



Management Plan

for Antarctic Specially Protected Area (ASPA) No. 124 CAPE CROZIER, ROSS ISLAND

Introduction

The Cape Crozier Antarctic Specially Protected Area (ASPA) is located at the eastern extremity of Ross Island, Ross Sea. Approximate area and coordinates: ~70 km² (centered at 77° 28' 54" S, 169° 19' 53" E), of which ~43 km² (61%) is marine (including ice shelf) and ~27 km² is terrestrial (39%). The primary reasons for designation of the Area are its diverse avian and mammalian fauna, locally rich vegetation and historic values. The emperor penguin (*Aptenodytes forsteri*) colony at Cape Crozier is one of the most southerly known, and it also has a long study record. The Adélie penguin colony is one of the largest known. The Area is also one of the most southerly recorded locations of snow algae. The Area provides representation of relatively undisturbed terrestrial and aquatic habitats on Ross Island, including of mosses, lichens, algae, invertebrate and microbial communities.

The Area was originally designated as Specially Protected Area (SPA) No.6 through Recommendation IV-6 (1966) after a proposal by the United States of America on the grounds that the region supports a rich bird and mammal fauna as well as microfauna and microflora, and that the ecosystem depends on a substantial mixing of marine and terrestrial elements of outstanding scientific interest. With adoption of the Site of Special Scientific Interest (SSSI) category of protection in 1972, Cape Crozier's designation as an SPA was terminated by Recommendation VIII-2 (1975) and the site was re-designated as SSSI No. 4 by Recommendation VIII-4 (1975). The reason for designation of SSSI No. 4 was to protect long-term studies of the population dynamics and social behavior of emperor (*Aptenodytes forsteri*) and Adélie (*Pygoscelis adeliae*) penguin colonies in the region. Information gathered since designation of SSSI No. 4 supported the inclusion of skua populations and vegetation assemblages as important values to be protected at Cape Crozier. The SSSI was extended through Recommendation X-6 (1979), Recommendation XII-5 (1983), Recommendation XIII-7 (1985), Recommendation XVI-7 (1991), and Measure 3 (2001). The site was renamed and renumbered as Antarctic Specially Protected Area (ASPA) No. 124 by Decision 1 (2002). In Measure 1 (2002) the boundaries were extended south to include Igloo Spur and to protect the range of vegetation assemblages representative of the Cape Crozier region. In Measure 7 (2008) the western boundary of the Area was modified to follow a simple line of longitude because visitors found the previous boundary hard to follow. This boundary was simplified in 2016 to follow a line directly between the summits of Bomb Peak and Post Office Hill, and to exclude the Cape Crozier hut from the Area (Measure 3 (2014)).

The Area comprises environments within two of the domains defined in the Environmental Domains Analysis for Antarctica (Resolution 3 (2008)): 'Environment P – Ross and Ronne-Filchner ice shelves' and 'Environment S – McMurdo – South Victoria Land geologic'. Under the Antarctic Conservation Biogeographic Regions classification the Area lies within 'ACBR9 – South Victoria Land' (Resolution 3 (2017)).

1. Description of values to be protected

The emperor penguin colony at Cape Crozier was first recorded by members of the British National Antarctic Expedition in 1902. The colony is one of the most southerly known and has the longest record of study on an emperor penguin population. The colony breeds on fast ice that forms between large cracks which develop in the Ross Ice Shelf where it abuts Cape Crozier. The positions of these cracks shift with movement of the ice shelf, and the colony itself is known to move around different parts of the cracks during the breeding season. The boundaries of the Area have been designed to include fast-ice areas consistently occupied by breeding birds.

Cape Crozier has a large Adélie penguin (*Pygoscelis adeliae*) population averaging around 150,000 breeding pairs, with just over 270,000 pairs in 2012, comprising ~14% of the estimated global population and making it one of the largest Adélie colonies in Antarctica. The colony is divided into two main groups 1 km apart known as East and West Colonies (Maps 1 and 2). The first observations of Adélie penguins apparently nesting on sea ice were made at Cape Crozier in November 2018, and this underscores the importance of the habitat associated with persistent sea ice that forms in the large cracks in the Ross Ice Shelf for various species, including emperor and Adélie penguins and Weddell seals. The first circovirus to be discovered in penguins, which was also a new species and given the name PenCV, was recorded at Cape Crozier in 2018/19. In addition, well-preserved ancient Adélie penguin remains found within the Area have particular scientific value for genetic studies. Associated with the penguin colonies is a large south polar skua (*Catharacta maccormicki*) colony, estimated at over 1000 breeding pairs which represents ~18% of the upper estimate of the global breeding population for this species.



Weddell seals (*Leptonychotes weddellii*) breed within the Area, while leopard seals (*Leptonyx hydrurga*) are frequent visitors and crabeater seals (*Lobodon carcinophagus*) are commonly seen at sea and on ice floes. Killer whales (*Orcinus orca*) are also frequently seen close off shore within the Area. While the mammal species recorded at Cape Crozier are neither unique to the Area nor known to be outstanding in this context, they form an integral and representative part of the local ecosystem.

There are moss, algae and lichen assemblages in the Area. Expanses of snow algae at Cape Crozier cover an area of more than 4 ha adjacent to the skua and penguin colonies. Growths as extensive as those at Cape Crozier have been noted only once before in the Continental Antarctic Zone, on the Wilkes Land Coast, and Cape Crozier has one of the most southerly records of snow algae. Lichens are also abundant, with large areas of bright orange crustose lichens on rocks and stones on the slopes above the Adélie colony, and rich growths of foliose and fruticose lichens in the vicinity of Wilson's Stone Igloo. Two lichen species (*Caloplaca erecta* and *C. soropelta*) observed within the Area have not previously been recorded in Antarctica. The Area therefore has value by providing representation of relatively extensive and pristine terrestrial and aquatic habitats on Ross Island that host a variety of moss, lichen, algal and microbial communities and an associated invertebrate fauna.

A message post from Scott's National Antarctic Expedition (1901–04) is situated in West Colony (77° 27' 16.7" S, 169° 14' 37.5" E) and was designated as Historic Site and Monument (HSM) No.69 through Measure 4 (1995). Wilson's Stone Igloo (77° 31' 51" S, 169° 17' 56" E), designated as HSM No.21 through Recommendation VII-9 (1972), is situated in the south of the Area. The rock shelter was constructed in July 1911 by members of the 1910–1913 British Antarctic Expedition during their winter journey to Cape Crozier to collect emperor penguin eggs.

The high scientific, ecological and historic values of this area along with its vulnerability to disturbance through trampling, sampling, pollution or alien introduction, are such that this Area requires long-term special protection.

