Agenda Item 4.6: **Review of new information on population distribution, sizes, structures and bycatches of small cetaceans**

Expert Paper: Passive acoustic monitoring of harbour porpoises (Phocoena phocoena) in the German Baltic Sea

Submitted by: **Germany**

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Passive acoustic monitoring of harbour porpoises (*Phocoena phocoena*) in the German Baltic Sea

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Summary

A passive acoustic monitoring with the help of porpoise detectors (T-PODs) has been conducted year around from summer 2002 to the end of 2005 on up to 44 measuring positions throughout the German Baltic Sea. Results show a geographical difference in the percentage of days with decreasing porpoise registrations from west to east, as well as a seasonal variation with fewer days with registrations in the winter than in the summer time. This study proves a regular use of the German Baltic Sea by harbour porpoises as well as a seasonal migration pattern of the German Baltic Sea porpoise stock.

Introduction

Harbour porpoises occur throughout temperate shelf waters of the northern hemisphere (Read, 1999). The harbour porpoise is the only 'German' resident cetacean in the waters of the country's Baltic Sea (Benke et al., 1998). The abundance of the animal in this area has mainly been investigated in the summer months with line transect methods conducted by ship or plane (Hammond et al., 2002; Heide-Jørgensen et al., 1993; Scheidat et al., 2004a). Whereas the study of Hammond et al. (2002) and Heide-Jørgensen et al. (1993) only delivered data for the Kiel bight, Scheidat et al. (2004a) included the entire German Baltic Sea area into their study, as well as spring and autumn survey data (Scheidat et al., 2004b).

In the western North Atlantic, porpoises show a migration into coastal waters during summer or a move offshore in the winter, probably to avoid advancing ice cover (Read, 1999). Seasonality in harbour porpoise abundance is also found around the coast of Iceland (Saemundsson, 1939) and the Faeroe Islands (IWC, 1996). Historical catches in the Little Belt area of Denmark in spring and winter time point towards a seasonal migration of harbour porpoises inhabiting the Baltic Sea (Kinze, 1995).

It has not yet been shown how the harbour porpoise abundance of the German Baltic Sea changes over seasons and if seasonal migration finds place in the German Baltic Sea harbour porpoise stock.

Results of 3.5 years of year around harbour porpoise monitoring in the German Baltic Sea are presented. Habitat use and relative abundance were investigated with a passive acoustic method, using harbour porpoise click detectors (T-PODs).

Methods

The T-POD

T-PODs are self-contained data loggers for cetacean echolocation clicks (for details, see www.chelonia.demon.co.uk/PODhome.html), consisting of a hydrophone, filter and digital memory. They register, in a 10-µsec resolution, the presence and length of high frequency click sounds matching specific criteria, logging for 24 hours a day for a period of eight to ten weeks. After this period, the data are downloaded and batteries have to be replaced.

T-POD application

Up to 44 measuring positions were selected to monitor the German Baltic Sea from the Kiel bight to the Pomeranian Bay (Figure 1) within a time frame of summer 2002 to the end of 2005. This net of measuring positions, shown in Figure 1, contained fewer positions when starting in 2002, and grew, especially in the beginning of 2005 to its final size.

On each measuring position, one T-POD at a time was deployed on a mooring, fixed five to seven metres under the water surface. T-PODs of versions 2, 3 and 4 were used. The mooring consisted of a 30-kg weight and anchor connected to several surface buoys via a rope. From the beginning of the recordings in 2002 until spring 2005, the listening criteria of the T-PODs were set to “porpoise-only high sensitivity” as given in the T-POD programme (T-POD version 2: filter A = 130 kHz, filter B = 90 kHz, ratio A/B = 4, ‘A’ filter sharpness = 10, ‘B’ filter sharpness = 18, minimum intensity = 6, scan limit on number (N) of clicks logged = 240; T-POD version 3: filter A = 130 kHz, filter B = 90 kHz, ratio A/B = 4, ‘A’ integration period = short, ‘B’ integration period = long, minimum intensity = 6, scan limit on N clicks logged = 240; T-POD version 4 were not used during that time). Eventually the ratio A/B was set to 6, which reduced the registration of high frequency background noise.

