 Polar Record 45 (235): 304–312 (2009). Printed in the United Kingdom. doi:10.1017/S0032247409008341

Emperor penguin colonies in the Australian Antarctic Territory: how many are there?

Barbara Wienecke
Australian Antarctic Division, 203 Channel Highway, Kingston, Tasmania 7050, Australia (Barbara.Wienecke@aad.gov.au)

Received November 2008

ABSTRACT. Emperor penguins *Aptenodytes forsteri* are endemic to Antarctica. Their breeding colonies are located in the coastal areas of the continent. The precise number of breeding locations is uncertain. This paper examines what is known about the colonies in the Australian Antarctic Territory and examines which colonies are without doubt breeding locations and which ones require further examination in order to determine their existence and status. Several colonies have not been seen since they were first reported. This begs the question of whether the reported sightings were indeed of breeding colonies. Given the extent of uncertainty with regard to the number of colonies, it is suggested that the listing of the species by the International Union for the Conservation of Nature be changed from 'of least concern' to 'data deficient'.

Contents

Introduction

The Australian Antarctic Territory (AAT) comprises all islands and land south of 60°S from 45–160°E, except for the area occupied by the French sector of Terre Adélie (136–142°) (Fig. 1). Its coastline extends over 11,200 km (excluding offshore islands and Terre Adélie) of which vast sections remain largely unexplored. In the western sector (45–136°E), Australia established three permanently occupied research stations in the 1950s and early 1960s from where the Australian National Antarctic Research Expeditions (ANARE) conducted an extensive mapping programme of sections of the Antarctic coastline from 1956–1960. Like other nations, the Australian programme employed aircraft to photograph the coastline (Koblents 1965). The Royal Australian Air Force (RAAF) conducted 121 Antarctic flights for photographic purposes, took 32,400 images and covered 13,900 nautical miles in the area 45–90°E (Anon. 1961). During the RAAF aerial surveys, five emperor penguin *Aptenodytes forsteri* colonies were discovered in the AAT (Willing 1958), doubling the number of colonies that were known Antarctica wide in 1955.

In the 1950s, members of the fifth and sixth Soviet Antarctic Expeditions (SAE) also conducted aerial surveys of vast stretches of the east Antarctic coast (for example Koblents 1965). As aircraft were used extensively in winter and early spring, another four emperor penguin colonies were added to the list by SAE (Korotkevich 1964).

Antarctica wide, there are currently more than 30 known emperor penguin colonies. It is highly likely that more breeding colonies are to be discovered in the AAT and other coastal regions of Antarctica. But even in areas that are comparatively well studied, the precise number of extant colonies is a source of some confusion. Not including the colony at Dumont d'Urville, Terre Adélie, Horne (1983) listed 13 colonies in the AAT, Wilson (1983) 15, and Woehler (1993) 17. One difficulty with these records is that when emperor penguins are observed in January/February, there is a possibility that the birds have gathered at a moult location, which is not necessarily the same as their breeding site. Even in winter, a group of emperor penguins on the ice is not immediately indicative of a breeding colony unless breeding activities are observed (incubation, presence of chicks). Juveniles and sub-adults are rarely seen at the colonies and it is likely that they congregate anywhere on the ice. These issues need to be considered in establishing which records represent true breeding colonies, especially when the only sightings reported for a location were made from aircraft as the determination of the breeding status of the birds would be difficult. This paper discusses the available information on the discoveries and locations of emperor penguin colonies in the AAT and examines the likelihood that sightings made in the past were, indeed, of breeding colonies. Based on the findings summarised in this paper, it is suggested that the listing status of emperor penguins by the International Union for the Conservation of Nature (IUCN) should be reviewed.

Methods

As far as possible, information was compiled from primary sources, including narratives of expeditions and log book entries. Observations published in the scientific literature were also included. Maps printed by the Ministry of the Merchant Fleet (MMF), of the USSR,

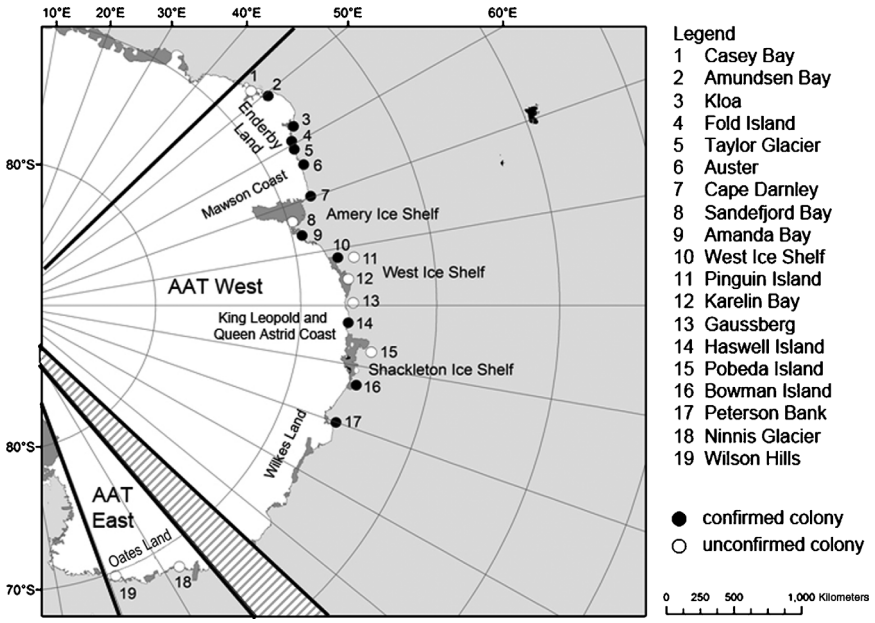

Fig. 1. Map of the Australian Antarctic Territory showing locations of confirmed and unconfirmed colonies of emperor penguins.