2. Aims and objectives

Management at Cape Crozier aims to:

- Avoid degradation of, or substantial risk to, the values of the Area by preventing unnecessary human presence, disturbance and sampling in the Area;
- Allow scientific research on the ecosystem of the Area, in particular on the avifauna, marine fauna and terrestrial ecology, provided it will not compromise the values for which the Area is protected;
- Allow other scientific research, scientific support activities and visits for educational and outreach purposes (such as documentary reporting (visual, audio or written) or the production of educational resources or services) provided that such activities are for compelling reasons that cannot be served elsewhere and will not compromise the values for which the Area is protected;
- Minimize the possibility of introduction of non-native species (e.g. plants, animals and microbes) to the Area;
- Minimize the possibility of introduction of pathogens that may cause disease in faunal populations within the Area;
- Allow visits to the historic sites under strict control by permit;
- Take into account the potential historic and heritage values of any artifacts before their removal and/or disposal, while allowing for appropriate clean-up and remediation if required;
- Allow visits for management purposes in support of the aims of the management plan.

3. Management activities

The following management activities shall be undertaken to protect the values of the Area:

- Durable wind direction indicators should be erected close to the primary designated helicopter landing site whenever it is anticipated there will be a number of landings at the site in a given season. These should be replaced as needed and removed when no longer required;
- Brightly colored markers, which should be clearly visible from the air and pose no significant threat to the environment, should be placed to mark the primary and secondary designated helicopter landing sites adjacent to the field hut;
- A notice showing the location of the Area (stating the special restrictions that apply) shall be displayed prominently, and a copy of this management plan shall be kept available, in the research hut facility at Cape Crozier;
- National programs shall take steps to ensure the boundaries of the Area and the restrictions that apply within are marked on relevant maps and nautical / aeronautical charts;
- Markers, signs or structures erected within the Area for scientific or management purposes shall be secured and maintained in good condition, and removed when no longer necessary;
- National Antarctic programs operating in the Area should maintain a record of all new markers, signs and structures erected within the Area;



- Personnel (national program staff, field expeditions, and pilots) in the vicinity of, accessing or flying over the Area shall be specifically instructed by their national program or appropriate national authority to observe the provisions and contents of the Management Plan;
- The Area shall be visited as necessary (no less than once every five years) to assess whether it continues to serve the purposes for which it was designated and to ensure management and maintenance measures are adequate;
- National Antarctic Programs operating in the region shall consult together for the purpose of ensuring that the above provisions are implemented.

4. Period of designation

Designated for an indefinite period.

5. Maps and photographs

Map 1: ASPA No.124 Cape Crozier – location and topography.

Projection: Lambert conformal conic; Standard parallels: 1st 77° 27' S; 2nd 77° 32' S; Central meridian: 169° 15' E; Latitude of Origin: 77° S; Spheroid and horizontal datum: WGS84.

Data sources:

Coastline, contours and bird data supplied by Gateway Antarctica; ASPA boundary: ERA (Feb 2014); Facilities: RPSC GPS survey (25 Dec 2007); Ice free ground: Quickbird (09 Oct 2011); Ice shelf front 1993 estimated from orthorectified aerial imagery (DoSLI / USGS SN7848) and for 2002, 2007 and 2011 from Quickbird (© Digital Globe). Emperor penguin colony: from Sentinel-2 imagery (2021; Australian Antarctic Division (AAD) *pers. comm.* 2022).

Inset 1: Ross Sea region, showing location of Inset 2.

Inset 2: Ross Island region, showing the location of Map 1 and McMurdo Station (US) and Scott Base (NZ).

Map 2: ASPA No. 124 Cape Crozier – access, facilities and wildlife.

Map specifications are the same as for Map 1. Emperor penguin colony: 2007 and 2011 from Quickbird (© Digital Globe).

6. Description of the Area

6(i) Geographical co-ordinates, boundary markers and natural features

Overview

Cape Crozier (77° 30' 30" S, 169° 21' 30" E) is at the eastern extremity of Ross Island, where an ice-free area comprises the lower eastern slopes of Mount Terror (Map 1). The designated Area is situated in the vicinity of Post Office Hill (407 m), Bomb Peak (740 m) and The Knoll (360 m), extending to encompass Gamble, Topping and Kyle Cones. Igloo Spur and the adjacent marine environment and an area of the Ross Ice Shelf where large cracks form as the shelf pushes against the land. The water in these cracks is generally covered by fast-ice, which is occupied annually by breeding emperor penguins.

Boundaries and coordinates

The marine northern boundary of the Area extends 6.5 km along the 77° 26' 00" S line of latitude from 169° 12' 00" E to 169° 28' 00" E. The western boundary extends 1.68 km south from the northern boundary to the coast, thence south for a further 800 m to the edge of icefree ground before ascending to the summit of a low hill (~ 300 m) above and east of the field hut (Map 1). The boundary thence proceeds directly to the summit of Post Office Hill (407 m) at 77° 27' 55" S, 169° 12' 40" E. The boundary thence follows a straight line southward direct to a point close to the summit of Bomb Peak (740 m) at 77° 31' 02" S, 169° 11' 30" E. The boundary extends down the SE ridge of Bomb Peak to Igloo Spur at 77° 32' 00" S, 169° 20' 00" E, from where it extends due east along latitude 77° 32' 00" S to the east boundary at 169° 28' 00" E.

Climate

The nearest Automatic Weather Station (AWS) to Cape Crozier is Laurie II, situated on the Ross Ice Shelf 35 km east of Cape Crozier. Air temperatures recorded at Laurie II between 2009–13 showed December as the warmest month over this period, with a mean temperature of -5.8 °C, and August as the coolest with a mean temperature of -33.1 °C (<http://uwamrc.ssec.wisc.edu/> 06 Mar 2014). The minimum air temperature recorded at Laurie II during this period was -56.5 °C in July 2010, whilst the maximum was 5.9 °C in December 2011. The average wind speed over the period was ~ 6.3 m/s with the winds predominantly coming from the south to southwest. Conditions at Cape Crozier are likely to differ as a result of the local geography; for example, nearby Mount Terror probably influences local airflow and katabatic winds to affect the local climate, and Broady (1989) observed that prevailing winds in the ice-free region near Cape Crozier tend to be from the southeast.



Geology, geomorphology and soils

The ice-free ground at Cape Crozier is of volcanic origin, with numerous small cones and craters evident among gentle slopes of scoria and fine-grained basalt lava. Phonolite cones at Post Office Hill and The Knoll are 1.4 million years old, while other volcanic rocks in the area are less than 1 million years old (Cole *et al.* 1971; Wright & Kyle 1999). Several of these hills, including Post Office Hill, shelter the penguin colonies from southwesterly winds. On the surface are many volcanic bombs and other evidence of small-scale volcanic explosions. To the south of the Area coastal cliffs adjacent to the ice shelf are up to 150 m high. The cliff faces show bedded lava and brown palagonitic tuffs with several lenticular patches of columnar basalt towards the base. Large erratics of continental origin transported by the Ross Ice Shelf can be found on the northern side of Cape Crozier.

