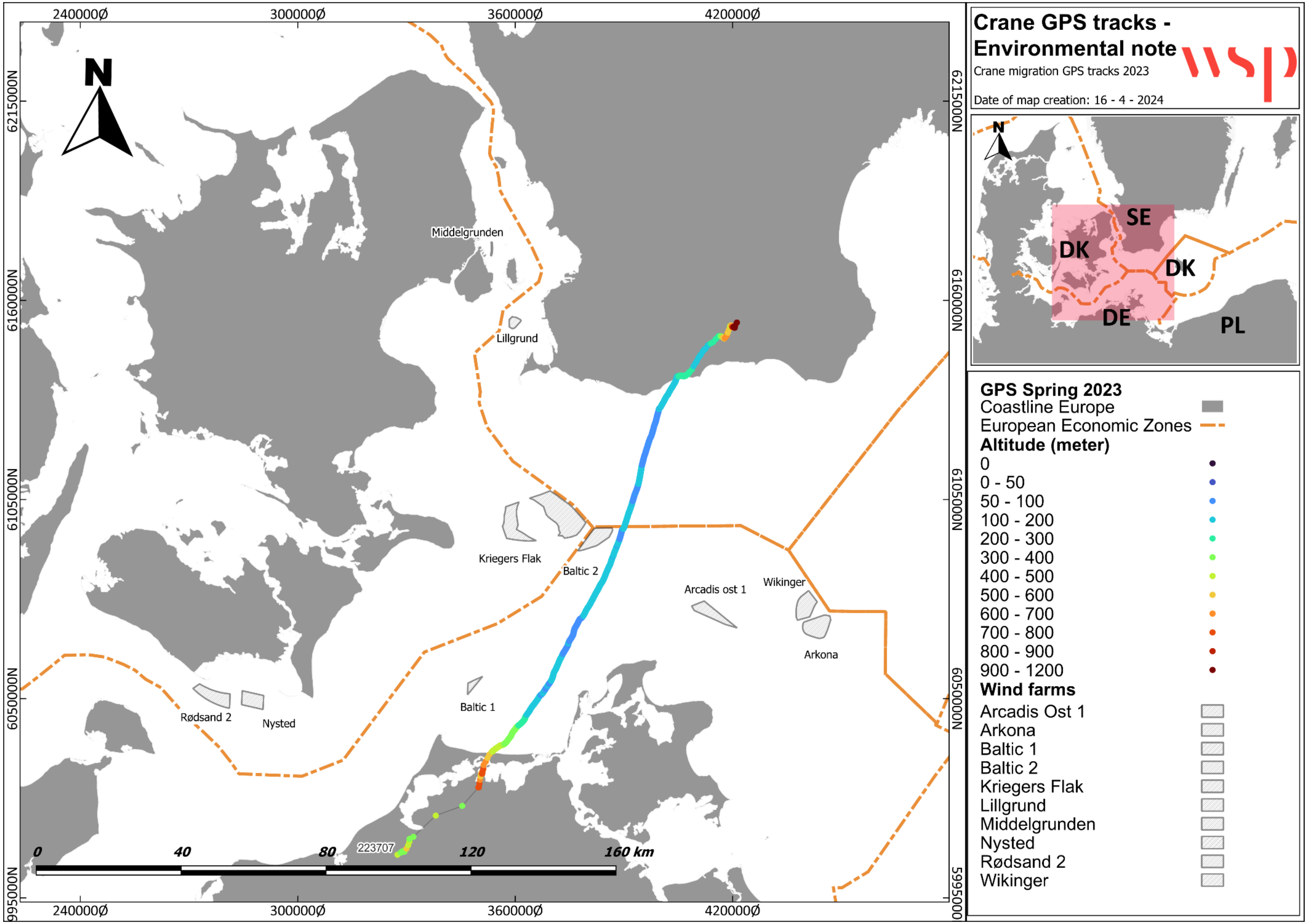

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
N
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
223709
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km


Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
SE
DK
DK
DE
PL
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
N
223710
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N

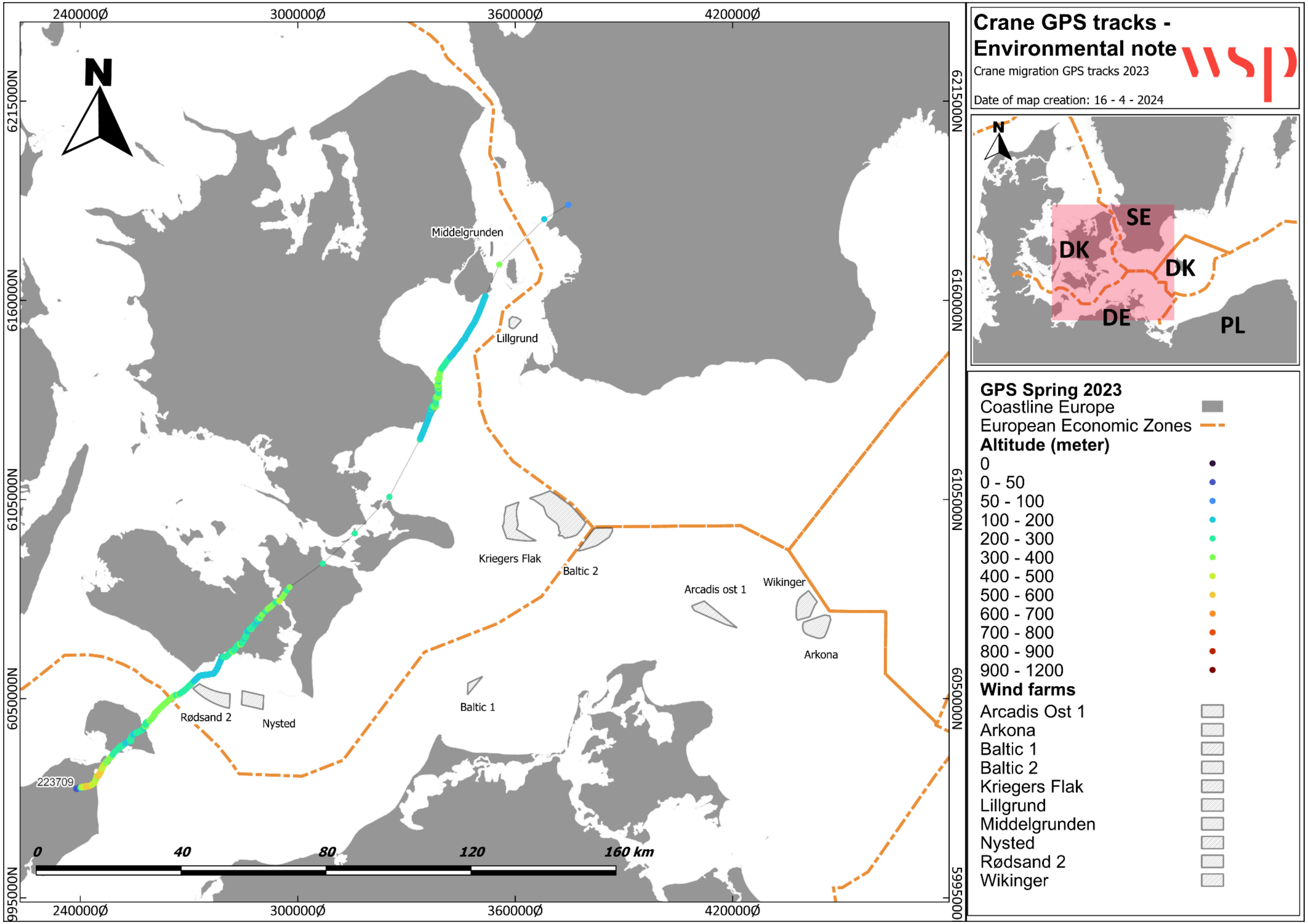

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
SE
DK
DK
DE
PL
Middelgrunden
Lillgrund
223711
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
0
40
80
120
160 km
2400000
3000000
3600000
4200000
6215000N
6160000N
6105000N
6050000N
5995000N


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
wsp
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223698
0
40
80
120
160 km
SE
DK
DK
DE
PL
GPS Spring 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger

