

## Revised abundance estimate of harbor porpoise in West Greenland

M.P. Heide-Jørgensen, N.H. Nielsen, K. Brix Zinglensen, Greenland Institute of Natural Resources, Box 570, 3900 Nuuk, Greenland

### Abstract

A large-scale multispecies aerial survey conducted in August-September 2007 was used to estimate the abundance of harbour porpoises in coastal areas of West Greenland (Hansen & Heide-Jørgensen, 2013). The resultant estimate of the at-surface abundance estimate of harbor porpoises inside the surveyed area corrected for perception bias was 10,314 (cv=0.35). Information from satellite tracking of 9 porpoises was used to estimate the proportion of porpoises that can be expected to be outside the survey strata during the survey period. The 9 porpoises spent a total of 73 % (cv=0.13) of their days in August-September 2012 and 2013 inside the strata covered by the aerial survey. Correcting for this increases the at-surface abundance estimate to 14,129 (cv=0.37) porpoises. Two porpoises tracked from July 2012 through October 2013 provided data on the time spent at the surface during daytime in August-September in both years. The average proportion of time spent at 0 m depth was 5.14 (cv=0.13). Correcting the at-surface abundance estimate for porpoises detected breaking the surface provided a fully corrected abundance estimate 274,883 (cv=0.39, 95% CI 130,974-576,909) harbour porpoises in West Greenland 2007.

### Introduction

An abundance estimate of harbour porpoise in West Greenland was presented by Hansen and Heide-Jørgensen (2013). It was based on a multispecies aerial survey of cetaceans conducted along West Greenland in August-September 2007 (Fig. 1). The survey was flown at an altitude of 700 feet and was conducted as a double platform survey to allow for estimation of perception bias. The total effort was 6098 linear kilometers completed in sea states less than 3 and this provided a total of 35 sightings of harbour porpoises. The resultant estimate of the at-surface abundance estimate of harbour porpoises corrected for perception bias was 10,314 (cv=0.35).

The estimate from the survey in 2007 covered the continental shelf areas of West Greenland and including a correction factor for detection of harbour porpoises in Danish waters to 1 m depth. However, recent satellite tracking of harbour porpoises have demonstrated that the porpoises that supply the coastal catches are recruited from a wider offshore area than included in the survey. Furthermore, new data on the availability of harbor porpoises to be detected at the water surface from telemetry studies in West Greenland provide estimate useful for correcting the at-surface abundance estimates to fully corrected estimates. Finally the correction for availability bias presented in Hansen and Heide-Jørgensen (2013) was considered unrealistic because it assumed detection to 1 m depth.

In this paper data from harbour porpoises tracked by satellite in West Greenland in 2012-13 were used to correct the at-surface estimate from 2007 for presence inside/outside the survey area and for the probability of detection at the surface.

### Material and Methods

### *Offshore occurrence of harbour porpoises in Greenland*

A total of nine harbour porpoises were instrumented with satellite transmitters in the area around Maniitsoq, central West Greenland in July 2012 and 2013 following techniques described in Nielsen et al. (2013). The transmitters provided positions every day in August and every other day in September. One position of good quality was chosen per day for detection of whether the porpoise was inside or outside the surveyed area. The percentage of days with porpoises outside the surveyed area was calculated for the months August and September for 2012 (n=2) and 2013 (n=xx including two animals tagged in 2012).

### *The proportion of time spent at the surface*

In order to estimate the fraction of time the porpoises are available to be detected at surface by an aerial survey two porpoises were instrumented with satellite-linked-time-depth-recorders in 2012. They provided data on the fraction of time spent at 0 m depth and at 0-2 m depth in 6hr intervals for August-September 2012 and 2013.

Cue identifications were extracted from the 2007-aerial survey in West Greenland (Hansen and Heide-Jørgensen 2013) for statistics on detections of porpoises below the surface and breaking the surface (surfacing or diving).

### *Correction of the 2007-aerial survey*

The delineation of the survey-strata used in the 2007-aerial survey does not include the entire harbor porpoise habitat in West Greenland and it does not cover the entire area that supplies the porpoises hunted in West Greenland. As a preliminary approach to adjust for this negative bias in the abundance estimate area usage and distribution of the 9 (+2 repeated the following year) porpoises instrumented with satellite transmitters were used to adjust the abundance estimate (denoted by the subscript 'c'):

$$\hat{N}'_c = \frac{\hat{N}'}{\hat{f}'}$$

Where  $\hat{N}'$  is the at-surface abundance estimate and  $\hat{f}'$  is the fraction of the porpoises inside the survey area with estimated CV:

$$CV(\hat{N}'_c) = \sqrt{CV(\hat{N}')^2 + CV(\hat{f}')^2}.$$

It is assumed that only porpoises detected at the surface (0m) are included in the 'at-surface' abundance estimate and that the proportion of time spent at 0m depth was known from satellite linked-data recorders. In order to account for this availability bias, corrected abundance was estimated in the same way as above.

