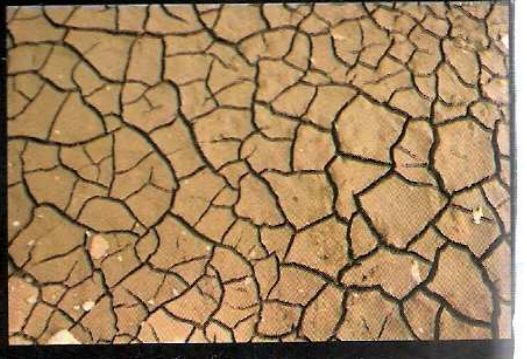
Climate Change

Man and Environment

Goutam Kumar Saha



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Climate Change and its Impact on the Distribution of Birds in Southern Indian Ocean and Antarctica

☆ *K. Sivakumar and S. Sathyakumar**

Introduction

Antarctica and the surrounding ocean have a unique assemblage of flora and fauna that have been threatened in the recent past due to global warming and also due to increasing human activities. Climate change impacts ocean biota in different ways and biological feedbacks in course of time may become amplified during any climate change signal (Camille, 2006). These feedbacks arise from changes in primary production or shifts in the phytoplankton community composition. Several ocean models have suggested that the Southern Ocean surface waters are going to become warmer and fresher with increased vertical stratification, reduced sea–ice, higher oceanic CO_2 concentrations and ultimately increased upwelling. Alteration of these ocean properties may affect the plankton dynamics and community composition in these waters. This is in turn could have a long lasting impact on oceanic birds and mammals, which are directly or indirectly linked to the availability of certain species of phytoplankton. Penguins, oceanic birds and whales are expected to be affected badly among vertebrates due to global warming in circumpolar region around Antarctica.

Monitoring the wildlife populations provides crucial information about the viability of the population being monitored and about the quality of the habitat or landscape in which the population occurs. Although the broad distribution, abundance and ecology of major mammal and bird species that occur in the southern Indian Ocean and Antarctica are known, information on population trends is essential for understanding the long-term conservation status of these species with respect to climate change. The impacts of regional climate change and extreme weather on wild species has been studied for several decades (Camille, 2006). Paleoclimatic studies have also shown that species have adjusted to climate changes at times in the past without mass extinctions (Isabel, 2007). Yet, it is uncertain if projected climate change widely foreseen today would mimic climate change events in the geological record and if human–ecosystem relationships would help or hurt adaptation. In the last ten years, scientists have documented the effects of climate change on species and populations on every continent and in most taxonomic groups. Some studies provide correlations between climate change and species changes, others predict changes with climate and species models and some demonstrate mechanistic connections between species changes and climate change (Root, 2003). Many studies report that climate change acts in concert with other factors to affect species and their habitat. For this reason and because of differences across biomes and species, it is difficult to generalize about the overall impacts of climate change on biodiversity and ecosystems.

The IUCN, the Scientific Committee on Antarctic Research (SCAR) and the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR, 2007) stress the importance of ecosystem monitoring that includes monitoring of wildlife species such as the penguins and seals that are indicators of Antarctic ecosystem. Having better understanding about the impact of climate change on wildlife in a ecosystem where anthropogenic pressures are comparatively less would help to prepare better conservation plan for the marine biodiversity of India and elsewhere, which are threatened by both anthropogenic pressures and climate change.

There are few studies that report the effects of climate change on species distribution, partly because of the difficulties of gathering data throughout a range during a period long enough to produce significant results (Camille, 2006). Such kind of studies in the southern Indian Ocean was even less (Jayasankar *et al.*, 2007). Therefore, this study was initiated by the Wildlife Institute of India aimed to observe the effect of climate change on birds of southern Indian Ocean.

Study Area

The sea voyage route of 28th Indian Scientific Expedition to Antarctica covering a stretch of the southern Indian Ocean from 40°S to 69°S was used as the study area. We carried out ship based surveys along the sea voyage route that started from Cape Town in Republic of South Africa to Larsemann Hills of Antarctica (68°54'92.1" S, 75°30'40.2" E) in almost a straight line; then to the Princess Astrid Coast (5–20°E and 69–72°N), also known as the India Bay along the coastal area of Antarctica; and from India Bay to Cape Town in a straight line. The unique biodiversity assemblage of southern Indian Ocean and Antarctica is home to 21 mammalian species and about 45 species of birds which include seven species of penguins. About 75 species of

oceanic birds have been recorded in the southern Indian Ocean especially between South Africa and Antarctica.