The T-PODs were calibrated before deployment to determine the specific minimum receiving level. This is the minimum sound pressure level a porpoise click needs to have at the devices hydrophone to be registered. The minimum receiving level of the deployed T-PODs was in the range of 117 dB re 1 $V_{(pp)}$/µPa up to 144 dB re 1 $V_{(pp)}$/µPa. From spring 2005 on, the T-PODs were - if possible - set to a standard sensitivity of 127 dB re 1 $V_{(pp)}$/µPa by adjusting the factor “minimum intensity”. From this time on also version 4 T-PODs were used, set to: filter A = 130 kHz, filter B = 92 kHz, click bandwidth = 5, noise adaptation = ++, sensitivity = set according to a sensitivity of 127 dB re 1 $V_{(pp)}$/µPa.

2.3 Data analysis

The click sounds registered from the T-PODs were scanned for trains of clicks with a specific signal pattern by means of a Train Detection algorithm (V2.2), which was included in the T-POD software. Click trains classified by the algorithm as ”high probability cetacean click trains” up to ”very doubtful trains” originated from harbour porpoises, boat noise (e.g. sonar, propeller noise) or background noise. Those click trains were manually reviewed for harbour porpoise echolocation click trains as described in Verfuß et al. (2004a, 2004b). Click trains classified by the algorithm, which were then manually attributed to porpoise origin, were included in the data set. For further analysis porpoise-positive days, defined as a day with at least one classified porpoise click train, were determined from all data recordings. The percentage of porpoise-positive days in the number of monitored days per quarter of a year was calculated for each position.

Statistics

The gained data of the percentage of porpoise positive days per quarter have been tested for geographical and seasonal differences.

For revealing geographical differences, the coefficient of a Spearman correlation on rank was calculated, separate for each combination of year and quarter (a total of 14 correlations). The correlation-coefficient was then tested with a sign test. P-values were calculated with the permutation method (10.000 permutations each). The alpha-correction has been conducted with a binomial approach after Cross and Chaffin (1982) as well as the fisher's omnibus test (Haccou and Meelis, 1994).

Furthermore, for the third quarter of 2005, the connection between the results of measuring positions and their geographical distance was investigated. Therefore for each pair (1; 2) of measuring points the dissimilarity (C_U) of their data (%PPD = percentage of porpoise positive days) was calculated:

C_U = (%PPD1 - %PPD2) / (%PPD1 + %PPD2), if %PPD1 + %PPD2 > 0, otherwise 0.

With a matrix correlation the connection between the dissimilarity and the geographical distance of the measuring points was determined. The significance of this correlation was gathered with a Mantel test (Sokal and Rohlf, 1995).

For revealing seasonal differences, the means over the years of the percentage of porpoise positive days for the first and the third quarter, respectively were built for each measuring position and tested with a Wilcoxon test.

For giving a better overview over the results the data of measuring positions placed in the same area (as indicated by the letters A to H in Figure 1) were merged to an overall mean percentage of porpoise positive days per quarter and area.

2.4 Influence of T-POD version / settings / sensitivity

Differences in the T-PODs' versions, their settings and / or their sensitivity are of great concern for the comparability of the data. Therefore several tests have been conducted to test the comparability of the data gathered for this project.

The change of the settings from ratio 4 to ratio 6 affected neither the sensitivity nor the comparability of the gathered data (Verfuß et al., 2004a). Also data recorded with version 2 T-PODs were comparable with the data of version 3 T-PODs (Verfuß et al., 2004b), as long as all train classes mentioned above were included into the data analysis.

The sensitivity of the T-PODs was included into the statistical analysis of the first year's data as described in Verfuß et al. (2006), to reveal any influence of the T-POD sensitivity differences. It could be shown that there was no influence of the sensitivity on the results.

Recordings of one T-POD of version 3 and two T-PODs of version 4 applied in the same spot of a porpoise rich area for 4 days showed comparable results. During this application, one v4 was set to noise adaptation = ++ while the other was set to noise adaptation = +. The T-PODs were set to the same sensitivity (Verfuß, pers. comm.).

Results

Geographical differences

A significant decrease of the percentage of porpoise positive days from west to east was seen in all quarters over the years (Figure 2, 3) (all P = 0,0001; rho = -0,328 (n = 10, 1st quarter 2004) to
-0,966 (n = 14, 4th quarter 2003); sign test: P = 0,00012; alpha-correction after Cross & Chaffin: P < 0,0001; Fischer's omnibus test: $\chi^2 = 257,8$; df = 28; P < 0,0001).