## **Results and Discussion**

A total of nine porpoises (two in 2012 and 7+2 from 2012 in 2013) provided data on daily presence inside or outside the surveyed area (Table 1). Only two animals spent all their time inside the survey area and on average all animals spent 73% (cv=0.13) inside the survey blocks (Fig. 2).

The at-surface abundance estimate corrected for the proportion of porpoises that potentially could have been outside the survey area during the time of survey was 14,129 (cv=0.37). This approach is however biased since

the start position of the nine tracked porpoises was not a random selection of the positions used by the animals and the animals are not a random subset of the population. If anything this should cause a negative bias in the fraction present inside the survey area and therefore a negative bias of the abundance estimate (Whitehead and Jonsen 2013).

The proportion of time spent at the surface was estimated as the mean of the two porpoises tagged in 2012 with each year (2012 and 2013) treated as separate samples as the two animals can be considered to represent two different developmental stages in the two years (Table 2). The average proportion of time spent at 0 m depth was 5.14% (cv=0.13).

All detections had 'animal' as cue and only one had 'blow' as cue. Some of the sightings (n=42 from both platforms) from the 2007-aerial survey in West Greenland had auxiliary information on the detection cues and about 81% of detections were porpoises at the surface, breaking the surface or diving from the surface (Table 3 and 4). Only 19% of the porpoises were detected below the surface. If only the front observer detection cues are used then all the porpoises (n=33 with cue specifications) were detected at the surface. It was noted that some of the porpoises reacted to the passage of the plane by diving and it is probable that the brief interval (median=3.5s) between front and rear observer is enough to change the state of the porpoise from 'at the surface' to 'diving' or 'submerged' especially if triggered by the noise from the aircraft. Detection was instantaneous except in two cases where time from first detection to the animal(s) passed abeam was 4 and 5 s. The short time-in-view and the short time between front rear detections can probably be attributed to the fact that the survey was a multispecies survey where large cetaceans sometimes detected at considerable distances (>1km) were the main target species.

Sightings of harbour porpoises from aerial surveys conducted at 600 feet in Danish waters in 1991-92 showed that 66% of the sightings were porpoises that were either resting at the surface or swimming while breaking the surface (n=168, Heide-Jørgensen et al. 1993). The survey was conducted over shallow water (<30m) where it in some areas would be possible to detect a submerged porpoise against the sandy bottom. This is very different from the West Greenland survey where water depths always exceeded 50 m and where it is unlikely that a submerged porpoise could be detected at the higher altitude (600 vs 750 feet) and slightly higher speed (163 vs. 170 km/hr) used for this survey. For a comparison, minke whale surveys in West Greenland also relied on detection at the surface (Heide-Jørgensen et al. 2010)

Correction for availability assuming only detection at the surface reveals a fully corrected abundance estimate of 274,883 (cv=0.39, 95% CI 130,974-576,909) harbour porpoises in West Greenland in August-September 2007.

### **Acknowledgements**

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**Table 1. List of harbor porpoises instrumented with satellite transmitters in 2012 and 2013.**

ID	Sex	Body length (m)	Body mass (kg)	Deployment date	Days of deployment in Aug. - Sept.	Percentages inside strata	Percentages outside strata
20169 (2013)	M	120	31	06.07.13	31	97	3
20160 (2013)	M	140	43	07.07.13	31	94	6
20164 (2013)	F	128	41	07.07.13	31	100	0
20165 (2013)	F	115	28	10.07.13	31	100	0
20166 (2013)	M	136	39	07.07.13	31	81	19
20167 (2013)	F	124	31	10.07.13	23	13	87
20168 (2013)	F	120	28	07.07.13	31	97	3
7617 (2012)	F	128	ca. 35	25.07.12	41	46	54
7617 (2013)	F			25.07.12	41	90	10
7618 (2012)	F	156	ca. 60	25.07.12	40	30	70
7618 (2013)	F			25.07.12	34	59	41
Mean					365	73	27
cv						0.13	0.35

