DISTRIBUTION AND ABUNDANCE OF BIRDS AND MAMMALS IN THE SOUTHERN INDIAN OCEAN, LARSEMANN HILLS AND PRINCESS ASTRID COAST, EAST ANTARCTICA

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ABSTRACT

The spatial distribution and abundance of sea birds, penguins and pack ice seals along the Southern Ocean, Ingrid Christensen and Princess Astrid Coast during 29th Indian Scientific Expedition to Antarctica was carried out between November 2009 and March 2010. A total of 34 species of birds with an encounter rate of 9.82/ nautical miles^2 were recorded. High species turnover of sea birds was observed between 40° and 50° S longitude. Six aerial sorties were flown along the Ingrid Christensen and Princess Astrid Coast to count penguins and seals along the coast, totalling a length of approx. 1200 km. Adelie and Emperor penguins were recorded with encounter rate of 0.63 ± 0.20 (#/nm ±SE) and 3.81 ± 1.68 (#/nm ±SE) respectively at Ingrid Christensen casts. At Princess Astrid Coast more number of Adelie penguins (1.22 ± 0.12/nm ±SE) was recorded when compared to Emperor penguin (0.60 ± 0.2/nm ±SE). In the present survey, a total of 3601 hauled-out seals were counted from six aerial sorties totalling a length of approx. 1200 km, with each sortie lasting about two hours. Weddell seal *Leptonychotes weddellii* was the most commonly sighted species in both the areas surveyed (98.2%), and had an encounter rate of 2.9 seals/km. The other species encountered during the survey were crab-eater seal *Lobodon carcinophagus* (1.7%) and leopard seal *Hydrurga leptonyx* (0.03%). Group size of hauled-out weddell seals varied considerably and ranged from solitary to maximum of 42 individuals. The median group size of weddell seals hauled-out along the Ingrid Christenson coast was found to be significantly different between the December 2009 and January 2010 survey. Further, along this Coast weddell seals were found hauled-out mainly close to the ice shelf and their spatial distribution appeared to be influenced by the extent of sea ice in the area.

KEY WORDS: Sea birds, Southern ocean, Antarctica, Penguin, Weddell seal, crabeater seal, leopard seal, aerial census, encounter rate, spatial distribution, group size

INTRODUCTION

Seabirds belonging to the order Procellariiformes (Albatrosses and Petrels) are amongst the most pelagic of seabirds and occur in all of the world's oceans. They are widely distributed along the Sothern Ocean and largely depend on marine resources for feeding (Shirihai, 2008). Among the albatross, Wandering albatross has wide distribution in the southern ocean (28° to 60°S) and feed mostly on crustaceans, cephalopods and fishes (Robertson, 2003). Similarly, the Cape petrel also has vide distribution (30° to 70°S) along the Southern Oceans and Antarctica coasts (Shirihai, 2008). Abundance distribution of albatrosses and petrels are based on the dynamics in the nutrient and food availability in the Southern Ocean. Abundance of sea birds, therefore, excellent potential indicators of the state of high seas marine ecosystems, increasingly recognised as amongst the least known, yet most imperilled, of marine systems and habitats. Shifts in the distribution and abundance of seabird prey species are already evident. The long-term implications of climate change on seabird populations are difficult to predict but are likely to be significant. Similarly, penguins and seals abundance distributions are highly dependent on trophic dynamics of Antarctica coasts. There are seven species of penguins are considered as Antartica penguins, they live and nest on the Antartica and Antartica coasts (Shirihai, 2008). Among the Antarctica penguins, Adelie and Emperor penguins are quite common in East Antarctica coasts (Sathyakumar, 1998; Hussain and Saxena, 2000; Sathyakumar and Sivakumar, 2009). The availability of fast ice and better moulting habitat for penguins determine the abundance and distribution of penguins in the Antarctica coasts (Hussain and Saxena, 2000).

Five of the 18 extant species of true seals: the Southern Elephant seal *Mirounga leonina*, Weddell seal *Leptonychotes weddellii*, Crabeater seal *Lobodon carcinophagus*, Leopard seal *Hydrurga leptonyx* and Ross seal *Ommatophoca rossii* occur exclusively in the Antarctica. They have a circumpolar distribution around the Antarctic Continent and also occur a little further north in the Southern Ocean and on subantarctic islands (Folkens et al., 2008). Being amongst the dominant top predators in the Antarctic ecosystem they likely play an important role, however the role of marine mammals in aquatic ecosystems is poorly understood (see (Bowen, 1997). Till recently, the population status of the Antarctic pack-ice seals except for the Southern Elephant seal was unknown. And, therefore a continent-wide census under the International Pack Ice Seals (IPIS) program has been initiated by the SCAR Group of Specialists on Seals (Southwell et al., 2012). In the 19th and early 20th centuries, the Southern

elephant seal was hunted almost to extinction, while the other species were never subjected to commercial exploitation (Shirihai, 2008). And, primarily escaped human depredation by virtue of their range being in dangerous and ice-filled seas (Testa and Siniff, 1987). All of these five species of seals are currently protected under the Antarctic Treaty and there has been no commercial sealing in Antarctica since the 1950's. Due to the present widespread occurrence and large population size globally all of the Antarctic pack-ice seals are classified as Least concern by the IUCN.