Methods

Abundance and Distribution of Oceanic Birds

The ship M.V. Emerald Sea was chartered by the Govt. of India for the 29th Indian Scientific Expedition to Antarctica (January–March 2009). Oceanic birds all along the sea voyage were sampled at regular intervals to estimate their abundance and to understand their distribution pattern from defined co–ordinates. Standard techniques for censusing seabirds at sea were used following Tasker *et al.* (1984). Briefly, all seabirds that entered a 90 arc from the bow to the beam and out to 150 m on the one side with best visibility (*e.g.* lowest sun glare) were enumerated and their behaviour recorded by two observers stationed on the bridge. A hand–held binoculars equipped with reticules was used to ground–truth the width of the 300–m survey strip. Belt transects were laid along the voyage line at the interval of two hours in a day for two hour observation each. Likewise, three observations covering six hours in a day were made. Start and end points of each transect was marked using a GPS. Speed of the ship during the transect sampling was consistent throughout voyage at the speed of 12 nm/hour. The average length of each belt transect in sea was 24 nm. The ocean between Cape Town and Antarctica was divided into following three zones (Bhatnagar and Sathyakumar, 1999) for data analysis as each zones differed in various environmental settings (Figure 12.1).

Zone 1: Temperate (36°S to 49°S)

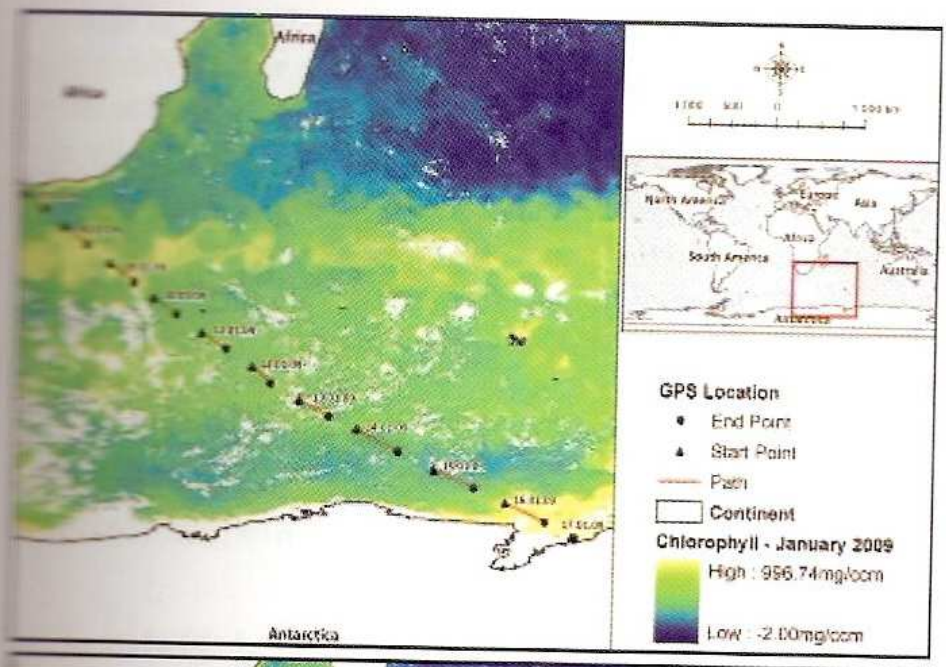
This zone is characterised by an abrupt reduction in sea temperature (of up to 4°C) and salinity along the north–south axis due to an oceanic frontal system, the *sub–tropical convergence* (STC), at approx. 40°S. Here, the cold sub–Antarctic and the warmer sub–tropical surface water meet and sink deep, 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 (Watson, 1975; Eastman, 1993).

Zone 2: Sub-Antarctic/Sub-Polar (50°S to 59°S)