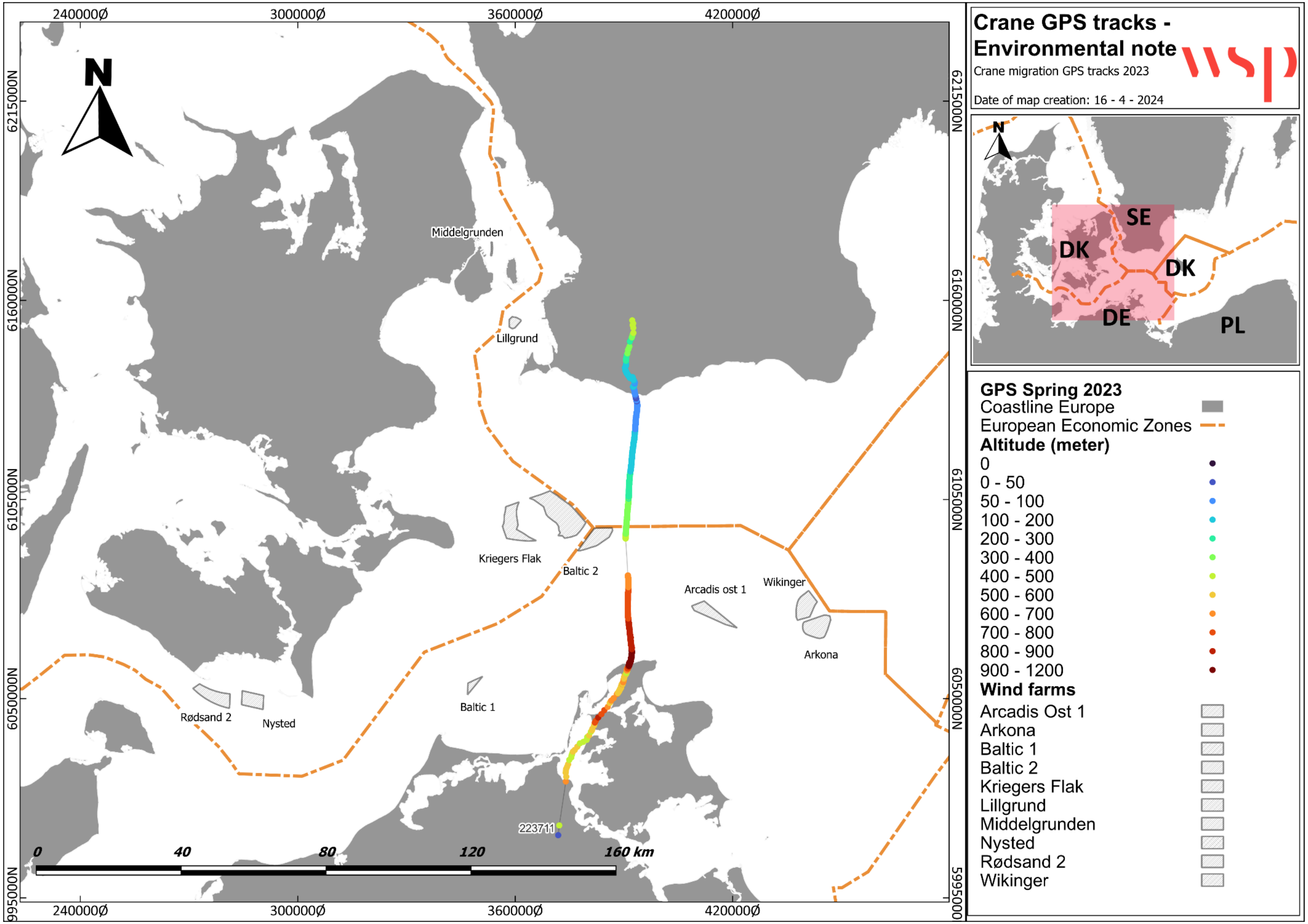

Crane GPS tracks - Environmental note
wsp
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
SE
DK
DK
DE
PL
GPS Spring 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223704
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N