in the 1960s also provided useful information about the location of colonies. Particular care was taken to note the mode of discovery (air or ground) of a colony, the dates of the discoveries, as well as any further information that was recorded about the location or the kind of penguins (adults, chicks) seen. An attempt was made to locate photographs that were taken when sightings were made, particularly of those from the air. However, only a few images were found and details, such as height from which the images were taken, could not be determined. This review also highlights the importance of reporting both year and month of a sighting to interpret the value of the information provided.

Moderate Resolution Imaging Spectroradiometer (MODIS) images demonstrating the temporal and spatial changes in ice shelves were obtained from the website of the National Snow and Ice Data Centre, University of Colorado, Boulder.

Results and discussion

The colonies confirmed to exist in the AAT and visited relatively recently (usually within the last decade) are listed in Table 1. These colonies were seen during the breeding season when adults were still caring for their offspring, thus leaving no doubt about their status as breeding sites. The locations listed in Table 2 are sightings in which some doubt exists concerning whether breeding colonies of emperor penguins were indeed observed. The various colonies and sightings are discussed in the following paragraphs.

Confirmed emperor penguin colonies in the AAT

Amundsen Bay

In the westernmost part of the AAT is Amundsen Bay (Fig. 1). This area is visited only infrequently. One documented visit occurred in January 1956, when staff members from Mawson station (67°36'S, 62°52'E) were flown into Amundsen Bay and noted several hundred emperor penguins, all adults, on the southeastern side of Mount Riiser-Larsen (66°47'S, 50°41'E) but no colony was seen (S. Kirkbly, personal communication, May 2008). Willing (1958) and Budd (1961) did not mention an emperor penguin colony here.

In December 1996, Japanese researchers flew to Amundsen Bay and photographed emperor penguins (~ 25 adults and 250 still downy chicks) on a frozen pond just west of Richardson Lake (66°45'S, 50°38'E) (Kato and Ichikawa 1999). Based on this recent visit, it appears that an emperor penguin colony does indeed exist in Amundsen Bay. Moreover, it may be the third known land based colony of emperor penguins after Taylor Glacier (see below) and the Dion Islands (67°52'S, 68°43'W). Incidentally, the colony at Dion Islands was discovered in October 1948. With only about 150 breeding pairs it was probably the smallest known colony (Stonehouse 1953). In recent years, however, it appears to have all but vanished.

Colonies at the Mawson Coast

There are five emperor penguin colonies along the Mawson Coast (Fig. 1) that have been visited comparatively frequently and are well known breeding colonies: Kloa, Fold Island (Figs. 2 and 3), Taylor Glacier, Auster, and Cape Darnely (Fig. 4). The colonies at both Taylor Glacier and Auster have been visited by researchers most frequently and are part of longterm studies.

Amanda Bay

The emperor penguin colony at Amanda Bay was discovered twice by independent Russian and Australian parties in 1956 and 1957, respectively (Wienecke and

https://doi.org/10.1017/S0032247409008341 Published online by Cambridge University Press

Table 1. Confirmed colonies of emperor penguins breeding in the Australian Antarctic Territory (45–160°E). Note that Taylor Glacier is the only colony for which continuous, long term population data are available.

Colony	Coordinates	Discovery of colony	Mode of discovery	Source	Last known visit	Primary purpose	Source
Amundsen Bay	66°47'S, 50°33'E	Jan 1956	ground	Syd Kirkby (personal comm., May 2008)	Dec 1996	census	Kato and Ichikawa (1999)
Kloa	66°38'S, 57°19'E	Sep 1957	air	Willing (1958)	Sep 2001	field trip	M.Dugdale – (station leader report 2001, unpublished)
Fold Island	67°20'S, 59°23'E	May 1956	air	Willing (1958)	Sep 2001	field trip	M.Dugdale – (station leader report 2001, unpublished)
Taylor Glacier	67°28'S, 60°53'E	Oct 1954	ground	Willing (1958)	Nov 2008	census	ASAC Project 484
Auster	67°23'S, 64°02'E	Aug 1957	air	Willing (1958)	Nov 2008	scientific study	G. Miller (personal comm., November 2008)
Cape Darnley	67°50'S, 69°45'E	Aug 1958	air	G. Newton (logbook 1960, unpublished)	Dec 1996	tourist visit	Todd and others (1999)
Amanda Bay	69°16'S, 76°20'E	Nov 1956	air	Korotkevich (1964)	Jul 2008	census	ASAC Project 484
West Ice Shelf	67°04'S, 81°34'E	Dec 1997	ground	Splettstoesser and others (2000)	Dec 1997	tourist visit	Splettstoesser and others (2000)
Haswell Island	66°33'S, 92°58'E	Nov 1912	ground	Mawson (1915)	Dec 1992	tourist visit	Todd and others (1999)
Bowman Island	65°18'S, 103°08'E	Oct 1960	ground	Korotkevich (1964)	Jan 1993	tourist visit	Todd and others (1999)
Peterson Bank	65°56'S, 110°12'E	Nov 1994	air	Melick and Bremmers (1995)			

Table 2. Emperor penguin sightings (unconfirmed breeding colonies) in the Australian Antarctic Territory (45–160°E).

