

ADELIE PENGUINS AND LEOPARD SEALS: ILLUSTRATIONS OF PREDATION — HISTORY, LEGEND AND FACT

By ELLIOT W. DAWSON

ABSTRACT

The often-told story of the antics of Adelie Penguins fearful of entering water where Leopard Seals may be lurking is recounted and reinterpretations of this behaviour pattern are discussed. Few observations have been made of the methods used by the seals in capturing penguins and only one illustration of a 'near miss,' a penguin that had escaped although with some injury, seems to have been published. Birds badly injured seen at Cape Adare in 1965 are illustrated and discussed in relation to the particular conditions at this site, the history and geographical setting of which is outlined. Accounts of predation by Leopard Seals, as given in the literature, are detailed and commented upon in the light of the casual observations at Cape Adare and of recent field work in the U.S. Antarctic Research Programme. Observations of such predation are shown to have been by good fortune rather than by deliberate intent. Physical conditions of ice, tides and local geography, as well as the numerical abundance of seals and the proximity of their breeding and foraging areas to the penguin rookeries are important but may vary in significance. The effect of Leopard Seal predation on the overall mortality of populations of both young and adult penguins is considered negligible in relation to the numerical size of their rookeries.

INTRODUCTION

The Leopard Seal is well known as an enemy of the Adelie Penguin. Many people who have seen neither animal in the wild have read the often quoted story describing the behaviour of Adelie Penguins about to enter the water from an ice floe but suspicious of the presence of a lurking Leopard Seal. It has been repeated in various forms many times in popular accounts of penguins. For example, *Purnell's Encyclopedia of Animal Life*, edited by Maurice Burton, tells it to the general reader —

"There is a story of Adelie penguins which seems to credit them not only with a high level of intelligence but with a selfishness that is rivalled only by the most callous of humans. The story as usually told is that the penguins will go to the edge of the ice, line up along it and then push one of their number into the water. If that one comes to the surface again all go in, because they know there are no leopard seals about. If the unfortunate one that has been ducked does not surface, they know a leopard seal has eaten it and all turn round and walk away, postponing their fishing until later.

"On the face of it this seems too extraordinary a story to swallow, and yet it has been reported again and again even by serious zoologists. It seems the story was brought back by the early Antarctic explorers and particularly by Ponting, the photographer on Scott's expedition to the Antarctic, who lectured widely on his return."

[Burton 1968. 16-17]

Similarly, Sparks & Soper (1968: 122-123), in their popular book *Penguins*, recount how — "It was a source of constant amusement to the early chroniclers of penguins to watch them line up on the shores near their rookeries waiting to enter the water. As more penguins jostled at the back of the group, one placed at the front would ultimately overbalance and dive into the sea below, its progress being keenly followed by all those left ashore. If all was well, they would quickly follow." The authors embellished their remarks with Robert Gillmor's sketches of a Gentoo leaping on to an ice floe ahead of a Leopard Seal (p. 116) and of a seal catching a Chinstrap Penguin (p. 123). Yet another version, that given in the magazine *Birds of the World*, edited by John Gooders, is:

"The only real natural danger to adult adelines is the leopard seal. These large predators lurk beside the ice floes waiting for penguins to take to the water . . . the moment of entry is fraught with danger. A group of adelines will stand on an ice flow peering into the sea jockeying for position, but trying not to be first one in. Eventually one bird slips in and the others watch intently to see his fate; if all is clear they promptly follow."

[Gooders 1969: 9]

Many other popular books of the sort such as Berrill's *Wonders of the Antarctic* (1958: 30, 35) repeat the essentials of this story. It is interesting to note that even quite recently the story of the hesitant Adelies has been given anew to a fresh audience from an "old hand" (Priestley 1962: 134).

Children's books, in particular, have developed the legend in quite a fascinating way. Allen Chaffee's *Penn, the Penguin* (1934: 11-12, fig. on p. 13) described and illustrated an attack on the adventurous little "Penn." Richard and Florence Atwater (1938) gave us a delightful comment from their "Mr Popper" —

"'Penguins are very intelligent,' continued Mr Popper. 'Listen to this, Mamma. It says here that when they want to catch some shrimps, they all crowd over to the edge of an ice bank. Only they don't just jump in, because a sea leopard might be waiting to eat penguins. So they crowd and push until they manage to shove one penguin off to see if it's safe. I mean if he doesn't get eaten up, the rest of them know it's safe for them to jump in.'

'Dear me!' said Mrs Popper, in a shocked tone. 'They sound to me like pretty heathen birds.'

[Atwater & Atwater 1962 ed.: 13]

Patricia Lauber (1958: 46; 1964: 43) gave yet another account —

“Fear of sea leopards probably explains an odd Adelie custom. No bird wants to be first into the water. Instead, all the Adelies line up. They elbow and push one another, dodging and crowding. Finally one penguin is shoved into the water. If nothing happens, all the others dive in. If the victim is seized by a sea leopard, the others wait awhile. Then they again begin elbowing and shoving until another bird is pushed in to test the safety of the water.”

And Margaret Rau (1968: 33) discussed the Leopard Seal as an enemy of the King Penguin, with appropriate illustrations (p. 34), and added her version of the story —

“They love the ocean, but before going into it they spend a lot of time running around on the ice shelf daring one another to take the first dive. No one wants to be number one, and for a very good reason — a sea leopard may be lurking below. Finally one of the Adelies finds the courage to take the plunge, or else he is pushed in by his fellows. If no sea leopard appears, the others dive in eagerly after him.”

Ross Hutchins (1969: 40), in his beautifully illustrated adventures of “Adelbert,” an Adelie Penguin, said his piece also —

“Before going into the sea they usually stood at the edge of the ice, as if afraid of the water. They tried to push each other in. They were afraid to jump in the water because hungry leopard seals, or sea leopards, were sometimes found there. After the first penguin had entered the water, the rest knew it was safe, so they all hopped off the ice and swam away.”

Jane Tompkins (n.d.) devoted a whole chapter (pp. 77-84) to the encounter of “The Penguin Twins” with the ferocious sea-leopard “lurking out of sight at the edge of the ice shelf.”

Finally, Richard Penney (1970), noted for his scientific work on penguins including prey/predator relationships (see Penney 1962, Penney & Lowry 1967), has written his own children's book in which the story again appears, making an interesting comparison with his own scientific conclusions on the same phenomenon (cf. Penney & Lowry 1967) and perhaps indicating a moral somewhere regarding how one relates science to the eager and retentive mind of a child —

“Then she goes to an ice cliff. Many female penguins stand at the edge. They push and shove. Suddenly one jumps into the water. The others jump too. There is danger below the cliff. Leopard seals wait in the sea. They eat penguins when they jump in. Most of the penguins get away.”

[Penney 1970: 33]

Of writers of popular accounts, apart from Penney with his extensive field experience, Kooyman (1965: 59) is perhaps the only one who has provided some verification by his own eye-witness description of happenings at Cape Crozier during the 1961/62 summer.

