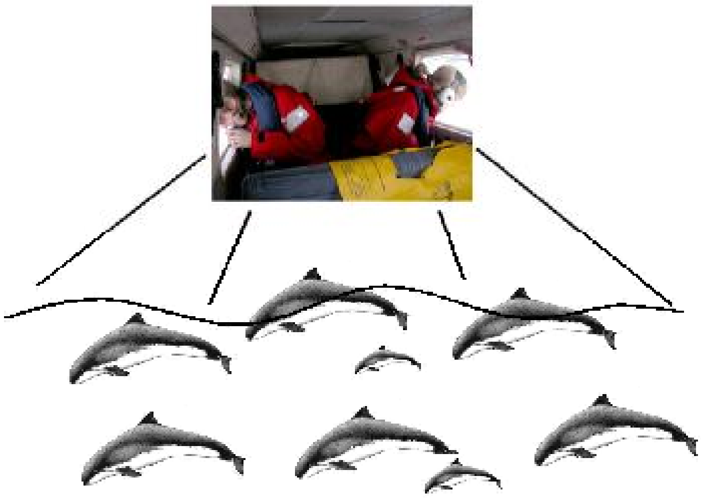
PROCEEDINGS OF THE WORKSHOP ON

ESTIMATION OF G(0) IN LINE-TRANSECT SURVEYS OF CETACEANS

Held at the
European Cetacean Society's 18th Annual Conference,
Vildmarkshotellet at Kolmården Djur Park, Kolmården, Sweden,
28th March 2004



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CONTENTS

AERIAL SURVEYS IN THE GERMAN BIGHT – ESTIMATING G(0) FOR HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) BY EMPLOYING INDEPENDENT DOUBLE COUNTS

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BACKGROUND

In the framework of environmental impact assessment studies, we conducted combined aerial surveys for harbour porpoises and seabirds in the German Bight. In the years 2001 to 2003, we carried out 44 flights in three different areas.

DATA RECORDING

We used twin engine high-winged "Partenavia (P 68)" planes to fly transects, which were separated by 3 km. The aircrafts were equipped with "bubble-windows", which enabled us to look straight down below the aircraft. The flight altitude was 76 m (250 feet). In summer, harbour porpoises are sufficiently abundant to ensure enough (at least 60 to 80) sightings to run statistical analysis for a single survey with the software package DISTANCE 4.0 (Thomas *et al*., 1998). In winter, pooling of data was necessary.

Three observers formed a counting team. On one side of the plane there were always two observers seated, sitting behind each other without having contact due to headsets and screen from view. This enabled us to quantify the number of missed animals. Every observer independently noted the following parameters on handheld tape recorders: school size, age category (new born and adult animal), time (minutes and seconds), sighting angle and observation cue. The ground speed of the plane was approximately 185 km/h (100 knots). A GPS-logger registered the position of the plane every five seconds.

Various studies stressed the influence of different sighting conditions (i.e. sea state, wind speed, sun glare, cloud coverage, altitude and observer skill) on detection rates of harbour porpoises (Barlow *et al*., 1988; Forney *et al*., 1991; Heide-Jørgensen 1992, 1993; Hammond *et al.*, 1995, 2002). Considering these findings, we excluded transect sections with sea state higher than 2, and unfavourable sighting conditions like glare, from the survey effort. When the conditions became unfavourable for a longer period of time, we stopped the survey. The accuracy of the distance measurement is crucial for computing densities with DISTANCE 4.0 (Thomas *et al*., 1998). In order to achieve an ungrouped data set, we measured the angle to each sighting without rounding.

Estimating g(0)

We have to consider an incomplete detection of animals at distance zero: $g(0) < 1$. In order to calculate densities, it is crucial to estimate the value of g(0). We estimated g(0) by combining two different sources of bias:

- proportion of missed animals near the sea surface (perception bias),
- proportion of diving animals (availability bias).

g(0) = perception bias x availability bias

Perception bias

We estimated the number of missed animals near the sea surface with our own data of independent double counts of two observers on one side of the plane. For this reason we calculated a sighting and re-sighting ratio. Flying at an altitude of 76 m, we were able not only to detect emerged harbour porpoises, but also animals in the upper first metre below the sea surface.

