Figure 3.7. Utilisation distribution maps for breeding Black-browed Albatrosses tracked from Isla Diego Ramirez at different stages in the breeding cycle. A. incubating birds (n=10,103 hrs); B. early breeding (incubation/brooding) (n=1,642 hrs); C. brooding (n=5,367 hrs); D. post guard (n=6,083 hrs). (Unable to determine number of individuals of each category from dataset, so sample sizes are only given in number of hours tracked).

waters. Main foraging areas were located over the continental shelf and slope south to 55ºS. During chick-rearing, albatrosses mixed two strategies, short trips over the surrounding waters in southern Chile (similar to distribution during brooding), representing up to 90% of total trips, with long trips to central Chile (similar to those made during incubation) and Antarctic waters, mainly along the continental shelf and slope of the western Antarctic Peninsula. Despite the difference in trip characteristics between breeding stages, Black-browed Albatrosses tracked from Diego Ramirez foraged mainly over Chilean territorial waters, especially inside the EEZ waters during breeding, with very occasional forays into Argentine Patagonian Shelf waters.

During incubation, birds tracked from Isla Ildefonso show a similar distribution to Diego Ramirez, with concentrations occurring off the Arauco Gulf, Los Chonos Archipelago (45ºS) and southern Chile (50–57ºS). This result is similar to that between Falkland Island (Malvinas) colonies during incubation.

There is a strong interaction between breeding albatrosses and fishing vessels, which produce food through offal discards and cause mortality by incidental capture (Arata and Xavier 2003, Moreno et al. 2003). Thus, it seems likely that fishing boats could affect the normal distribution patterns of Black-browed Albatrosses in southern Chile and reduce inter-colony competition by food, allowing greater than normal levels of foraging range overlap.

Javier Arata and Graham Robertson

3.1.2 Distribution of breeding birds in relation to sex

Northern and Southern Giant-petrels *Macronectes halli* and *M. giganteus* – South Georgia

Giant-petrels are the largest birds of the family Procellariidae, weighing about 4–5 kg and with a wingspan of 150–210 cm. Both sibling species, the Northern *Macronectes halli* and the Southern *M. giganteus,* show a noticeable sexual size dimorphism in which males are between 16 and 35% heavier and have disproportionately larger bills than females (González-Solís 2004). The two species are the dominant scavengers of the Southern Ocean; males and females of both species rely mainly on penguin and pinniped carrion, but complement this diet by taking live seabirds, scavenging on food waste and feeding on marine prey such as crustaceans, cephalopods and fish (Hunter 1985).

There is much evidence, from various sources, that both species of giant-petrels are among the more remarkable examples of sexual segregation in feeding habits in birds. Direct observation of feeding habits, diet analysis and stable isotope heavy metal studies, all suggest clear segregation in the trophic habits of males and females in both species (Hunter 1983, Becker *et al*. 2002, González-Solís *et al*. 2002b, González-Solís and Croxall 2005). Such sexual differences in the type of prey consumed imply a fundamental decision to direct the searching effort to particular habitats.

This is well demonstrated in the areas exploited by each sex during the incubation period. In both species most males engaged in short trips close to the breeding grounds whereas most females foraged in pelagic waters further away from

South Georgia (Figures 3.8 and 3.9). Satellite tracking of southern giant-petrels breeding in Patagonia and at Palmer Station (Antarctica) also suggest a similar segregation in foraging areas between males and females (Quintana and Dell'Arciprete 2002, Patterson and Fraser 2003). At South Georgia, males of the Northern species seem more restricted to shorelines than the more pelagic Southern species, which accords well with the greater specialisation of
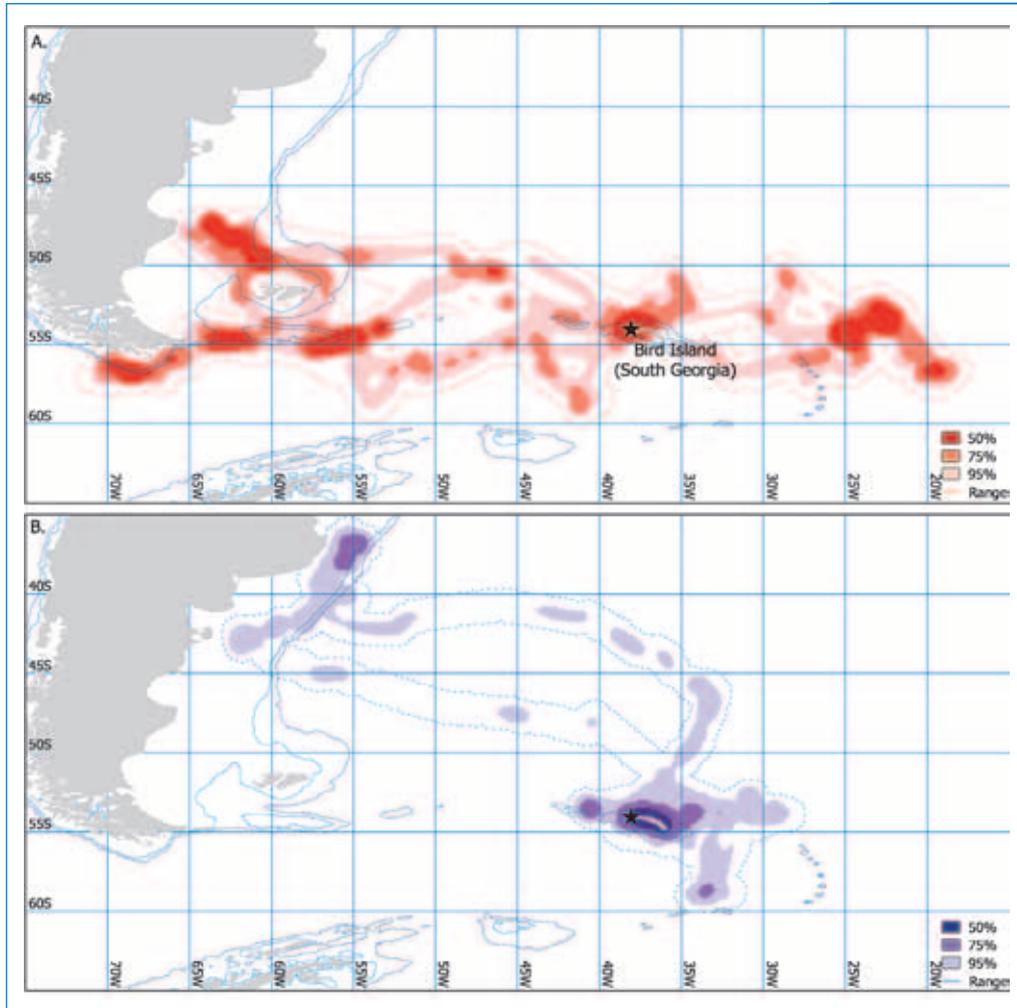

Figure 3.8. Utilisation distribution maps for incubating male and female Northern Giant-petrels, tracked from Bird Island, South Georgia. A. incubating females (n=2,048 hrs, 9 individuals); B. incubating males (n=1,873 hrs, 9 individuals).
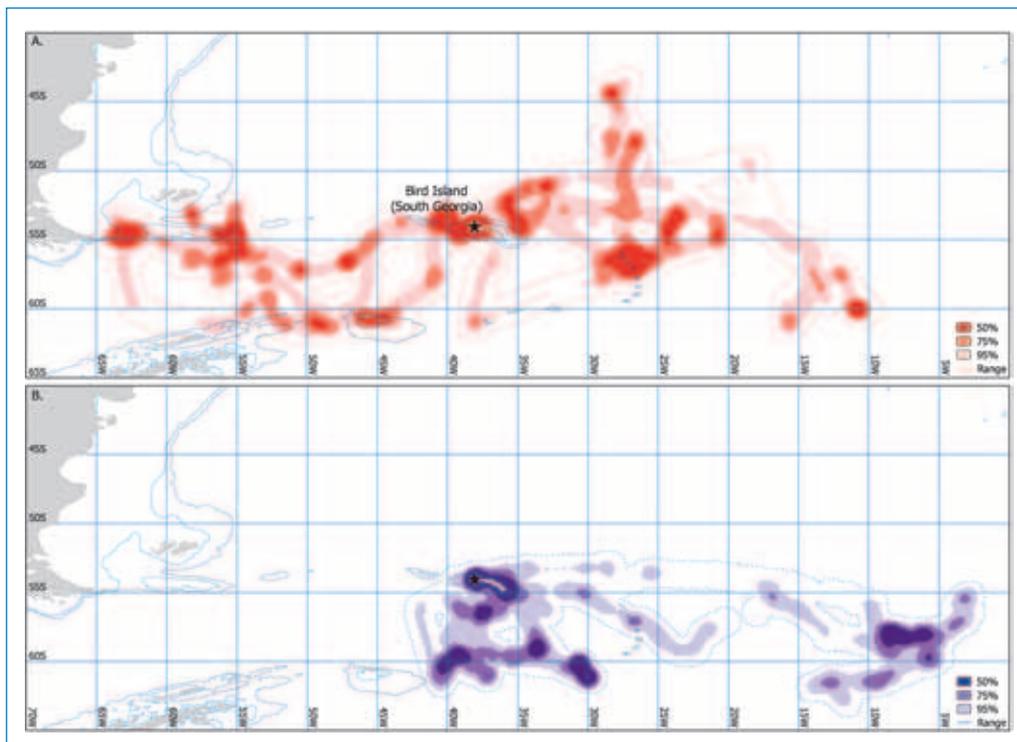

Figure 3.9. Utilisation distribution maps for incubating male and female Southern Giant-petrels, tracked from Bird Island, South Georgia. A. incubating females (n=1,973 hrs, 5 individuals); B. incubating males (n=1,379 hrs, 6 individuals).

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the former species in exploiting fur seal carcasses. This difference is also supported by the data from activity recorders deployed together with some satellite PTT's, which registered longer dry periods (out of contact with salt water) for Northern Giant-petrel males. (González-Solís *et al*. 2002a). Overall, sexual segregation in the foraging areas was reflected in a number of trip features: males showed lower median trip duration, daily distance covered, flight speed, maximum foraging range and activity range than females (González-Solís *et al*. 2000a, González-Solís *et al*. 2000b).

Pelagic areas exploited by males and females also differed in their directionality with respect to the breeding site. Females of both species showed similar foraging areas, exploiting pelagic waters east and west of South Georgia, but Southern Giant-petrel females showed a more pronounced tendency to forage towards eastern waters and Northern females towards the Patagonian Shelf. Similarly, Southern Giant-petrel males also foraged mainly towards east and south of South Georgia and the unique long trip performed by a Northern Giant-petrel male was north of the Patagonian Shelf. These differences may partly be shaped by the intraspecific competition among the different colonies of the two species. Whereas there are no Northern Giant-petrel colonies at the Patagonian Shelf, Southern Giant-petrels breeding at South Georgia and intending to forage towards South America may compete with the substantial breeding population there.

Jacob Gonzalez-Solis

Wandering Albatross *Diomedea exulans* – South Georgia
Although results from the first satellite-tracking study hinted at potential latitudinal segregation (Prince *et al.* 1992), these maps suggest there is little difference in the overall distribution of male and female Wandering Albatrosses from South Georgia during breeding. However, as with Wandering Albatrosses at Crozet (Weimerskirch *et al.* 1993), this masks some rather subtle distinctions depending on breeding stage. Detailed examination of these data and more recent GPS tracks suggests that females have a slight tendency to forage in more northerly waters, particularly during incubation. However, a rigorous statistical comparison has not been
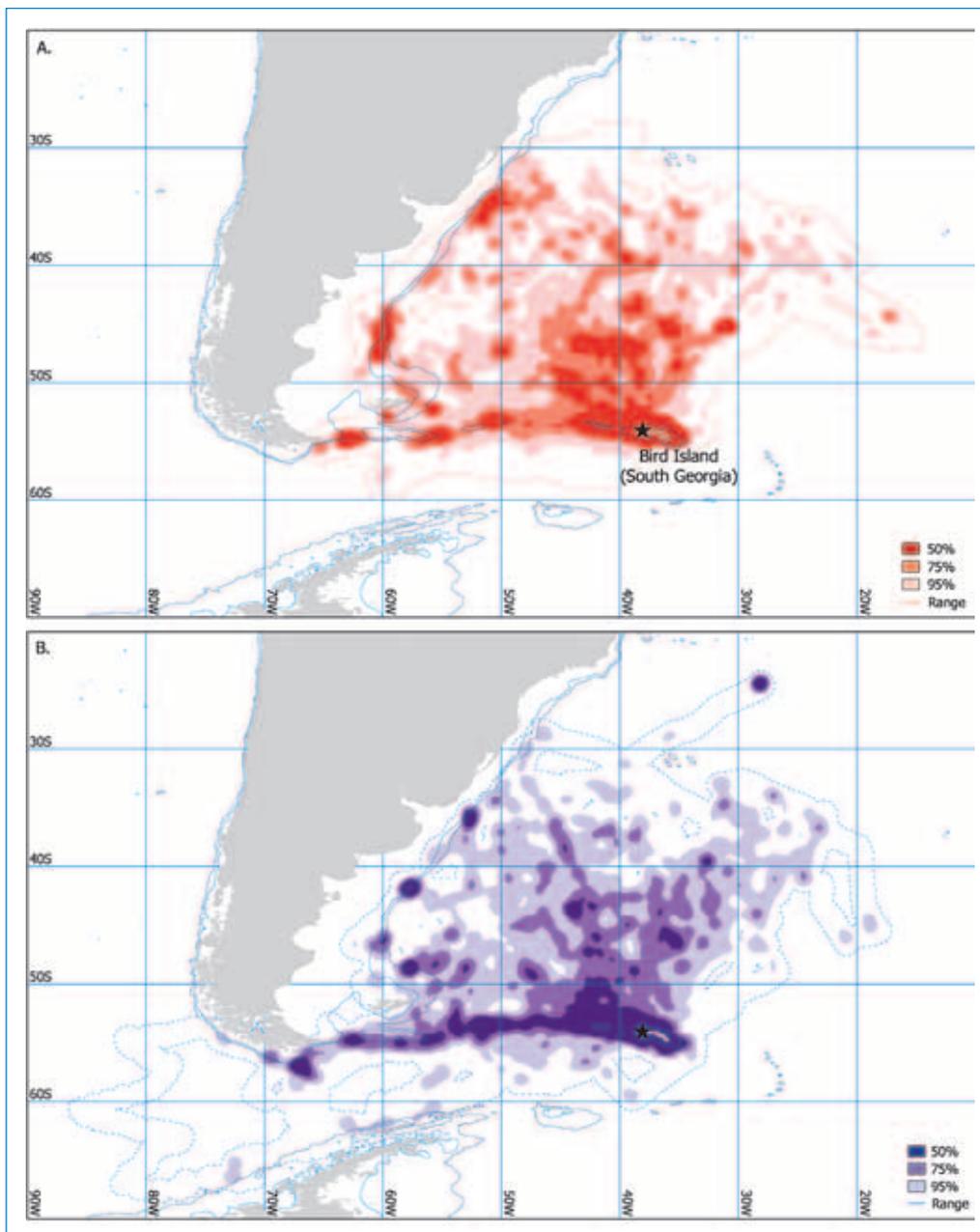
Figure 3.10. Utilisation distribution maps for breeding male and female Wandering Albatrosses, tracked from Bird Island, South Georgia. A. breeding females (n=17,772 hrs, 58 individuals) B. breeding males (n=18,123 hrs, 64 individuals).

undertaken. It is worth noting, for example, that the most recent GPS data indicates that during incubation, females also travel through the Drake Passage as far as 78°W (c.f. Figure 3.10). This emphasises that conclusions concerning sexual segregation based on small samples sizes must be viewed with considerable caution.