This story, frequently attributed in its popular appeal to Herbert Ponting, pioneer photographer of the Antarctic (and of elsewhere, Arnold 1969), who lectured widely on his polar experiences, was probably first noted by Borchgrevink (1901: 228-229) who wintered at Cape Adare although he did not relate the hesitant behaviour to lurking predators but rather "just like some people before going into cold water." The story became established in the literature by Levick's (1915) classic report on penguin studies at Cape Adare made while surgeon/naturalist of the northern party of the British Antarctic ("Terra Nova") Expedition of 1910-13 in which he has written much of penguin play and behaviour. Levick's (1914) popular book, *Antarctic Penguins*, remains a basic source of information on the habits of the Adelie Penguin, many of the original observations appearing in new forms from later writers (e.g. Barrett 1948: 41; Lauber 1958: 43-44). Although Levick made a notable career elsewhere (Anon. 1956), it is a matter of regret that he did not continue in the field of natural history. Ponting himself did not mention such behaviour in his own narrative of this expedition *The Great White South*, and, indeed, he stated that he saw a Leopard Seal on only one occasion during his time at Cape Evans (Ponting 1921: 200). Considering how much time Ponting spent photographing on ice floes, his single record illustrates how infrequently the seals may be seen even by those who have specially set out to study them, as will be shown later when discussing recent results of such projects.

Observations and interpretations by more recent workers (Penney 1962; Penney & Lowry 1967) suggest that, although some kind of "mutual stimulation" or "interstimulation" takes place amongst the assembled penguins, it is not necessarily such an anthropomorphic event as Burton, Sparks & Soper and others have led us to believe, and Penney (1962: 21) pointed out that it may not even be directly related to the presence of a would-be predator.

Stonehouse (1968: 56-60) has also reinterpreted the story, making the point — "Entering the water is far more of a business for penguins than one might expect in such highly aquatic animals," and he commented on the oft-told story in this way — "Like so many other penguin yarns, it is a good story but untrue. It invests penguins with an experimental approach to problems (and a cheerful cynicism) far beyond their mental capabilities."

He believed that the first plunge is an entirely voluntary act and part of the general play of bathing behaviour indulged in by penguins irrespective of the presence of a predator, although a general reluctance to enter the water evident especially in winter from May to early November is attributable to a fear of lurking Leopard Seals. Frequent "panics" without apparent reason (as will be familiar to those who know the behaviour of colonially-nesting terns and gulls) brought the penguins ashore in a rapid scramble, and Stonehouse found that he could bring the birds out of the water by clapping his hands in imitation of the alarm signal of flippers beating on the water. In summer, "when the leopard seals are away breeding on the pack ice,"

the birds played freely without frequent alarms and experimental clapping had no effect although any dark object in the surf was still "an effective bogey-man." These seasonal differences in appearances of the Leopard Seals, as alleged by Stonehouse, are important in relating to field studies concerned with the contribution of Leopard Seal predation to mortality rates in penguin rookeries and will be discussed later.

Levick (1914, 1915) and Murphy (1936) also described the "play" of penguins and Perry (1973) has recently given a readable summary of the different sorts of swimming behaviour based on earlier accounts. In fact, Levick's original observations on which the now classic story of the Adelies on the ice edge was developed suggested play rather than deliberate "heathen" behaviour, as the children's "Mr Popper" might have called it —

"The reluctance shown by each individual of a party of intending bathers to be the first to enter the water may partly have been explained when, later on, we discovered that a large number of sea-leopards were gathered in the sea in the neighbourhood of the rookery to prey on the penguins . . . It seemed to me then, that all the chivvying and preliminaries which they went through before entering the water, arose mainly from a desire on the part of each penguin to get one of its neighbours to go in first in order to prove whether the coast was clear or not, though all this manoeuvring was certainly taken very lightly, and quite in the nature of a game."

[Levick 1914: 83-84]

Unlike the story itself, however, reports of actual instances of such predation are not so easily found in the literature. Indeed, few accounts exist of the methods used by Leopard Seals in catching and consuming their prey. Sladen (1957; 1958: 68) was very fortunate in being able to film an attack by a Leopard Seal but only one pictorial illustration seems to have been published of one of the "near misses," a penguin which had escaped the clutches of the Leopard Seal (Kooyman 1965: photo. on p. 63).

Until recently, the best account of penguin predation by the Leopard Seal was that of Levick (1915) based on his observations at Cape Adare while a member of the Northern Party of Scott's expedition:

"When they are hungry, the Sea-leopards swallow the penguins whole, feathers and all, but when they are well fed they skin them first. This they do by seizing the bird by the feathers and shaking it from side to side till a large portion of the skin comes away, when they drop this, take a fresh hold, and tear another piece off, and so on till, at any rate, the greater part of the skin and feathers is removed from the body.

"It is evident that sometimes a penguin escapes, as occasionally we saw them making their way along the ice-foot, terribly injured, and these generally had the skin of the whole of their breasts peeled away and hanging from them like an apron, and their breast-muscles were bared and bleeding."

[Levick 1915: 75-6]

Such a phenomenon I also observed at Cape Adare in 1965 while participating in the joint New Zealand-United States Ross Sea-Balleny Islands Expedition aboard the *USS Glacier*. Because I believed that such a sight would have been an everyday occurrence to biologists working in or near large penguin colonies, I desisted from writing up my notes on this quite gruesome spectacle. To my surprise, however, I found that none of the New Zealand penguin biologists of my acquaintance had seen the results of such Leopard Seal behaviour. Now, deliberate studies of the roles of Leopard Seal and Adelie Penguin in prey-predator relationships are being undertaken (Muller-Schwarze 1971, 1972; Muller-Schwarze & Muller-Schwarze 1970, 1972; NSF 1973: 44, 78; Hofman *et al* 1973), and I propose to illustrate here my own record of the Leopard Seal's "ones that got away" as seen at Cape Adare, as well as describing more fully the setting of these observations and some sidelights on the history of the locality itself. In addition, this is a timely opportunity for reviewing and commenting upon what has been published regarding Leopard Seal-penguin relationships.

CAPE ADARE AND ITS PENGUINS

Cape Adare, as Reid (1962: 98) has already rightly pointed out, "must vie with Ross Island as the most historical place in the Antarctic." It was visited for three hours early in the morning of 24 January 1895 (although Borchgrevink, in his version, gave the date at 23 January 1894) by a party from the whaler *Antarctic*, led by H. J. Bull, the men ever to set foot on the Antarctic Continent (see Bull 1896) and among whom was C. E. Borchgrevink. He returned with his own expedition in 1899 in the *Southern Cross* to become the first to winter-over in the Antarctic, landing again at Cape Adare on 17 February 1899 and remaining until 28 January 1900 (see Borchgrevink 1901; Bernacchi 1901; and note on last survivor, Hugh Blackwall Evans, now in his 100th year, Anon. 1973a: 192-3. Edward Wilson, naturalist and surgeon of the *Discovery* and *Terra Nova* expeditions, visited Ridley Beach for six hours on 9 January 1902 (see Wilson 1907b; Wilson 1966) with a party from the *Discovery* Expedition in which was included Louis Bernacchi who knew the place well from his long stay there as meteorologist of the *Southern Cross* Expedition of 1898-1900. The relief ship *Morning*, under Lt W. Colbeck, RNR, who had also been a member of Borchgrevink's expedition, called at Cape Adare on 8 January 1903 to collect a message cylinder left by the *Discovery* party in one of the huts. Such was the means of telling of a safe arrival at each stage of an expedition in those days, a far cry from the daily "Sitrep" sent from the *Glacier*! Later, in 1911, Scott's Northern Party, under Lt Victor Campbell, from the British Antarctic Expedition in the *Terra Nova* (see Ponting 1921: pl. CXVII, and Priestley 1962: fig. opp. p. 134), wintered at Cape Adare from 18 February 1911 to 3 January 1912 during which time Levick made his observations on the penguins. The main hut built by Borchgrevink's party is still standing and is in excellent condition

with its contents frozen but intact. His stores hut nearby is now unroofed but the walls, stoutly constructed from Norwegian pine logs in interlocking Scandinavian style, are still upright and sound. The *Terra Nova* hut, in contrast, is unroofed and almost flattened with its four walls splayed out and interior open to the weather (Fig. 1). At the time of our visit, 70 years after Borchgrevink, in January 1965, thousands of Adelie Penguins with fledging young were gathered in "creches" in and around these huts and over a mass of boxes of stores, including wine bottles, ammunition, foodstuffs, and other miscellaneous equipment left behind by both the *Southern Cross* and *Terra Nova* Expeditions, with even a mound representing the 10 tons of coal listed by Borchgrevink (1901: 252-253) which might baffle future geologists. A fortunately short-lived wind storm across the pebbly beach flat, while we sheltered in Borchgrevink's store hut, served to remind us of the harrowing experiences narrated by Borchgrevink (1901) in his account of the winter stay. Readers should contrast the view of the *Southern Cross* huts in winter (Borchgrevink 1901: 122) with my illustrations of summer conditions (Fig. 1).