Data from two observers, recorded at the same time and side of the plane, were compared and the following ranking for the double sighting identification (animal or group of animals) was applied:

1. number of animals and presence of calves,
2. temporal proximity,
3. spatial proximity,
4. cue.

If both sightings from the observers sitting behind each other consisted of more than one animal, this school characteristic was reliable to identify a double sighting. This was also the case for other parameters such as temporal proximity of less than 10 seconds. Most sightings were single animals, so the time measurement primarily contributed to the double sighting identification. 79% of the identified double sightings differed from one another by only up to three seconds (Fig. 1). Additionally, we considered the angle and cue of the sighting (emerged/submerged animal, splash, bird etc.). The generally low sighting rates are favourable for the double count identification.

Pollock *et al.* (1987) described line-transect surveys with two observers on one side of the plane, and stressed both the necessity as well as the difficulty in achieving independent counts. We ensured independent counts by visual (curtains between the two rows of seats of the plane) and acoustic (headsets) isolation of the observers. Furthermore, the frequent sightings of birds mask the more rare sightings of harbour porpoises.

Availability bias

The portion of time spent in different depths of the water column has been measured with time-at-depth-loggers (TAD) by different researchers. Teilmann *et al*. (1998) tracked a juvenile harbour porpoise (30 kg), which dived 351 times within 10 hours of registration with a mean dive duration of 1.1 min. The animal swam 34% of the time in water depths between 0 and 2 metres. More detailed studies relating to diving patterns of harbour porpoises come from the US and Canadian east coast (Westgate 1995), from Japan (Otani *et al*., 1998, 2000) and from the inner Danish Waters (Teilmann, 2000). Despite study areas on different continents, the common outcome was a diving rate of 30 dives per hour in spring and summer. We feel confident to refer to the large TAD data set of Teilmann (2000) for our density estimations due to approximately equal water depths and approximately the same prey species and sizes involved. We did not take into account the diurnal variation of TAD data (Teilmann, 2000) because our effort covered a large part of the daytime (Figure 2).

RESULTS

In total, the first observer detected (marked) 772 schools, and the second observer at the same side of the plane detected (recaptured) 446 schools: the general ratio was 0.58. This ratio decreased with increasing distance to the transect line (Fig. 3). Due to the fact that we did not see enough schools on the proper transect line with g = 0, we had to include more distant sightings, and created a g(0)-zone rather than referring to a proper g(0)-line. We suggest to pool the sighting/re-sighting rates up to 120 m (33° at a flight altitude of 250 ft), and to generate a general rate of 0.66 for the overall perception bias (Fig. 3). In 9 out of 44 surveys, more than 25 schools were marked. The flight specific ratio differed from 0.41 to 0.71 (Table 1).

Referring to Teilmann (2000), harbour porpoises spend on average half of the time (0.56) in the upper two metres of the water column. This rate decreases from 0.64 in April to 0.51 in August.

The estimation of g(0) for density calculation with DISTANCE 4.0 is now feasible:

	g(0) = perception bias	x	availability bias	
in general:	g(0) = 0.66	x	0.56	= 0.37
flight specific:	g(0) = 0.41 to 0.71	x	0.51 - 0.64	= 0.21 - 0.45

Method evaluation of g(0) estimation

Advantages

- Both platforms are in one plane: no assumptions for swimming speed or directionality of animal movements are necessary.
- The independent observers have identical sighting conditions: position of the platforms, glare and sea state.
- No additional plane is necessary (availability of planes and high charter costs).
- Flight specific g(0) estimation is possible (integrating conditions, observer skills, seasonal differences in diurnal dive patterns) or pooling of subsequent surveys in low density areas or seasons.