During brood-guard, differences are more clear-cut. Occasionally, both males and females (cf. Prince *et al.* 1998) have been recorded travelling to Falkland Islands (Malvinas)/Burdwood Bank waters (Croxall *et al.* 1999). Otherwise, males feed predominantly on the local South Georgia shelf and shelf-slope. By comparison, females utilise these habitats to a lesser extent, instead feeding routinely in oceanic waters from 51°–56°S. This is corroborated by dietary analyses: during brooding, males consume large amounts of Patagonian Toothfish *Dissostichus eleginoides* presumably obtained as discards from long-line fishing vessels, whereas females feed on a much greater diversity of fish and squid

Richard Phillips and John Croxall

Buller's Albatross *Thalassarche bulleri* – Snares
Among breeders from the Snares Islands, foraging distributions of males and females tended to be largely segregated during most of the breeding cycle as a result of differences in foraging time allocation between long and short trips, in foraging destinations and range during long trips, and in habitat utilisation with respect to water depth (Stahl and Sagar 2000b).

During the pre-egg stage (Figure 3.11A, B), foraging trips of both males and females were either to the Tasman Sea (long trips) or within 180 km of the Snares (short trips). Males then spend much more time at the nest than females, and allocated 69% of foraging time to short trips, with sites of most intensive foraging located over the shelf and slope south and east of the Snares. Females overlapped with males in that area, but in contrast to males, allocated 99% of foraging time to long trips, with sites of most intensive utilisation located over oceanic waters in the southern and central part of the Tasman Sea.

During the incubation period (Figure 3.11C, D), long trips accounted for over 98% of foraging time in both sexes, and sexual segregation at that time stemmed primarily from
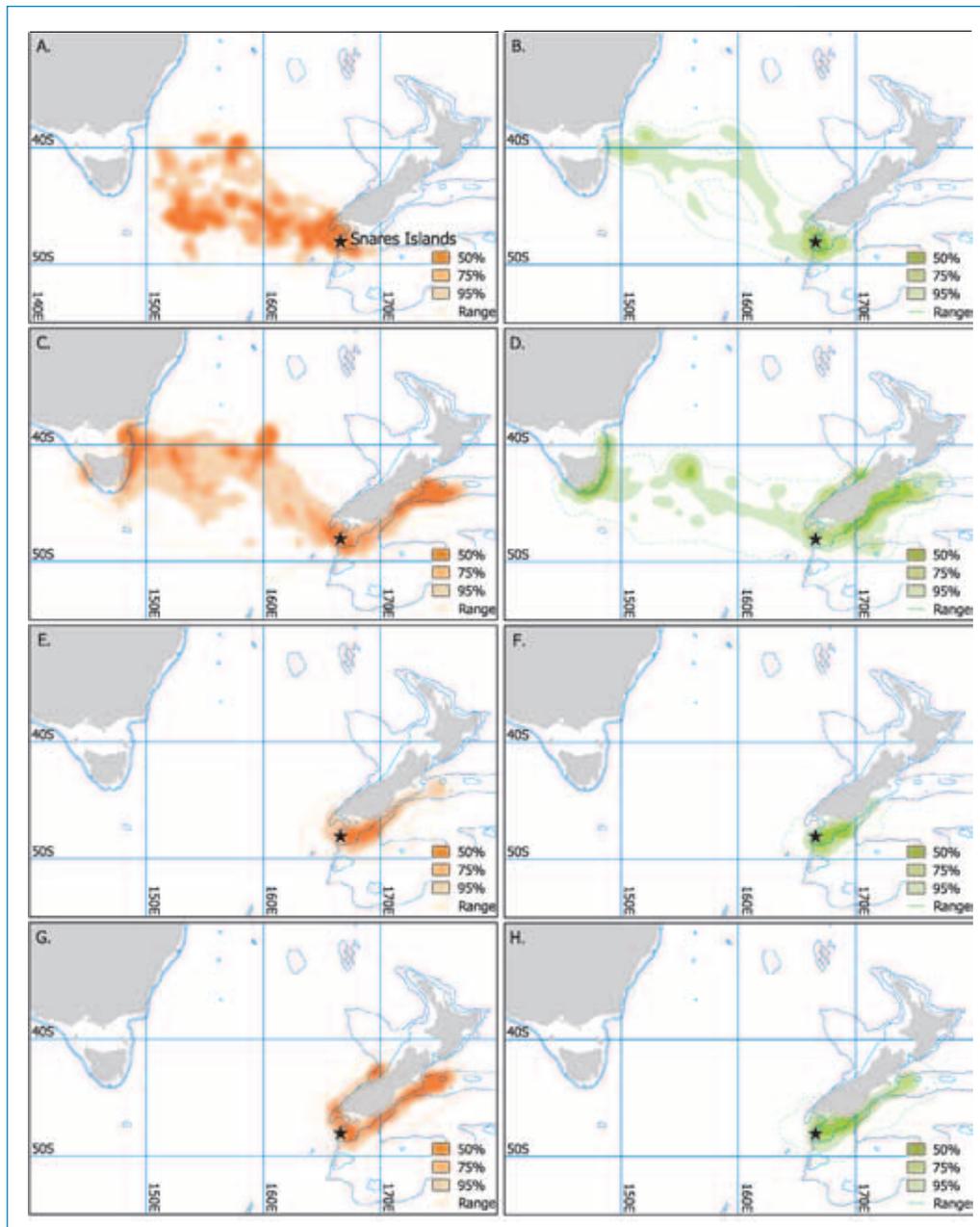

Figure 3.11. Utilisation distribution maps for breeding male and female Buller's Albatrosses tracked from the Snares Islands.
A. pre-egg females (n=1,497 hrs, 2 indivs);
B. pre-egg males (n=1,128 hrs, 2 indivs); C. incubating females (n=4,622 hrs, 15 indivs); D. incubating males (n=3,750 hrs, 12 indivs);
E. guard stage females (n=1,803 hrs, 7 indivs);
F. guard stage males (n=1,229 hrs, 6 indivs);
G. post guard females (n=2,902 hrs, 6 indivs);
H. post guard males (n=5,684 hrs, 7 indivs).

a greater utilisation by males of foraging areas off the South Island east coast (52 vs. 29% of foraging time) and west coast (9 vs 0%), and a greater utilisation by females of foraging areas in the Tasman Sea (69 vs. 38%). Off the South Island east coast, females tended to forage at greater distances from the Snares than males (Stahl and Sagar 2000b), with their area of most intensive use located further north-east (western part of Chatham Rise) than that of males. Areas of intensive use were also segregated in the Tasman Sea, where males foraged primarily over shelf and slope areas south-east of Tasmania, and females primarily over oceanic waters around 40ºS and the eastern approaches to Bass Strait.

Foraging distributions of males and females overlapped most extensively during the brood guard stage (Figure 3.11E, F), when both allocated most foraging time to short trips (86 and 82% respectively). At that time, areas of most intensive use were located east and north-east of the Snares in both sexes, with females tending to forage over deeper waters than males (Stahl and Sagar 2000b).

During the early part of the post guard stage (up to mid-June), both sexes switched to a dual strategy of short trips and long trips to the South Island east coast (Figure 3.11G, H). At that time, the distributions of males and females again over-lapped east and north-east of the Snares, but females made much more extensive use of distant foraging areas east of the South Island (Otago and western part of the Chatham Rise) as a result of greater time allocation to long trips compared to males (89 vs. 56%). Sexual segregation was most pronounced after mid-June, when males switched to a foraging regime of solely short trips (shelf and slope areas east and north east of the Snares), while females retained a foraging regime of mostly long trips (83% of foraging time) combined with a shift to the South Island west coast during both long trips (area of most intensive use off Westland) and short trips (Fiordland).

Jean-Claude Stahl and Paul Sagar

3.1.3 Distribution of breeding birds in relation to year

Grey-headed Albatross *Thalassarche chrysostoma* – South Georgia

Despite extensive overlap between years in 60–70% of the overall range and in several presumably key areas, there was also a considerable degree of inter-annual variability in foraging site selection of Grey-headed Albatrosses during chick-rearing (Figure 3.12). Thus, the maximum range was much smaller (with less reliance on Antarctic waters), and the use of shelf and shelf-break areas far more restricted in 1993, compared with the other two years. Nonetheless, core feeding areas in Antarctic Polar Frontal Zone (APFZ), which follows a roughly east-west axis to the north of South Georgia, were used in every season. This is presumably because birds travelling to this region can to an extent predict the likely location of prey aggregations (notably those of the ommastrephid squid, *Martialia hyadesi*) associated with mesoscale oceanographic features such as eddies (Rodhouse *et al.* 1996, Xavier *et al.* 2003).

In every year, foraging birds also dispersed widely into oceanic waters (the Scotia Sea) to the south of South Georgia. Core sites here appeared to be much less predictable, and for example only in 1993 was there an apparent concentration centred around 56ºS 45ºW. This was not associated with any discernable bathymetric or hydrographic feature (Prince *et al.* 1998, Wood *et al.* 2000), and its absence in succeeding seasons suggests it may have resulted from some ephemeral or transient set of oceanographic conditions.

Figure 3.12. Utilisation distribution maps for breeding Grey-headed Albatrosses tracked from Bird Island, South Georgia during the first quarter (mid-January to March – post-guard stage) in different years. A. 1993 (n=4,261 hrs, 9 indivs); B. 2000 (n=2,395 hrs, 8 indivs); C. 2001 (n=9,315 hrs, 10 indivs).
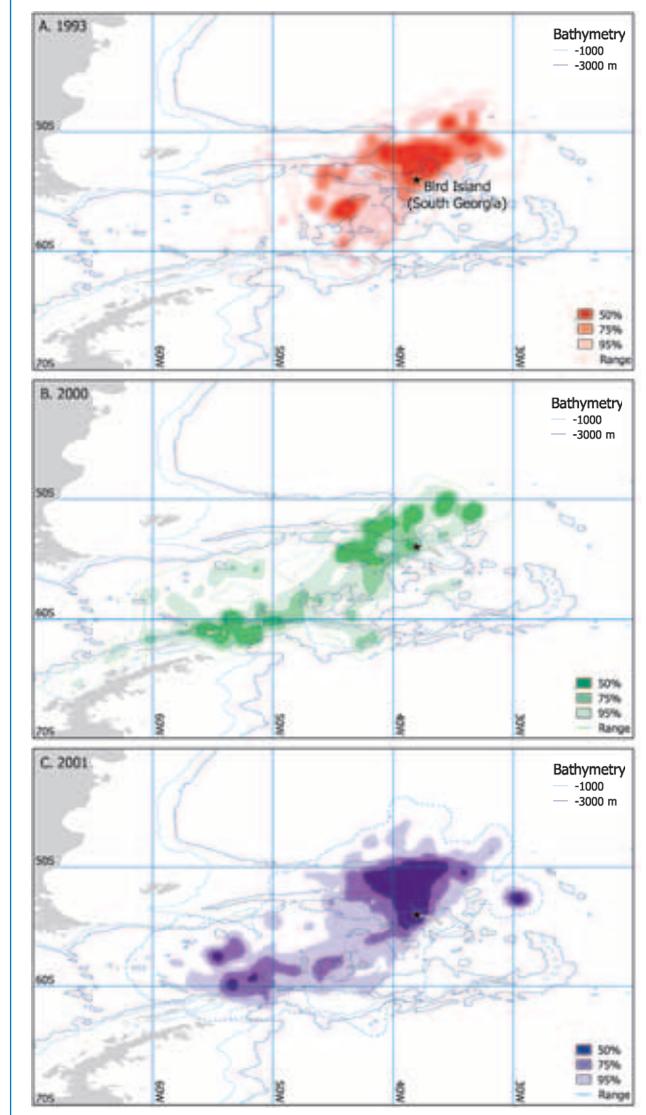
One striking difference among the three years was in the relative use of shelf and shelf-break waters. In 1993, relatively few birds travelled to the shelf to the north-west of South Georgia or to the South Orkney Islands, which led Prince *et al*. (1998) to conclude that Grey-headed Albatrosses feed only to a limited extent in neritic waters. By contrast, the more recent tracking data (particularly from 2000) illustrate that breeders can make extensive use of shelf waters around the South Orkneys, South Shetlands and as far south as Adelaide Island in the Antarctic Peninsula region, where krill *Euphausia superba* are the dominant prey items (Xavier *et al.* 2003). Remotely-sensed Sea Surface Temperature data indicate that conditions near South Georgia were unusually warm in March 2000, which was associated with poor overall breeding performance in Grey-headed Albatrosses (Xavier *et al.* 2003). This might suggest that foraging as far away as the Antarctic Peninsula is exceptional, were it not that one of only four birds tracked during late February to early March 2003 also switched to these alternative feeding grounds after experiencing poor feeding success near the APFZ (Catry *et al*. in press b).

