# Abundance survey of harbour porpoises in Kattegat, Belt Seas and the Western Baltic, July 2012

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## Preface

In a joint cooperation between Aarhus University and Institute for Terrestrial and Aquatic Wildlife Research, University of Veterinary Medicine Hannover (ITAW), a visual ship survey targeting harbour porpoises (*Phocoena phocoena*) was carried out from 2 July to 21 July 2012. The survey was funded as part of the NOVANA program (2011-2015) under the Danish Nature Agency, Danish Ministry of Environment and the German Federal Ministry for Food, Agriculture and Consumer Protection.

## Background and objective

The harbour porpoises inhabiting the Kattegat, the Belt Seas, the Sound and the western Baltic constitute a distinct population (hereafter called the Belt Sea population), which is genetically and morphologically distinguished from the two neighbouring populations in the North Sea/Skagerrak and in the Baltic Proper (Galatius et al. 2012, Wiemann et al. 2010). Abundance estimates based on two European surveys (SCANS in 1994 and SCANS II in 2005) have suggested a large decline in this region (Hammond et al 2002, SCANS-II 2008), which has been a cause for concern in the management of harbour porpoises in both Denmark and Germany as well as in international conservation bodies such as ICES, IWC and ASCOBANS. The original survey strata in the 1994 and 2005 surveys were not directly comparable due to strata size differences. However, since the transects within each stratum were planned using an equal coverage design, the Distance Sampling method allows for dividing the strata into smaller areas as long as a sufficient number of observations are included (Thomas et al 2007, Williams & Thomas 2007). Thus, the objective of this project was to conduct a third harbour porpoise survey (called "MiniSCANS") within the overlapping area from the 1994 and 2005 surveys to improve the knowledge of the conservation status of the population inhabiting the Belt Sea by comparing the three abundance estimates.

## Methods

The study area covered southern Kattegat, the Belt Seas, the Sound and the Western Baltic. Studies of satellite tracked porpoises in this region have shown that there is some geographical overlap in distribution between the Belt Sea population and the neighbouring populations. Thus, the northern border of the Belt Sea population area was defined as the line with least possible overlap of satellite tracked porpoises from this population and porpoises from the North Sea/Skagerrak population (for details see Teilmann et al 2011). The south-eastern border between the Belt Sea population and the Baltic Proper population is thought to be further east than Fehmarn Belt, so for comparison the largest possible area with survey coverage in all three surveys (1994, 2005, 2012) was used (Fig. 1). This total survey area was 30,130 $km^2$.