In recent times, sea ice loss due to climate change however has been reported to have an impact on marine wildlife (Learmonth et al., 2006). Loss of suitable breeding and resting habitats of pack-ice seals due to sea ice loss, coupled with changes in food web dynamics is reported to may negatively impact marine wildlife populations (Siniff et al., 2008; Costa et al., 2010; Forcada et al., 2012). Considering the above potential threat, it becomes important to monitor population trends of sea birds and along the Southern Ocean and Antarctica coasts.

In this background, the National Centre for Antarctic and Ocean Research (NCAOR), under the Ministry of Earth Sciences, Government of India has been undertaking annual expeditions to the Antarctic continent since 1981. As part of the research activities a project on "Long-term monitoring of wildlife and their habitats in Antarctica", primarily focussing in the region where the Indian research stations are located is being carried out. Under this project regular count of sea birds, seals and other marine mammals through aerial and ship based surveys have been taken up (Sathyakumar, 1998; Bhatnagar and Sathyakumar, 1999; Hussain and Saxena, 2000; Sathyakumar and Sivakumar, 2009). Here we report the distribution and abundance of birds and mammals in the Southern Indian Ocean, Ingrid Christensen, Larsemann Hills and Princess Astrid Coast, East Antarctica recorded between December 2009 and February 2010 in the 29th Indian Scientific Expedition to Antarctica.

MATERIAL AND METHODS

Study area

The 29th Indian scientific expedition to Antarctica (InSEA) set out from Cap Town, South Africa on 1st December 2009 and returned back to Cap Town on 18th March, 2010. The

counting of sea birds was covered in three routes: Cape Town to Ingrid Christensen coast, Larsemann Hills; Larsemann Hills to Astrid coast and Astrid coast to Cape Town. The survey routes were depicted in Figure 1. Surveys for seals and penguins were carried out in the region around the two Indian research stations: Bharti and Maitri in Antarctica during this expedition (Figure 2). The first station visited was Bharti located in the Larsemann hills along the Ingrid Christenson Coast, East Antarctica. Two other research stations: Zhongshan (China) and Progress II (Russia) are also located along this coast. There surveys were carried out within the Prydz Bay between 74-77°E longitudes and during December 2009 and January 2010. This coastline is characterised by coastal hills and ice shelf's including that of the Amery ice shelf, and several rocky islands. Fast ice covered much of the offshore areas here up to 25 km till the third week of January 2010, and gradually declined in its extent, and later became entirely ice free over large stretches of the area. The second station Maitri located in the Princess Astrid Coast was visited in February 2010, where surveys were carried out between 11-14°E longitudes. Here the coastline was completely unlike that of the Prydz bay region, and is primarily the Fimbul and Lazarev ice shelf. During the time of visit to this site much of the area surveyed was open water and pack ice.

Methods

Sea bird count

Counting of sea birds was as soon as the expedition set sail from Cape Town and regular observations for oceanic birds and other wildlife were made from onboard the expedition vessel *Ivan Papanin* between 1st and 12th December 2009. As per protocol developed by Sathyakumar (1998), 6 hrs were spent daily observing birds (morning 2 hr, after noon 2 hr and evening 2 hr) and other wildlife. Fixed transect width of 150m from both sides of on board ship were considered for observation and two observer were engaged for recording birds at the time. Other information on the outside temperature, pressure, wind velocity, ship speed along with GPS coordinates were collected from the instruments installed in the bridge of the ship. Bird species encountered are photographed using Nikon digital field camera (70-300 mm), later species were confirmed using Antarctica Wildlife field guide (Shirihai, 2008). Same protocol was followed for other two routes, i.e. Larsemann Hills to Astrid coast (6 to 10th February 2010) and Astrid coast to Cape Town (12 to 18th March 2010).

Seal and penguin Count

Aerial sorties using a single-engine Eurocopter AS 350 B2 were made for survey of pack ice seals at both the study sites. Due to limited number of sorties being available for the survey and given the operational capacity of the helicopter no systematic design could be followed. In the Prydz Bay, Larsemann Hills region four sorties were flown in each of the two months surveyed, while in the second site only two sorties could be flown. Using the ship as the base, surveys were made to the East and to the West of the region, and each trip covered a distance of about 200 to 250 km, lasting on average two hours. Each flight followed a pattern of first flying along the contour of the coastline covering on average 100 km, then fly out over the fast ice and up to the pack ice edge, and then survey all along the pack ice edge and over fast ice before returning to the ship. Census of weddell seals in particular is recommended to be carried out after 1430 and before 1700 hr local time, especially in the moulting season, which is from January to March (Lake et al., 1997). While our study partly overlapped this period we could not conduct surveys during the recommended time due to logistical difficulties, and all sorties were flown between 0900 and 1100 hrs local time.

Two observers along with the pilot searched for hauled-out seals on either side of the helicopter. The helicopter was flown at a constant speed on average 90 knots and at an altitude of approx. 80 m. The pilot and the observer seated next to him reported the seal and penguin sightings, the species, and group size, while the observer seated at the back recorded the data. The observer in the front also recorded a location of every seal and penguin sighting using a hand-held GPS, and reported the perpendicular distance of the seal from the track-line. To take count of seals and penguins in a large congregation the helicopter was slowed down. On some occasions when the seal and penguin species could not be identified or the number of seals and penguins in a large congregation could not be counted a photograph of the same was taken. The photos were later examined in camp to identify and or count the number of seals and penguins recorded at that point. Following, (Erickson et al., 1993) all seals and penguins occurring within 20 m of each other where considered as a group.