Although these utilisation distributions provide a clear illustration of differences in foraging site selection of Grey-headed Albatrosses tracked at the same stage of the season in different years, this variation is much less extensive than that associated with breeding stage (incubation versus brooding versus post-brood chick-rearing) at the same site (Phillips *et al.* 2004b).

Richard Phillips and John Croxall

Wandering Albatross *Diomedea exulans* – Crozet
No critical study has been carried out to investigate whether significant differences exist between years in the foraging zones of Crozet's Wandering Albatrosses. The data would need careful analysis, taking into account not just the stage of tracking period (as in Figures 3.13 and 3.14), but also the sex and the colony whence tracking was carried out. Preliminary examination suggest that if differences exist, they are probably not important. When foraging over

Figure 3.13. Utilisation distribution maps for breeding Wandering Albatrosses tracked from Iles Crozet during different years. A–C. 1990, first (n=1,901 hrs), second (n=4,753 hrs) and third (n=2,795 hrs) quarters; D–F. 1992, first (n=1,649 hrs), second (n=1,836 hrs) and third (n=795 hrs) quarters. The first quarter is January to March (incubation), the second is April to June (early chick rearing) and the third is July to August (late chick rearing). (Unable to determine number of individuals for each period from dataset, so sample sizes are only given in number of hours tracked.)
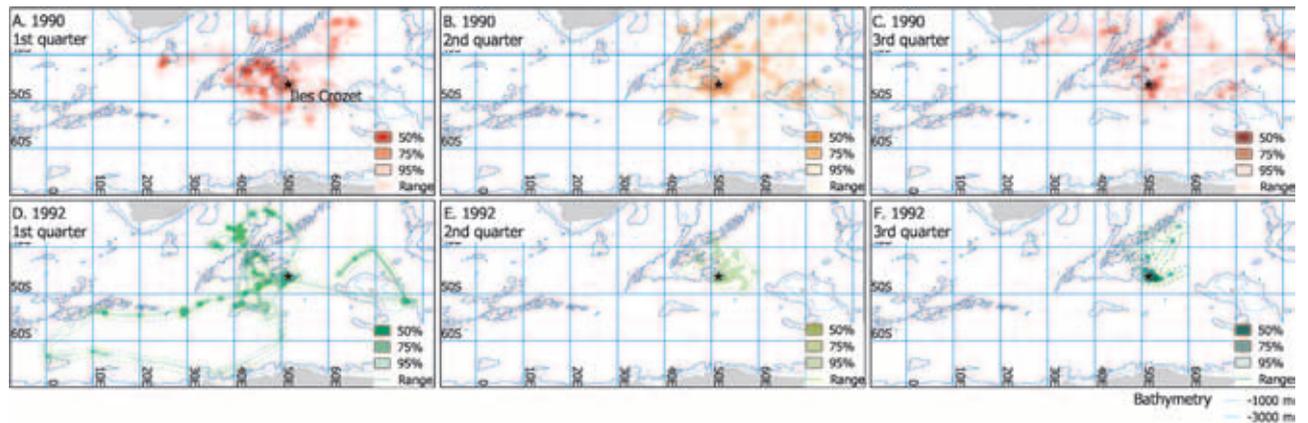
Figure 3.14. Utilisation distribution maps for breeding Wandering Albatrosses tracked from Iles Crozet during different years. A and B. 1998, first (n=7,193 hrs) and second (n=670 hrs) quarters; C and D. 1999, first (n=11,804 hrs) and second (n=1,107 hrs) quarters; E and F. 2000, first (n=2,882 hrs) and second (n=403 hrs) quarters. The first quarter is January to March (incubation) and the second is April to June (early chick rearing). (Unable to determine number of individuals for each period from dataset, so sample sizes are only given in number of hours tracked.)
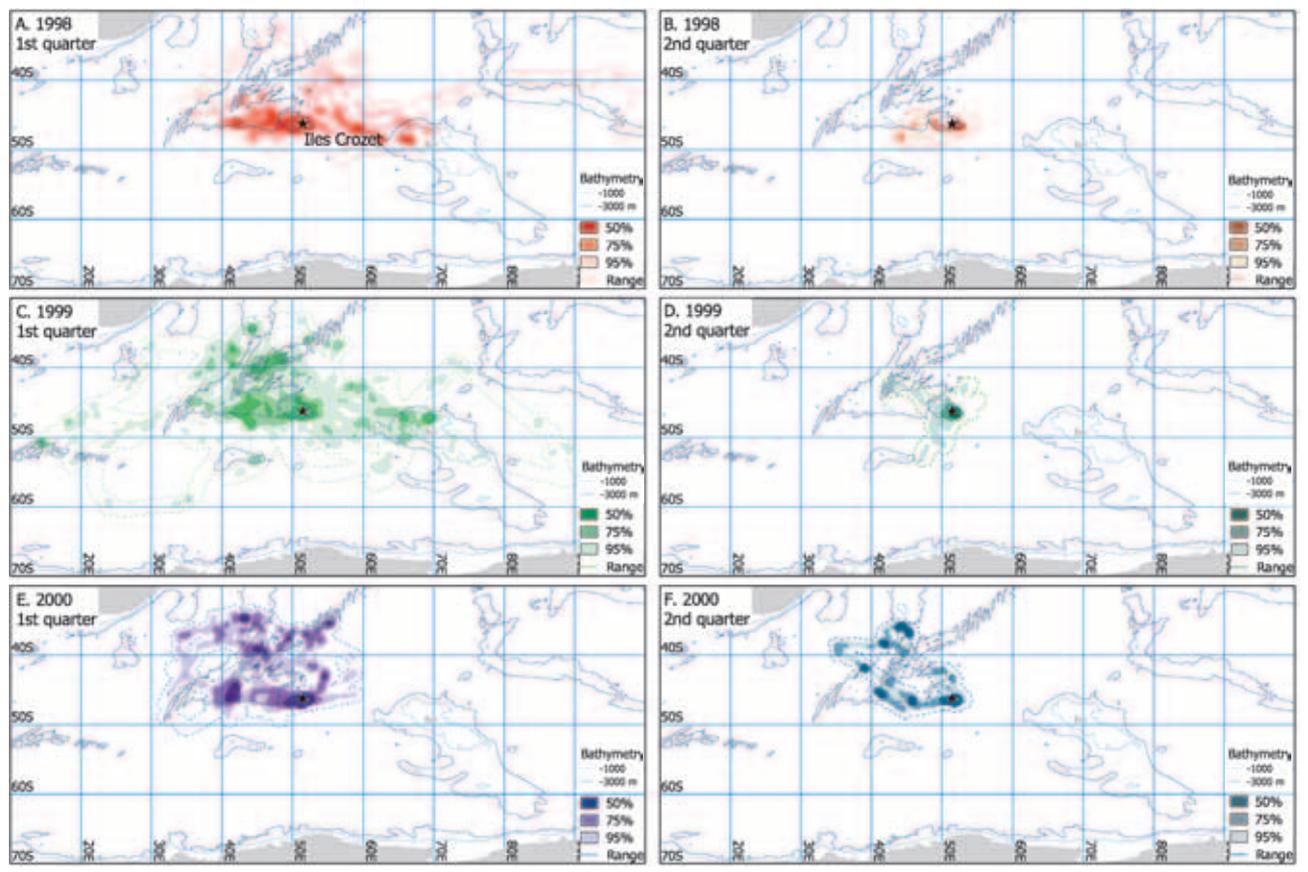
Figure 3.15. Utilisation distribution maps for incubating Black-browed Albatrosses tracked from Islas Diego Ramirez (A) (n=10,103 hrs) and Islas Ildefonso (B) (n=5,015 hrs). (Unable to determine number of individuals of each category from dataset, so sample sizes are only given in number of hours tracked.)
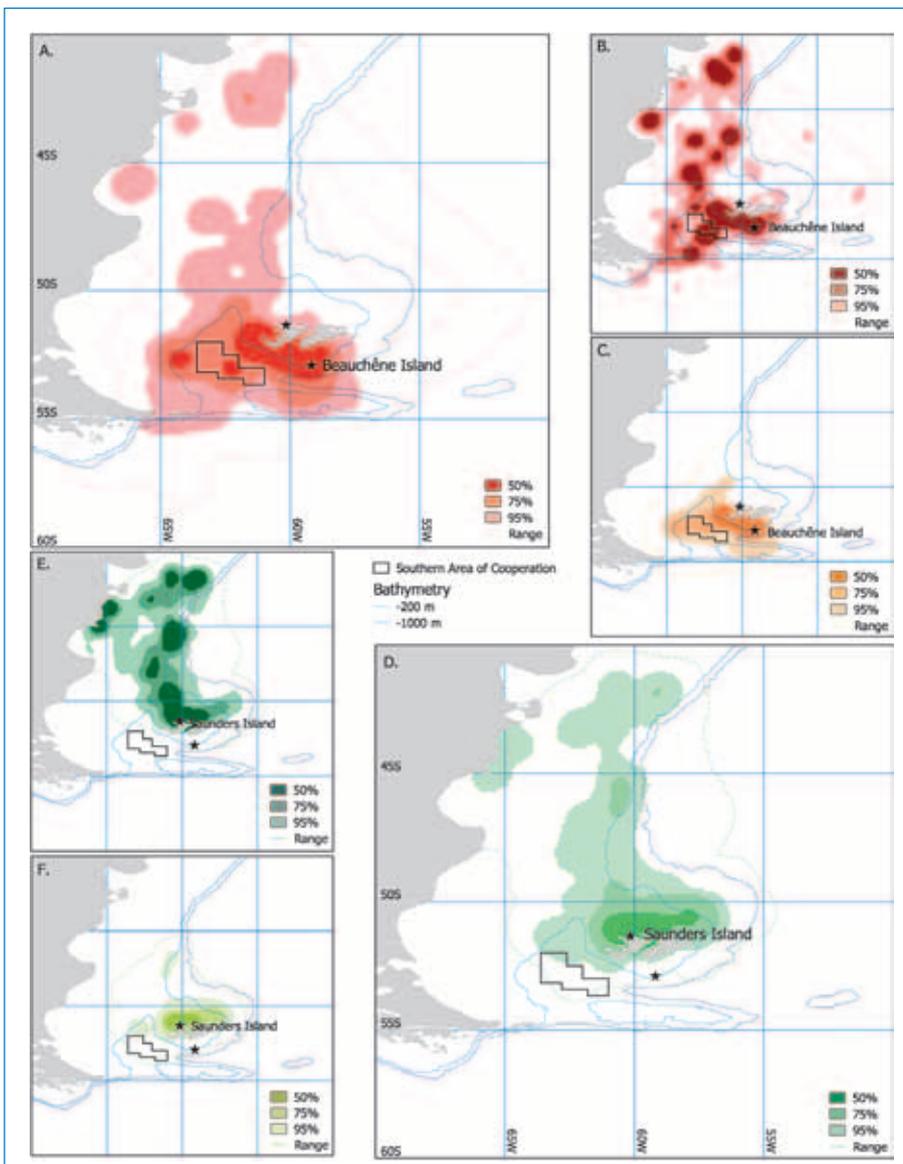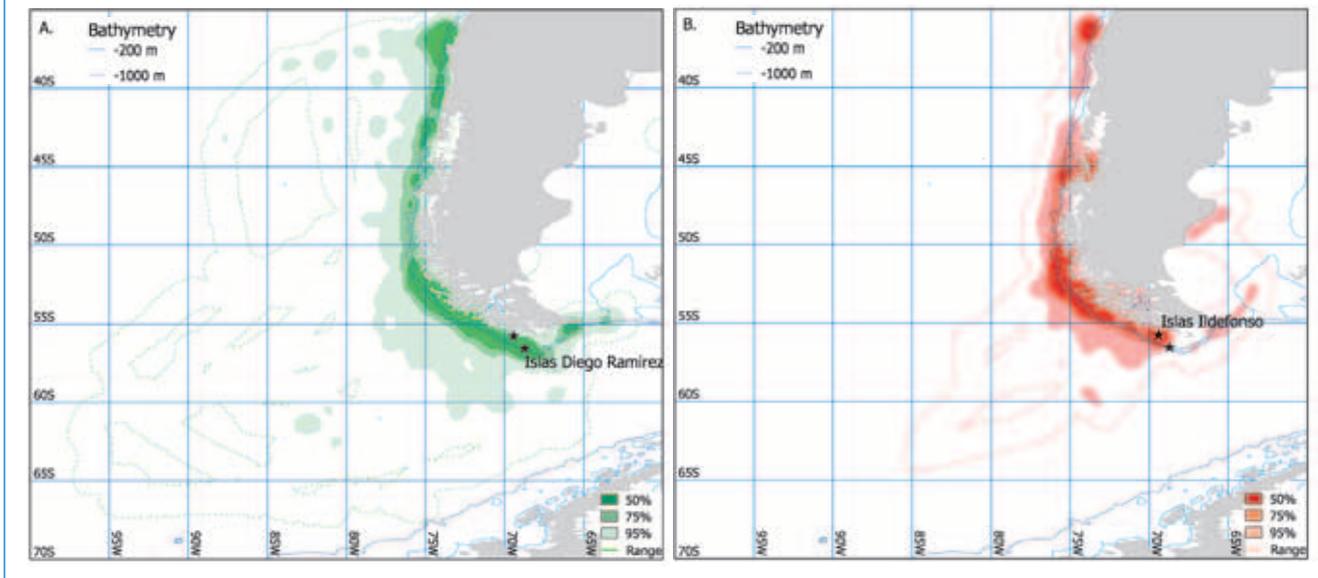
Figure 3.16. Utilisation distribution maps for breeding Black-browed Albatrosses tracked from different colonies at the Falkland Islands (Malvinas). A. all breeding birds from the Beauchêne colony (n=6,050 hrs, 8 indivs); B. incubating birds from Beauchêne (n=2,653 hrs, 4 indivs); C. post guard birds from Beauchêne (n=3,397 hrs, 4 indivs); D. all breeding birds from the Saunders colony (n=7,346 hrs, 15 indivs); E. incubating birds from Saunders (n=2,759 hrs, 7 indivs); F. post guard birds from Saunders (n=4,587 hrs, 8 indivs).

oceanic waters the movement of birds is influenced in a large extent by wind conditions, and thus changes in wind conditions might influence zones of foraging. The presence of fisheries might also influence foraging zones, especially for short trips to the shelf edges, or long trips to other continental shelves. For example it has been shown that in the late 1980s and early 1990s no Wandering Albatrosses from Crozet spent time on the northern and eastern edge of the Kerguelen shelf, but later Crozet birds started to exploit this area, at the same time that a fishery developed there.