Location	Coordinates	Sighting	Mode of discovery	Source	Comments
Casey (Lena) Bay	67°30'S, 43°07'E	16 Nov 1961	ground	Korotkevich and Ledev (1962)	'Emperor penguins were found in large groups in Lena Bay, where they apparently form a colony in winter'
Sandefjord Bay	69°40'S, 73°20'E	26 Feb 1968	air	A. Gilchrist – Bird log *Nella Dan* (AAD library)	emperor penguins seen from helicopter; incorrectly noted as 'rookery'; sighting made by Neville Collins
Pingvin Island	65°55'S, 81°55'E	30 Nov 1956	air	Korotkevich (1964)	not seen since first sighting
Karelin Bay	66°30'S, 85°30'E	1 Aug 1958	air	Korotkevich (1964)	detected from airplane; not seen sinces
Gaussberg	66°13'S, 89°35'E	5 Dec 1902	air	von Drygalski (1904)	'a small number of penguins' were seen in June 1960 and visited in August 1960 (Korotkevich 1964); not seen since
Shackleton Ice Shelf	64°40'S, 97°30'E	26 Oct 1960	air	Korotkevich (1964)	'Pobeda Island', not seen since
Ninnis Glacier	68°12'S, 147°12'E	Feb 1959	ship	Law (1961)	Emperor penguins sighted from vessel mainly in pack-ice; no colony seen
Wilson Hills	69°40'S, 158°30'E	20 Feb 1959	ship	W.R.J. Dingle – Bird log *Magga Dan* (AAD library)	adult emperor penguins seen that had finished the moult; Dingle incorrectly called the group 'rookery'

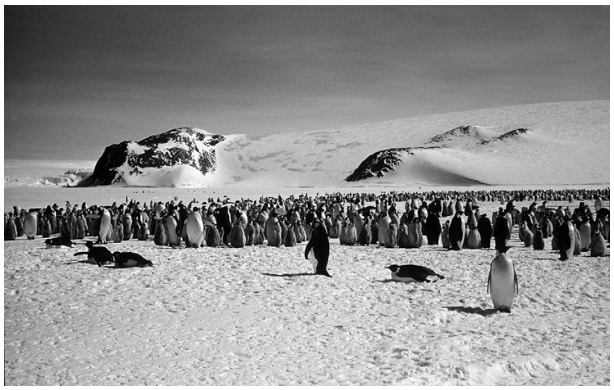

Fig. 2. Emperor penguin colony at Kloa in October 1960 (photo: C. Armstrong).

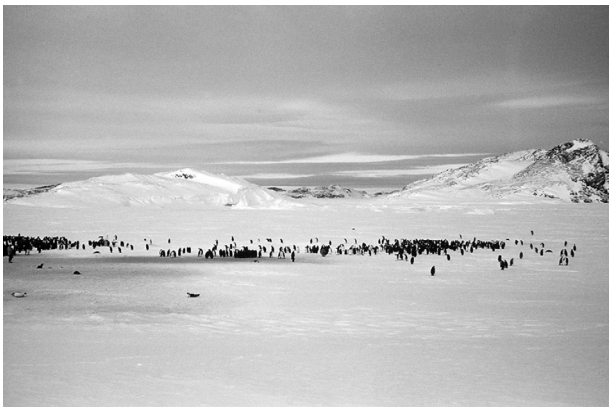

Fig. 3. Emperor penguin colony at Fold Island in May 1960 (photo: G. Newton).

Pedersen 2009). It has been visited frequently and has become an Antarctic Specially Protected Area in 2008 to safeguard the future of the penguins there (Antarctic Treaty Secretariat 2008).

West Ice Shelf (~81–89°E)

A breeding colony probably exists somewhere at the western side of the West Ice Shelf but its location may have shifted over time. On 30 November 1956, Korotkevich (1964) reported a colony at 65°55'S, 81°55'E and noted it again in the winter of 1960. It is not known whether the winter sighting was a ground visit or not and no further information is available. A Russian topographic map of the King Leopold and Queen Astrid Coast, based on aerial photography (MMF 1960), indicated an emperor penguin colony near 'Pingvin Island' at approximately 65°45'S, 81°46'E. 'Pingvin Island' is located north of the northernmost point of the 'Chelyuskintsy Peninsula' near 'Cape Penguin'. The shading of the peninsula marked it as an ice shelf that extended to 65°46'S in February 1957. Another Russian map based on surveys conducted in 1965 (MMF 1969) shows that the northern point of the peninsula had retracted by about 50 km since 1957. While the colony was still marked at a similar location as on the previous map (~ 66°S, 82°E), there was no indication of an island. Tret'Yakov and Mikheyev (1972) reported that

https://doi.org/10.1017/S0032247409008341 Published online by Cambridge University Press

