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# The spatial dispersion of seabirds near the South Orkney Islands and the Weddell-Scotia confluence

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**Summary.** We used five transects radiating from the South Orkney Islands to describe the distribution and abundance of marine birds during three days in late summer 1983. We found elevated numbers of birds at most crossings of steep physical gradients (fronts), but species were not equally attracted to each front. Our data suggest that the fronts around the South Orkney Islands, especially the Weddell-Scotia Confluence, provide important foraging habitat for birds. Albatrosses and fulmars appeared to aggregate preferentially near fronts overlying the insular slope, whereas Chinstrap Penguins were most abundant over the shelf.

## Introduction

Marine birds in the Arctic and sub-Arctic often concentrate their foraging at hydrographic fronts near nesting colonies (Kinder et al. 1983; Schneider et al. 1987). Hydrographic fronts differ in size, strength and persistence; the larger, steeper or more persistent ones tend to be more important biologically. Fronts seem to be attractive to birds because they may concentrate prey, bring prey closer to the surface, or enhance prey production through replenishment of nutrients (Lutjeharms et al. 1985; Pingree et al. 1974). In the Antarctic, birds aggregate at fronts far offshore (e.g. Ainley and Jacobs 1981; Griffiths et al. 1982), but the use by birds of fronts near nesting colonies has not been documented. When three days became available in February and March 1983 during a circumnavigational cruise of Antarctica (Holm-Hansen and Chapman 1983) we used the time to examine the dispersion of pelagic birds around the South Orkneys, especially with respect to the location of fronts.

The South Orkney Islands lie on a submarine ridge which forms the southern boundary of the Scotia Sea.

Oceanographically, the waters surrounding the islands are of particular interest because of turbulence associated with the interface of the Antarctic Circumpolar Current and the Weddell Sea Gyre. The Weddell-Scotia Confluence, as this interface is called, is often situated just to the north of the South Orkneys (Deacon 1982; Patterson and Sievers 1980; Foster and Middleton 1984). To the north of the Confluence, surface temperatures usually exceed +1.0°C, whereas to the south of it, temperatures are generally lower than 0°C. We refer to the abrupt horizontal transition between these two water masses as a *front*.

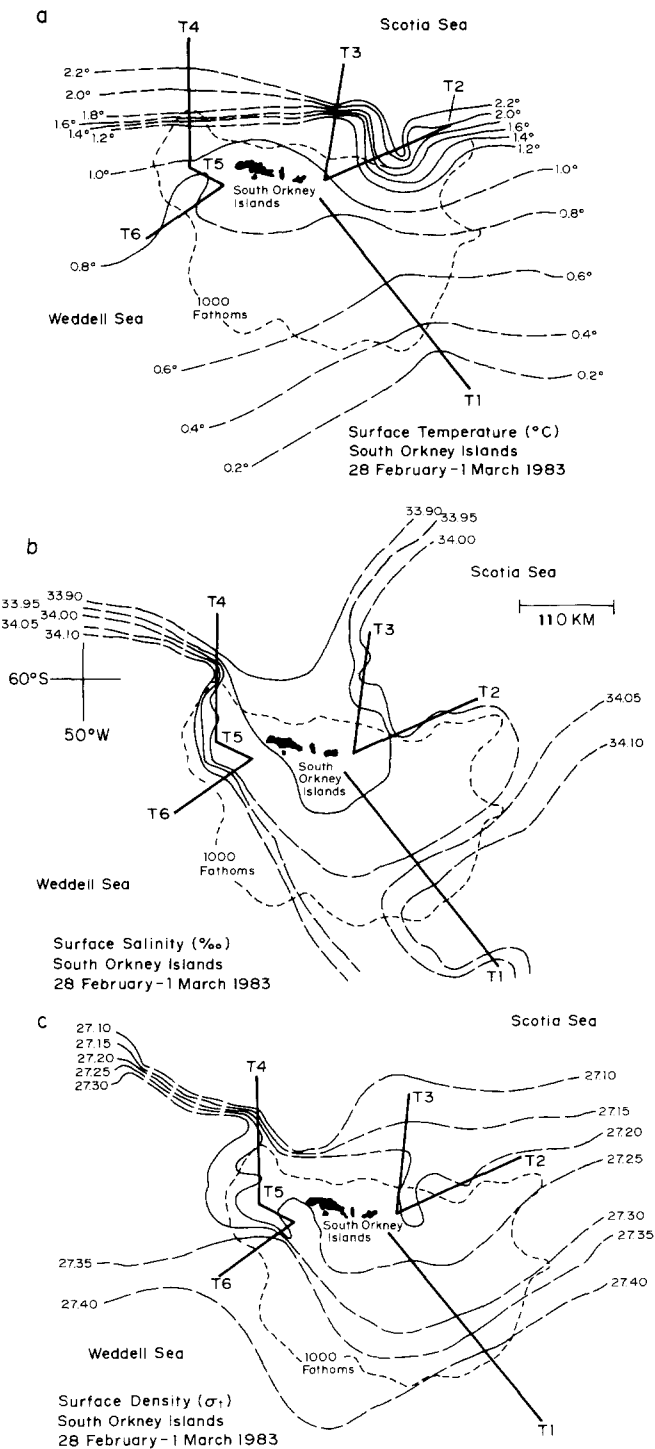
There is evidence that the Weddell-Scotia Confluence is biologically important. For example, some age classes of euphausiids and copepods preferentially aggregate within the Weddell-Scotia Confluence (Brinton 1985; Marin 1987). However, the confluence does not seem to form a faunal barrier, because species composition of plankton communities does not seem to differ appreciably between the water masses to either side. In this paper, we describe the dispersion of birds near the South Orkney Islands and examine whether the distribution of birds is influenced by the location of hydrographic fronts.

