A note on cue rates for common minke, fin and humpback whales off West Greenland

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ABSTRACT

Field observations of cue rates for common minke whales, fin whales and humpback whales were conducted in July 1996 and May-September 2006. The cue for minke whales was usually the dorsal ridge breaking the water surface. A total of 295min of surfacings of five minke whales ranging 27-106min were observed and the simple mean was 46.1 surfacings per hour (CV=0.11). The cue for fin and humpback whale surfacings was sometimes the head breaking the surface but most often a blow. Twenty-three trials of fin whale groups ranging 1-4 individuals provided 620min of observations. The simple mean of all the trials was 52 blows hr^{-1} (CV=0.06). When trials <10min were excluded the surfacing rate remained unchanged, but when trials <30min were excluded the surfacing decreased to 50 blows hr^{-1} (CV=0.07, *n*=8 trials). A total of 860min (*n*=39 trials) and 1,232 blows from surfacing humpback whales were collected from groups of 1-4 individuals. The simple mean of all trials was 71 blows hr^{-1} (CV=0.07). The minke, fin and humpback whale cue rate estimates are close to values obtained from other studies, but they are the first that are specific to West Greenland and it is suggested that they should be used for correcting abundance estimates obtained from the aerial cue counting method.

KEYWORDS: COMMON MINKE WHALE; FIN WHALE; HUMPBACK WHALE; CUE RATES; WEST GREENLAND; NORTHERN HEMISPHERE; SURVEY-VESSEL; SURVEY-AERIAL; NORTH ATLANTIC

INTRODUCTION

Frequent surveys of common minke whales (*Balaenoptera acutorostrata*), fin whales (*B. physalus*) and humpback whales (*Megaptera novaeangliae*) in West Greenland are an important part of the scientific background for developing advice on the sustainable utilisation of whales in West Greenland. Several types of sighting surveys of cetaceans have been undertaken in West Greenland. Ship-based surveys were conducted in 1982, 1983 and 2005, aerial line-transect surveys were conducted in 1984-85, aerial cue-counting surveys were conducted in 1987-89, 1993 and 2005 and aerial photographic surveys were attempted in 2002 and 2004. Of the four different types of surveys, aerial cue-counting surveys show the best performance, at least for common minke whales. Aerial surveys have the advantage that large areas can be covered during the relatively short windows, with optimal sighting conditions in West Greenland in summer. The cue-counting method (see review in Hiby, 1992) has the advantage of utilising an independent cue rate as a means to correct for whales that are submerged during the passage of the plane. However, estimates of cue rates for the target species have to be developed based on observations, preferably over long periods in the same time period and area as the survey is covering. Various compromises have of course to be implemented to meet these ideal conditions, but it is evident that area-specific cue rate estimates are necessary since diving patterns of whales vary with behaviour, depth, prey and season (cf. Kopelman and Sadove, 1995; Laidre *et al*., 2003); thus cue rate estimates from one area are not necessarily applicable to a survey in a different area.

In order to develop cue rate estimates for minke, fin and humpback whales that are specific to the West Greenland survey area, field observations of diving patterns of whales were conducted at two sites in West Greenland.

METHODS

A cruise targeting common minke whales was conducted on 7-8 July 1996 in Nuuk fjord, West Greenland, with the research vessel *Adolf Jensen* and four trained whale observers (Fig. 1). Observations were conducted using binoculars (Leitz 7×42). Observations of diving patterns of fin and humpback whales were made from 15 to 27 August 2006 in Disko Bay (Fig. 1) from a dinghy with two observers following similar procedures as for the minke whales. Additional observations of humpback whales were made from land-based lookout points and from boats with binoculars (Optimic 10×42) in Nuuk fjord from May to September 2006.

When a whale was located during ship-based observations the boat was directed towards the area. If the whale was resting in the area the engine was shut down at distances >250m from the whale and it was followed visually for as long as possible. If the whale was travelling the engine was kept running and the boat followed at a distance of >250m and at a slow speed. Data were continuously recorded by two observers that recorded time stamps for each event with precision to the nearest second on dictaphones. Observations were initiated when the first cue was observed and only terminated when the whale was lost or weather or light conditions did not allow for reliable sightings.

Cues for minke whale surfacings were defined as: (1) the dorsal ridge breaking the surface; (2) the dorsal fin; or (3) a blow from the whale.