Neighbouring measuring positions showed similar results and data turned out to become more dissimilar with growing distance in between the positions. For the third quarter 2005 the statistical analysis of this phenomenon revealed a significant correlation between distance of two positions and their differences in results (rho = 0,573, P = 0,001).

Seasonal differences

Significant seasonal differences have been revealed for the percentage of porpoise positive days (Figure 2, 3). Averaged over the years, the measuring positions showed a significant higher percentage of porpoise positive days in the third quarter, which mainly mirrors summer than in the first quarter, resembling mainly winter time. (z = 3.63; N = 21; P < 0.001).

Discussion

Our results show clear geographical and seasonal differences in the percentage of porpoise positive days per quarter of the years, with decreasing porpoise registrations from west to east and fewer registrations in winter than in summer (Figure 2, 3).

Verfuß et al. (2005) showed the importance of echolocation for harbour porpoises. Porpoises, which were living in a well-known, semi-natural outdoor pool, permanently used echolocation even in easy orientation tasks during daylight regardless of the season. Therefore, a regular use of echolocation by harbour porpoises is likely. The changes in the portion of porpoise positive days during the course of the year and differences across areas are assumed to be caused by temporal changes and geographical differences in harbour porpoise density. A decrease in harbour porpoise density from west to east in the German Baltic Sea is also confirmed by the aerial surveys conducted by Scheidat et al. (2004b) in 2002 and 2003.

Morphological and genetic studies revealed the existence of a separate subpopulation of harbour porpoises in the Baltic proper, i.e., east of Darss Sill (Huggenberger et al., 2002, Tiedemann, 2001). Low density of this subpopulation raises deep concern for the survival of the population, which is especially emphasised in the recovery plan for Baltic harbour porpoises (Jastarnia Plan, ASCOBANS). The T-POD data confirm a very low density of harbour porpoises in the German part of the Baltic proper. Any negative anthropogenic influence (e.g., incidental fishery by-catch, chemical or noise pollution) on this very small and therefore highly endangered subpopulation might sooner or later lead to its extinction if no action is taken.

Until the mid-20th century migration of harbour porpoises was assumed for the North and Baltic Sea (reviewed in Koschinski, 2003). In spring, the porpoises were thought to have followed movements of herring, passing Danish waters into the Baltic Sea. In late autumn and winter, when the Baltic tended to freeze over in some years, the porpoises may have migrated back out of the Baltic Sea. Nowadays, the porpoise stocks are too small to easily prove such migrations. Teilmann et al. (2004) could prove seasonality in the use of areas in Danish waters with the help of satellite tags on porpoises. Siebert et al. (submitted) showed seasonality in incidental sightings and stranding rates in the German Baltic Sea, with a peak in the summer months. The authors discuss that the data of incidental sightings might be biased by a lower effort in winter (e.g. less sailing boats), whereas stranding events can be biased by a longer submersion time of carcasses when water temperature is low (Moreno, 1993). The T-PODs proved seasonal changes in the use of the Baltic Sea areas, being very obvious for the area west of the island of Rügen (Figure 3).

The method of T-POD deployment proved to be a valuable tool for investigating the habitat use by harbour porpoises of the German Baltic Sea in a temporal and geographical scale. The presented results show a regular use of the German Baltic Sea west of the island of Rügen, demonstrating the importance of this area for the porpoises.