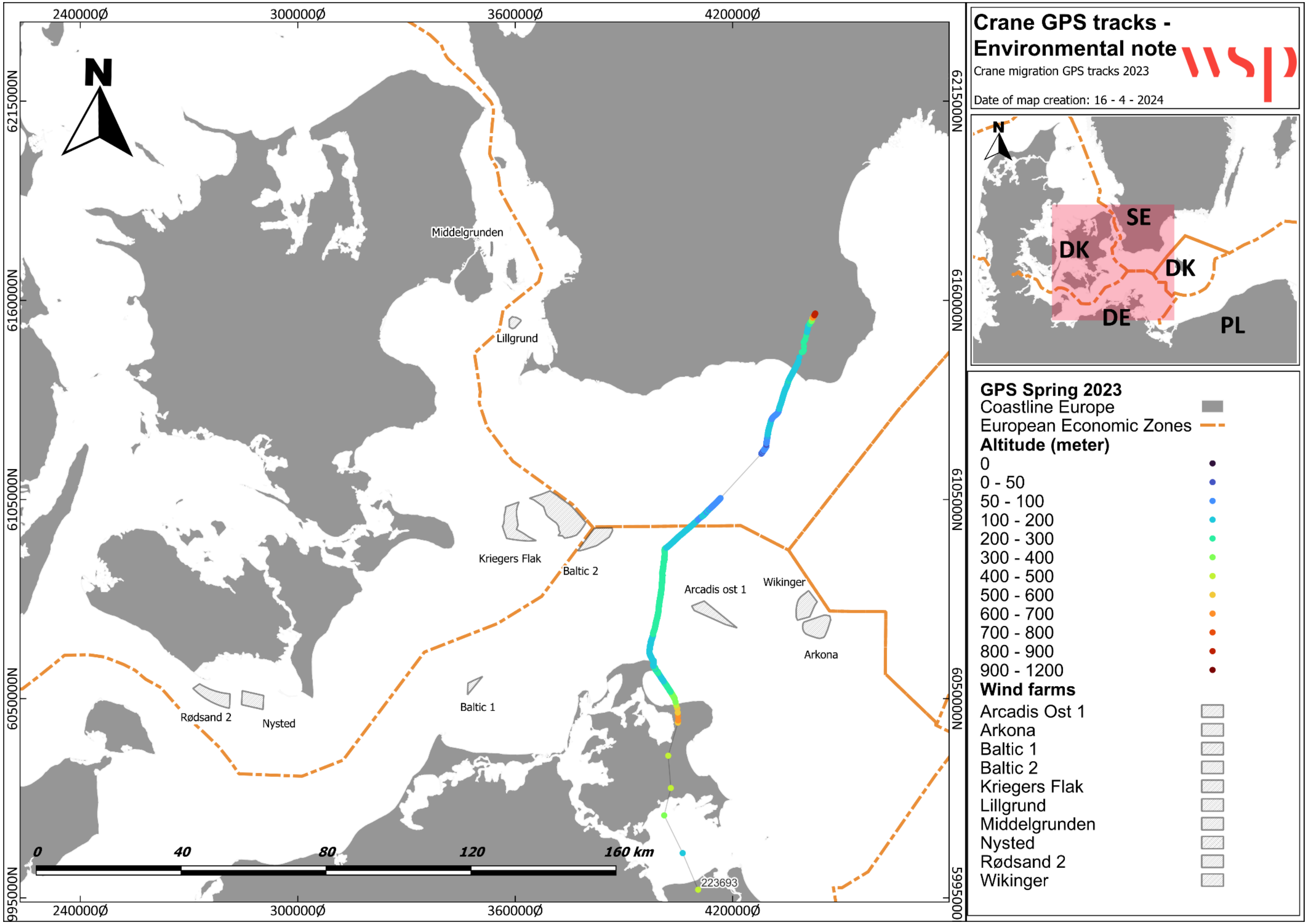


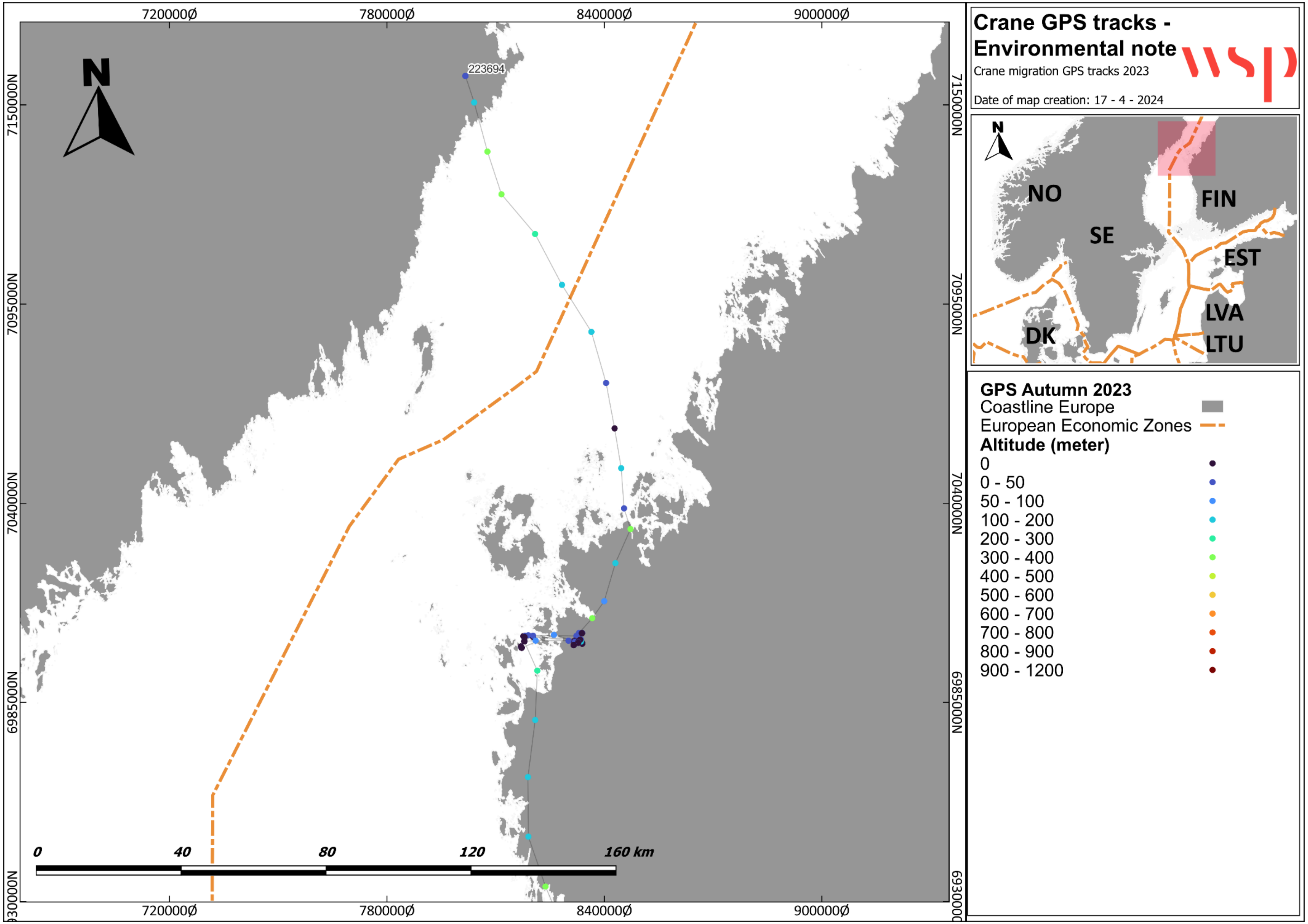
Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
GPS Spring 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
SE
DK
DK
DE
PL
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223707
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N



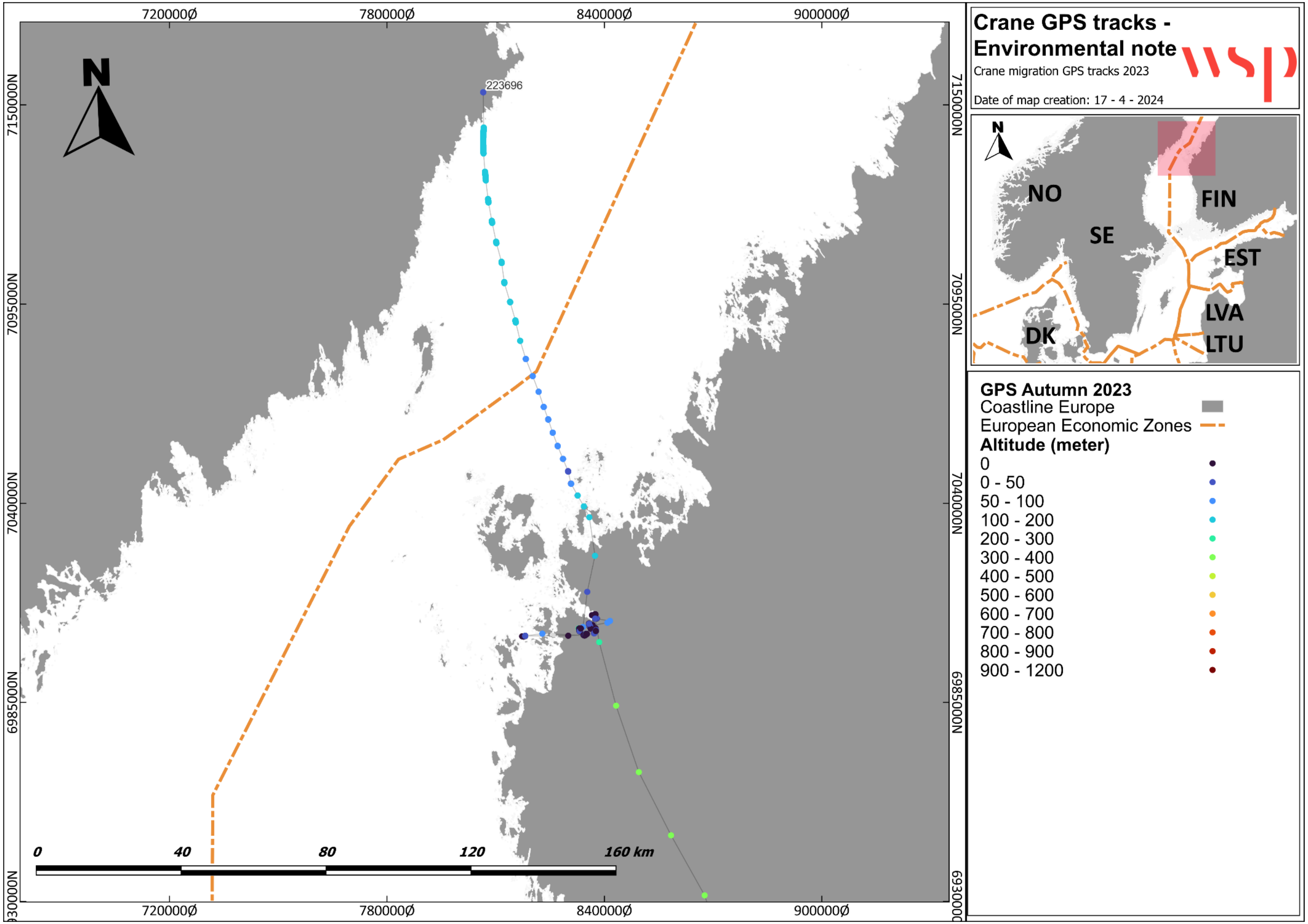
Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
GPS Spring 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
SE
DK
DK
DE
PL
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223709
0
40
80
120
160 km
2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N

