Killer whale studies, McMurdo Sound, Ross Sea, Antarctica, Jan-Feb 2014

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ABSTRACT

Ecotype B and C (TBKW, TCKW) killer whales (*Orcinus orca*) were studied in McMurdo Sound, Antarctica, in late January and early February 2014. While the unusually extensive break-out of the sea ice in the 2013-14 season limited opportunities for the collection of dart biopsies, three whales were sampled. In the period from 20-28 January, a total of 307 whales were detected including 297 TCKW and 10 ecotype B killer whales (TBKW) along a 20-30 nautical mile stretch of fast ice at the western margin of McMurdo Sound. Feeding behaviour of TCKW was recorded during 5 of the 8 flights. TCKWs with prey items held in their jaws were seen on 5 occasions; in 3 cases, the prey was clearly identifiable as toothfish (*Dissostichus mawsoni*). A large number of images were collected for photo-identification. Additional observations of hunting behaviour of Type B killer whales directed at seals and penguins were made from Scott Base between 30 Jan and 16 Feb 2014.

KEYWORDS: ANTARCTIC, KILLER WHALE, ECOTYPES, FEEDING, PHOTO-ID, TOOTHFISH, MINKE WHALE

INTRODUCTION

In January 2014, killer whale research was conducted in McMurdo Sound, Ross Sea, Antarctica, as part of a collaborative study of megafauna trophic relationships led by the University of Canterbury and funded by the New Zealand Antarctic Research Institute (NZARI RFP 2013-1). The aim was to study the diet of killer whales (*Orcinus orca*), Weddell seals (*Leptonychotes weddellii*) and Adélie penguins (*Pygoscelis adeliae*) as key predators of the region. The killer whale component focussed on ecotype C killer whales (*sensu* Pitman & Ensor 2003). This ecotype has a wide distribution in Antarctic waters and in the Austral summer is particularly abundant in the shallow waters of the Ross Sea. Ecotype C killer whales (TCKW) are postulated to feed primarily on fish based on analyses of stomach contents from Soviet whaling (Berzin & Vladimirov 1983; Pitman & Ensor 2003), although neither the species of fish nor the ecotype of whale examined were reported. There are a two reports of killer whales feeding on Antarctic toothfish *Dissostichus mawsoni* in channels in the sea ice made by US icebreakers operating in McMurdo Sound during the austral summer (Thomas *et al.* 1981; Wu & Mastro 2004) as well as an observation near the ice edge in Terra Nova Bay (Ainley *et al.* 2009), suggesting that toothfish may be an important prey item for TCKW. However, TCKW have also been reported to feed on Antarctic silverfish

Pleuragramma antarcticum near Terra Nova Bay (Lauriano *et al.* 2007). A study on skin stable isotope signatures of TCKW sampled in McMurdo Sound (*n = 28*; Krahn *et al.* 2008) did not support toothfish as a major prey item, although results are consistent with toothfish being a seasonally important prey of TCKW during summer. At this time, considerable uncertainty remains regarding the diet of TCKW or other killer whale ecotypes in the Ross Sea. Thus, to help quantify the level of summer predation on toothfish, the primary aim of our research was to collect dart biopsies for investigation of stable isotope signatures of skin and blubber. Additional data collected included images for photo-identification (ID), distribution of sightings, group composition, and behavioural observations. Skin samples were also retained for genetic analysis. This work builds on the results of previous studies of killer whales in the McMurdo Sound region that have been conducted predominantly in the vicinity of an icebreaker channel (Pitman *et al.* 2007; Andrews *et al.* 2008; Krahn *et al.* 2008).

METHODS

Killer whales were studied during helicopter flights and from the fast ice edge in southwestern McMurdo Sound (Fig. 1) during eight helicopter flights between 20 to 28 January 2014 (Table 1) using a four-person research team, including a field safety guide. The research was staged from the New Zealand Antarctic station, Scott Base (77°51' S, 166°46' E) using a model AS350 B2 helicopter operated for Antarctica NZ by Southern Lakes Helicopters, NZ.