Henri Weimerskirch

3.1.4 Distribution of breeding birds in relation to colony

Black-browed Albatross *Thalassarche melanophrys* – Chile and Falkland Islands (Malvinas)
During the incubation period birds tracked from neighbouring colonies in Chile (Figure 3.15 – Diego Ramirez and Ildefonso) and the Falkland Islands (Malvinas) (Figure 3.16B, Saunders and Beauchêne) show broadly overlapping foraging areas.

However, during the chick-rearing period, breeding adults from the Saunders and Beauchêne Islands (Falkland Islands/Malvinas) showing virtually mutually exclusive foraging areas (Figure 3.16C,F). Thus birds from Saunders Island stayed to the north of the main islands and birds from Beauchêne stayed to the south (Huin 2002). This suggests that partitioning of foraging areas is favoured when birds are restricted to relatively small areas.

Nic Huin, Javier Arata and Graham Robertson

Shy Albatross *Thalassarche cauta* – Tasmania
Shy Albatrosses breed only on three localities around Tasmania, south of continental Australia. All colonies are within 100 km of the Tasmanian mainland with one (Albatross Island 40°23'S, 144°39'E – ~5,000 pairs) located in western Bass Strait and the other two (Pedra Branca 43°52'S 146°58' – 200 breeding pairs and Mewstone 43°45'S 146°23'E – 7,000 breeding pairs) located to the south of Tasmania. Shy Albatrosses breed annually with eggs laid in September and chicks typically fledging in April.

Breeding birds were satellite tracked from Albatross Island (n=12), Pedra Branca (n=4) and Mewstone (n=2) colonies during incubation and early chick rearing (Figure 3.17). These birds foraged in relatively local waters, either over the continental shelf or shelf break and never crossed into oceanic pelagic waters. The highest density of foraging locations of birds from Albatross Island occurred 74 km west of the island during incubation with a foraging area of some 28,000 km² over the Australian continental shelf. There was little overlap between the foraging areas of birds from this colony and the other two southern colonies. This foraging area decreased during early chick rearing with the highest density occurring just 9 km to the west of Albatross Island, although there was still considerable overlap in foraging areas during incubation and early chick rearing. Breeding birds from Pedra Branca foraged over a relatively small area (9,500 km²) to the east or southeast towards the continental shelf (Brothers *et al.* 1998, Hedd *et al.* 2001). Mewstone breeding birds also primarily foraged in local waters over the southern shelf and shelf break and there was considerable overlap in areas used by birds from this colony and the Pedra Branca colony.

Figure 3.17. Utilisation distribution maps for incubating Shy Albatrosses, tracked from Albatross Island (A) (n=10,751 hrs), Mewstone (B) (n=2,521 hrs) and Pedra Branca (C) (n=2,906 hrs). (Unable to determine number of individuals of each category from dataset, so sample sizes are only given in number of hours tracked.)
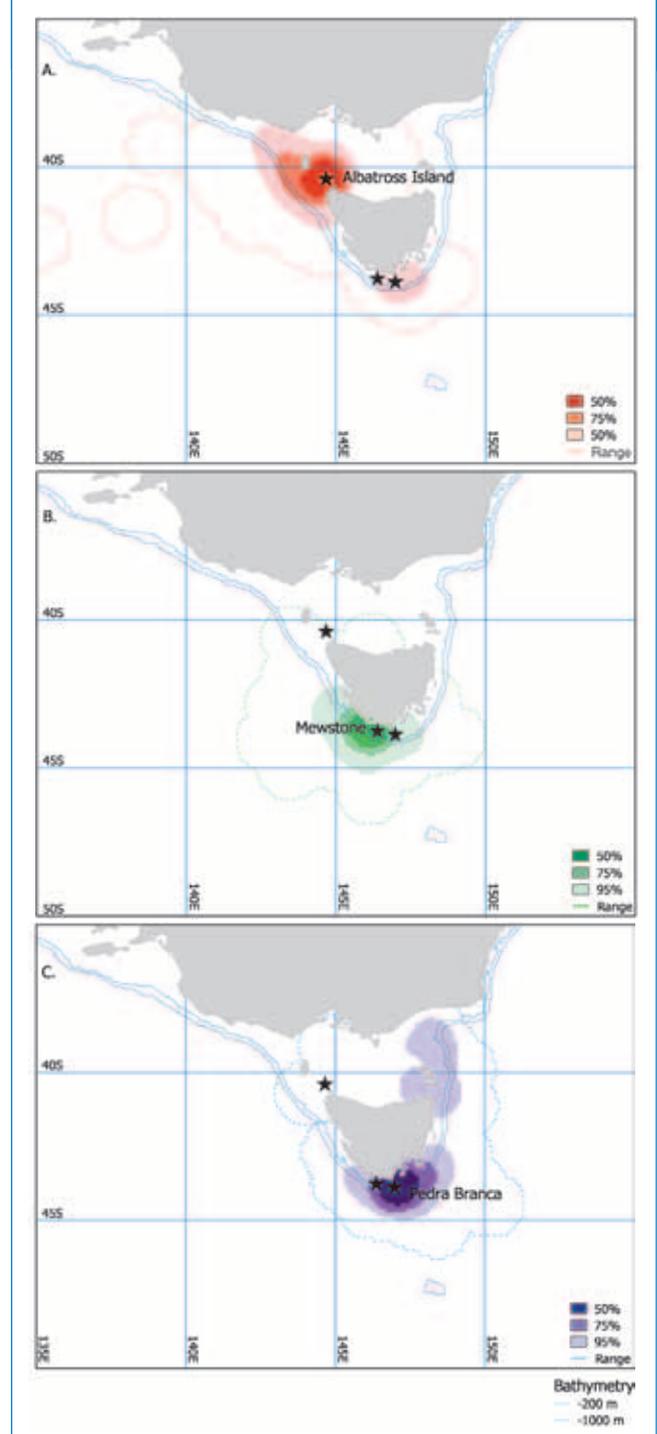
The progression of foraging trips were similar to that observed with other albatross species, with trip duration and distance longest during incubation and shortening progressively as hatching approached, with further reductions during the early chick rearing period. In general breeding adult Shy Albatrosses are relatively sedentary, travelling slowly and feeding over the continental shelf within 200 km of their breeding colonies. Most foraging trips occurred in waters of less than 200 m

in depth with occasional trips into deeper waters associated with the shelf edge. (Brothers *et al.* 1998, Hedd *et al.* 2001)

Aleks Terauds and Rosemary Gales

3.2 SYNTHESIS OF DISTRIBUTION OF BREEDING BIRDS FROM DIFFERENT POPULATIONS OF SELECTED SPECIES

Black-browed Albatross *Thalassarche melanophrys*
The utilisation distribution map (Figure 3.18) illustrates the largely mutually-exclusive foraging ranges of breeding Black-browed Albatrosses from different populations. This was particularly apparent for the South Atlantic/South American region, where data coverage represented all populations and most breeding stages. Although birds from both South Georgia and Chile foraged in many cases at very large distances from nest sites (hence the greater overall ranges), there was little or no spatial overlap between the two populations, or with birds from the Falkland Islands (Malvinas). The same applies in the New Zealand sector where satellite-tracking of the closely-related Campbell Albatross *Thalassarche impavida* (Waugh *et al.* 1999) indicates only marginal overlap with Black-browed Albatrosses tracked from Macquarie Island, despite their relative geographical proximity.

Although not indicated on these maps, the distribution of Black-browed Albatrosses during winter, as determined through GLS tracking (BAS unpublished data: see also Section 3.3.3, Figs. 3.27, 3.28 and 3.29), also shows that most foraging areas are exclusive to birds from a particular island group. However, there is rather more overlap than during the breeding season, with, for example, movements to the Chilean shelf by Black-browed Albatrosses from the Falkland Islands (Malvinas), and to northern New Zealand waters by birds from Diego Ramirez.

In terms of habitat preferences, more than half the breeding birds tracked from each site visited shelf or shelf-break waters, in many cases relatively close to their colony. Indeed, Black-browed Albatrosses from the Falkland Islands (Malvinas) were confined almost exclusively to the Patagonian Shelf, either very close to breeding sites or in several discrete areas to the north, including one inshore area close to Argentinean fishing ports (Huin 2002 and see Section 3.1.1). Similarly, birds tracked from Kerguelen mostly travelled to the northern and eastern Kerguelen shelf and to the north-east of Heard Island (Weimerskirch *et al.* 1997c). By comparison, although many Black-browed Albatrosses from South Georgia also foraged in shelf and shelf-slope areas (around and to the north-west of South Georgia, and at the South Orkney and South Shetland Islands), many others visited Antarctic Polar Frontal Zone (APFZ) waters to the north, and deep, oceanic waters to the south (Prince *et al.* 1998). Similarly, although Campbell Albatrosses spent more than 50% of the time in adjacent

Figure 3.18. Overlap of utilisation distributions for breeding Black-browed Albatrosses tracked from five different populations. Chile (Isla Diego de Almagro, Islas Ildefonso: incubation, Islas Diego Ramirez: incubation, brood and post guard) (n=30,863 hrs); Falkland Islands/Malvinas Beauchêne and Saunders Islands: incubation and post guard) (n=13,396 hrs); South Georgia (Bird Island: incubation and chick rearing) (n=7,718 hrs); Iles Kerguelen (incubation and chick rearing) (n=7,678 hrs); Macquarie Island (incubation and brood guard) (n=3,956 hrs). Where possible, density distributions were weighted by the proportion of time spent in each breeding stage and the proportion of breeders at sea during the breeding stage, as well as by the colony size. (Unable to determine number of individuals from all datasets, so sample sizes are only given in number of hours tracked.)
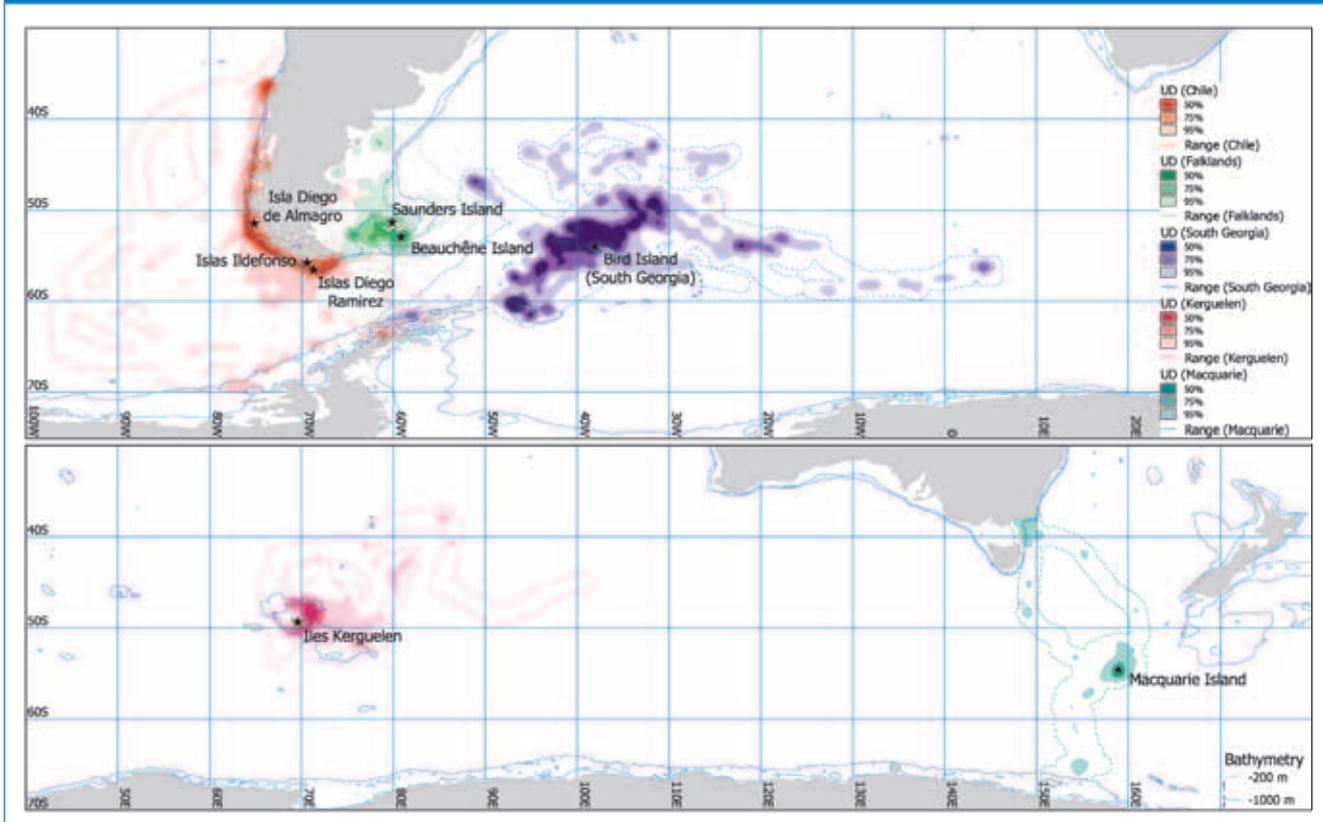
Figure 3.19. Overlap of utilisation distributions for breeding Wandering Albatrosses tracked from four different populations. Prince Edward Islands (Marion Island: incubation, brood guard and post guard) (n=8,142 hrs); Iles Kerguelen: chick rearing (n=1,742 hrs); Iles Crozet: incubation and chick rearing (n=48,870 hrs); South Georgia (Bird Island: incubation and chick rearing) (n=37,712 hrs). Where possible, density distributions were weighted by the proportion of time spent in each breeding stage and the proportion of breeders at sea during the breeding stage. (Unable to determine number of individuals from all datasets, so sample sizes are only given in number of hours tracked.)
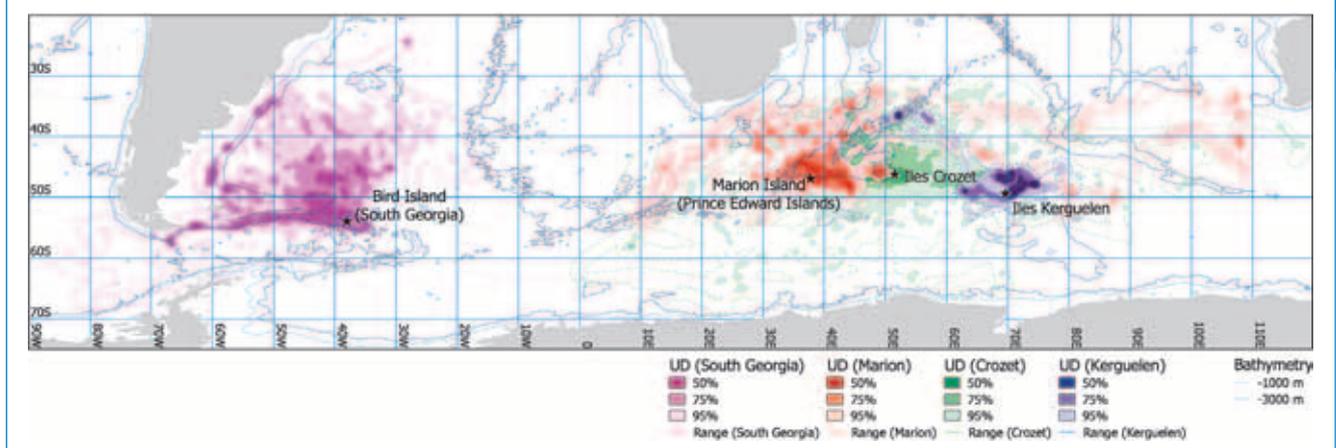
shelf areas, some travelled as far as inshore waters on the west coast of South Island, New Zealand, or to the APFZ at a considerable distance south of the colony (Waugh *et al*. 1999). This shows an interesting parallel with the situation at Macquarie Island, where birds foraged in nearby shelf waters as well as far to the north at the eastern end of the Bass Strait. However, unusually for this species, foraging also took place at the ice edge, far south of the colony.

