THE USE OF MARINE WATERS OF SKÅNE BY HARBOUR PORPOISES IN TIME AND SPACE

Technical Report from DCE – Danish Centre for Environment and Energy No. 236 2022

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Data sheet

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Abstract: This report is mapping harbour porpoise movements, distribution and important habitats of the Swedish waters of Skåne. The maps are based on Argos satellite tracking of 111 harbour porpoises tracked between 1997-2021 in the Belt Sea harbour porpoise population, management area and the gap area between the summer management units of the Belt Sea and Baltic Proper populations. Eight sets of maps are presented based on area, season, month, inter annual differences and a separate set of maps for mature females.

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Contents

Aim

The purpose of this report is to map harbour porpoise movements, distribution and important habitats based on Argos satellite tracking of 111 harbour porpoises tracked between 1997-2021 in the range of the Belt Sea harbour porpoise population management area + the gap area between the summer management units of the Belt Sea and Baltic Proper populations (Figure 1, Sveegaard et al. 2015, Carlén et al. 2018). This report was commissioned by Länsstyrelsen Skåne, Malmø, Sweden and consequently, special emphasis will be on the waters of Skåne in Sweden and sub-areas within (see Figure 1).

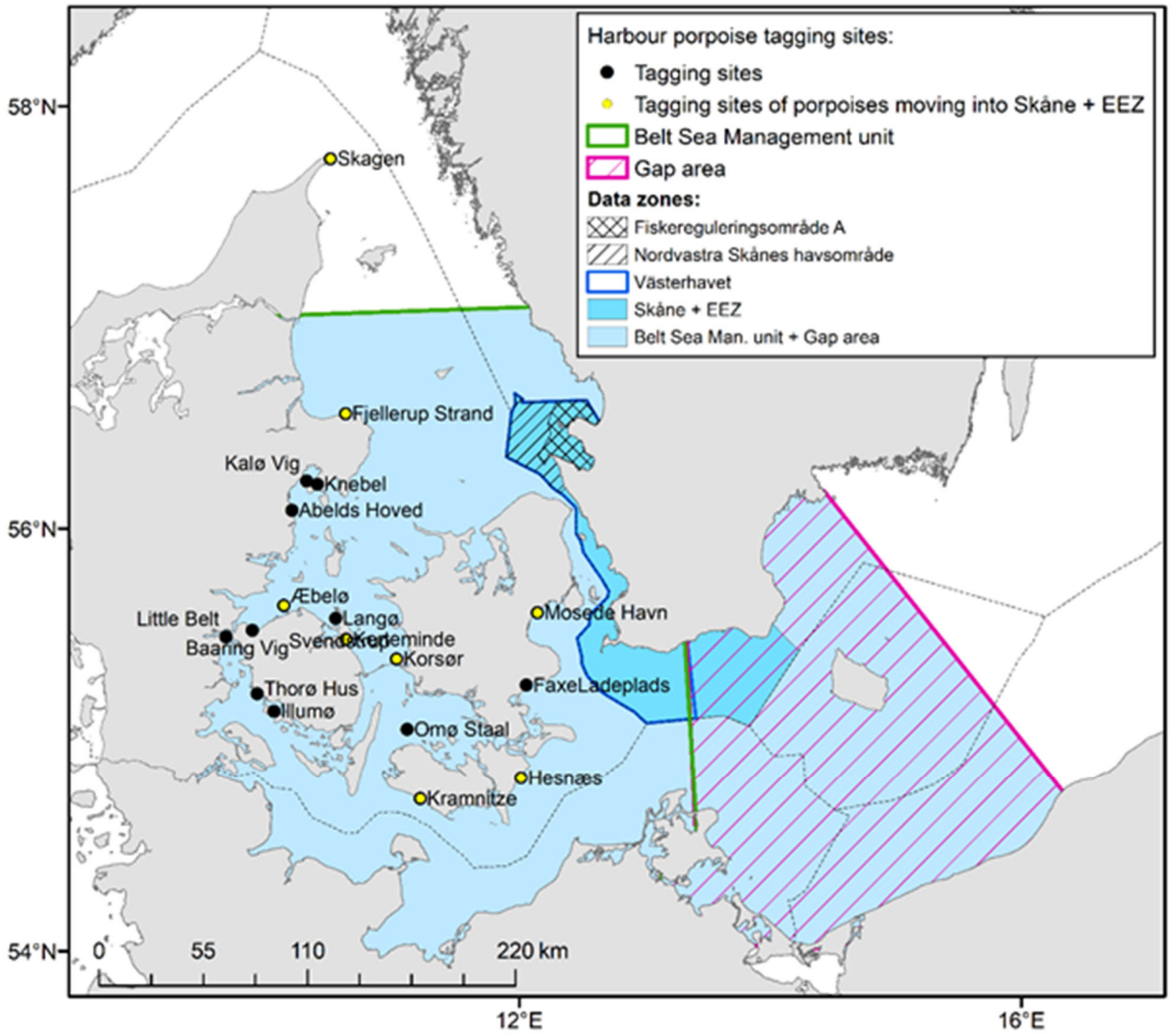


Figure 1. Map of study area. Areas analysed in this report are indicated as well as management units and tagging sites of the 111 harbour porpoises analysed in this study. Yellow dots indicate where the porpoises that moved into the Swedish waters of Skåne were tagged.

Method

All harbour porpoises were incidentally live caught in the Danish pound net fishery. The porpoises could swim freely inside these without getting entangled in the nets that are open to the surface and have a 2x2 cm mesh size. The fisherman would call the scientists as soon as he discovered a porpoise in his net, and the scientists would reach the site on the same day if possible, or alternatively the following day depending on weather conditions. The animal was brought on board the fishing boat in a cradle, the health status was assessed, measurements were taken and the animal was tagged with Argos satellite transmitters (SPOT or SPLASH tags from https://wildlifecomputers.com/). The procedure took less than 30 min, and afterwards, the porpoise was released again. The 111 porpoises were tagged during 1997-2021 and positions were received for up to 522 days (Appendix Table A1). Details on the tagging methodology can be found in e.g. Teilmann et al. (2007 and 2008) and Sveegaard et al. (2011a and 2018). The maturity state and sex of all tagged porpoises included in this report are provided in Table 1 and Appendix Table A1. Mature porpoises were defined as length > 138 cm for males and length > 142 cm for females (from Lockyer and Kinze 2003).

Table 1. Number of harbour porpoises tagged for each sex and maturity category during 1997-2021.

	Female	Male	Grand Total
Juvenile	29	51	80
Mature	12	19	31
Grand Total	41	70	111

Kernel density distribution maps (Figure 3-27, 54-59) show the concentration of positions in 10 % intervals as a heat map. In the Kernel density countour, the blue area covers 100 % of the positions while the red area shows the smallest possible area to include 10 % of the positions (highest concentration of positions). Kernel analysis and maps were produced in ArcGIS v.10.3 using the built-in Kernel Density tool (Spatial Analyst). The impact of the smoothing factor on the results of the kernel density estimations have been widely studied, although no congruence of best practice has been established (Worton 1989, Blundell et al. 2001). Sveegaard et al. (2011a) evaluated the effects of smoothing on kernel estimates for harbour porpoises by calculating the Kernel density estimates using three different band widths: 10, 20 and 30 km. These correspond to the window within which local density estimates are 'smoothed'. While 10 km windows result in estimates that are too fragmented on the landscape scale, it can be ideal on a local scale as it can capture small-scale variations in positions. In the present report, we show maps with both smoothing factor 10 and 20 km for comparison (see figure 3a-c). We use 20 km smoothing for the large Belt-Gap area and 10 km smoothing for all Kernel maps of the four smaller areas around Skåne to increase the resolution. Since the Kernel density estimates are affected by observations outside the area of interest, i.e. from an area that correspond to the band width, we included observations outside the area of interest when calculating kernel density estimates, but later omitted results from this buffer zone. We used a buffer of 10 km for the four Skåne sites and 20 km for the Belt-Gap area. The process are illustrated in figure 2.

Isopleths (Kernel percentages) were made in the ArcGIS add-on programme Geospatial Modelling Environment (GME). All projections are UTM32 / ETRS89.

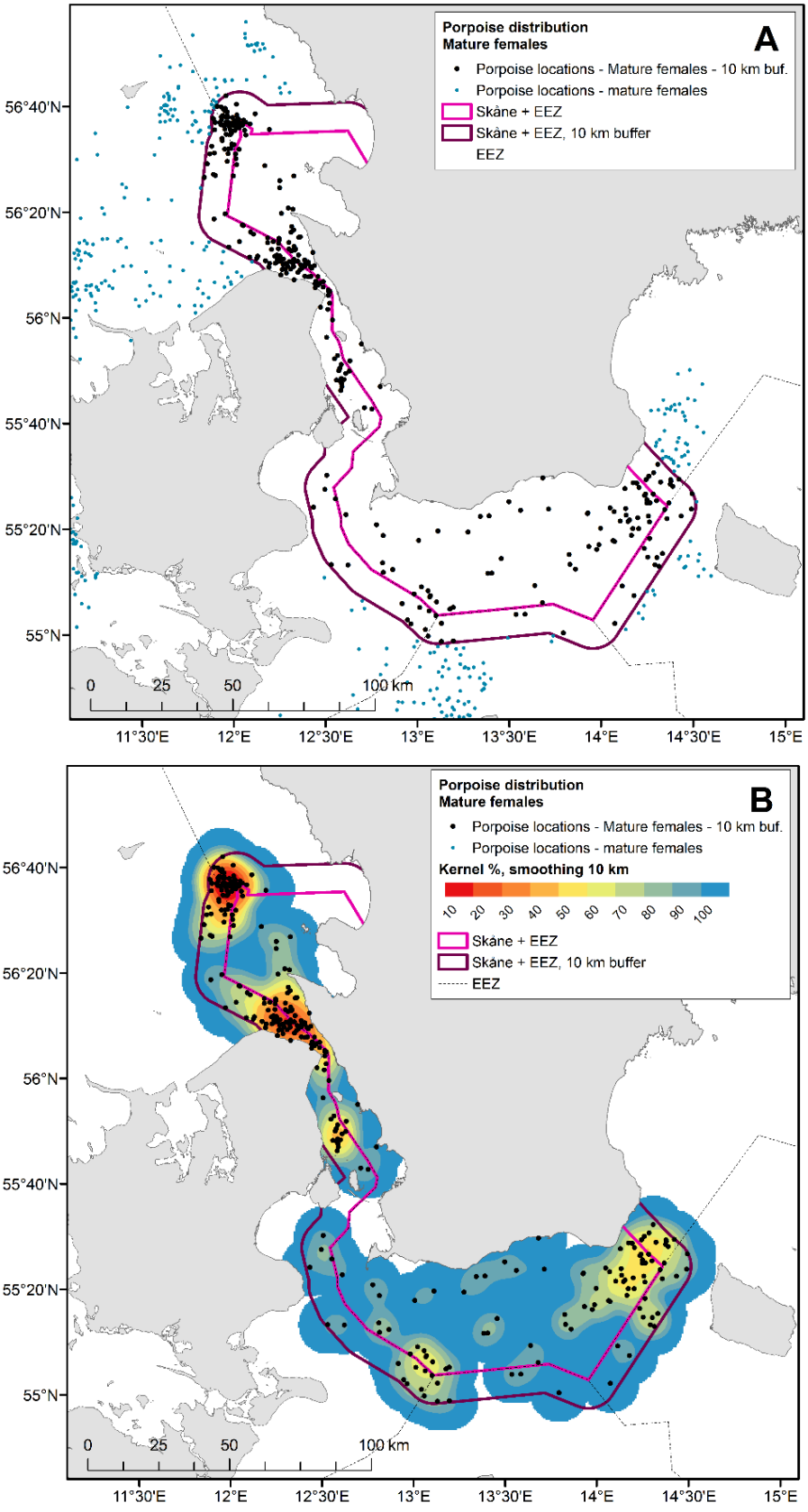
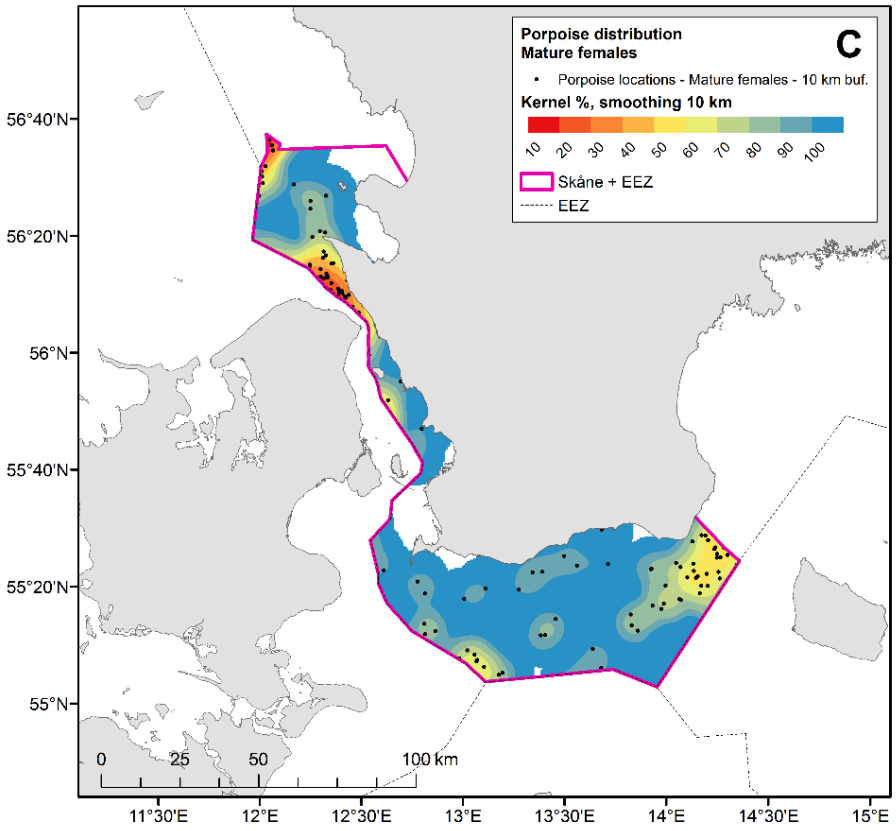


Figure 2. Kernel density analysis for mature females within the Skåne + EEZ area: A) A buffer zone extending up to 10 km from "Skåne + EEZ" is created. Locations within the Skåne+EEZ and the buffer are selected and used in the following analysis. B) the build in Kernel Density tool in ArcGIS v10.3 is used to create the Kernel Density raster layer (not shown) and the add-on GME program is used to create isopleths (=% kernel contours). Note that porpoise densities often appear to be decreasing near the edge of the buffer zone, which introduces a bias of the kernel density estimates within this zone. C) The 10 km buffer area is lastly omitted from the map since the Kernel density layer in this zone is biased due to the omission of observations from the neighbouring area outside the area of interest. This ensures that the Kernel Density layer within the "Skåne + EEZ" area is unaffected by the edge effect.



This report consists of eight geographical sections each including a set of maps as outlined below:

Kernel plots of all porpoises tagged within the Belt Sea population as defined in Sveegaard et al. (2015). Five maps divided into All Year, Spring (March-May), Summer (June-August), Fall (September-November) and Winter (December-February). The maps include all locations within the area defined as the management unit for the Belt Sea porpoise population as well as the gap area between the Belt Sea porpoise population and the Baltic Proper porpoise population towards the east.

Skåne + EEZ (all waters around Skåne). Kernel plots of all positions within this area. Five maps divided into All Year, Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December-February).

Västerhavet (all waters around Skåne except the south-eastern area). Kernel plots of all positions within this area. Five maps divided into All Year, Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December-February).

Nordvästra Skånes havsområde. Kernel plots of all positions within this area. Five maps divided into All Year, Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December-February).

Fiskereguleringsområde A. Kernel plots of all positions within this area. Five maps divided into All Year, Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December-February).

Monthly maps based on all positions received during the contact for all animals combined within the Belt Sea population area. This is the raw data, which all the Kernel maps are based on.

Tracks of the 12 mature females where at least one position was within the Belt Sea population area.

Kernel plots of all porpoises tracked within the Belt Sea + gap area and the Skåne + EEZ area, respectively. Maps are divided into three periods: 1997-2004, 2005-2012, 2013-2021.

Interpretation of the maps and uncertainties

There are no fixed rules about how much data is needed to make robust Kernel maps, but in general the fewer animals and positions that are used to create a map, the higher the uncertainty will be and therefore more caution should be given when interpreting the maps.

Thus, when interpreting the Kernel density maps it is important to know how much raw data is behind the maps. Therefore, on all maps, the number of animals and satellite positions used to create the particular map is given in the legend.

Sequeira et al. (2019) reviewed a number of marine megafaunas tagging studies (birds, turtles, sharks and pinnipeds) and summarised the importance of sample sizes within a comparable group of animals to answer research questions. Their review provides a general overview of the possibilities and limitations of different sample sizes and may be used as a guideline when interpreting the maps in this report as listed below:

- Sample size 1; even one tagged individual can provide proof of concept or discover new behaviour.
- Sample size up to 10; can provide initial insights into individual variability, scale of movements, and drivers of movement and can be used to generate hypotheses for further targeted research.
- Sample size 10-100; can provide estimates of space-use, characterize spatial-temporal patterns and identify specific behaviours (e.g., sex and age differences).
- Sample size > 100; can quantify habitat use over large spatial scales, assess shifts in space-use with time, among sub-populations or with gender, age class and period (e.g., breeding cycles) and estimate susceptibility to interactions with human activities.

Another uncertainty is the precision of the Argos positions. These positions are not as precise as GPS positions (Costa et al. 2010). Many positions in an area will even out this uncertainty, while few positions will have a higher uncertainty. To avoid unrealistic outliers, we filtered all data (Dave Douglas SAS-routine, Argos-Filter v7.03, see details in Sveegaard et al. 2011a) and delete positions that show unrealistic swimming pattern, e.g. high speed between two positions and a series of positions where one is far away from previous and following positions. However, to avoid excluding valuable data, all positions that have passed the Argos filter have been included in this report and since the tags and settings have changed and satellite coverage improved over the years, some individuals may have several positions every day and others only a few positions every second or third day. Also, the length of the tracking duration varies substantially between the individual porpoises. This means that some individuals will be overrepresented in the analysis. However, our priority was to include all available data and therefore all positions that passed the filter were included. For details on tracking duration and number of positions for all individuals see Appendix Table A1.

We believe that all the tagged porpoises included in this report belong to the Belt Sea population (99 porpoises were tagged within the Belt Sea management unit, and 12 porpoises were tagged at Skagen (North Sea population area), but afterwards moved south into the Belt Sea area (Figure 1 and Appendix Table 1A). It cannot be ruled out that some of the porpoises might belong to the Baltic proper population, as 7 of these swam east of the 13.5-degree longitude that was proposed as a transition zone (gap area) between the Belt Sea and the Baltic Proper porpoise populations (Sveegaard et al. 2015, Carlén et al. 2018). Especially the mature female shown in Figure 53 was using the area throughout the breeding season and contributed most of the positions in the transition zone or gap area.

The assignment of each of the tagged porpoises to a specific population await ongoing genetic analysis.

The latest abundance estimate for the Belt Sea population was made in 2020 (Unger et al. 2021). A total of 17,301 harbour porpoises (95 % CI = 11,695-25,688; CV = 0.20), with an average density of 0.41 individuals / km² (95 % CI = 0.28-0.61) was estimated to be in the Belt Sea porpoise population management area during summer 2020. The number of tagged porpoises included in this report only represent 0.64 % of the total population. Although this might seem as a low number, the combined contact duration for all 111 tagged porpoises represents almost 33 years of porpoise life during 1997-2021. As the porpoises are generally wide ranging within the population area, we consider the data set relatively robust to both spatial use, individual differences, time of year and inter-year variations. Independent methods have been used to verify the high-density areas obtained by tagging porpoises (Sveegaard et al. 2011b, Mikkelsen et al. 2016).

Pound nets are not used in the waters of Skåne. Thus, none of the porpoises were tagged in these waters. However, a few were tagged in the nearby region at Mosede Havn, Faxe Ladeplads and Helnæs (Figure 1). Only a few porpoises were caught in the western Baltic, which is likely due to the lower density of porpoises in this area. Despite this, the movements of porpoises show that the tagged porpoises roam widely within the Belt Sea population area. It is therefore likely that the tagging location within the population range is not of major importance when interpreting important habitats within the Belt Seas based on the dataset presented in this report (see also Sveegaard et al. 2011a).

Section 1 - Belt Sea and gap area

This section includes all 9001 positions from 111 porpoises tagged within the Belt Sea population management unit during 1997-2021. The maps include all locations within the Belt Sea and gap area. The other sections with detailed maps below are also indicated. All seasons are based on 30-77 individuals and more than 1000 positions (range: 1028-3088 positions) and may be considered a robust dataset and covers the distribution of the population.

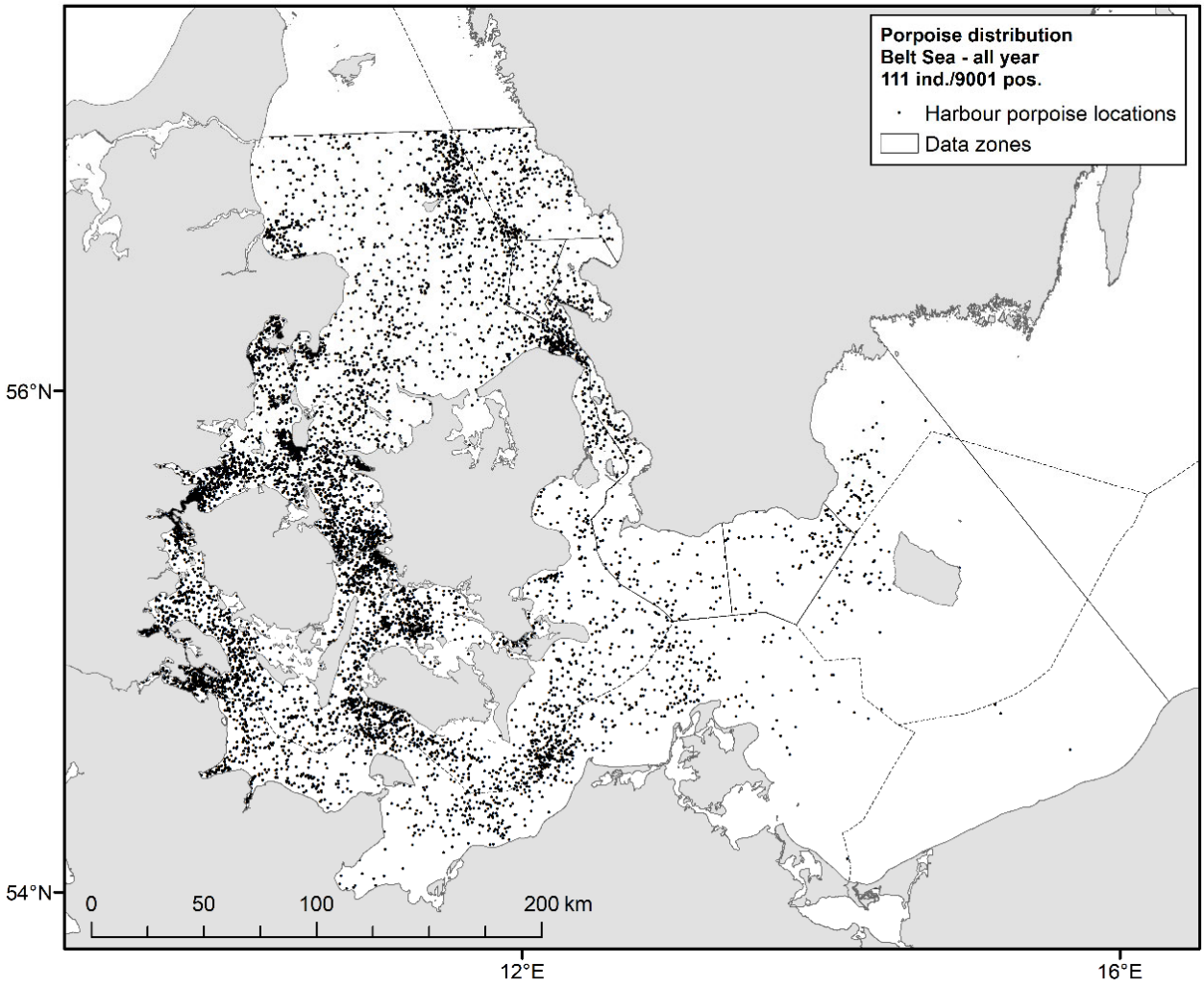


Figure 3a. Distribution data on the 111 harbour porpoises tracked within the Belt Sea and gap area (see text for definition) showing all locations.

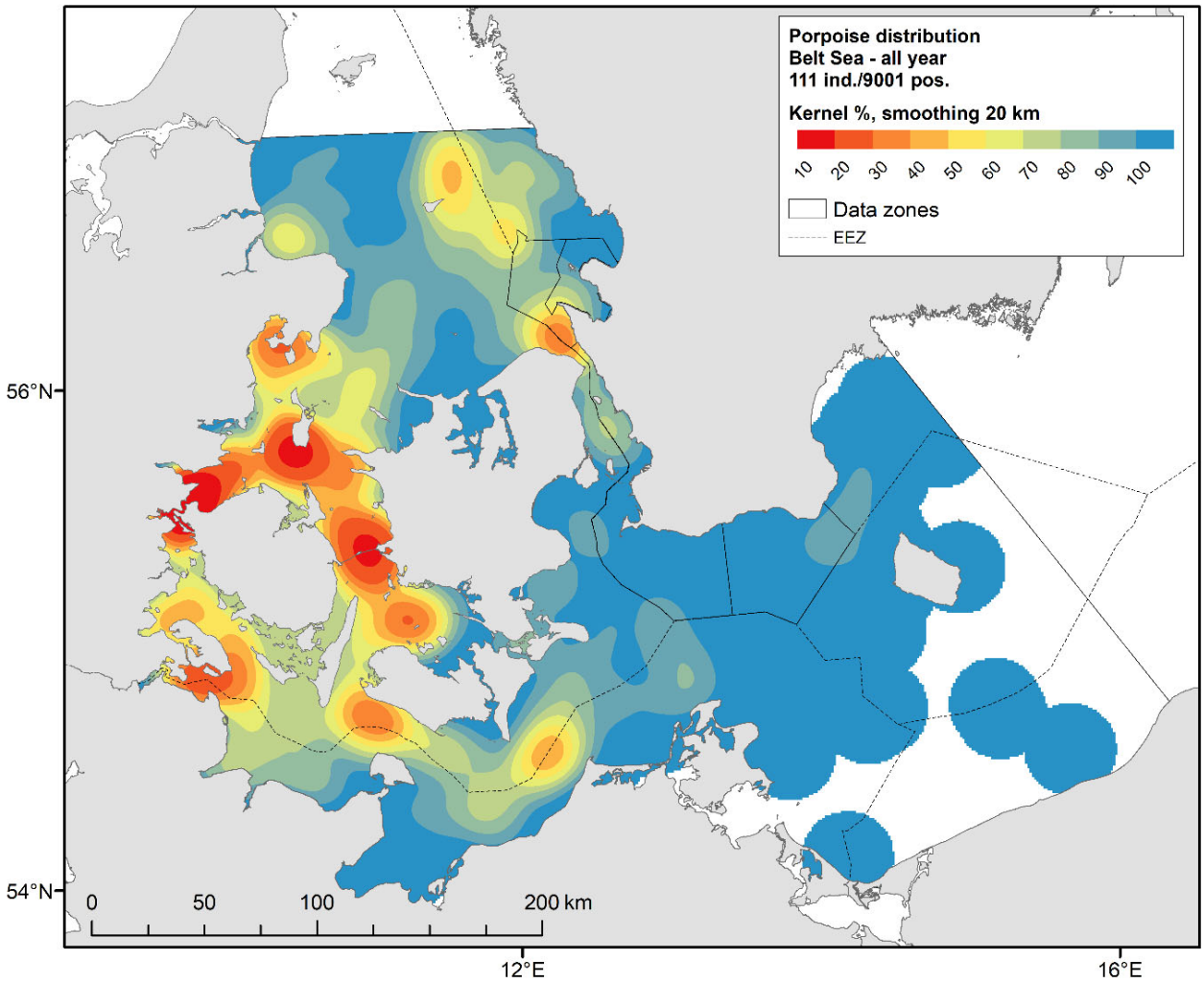


Figure 3b. Distribution data on the 111 harbour porpoises tracked within the Belt Sea and gap area (see text for definition) showing Kernel plots of all positions year round (smoothing factor of 20 km).

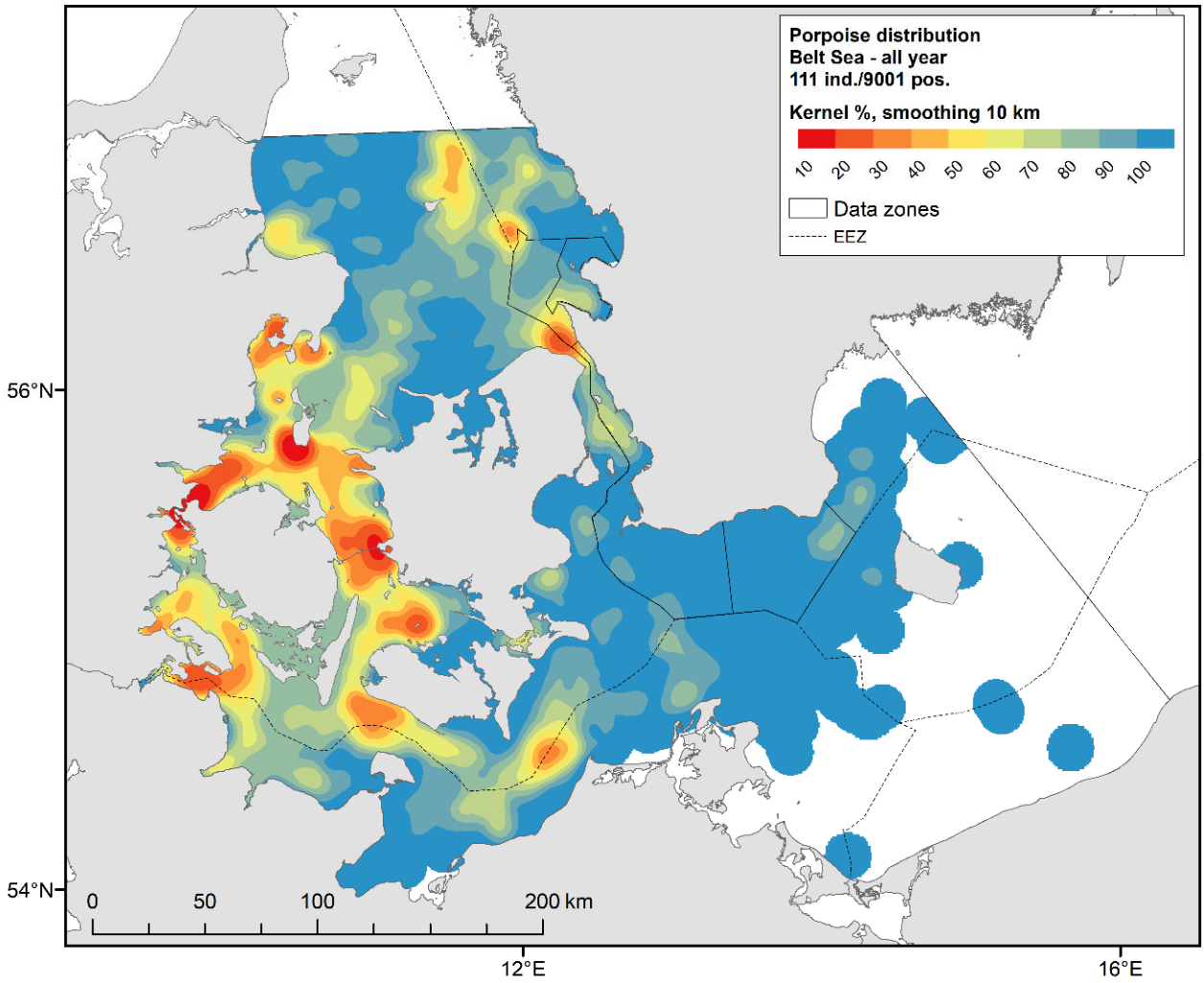


Figure 3c. Distribution data on the 111 harbour porpoises tracked within the Belt Sea and gap area (see text for definition) showing Kernel plots of all positions year round (smoothing factor of 10 km).