## Methods

From 27 February to 1 March 1983 we made observations along five 145 km-long transects, each radiating outward from the South Orkney Islands (Fig. 1). During 38 daylight hours, we counted birds continuously from the flying bridge (16 m above sea level) of the USCGC Polar Star while moving at 10 to 16 knots. Most data were collected by a single observer, but both of us worked simultaneously in areas of high bird density. We counted all birds within a 90° arc of radius 300 m, extending from dead ahead to the side of the ship that afforded the best visibility (i.e. the least glare and wind; Tasker et al. 1984). During our three day survey there was little wind, and no rain, snow or fog, so conditions for detecting birds were ideal. Surface water samples were taken by bucket every hour during our transects and were analyzed for temperature ( $\pm 0.1^\circ\text{C}$ ) and salinity ( $\pm 0.01$  ppt). We also dropped a series of eight expendable bathythermographs on Transect 3 (T3), to the north of Laurie Island to determine the thermal structure of the water column.

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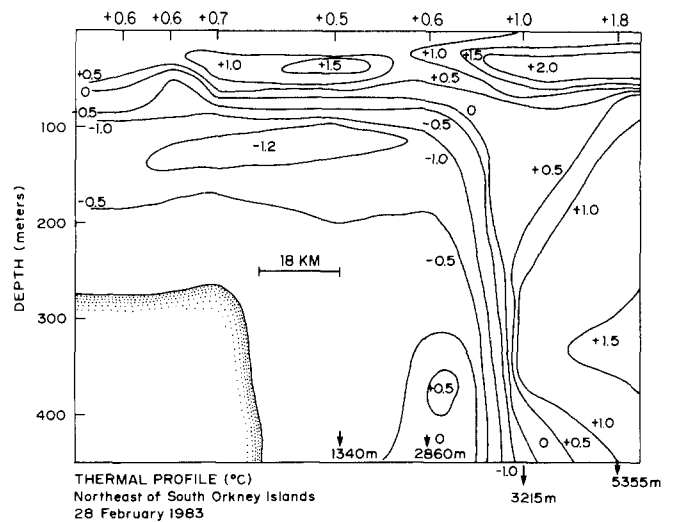


**Fig. 1.** Surface temperature (a), salinity (b) and density (c) along transects T1, T2, T3, T4, T5 and T6

Because our aim is to describe patterns and to suggest goals for future research, rather than to test hypotheses, we have kept statistical analysis to a minimum. We therefore emphasize those aspects of our data that are plainly evident on the figures.