Analysis

Sea birds encountered during the survey were grouped and longitude wise distribution of species richness were analysed. Species richness and encountered rate were calculated. The seals and penguin sighting data was segregated according to the sighting location such as shelf-ice/edge, fact ice and pack ice. Considering that no systematic design could be followed

during this study we did not estimate the density of seals, and instead calculated encounter rates. A two proportion z-test was used to test for differences in group size proportions across the months of survey in the Prydz Bay. The mean, median and mean crowding of the seal group size data was analysed in Flocker (version 1.1). To identify areas where weddell seals hauled-out maximum in the Prydz Bay site fixed kernel contours (95% and 50%) were generated in ArcGiS (version 9.3) using the seal locations obtained from the aerial survey. This was not done for the Fimbul ice shelf site as much of the area was open waters during the survey, which resulted in low encounters of seals hauled-out.

RESULTS

Sea bird survey

A total of 102 hr were spent observing birds during the voyage (21 days) and a total of 34 species of birds were recorded during the voyage. Forty eight transect covering 1232 nautical mile (nm) distance were covered. In the present survey a total of 1,936 birds counted with an encounter rate of 9.82/ nm^2. The followings are the notable bird species recorded during our voyage: Wandering Albatross, Indian Yellow nosed Albatross, Back browed Albatross, Grey headed Albatross, Light mantle Sooty Albatross, Sooty Albatross, Southern Giant Petrel, Northern Giant Petrel, Cape Petrel, Antarctica Petrel, Southern Fulmar, Soft-plumaged Petrel, White-headed Petrel, Grey-winged Petrel, Grey Petrel, White-chinned Petrel, Salvins Prion, Antarctica Prion, White-bellied storm Petrel, Wilson storm Petrel, Cape Gannet, Subantarctic Skua, Arctic Tern and Snow Petrel. A gradual shift in the bird species assemblage along the sea route and high number of species turnover was observed between 40° and 50° S longitude (Figure 3).

Seal and Penguin survey

A total of six aerial sorties were flown during this study, totalling a length of approx. 1200 km that is four sorties in the Prydz Bay, Larsemann hill region totalling 800 km, and two sorties along the Fimbul ice shelf totalling 400 km. Two species of penguins, Adelie and Emperor penguin were recorded with encounter rate of 0.63 ± 0.20 (#/nm ±SE) and 3.81 ± 1.68 (#/nm ±SE) respectively. In contrast, the Princess Astrid Coast more number of Adelie penguins (1.22 ± 0.12/nm ±SE) was recorded when compared to Emperor penguin (0.60 ± 0.2/nm ±SE). Two very large penguin rookeries, one of Emperor Penguin (numbering

5000+birds) and Adelie penguin (numbering 3000 + birds) were observed on the eastern part of the Larsemann hills (Figure 4).

In the case of seal, except the southern elephant seal and Ross seal, all the other species of pack ice seals were recorded during the aerial surveys. A total of 3645 seals that included weddell, crab-eater and leopard seals were counted during the six aerial sorties; of these in the Prydz Bay region alone 3273 seals were counted (see Table 1a & 1b). A total of 41 seals in the Prydz bay and 3 in the Fimbul Ice shelf site could not be distinguished as to whether they were weddell or crabeater seal. Weddell seal was the most commonly sighted species in both the areas surveyed (97.0%), and had an encounter rate of 2.9 seals/km. This was followed by the sightings of crab-eater seal (1.7%) and a single record of leopard seal (0.03%). Ross seal was not encountered during the aerial surveys however a pair was seen once from the ship en route to the Fimbul ice shelf, hauled-out on fast ice (Figure 5).

The encounter rate of weddell seal in Prydz Bay (4.0 seals/km) was much higher compared to that of the Fimbul ice shelf site (0.8 seals/km). Within Prydz Bay the encounter rate of weddell seal differed between the months of survey; there 2.7 seals/km was recorded during December while in January 6.1 seals/km was encountered (Mann-Whitney $U = 0.0004$, $p < 0.05$). Weddell seal sightings between the western and eastern shelf during the December survey was not significantly different (Mann-Whitney $U = 0.0085$, $p = 0.501$), while it was significantly different for surveys in January (Mann-Whitney $U = 0.0001$, $p < 0.05$). The encounter rate of weddell seals also differed with respect to location and sea ice conditions. Maximum sightings occurred along the shelf-ice/edge with an encounter rate of 6.8 seals/km, while over the fast ice and pack ice 2.3 and 0.1 seals/km was recorded respectively.