Breeding birds

The emperor penguin (*Aptenodytes forsteri*) colony at Cape Crozier was discovered in October 1902 by R.S. Skelton, a member of Scott's Discovery Expedition. The presence of the colony depends on fast-ice locked within cracks in the Ross Ice Shelf where it abuts Cape Crozier. The size of the colony is limited by the area and condition of the fast ice, which also affects the availability of breeding sites sheltered from the strong katabatic winds that descend from Mount Terror. The location of the colony varies from year to year (Map 2) and the colony moves within a breeding season, beginning the season near to shore and moving further offshore as fledging approaches. The breeding population has fluctuated widely since the turn of the century, for example with 400 adults recorded in 1902, 100 in 1911, and 1,300 in 1969. The number of chicks fledged and the fledging success of the colony has also been variable (Table 1). The mean number of chicks fledged at Cape Crozier is 769 over the years for which data are available (Table 1).

Table 1. Cape Crozier emperor penguin live chick counts 1983–2018 and adults 2007–12.

Year	Chicks	Year	Chicks	Year	Chicks	Year	Adults
1983	78	1996	859	2004	475	2007	537
1986	?	1997	821	2005	0	2008	623
1989	?	1998	1108	2006	339 (b)	2009	303 (c)
1990	324	1999	798	2015	1737	2010	856
1992	374	2000	1201	2016	1759	2011	870
1993	?	2001	0	2017	1743	2012	1189
1994	645	2002	247	2018	1911		
1995	623	2003	333 (a)				

Sources: chick counts Barber-Meyer, Kooyman & Ponganis 2008; Schmidt & Ballard 2020. Adult counts: Kooyman pers. comm. 2014. All counts made between October–December of the stated year.

- a) All chicks not counted due to rugged ice conditions and thus one chick assumed per adult counted.
- b) G. Kooyman, *pers. comm.*, Nov. 2007.
- c) Estimate from 2009 satellite imagery (Fretwell *et al.* 2012).

In 2000, a section of the Ross Ice Shelf calved to form an iceberg 295 km long and 40 km wide. A fragmented section of this iceberg, known as B15A, together with another iceberg (C16) lodged near Ross Island in 2001. These icebergs had a major effect on sea ice distribution and primary production, and impeded the arrival of emperor penguins. In 2001 and several subsequent years, icebergs C16 and B15A affected the breeding success and colony locations of emperor and Adélie penguins by blocking access to foraging areas and destroying nesting habitat. In 2005, the emperor colony remained well below its pre-2000 size, with no sign of breeding (Kooyman *et al.* 2007). However, in 2006 the emperor colony had returned to its pre-iceberg location and 339 chicks were produced (G. Kooyman, *pers. comm.*, Nov. 2007; Table 1), and in recent years the number of adults has returned to levels similar to those last observed in the 1996–2000 period. Emperor chick counts since 2015 all exceeded 1325, which was the previous highest number (recorded in 1960). However, a significant loss of emperor chicks occurred in 2018 when the fast ice broke up unusually early, highlighting the vulnerability of the species to changes induced by a warming climate (Schmidt & Ballard 2020).

A comprehensive population study of Adélie penguins occurred at Cape Crozier from 1961/62 through the 1981/82 austral summers, with 2000 to 5000 chicks banded yearly. There are two Adélie penguin (*Pygoscelis adeliae*) colonies at Cape Crozier, known as East and West Colonies. These are about 1 km apart, separated by a 45-m high ridge and a sloping ice field across which the birds do not travel. A coastline of 1.6 km with three beaches separated by rock outcrops provides penguins with access to West Colony. By contrast, East Colony has one 50-m wide rocky beach and 550 m of sea cliffs. The population of the two colonies has increased substantially over the last 50 years, numbering 65,000 breeding pairs in 1958, 102,500 in 1966 and 177,083 in 1987. Numbers fell to 136,249 in 1989 and 106,184 in 1994. In 2000, the number of breeding pairs was estimated to be 118,772 (based on a projection from counts of selected subcolonies) (Ainley *et al.* 2004). The combined mean population of the East and West Colonies at Cape Crozier over a 28-year period was 153,632, and in 2012 there were 270,340 breeding pairs representing ~14% of the global population (Lynch & LaRue 2014), making it one of the largest Adélie penguin colonies in Antarctica (Lyver *et al.* 2014). The presence of the B15A and C16 icebergs from 2001 to 2005 in the foraging area had a significant effect on the Adélie penguin colony at Cape Crozier (Arrigo *et al.* 2002; Ballard *et al.* 2010; Dugger *et al.* 2010).



A subcolony of 426 Adélie penguins was observed on the fast ice ~3 km from the main Cape Crozier colony over a one month period in November 2018, displaying behavior associated with nesting (LaRue *et al.* 2019). This is the first time Adélie penguins have been observed using sea ice as a possible breeding habitat separate from regularly occupied terrain to form an apparent breeding 'subcolony' over a prolonged period, making this discovery unique to Cape Crozier and in Antarctica. La Rue *et al.* (2019) put forward several hypotheses to explain the observation:

1. Juvenile birds 'practicing' nesting and forming a 'critical mass', despite the unsuitable habitat;
2. Individuals becoming disoriented on the way to the main colony in a dynamic landscape;
3. Nesting overflow from Cape Crozier, a colony that has been growing rapidly since 2010;
4. A fluke incident with limited, if any, implications for the life history of the species.

The 'subcolony' was absent from high resolution satellite imagery the following year (C. Harris *pers. comm.* Aug 2020; Worldview 3, 23 December 2019 © Digital Globe), when the 2018 'breeding' site was open water. While perhaps a rare and transitory event, the presence of the 'subcolony' in 2018 is further evidence for the importance of the sea ice habitat close to Cape Crozier, which persists longer in the ice shelf 'canyons' than in the open sea. Numerous Adélie penguins congregate in this area, and the feature also provides habitat for breeding emperor penguins and Weddell seals.

A novel circovirus (named PenCV) was identified in Adélie penguins at Cape Crozier in 2018/19, which is the first report of a circovirus in a penguin species (Morandini *et al.* 2019). The virus is associated with, and may be the cause, of feather loss in penguin chicks.

Over 1000 pairs of south polar skuas (*Catharacta maccormicki*) breed on ice-free ground surrounding the Adélie penguin colony, with ~1099 breeding pairs in the 2011/12 summer season and 1347 in 2012/13 (Wilson *et al.* 2016). A demographic study of this colony began in 1961/62 and was continued until 1996/97. Chinstrap penguins (*Pygoscelis antarcticus*), Wilson's storm petrels (*Oceanites oceanicus*), snow petrels (*Pagodroma nivea*), Antarctic petrels (*Thalassoica antarctica*), southern fulmars (*Fulmaris glacialisoides*), southern giant petrels (*Macronectes giganteus*), kelp gulls (*Larus dominicanus*), and south polar skuas from more northerly breeding sites, have been recorded as visitors to Cape Crozier.