To assess the degree to which seabirds formed aggregations, we calculated Green's Coefficient of Dispersion,  $G_x$ :

$$G_x = \frac{\{(S^2/\bar{x}) - 1\}}{(\Sigma \bar{x}) - 1}$$



**Fig. 2.** Thermal structure of water column (surface to 450 m) along T3 based upon expendable bathythermograph casts

where  $\bar{x}$  and  $S^2$  are the mean and variance, respectively, of the number of birds seen per ten minute segment for each transect.  $G_x$  ranges in value from  $-1/(\Sigma x - 1)$  for maximum regularity, to 1 for maximum patchiness, and is independent of sample size (Andrew and Mapstone 1987).

## Results

### Oceanography

The most distinctive oceanographic feature we encountered was located to the north of the South Orkneys, along T3 and T4. Comparison of our Fig. 2 to Fig. 4a in Patterson and Sievers (1980) and to Fig. 2 in Foster and Middleton (1984) strongly suggests that the front we observed was the Weddell-Scotia Confluence. All three sections show an abrupt transition in temperature of the upper 400 m from about  $+2.0^\circ$  to  $-1.5^\circ\text{C}$ . The front is clearly visible as a series of dramatic vertical isotherms in each figure.

The thermal gradients that we crossed did not always coincide with the saline gradients. For example, on T6 a saline gradient near the continental slope was not associated with a change in temperature. On T3, a steep thermal gradient was associated with a relatively minor change in salinity. The one front across which both temperature and salinity changed at the same place was located along T4. These last two fronts were the surface manifestations of the Weddell-Scotia Confluence.

### Birds

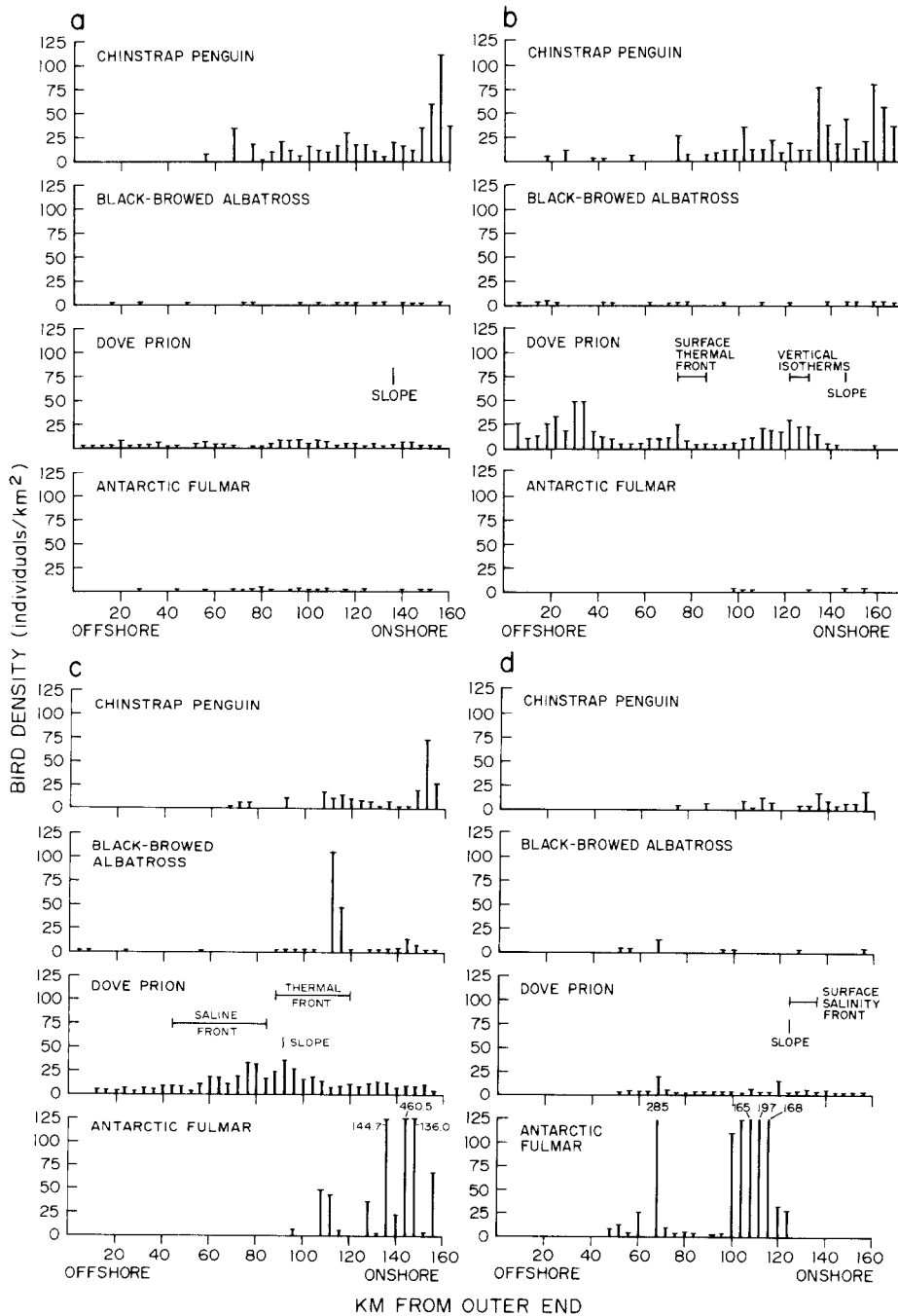
Bird densities differed between bathymetric zones (Table 1). Chinstrap Penguins (*Pygoscelis antarctica*) were common over the shelf but comparatively scarce over deep water. Black-browed Albatrosses (*Diomedea melanophris*) were most abundant over the insular slope, as were Antarctic Fulmars (*Fulmarus glacialis*). Among the