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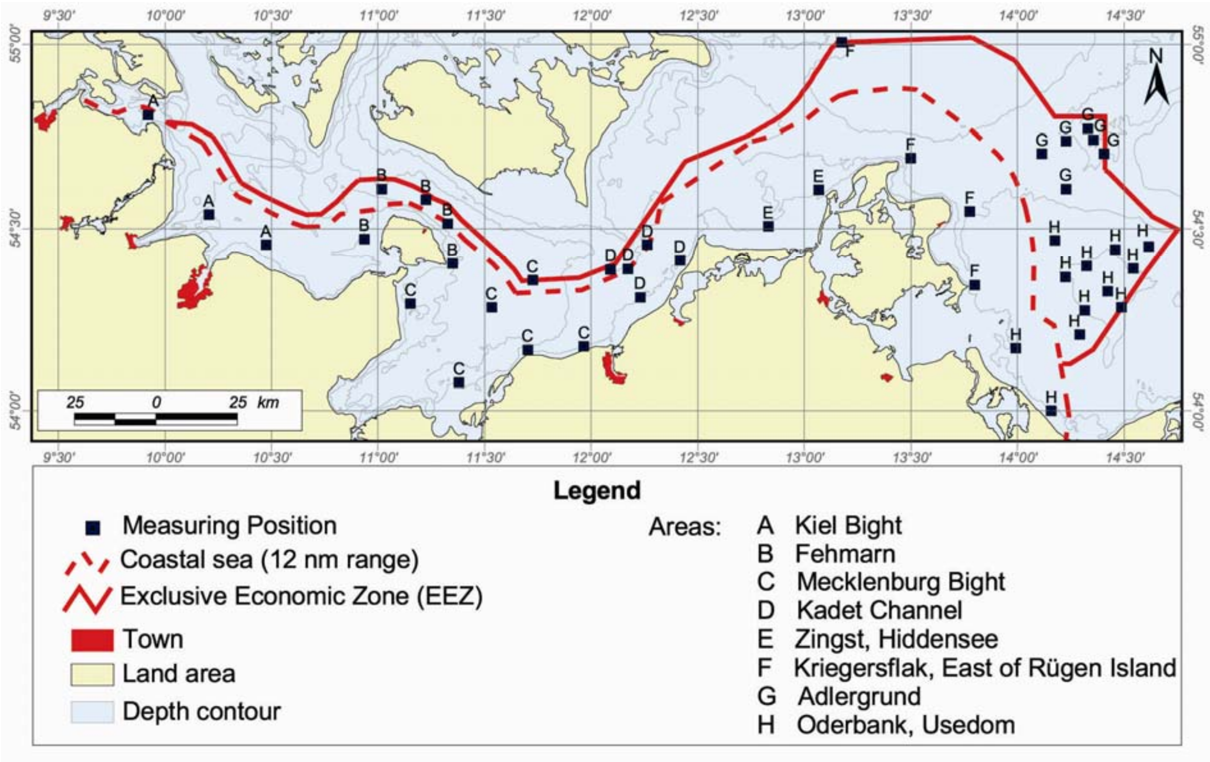
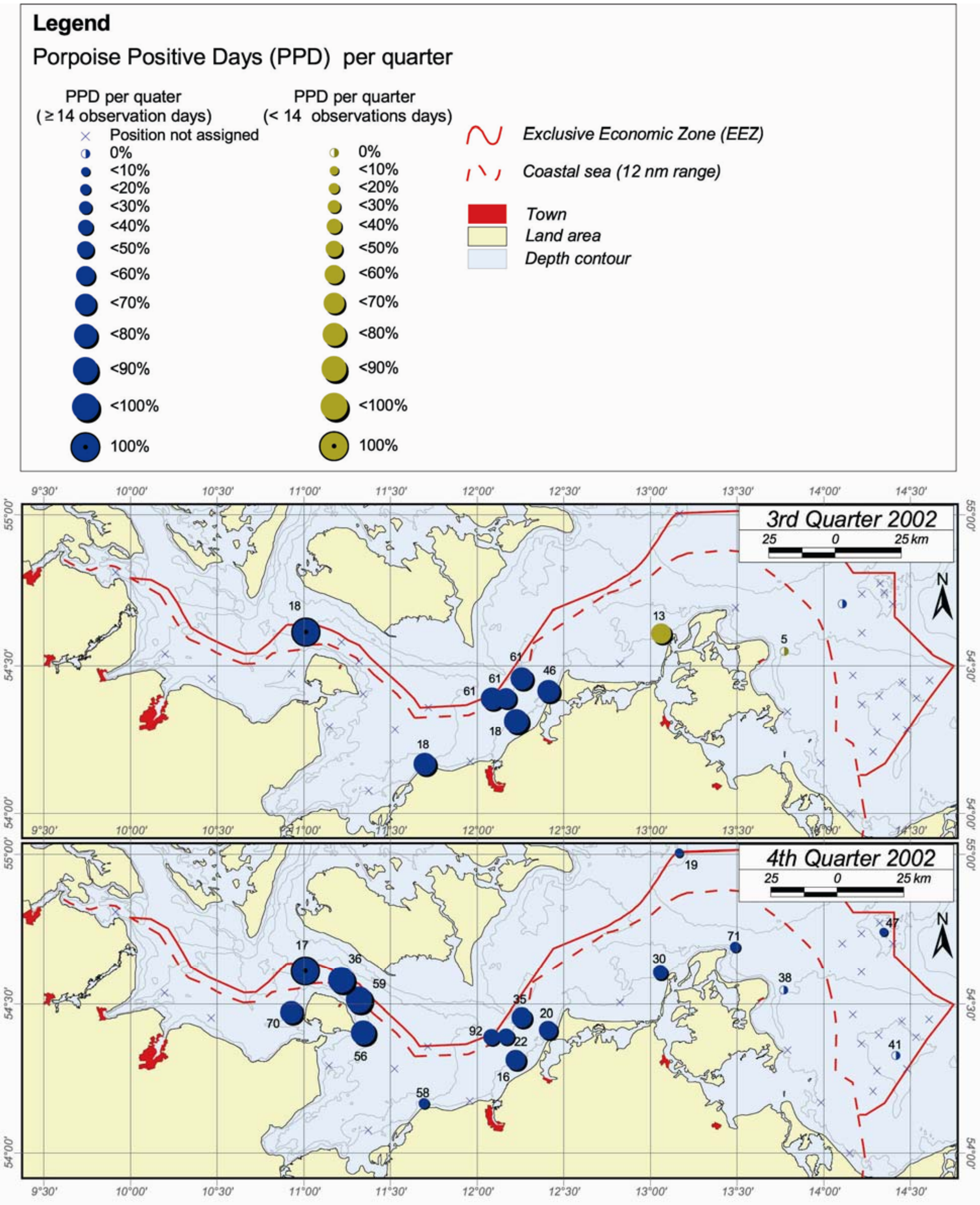


