Using Helicopters to Survey Antarctic Minke Whale Abundance in the Ice

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Abstract

During the ANT XXIII/8 cruise (November 26th 2006 to January 29th 2007) the German research vessel 'Polarstern' surveyed waters of the Weddell Sea. The helicopters on board were used to conduct surveys for minke whales in the pack ice as well as areas around the Antarctic Peninsula (Antarctic Sound, around James Ross Island, Larsen A and B). Helicopter surveys followed line transect distance sampling protocol flying 'ad hoc' survey patterns as well as pre-designed tracklines covering a total of 8619km. Environmental information was collected continuously during the surveys and included percent ice coverage. A total of 71 sightings of 155 minke whales were recorded. The mean group size was 2.18 with a maximum group size of 7 animals. Sighting rates were lowest in the surveys in the pack-ice with a mean of 0.0021 sightings per km. Sighting rates were 0.0034 for the Larsen A area, 0.006 in Larsen B and 0.026 in the Antarctic Sound. The highest sighting rates were found in the area around James Ross Island (0.074 sightings/km). The helicopter work off the Polarstern showed that helicopters can be a useful survey platform for cetacean surveys. They cover large distances effectively and, in comparison to ship surveys, they are especially well suited to survey areas with higher ice coverage.

Introduction

The IWC/SOWER cruises have focused on the distribution and abundance of Antarctic minke whales (*Balaenoptera bonaerensis*) over the last 3 decades. Considerable differences in the abundance of minke whales have been found between the first two and third circum – Antarctic surveys. These differences are still awaiting reconciliation. Uncertainty over the number of minke whales present in the pack – ice zone (outside the reach of the survey vessels) was one of the explanations offered to explain these large differences.

Information on the macro- and mesoscale distribution of minke whales in the pack-ice and how and when they are utilizing the pack – ice zone as habitat is still insufficient (Shimada and Kato, 2005). Minke whales have been sighted far into the pack ice in all seasons (Ainley, 1985; van Franeker, 1992; Thiele *et al.*, 2002; Shimada and Kato, 2005). Thiele and Gill (1999), for example, found minke whales 180 to 350 km south of the ice edge. Minke whale distribution in the ice depends on the type of ice and the degree of ice coverage (Thiele *et al.*, 2002). Recently, Ainley *et al.* (*in press*) found a strong inverse relationship between minke whale density and sea ice concentration in the marginal ice zone and in polynyas, of the Amundsen and Bellingshausen Seas. These results confirm, and begin to quantify the complex relationship between pagophilic minke whales and their habitat in the Antarctic. The

scarcity of observations on the distribution and abundance in the pack ice stressed the need to collect more information.

Surveys focusing on Antarctic minke whales, such as the IWC/SOWER cruises, are usually ship-borne surveys. They are typically conducted by at most ice strengthened vessels which cannot penetrate any distance into the marginal ice zone. Survey effort is mostly concentrated in the summer months when the ice retreats far south and large stretches of open water can be surveyed. Some opportunistic sighting surveys have penetrated into the pack ice and have also been conducted in seasons other than the summer, such as late autumn - winter (Ainley *et al. in press*, Thiele *et al.* 2002).

Helicopter surveys have been used in Antarctic waters to survey pinnipeds in the fast ice zone and pack ice zone (Southwell, 2005a,b). But only few surveys have included cetaceans as a target species (Ploetz, 1991; van Franeker, 1992). The goal of this effort was to elucidate the value of using helicopters for line-transect surveys of cetaceans in the pack ice. Furthermore, we were interested in how these data can be used to better understand the distribution and relative abundance of minke whales to varying sea ice conditions and proximity to the ice edge.

During cruise ANT XXIII/8 the German research vessel ‘Polarstern’ entered the pack ice at 58° S and passed through approximately 1200 nm of ice across the eastern Weddell Sea to reach Neumayer Station (70°39’S / 08°15’W) on the Antarctic shelf ice. From Neumayer Station the vessel continued in a north-westerly direction until the vessel left the pack ice southwest of Elephant Island (see figure 1).

