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DEVELOPING A LONG TERM MONITORING PROGRAMME FOR BIRDS AND MAMMALS IN THE INDIAN OCEAN AND ANTARCTICA

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Abstract

The Wildlife Institute of India participated for the second consecutive year, in the 15th Indian Antarctic expedition, 1995-96 with the objective of continuing monitoring of birds and mammals in the Indian Ocean and in Antarctica. Daily watch was maintained en-route from the ship for wildlife and on sighting a bird or mammal, the position, species and their numbers were recorded. The entire route was divided into latitudinal climatic zones viz. tropical (north), tropical (south), sub-tropical, temperature, sub-Antarctic and Antarctic. During the voyage, fifty bird species and fourteen mammal species were recorded of which 41 and 9 were identified, respectively. Among the birds, members of Diomedidae, Spheniscidae, Stercorariidae, and some Procellariidae dominated in the cold temperate to Antarctic waters, while members of Sulidae, Sternidae, Phaethotidae and some Procellariidae dominated in the tropical and sub-tropical regions. During the onward journey, the temperate zone was the most species-rich zone (14 species) while during the return journey, the Antarctic zone had the highest richness (14). Shannon's diversity was highest in the sub-Antarctic zone (1.676) during the onward journey while during the return journey, it was highest in the Antarctic zone (1.728). The species richness and H' was lowest in the sub-tropical zone during the onward (5 and 0.728, respectively) and return journeys (5 and 0.833, respectively). Bird abundance was highest in the Antarctic zone during both journeys - 0.83 birds/km during the onward and 1.62/km during the return, while they were lowest in the tropical (S) during the onward (0.32/km) and the tropical (N) zone during the return journey (0.16/km). The data clearly shows that the diversity as well as abundance of species was highest in the cold waters beyond ca. 25° S with the sub-tropical convergence, Antarctic convergence and Antarctic divergence. The Soresen's similarity index between neighbouring zones was high for the temperate to Antarctic latitudes while the warm water zones had lesser similarity.

Introduction

The Wildlife Institute of India (WII) participated for the first time in the summer team of the 14th Indian Scientific Expedition to Antarctica (December-94 to March-95), with the purpose of developing 'Long Term Monitoring Protocols for birds and mammals in the Indian Ocean and Antarctica' with details of how, when and where to monitor. This study had two major components, viz., en-route monitoring of birds and mammals in the Indian ocean and census of animals in Antarctica. (The latter aspect is presented in detail in the next paper.)

The study is continuing with the following objectives :

General objectives

1. To monitor species en-route to Antarctica and back.
2. To count penguins and seals in the 'India bay region' of Antarctica using aerial census.
3. To classify wildlife habitats and their use by wildlife.
4. To conduct behavioural studies on penguins and seals.
5. To standardise techniques for the above objectives.

En-Route Monitoring of Birds and Mammals in Indian Ocean

Oceans cover approximately three fourths of earth's surface and greatly influence world's climate. They are a rich source of food, energy, medicines and minerals. With advancements in technology, and decline of land resources, greater dependence on the oceans is inevitable. Such trends are already visible on a global scale (Beazlcy, 1991; Murphy and Duffins, 1996). Marine fish harvests are already expected to have crossed the sustainable limits and demands are continuing to rise. Instances of coastal and marine pollution are also increasing.

The long voyage to Antarctica by the Indian expedition, passes through a vast spectrum of marine zones (from the tropics to the south polar zone) and provides an excellent opportunity of monitoring species en-route. Few biologists pass through the high seas and information on the status and distribution of marine bird and mammal species is rarely encountered. Watson (1975), Siegfried (1985) and Viet and Hunt (1991) emphasise the importance of monitoring along voyages for developing data bases on the distribution abundance and diversity of pelagic birds and their relation to various environmental factors such as sea water temperature, salinity, sea depth and food availability.

Although the species richness per se in the oceans is lower than on land, considering the number of taxa inhabiting the oceans, the bio-diversity exceeds that on the land (Beazley, 1991). There is a vast group of pelagic bird species and cetaceans (the whales and dolphins) which contribute to oceanic bio-diversity. Information on the distribution and status of these animals is rare, but nevertheless, important for understanding the ocean ecosystem.

Objectives

1. To develop a checklist of bird and mammal species in the Indian ocean.
2. To study the bird and mammal distribution patterns in the Indian ocean.
3. To determine the status of birds and mammals in the Indian Ocean.
4. To standardise methods for monitoring birds and mammals en-route.

Study Area

The route taken by the Indian Expedition vessel covers a stretch of approx. 11,000 km, from the tropical to the polar zone, crossing *ca.* 85 degrees of latitude and 58 degrees of longitude. This range is not homogeneous and different climatic zones can be recognised based on the physical and chemical properties of water. Nutrition in the form of nitrates and phosphates is mainly available in the oceanic depths while photosynthetic production is mainly possible in the upper photic zone. Surface waters in open oceans, hence are usually poor in nutrition except in the areas of upwelling (divergence) and downwelling (convergence) where nutrition is brought out on to the photic zone or circulated (Barnes and Hughes,-1989). These areas have higher diversity and abundance of the prey species available to the pelagic birds and cetaceans (Watson, 1975; Barnes and Hughes, 1989) and have been kept in mind while defining the six zones, along with climatic data as given in below.

Zone 1: Tropical 'North' (16° N to 0°)

Warm air and water, usually calm seas (during this cruise period) and high salinity mark this zone. Except for the coastal areas of the Arabian sea, most of this zone is poor in phytoplanktonic productivity (Barnes and Hughes, 1989).

Zone 2 : Tropical 'South' (1°S to 25°S)

The zone is also characterised by warm air, water and high salinity but separated by the equatorial divergence from the northern hemisphere. Ambient and sea temperatures ranged between 27° and 30°C in the above two zones during the expedition period. In this zone, the ship passes over shallow seas and repeatedly, close to land, including a halt at Mauritius.

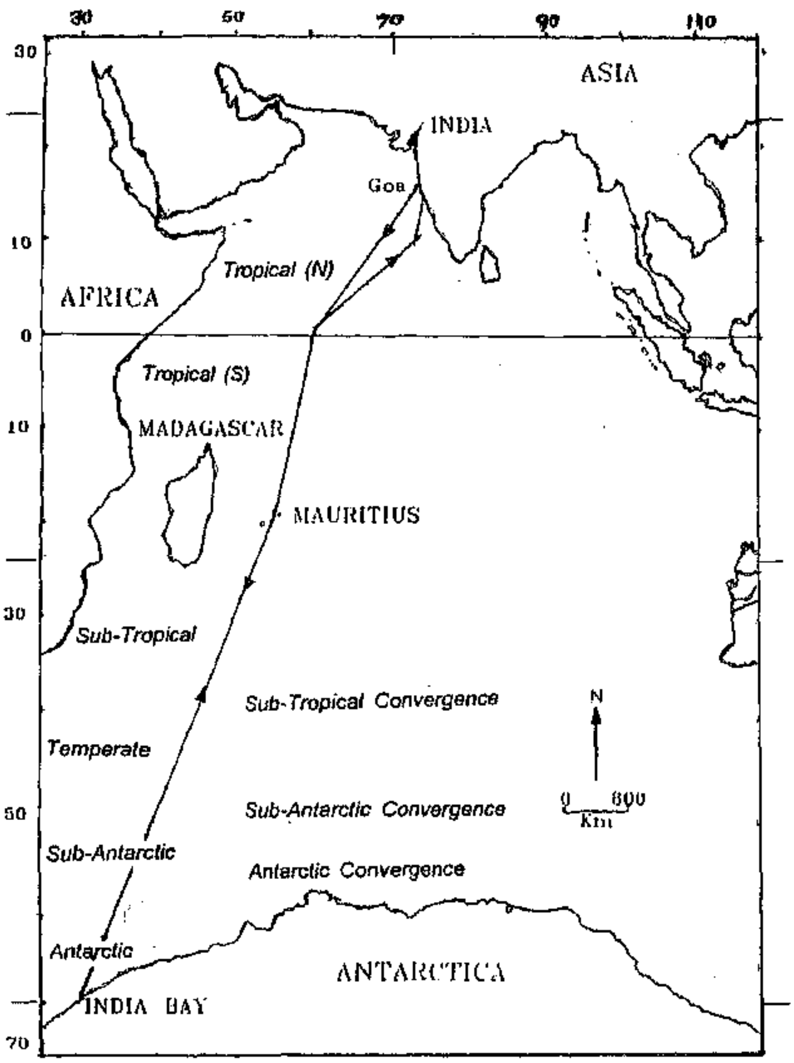


Fig. 1: The Indian Ocean route showing the. locations of various zones

Zone 3 : Sub-tropical (26°S to 35°S)

Open seas and a slight dip in air and water temperature occurred (26° to 23°C) in this zone. Weather was usually calm during the cruise.