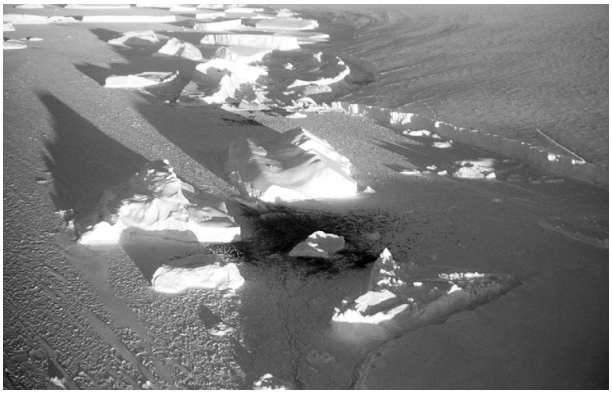

Fig. 4. Emperor penguin colony at Cape Darnley, 22 May 1960 (photo: G. Newton).

the 'Chelyuskintsy Peninsula' had completely separated from the ice shelf. On modern maps, the ice of the western part of the West Ice Shelf has retreated even further to ~67°S and 'Pingvin Island' is no longer shown. It is possible that in the early 1950s an iceberg was mistaken for an island.

In December 1997, a tourist vessel, the *Kapitan Khlebnikov*, visited east Antarctica and some of the emperor penguin colonies there. At the western side of the West Ice Shelf, approximately 100 emperor penguin chicks and about a dozen adults were seen at 67°04.7'S, 81°34.3'E (Splettstoesser and others 2000). Given the extensive changes to the West Ice Shelf, it is quite possible that the colony noted in 1956 near 'Pingvin Island' had shifted further south. Splettstoesser and others (2000) suspected this. Thus, the colony of emperor penguins referred to as 'Pingvin Island' by Korotkevich (1964) and 'West Ice Shelf' by Splettstoesser and others (2000) is probably one and the same.

Haswell Island

The colony at Haswell Island, near the coast between the two ice shelves, was first seen by members of Mawson's Australian Antarctic Expedition (AAE) (1911–1914) in November 1912 (Mawson 1915) and has since been described in detail (see Pryor 1964, 1968).

Bowman Island

Bowman Island was discovered on 28 January 1931 during the British, Australian, and New Zealand Antarctic Research Expeditions (BANZARE) (1929–1931) led by Douglas Mawson. The ship was 22 miles from the island (Jacka and Jacka 1988) and no emperor penguins were mentioned by Falla (1937). On 26 October 1960, Korotkevich (1964) stated that a colony, 'was detected from aircraft and inspected by author' but no further details were given. On 4 January 1993, Todd and others (1999) sighted '28 downy chicks and 30–35 adults' not far from the island confirming the existence of an emperor colony near Bowman Island.

Peterson Bank

The breeding colony at Peterson Bank was first visited in early November 1994, when downy chicks were abundant and were still being cared for by their parents, but it has not been visited since (Melick and Bremmers 1995). The ice between nearby Casey Station and Peterson Bank is notoriously unstable even in winter and the colony is virtually impossible to access via the sea ice. Since the usual operational flight paths do not approach Peterson Bank a special effort needs to be made to resight this colony.

Unconfirmed emperor penguin colonies in the AAT

Casey Bay

In March 1961, members of the fifth and sixth SAE observed large groups of emperor penguins in Casey Bay (Lena Bay in Russian) and suspected that the birds probably bred there in winter but a colony was never seen (Korotkevich and Ledenev 1962). At the time of their observation (February 1961), the penguins were without doubt moulting. Interestingly, the Russian scientists never reported emperor penguins in nearby Amundsen Bay although field camps and air strips were established there from February to March 1961 (Korotkevich and Ledenev 1962). Budd (1962) listed both Casey and Amundsen Bay as colonies but did not provide any reference to the source of this information.

Sandefjord Bay

According to various publications, there is an emperor penguin colony just west of Amanda Bay. Horne (1983) referenced this observation as ANARE (Collins); Wilson (1983) ascribed this observation as a personal communication to R. Horne, and Woehler (1993) cited Horne (1983) as a reference. The entry in the bird log of the *Nella Dan*, one of the supply ships used by ANARE in the 1960s, reads: '. . .Collins reports rookery of emperor penguin chicks (about 200) at Sandefjord Bay, also seals (unidentified) about 200. Seen from helicopter engaged in other business and no time for investigation. Leader has offered to put 2 men ashore to count if opportunity offers.' (Gilchrist 1968). Unfortunatley the opportunity never arose to investigate this penguin aggregation further. Neville Collins explained that the penguins were seen only briefly from the air by him and the helicopter pilot and that the penguins were definitely not Adélie penguins *Pygoscelis adeliae*. However, he was not entirely certain that the birds were indeed all chicks (N. Collins, personal communication, October 2008). In late Feburary, most chicks will have left their natal colony and start to disperse. Given that the penguins were seen in late January and that Amanda Bay is only about 100 km east, it is possible that the penguins had come from there. There is no certainty about the number of birds that were present in Sandefjord Bay in 1968 nor have emperor penguins been reported on any other visit. ANARE personnel flew over Sandefjord Bay in May 1957 but did not report any penguins (Fisher 1957). Hence, at this stage it is doubtful that an emperor penguin colony exists there.

https://doi.org/10.1017/S0032247409008341 Published online by Cambridge University Press

Sightings made in the area of 80–105°E: Karelin Bay, Gaussberg and Shackleton Ice Shelf

In this section of the AAT, there are two areas where emperor penguins were sighted but again there are some uncertainties about the existence and location of breeding colonies (Fig. 1). Previous publications (Horne 1983; Wilson 1983; Woehler 1993) list six colonies that were roughly associated with two major ice shelves, the West Ice Shelf (~ 81–89°E) and the Shackleton Ice Shelf (~ 95–105°E): Penguin Island, Karelin Bay, Gaussberg, Haswell Island, Shackleton Ice Shelf (Pobeda Iceberg in Horne 1983), and Bowman Island (from west to east, Fig. 1).