**Table 2. Surface time for two harbor porpoises from West Greenland in August-September 2012-2013.**

Porpoise	2012										2013									
	22-04		04-10		10-16		16-22		Total		22-04		04-10		10-16		16-22		Total	
	n	mean	n	mean	n	mean	n	mean	n	mean	n	mean	n	mean	n	mean	n	mean	n	mean
7617	28	3.6	31	4.2	27	5.1	26	5.8	112	4.6	43	4.9	40	3.4	31	3.3	39	5.2	153	4.3
7618	15	3.8	12	3.7	17	4.9	22	3.1	66	3.8	32	4.1	12	4.3	25	6.9	25	6.8	94	5.6
Both	43	3.7	43	4.1	44	5.0	48	4.5	178	4.3	75	4.6	52	3.6	56	4.9	64	5.8	247	4.8

Porpoise	Year	Estimate
7617	2012	5.45
7617	2013	4.25
7618	2012	4.00
7618	2013	6.85
Mean		5.14
cv		0.13

**Table 3. Distribution of harbour porpoise detection cue's on categories from the aerial survey in West Greenland in 2007 (Hansen and Heide-Jørgensen 2013). For raw data see table 4.**

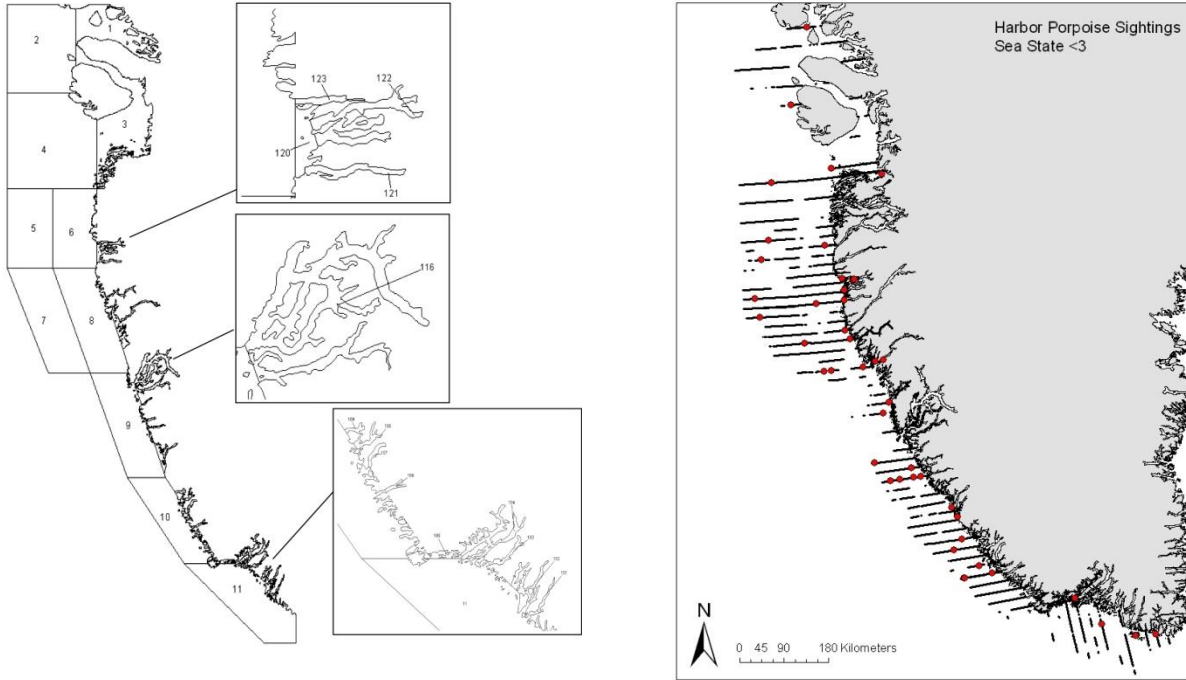
Cue both observers	n	Percentage
Diving	13	31
Surfacing	21	50
Below surface	8	19
Total	42	

**Table 4. Observations of harbour porpoises from an aerial survey in West Greenland 2007. Yellow marking indicate duplicate observations between front and rear observers.**