FIGURE 1 — Adelie Penguin "creche" at Ridley Beach, Cape Adare, "Terra Nova" hut on left, "Southern Cross" huts on right, looking south into Robertson Bay on right, 25 January 1965.

Photo: F. O'Leary

Indeed such was the emotion and reverance generated in me, at least, in visiting this historically and physically stimulating Antarctic shrine of exploration that I must be allowed to digress and to recall Edward Wilson's own reaction which he so well described in his diary and illustrated so beautifully with his characteristic paintings which show, amongst other things, an Adelie Penguin creche alongside Borchgrevink's hut, just as we found a few weeks later in the season, together with views of the striking and long remembered profile of Cape Adare itself. His words sum up not only the emotions and impressions of a zoologist of 1902 but also those of another zoologist landing there 63 years later beholding the same sights with his own eyes but with a less facile pen and sketchbook.

"9 JANUARY 1902

A day to be remembered, for we landed on Antarctic continent, at Cape Adare, Camp Ridley, where Bernacchi had lived so long with Borchgrevink. About 5 pm we at last rounded Cape Adare and could see past two rocks (the "Sisters") the flat triangle of shingle on which stood the huts of the *Southern Cross* Expedition and some millions of the Adelie Penguins. Such a sight! There were literally millions of them. They covered the plain which was nearly 200 acres in extent, and they covered the slopes of Cape Adare above the plain, to the very top, and were [over 1000] feet up from the plain. The place was the colour of anchovy paste from the excreta of the young penguins. It simply stunk like hell, and the noise was deafening. There were a series of stinking foul stagnant pools, full of green confervae, and the rest of the plain was literally covered with guano. And bang in the centre of this horrid place was the camp with its two wooden huts, and a midden heap of refuse all round and a mountain of provision boxes, dead birds, seals, dogs, sledging gear, ski, snow shoes, flags, poles and heaven only knows what else."

[Wilson 1966: 93]

In 1956, attempts were made to land on Ridley Beach from the ice breaker USS *Edisto* but without success. Austin (1957) has related the dramatic events including a helicopter rescue in high winds during two attempts to get ashore on 9 and 10 February 1956. He had to content himself finally by viewing the penguin rookery through the ship's glasses. He estimated that there were "... at least 75,000 and perhaps more than 100,000 breeding pairs of Adelies" (Austin 1957: 19).

The next visitors known seem to have been a party from the U.S. icebreaker *Staten Island* which called at Cape Adare in January 1959 with Sir Raymond Priestley, last surviving member of Scott's Northern Party (see Priestley 1914, 1962) aboard. Dr D. C. Thompson (1959), now of the N.Z. Meteorological Service, has given an account of this historic visit, the first recorded landing since Priestley's own last day in January 1912. From 12 January to 3 February 1961, Brian Reid, now of the Wildlife Service of the N.Z. Department of Internal Affairs, accompanied by Dr Colin Bailey, made a survey of the penguin rookery (Reid 1962), having been landed from the icebreaker *Eastwind*.

A visit may have been made to Ridley Beach in 1962 during the "Topo West" tellurometric survey of northern Victoria Land carried out from Iroquois helicopters by the United States Geological Survey between 1 and 28 November 1962 (USGS 1963). At any rate, a Tellurometer Station was established at Cape Adare in 1961/62 (see topographical map NZMS 166, Sheet SR 59-60, 13). Later visitors to Cape Adare have been the joint U.S.-N.Z. Western Ross Sea and Balleny Islands Expedition in 1965 aboard the USS *Glacier* and a tourist party in 1971, led by the biologist Marie Darby, from the cruise ship *Lindblad Explorer*. In February 1973, S. Norman and L. K. Cairns landed from the USCGC *Burton Island* and made a preliminary survey of the condition and need for restoration of the historic huts (see Anon. 1973b: note — this account refers to a "New Zealand magnetic survey party" landing in 1964 but this may be a confusion with the 1965 USARP/NZARP Expedition of which no mention was made by the writer). Quartermain's (1963: 12-13, fig. 1; also 1960 etc.) account of these historic huts should be referred to by those wanting details of their history.



FIGURE 2 — Aerial view of Adelie Penguin rookery, Ridley Beach, Cape Adare. Historic huts lie inshore from single ice floe visible off western beach on left. The Scuba divers were off the point in the middle of the photograph and the Leopard Seal worked along the northern beach to the right of it, 26 January 1965.

Photo: E. W. Dawson

The flat area extending from Cape Adare itself to the west and forming a triangular projection of about a mile east to west and a mile and a half north to south extending into Robertson Bay (see Reid 1962: map 1, p. 99) is known as Ridley Beach originally named "Camp Ridley" from Borchegrevink's mother's maiden name. It lies, on an average, some 20 feet above sea level and consists of a stony, hummocky flat of nearly 300 acres with many small ponds filled with thawing ice, mud and penguin debris and excreta during the summer and, as so well described by Wilson in 1902, Adelie Penguins cover the flat during their breeding season and provide a memorable sight especially from the air (Fig. 2).

No report has yet appeared on the ornithological work of the joint USARP/NZARP Expedition of 1965, apart from a short general narrative by Robertson (1965), so that the latest reliable figures for the Cape Adare Adelie Penguin populations are those of Reid (1962): breeding pairs at 289, $400 \pm 3.0\%$ with non-breeders representing nearly 20% of the breeding population, the estimated total population being ($\pm 3\%$) 695,000 birds. Levick (1915) estimated the population at 750,000 birds and Austin (1957) at 75,000 to 100,000 as listed by Taylor (1964: 561, table 1). Norman and Cairns (Anon, 1973b: 304) gave the number of penguins in February 1973 as 50,000 but it was said that in "November, nesting time, this figure could rise to more than 200,000." The estimates of Levick and Reid, both of whom were on Ridley Beach sufficiently long to make a detailed census, tally well enough to suggest that 700,000 birds live on this 300 acre flat in the season. These figures are important to recall if future investigators of Leopard Seal/penguin behaviour base themselves at Cape Adare and follow the techniques adopted by Hofman *et al* (1973: 196) at Palmer Station in which Adelie Penguin colonies "were censused to determine the number of penguins available as a potential food source for resident leopard seals."