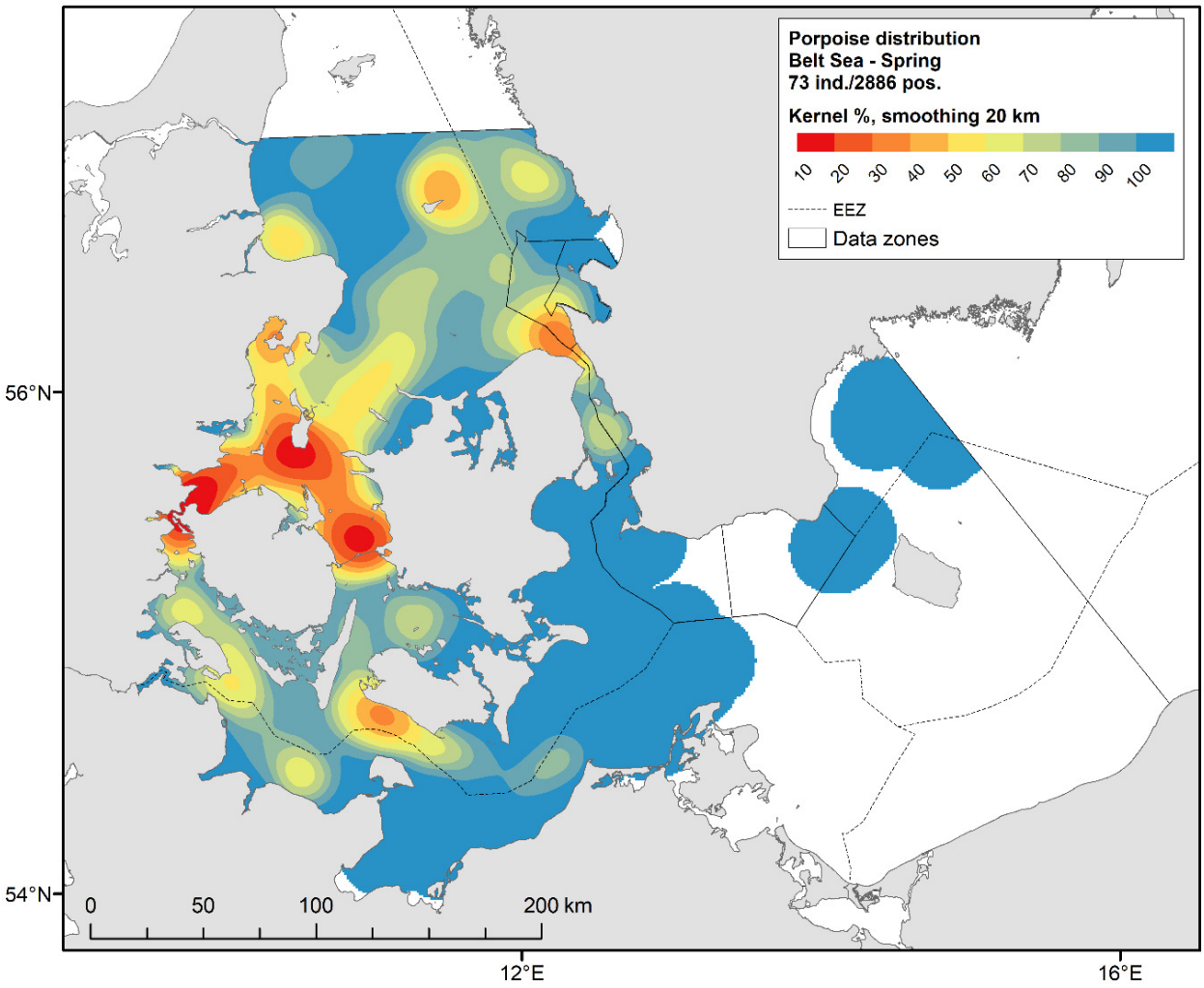


Figure 4. Kernel plots of all porpoises tracked within the Belt Sea and gap area (see text for definition) during Spring (March-May).

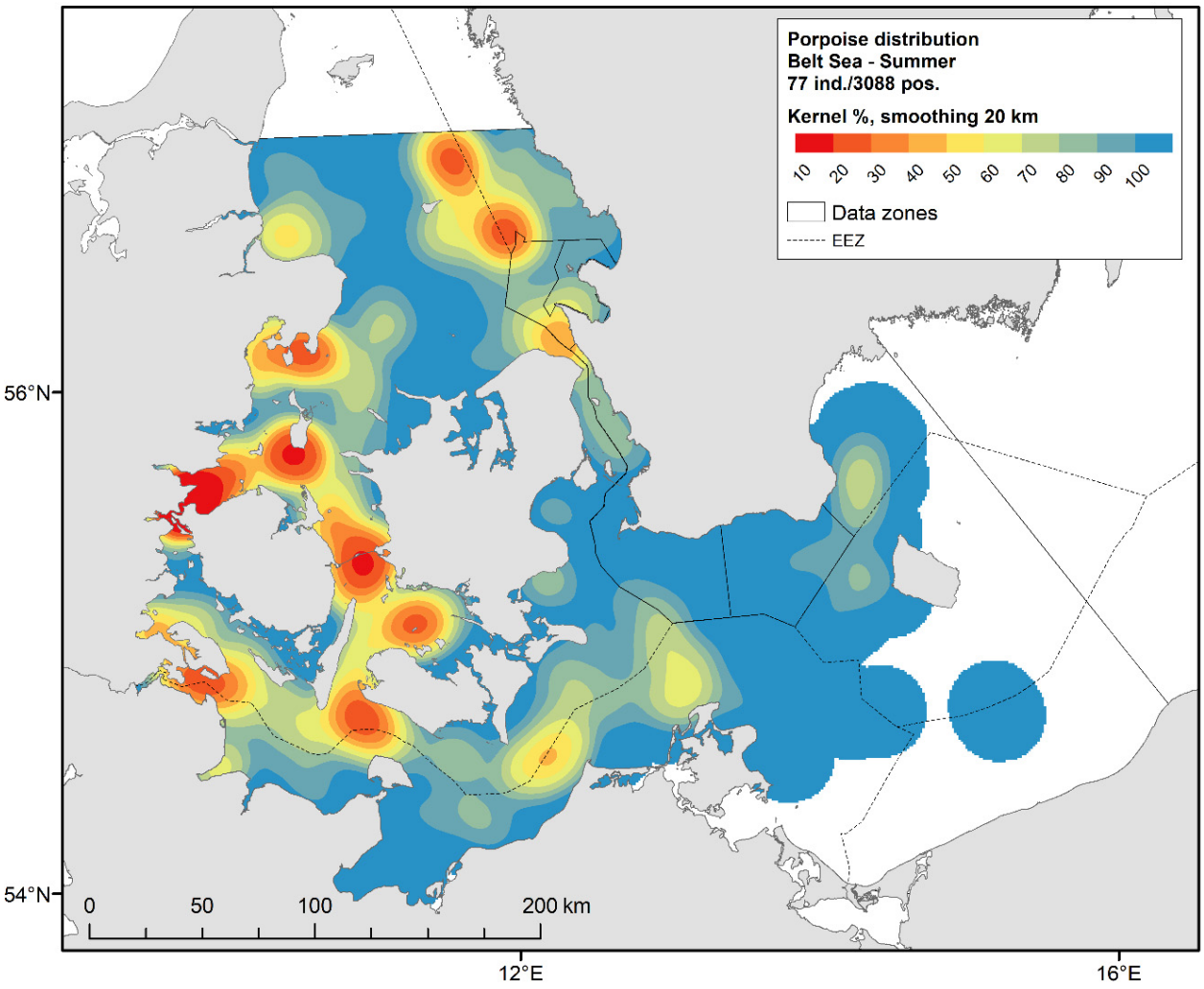


Figure 5. Kernel plots of all porpoises tracked within the Belt Sea and gap area (see text for definition) during Summer (June-August).

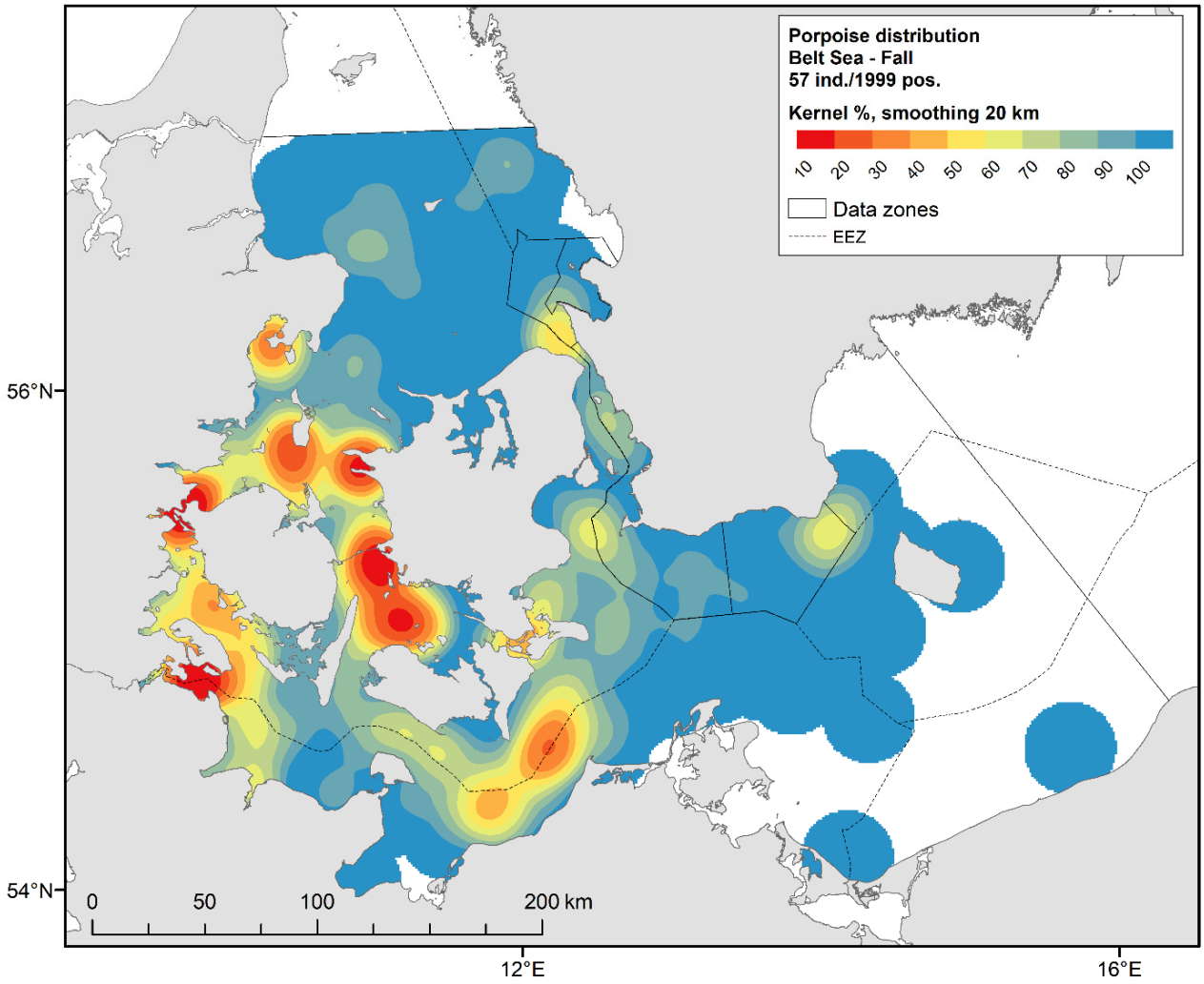


Figure 6. Kernel plots of all porpoises tracked within the Belt Sea and gap area (see text for definition) during Fall (September-November).

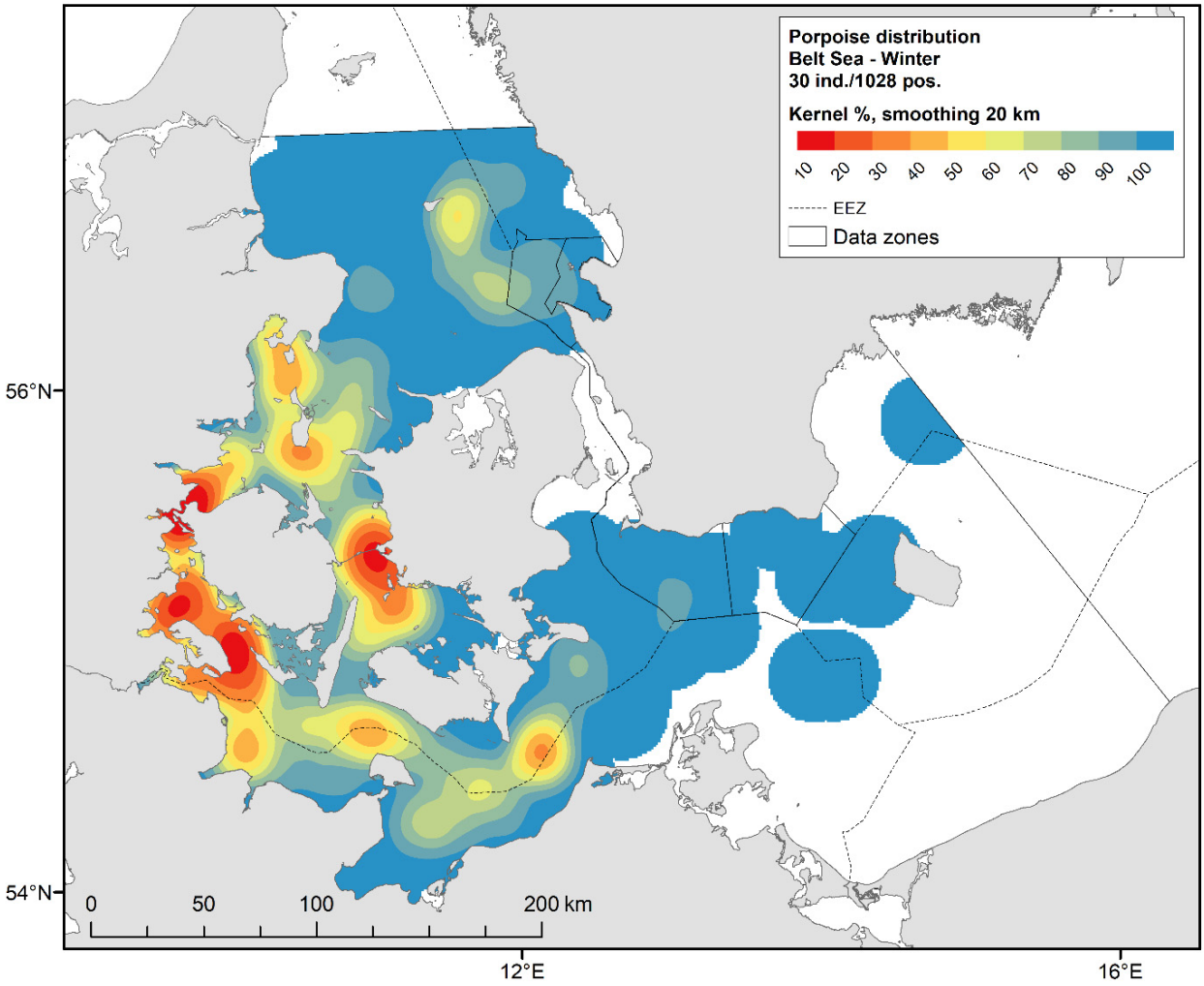


Figure 7. Kernel plots of all porpoises tracked within the Belt Sea and gap area (see text for definition) during Winter (December-February).

Section 2 – Skåne + EEZ

This section includes 454 positions from 37 porpoises tracked within the Skåne + EEZ area during 1997-2021. Each season is based on 24-169 positions from 6-20 individuals and should be interpreted with some caution due to the limited dataset and the fact that this is a subsample of the Belt Sea population area. The number of individual harbour porpoises and number of positions within the Skåne + EEZ are noted in the legend of each figure.

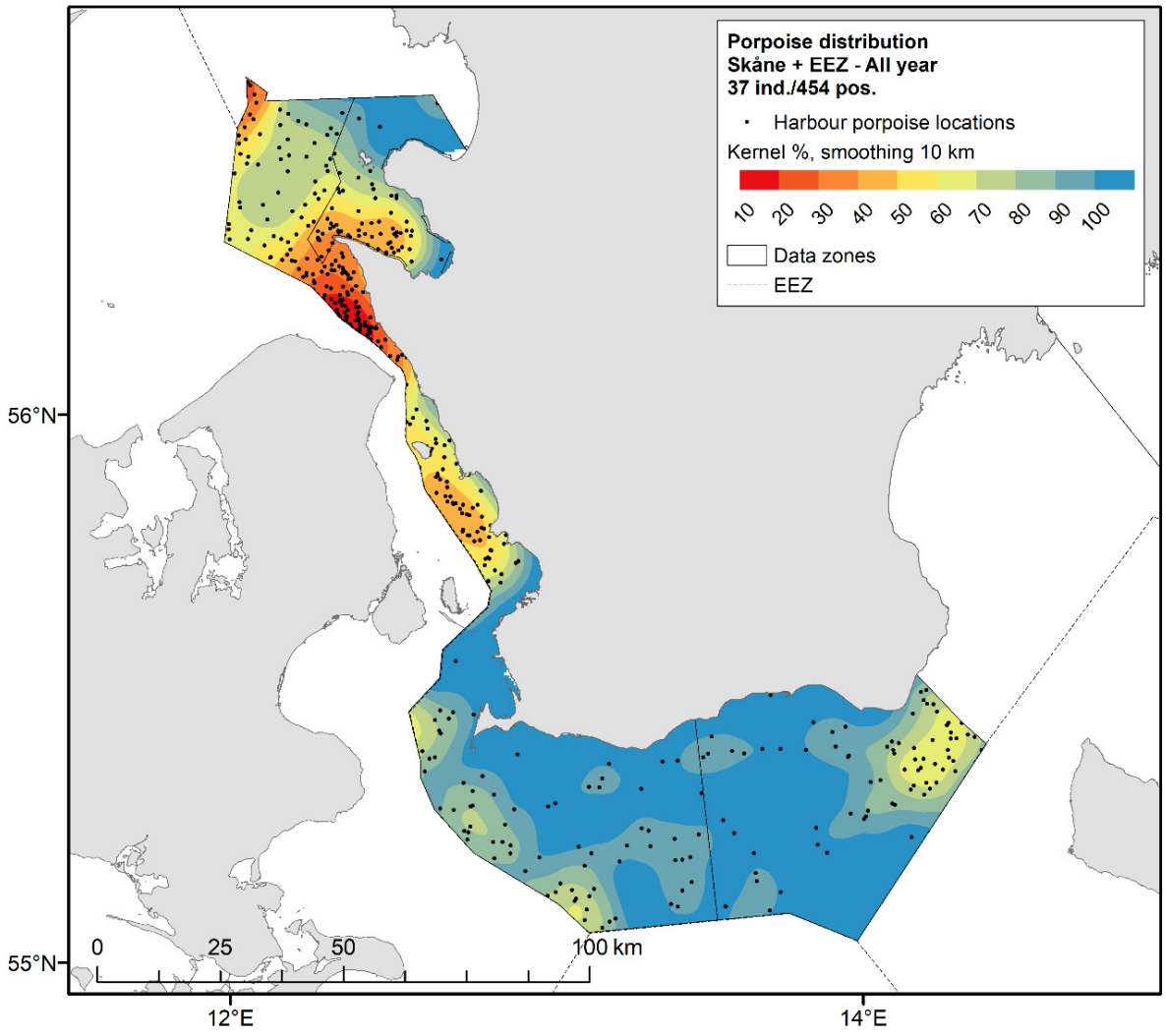


Figure 8. Kernel plots of positions year-round within Skåne + EEZ waters.

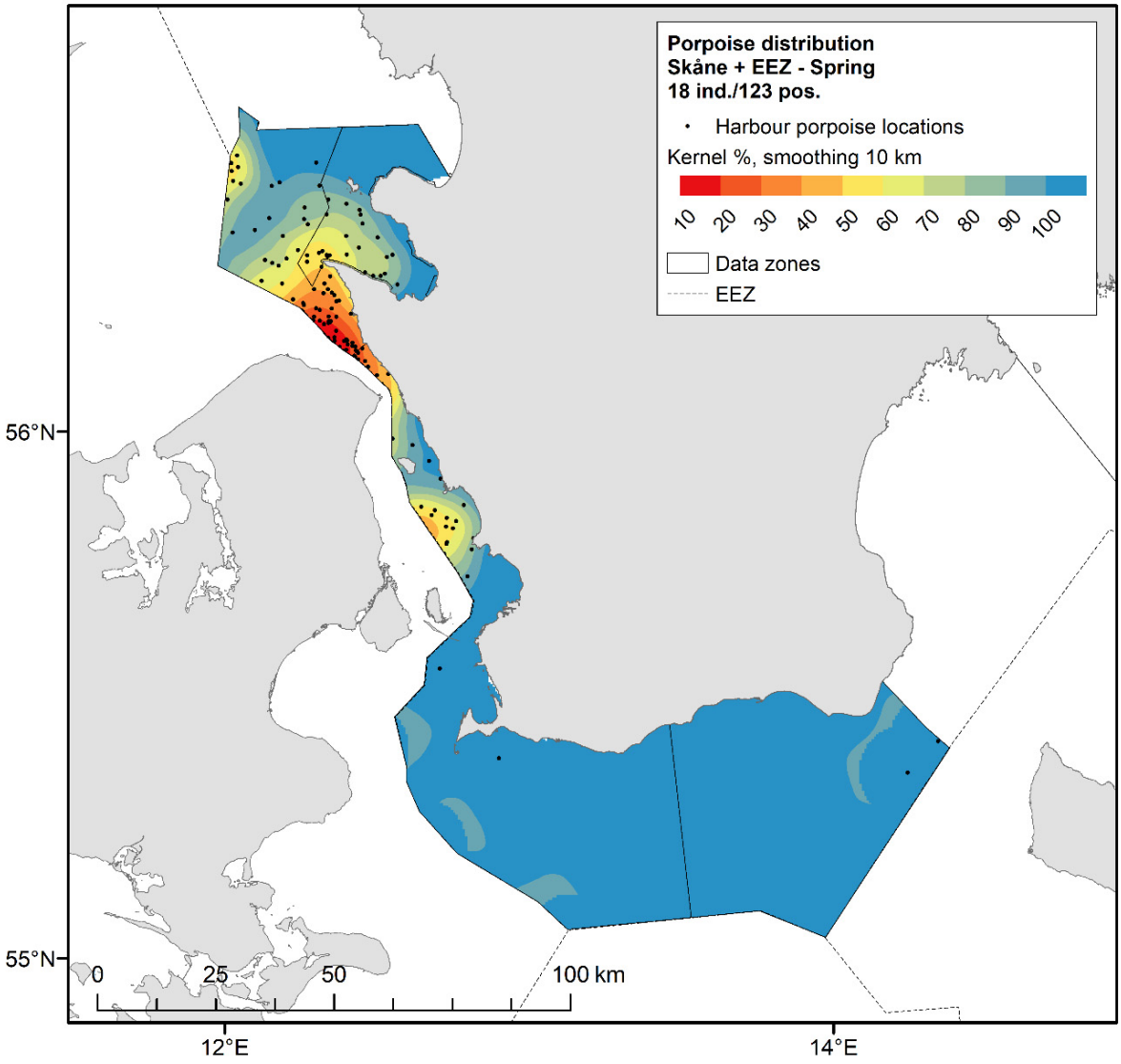


Figure 9. Kernel plots of positions received during Spring (March-May) within Skåne + EEZ waters.

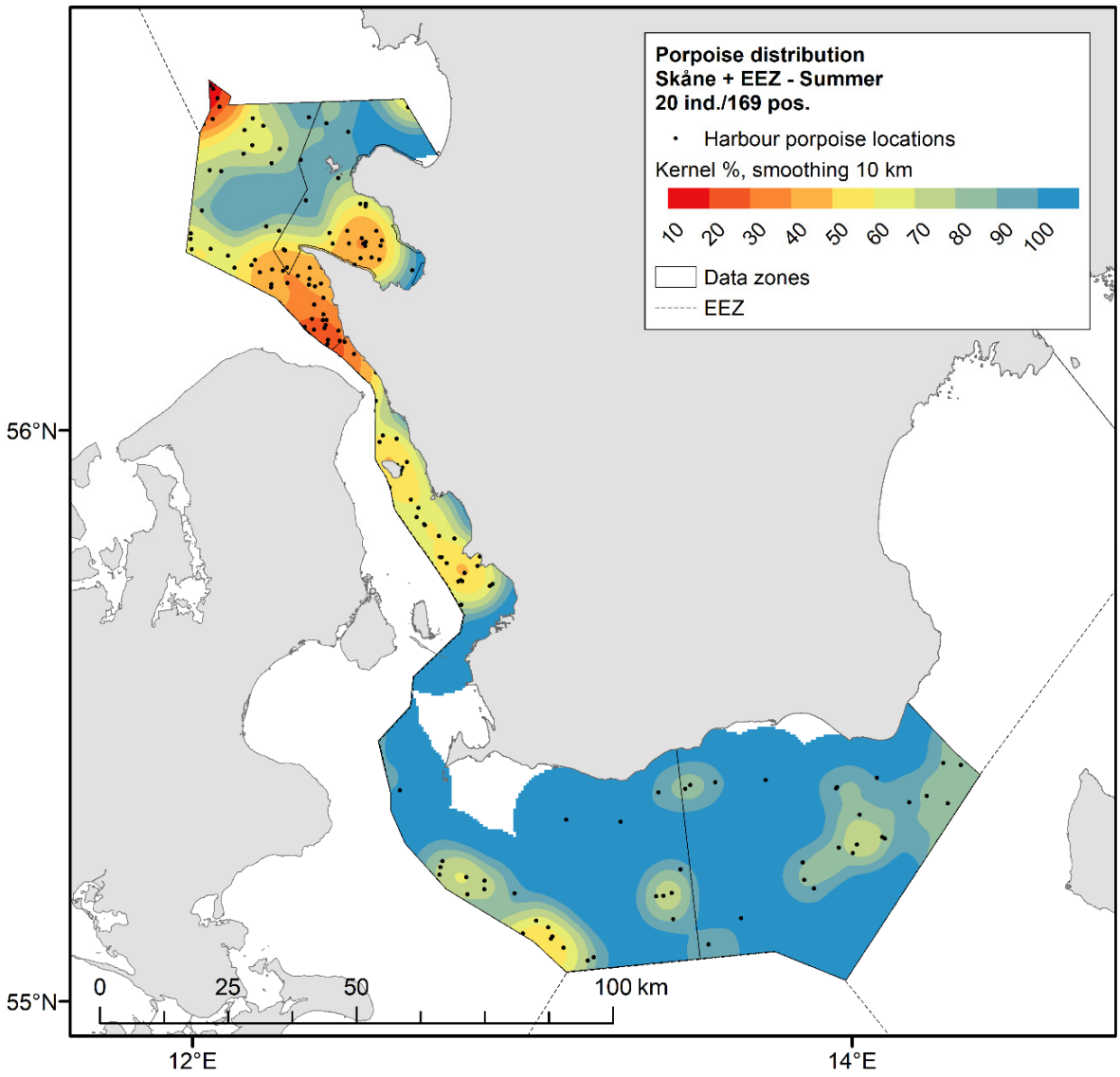


Figure 10. Kernel plots of positions received during Summer (June-August) within Skåne + EEZ waters.

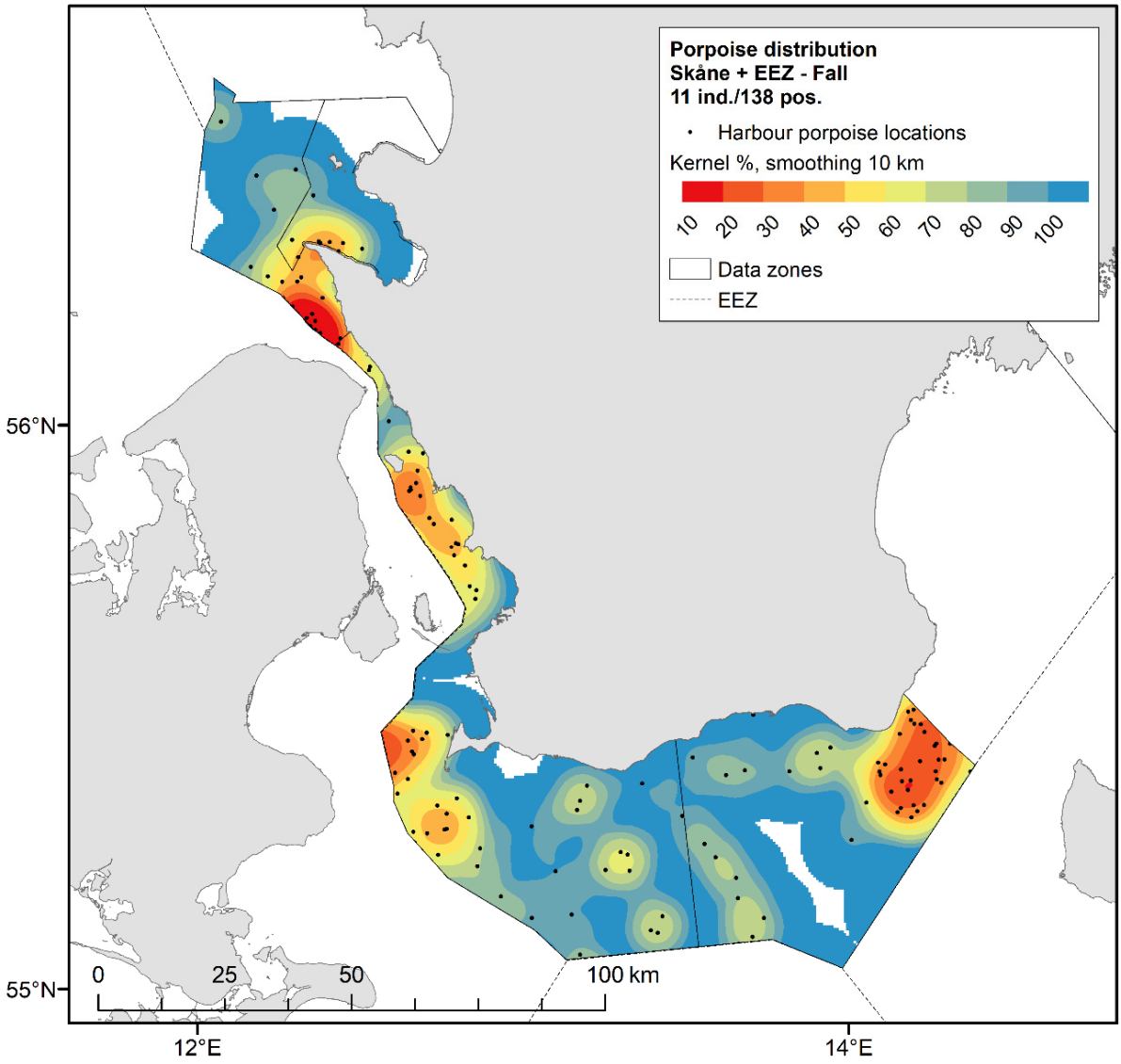


Figure 11. Kernel plots of positions received during Fall (September-November) within Skåne + EEZ waters.

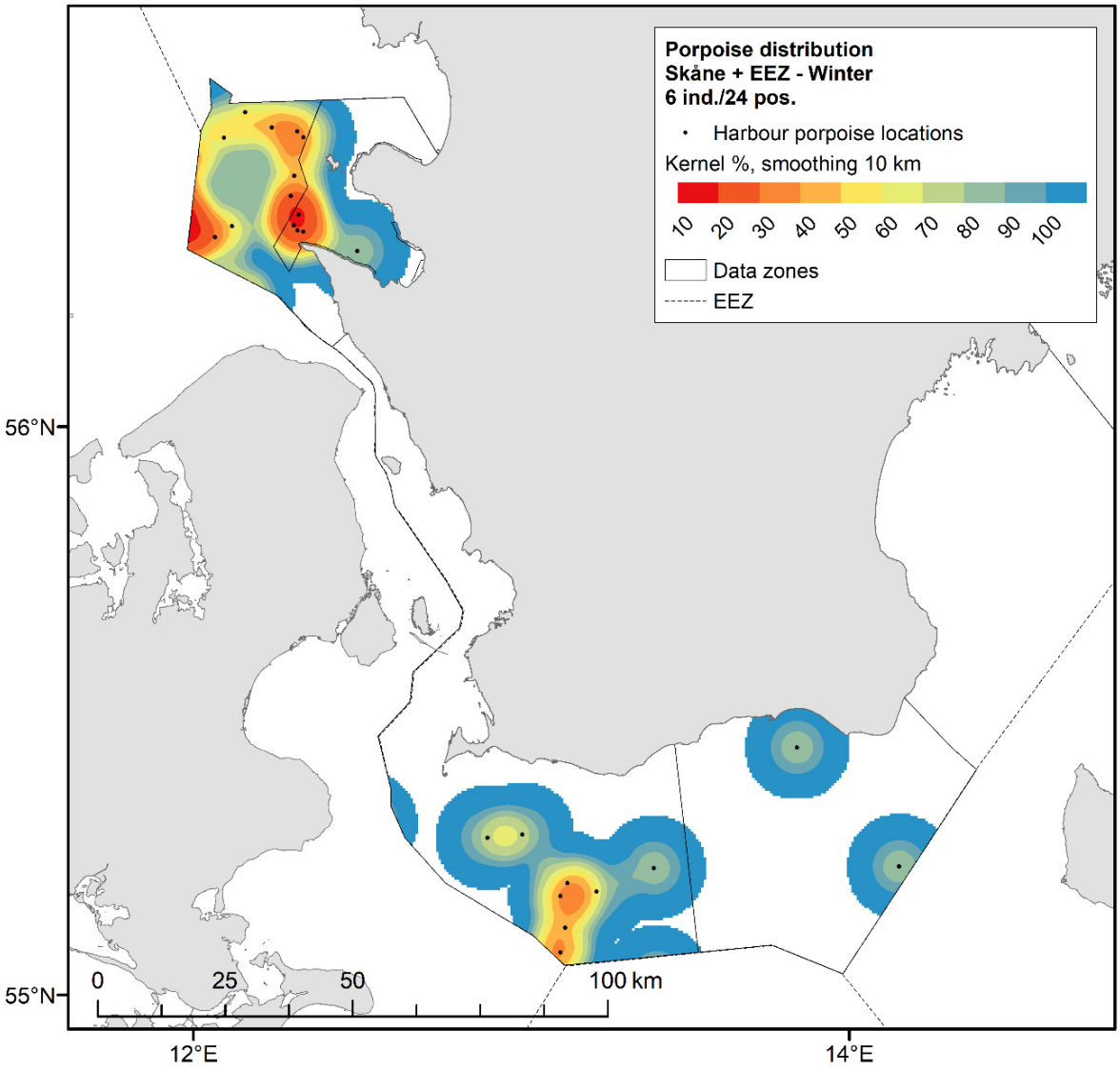


Figure 12. Kernel plots of positions received during Winter (December-February) within Skåne + EEZ waters.

