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DAILY MONITORING AND AERIAL CENSUS OF PENGUINS AND SEALS IN ANTARCTICA

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Abstract

In Antarctica, five aerial census sorties were conducted to record penguin and seal abundance, habitat occupancy and distribution in ca. 34 nautical miles (nm) along the west, and 35 nm along the east shelf. Six habitat types were identified in relation to the perceived value to penguins and seals viz. shelf, sastrugi, fast ice, pack ice, ice bergs and polynea (shelf was further classed into two and fast ice, into five habitat types). (Discussion regarding habitat are mainly in reference to visibility during sorties and not to habitat use per say). The proportions of fast ice, pack ice and sastrugies were found to be highly dynamic. While the proportion of the former two declines as the summer advances, that of the latter increases. Species abundance trends differed significantly (Chi sq. test, $p<0.0001$) in the five sorties. Taking the largest numbers of any species seen during a sortie to the east and west, Adelie penguins dominate (597 individuals), followed by Emperor penguins (565), Weddel seals (285) and Crabeater seals (140). West shelf areas consistently had higher abundance of penguins and seals (Mann Whitney U test, $p<0.05$), this area also had a greater availability of fast ice, pack ice and sastrugies. In the early summer Weddel Seal and Emperor penguin were the most dominant species while later in the season Adelie penguins became most dominant. Weddel seals probably migrated out of the region during February with the depletion of fast ice, their preferred habitat while the other species largely shifted to the newly available habitats i.e. sastrugi, eroded shelf and ice bergs. An influx of Adelie penguins seems to have occurred during the fourth sortie when their highest numbers were recorded. It is also possible that the high numbers were due to the peak in the moulting, as during that period penguins do not enter water. Hence, the major reason for the variation in numbers of animals seen seems to be the dynamic ice habitat that is used for basking by the animals. The prevailing weather conditions, dial activity pattern, the moulting period and the low sample size (no. of sorties) also affect the number of animals' seen, thus causing variations in counts. Some corrective measures have been suggested and it is stressed that these factors be further investigated to develop, correction factors for abundance estimates.

Introduction

• Antarctica has a unique assemblage of flora and fauna. These are unique in their adaptations to the extremes of the polar environment. The Antarctic region is home to 21 mammal species which include 6 species of seals and 15 of whales (Bonner, 1985) and about 45 species of birds (Siegfried, 1985). Till recently the Antarctic environment was unspoilt, but now human activity and commercial interest in Antarctica are on the rise. Over 20 nations have their permanent stations in Antarctica who invariably pollute their surroundings (May, 1988). Instances of oil spills and tourist inflow into the continent in the recent years have increased. These ventures may disturb the ecological balance of the area unless special interest is taken in understanding the impacts and protecting wildlife and the environment. The fauna of Antarctica is influenced by human activities undertaken in the Antarctic and Sub-Antarctic zones. The over-hunting of whales in these waters left penguins and seals as the largest group of animals feeding on krill and the abundance of some penguin and seal species is said to have increased (Watson, 1975; Bonner and Walton, 1975; Bonner, 1985; Laws, 1993). The subsequent ban on whaling in these waters is expected to affect penguin and seal abundance. Interest by countries in commercial krill harvesting and sealing are matters of direct intervention in the Antarctic ecosystem, which may result in changing abundance patterns of species. In such situations, it becomes difficult to assess the impact on wildlife because of lack of their baseline status (Goldsmith, 1992).

In contrast to studies by other countries, where detailed information on population status and ecology of Antarctic species is available (Viet and Hunt, 1991; Miller and Davis, 1993; Chappell, *et.al,* 1993a; Chappell, *et. al* 1993b; Laws, 1993; Young, 1994) our knowledge of these species is limited. Information on Antarctic wildlife in the region close to the Indian station (henceforth referred to as the India Bay region) is limited, except for some studies by the Zoological Survey of India from the 1st and the 11th Indian expeditions (Parulaker, 1982; Chattopadhyaya, 1995). Comparable studies in this region will help in a better understanding of the ecology of the species and help in devising better conservation measures. Also, it may warn us of certain localised impacts on wildlife of the region.

Keeping such issues in mind, the International Union of Conservation of Nature and Natural resources (IUCN), the Scientific Committee on Antarctic Research (SCAR) and the Convention for the Conservation of Marine Living Resources (CCAMLR) stress the importance of ecosystem monitoring (Annon, 1991; Laws, 1993). This includes the monitoring of penguins and seals in this region which are indicator species for the Antarctic ecosystem (Croxall *et al,* 1988; Laws, 1993).

There is a need to standardise methodologies for such studies for comparability of results. Also, there is a need to address the bias in counts induced by the diurnal activity (influencing the basking time, when animals can be observed and counted) and the dynamic ice conditions (which influence the basking site availability) (Laws, 1993). Status information not only helps in indicating ecosystem health, but is also crucial for any detailed ecological study.

During the 14th expedition, it was found that aerial census along the shelf was the most feasible monitoring technique and penguins and seals were the best indicator species representing the Antarctic environment and were most suitable for monitoring (Sathyakumar, 1995).

Objectives

1. To examine the habitat relationships of penguin sand seals in Antarctica.
2. To standardise aerial census techniques used in Antarctica.
3. To determine the relative abundance of penguin and.seaf species in the India Bay region of Antarctica.