THE VICTIMS OF PREDATION

The US/NZ Western Ross Sea - Balleny Islands - Macquarie Ridge Expedition, 13 New Zealanders and 8 American scientists aboard the icebreaker USS *Glacier* (Cdr (now Capt.) Vie J. Vaughan, USN), left McMurdo Sound on 10 January 1965 and reached Lyttelton by way of the islands on the western edge of the Ross Sea, the Balleny Islands and zigzagging across the submarine ridge to the north to Macquarie Island and across the Campbell Plateau east of the Auckland Islands to New Zealand on 5 March (see Quartermain 1965; Forbes 1965). During this time two days were spent in Robertson Bay, an indentation beyond the western edge of the Ross Sea formed, on the east, by the Adare Peninsula ending in Cape Adare and on the west by the Pennell coast of Victoria Land (see topographic map NZMS 166/SR 59-60, 13 Cape Adare, 1:250,000, 1st ed. Nov. 1968), lying some 500 miles to the north of the United States and New Zealand bases in McMurdo Sound. On 25 January 1965, the ship's helicopters were kept busy

ferrying geologists and surveyors along the western coast as far as Flat Point and south to Duke of York Island. The ornithologists of the expedition also participated in these flights trying to locate and count penguin colonies. At the same time marine biologists aboard the *Glacier* trawled in Robertson Bay at stations, including a repeat of Station 220 occupied by the *Terra Nova* on 3 January 1912 on the day of departure of the Northern Party from Cape Adare, while others went ashore on Ridley Beach to collect marine invertebrates in company with entomologists who searched hopefully for Antarctic insects. On this day I was ashore from 1330 to 2113 and explored a good part of the shoreline of Ridley Beach as well as traversing much of the larger colony of Adelie Penguins occupying the flat above the beach. Next day, 26 January, a three-man diving team was put ashore on the northern edge of Ridley Beach to search for marine algae (see Zanefeld 1968) and I went with them from 0800 to 1030 to cover the coastline towards Cape Adare itself. Later in the morning I was able to fly over Ridley Beach and the long promontory of Cape Adare and make a photographic record of the penguin nesting area and the shoreline (Fig. 3).

Not long after being set ashore from the helicopter I was wandering along the strand line searching for marine invertebrates when I met the algologist of our expedition, Dr Jacques S. Zanefeld,

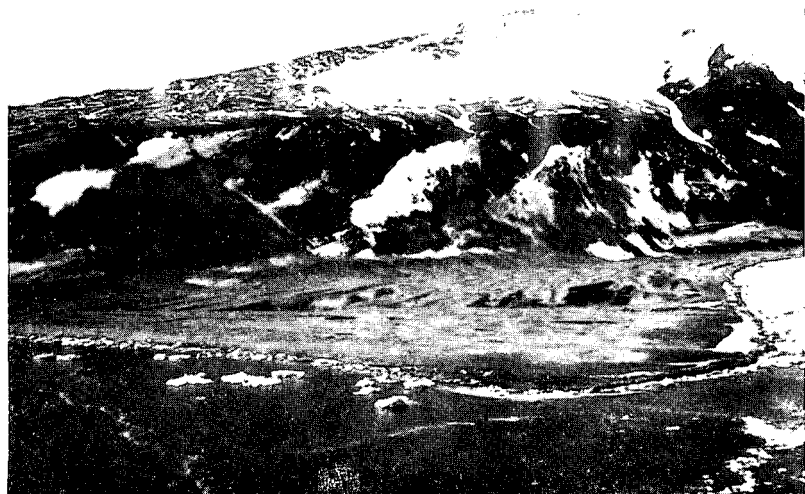


FIGURE 3 — Aerial view of coastline of Ridley Beach towards Cape Adare showing northern beach along which the Leopard Seal worked, 26 January 1965.

Photo: E. W. Dawson



FIGURE 4 — Side view of Adelie Penguin injured by Leopard Seal, fledging chick in background, Ridley Beach, Cape Adare, 26 January 1965.

Photo: E. W. Dawson



FIGURE 5 — Frontal view of Adelie Penguin injured by Leopard Seal, Ridley Beach, Cape Adare, 26 January 1965.

Photo: E. W. Dawson

of Old Dominion College, Norfolk, Virginia, with his two assistants, Jim Curtis and Jack Fletcher, struggling out of the surf laden with their scuba gear. They had been diving for seaweeds amongst the ice floes when they sighted a Leopard Seal, and, not wanting to provide a practical test of the alleged aggression of Leopard Seals towards Man, they fled from it as best they could. Moving along the water's edge, I met many groups of penguins coming equally rapidly out of the water, and I noticed, in particular a solitary bird walking out of the surf as my colleagues had but looking much more the worse for wear than they had done (Figs 4-5). The penguin was exactly as Levick had described in 1915 — "terribly injured . . . the skin of the whole of their breasts peeled away and hanging from them like an apron, and their breast muscles were bared and bleeding."

The penguin on Ridley Beach was indeed a gruesome sight, with a deep cut on the breast laying bare the sternum with streams of blood creeping over the otherwise uniformly white shirt front of the Adelie, a much more striking impression of injury than the blood-stained front sometimes seen which is caused by abrasion in travelling over rocky surfaces as Wilson (1907b: 41, fig. 34) has illustrated and quite different from the sort of injuries due to landslides described by Levick (1914: 103).



FIGURE 6 — Ice floes stranded along northern edge of Ridley Beach, Cape Adare, 26 January 1965.

Photo: E. W. Dawson



FIGURE 7 — Adelie Penguin with back injuries from Leopard Seal, Ridley Beach, Cape Adare, 26 January 1965.

Photo: E. W. Dawson

There were quite a number of ice floes close in to this gently sloping beach or stranded on it (Fig. 6), around which the Leopard Seal was seen swimming. Penguins were either clambering on to the floes or coming on shore in a steady stream giving some impression of the sort of "panic" which Stonehouse (1968: 59) has described. The surf was low and the sea generally calm and undisturbed except for some current movement, visible from the air (Fig. 2) at the NW tip of Ridley Beach. One other similarly injured penguin was seen after a little search (Fig. 7). This bird had its cut on the opposite side of the body, and, like the first bird (Fig. 8), appeared to be shunned by its neighbours, standing on its own away from the general group. The bird was seen at about 0930 on what was a bright, sunny morning, but one wondered how long this unfortunate bird would survive. Anthropomorphically feeling for the bird's condition, one admired the stoical expression it bore. However, as it moved up at a good walking-speed to the stony flat above Ridley Beach, nearby penguins stood back and once or twice formed a circle around it, seemingly disconcerted by its appearance, an interesting reaction recalling Murphy's (1936: 401) remark that "Sick or wounded penguins are never molested by their fellows" (cf. also Levick 1914: 105). Perhaps, following Murphy's and earlier remarks on the indifference of Adelies in seeing their fellows being killed, one might have expected not even so passive a rejection of the injured bird by its fellows.



FIGURE 8 — Injured Adelie Penguin shunned by its fellows, Ridley Beach, Cape Adare, 26 January 1965.

Photo: E. W. Dawson

STUDIES OF LEOPARD SEAL PREDATION

Irrespective of behaviour related to predation on penguins, there is relatively little known about the life-history and habits of the Leopard Seal which is a wide-ranging, circum-Antarctic breeding species straggling north to the coasts of South America, South Africa, Australia and New Zealand (Scheffer 1958: 120-121, fig. 11; King 1964: 168, map 23). Many writers have stated how infrequently Leopard Seals are encountered and, hence, observations and studies of the species have been quite limited. It is interesting to note some figures of observations of this animal, "swift and crafty, graceful beyond any other antarctic seal, and a devourer of penguins both along the coast of their breeding grounds and in the pack-ice" (as Murphy 1936: 414 called it) as they have been recorded in narratives of some of the well known expeditions.