The cue for fin and humpback whales was almost always a blow, however in a few instances the rostrum broke the surface and no blow was seen. Both fin and humpback whales often travelled in pods of 1-4 whales and it was not possible to determine blows from the same individuals. Instead the pod size was determined and the number of

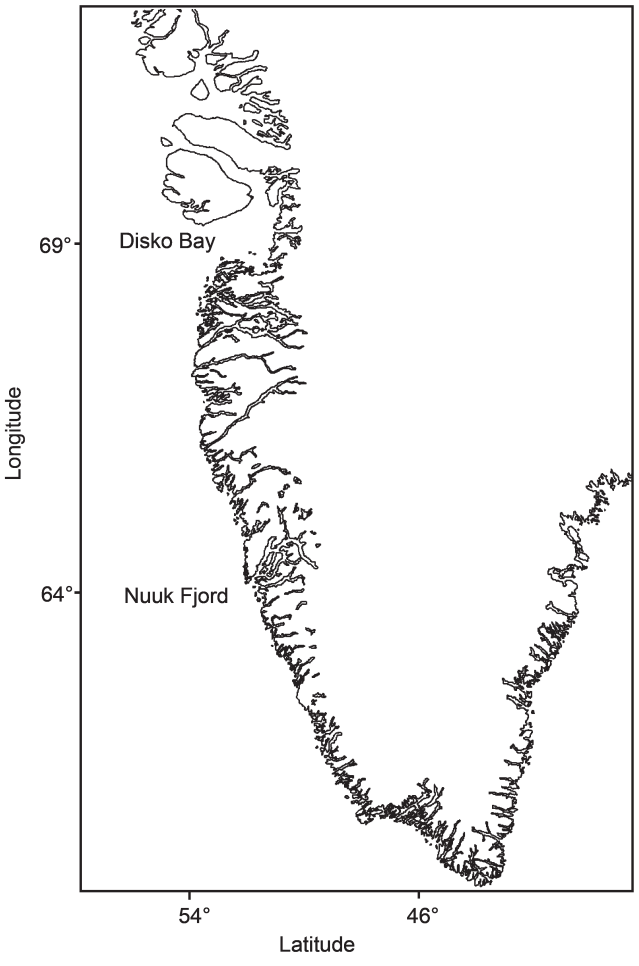

Fig. 1. Map of West Greenland.

blows per individual as a fraction of the pod size was calculated.

It could not be assessed if the minke whales were feeding or travelling, but for the observations of fin and humpback whales it is likely that they were feeding on capelin (*Mallotus villosus*) based on their relatively stationary occurrence during the observation periods.

RESULTS AND DISCUSSION

A total of five surfacing sequences of common minke whales ranging 27-106min were obtained in the Nuuk area in 1996 (Table 1). All dive cycles lasted <5min. A simple mean of the five sequences gives 46.1 cues per hour (Coefficient of Variation CV=0.11). Dive cycles for fin and humpback whales lasted up to 19 and 16min, respectively (Fig. 2). There was a slight tendency for lower cue rates for longer observation periods for humpback whales (r^2=0.08, p=0.09) and similarly for longer cue rates for fin (r^2=0.003, p=0.79) and minke whales (r^2=0.294, p=0.35). The lower cue rates for humpback whales could be a result of the increased risk of missed surfacings during longer observation periods. The weakly positive correlation between cueing rate and observation duration for minke and fin whales is far from being statistically significant. Thus no clear indication of the effect of observation duration was provided and it was decided to use a simple mean rather than a mean weighted by the observation period.

Table 1

Duration of trials and cue rates from common minke whales from Nuuk, West Greenland, July 1996.

Trial	Duration (min)	Number of cues	Cue rate (cues/whale/hr)	Time at surface (s)		
				Mean	Min.	Max.
1	107	101	56.92	4.48	2.9	7.4
2	49	26	32.08	3.35	2.0	4.7
3	50	50	60.67	2.97	2.0	4.5
4	64	47	44.27	3.93	2.7	5.7
5	27	17	37.62	2.78	1.7	4.6