The primary objective of survey flights was to land and take dart biopsies (using Paxarms B24 guns fitted with a tethered biopsy dart system) as well as collect photo-ID/ behavioural observations. Behaviour of killer whales was recorded in the following categories: feeding, travelling, milling, spyhopping, and resting. Helicopter flights tracked the edge of the fast ice as we could not fly over pack ice or ice-free water, and flight paths changed markedly from day to day due to the rapid break-up of the ice (Fig. 1A,B). The aircraft normally flew at an altitude of approximately 300 feet at a speed of about 80 knots. When killer whales were detected, a circle-back manoeuvre at reduced altitude was implemented to observe the whales and collect photo-ID images (using 2 Canon Eos 7D cameras equipped with stabilized 28-300 and 18-85 mm zoom lenses), as well as to assess the fast ice conditions in the locality for potential helicopter landing sites. Strategies for deployment of the team depended on the behaviour of the whales; for feeding killer whales, we attempted to land close to the whale's location, and for travelling whales, we advanced along the fast ice edge in the anticipated direction of their travel ('ambush sampling').

The most frequently recorded behaviour of killer whales during the aerial observations was 'travelling' along the fast ice edge. Spy-hopping was mainly observed in ice holes and narrow leads in the fast ice.

The approximate size of toothfish prey taken by killer whales was estimated from photographs by comparing the estimated body length of the whale (using data from Berzin & Vladimirov 1983 and Pitman *et al.* 2007) with toothfish morphometrics based on images of adult toothfish in Calhaem & Christoffel (1969) and Ainley *et al.* (2012).

After the last of the scheduled helicopter flights on 28 January, the fast sea ice continued to recede beyond Scott Base. Killer whales (both ecotypes C and B) started appearing in the open water near the base, and additional observations and photo-ID images were collected by RE and Scott Base personnel on most days until 16 February.

RESULTS

Aerial surveys

Eight survey flights were conducted on seven days: 20 Jan, 22 Jan, 23 Jan (two flights), 24 Jan, 25 Jan, 27 Jan and 28 Jan 2014 (Tables 1 and 2). Helicopter flight durations ranged from 67 to 248 min for a total of 18.5 hours, with landings on the ice accounting for 8.5 hours. Survey for whales and observations from the air were conducted during a total of 10 hours during eight flights. Weather conditions and whale sighting conditions during all flights were excellent (see Table 1).

The area surveyed was the western margin of the fast ice edge in southern McMurdo Sound and flights usually extended from Scott Base along the current ice edge to the vicinity of the Dailey Islands (77°53′S 165°8′E), encompassing approximately 30 nautical miles of ice edge. The farthest north (New Harbour; 77°31'53"S 164°36'34"E) was reached on 27 January, a straight-line distance of 24 nautical miles from Scott Base (Fig. 1). We did not survey the eastern side of McMurdo Sound (from Hut Point towards Cape Evans/Cape Royds), as the fast ice in that area was in poor condition that would have likely precluded landing the helicopter.

The extent of breakout of fast ice in McMurdo Sound during the 2013-14 austral summer was exceptional (though broadly similar to the 2010-11 season). In both these years, there was breakout of the fast ice to the McMurdo Ice Shelf margin, a condition not seen for more than a decade according to Antarctica New Zealand staff, but apparently common during the 1960s and 1970s (see Fig. 4 in DeVries *et al.* 2008).

In the period from 20-28 January, a total of 307 killer whales were detected including 297 TCKW and 10 ecotype B killer whales (TBKW). Aggregations of TCKW were seen on all flights, with numbers of TCKW seen per flight ranging from 15 to 75 (Table 2). Typically, TCKW were somewhat aggregated with small subgroups of the aggregation spread along approximately 2 miles of ice edge. Mixed ages of TCKWs were observed in all aggregations, and small calves were seen in many subgroups observed. We focussed on collection of photo-ID images rather than determining precise numbers of animals in aggregations.

In addition to the TCKW, a total of 10 individual TBKW were seen during the helicopter flights in the period from 20-28 January. A group of 7 animals were detected during one flight (including a calf) and a group of 3 animals was seen from a landing site on the margin of the McMurdo Ice Shelf (Table 2).

For dart biopsy sampling, it was necessary to land the helicopter and deploy the team on stable fast ice. Opportunities to do so were limited due to unsafe ice conditions and progressive break-out. Helicopter landings were made on the fast ice edge (or McMurdo Ice shelf margin) during 4 flights (22, 23, 24 and 25 Jan; Table 2). During the landings on 22 and 24 January, groups of killer whales were travelling along the ice edge (TCKW on 22 January and TBKW on 24 January) and the team stationed on the ice attempted to collect biopsy samples and photo-ID images from passing whales. Due to unsuitable ice conditions there were no opportunities to land the helicopter and deploy the team in the vicinity of feeding killer whales.