Edward Wilson, reporting on the collections made by the *Southern Cross* Expedition, said (Wilson 1902: 71-72) — "Leopard-Seal was nowhere, and at no time, common. Two young ones were captured in the pack-ice on January 3rd. A male was killed at Cape Adare on December 22nd, and another was seen and successfully photographed [see photo, on p. 26, taken from Bernacchi 1901] by Mr Bernacchi, also at Cape Adare. They are therefore obviously rare at all times, though widely distributed." Bernacchi (1901: 206), himself, noted that they were "exceedingly scarce" during his long stay at Cape Adare, only the four specimens discussed by Wilson (1902) and by Hanson (1902) having been met with. Wilson (1907a: 27, fig. 22; 1966: 91) later recorded how only one Leopard Seal had been seen from the *Discovery* during her passage through the pack into the Ross Sea in January 1902. On the homeward voyage only two more were seen, near the Balleny Islands on 1 March 1904 (Wilson 1907a: 27; Wilson 1966: 345). Rudmose Brown (1913: 192) also found the Leopard Seal a solitary animal during the Scottish National Antarctic Expedition aboard the *Scotia* — "Three were seen together on one occasion only, and we never saw more in company." It is not clear from Levick's (1915) account of Adelie behaviour how commonly he saw Leopard Seals during his 10 months at Cape Adare nor what the relative seasonal abundance was but he has mentioned (1914) "a large number . . . gathered in the sea in the neighbourhood of the rookery . . ." (pp. 83-84), "With dozens of their enemies about . . ." (p. 84) and " . . . there were always many about " (p. 87). His notes suggest that he was more fortunate than most other observers in his opportunities and certainly luckier than the *Southern Cross* party had been at the same locality. Hamilton (1939: 259) stated, similarly, from the *Discovery* investigations in South Georgia — "A most striking characteristic is the solitariness of its life." He remarked that one may meet only three or four seals in steaming 30 or 40 miles through the pack ice and thought 10 recorded in one day by Worsley to be "quite an exceptionally high number." Indeed, Bonner & Laws

(1964: 182) concluded that the Leopard Seal might be only a "little less rare" than the Ross Seal, a rarely seen but not uncommon species as we, ourselves, found in the Ross Sea in 1965. Scheffer (1958: 5, table 1) gave a world population estimate of 100,000 - 300,000 Leopard Seals, contrasting with the estimate of 2 - 5 million for the Crabeater, 200,000 - 500,000 for the Weddell Seal and 20,000 - 50,000 for the Ross Seal.

A number of early observers apparently confused the identity of the seals which they met with in the Antarctic ice. In fact, the first illustration made of a Weddell Seal was captioned "Sea Leopard of the Orkneys" by Weddell in January 1823 in his *Voyage towards the South Pole* (Weddell 1827). Wilson (1907a: 27) has pointed out already that both Borchgrevink and Bruce frequently confused Leopard Seals with Weddell Seals in their narrative of the *Southern Cross* and the *Scotia* cruises respectively especially referring to Bruce's observations of "a great host, moaning loudly." Rudmose Brown (1913: 192) repeated Bruce's estimate that "the crew of the *Balaena* [one of the three whalers of the Dundee whaling expedition of 1892/93 to Grahamland in which Bruce took part] killed fully a thousand during December, January and February." Moseley, on the *Challenger* Expedition, had similarly mistaken the identity of a herd of 400 seals at Kerguelen. Gain (1913: 48), zoologist of the second French Antarctic Expedition of 1908/10 included the Crabeater (or "heron seal" as he called it) and the Weddell Seal as formidable enemies which "take for their nourishment an ample supply of [Adelie] penguins." It is interesting also to read in the diary of Nicolai Hanson, ill-fated zoologist of the *Southern Cross* Expedition, how he learned to distinguish the various species of Antarctic seals as he encountered them (Hanson 1902). Indeed, Bowdler Sharpe in a postscript (p. 105) pointed out that although four species of seals have been identified from the *Southern Cross* collections apparently six species were recognised as different by Hanson. However, such zoologists as Edward Wilson (cf. Wilson 1966) who were able to collect and examine specimens as their ship worked through the ice, were left in no doubt what the species were and soon learned to recognise the Leopard Seal, as we did on our *Glacier* cruise after collecting a 14-foot specimen which, as Robertson (1965: 76) has related, "gave all members of the party and crew ample opportunity to see why this animal is entitled to a large amount of respect."

Although this review is of Leopard Seal predation, it should be mentioned that some other species of seals (although not the Antarctic species confused by the early observers) feed on penguins. Stonehouse (1967) has summed up most of what is known —

"Fur seals (*Arctocephalus* sp.), sea lions of three genera, and phocid seals of five genera, inhabit penguin waters and nearly all, at one time or another, have been suspected of predation. The

only seal known to be a regular predator of penguins is the Leopard seal . . .

Penguins do not feature among the main foods of fur seals . . . except on Campbell Island, where the New Zealand *Arctocephalus forsteri* takes Rockhoppers in quantity . . . and perhaps also at Macquarie Island where the same species is currently expanding and taking increasing numbers of Rockhoppers . . . At Gough Island, Swales . . . saw *A. t. tropicalis* snapping at penguins on the beach and harrying them in the water; at Macquarie Island Hooker's sea lion *Phocarcos hookeri* takes Gentoos on the beach and in the water . . ."

[Stonehouse 1967: 171]

Maxwell (1967) made another summary of the feeding habits of other species of seal — The New Zealand Fur Seal, *Arctocephalus forsteri* (p. 43): "They also take Shags and Penguins, which they skin as do Leopard Seals"; Kerguelen Fur Seal, *A. t. tropicalis*, *A. t. gazella* (p. 46): "Both forms . . . are known to eat . . . Gentoo Penguins . . ."; the Southern Sea Lion, *Otaria byronia* (p. 61): "The food is similar to that of other species . . . and penguins"; the Australian Sea Lion, *Neophoca cinerea* (p. 65): ". . . the two staple ingredients of their diet are penguins and fish"; Hooker's Sea Lion, *Phocarcos hookeri* (p. 67): ". . . the sealions have been seen to chase and catch penguins which they take out to deeper water and tear apart." Conway (1971: 7-8) has since described the taking of Magellanic Penguins at Punta Tombo, Argentina, by Patagonian (= Southern) Sea Lions. Boswell (1972b) has brought together some recent observations of penguins as prey of the South American (= Southern) Sea Lion that "suggest the habit may be more frequent and widespread than the literature indicates." Rockhoppers, Gentoo and Magellanic Penguins are recorded as prey of sea lions and Boswell's (1972b) own observations and movie film (Boswell 1972a) of the taking of rockhoppers at Staten Island, Tierra del Fuego, have provided a most useful record of the behaviour of this species of seal which will be valuable for a direct comparison with Sladen's (1957) film of the Leopard Seal.

The pioneer work on the biology of the Leopard Seal was done during the *Discovery* investigations on South Georgia by Hamilton (1939), although Barrett-Hamilton (1902) had already provided a valuable report on what was then known, based on the *Southern Cross* collections, and including the discovery and investigation of the species, a detailed synonymy, description and discussion, to which Wilson (1907a: 26) later paid tribute. Further information on breeding, biology and population structure was given by Brown (1957) based on his 4-year study at Heard Island but, although he analysed stomach contents, no information was given about predatory behaviour towards penguins despite the length of his field operations. Kooyman (1965) has more recently provided a well-illustrated popular account of the

life and behaviour of the Leopard Seal at Cape Crozier in the Ross Sea. A particularly good brief summary has been given by Bonner & Laws (1964: 182-183) and the summaries compiled by Scheffer (1958: 120-122) and by King (1964: 70-71) indicate many of the gaps in our knowledge of this species of seal. Recent reports from participants in the United States Antarctic Research Programme show that the Leopard Seal is still a difficult animal to study in the field despite modern techniques, sophisticated equipment and greatly improved logistic support.