Antarctic Important Bird Area (IBA) No. 187, Cape Crozier was identified because the Adélie penguin colony contained ~14% of the estimated global Adélie penguin population in 2012/13 (Lynch & LaRue 2014; Harris *et al.* 2015) and because the south polar skua colony comprised almost 18% of the upper estimate of the global population for this species in 2012/13 (Harris *et al.* 2015). The south polar skua colony is the largest documented in Antarctica. In addition, the emperor penguin is listed as Near Threatened on the IUCN Red List. The Area therefore more than meets the thresholds of criteria for IBA designation (Harris *et al.* 2015). The IBA has the same boundary as the ASPA (Map 1).

Breeding mammals

Weddell seals (*Leptonychotes weddellii*) breed within the Area, with approximately 20 pups being recorded in recent years. Approximately 60 seals, presumed to be Weddells, were evident in satellite imagery on 23 December 2019, hauled out near cracks in the sea ice persisting in the ice shelf 'canyons' (C. Harris *pers. comm.* Aug 2020; Worldview 3 image © Digital Globe). Leopard seals (*Leptonyx hydrurga*) frequent the Area, with approximately 12 individuals recognized as regular visitors, while crabeater seals (*Lobodon carcinophagus*) are commonly seen at sea and on ice floes in the vicinity. Other mammals frequently observed within the Area include killer whales (*Orcinus orca*), of which several distinct types have been recognized. Regular killer whale observations were carried out at Cape Crozier between 2002-09 (Ainley *et al.* 2009), with the finding that sightings of killer whales of ecotype-C (also referred to as 'Ross Sea killer whales') appear to have been decreasing at Cape Crozier contemporaneously with an increase in Ross Sea commercial fishing, in particular for Antarctic toothfish (*Dissostichus mawsoni*). 'Ross Sea killer whales' appear to feed principally on fish, including Antarctic toothfish, so the authors suggest that changes to the foraging patterns of these whales in this region could be linked to decreased prey availability as a result of the fishery.

Terrestrial biology – aquatic and non-aquatic habitats

Algae can be found throughout the Area on large patches of snow and on soils and stones, often below the soil surface layer. Large areas of green snow algae, covering more than 4 ha, can be found in the north of the Area in snowfields around the periphery of the Adélie penguin colony and skua nesting areas (Broady 1989). Particularly large patches have been reported in the snow-filled valley between the two coastal hills at the northern end of the Adélie penguin colony, with green-tinted snow over at least one hectare. However, the extent of snow algae is not always obvious, with the green color often not revealed until a surface crust of white ice is broken away. Snow algae samples are dominated by a species of *Chlamydomonas*, and associated with occasional *Ulothrix*-like filaments and diatoms. Growth requires percolating meltwater during summer and nutrients derived from the bird colonies.

Prasiola crispa grows in slow water flows in the vicinity of the penguin colonies and ribbon-like growths of *P. calophylla* are found where water percolates over stones on the talus slopes. Numerous small ponds are found throughout the Area, from small pools of ~1 m in diameter to a lake of ~150 m in diameter situated immediately south of The Knoll. The four ponds in the penguin colonies contain abundant phytoplankton populations of *Chlamydomonas* cf. *snowiae*, while ponds elsewhere support growths of red-brown to dark blue-green benthic mats dominated by Oscillatoriaceae. Occasional epilithic algae (dominated by *Gloeocapsa*, *Nostoc* and *Scytonema*) are found as blackish crusts coating rock surfaces where meltwater percolates.

Mosses are sparse and scattered in their distribution with most occurrences being of one or a small number of isolated cushions no larger than 10 cm in diameter. Richer growths than this occur up to 0.5 km NE of the hut on north and NW facing slopes and on slopes immediately above the coastal cliffs about 1 km south of the penguin colonies. The moss species occurring at Cape Crozier have yet to be identified.



Encrusting orange lichens are present in shallow hollows, on rock outcrops, boulders and encrusting bryophytes on the slopes above the penguin colonies. Also present adjacent to Wilson's Stone Igloo is the fruticose lichen *Usnea* and the foliose lichen *Umbilicaria*, both duller in color but structurally more complex. Green algal crusts are found throughout the Area. A survey conducted in 2010 near the Adélie colony identified 14 lichen species, of which two (*Caloplaca erecta* and *C. soropelta*) had not previously been recorded in Antarctica, and one (*Lecania nylanderiana*) had not previously been recorded in Victoria Land (Smylka *et al.* 2011). *Caloplaca soropelta* had not previously been recorded in the Southern Hemisphere, and is known as an Arctic species. The 11 other species, previously known in Antarctica, are *Buellia darbishirei*, *B. pallida*, *Caloplaca citrina*, *C. saxicola*, *C. schofieldii*, *Lecanora expectans*, *L. mons-nivis*, *Lecidella siplei*, *Physcia dubia*, *Rhizoplaca melanophthalma*, and *Rinodina* sp.

Human activities and impact

Cape Crozier is relatively isolated and difficult to access, and the number of visitors to the Area each year is generally low, with only 30 permits for entry being issued by NZ and the US over the period 2009-14. Access is generally made by helicopter, and the designated landing site near the Cape Crozier hut requires careful approach to avoid inadvertent overflight of the Adélie penguin colony (Map 2). Pilots are briefed in advance to avoid the colonies when flying at low elevations.

Some materials such as nails, screws and hinges remain at the site of the old 'Jamesway' hut which has now been removed (Map 2). Vehicle tracks apparently made in the early 1970s remain evident in soils along the bench below Kyle, Topping and Gamble Cones (Ainley *pers. comm.* 2014).

6(ii) Access to the Area

The Area may be accessed by traversing over land or sea ice, by sea or by air. Particular routes have not been designated for access to the Area. Overflight and aircraft landing restrictions apply within the Area, the specific conditions for which are set out in Section 7(ii) below.

6(iii) Location of structures within and adjacent to the Area

The Cape Crozier hut (US) (77° 27' 41" S, 169° 11' 13" E) is situated on the NW side of a low peak ~ 675 m NW of Post Office Hill (Maps 1 and 2). A radio communications antenna is installed above the hut on a seasonal basis (Map 2). An observation hide installed during the period 1960-80 was located at the foot of the north side of Post Office Hill although no longer exists. An old 'Jamesway' hut was built on a small terrace approximately 1 km NE of the present hut (Map 2), although this was destroyed by fire and, with the exception of some small items such as nails etc., the hut debris has since been removed.