Section 3 - Västerhavet

This section includes 379 positions from 37 porpoises tracked within the Västerhavet area during 1997-2021. Each season is based on 22-146 positions from 4-20 individuals and should be interpreted with some caution due to the limited dataset, and the fact that this is a subsample of the Belt Sea population area. The number of individual harbour porpoises and number of positions within Västerhavet are noted in the legend of each figure.

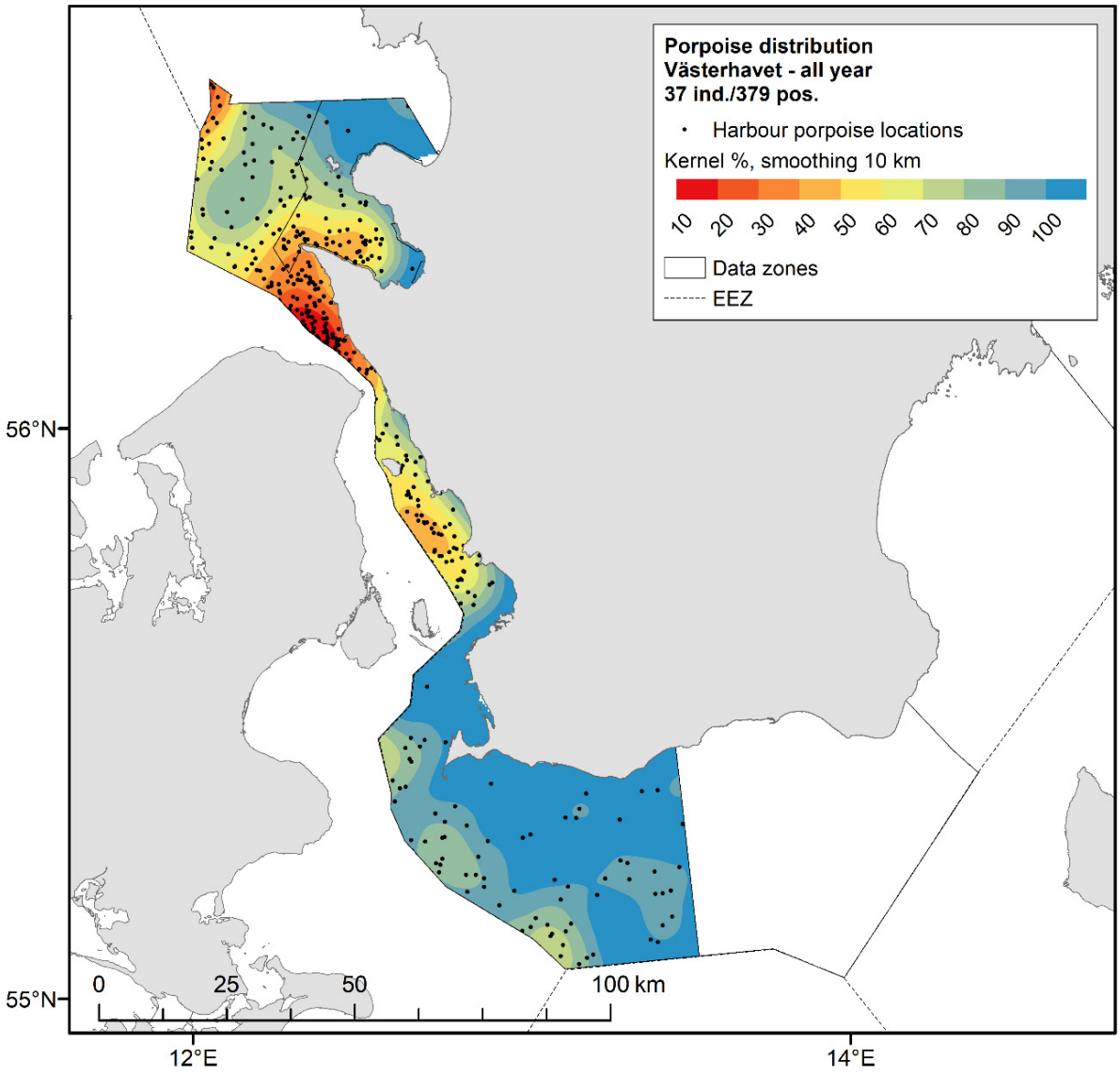


Figure 13. Kernel plots of positions received all year within Västerhavet waters.

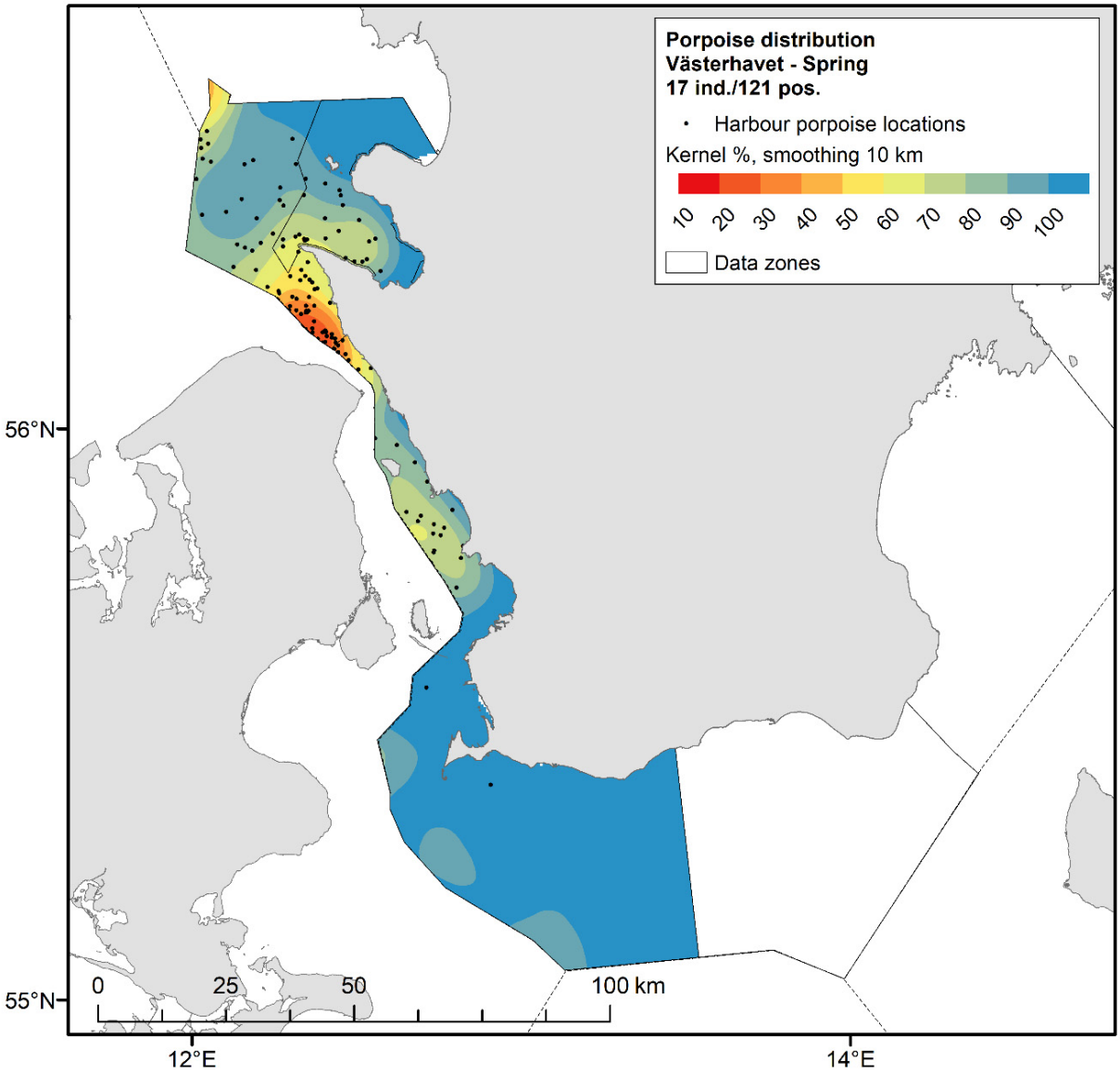


Figure 14. Kernel plots of positions received during Spring (March-May) within Västerhavet waters.

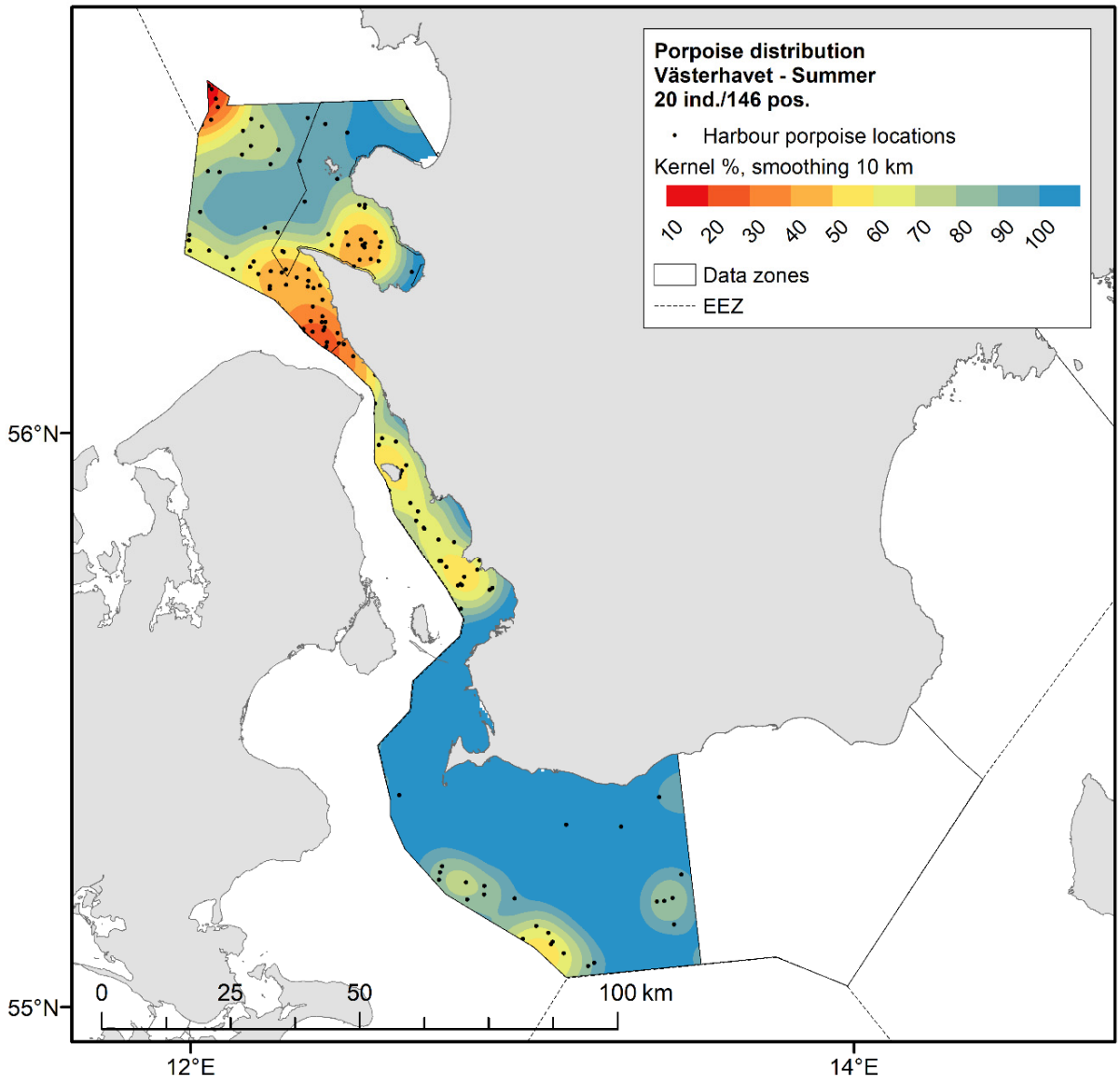


Figure 15. Kernel plots of positions received during Summer (June-August) within Västerhavet waters

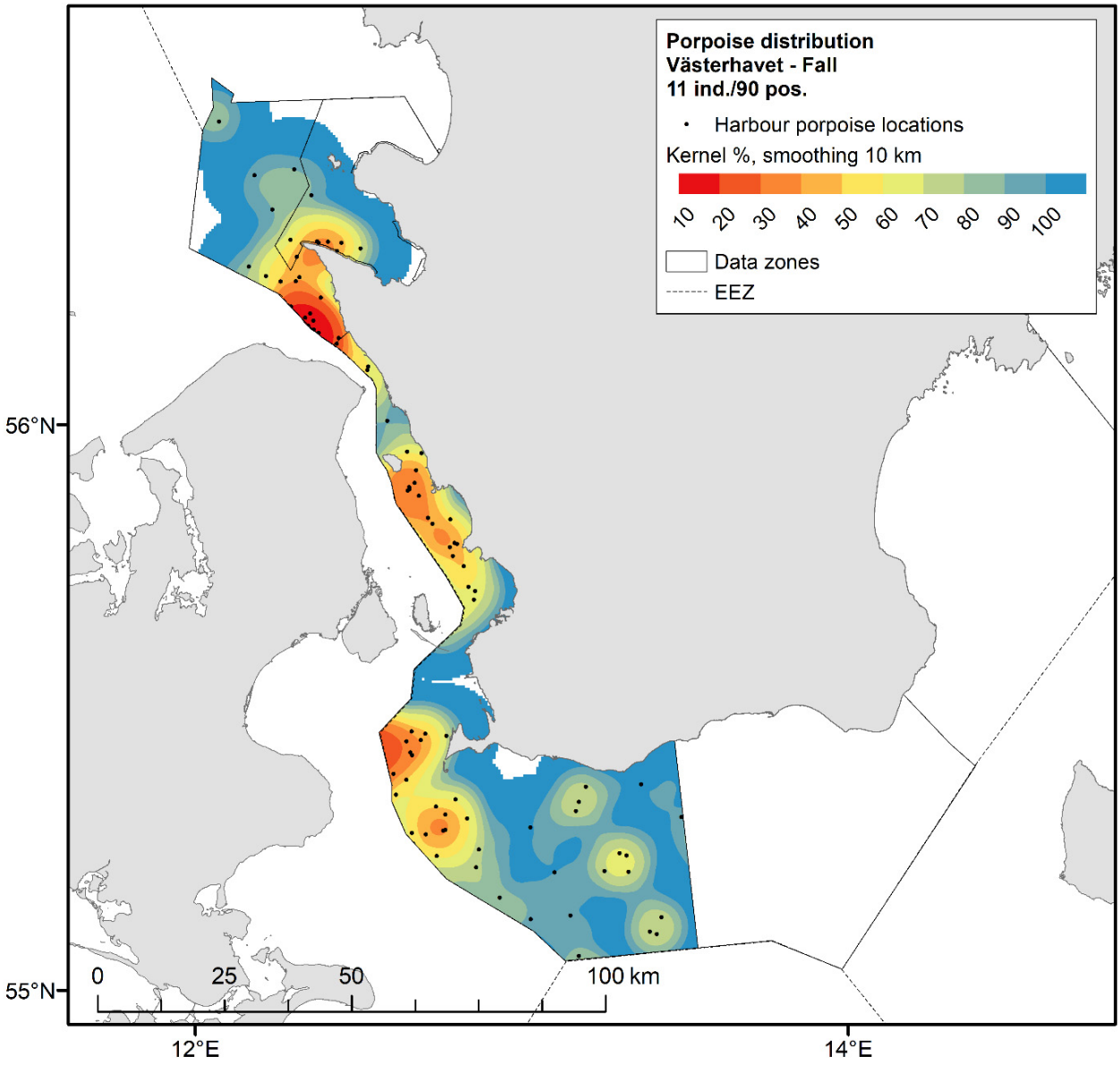


Figure 16. Kernel plots of positions received during Fall (September-November) within Västerhavet waters.

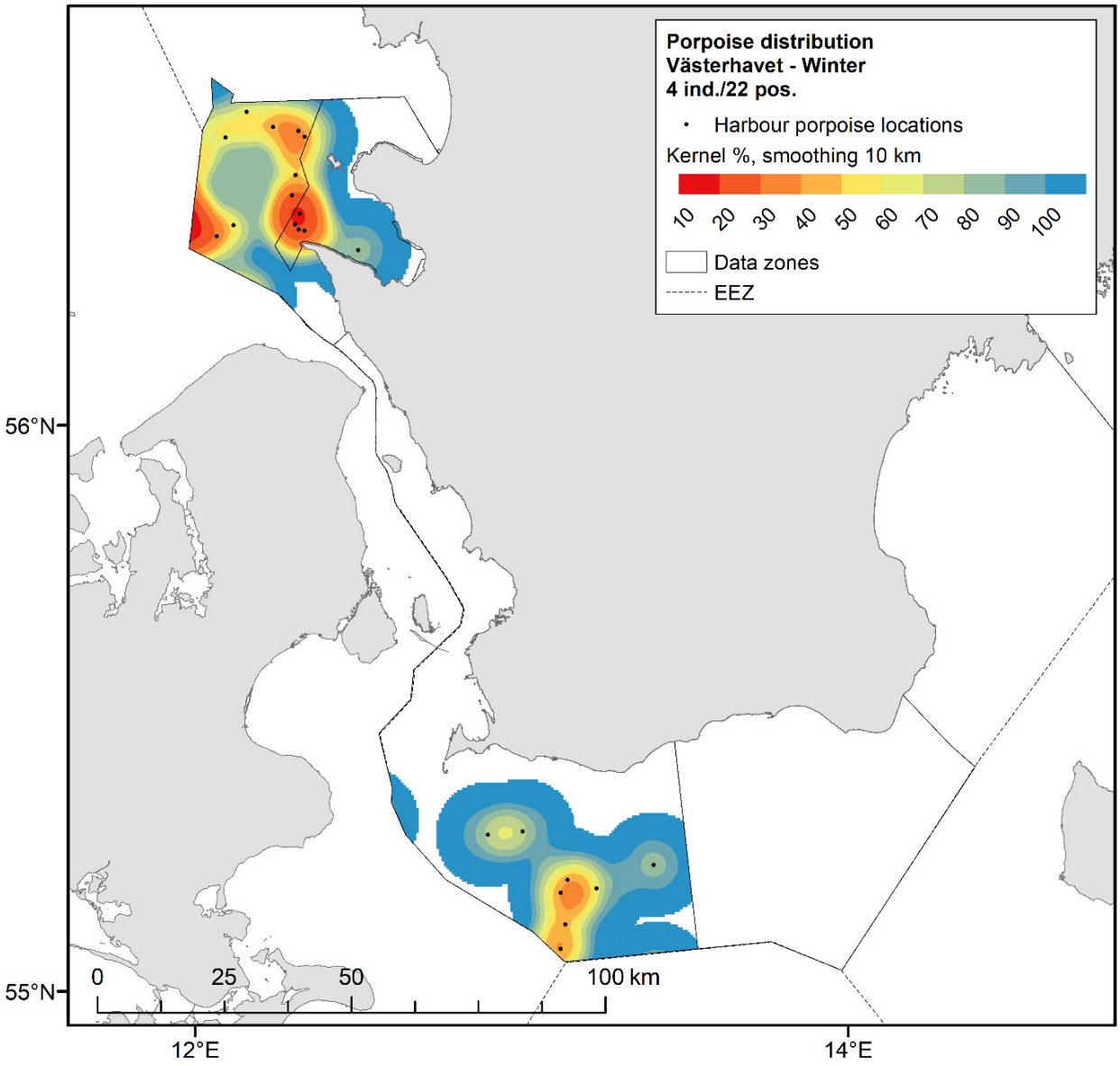


Figure 17. Kernel plots of positions received during Winter (December-February) within Västerhavet waters.

Section 4 - NV Skåne

This section includes 222 positions from 33 porpoises tracked within the NV Skåne area during 1997-2021. Each season is based on 14-92 positions from 3-16 individuals and should be interpreted with considerable caution due to the limited dataset and the fact that this is a subsample of the Belt Sea population area. The number of individual harbour porpoises and number of positions within the NV Skåne area are noted in the legend of each figure.

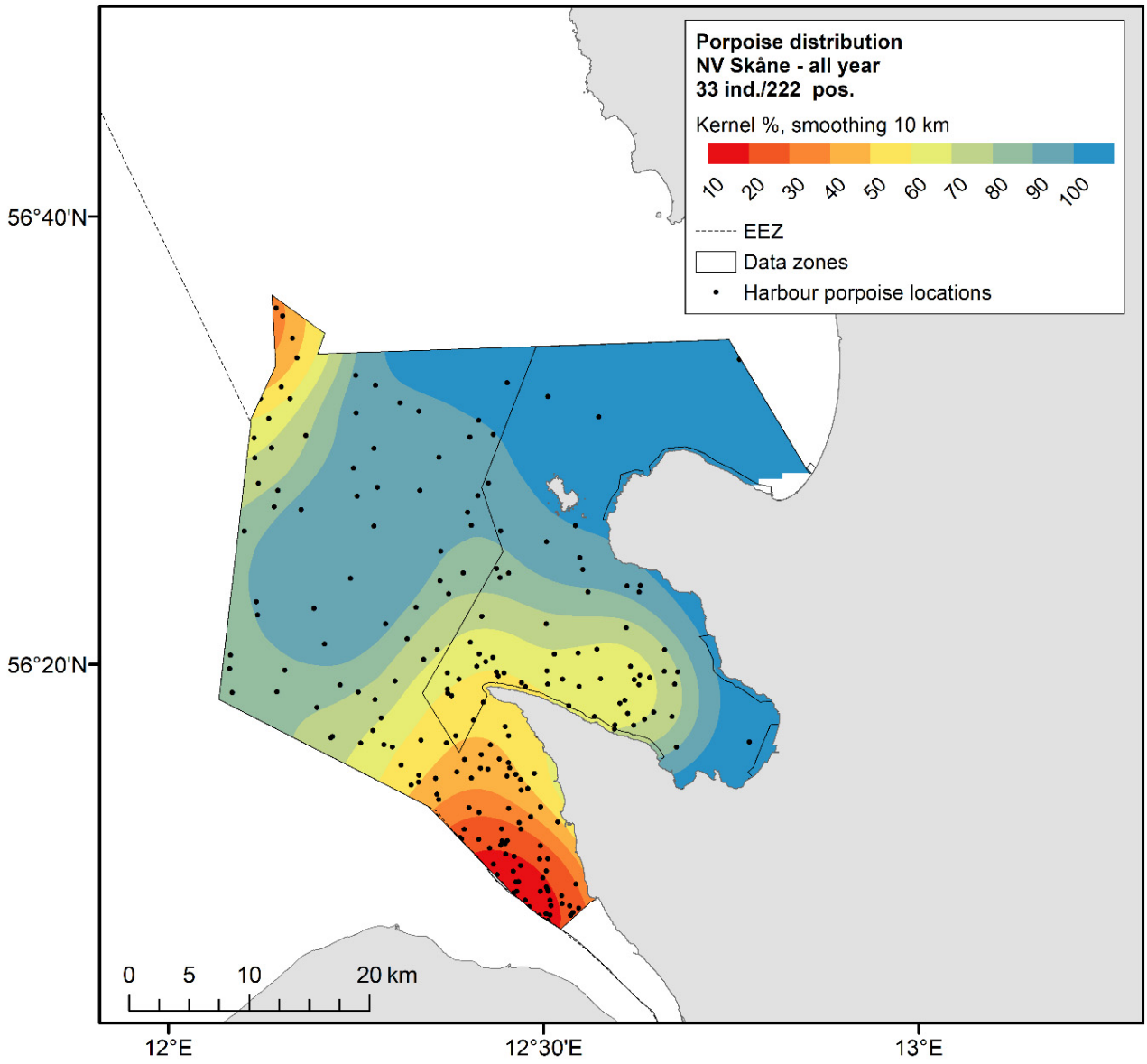


Figure 18. Kernel plots of all positions received all year within NV Skåne waters.

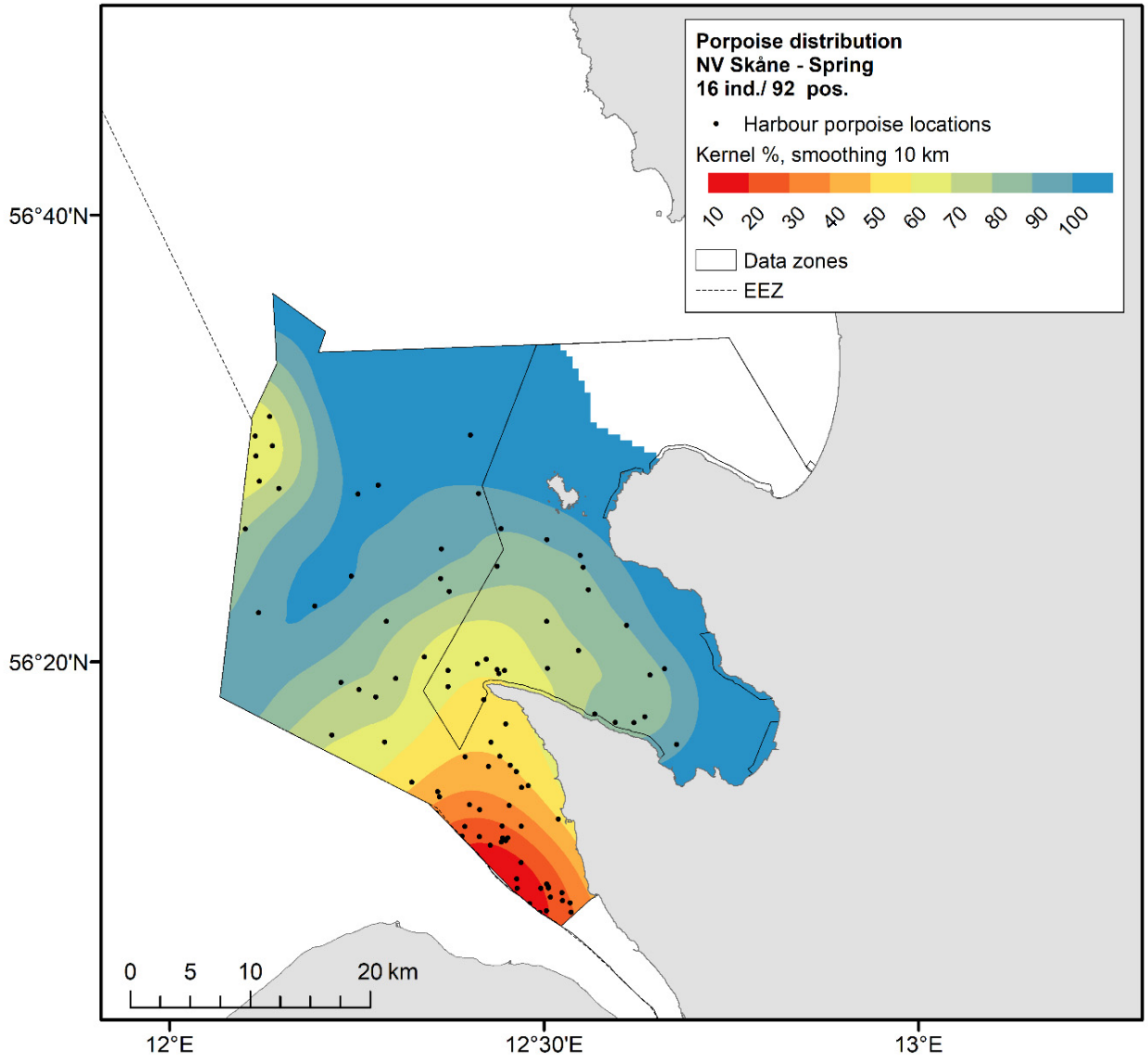


Figure 19. Kernel plots of positions received during spring (March-May) within NV Skåne waters.

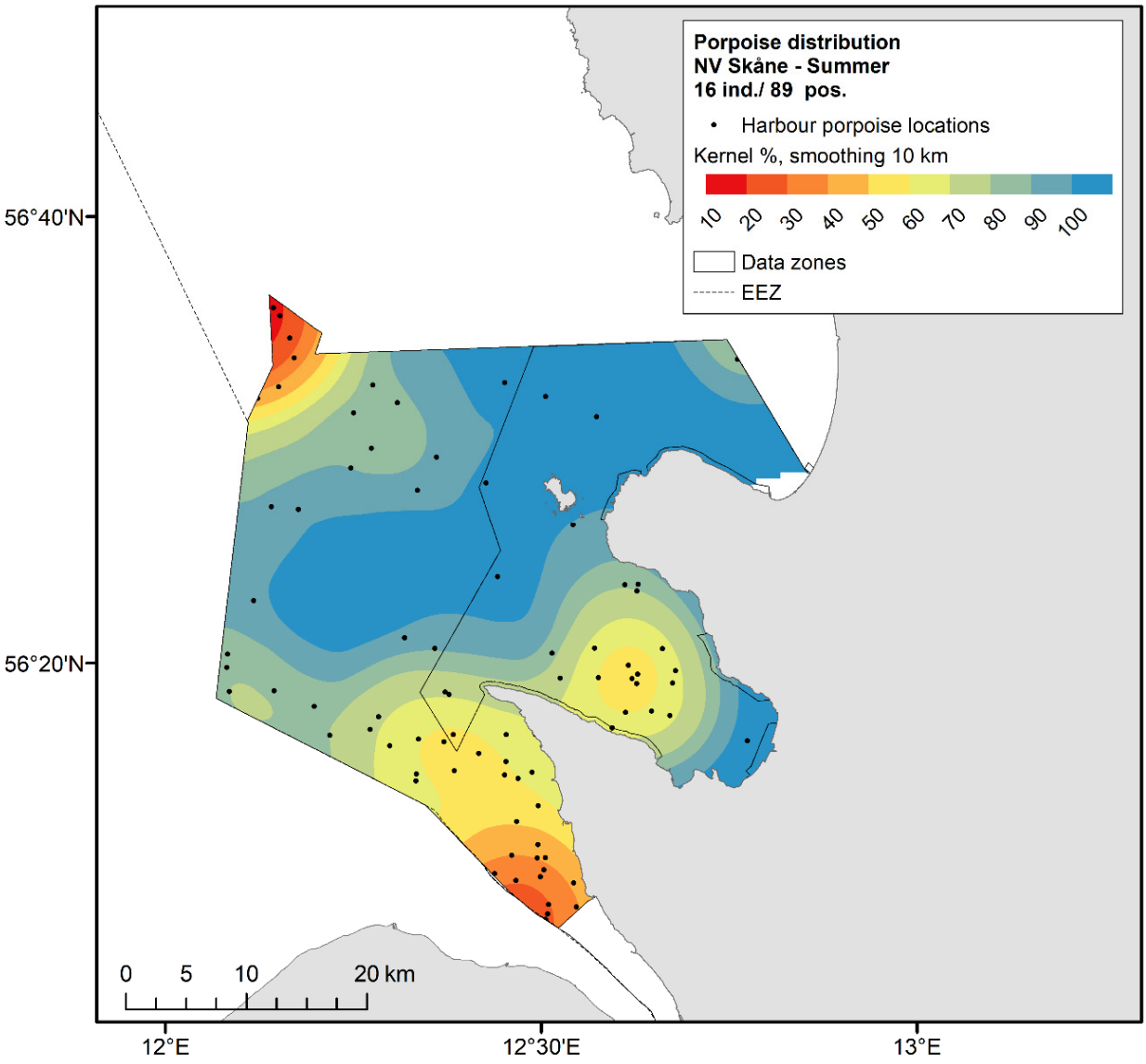


Figure 20. Kernel plots of positions received during summer (June-August) within NV Skåne waters.