Figure 1:

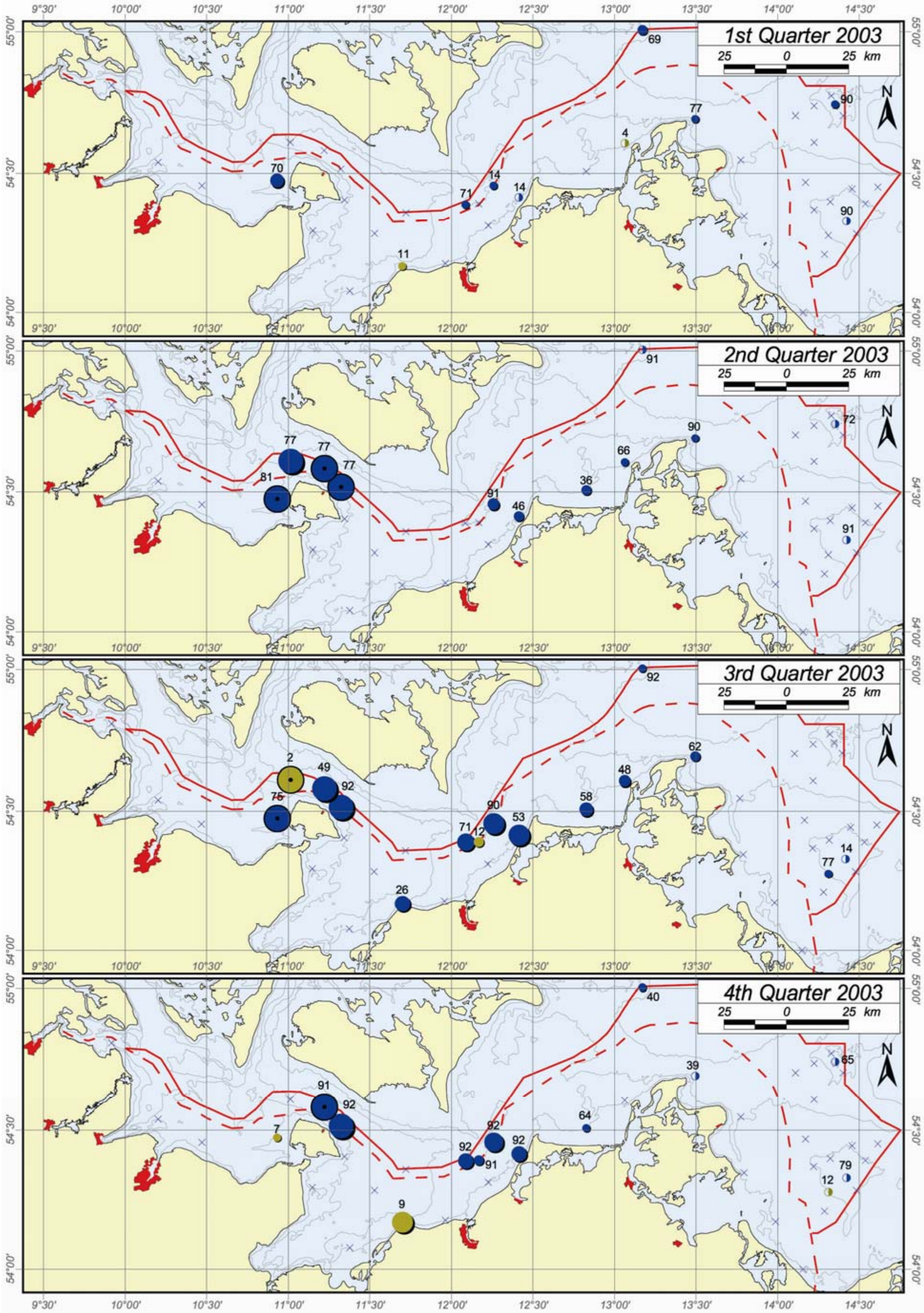
T-POD measuring positions in the German Baltic Sea (blue squares). The letters A to H indicate which positions are considered to belong to the same area for calculating average data as seen in Figure 3.