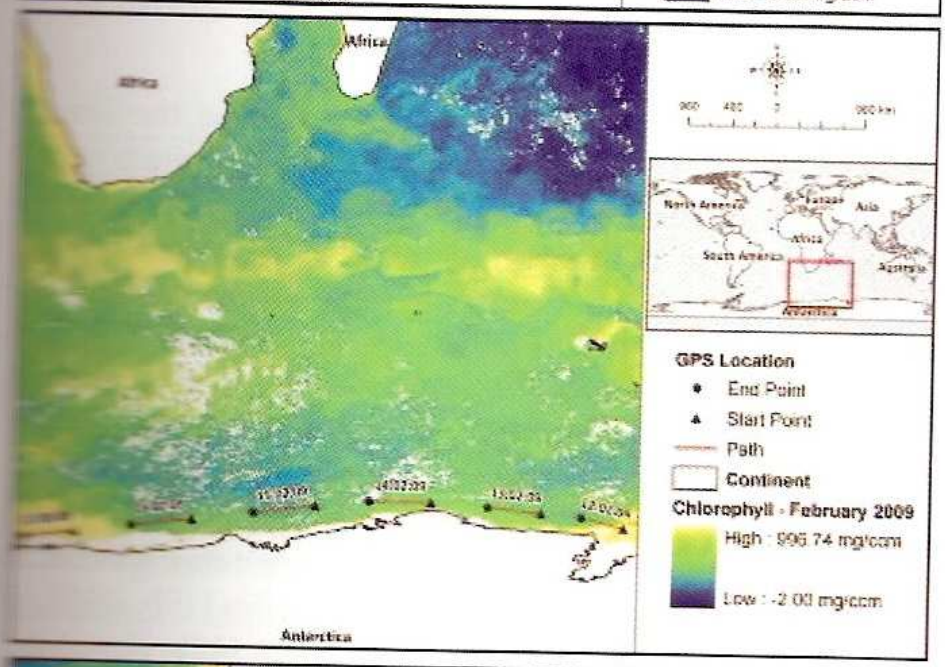
In this zone, a decline of another 2° to 3°C occurs in sea water temperature across another frontal system, the *Antarctic convergence* (AC). This convergence marks the subduction of the cold and denser Antarctic surface water under the slightly warmer, sub–Antarctic surface water. Water temperatures are ca. 5°C to 10°C during winter and 8°C to 14°C during summer months in the sub–Antarctic zone, north of the AC. Ambient temperatures dip to 4°C to 8°C and the ocean usually remains rough. Salinity is reported to be ca. 34.3 ppt (Eastman, 1993).

Zone 3 : Antarctic/Polar (60°S to 69°S)

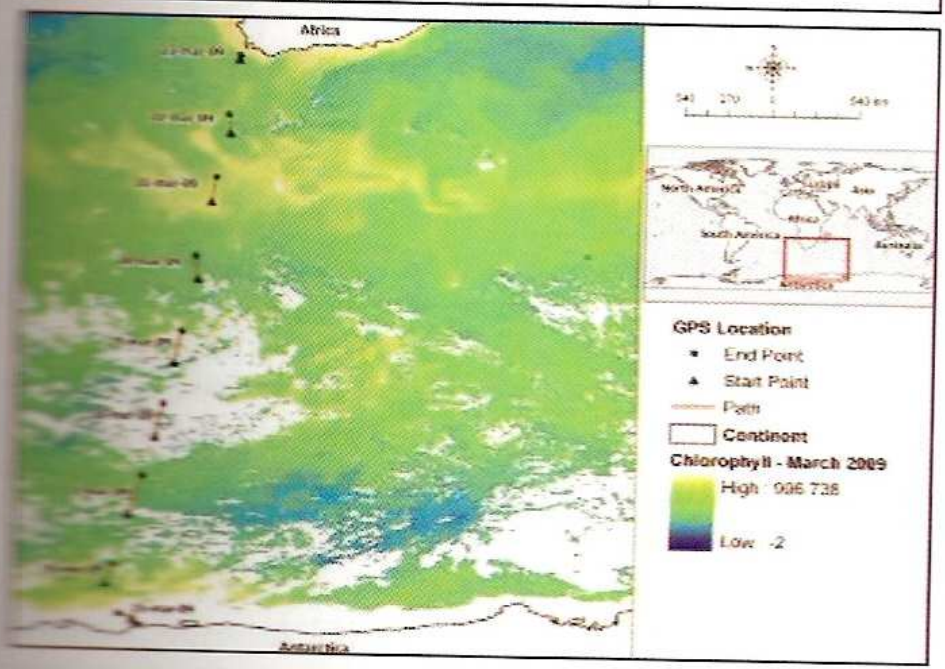
Water temperature near the shelf usually remains sub–zero round the year, but further north, on an average is ca. 1°C to 2°C in winter and 4°C to 5°C during summer (Watson, 1975). An ocean front, the *Antarctic divergence*, occurs at ca. 65°S. The



Cape Town in South Africa to Larsemann Hills in East Antarctica, January 2009



(A) Larsemann Hills to Princess Astrid Coast (India Bay, near Maitri), February, 2009



(B) India Bay (near Maitri) to Cape Town, March, 2009

Figure 12.1: A map of the southern Indian Ocean showing the sea voyage route undertaken during the study and the average chlorophyll content during the study period, January–March 2009.

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; Eastman, 1993).