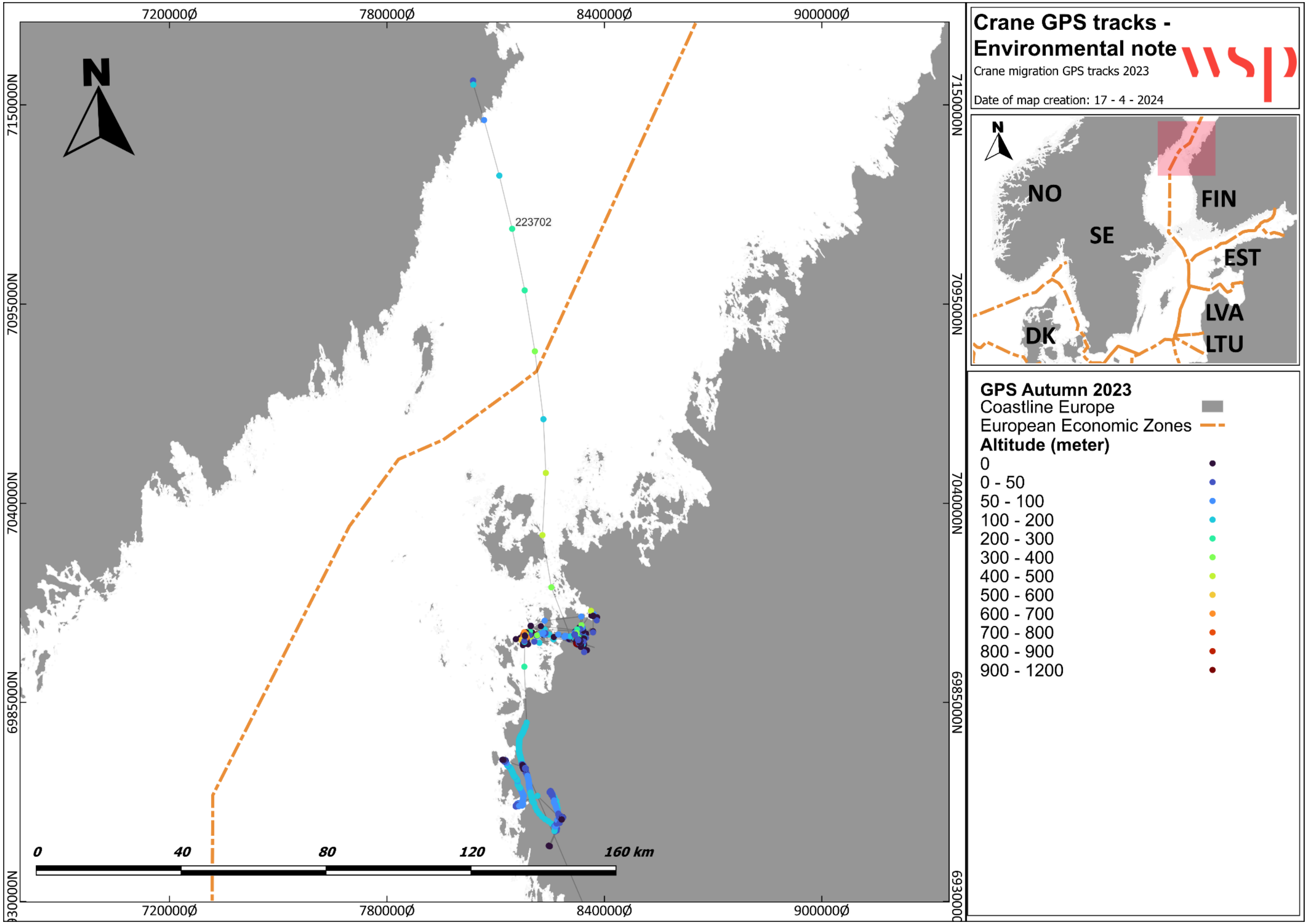

Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
wsp
N
SE
DK
DK
DE
PL
GPS Spring 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger
2400000
3000000
3600000
4200000
6215000N
6160000N
6105000N
6050000N
5995000N
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223711
0
40
80
120
160 km

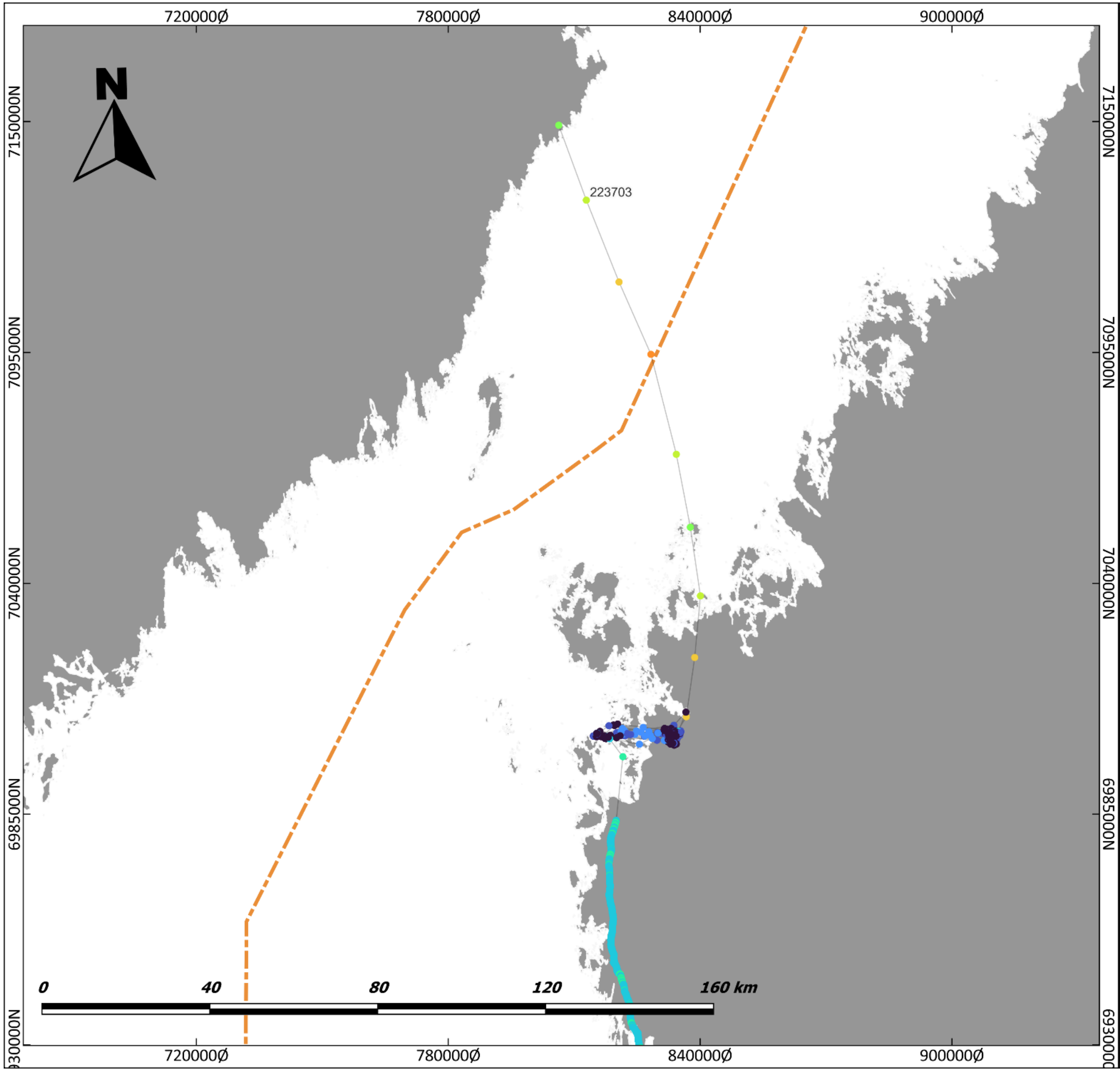

2400000Ø
3000000Ø
3600000Ø
4200000Ø
6215000N
6160000N
6105000N
6050000N
5995000N
N
Middelgrunden
Lillgrund
Kriegers Flak
Baltic 2
Arcadis ost 1
Wikinger
Arkona
Baltic 1
Rødsand 2
Nysted
223693
0
40
80
120
160 km
Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 16 - 4 - 2024
SE
DK
DK
DE
PL
GPS Spring 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
Wind farms
Arcadis Ost 1
Arkona
Baltic 1
Baltic 2
Kriegers Flak
Lillgrund
Middelgrunden
Nysted
Rødsand 2
Wikinger

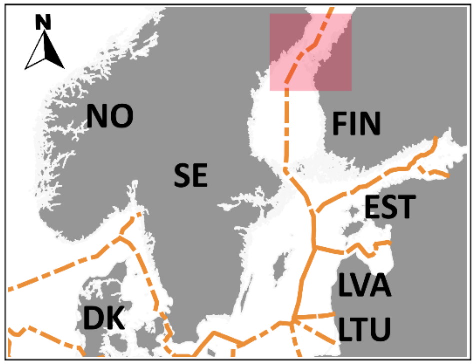


Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
N
223694
7200000Ø
7800000Ø
8400000Ø
9000000Ø
7150000N
7095000N
7040000N
6985000N
6930000N
0
40
80
120
160 km
NO
SE
FIN
EST
LVA
LTU
DK
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
N
223696
7200000Ø
7800000Ø
8400000Ø
9000000Ø
7150000N
7095000N
7040000N
6985000N
6930000N
0
40
80
120
160 km
NO
SE
FIN
EST
LVA
LTU
DK
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
NO
SE
FIN
EST
LVA
LTU
DK
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
223702
0
40
80
120
160 km
720000Ø
780000Ø
840000Ø
900000Ø
7150000N
7095000N
7040000N
6985000N
6930000N