Study Area

Geographical information

India Bay (ca. 69° 56' 85" S and 11° 52' 58" E) forms the base for the Indian expeditions ship and as the helicopters for aerial census sorties are kept on board, is most suited as the base for scientists from the Wildlife Institute of India (WII). A total stretch of about 50 nautical miles (ca. 95 km) on either side of the India bay is the region monitored by WII for penguin and seal abundance (western limit ca. 10° 47' E and eastern limit ca. 13° 28' E). This is the stretch which can be monitored within the constraints of the helicopter— fuel capacity and observer fatigue.

Climatic information

Details about the climate of Antarctica can be found in Watson (1974) and Eastman (1993). Weather data recorded during this Expedition at the India Bay are given in Appendix 3. Temperatures at india bay varied between a minimum of-14°C and a maximum of +5°C during the stay. The mean daily temperature were mostly in the range of -3° to -5°C. From 8 to 14 January, 1996, the maximum temperatures rose upto +4°C resulting in considerable increase in water channels on the shelf and, accompanied by storms, in the breakage of the shelf edge. The month of February had frequent storms lasting from one to five days at a time. There was a sudden drop in temperatures around 22 February, 1996 from a daily mean of about -4°C to -12°C, The sea started freezing in the first week of February with the formation of 'grease ice' and by the end of February 'platelet ice' had begun to form on the sea surface.

Species Studied

Penguins

Seven species of penguins occur in the Antarctic and Sub- Antarctic zones. These belong to three genera — *Aptenodytes, Pygoscelis,* and *Eudyptes.* The emperor (*Aptenodytes forsteri)* and Adelie (*Pygoscelis adeliae)* penguins largely breed in mainland Antarctica, emperors breeding farthest south on the fast ice through winter (Watson, 1975). These are also the species regularly found in the India bay region. The only other species was the chins trap penguin (*P. antarctica)* seen once during the 11th Indian Expedition (Chattopadhyaya, 1995). Stonehouse (1985) roughly estimates a world population of ca. 5 to 10 million Adelie and ca. 250,00 emperor penguins. Emperor penguins feed on marine crustaceans and fish (Watson, 1975) and Adelie penguins almost exclusively feed on various krill species (Croxall *et al., 19*88; Miller and Davis, 1993). Sexual dimorphism does not exist, except that the males are slightly larger.

Adelie penguins court and lay eggs during October-November and their young hatch by mid to late December. Moulting occurs on the shelf or pack ice between January and March (Watson, 1975), but was observed mainly during late February in the India bay region during this study. Emperor penguins court and lay eggs at the onset of winter, during May-June and the young hatch after a long incubation of about 60-65 days, in July-August. Moulting occurs between mid November to February (Watson, 1975). Most moulting in the study area occurred in late January. Further biological details about penguins can be found in Watson (1975) and Grizemek (1972).

For the purpose of aerial counts some quick identification features of the two main penguin species occurring in the monitored region, i.e. Emperor (EP) and Adelie (AP), are as follows :

Emperor penguins are more than double the size of APs, and have a distinct, slower gait while walking on ice. The tobogganing on ice is also slower with head held up straight, and with more graceful movements compared to APs. EPs have a distinct white to orange cheek mark that merges with the white of the chest. The smaller, Adelie penguins have a quicker, almost comical walk and tobogganing style on ice.

Seals

Seals are included under the order Pinnipedia, and were till recently classed under the order Carnivora (Laws, 1993). There are seven species of seals occurring in the southern oceans, of these, four are truly Antarctic species, i.e. they occur south of the Antarctic circle. These are the Ross *(Ommatophoca rossi),* Weddell (*Leptonychotes weddellii),* Leopard *(Hydrurga leptonyx)* and Crabeater seals *(Lobodon carcinophagus).* In the Indian bay region, Ross seal has never been spotted.

The crabeater seal is the most abundant seal in the world, numbering ca. 14,858,000 individuals. Weddell seal is common (730,00) while the Leopard seal *(Hydrurga leptonyx)* which preys on other seals and penguins is rarer (222,000) (Bonner, 1985).

Females are slightly larger than male's in these species. Besides this, there is little sexual dimorphism between the two sexes. Further details on pinniped biology and behaviour are discussed in Grizemek (1990), Laws (1993) and Renouf(1991).

Some of the important field characters distinguishing the weddell (WS) with the crabeater seal (CE) are as follows (based on Lauw, 1993 and personal observation):

Weddell seal is bulkier, 'barrel' shaped and with a shorter muzzle. The pelage colour is mostly dark with slightly paler underparts. The underparts are often mottled with large patches. WS moved with a slow and 'humped' motion. When disturbed by the sound of the helicopter, WS often 'saluted' i.e. reared on its side and raised one flipper.

Crabeater seal has a more streamlined body with a prominent snout. They have a large variation in colour, ranging from almost cream, brown to silver grey (Laws, 1993). Occasionally, individuals may have some mottling, but the patches may never be as large as in WS. CE move with ease on ice in usually 'snake like' pattern. When disturbed, CE typically show a 'pointing' behaviour, with muzzle pointing upwards.