A total of 66 belt transects of 24 nm each were laid in ocean between January and March 2009. Total observation time was 136 hours and sampled 1613 nm. Total area of bird count was 261 nm^{-2}.

Abundance and Distribution of Birds in the Coastal Habitat of Antarctica

Aerial strip–line transect method was used. Building on this method, the density of birds of Antarctica had been estimated with relation to different habitats which occurred there all along the coast of Larsemann Hills and India Bay (near Maitri). All identified major habitats in Antarctica *i.e.* the maritime, polynea–pack ice, ice shelf and mainland habitats were surveyed using a helicopter. For the aerial transects, the helicopter was flown at a ground speed of 100 km h^{-1} at an altitude of around 70 to 100 m above sea surface all along the coastal line. Number of groups or flocks of birds, size of groups or flocks and their demographic pattern was noted from the aircraft. Aerial photography was also done to reconfirm the aerial census data. On the mainland habitat of Antarctica, few 'Variable width ice–line transects or total count or flock count' was used to monitor the populations of major avian species. A total of three aerial surveys had been carried out along the Larsemann Hills and four surveys along the India Bay. Total distance surveyed at Larsemann Hills was about 60 nm with three replications. Total length of coasts surveyed along India Bay was about 140 nm with four replications.

Results

Species Richness

In the southern Indian Ocean, between Cape Town and Antarctica, a total of 46 oceanic bird species were recorded during the summer months of January, February and March 2009. The list of birds along with their common and scientific names recorded during the expedition are given in Table 12.1. The species composition of birds changed significantly along latitudinal gradient (R^2=0.531) but number of species sighted throughout the region was not changed significantly (R^2=0.003, Figure 12.2).

At Larsemann Hills where India is establishing her third Antarctic Research Station, six species of birds were recorded. These include: Adelie penguin, emperor penguin, south polar skua, snow petrel, Wilson's storm petrel and light mantled

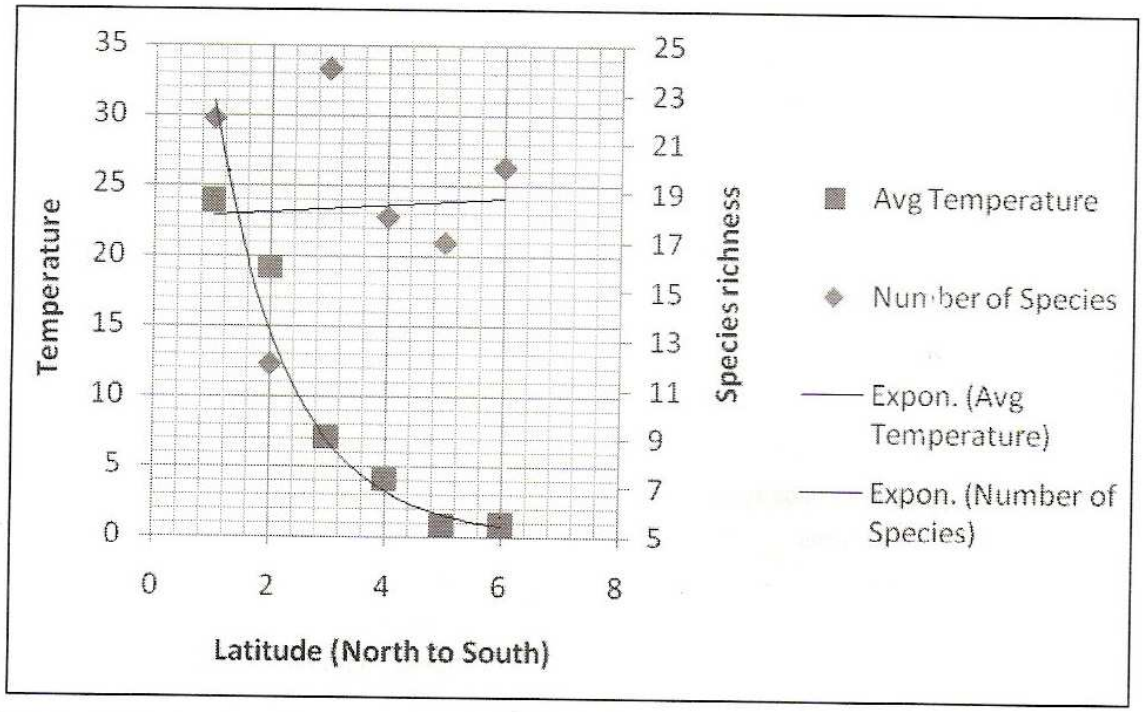


Figure 12.2: Species richness of oceanic birds in the southern Indian Ocean (from Cape Town to Antarctica) January–March 2010.

sooty albatross. Of these, south polar skua and storm petrel were observed breeding in this group of islands. It was also observed that Adelie and emperor penguins were using some of these islands for moulting especially on Fisher and Stornes islands.