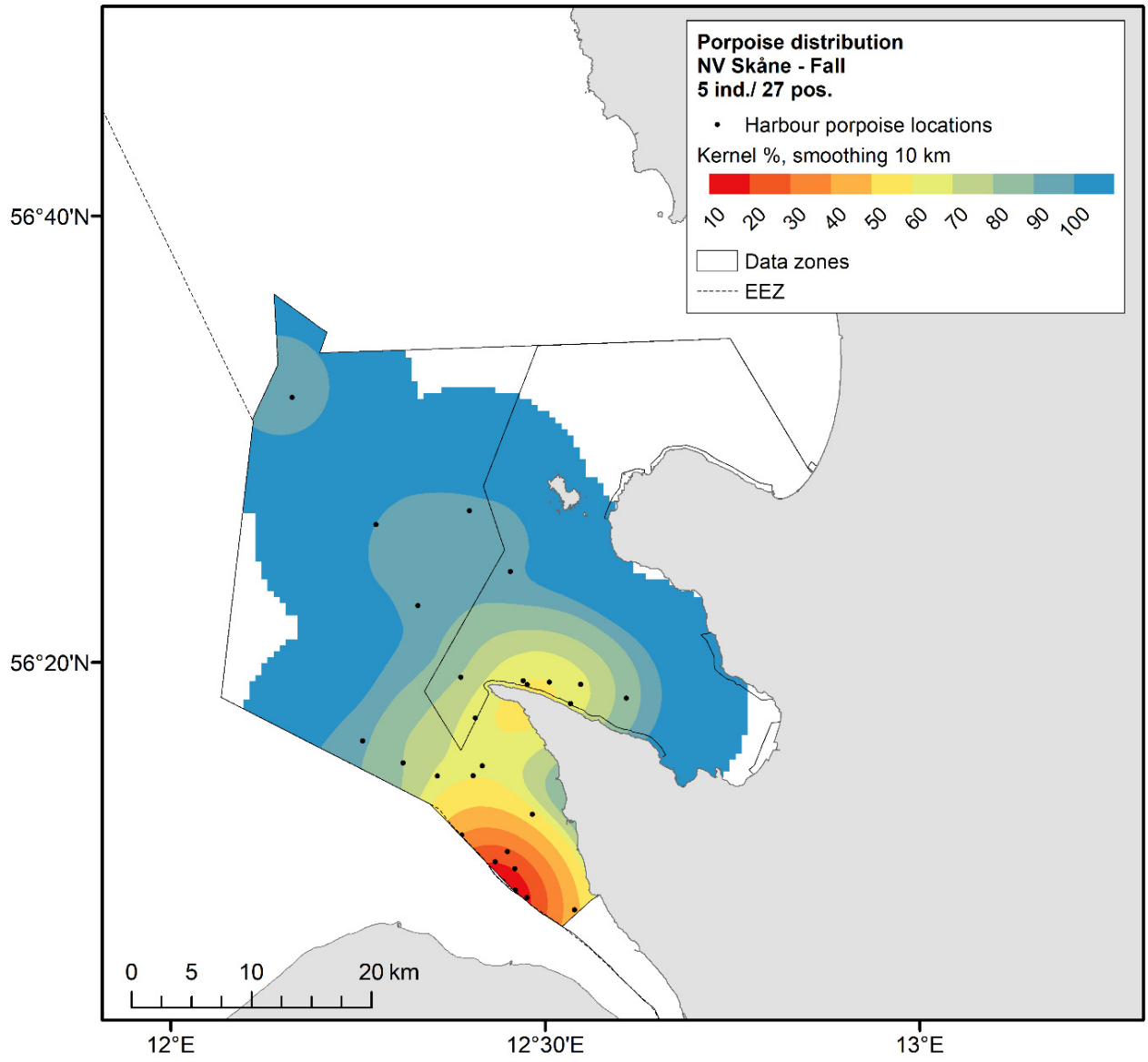


Figure 21. Kernel plots of positions received during Fall (September-November) within NV Skåne waters.

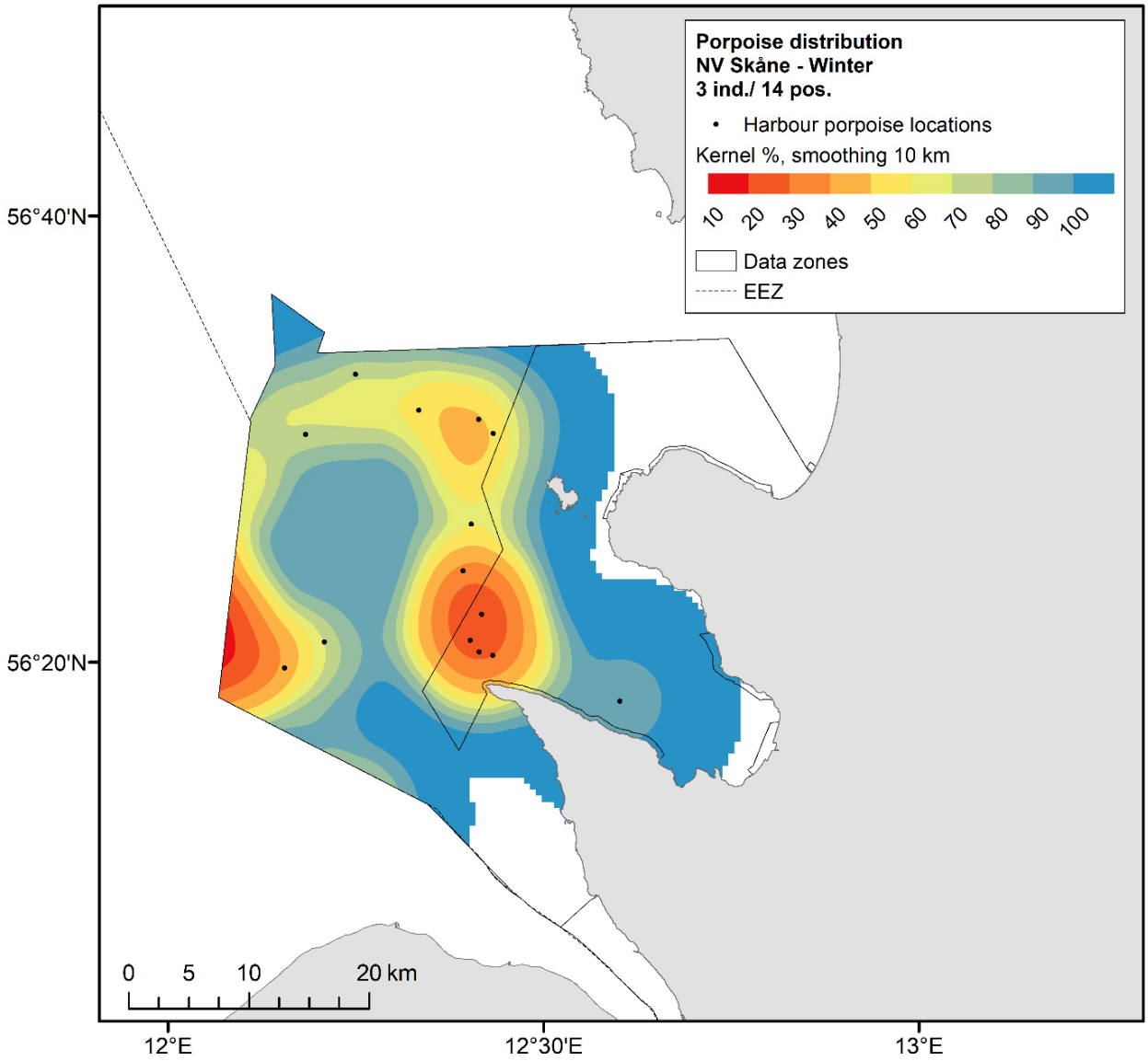


Figure 22. Kernel plots of positions received during Winter (December-February) within NV Skåne waters.

Section 5 - Fiskereguleringsområde A

This section includes 66 positions from 17 porpoises tracked within the Fiskereguleringsområde A during 1997-2021. Each season is based on 5-27 positions from 1-9 individuals and should be interpreted with great caution due to the limited dataset and the fact that this is a subsample of the Belt Sea population area. The number of individual harbour porpoises and number of positions within the Fiskereguleringsområde A area are noted in the legend of each figure.

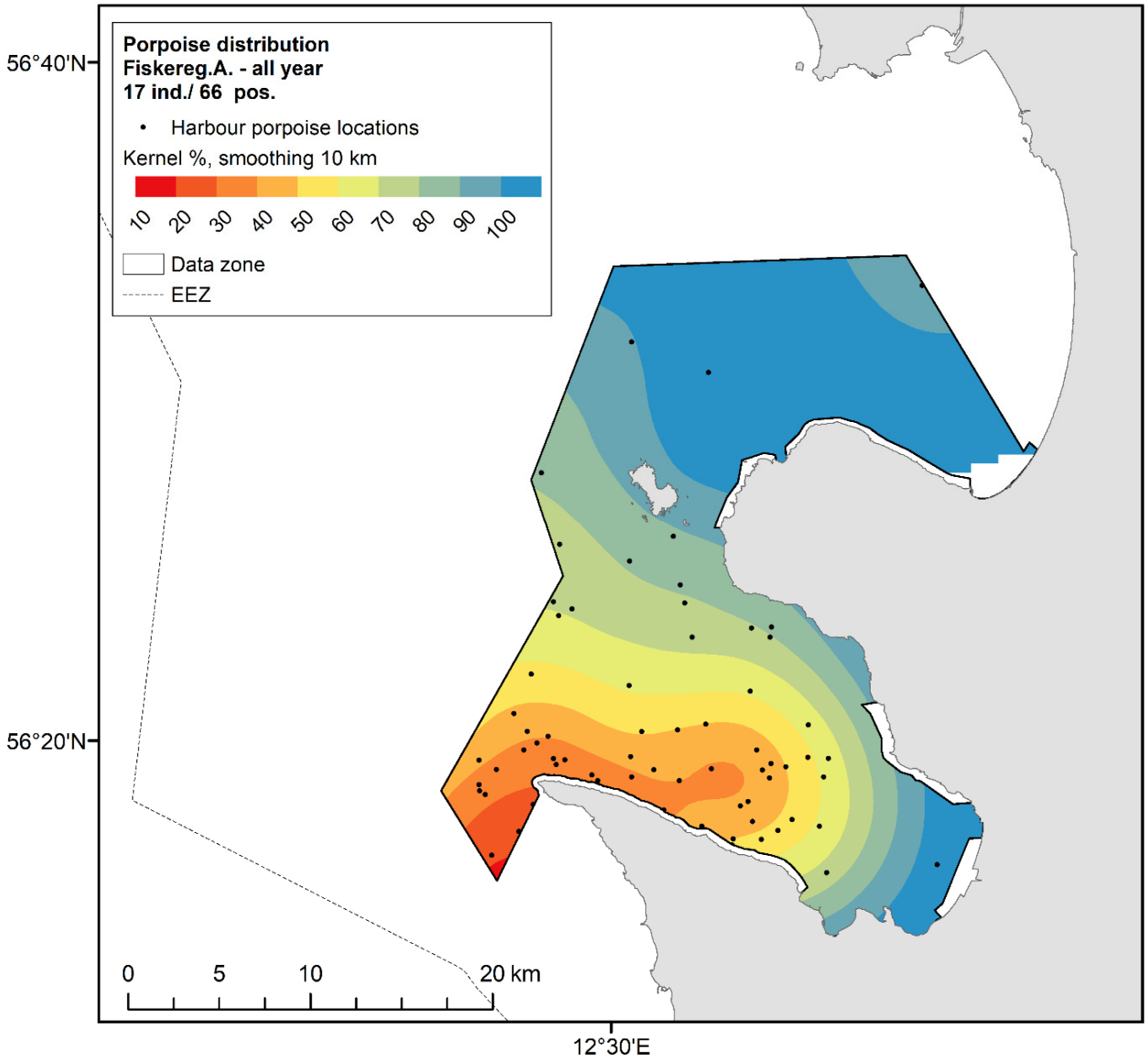


Figure 23. Kernel plots of all positions received All Year within the waters of Fiskereguleringsområde A.

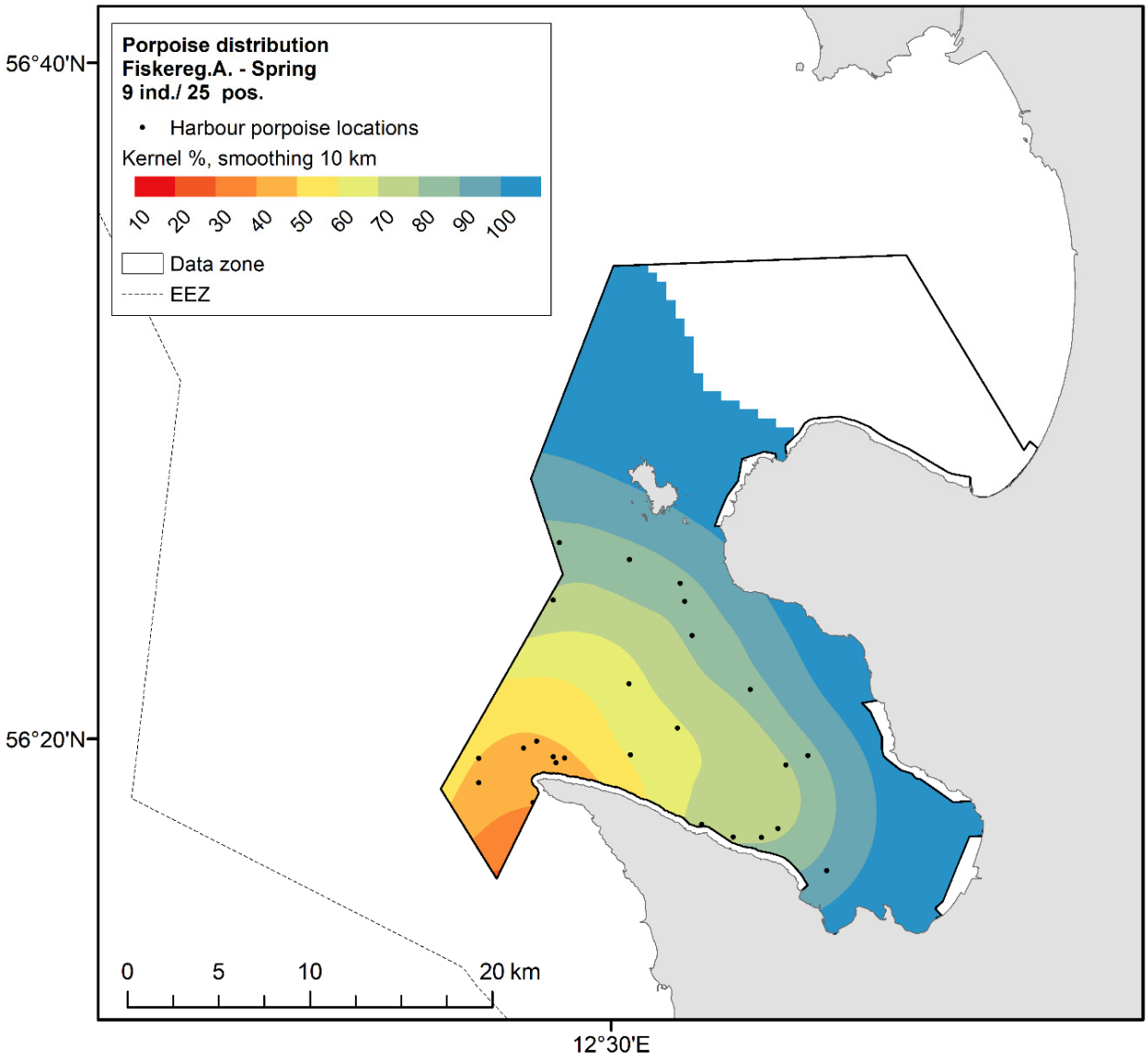


Figure 24. Kernel plots of all positions received Spring within the waters of Fiskereguleringsområde A.

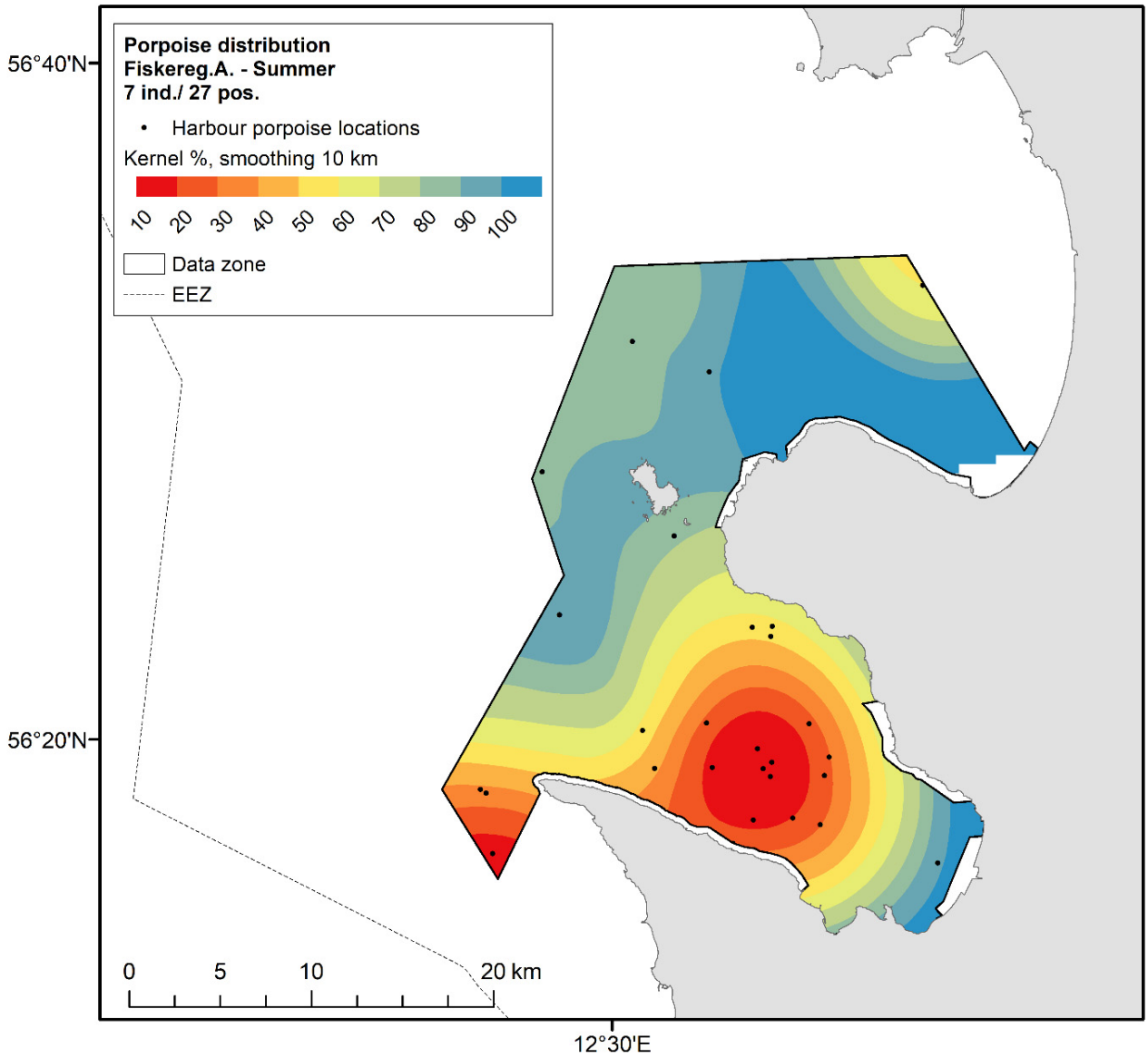


Figure 25. Kernel plots of all positions received Summer within the waters of Fiskereguleringsområde A.

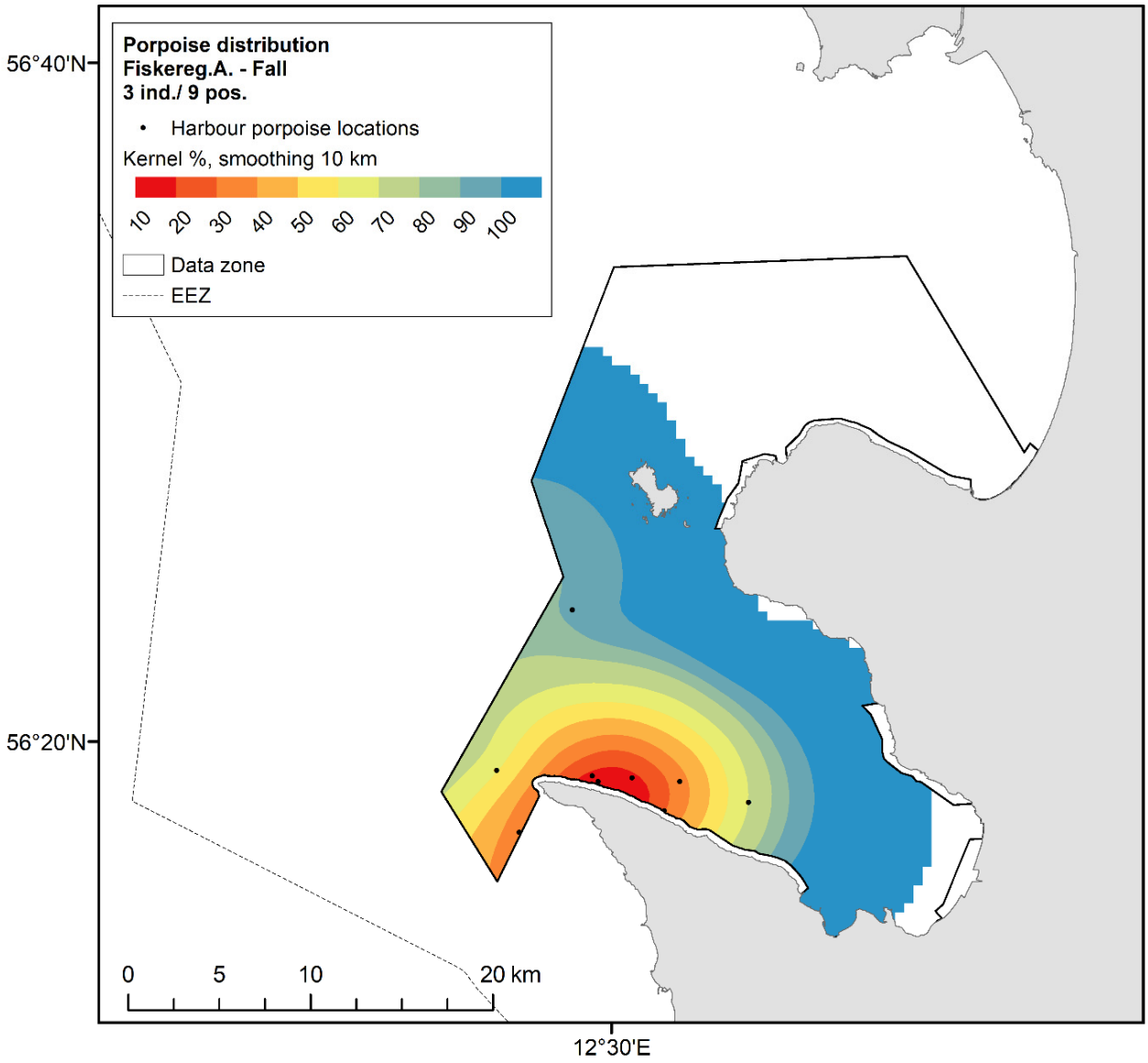


Figure 26. Kernel plots of all positions received Fall within the waters of Fiskereguleringsområde A.

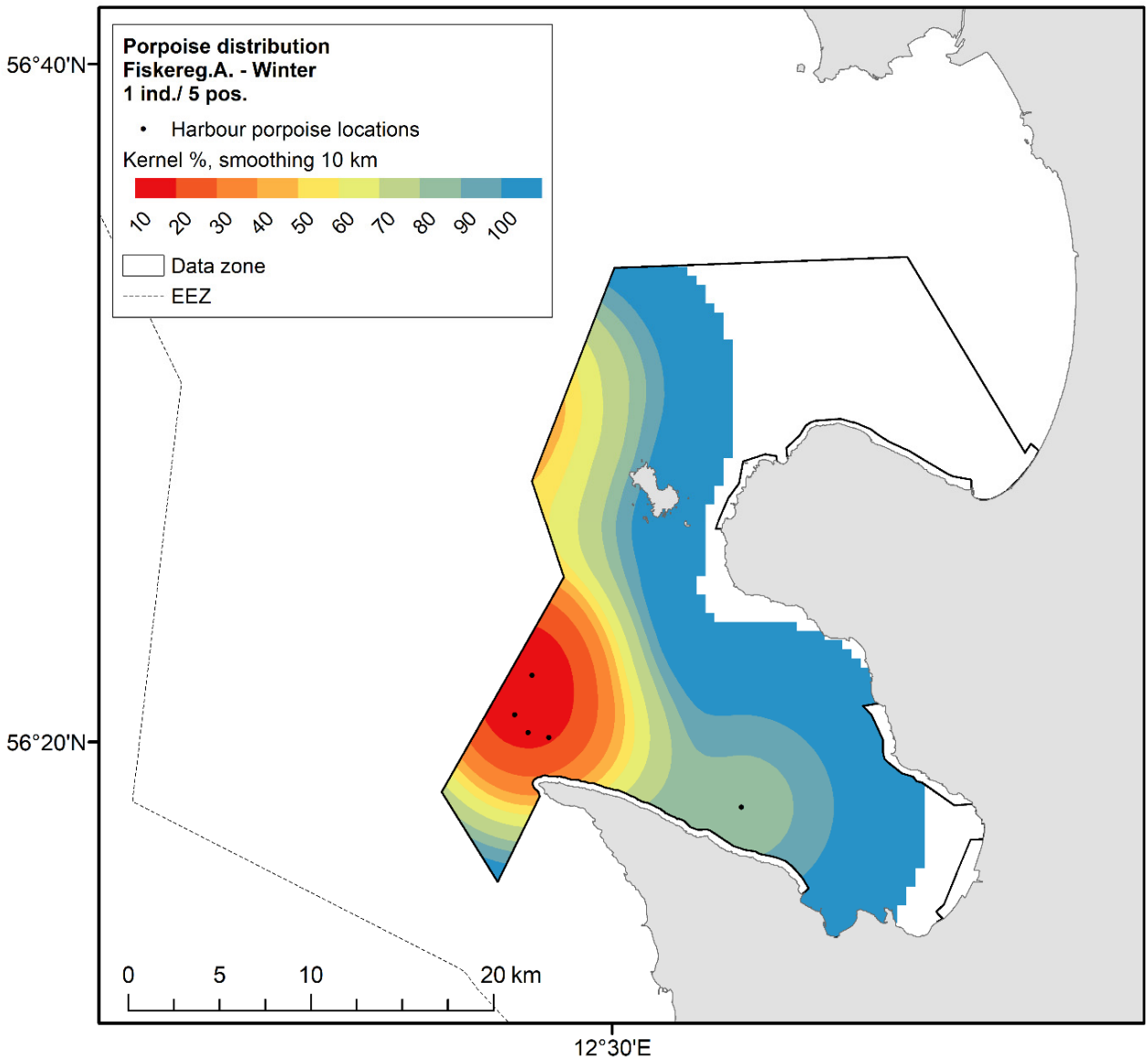


Figure 27. Kernel plots of all positions received Winter within the waters of Fiskereguleringsområde A.

Section 6 – Monthly maps

This section includes monthly maps of the Belt Sea and gap area showing all the positions used for the Kernel maps shown in section 1-5. Each month includes positions from 17-66 porpoises providing 173-1622 positions for each month during 1997-2021. The number of individual harbour porpoises and number of positions within the Belt - Gap area is noted in the legend of each figure.

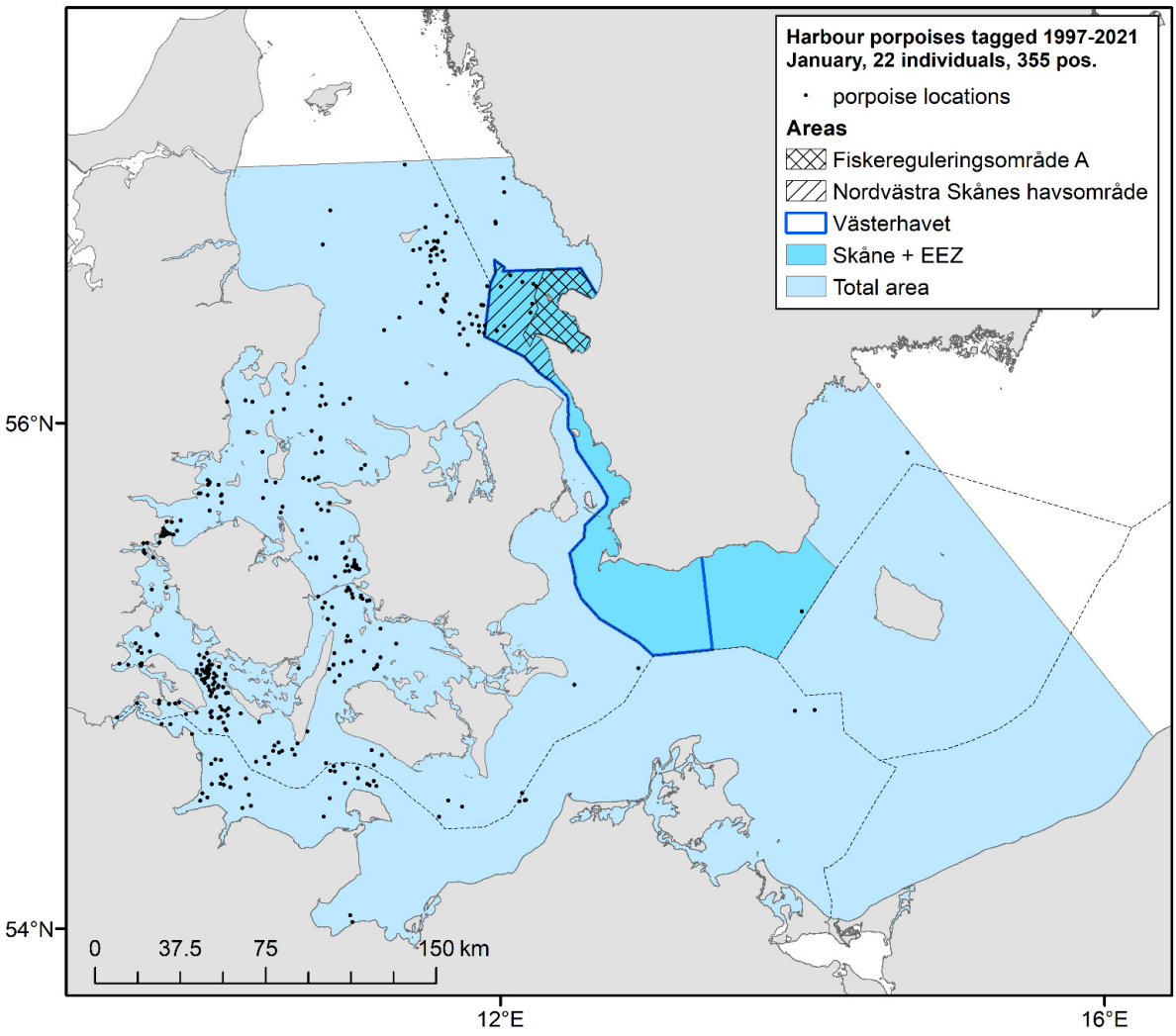


Figure 28. All positions received during January 1997-2021 within the Belt Sea population area.

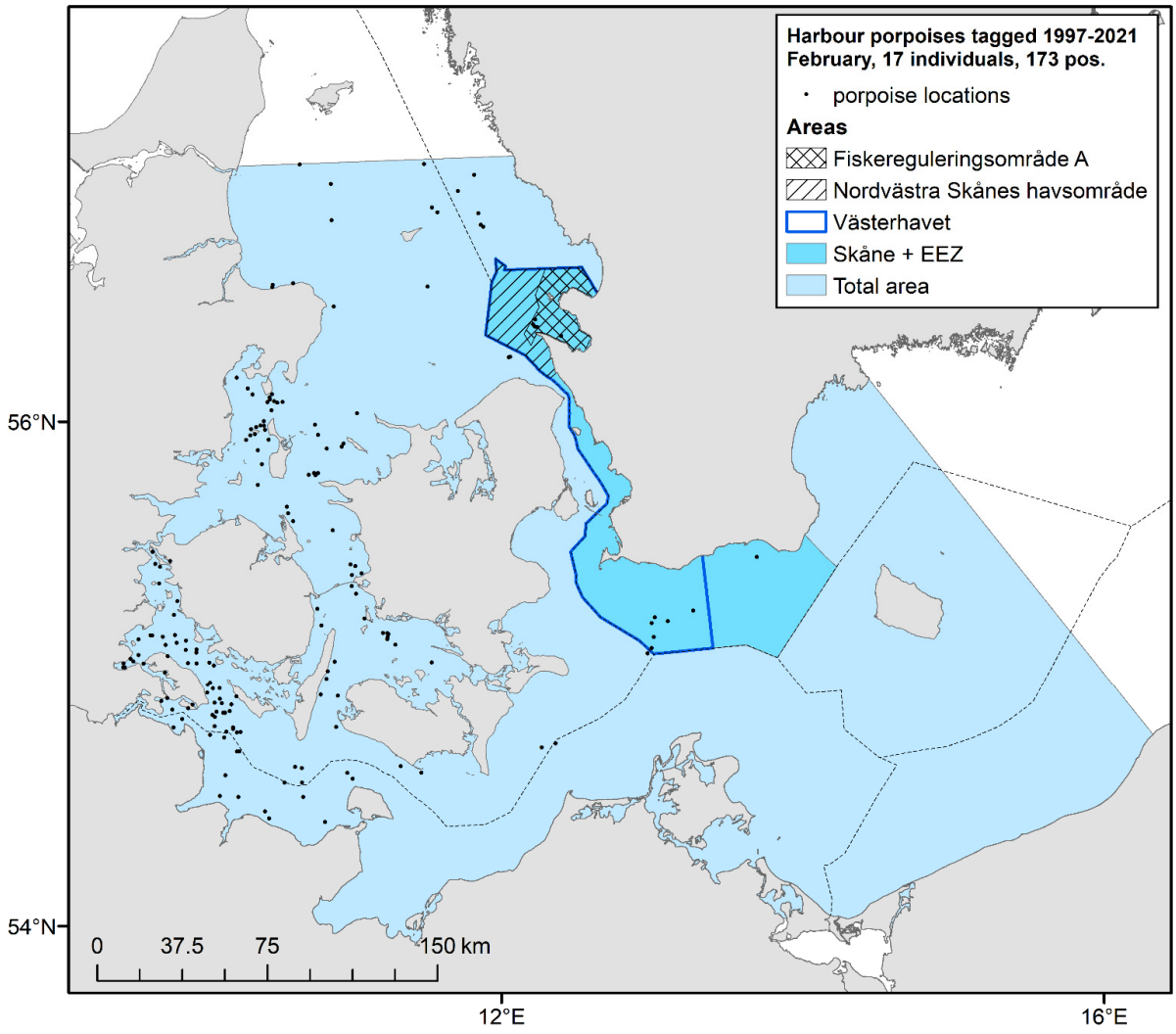


Figure 29. All positions received during February 1997-2021 within the Belt Sea population area.