Habitat types

During the 14 expedition, four broad habitat types were identified for Antarctica, the maritime, polynea-pack ice, ice shelf and mainland habitats (Sathyakumar, 1995). With a view on value to penguins and seals, 6 habitats with 8 sub-habitats (for two of the habitats) have been identified during this study, based on Watson (1975) and Laws (1993) as detailed in **Table-6. Fig.4** shows a schematic representation of these habitat types and the discussion deals with the perceived value of the habitats for the penguin and seal species. It is

Table 6 : Wildlife habitats identified in the monitored area

HABITAT	SUB-HABITAT
Shelf (SH)	**Shelf, Shelf eroded**
The thick ice sheet covering the Antarctic coastline formed from glacial movements. It is a more or less permanent feature. The sea-ward edge gets eroded as summer advances.	
Sastrugi (SA)	
Wind accumulated snow in cracks of the shelf, where fast ice doesn't break : forms a wavey substratum. Observed more in February & March.	
Fast ice (FI)	**Fast ici, ... ice-Shelf edge, Fast ice edge, Fast ice crack, Fast ice hole, Standard ice bergs.**
The continuous sheet of frozen sea, about 3 m in thickness, adjacent to the shelf. Observed during January but progressively broke off as summer advanced.	
Pack ice (PI)	
Broken, drifting chunks of fast ice, measuring from 3 m to almost 300 m in length. Drifts away, northwards as summer advances.	
Polynea (PO)	
Open sea, north of the shelf or fast ice. Main feeding area of all monitored species. Becomes available in a larger proportion as summer progresses.	
Ice bergs (IB)	
Broken off and floating mass of the shelf or Antarctic glaciers.	

being emphasised here that the term 'habitat' is used hitherto only in reference to basking, resting or moulting habitat and will not be any reference to the animals marine feeding habitat. It refers to the substrate. Habitat is widely known to influence animal abundance (Caughley, 1980) and in the present case we have a dynamic habitat. Besides, habitat also determines to detectability of the study animals. The study on habitat utilisation was hence, conducted in reference to animal visibility during the census data.

The dynamic habitat

Fast ice (FI) covers much of the Antarctic and Sub-Antarctic waters in winter (Watson, 1975; Eastman, 1993; Laws, 1993). As summer progresses, increasing temperatures and frequent cyclones (causing swell in the ocean) break up the fast ice (FI),' to fprm pack ice (PI). This PI eventually drifts northwards under the influence of local currents. As the season progresses, the smooth and large PI becomes, smaller in size and more irregular at the edges ('cake ice' : Laws, 1993). Later in the summer, little FI is available in some narrow bays and most of the PI either drifts away or occasionally may return alongside the shelf with currents. With the breaking up of the FI and drifting away of the PI; more open sea (Polynea) becomes available but the hauling out

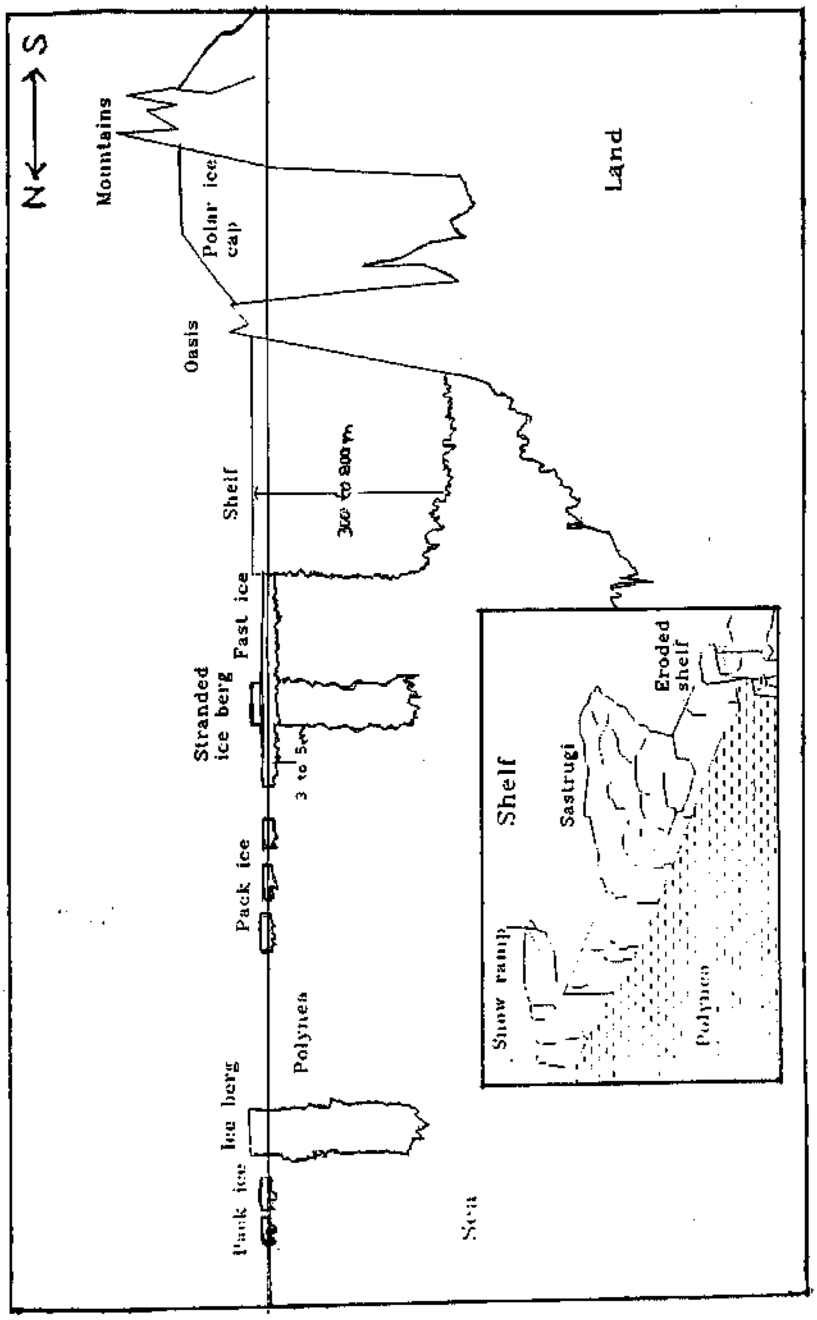

Fig. 4: *Schematic representation of habitat types in Antarctica*

areas for animals becomes progressively limited. By this time, however, the high temperatures and blizzards may erode the edges of the shelf and hauling out areas or ramps may appear in such areas. Sastrugies also form due to snow drift accumulating in the narrow bays with FI or sloping shelf edges.