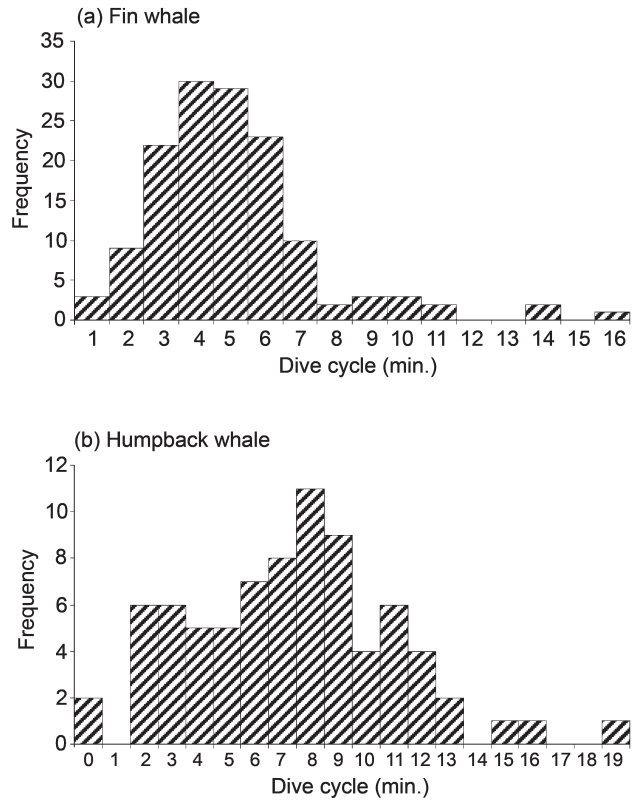

Fig.. 2. Frequency distribution of dive cycles for fin and humpback whales.

Several studies have addressed cue rates for common minke whales in other parts of the North Atlantic (see review in IWC, 2006). Gunnlaugsson (1989) reported an overall average cue rate of one per 52.7s (CV=0.06) from 16 series of visual observations, totalling 501 surfacings mostly collected from presumably feeding minke whales in Icelandic waters in July and August 1987. From the Norwegian Sea, Joyce *et al*. (1989) reported a mean rate of 52.4 cues hr^{-1} (SE=9.4) from four trials. However, this sample size was augmented by a study by Øien *et al*. (1990) that gave a time-weighted average of 36.7 cues hr^{-1} for over 1,000min observations from five vessels in the Norwegian Sea and along the Norwegian coast.

Surfacing rates of minke whales have also been estimated from VHF radio tracking of instrumented whales and Joyce *et al*. (1990) obtained an average day time rate of 60.35 surfacings hr^{-1} (CV=0.43) from one minke whale in Faxaflói, Iceland. Øien *et al*. (2003) summarised Norwegian data on surfacings based on VHF tracking of 14 whales in the North Sea, the Norwegian Sea and off Lofoten and the simple mean of all the whales was 48.1 surfacings hr^{-1} (SD=9.5).

Visual observations and VHF tracking may not be entirely compatible in estimating surfacing rates. Both methods may miss surfacings but depending on the position of the transmitter on the whale, VHF tracking may also give false positive surfacing indications when the antenna is close to the surface but without the whale actually breaking the surface. Independent of this there seems to be generally good agreement between surfacing estimates derived for a variety of studies in very different parts of the North Atlantic thus it seems reasonable to assume that the surfacing rate is a robust parameter with limited population-wide variability.

Witting and Kingsley (2004) used sequences of images of surfacing common minke whales taken during an aerial photographic survey in Faxaflói, Iceland, in 2003 to estimate the average time period during which a surfacing common minke whale can be identified on an image. They estimated this to be 7.2sec (SE=0.07), which is twice as much as that estimated from the visual observations in this study (mean=3.5, SE=0.31). The difference is probably due to the fact that a whale can be seen on aerial photos for some time when the whale is submerged but close to the surface in addition to the time it is breaking the surface.

Data on surfacing from 23 trials of fin whales were collected comprising a total period of 620min and more than 1,000 blows (Table 2 and 3). The simple mean of all the trials was 52 blows hr^{-1} (CV=0.06). If only trials <10min are excluded the surfacing rate remains unchanged, but if trials <30min are excluded the cue rate decreases to 50 blows hr^{-1} (CV=0.07) based on only eight trials. None of these values are significantly different from the value of 52.4 blows hr^{-1} (Hiby, 1992) that has been used as the cue rate for fin whales in West Greenland in past aerial cue counting surveys (Larsen, 1995). However, the present estimate of the blow rate has an associated estimate of the variance and it is specific to whales in West Greenland and must therefore be considered a more realistic value for correcting surveys of fin whales.