*Zone 4: Temperate (36°S to **49**°S)*

This zone is characterised by an abrupt reduction in sea temperature (of up to 4°C) and salinity along the north-south axis due to an oceanic frontal system, the *sub-tropical convergence* (STC), at approx. 40°S. Here, the ceol sub-Antarctic and the warmer sub-tropical surface water meet and sink deep, leaving a distinct line of oceanic disturbance, popularly called the 'Roaring Forties'. Temperatures just north of the STC are ca. 14°C during winter and 18°C during summer, and usually remain ca. 4°C lower to the south of the STC. Salinity is also high in this zone 34.9 ppt-parts per thousand) (Watson, 1975, Barnes and Hughes, 1989; Eastman, 1993).

Zone 5 : Sub-Antarctic/Sub-polar (50°S to 59°S)

In this zone, a decline of another 2° to 3°C occurs in sea water temperature across another frontal system, the *Antarctic convergence* (AC). This convergence marks the subduction of the cold and denser Antarctic surface water under the slightly warmer, sub-Antarctic surface water. Water temperatures are *ca.* 5° to 10°C during winter and 8° to 14°C during summer months in the sub-Antarctic zone, north of the AC. Ambient temperatures dip to 4° to 8°C and the ocean usually remains rough. Salinity is reported to be *ca.* 34.3 ppt (Barnes and Hughes, 1989).

Zone 6 : Antarctic/Polar (60°S to 69°S)

Water temperature near the shelf usually remains sub-zero round the year, but further north, on an average is ca. 1° to 2°C in winter and 4° to 5°C during summer (Watson, 1975). An ocean front, the *Antarctic divergence,* occurs at approx. 65°S. The Antarctic water, cooled by ice and wind, off the ice shelf becomes dense and sinks to the bottom. The 'hole' thus formed is filled by the circumpolar deep water which rises and diverges south towards Antarctica and north towards the AC. This deep water is profuse in nutrition and consequently, this zone is known to be a biologically rich zone. The Antarctic sea ice has considerable influence on the phytoplankton productivity. The ice edge is particularly rich because of the 'phyto-planktonic bloom' (Sakshaug and Skjoldal, 1989).

The salinity of the sea water in the immediate vicinity of the shelf varies between 30.5 to 34.5 ppt seasonally, with a mean of 33.9 ppt. The summer melt dilutes the sea water and in winter, the freezing sea leaves out salt which makes the water more saline (Watson, 1975; Barnes and Hughes, 1989; Eastman, 1993).

Wind blows east to west ('East wind drift') along the Antarctic coastline and west to east ('West wind drift'), north of the Antarctic divergence.The former carries cyclones which intermittently hit the Antarctic coastline.

Climatic information:

Meteorological data was collected by the crew of M/V Brinknes and was obtained with permission from the Captain. Appendix 3 shows a gradual drop in both sea and water temperatures along the onward journey and a reverse trend on the return journey. Atmospheric pressure south of *ca.* 55° S was mostly less than 1000 mm Hg, and often had cyclonic disturbances. Note the drops in the sea water temperature in the STC (ca. 39°S to 44°S), AC (ca. 58°S) latitudes.

Methods

Observations from bridge

En-route monitoring of animals was carried out in the Indian Ocean and Antarctic Ocean regions between 07.12.95 and 31.12.95 during the onward journey and between 27.2.96 and 19.3.96 during the return journey. A total of 281 day-light hours, covering ca. 5081 km were spent in monitoring the ocean from the bridge of the ship (mean ca. 7.5 hrs/day and 175 km/day, respectively) (Please see Table-1 and Table-4, for more details).

On sighting an animal, the date, local time, species, its numbers, perpendicular distance from the ship's course, angle relative to the ship's course, the geographical position and notes on activity and behaviour were recorded. Since some marine birds mainly occur in the wake of the ship and cetaceans also often occur in the rear 180° of the field of vision, vigil was maintained in the entire 360° around the ship.

Distance travelled each day were calculated based on the Global Positioning Systems (GPS) locations. Encounter rates were calculated as numbers seen per km and also numbers seen per hour.

Zonal species diversity was calculated using the Shannon's diversity index (H';Magurran, 1988):

$$H' = -\Sigma p_i \ln p_i$$

where, 'p_i' is the proportion of individuals belonging to the i^{th} species.

The similarity between neighbouring zones was calculated using the Sorensen's index (Magurran, 1988) as :

$$C_s = 2j/(a+b)$$

Table 1: Details of duration and distance monitored on the onward and return journeys

	Onward Journey			Return Journey		
	Forenoon	Afternoon	Total	Forenoon	Afternoon	Total
#Days Monitored	16	20	20	17	20	20
Mean Duration (hrs/day)	2.7	5.3	8.0	3.2	3.9	7.1
Min. Duration (hrs)*	1.5	1.0	-	1.5	1.0	-
Max. Duration (hrs)*	5.5	9.3	-	5.8	10.5	-
Total Duration (hrs)	42.4	106.2	148.6	54.6	78.2	132.8
Mean Distance (km/day)	46.1	72.8	118.9	83.1	77.4	160.5
Min. Distance (km)*	19.3	6.1	-	18.0	22.3	-
Max. Distance (km*)	130.0	165.9	-	206.1	164.7	-
Total Distance (km)	738.2	1382.5	2120.7	1411.8	1548.7	2960.5
#Days not monitored	5	2	1	3.	0	0
Mean Ship Speed (Knots)			11.5			12.9
	Total days of cruise = 21.5 at Mauritius - 4.5 days			Total days of cruise = 20 at Mauritius - 2 days		

* Minimum & Maximum duration or distance monitored out of the no. days monitored.

where, 'j' is the number of species common to the two zones, 'a' is the, number of species in zone 'A' and 'b' is the number of species in zone 'B'.

A pair of 10X binoculars was used to facilitate identification of species. Reference books and field guides by Watson (1975) and Harrison (1983) for birds; Watson (1988), Quayle (1988) and Savage (1990) for cetaceans; Laws (1993) and Annon (1974) for pinnipeds were used to identify species.

Results

Species encountered

Fourteen mammal and 50 bird species were encountered in the entire voyage, of which 5 and 9, respectively, could not be identified. In addition, the lesser black backed gull was seen only once in the India Bay, Antarctica. Most of the unidentified individuals were seen momentarily or were too far. Journey wise details on various taxa encountered are given in **Table-2.** The species checklist with the scientific names is given in **Appn-1.** Unconfirmed sightings have been split into species which are probably one of the identified species

Table 2: Number of species seen en-route to Antarctica during the onward (OW) and the return (R) Journeys

Animal group	No. species seen			No. species identified			Species yet to be identified		
	OW	R	TOT	OW	R	TOT	OW	R	TOT
Mammals	12	6	14	8	5	9	4	1	5
Whale	6	3	6	3	2	3	3	1	3
Dolphin	4	3	5	3	[illegible]	4	1	1	1
Porpoise	1	1	2	1	0	1	0	1	1
Seal	1	1	1	1	1	1	0	0	0
Birds*	32	34	50	27	31	41	5	4	9
Reptiles	1	0	1	0	0	0	1	0	1
Other (fish,crab,.etc.)	3	1	3	0	0	0	3	0	3
Total	47	43	68	34	36	51	13	6	17

and those that are different and were therefore, included in the species richness and diversity measures.

Three land birds were also sighted during the onward journey. The red legged falcon (at 4° 30' 40" N/66° 59' 57" E) and probably the cattle egret (egret with yellow-orange legs and beak observed at 3° 45' 34" N/66° 33' 18" E) were seen in mid ocean, ca. 600 km west of Maldives. Both species were flying in a south- westwardly direction. The red legged falcon could be expected as the ships route crosses their winter migratory route from north-east India to the east coast of Africa (Ali and Ripley, 1987). There is at present no explanation regarding the cattle egret sighting. Similarly, an unidentified falcon was spotted in line with the southern tip of Madagascar, but far from land (31° 10' 35" S/ 50° 21' 51" E). One black backed gull (Larus fuscus) was sighted in the India bay region in early February, 1996. It is reported as vagrant from the southern seas but is mainly distributed along the east and west coast of Africa and in Europe (Watson, 1975; Harrison, 1986).

[The Zonal species composition and relative abundance (encounter rates) are given in Table-5 (Appn.3).]