Not surprisingly, given they exploit of a variety of foraging areas and habitats, Black-browed Albatross have a varied diet (depending on the site, generally fish, krill or squid when feeding in shelf and shelf-break areas, and squid when feeding at frontal zones or in deeper oceanic water; Prince *et al*. 1998, Waugh *et al*. 1999, Cherel *et al*. 2000, Arata and Xavier 2003). The inevitable overlap with commercial fishing interests in shelf waters has had marked effects on population trajectories, initially resulting in increases at some sites where discarded fish and offal constituted an important supplementary food resource, but latterly (and more typically), major declines as the effects of incidental mortality in trawl and long-line fisheries resulted in reduced adult and juvenile survival rates (Croxall *et al*. 1998, Huin 2002, Reid and Sullivan 2004).

Richard Phillips, Javier Arata, Rosemary Gales, Nic Huin, Graham Robertson, Aleks Terauds and Henri Weimerskirch

Wandering Albatross *Diomedea exulans*
Wandering Albatrosses have been tracked from all their breeding sites (South Georgia, Marion, Crozet and Kerguelen) (Figure 3.19), with the exception of Macquarie Island where the population is extremely small. Wandering Albatrosses are wide-ranging species, and the foraging area covered by breeding populations is huge. As a consequence, there is an extensive overlap between populations in the Indian Ocean due to the relative proximity of the groups of islands (Prince Edwards, Crozet and Kerguelen) that constitute the stronghold of the species. South Georgia (and Macquarie) are considerably more distant. The zones of overlap between populations in the Indian Ocean are mainly the seamounts between Crozet and Marion Island, and the eastern edge of the Kerguelen shelf, the Crozet population overlapping with the Marion and Kerguelen

populations. Thus if competition takes place, it is especially relevant to the Crozet birds whose range is encompassed both by Marion and Kerguelen birds.

The foraging habitat preferences of each population are strikingly similar, and probably explain why diet is also similar. The water masses exploited by the species are basically sub-Antarctic and subtropical waters, although they can regularly reach Antarctic as well as tropical waters. Wandering Albatrosses are basically wide-ranging oceanic foragers, but during long foraging trips, they can also reach distant shelf areas. For example South Georgia birds reach the Patagonian Shelf edge and Crozet birds reach the Kerguelen shelf area. However it is notable that Wandering Albatrosses spend a very substantial proportion of their time foraging over neritic waters, especially during the short trips of the chick-rearing period, in the immediate proximity of the breeding grounds. This has important implications for conservation, especially the potential susceptibility of the species, considered as oceanic, to the development of fisheries around the breeding grounds, for example for Patagonian Toothfish.

The propensity of Wandering Albatrosses to have an extended foraging range over a wide variety of water masses may increase the potential contact with many different fisheries, pelagic as well as shelf fisheries, tropical as well as sub-Antarctic fisheries. The similarity in habitats exploited and the overlap between populations probably explains the similar population trajectories of the three populations of the Indian Ocean. The decline of the populations in the early 1970s has been linked to the development of sub-tropical tuna fisheries in the Indian Ocean, and recovery to the reduction in the fishing effort there. Being based in a different ocean, with different fisheries, it is not surprising that the South Georgia population has a contrasting trajectory, one of continuing decline since the 1970s (e.g. Tuck *et al*. 2001).

Given the good coverage of breeding Wandering Albatrosses in the Indian Ocean, future tracking research should focus on the non-breeding part of the population. A small number of non-breeding adult birds have been tracked with geolocators from Crozet, and some juveniles have been tracked for two years from Crozet. Both studies show that birds forage extensively outside the range of breeding birds,

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showing the importance of tracking the non-breeding part of the population (more than 50% of the entire population during a season) to understand the dynamics of the populations of these species. Similar tracking from other sites, particularly involving more individuals of adult non-breeding birds or immatures, is highly desirable.

Henri Weimerskirch, John Croxall and Deon Nel

3.3 DISTRIBUTION OF NON-BREEDING BIRDS

3.3.1 Adults and immatures during the breeding season

Buller's Albatross *Thalassarche bulleri* – New Zealand
In Buller's Albatrosses, about 45% of birds associated with colonies are successful breeders, 20% are unsuccessful breeders, 25% are immature prebreeders, and 10% are non-breeding adults (Sagar and Stahl unpubl. data). Thus a third (and up to half when including failed breeders) of birds foraging from those colonies are non-breeders, a figure comparable to that reported for other albatrosses (e.g. Woodward 1972, Weimerskirch 1982, Anderson *et al.* 2002). Foraging patterns of such birds are virtually unknown, although likely to differ from those of breeders because of different constraints of coming ashore. With the aim of modelling interactions between this albatross and New Zealand fisheries (Broekhuizen *et al.* 2003), we tracked breeders and non-breeders from Snares and Solander Islands colonies via the Argos system. We here summarise the patterns recorded among Snares Islands birds (based on Stahl and Sagar 2000b and unpubl. data) to illustrate how breeding status can affect the distribution and hence contact with fishing fleets of birds foraging from the same central place.

Based on tracking data from 32 birds (16M, 16F), the foraging distribution of Snares Island breeders extends from Tasmania to the Chatham Rise east of the South Island of New Zealand, and from the southern edge of the Snares shelf (49°S) north to about 40–43°S (Figure 3.20). Overall, their sites of most intensive foraging are located around the Snares and southern New Zealand (short trips), off the South Island east and west coasts, and in the western Tasman Sea (long trips), although utilisation of those areas changes greatly throughout the breeding season. Thus, breeders of both sexes undertake primarily long trips during the incubation period (mostly Tasman Sea and South Island east coast) and early post guard (mostly South Island east coast), and primarily short trips within 450 km from the Snares during the brood guard. After mid-June (late post guard), males switch to solely short trips, whereas females retain a foraging regime of mostly long trips but switch to the South Island west coast. A similar sexual difference is recorded during the pre-egg stage, when males undertake mostly short trips, females mostly long trips to the Tasman Sea.

Tracked non-breeding adults (1M, 2F) foraged within the range of breeders, and their two sites of most intensive foraging (vicinity of Snares, South Island west coast) also coincided with foraging hotspots of breeders. Unlike breeders, they never foraged in the Tasman Sea (as recorded in failed breeders from Solander Island, Stahl and Sagar 2000a and unpubl. data) or off the South Island east coast (probably an artefact of small sample size, as Solander Island birds did forage there). When controlling for the stage of the breeding cycle (stages delineated by mean

dates), non-breeding adults tended to forage closer to the Snares than breeders as a result of greater time allocation to short trips. This was most pronounced during the incubation period, when two failed breeders initiated solely short trips and barely overlapped with breeders, and also recorded during the early post guard, when short trips accounted for 61% of foraging time in a remating female compared to 23% in breeders. After mid-June, however, this female switched to a foraging pattern identical to that of breeding females (long trips to the South Island west coast).

Seven immature prebreeders (4M 3F) made a greater use of Tasmanian waters than breeding adults, and foraged farther offshore south-west of Tasmania and east of the South Island. This overall pattern is, however, a composite of distinct foraging patterns recorded among those birds, which we interpret as reflecting the sequence of foraging patterns during pre-breeding years. Thus, the two youngest birds tracked (aged 6–7 years, 1st–2nd season ashore) dispersed to Tasmanian waters shortly after instrumentation in May (post guard, main colony attendance period of those age classes) and foraged there until at least early August (about two weeks from the onset of fledging). This, and records of subadults off Victoria in February (Stahl *et al.* 1998), suggest that the youngest prebreeders make occasional (possibly single) visits to the Snares from a staging area in Southeast Australian waters.

Older pre-breeders (aged 8–9 years) were tracked during consecutive roundtrips from the Snares. Two of those (1M, 1F, 1st–2nd season ashore) initiated mostly long trips throughout the incubation period (Tasman Sea, shared with breeders) and brood guard (South Island east coast, beyond the main foraging area of breeders). Two others (males associated with a nest site, 2nd–3rd season ashore) initiated mostly short trips throughout the breeding season, thus foraging closer to the Snares than breeders during the incubation period and early post guard, but largely overlapping with breeders during the brood guard and late post guard. The remaining bird (female, 1st season ashore) initiated solely short trips during the incubation period, but switched to mostly long trips (South Island east and west coasts) during the brood guard, thus foraging closer to and farther from the Snares than breeders respectively. A similar pattern was recorded among two experienced non-breeding females from the Solander Island (Sagar and Stahl unpubl. data).

On present evidence, breeders and non-breeders commute to the same rather than distinct foraging areas, but use those areas in different sequence and proportion, and as a result tend to be segregated at sea at most times. Use of those foraging areas also seems to differ fundamentally between inexperienced prebreeders, which tend to forage over distant areas at all times, and experienced non-breeders (prebreeders and adults, including failed breeders), which tend to forage in the vicinity of colonies during all (males) or part (females) of the breeding season. These and some of the recorded segregation patterns are probably applicable to other procellariiforms, as consistent with the age- and experience-related progression in colony attendance (e.g. Fisher and Fisher 1969, Pickering 1989) and concentrations of non-breeders around colonies (Anderson *et al.* 1998) documented in other species. Only the pattern recorded during the late post guard may be specific to Buller's Albatross, as associated with a late switch in the foraging regimes of breeders not yet documented in other species.

