

**Developing A Long-term Monitoring Programme for  
Birds and Mammals in the Indian Ocean and Antarctica  
Using GPS and GIS Technologies**

S. SATHYAKUMAR

Wildlife Institute of India  
Chandrabani, Dehradun- 248001

**Introduction**

Antarctica, the most remote, barren and inhospitable of the world's continents, surrounded by an unique array of biological resources and is widely known for its hydrological, environmental and aesthetic values. Man's concern for Antarctica has now shifted to conservation not only for its rich biological resources but also for the balance of nature and well being of the inhabitants of the world. The ongoing human activities and any potential use of natural resources in Antarctica has to be accomplished without any damage to the environment. The recent focus on scientific research in Antarctica is towards monitoring and applied research. The IUCN statement on strategies to conserve Antarctica has emphasised on monitoring as crucial (IUCN 1990).

The developing of long-term programme for birds and mammals in the Indian Ocean, Dakshin Gangotri and Maitri regions of Antarctica is to define and evaluate ecosystem health and to explore cause and effect relationships among the ecosystem components. This programme envisages developing monitoring protocols for identified species/taxa alongwith details on How, When and Where to monitor. Implementing this programme in the Indian Ocean, Dakshin Gangotri and Maitri regions of Antarctica would act as good indicator of impending disasters, if any. Collecting information on the baseline status of wildlife is considered crucial for initiating such programme (Goldsmith, 1992).

Mammals of Antarctic region include 6 species of seals and 15 species of whales. Among the seals, the crab eater seal (*Lobodon carcinophagus*) is the most abundant. The leopard seal (*Hydrurga leptonyx*) seems to be rare (Bonner, 1985). About 45 species of birds are reported from Antarctica of which penguins (7 species), petrels (19 species), storm petrels (3 species), gulls and

skuas (5 species) breed throughout Antarctica (Siegfried, 1985). The status and distribution of penguins in Antarctica has been reviewed by Stone House (1985).

Existing information on the status of wildlife in the Indian expedition route and in and around the Indian field stations in Antarctica is limited to the inventory of 1981-82 expedition which reported 14 species of birds and five species of mammals (Parulekar, 1982). Apart from this, there is a virtual lack of information on the present status, distribution, relative abundance and population of birds and mammals in the Indian Ocean, Dakshin Gangotri and Maitri regions of Antarctica. With this in view, this study was carried out with the following objectives:

### **Objectives**

- i. Establish baseline status of birds and mammals in the Indian Ocean, Dakshin Gangotri, Maitri and Indian Bay regions of Antarctica.
- ii. Identify suitable monitoring techniques and attempt trial runs.
- iii. Develop "monitoring protocols" for the identified species/taxa.
- iv. Classify the different wildlife habitats and their use by wildlife using GIS and GPS technologies.

### **Study Area**

The expedition route was from Goa (15° 24' 17" N, 73° 48' 34" E) to Indian Bay (69° 56' 15" S, 11° 54' 42" E) in Antarctica via Mauritius (20° 09' 27" S, 57° 29' 42" E). About 10,000 km stretch of the Indian Ocean was traversed during the onward journey (17.12.94 to 13.01.95) and the same during the return journey (06.03.95 to 29.03.95) (Table 1). The status of wildlife in the Indian Ocean was studied during the onward and return journeys. In Antarctica, the status and relative abundance of wildlife were studied in the Indian Bay (69° 59' 49" S 12° 30' 21" E), Dakshin Gangotri (70° 04' 50" S 12° 00' 09" E), Maitri (70° 45' 56" S 11° 43' 52" E), Russian Dump (69° 56' 37" S 11° 57' 40" E) and Russian Bay (70° 02' 35" S 11° 35' 13" E) areas (Table 1). Aerial surveys were conducted all along the eastern and western shelf areas covering 35 to 50 nautical mile stretch each.