Zonal distribution, richness and diversity of species

Penguins (Spheniscidae), albatrosses (Diomedidae), skuas (Stercorariidae), prions, fulmars (Procellariidae) were restricted to the cold waters, i.e. temperate to Antarctic zones while shear waters, boobies (Sulidae), tropic-bird (Phaethotidae) and terns (Sternidae) were common in the warm waters. Petrels,

Table 3: Zonal distribution of birds in the Indian Ocean and adjacent seas. Figures in parentheses indicate number of species of each group sighted

Family	Common name	Zone					
		T(N)	**T(S)**	**ST**	**TE**	**SA**	**A**
Phaethonitidae	Tropic-bird (2)	+	+	-	-	-	-
Sternidae	Tern (4)	-	+	-	-	-	-
Sulidae	Booby (2)	+	+	-	-	-	-
Falconidae	Falcon (1)	+	-	-	-	-	-
Oceanitidae	Storm-petrel (2)	+	+	-	+	+	+
Procellariidae	Petrel (9)	+	+	-	+	+	+
	Shearwater (5)	+	+	+	+	+	-
	Fulmar (3)	-	-	+	+	+	+
	Prion (2)	-	-	-	+	+	+
Diomedeidae	Albatross (7)	-	-	+	+	+	+
Spheniscidae	Penguin (2)	-	-	-	-	+	+
Stercorariidae	Skua (2)	-	-	-	-	+	+
Laridae	Gull (1)	-	-	-	-	-	+

shear waters (Procellariidae) and storm petrels were found in all zones **(Table-3).**

Dolphin species were mainly spotted in the tropical waters in both hemispheres while whales were also seen in the sub-Antarctic and Antarctic waters during both journeys.

Shannon's species diversity index (H') for birds was comparatively higher during the return journey for all zones except the temperate and the sub-Antarctic zones **(Table-4).** The diversity of the Tropical (N) and sub-Tropical zone was low in both journeys, so also was that of the Antarctic zone in the onward journey. In the latter case, however, the abundance of birds was high (203) **(Table-4).** The H' value for the onward journey was highest in the sub-Antarctic zone (1.676) followed by the temperate zone (1.614). In the return journey it was highest in the Antarctic zone (1.728), followed by the tropical (S) zone (1.496). The value was lowest in the sub-tropical zone in both journeys (0.728 & 0.833, respectively, in the onward and return journeys).

Bird species richness was also higher in all zones during the return journey, except in the temperate zone **(Table-4).** The species richness trends are similar to those of H'. The species richness in the sub-Antarctic zone during the return journey was higher than that for the onward journey, even though the diversity was lower. This was probably because of higher domination by a few species such as the short tailed shear water.

Table 4 : Zonal bird species richness, Shannon's diversity index and abundance

Zone	Onward Journey			Return Journey		
	Species Richness	Shannon's Diversity	Total Abundance	Species Richness	Shannon's Diversity	Total Abundance
Tropical (N)15°N-00°	5	0.804	32	6	0.859	110
Tropical (S) 01° - 25°S	10	1.415	196	12	1.496	231
Sub-Tropical 26° -35°S	5	0.728	48	5	0.833	122
Temperate 36° - 49°S	14	1.614	153	13	1.470	357
Sub-Antarctic 50° - 59°S	10	1.676	87	12	1.314	240
Antarctic 60° - 69°S	8	0.747	203	14	1.728	336

Relative abundance

The Zonal abundance of birds ranged between 0.32/km and 1.75/km and of cetaceans, between none and 0.26/km during both journeys **(Table-5).** During the onward journey, the Antarctic zone had the highest encounter rate for birds (0.83/km) followed by the sub- Tropical zone (0.53/km). The sub-Antarctic, tropical (N), temperate and tropical zones (S) followed with 0.52, 0.48, 0.46 and 0.32 birds/km respectively. During the return voyage, the Antarctic zone had the highest abundance (1.62/km) followed by the sub-Antarctic zone (0.99/km). The temperate, tropical (S), sub-tropical, and the tropical (N) zones followed with 0.67, 0.41, 0.34 and 0.16 individuals, respectively. It may be noted here that the abundance of birds was usually higher during the return joruney (Table-5 & Appn.3).

Among the identified species, Sooty shear water (0.11/km), Sooty tern (0.07) and Little shear water (0.05) were the most abundant species in the tropical (S) zone during the onward journey. White chinned petrel was dominant in the sub-tropical zone (0.43/km) but continued to occur in moderate numbers (0.09/km and 0.12/km) in the temperate and sub-Antarctic zones. Antarctic prions were dominant in the temperate (0.16/km) and sub-Antarctic (0.21/km) zones while Antarctic petrels, southern giant fulmar and Snow petrels were most abundant in the Antarctic zone (0.66/km, 0.18 & 0.10/km, respectively). During the return, Antarctic prions and Adelie penguins were most abundant (0.66 & 0.48/km, respectively) in the Antarctic zone. Short tailed shear water dominated in the sub-Antarctic zone (0.57/km). White chinned petrel occurred in moderate numbers in the sub-Antarctic (0.19/km), but dominated in the temperate (0.37/km) and sub- tropical (0.25/km) zones. Wandering albatross (0.11/km) was also quite abundant in the temperate zone. Little shear water dominated the tropical (S) (0.16/km) and the tropical (N) (0.12/km) zones. In the former zone, it was closely followed by the sooty shear water (0.15/km).

Table 5a : Zone wise encounter rates of species of birds and mammals seen in the Indian Ocean. Figures at the end of each table give the duration and distance monitored in each zone

Species	Onward Journey (7/12/95 to 31/12/95)						Return Journey (27/2/96 to 19/3/96)					
	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-59°S	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-69°S
Bird												
Falcon, redlegged	0.001	-	-	-	-	-	-	-	-	-	-	-
Shear-water, Sooty	-	0.11	-	-	-	-	-	0.15	-	-	-	-
Tern, Sooty	-	0.001	-	-	-	-	-	0.03	-	-	-	-
Shear-water, Little	-	0.05	0.03	0.01	-	-	0.12	0.16	-	0.002	-	-
Petrel, Great winged	-	0.01	0.02	-	-	-	-	-	-	-	-	-
Tropic-bird, white tailed	-	0.001	-	-	-	-	0.002	0.002	-	-	-	-
Tern, Caspian	-	0.001	-	-	-	-	-	-	-	-	-	-
Booby, Masked	-	0.001	-	-	-	-	-	-	-	-	-	-
Petrel, White chinned (F)	-	-	0.43	0.09	0.12	-	-	-	0.25	0.37	0.19	0.07
Shear-water, Audobon's	-	-	0.03	0.01	-	-	-	-	-	-	-	-
Prion, Antarctic (F)	-	-	-	0.16	0.21	-	-	-	-	0.01	0.04	0.66
Petrel, Blue (f)	-	-	-	0.02	-	-	-	-	-	-	-	0.01
Storm petrel, Grey backed	-	-	-	0.01	0.03	-	-	-	-	-	-	-
Albatross, Wandering (F)	-	-	-	0.01	-	-	-	-	0.04	0.11	0.02	0.005
Fulmar, Northern giant (f)	-	-	-	0.01	-	0.004	-	-	-	-	0.004	-
Albatross, Black-browed (f)	-	-	-	0.01	0.006	-	-	-	-	-	-	-

(Contd.)

Table 5a— Contd.

Fulmar, Southern giant (f)	-	-	-	0.003	0.01	0.18	-	-	-	-	-	0.02
Albatross, Royal (F)	-	-	-	0.003	-	-	-	-	-	0.002	0.004	0.04
Prion, Fairy (F)	-	-	-	0.003	-	-	-	-	-	-	-	-
Skua, Brown	-	-	-	-	0.01	0.01	-	-	-	0.002	-	-
Storm petrel, Wilson's	0.005	-	-	-	-	-	-	0.01	-	0.02	-	-
Petrel, Cape (f)	-	-	-	-	0.09	0.02	-	-	-	-	-	0.02
Petrel, Antarctic (F)	-	-	-	-	0.02	0.66	-	-	-	-	-	0.02
Albatross, Sooty (F)	-	-	-	-	0.02	-	-	-	-	0.02	-	0.02
Fulmar, Southern (f)	-	-	-	-	0.01	0.004	-	-	-	-	-	0.02
Penguin, Adelie	-	-	-	-	-	0.01	-	-	-	-	-	0.48
Albatross, Light mantled sooty (F)	-	-	-	-	-	-	-	-	-	0.002	0.01	0.03
Albatross, Grey headed (f)	-	-	-	-	-	-	-	-	-	-	0.01	-
Petrel, Snow (F)	-	-	-	-	-	0.10	-	-	-	-	-	0.11
Shear-water, Flesh footed	-	-	-	-	-	-	0.009	0.03	-	-	-	-
Petrel, Jouanin's	-	-	-	-	-	-	0.002	0.01	0.003	-	-	-
Petrel, Bulwer's	-	-	-	-	-	-	-	0.01	-	-	-	-
Petrel, Soft plumaged	-	-	-	-	-	-	-	-	0.04	0.02	0.01	-
Albatross, yellow nosed (F)	-	-	-	-	-	-	-	-	0.003	0.05	0.004	-
Petrel, Kerguelen	-	-	-	-	-	-	-	-	-	0.002	0.11	-
Penguin, Emperor	-	-	-	-	-	-	-	-	-	-	-	0.10
Booby, brown	-	-	-	-	-	-	-	-	-	-	-	-

(Contd.)