Disadvantages

- The values for 0 - 1 and 0 - 2 m (TAD) differ up to 15% (Teilmann, 2000) and the water depth in which the animal was detected cannot be measured by the observer from the plane.
- Only few data on the time that porpoises spent in different water depths are available. No data exist from the German Bight.

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REFERENCES

Barlow, J., Oliver, C.W, Jackson, T.D. and Taylor, B.L. 1988. Harbour porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon and Washington: II Aerial surveys. *Fish. Bull*. **86**: 433-444.

Forney, K., Hanan, D.A. and Barlow, J. 1991. Detecting trends in harbour porpoise abundance from aerial surveys using analysis of covariance. *Fish. Bull*. **89**: 367-378.

Heide-Jørgensen, M.-P., Mosbach, A., Teilmann, J., Benke, H. and Schultz, W. 1992. Harbour porpoise (*Phocoena phocoena*) densities obtained from aerial surveys north of Fyn and in the Bay of Kiel. *Ophelia* **35**: 133-146.

Hammond, P.S., Benke, H., Berggren, H., Borchers, D.L., Buckland, S.T., Collet, A., Heide-Jørgensen, M.-P., Heimlich-Boran, S., Hiby, A.R., Leopold, M.F. and Øien, N. 1995. *Abundance and distribution of harbour porpoises and other small cetaceans in the North Sea and adjacent waters*. Life 92-2/UK/027. Final report to the European Commission, October 1995, 242 pp.

Hammond, P.S., Berggren, P. , Benke, H., Borchers, D.L. , Collet, A. , Heide-Jørgensen, M.-P. , Heimlich, S. , Hiby, A.R., Leopold, M. F. and Øien, N. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *J. Appl. Ecol*. **39**: 361–376.

Heide-Jørgensen, M.-P., Teilmann, J., Benke, H. and Wulf, J. 1993. Abundance and distribution of harbour porpoises *Phocoena phocoena* in selected areas of the western Baltic and the North Sea. *Helgoländer Meeresunters*. **47**: 335-346.

Otani, S. , Naito, Y. , Kawamura, A. , Kawasaki, M., Nishiwaki, S and Kato, A. 1998. Diving behaviour and performance of harbour porpoises, *Phocoena phocoena*, in Funka Bay, Hokkaido, Japan. *Mar. Mamm. Sci*. **14**: 209-220.

Otani, S. , Naito, Y., Kato, A. and Kawamura, A. 2000. Diving behaviour and swimming speed of a free-ranging harbour porpoise, *Phocoena phocoena*. *Mar. Mamm. Sci*. **16**: 811-814.

Pollock, K.H. and Kendall, W.L. 1987. Visibility bias in aerial surveys: A review of estimation procedures. *J. Wildl. Manage*. **51**: 502-510.

Teilmann, J., Heide-Jørgensen, M.-P., Dietz, R., Sonntag, R., Benke, H., Siebert, U. and Desportes, G. 1998. Diving behaviour of a harbour porpoise (*Phocoena phocoena*) in Danish waters. P. 201. In: *European Research on Cetaceans – 11*. (Editors P.G.H. Evans, E.C.M. Parsons and S.L. Clark). Proceedings of the Eleventh Annual Conference of the European Cetacean Society, Stralsund, Germany, 10-12 March 1997. European Cetacean Society, Kiel, Germany. 314pp.

Teilmann, J., 2000. *The behaviour and sensory abilities of harbour porpoises (Phocoena phocoena) in relation to bycatch in Danish gillnet fishery*. Ph. D. thesis, University of southern Denmark, Odense.

Thomas, S.C., Laake, J.L., Derry, J.F., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Strindberg, S. Hedley, S.L., Marques, F.F.C., Pollard, J.H. and Fewster, R.M. 1998. *Distance 3.5*. Research Unit for Wildlife Population Assessment, University of St Andrews, St Andrews, UK.

Westgate, A.J. , Read, A. , Berggren, P., Koopman, N.H. and Gaskin, D.E. 1995. Diving behaviour of harbour porpoises, *Phocoena phocoena*. *Can. J. Aquat. Sci*. **52**: 1064-1073.