### **Methods**

Data on the species, number and geographical position were recorded for all the wildlife sightings from Goa to Indian Bay in Antarctica. This was done

**Table 1: The geographical locations of the study sites and the study period**

Area	Location	Study Period
<b>Indian Ocean</b>		
Goa-)	15°24' 30 17" N 73°48'30 34"E	17.12.94 to 10.01.95
Mauritius -)	20° 09'30 27" S 57° 29'30 42" E	and
Antarctica)	69°56'30 15"S11°54'30 42"E	06.03.95 to 29.02.95
<b>Antarctica</b>		
Indian Bay	69° 59'30 49" S 12° 30'30 21" E	10.01.95 to 26.01.95 02.02.95 to 12.02.95 18.02.95 to 06.03.95
Dakshin Gangotri	70°04' 30 50"S 12°00' 30 09"E	26.01.95 to 02.02.95
Maitri	70° 45'30 56" S 11° 43'30 52" E	12.02.95 to 18.02.95
Russian Dump	69°56'30 37"S 11°57'30 40"E	15.01.95 to 19.01.95
Russian Bay	70° 02'30 35" S 11°35'30 13"E	24.01.95 to 25.02.95 09.02.95 to 10.02.95 19.02.95 to 26.02.95
R.Bay Iceberg	70°02'30 38"S 11°39'30 36"E	09.02.95 to 10.02.95 18.02.95 to 06.03.95

by continuous observations on all days of the onward journey except for days with inclement weather conditions. Identification of species was done using relevant field guides. The position for each sighting was obtained by using the Magellan GPS 5000 NAV PRO equipment.

Data on wildlife status were collected from the Russian Dump area by visiting the area using the ship as base. While for Dakshin Gangotri and Maitri data were collected by a week stay at the field stations. Information on wildlife status of Indian Bay and Russian Bay was collected, having the ship as base when it was at berth or moved towards Russian Bay during bad weather conditions and also by boat surveys.

Aerial surveys were conducted for estimating abundance of wildlife in the ice shelf areas of the Indian Bay region. The methodology involved flying over the shelf for 35 to 50 nautical miles on the eastern and western shelf areas around noon hours (local time). The aerial surveys were repeated four times for each shelf area. The Indian Navy Chetak helicopters were used for aerial surveys and were flown at a constant speed of 75 nautical mile/hour. The helicopters were either made to hover near or make short circles around rookeries/sastrugies to count penguins/seals. The counts were cross checked with the counts made by both the pilots. Data on species, number and position were recorded for every wildlife sighting during the aerial surveys. The satellite imagery of the Indian region in Antarctica, the geo-morphological map of this area prepared by NRSA and by limited ground truthing wildlife habitats were identified.

### Results

In total, 19 species of birds and five species of mammals were sighted during this study (Table 2). Of the 19 birds, two species viz., Tern and Frigate birds are yet to be confirmed. Seven species of birds namely the yellow nosed albatross, northern giant petrel, white headed petrel, Antarctic tern, Antarctic fulmar, Dominican gull and King shag; and two species of mammals viz., Blue whale and bottle nosed dolphin which have been reported to occur in this region (Parulekar, 1982) were not sighted during this study.

**Table 2: Birds and Mammals sighted during the Study (Dec.'94 - March' 95)**

S.No.	Species	No. of sightings	Total number seen
<b>Birds</b>			
1.	Little Shear Water ( <i>Calonectris assimilis</i> )	2	2
2.	Cory's Shear Water ( <i>C.diomedea</i> )	36	+663
3.	Red footed Booby ( <i>Sula sula rubripes</i> )	4	4
4.	Red billed tropic bird ( <i>Phaethon aetherus</i> )	10	25
5.	Tern (?)	2	9
6.	Frigate bird (?) ( <i>Fregata</i> spp.)	2	2
7.	Wandering Albatross ( <i>Diomedea exulans</i> )	18	56
8.	Sooty Albatross ( <i>Phoebetria fusca</i> )	16	56
9.	Light Mantled Sooty Albatross ( <i>P.palpebrata</i> )	3	5
10.	Wilson's Diving Petrel ( <i>Pelecanoides</i> spp.)	1	3
11.	Common Diving Petrel ( <i>P. urinatrix</i> )	5	25
12.	Antarctic Prion ( <i>Pachyptila desolata</i> )	15	4418
13.	Cape Petrel ( <i>Daption capense</i> )	10	101
14.	Skua ( <i>Catharacta maccomicki</i> )	27	91
15.	Wilson's Storm Petrel ( <i>Oceanites oceanicus</i> )	17	34
16.	Snow Petrel ( <i>Pagodroma nivea</i> )	44	183
17.	Southern Fulmar ( <i>Fulmarus glacialoides</i> )	1	1
18.	Emperor Penguin ( <i>Aptenodsytes forsteri</i> )	68	+1,075
19.	Adelie Penguin ( <i>Pygoscelis adeliae</i> )	67	+918
<b>Mammals</b>			
1.	Common Dolphin ( <i>Delphinus delphinus</i> )	6	+59
2.	Hump-backed Whale ( <i>Megaptera novaeangliae</i> )	3	9
3.	Killer Whale ( <i>Orcinus orca</i> )	3	4
4.	Crabeater Seal ( <i>Lobodon carcinophagus</i> )	34	+363
5.	Leopard Seal ( <i>Hydrurga leptonyx</i> )	2	2