Even with the seeming rarity of the Leopard Seal and the early confusion with other Antarctic species, enough observations have been made of its association with penguins to build up a picture of its predatory behaviour in general terms. Perhaps the best overall impression at present available is that lucidly given by Richard Perry (1973) in his latest popular natural history book, *The Polar World*, in which he has devoted a chapter to "Penguins and their Enemies" based on many of the original accounts discussed here. Perry's book, despite the harsh criticism levelled at it by a recent reviewer (Fraser 1973), has a quality, rare in books of this sort, in that he documents his sources of information with a useful bibliography.

There is no doubt that penguins, Adelies, Chinstraps and other species including the Emperor, form a significant part of the diet of Leopard Seals at least at certain times of the year and in certain geographic localities according to the local conditions.

The Leopard Seal seen in the Ross Sea by Wilson on 7 January 1902 was shot, photographed, and preserved, as related in Wilson's diary (1966: 91), and was found to have a 3-foot skin of an Emperor Penguin in its gut. Rudmose Brown (1913: 193) stated — "the food of this seal seems to consist chiefly of penguins, which it chases with great ability under the surface of the water, and even catches on the ice." He recounted how he had seen a Gentoo Penguin seized by the leg from an ice floe in Scotia Bay (although Wilton in the Zoological Log (1908: 39) referred to this bird as a "black-throated penguin" i.e. an Adelle). Levick (1915: 75) cut open a Leopard Seal which he had shot at Cape Adare and "found its stomach distended by the carcasses of no fewer than eighteen penguins in different stages of digestion, whilst its intestines were stuffed with the feathers of many more." Murphy (1936) mentioned predation by Leopard Seals in the case of each of the several species of penguins discussed by him for South American waters, and a more recent comment was made by Strange (1973). Hamilton (1939: 260), recounting Ponting's story (1921: 200-201) of how he was pursued over the ice by an irritated Leopard Seal, supported Rudmose Brown's (1913: 193) observations in stating — "I have myself seen it run down and catch a ringed penguin in open water, an impressive demonstration of the speed of the mammal." He gave an analysis of the gut contents of 32 animals,

taken by various expeditions, in which penguin remains occurred in 8 cases. Seal carrion, fresh seal, squid, fish and crustaceans were also common. Bonner & Laws (1964: 183) called Leopard Seals "unselective predators of catholic tastes," based presumably on Hamilton's analysis. They also commented wisely — "There is a bias present, because most of the animals examined were taken in island groups at certain times of the year. More representative observations made in the pack ice and at other times of the year might show a greater proportion of fish and squid. The main point to make, however, is that the leopard seal, unlike other species, takes a great variety of prey, some of it very large." It is interesting, in passing, that the 9 cent stamp of the recently issued Australian Antarctic set depicts a Leopard Seal chasing a group of two species of fish, despite the strength of the legends about penguins (see Australian Post Office 1973).

Of more recent illustrations of predatory behaviour, since the observations given by Levick (1915), the outstanding one is undoubtedly that given by Sladen (1958) who filmed an encounter between a Leopard Seal and a Chinstrap Penguin —

"On February 25th, 1951, our ship R.R.S. *John Biscoe* had anchored in Sandefjord Bay, Coronation Island, and I was one of a small shore party chosen to inspect the F.I.D.S. hut and depot there. On the way back to the ship, our life-boat was pushing slowly through a belt of thick brash ice, just off-shore from a large Chinstrap rookery, when a tail and two penguin feet attracted our attention. They were sticking out of the ice in a most unusual manner. Dominican Gulls were circling above, but they did not land on the object. Suddenly it disappeared under the ice as though something was tugging it from below. I had a cine-camera in my hands and was able to record what followed. A Leopard Seal's head shot out of the water and flung a part of the carcass away from it. Subsequent analysis of this film [see Sladen 1957] showed a very quick movement of the seal's head, first in extension and then flexion, flinging what appeared to be the skin forwards with great strength. Before the head disappeared beneath the ice, the mouth opened wide to swallow what appeared to be part of the body. The skin floated away, and the Gulls swooped lower. A few seconds later the seal's head came out of the ice again and, with wide open mouth and astonishingly quick action, swallowed the rest."

[Sladen, 1958: 68]

Sladen noted also — "There are only a few records of Leopard seals actually seen killing penguins." A few other photographers have been almost as fortunate as Sladen in catching the Leopard Seal in the act and attention should be drawn to Curtsinger's (1969) illustration of a Leopard Seal at Cape Crozier mounting an ice floe on which a solitary Adelie is seen standing with its back to the would-be predator. Smith's (1969) colour photograph of a seal holding a successful catch is also quite remarkable.

Boswell's (1972a) film of a similar encounter of a Southern Sea Lion with Rockhopper penguins on Tierra del Fuego rivals Sladen's in its opportunism (see Boswell 1972b: 130-131).

Attempts are now being made to provide quantitative information on the numbers of Leopard Seals around penguin colonies and how they contribute to the overall mortality rates of both adults and chicks. It will be recalled that Levick (1915: 25) stated — "The sea-leopards congregate in the sea in the neighbourhood of the rookeries during the breeding-season, and *the number of adielies they kill and eat is almost incredible.*" [italics mine]. Sladen (1958: 5) said, in similar vein: "The only important predator at sea is the Leopard Seal. A study of available literature suggests that, like the Skua, the Seal's predation is selective, a healthy alert and experienced Adelie being able to outmanoeuvre the seal in the water. *The Leopard Seal takes a heavy toll of young when they enter the water.*" [italics mine].

There is, in fact, a great deal one would like to know about kill-rates, numbers and effects, if only to test the truth and significance of such a conclusion as reached by Levick. How significant is the toll taken by Leopard Seals in relation to other features of the ecology of penguins?

The first quantitative study of Leopard Seal predation on penguins was made by Penney & Lowry (1967). Their conclusions are worth reiterating and discussing here since they place my own casual observations in perspective and they give a basis for comparison of results from later work (Muller-Schwarze 1971). Between 21 January and 16 February 1965, Penney and Lowry made regular observations along a 100 x 400 yard study area on a beach at Cape Crozier, Ross Dependency, part of a breeding colony of about 300,000 Adelie Penguins. Noting wind, surf, and ice conditions, numbers of birds seen caught, killed or injured, and the number of Leopard Seals seen in the area over 64½ hours, they reached the following conclusions —

"Active predation, involving up to four seals, was observed during 58% of the time with average kill rates of 0.61 birds/hour. Predation rates increased with the height of incoming waves and also when landing penguins were encumbered by floating ice on the beach. Time of day was not found to influence predation rates. When young penguins began their exodus from the rookery in January, seals no longer preyed on adults. Seasonal depredation from Leopard Seals on the Cape Crozier beaches approximates 5% of the breeding population. The predators are thought to be utilizing a temporary, but abundant food resource."