We used the following criteria for feeding activity: whales surfacing in an oil slick on the water surface, milling behaviour of the whales, accompanying flocks of attentive South polar skuas (*Stercorarius maccormacki*), and visible prey fragments held in the whales' jaws. Feeding behaviour of TCKW was recorded during 5 of the 8 flights (Table 2). Most feeding activity was observed for small subgroups of killer whales (comprising approximately 5-10 animals) typically judged to be part of a larger aggregation of whales.

TCKWs with prey items held in their jaws were seen on 5 occasions, with 4 separate observations during one flight (27 Jan) and one occasion on 23 Jan. For 3 of these observations, the prey was identifiable as toothfish parts (*e.g.*, Fig. 1). The estimated length of the toothfish in Fig. 1 was 1.5 m (plausible range 1.2 to 1.6 m depending on whale body length).

The appearance of prey scraps scavenged by skuas also supported the conclusion that whales were feeding on toothfish, as tissue fragments were large (*ca*. 5-7 cm^2), white rather than red or pink, and devoid of skin. Fish in McMurdo Sound other than toothfish are less than 30 cm standard length (Gon & Heemstra 1990) and would not yield scraps of this size. Skinless blubber is another possibility (and was in fact observed in association with TBKW; see below) but while Adélie and emperor penguins (*Pygoscelis adeliae*, *Aptenodytes forsteri*) and Weddell and crabeater seals (*Leptonychotes weddellii*, *Lobodon carcinophaga*) were present in McMurdo Sound, none were observed near the feeding TCKW. Seals and penguins occur primarily along the eastern margin and the southern end of McMurdo Sound, not towards on the western margin where feeding TCKW were observed.

Feeding activity was always observed relatively near the fast ice edge, though this was also where the search for whales was focussed due to operational limitations. Water depths in the regions where feeding behaviour of the killer whales was recorded ranged approximately 180-400 m. Feeding was not observed for TBKW during the aerial observations in January (but see below, *Killer whale observations from Scott Base*).

Biopsy Sampling

Biopsy sampling was attempted on two subgroups of one aggregation of TCKW and on a group of TBKW (comprising three whales). Three darts hit whales in the aggregation of TCKW resulting in biopsy samples. A dart was fired at the TBKW, however it missed the targeted whale.

Photo-ID Studies

Large numbers of images of ecotypes C and B killer whales were collected for individual identification (including images of eye-patch, dorsal fin, saddle and flanks). The best conditions for photo-ID existed when the team was stationed on the fast ice, but images were also collected from the aircraft. No assessment of image quality has been completed and therefore the total number of individuals photographed or the level of re-sighting of individual whales is currently unknown. However, from preliminary inspections of the images, it is clear that some distinctly marked individuals were seen on multiple days.

We observed and photographed several killer whales with circular marks on the dorsal fins with a centre piercing or scar (Fig.3), possibly the result of previous killer whale tagging experiments near McMurdo Station (*e.g.,* Andrews *et al.* 2008; R. Pitman, pers. comm.). Such marks were observed on 3 TCKW (all male) and 1 TBKW (female).

Collection of prey fragments and faecal samples

Prey scraps were photographed but none collected during 20-28 January as there was no opportunity to land on the fast ice near feeding killer whales (but see later section *Killer whale observations from Scott Base*). No whale faeces were observed.

Killer whale observations from Scott Base

By the end of January, the southernmost limit of the open water in McMurdo Sound was near Scott Base and coincided approximately with the edge of the ice shelf. Both ecotypes B and C were first seen from Scott Base on 30 January following breakout of the sea ice; while biopsy sampling was not attempted (equipment had been shipped back to NZ by 30 January), a large number of images were collected by RE and Scott Base staff and scientists.