Method

Aerial surveys following standard line-transect distance sampling methodology were conducted with a helicopter on board RV ‘Polarstern’ from 1 December 2006 to 26 January 2007 (Figures 2 and 3). Each flight was planned to last 2 hours. Track design was completed immediately prior to the survey, adjusting the survey area and track to changing weather conditions when necessary.

Flying altitude was 600 feet and helicopter speed was 80 knots. The first observer sat on the port front seat of the helicopter and observed the area to the front, focusing on the transect line. The second observer was positioned behind in the back of the helicopter and observed the area to the port side of the helicopter, perpendicular to the cruise track. The program VOR was used to continuously log GPS position, environmental conditions (ice concentrations, sea state, etc.) and information on sightings. A digital tape recorder was used as an audio backup for later reference. Additionally, a web cam was used to record the ice condition in front of the helicopter every 30 seconds (part of the “Logger” program). For each whale sighting the following information was collected: species, group size, group

composition, behavior, cue, swimming direction and detectable reaction to the helicopter (while in passing mode). When a sighting was abeam an inclinometer was used to take the vertical angle to determine distance to the transect. If the species or the group size could not be identified during the sighting, the survey was interrupted and the helicopter approached the sighting and stopped for observation (closing mode). Once the missing information was obtained the helicopter returned to the transect and the survey was continued.

Results

In this paper we present the results of the helicopter survey effort in the Weddell Sea. A total of 8619km of survey flights were covered by helicopter. About half of this effort (4722km) covered the pack-ice covered area of the Weddell Sea (figure 1). 3897km were spent surveying the Antarctic Sound, James Ross Island as well as Larsen A and B (figure 2). During the transit of the boat through the ice of the Weddell Sea 20 separate flight surveys were conducted, each lasting around 2 hours (see table 1). In some areas the Polarstern remained stationed for several days allowing for more intense coverage. These survey areas were Antarctic Sound, James Ross Island, Larsen A and the Larsen B area (figure 2). Sea ice coverage (as collected continuously during the flight) for each survey varied from 0% to 100%. The mean ice coverage per survey flight or in each survey area varied from 4% to 72% (see table 1).

A total of 71 sightings of 155 minke whales were recorded while on search effort. Only one calf was seen. The majority of sightings were made up of single animals or pairs. The mean group size was 2.18 with a maximum group size of 7 animals. The distribution of group sizes for the minke whale sightings is shown in figure 4.

The main behavior observed was slow swimming or resting (37%) followed by directional swimming (27%), milling or feeding (18%) and fast swimming (3%). In 15% of the sightings the behavior could not be determined (figure 5). Red faeces was observed during some sightings, indicating that the animals had been feeding on krill species. In one case, a minke was observed to repeatedly swim under the ice and returning to an opening to breathe, possibly feeding under the ice floe. None of the whales showed an obvious reaction to the passing helicopter. The survey was changed to closing mode in all cases when whales were seen in order to ascertain initial group size estimates. During one observation (H08) the helicopter was positioned at a distance of about 300 m parallel to the animals. The four minkes were observed to change their swimming direction and head towards the helicopter. All animals were underneath the surface at a depth of several meters. One of the animals turned on its side.

Sighting rates were lowest in the surveys in the pack-ice (surveys H01 - H18, H38 and H56). Eleven of the 20 surveys had no sightings at all. During the remaining 9 survey flights, 10

sightings of Minke whales with a total of 20 animals were made (table 1). This resulted in 0.0021 sightings per km and 0.0042 animals per km survey flight. Sighting rate for the Larsen A area was 0.0034 sightings per km survey effort with an animal/km rate of 0.0075. In Larsen B these valued approximately doubled with 0.0060 sightings per km and 0.0139 animals per km. The Antarctic Sound had values more than a magnitude higher than the ice surveys, with 0.026 sightings/km and 0.0469 animals/km. The highest sighting rates were found in the area around James Ross Island. On the eastern side of the island, just south of the Antarctic Sound a large aggregation of minke whales was found (figure 2). This resulted in values of 0.074 sightings/km and 0.1632 animals/km. The furthest distance of a minke whale sighting from the ice edge into the pack ice was 315km. The furthest distance of a sighting from open water to the ice edge was 156km.