Table 2

Duration of trials and cue rates defined as blows per whale from fin whales from Disko Bay, West Greenland, September 2006.

Trial	Duration (min)	Number of blows	Number of whales	Blows/hour	Cue rate (blows/whale/hr)
1	14	21	1	90	90.0
2	7	9	1	77	77.1
3	43	80	2	112	55.8
4	32	78	3	146	48.8
5	9	14	2	93	46.7
6	114	246	2	129	64.7
7	12	11	1	55	55.0
8	49	155	3	190	63.3
9	40	142	4	213	53.3
10	24	79	4	198	49.4
11	12	10	1	50	50.0
12	23	40	2	104	52.2
13	6	4	2	40	20.0
14	20	46	3	138	46.0
15	31	27	3	52	17.4
16	5	13	3	156	52.0
17	9	31	3	207	68.9
18	18	41	2	137	68.3
19	11	17	2	93	46.4
20	11	17	2	93	46.4
21	64	100	2	94	46.9
22	19	28	2	88	44.2
23	47	64	2	82	40.9

Table 3

Duration of trials and cue rates defined as blows per whale from humpback whales from Disko Bay and Nuuk Fjord, West Greenland, May-September 2006.

Trial	Location	Duration (min)	Number of blows	Number of whales	Blows/hr	Cue rate (Blows/whale/hr)
1	Disko	7	16	1	137	137.1
2	Disko	24	53	1	133	132.5
3	Disko	25	43	1	103	103.2
4	Disko	5	10	1	120	120.0
5	Disko	8	12	2	90	45.0
6	Disko	16	18	1	68	67.5
7	Disko	5	13	1	156	156.0
8	Disko	7	9	1	77	77.1
9	Disko	5	13	2	156	78.0
10	Disko	23	27	1	70	70.4
11	Disko	12	7	1	35	35.0
12	Disko	27	36	1	80	80.0
13	Disko	8	14	2	105	52.5
14	Disko	6	46	4	460	115.0
15	Disko	34	83	2	146	73.2
16	Disko	19	119	3	376	125.3
17	Disko	11	44	4	240	60.0
18	Disko	11	42	2	229	114.5
19	Disko	24	19	1	48	47.5
20	Nuuk	9	4	1	27	26.7
21	Nuuk	49	48	1	59	58.8
22	Nuuk	22	28	1	76	76.4
23	Nuuk	20	20	1	60	60.0
24	Nuuk	19	14	2	44	22.1
25	Nuuk	16	18	1	68	67.5
26	Nuuk	29	37	2	77	38.3
27	Nuuk	65	75	1	69	69.2
28	Nuuk	15	20	1	80	80.0
29	Nuuk	16	13	1	49	48.8
30	Nuuk	27	19	1	42	42.2
31	Nuuk	28	27	1	58	57.9
32	Nuuk	7	7	1	60	60.0
33	Nuuk	39	33	1	51	50.8
34	Nuuk	61	77	2	76	37.9
35	Nuuk	32	39	1	73	73.1
36	Nuuk	22	16	1	44	43.6
37	Nuuk	28	18	1	39	38.6
38	Nuuk	48	59	1	74	73.8
39	Nuuk	31	36	1	70	69.7

Data from 39 trials, from 5 to 65min duration, on surfacing humpback whales (19 trials from Disko Bay and 20 trials from Nuuk fjord) were collected, comprising a total period of 860min and 1,232 blows. The simple mean of all trials was 71 blows hr^{-1} (CV=0.07). This value is close to the mean blow rate estimates of 72 blows hr^{-1} obtained from humpback whales in Fredericks Sound, Alaska (Dolphin, 1987).

Time spent at the surface was determined for 436 fin whale surfacings and had a mean of 4s (SD=2) with a range from 2-11s and for 479 humpback whale surfacings in Disko Bay and had a mean of 4s (SD=2) with a range of 1-18s.

The present study provides the first cue rates with associated variances for common minke, fin and humpback whales for West Greenland and it is therefore suggested that these estimates can appropriately be deployed to reduce the availability bias in visual aerial cue-counting surveys of these whales in West Greenland (see Heide-Jørgensen *et al*., 2007).

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