One of the particularly interesting features of their report is the comparison of predation on adult and young penguins in the course of the breeding season. After the movement of young birds of the year out of the colony (beginning 30 January), all the observed predation was on young birds and, despite the fact that the seals were

seen to find the chicks an easier prey, the observed hourly rate for chick predation was only half that for adults. Penney & Lowry explained this as being due to the greatly decreased movement by adult penguins to and from the rookery in the short time period of about one week during which the chicks depart to the sea. In the 26½ hours of observation of young penguins, there were also 6½ hours over which the numbers of chicks leaving the breeding area had reached very low numbers. Nevertheless, Penney & Lowry remarked — "Young penguins usually enter the water along with groups of adults, but due to their slow surface swimming, they become easy prey as they are outdistanced by the adults." They commented that their predation rates (30 kills of adults at 0.78 kills/hour and 9 kills of young at 0.34 kills/hour) are a little misleading." It is clear that the behaviour of the birds in the particular field conditions is a very necessary factor of interpretation of such statistics.

Although Penney & Lowry made counts of — "(1) Number of carcasses afloat; (2) Number of obviously seal injured penguins ashore; (3) Numbers of birds obviously injured before or during landing mishaps in heavy seas," their study was of kill rates based on either on kills actually seen or on carcasses afloat in the study area. They quoted W. Emison's observations of 23 January 1966 along 200 yards of beach in which 32 dead or injured birds were found in a 24 hour period. Of these birds, 5 were dead from ruptured stomach due to ice crushing, 14 had broken legs, 11 had seal wounds on the neck and 2 more had deep seal wounds on the abdomen. In contrast, Penney & Lowry found 12 adults in their study area with a serious injury due to ice buffeting, but only 2 birds with "obvious injuries from Leopard Seals." No photographs of dead or injured birds, from either ice or seals, were given.

A later quantitative study, and the only other one so far published in any detail, was made in 1969/70 in the same general area at Cape Crozier and has been reported on briefly by Muller-Schwarze (1970: 270-275, tables 1-2) in his long summary of post-1964 studies on the behaviour of penguins and seals in which only a few pages are devoted to Leopard Seal predation and the antipredator behaviour of the penguins. Over the summer of 1961/70, up to six Leopard Seals were seen simultaneously working along the beaches of Cape Crozier, patrolling at distances of 5 to 100 metres from the shore. Based on about 45 hours of observations in October to December 1969 (Table 1), it was found that the success rate of the seals' predation depended on environmental factors such as ice conditions or tide. More penguins were seen to be attacked or killed at low tide (40% success, 2.3 attacks per hour and a kill-rate of 1 per hour over 6 hours of observations) than at high tide (35% success, 1.3 attacks per hour and a kill-rate of 0.43 per hour over 15 hours) because when attacked, the penguins could not jump to safety on the 2-3 metres high overhanging

ice foot. Early in the summer (October to early November) when heavy and continuous ice covers the coastal waters, the seals have to push their way through the ice from below to attack the penguins (cf. Muller-Schwarze 1972: Fig. 8). Under such conditions the seals were found to be less successful, the frequency of attacks being greater at 4.9 per hour but the success of 7.5% at a kill-rate of 0.37 per hour over 24 hours of observations. The kill-rates found by Muller-Schwarze (Table 1) were much the same as those found previously at Cape Crozier by Penney & Lowry (1967).

Muller-Schwarze also noted "peculiar temporal relationships between the activity times of the predator and their prey." His analysis of "Relations between the activity levels of leopard seals and Adelie Penguins at Cape Crozier in 1969" (Table 2) shows that when most of the penguins (taken as 100%) were in the water, i.e. between 8 am and noon, the activity of the seals was only 52% (24 active, 22 resting). Conversely, at the time when most of the seals were active, between midnight and 4 am, only 25% of the penguins were in the water. Presumably these are cumulative totals derived from the observations of the "up to six" seals seen simultaneously during the summer. Such a tendency towards "nocturnal" activity (in the daylight of the Antarctic summer night!) has been shown also for the Weddell Seal which is not a predator of penguins. Muller-Schwarze suggested, however — "This apparent paradox can perhaps be interpreted as a different dispersion pattern for seals in the ocean, possibly in relation to dispersion of penguins." I am not sure that I understand what Muller-Schwarze meant by this, but he concluded — "At any rate, it shows how misleading any one parameter may be, if used alone." Nevertheless, such a demonstrated inverse relationship between levels of activity of predacious seals and their penguin prey become significant when attempts are being made to assess the likely effects of such predation on penguin populations.

DISCUSSION

Some consideration still needs to be made of the old story of the "callous" penguins as Burton called them. Following Levick's (1914: 74-78; 1915: 72) descriptions of the "play" of penguins at Cape Adare, Murphy (1936: 399) gave the clue for the interpretation of this spectacle by saying — "The sea and its ice are their playground. Here the bands of birds play tag ["touch-last" in Levick's terminology!] and also use the floes in the tideway as excursion boats. Sometimes they crowd on, amid much bantering, until the embarking of each new bird means the pushing off of another on the far side." Quite definitely more observations are needed of such play and how it varies especially according to the real or imagined presence of a predator. Patterns of behaviour of both adult and first-year birds might be able to be distinguished and lend themselves to a more precise ethological analysis as, indeed, Murphy (1936: 339) had hinted at when discussing Levick's "excellent records" from Cape Adare.

It is clear also that more observations are necessary of the predatory behaviour of Leopard Seals as well as of the antipredation measures taken by the penguins themselves, and how innate or learned such responses might be, not only under various physical conditions but also throughout the breeding season and in contrasting times of the year when both penguin and seal populations have moved away from the shore. For example, Stonehouse's (1968: 57, 60) comments on the differing behaviour of penguins according to the degree of patrolling of beaches by Leopard Seals in winter (when the seals were not breeding and more in evidence off the beaches) and in summer (when the seals were away on the ice and penguin behaviour was less interrupted by panics or alarms) may be true only for such lower latitude polar regions as South Georgia where he made these observations. It seems well established that Leopard Seals are found along the Antarctic coasts in numbers only in the summer and that they move further north towards the subantarctic islands in winter and spring with numbers building up to as much as 600 at places like Heard Island (Brown 1957). Little is known of their breeding areas, reproductive behaviour or the movements of non-breeders or immatures but the young are thought to be born on the pack-ice and some difference in dispersal of adults, juveniles and immatures might be suspected. Maxwell (1967: 97) noted: "The Leopard Seal does not migrate. Whilst many of the animals keep to the outer edges of the pack ice during the winter, others remain on the firm ice to the south, and still others stay near the sub-Antarctic islands such as South Georgia, St Paul and Macquarie."

Perhaps at Cape Crozier and at Cape Adare little or no activity of either seals or penguins would be seen by shore-based observers other than in summer when the penguins were breeding.

Interesting comparisons might be made with the habits and seasonal movements of such other seals known to feed on penguins to a marked extent, notably the South American or Southern Sea Lion (cf. Boswell 1972b).

The nature of the shores adjoining penguin rookeries seems to be specially significant. Although floes become stranded on the beach, Ridley Beach has a gradually sloping shore on the north side (where my observations were made — see Fig. 6) without any ice overhang or continuous ledge, other than on the derelict floes themselves, which would hinder penguins from coming ashore quickly. Hence one might expect some difference in behaviour and mortality rates between birds at Cape Adare and Cape Crozier. The Palmer Station area where the latest studies have been made doubtless has its own particular physical characteristics also.