Table 5a— Contd.

Tern, Royal	-	-	-	-	-	-	-	0.004	-	-	-	-
Tern, Gull beaked	-	-	-	-	-	-	-	0.002	-	-	-	-
Shear-water, short tailed	-	-	-	-	-	-	-	-	-	-	0.57	-
Tropic bird, Red tailed	-	-	-	-	-	-	-	0.002	-	-	-	-
Mammals												
Porpoise, Finless	0.17	-	-	-	-	-	-	-	-	-	-	-
Dolphin, Spinner	0.07	-	-	-	-	-	0.08	-	-	-	-	-
Dolphin, Bottled nosed	0.06	0.02	-	-	-	-	-	-	-	-	-	-
Whale, Blue	0.005	-	-	-	-	-	0.003	-	-	-	-	-
Dolphin, Striped	-	0.03	-	-	-	-	-	-	-	-	-	-
Whale, Minki	-	-	-	-	0.01	-	-	-	-	-	-	0.01
Whale, Killer	-	-	-	-	-	0.01	-	-	-	-	-	-
Dolphin, Common	-	-	-	-	-	-	-	0.002	-	-	-	-
Whale, Hump backed	-	-	-	-	-	0.01	-	-	-	-	-	-
Seal, Crab eater	-	-	-	-	-	0.01	-	-	-	-	-	0.13
Overall BIRD encounte rate(#/km)	0.48	0.32	0.53	0.46	0.52	0.83	0.16	0.41	0.34	0.67	0.99	1.62
# hours monitored in each zone	15.0	55.4	6.6	20.4	13.8	24.6	36.8	18.3	16.0	16.6	10.0	21.0
# kms monitored in each zone	200.4	778.4	90.4	348.4	168.5	245.3	668.0	563.6	364.0	537.2	244.2	207.2

F : Followers ; f: Occasional followers

Zones : 15°N-00° Tropical (N); 01°-25°S Tropical (S); 26°-35°S sub-Tropical; 36°-49°S Temperate; 50°-59°S sub-Antarctic; 60°-69°S Antarctic

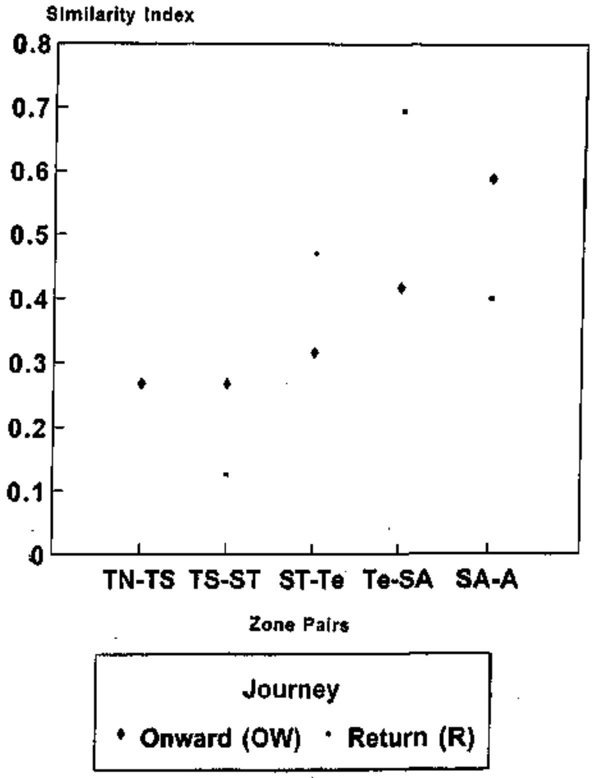
Table 5b : Zone wise relative abundance of unconfirmed species of birds and mammals seen in the Indian Ocean. Figures at the end of each table give the duration and distance monitored in each zone

Species	Onward Journey (7/12/95 to				31/12/95)		Return Journey (27/2/96 to 19/3/96)					
	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-49°S	60°-69°S	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-69°S
Birds												
? Storm petrel	0.32	0.03	-	-	-	-	-	-	-	-	-	-
?Bird	0.12	0.001	-	-	-	-	-	-	-	-	-	-
? Booby, brown	0.01	0.001	-	-	-	-	-	-	-	-	-	-
? Egret, cattle	0.01	-	-	-	-	-	-	-	-	-	-	-
? Petrel, Jouanin's	-	0.04	-	-	-	-	-	-	-	-	-	-
? Petrel, (Black & white)	-	0.001	-	-	-	-	-	-	-	-	-	-
? Kestrel 2	-	-	0.01	-	-	-	-	-	-	-	-	-
? Albatross, Royal/ Wandering	-	-	-	0.02	-	-	-	-	-	0.04	-	-
? Prion	-	-	-	0.02	-	-	-	-	-	-	-	-
? Penguin, King	-	-	-	0.01	-	-	-	-	-	-	-	-
? Skua	-	-	-	0.003	-	-	-	-	-	-	-	-
? Tern	-	-	-	-	-	-	0.03	-	-	-	-	-
? Tern, white	-	-	-	-	-	-	0.003	-	-	-	-	-
?Gull	-	-	-	-	-	-	-	0.002	-	-	-	-
? Tropic-bird	-	-	-	-	-	-	-	0.002	-	-	-	-
? Petrel, Kerguelen	-	-	-	-	-	-	-	-	0.003	-	0.01	-
? Shear-water, Cory's	-	-	-	-	-	-	-	-	-	-	0.004	-
? Storm petrel, Wilson's	-	-	-	-	-	-	-	-	-	-	-	-
Mammals												
? Whale	0.005	-	-	-	-	-	0.002	-	-	-	-	-
? Whale, Sperm	-	0.01	-	-	-	-	-	-	-	-	-	-
? Dolphin	-	0.004	-	-	-	-	0.02	0.07	-	-	-	-
? Whale, Hump backed	-	-	0.02	-	-	0.004	-	-	-	-	-	-
? Dolphin, Common	-	-	-	-	-	-	0.02	-	-	-	-	-
? Porpoise	-	-	-	-	-	-	0.01	-	-	-	-	-
? Seal	-	-	-	-	-	0.04	-	-	-	-	-	-
# hours monitored in each zone	15.0	55.4	6.6	20.4	13.8	24.6	36.8	18.3	16.0	16.6	10.0	21.0
#kms monitored in each zone	200.4	778.4	90.4	348.4	168.5	245.3	668.0	563.6	364.0	537.2	244.2	207.2

F : Followers ; f: Occasional followers

Species similarity between zones

As is evident from the above description, the two journeys differed in species composition and abundance patterns. Sorensen's similarity index (C_s) was calculated for pairs of adjoining zones. During the onward journey, the pairs, Tropical (N) - Tropical (S) and Tropical (S) - Sub-Trpical zones (C_s = 0.27) and the Sub-Tropical - Temperate zones (C_s = 0.31) differ in their species composition (and abundance patterns), while the Temperate - Sub-Antarctic and the Sub-Antarctic - Antarctic species complexes were quite similar (0.41 & 0.59 respectively) (Fig.2). During the return journey, the trends for similarity between neighbouring zones were different from the onward journey. The similarity between the two tropics, the Sub- Tropical and the Temperate, the Temperate and the Sub-Antarctic zones was high (0.5, 0.47 and 0.70 respectively). The Sub- Antarctic and the Antarctic zones were similar (0.4), but the



Pl. see text for explanation of zones

Fig. 2: Soresen 's bird species similarity index between neighbouring zones

value was lower than during the onward journey. The species complexes of the Sub-Tropical and the Tropical (S) zones, was quite dissimilar (0.13).

Discussion

Bridge as the observation post

Various sites on the ship were tested for use as observation points to determine the best site for optimal visibility and accessibility during all weather conditions. The bow of the ship afforded a small field of vision and sightings behind the ship were not possible. Further in rough weather conditions this site was not accessible. Similar problems were faced in using the stern of the ship from which sightings could be made only in the rear 180° of the ship. The portion above the bridge was most suitable in affording a 360° field of vision and was accessible in all weather conditions. The only constraint faced was that the various microwave transmitters posed a health hazard on continued exposure. Observations in this study were made from this-site.