The two ecotypes showed different behaviour: TCKW were sighted nearly every day at considerable distance from shore, in open water of the Haskell Strait or in the vicinity of the ice shelf. TCKW were almost always too distant for behavioural observations or photo-ID, and ecotype was confirmed with the aid of a telescope installed at Scott Base. Group sizes varied from *ca*. 5 to 30 whales. By contrast, TBKW closely approached the edge of the remaining fast ice (where both seals and penguins were hauled out) and Scott Base, and on several occasionas approached people on shore. Groups of TBKW consisting of 6 to 15 individuals, including calves, were observed to visit on 30, 31 Jan, 03, 13, and 16 February, moving in rapidly and remained near the shore/ice edge for approximately 0.5 to 2 hours before leaving again. TBKW were observed tossing a seal in the air on 30 Jan (species unconfirmed), made confirmed kills on 31 January (possibly two separate events) and 01 February, and were photographed unsuccessfully harassing a Weddell seal on 16 February. Prey species likely included Weddell seals and possibly Adélie or emperor penguins, since all three species were present and whales were seen to interact with seals. On 31 January, four TBKW were photographed feeding with a large amount of blood visible in the water (consistent with large warm-blooded prey rather than fish), and a killer whale was photographed 20 min later holding what appeared to be a penguin in its jaws. On 01 February, a skua attending a group of feeding TBKW scavenged a piece of blubber (*ca*. 30 cm long and 2-6 cm wide) off the water's surface and subsequently dropped it when harassed by another skua. The blubber has been collected and will be analysed to determine species, likely Weddell seal. No attempts at 'wave-washing' seals or penguins off ice floes (Visser *et al.* 2008) were observed.

Antarctic minke whales

Large adult Antarctic minke whales (*Balaenoptera bonaerensis*) were also seen during all flights (Table 2). In the north of the research area, solitary minke whales were seen while group sizes were larger near the fast ice edge in the south, near Scott base. The highest number of individuals were sighted on 23 January, a loose aggregation comprising approximately 40 minke whales off the fast ice edge in addition to about 20 animals in small ice-free areas in the fast ice immediately adjacent to Scott Base.

DISCUSSION

The 2014 killer whale research represents the first cetacean research project supported by the New Zealand Antarctic Programme (Antarctica New Zealand). Field work was scheduled as late in the summer season as practical within the constraints of Antarctica NZ logistics to (1) take advantage of the icebreaker channel for collecting dart biopsies (Andrews *et al.* 2008) and (2) allow for a potential seasonal time-lag in accumulation of stable isotopes, and thus increase the efficacy of stable isotope signatures as an indicator of (potentially seasonal) predation on toothfish. The schedule for the flights was developed by Antarctica NZ field logistics taking into account other research needs.

The absence of the normally well-defined icebreaker channel in the fast ice of southern McMurdo Sound in 2014 meant that we had to develop a Standard Operating Procedure (SOP) for helicopter landings and personnel deployment along the margin of the fast ice, something that had not been attempted before by Antarctica NZ-supported projects.

Late-season observations of toothfish predation by TCKW in McMurdo Sound substantiate the hypothesis that toothfish is an important prey item for this ecotype during the summer. Surprisingly, there has been an absence of any records of TCKW feeding on toothfish in McMurdo Sound since the 2000-01 season, despite ongoing research by US scientists in the area (Wu & Mastro 2004; Ainley *et al.* 2009; R. Pitman, pers. comm.). Our observations may have been facilitated by a variety of reasons, including:

- focus on aerial observations, necessitated by unsafe ice conditions;
- investigation of the western side of McMurdo Sound rather than the more thoroughly studied eastern side;
- the greater-than-average fast ice recession in 2013-14 that exposed new shallow areas of the Sound that are usually covered in multi-year fast ice.

Our estimate of toothfish prey size (*n=1*; Fig. 1) of 1.5 m coincides with the modal size classes (130 – 159 cm) of toothfish caught in McMurdo Sound by scientists (Ainley *et al.* 2012). Based on estimated TCKW metabolic rates (Kriete 1995; Williams *et al.* 2004; Noren 2011) and differences in the energy content of potential fish prey (Lenky *et al.* 2012), toothfish is likely to be the only fish prey of sufficient size, energy density, and fat content in the Ross Sea region to support fish-eating killer whales, in particular during periods of increased energy requirements such as lactation.

Assuming that circular scars we observed on both type B and C killer whales (*e.g.*, Fig. 3) are in fact caused by previous tagging attempts, this would suggest that individual whales or groups of killer whales show inter-annual residency in the McMurdo Sound region; one reason why McMurdo Sound is attractive to TCKW may be toothfish, which is also preyed on by Weddell seals in this area. More research is required to determine the abundance and ecology of killer whales in the southern Ross Sea, their prey spectrum, and possible seasonal reliance on toothfish.