The historic Discovery's Message Post, designated as HSM No.69 through Measure 4 (1995), was erected on 22 January 1902, and is situated in the West Colony on the NE coast of the Area (77° 27' 16.7" S, 169° 14' 37.5" E). The post was used by the 1901-04 British National Antarctic Expedition to provide information to the expedition's relief ships. An historic rock hut known as Wilson's Stone Igloo (HSM No.21) (77° 31' 51" S, 169° 17' 56" E) is located on Igloo Spur (Map 1).

6(iv) Location of other protected areas in the vicinity

The nearest protected areas to Cape Crozier are on Ross Island: Lewis Bay (ASPANo.156), the site of the 1979 DC-10 passenger aircraft crash is the closest and 45 km west; Tramway Ridge (ASPANo.130) near the summit of Mt. Erebus is 55 km west; Discovery Hut on the Hut Point Peninsula (ASPANo.158 and HSM No.18); Arrival Heights (ASPANo.122) is 70 km to the SW adjacent to McMurdo Station; Cape Royds (ASPANo.121), Backdoor Bay (ASPANo.157 and HSM No.15) and Cape Evans (ASPANo.155) are 75 km west; and New College Valley (ASPANo.116) are 75 km NW at Cape Bird.

6(v) Special zones within the Area

There are no zones designated within the Area.

7. Terms and conditions for entry permits

7(i) General permit conditions

Entry into the Area is prohibited except in accordance with a permit issued by an appropriate national authority. Conditions for issuing a permit to enter the Area are that:

- It is issued for scientific research, and in particular for research on the avifauna, marine or terrestrial ecosystems in the Area, or for compelling scientific, educational or outreach reasons that cannot be served elsewhere, or for reasons essential to the management of the Area;
- The actions permitted are in accordance with this Management Plan;
- The activities permitted will give due consideration via the environmental impact assessment process to the continued protection of the environmental, scientific and historic values of the Area;
- Approach distances to fauna must be respected, except when scientific needs may require otherwise and this is specified in the relevant permits;
- Visitors shall not enter Wilson's Stone Igloo (HSM No.21) or in any other way disturb this structure or the Discovery's Message Post (HSM No.69) unless specifically authorized to do so by the permit;
- The permit shall be issued for a finite period;
- The permit, or a copy, shall be carried when in the Area.



7(ii) Access to, and movement within, or over the Area

Access to the Area shall be by helicopter, by boat or on foot. Vehicles are prohibited on land within the Area.

Foot access and movement within the Area

Movement on land within the Area shall be on foot. All people in aircraft, boats, or vehicles are prohibited from moving on foot beyond the immediate vicinity of their landing or access site unless specifically authorised by permit. Pedestrians should maintain a minimum approach distance of 5 m from wildlife, unless it is necessary to approach closer for purposes allowed for by the permit.

Visitors should move carefully so as to minimize disturbance to flora, fauna, soils, and water bodies. Pedestrians should walk on snow or rocky terrain if practical, but take care not to damage lichens. Particular care should be exercised when walking on rocky terrain in the vicinity of Wilson's Stone Igloo (HSM No.21) (77° 31' 51" S, 169° 17' 56" E) on Igloo Spur (Map 1), where fragile lichens are present on rocks. Wilson's Stone Igloo is itself fragile, and visitors should not enter or in any other way disturb the structure unless specifically authorized to do so by permit.

Pedestrians should walk around the penguin colonies and should not enter sub-groups of nesting penguins unless required for research or management purposes. Care should be taken to avoid trampling nests when moving through skua territories. Pedestrian traffic should be kept to the minimum consistent with the objectives of any permitted activities and every reasonable effort should be made to minimize effects.

Ship or small boat access

Restrictions on ship and / or small boat operations apply during the period from 01 April through to 01 January inclusive, when ships and / or small boats shall operate within the Area according to strict observance of the following conditions:

- Ships and / or small boats are prohibited from the Area, including entering sea ice within the Area, unless authorized by permit for purposes allowed for by this Management Plan;
- There are no special restrictions on where access can be gained to the Area by small boat, although small boat landings should avoid areas where penguins are accessing the sea unless this is necessary for purposes for which the permit was granted.

Aircraft access and overflight

Aircraft may operate and land within the Area according to strict observance of the following conditions:

- Aircraft landings within the Area are prohibited unless authorized by permit for purposes allowed for by the Management Plan;
- Overflight of the Area by piloted aircraft below 2000 ft (~610 m) Above Ground Level is prohibited, except in accordance with a permit issued by an appropriate national authority;
- Pilots should ensure aircraft maintain a horizontal separation distance of at least 2000 ft (~610 m) from the edges of the penguin colonies (Maps 1 & 2) when accessing the designated landing sites, or otherwise operating within the Area. Pilots should be aware that congregations of penguins commonly occur on sea ice adjacent to the coast, and associated with the ice shelf 'canyons';
- Aircraft landings on sea ice within ½ nautical mile (~930 m) of the emperor colony are prohibited. Pilots should note that the emperor colony may shift from year to year, and move throughout the breeding season, and may be several kilometers from the nominal position shown in Map 1, and the colony may also comprise a number of smaller units within the Area;
- The primary helicopter landing site preferred for most access to the Area is located at 77° 27.64' S, 169° 11.19' E (elevation 240 m). This landing site is below and 150 m northwest of the Cape Crozier (US) field hut, and outside of the Area approximately 430 m west of the western ASPA boundary (Map 2). The site is marked by a circle of bright orange painted rocks. An alternative, secondary, landing site may be used when necessary, located at 77° 27.72' S, 169° 11.28' E. The landing site is 150 m above the hut and approximately 450 m west of the ASPA boundary;
- A third designated helicopter landing site is located above and 350 m northwest of Wilson's Stone Igloo at 77° 31.75' S, 169° 17.19' E (Map 1) in an area of relatively flat terrain;
- To minimize the risks of inadvertent overflight of bird colonies, helicopter pilots accessing the Area for the first time should be accompanied by another pilot with previous experience of flying into the Area or be briefed in advance by those with that experience;
- Overflight below 2000 ft (610 m) and landings within the Area by Remotely Piloted Aircraft Systems (RPAS) are prohibited except in accordance with a permit issued by an appropriate national authority. RPAS use within the Area should follow the Environmental Guidelines for Operation of Remotely Piloted Aircraft Systems (RPAS) in Antarctica (Resolution 4 (2018)).



7(iii) Activities that may be conducted within the Area

Activities that may be conducted within the Area include:

- Scientific research that will not jeopardize the values of the Area;
- Activities with educational and / or outreach purposes (such as documentary reporting (e.g. visual, audio or written) or the production of educational resources or services) that are for compelling reasons that cannot be served elsewhere. Activities for educational and / or outreach purposes do not include tourism;
- Activities with the aim of documenting, preserving or protecting historic resources within the Area;
- Essential management activities, including monitoring and inspection.