Two other cetacean species were sighted: one sighting of four Arnoux's beaked whales (*Berardius arnouxii*) (figure 1) and five sighting of Antarctic killer whales (*Orcinus orca*) (figure 2). A group of 18 killer whales were observed attacking a group of five minke whales during one sighting.

Discussion

The use of a helicopter to survey cetaceans in the Southern Ocean has been found to be advantageous in several respects: Weather permitting, the helicopter allowed large areas to be covered in a comparatively short period of time of a few hours as opposed to ship-based surveys which would take several days to cover the same area. The track design can be adapted close to the start of each survey flight, for example, to cater for waters with higher ice coverage or to avoid poor local weather conditions. Another advantage was the ability to discontinue the survey at any time and position the helicopter in a way in which the sighting itself could be ascertained and the group size could be determined. It was found that initial group size estimates often increased during observation of the sighting in closure mode. Also, surveying in the ice meant that sea states were generally low (less than 3). This allowed good observations above water as well as under the surface. Additionally the blow of the minke whales was normally well defined and conspicuous while in the ice.

The comparison of minke whale relative abundance obtained in the pack ice versus those east of the Antarctic Peninsula, showed an increase in sighting rate of several magnitudes. One reason for the low sighting rates in the pack ice could have been that most of those survey flights (H01 to H18) took place in December. However, peak densities of minkes close to the ice edge have not been reported before January (Kasamatsu, 1996). It is also possible that some of the animals seen stayed in the ice over winter. Thiele and Gill (1999) have proposed that, while biological productivity is known to be reduced from summer levels, a small number of whales may be supported by krill during winter. A number of authors have described winter sightings of minkes in the Antarctic sea ice. Minke whales have been sighted in winter months close to the ice edge of Antarctic waters (Thiele *et al.* 2004). During

a winter cruise (July to September 1986) Plötz *et al.* 1991 observed a total of 29 minke whales with one sighting 1300km distance from the northern ice edge. Aguayo-Lobo (1994) observed minke whales in early spring in the Bellingshausen and Amundsen Seas.

This first analyses of the data indicates that sighting rates are highest in the coastal polynyas, such as the Larsen B area, and lowest in the pack ice. Ainley *et al. in press* found that the probability of detecting minke whales was related to the proximity of coastal polynyas in early autumn and that the density index for minkes was strongly related to ice concentration in an inverse relationship. The Larsen A and B ice shelves collapsed in 1995 (Larsen A) and 2002 (Larsen B) thus providing a fairly new habitat. Additionally to the high minke whale sighting rates, a large number of seals (crabeater, weddell and leopard) were observed on the pack ice in Larsen A and B. This high biomass of top-predators indicates a high production in this area. A possible cause could be the currents of the Weddell Sea forcing the waters particularly into the Larsen B area. It would be important to monitor this observed pattern to see if it is a short term reaction or if these areas will be continuously used.

The greatest number of minkes overall was found in a comparatively small area east of James Ross island. This habitat was close to the ice edge, but connected to open water through the Antarctic Sound. High densities of krill are associated with a retreat of the outer edge of the sea ice in combination with particular continental shelf and slope environments (e.g. Nicol *et al.*, 2000; Murase *et al.* 2002). Dense concentrations of krill may have caused minke whales to concentrate in the area. Further investigation of the oceanographic characteristics of this area would be important to understand the reasons for the observed aggregation.

In summary, conducting helicopter surveys seems to be an efficient method to investigate minke whale abundance and distribution. This is especially true for areas in which high ice coverage makes survey work with a vessel impractical. Nevertheless, it is difficult to conduct pre-designed survey while working from a transiting research vessel. But recent developments in modeling methodology as well as the analyses of sea ice coverage from satellite data will allow us to use this distance sampling data to model abundances in future work.

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Figure 1: Cruise track of the Polarstern ANT XXIII/8 (23rd November 2006 to 30th January 2007).