**Table 1.** Mean bird density (birds/km<sup>2</sup>) per 10-min segment, ± 1 standard error

	Shelf 0–500 m	Slope 500–2,000 m	Deep > 2,000 m
N	49	46	144
Chinstrap Penguin	18.9 ± 4.3	7.2 ± 1.5	3.5 ± 0.8
Black-browed Albatross	1.0 ± 0.3	3.9 ± 2.4	0.4 ± 0.1
Antarctic Fulmar	15.9 ± 9.4	21.9 ± 7.3	3.5 ± 2.5
Dove Prion	2.4 ± 0.4	5.8 ± 0.8	8.8 ± 0.9

commoner species, only Dove Prions (*Pachyptila desolata*) were most abundant over deep water.

Distributional patterns of birds were different on each transect but aggregations usually occurred near fronts (Fig. 3a–d). Birds were more aggregated on T4, T5 and T6 than they were on the other transects (Table 2). Close to the steepest front that we crossed, on T4, several mixed flocks of Black-browed and Gray-headed (*D. chrysostoma*) Albatrosses and Antarctic Fulmars sat on the water (Fig. 3c). On T6, hundreds of Antarctic Fulmars were sitting on the water close to the insular slope, but offshore



**Fig. 3.** Bird density along a T2, b T3, c T4 and d T6. Position of 1,000 m depth contour labelled as “slope” and thermal/saline gradients indicated. The islands are situated at the right hand end of each transect

**Table 2.** Mean bird density (no./km<sup>2</sup>) and degree of aggregation ( $G_x$ ; see text) on each transect

Transect	Mean density	Aggregation
T1	10.6	0.01
T2	24.5	0.02
T3	33.0	0.01
T4	56.4	0.07
T5-6	55.2	0.06

from the saline front (Fig. 3d). On T3, Chinstrap Penguins were present in large numbers out to 72 km offshore, just inside of the thermal front (Figs. 1, 3b). On T3, large numbers of Dove Prions flew by the ship headed to the west. They were concentrated into two areas. The smaller, more inshore peak was situated over a subsurface front (Fig. 3b). On T1, which crossed no fronts, bird density was generally low, and we encountered no aggregations (Table 2). Similarly, T2 ran parallel to the shelf edge and to a thermal gradient, and therefore did not cross any steep gradient. Bird density was somewhat higher on T2 than on T1, due mainly to large numbers of Chinstrap Penguins that were seen swimming towards the islands, beginning 109 km offshore (Fig. 3a).