Methods

Daily monitoring

Daily monitoring of wildlife species and their numbers around the ship in the Antarctic shelf region in relation to the presence of different identified habitat types was carried out in order to study any correlation between the two. Proportion of the identified habitat types in an approx. 4 km. radium circle was visually estimated from the bridge, at least on five random occasions daily and the species within this range were recorded with their numbers, approximate distance from the ship, sighting angle and habitat.

Aerial census

Five sorties, each, on the East (30 nautical miles) and West (ca. 20 nautical miles),of the Indian bay were conducted between 2 January, 1996 and 26 March, 1996 (Table-7). Aerial counts of penguins and seals in this region was conducted to obtain abundance estimates and habitat-use trends. The helicopter was usually flown at an altitude of ca. 300 feet and at a speed of ca. 70 knots,

Table 7 : Details of the aerial census sorties for penguin and seal population monitoring in the India bay region of Antarctica

Date	Direction	ca. Duration		Turn-around Longitude	%Habitat		Coverage^	
		hour	min,		FI	PI	S	P
3/1/96	West	1	54	11° 59'	35	5	30	30
4/1/96	East	1	32	13° 28'	5	20	40	35
15/1/96	West	1	33	10° 47'	30	10	30	30
15/1/96	East	1	05	13° 15'	+	15	40	45
31/1/96	West	1	35	10° 55'	10	20	50	20
31/1/96	East	1	00	13° 15'	+	25	50	25
17/2/96	West	1	15	10° 48'	5	+	50	45
17/2/96	East	1	13	13° 00'	+	+	50	50
26/2/96	West	1	15	10° 58'	+	+	'50	50
26/2/96	East	1	30	13° 00'	+	+	50	50

^ Rough estimates; '+' traces

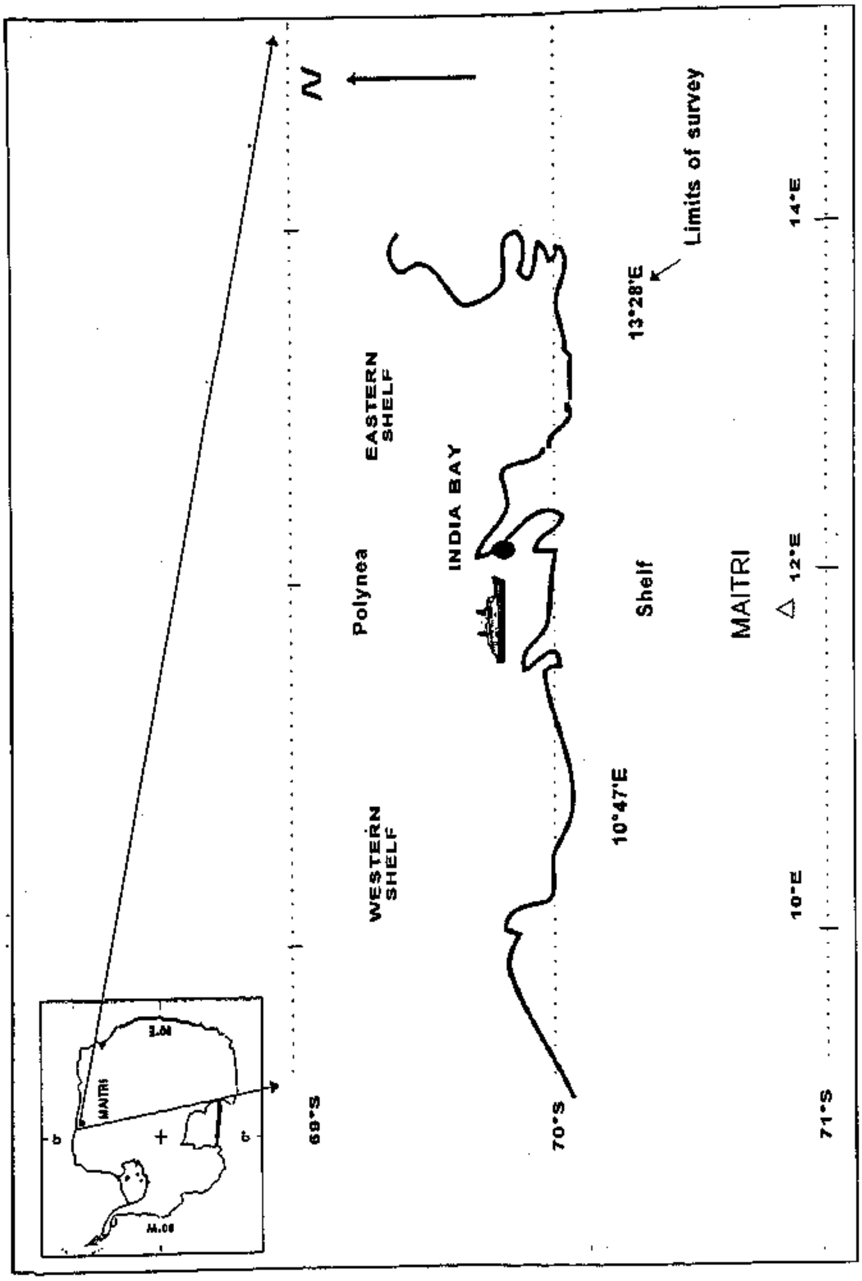

Fig. 5: The Antarctic study area

from where animals could be safely identified and there was minimal disturbance to wildlife. Apart from the author, the pilot, and one another observer in the rear seat counted animals. Species identification for each sighting was done by the author and dictated to another member along with data on species, numbers, habitat and co-ordinates (stored as waypoints in Magellan, ProMark V GPS). During the period when fast ice and pack ice was present close to the shelf, the edge of these areas was also counted on the return flight.