Table 12.1: Checklist of birds recorded in the southern Indian Ocean and off-Antarctica, January – March, 2009.

S.No.	*Species*	*Scientific Names*
1.	Adelie Penguin	*Pygoscelis adeliae*
2.	Antarctic Fulmar	*Fulmarus glacialoides*
3.	Antarctic Petrel	*Thalassoica antarctica*
4.	Antarctic Skua	*Catharacta antarctica*
5.	Antarctic Tern	*Sterna vittata*
6.	Atlantic petrel	*Pterodroma incerta*
7.	Black–bellied Storm Petrel	*Fregetta tropica*
8.	Black–browed Albatross	*Diodedea melanophris*
9.	Blue Petrel	*Halobaena caerulea*
10.	Broad–billed Prion	*Pachyptila vittata*
11.	Cape Gannet	*Sula capensis*
12.	Cape Petrel	*Daption capense*
13.	Coommon Diving Petrel	*Pelecanoides urinatrix*
14.	Cory's Shearwater	*Calonectris diomedea*

Contd...

Table 12.1–*Contd...*

S.No.	Species	Scientific Names
15.	Emperor Penguin	*Aptenodytes forsteri*
16.	Fairy prion	*Pachyptila turtur*
17.	Flesh footed shearwater	*Puffinus pacificus*
18.	Great Black backed Gull	*Larus marinus*
19.	Great–winged Petrel	*Pterodroma macroptera*
20.	Grey headed albatross	*Deomedea chrysostoma*
21.	Grey Petrel	*Procellaria cinerea*
22.	Grey–backed Storm Petrel	*Garrodia nereis*
23.	Grey–headed Albatross	*Diomedea chrysostoma*
24.	Kerguelen Petrel	*Pterodroma brevirostris*
25.	King Penguin	*Aptenodytes patagonicus*
26.	Laysen albatross	*Diomedea immutabilis*
27.	Leach's Storm Petrel	*Oceanodroma leucorhoa*
28.	Light mantled sooty albatross	*Phoebetria palpebrata*
29.	Pomarine skua	*Stercorarius pomarinus*
30.	Royal albatross	*Diomedea epomophora*
31.	Salvin's Albatross	*Diomedea cauta salvini*
32.	Snow Petrel	*Pagodroma nivea*
33.	Soft–plumaged Petrel	*Pterodroma mollis*
34.	Sooty Albatross	*Phoebetria fusca*
35.	Sooty Shearwater	*Puffinus griseus*
36.	South Polar Skua	*Catharacta maccormicki*
37.	Southern Giant Petrel	*Macronectes giganteus*
38.	Thin–billed Prion	*Pachyptila belcheri*
39.	Wandering Albatross	*Diomedea exulans*
40.	White capped albatross	*Deomedea cauta cauta*
41.	White chinned Petrel	*Procellaria aequinoctialis*
42.	White–bellied Storm Petrel	*Fregetta grallaria*
43.	White–capped Albatross	*Deomedea cauta*
44.	White–headed Petrel	*Pterodroma lessonii*
45.	Wilson's Storm Petrel	*Oceanites oceanicus*
46.	Yellow nosed albatross	*Diomedea chlororhynchos*

At India Bay and *Maitri*, six species of birds were recorded. These include: Adelie penguin, emperor penguin, south polar skua, snow petrel, Wilson's storm petrel and southern giant petrel. Of these, skua and snow petrel were observed breeding in the Schirmacher Oasis. More number of species recorded along the coast. South polar skua is a common bird in interior Antarctica and they are largely seen around the

scientific research stations looking for food and also known to hunt snow petrels. South polar skua and snow petrels along the Adelie were seen with chicks during survey period.

Abundance and Distribution Pattern

In the 1,613 nm long total transects, a total of 5,727 birds belonging to 46 species were recorded and the density estimated at 21.9 birds/nm^2 in the southern Indian Ocean. Although, the number of bird species recorded in the different latitudinal zones were more or less similar (R^2=0.003, Figure 12.1), higher number of oceanic birds were recorded between 60ºS and 70ºS. Density and sightings of oceanic birds towards south was higher than north in the southern Indian Ocean (Figure 12.3).