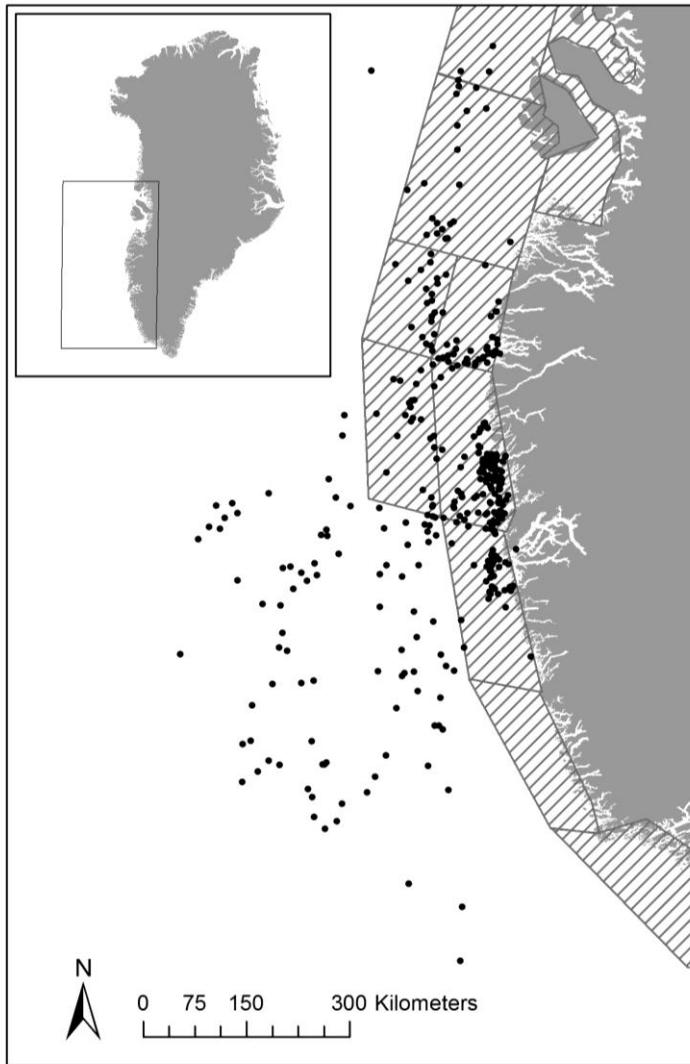
date	stratum	Line	no. of dives	dec. when abeam	no. on surface abeam	pod size	initial cue	time_dives (UTC)	time_abeam (UTC)	side	obs	comments
25-8 2007	3	28	0	80	0	1	Animal		25-08-07 13:54:16	L	1	diving
27-8 2007	6	62	0	70	0	2	Animal		27-08-07 15:43:00	L	2	came up after passing abeam
28-8 2007	8	77	0	36	2	2	Animal		28-08-07 13:46:50	L	2	surfacing
28-8 2007	8	78	0	68	0	1	Animal		28-08-07 14:44:43	L	1	diving, swimming direct. 200°
1-9 2007	13	207	0	50	1	1	Animal		01-09-07 16:37:28	R	1	
1-9 2007	13	207	0	61	1	1	Animal		01-09-07 16:37:55	R	1	
1-9 2007	6	56	0	85	0	1	Animal		01-09-07 12:03:05	L	1	diving
1-9 2007	5	48	0	60	0	1	Animal		01-09-07 13:22:09	L	1	diving, swimming towards 150°
1-9 2007	12	200	0	39	1	1	Animal		01-09-07 15:55:29	L	1	surfacing
1-9 2007	12	200	0	42	0	2	Animal		01-09-07 15:55:36	L	2	underneath the surface
1-9 2007	12	199	0	35	1	1	Animal		01-09-07 16:04:11	L	2	shortly surfacing
1-9 2007	13	201	0	59	0	1	Animal		01-09-07 16:15:42	L	1	diving
1-9 2007	14	208	0	45	1	1	Animal		01-09-07 16:39:08	L	1	surfacing
4-9 2007	8	81	0	75	0	1	Animal		04-09-07 12:29:46	L	1	diving
4-9 2007	8	81	0	70	0	1	Animal		04-09-07 12:29:47	L	2	swimming slowly under the surface
4-9 2007	8	81	0	60	1	1	Animal		04-09-07 12:35:12	L	1	surfacing
4-9 2007	7	66	0	63	2	2	Animal		04-09-07 14:00:01	L	1	surfacing
4-9 2007	7	63	0	65	0	1	Animal		04-09-07 16:11:41	L	1	diving
4-9 2007	5	52	0	84	1	1	Animal		04-09-07 17:46:24	L	1	surfacing, travelling towards 360°
5-9 2007	5	51	0	44	1	1	Animal		05-09-07 13:24:18	L	1	surfacing
5-9 2007	5	51	0	48	0	2	Animal		05-09-07 13:24:23	L	2	underneath the surface swimming
5-9 2007	4	40	0	45	0	1	Animal		05-09-07 17:56:42	L	2	fast swimming 1m underneath the surface, when I saw it, it was already abeam
11-9 2007	11	123	0	86	0	2	Animal		11-09-07 12:17:51	L	1	diving; travelling towards 180°
11-9 2007	11	121	0	46	0	1	Animal		11-09-07 13:28:52	L	1	diving
11-9 2007	11	120	0	61	1	1	Blow		11-09-07 15:48:50	L	1	surfacing
12-9 2007	10	102	0	60	1	1	Animal		12-09-07 20:22:22	R	1	