Problems and biases in techniques

Daily monitoring was done primarily from five sites were the ship moored. The data thus collected may lack independence. Further, the most abundant species, Adelie penguins seemed to be strongly influenced by the presence of the ship. Bulk (>80%) of their sightings were in the vicinity (<300 m) of the ship (more than 4 km being clearly visible). The reason for this behaviour is difficult to explain but has been widely observed (Grzimek, 1972; Watson, 1975).

The first aerial census sortie took a longer time as the author had to familiarise with species identification, the habitat and the counting conditions. Ideally, the sighting distance and angle for each sighting should have been recorded (Burhnam *et al.,* 1980). This was difficult owing to the moving, aircraft, time taken to identify and count the animals, note habitat and co-ordinates and above all, inability to judge distances without any reference for size. Using a strip transact was the only viable alternative but could not be followed partly due to the above reasons and partly due to the structure of the helicopter where markers could not be provided. Because of this problem, encounter rates have been calculated instead of density.

Aerial Census Results

Relative abundance of species

There was a significant difference in the animal abundance in the five sorties (Chi sq. test, $p<0.0001$). The number of animals, of each species, using the western shelf areas was consistently higher (Table-8) (Mann-Whitney U test used for each species, $p<0.05$). On the whole, Weddell seal and the Emperor penguins dominate in this region. If the maximum numbers for each species seen during one set of sorties, to the East and West is considered, there are at least 565 Emperor penguins (II sortie), 597 Adelie penguins (III sortie), 285 Weddell seals (II sortie) and 140 Crabeater seals (III sortie) inhabiting approximately 50 (ca. 95"km) nautical miles along the shelf in this region.

Table 8 : Encounter rates for each sortie. Encounter rates for sightings are expressed as sigt/km and for the numbers encountered on a sortie is expressed as No/km

species	Sortie 1		Sortie 2		Sortie 3		Sortie 4		Sortie 5	
	Sigt/ km	Mo./ km	Sigt/ km	No./ km	Sigt/ km	No./ km	Sigt/ km	No./ km	Sigt/ km	No./ km
WEST										
Adelie penguin	0.13	0.86	0.19	2.65	0.32	3.10	1.16	7.90	0.22	0.75
Emper. penguin	0.60	3.80	0.43	7.16	0.39	3.97	0.51	3.54	0.35	8.95
Crab-eatersseal	0.40	1.80	0.2.1	1.18	0.25	0.38	0.57	1.71	0.21	0.65
Weddell seal	0.70	3.70	0.38	3.70	0.17	0.49	0.06	0.06	0.03	0.08
EAST										
Adelie penguin	·0.00	0.00	0.15	1.05	0.14	1.68	0.15	1.52	0.29	1.77
Emper. Penguin	0.05	0.32	0.20	1.75	0.26	0.94	0.03	0.06	0.03	0.05
Crab-eaterseal	0.25	1.01	0.23	0.77	0.38	0.80	0.35	1.09	0.14	0.55
Weddell seal	0.40	1.97	0.35	2.23	0.10	0.26	0.04	0.04	0.03	0.06

Note : Also see Fig. 8 tor sortie-wise (east + west) encounter rates.

Encounter rates of the penguin and seal species were calculated by dividing the total sightings and numbers seen during each sortie by the total distance travelled, to obtain the sightings/km and numbers/km, respectively **(Table-7).** The trend for this is also similar to that of the total counts, in that the values for all species are higher in the western region compared to the eastern region, except for the crabeater seal in the third sortie.

Species abundance differed significantly in the five sorties (Chi sq = 1140, $p<0.0001$). **Fig.6** shows the overall sortie-wise encounter rates. In the last sortie, the numbers of all species, except EP declined remarkably. The abundance of CE and EP fluctuate without any discernible trend and the variation is comparatively low. Adelie penguin encounter rates steadily increased from about 0.4/km in the first sortie to ca. 4.7/km, in the fourth sortie and then declined to about 1.3/km in the last sortie. Weddell seals were abundant in the first two sortie (ca. 2/km) but declined to almost none by the last sortie.