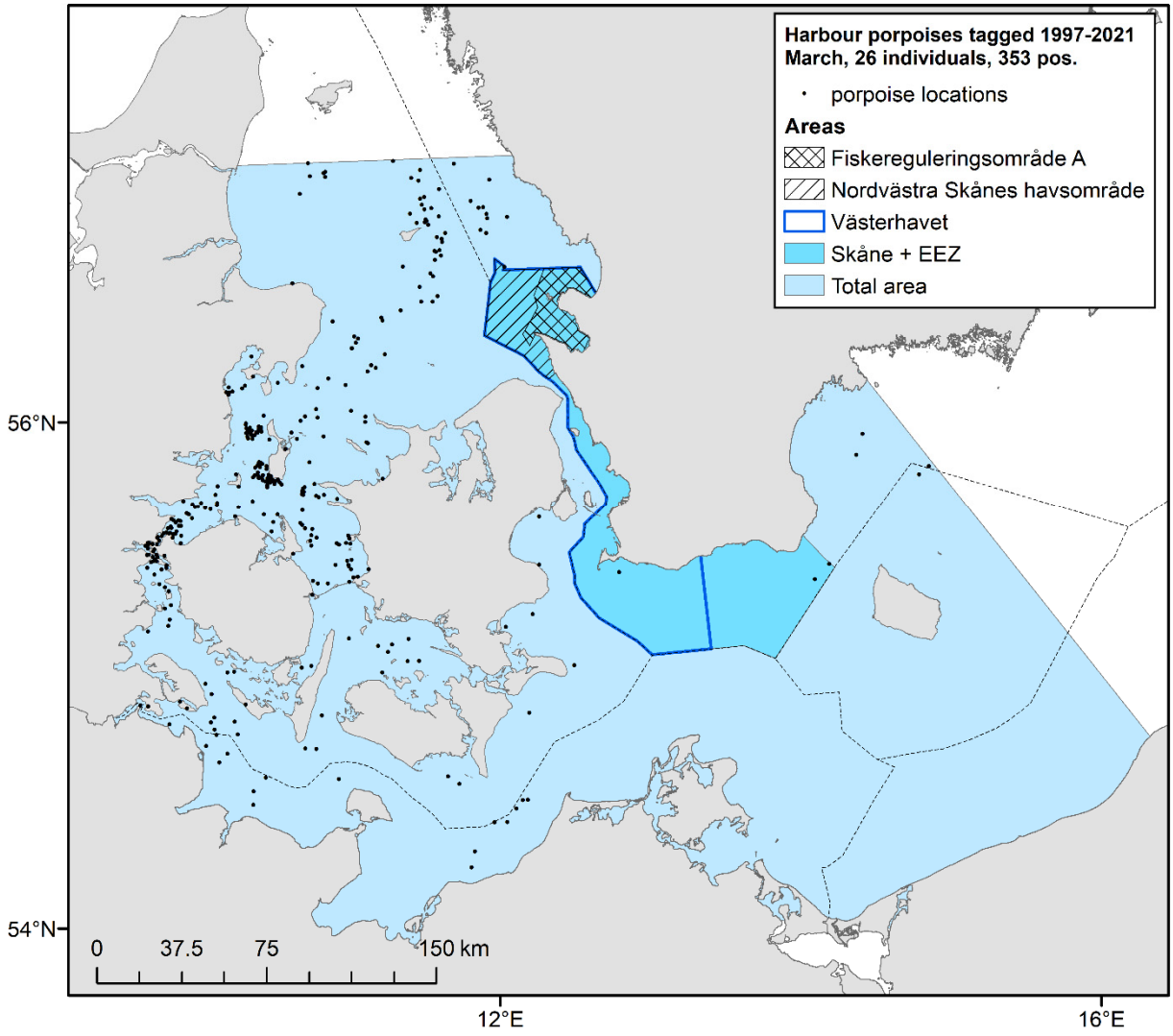


Figure 30. All positions received during March 1997-2021 within the Belt Sea population area.

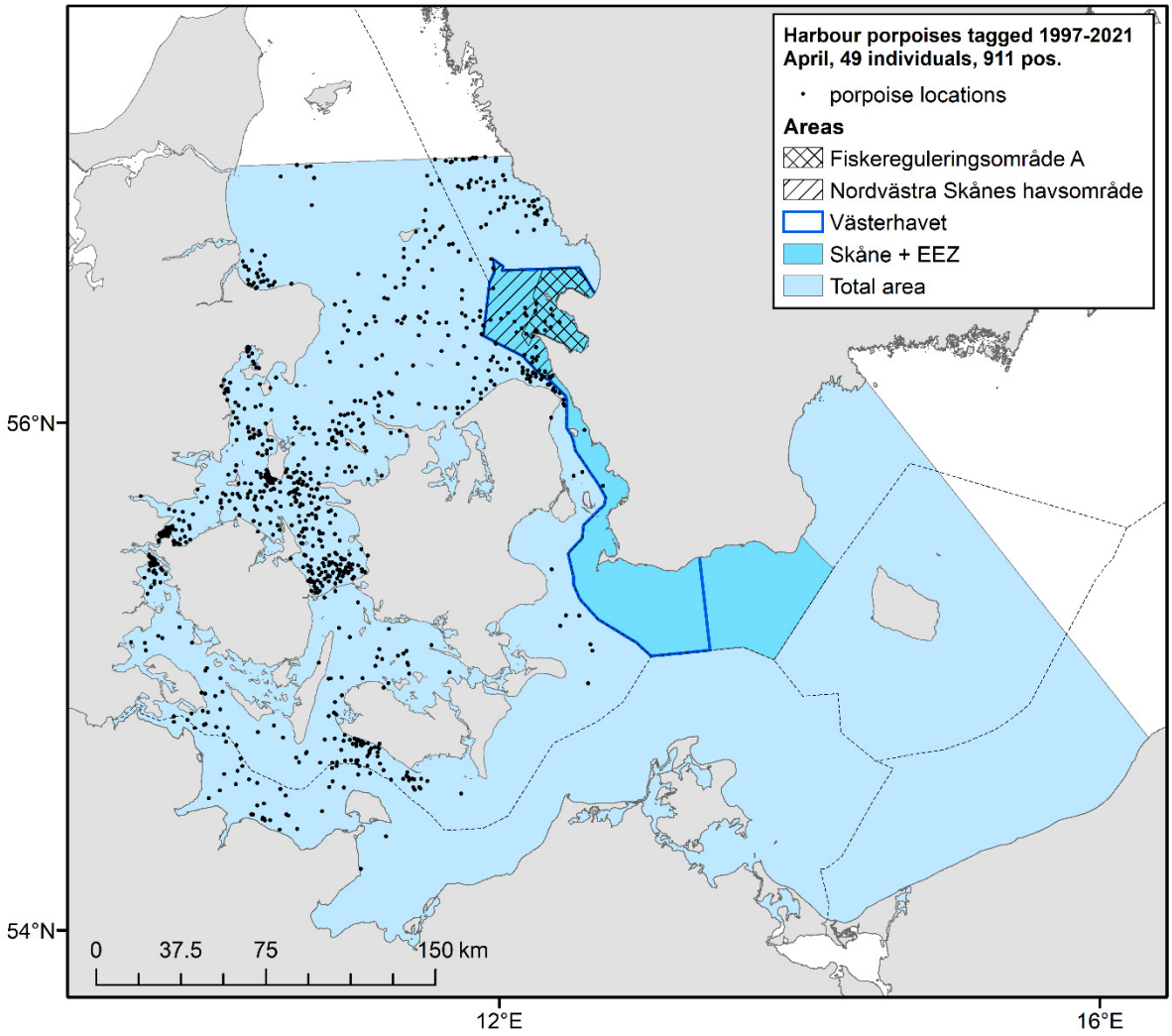


Figure 31. All positions received during April 1997-2021 within the Belt Sea population area.

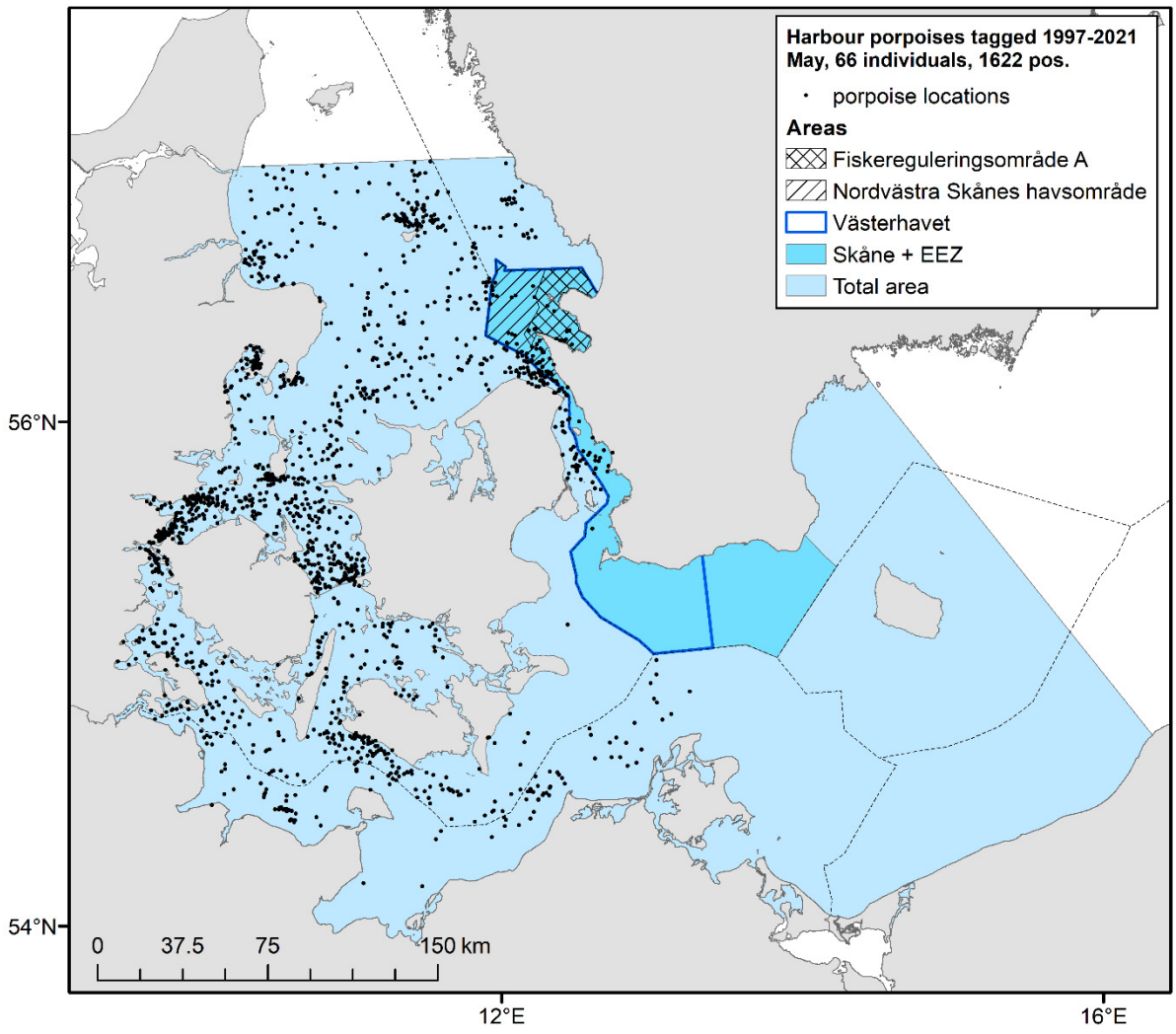


Figure 32. All positions received during May 1997-2021 within the Belt Sea population area.

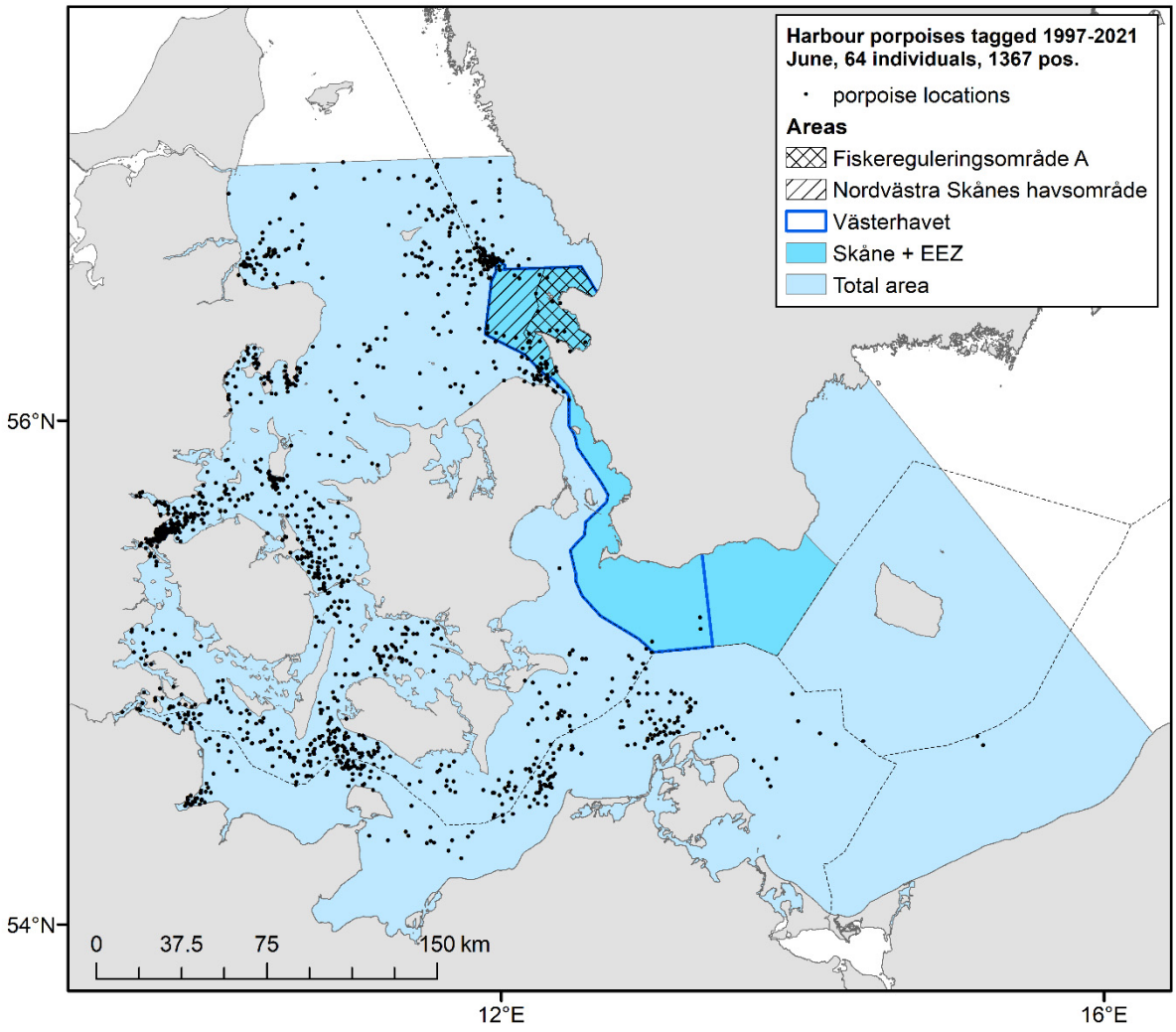


Figure 33. All positions received during June 1997-2021 within the Belt Sea population area.

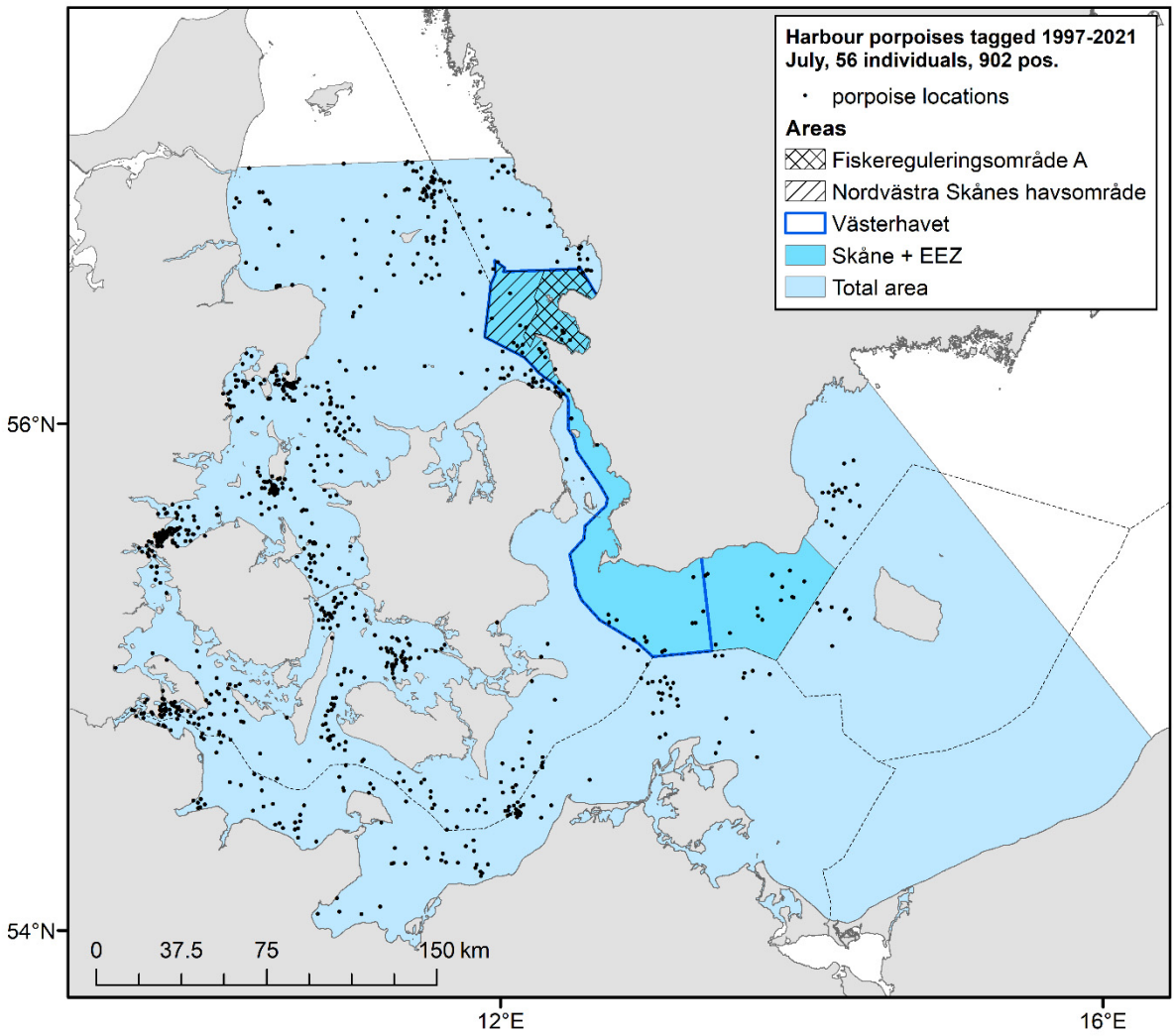


Figure 34. All positions received during July 1997-2021 within the Belt Sea population area.

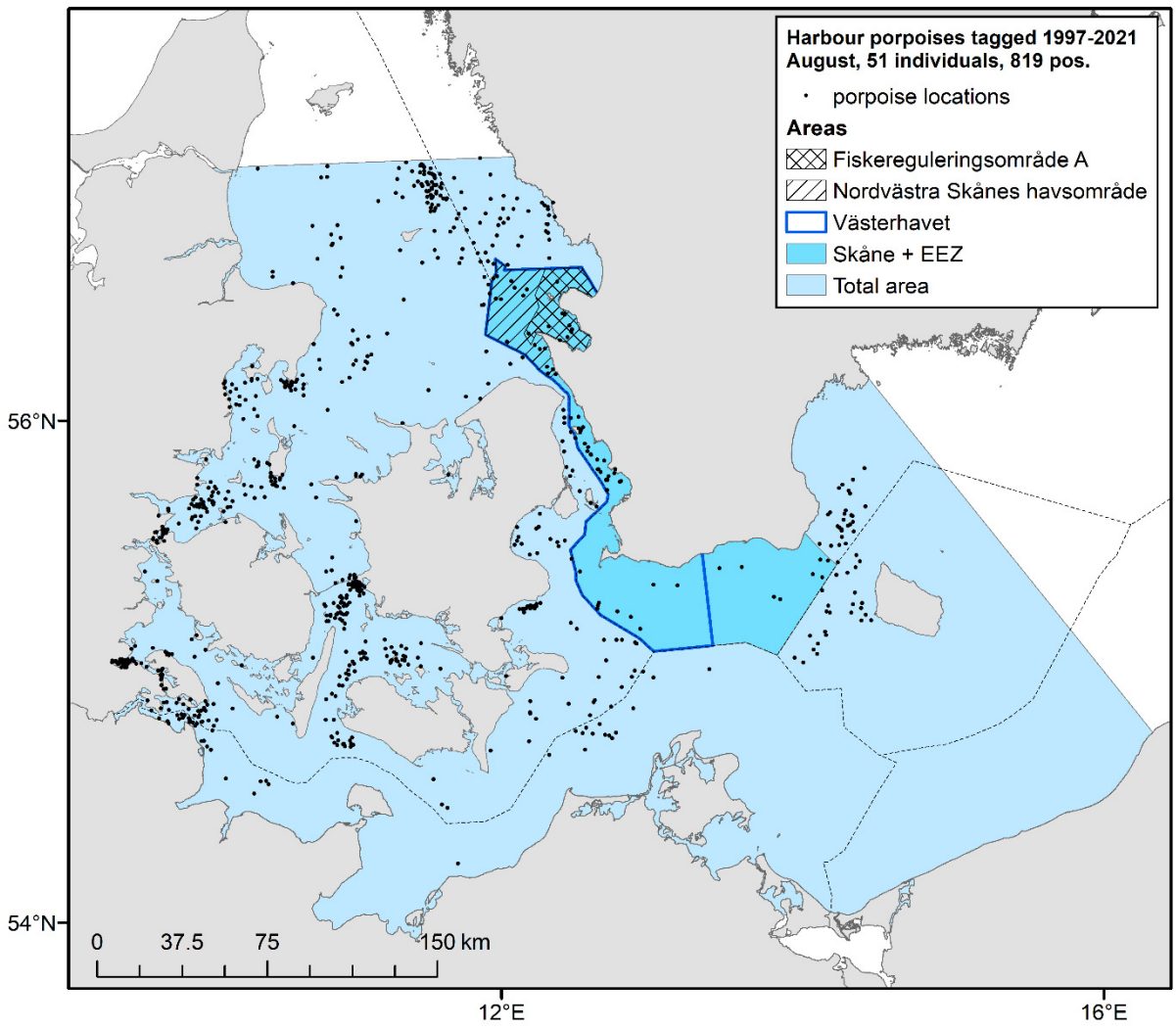


Figure 35. All positions received during August 1997-2021 within the Belt Sea population area.

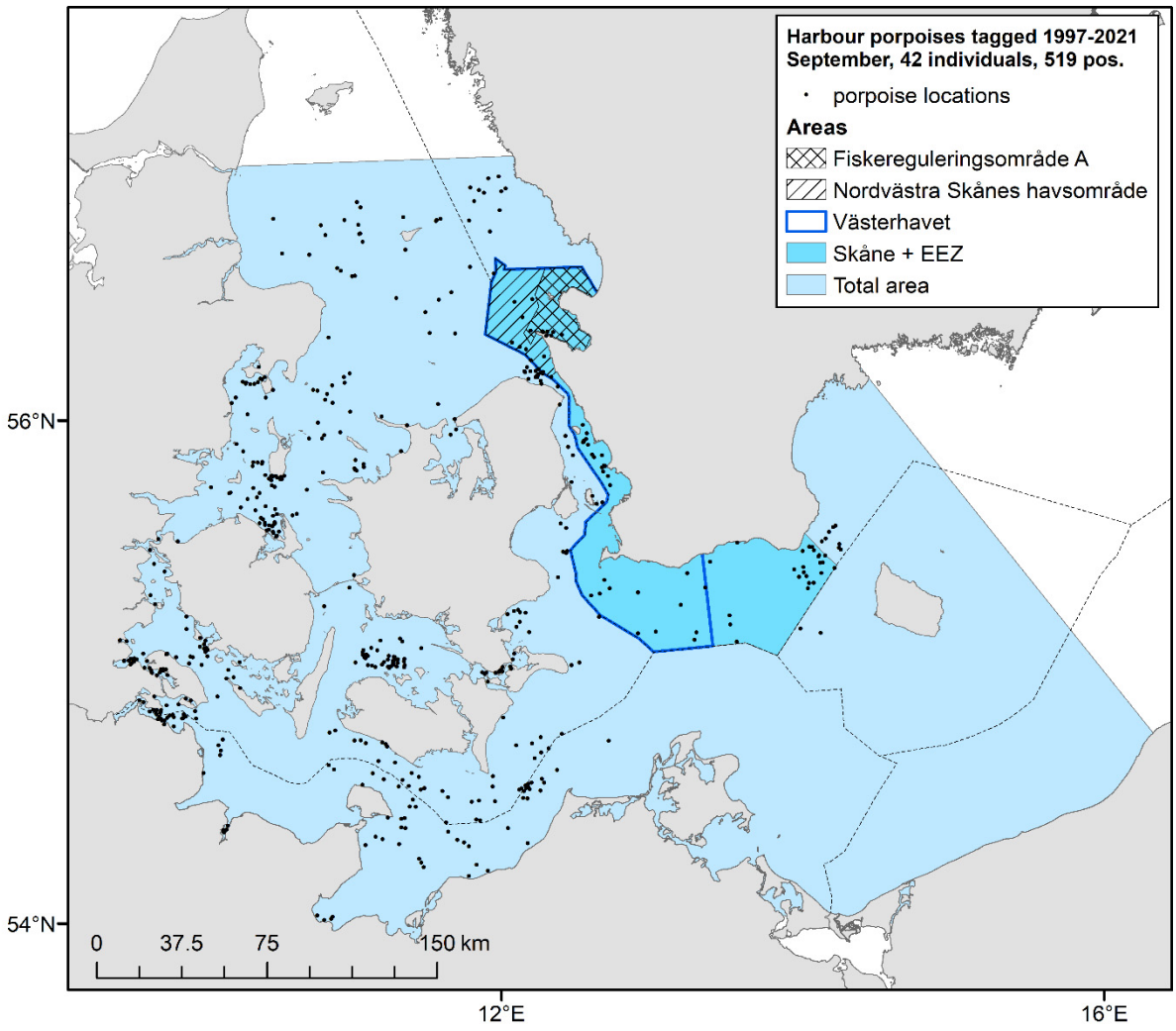


Figure 36. All positions received during September 1997-2021 within the Belt Sea population area.

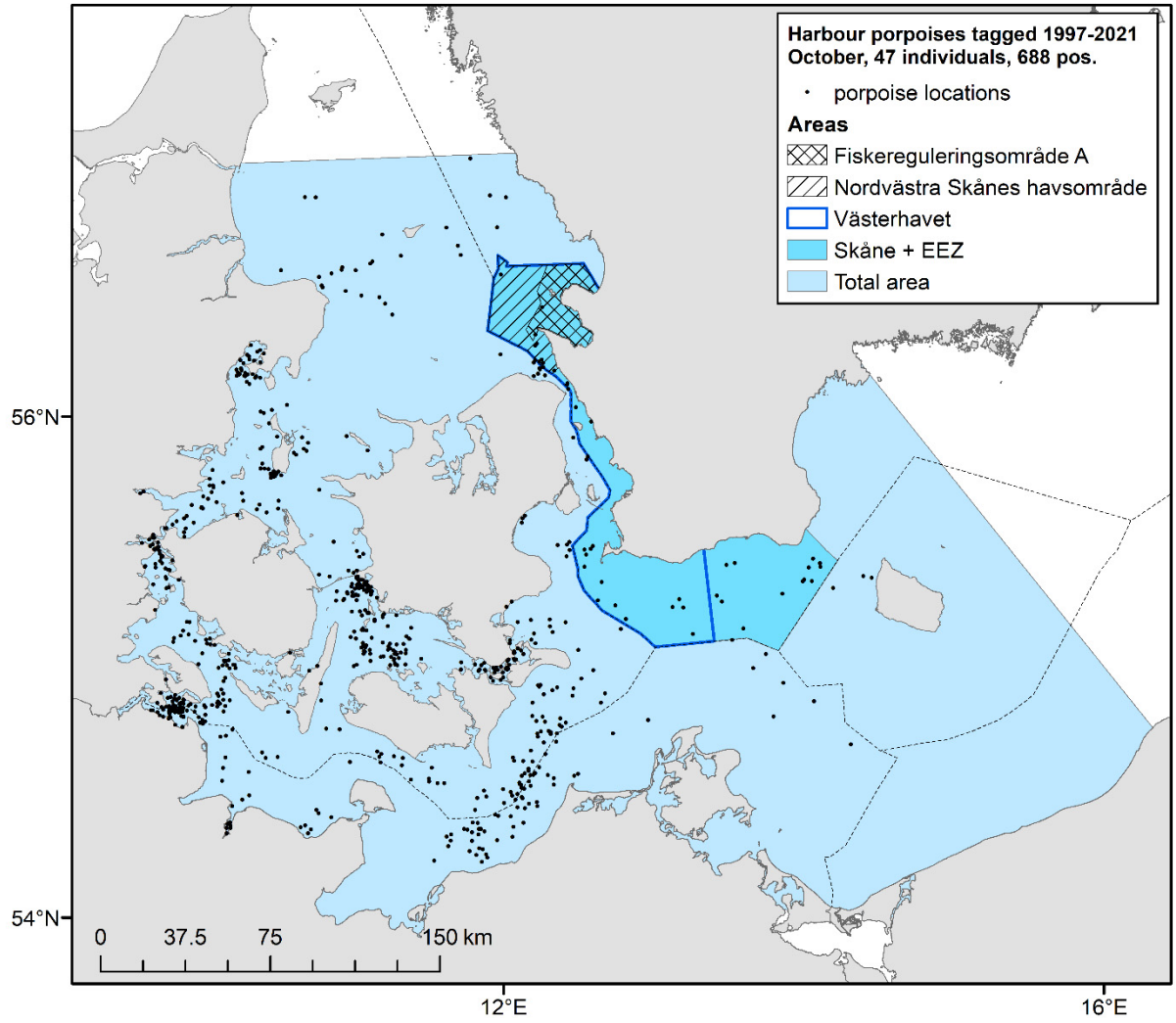


Figure 37. All positions received during October 1997-2021 within the Belt Sea population area.

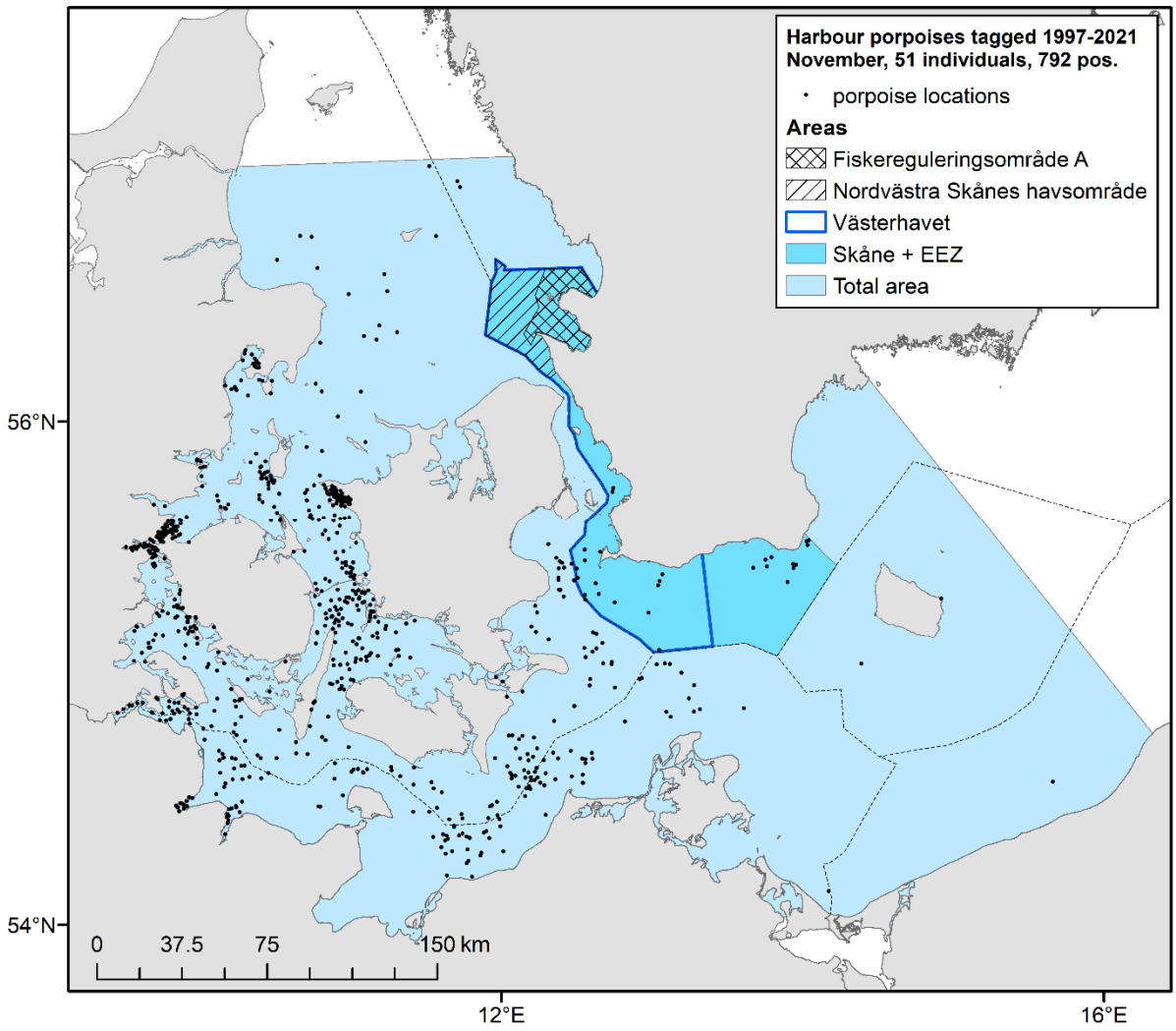


Figure 38. All positions received during November 1997-2021 within the Belt Sea population area.