### **Status of wildlife in the Indian Ocean**

The onward journey covered the Indian Ocean and Southern Ocean from 15°N to 69°S. The wildlife sightings had in different sub zones of the maritime region are given in Table 3. The species diversity was comparatively low in the equatorial zone (15°N to 20°S) represented by shear waters, booby, tropic bird and common dolphin, but the abundance of Cory's shear water was high. Between 20°S and 40°S, the species encountered include Cory's shear water, tropic bird, albatrosses and hump-backed whale. Between 40°S and 50°S, two species of albatrosses, four species of petrels and prion were sighted. Only three species were encountered in the fifties which was largely due to the bad weather that prevented observations on wildlife. Hump backed whales were seen in fairly good numbers in the fifties. The abundance of prion was high in the forties and fifties. In the sixties, the species diversity was high and represented by penguins, crabeater seal, skua, prion, petrels and albatrosses. The distribution of birds in the Indian Ocean showed a specific pattern in relation to geographical position. Though the species diversity was low, the relative abundance of some bird species were very high (Cory's shear water, Antarctic prion). The locations for the wildlife sightings had in the Indian Ocean were obtained using the GPS. These data points were projected and distribution maps generated using the software PC ARC/INFO. The locations of wildlife sightings had in the Indian Ocean are shown in Fig. 1.

### **Status of wildlife in Antarctica**

The wildlife sightings in different localities of the study area excluding aerial surveys are presented in Table 4. Six localities viz., Indian Bay, Dakshin Gangotri, Maitri, Russian Dump, Russian Bay and Russian Bay Iceberg area were selected for collecting baseline data and for future monitoring. Excepting Maitri, all the other localities are along the ice shelf and hence rich in wildlife. At Indian Bay, four Emperor penguins, five Adelie penguins, four skuas, and two Wilson's storm petrels were sighted regularly. Three killer whales were also sighted in Indian Bay. At Dakshin Gangotri, though only three Adelie and four Emperor penguins were sighted, at least four skuas, six snow petrels and two Wilson's storm petrels were sighted regularly. About 18 to 22 Adelie penguins use the Russian Dump rookery but in March 1995 they were not sighted as the sea had frozen up in this region. Limited observations at Russian Bay and Russian Bay Iceberg suggest that about 75-100 Adelie penguins use the area apart from other species such as Emperor penguins, skuas, snow and Wilson's storm petrels. Based on total counts of skuas in Maitri it appears that at least 8 to 12 individuals inhabit this area. The boat surveys were attempted in the Indian Bay region but found unsuitable due to the following reasons: (i)