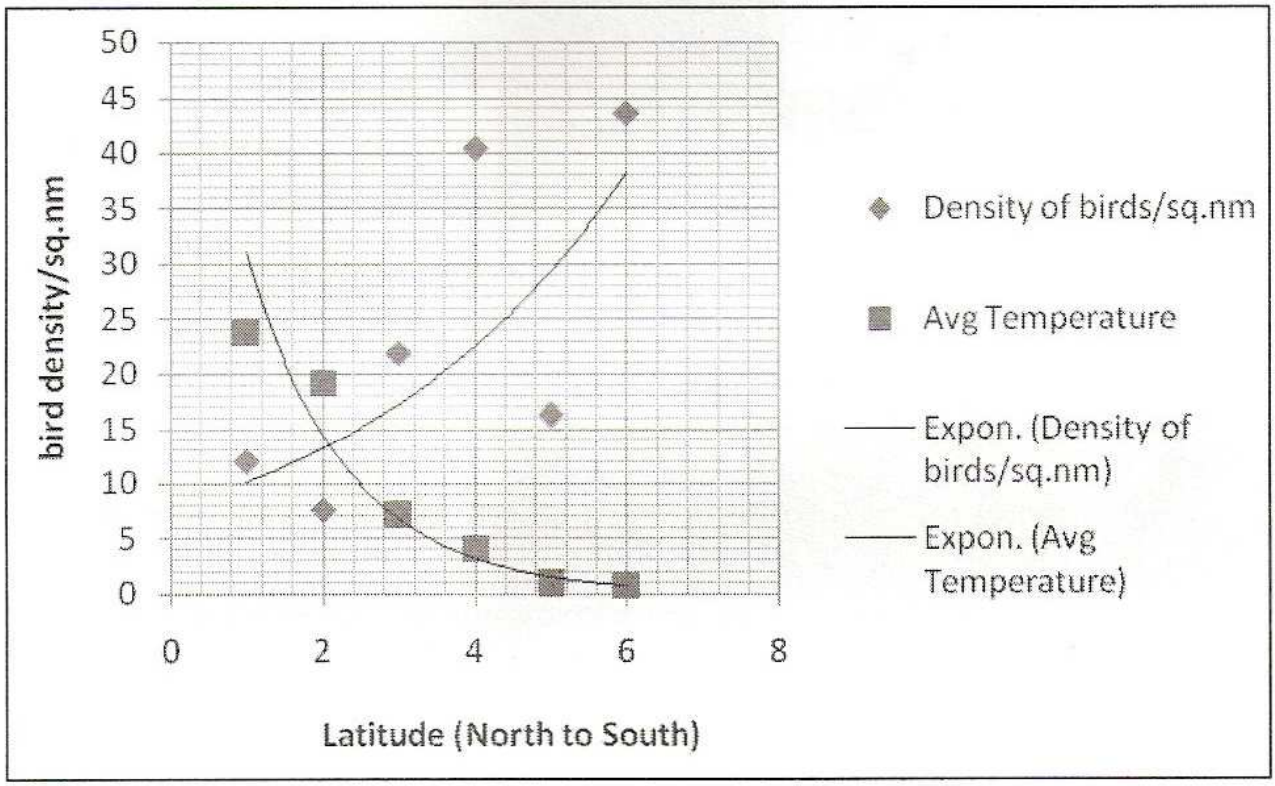


Figure 12.3: Density of oceanic birds in the southern Indian Ocean (from Cape Town to Antarctica), January–March 2010.

In the southern Indian ocean, Antarctic petrel, broad–billed prion, Antarctic skua, Kerguelen petrel, light–mantled sooty albatross, wandering albatross, cape petrel, great–winged petrel, Antarctic fulmer and thin–billed prion were recorded as common birds and had more sightings. Black bellied storm petrel, Atlantic petrel, Antarctic tern, common diving petrel, grey petrel, Salvin's albatross, Layson albatross, Leach's storm petrel, black browed albatross and king penguin were observed rarely in the study area with few sightings. There was a significant negative correlation between ambient temperature and bird density as well as sightings in the southern Indian Ocean. Number of sightings and density of birds increased when the ambient temperature reduced (Figure 12.4).