As mentioned above, both Haswell Island and Bowman Island are confirmed breeding locations and Penguin Island is probably the same as the 'West Ice Shelf' colony. However, the locations of the remaining three colonies in this region are uncertain.

Karelin Bay

Karelin Bay, an indentation in the West Ice Shelf, was located at 85°30'E in August 1958 when the third SAE detected emperor penguins from the air (Korotkevich 1964). A ground visit was apparently never made, and as this 'colony' has never been seen again, it is doubtful that it ever existed here.

Gaussberg

Just east of the West Ice Shelf is Posadowsky Bay where according to Horne (1983), Wilson (1983) and Woehler (1993) an emperor penguin colony is located at 66°13'S, 89°35'E. All three authors cited Korotkevich (1964) as the reference while Korotkevich referred to von Drygalski's account of the German South Polar Expedition (1901–1903). The location where the emperor penguin colony was supposedly located is the position of the winter station as indicated on von Drygalski's (1904) map. While their ship *Gauss* was beset in the winter ice, the expedition members mounted several dog sledging parties to explore the area (Fig. 5). Throughout the winter, emperor penguins were seen near the ship, sometimes in large numbers, leading the expedition members to suspect that a breeding colony might be nearby (Vanhöffen 1905). On 5 December 1902, a sleding party returned and reported the sighting of 'a huge number of emperor penguins on the move about 10 km south of the *Gauss*, including chicks' (von Drygalski 1904). However, von Drygalski also noted that '. . . while the place Stehr found could not with certainty be identified as a rookery. . . We did not, unfortunately, ever find any emperor penguin rookeries for sure' (von Drygalski 1904). Korotkevich (1964) commented on the difficulties encountered by SAE members when trying to find this colony and described how several flights were unsuccessful in locating it. Then, on 21 June 1960, penguins were seen in 'a small group standing between icebergs'. Unfortunately, no further details were provided in terms of numbers or breeding status or precise location. While it is highly possible that a colony exists in the general vicinty of Gaussberg, its location is currently still unknown.

Fig. 5. View from Gaussberg, March 1997, about 100 km south of the wintering position where the German South Polar Expedition was beset in 1902 (photo: A. Cianchi). To see an emperor penguin colony in the maze of icebergs would have been difficult.

Shackleton Ice Shelf (Pobeda Island)

The last sighting made by Korotkevich (1964) was off the Shackleton Ice Shelf near 'Pobeda Island' where he detected emperor penguins from an aircraft on 26 October 1960 (Fig. 1). Apparently no ground visit was made to this area rendering this another unconfirmed sighting. Incidentally, 'Pobeda Island' was a massive tabular ice berg that was first seen by Charles Wilkes in February 1840 (Wilkes 1845) and was named Termination Land (Henderson 1953). Von Drygalski (1904) noted on his map the location where Wilkes had indicated 'Termination Land' but the German expedition did not find it. Mawson encountered this barrier on his 1911–1914 expedition and re-named it 'Termination Ice Tongue' (Mawson 1915) but he did not see it during BANZARE (1929–1931) (Jacka and Jacka 1988). The reason for the variability of the sightings is not the result of erroneous navigation but the fact that this barrier is a series of recurring tabular icebergs. The most likely source of these bergs is the Denman Glacier in the eastern part of the Shackleton Ice Shelf. Clearly, another iceberg had appeared before the SAE explored the area in the 1950s. 'Pobeda' was about 70 km long and 36 km wide. A radar survey of the ice island by the fourteenth SAE was conducted in January 1969 and demonstrated that the ice berg had moved about 25 km to the northeast since 1960 and nearly 9 km to the west since 1967 (Tret'Yakov and Mikheyev 1972). Recent satellite images of the Shackleton Ice Shelf show that ice bergs still appear in the same position as 'Pobeda' and eventually vanish (see Figs. 6 and 7). With regard to emperor penguins, it is currently uncertain whether a colony exists in such a dynamic environment or not.

Interestingly, on 28 January 1914, Mawson wrote in his diary that some 19 km (10 miles) from the ship a 'mass' of emperor penguins was seen (Jacka and Jacka 1988). Mawson's ship was on the western side of the

https://doi.org/10.1017/S0032247409008341 Published online by Cambridge University Press

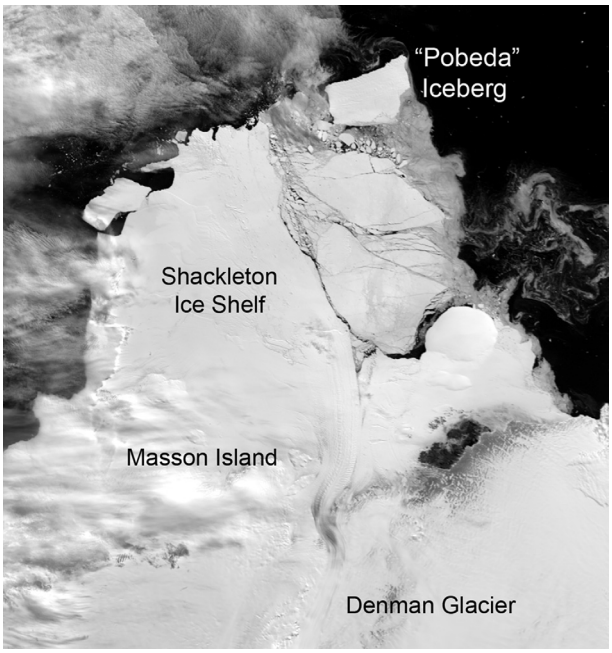

Fig. 6. MODIS satellite image taken in October 2003. A large tabular iceberg is clearly visible where Korotkevich (1964) indicated Popeda Island to be.