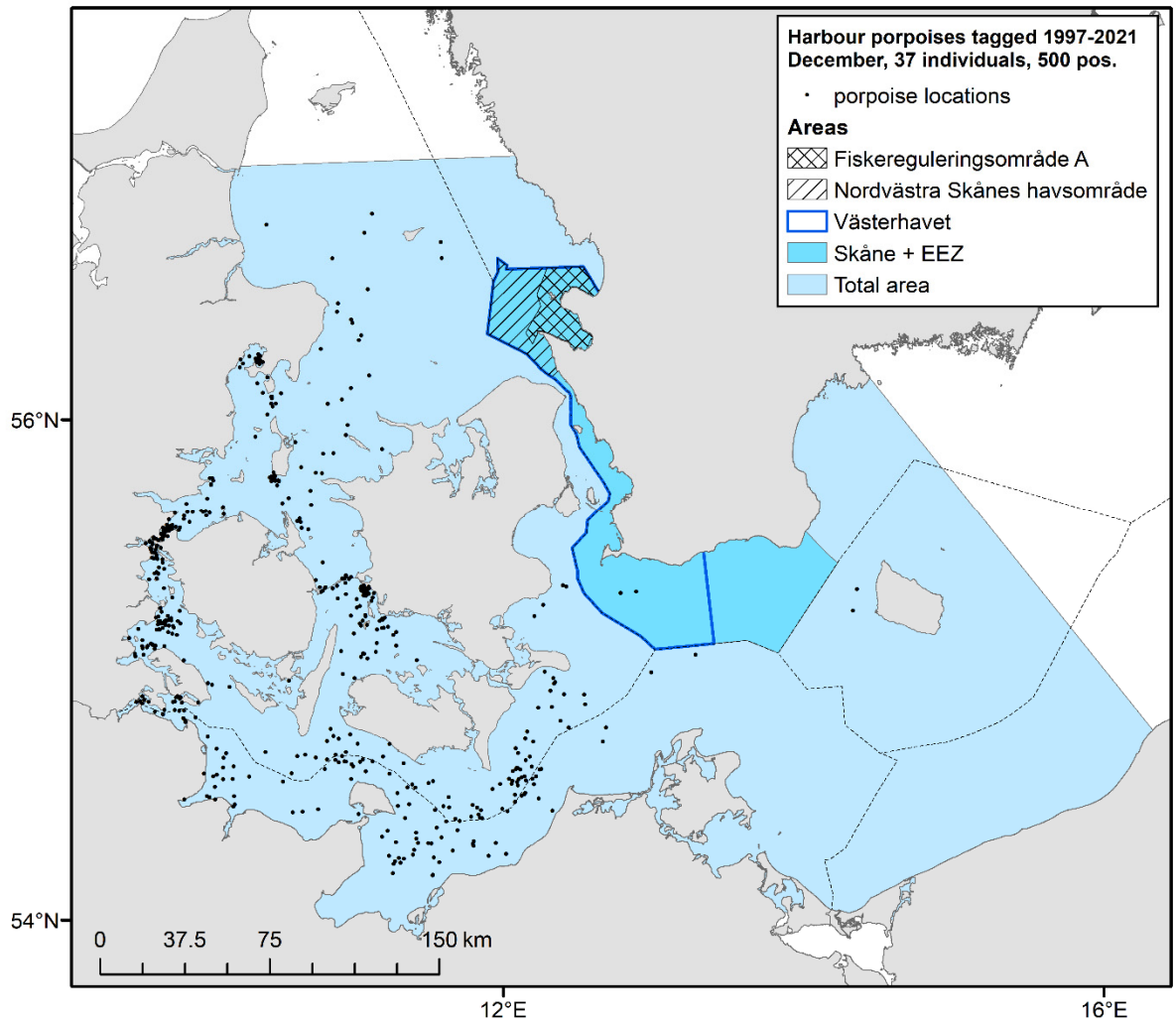


Figure 39. All positions received during December 1997-2021 within the Belt Sea population area..

Section 7 – Mature females

This section includes only maps of mature females that spend time entirely or partly within the Belt Sea population area during 1997-2021. The females that spend some of their time outside the Belt Sea population area are also included to show the full tracks. Both a combined Kernel map of the entire area and specifically the Skåne waters, as well as 12 individual maps of each mature female (length < 142 cm) are presented below. As females give birth during summer and nurse their calves the rest of the year, the movements of adult females year-round (months indicated with different colours in figure 42-53) is relevant to consider for protection as breeding areas for porpoises. The number of individual harbour porpoises and number of positions within the Belt – Gap area and the Skåne + EEZ area are noted in the legend of each figure.

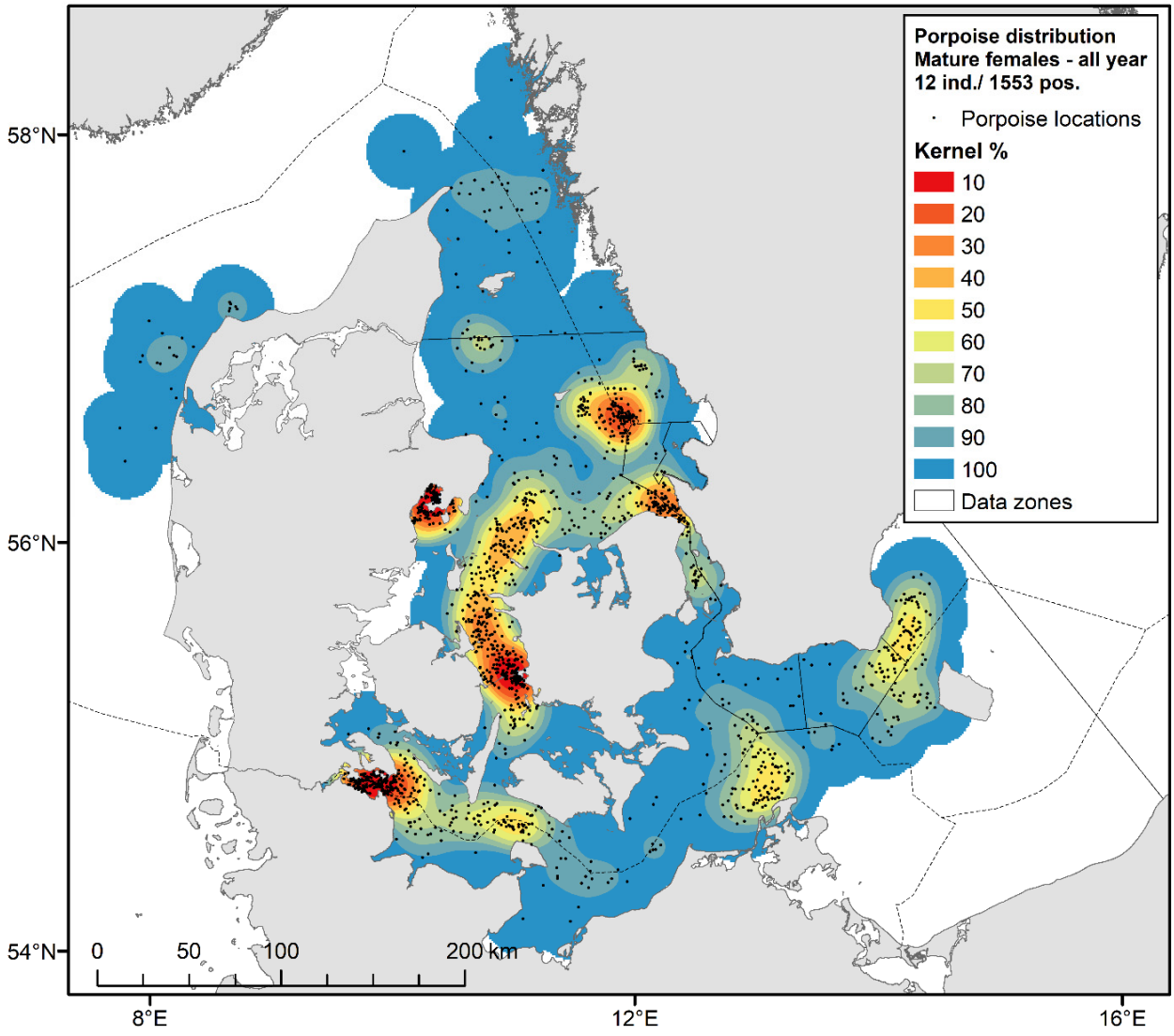


Figure 40. Kernel plots of all positions received from all 12 mature females All Year. Positions are also shown. Kernel smoothing factor = 20 km.

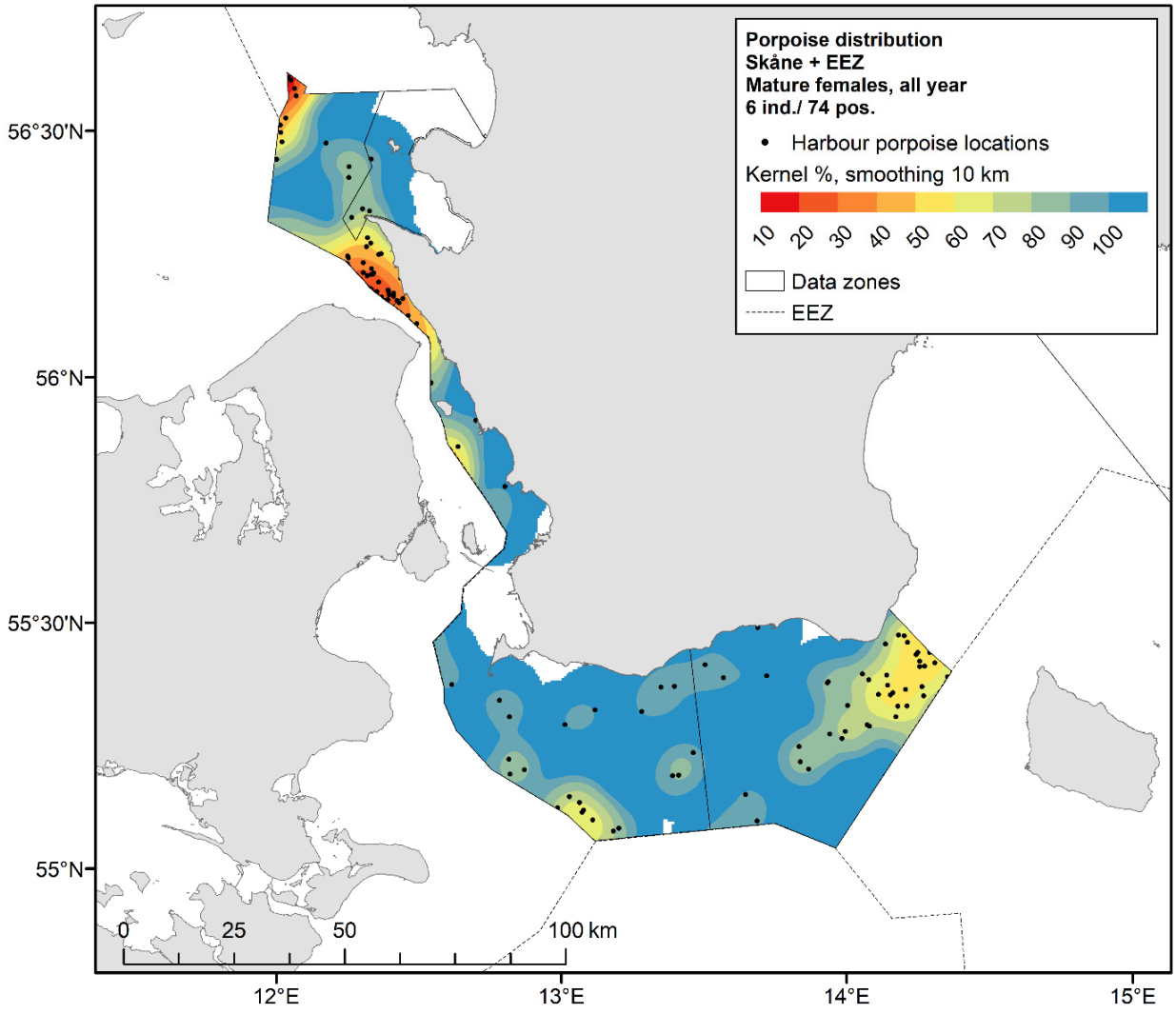


Figure 41. Kernel plots of all positions received from all six mature females All Year within the datazone “Skåne + EEZ”. gur **Error! No text of specified style in document.**.1.

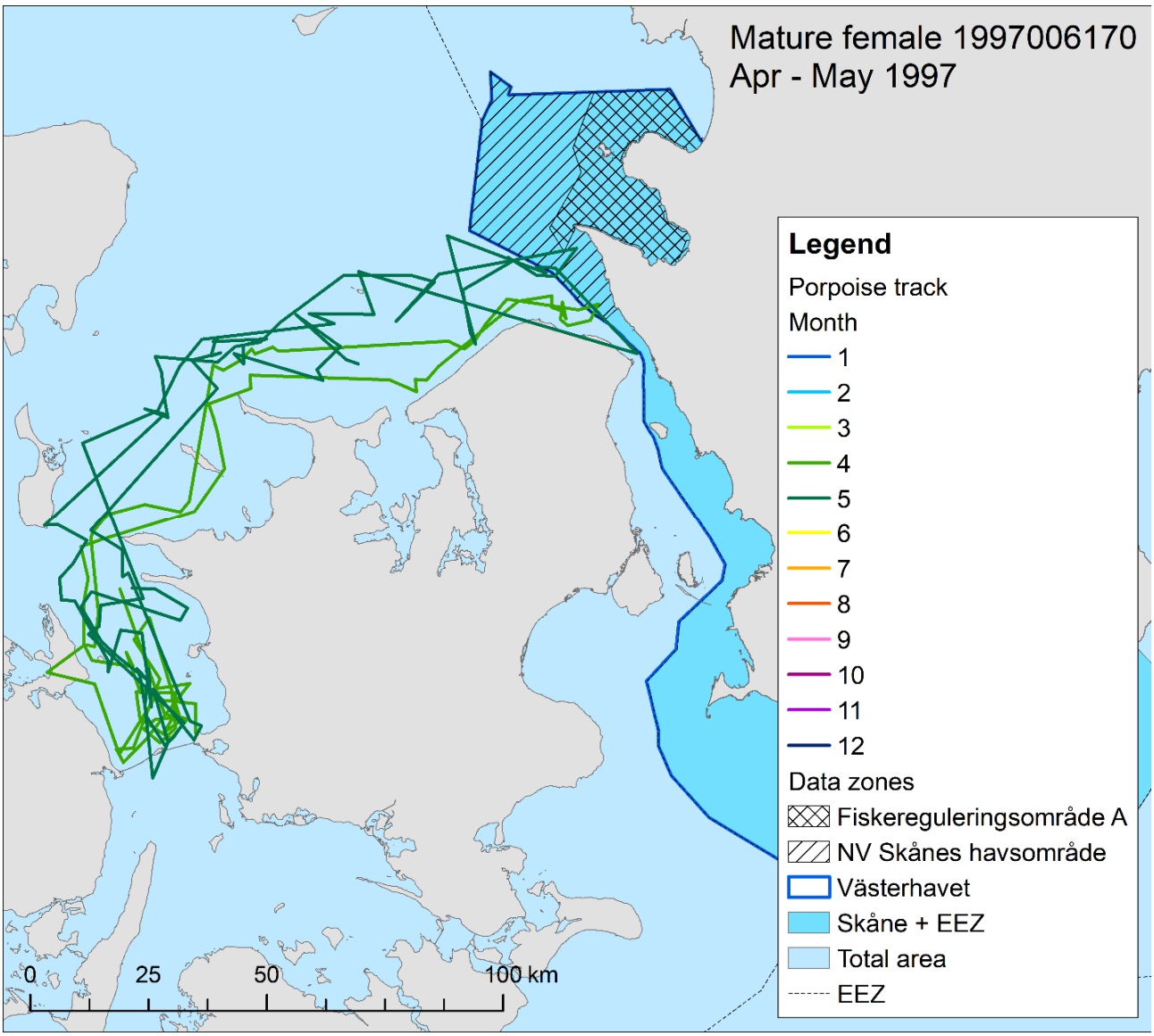


Figure 42. Track of mature female with Skåne waters highlighted.

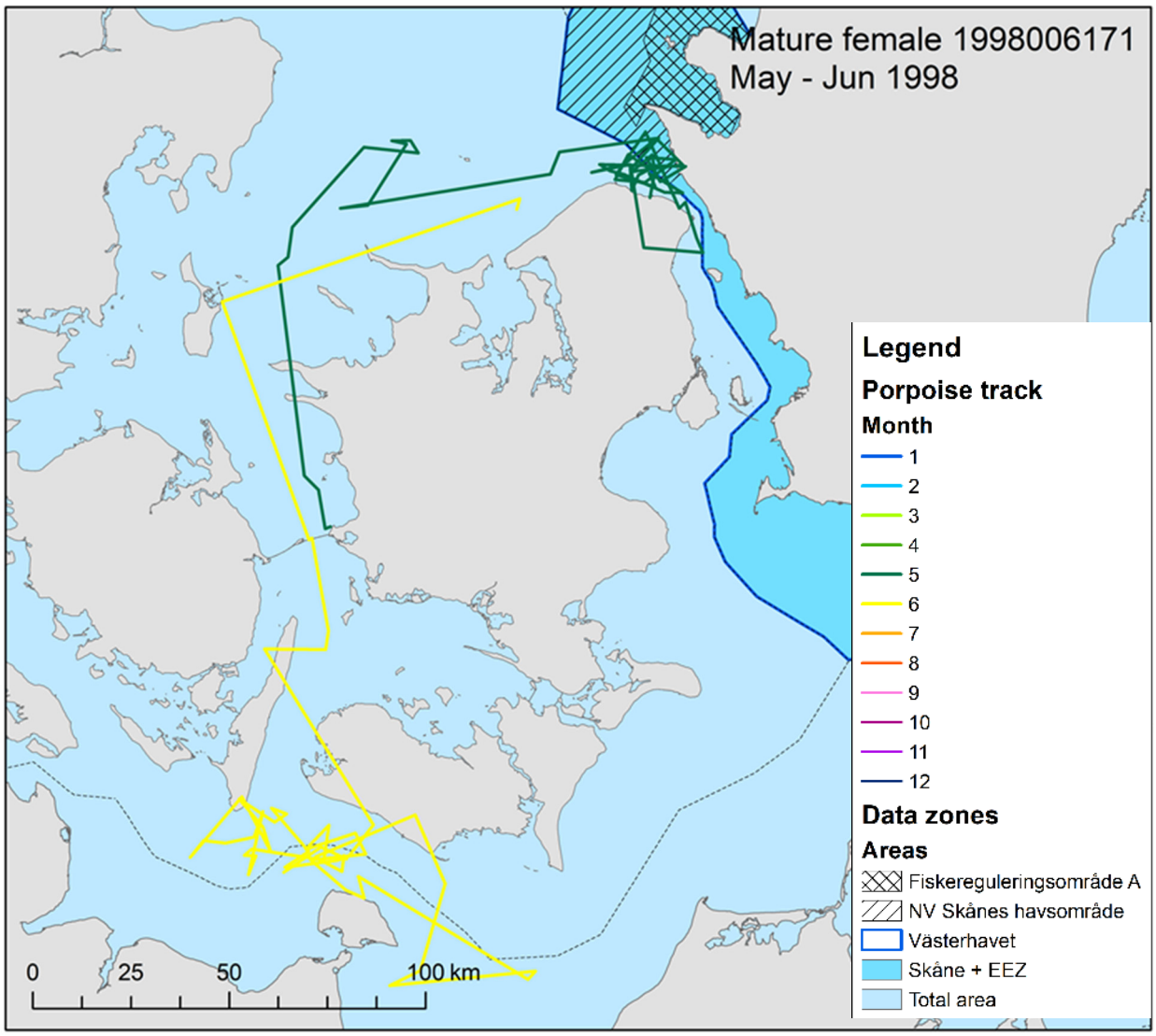


Figure 43. Track of mature female with Skåne waters highlighted.

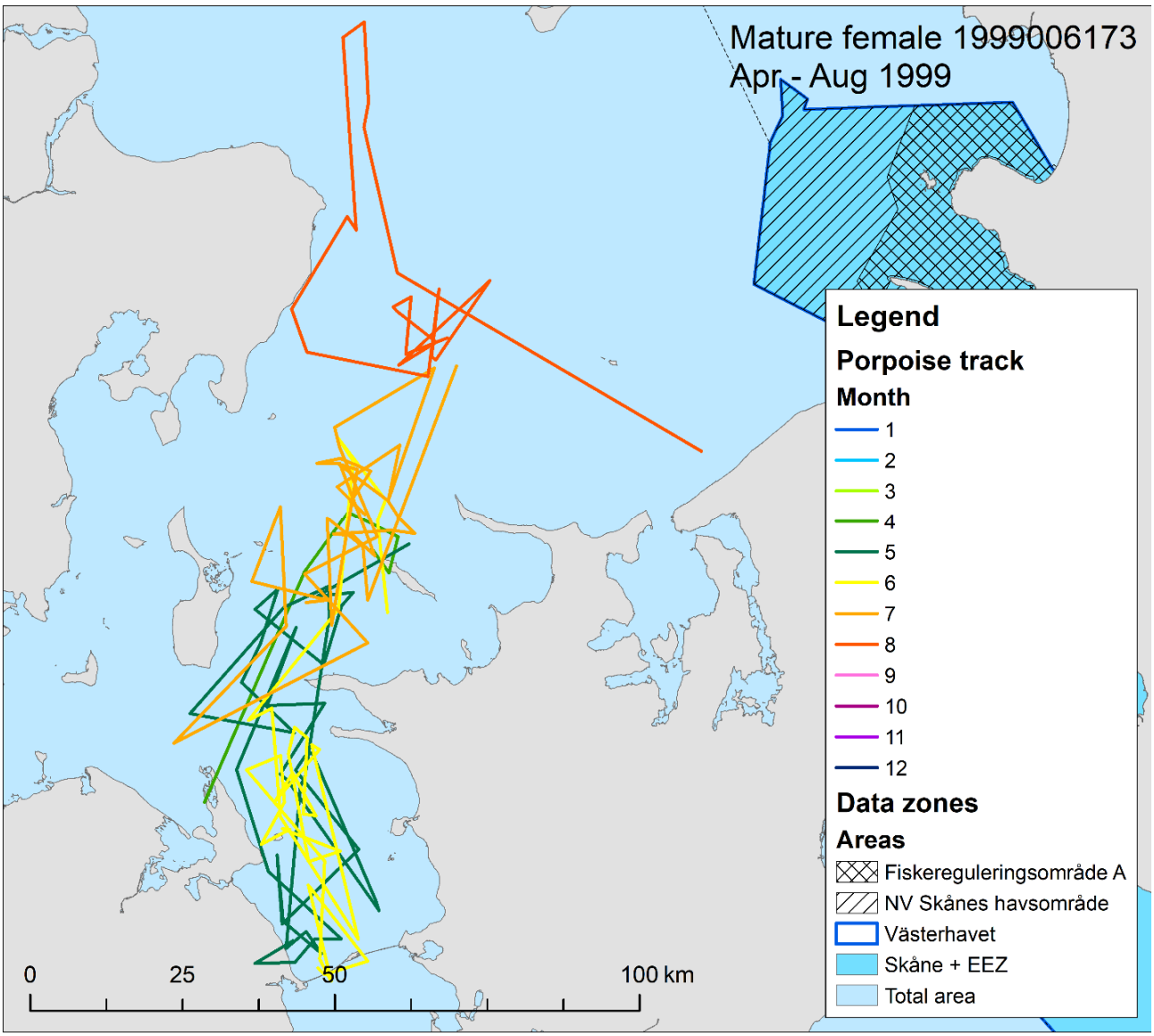


Figure 44. Track of mature female within Skåne waters highlighted.

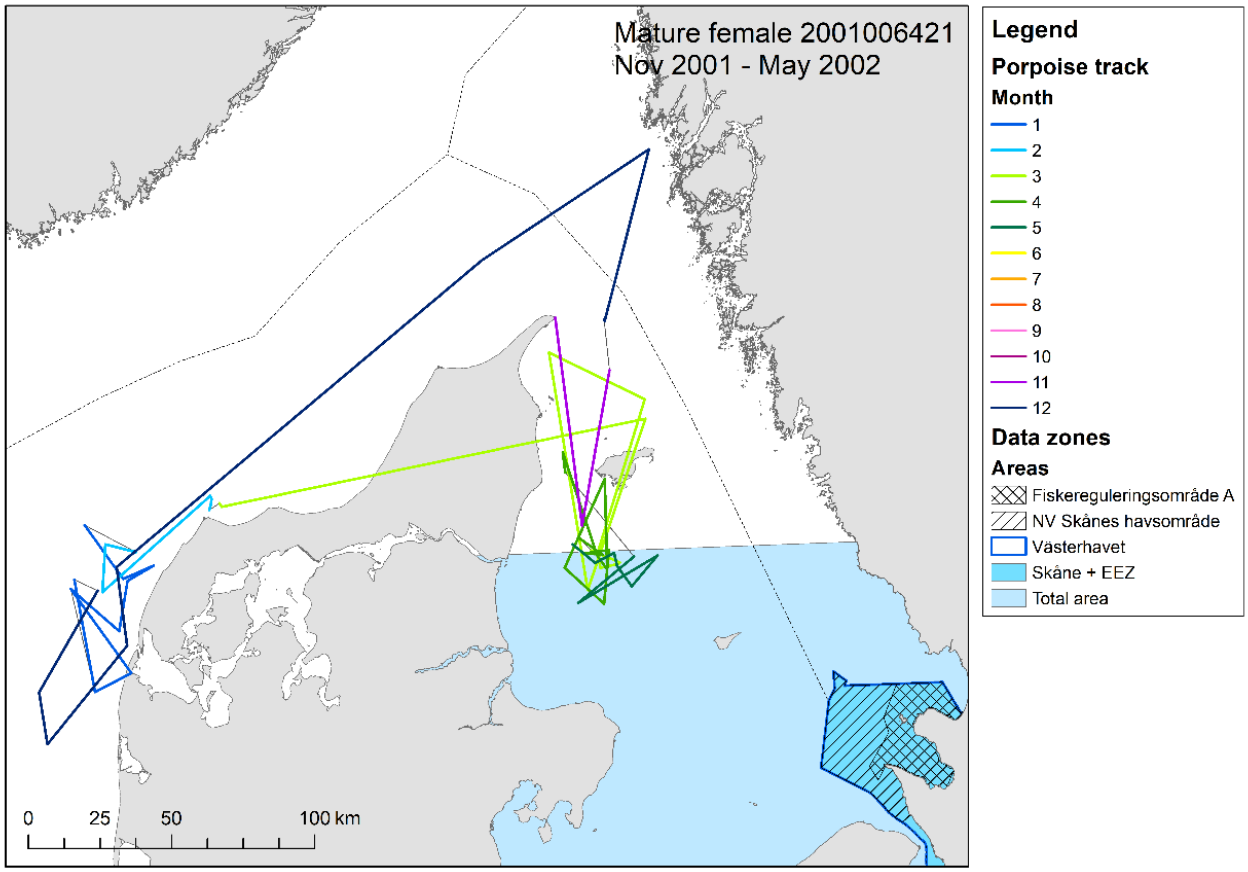


Figure 45. Track of mature female with Skåne waters highlighted.

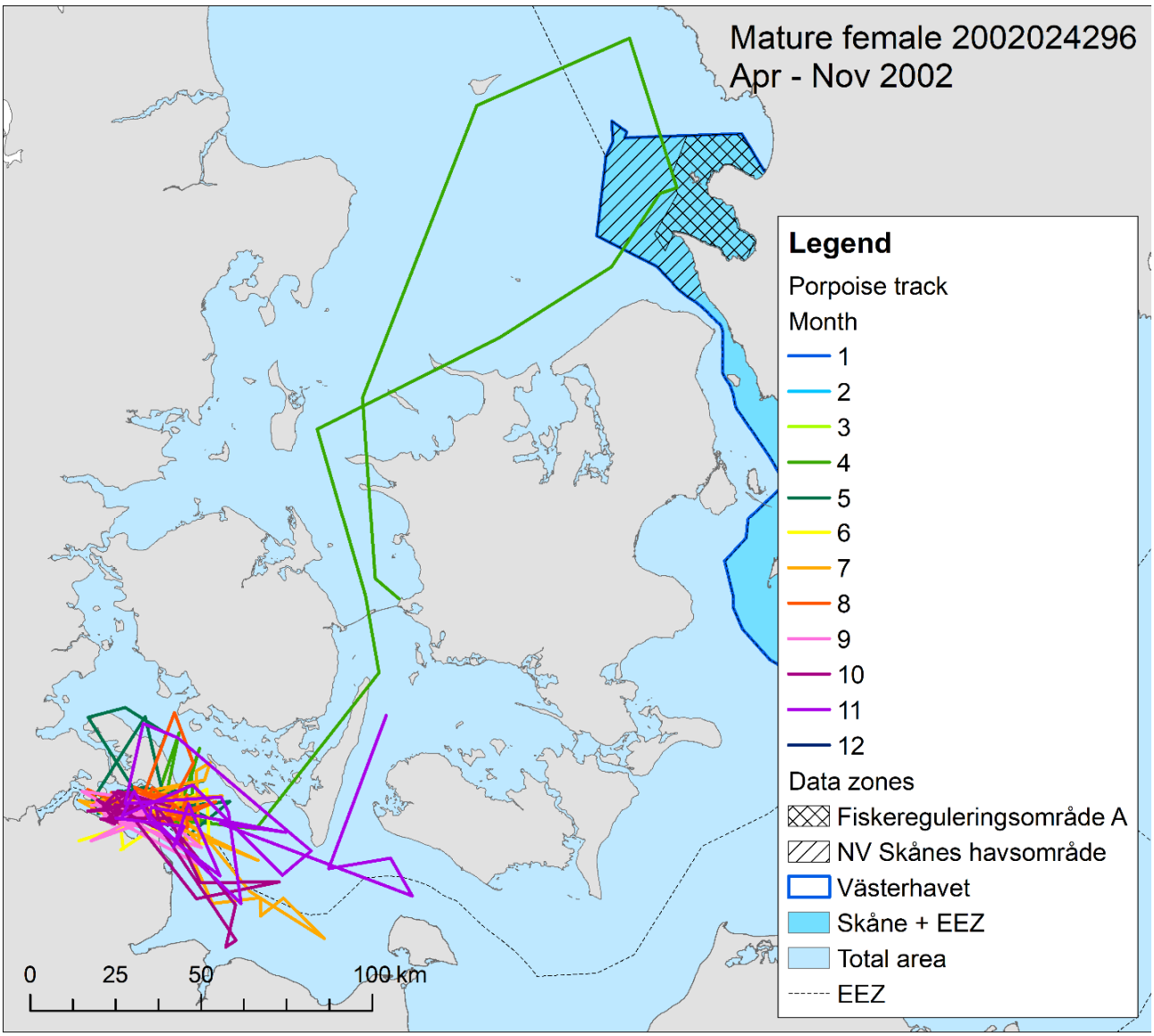


Figure 46. Track of mature female with Skåne waters highlighted.