12-9 2007	11	112	0	88	1	1	Animal		12-09-07 14:02:39	L	1	started to dive when it passed abeam
12-9 2007	11	112	0	40	2	2	Animal		12-09-07 18:29:45	L	1	surfacing
12-9 2007	10	104	0	83	0	1	Animal		12-09-07 18:30:11	L	2	resting underneath the surface, dir 360
12-9 2007	10	104	0	61	0	1	Animal		12-09-07 18:47:52	L	1	diving, travelling towards 190°
12-9 2007	10	104	0	62	0	1	Animal		12-09-07 18:47:54	L	2	swimming in dir 270, it was already at abeam when I saw it, it came up but didn't surface
12-9 2007	10	104	0	84	0	1	Animal		12-09-07 19:13:40	L	1	diving
12-9 2007	10	104	0	78	1	1	Animal		12-09-07 19:13:41	L	2	swimming dir 180
14-9 2007	9	98	1	85	1	1	Animal		14-09-07 16:37:26	R	2	
14-9 2007	9	99	2	87	2	2	Animal	14-09-07 16:48:05	14-09-07 16:48:09	R	2	
14-9 2007	23	262	0	85	1	1	Animal		14-09-07 11:54:42	L	1	surfacing, travelling towards 180°
14-9 2007			0	79	1	1	Animal		14-09-07 11:54:43	L	2	resting at the surface, start diving when the plane came abeam
14-9 2007	9	91	0	49	2	2	Animal		14-09-07 12:38:05	L	1	surfacing; milling
14-9 2007	9	93	0	45	1	1	Animal		14-09-07 13:23:25	L	2	slowly swimming in dir 90
14-9 2007	9	93	0	64	1	1	Animal		14-09-07 13:29:33	L	1	surfacing; milling
14-9 2007	9	93	0	84	0	1	Animal		14-09-07 13:38:20	L	2	swimming in dir 300, 1m underneath the surface
14-9 2007	9	93	0	68	0	3	Animal		14-09-07 13:42:50	L	2	swimming in dir 20, all underneath the surface, saw them late bec of glare
14-9 2007	10	99	0	35	1	1	Animal		14-09-07 16:12:12	L	1	surfacing
19-9 2007	10	99	0	70	1	1	Animal		19-09-07 12:49:36	R	1	
19-9 2007	10	86	0	40	1	1	Animal		19-09-07 13:54:23	L	2	in dir 360 deg, seems that it was only very slowly moving
19-9 2007	18	245	0	60	1	1	Animal		19-09-07 15:30:28	L	1	surfacing
21-9 2007	2	10		88	1	1	Animal		21-09-07 18:10:39	L	1	sighting was in the glare, unsure about correct species ID, most likely a porpoise
21-9 2007	1	1		63	1	1	Animal		21-09-07 19:34:50	L	2	surfacing in dir 360
21-9 2007	2	16		46	1	1	Animal		22-09-07 17:30:16	R	1	
24-9 2007	6	57		43	1	1	Animal		24-09-07 16:57:18	L	1	surfacing
24-9 2007	6	57		50	1	1	Animal		24-09-07 16:57:24	L	2	swimming fast under water and suddenly surfacing for a very short time, saw it late, dec angle might be not very accurate
24-9 2007	17	237		84	2	2	Animal		24-09-07 16:57:31	L	1	surfacing
24-9 2007	17	237		78	2	2	Animal		24-09-07 16:57:37	L	2	swimming fast under water and suddenly surfacing for a very short time
28-9 2007	8	81	1	83	0	1	Animal	28-09-07 13:53:46	28-09-07 13:53:51	R	1	



**Fig. 1. Survey strata (left), effort and sightings of harbor porpoises in West Greenland August-September 2007.**



**Fig. 2. Distribution of daily positions of harbour porpoises relative to survey strata used for the aerial survey in West Greenland 2007.**