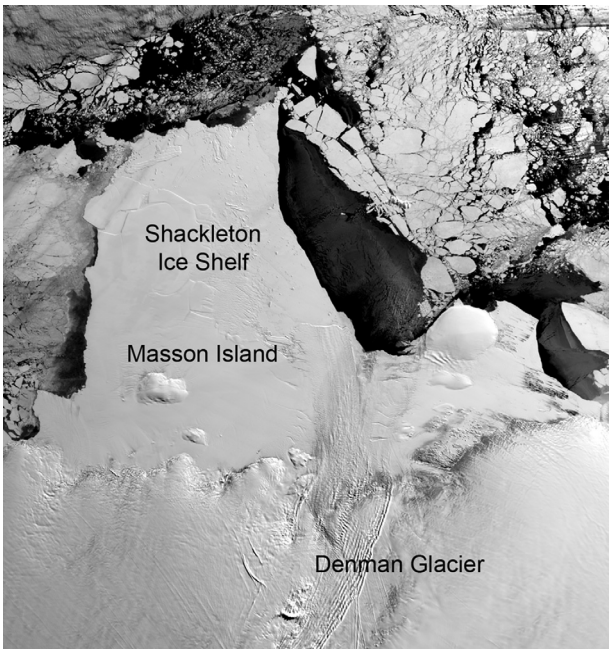

Fig. 7. MODIS satellite image taken in September 2004. The large tabular iceberg is no longer there.

Shackleton Ice Shelf attempting to reach the area where his men wintered in 1911–1914 but heavy ice prevented the ship from continuing south. R.A. Falla who travelled with Mawson in 1929–1931 rightly noted the possibility that the birds seen were not a colony but 'only moulting adults' (Falla 1937). H. Fletcher, another member of BANZARE mentioned in his account of the expedition that the men of the 1911–1914 expedition had discovered two emperor penguin colonies, one at Haswell Island,

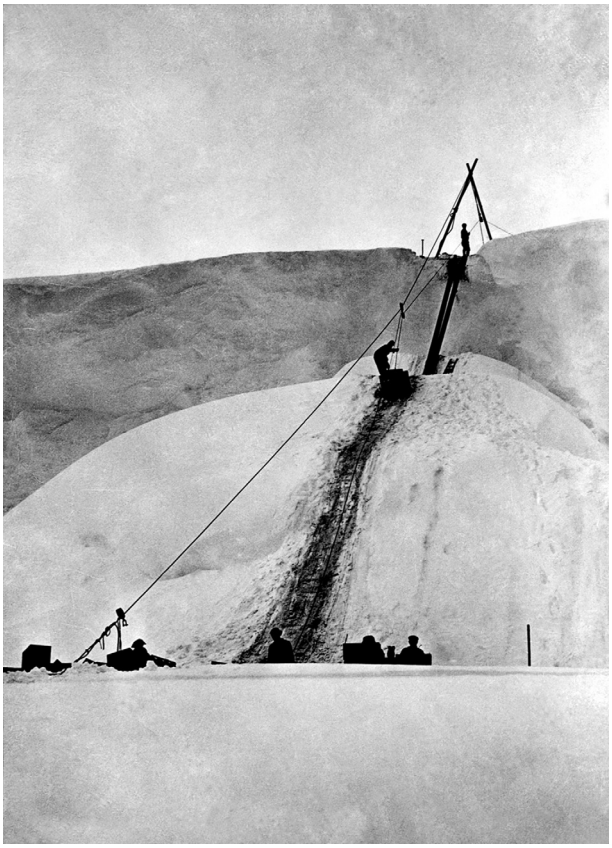

Fig. 8. Hoisting equipment onto the Shackleton Ice Shelf with a flying fox during the landing of the western party of the Australian Antarctic Expedition (1911–1914) under the leadership of Frank Wild (photo: F.J. Gillies). The shear cliffs make access to the ice shelf impossible for penguins.

the other at Masson Island (66°08'S, 96°34'E). The latter is an unlikely location for an emperor penguin colony as it is entirely engulfed by the ice shelf and access would be difficult if not impossible for penguins (Fig. 8). Moreover, neither F. Wild nor S.E. Jones, who wintered at the ice shelf during Mawson's earlier expedition and who described the colony at Haswell Island in great detail, ever mentioned emperor penguins on top of the ice shelf (Mawson 1915).