Jean-Claude Stahl and Paul Sagar
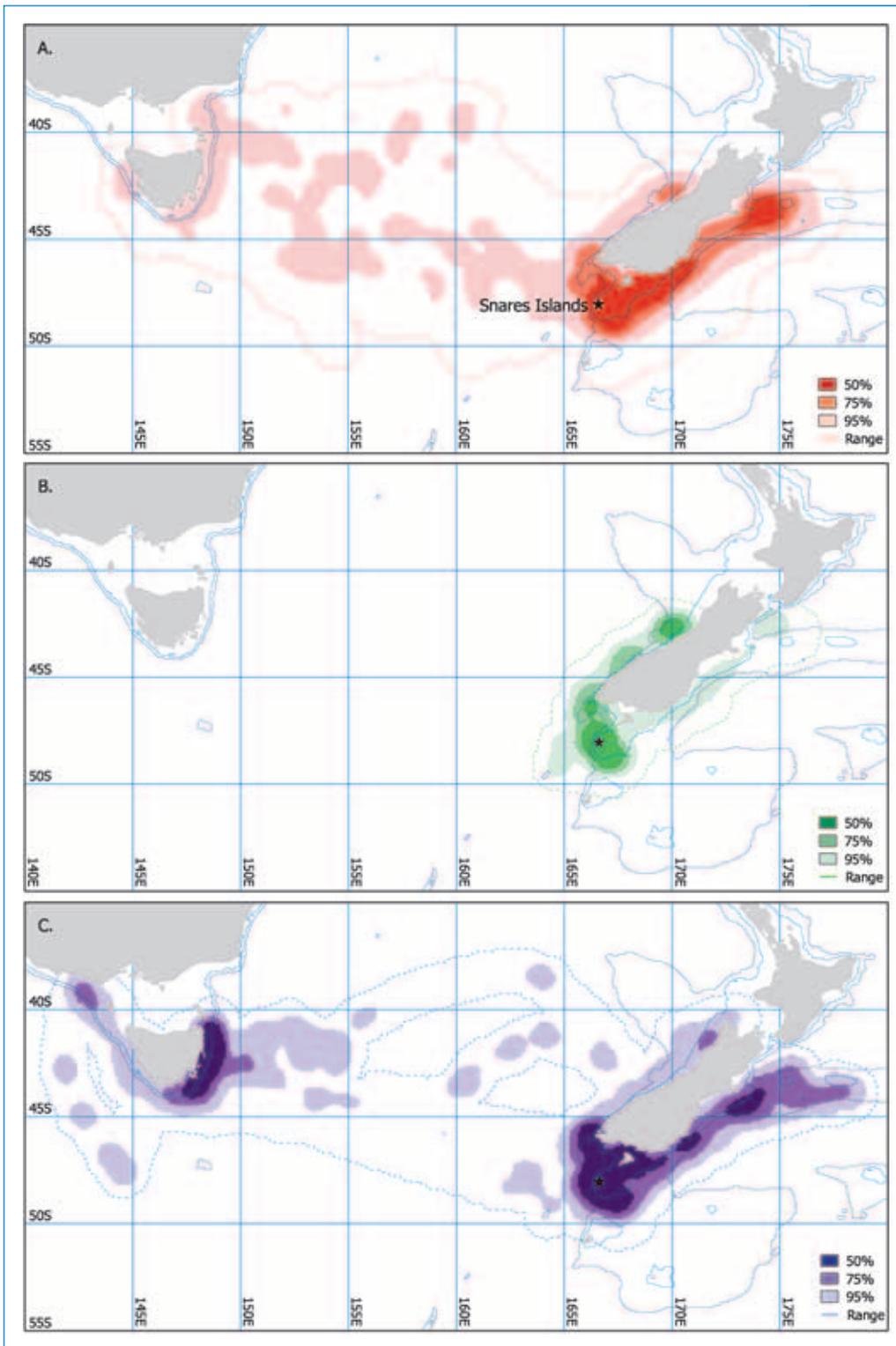
Figure 3.20. Utilisation distribution maps for Buller's Albatrosses tracked from three colonies at the Snares Islands during the breeding season (mid-December to July). A. adult breeders (n=22,615 hrs, 57 individuals); B. adult non-breeders (including failed breeders) (n=1,192 hrs, 3 individuals); C. immatures (n=7,005 hrs, 6 individuals).

Grey-headed Albatross *Thalassarche chrysostoma* – South Georgia

The utilisation distribution maps in Figure 3.21 compare the foraging ranges of three groups of Grey-headed Albatross from Bird Island, South Georgia during the austral summer: (1) breeding birds (late incubation to late chick-rearing); (2) non-breeding adult birds (i.e. birds of known breeding status between breeding attempts); and (3) failed breeders (nests failed in late incubation). All data for birds in groups 2 and 3 were collected using GLS loggers and locations are therefore subject to greater errors (mean error ± 186 km; Phillips *et al.* 2004a)

compared with the satellite tracking data obtained for breeding birds.

During December to April, breeding Grey-headed Albatrosses (Figure 3.21A) foraged extensively in the Antarctic Polar Frontal Zone (APFZ), at widely dispersed sites in oceanic waters to the south-west of South Georgia, and over shelf waters around the South Orkney Islands and the northern tip of the Antarctic Peninsula (for more details see Section 3.1.3).

Non-breeding Grey-headed Albatrosses from South Georgia have a circumpolar winter distribution (see non-breeding season maps in Section 3.3.3). During October and

Figure 3.21. Utilisation distribution maps for breeding and non-breeding Grey-headed Albatrosses tracked from Bird Island at South Georgia. A. breeding birds (n=25,217 hrs, 40 indivs) tracked using PTT's from December to June; B. non-breeding birds (n=6 indivs) tracked using geolocators during October and November; C. non-breeding birds (n=6 indivs) tracked using geolocators during February and March; D. failed breeders (n=5 indivs) tracked using geolocators from January to April.
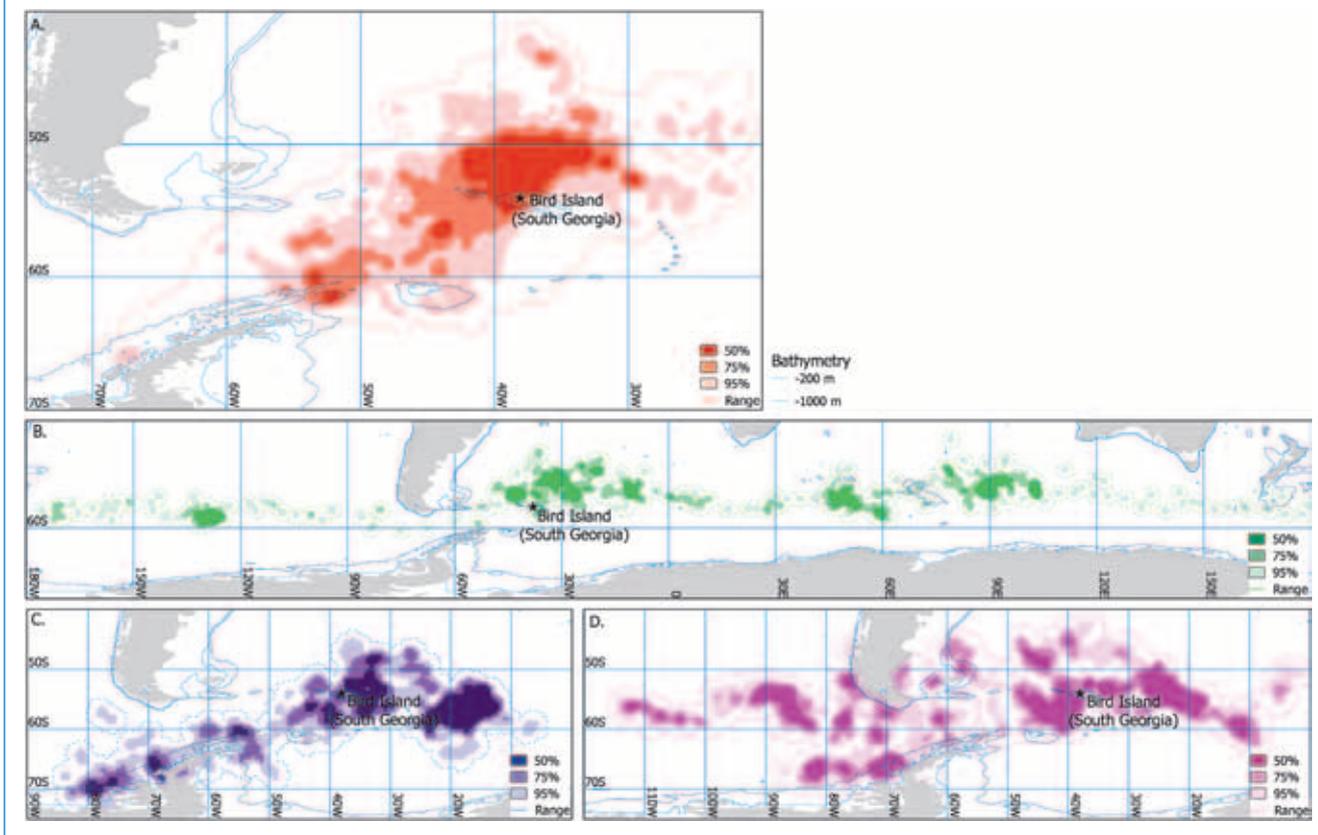
November (corresponding to the incubation period for breeding birds) they were still widely distributed in the Southern Ocean (Figure 3.21B), with obvious concentrations in the South Atlantic, to the south of the Prince Edward Islands, along the Indian-Antarctic Ridge and on the Pacific-Antarctic Ridge. By February and March (Figure 3.21C) all birds had moved to between 5°W to 85°W, much closer to the breeding colony at 38°W and in areas more or less corresponding to those used by breeding birds.

Failed breeders tracked during January to April (corresponding to the chick-rearing period) showed a similar distribution to the non-breeding birds, but were dispersed more widely in the south-east Pacific and around the Falkland Islands (Malvinas) and the coast of southern Chile (Figure 3.21D).

These maps show clearly that during the main summer breeding period there is a great deal of overlap in the distribution of birds of different status from the same colony. However, non-breeding and failed birds, which are not constrained by the requirement to return frequently to the colony to feed their chicks, are able to extend their range further into the deep oceanic waters to the east of the South Sandwich Islands and westwards into the Bellingshausen Sea.

Janet Silk, Richard Phillips and John Croxall

Chatham Albatross *Thalassarche eremita* – Chatham Islands
The annually breeding Chatham Albatross, (one of the larger *Thalassarche* mollymawks) is restricted to one breeding site with difficult access at The Pyramid (Chatham

Islands). Total research time ashore has been limited to about 110 days over 30 years, mainly concentrated at the end of hatching in early December. Before tracking, little was known of its distribution, with confirmed records away from New Zealand (from Peru) not being recorded until 1987.

In February 1997, a breeding male (with large chick) was tracked for 111 days until the battery expired. In October 1997 a breeding pair was tracked for about 300 days (until battery expiration) using transmitting regimes that provided positions every 1.5 to 2.5 days. In December 1998, ten birds (3 breeding pairs, 1 failed breeding pair and 2 adolescent pre-breeders) were tracked using an intermittent rolling transmission cycle that covered all parts of the day during the 8-day cycle.

Both observations ashore and the satellite tracking demonstrated that incubating and chick rearing parents have short incubation and guarding stints of about 2–4 days with a range of 0.5 to 8 days and their at sea locations were concentrated within a radius of 260 km (maximum 450 km) of the breeding colony when on eggs, increasing to 360 km (maximum 600 km) when feeding chicks, especially as the chicks increased in age. This range was all within 12–18 hours direct flying from the colony and enabled some non-incubating mates to return to the nest nightly.

There was no obvious sexual difference in either incubation/guarding nest site behaviour or at sea distribution, at any time of the breeding season.

At sea locations (Figure 3.22A) were concentrated along continental slope features (1,000 m to 3,000 m), most especially on the southern and eastern edge of the Chatham

Rise, which features extensive cold-water upwellings. Notwithstanding the kernel map, there were few records close to the Chatham Islands and within the 200 m isobath. Some individuals demonstrated repeated visits to similar locations.

Failed breeders, after losing an egg or young chick, generally retain a regular association with the nest site until late December, before migration. Following failure, the movements at sea became more widespread, both eastwards and westwards. Flights tended to be longer and included a wider range of pelagic areas away from the continental shelf and slope.

The two 4 and 5 year old adolescents had a relatively short tracking life. Neither adolescent foraging range overlapped to any significant extent with the breeding or failed breeding birds. The more northerly distribution pattern suggested a wider ranging exploratory regime in more temperate waters, with a minimum of attachment to the breeding colony.

Christopher Robertson and David Nicholls

Northern Royal Albatross *Diomedea sanfordi* – Chatham Islands and Taiaroa
The biennially breeding Northern Royal Albatross breeds primarily on 3 small islets in the Chatham Islands, and a small mainland colony at Taiaroa Head on the South Island of New Zealand. The Little Sister Islet at the northern extremity of the Chatham Islands and Taiaroa Head were the breeding locations studied.

Various tracking experiments were undertaken from November 1993 to November 1998 mainly designed to test different transmission regimes over extended periods. Tracking periods ranged from 5 days to 564 days over 20 deployments covering most parts of breeding, migration, and wintering, over the two-year biennial cycle. Most of the long distance deployments used transmitters with duty cycles of up to 6 days between transmissions.

As with the Chatham Albatross, both observations ashore and the satellite tracking demonstrated that incubating and chick rearing parents have short incubation and guarding stints of about 2–4 days and their at sea locations were concentrated primarily within a radius of 300 km of the breeding colony when on eggs and guarding the chick. The range then increases as the chick advances in age. This range was all within 12–18 hours direct flying from the colony. Some non-incubating mates returned to the nest nightly. Most locations are confined to the shelf edge, break and slope over bathymetry from 1,000–2,000 m, but the kernel map probably overemphasises use of shallower areas over
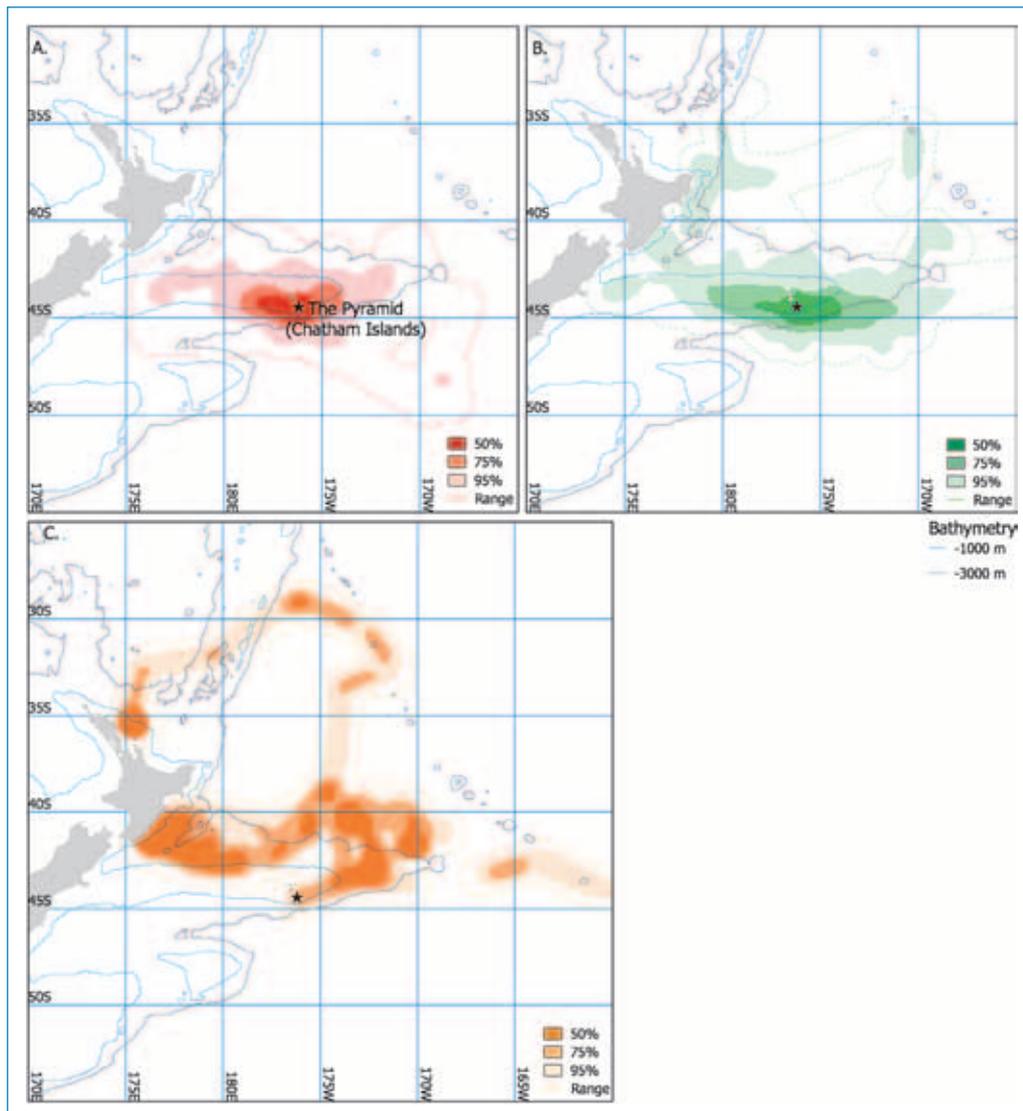
Figure 3.22. Utilisation distribution maps for breeding and non-breeding Chatham Albatrosses tracked from the Chatham Islands during the breeding season. A. breeding birds tracked during the breeding season (Oct–Mar) (n=8,136 hrs, 10 indivs); B. resident failed breeders, tracked from Nov–Feb i.e. during the breeding season (n=7,745 hrs, 6 indivs); C. adolescent pre-breeders tracked from Nov–Dec i.e. during the breeding season (n=1,626 hrs, 2 indivs).