Habitat occupancy by penguins and seals

Figs.7 (a to d) show the overall and sortie-wise habitat occupancy trends. During the early summer period (Sortie # 1 & 2), the range of habitats, available

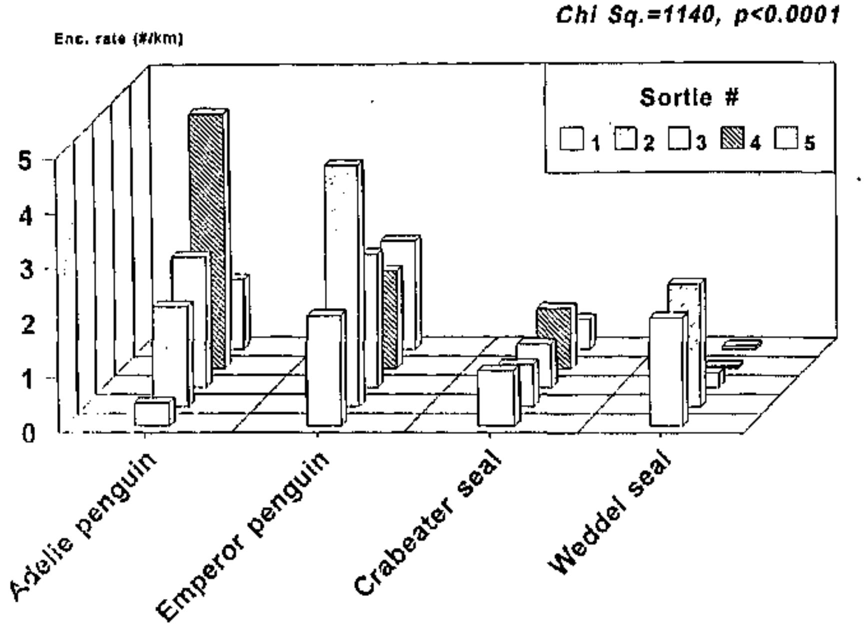

Fig. 6: Encounter rates of penguins and seals in ca. 95 km around the 'India bay' region

was limited to fast ice (FI), pack ice (PI) and some eroded shelf (SER), and the wildlife use was limited to these habitats. With the advance of summer, the FI and PI availability declined and the animals shifted to the newer habitats that appeared **(Fig.7).** Species-wise habitat occupancy trends, however, varied. In general, penguins used a wider range of habitat types, from the fast ice to the shelf **(Fig.7 a & b).** Seals ranged over a narrower range and their habitats included only the fast ice, pack ice, eroded shelf and sastrugies.

Adelie penguins **(Fig.7a)** depended primarily on fast ice (FI) in. the first sortie, shifted to pack ice (PI) in the second and then remained on the newly available habitats on the shelf (SH), sastrugi (SA) and eroded shelf (SER). Emperor penguins **(Fig.7b)** depended less on PI but kept using FI till it was available (Third sortie). Later they shifted to the SH, SA and SER. The use of ice bergs was high in the last sortie. Weddell seals **(Fig.7c)** congregated mainly on FI and in the later part on PI. Their use of SER was very limited, and was restricted to the last two sorties when their abundance was very low. Crabeater seal **(Fig7d)** was less dependent on the FI and used it mainly during the first two sorties. It primarily used PI, SA and SER during the last three sorties.

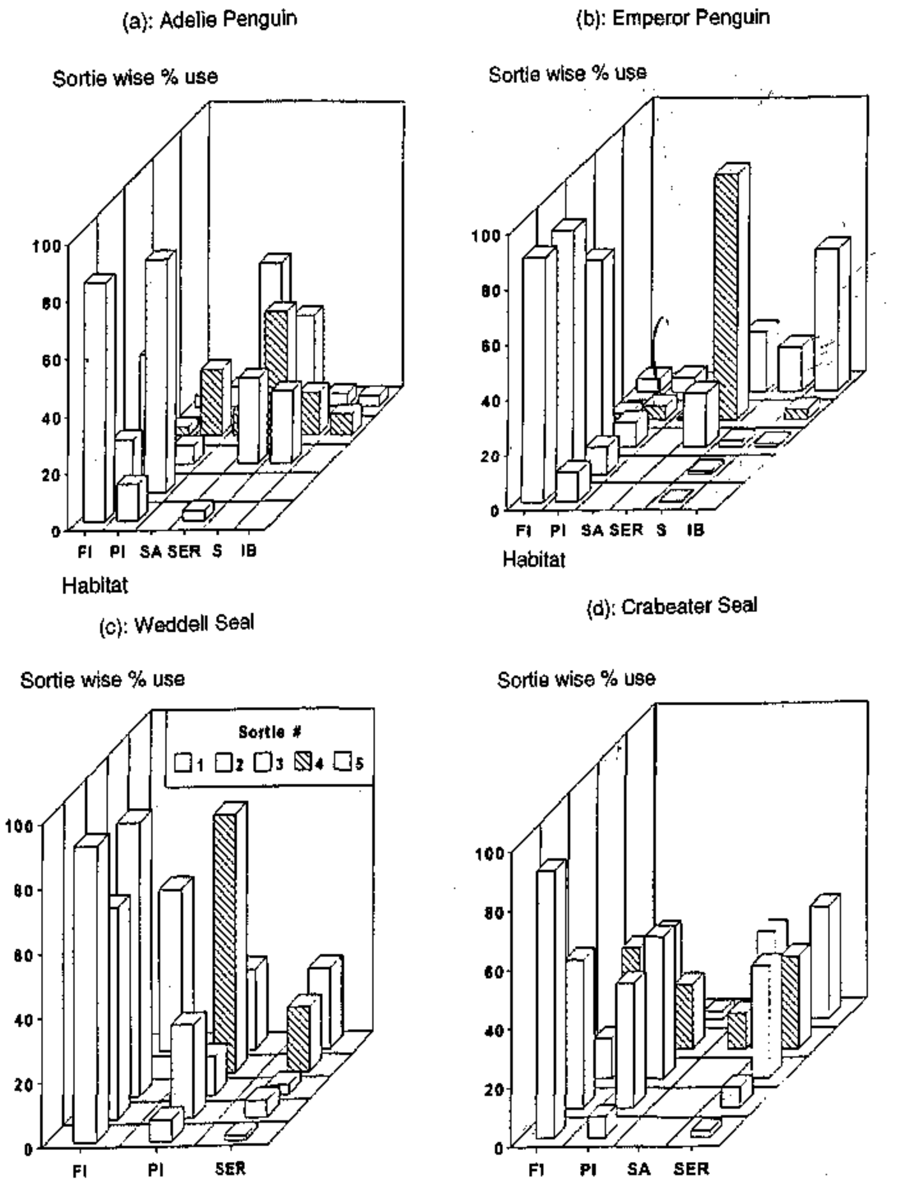

Fig. 7: Habitat occupancy trends of penguins and seals; a. Adelie penguins ;b. Emperor penguins; c. Weddell seals; d. Crabeater seals