Eastern sector of the AAT

With the exception of the colony at Dumont d'Urville, the 1400 km stretch of coastline from Peterson Bank to Dumont d'Urville appears void of emperor penguin colonies, as is the eastern sector of the AAT. Since there are no permanently occupied research stations requiring regular resupplies, visits to this area occur infrequently. In 1959, *Magga Dan*, one of the ANARE supply vessels, was sent to explore the coastal areas of Oates Land (153°45'E – 160°00'E) (see Fig.1). In February 1960, the ship reached the Ninnis Glacier where 'numerous' emperor penguins were seen. Law (1961) suggested that a colony could possibly exist in the general vicinity but none was seen.

https://doi.org/10.1017/S0032247409008341 Published online by Cambridge University Press

A few days later, some 90 adult emperor penguins were spotted on the ice near Wilson Hills (see Table 2). W.R.J. Dingle who recorded bird sightings noted that these birds had just finished their moult (Dingle 1959). These observations were listed in Woehler (1993) but not in Wilson (1983); however, the sightings were not reports of colonies. Since emperor penguins tend to disperse widely after the breeding season and can moult hundreds of kilometres away from their breeding colonies (for example Kooyman and others 2000; Wienecke and others 2004), their presence on the ice in late summer does not imply that a breeding colony is nearby. Thus, with the exception of the colony at Dumont d'Urville, there are currently no known emperor penguin colonies along the entire coast of Wilkes Land.

Conclusions

Of the seventeen emperor penguin colonies listed by Woehler (1993) in the AAT, only 11 are certain to exist. A twelfth colony at Peterson Bank was discovered only in 1994. The colony listed by Woehler (1993) as 'Pingvin Island' may well be the same as the one described by Splettstoesser and others (2000) at the West Ice Shelf. At seven locations emperor penguins were sighted 40–50 years ago but have not been seen since. Moreover, the sightings, such as those at Ninnis Glacier and Wilson Hills, occurred at a time when emperor penguins moult. In his account from the 1929–1931 expedition, R. Falla already noted that 'the presence of young birds still wholly or partially in down during the summer seems to be the only safe criterion in indicating nesting spots' (Falla 1937).

Clearly, there is a need to explore the coastline of the AAT in detail to clarify the existence of emperor penguin colonies, particularly in the eastern section. Given the remoteness and inaccessibility of long stretches of coastline, advanced technological means, such as satellite imagery, may have to be employed to resolve the uncertainties of the locations of emperor penguin colonies (see Sanchez and Kooyman 2004; Barber-Meyer and others 2007). However, the timing is crucial and only images available throughout the breeding season of emperor penguins (preferably in October/November) should be used to avoid misinterpretation of gatherings of moulters as colonies. Even if successful, findings based on satellite technology will eventually have to be verified by ground visit as that is the most likely way to determine the breeding status of the birds. We have no knowledge about the distribution and behaviour of juvenile, sub-adult and non-breeding birds, whether they remain in groups, or, if they do, how large these groups can be.

Until these uncertainties are resolved, it seems advisable for the IUCN to change the listing of emperor penguins from 'of least concern' to 'data deficient'. For many colonies there is no detailed census information and long term population data are scarce. Since we have no firm understanding of the number of extant breeding colonies, we cannot estimate the size or trends of the global population of emperor penguins. Only targeted future research will be able to determine this.

Acknowledgments

The author is grateful for the help received from the library staff of the Australian Antarctic Division (AAD) in locating historical materials and the staff of the multimedia section of the AAD for making available the images. Comments and suggestions made by Drs. A. Constable and C. Meathrel improved this article. The author is also grateful to two anonymous referees for their comments which improved the paper.

References

Antarctic Treaty Secretariat. 2008. Management plan for Antarctic specially protected area 169, Amanda Bay, Ingrid Christensen Coast, Princess Elizabeth Land, East Antarctica. Kyiv: Antarctic Treaty Consultative Meeting XXXI (measure 3 (2008), annex A).

Anon. (Anonymous). 1961. General report on air operations, 1956–1961. Melbourne: Antarctic Division, Department of External Affairs.

Barber-Meyer, S., G.L. Kooyman, and P.J. Ponganis. 2007. Estimating the relative abundance of emperor penguins at inaccessible colonies using satellite imagery. *Polar Biology* 30:1565–1570.

Budd, G.M. 1961. The biotopes of emperor penguin rookeries. *Emu* 61: 171–189.

Budd, G.M. 1962. Population studies in rookeries of the emperor penguin *Aptenodytes forsteri. Proceedings of the Zoological Society, London* 139: 365–389.

Dingle, W. 1959. ANARE log – bird log *Magga Dan*, Wilkes Voyage. Kingston: Australian Antarctic Division archives (unpublished report).

Dugdale, M. 2001. Station leader report, Mawson 2001. Kingston: Australian Antarctic Division archives (unpublished report).

Falla, R.A. 1937. Birds. London: BANZARE reports, Series B (2): 1–304.

Fisher, M.M. 1957. Survey report Mawson 1957. Kingston: Australian National Antarctic Research Expedition (unpublished report).

Gilchrist, A. 1968. Bird log *Nella Dan*, 1967–1968, vol 1. 26 January 1968. Kingston: Austrailian Antarctic Division archives (unpublished ANARE log).

Henderson, D. 1953. *The hidden coasts*. New York: William Sloan Associates Publishers.

Horne, R.S.C. 1983. The distribution of penguin breeding colonies on the Australian Antarctic Territory, Heard Island, the McDonald Islands, and Macquarie Island. *ANARE Research Notes* 9: 8–13.

Jacka, F., and E. Jacka (editors). 1988. *Mawson's Antarctic diaries*. Sydney: Allen and Unwin Australia.