Figure 3.23. Utilisation distribution maps for breeding and non-breeding Northern Royal Albatrosses tracked from the Chatham Islands and Taiaroa Head during the breeding season. A. breeding birds tracked during the breeding season (Nov–Sep) (Taiaroa: n=6,370 hrs, 3 indivs; Chathams: n=6,370 hrs, 13 indivs); B. resident failed breeders, tracked from the Chathams from Feb–Jul (Taiaroa: n=98 hrs, 1 indiv; Chathams: n=341 hrs, 1 indiv); C. adolescent pre-breeders tracked from Taiaroa Head from Feb–Apr (n=883 hrs, 2 indivs).
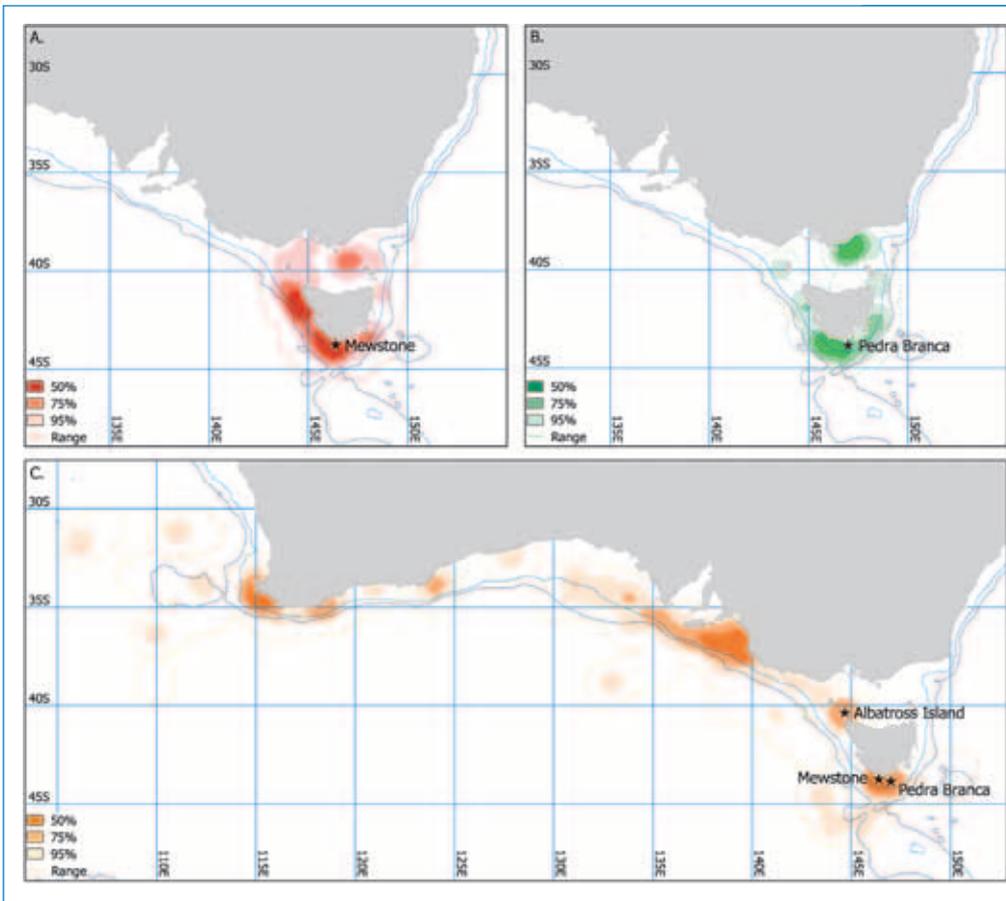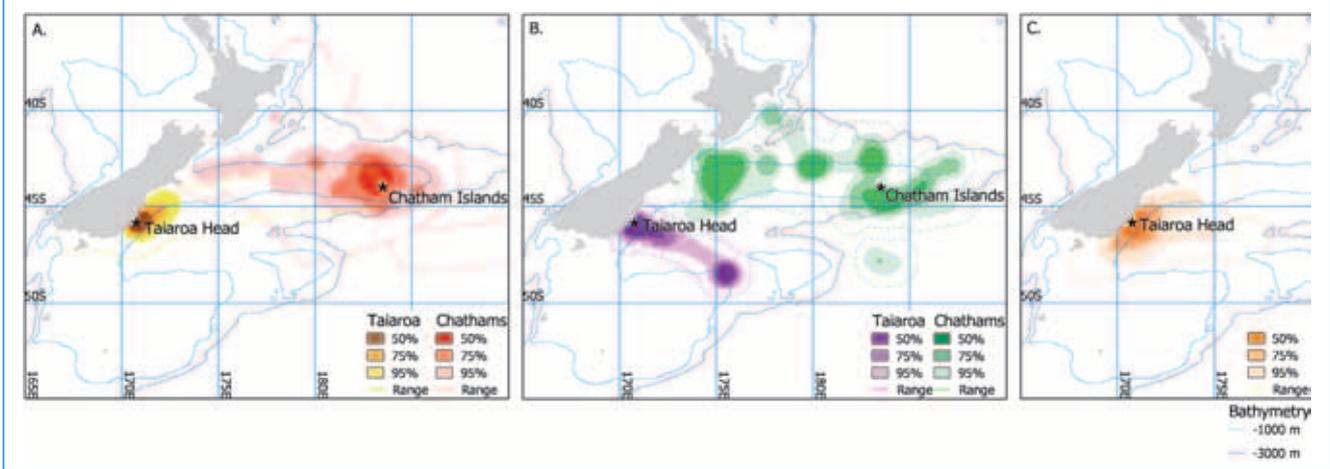
Figure 3.24. Utilisation distribution maps for adult and juvenile non-breeding Shy Albatrosses tracked from Tasmania. A. post-breeding adults tracked from Mewstone from Apr–May (n=913 hrs, 3 indivs); B. post-breeding adults tracked from Pedra Branca from Apr–Aug (n=212 hrs, 2 indivs); C. post-fledging juveniles tracked from Albatross Island, Mewstone and Pedra Branca from Mar–Jul (n=2,587 hrs, 3 indivs).

the Chatham Rise, which were possibly commuting positions.

One female tracked in 1993 and again in 1998 demonstrated a strong affinity for visiting the same locations five years apart.

There was no obvious sexual difference in either incubation/guarding nest site behaviour or at sea distribution, at any time of the breeding season.

Christopher Robertson and David Nicholls

3.3.2 Adults and immatures during the non-breeding season

Shy Albatross *Thalassarche cauta* – Tasmania
After breeding, adults ranged more widely than breeding birds with considerable larger foraging areas. Post breeding adults from Albatross Island travelled up to 750 km from the colony with individuals travelling north and crossing Bass Strait and south along the west coast of Tasmania (Brothers *et al.* 1998). Post-breeding adults from Pedra

Branca and the Mewstone also showed a similar range with the distances travelled increasing in the months following chick fledging. Post breeding adults from the southern colonies generally remained within 200 km of their respective colonies for the first two week following chick fledging then increased their range to utilise waters all around Tasmania, concentrating around known 'hot spots' of production off the south east coast of continental Australia and the west coast of Tasmania. Although these birds travelled thousands of kilometres during June and July, no birds were ever recorded in oceanic waters and all foraging was concentrated in shallow waters on the shelf or at the shelf edge. As the breeding season approached through August, breeders tended to return waters closer to their respective breeding colonies. Successful parents from Albatross Island spent just nine weeks at-sea off the southeast Australia before returning to the breeding colony and foraging in localised waters. Consistent travelling speeds, foraging trip durations and foraging locations across years suggest relatively stable prey availability and/or accessibility for adult Shy Albatrosses.

One fledgling from each breeding colony was tracked during 1996, with tracks obtained for the first 60–80 days at sea. All chicks moved westwards immediately after fledging and over the first three months foraged almost exclusively in southern Australian continental shelf waters. Dispersal from the colonies was rapid with all chicks moving at least 500 km from the colony within six days of fledging. Chicks from Albatross Island and Pedra Branca travelled relatively quickly to the eastern side of the Great Australian Bight where they remained foraging for six weeks. The chick from the Mewstone travelled further west before concentrating its activity off the southwest coast of Western Australia some three weeks after fledging. During this time the fledgling covered 4,113 km and flew an average of 206 km each day. Although foraging was concentrated around the shelf and shelf edge, all fledglings undertook long looping flights into more oceanic waters at some stage during the tracking period.

Aleks Terauds and Rosemary Gales

3.3.3 Migration routes and wintering areas

Chatham Albatross *Thalassarche eremita* – Chatham Islands
Upon migratory departure eastwards from the breeding location, birds took from 11–30 days to cross the south Pacific and reach the coast of South America. Four females averaged 14.5 days and 4 males 24.5 days. This may have been a consequence of weather systems becalming birds for a period during migration. Such an explanation must be
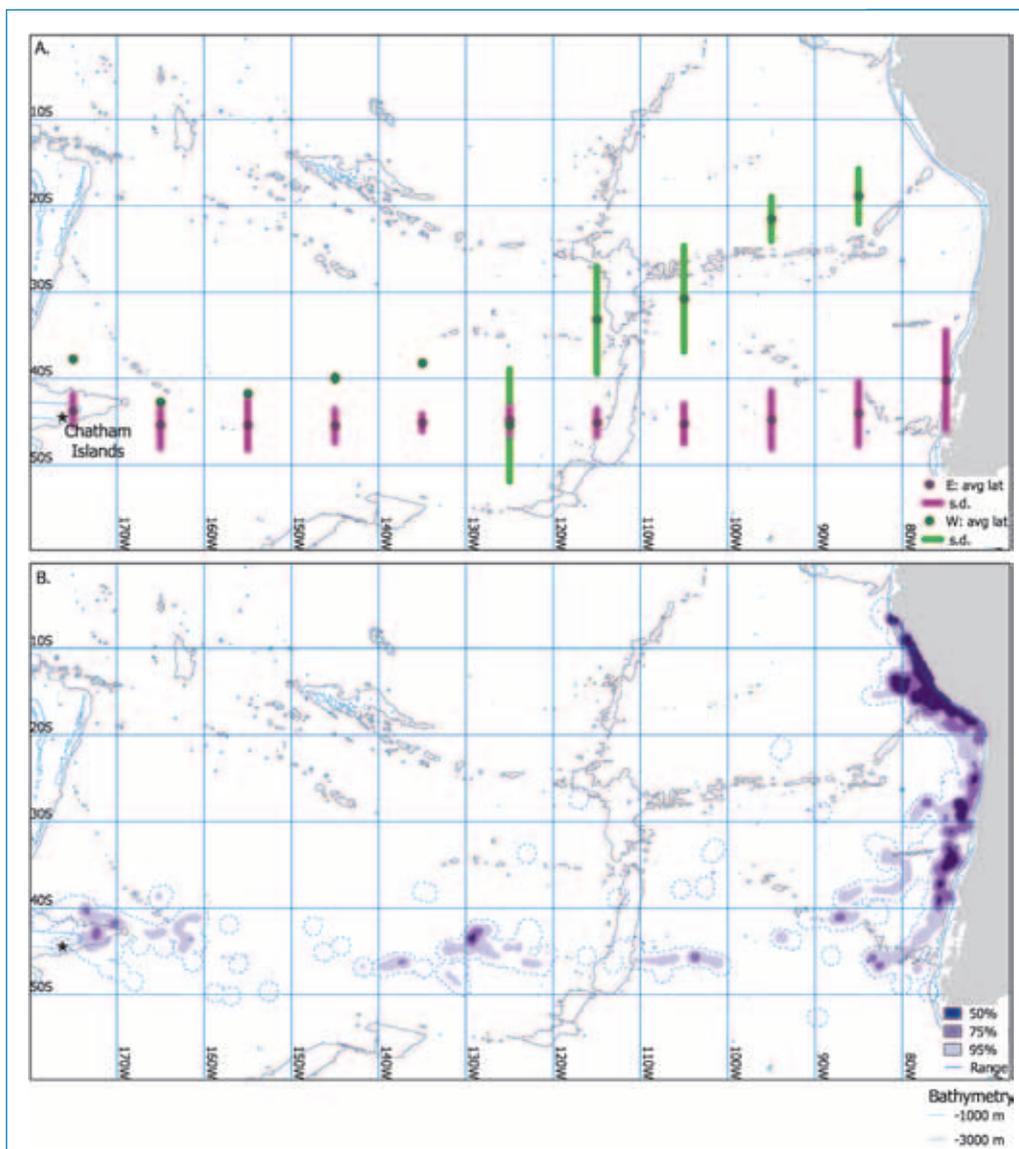
Figure 3.25. Utilisation distribution and migration route maps for dispersing Chatham Albatrosses tracked from the Chatham Islands. A. easterly and westerly migration routes of failed and post-breeders tracked from Jan–Aug (east: n=1,359 locations, 10 indivs; west: n=80 locations, 4 indivs all of whom were tracked migrating east). (Only locations where the bird was consistently moving > 20 km/hr in an east-west direction were used.) B. foraging areas of dispersing failed and post-breeders tracked from Jan–Aug (n=10,235 hrs, 9 indivs). (Transit locations used to generate map A. were excluded.)