Group Size

A total of 668 weddell seal groups with sizes ranging from solitary to maximum of 42 individuals were sighted during the surveys in the Prydz Bay site. Maximum number of weddell seals were observed solitary ($n = 237$) and accounted 35.5 % of all groups sighted. More number of solitary individuals was sighted during surveys in January (40.8 %) than in December (27.7 %) in the Prydz Bay (Figure 6), and was found to be significantly different ($z = -1.96$, $p < 0.05$). Due to aggregated distribution of weddell seals, group sizes were right-skewed and comparison based on mean group sizes was incorrect. Therefore, median group size of weddell seals when compared were found to be significantly different and larger in

December (4.0) than in January (2.0). Higher number of groups with >10 individuals were seen in January (n = 50) as compared to December (n = 31), however the comparison of the mean crowding of seals between the two months was non-significant (Table 2).

Spatial distribution

The areas where maximum weddell seals hauled-out (50% kernel contours) within the study area in the Prydz Bay was primarily in the western parts along the shelf-ice/edge starting from the Bharti Station to up to the Amery ice shelf. The 50% kernel contours for the month of December encompassed an area of 354 km^2, and the same reduced to 103 km^2 during the month of January. Similarly, the extent of the 95% kernel contours changed considerably, from 1150 km^2 in December to 184 km^2 in January (Figure 7).

DISCUSSION

Sea bird species encountered in the present expedition is quite less when compared to the previous expedition where 46 species birds (vs. 34 species) were recorded. On the other hand, similar patterns of species shift across the longitude and both expedition maximum number of species recorded between 40° and 50° S longitude. The highly threatened large oceanic birds such as Wandering Albartross, Indian Yellow nose Albartross and Sooty Albartross were more frequently encountered between 40° and 60°S longitude, beyond 60°S Albartross were not recorded during the survey. It indicates that the distribution of these birds is restricted only Southern Ocean not at Antarctic coast. Since the oceanic islands such as Prince Edward & Marion, Crozet, Bovetoya Kerguelen and Heard & McDonald are located between 40° and 60°S, which provide suitable breeding and resting grounds for Albartross (Shirihai, 2008).

The high number of weddell seal encounters during this expedition in both Prydz bay and the Fimbul Ice Shelf site is because the survey tracks there were almost entirely near the coast of Antarctica, where the species is known to largely inhabit (Lugg, 1966; Stirling, 1969a; Kooyman, 1975; Testa and Siniff, 1987). The presence of fast ice is known to not necessarily limit the weddell seal occurrence as they can maintain breathing holes by abrading the sea ice with their canine teeth. Moreover, in the inshore fast ice areas weddell seals use ice breaks or cracks caused by tidal action and glacial movement for breathing, hauling out and pupping (Stirling, 1969a). This was typical of the surveyed site in the Prydz bay, which is located far

inshore and with smaller bays sheltered by the rocky slopes of the Larsemann hills, and is possibly the reason why more number of weddell seals was encountered there. In the western Ross sea counts of weddell seal in a square mile of pack ice was reported to be only few when compared to a similar track length in fast ice where more than 100 seals were recorded (Stirling, 1969b), suggesting the species to primarily occur in the fast ice. Sathyakumar and Sivakumar (2009) encountered 7.2 weddell seals/km during January 2009 in the Prydz bay, and 1.2 seals/km during February 2009 in the Fimbul Ice shelf area, which is similar to our observations of this study. The lower encounter rate of weddell seals at the Fimbul site recorded during 2009 and the current study is perhaps related to the time of survey. The visit to this site was in late summer when much of the fast ice cover was reduced to open water, resulting in poor detect-ability of seals.

Within the Prydz bay site the higher encounters of weddell seal in the western shelf (5.4 seals/km) than in the east (2.3 seals/km) appeared to be as a result of availability of fast ice in the area. Much of the fast ice cover along the eastern shelf was reduced to open water earlier than the western parts. In a span of a month the fast ice cover in the entire area observed in mid-December of approx 2500 sq. km reduced to approx. 600 sq. km in January, much of which remaining to the western parts (Figure 4). This resulted in the highest encounter rate of weddell seals observed (12.2 seals/km) along the shelf-ice/edge in the western parts during January 2010 (Table 1). Along the western parts the break-away ice sheets from the Amery ice shelf provided hauling sites for seals, which likely lead to the crowding of weddell seals there. Along the Princess Martha Coast seal densities were reported to increase as the amount of pack ice diminishes with the advance of summer (Bester et al., 1995).

Weddell seals are known to form large aggregations in breeding colonies (Stirling, 1969a), but females are reported to be solitary after giving birth; the pupping season being late September to early November (Smith, 1965; Stirling, 1969a). By end of November weddell seal females are known to wean away pups (Lake et al., 1997), which period coincided with this study, and is possibly why high number of solitary weddell seals were seen. Further, during January the progressing austral summer in the Prydz bay resulted in the sea ice melt and the innumerable cracks in the fast ice became available for seals to haul-out leading to higher number of solitary weddell seal sightings. Large aggregations (ranging from 11 to 42 individuals) in the Prydz bay area were found only when there was a single tidal crack along

a vast stretch of thick fast ice (Figure 4). These groups may not represent any sociality and is only as a result of limited number of natural openings in the fast ice.