7(iv) Installation, modification or removal of structures / equipment

- No structures are to be erected within the Area except as specified in a permit and, with the exception of permanent survey markers and signs, permanent structures or installations are prohibited;
- All structures, scientific equipment or markers installed in the Area must be authorized by permit and clearly identified by country, name of the principal investigator, year of installation and date of expected removal. All such items should be free of organisms, propagules (e.g. seeds, eggs) and non-sterile soil, and be made of materials that can withstand the environmental conditions and pose minimal risk of contamination or damage to the values of the Area;
- Installation (including site selection), maintenance, modification or removal of structures or equipment shall be undertaken in a manner that minimizes disturbance to flora and fauna, preferably avoiding the main Adélie penguin and skua breeding season (01 Oct – 31 Mar);
- Removal of specific structures / equipment for which the permit has expired shall be the responsibility of the authority which granted the original permit, and shall be a condition of the permit.

7(v) Location of field camps

Camping outside of the Area should be within a 100 m radius of the field hut (77° 27' 39" S, 169° 11' 14" E). When necessary for essential purposes specified in the Permit, camping is permitted within the Area to facilitate access to sites inaccessible from the hut. Such camping should preferably be at sites that have been previously used, are not vegetated or occupied by breeding birds, and should be on snow or ice-covered ground if available. Researchers should consult with the appropriate national authority to obtain up-to-date information on any sites where camping may be preferred.

7(vi) Restrictions on materials and organisms which may be brought into the Area

In addition to the requirements of the Protocol on Environmental Protection to the Antarctic Treaty, restrictions on materials and organisms which may be brought into the Area are:

- Deliberate introduction of animals, plant material, micro-organisms and non-sterile soil into the Area is prohibited. Precautions shall be taken to prevent the accidental introduction of animals, plant material, micro-organisms and non-sterile soil from other biologically distinct regions (within or beyond the Antarctic Treaty area);
- Visitors shall ensure that sampling equipment and markers brought into the Area are clean. To the maximum extent practicable, clothing, footwear and other equipment used or brought into the Area (including e.g. backpacks, carry-bags, tents, walking poles, tripods and other equipment) shall be thoroughly cleaned before entering the Area. Visitors should also consult and follow as appropriate recommendations contained in the Committee for Environmental Protection Non-native Species Manual (Resolution 4 (2016); CEP 2019), and in the Environmental Code of Conduct for terrestrial scientific field research in Antarctica (Resolution 5 (2018));
- Poultry and all poultry products are prohibited from the Area;
- Herbicides or pesticides are prohibited from the Area;
- Any other chemicals, including radio-nuclides or stable isotopes, which may be introduced for scientific or management purposes specified in the permit, shall be removed from the Area at or before the conclusion of the activity for which the permit was granted;
- Fuel, food, chemicals and other materials are not to be stored in the Area, unless required for essential purposes connected with the activity for which the permit has been granted. In general, all materials introduced shall be for a stated period only and shall be removed at or before the conclusion of that stated period;
- All materials introduced shall be for a stated period only, shall be removed at or before the conclusion of that stated period;
- All materials shall be stored and handled so that risk of their introduction into the environment is minimized;
- If release occurs which is likely to compromise the values of the Area, removal is encouraged only where the impact of removal is likely to be greater than that of leaving the material *in situ*.



7(vii) Taking of, or harmful interference with, native flora or fauna

Taking or harmful interference with native flora and fauna is prohibited, except in accordance with a permit issued under Article 3 of Annex II of the Protocol on Environmental Protection to the Antarctic Treaty. Where animal taking or harmful interference is involved, this should, as a minimum standard, be in accordance with the SCAR Code of Conduct for the Use of Animals for Scientific Purposes in Antarctica.

7(viii) The collection or removal of materials not brought into the Area by the permit holder

- Material may be collected or removed from the Area only in accordance with a permit and should be limited to the minimum necessary to meet scientific or management needs. This includes biological samples, rock specimens, soil and historical items.
- Material of human origin likely to compromise the values of the Area, and which was not brought into the Area by the permit holder or otherwise authorized, may be removed from any part of the Area, unless the impact of removal is likely to be greater than leaving the material *in situ*. If this is the case the appropriate authority should be notified and approval obtained.
- Unless specifically authorized by permit, visitors are prohibited from interfering with or attempting restoration of Wilson's Stone Igloo in any way, or from handling, taking or damaging any artifacts. Evidence of recent changes, damage or new artifacts observed should be notified to the appropriate national authority. Relocation or removal of artifacts for the purposes of preservation, protection, or to re-establish historical accuracy is allowable by permit.

7(ix) Disposal of waste

All wastes, including all human wastes, shall be removed from the Area.

7(x) Measures that may be necessary to continue to meet the aims of the Management Plan

Permits may be granted to enter the Area to:

1. Carry out monitoring and Area inspection activities, which may involve the collection of a small number of samples or data for analysis or review;
2. Install or maintain signposts, markers, structures or scientific or essential logistic equipment;
3. Carry out protective measures;
4. Carry out research or management in a manner that avoids interference with long-term research and monitoring activities or possible duplication of effort. Persons planning new projects within the Area are strongly encouraged to consult with established programs working within the Area, such as those of the United States and New Zealand, before initiating the work.