Kato, A., and H. Ichikawa. 1999. Breeding status of Adélie and emperor penguins in the Mt Riiser-Larsen area, Amundsen Bay. *Polar Bioscience* 12: 36–39.

Koblents, Y.P. 1965. Mapping of the Antarctic by foreign countries during the IGY. *Soviet Antarctic Information Bulletin* (English) 2: 75–77.

Korotkevich, Y.S. 1964. The distribution of Emperor penguins. *Soviet Antarctic Expedition Information Bulletin* (English) 4: 371–375.

Korotkevich, Y.S., and V.G. Ledenev. 1962. Investigations in Enderby Land. *Soviet Antarctic Expedition Information Bulletin* (English) 2: 65–68.

Korotkevich, Y.S. 1964. The distribution of Emperor penguins. *Soviet Antarctic Expedition Information Bulletin* (English) 4: 371–375.

Kooyman, G.L., E.C. Hunke, S.F. Ackley, R.P. van Dam, and G. Robertson. 2000. Moult of the emperor penguin: travel, location, and habitat selection. *Marine Ecology Progress Series* 204: 269–277.

Law, P. 1961. Australian coastal explorations in Antarctica, 1959. *The Geographical Journal* 127: 427–435.

Mawson, D. 1915. *The home of the blizzard*. London: Wilhelm Heinemann.

Melick, D., and Bremmers, W. 1995. A recently discovered breeding colony of emperor penguins *(Aptenodytes forsteri)* on the Budd Coast, Wilkes Land, East Antarctica. *Polar Record* 31: 426–427.

MMF (Ministry of the Merchant Fleet). 1960. Map of the Leopold and Astrid Coast. Q44 XV, XVI. Scale 1:200,000. Moscow: Ministry of the Merchant Fleet.

MMF (Ministry of the Merchant Fleet). 1969. Maps of Antarctica, Sheet 6. Scale 1:3,000,000. Moscow: Ministry of the Merchant Fleet.

Newton, G. 1960. Biology log, Mawson 1960. Kingston: Australian Antarctic Division archives (unpublished log).

Pryor, M.E. 1964. Notes on the life history of the emperor penguin, *Aptenodytes forsteri* Gray, at Mirny Observatory, Antarctica, 1962. *Soviet Antarctic Expedition Information Bulletin* (English) 3: 183–184.

Pryor, M.E. 1968. The avifauna of Haswell Island, Antarctica. In: Austin, O.L. jr., (editor). *Antarctic Bird Studies*, Washington DC: American Geophysical Union (Antarctic Research Series 12): 57–82.

Sanchez, R.D., and G.L. Kooyman. 2004. Advanced systems data for mapping emperor penguin habitats in Antarctica. Reston: US Geological Survey (open file report 2004–1379).

Splettstoesser, J.F., M. Gavrilo, C. Field, C. Field, P. Harrison, M. Messick, P. Oxford, and F.S. Todd. 2000. Notes on Antarctic wildlife: Ross seals *Ommatophoca rossii* and emperor penguins *Aptenodytes forsteri*. *New Zealand Journal of Zoology* 27: 137–142.

Stonehouse, B. 1953. The emperor penguins *Aptenodytes forsteri* Gray. I. Breeding behaviour and development. Cambridge: Falkland Islands Dependencies Survey (scientific report 6: 1–33).

Tret'Yakov, N.F., and Mikheyev, O.F. 1972. Change in the front of some ice shelves of East Antarctica. *Soviet Antarctic Expedition Information Bulletin* (English) 8: 30–31.

Todd, F.S., J.F. Splettstoesser, R. Ledingham, and M. Gavrilo. 1999. Observations in some emperor penguin *Aptenodytes forsteri* colonies in East Antarctica. *Emu* 99: 142–145.

Vanhöffen, E. 1905. Bericht über die bei der deutschen Südpolarexpedition beobachteten Vögel. *Journal für Ornithologie* 53: 500–515.

Von Drygalski, E. 1904. Zum Kontinent des eisigen Südens: Deutsche Südpolarexpeditionsfahrten und Forschung der *Gauss* 1901–1903. Berlin: Georg Reimer.

Wienecke, B., and Pedersen, P. 2009. Population estimates of emperor penguins at Amanda Bay, Ingrid Christensen Coast, Antarctica. *Polar Record* 45(234): 207–214.

Wienecke, B., R. Kirkwood, and G. Robertson. 2004. Pre-moult foraging trips and moult locations of emperor penguins at the Mawson Coast. *Polar Biology* 27: 83–91.

Wilkes, C. 1845. Narrative of the United States exploring expedition during the years 1838, 1839, 1840, 1841, 1842. vol. 2. Philadelphia: Lea and Blanchard.

Willing, R.L. 1958. Australian discoveries of emperor penguin rookeries in Antarctica during 1954–57. *Nature* 182: 1393–1394.

Wilson, G.J. 1983. Distribution and abundance of Antarctic and sub-Antarctic penguins: a synthesis of current knowledge. Cambridge: Scott Polar Research Institute (report compiled on behalf of the biomass working party on bird ecology).

Woehler, E.J. 1993. The distribution and abundance of Antarctic and Subantarctic penguins. Cambridge: Scott Polar Research Institute (report on half of the bird biology subcommittee of the Scientific Committee on Antarctic Research).