**Crane GPS tracks - Environmental note**

Crane migration GPS tracks 2023

Date of map creation: 17 - 4 - 2024

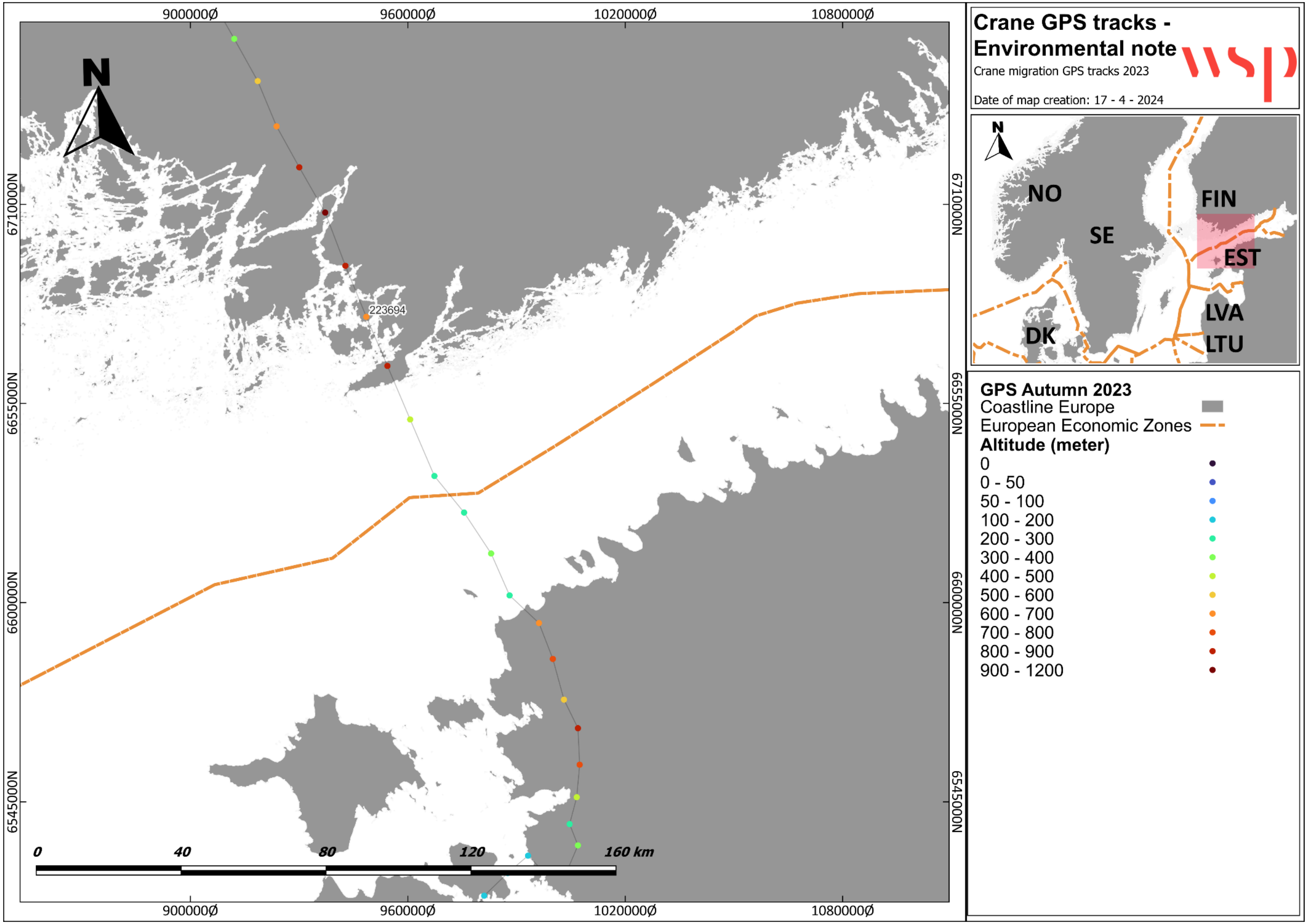
**GPS Autumn 2023**

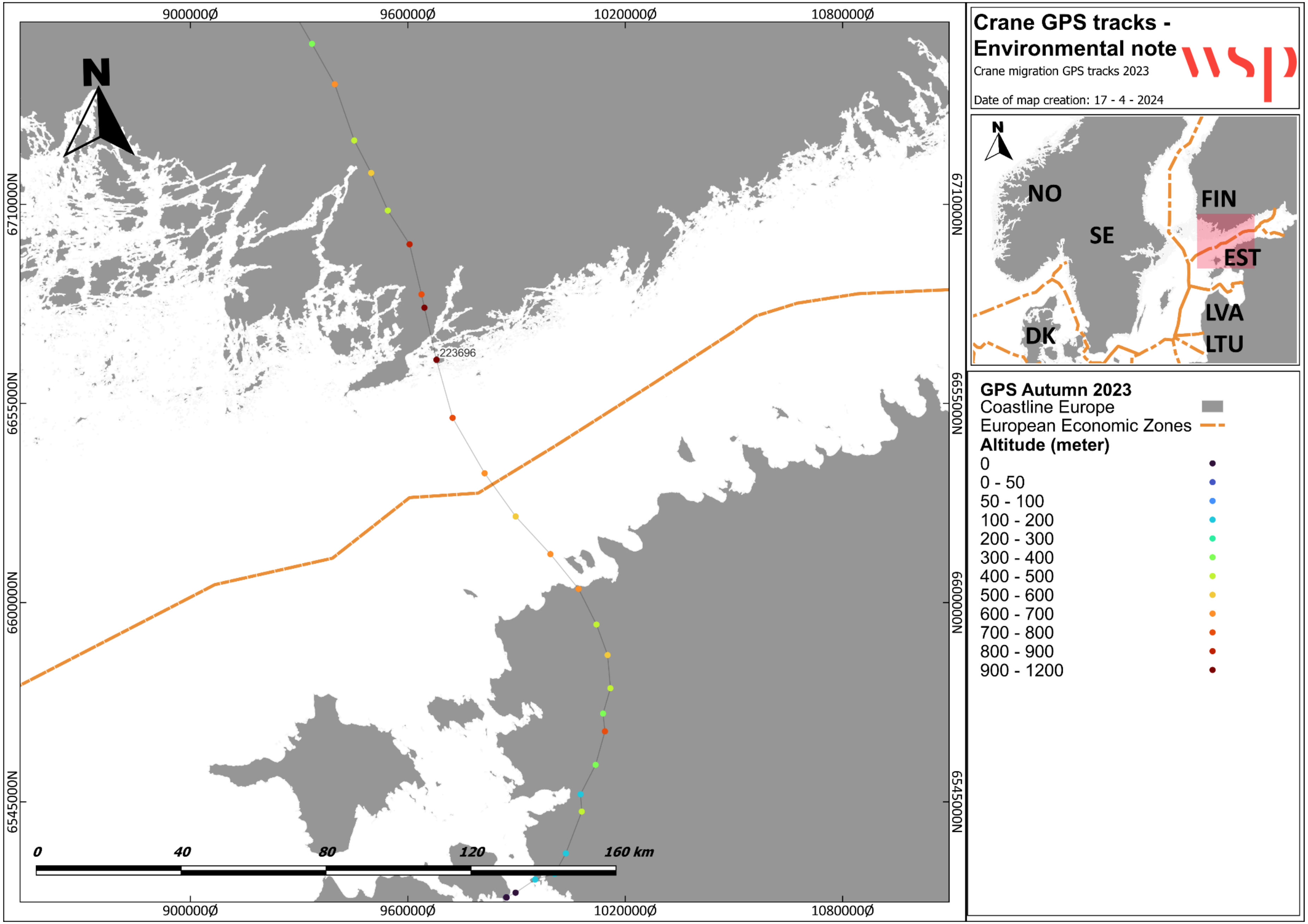
Coastline Europe

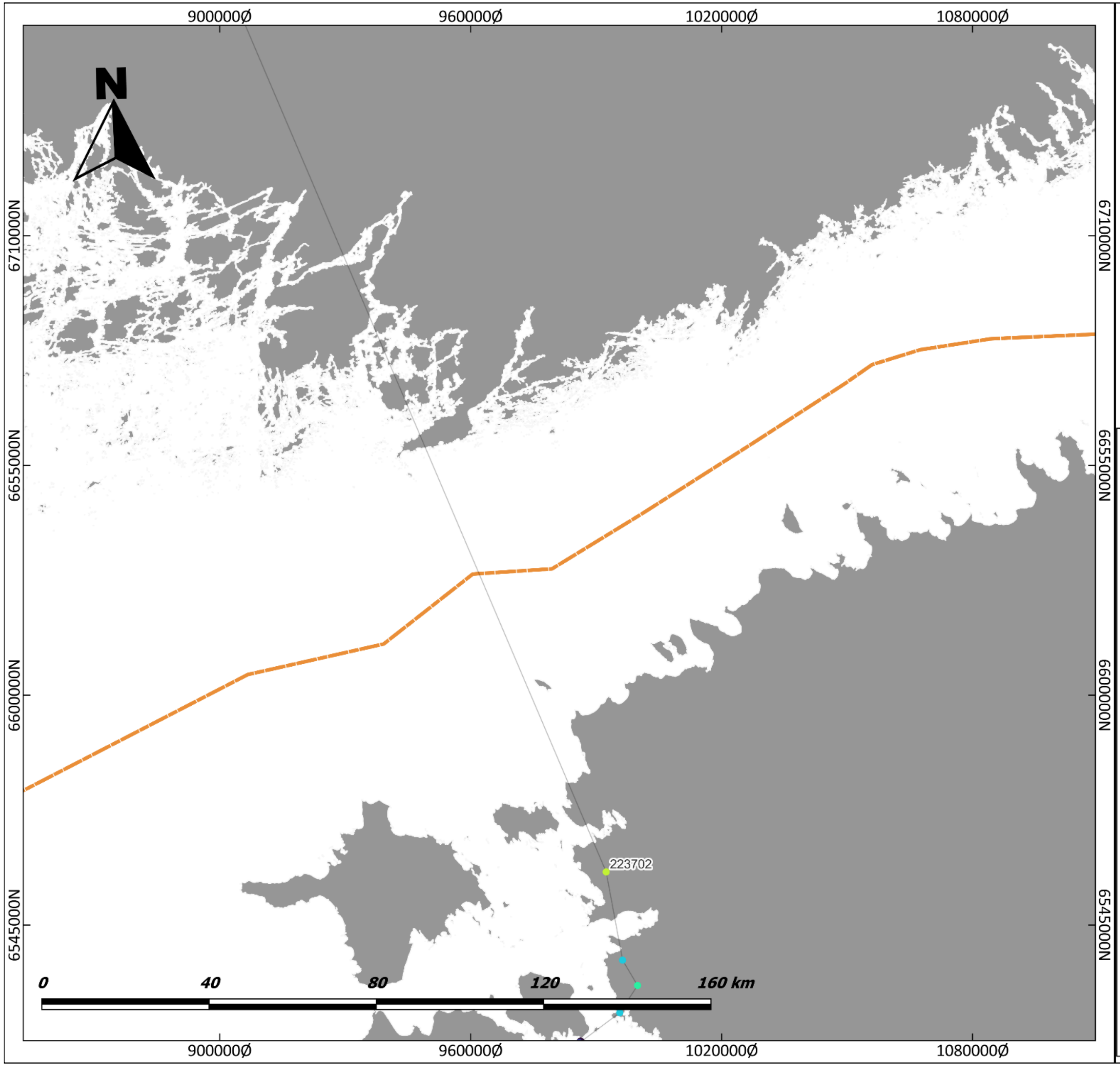
European Economic Zones

**Altitude (meter)**

0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
900000Ø
960000Ø
1020000Ø
1080000Ø
6710000N
6655000N
6600000N
6545000N
223694
0
40
80
120
160 km
N
NO
SE
FIN
EST
LVA
LTU
DK
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200


Crane GPS tracks - Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
9000000Ø
9600000Ø
10200000Ø
10800000Ø
6710000N
6655000N
6600000N
6545000N
N
223696
0
40
80
120
160 km
NO
SE
FIN
EST
LVA
LTU
DK
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200