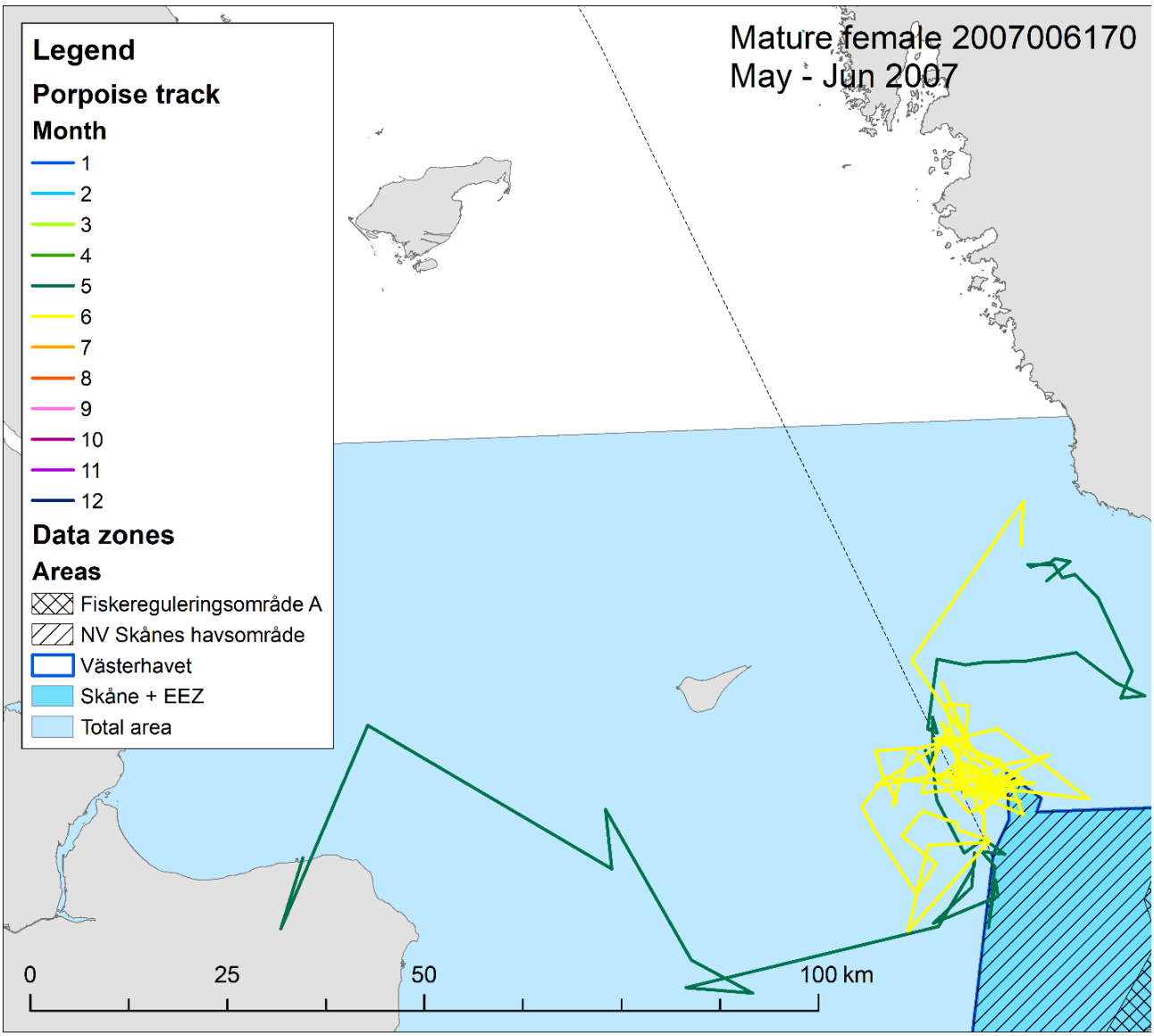


Figure 47. Track of mature female with Skåne waters highlighted.

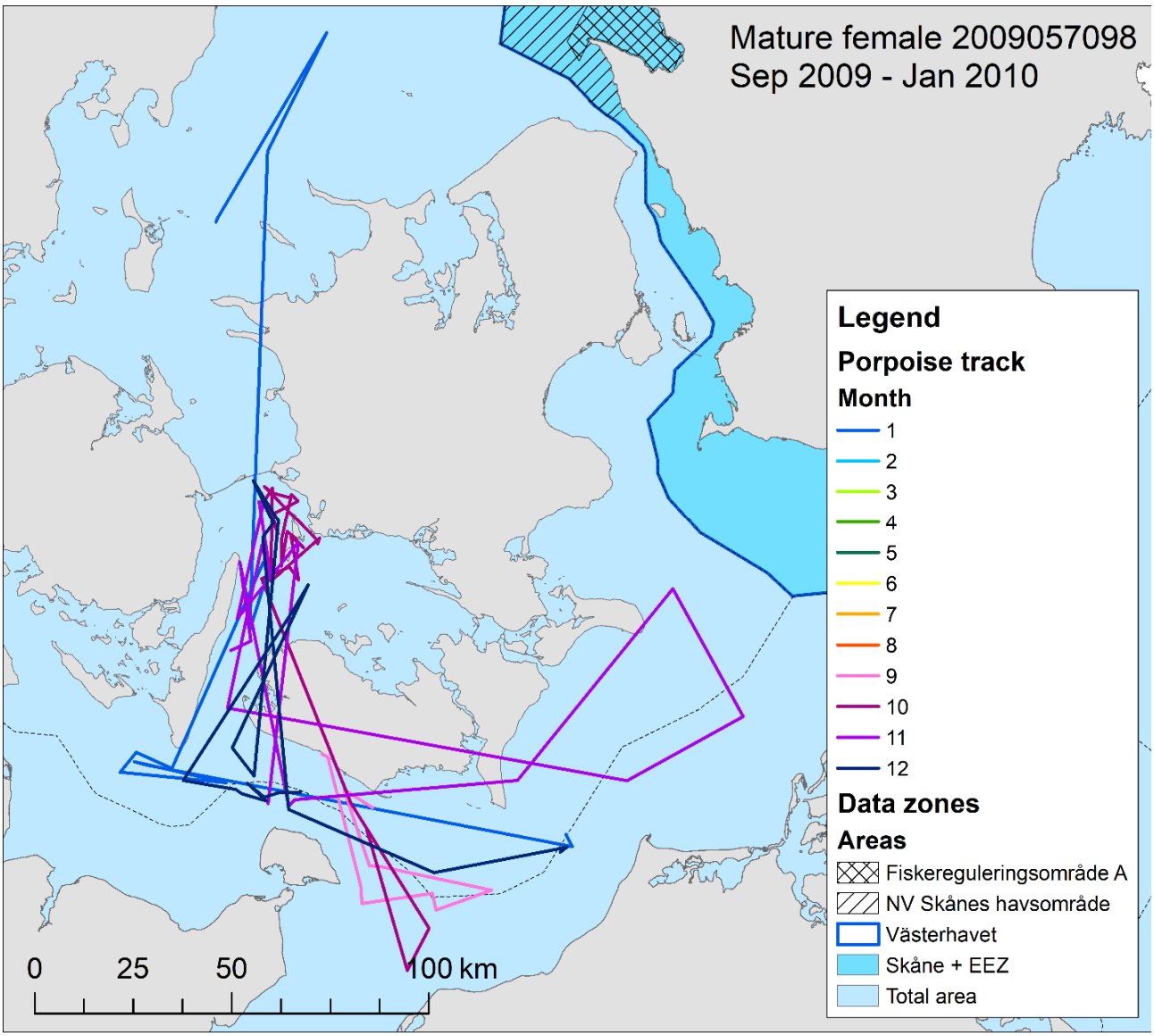


Figure 48. Track of mature female with Skåne waters highlighted.

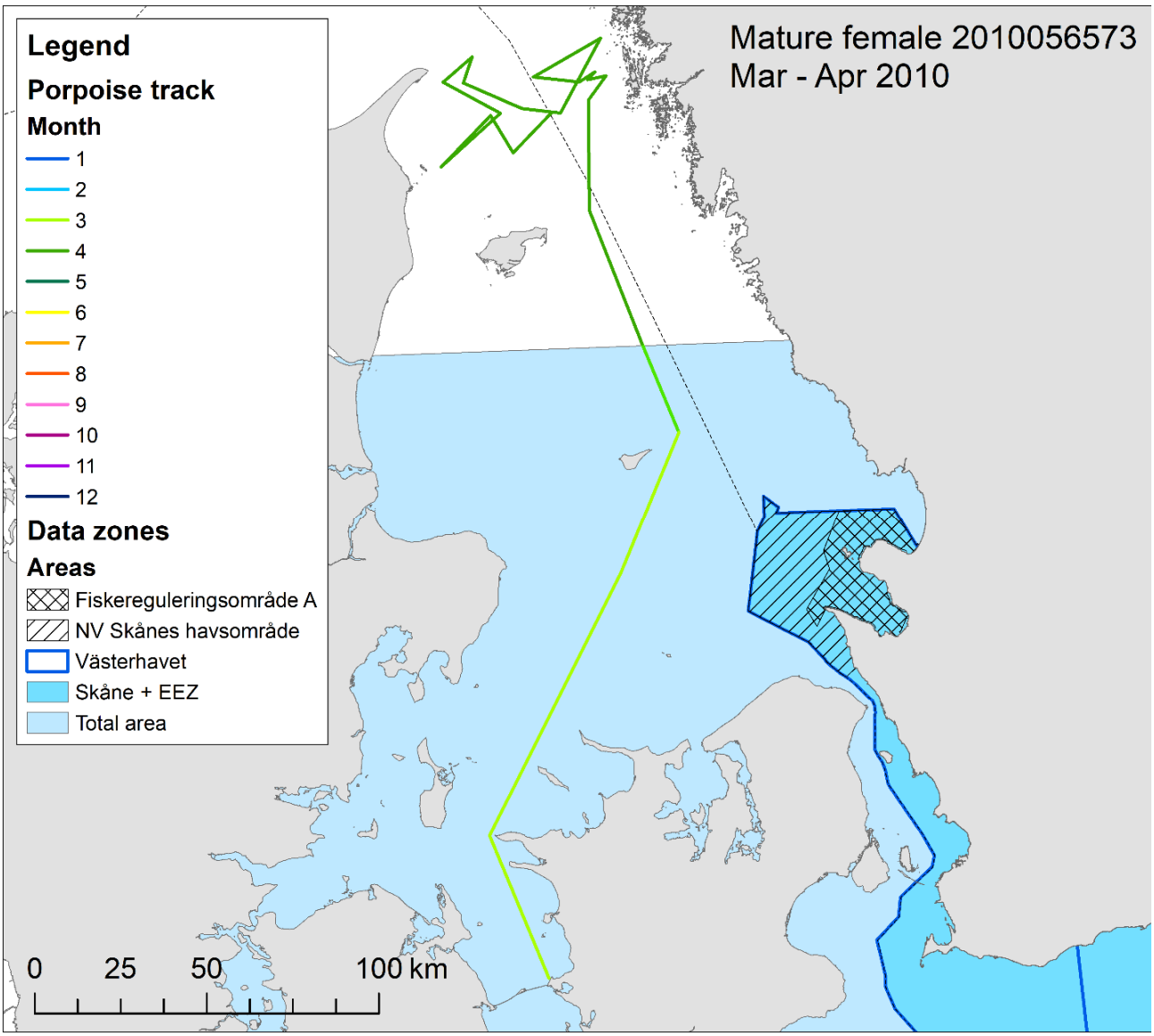


Figure 49. Track of mature female with Skåne waters highlighted.

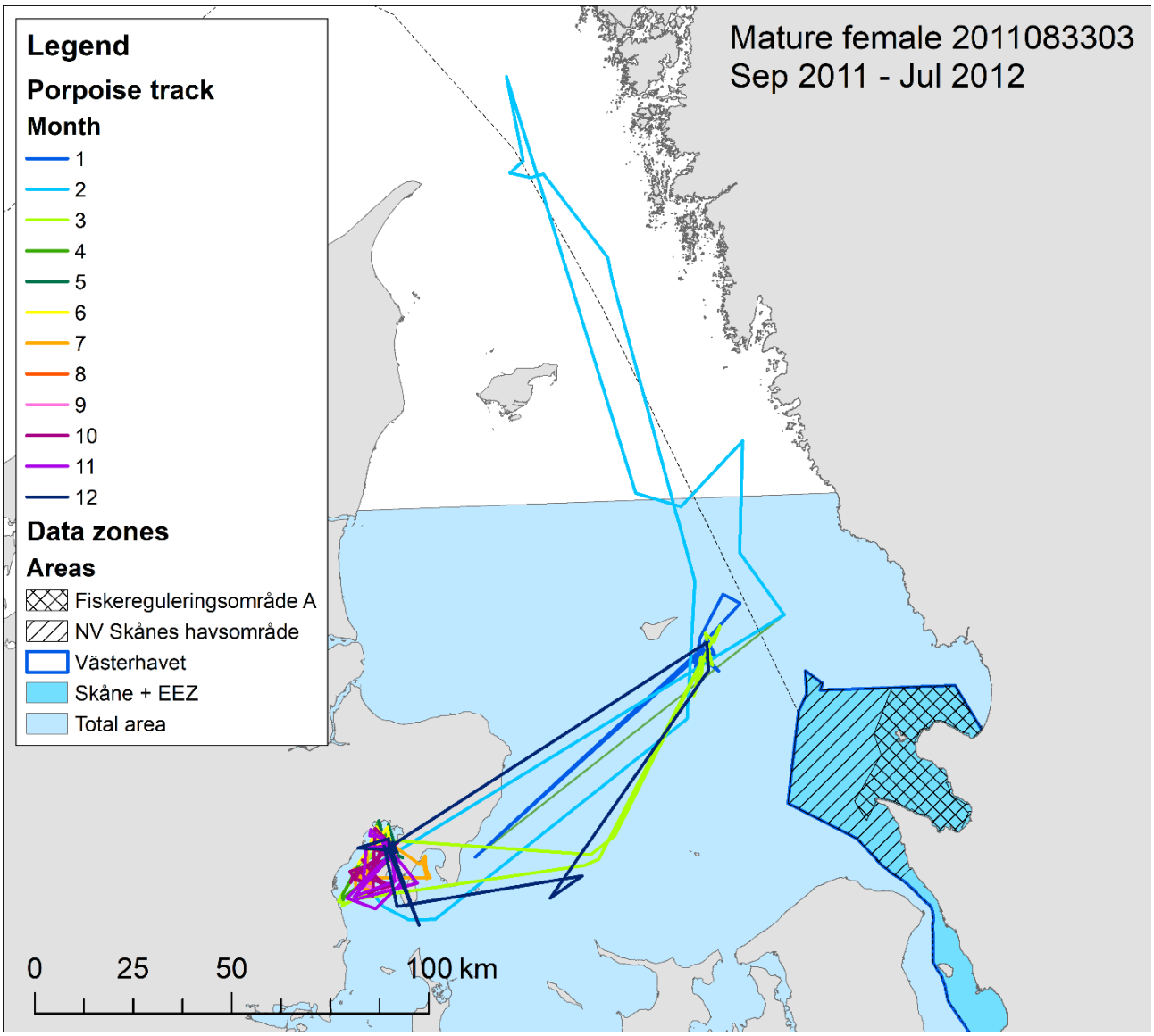


Figure 50. Track of mature female with Skåne waters highlighted.

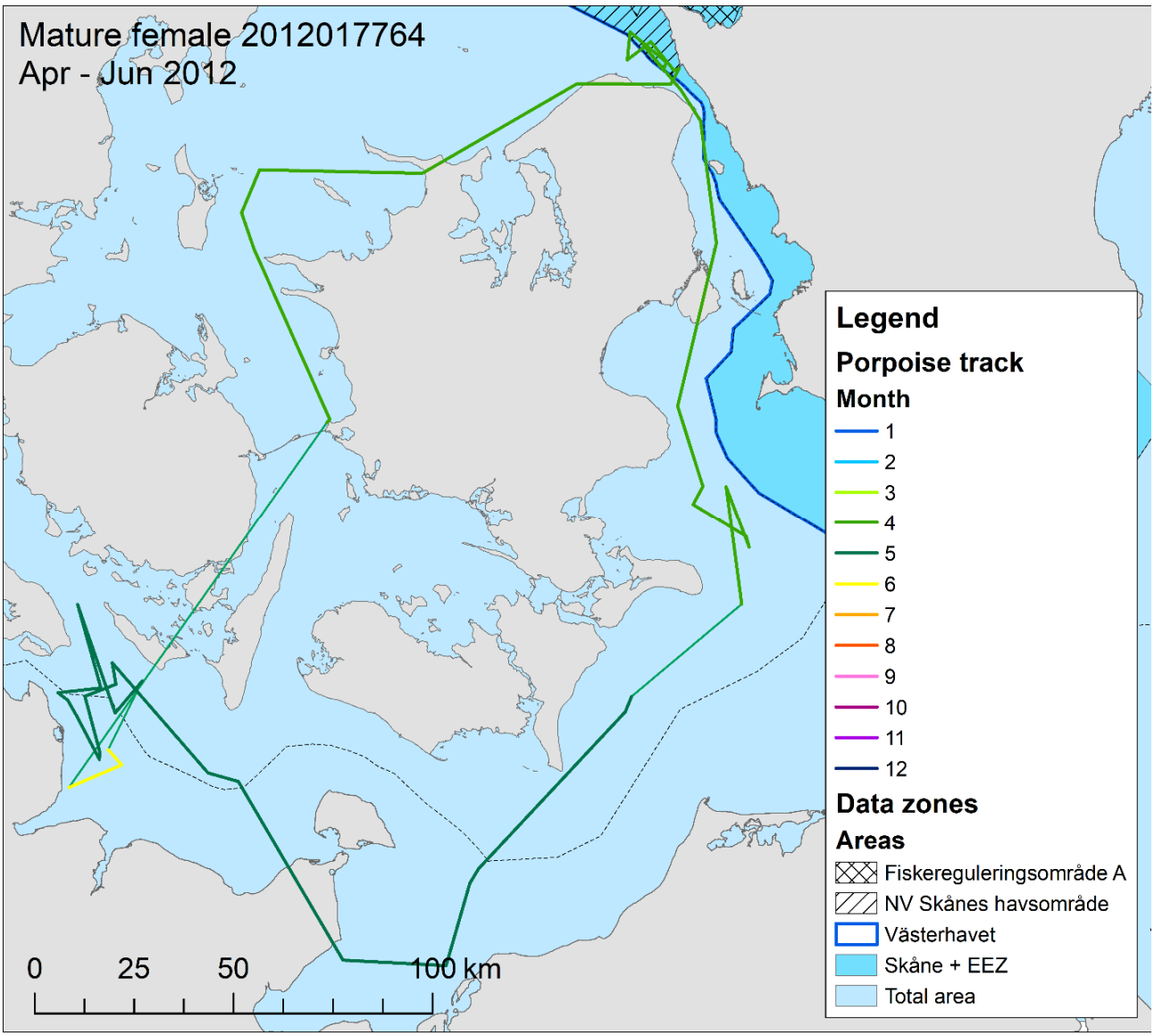


Figure 51. Track of mature female with Skåne waters highlighted.

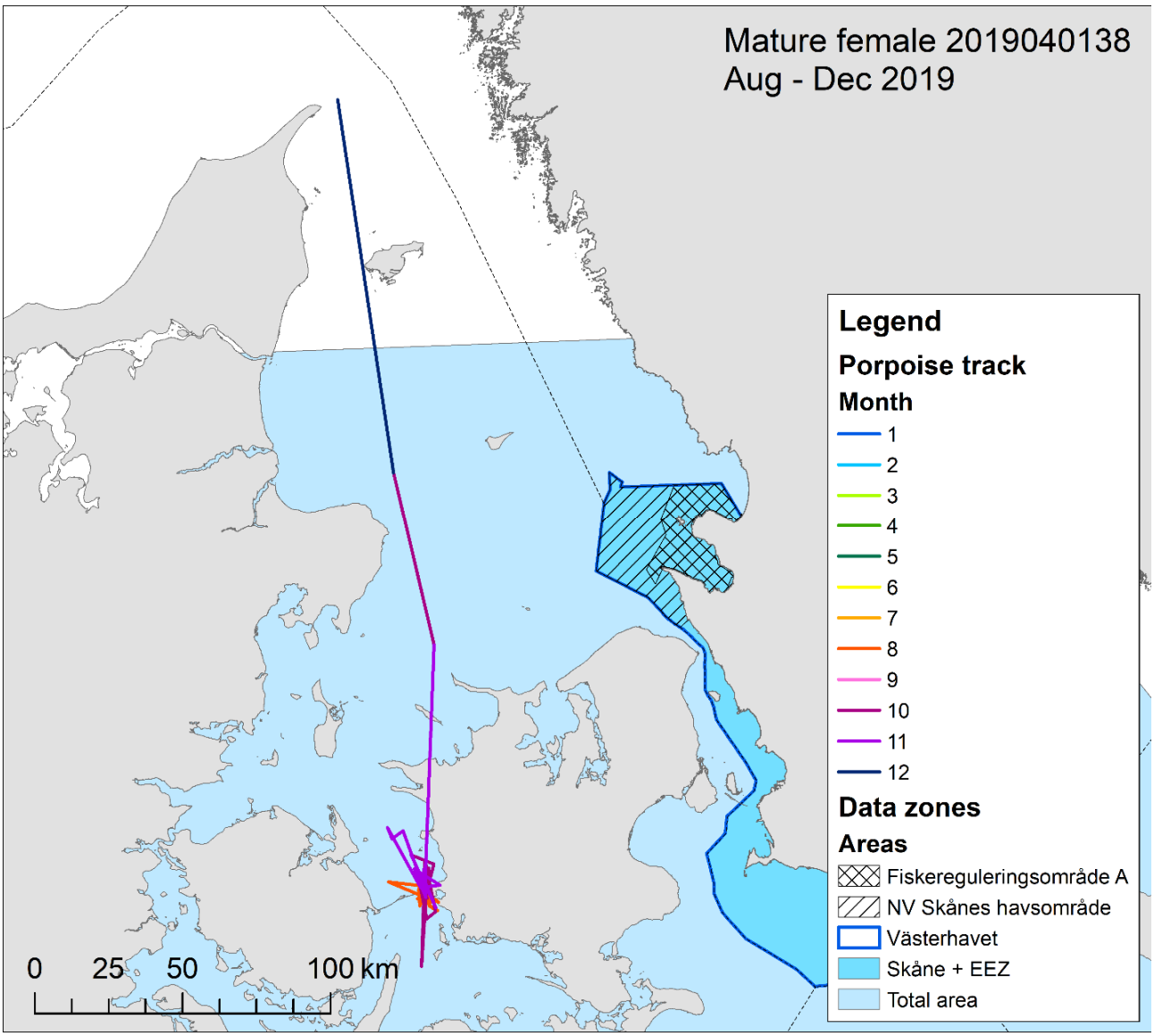


Figure 52. Track of mature female with Skåne waters highlighted.

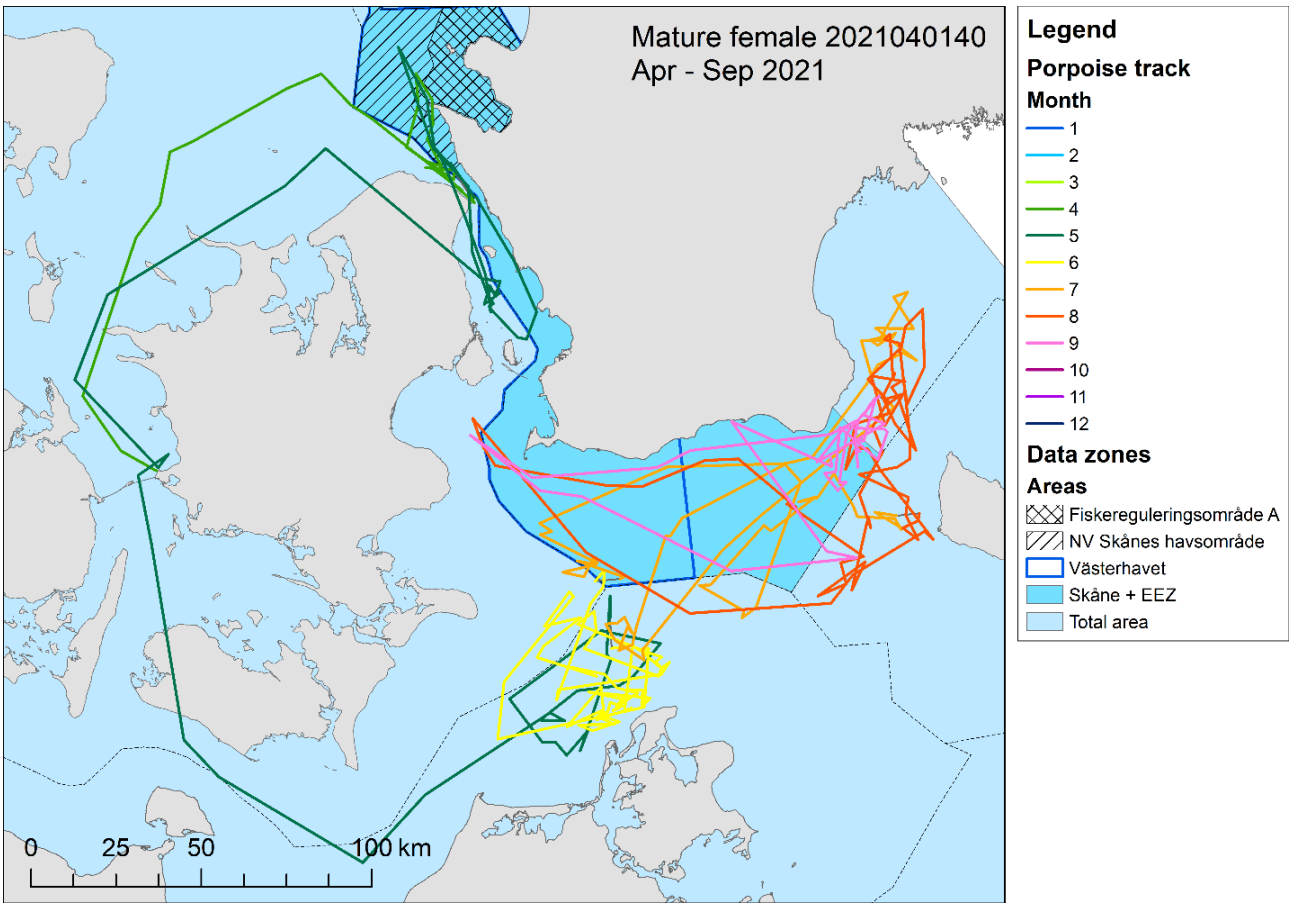


Figure 53. Track of mature female with Skåne waters highlighted.

Section 8 – Maps divided into three periods: 1997-2004, 2005-2012, 2013-2021

Here Kernel maps for two areas, namely the Belt Sea + gap area and the Skåne + EEZ are shown for the three time periods: 1997-2004, 2005-2012 samt 2013-2021. It was not possible to show changes in key habitats for smaller areas due to the limited data set. These maps show whether there has been a change in movements and distribution of porpoises over time.

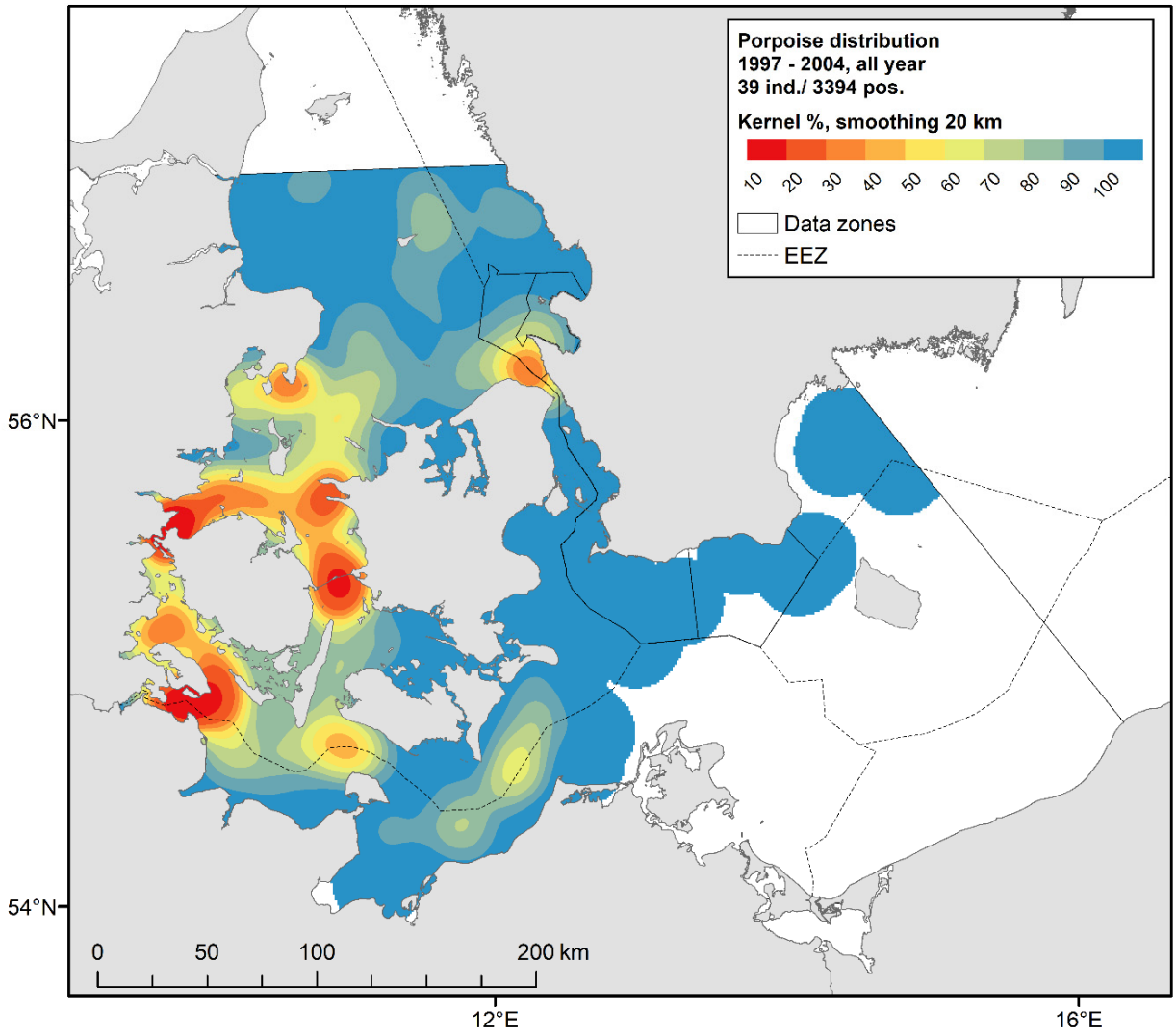


Figure 54. Kernel plots of positions year-round within the Belt Sea – gap area for 1997 - 2004.

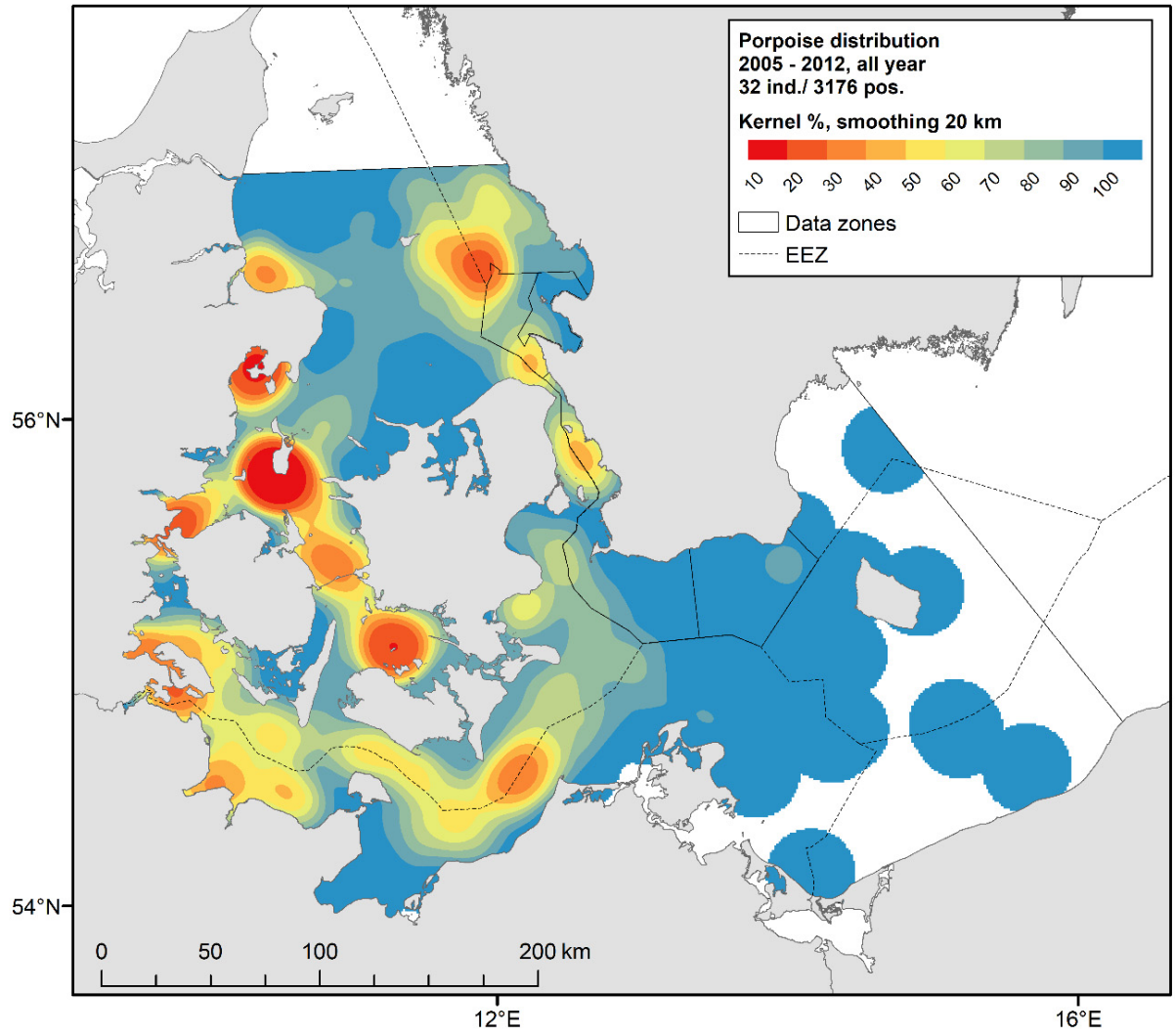


Figure 55. Kernel plots of positions year-round within the Belt Sea – gap area for 2005 - 2012.