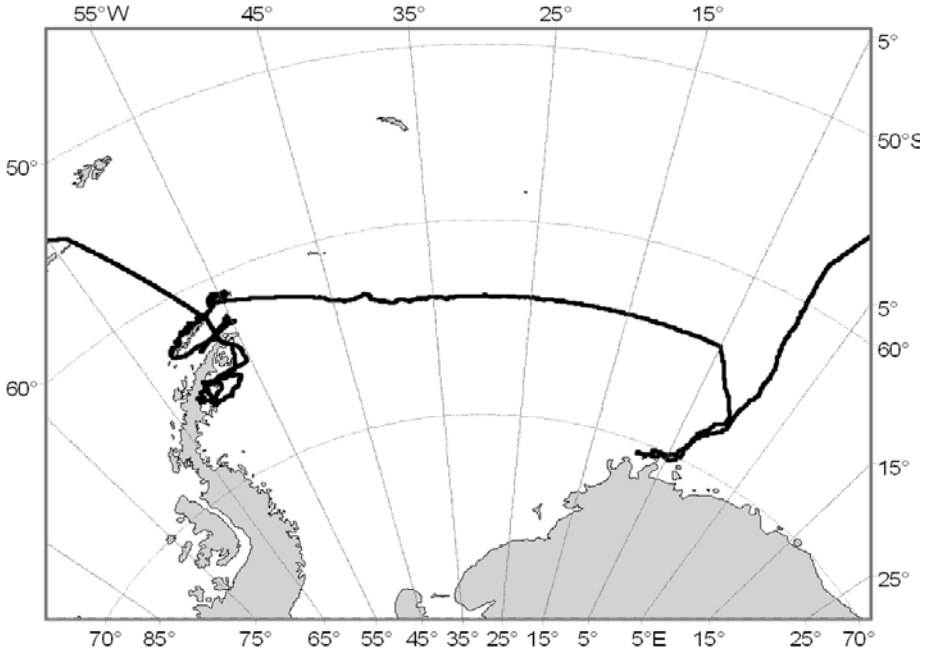

Figure 2: Helicopter surveys from December 1st to December 18th 2006 in the Weddell Sea. Polar Stereographic Projection (central meridian 20° west).