Range extension of Cory's shearwater, Antarctic skua, cape petrel, white–capped albatross, grey–headed albatross, blue petrel, sooty albatross, kerguelen petrel and

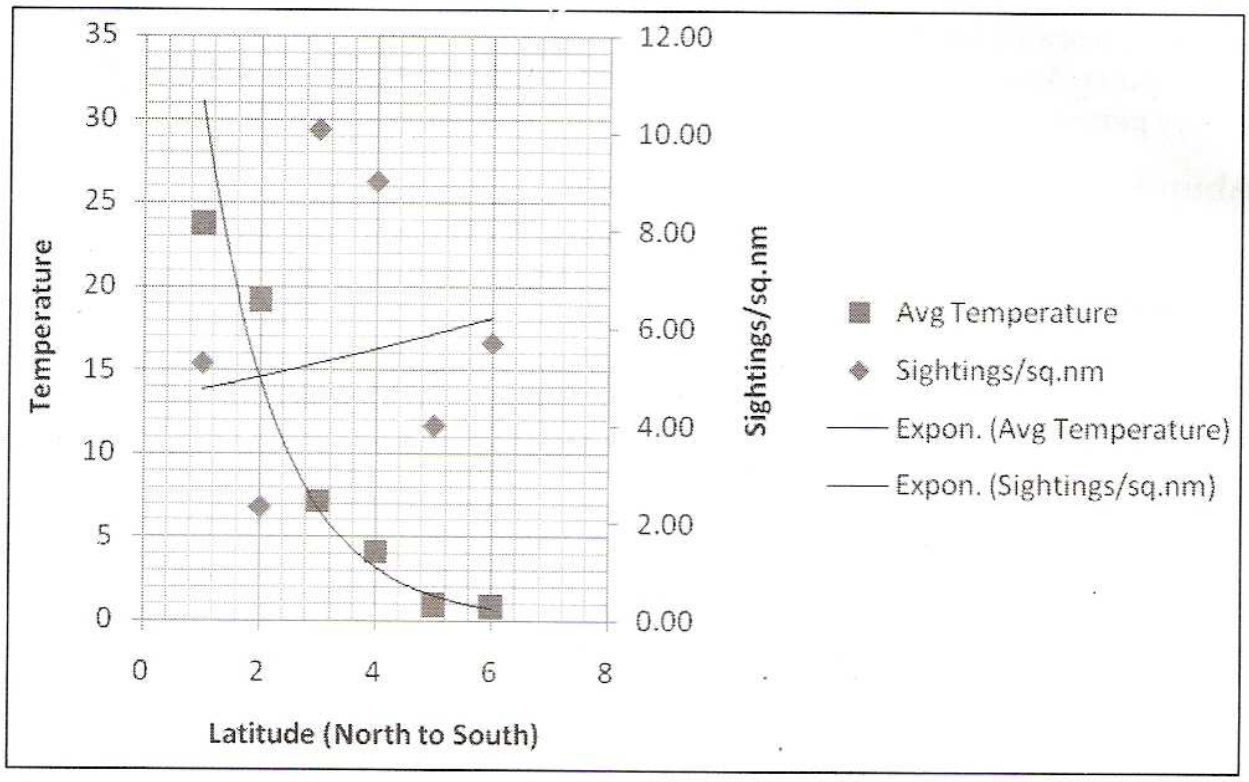


Figure 12.4: Number of sightings and Bird density in the Southern Indian Ocean (from Cape Town to Antarctica), January–March 2010. Increase in temperature due to climate change may affect this population trends.

great winged petrel towards south in the southern Indian Ocean were observed during this study.

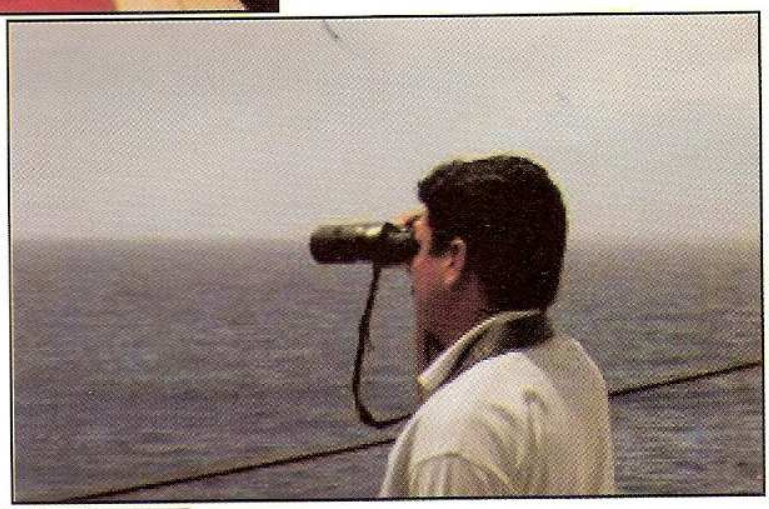
In Antarctica, the encounter rate of two penguin species, along the coast from Clements Bay to Stornes Island in Larsemann Hills, were 24±21/aerial sortie for Adelie penguin and 2±1/aerial sortie for emperor penguin. The total coastal line surveyed was 60 nm. Although, king penguin were sighted in the Laresemann Hills, they were not recorded during the aerial survey as they were very rare. Observations on Adelie penguins in the rookery at Hop Island was also made and we estimated the population to about 5,000 birds which were mostly chicks as their parents were in sea, searching food for their young ones.