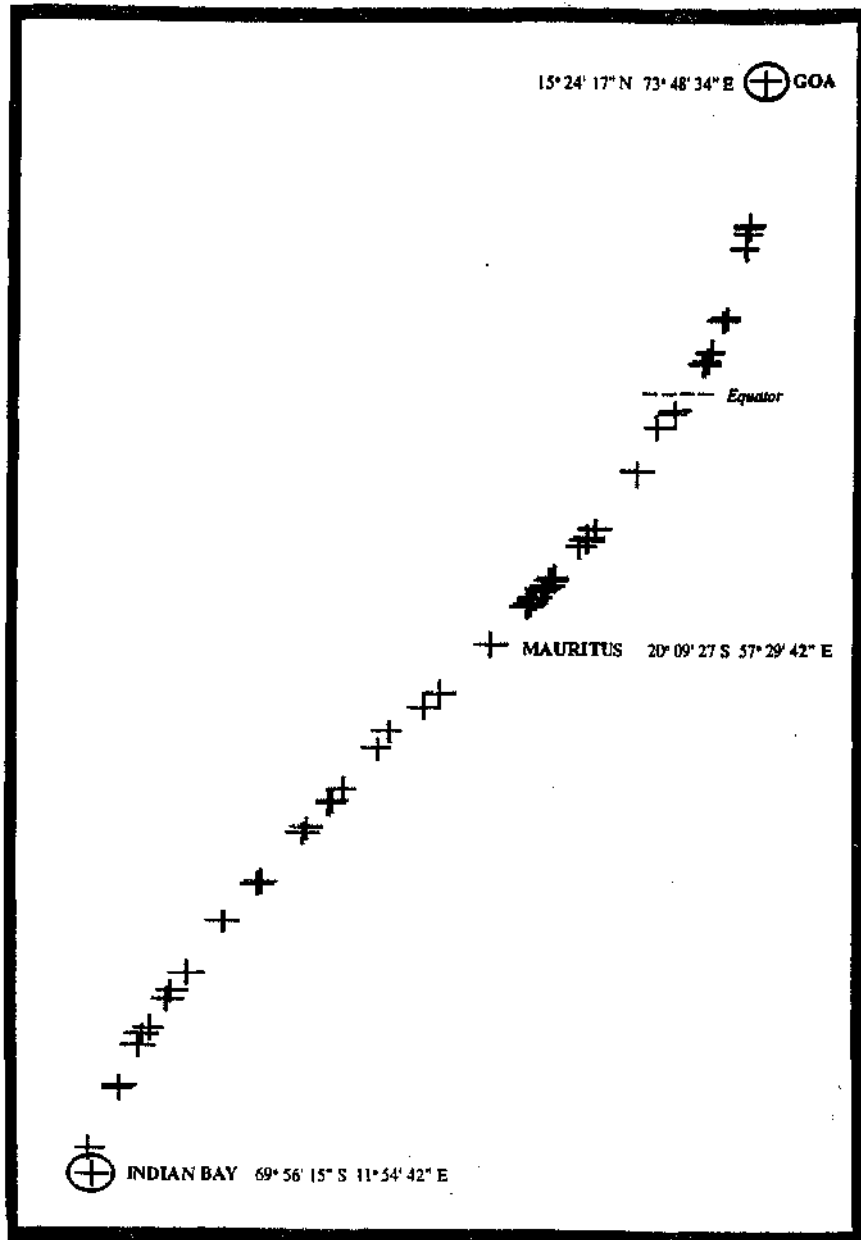


Fig.1: Geographical locations of wildlife sightings in the Indian Ocean

**Table 3 : Wildlife sightings enroute the onward journey (Goa - Mauritius - Antarctica) [17 Dec'94 to 13 Jan.'95]. Figures in parentheses indicate total number seen**

Location	Species	Number of sightings
15° 24' 17" N	Little Shear Water	2(2)
73° 48' 34" E	Cory's Shear Water	7(272)
	Common Dolphin	2 (29)+
01° 19' 20" S	Red-footed Booby	4(4)
66° 27' 13" E	Cory's Shear Water	8(144)
	Red-billed Tropic Bird	7(21)
	Tern (?)	1(1)
20° 09' 27" S	Cory's Shear Water	16(51)
57° 29' 42" E	Red-billed Tropic Bird	2(3)
	Wandering Albatross	5(10)
	Sooty Albatross	2(2)
	Tern (?)	1(1)
	Dolphin (?)	1(1)
	Hump-backed Whale	2(2)
41° 41' 34" S	Wandering Albatross	3(15)
42° 52' 01" E	Sooty Albatross	1(1)
	Antarctic prion	3(118)
	Wilson's Diving Petrel	1(3)
	Common Diving Petrel	4(23)
	Wilson's Storm Petrel	2(10)
	Cape Petrel	1(3)
50° 03' 04" S	Antarctic prion	3(173)+
35° 49' 18" E	Cape Petrel	2(4)
	Hump-backed Whale	1(7)
60° 03' 56" S	Antarctic prion	1(1)+
25° 39' 38" E	Cape Petrel	5(87)
	Wandering Albatross	1(1)
	Sooty Albatross	1(2)
	L.M. Sooty Albatross	1(3)
	Wilson's Storm Petrel	2(4)
	Skua	1(1)
	Adelie Penguin	5 (35)+
	Emperor Penguin	1(1)+
69° 56' 54" S	Crabeater Seal	1(5)+
11° 54' 42" E		

**Table 4 : Wildlife sightings in different localities of the study area (excluding aerial surveys) [13 Jan.'95 to 7 March' 95]. Figures in parentheses indicate total number seen. The geographical locations of these localities are given in Table 1**