The Weddell-Scotia Confluence did not form a boundary between avian communities. Dove Prion was the most numerous species to the north of the confluence, and Antarctic Fulmar was the most numerous species to the south. Otherwise, bird species composition was similar to either side of the front.

Other species we saw included: Wandering Albatross (*Diomedea exulans*), 12 individuals, nine of which were over water >2000 m deep, Light-mantled Sooty Albatross (*Phoebastria palpebrata*), 28, twenty of which were over Weddell Sea water to the southeast of the islands, and Southern Giant-Petrel (*Macronectes giganteus*), 64 seen. Cape Petrels (*Daption capensis*) were evenly distributed, but were somewhat more numerous to the south of the islands than to the north. Wilson's Storm-Petrel (*Oceanites oceanicus*) (449 sightings) and Black-bellied Storm-Petrel (*Fregatta tropica*) (142 sightings) were most abundant near the islands, where both species nest. In contrast, most of the 75 White-chinned Petrels (*Procellaria aequinoctialis*) that we saw were farther offshore than the shelf break. The least common species we recorded were: Snow Petrel (*Pagodroma nivea*), 5, Kerguelen Petrel (*Pterodroma brevirostris*), 4, Soft-plumaged Petrel (*Pterodroma mollis*), 3 at the northern end of T4, South Polar Skua (*Catharacta maccormickii*), 1, and Antarctic Tern (*Sterna vittata*), 2.

## Discussion

The most patchy dispersion of seabirds we observed was associated with the steepest front that we crossed. This observation is consistent with the idea that hydrographic processes associated with fronts are attractive to foraging birds.

Since hydrographic fronts often coincide with steep bottom topography, it is not clear which of these kinds of features is most important to birds. On T6, Antarctic Fulmars were aggregated directly over the insular slope, but quite distant from a steep saline gradient further up on the shelf. This distribution suggests attraction of the fulmars to the water column over the slope *sensu stricto*. Black-browed and Gray-headed Albatrosses and Antarctic Fulmars clustered over a thermal front on T4, but not an apparently similar front on T3. The front on T4 coincided with the insular slope, whereas the front on T3 was farther offshore. These distributional patterns suggest that hydrographic fronts situated directly over insular slopes may be particularly important to foraging seabirds.

In evaluating the biological importance of hydrographic fronts, it is illuminating to consider how far birds travel to forage at them. Of the commonest species we saw, Chinstrap Penguins, Dove Prions and Antarctic Fulmars all breed on the South Orkneys, as well as elsewhere in the Scotia Sea. Black-browed and Gray-headed Albatrosses, on the other hand, have their nearest colonies on South Georgia, 830 km away. Prince and Francis (1984) cite a record of a Gray-headed Albatross seen foraging near the South Orkneys that was known to have a chick at Bird Island, South Georgia at the time. Although the albatrosses we saw near the South Orkneys may have been non-breeders, our observations suggest that the front we crossed may be sufficiently productive to attract albatrosses from several hundred kilometers away.

The species we observed differed in their spatial dispersion. For example, Black-browed Albatrosses and Antarctic Fulmars were tightly clumped, whereas Chinstrap Penguins and Dove Prions were more spread out. Over 95% of the Black-browed Albatrosses were located within a 10 km segment, and 80% of the fulmars were seen in three segments of total length 20 km. This disparity is interesting since all four species are known to feed principally on krill (Croxall and Prince 1980). It is possible that the difference in patchiness between species reflects differences in timing of foraging. For example, the flocks of albatrosses and fulmars that were sitting on the water may have fed during the previous night. (Black-browed and Gray-headed Albatrosses at South Georgia feed extensively at night – Prince and Morgan 1987, personal observation). Chinstrap Penguins on the other hand, feed primarily during daylight hours (Volkman et al. 1980).

Although this study was brief, we provide evidence that fronts near breeding colonies are important to some Antarctic seabirds. We did not find concentrations of other species, such as penguins, at features that we expected might enhance the availability of their prey. Future studies should simultaneously sample birds and their prey across fronts to ascertain why some fronts attract birds whereas others do not.

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