Sighting distances and angles

Sighting distance and angle relative to the direction of the ship's movement were recorded for each sighting. The perpendicular sighting distance was estimated based on the reference of the ships dimensions. Distance estimation was difficult and the distances beyond ca. 300 m may be prone to heavy biases. Angle was measured relative to the direction of ship's movement, from right to left, i.e. the perpendicular on the right was 90°, while that on the left was 270° and so on.

Over half of the 497 sightings in all zones were within 100 m from the ship (perpendicular distance) while only ca. four percent were beyond 500 m. Does it mean that birds mainly occur within 100 m from the ship or the sighting efficiency declines beyond this range and mainly the large or conspicuous birds can be spotted at this range?

Most sightings in the sub-Tropical (75%), Temperate (88%) and the sub-Antarctic zones (65%) occurred in the rear half of the field of vision (91 ° through 180° to 269°). In the Tropical (N) (85%), Tropical (S) (81%) and the Antarctic (74%) zones, however, most sightings were in the front half of the ship (90° through 0° to 270°). This proves that for best efficiency in recording species, the rear half also should be covered.

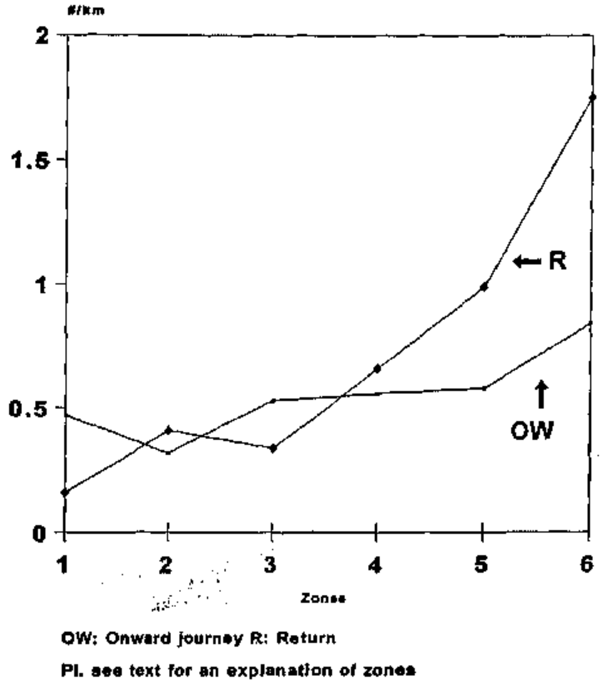


Fig. 3: Graphical representation of zonal encounter rates for birds seen en-route(No/km)

Species richness, diversity and abundance

Out of approx. 86 bird species plus one vagrant reported (Harrison, 1983) from the monitored range, 41 were seen during this expedition. The distribution trends of bird and mammal species in different zones as given in Table-5, conform to the available literature for birds (Watson, 1975; Harrison, 1986) and cetaceans (Savage, 1990) except for the cattle egret (?), Cory's shearwater and the grey petrel which were probably vagrants.

The basis of marine food webs are the phytoplankton which utilise the nutrient salts, such as nitrates, phosphates and silicates dissolved in sea water and sun rays near the sea surface for their growth. Zooplankton survive on these plankton and the entire range of fish and other life such as krill (Euphausia spp.), amphipods, copepods, isopods, pteropods, squid which are important food species of birds, especially in the Sub-Antarctic and Antarctic zones (Watson, 1975) survive on this. Nutrients from the deep sea are brought close to-the surface in areas of upwelling, such as Sub-oceanic ridges, continental shelf and the Antarctic divergence. Other areas of surface disturbance such as the Sub-tropical convergence help in recycling the nutrients. This way, there is a local super-abundance of nutrition which may far exceed other tropical and temperate seas. The average daily phytoplanktonic productivity of the various areas with divergence has been estimated to be between 500 and 1250 mg C/m^2 daily (Barnes and Hughes, 1989). The circumpolar, Antarctic convergence is another area of abundant buoyant phytoplankton. In this area of convergent, sinking waters, a concentration of such plankton is maintained which support a large number of birds (Watson, 1975; Siegfried, 1985).

The tropical and Sub-Tropical seas lack seasonality in planktonic productivity, unlike the highly seasonal temperate to Antarctic seas (Barnes and Hughes, 1989). These latter areas have a super abundance of resources during summer and many bird species in large numbers arrive to take advantage of these super-abundant resources. In both journeys, the cold waters had highest species diversity and abundance while the Sub-Tropical zone had the least. It is evident that in the potentially food rich zones i.e. convergence, divergence and areas near land (see Fig.1), the species richness, diversity and abundance of bird species was high. Also, in the regions of seasonal super-abundance such as the Sub-Antarctic and the Antarctic zones, the bird abundance was remarkably high in both journeys even though the diversity in the onward journey was low. Such areas of confluence of oceanic waters usually have high abundance of animals, though, not always in species richness (Angel, 1993). These zones also had similar species composition. The zones of poorer diversity of avifauna [Tropical (N) and Sub-Tropical zones] correspond to open sea areas, far from land and areas without any oceanic convergence or divergence [it should be noted that the coastal regions of India, in the Tropical (N) zone, could not be monitored in both the journeys]. The diversity of organisms is known to be higher in the tropical and Sub-tropical waters (Harrison, 1983; Angel, 1993), but probably due to lower abundance, the net chances of encountering species reduces. The cold waters, on the other hand, have comparatively lower number of species of birds (Harrison, 1983; Watson, 1975), but with high abundance, hence the chances of encountering species is higher in such zones.

The phytoplanktonic bloom and the consequent zooplankton bloom (including krill) occurs in the later part of summer in the Antarctic zone (Watson, 1975; Barnes and Hughes, 1989). Hence, the diversity as well as the abundance of bird species was much higher in this zone during the return journey **(Table-5).** A similar reason for the higher abundance in all zones during the return journey is likely.

It should be noted here that it will be difficult to answer many questions about the ecology of the pelagic bird species encountered without sampling for food and/or nutrient status along with bird species occurrence and abundance data and must be systematically collected in the future.

problems and biases in technique

As has been mentioned, the area all around the ship, i.e. 360° was monitored. This was because cetaceans and birds often appear in the rear 180° of the ship and especially in the Sub-Antarctic and Antarctic zones, some bird species mainly appear in the rear 180° of the ships course (follower birds). This entails difficulty in maintaining constant vigil all around by one observer. Observer fatigue was noticed in all instances when monitoring was done continuously for more than three hours.

The 'follower bird' posed another problem. These are species who follow the ship for long durations, probably to take advantage of the galley refuge and the opening up of the sea surface by the moving ship. In the entire Sub-Antarctic and Antarctic zones, some species were constant followers. The number of individuals of each species following kept varying frequently, and thus, it was difficult to make a judgement in recording this data. A sighting was taken to be new when : ,

There was an increase in the number of individuals of the species following, & *Jor*

The birds reappeared after going out of view (the region for ca. one to two kms. Was thoroughly searched in this case).

Because of these assumptions, the abundance of the follower birds are likely to be overestimates.

Cetaceans posed a problem in species identification and counting their numbers. These animals were, visible only when they appeared on the sea surface, i.e. while they 'breached', 'proposed' or when a 'spout' was seen. Any surfacing by these species without any of these behavioural patterns is also likely to be missed. Lack of records of cetaceans in any zone is thus not an indication of their absence from that zone. Most of the whale sightings were momentary and their identification became difficult. Problem in identifying dolphins were also exacerbated due to their appearance against the light. Dolphins numbers could not be reliably estimated because not all individuals of a pod may appear above water simultaneously.

The effective area being monitored from the ship is a very small proportion of the available area in each zone and probably can't be used for abundance estimates. Not seeing a species is hence not a complete indication of absence of the species from an area. Hence, there is little comparability of data between years.

Comparison with 14th expedition results (Sathyakumar, 1995)

'There Were 13 bird species common out of 17 bird species identified in the 14th expedition and 42 identified during the 15th expedition. Out of the 5 mammal species identified during the 14th and ten identified during the 15th expedition, 4 are common. Cory's shear water was the most dominant species seen *en- route* during the 14th expedition followed by the Antarctic prion and the cape petrel. During the 15th expedition, the little shear water and sooty shear water dominated the tropical zones during both journeys. The white chinned petrel followed by the Antarctic prion, Antarctic petrel, short tailed shear water and Adelie penguin dominated in the Temperate to Antarctic zones.

The results of both year's studies differ considerably, both in terms of species composition and abundance patterns. Reasons for these may be related to slight seasonal differences and different food resources available at the time of the two studies. The 15th expedition left 10 days before and returned about a week earlier than the 14th, this may have some contribution in the differences. Comparison of the climatic data of the expeditions and sampling for food availability is crucial for being able to understand the trends and relevant differences.