**Crane GPS tracks - Environmental note**

Crane migration GPS tracks 2023

Date of map creation: 17 - 4 - 2024

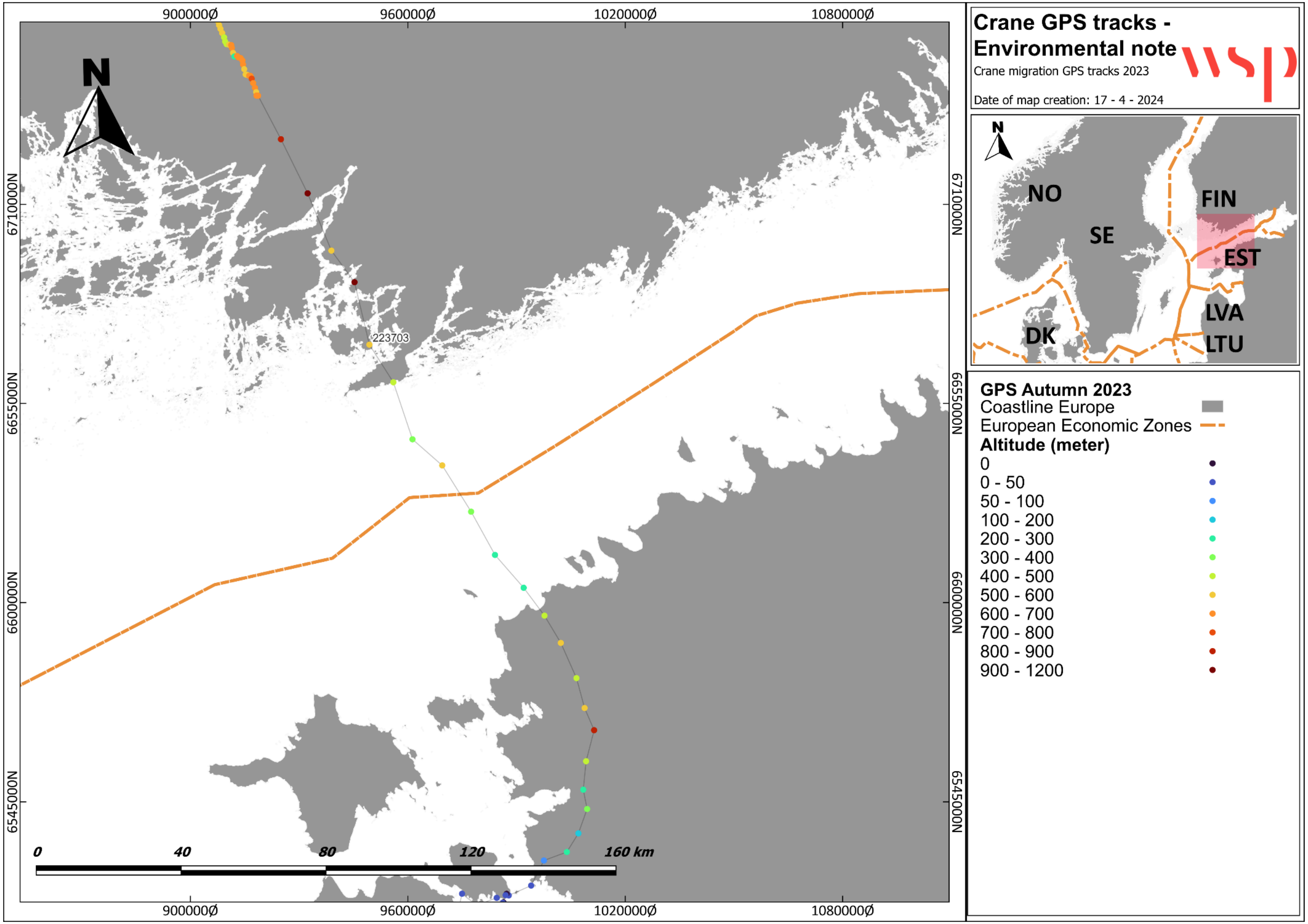
**GPS Autumn 2023**

Coastline Europe

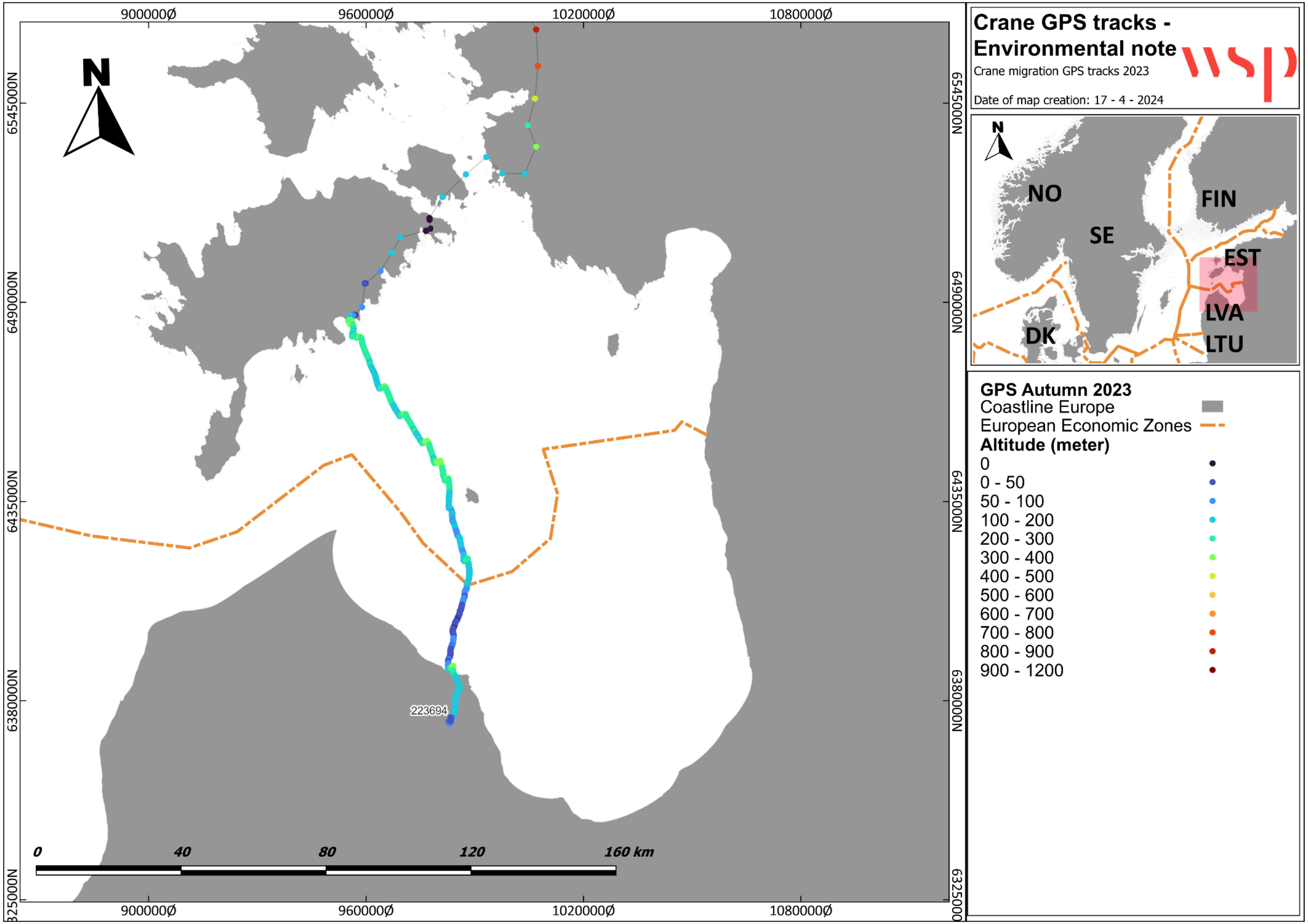
European Economic Zones

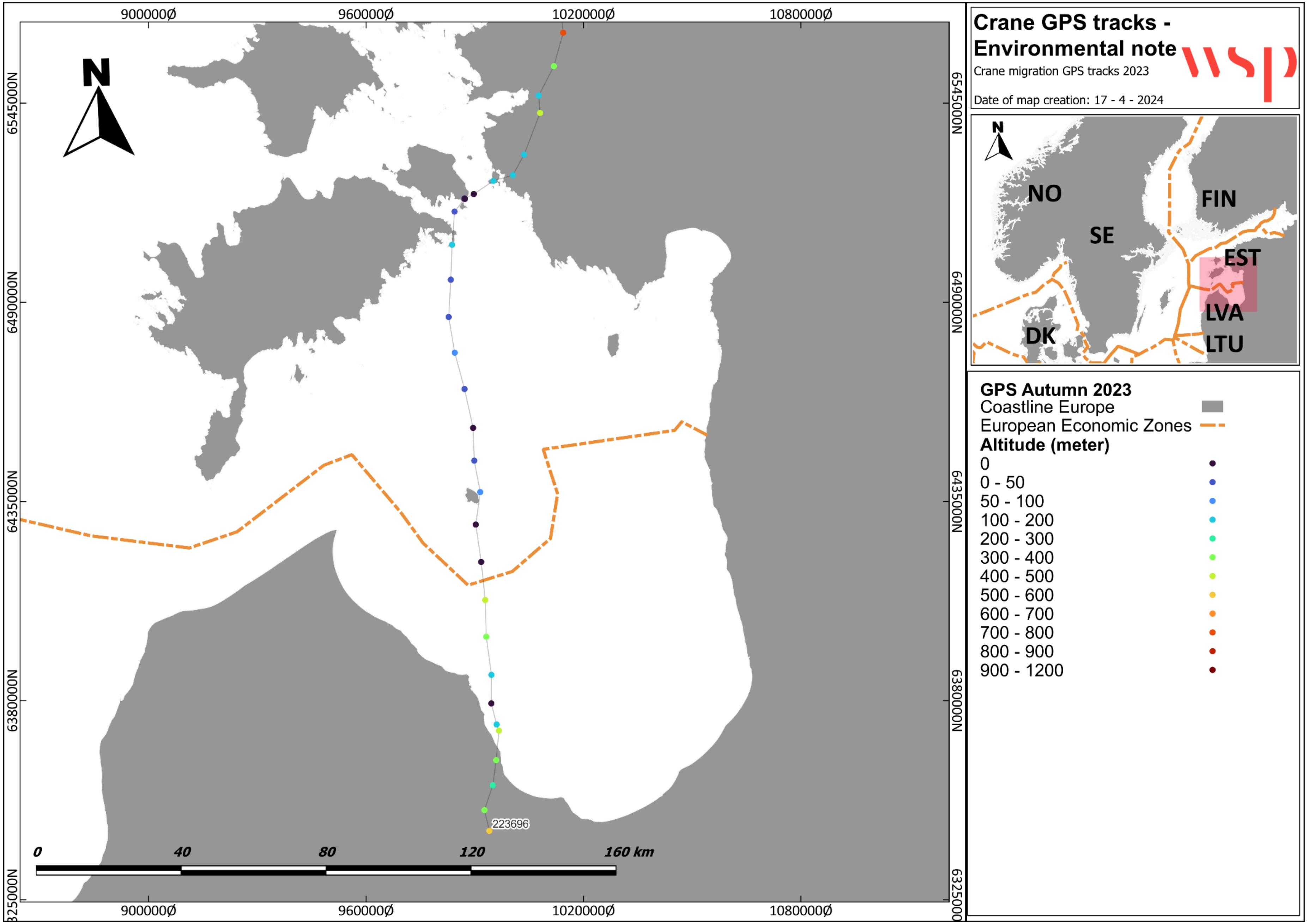
**Altitude (meter)**

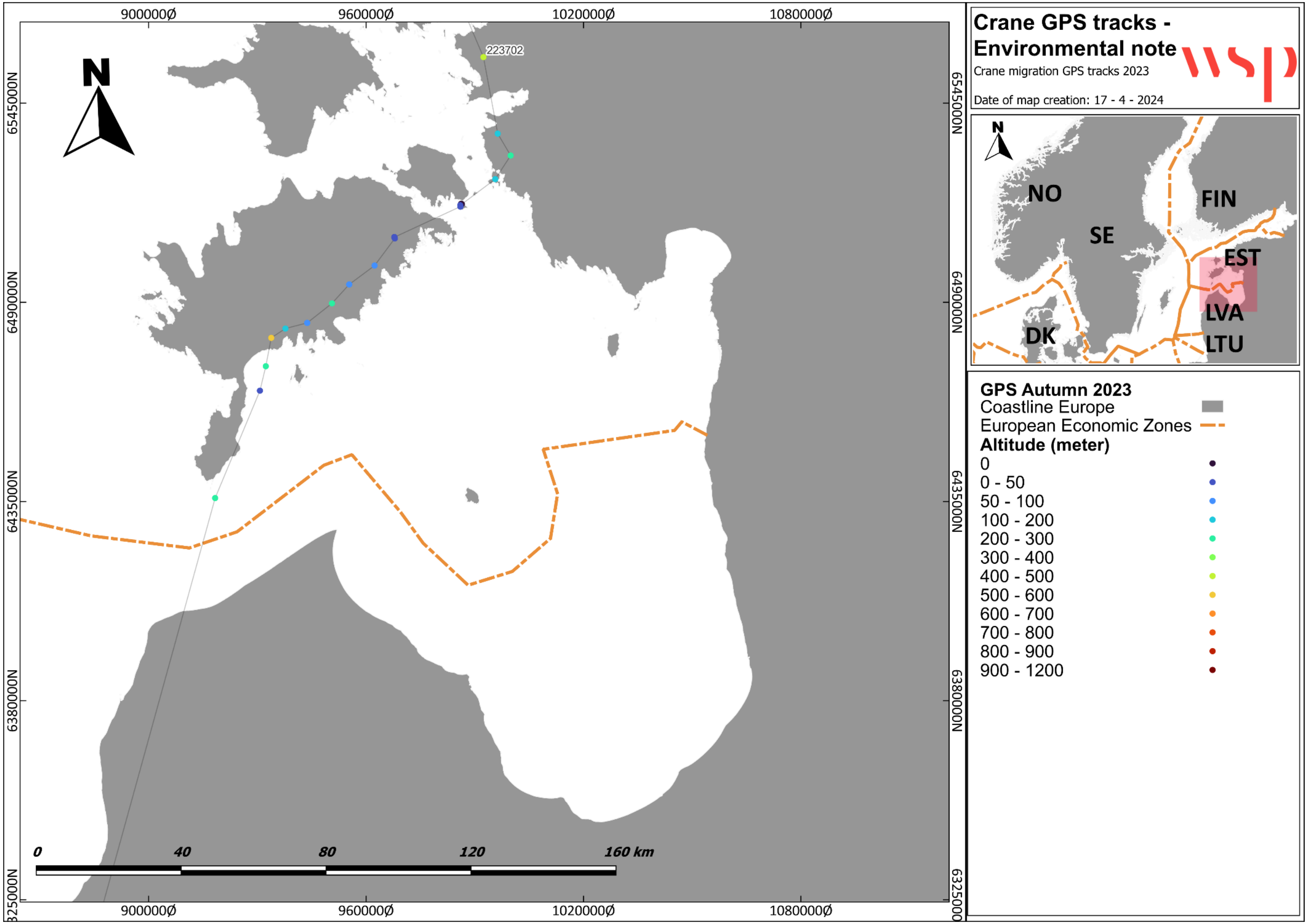
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200



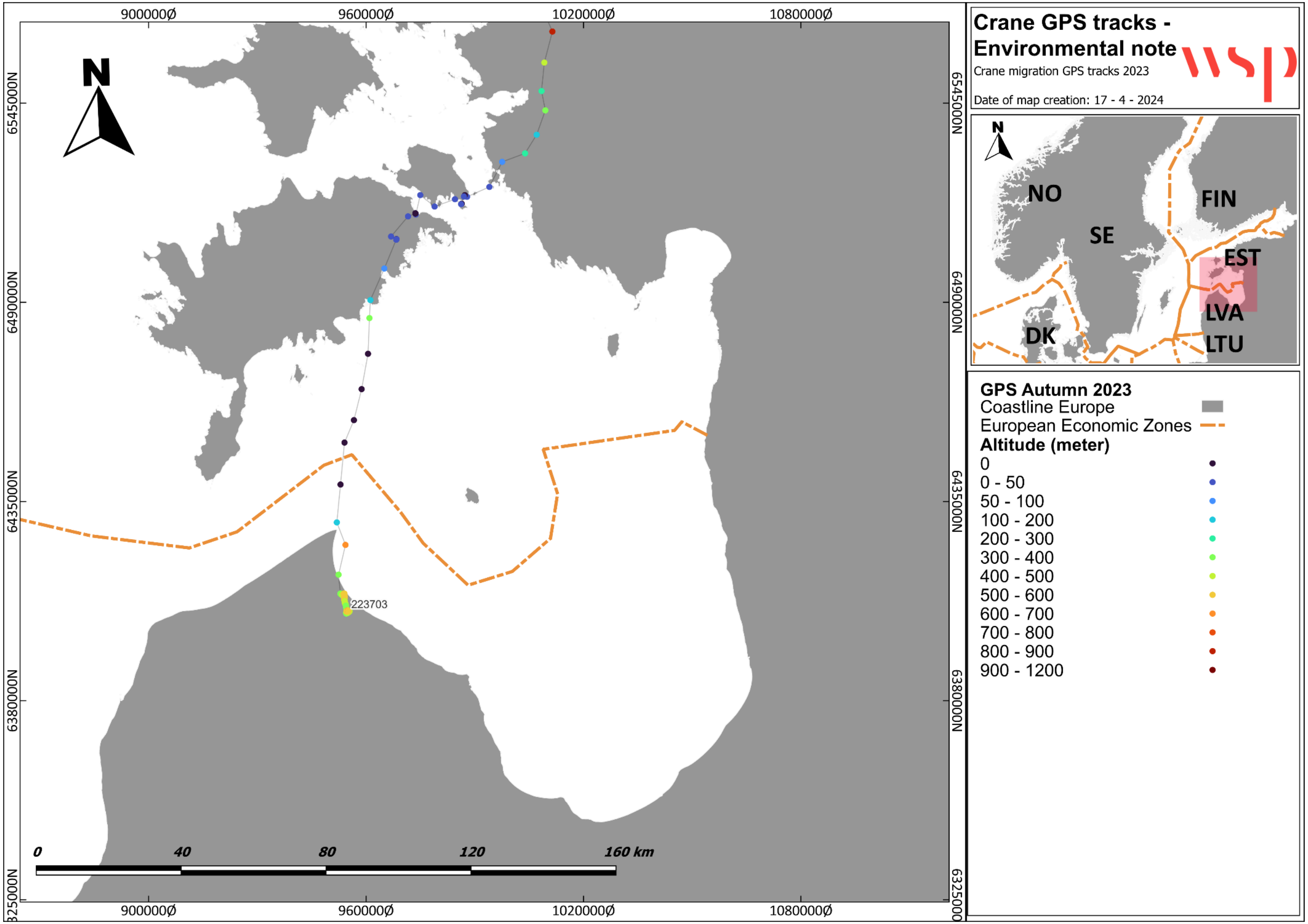
9000000
9600000
10200000
10800000
N
223703
0
40
80
120
160 km
6710000N
6655000N
6600000N
6545000N
Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
NO
SE
FIN
EST
LVA
LTU
DK
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
NO
SE
FIN
EST
LVA
LTU
DK
223694
0
40
80
120
160 km
9000000
9600000
10200000
10800000
6545000N
6490000N
6435000N
6380000N
6325000N


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
NO
SE
FIN
EST
LVA
DK
LTU
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
N
223696
0
40
80
120
160 km
9000000
9600000
10200000
10800000
6545000N
6490000N
6435000N
6380000N
6325000N



Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
9000000Ø
9600000Ø
10200000Ø
10800000Ø
6545000N
6490000N
6435000N
6380000N
6325000N
223702
N
0
40
80
120
160 km
NO
SE
FIN
EST
LVA
DK
LTU
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200


Crane GPS tracks -
Environmental note
Crane migration GPS tracks 2023
Date of map creation: 17 - 4 - 2024
wsp
NO
SE
FIN
EST
LVA
DK
LTU
N
GPS Autumn 2023
Coastline Europe
European Economic Zones
Altitude (meter)
0
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1200
223703
0
40
80
120
160 km
9000000
9600000
10200000
10800000
6545000N
6490000N
6435000N
6380000N
6325000N