Locality	Species & number of sightings				
	Adelie penguin	Emperor penguin	Skua	Snow petrel	Wilson's storm petrel
Indian Bay <sup>***</sup>	5(24)	4(8)	6(9)	9(16)	62(9)
Dakshin Gangotri	2(3)	1(4)	3(8)	3(15)	4(7)
Russian Dump	2(39)	-	2(6)	1(1)	1(2)
Russian Bay	8(105)	-	6(16)	4(16)	1(2)
Maitri	1(1)@	-	[8-12]**	-	1(2)@
R.Bay Iceberg	8[76+]	2(11)	-	1(3)	-

\* One crabeater seal sighted in Russian Bay.

\*\* Estimate based on total counts for five days.

\*\*\* Three killer whales sighted

@K. Venkataraman pers. *comm.*

Non availability of a suitable boat to suit the Antarctic conditions; (ii) the height of shelf, visibility and hazards involved in sailing in Antarctic waters; and (iii) time consuming and only short distances could be covered.

### Wildlife abundance monitoring by aerial surveys

The counts for major species such as adelie penguin, emperor penguin and crabeater seal were made by aerial surveys. However attempts were also made to count skuas and snow petrels during the exercise. The results of the aerial surveys are given in Table 5. As this has been the first attempt to document the relative abundance of penguins and seals in the 100 nautical mile stretch on either side of Indian Bay only major tentative conclusions were drawn. The abundance of penguins and seals in the western shelf area was comparatively higher than the eastern shelf area. Based on the maximum number that was counted for any species on any one day, it appears that atleast 268 emperor penguins, 363 adelie penguins and 137 crabeater seals inhabit the 50 nautical mile stretch on either side of the Indian Bay.

The Encounter Rates (number sighted/nautical mile) for penguins and seals based on aerial surveys are provided in Table 6. The causes for large variations in abundance estimates of penguins and seals by aerial censuses may be due to the inherent variation in the activity and movement pattern of wildlife and/or inadequate sampling.



**Table 5 : Wildlife counts based on the aerial surveys conducted in Antarctica (summer 1994-95). Figures in parentheses indicate number of sightings**

Date	Distance surveyed (nau.m)	Adelie penguin	Emperor penguin	Crabeater seal	Skua	Snow petrel
<b>(a) Eastern Shelf Area</b>						
16.1.95	35	6(1)	23(5)	24(4)	3(2)	4(1)
26.1.95	35	12(1)	80(7)	53(4)	3(1)	76(12)
19.2.95	50	78(3)	34(2)	61(3)	4(1)	9(4)
2.3.95	50	21(3)	103(3)	59(2)	1(1)	15(6)
$\bar{X}$		29.2±	60.0+	49.3±	2.8+	26.0±
S.E		16.5	18.9	8.6	0.6	16.8
Max. counted on any one day		78	103	61	4	76
<b>(b) Western Shelf Area</b>						
19.1.95	35	130(5)	250(13)	5(1)		
29.1.95	35	30(3)	260(11)	52(3)	1(1)	13(1)
18.2.95	35	125(10)	41(9)	21(3)		12(5)
2.3.95	50	190(11)	195(9)	76(11)		
$\bar{X}$		118.8±	186.6+	38.5+	0.2±	6.2±
S.E		33.0	50.1	15.9	0.2	3.6
Max. counted on any one day		190	260	76	1	13
Grand total		268	363	137	5	89

**Table 6 : Encounter rates (#/nau.m) for major wildlife species in Antarctica based on aerial surveys conducted in Antarctica (summer 1994-95)**

Date	Adelie penguin	Emperor penguin	Crabeater seal	Skua	Snow petrel
<b>(a) Eastern Shelf Area</b>					
16.1.95	0.17	0.66	0.69	0.09	0.11
26.1.95	0.34	2.26	1.51	0.09	2.17
19.2.95	1.56	0.68	1.22	0.08	0.18
2.3.95	0.42	2.06	1.18	0.08	0.30
$\bar{X}$	0.62±	1.42±	1.15±	0.09±	0.69±
S.E	0.32	0.43	0.34	0.00	0.49
<b>(b) Western Shelf Area</b>					
19.1.95	3.71	7.14	0.14		
29.1.95	0.86	7.42	1.48		0.37
18.2.95	3.57	1.17	0.60	0.08	0.34
2.3.95	3.80	3.90	1.52		
$\bar{X}$	2.99±	4.91±	0.94±	0.02±	0.18±
S.E	0.71	1.48	0.34	0.02	0.10