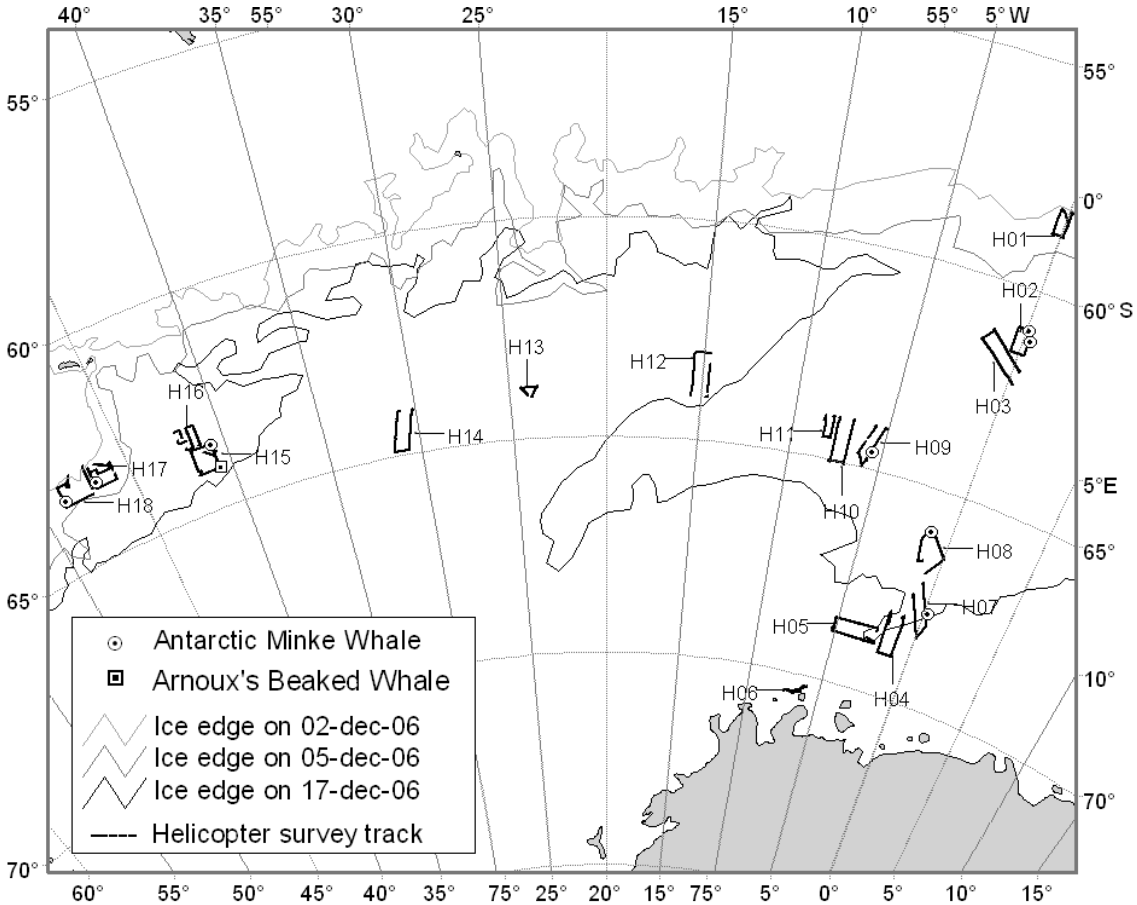

Figure 3: Helicopter surveys in the western Weddell Sea. The ice edge contour from January 18th 2007 indicates the coastal polynyas in Larsen A and B.