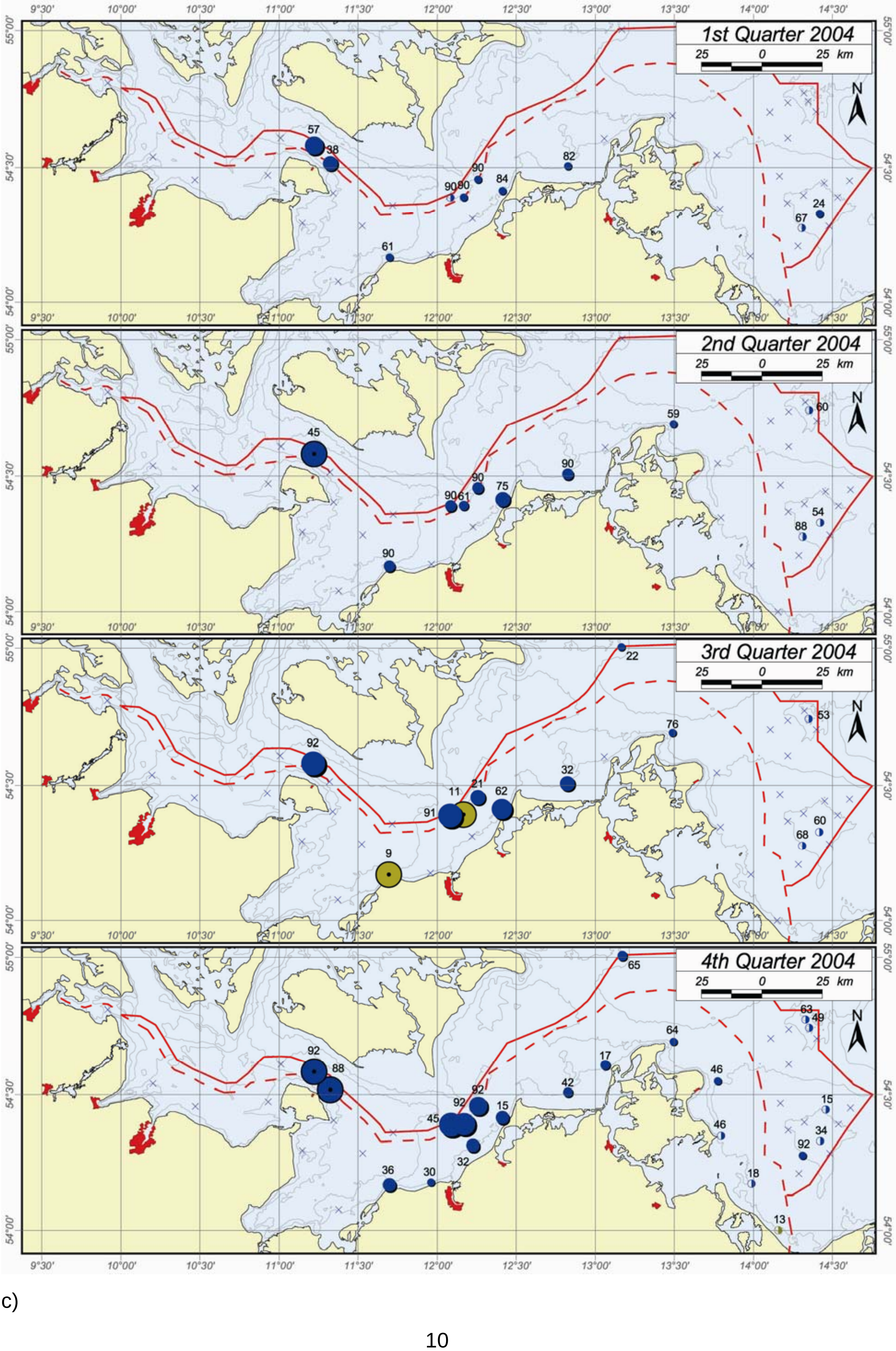
a)