Recommendations

En-route monitoring in the Indian Ocean

A checklist of animals and their distribution patterns emerge out of the study, but in order to have a better understanding of the patterns, it is important to have data on the physio-chemical properties of sea water, such as temperature and nutrient content (nitrates and phosphates) and on food availability. The data on food availability may be difficult to obtain independently but can be obtained with the help of the National Institute of Oceanography, Goa.

As per the problems discussed, it is recommended that two members monitor the entire 360° from the bridge of the ship. Caution will have to be taken not to have any double counts. The roof of the ship's bridge is the most suitable site for monitoring by the two observes, one in the front half and another in the rear half.

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APPENDIX 1

Checklist of species encountered en-route to Antarctica, during Decemb-m- ber, 1995 and on return to Goa during February, March, 1996. (XV Indian Scientific Expedition to Antarctica)

CONFIRMED IDFNTIFICATION

BIRDS

Diomedeidae

Albatross. Black-browed	Diomedea melanophris
Albatross. Grey headed	Diomedea chrysostoma
Albatross. Light mantled sooty	Phoebetria palpebrata
Albatross. Royal	Diomedea epomophora
Albatross. Sooty	Pheobetria fusca
Albatross. Wandering	Diomedea exulans
Ablatross. Yellow nosed	Diomedea chlororhynchos

Sulidae

Booby. Masked	Sula dactylatra
Booby. Brown	Sula leucogaster

Falconidae

Falcon. Red-legged	Falco amurensis

Procellariidae

Fulmar. Northern giant	Macronectes halli
Fulmar. Southern	Pulmonis glacialoides
Fulmar, Southern giant	Macronectes giganteus
Petrel, Antarctic	halassoica antarctica
petrel , Blue	Halobaeona caerulea
Petrel, Bulwer's	Bulweria bulwerii
Petrel, Cape	Daption capensis

(contd.)

Appendix 1 — contd.

	Petrel, Great winged	Pterodroma macroptera
	Petrel Jouanin's	Bulweria fallax
	Petrel, Kerguelen	Peterodroma brevirostris
	Petrel, Snow	Pagodroma nivea
	Petrel, Soflt plumaged	Pterodroma mollis
	Petrol, White chinned	Porcelllaria aequinoctialis
	Prion, Antarctic	Pachyptila desolata
	Prion, Fairy	Pachyptila turtur
	Shearwater, Audobon's	Puffinus lherminieri
	Shearwater, Flesh footed	Puffinus carneipes
	Shearwater, Little	Puffinus assimilis
	Shearwater, Short tailed	Puffinus tenuirostris
	Shearwater, Sooty	Puffinus griseus
Spheniscidae		
	Penguin, Adelie	Pygoscelis adeliae
	Penguin, Emperor	Aptenodytes forsteri
Stercorariidae		
	Skua, Brown	Catharacta lonnbergi
	Skua, South polar*	
Oceanitidae		
	Storm-petrel, Grey backed	Garrodia nereis
	Storm-petrel, Wilson's	Oceanites oceanicus
Sternidae		
	Tern, Caspian	Sterna caspia
	Tern, Gull billed	Sterna nilotica
	Tern, Royal	Sterna maxima
	Tern, Sooty	Sterna fuscata

(Contd.)

Appendix 1 — contd.

Laridae		
Gull, Lesser black backed*		Larsus fuscus
Phaulhontidae		
Tropic-bird, Red tailed		Phaethon rubricauda
Tropic-bird, White tailed		Phaethon lepturus
CETACEANS		
Dolphin, Bottle nosed	(Delphinidae)	Tursiops truncatus
Dolphin, common	(Delphinidae)	Delphinus delphis
Dolphin, Spinner	(Delphinidae)	Stenella longirostris
Dolphin, Striped	(Delphinidae)	Stenella coerulealba
Porpoise, Fin less	(Phocoenidae)	Neophocaenaphocaenoides
Whale, Blue	(Balanopteridae)	Balaenoptera musculus
Whale, Killer	(Delphinidae)	Orcinus orca
Whale, Minki	(Balaenopteridae)	Balaeonoptera acutorostrata
PINNIPEDS		
Seal, Crab eater		Lobodon-carcinophagus
Weddell seal*		Leptonychotes weddellii
Leopard seal*		Hydruga leptonyx

UNCONFIRMED IDENTIFICATION

BIRDS

(i) Unidentified species :

? Bird

? Egret, cattle

? Gull

? Kestrel 2

? Penguin, King *(Aptenodytes patagonicus)*

? Petrel, (Black & white)

? Petrel, Grey *(Procellaria cinerea)*

(contd)

Appendix 1 — contd.

? Prion

? Shear-water, Cory's *(Calonectris diomedea)*

?Tern

? Tern, White

(ii) Probable repetitions :

? Albatross, Royal/Wandering

? Booby, brown

? Skua

? Storm petrel

? Tropic-bird

? Petrel, Jouanin's

? Petrel, Kerguelen

CETACEANS

? Dolphin

? Dolphin, Common

? Porpoise

? Whale

? Whale, Sperm (Physteridae) Physeter macrocephalus

? Whale, Hump backed (Balaenopteridae)Megaptera novaeangliae

PINNIPEDS

?Seal

OTHERS

?Crab

? Turtle, Brown (Olive ridlee)

*Seen only during aerial census and daily monitoring and not en-route monitoring .

Appendix 2a:Zone wise relative abundance of species of birds and mamals seenin the indian Ocean.Figures at the end of each table give the duration and distance monitored in each zone

Species	Onward Journey (7/12/95 to 31/12/95						Return Journey (27/2/96 to 19/3/96)					
	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-69°S	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-69°S
Bird												
Falcon, redlegged	1	-	-	-	-	-	-	-	-	-	-	-
Shear-water, Sooty	-	87	-	-	-	-	-	86	-	-	-	-
Tern, Sooty	-	52	-	-	-	-	-	15	-	-	-	-
Shear-water, Little	-	37	3	2	-	-	80	91	-	2	-	-
Petrel, Great winged	-	10	2		-	-	-	-	-	-	-	-
Tropic-bird, White tailed	-	3	-		-	-	1	1	-	-	-	-
Tern, Caspian	-	3	-		-	-	-	-	-	-	-	-
Booby, Masked	-	1	-		-	-	-	-	-	-	-	-
Petrel, White chinned (F)	-	-	39	30	20	-	-	-	89	201	48	35
Shear-water, Audobon's	-	-	3	2	-	-	-	-	-	-	-	-
Prion, Antarctic (F)	-	-	-	82	35	-	-	-	-	6	10	337
Petrel, Blue (f)	-	-	-	8	-	-	-	-	-	-	-	2
Storm petrel, Grey backed	-	-	-	5	5	-	-	-	-	-	-	-
Albatross, Wandering (F)	-	-	-	4	-	-	-	-	15	61	5	1
Fulmar, Northern giant (f)	-	-	-	3	0	1	-	-	-	-	3	-
Albatross, Black-browed (f)	-	-	-	2	1	0	-	-	-	-	-	-
Fulmar, Southern giant (f)	-	-	-	1	2	3	-	-	-	-	-	5
Albatross, Royal (F)	-	-	-	1	-	-	-	-	-	1	1	8
Prion, Fairy (F)	-	-	-	1	-	-	-	-	-	-	-	-
Skua, Brown	-	-	-	-	2	2		-	-	1	-	-
Storm petrel, Wilson's	-	-	-	-	-	-	-	5		9	-	-
Petrel, Cape (f)	-	-	-	-	15	5	-	-	-	-	-	5
Petrel, Antarctic (F)	-	-	-	-	4	163	-	-	-	-	-	4
Albatross, Sooty (F)	-	-	-	-	2	-	-	-	-	13	-	4
Fulmar, Southern (f)	-	-	-	-	1	1	-	-	-	-	-	5

(Contd.)

Appendix 2a—Contd.