The low occurrence of other species such as crabeater and leopard seal particularly in the Prydz bay area during this study is possibly because these seals are inhabitants of the pack-ice edge. Their absence may also be related to their seasonal movements associated with breeding and feeding. Crabeater seals are predominantly krill feeders and use pack ice to haul out (Gilbert & Erickson, 1977; Kooyman, 1981; Nordøy et al., 1995; Bengtson & Cameron, 2004). This is where krill is reported to be abundant and occur most commonly in close proximity to the 1000 m isobaths around the Antarctic coast during summer (Ichii, 1990; Hosie et al., 2000). Similarly, leopard seals are believed to breed on the outer fringes of the pack ice in summer, when they are solitary and sparsely distributed (Erickson et al. 1971; Sniff & Stone, 1985). In the adjoining Vestfold hills in the Prydz bay encounter rates of leopard seals during austral spring and summer surveys in 1992 and 1993 were only 0.06 and 0.14, and seals were reported confined to the very outer edge of the fast ice (Rogers & Bryden, 1997).

It is concluded that seal abundance particularly within the Prydz bay is related to the extent of fast ice in the area. It is possible that more number of hauled-out seals may have been encountered had the aerial surveys been conducted mid-day as recommended by Lake et al. (1997). We therefore recommend that future surveys in the area take into consideration the time of the aerial surveys. Also, there is a well-established protocol for census of pack ice seals under the IPIS program, and for the eastern Antarctic section it is being carried out by the Australian Antarctic Division. It may be useful to follow this protocol thereby contributing to the IPIS program. We also suggest that detailed account of the wind speed, air temperature and cloud cover be recorded as these have been found to influence the haul-out behaviour of pack ice seals.

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Table 1a. Details of the aerial survey for seals carried out in the Prydz bay during December 2009 and January 2010.

Region & Date	Survey stretch	Distance (km)	Duration (hr:min)	Weddel (seal/km)	Crabeater (seal/km)	Leopard (seal/km)	Unknown (seal/km)
Eastern Shelf							
20.12.2009	Temperature - 2°C; Wind speed – 10.7 knots; Cloud cover - Clear						
	Shelf-ice/edge	93	00:54	271 (2.9)	0	0	2 (0.02)
	Fast Ice	76	00:34	261 (3.4)	0	0	4 (0.05)
	Pack Ice	79	00:27	12 (0.2)	1 (0.01)	0	0
	Total	248	01:55	544 (2.2)	1 (0.004)	0	6 (0.02)
18.01.2010	Temperature - 2°C; Wind speed – 10.7 knots; Cloud cover - Clear						
	Shelf-ice/edge	94	00:50	257 (2.7)	0	0	3 (0.03)
	Fast Ice	-	-	-	-	-	-
	Pack Ice	19	00:06	3 (0.2)	0	0	0
	Total	113	00:56	260 (2.3)	0	0	3 (0.03)
Eastern Shelf Total		**361**	**02:51**	**804 (2.2)**	**1 (0.003)**	**0**	**9 (0.02)**
Western Shelf							
22.12.2009	Temperature - 2°C; Wind speed – 10.7 knots; Cloud cover - Clear						
	Shelf-ice/edge	100	00:56	708 (7.1)	0	0	12 (0.12)
	Fast Ice	78	00:30	99 (1.3)	0	0	1 (0.01)
	Pack Ice	76	00:27	3 (0.03)	0	0	0
	Total	254	01:53	807 (3.2)	0	0	13 (0.05)
17.01.2010	Temperature - 2°C; Wind speed – 7.8 knots; Cloud cover - Clear						
	Shelf-ice/edge	130	01:20	1580 (12.2)	0	0	19 (0.15)
	Fast Ice	15	00:05	25 (1.7)	0	0	0
	Pack Ice	48	00:20	15 (0.3)	0	0	0
	Total	193	01:45	1620 (8.4)	0	0	19 (0.09)
Western Shelf Total		**447**	**03:38**	**2427 (5.4)**	**0**	**0**	**32 (0.07)**
Prydz Bay (Overall)		**808**	**06:29**	**3231 (3.9)**	**1 (0.001)**	**0**	**41(0.05)**

Table 1b. Details of the aerial survey for seals carried out in the Fimbul Ice Shelf site during February 2010.

Region & Date	Survey stretch	Distance (km)	Duration (hr:min)	Weddel (seal/km)	Crabeater (seal/km)	Leopard (seal/km)	Unknown (seal/km)
Fimbul Eastern Shelf							
15.02.2010	Temperature: - 2°C; Wind speed: 15 knots; Cloud cover - Clear						
	Shelf-ice/edge	205*	01:55	94 (0.4)	3 (0.01)	0	0
	Fast Ice	-	-	-	-	0	0
	Pack Ice	-	-	-	-	0	0
	Total	205	01:55	94 (0.4)	3 (0.01)	0	0
Fimbul Western Shelf							
21.02.2010	Temperature: -10°C; Wind speed – 25 knots; Cloud cover - Clear						
	Shelf-ice/edge	125#	01:30	181 (1.4)	42 (0.3)	0	3
	Fast Ice	-	-	-	-	0	0
	Pack Ice	75	00:30	31 (0.4)	17 (0.2)	1 (0.01)	0
	Total	200	02:00	212 (1.1)	59 (0.3)	1 (0.005)	3 (0.01)
Fimbul Ice Shelf (Overall)		**405**	**03:55**	**306 (0.8)**	**62 (0.2)**	**1 (0.002)**	**3 (0.01)**