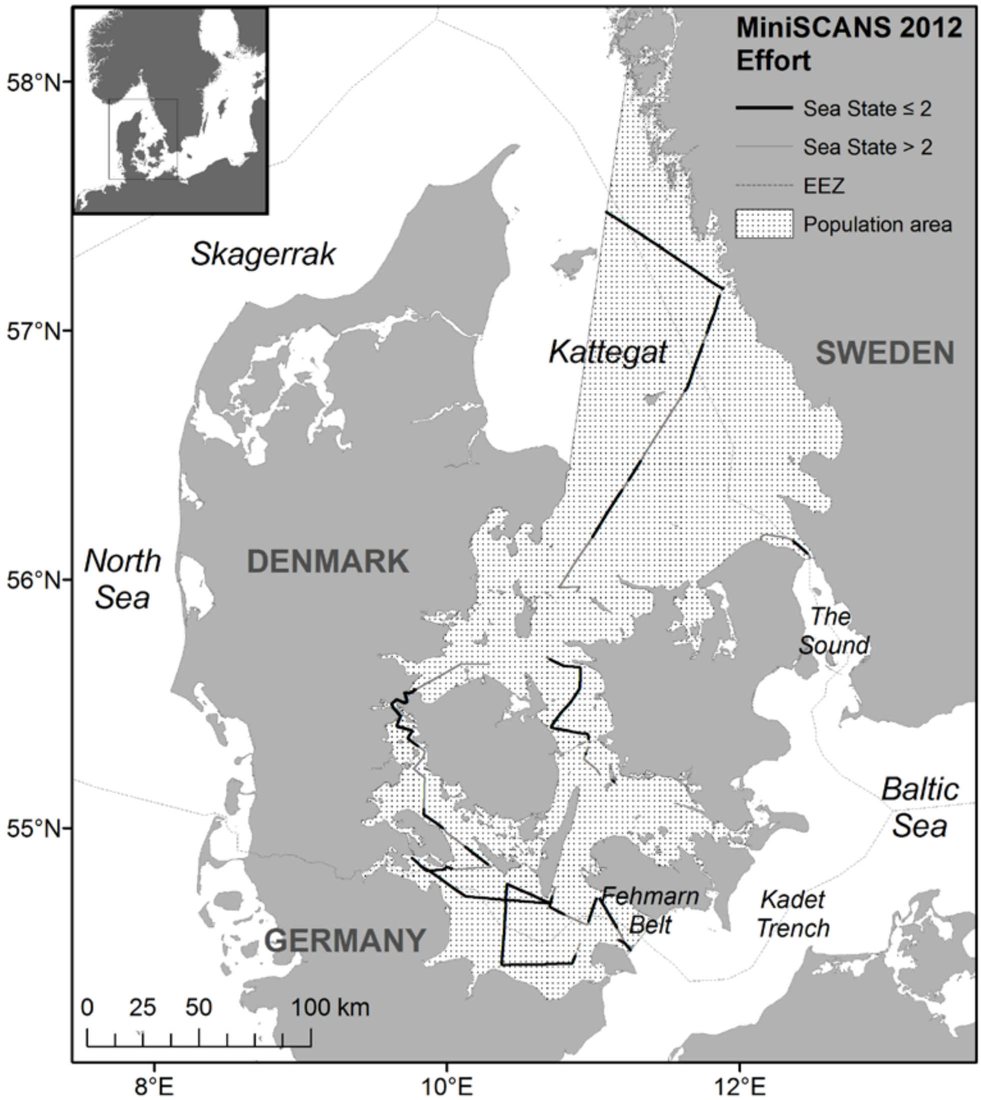


*Figure 1 Map of survey area showing effort in Beaufort Sea State ≤ 2 (black line) and Sea State > 2 (grey line, not used for the analysis in this report). The shaded area indicates the area for which the abundance estimates of the harbour porpoise Belt Sea Population were calculated.*

The survey transect design was replicated from the SCANS-II survey in 2005 (SCANS-II 2008) and designed to provide equal coverage probability. The survey was conducted on board RV Skagerak, a research vessel owned by Gothenburg University. This ship was also used during SCANS-II and proved very suitable due to low noise emission and two separated observation platforms (Fig. 2). RV Skagerak was kept at a constant speed of 9-10 knots. The Danish ship Gunnar Thorsen was used in 1994, but there is no reason to believe that differences between the two ships used over the years should affect the results.


*Figure 2 The research vessel "Skagerak" used for the survey with the two observation platforms indicated. Photo: Signe Sveegaard.*

The survey method adopted was double platform line transect survey with two teams of observers: a primary team (two people at a time) on the foredeck (6 m above sea surface) and a tracker team (four people at a time) on top of the Bridge (10 m above sea surface). By using two observation platforms, abundance estimates can be generated that are corrected for animals missed on the transect line and for the effects of animals moving in response to the ship (Buckland et al. 2001, Laake & Borchers, 2004).

Data were analysed to obtain animal density and abundance using the Mark Recapture Distance Sampling engine (MRDS) in Distance 6.0 r2 (Thomas et al 2009) and incorporating covariates that could possibly affect detectability of the porpoises such as Beaufort Sea State (The state of the sea according to the Beaufort scale), sightability (a subjective judgement of the potential for spotting a porpoise under the given environmental conditions), glare from the sun, swell, perpendicular distance to the track line, behaviour of the porpoise, group size and observer name. We chose a Full Independence model, which was also used in 1994 and 2005 and which is suitable when porpoises display responsive movement towards the survey vessel (i.e. are either attracted to or repelled from the ship, Fig. 3).