Figure 2 (above and next pages):

Percentage of porpoise positive days per observation period and measuring position for the quarters of the years 2002 (a), 2003 (b), 2004 (c) and 2005 (d). The size of the circles resembles the value of the percentage of porpoise positive days per quarter. The number of observation days is given next to the circles. For observation periods below 14 days, the circles are filled ochre. For observations periods with 14 or more days the circles are filled blue. Measuring positions, at which no data were gathered for the specific quarter, are marked with grey crosses.


1st Quarter 2003
2nd Quarter 2003
3rd Quarter 2003
4th Quarter 2003
25 0 25 km
N
9°30'
10°00'
10°30'
11°00'
11°30'
12°00'
12°30'
13°00'
13°30'
14°00'
14°30'
55°00'
54°30'
54°00'

b)


1st Quarter 2004
25 0 25 km
N
57
38
90
90
80
84
82
24
67
61
2nd Quarter 2004
25 0 25 km
N
45
60
59
90
90
90
61
75
54
88
90
3rd Quarter 2004
25 0 25 km
N
22
53
76
92
32
11
21
62
91
60
68
9
4th Quarter 2004
25 0 25 km
N
65
63
49
64
17
46
92
88
42
92
92
15
45
32
46
15
34
92
36
30
18
13
9°30'
10°00'
10°30'
11°00'
11°30'
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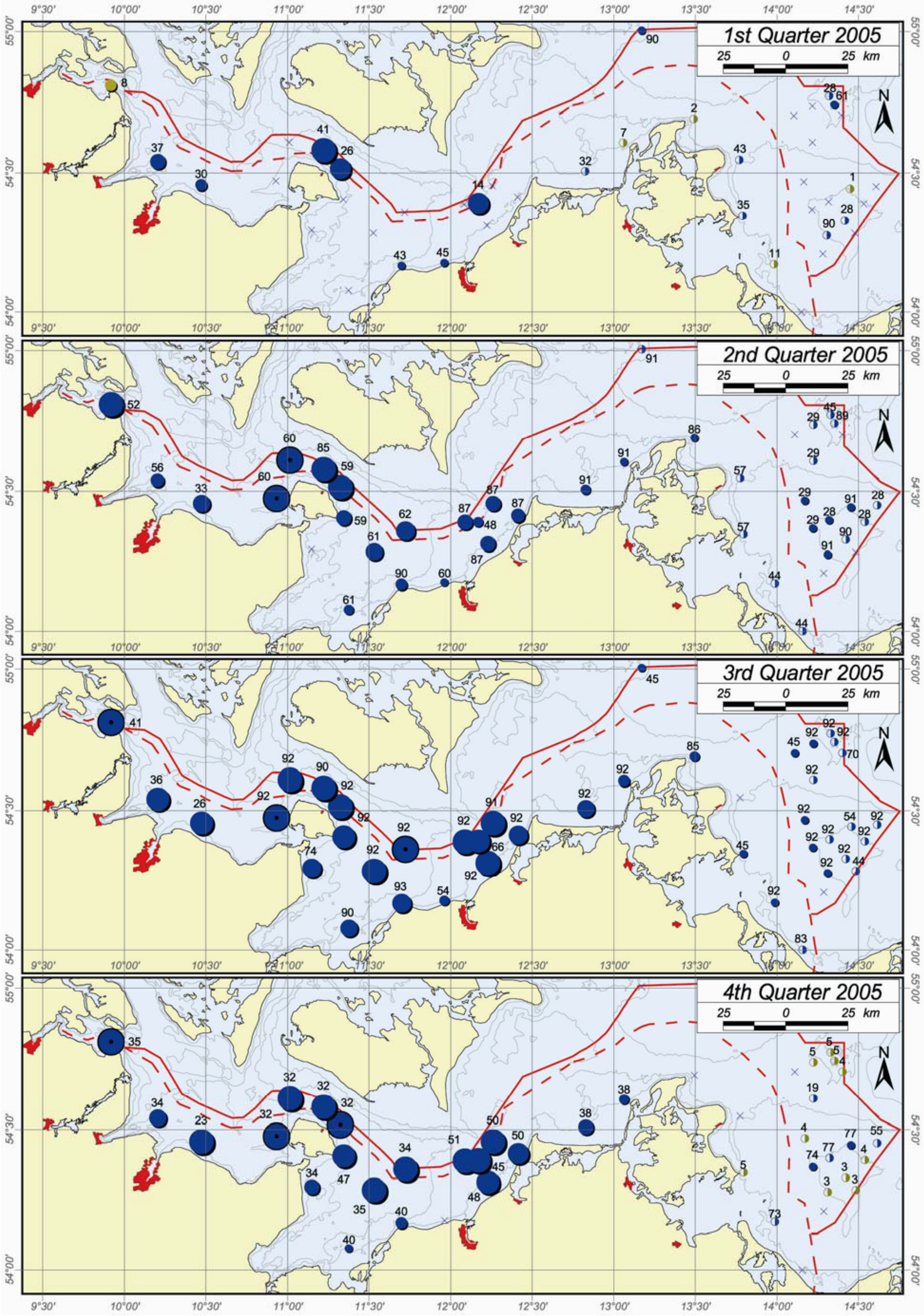
54°30'
54°00'