The skua population at and around *Maitri*, the second research station of India, was also estimated as six breeding pairs. The mean number of individuals (±SD) recorded during aerial surveys along the Princess Astrid Coast were as follows: Adelie penguin 13±10, emperor penguin 23±19, each sortie covered around 140 nm.

Remarks

In the southern Indian Ocean, bird species richness seems to be more or less similar from north to south during the southern summer. However, the bird density increased significantly from north to south due to low temperature towards Antarctica (Figure 12.4). In the circumpolar region, life gets activated during summer due to favourable temperature that facilitates the production of primary producers and consumers. This ecological phenomenon has been attracting several major vertebrates

Figure 12.5: Observations on birds and mammals made during the sea journeys.



Antarctic Petrel

Cape Petrel

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Figure 12.5–*Contd...*

Humpbacked whales

including ocean birds to forage and breed here. Any change in the temperature of southern Indian Ocean may have adverse impacts on the species composition as well as abundance of ocean birds as climate change impacts ocean biota in different ways and biological feedbacks in course of time may become amplified during climate change (Fung *et al.*, 2005). Because of alteration of ocean properties such as temperature and salinity, these may affect the phytoplankton dynamics and could result in a shift in phytoplankton community composition in these waters. This in turn could have a long lasting impact on zooplankton and other faunal populations such as oceanic birds, which are directly or indirectly linked to the availability of certain species of phytoplankton (Moline *et al.*, 2004).

Figure 12.6: Wildlife species encountered during aerial surveys.

Emperor Penguins and Weddel Seals at Thala Fjord, Larsemann Hills

Figure 12.6–*Contd...*

Adelie Penguins

Leopard Seal

A group of Weddel Seals

Range extension of Cory's shearwater, Antarctic skua, cape petrel, white–capped albatross, grey–headed albatross, blue petrel, sooty albatross, kerguelen petrel and great winged petrel towards south in the southern Indian Ocean were observed during the summer 2009, this may be due to increase in temperature in south because of climate change.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) concluded that the earth's dramatic warming is "unequivocal". Across the globe, the atmosphere and the ocean are warming, and snow and ice have been melting at faster rates. Many plants and animal species have had to adapt, migrate or change the timing of their growth stages in order to avoid extinction. Even oceanic birds and penguins towards the southern pole have not escaped from these changes.

The polar regions at the northern and southern ends of the planet have been seriously affected by global warming. In fact, they are among the regions warming the fastest. The World Wide Fund for Nature has assessed that the Antarctic Peninsula is warming five times faster than the average rate of earth's overall warming. The vast Southern Ocean has warmed all the way down to a depth of 3,000 m. Sea ice that forms from sea water and a key feature of polar oceans covers an area that is 40 per cent less than it did 26 years ago off the west Antarctic Peninsula. Many species that had evolved the capacity to live in the cold, icy and harsh conditions of these polar regions, are now losing their only home.

Breeding areas of emperor penguin have suffered dramatic changes in Antarctica due to climate change. Warmer winter temperatures have led to thinner ice which has then been broken up and swept out to sea by frequently stronger winds. As a result, emperor penguin eggs and chicks have been blown away and before the chicks being able to survive on their own. Of all the Antarctic bird and mammal species, the emperor penguin has become the most vulnerable to the rapidly changing climate. It needs stable, land–locked sea ice on which to breed (it is too clumsy to climb over icy, coastal slopes), but wind–swept, ice–free ocean areas in which to feed. Ironically, climate change has made it easier to feed at the expense of strong thick ice needed for nesting.

We need a long term database on the abundance and distribution patterns of oceanic birds, along with data on the changing environmental settings of the southern Indian Ocean to relate the effects of climate change on biodiversity, which is largely lacking at present. However, it is certain that birds in Antarctica and in the southern Indian Ocean have been affected by the climate change as many oceanic birds appear to be extending their range towards south. Range extension of oceanic birds either towards south or north will affect the normal distribution pattern and species composition of the oceanic birds. Change in species composition may increase the competition for food and habitat, which will ultimately affect the biodiversity in the southern polar region. Actions initiated by the global community to reduce the gas emission therefore minimise the effect of climate change needs to be supported to safeguard the biodiversity of southern Indian Ocean and Antarctica.

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