We estimated a probability distribution for the change in abundance between 1994 and 2005, 1994 and 2012 and 2005 and 2012 using the point estimates and their standard errors in the Bayesian approach of Gerrodette (2011) and Gerrodette et al. (2011). We assumed the same uniform priors of abundance for all three surveys (range: 635-86040). The Bayesian analysis was performed in R (R development core team 2008).

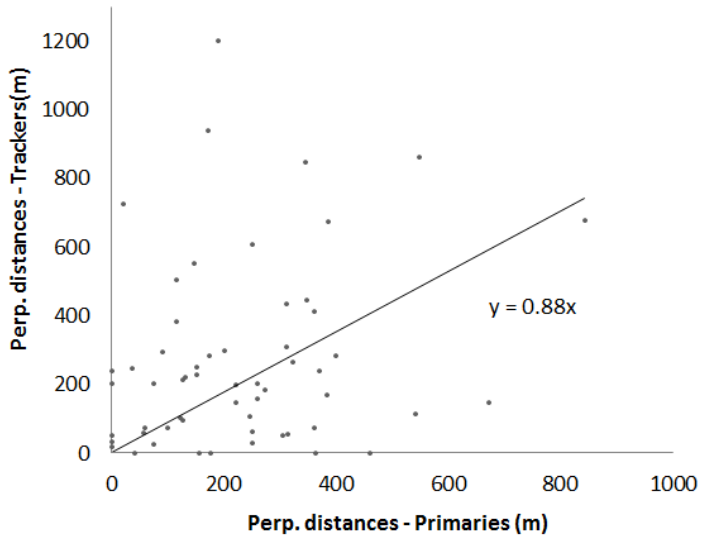


*Figure 3 Perpendicular distances of duplicate observations at the time they were detected by observers on the Primary platform (x-axis) and by observers on the Tracker platform (y-axis). Since trackers use binoculars and search an area >1 km away from the vessel, the tracker observations (animal behaviour) are believed to be unaffected by the vessel. So if y = x (displayed by the diagonal line) there is no responsive movement to the boat. Here, y = 0.88x, indicating that the porpoises observed by the primaries are slightly repelled by the vessel.*

## Results

Of the 21 potential survey days, visual observation was carried out on 9 days. In the remaining 12 days, poor weather conditions prevented any visual surveying. In total, 516 km was surveyed in Beaufort Sea States ≤ 2, which are the recommended conditions for visual surveys of harbour porpoises.

In total, the primary observers detected 149 individual porpoises distributed in 106 groups and the tracker observers observed 147 individual porpoises in 98 groups. 33 sightings (groups) were duplicate sightings in which the tracker observation was also observed by a primary observer.

Abundance models were created for each of the three surveys and model selection was based on the lowest AIC score (Akaike Information Criterion, see Akaike 1974). The covariables affecting detectability of the porpoises varied slightly between years with perpendicular distance, group size, sightability and Beaufort Sea State being the best explanatory variables (Table 1).

*Table 1 Details on abundance estimation models for the three harbour porpoise surveys in 1994, 2005 and 2012. Truncation refers to right side truncation of primary observations further than 1000 m from the survey trackline. For definition of model parameters see text.*

| Survey | Year | Model | Truncation (m) | Model parameters |
|---|---|---|---|---|
| **SCANS** | 1994 | Full Independence | 1000 | Distance + Group Size + Beaufort |
| **SCANS-II** | 2005 | Full Independence | 1000 | Distance + Sightability |
| **MiniSCANS** | 2012 | Full Independence | 1000 | Distance + Beaufort |

For the 2012 survey, we estimated the abundance of harbour porpoises within the population area of 30,130 km² to be 18,495 animals (95% CL: 10,892–31,406, CV = 0.27), the associated density to 0.61 animals/km² (95% CL: 0.36–1.04, CV = 0.27) and the expected cluster size to be 1.51 animals/group (Table 2). Table 2 also displayed the abundance estimates for the 1994 survey: 27,923 (CV = 0.46) and the 2005 survey: 10,614 (CV: 0.28). The population estimate of 1994 is by far the largest being 62% higher than the 2005 estimate and 34% higher than the 2012 estimate (Fig. 4). The 2012 survey estimate is 43% higher than the 2005 survey. Despite these differences, all surveys had overlapping confidence intervals, due to the inherent statistical uncertainty of surveys for cetaceans in general and porpoises in particular.