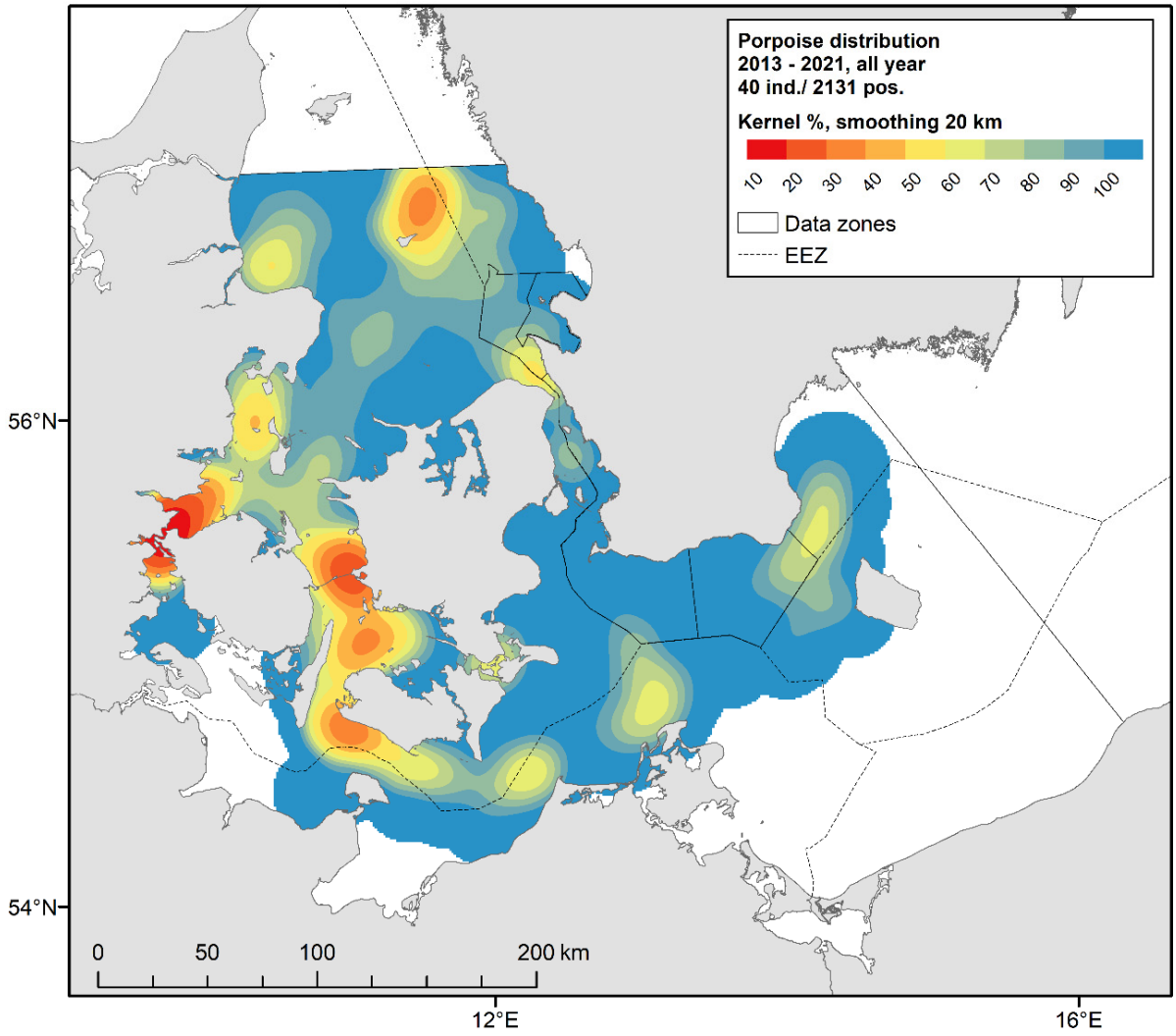


Figure 56. Kernel plots of positions year-round within the Belt Sea – gap area for 2013 – 2021.

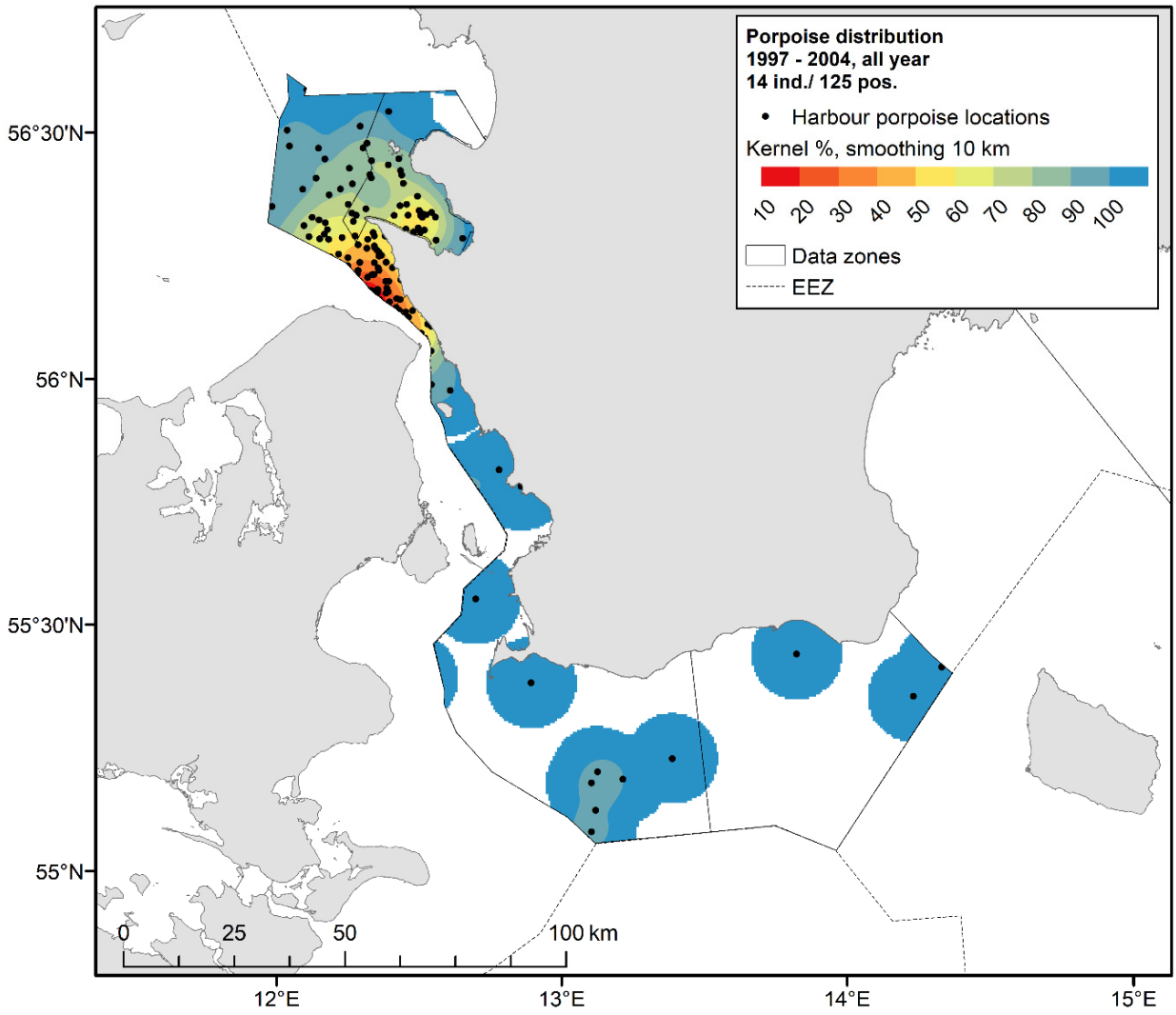


Figure 57. Kernel plots of positions year-round within Skåne + EEZ waters for 1997 – 2004.

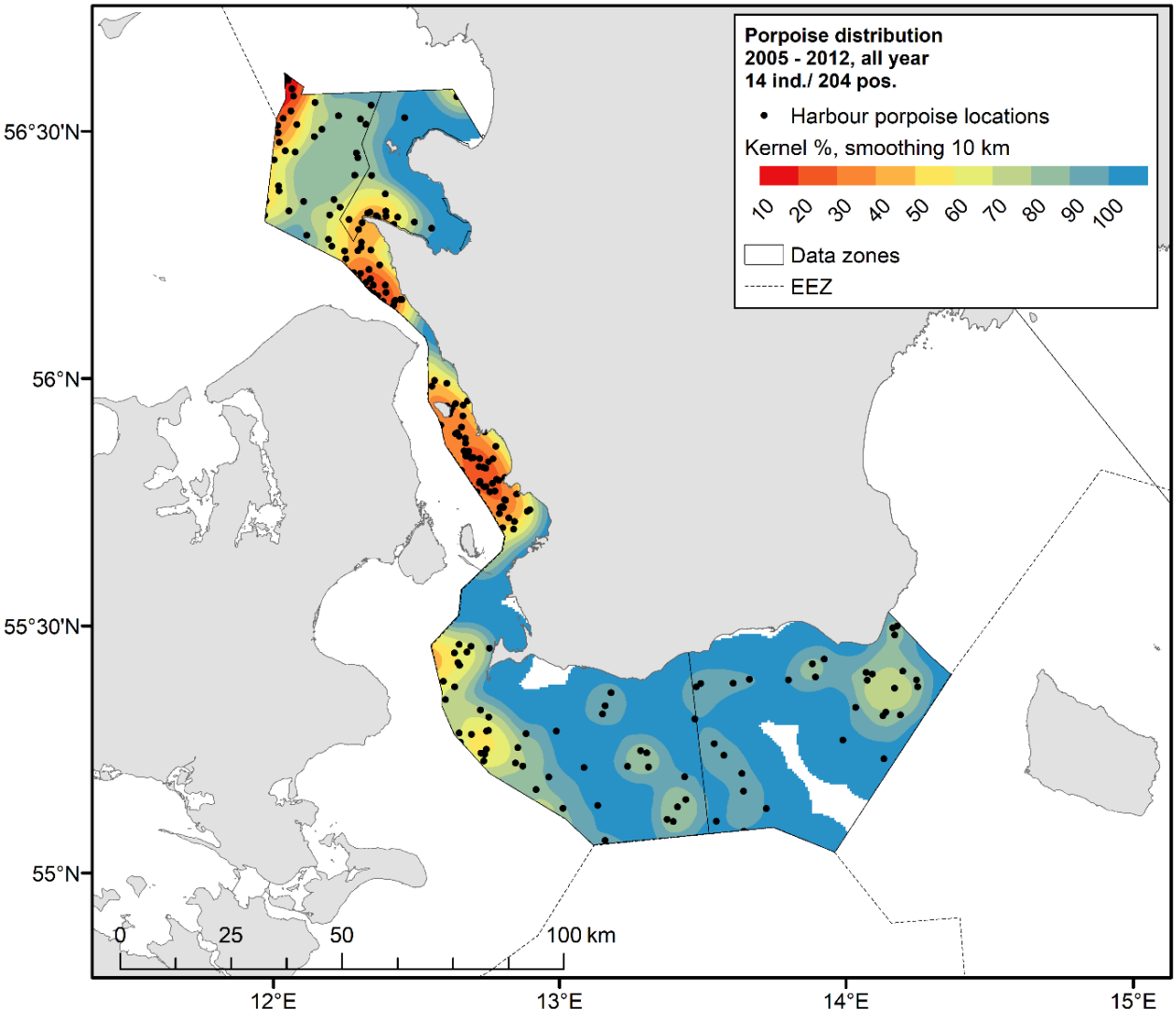


Figure 58. Kernel plots of positions year-round within Skåne + EEZ waters for 2005 - 2012

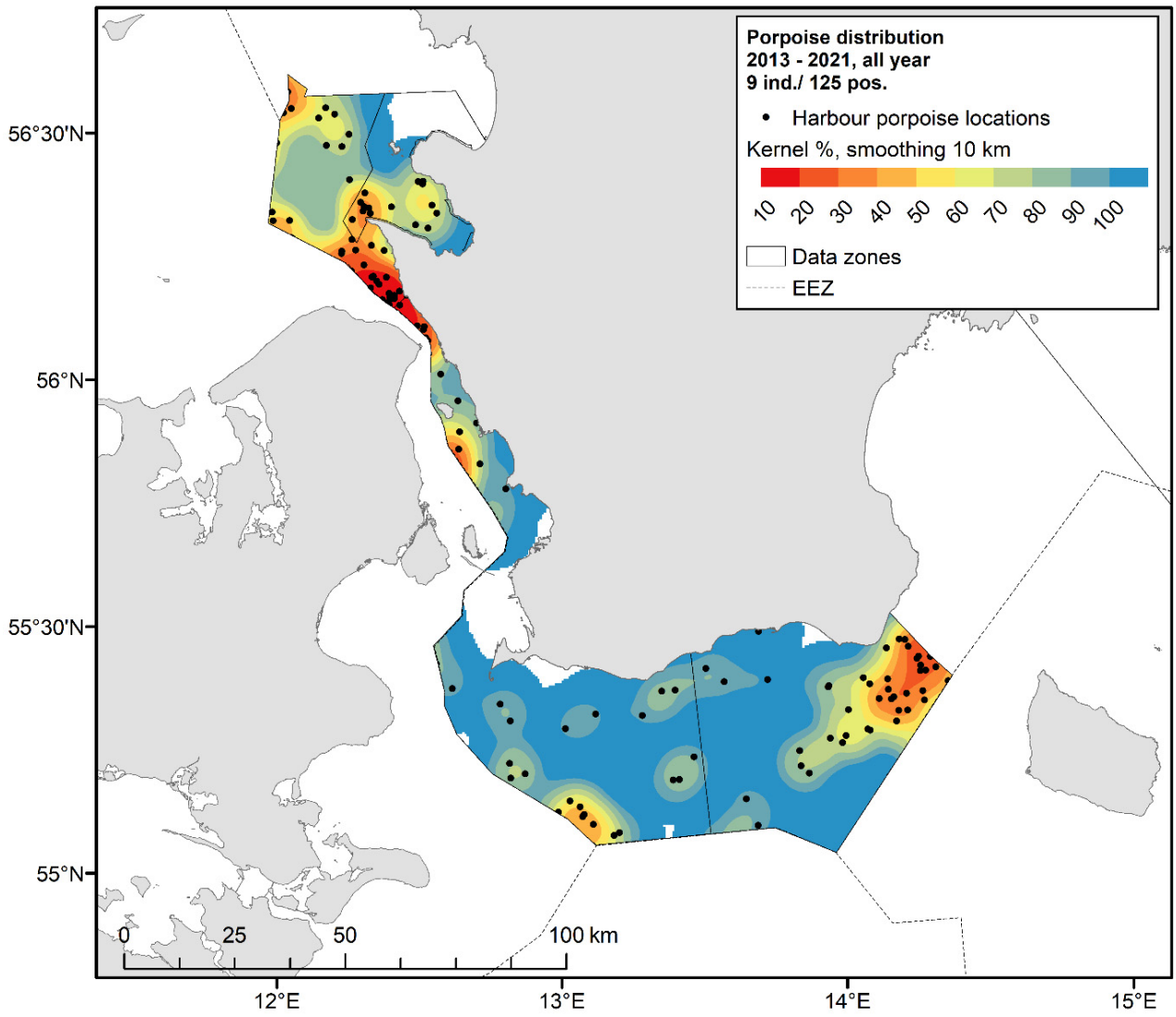


Figure 59. Kernel plots of positions year-round within Skåne + EEZ waters for 2013 - 2021.

Conclusion

This report covers 25 years of tagging results from harbour porpoises caught in Danish pound nets. In total, 111 porpoises were tagged and represented almost 33 full porpoise years covering all months of the year representing both juveniles and adults as well as females and males. We are confident that the data are representative of the general movements and habitat use within the Belt Sea population area. This report focuses especially on the Swedish waters along Skåne. Some of the areas analysed are relatively small in relation to the wide-ranging movements of porpoises, but also in relation to the number of individual porpoises and number of positions and should therefore be interpreted with some caution. Some areas may seem very important but could be due to one or a small number of animals spending a lot of time within a small area. Unfortunately, it is not possible to give precise guidelines to the number of animals tagged or the number of positions required within a certain area to have enough data on the habitat use. This is due to high individual variation in behaviour and potential age and sex differences (Sveegaard et al. 2011a). In addition, prey availability, climate change and other environmental changes might have caused some changes in habitat use within the study area over the years. This may be the reason for the variations seen in Figures 54-59, where data were pooled into three periods of 7-9 years to evaluate potential changes in habitat use in the study period. The data show an increased use of the central Øresund and the areas south of Sweden. However, in all three periods the area around Kullen is a key habitat.

An obvious distribution pattern in the Skåne waters is that the tagged porpoises are more abundant during spring, summer and fall around Kullen and central Øresund. The areas south of Sweden are used more often in summer and fall than in winter and spring. During winter, the waters of Skåne are generally of least importance to the tagged porpoises of the Belt Sea population. (Figures 4-7). In Figures 8-27 each of the Skåne areas are analysed and shown separately by season, giving the relative importance of each individual area. The Kernel percentages are directly comparable between the areas, seasons and years.

Figure 40-41 show the distribution of 12 tagged mature females for all the year and individual maps in Figure 42-53. Six of these animals spend time in Skåne waters. Some of them only for a short time, but especially the female shown in Figure 53 was registered in all regions of Skåne waters during April-September. According to the available data, northern Øresund west of Kullen is the most important area for adult females in Skåne waters. As the majority of females give birth every year during summer and nurse their calves the rest of the year, the distribution of adult females year-round is relevant to consider as breeding areas for porpoises.

References

Blundell, G. M., J. A. K. Maier, and E. M. Debevec. (2001). Linear home ranges: Effects of smoothing, sample size, and autocorrelation on kernel estimates. Ecological Monographs 71: 469-489.

Carlén, I., Thomas, L., Carlström, J., Amundin, M., Teilmann, J., Tregenza, N., Tougaard, J., Koblitz, J.C., Sveegaard, S., Wennerberg, D., Loisa, O., Dähne, M., Brundiers, K., Kosecka, M., Kyhn, L.A., Ljungqvist, C.T., Pawliczka, I., Koza, R., Arciszewski, B., Galatius, A., Jabbusch, M., Laaksonlaita, J., Niemi, J., Lyytinen, S., Gallus, A., Benke, H., Blankett, P., Skóra, K.E., Acevedo-Gutiérrez, A. (2018). Basin-scale distribution of harbour porpoises in the Baltic Sea provides basis for effective conservation actions. Biological Conservation 226: 42-53. https://doi.org/10.1016/j.biocon.2018.06.031

Costa DP, Robinson PW, Arnould JPY, Harrison A-L, Simmons SE, et al. (2010) Accuracy of ARGOS Locations of Pinnipeds at-Sea Estimated Using Fastloc GPS. PLoS ONE 5(1): e8677. doi:10.1371/journal.pone.0008677

Lockyer, C., & Kinze, C. (2003). Status, ecology and life history of harbour porpoise (*Phocoena phocoena*), in Danish waters. NAMMCO Scientific Publications, 5: 143–175. https://doi.org/10.7557/3.2745

Mikkelsen L, Rigét FF, Kyhn LA, Sveegaard S, Dietz R, Tougaard J, Carlström JAK, Carlén I, Koblitz JC, Teilmann, J 2016. Comparing Distribution of Harbour Porpoises (Phocoena phocoena) Derived from Satellite Telemetry and Passive Acoustic Monitoring. PLoS ONE 11(7): e0158788. doi:10.1371/journal.pone.0158788

Sequeira, A. M. M., Heupel, M. R., Lea, M. A., Eguíluz, V. M., Duarte, C. M., Meekan, M. G., et al. (2019). The importance of sample size in marine megafauna tagging studies. Ecol. Appl. 29, e01947. https://doi.org/10.1002/eap.1947

Sveegaard, S., Teilmann, J., Tougaard, J., Dietz, R., Mouritsen, K.N., Desportes, G. and Siebert, U. (2011a). High density areas for harbor porpoises (Phocoena phocoena) identified by satellite tracking. Marine Mammal Science 27(1): 230-246. https://doi.org/10.1111/j.1748-7692.2010.00379.x

Sveegaard, S., Teilmann, J., Berggren P., Mouritsen, K.N., Gillespie, D. & Tougaard, J. (2011b). Acoustic surveys confirm high density areas of harbour porpoises found by satellite tracking. ICES journal of Marine Science: 68(5), 929–936. DOI: 1093/icesjms/fsr025

Sveegaard, S., Galatius, A., Dietz, R., Kyhn, L., Koblitz J.C., Amundin, M., Nabe-Nielsen, J., Sinding, M.H.S., Andersen, L.W. and Teilmann, J. (2015). Defining management units for cetaceans by combining genetics, morphology, acoustics and satellite tracking. Global Ecology and Conservation 3: 839-850, doi:10.1016/j.gecco.2015.04.002

Sveegaard, S., Nabe-Nielsen, J. & Teilmann, J. (2018). Marsvins udbredelse og status for de marine habitatområder i danske farvande. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 36 s. - Videnskabelig rapport nr. 284. http://dce2.au.dk/pub/SR284.pdf

Teilmann, J., Larsen, F. & Desportes, G (2007): Time allocation and diving behaviour of harbour porpoises (*Phocoena phocoena*) in Danish waters. Journal of Cetacean Research and Management 9(3): 35-44 https://www.researchgate.net/publication/284678353_Time_allocation_and_diving_behaviour_of_harbour_porpoises_Phocoena_phocoena_in_Danish_and_adjacent_waters

Teilmann, J., Sveegaard, S., Dietz, R., Petersen, I.K., Berggren, P. & Desportes, G. (2008): High density areas for harbour porpoises in Danish waters. National Environmental Research Institute, University of Aarhus. 84 pp. – NERI Technical Report No. 657. http://www.dmu.dk/Pub/FR657.pdf and https://www2.dmu.dk/Pub/FR657_appendix.pdf

Unger, B., Nachtsheim, D. Ramírez Martínez, N., Siebert, U., Sveegaard, S., Kyhn, L., Balle, J.D., Teilmann, J. Carlström, J., Owen, K., Gilles, A. 2021. MiniSCANS-II: Aerial survey for harbour porpoises in the western Baltic Sea, Belt Sea, the Sound and Kattegat in 2020. Joint survey by Denmark, Germany and Sweden. Final report to Danish Environmental Protection Agency, German Federal Agency for Nature Conservation and Swedish Agency for Marine and Water Management. 28 pp. https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Eksterne_udgivelser/20210913_Report_MiniSCANSII_2020_revised.pdf

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70: 164–168.

Appendix 1

Table A1. Information on the 111 harbour porpoises tagged in the period 1997-2021 and included in this report. *indicate that porpoises entered Swedish waters of Skåne and the adjacent EEZ at some point during their period of tagging. Note that only positions within the Belt Sea porpoise population management area + the gap area (see Figure 1) are included in this table. Some animals moved outside the area and those positions are therefore not included

					Transmissions within Belt Sea and gap areas		
Porpoise ID	**Sex**	**Length (cm)**	**Age group**	**Tagging site**	**First position within the area**	**Last position within the area**	**Number of transmission days within the area**
1997006170*	F	164	Mature	Korsør	16/04/1997	22/05/1997	36
1997006171	F	110	Juvenile	Baaring Vig	14/04/1997	28/04/1997	14
1997006172	M	138	Mature	Baaring Vig	27/10/1997	01/12/1997	35
1997006173	M	114	Juvenile	Thorø Hus	01/11/1997	13/11/1997	12
1998006170	M	135	Juvenile	Korsør	04/04/1998	11/06/1998	68
1998006171*	F	166	Mature	Korsør	11/05/1998	23/06/1998	43
1998006173*	F	110	Juvenile	Korsør	11/05/1998	21/06/1998	41
1998006174	M	119	Juvenile	Korsør	04/04/1998	12/04/1998	8
1998006420	M	116	Juvenile	Baaring Vig	19/05/1998	13/07/1998	55
1999004108	M	117	Juvenile	Illumø	14/10/1999	02/11/1999	19
1999004540*	F	109	Juvenile	Kerteminde	02/11/1999	08/08/2000	280
1999006170	M	118	Juvenile	Abelds Hoved	27/04/1999	30/08/1999	125
1999006171	F	116	Juvenile	Baaring Vig	26/04/1999	03/08/1999	99
1999006172*	F	138	Juvenile	Korsør	30/03/1999	15/07/1999	107
1999006173	F	144	Mature	Langø	25/04/1999	16/08/1999	113
1999006174	F	112	Juvenile	Langø	25/04/1999	16/08/1999	113
1999006420*	M	107	Juvenile	Æbelø	28/07/1999	06/04/2000	253
1999006421*	M	127	Juvenile	Korsør	13/04/1999	04/07/1999	82
1999006422	F	120	Juvenile	Baaring Vig	13/04/1999	31/07/1999	109
2000002919*	M	121	Juvenile	Hesnæs	01/09/2000	05/01/2001	126
2000004178*	F	116	Juvenile	Kerteminde	26/03/2000	09/08/2000	136
2000004542*	M	142	Mature	Kerteminde	08/11/2000	29/08/2001	294
2000004961	M	134	Juvenile	Skagen	08/08/2000	08/08/2000	0
2000006171	M	150	Mature	Skagen	14/08/2000	29/05/2001	288
2001004108	F	98	Juvenile	Skagen	13/02/2002	13/02/2002	1
2001006170	M	109	Juvenile	Skagen	30/05/2001	15/06/2001	16
2001006421	F	163	Mature	Skagen	09/03/2002	25/05/2002	77
2001010336*	M	128	Juvenile	Fjellerup Strand	03/05/2001	28/08/2001	117
2001010341	M	123	Juvenile	Skagen	14/06/2001	14/06/2001	1
2001010343*	M	140	Mature	Svendstrup	22/04/2001	17/07/2001	86
2002002919	M	101	Juvenile	Korsør	06/10/2002	26/12/2002	81
2002006174	M	131	Juvenile	Thorø Hus	26/09/2002	21/05/2003	237
2002006422	F	105	Juvenile	Korsør	27/09/2002	25/02/2003	151
2002010342	M	140	Mature	Fjellerup Strand	10/05/2002	20/07/2002	71
2002024287*	F	129	Juvenile	Korsør	05/04/2002	18/06/2002	74
2002024296*	F	170	Mature	Korsør	05/04/2002	25/11/2002	234

2003006170	M	143	Mature	Fjellerup Strand	14/03/2003	18/03/2003	4
2003010340	M	153	Mature	Korsør	17/04/2003	28/07/2003	102
2003026634	M	130	Juvenile	Korsør	19/08/2003	24/09/2003	36
2005006420	M	120	Juvenile	Baaring Vig	08/06/2005	27/10/2005	141
2006006171	F	106	Juvenile	Fjellerup Strand	15/05/2006	15/05/2006	1
2006006172*	M	111	Juvenile	Fjellerup Strand	26/04/2006	08/11/2006	196
2006006421	M	125	Juvenile	Korsør	02/05/2006	20/11/2006	202
2006006422	M	149	Mature	Korsør	23/04/2006	06/11/2006	197
2007006170*	F	166	Mature	Fjellerup Strand	19/05/2007	15/06/2007	27
2007017776	M	146	Mature	FaxeLadeplads	08/10/2007	07/11/2007	30
2008006170*	M	122	Juvenile	Korsør	30/10/2008	30/07/2009	273
2008017758*	F	127	Juvenile	Mosede Havn	13/10/2008	17/05/2009	216
2008017764*	M	139	Mature	Mosede Havn	13/10/2008	31/01/2009	110
2009006172	M	126	Juvenile	Fjellerup Strand	01/03/2009	05/08/2010	522
2009006422*	M	139	Mature	Korsør	09/04/2009	06/09/2010	515
2009056570	M	114	Juvenile	Fjellerup Strand	19/08/2009	26/09/2009	38
2009056571*	M	104	Juvenile	Kramnitze	25/09/2009	04/11/2009	40
2009056572*	F	110	Juvenile	Fjellerup Strand	09/06/2009	06/11/2009	150
2009057098	F	160	Mature	Kramnitze	25/09/2009	21/01/2010	118
2009057100	F	129	Juvenile	Kalø Vig	10/10/2009	12/09/2010	337
2010056573	F	150	Mature	Korsør	28/03/2010	31/03/2010	3
2010056574	M	107	Juvenile	Fjellerup Strand	19/05/2010	28/05/2010	9
2010057099*	F	108	Juvenile	Fjellerup Strand	19/05/2010	04/01/2011	230
2010057101	M	115	Juvenile	Fjellerup Strand	16/05/2010	13/08/2010	89
2010057102*	M	119	Juvenile	Korsør	28/03/2010	12/09/2010	168
2011006170	M	135	Juvenile	Korsør	29/03/2011	09/04/2011	11
2011006171*	M	130	Juvenile	Korsør	14/04/2011	28/08/2011	136
2011006421	F	118	Juvenile	Fjellerup Strand	15/07/2011	16/07/2011	1
2011017758	M	125	Juvenile	Fjellerup Strand	06/05/2011	07/05/2011	1
2011056570	M	125	Juvenile	Fjellerup Strand	03/08/2011	14/10/2011	72
2011083303	F	147	Mature	Knebel	25/09/2011	30/07/2012	309
2011083304*	M	117	Juvenile	Fjellerup Strand	04/07/2011	06/10/2011	94
2011083306*	M	126	Juvenile	Fjellerup Strand	04/07/2011	09/11/2012	494
2011083307	F	125	Juvenile	Korsør	21/09/2011	30/07/2012	313
2012017764*	F	155	Mature	Korsør	03/04/2012	10/06/2012	68
2013006170	F	116	Juvenile	Little Belt	31/10/2013	10/05/2014	191
2013006171	F	132	Juvenile	Omø Staal	22/08/2013	09/12/2013	109
2013017758	F	114	Juvenile	Little Belt	24/10/2013	01/02/2014	100
2013056571	M	141	Mature	Korsør	02/05/2013	04/09/2013	125
2013057099	M	146	Mature	FaxeLadeplads	30/08/2013	07/11/2013	69
2013057100	F	119	Juvenile	Little Belt	24/10/2013	14/01/2014	82
2013057101	M	141	Mature	Korsør	22/04/2013	14/06/2013	53
2013057102	M	116	Juvenile	Little Belt	23/05/2013	04/07/2013	42
2014006421	F	122	Juvenile	Baaring Vig	20/03/2014	14/07/2014	116
2014056570	F	127	Juvenile	Fjellerup Strand	28/02/2014	28/02/2014	1
2014083303*	M	136	Juvenile	Skagen	23/01/2015	23/04/2015	90

2014138065	M	116	Juvenile	Fjellerup Strand	23/04/2014	06/07/2014	74
2014138066	M	122	Juvenile	Little Belt	02/06/2014	07/06/2014	5
2014138068	M	112	Juvenile	Fjellerup Strand	04/06/2014	12/07/2014	38
2014138069*	F	115	Juvenile	Fjellerup Strand	04/06/2014	04/09/2014	92
2014138070	M	113	Juvenile	Begtrup Vig	04/09/2014	10/09/2014	6
2014138071	M	147	Mature	Skagen	13/02/2015	14/04/2015	60
2014138072	M	143	Mature	Korsør	13/11/2014	25/03/2015	132
2014138073	M	107	Juvenile	Little Belt	30/10/2014	04/01/2015	66
2014138075*	M	127	Juvenile	Fjellerup Strand	16/06/2014	27/08/2014	72
2015020164*	M	118	Juvenile	Skagen	02/04/2016	15/08/2016	135
2015149158	M	129	Juvenile	Skagen	05/11/2015	05/11/2015	1
2015149159	F	138	Juvenile	Skagen	02/11/2015	02/11/2015	1
2015149162	M	134	Juvenile	Skagen	24/11/2015	24/11/2015	1
2015149163	M	144	Mature	Baaring Vig	28/04/2015	25/08/2015	119
2015149169	M	133	Juvenile	Baaring Vig	21/04/2015	08/07/2015	78
2016149164*	F	110	Juvenile	Korsør	06/05/2016	13/08/2016	99
2018040126	M	123	Juvenile	Kalø Vig	05/05/2018	03/08/2018	90
2018040129*	M	136	Juvenile	Fjellerup Strand	09/05/2018	19/08/2018	102
2018040130	M	114	Juvenile	Fjellerup Strand	23/05/2018	09/08/2018	78
2018040131*	M	118	Juvenile	Fjellerup Strand	23/05/2018	13/02/2019	266
2018040133*	M	134	Juvenile	Korsør	31/05/2018	18/06/2018	18
2018040134	M	112	Juvenile	Begtrup Vig	23/07/2018	17/10/2018	86
2019040138	F	171	Mature	Korsør	22/08/2019	01/12/2019	101
2019163553	M	123	Juvenile	Begtrup Vig	18/06/2019	21/06/2019	3
2021006170	F	111	Juvenile	Little Belt	30/09/2021	30/09/2021	1
2021006422	M	146	Mature	Korsør	19/03/2021	11/06/2021	84
2021040140*	F	156	Mature	Korsør	18/04/2021	29/09/2021	164
2021083303	M	153	Mature	Korsør	19/03/2021	11/07/2021	114
2021083307	F	108	Juvenile	Little Belt	30/09/2021	30/09/2021	1

THE USE OF SCANDINAVIAN MARINE WATERS/MARINE WATERS OF SKÅNE BY HARBOUR PORPOISES IN TIME AND SPACE

This report is mapping harbour porpoise movements, distribution and important habitats of the Swedish waters of Skåne. The maps are based on Argos satellite tracking of 111 harbour porpoises tracked between 1997-2021 in the Belt Sea harbour porpoise population, management area and the gap area between the summer management units of the Belt Sea and Baltic Proper populations. Eight sets of maps are presented based on area, season, month, inter annual differences and a separate set of maps for mature females.

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