Table 2. The mean, median and mean crowding of the weddell seal groups encountered during the survey in the Prydz bay size during December 2009 and January 2010

Month	**Group Size**		**Mean crowding (95% C.I)**
	Mean ± SD (Range)	**Median**	
December (*n*= 271)	4.9 ± 4.9 (1-34)	4.0	9.7 (8.2 to 12.3)
January (*n*= 397)	4.7 ± 6.4 (1-42)	2.0	13.4 (11.1 to 16.7)
	$p = 0.628$	$p < 0.05$	$p > 0.05$

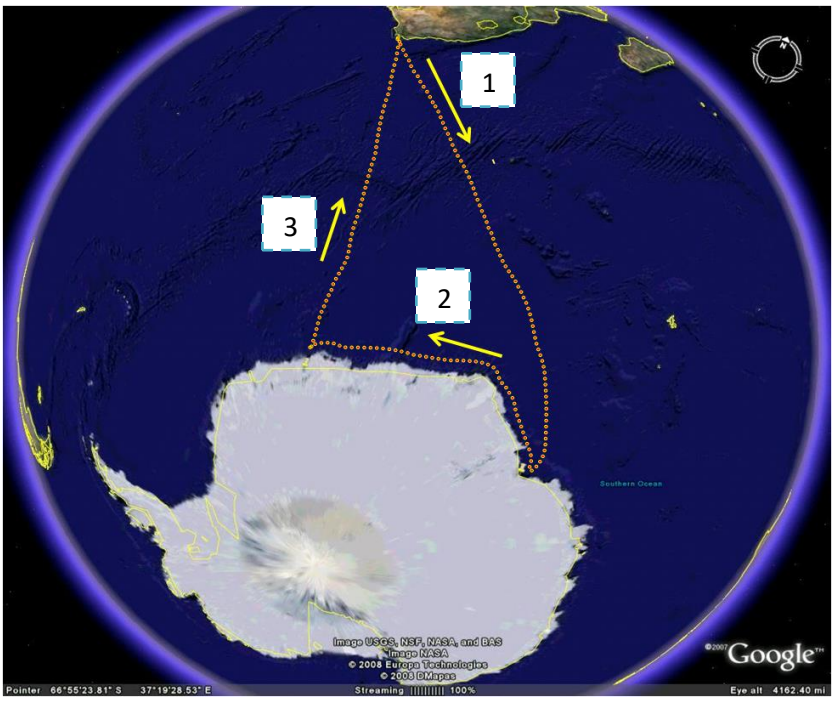

Figure 1. Picture showing the 29th Indian scientific expedition rout to Antarctica. [1] Cape Town to Larsemann Hills; [2] Larsemann Hills to Astrid coast and [3] Astrid coast to Cape Town.