*Table 2 Abundance estimates (N) of harbour porpoises in the population area (Fig. 1) for three visual surveys in 1994, 2005 and 2012. Effort includes only conditions with Beaufort Sea State≤2. CV= Coefficient of Variation. LCL= 95% lower confidence limits, UCL = 95% upper confidence limits. Group size is average harbour porpoise group size for each survey.*

| Survey | Effort (km²) | N | CV | LCL | UCL | Density | Group size |
|---|---|---|---|---|---|---|---|
| **SCANS** | 607 | 27,923 | 0.46 | 11,916 | 65,432 | 1.13 | 1.61 |
| **SCANS-II** | 644 | 10,614 | 0.28 | 6,218 | 18,117 | 0.35 | 1.45 |
| **MiniSCANS** | 516 | 18,495 | 0.27 | 10,892 | 31,406 | 0.61 | 1.51 |

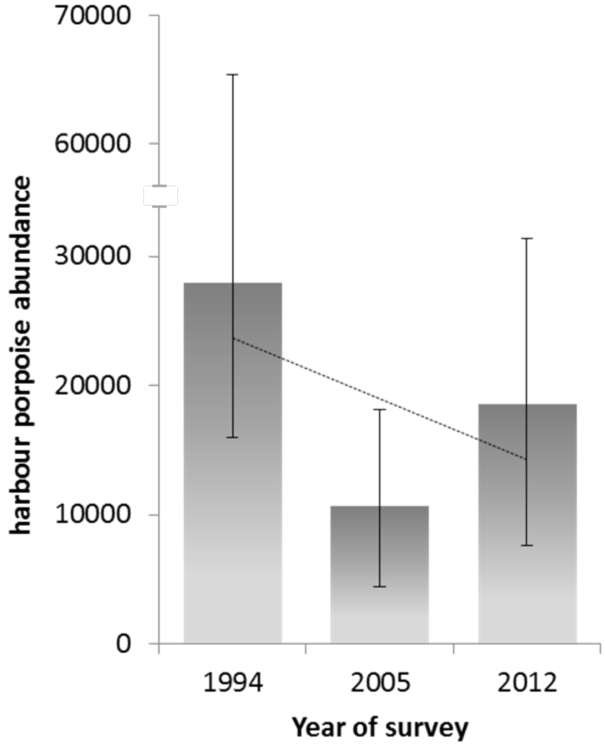


*Figure 4 Estimated abundance of harbour porpoises in the population area (Southern Kattegat, the Belt Seas, the Sound and the western Baltic) for three surveys: SCANS in 1994, SCANS-II in 2005 and MiniSCANS in 2012. Bars illustrate the lower and upper 95% confidence limits. Note the broken y-axis.*

By using Baysian statistics, we found that the posterior distribution analyses had highest support (distribution peak) for a change in abundance of -9392 porpoises from 1994-2005, -4270 porpoises from 1994-2012 and +7701 porpoises from 2005-2012. This corresponds to a 96.2% support for a decline in abundance between 1994 and 2005, a 75.6% support for a decline from 1994-2012 and only 7.3% support for a decrease from 2005-2012 (Table 3).

*Table 3 Comparison of three abundance estimates from harbour porpoise surveys in 1994, 2005 and 2012 for the population area (Fig. 1). Analysis conducted according to method described by Gerrodette (2011) and Gerrodette et al. (2011).*

| | **Change in abundance between surveys** | | |
|---|---|---|---|
| | **1994-2005** | **1994-2012** | **2005-2012** |
| Posterior distribution peak | -9392 | -4270 | 7701 |
| Support for negativ udvikling | 96.2% | 75.6% | 7.3% |

## Discussion

Here, we present abundance estimates for the Belt Sea harbour porpoise population, based on surveys in 1994, 2005 and 2012 that are directly comparable in geographical extent as well as survey method and data analysis. The highest abundance estimate was found in 1994 which was 62% higher than in 2005 and 34% higher than in 2012. This may result from one of the following explanations:

1. The inherent uncertainty in survey for cetaceans
2. An overall decreasing trend from 1994 to 2005 encompassing a decrease from 1994 to 2005 and an increase from 2005 to 2012
3. Immigration and emigration of porpoises in to and from the survey area

None of the hypotheses can be ruled out but they do not exclude each other. Below, we explore each option.