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Table 1. Survey flights for killer whales McMurdo Sound, 2014. DNL, did not land.

Date	Flight number	Start time	End time	Total flight duration [hh: min]	Region landed on ice and duration	Duration on ice [hh: min]	Wind speed (km) and direction	Visibility	Weather
20 Jan	1	15:38	16:50	01:12	DNL	0	13 NE	Excellent	Partly cloudy
22 Jan	2	15:45	19:49	04:04	Fast ice edge NE of Dailey Islands	02:27	18 ENE	Excellent	Partly cloudy
23 Jan	3	13:35	14:43	01:07	DNL	0	10 NNE	Excellent	Partly cloudy
	4	14:51	17:22	02:31	Fast ice edge NE of Dailey Islands	01:40	10 NNE	Excellent	Partly cloudy
24 Jan	5	08:05	12:14	04:08	McMurdo Ice Shelf margin	02:43	16 ENE	Excellent	Overcast
25 Jan	6	14:46	17:23	02:37	McMurdo Ice Shelf margin	01:40	14 NE	Excellent	Overcast
27 Jan	7	09:09	10:53	01:44	DNL	0	15 NE in south, 5 W in north	Excellent	Partly cloudy
28 Jan	8	09:18	10:26	01:08	DNL	0	15-NE	Excellent	Overcast

Table 2. Summary of observations during survey flights for killer whales McMurdo Sound, 2014. H, from the helicopter, I, from the ice.

Date	Flight no.	Killer whales						Antarctic minke whales
		Ecotype and number of whales (high, low, best)	Area	Biopsy	Photo-id	Number of Type C feeding subgroups*	Images of Type C killer whales with prey items (including toothfish)	
20 Jan	1	Type C 60, 45, 50	Fast ice edge NE of Dailey Islands Recce landing only	No attempt	Yes H	3 at fast ice edge	No	5 solitary whales scattered along fast ice edge mostly towards the south
22	2	Type C 80, 70, 75	Fast ice edge mainly E of Dailey Islands Landed	Type C 3 samples collected; several misses	Yes H/I	4-5 300-500m offshore from fast ice edge, 1 in pack ice	No	8-10 off Scott Base fast ice edge
23	3	Type B 7; Type C 35	Type B McMurdo Ice Shelf margin (southern section) Type C fast ice edge mainly north of Dailey Islands Recce	No attempt	Yes H	2 (including one 400m off shore)	Yes	35 off fast ice edge 15 in ice-free areas adjacent to Scott Base
	4	Type C 15	Type C fast ice edge north of Dailey Islands Landed	Attempted but no whales seen from ice	Yes H	0	No	4 solitary off fast ice in north aggregation of 40 at fast ice in southern McMurdo Sound 20 in ice-free areas near Scott Base
24	5	Type B 3 Type C 30, 20, 25	Type B McMurdo Ice Shelf margin (southern section) Type C fast ice edge and fractures north of Dailey Islands Landed	Type B Dart missed	Yes H/I	0	No	25 at fast ice Southern McMurdo Sound 20 in ice-free areas near Scott Base
25	6	Type C 25, 15, 20	McMurdo Ice Shelf margin (northern section) Landed	Attempted but no whales seen from ice	Yes H	1 (initially travelling but later seen with attendant skuas)	No	5 off fast ice edge near Scott Base, 2 travelled past landing site on McMurdo Ice Shelf margin 5 in ice-free water off Scott Base
27	7	Type C 55, 45, 50	Fast ice edge Northeast of Dailey Islands No landing	No attempt	Yes H	2 near fast ice edge	Yes 3 individuals with toothfish	12 in 5 scattered groups 1-3 animals off fast ice southern McMurdo Sound.