Daily Monitoring Results

Penguins and seals are present in the polynea as that is their feeding habitat, but they are visible to us for monitoring only on the ice and very rarely on the polynea surface. This data suggests that penguin and seal occurrence is a function of the amount of fast ice available ($r=0.68$ & $r=0.42$ for penguins and seals respectively; $p<0.0001$). To a lesser degree it is a function of the pack ice ($r=0.27$; $p<0.01$: penguins; $r=0.36$; $p<0.001$: seals) and is negatively correlated with the amount of shelf ($r=-0.38$ & $r= -0.34$, respectively; $p<0.001$) and polynea ($r=—0.42$ and —0.33, respectively; $p<0.001$) available. Further improvement on this information will help in obtaining correction factors for the aerial census data.

Discussion

Abundance and habitat occupancy

Polynea is the habitat where the monitored species feed, but are difficult or sometimes impossible to spot. The ice covered areas, are ideal for spotting animals. Such areas are also necessary for the animals to come out of water to rest and bask. It may not be feasible or possible for penguins and seals to climb the steep shelf except when there is a snow ramp. Also, it may not be necessary to go away from the feeding area unless the animals are in breeding stage or moulting (when penguins can't enter water due to insufficient insulation) or when easier access to fast ice or pack ice is available. This reasoning holds true for the use of icebergs too.

If there is an extensive sheet of fast ice, animals are not expected to break through and climb on it, unless if there is a crack, a breathing hole made by Weddell seal, a broken border with the self, stranded ice berg or the fast ice edge. Hence, too much of fast ice or too little of it may not be conducive for animals. Animals can also climb on to pack ice with ease. They can rest/bask on the sastrugies when they form in the later part of summer. All these habitats were dynamic and changed for each of these 5 sorties (approx. figures for proportions is given in Table-7).

The high positive correlation of animal numbers with fast ice and negative correlation with shelf and polynea availability also indicates that animal numbers and 'sightability' by observers are a function of the availability of different habitats. The census figures, hence were expected to be not only a function of the diurnal activity of the animals, but also the proportion of each of the above habitats available at a given time.

The western shelf area, which had higher ice cover throughout, also had more wildlife, especially WS, AP and EP **(Table-8, Appn.3). Fig.6** illustrates the sortie-wise variation in encounter rates of penguins and seals. The abundance of species differed significantly across sorties (Chi sq. test, $p<0.0001$). Trends in case of the Adelie penguin and Weddell seal change remarkably in the five sorties. While AP encounter rates increase, those of WS sharply decline in successive sorties. There is a possibility of migration of AP and WS, prompted by the opening of polynea and some biological needs such as moulting.

Weddell seal decline can be clearly related to the loss of its preferred habitat, FI as also discussed by Condy (1977) and Laws (1993). They report WS using FI and dense pack ice areas, especially close to land. Crabeater seals were, on the other hand found to use open, outer pack ice areas, where access to water was more uniformly available. In this study area, however, the CE encounter rates did not show any remarkable increase in the later sorties but remained almost constant.

Adelie penguins showed a remarkable increase till the fourth sortie whereas emperor penguins did not show any drastic fluctuation during the five sorties. The peak in the number of penguins seen corresponded to their respective peak observed moulting periods when they do not enter water due to insufficient insulation (Watson, 1975). Most APs seen during the fourth sortie (17.2.96) were moulting and so were most EPs during the second sortie (15.1.96). Some moulting individuals of each species were, however, observed during all sorties. The phytoplankton bloom is the highest near the ice edge (Sakshaug and Skjoldal, 1989) and hence, between year variations in sea ice cover may influence the temporal availability of phyto and zooplankton. This may also contribute to inter year differences, as caused by habitat.

The points that emerge are that census figures are a function of:

a) the basking/resting habitat availability

b) the diurnal activity of animals

c) the moulting time and moulting habitat availability

d) the prevailing weather conditions

e) low sample size

As the habitat may change rapidly within a summer-study and also between years, correction factors need to be developed in order to reduce variability and facilitate better comparison between years.