The Leopard Seal is certainly a rarely observed animal, at least by comparison with the Weddell Seal, as a study of the literature

and one's own field experience show. Opportunities for seeing seals amid the pack ice may well have been no less in the days of slow-moving expedition ships than with the increased height and airborne facilities now available on the modern ice breakers. Information is still required about the locations of breeding areas of Leopard Seals, particularly in relation to food sources such as penguin rookeries and more details on seasonal dispersal would be welcome. Analyses of gut contents, especially from animals taken in the pack ice, need to be made whenever the chance arises and must be related to available food supply both geographically and seasonally. It is surprising, perhaps, that the Leopard Seals do not frequent the precincts of penguin rookeries in greater numbers, even allowing for their solitary nature, wide-ranging habits and "catholic tastes," when it would seem that a ready food supply awaits them with plenty for all comers. All of Penney & Lowry's study concerned the activities of only four seals even if they have been credited with disposing of 15,000 penguins between them. Kooyman's observations at Cape Crozier on 30 December 1964 were of only four seals also and in my own very brief observations of some 1½ hours on 26 January 1965 I saw only one Leopard Seal. Penney & Lowry (1967: 881) suggested that possibly the Leopard Seals which "predate at specific rookeries around Antarctica are pioneering individuals which have learned to capitalize on a temporary resource." Might we, therefore, expect to find a gradual increase in predation rates as these pioneers lead the way for future adventurous seals?

In the case of the South American Sea Lion, Strange (*in* Boswell 1972b: 130) believes that "it is the odd rogue pushed out of a breeding harem which adopts this habit. I have yet to see a female or young seal taking penguins . . ."

If one takes statements that have been made by other observers or compilers one finds that such beliefs as "the number of adélies they kill and eat is almost incredible" (Levick 1915: 75), "What hope of escape has a Penguin when chased in the sea by one of these monsters?" (Barrett 1948: 60), "The Leopard Seal takes a heavy toll of young when they enter the water" (Sladen 1958: 5), ". . . it appears that the largest numbers of penguins are killed at a time of the season when the young penguins are leaving the rookeries, and at other times comparatively few are taken" (Sladen 1958: 69), "Penguins seem to be the main prey, but other birds and seals are also consumed" (Walker *et al.* 1964: 1312), "Since there are almost 100,000 of these animals off the Antarctic coasts, they must take a considerable toll of penguins over the course of a year" (Sparks & Soper 1967: 123), or ". . . near Antarctic and sub-Antarctic islands they tend to feed mainly on penguins, especially those resident throughout the winter" (Stonehouse 1967: 171) cannot, even at the present time, be substantiated by the qualitative evidence available. Some

of the more positive information is, in itself, questionable or at least capable of varying interpretations according to particular field conditions and localities such as indicated by the "nocturnal" activity of Leopard Seals noted by Muller-Schwarze and the predation rates thought to be "a little misleading" found by Penney & Lowry.

The effects of Leopard Seal predation on penguin populations have been revealed to some extent by Penney & Lowry in their study at Cape Crozier. "Extrapolating" their records of 30 observed kills of adults over 38½ hours and 9 kills of young seen over 26½ hours due to the activities of perhaps 4 seals, they conclude that 19 adult penguins are killed each day in the 100 yards of their study area. The West Rookery at Cape Crozier lies along 750 yards of beach and the nesting season lasts for some 15 weeks. They calculated, therefore, that the adult mortality would be about 15,000 birds which in a rookery of some 300,000 breeding birds would amount to a 5% mortality. Their estimate of chick mortality, based on an extrapolation giving a figure of about 860 chicks over a two-week period of going to sea, is also quite minor even if it is assumed that the "total production of departing chicks is probably one chick per breeding pair of adults." Nevertheless, these numbers indicate quite an active predation and an abundant food source for merely four Leopard Seals! At Cape Adare the northern beach (Fig. 3), along the whole length of which penguins move to and from the sea, is much longer at some 1740 yards with over 700,000 birds nesting behind it. If four seals patrolled this beach throughout the season as at Cape Crozier the effects on both the adult breeding population and on the chicks would also be minimal, and, indeed, I saw much more evidence of mortality from other causes as I walked through the colonies. With a much longer shore line to patrol the seals might be no more of a menace than on a closely packed area but there is no evidence, unless one reads more into Levick's account than he might have intended, to suggest that the number of seals would be proportionate to the length of the shore.

My observations at Ridley Beach were made some days too early, before the bulk of the chicks had fledged and taken to sea (Fig. 8). It would be interesting to follow the predatory activities of the seals once the majority of the penguins were moving offshore particularly to see if the increasingly wide dispersal of the individual penguins makes them less attractive as prey. Penney & Lowry concluded that — "Cape Crozier offers a unique opportunity for further study of this predator-prey system with emphasis on both behaviour and population ecology throughout an entire season." However, if logistic support could be obtained equally readily for parties to work at the Cape Adare rookery, the geographic setting there is undoubtedly even better than the "unique opportunity" presented by the Cape Crozier rookery. From the northern edge of Ridley Beach with its gentle slope penguin traffic to and from the sea would be easily observed and on the eastern

beach with its steeper, ice-overhung shore, a contrast would be given (Fig. 3). The long promontory of Cape Adare rising some 4000 feet above the penguin colonies on the flat gives an unrivalled vantage point (Fig. 9) from which the movements of both seals and penguins could be followed with not only optical aids but also some of the telemetric devices tried recently by the USARP team at Palmer Station.



FIGURE 9 — Cape Adare and eastern end of northern part of Ridley Beach. The grave of Nicolai Hanson, zoologist of the "Southern Cross" Expedition, who died 14 October 1899, the day the penguins returned to the rookery, lies on the highest part of the promontory on the right. 26 January 1965.

Photo: E. W. Dawson

In conclusion, it is important to stress the point on which the present review of penguin/seal relationships is based, i.e. the role that chance or opportunity may play in allowing such biological phenomena as have been illustrated here to be seen in the field. This is well shown by the recent report of the USARP team from the University of Minnesota and Utah State University making "an integrated study" of the inter-relationships of leopard seals and Adelie penguins in the vicinity of Palmer Station on the Antarctic Peninsula (Hofman *et al.* 1973). "The study area was selected to provide contrast with sites on Ross Island, where most penguin-leopard seal interactions have been observed" but seal predation near Palmer Station appeared to be "less than might have been anticipated." With a great deal of expenditure in time and logistics, together with elaborate preparations and techniques involving underwater television, 16mm

movie photography and radio telemetry with seals previously caught and drugged, it must have been very disappointing for these investigators to have to report that —

“Leopard seals were frequently seen patrolling areas inhabited by penguins, but only two kills and three unsuccessful attempts were observed. Fecal analysis suggested that the primary food source of most of these leopard seals was krill. The early arrival of UNS *Mirjak* (February 6) resulted in the premature termination of the project before the Adelie fledglings entered the water. Predation may have increased when young birds left the rookeries, but the actuality remains an unknown.”

[Hofman *et al.* 1973: 197]

My brief visit to a similar penguin terrain gave me an opportunity of seeing and providing some illustrative evidence of such predation. It is a fine example of how fortunate one may be in seeing, quite casually, something that may be rarely encountered even by those who are able to spend considerable time over their observations.

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E. W. Dawson,
N.Z. Oceanographic Institute,
DSIR,
Wellington

[A visit early in 1974 to Cape Adare by a party from the *Lindblad Explorer* has been reported on by Baden N. Norris who was appointed as a temporary ranger by the Lands & Survey Department to supervise tourist activities (see NORRIS, B. N. 1974. Antarctica's first burial in the 'banana belt.' The Press [Christchurch], 27 April 1974: 12, 2 figs.) — E.W.D.]