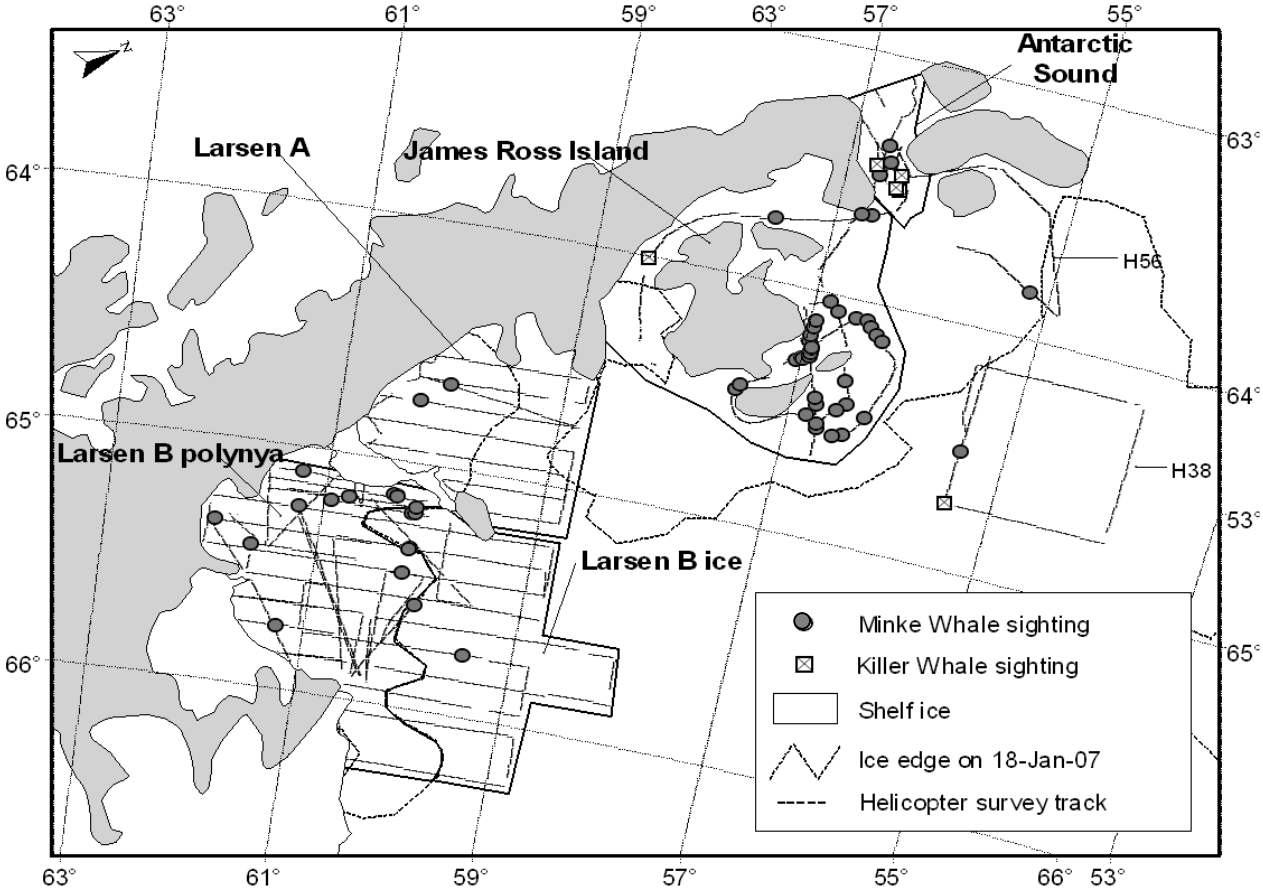

Table 1: Overview of survey effort and sightings during the Weddell Sea helicopter flights.

date	survey name	km surveyed	number animals	number sightings	sighting rate (sightings per km)	mean sea ice coverage % per survey
01.12.06	H01	251	0	0	0.0000	22
02.12.06	H02	178	2	2	0.0112	61
02.12.06	H03	293	0	0	0.0000	50
04.12.06	H04	281	0	0	0.0000	60
04.12.06	H05	290	0	0	0.0000	72
05.12.06	H06	155	0	0	0.0000	42
12.12.06	H07	258	1	1	0.0039	49
12.12.06	H08	241	4	1	0.0041	18
13.12.06	H09	220	1	1	0.0045	20
13.12.06	H10	245	0	0	0.0000	38
13.12.06	H11	132	0	0	0.0000	22
14.12.06	H12	252	0	0	0.0000	39
15.12.06	H13	90	0	0	0.0000	58
16.12.06	H14	249	0	0	0.0000	45
17.12.06	H15	258	2	1	0.0039	54
17.12.06	H16	250	0	0	0.0000	45
18.12.06	H17	284	2	1	0.0035	33
18.12.06	H18	205	1	1	0.0049	26
07.01.07	H38	292	3	1	0.0034	36
24.01.07	H56	298	4	1	0.0034	29
01/07	Antarctic Sound	192	9	5	0.0260	4
01/07	James Ross Island	527	86	39	0.0740	21
01/07	Larsen A	663	5	2	0.0030	46
01/07	Larsen B	2515	35	15	0.0060	33
	Total	8619	71	155	0.0082	