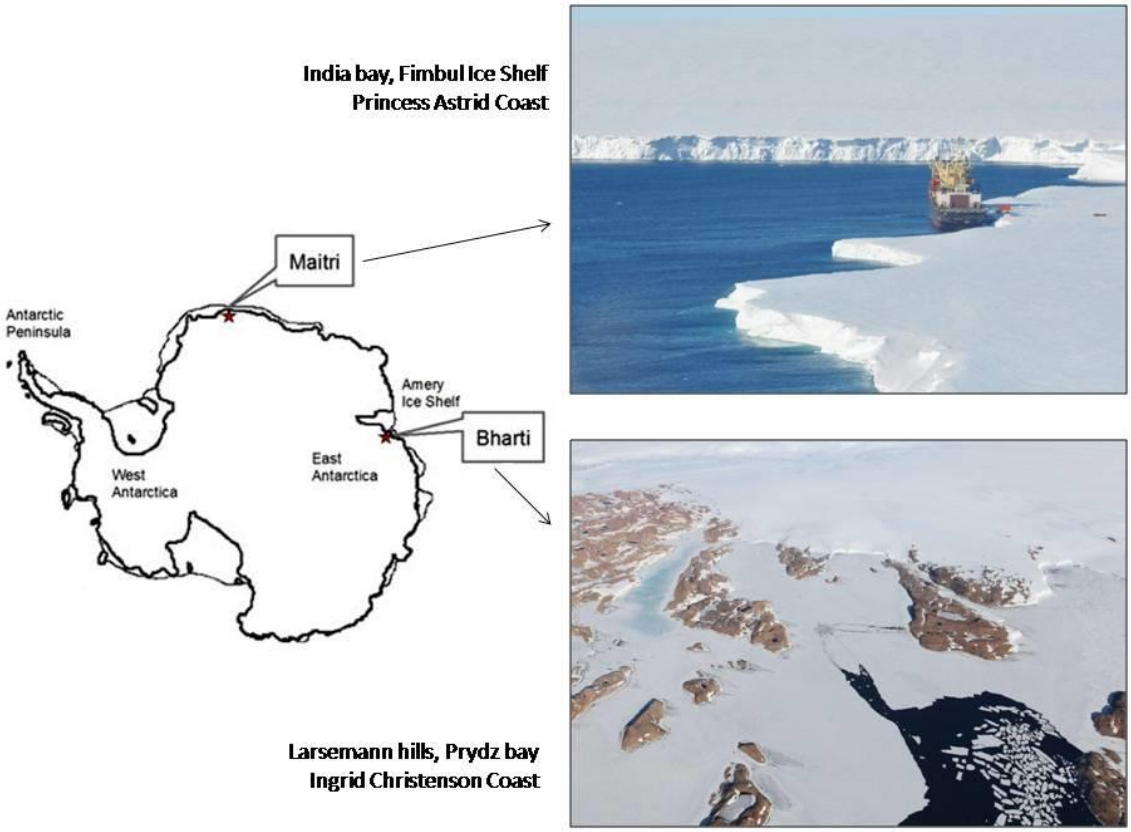

Figure 2. Map of Antarctica showing the locations of the two Indian research stations Maitri, Fimbul Ice Shelf, Princess Astrid Coast and Bharti located in the Larsemann hills, Prydz bay, Ingrid Christenson Coast.

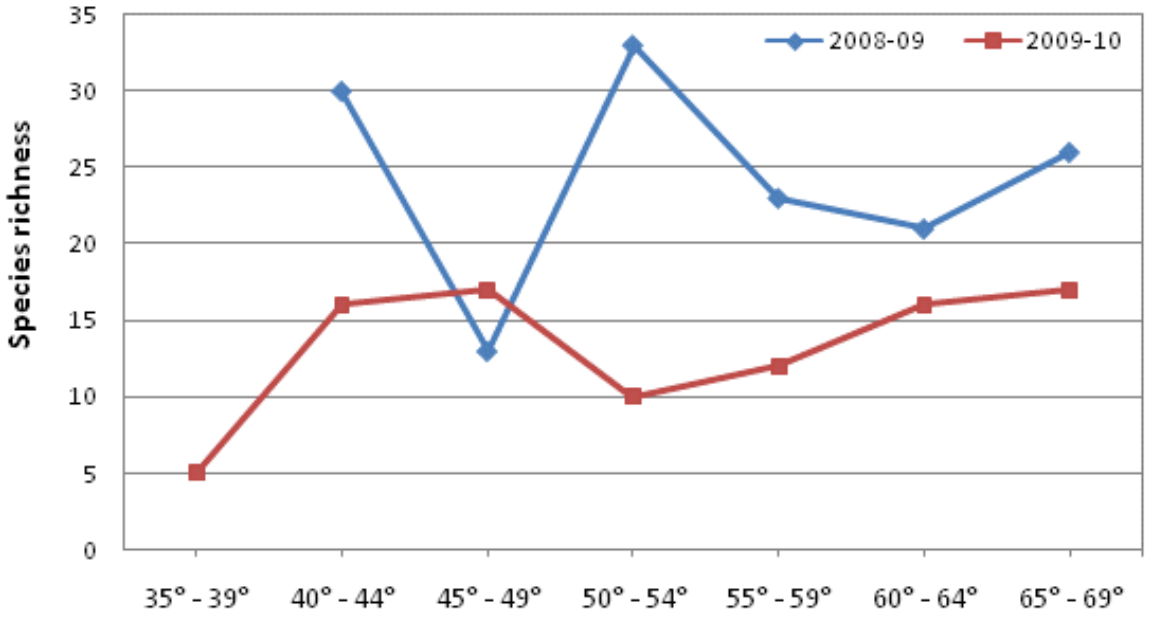

Figure 3. Patterns of sea bird richness recorded along the longitudinal gradients between two successive expedition (28 & 29th InSEA).

Figure 4. Adelie and Emperor penguin rookeries in Larsemann Hills, East Antarctica.

Figure 5. The four species of pack ice seals a. Weddell seal *Leptonychotes weddellii*, b. Crabeater seal *Lobodon carcinophagus*, c. Leopard seal *Hydrurga leptonyx* and d. Ross seal *Ommatophoca rossii* encountered during the surveys in the Prydz bay and Fimbul Ice Shelf during the expedition.