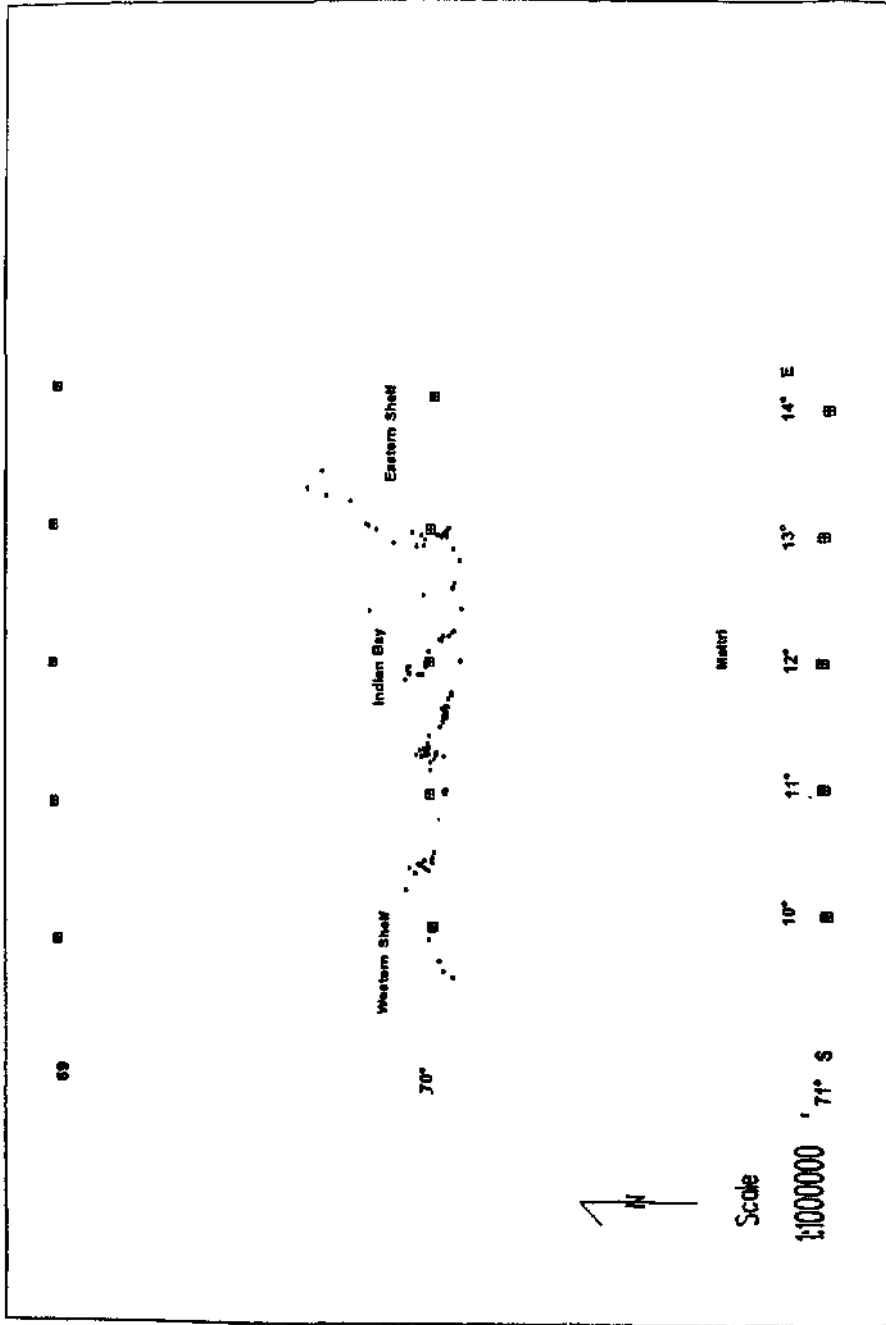


Fig 2: Geographical locations of wildlife sightings in Antarctica

**Wildlife habitat classification and their use by wildlife**

Four major wildlife habitats viz., the maritime, the polynya-pack ice, the ice shelf and the mainland habitats were identified of which, the polynya-pack ice and the ice shelf habitats were largely used by penguins and seals.