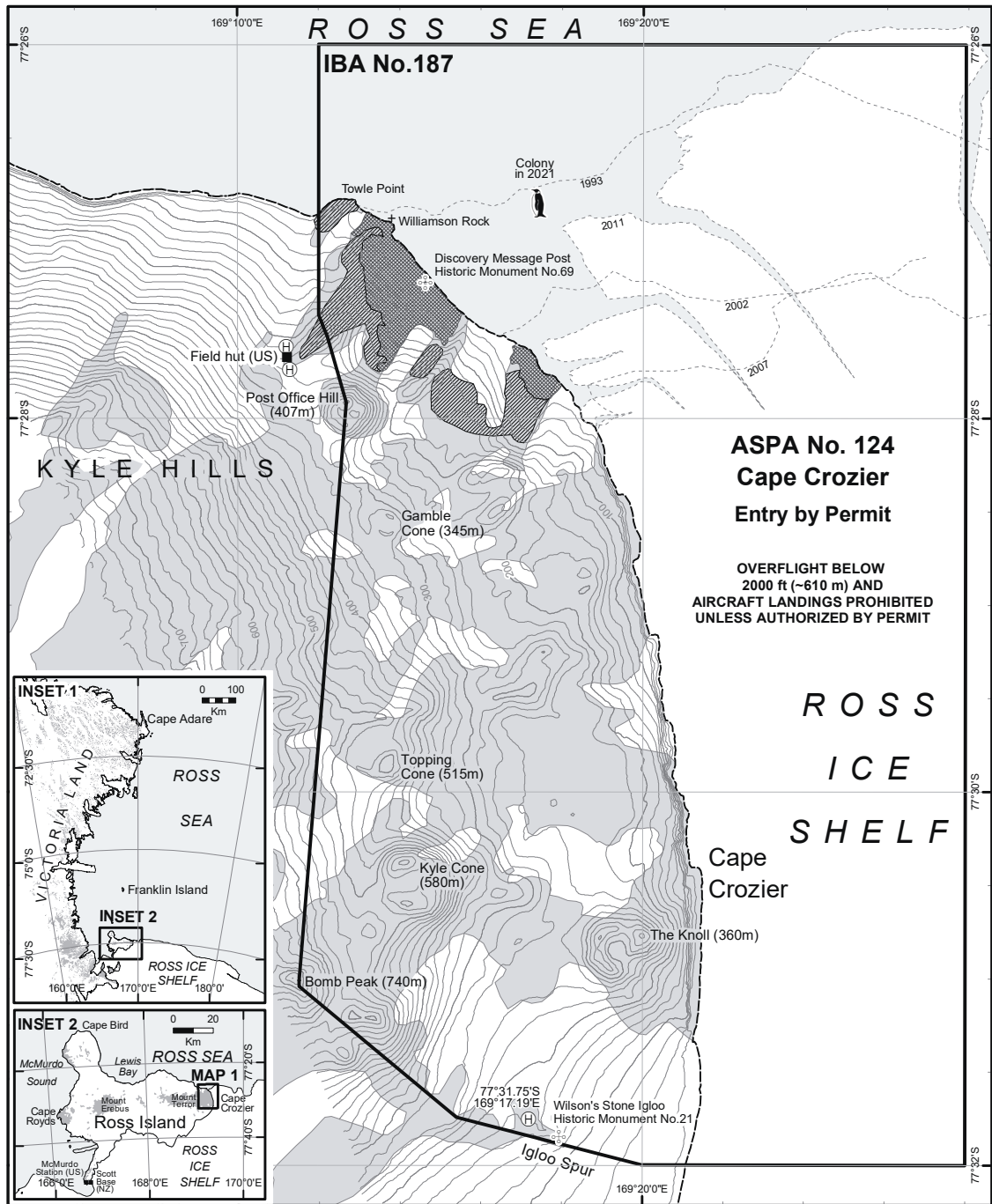
7(xi) Requirements for reports

- The principal permit holder for each visit to the Area shall submit a report to the appropriate national authority after the visit has been completed in accordance with national procedures and permit conditions.
- Such reports should include, as appropriate, the information identified in the visit report form contained in the Guide to the Preparation of Management Plans for Antarctic Specially Protected Areas (Resolution 2 (2011)). If appropriate, the national authority should also forward a copy of the visit report to the Parties that proposed the Management Plan, to assist in managing the Area and reviewing the Management Plan.
- Parties should, wherever possible, deposit originals or copies of such original visit reports in a publicly accessible archive to maintain a record of usage, for the purpose of any review of the Management Plan and in organising the scientific use of the Area.
- The appropriate authority should be notified of any activities/measures that might have exceptionally been undertaken, or anything removed, or anything released and not removed, that were not included in the authorized permit.



8. Supporting documentation

- Ainley, D.G., C.A. Ribic, G. Ballard, S. Heath, I. Gaffney, B.J. Karl, K.J. Barton, P.R. Wilson & S. Webb. 2004. Geographic structure of Adélie penguin populations: overlap in colony-specific foraging areas *Ecological Monographs* **74**(1):159–78.
- Ainley, D.G., G. Ballard & S. Olmastroni. 2009. An apparent decrease in the prevalence of 'Ross Sea Killer Whales' in the southern Ross Sea. *Aquatic Mammals* **35**(3): 335–47.
- Arrigo, K. R., G.L. van Dijken, D.G. Ainley, M.A. Fahnestock & T. Markus. 2002. Ecological impact of a large Antarctic iceberg. *Geophysical Research Letters* **29**(7): 1104.
- Ballard, G., K.M. Dugger, N. Nur, & D.G. Ainley. 2010. Foraging strategies of Adélie penguins: adjusting body condition to cope with environmental variability. *Marine Ecology Progress Series* **405**: 287–302.
- Barber-Meyer, S.M., G.L. Kooyman & P.J. Ponganis. 2008. Trends in western Ross Sea emperor penguin chick abundances and their relationships to climate. *Antarctic Science* **20** (1), 3–11.
- Broady, P.A. 1989. Broadscale patterns in the distribution of aquatic and terrestrial vegetation at three ice-free regions on Ross Island, Antarctica. *Hydrobiologia* **172**: 77–95.
- Cole, J.W., P.R. Kyle & V.E. Neall. 1971. Contribution to Quarternary geology of Cape Crozier, White Island and Hut Point Peninsula, McMurdo Sound region, Antarctica. *N.Z. Journal of Geology and Geophysics* **14**: 528–546.
- Dugger, K.M., Ainley, D.G., Lyver, P., Barton, K. & Ballard, G. 2010. Survival differences and the effect of environmental instability on breeding dispersal in an Adélie penguin meta-population. *Proceedings of the National Academy of Sciences of USA* **107** (27): 12375–80.
- Fretwell, P.T., M.A. LaRue, P. Morin, G.L. Kooyman, B. Wienecke, N. Ratcliffe, A.J. Fox, A.H. Fleming, C. Porter, & P.N. Trathan. 2012. An Emperor penguin population estimate: the first global, synoptic survey of a species from space. *PLoS ONE* **7**(4): e33751.
- Kooyman, G.L. 1993. Breeding habitats of emperor penguins in the western Ross Sea. *Antarctic Science* **5**(2): 143–48.
- Kooyman, G.L., D.G. Ainley, G. Ballard, & P.J. Ponganis. 2007. Effects of giant icebergs on two emperor penguin colonies in the Ross Sea, Antarctica. *Antarctic Science* **19**(1): 31–38.
- LaRue, M., D. Iles, S. Labrousse, G. Ballard, D. Ainley & B. Saenz. 2019. A possible Adélie penguin sub-colony on fast ice by Cape Crozier, Antarctica. *Antarctic Science*. **31** (4): 189–194.
- Lyver, P.O'B., M. Barron, K.J. Barton, D.G. Ainley, A. Pollard, S. Gordon, S. McNeill, G. Ballard, and P.R. Wilson. 2014. Trends in the breeding population of Adélie penguins in the Ross Sea 1981–2012: a coincidence of climate and resource extraction effects. *PLoS ONE* **9** (3): e91188. <https://doi.org/10.1371/journal.pone.0091188>.
- Morandini, V., K. Dugger, G. Ballard, M. Elrod, A. Schmidt, V. Ruoppolo, A. Lescroel, D. Jongsomjit, M. Massaro, J. Pennycook, G. Kooyman, K. Schmidlin, S. Kraberger, D. Ainley & A. Varsani. 2019. Identification of a Novel Adélie Penguin Circovirus at Cape Crozier (Ross Island, Antarctica). *Viruses*. **11** (12): 1088.
- Schmidt, A. & G. Ballard. 2020. Significant chick loss after early fast ice breakup at a high-latitude emperor penguin colony. *Antarctic Science*. **32** (3): 180–185.
- Smykla, J., B. Krzewicka, K. Wilk, S.D. Emslie & L. Šlima. 2011. Additions to the lichen flora of Victoria Land. *Polish Polar Research* **32**(2): 123–138.
- Wilson, D., P. Lyver, T. Greene, A. Whitehead, K. Dugger, B. Karl, J. Barringer, R. McGarry, A. Pollard & D. Ainley. 2016. South Polar Skua breeding populations in the Ross Sea assessed from demonstrated relationship with Adélie Penguin numbers. *Polar Biology*. **40** (3): 577–592.
- Wright, A.C. & P.R. Kyle. 1990. A.16. Mount Terror. In: Volcanoes of the Antarctic Plate and Southern Oceans (Eds. W.E. LeMasurier, J.W. Thompson). *Antarctic Research Series* **48**, American Geophysical Union: 99–102.