Penguin, Adelie	-	-	-	-	0	3	-	-	-	-	-	100
Albatross, Light mantled sooty (F)	-	-	-	-	-	-	-	-	-	3	3	7
Albatross, Grey headed (0	-	-	-	-	-	-	-	-	-	-	3	-
Petrel, Snow (F)	-	-	-	-	-	25	-	-	-	-	-	22
Shear-water, Flesh footed	-	-	-	-	-	-	6	18	-	-	-	-
Petrel, Jouanin's	-	-	-	-	-	-	1	5	1	-	-	-
Petrel, Bulwer's	-	-	-	-	-	-	-	5	-	-	-	-
Petrel, Soft plumaged	-	-	-	-	-	-	-	-	16	10	3	-
Albatross, yellow nosed (F)	-	-	-	-	-	-	-	-	1	30	1	-
Petrel, Kerguelen	-	-	-	-	-	-	-	-	-	1	26	-
Penguin, Emperor	-	-	-	-	-	-	-	-	-	-	-	21
Booby, Brown	-	-	-	-	-	-	-	-	-	-	-	-
Tern, Royal	-	-	-	-	-	-	-	2	-	-	-	-
Tern, Gull beaked	-	-	-	-	-	-	-	1	-	-	-	-
Shear-water, Short tailed	-	.	-	-	-	-	-	-	-	-	140	-
Tropic bird, Red tailed	-	-	-	-	-	-	-	1	-	-	-	-
Mammals												
Porpoise, Fin less	35	-	-	-	-	-	-	-	-	-	-	-
Dolphin, Spinner	15	-	-	-	-	-	52	-	-	-	-	-
Dolphin, Bottled nosed	12	20	-	-	-	-	-	-	-	-	-	-
Whale, Blue	1	-	-	-	-	-	2	-	-	-	-	-
Dolphin, Striped	-	24	-	-	-	-	-	-	-	-	-	-
Whale, Minki	-	-	-	-	2	-	-	-	-	-	-	3
Whale, Killer	-	-	-	-	-	3	-	-	-	-	-	-
Dolphin, Common	-	-	-	-	-	-	-	1	-	-	-	-
Whale, Hump backed	-	-	-	-	-	-	-	-	-	-	-	-
Seal Crab eater	-	-	-	-	-	3	-	-	-	-	-	27
# hours monitored in each zone	15.0	55.4	6.6	20.4	13.8	24.6	36.8	18.3	16.0	16.6	10.0	21.0
# kms monitored in each zone	200.4	778.4	90.4	348.4	168.5	245.3	668.0	563.6	364.0	537.2	244.2	207.2

F:Follower; f: Occasional followers

Appendix 2b: Zone wise relative abundance of unconfirmed species of birds and mammals seen in the Indian Ocean. Figures at the end of each table give the duration and distance monitored in each zone

Species	Onward Journey (7/12/95 to 31/12/95)						Return Journey (27/2/96 to 19/3/96)					
	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-69°S	15°N-00°	01°-25°S	26°-35°S	36°-49°S	50°-59°S	60°-69°S
Birds												
? Storm petrel	63	**22**	-	-	-	-	-	-	-	-	-	-
?Bird	25	**1**	-	-	-	-	-	-	-	-	-	-
?Booby, brown	3	**1**	-	-	-	-	-	-	-	-	-	-
? Egret, cattle	2	-	-	-	-	-	-	-	-	-	-	-
? Petrel, Jouanin's	-	**31**	-	-	-	-	-	-	-	-	-	-
? Petrel, (Black & white)	-	**1**	-	-	-	-	-	-	-	-	-	-
? Kestrel 2	-	-	**1**	-	-	-	-	-	-	-	-	-
? Albatross , Royal/ Wandering	-	-	-	7	-	-	-	-	-	**22**	-	-
? Prion	-	-	-	6	-	-	-	-	-	-	-	-
? Penguin, King	-	-	-	5	-	-	-	-	-	-	-	-
7 Skua	-	-	-	1	-	-	-	-	-	-	-	-
?Tern	-	-	-	-	-	-	**20**	-	-	-	-	-
? Tern, white	-	-	-	-	-	-	**2**	-	-	-	-	-
?Gull	-	-	-	-	-	-	-	**1**	-	-	-	-
? Tropic-bird	-	-	-	-	-	.	-	**1**	-	-	-	-
? Petrel, Kerguelen	-	-	-	-	-	-	-	-	**1**	-	**2**	-
? Shear-water, Cory's	-	-	-	-	-	-	-	-	-	-	**1**	-
? Storm petrel, Wilson's	-	-	-	-	-	-	-	-	-	-	-	-
Mammals	-	-	-	-	-	-	-	-	-	-	-	-
? Whale	**1**	-	-	-	-	-	**1**	-	-	-	-	-
? Whale, Sperm	-	**7**	-	-	-	-	-	-	-	-	-	-
? Dolphin	-	**3**	-	-	-	-	**13**	42	-	-	-	-
? Whale, Hump backed	-	-	2	-	-	**1**		-	-	-	-	-
? Dolphin, Common	-	-	-	-	-	-	**15**	-	-	-	-	-
? Porpoise	-	-	-	-	-	-	**5**	-	-	-	-	-
? Seal	-	-	-	-	-	**10**	-	-	-	-	-	-
# hours menitored in each zone	15.0	55.4	6.6	20.4	13.8	24.6	36.8	18.3	16.0	16.6	10.0	21.0
# kms monitored in each zone	200.4	778.4	90.4	348.4	168.5	245.3	668.0	563.6	364.	537.2	244.2	207.2

F: Followers; F: Occasional followers

Zones : 15°N-00° Tropical (N); 01°-25°S Tropical'(S);26°-35°S sub-Tropical; 36°-49°STem perate;50°-59°S sub - Antarctic & 60°-69°S Antarctic

APPENDIX 3

Penguin and seal numbers seen in ca. 63 km on the western and 65 km on the eastern shelf areas. Figures in parenthesis are the no. of sightings.

Sortie Date	Penguins			Seals				ER^
	Emperor	Adelie	Uniden.	Weddell	Crab Eater	Leopard	Uniden.	
				WEST TRANSECT				
3 Jan.	238 (35)	54 (8)	5 (2)	235 (42)	115 (23)	7 (4)	1 (1)	10
15 Jan.	451 (27)	167 (12)	1 (1)	233 (24)	74 (13)	0 (0)	0 (0)	14
11 Feb.	250 (25)	195 (20)	0 (0)	31 (11)	24 (16)	0 (0)	3 (1)	8
17 Feb.	223 (32)	498 (73)	0 (0)	4 (4)	108 (36)	0 (0)	0 (0)	13
26 Feb.	249 (22)	47 (14)	0 (0)	5 (2)	41 (13)	0 (0)	0 (0)	5
				EAST TRANSECT				
4 Jan.	21(3)	0(0)	0(0)	17(9)	14(9)	1(3)	1(1)	1
15 Jan.	114(13)	68(10)	0(0)	52(21)	25(16)	1(2)	6(2)	4
*12 Feb.	61(17)	109 (9)	0(0)	2(2)	78 (33)	0(0)	0(0)	4
17 Feb.	4(2)	99(10)	0(0)	1(1)	32(7)	0(0)	0(0)	2
26 Feb.	3(2)	115(19)	0(0)	3(2)	30(5)	0(0)	0(0)	2
					TOTAL			
Sortie # I	259 (38)	54(8)	5(2)	252(51)	129(32)	8(7)	2(2)	6
II	565 (40)	235 (22)	1(1)	285 (45).	99 (29)	1(2)	6(2)	9
III	311(42)	304 (29)	0(0)	33(13)	102(49)	0(0)	3(1)	6
IV	227 (34)	597 (83)	0(0)	5(5)	140 (43)	0(0)	0(0)	8
V	252 (24)	162 (33)	0(0)	8(4)	71(18)	0(0)	0(0)	4

^ Over all encounter rate (# animals/km)

*5 Killer Whales were also seen

APPENDIX 4

Meteorological data recorded by the crew of M.V. Brinknes during the onward (December. 1995), and return journeys (February / March. 1996) and during the stay at India Bay (January. 1996 to 26 February. 1996). (Latitudes recorded at 1200 hours)