The geographical locations of all wildlife sightings recorded with the help of GPS in Antarctica were projected and distribution maps were generated using the computer software PC ARC/INFO. The locations of wildlife sightings are shown in Fig.2 where each data point represents a sighting. All sightings were along the ice shelf which is one of the most used habitats by wildlife.

The GPS provided reliable geographical positions for all wildlife sightings and for marking the survey lines and study sites for future monitoring. The work on satellite data of the study areas in the GIS for wildlife habitat classification and use by wildlife are in progress.

**Discussion and Recommendations**

One of the objectives of developing this long-term monitoring programme was to evolve "monitoring protocols" for the identified species or taxa. As only one summer study has been done, it is concluded that tentatively, to monitor all mammalian species and all bird species with special reference to presence/absence of rare species and abundance of common species. This is because for a long-term monitoring programme it is necessary and crucial to establish the baseline status. It is not known as to how many years of data would be required to establish the baseline status. However, it is evident that as regular data collection continues, the baseline status would also build up simultaneously.

Therefore for future expeditions the following suggestions are made:

- 1) Continuous data collection for establishing baseline status for wildlife in the Indian Ocean (onward and return journeys).
- 2) Aerial surveys seem to be the most appropriate technique for estimating abundance of wildlife in the Indian Bay region.
- 3) However, standardisation of the aerial survey technique by direct counts with GPS and aerial photograph based counts by two well trained wildlife biologists would be necessary. Moreover, adequate sampling would be required to arrive at reliable abundance estimates.
- 4) Data collection from the study sites and survey lines established needs to be repeated following the techniques adopted with modifications wherever necessary.

- 5) The wildlife abundance of polynya-pack ice zone area is important and needs to be monitored carefully. It would be ideal if the ship travels in this zone only during clear weather period to enable complete data collection.

### **Acknowledgements**

At the outset, I express my thanks to the Dept. of Ocean Development, New Delhi for providing me with this unique opportunity to conduct this study and evolve a long-term monitoring programme for wildlife. I thank all the members of the National Coordination Committee of the Indian Antarctic Science Programme for selecting me to participate in the XIV expedition. I thank Dr. S.D. Sharma, Leader, XIV expedition, Dr. A. Mitra, DOD and all members of the XIV expedition for their encouragement, help and cooperation. My special thanks are due to the Indian Navy pilots for helping me in conducting aerial surveys.

At the Wildlife Institute of India, my special thanks are due to Shri. S.K. Mukherjee, Director for nominating me and encouraging me to participate in the expedition and for his guidance. The Chairman and the members of the WII's Research Advisory Committee are specially thanked for sanctioning this project and for purchase of a GPS equipment. Dr. P.K. Mathur, Dr. V.B. Mathur and Shri. B.C. Choudhury, my senior faculty colleagues were the advisors for this study and helped me in different stages of this study. I thank Shri. Navneet Gupta, computer programmer, for his help in GPS data analyses using PC ARC/INFO software. Shri Manoj Agarwal, Asst. Computer Programmer, helped in preparation of the figures and DTP of this document. I thank my colleagues at WII for their help and encouragement. My special thanks are to my wife Archana for helping me in preparation of this report, her encouragement and support.

### **References**

- Goldsmith, B. 1992. Monitoring overseas: Prespa National Park, Greece, In: Monitoring for Conservation and Ecology (Eds.) F.B. Goldsmith. Chapman & Hall, London, pp 213-224.
- IUCN, 1990. A strategy for Antarctic conservation. International Union for Conservation of Nature and Natural Resources. General Assembly Paper GA/18/90/19, pp. 111.
- Parulekar, A.H. 1982. Sea Birds and Marine Mammals of the First Indian Antarctic Expedition (1981-82), In: First Indian Expedition to Antarctica. Dept. of Ocean Development, New Delhi, pp 224-231.

- Siegfried, W.N. 1985. Birds and Mammals - Oceanic birds of the Antarctic, In: Antarctica (Eds.) W.N. Bonner & D.W.H. Walton, IUCN, Pergamon Press, New York, pp 242-265.
- Stonehouse, B. 1985. Birds and Mammals - Penguins, In: Antarctica (Eds.) W.N. Bonner & D.W.H. Walton, IUCN, Pergamon Press, New York, pp 266-292.