It is well known that cetacean abundance surveys such as these, inherently produce large uncertainty, and it is thus highly recommended to invest in long time monitoring to adjust for these variations (Taylor et al 2000). However, for now, these are the best available data to evaluate the status of this population. Furthermore, it should be noted that cetacean surveys covering entire populations are rare and that these three surveys over 18 year covering the core geographical area of a distinct harbour porpoise population is a unique data set.

The decline in estimates from 1994 to 2005 has been the cause of much concern and consequently, a further decline from 2005 to 2012 would have been seriously alarming. This is, however, not the case, so although the results still indicate an overall negative trend from 1994 to 2012, the population decline seen in 2005 seems to have stopped and may even be improving. We can only speculate as to what could have caused these changes. The harbour porpoise faces several threats in Danish and adjacent waters such as food depletion, bycatch, chemical pollution, noise pollution, and habitat degradation. Consequently, variations in the pressure from these threats may influence the abundance of porpoises. Unfortunately, the direct link between pressures and abundance is difficult and for some pressures impossible to access. For instance, incidental bycatch in gillnet fisheries is considered a significant threat to harbour porpoises in European waters (Carlström et al., 2009; Kock and Benke, 1996) and in the North Sea alone an estimated 5900 animals were bycaught annually in 1987–2001 just by the Danish gillnet fleet (Vinter and Larsen, 2004). However, no estimate of the bycatch rate exists for the area inhabited by the Belt Sea population, and although the overall number of days at sea for the Danish gillnet fishermen has not changed significantly from 1998 to 2011 (DTU Aqua, unpublished data), gillnet types or fishing areas may have shifted causing a change in the pressure on porpoises.

A Bayesian model including all three years is under development and will define continuous probability intervals for abundance trends throughout the period. This will help elucidate the current status as well as population development.

The harbour porpoise is a wide-ranging species and satellite tracking has showed that individuals may move over 1000 km away from original tagging site in six months (Teilmann et al. 2008, Sveegaard et al. 2011). The Belt Sea population has, however, proven to

be relatively spatially stationary, especially during summer at which time the survey was carried out (Sveegaard 2011). Since studies of genetics and morphology support this (Galatius et al. 2012, Wiemann et al. 2010) we find it unlikely that major emigration between neighbouring populations is the cause of the observed differences in abundance between the three surveys.
However, due to the limited extent of the 1994 strata, our analysis does not include the waters between Fehmarn Belt and Rügen (approx. 13°E) including the southern part of the Sound. Satellite tracking of porpoises since 1997 as well as the preliminary results from the SAMBAH project (www.sambah.org, Aarhus University, unpublished data) suggests that these areas are also inhabited by the Belt Sea population, and furthermore that this area in the last couple of years holds increasing densities of porpoises from the Belt Sea population. Thus it is possible that a larger proportion of the animals were present east of the comparable survey area during all three surveys, which could have resulted in the lower abundance estimates. For the 1994 survey this cannot be evaluated due to lack of survey effort, but in 2005 relatively few sightings were detected east of Fehmarn Belt. In 2012, though, many sightings were noted in both the Sound and the area between Fehmarn Belt and the Kadet Trench, suggesting an expansion of the population into these areas. For future surveys aimed at abundance estimation, a population boundary further east should be used.

In conclusion, we found high support (>75%) for an overall decrease in abundance from 1994 to 2012, but the alarming decline in estimates from 1994 to 2005 was not perpetuated, as the 2012 estimate was higher than the 2005 estimate. The only way to reduce the inherent uncertainty when estimating trends in harbour porpoise abundance surveys is to carry out surveys on a regular basis in a long-term monitoring scheme. This may be obtained by participating in future European cetacean surveys such as the planned SCANS-III in 2015-2017 and by incorporating surveys for abundance estimates into future NOVANA programmes.

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