		MEAN					MIN.				MAX.			
Month	Date	Temp.	Pressure	Sea Temp.	Course	Speed	Temp	Pressure	Sea Temp.	Temp.	Pressure	Sea Temp.	Lat.
12	7	29.6	1013	29	216.0	14	28.0	1011	29	32.0	1014	29.0	14°N
12	8	29.7	1013	29	209.0	14	28.0	1011	28	32.0	1015	29.0	9°
12	9	30.0	1012	29	209.0	14	28.0	1009	28	34.0	1014	29.0	4°
12	10	29.8	1011	30	209.0	14	29.0	1009	29	31.0	1013	30.0	1°S
12	11	29.4	1011	29	209.0	14	27.0	1010	29	32.0	1013	29.0	4°
12	12	27.7	1012	28	195.6	14	26.0	1011	27	30.0	1014	28.0	10°
12	13	27.4	1014	27	188.0	14	26.0	1013	27	28.0	1015	27.0	15°
12	14	26.4	1015	27	548.4	7.3	25.0	1014	27	28.0	1016	-	20°
12	15	25.5	1016	-	-	.0	25.0	1015	-	26.0	1017	-	20°
12	16	25.8	1017	-	-	.0	25.0	1015	-	27.0	1018	-	20°
12	17	25.0	1018	-	-	.0	25.0	1017	-	25.0	1018	-	20°
12	18	26.3	1015	-	-	.0	24.0	1013	-	28.0	1016	-	20°
12	19	26.7	1014	25	210.0	14	24.0	1013	24	29.0	1015	26.0	20°
12	20	23.8	1012	23	210.0	13	21.0	1012	21	26.0	1013	24.0	26°
12	21	21.4	1010	20	210.0	13	19.0	1007	19	23.0	1011	22.0	31°
12	22	18.0	1005	18	210.0	13	14.0	1004	17	20.0	1008	19.0	36°
12	23	12.8	1016	15	210.0	10	11.0	1009	10	14.0	0120	17.0	39°
12	24	9.8	1021	8.3	210.0	12	9.0	1018	7.0	12.0	1023	9.0	44°
12	25	7.7	1021	5.2	217.0	13	5.0	1015	4.0	9.0	1024	6.0	48°
12	26	4.8	1015	2.9	218.0	12	2.0	1011	4.0	6.0	1018	4.0	52°
12	27	2.2	998	3.0	226.8	11	2.0	985	1.0	4.0	1016	5.0	55°
12	28	2.5	1004	3.3	220.0	12	2.0	993	3.0	4.0	1008	4.0	58°
12	29	-0.4	1002	-.7	197.3	13	-1.0	992	-1	1.0	1007		63°
12	30	1.3	986	-.7	428.5	12	-1.0	985	-1	5.0	990		67°
12	31	-0.9	987		696.3	5.8	-2.0	985		.0	988		69°
1	1	0	980		-	.0	-1.0	976		3.0	987		69°
1	2	-1.0	977		-	.0	-1.0	976		-1.0	978		69°
1	3	-2.3	979		-	.0	-3.0	976		-1.0	982		69°
1	4	-0.2	986		-	.0	-1.0	983		.0	987		69°
1	5	-7	989		-	.0	.0	988		2.0	990		69°
1	6	-.7	994		-	.0	-3.0	991		.0	996		69°
1	7	-1.7	998		-	.0	-3.0	996		-1.0	1001		69°
1	8	-.7	1001		-	.0	-2.0	1001		.0	1002		69°

Appendix 4 - contd.

1	9	-.2	999	943.5	.0	-1.0	998	3.0	1001	69°
1	10	.3	1000	943.5	.0	-1.0	999	3.0	1001	69°
1	11	1.5	998	-	.0	.0	995	*5. 0*	1001	69°
1	12	.7	992	-	.0	.0	**990**	1.0	995	69°
1	13	-1.5	989	-	.0	-4.0	988	.0	990	69°
1	14	-.5	**991**	-	.0	-10	990	.0	991	69°
1	15	-.7	**991**	-	.0	-2.0	990	.0	992	69°
1	16	-1.5	**991**	-	.0	-2.0	990	-1.0	992	69°
1	17	-2.3	989	-	.0	-3.0	988	-2.0	990	69°
1	18	-2.4	987	-	.0	-4.0	980	-1.0	996	69°
1	19	-.8	979	-	.0	-2.0	978	.0	979	69°
1	20	-3.2	988	-	.0	-7.0	980	-1.0	995	69°
1	21	-4.5	996	-	.0	-7.0	995	.0	997	69°
1	22	-3.5	990	-	.0	-7.0	98	1.0	993	69°
1	23	-4.0	989	-	.0	-7.0	988	-2.0	989	69°
1	24	-3.5	989	-	.0	-7.0	987	.0	989	69°
1	25	4.0	987	-	.0	-8.0	985	2.0	989	69°
1	26	-3.5	998	-	.0	-7.0	**991**	-1.0	1002	69°
1	27	-2.8	1005	-	.0	-5.0	1004	.0	1006	69°
1	28	-3.3	1006	-	.0	-4.0	1004	-3.0	1007	69°
1	29	-2.7	1002	-	.0	-4.0	1001	-1.0	1003	69°
1	30	-1.3	1002	-	.0	-5.0	1000	1 .0	1004	69°
1	31	-3.7	990	-	.0	-5.0	983	-1.0	998	69°
2	1	-3.2	997	-	.0	-4.0	**988**	-2.0	1003	69°
2	2	-3.2	998	-	.0	-4.0	**993**	-1.0	1002	69°
2	3	-.2	996	-	.0	-1.0	994	.0	998	69°
2	4	-2.2	1000	-	.0	-5.0	999	.0	1001	69°
2	5	-2.0	994	-	.0	-3.0	990	-1.0	998	69°
2	6	-2.7	990	-.	.0	-4.0	988	.0	991	69° 69°
2	7	-3.0	**993**	-	.0	-5.0	991	-1.0	994	69°
2	8	-2.5	996	-	.0	-4.0	995	-2.0	997	69°
2	9	-3.5	998	-	.0	-5.0	997	-3.0	998	69°
2	10	-4.8	**997**	-	.0	-8.0	995	-4.0	998	69°
2	11	-6.0	**998**	-	.0	-7.0	995	-5.0	1000	69°
2	12	-5.0	999	-	.0	-7.0	996	-4.0	1002	69°
2	13	-4.7	987	-	.0	-6.0	976	-3.0	996	69°
2	14	-4.2	968	-	.0	-9.0	965	-2.0	972	69°
2	15	-3.3	**984**	-	.0	-6.0	976	-1.0	989	69°
2	16	-5.2	989		.0	-8.0	988	-4.0	990	69°

(Contd.)

Appendix 4 — contd.

2	17	-5.0	987	.	-	.0	-9.0	985	.	-4.0	989	.	69°
2	18	-5.3	989	.	-	.0	-8.0	988	.	-4.0	990	.	69°
2	19	-5.0	989	.	-	.0	-5.0	988	.	-5.0	989	.	69°
2	20	-4.3	990	.	-	.0	-5.0	989	.	-4.0	990	.	69°
2	21	-3.5	991	.	-	.0	-4.0	990	.	-3.0	992	.	69°
2	22	-4.2	990	.	-	.0	-6.0	986	.	-2.0	992	.	69°
2	23	-8.2	975	.	-	.0	-9.0	972	.	-8.0	983	.	69°
2	24	-7.7	978	.	-	.0	12.0	973	.	-4.0	981	.	69°
2	25	-8.0	981	.	-	.0	-1.0	977	.	-6.0	988	.	69°
2	26	-8.5	994	.	-	.0	14.0	981	.	-5.0	998	.	69°
2	27	-5.7	992	.	837.5	7.5	-8.0	990	.	-3.0	994	.	69°
2	28	-2.2	990	-2	36.7	12	-5.0	989	-3	-1.0	990	-2.0	67°
2	29	-.5	981	.2	34.0	12	-1.0	975	.0	1.0	988	1.0	63°
3	1	1.2	985	1.2	180.9	13	-1.0	976	.0	2.0	995	2.0	58°
3	2	2.9	1000	2.6	80.8	11	2.0	997	2.0	5.0	1004	3.0	54°
3	3	5.4	1008	4.7	25.2	14	3.0	998	3.0	8.0	1015	8.0	48°
3	4	12.1	1020	11	35.0	14	9.0	1016	8.0	15.0	1025	15.0	44°
3	5	15.8	1026	14	35.0	15	13.0	1025	12	18.0	1028	15.0	38°
3	6	19.3	1020	17	35.0	12	17.0	1016	13	21.0	1025	19.0	35°
3	7	23.2	1011	21	35.0	13	21.0	1008	19	25.0	1014	24.0	32°
3	8	23.6	1016	23	38.5	13	22.0	1012	22	25.0	1018	24.0	29°
3	9	24.4	1016	23	32.5	12	23.0	1015	21	25.0	1018	24.0	24°
3	10	24.0	1014	23	276.0	12	24.0	1013	23	24.0	1014	23.0	20°
3	11	24.0	1012	23	8.0	12	24.0	1012	23	24.0	1012	23.0	20°
3	12	23.6	1013	22	8.0	14	23.0	1012	22	24.0	1014	22/0	20°
3	13	26.9	1010	23	6.1	15	25.0	1009	22	28.0	1011	23.0	13°
3	14	26.5	1009	24	21.1	13	25.0	1007	23	28.0	1010	24.0	8°
3	15	26.5	1008	25	25.2	14	25.0	1006	24	28.0	1009	26.0	4°
3	16	26.5	1008	24	41.7	13	25.0	1006	22	28.0	1010	24.0	0°
3	17	26.6	1009	24	47.5	14	25.0	1006	23	28.0	1011	25.0	4° N
3	18	27.6	1008	24	27.6	13	27.0	1008	23	28.0	1009	25.0	8°
3	19	27.5	1006	25	6.5	14 .	27.0	1004	24	28.0	1008	25.0	12°

Units: Temperature (°C); Pressure (mm Hg); Ship course (°); Ship speed (Knots)
'-' or '.' Indicates missing data; for ship course, '-' may also indicate a zig-zag course.