Table 1: Flight specific re-capture ratio of schools (9 out of 44 flights with > 25 marked schools)

date	mean sea state	marked schools	re-captured schools	ratio
27.05.2003	1,0	76	54	0,71
17.06.2003	0,3	70	53	**0,76**
02.06.2002	1,5	66	37	0,56
16.08.2002	0,6	66	46	0,70
30.04.2001	0,5	44	30	0,68
13.04.2003	1,0	41	17	**0,41**
21.08.2001	1,0	33	22	0,67
14.07.2003	1,6	30	14	0,47
03.08.2003	0,3	27	17	0,63

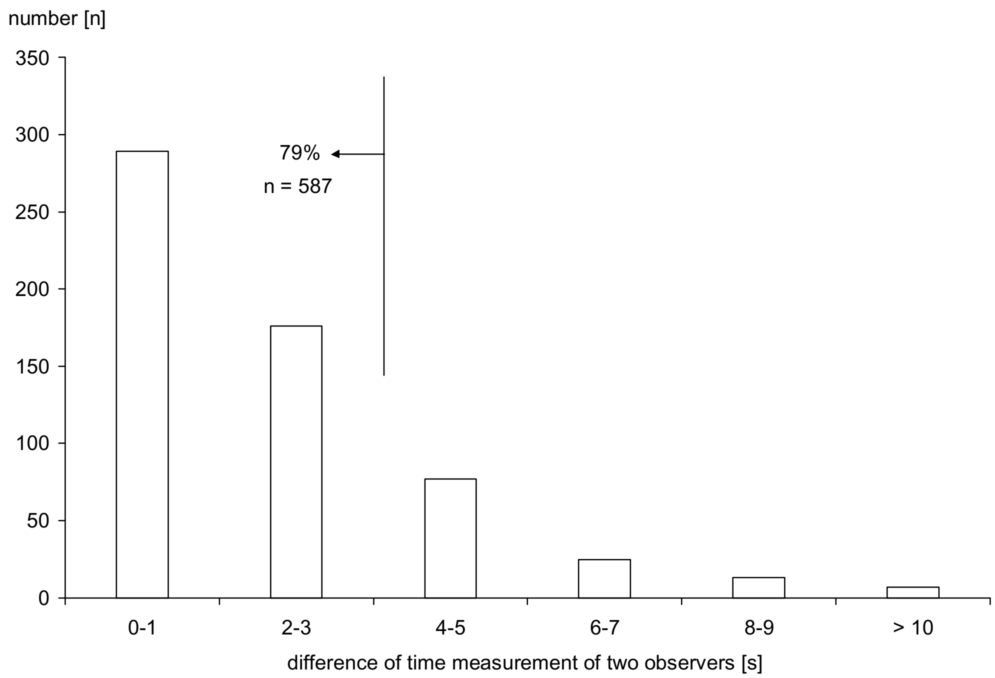

Fig 1. Error of time measurement for identified double sightings

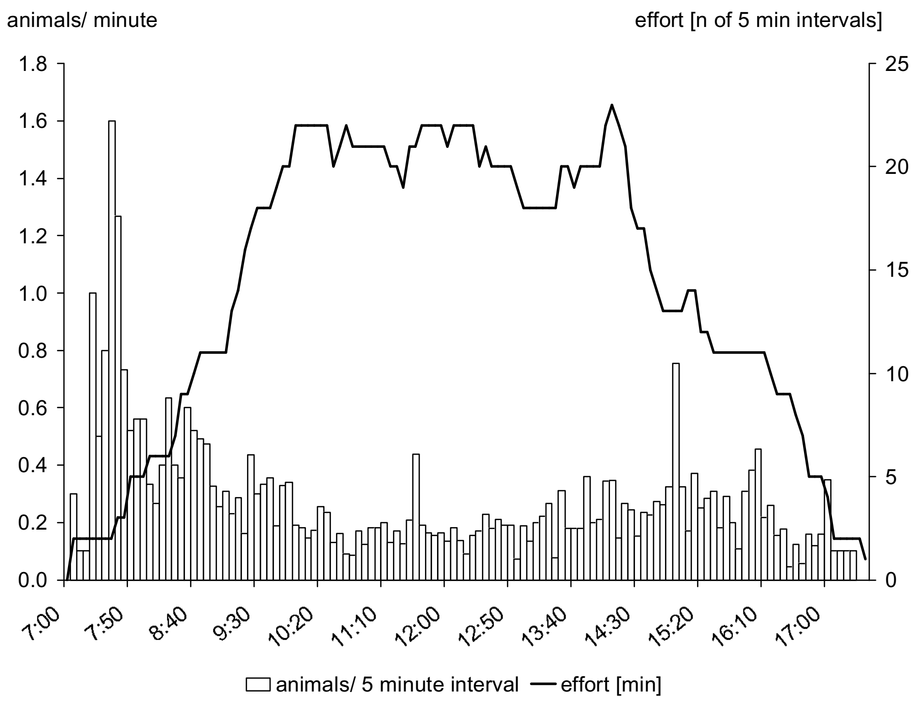

Fig. 2. Effort of the survey and number of harbour porpoises (29 flights in one study area)

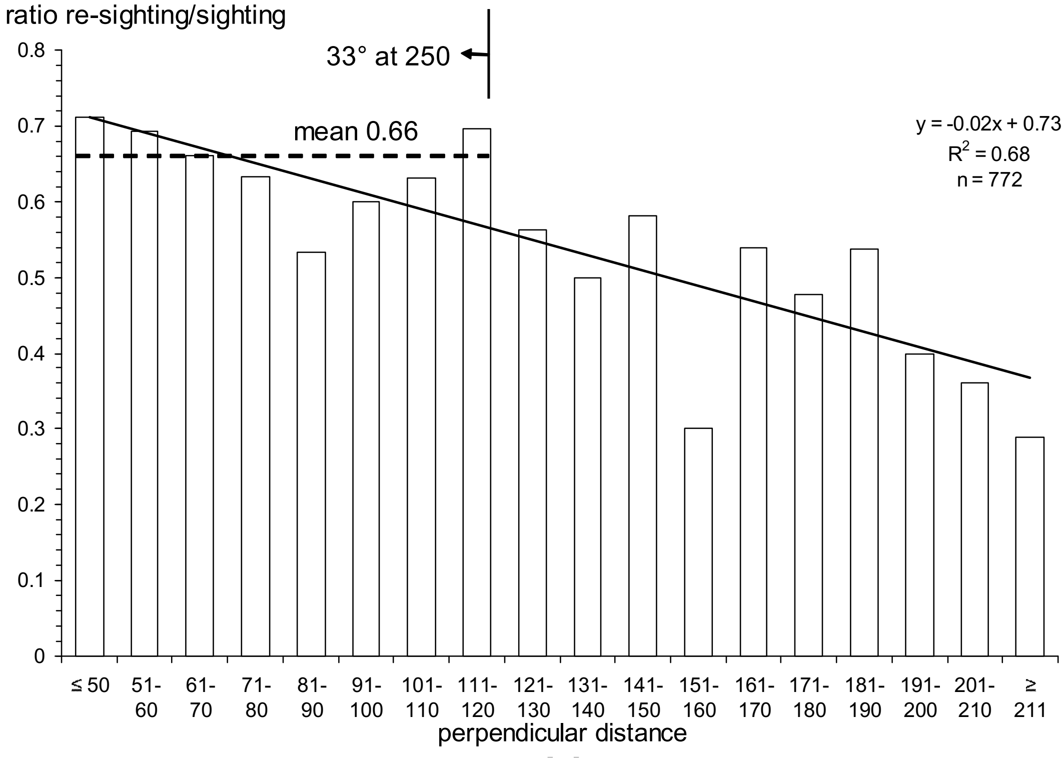

Fig. 3. Influence of distance of the animals to the transect line on the sighting / re-sighting ratio