c)


1st Quarter 2005
2nd Quarter 2005
3rd Quarter 2005
4th Quarter 2005
25 0 25 km
N
9°30'
10°00'
10°30'
11°00'
11°30'
12°00'
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13°30'
14°00'
14°30'
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54°30'
54°00'

d)

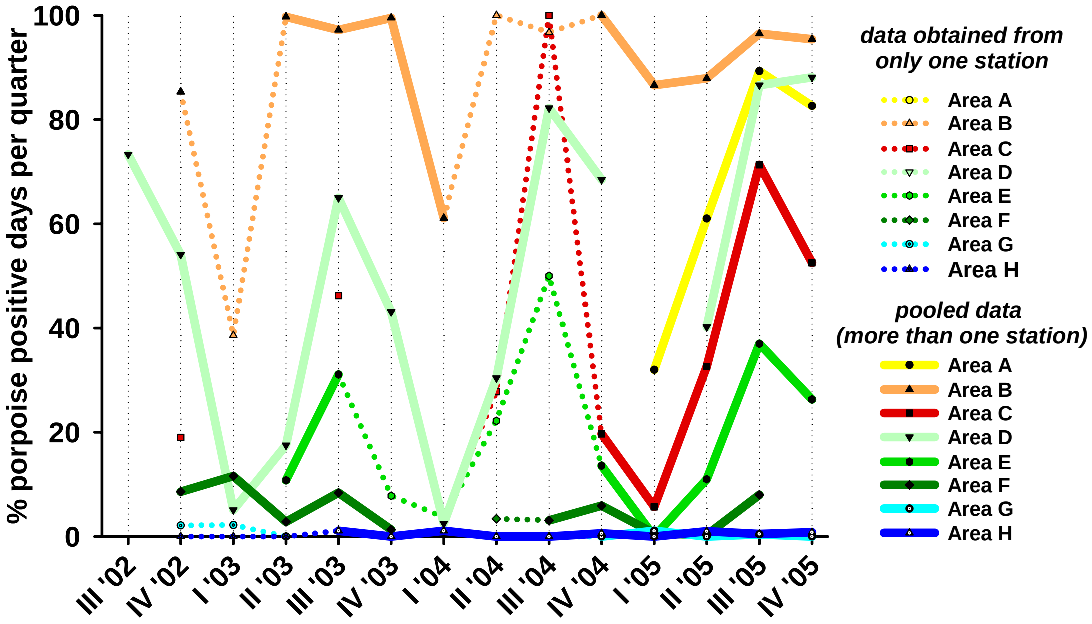

Figure 3: Mean percentage of porpoise positive days per quarter (I-IV) for areas A to H given over the course of the years 2002 to 2005. Dotted lines and coloured symbols indicate data obtained from one measuring position only. Straight lines and black symbols indicate the average value calculated from several positions.