						1 group 300m off ice	1 individual with prey fragment	2 in ice-free water off Scott Base
28	8	Type C 27	Fast ice edge centered on Dailey Islands No landing	No attempt	Yes H	0	No	5 in ice-free water off Scott Base

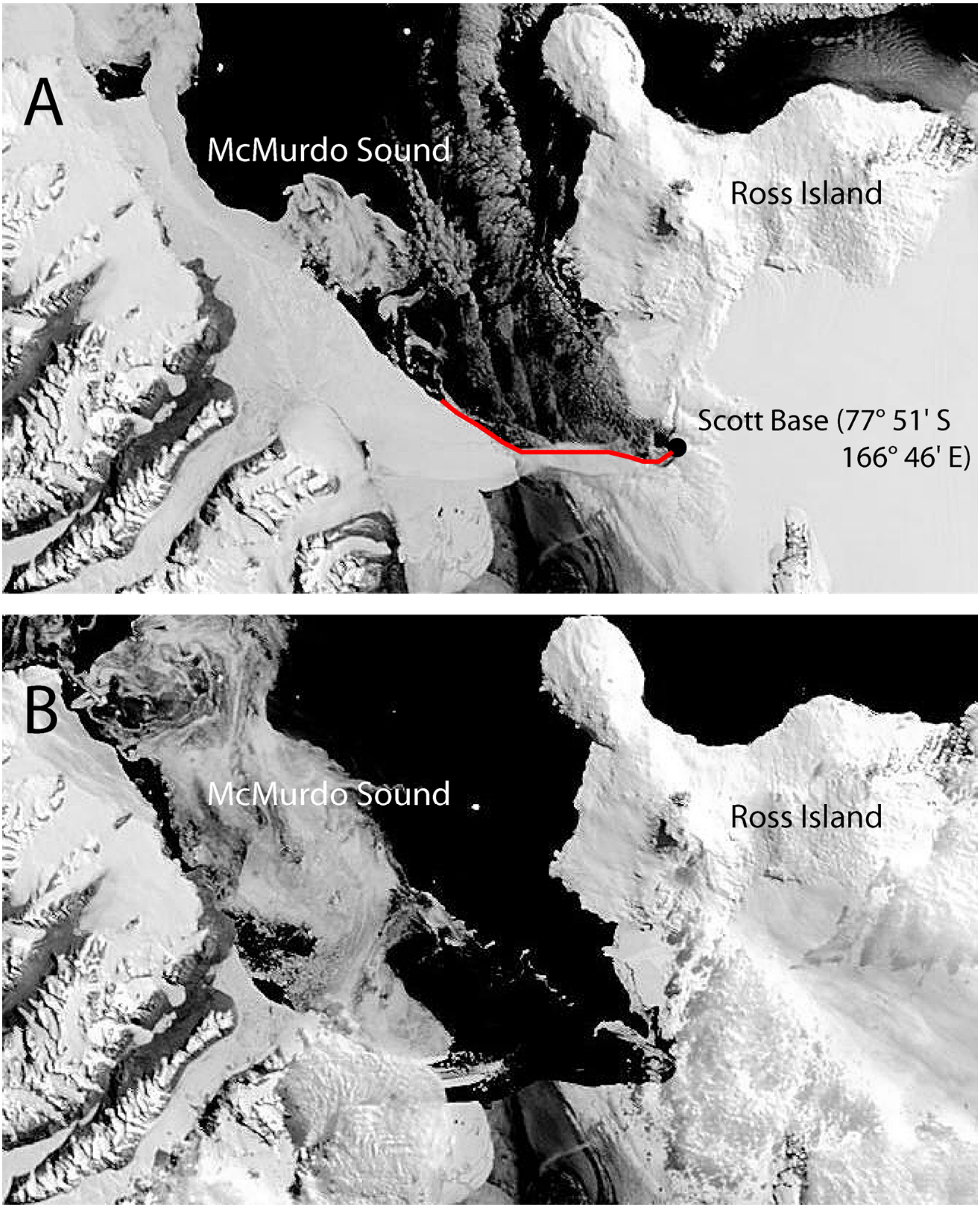

Figure 1. Rapid changes in sea ice cover in McMurdo Sound from 22 January (A) to 27 January (B). Helicopter flight path tracking the fast ice edge is shown in red for the flight on 22 January. Images courtesy of EOSDIS/NASA.

Figure 2: Male ecoype C killer whale with Antarctic toothfish (*Dissostichus mawsoni*). The posterior half of the fish is missing. Estimated intact length of this toothfish is *ca*. 1.5 m (see text). Photo: Paul Ensor.

Figure 3. Male ecotype C killer whale with a scar possibly caused by deployment of a single-dart tag on the dorsal fin. Photo: Paul Ensor.