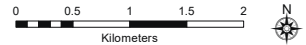


Map 1: ASPA No.124 Cape Crozier - Location & topography

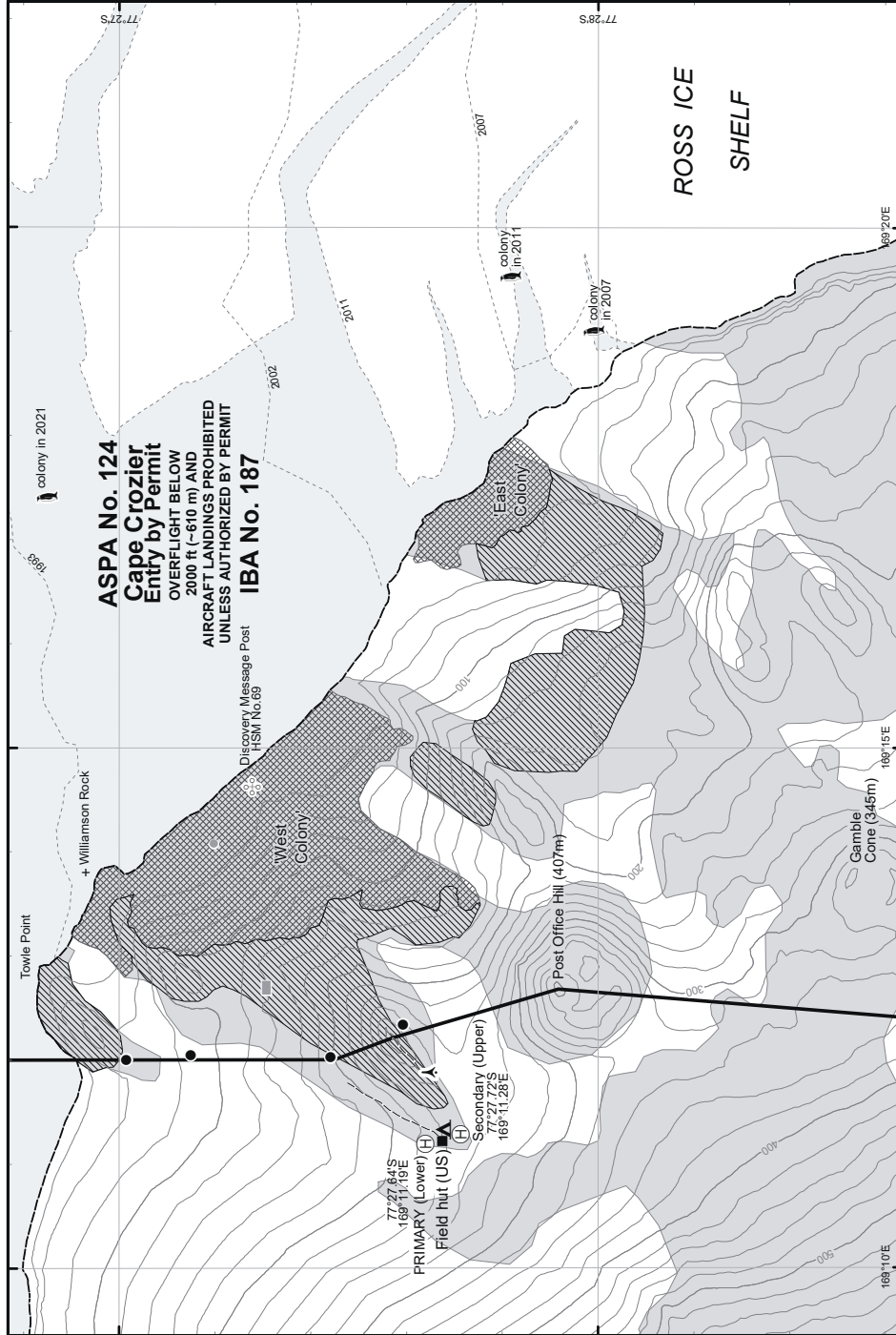
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- Coastline (approx)
- Index contour (100 m)
- Contour (20 m)
- Ice free ground
- Permanent ice
- Ocean
- Ice shelf edge
- Antarctic Specially Protected Area (ASPA) boundary
- Historic Site & Monument
- Field hut
- Helicopter landing site
- Skua nesting area
- Adélie penguin colony
- Emperor penguin colony



Projection: Lambert Conic Conformal,
Spheroid and horizontal datum: WGS 84
Data sources: ASPA boundary: ERA (Aug 2020);
Coastline, contours and bird data: Gateway Antarctica;
Facilities: RPSC GPS survey (25 Dec 2007); Ice shelf,
icefree ground: Quickbird © 03 Oct 2011 Digital Globe.
Emperor colony location: Sentinel-2 2021 (AAD 2022).



Map 2: ASPA No. 124 Cape Crozier - access, facilities and wildlife

United States Antarctic Program
 Environmental Research & Assessment

Coastline (approx) Ocean Skua resting area Designated camp site

Index contour (100 m) Ice shelf edge Adèle penguin colony Radio antenna (seasonal)

Contour (20 m) ASPA boundary Emperor penguin colony Signpost

Ice free ground Historic Site & Monument Helicopter landing site Former 'Jamesway' site

Permanent ice Path Field hut Former weigh station

Projections: Lambert Conformal Spheroid and horizontal datum: WGS84;
 Data sources: Coastline, contours and bird data: Gateway Antarctica; ASPA boundary: ERA (Feb 2014); Facilities: RASC GPS survey (25 Dec 2007); Emperor penguin colony: Quickbird 2007, 2011; Sentinel-2 2021 (AAD 2022); Historical ice shelf from imagery; orthophoto 1993; Quickbird 2002/2007.

0 0.5 1 Kilometers

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