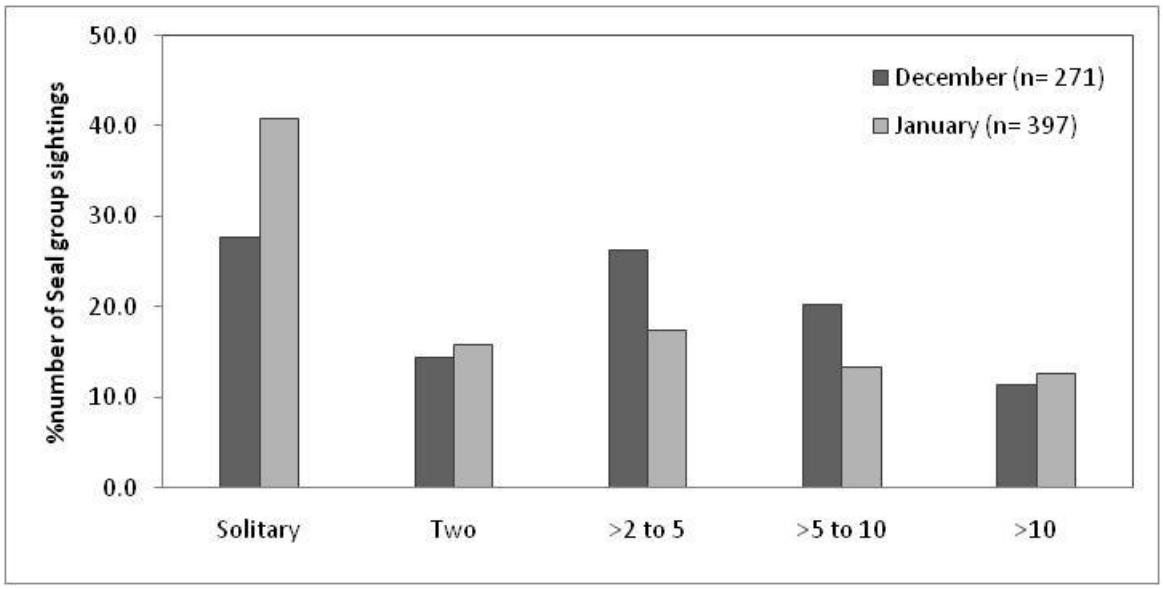

Figure 6. The percentage distribution of different seal groups observed in the Prydz bay during December 2009 and January 2010.

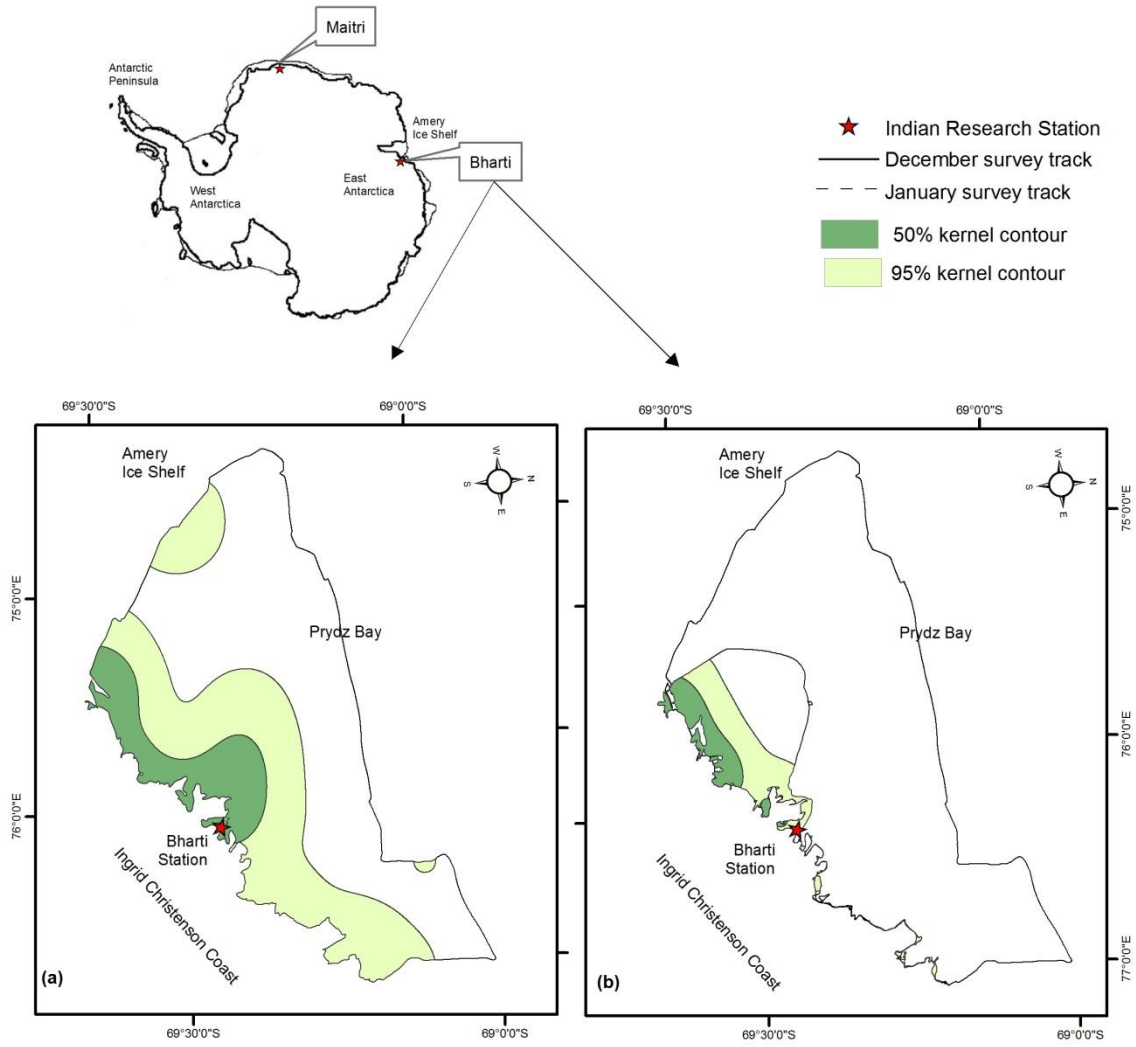

Figure 7. Map of the Prydz bay survey area showing the spatial distribution of hauled-0ut weddell seals encountered (95% and 50% fixed kernel contours) during December 2009 (a) and January 2010 (b). Also, the fast ice cover drastically reduced from 2500 sq. km in mid-December 2009 to approx. 600 sq. km in January 2010.