Figure 4: Distribution of group sizes of Minke whale sightings

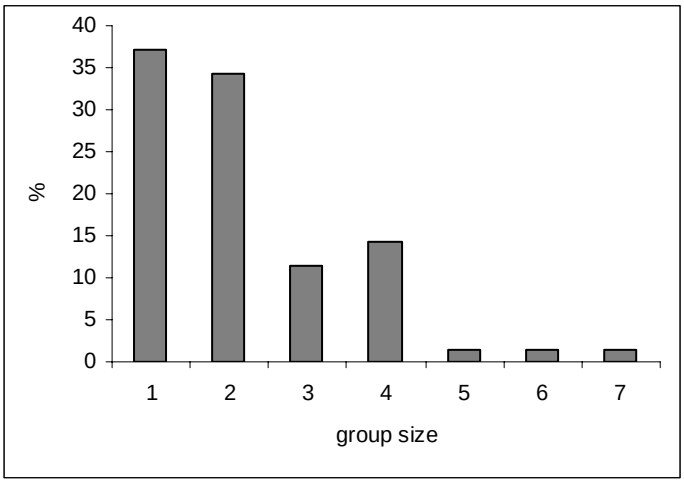

Figure 5: Distribution of observed behaviour of Minke whales during the surveys

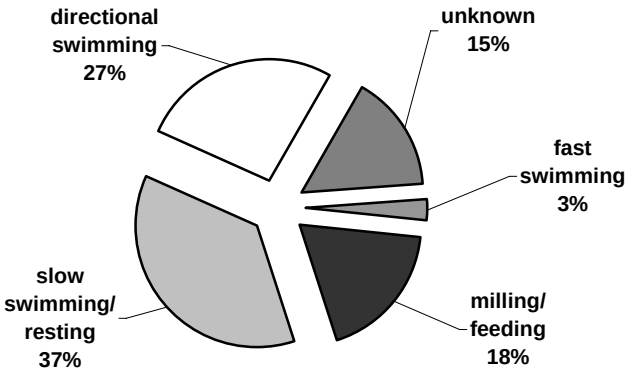
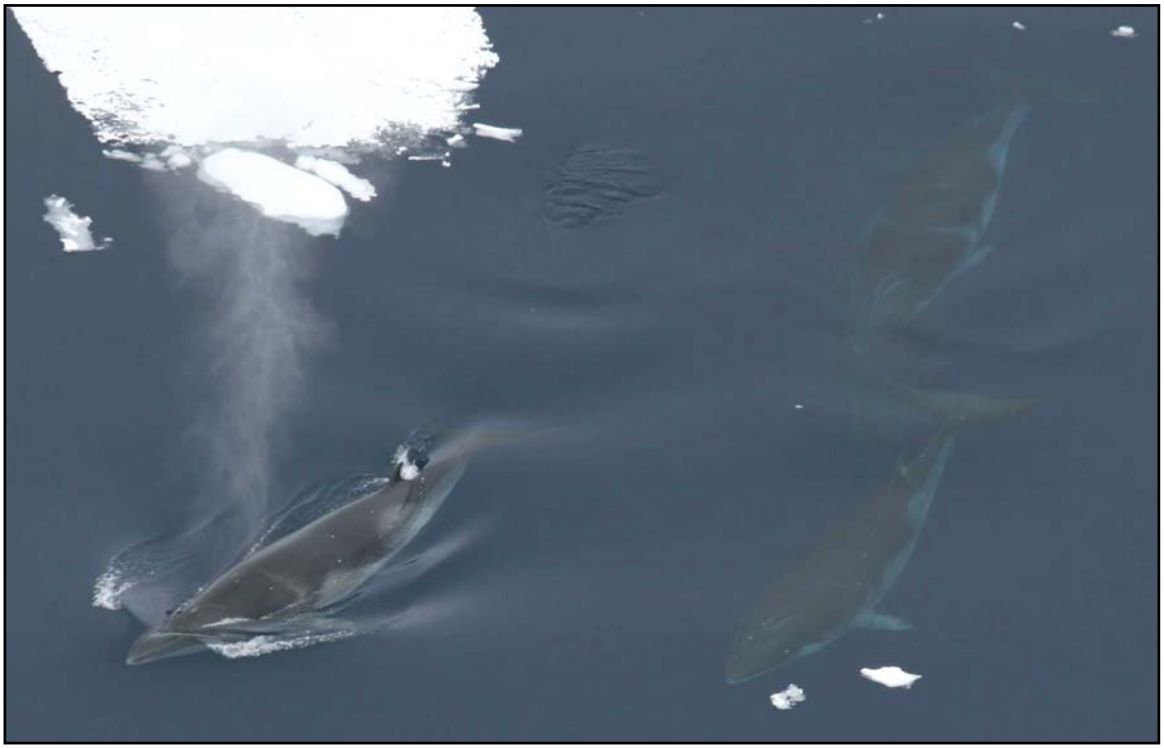
Figure 6: Photograph of minke whale group in the pack ice of the Weddell Sea