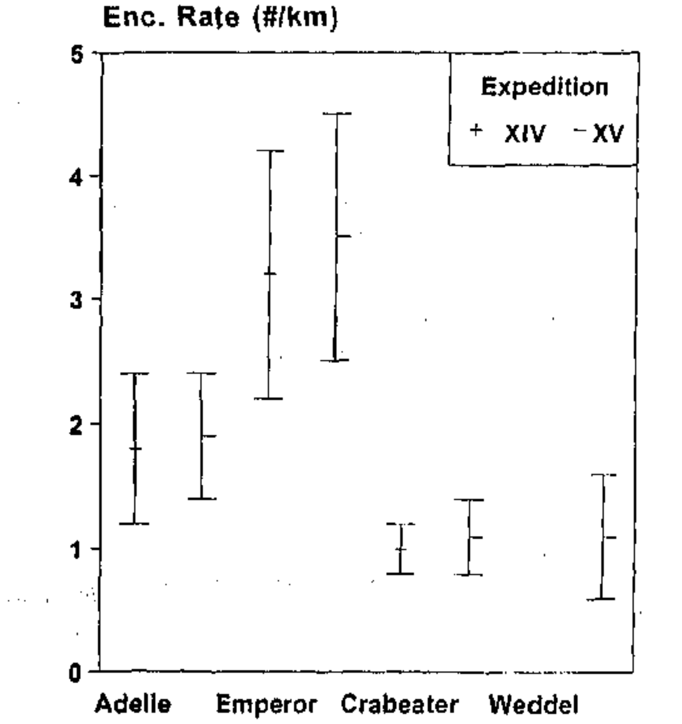

Fig. 8: Comparison of penguins and seal encounter rates during the XIV and XV expeditions

Comparison with 14th expedition results

The abundance and encounter rates of most species observed in this study were higher (Fig.8) than those seen in the 14th expedition (Sathyakumar, 1995), although not significant (Mann- Whitney U Test, $p>0.05$). Weddell seal numbers in the initial sorties was high this year, whereas they were not seen during the 14[1] expedition. Their numbers, this year declined sharply with the decline in fast ice and dense pack ice. The primary reason for these differences was probably a generally larger extent and late breakage and dispersal of fast ice during this expedition. The trend of the encounter rates of AP, EP and CE however, are strikingly similar in both the years i.e., Emperor penguins dominate in the region followed by Adelie penguins and then, the Crabeater seal (Fig.8). The western shelf had a significantly higher abundance of all species during both expeditions (Mann- Whitney U Test, $p<0.05$). It must be noted here

Table 9 : Mean and confidence intervals (CI) of penguins and seals seen in the ten sorties based on (a) total animals seen, and (b) encounter rates for each sortie. Note the high variation in the data, as indicated by the CV value.

Species	Mean & 95% CI	CV (%)	Min.	Max.
	a) Based on total # seen			
Emperor penguin	161±104	90	227	565
Adelie penguin	135 ±100	103	54	597
Weddell seal	58 ± 94	161	6	285
Crabeater seal	54 ± 22	68	71	140
	b) Based on encounter rates			
Emperor penguin	3.5 ± 2.3	91	2.47	4.69
Adelie penguin	1.9 ± 1.0	75	0.88	6.12
Weddell seal	1.1 +-1.1	150	0.05	4.13
Crabeater seal	1.1±0.6	75	0.77	2.11

that with the current level of high variations in abundance estimates, it is unlikely that significant differences will ever be observed between years.

The problem of high variations, within and between years

Table-9 highlights the problem of high variation in the estimates for mean population size and encounter rates. These are too high for good comparison between years. As discussed, the prevailing weather conditions, the dynamic habitat (both between years and between one sampling season) and the time of the sortie (depending on the diurnal activity patterns of species) and the low sample sizes possible, limited by the number of sorties available, may affect numbers encountered in sorties and are the main causes of variation. Also, if a sortie coincides with the peak moulting period of any penguin species, it is likely to yield a high number of individuals. These problems need to be urgently addressed to, in order to obtain robust estimates of animal abundance and facilitate comparison between years.

Recommendations

Aerial census *in Antarctica*

Various problems encountered related to aerial census have been discussed. The main recommendations are :

1. A reconnaissance flight should be provided for the members from WII to familiarise with the habitat conditions and animal identification.
2. In order to come up with density estimates fixed width transact (Caughley, 1980) should be attempted. Animals occurring within the

strip defined by markers on the wind screen of the helicopter should be recorded.

3. The high variations in the animal numbers seem to be caused mainly by low sample size (number of sorties) and the dynamic habitat. Within year variations may be reduced by having sorties on consecutive or alternate days in early January, and late February, when the chances of drastic differences in the proportion of habitats is lower. Having sorties only in early January is likely to underestimate the number of more open water or pack ice animals such as Adelie penguin and Crabeater seal. Hence, in order avoid this, a similar set of sorties should be held in the second fortnight of February and the data be analysed separately for each year.

4. Both year studies have shown a higher abundance of animals in the western shelf region. There is astrong limitation on the number of sorties available from the Department of Ocean Development. It may be prudent to maximise benefits by having sorties only in the western shelf region where the sortie length may be decided by the maximum possible capacity of the helicopter. This way, the habitat differences could be minimised and over twenty sortie will be possible, thus reducing the variability.

5. The numeric relation between the proportion of habitat and animal abundance needs to be understood. One possibility is to take periodic vertical photographs of the ground from a fixed altitude using a normal lens during a sortie. Based on this, the proportion of each habitat and animal numbers can be obtained which can be subjected to multiple regressions to yield correction factors. (Details of this techniques are being worked out at WII).

6. The proportion of habitat available during each sortie will be crucial to enable the use of correction factors based on habitat. Also, for a 'habitat' preference analysis (Neu *et al, 19*74) this data is required. Periodic records on habitat occurrence vertically below and at a certain angle on the left and right of the helicopter should be carried out. One observer should hence, exclusively concentrate on recording these data since during a sortie the other observer will be busy in animal identification, counts, recording location and habitat at each sighting.

7. The Schirmacher oasis forms an isolated and simple ecosystem which may be under inadvertent threat due to the research station's. The possible increase in the numbers of skua and reduction in the number of other birds is worth examining in reference to the entire oasis ecosystem.