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Figure 3.26. Utilisation distribution and migration route maps for dispersing Northern Royal Albatrosses tracked from the Chatham Islands and Taiaroa Head. A. easterly and westerly migration routes of failed breeders and adolescents tracked from the Chathams and Taiaroa Head from Jan–Nov (east: n=822 locations, 7 indivs; west: n=78 locations, 1 indiv). (Only locations where the bird was consistently moving > 20 km/hr in an east-west direction were used.); B. foraging areas of dispersing failed breeders tracked from the Chathams and Taiaroa Head from Jan–Oct (Taiaroa: n=3.422 hrs, 1 indiv; Chathams: n=2.094 hrs, 4 indivs); C. foraging areas of dispersing adolescents tracked from Taiaroa Head from Mar–Nov (n=1.193 hrs, 2 indivs). (Transit locations used to generate map A. were excluded from maps B. and C.)
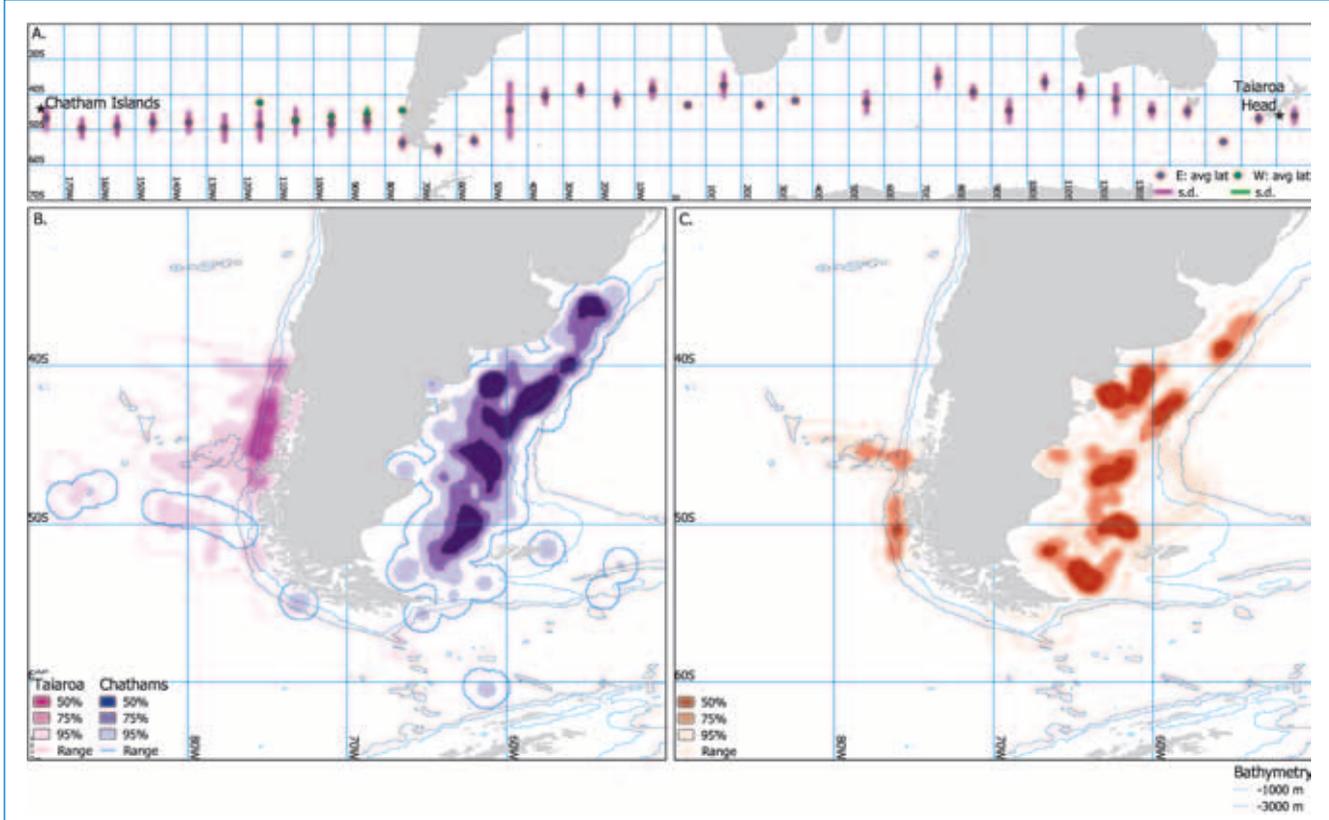
considered, as the areas of concentration in the central Pacific do not seem to relate bathymetrically to any other potential foraging sites throughout the year. Migration was direct once started, with any backtracking confined to the starting area. Mean outward migration rates ranged from 350–650 km per day, with a maximum of 900 km.

Failed breeders followed by successful breeders arrive in a broad band along the South American coast (between 30°S and 50°S) from late January to early April and then progress rapidly north as far as 5°S before consolidating in the wintering area off the coast of Peru, north of 20°S. They are transiting the northward moving Humboldt and Peruvian Currents in a narrow band along the steep continental shelf slope between isobaths 500–5000 m. Concentrations were found at upwellings from 6°S–10°S, and the landward end of the Nazca Oceanic Ridge at 15°S. These are parts of one of the most productive marine habitats in the world. Variations between years, that may be related to changes in La Nina weather patterns, saw a greater use of the upper shelf areas in one year.

Homeward migration data are few but, apart from some backtracking in one individual at the start, seemed to be direct, as with the outward pattern. At least one bird travelled to the Chathams in 21 days at a mean rate of 530 km per day. The more northerly return route suggests a downwind migration pattern round the central Pacific high-pressure system.

Some 90% of the sedentary wintering time of 3–4 months is spent within the EEZ's of Peru and Chile.

Christopher Robertson and David Nicholls

Northern Royal Albatross *Diomedea sanfordi* – Chathams and Taiaroa

Migration tracking experiments were confined to failed breeders and adolescents who could be expected to return to the breeding colony. Two individuals from the Chathams marked as failed breeders, were tracked round the world, failed breeding a second time and were two thirds of the way home the second time when the batteries failed. Both demonstrated a remarkable synchrony of travel, visiting similar areas to within 3 days of a calendar year later. All satellite-tracked birds completed their migrations in a downwind easterly progression without backtracking. Significant distances of up to 1800 km were travelled in 24 hours with regular movement patterns of 10 degrees of longitude at 40°S to 50°S.

Outward migration averaged 7–10 days from New Zealand breeding colonies to wintering areas in South America. Homeward migration averaged 20–30 days. However, it was noted that females tended to leave wintering grounds later than males and return home more rapidly. Egg yolk deposition is known to commence about 42 days before egg laying which is when they are approximately two thirds of the migration distance towards the breeding colony.

One Taiaroa failed breeder wintered on the Chilean coast of South America, including a mid-winter excursion of some 2,000 km westward back into the south Pacific. However, it returned to Chile and then migrated home downwind (without stopping at the Patagonian Shelf) via the Atlantic and Indian Ocean.

The main wintering area was on the Patagonian Shelf, where after some possible northward exploration on arrival, there was a steady progression from the south to the northern end of the range throughout the year with departure thence on migration being from the northern end of the range. Individuals tracked to the wintering area more than once showed little variation to the pattern in successive years.

Testing of a type of geolocation and activity logger since the satellite tracking, indicates that while on migration only 40% of the time is spent flying with 90% of flights being less than 4 hours in duration. During wintering periods in Chile and Argentina only 20% of the time is spent flying. The downwind use of the strong westerly wind belt especially for the rapid homeward migration close to the equinoxial gales is used to cover extensive ocean areas between prime shelf feeding locations.

The subsequent geolocation data experiment has also recorded that, with a similar mix of failed breeders and adolescents from Taiaroa, one migrated round the world wintering in Argentina, two migrated to Chile and returned via the Pacific, and two did not migrate at all from New Zealand waters during the winter. Notable variations in breeding behaviour at Taiaroa were also noted at the same time, suggesting substantial variation in normal food patterns related to El Niño conditions round South America.

Christopher Robertson and David Nicholls

Black-browed Albatross *Thalassarche melanophrys* – South Georgia, Falkland Islands (Malvinas) and Chile
After breeding, Black-browed Albatrosses from South Georgia migrate directly several thousand km to South African waters, spending the first half of the winter in

the highly productive Benguela Current region, where they are frequently found in association with fishing vessels (Prince *et al.* 1998, Figure 3.27). By late July, birds start to return towards South Georgia, in most cases stopping en route for several weeks in oceanic waters in the central South Atlantic, and arriving at the colony in early October.

In contrast, most Black-browed Albatrosses from the Falkland Islands (Malvinas) winter on the Patagonian shelf, in much closer proximity to breeding colonies (Figure 3.28). There is an intriguing gender-difference in distribution; males are restricted to the Patagonian Shelf and deeper water to the east and south whereas females disperse more widely, utilising the Patagonian Shelf, a much greater area of oceanic water in the central South Atlantic, and the narrow Chilean shelf from 28°– 46° S (Figure 3.28). The 27 birds followed in this study included six breeding pairs, and there was no evidence of a link in distribution of pair members at sea at any point during the winter period.

Black-browed Albatrosses from Diego Ramirez make more extensive use of the Chilean shelf and deeper waters offshore, with some migrating to the Patagonian Shelf and others travelling over 8000 km to spend the non-breeding season around northern New Zealand (Figure 3.29). This overlap in distribution of non-breeding Black-browed Albatrosses from the Chilean and Falkland Islands (Malvinas) populations in shelf areas on both the eastern and western seaboard of South America contrasts with the largely mutually-exclusive foraging ranges observed during the chick-rearing period (Sections 3.1.1 and 3.1.4, Figs 3.6, 3.15 and 3.16).

Richard Phillips, Javier Arata, John Croxall, Nic Huin, Graham Robertson and Janet Silk
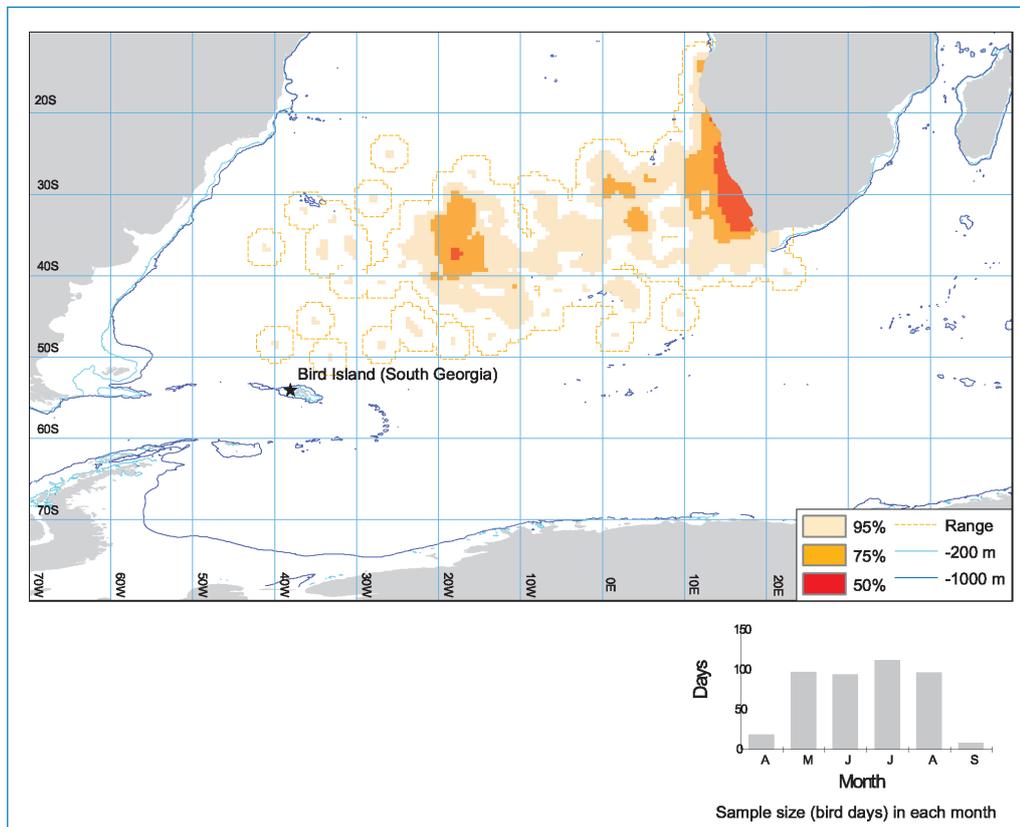
Figure 3.27. Utilisation distribution maps for Black-browed Albatrosses tracked from Bird Island, South Georgia during the non-breeding season (n=4 indivs).

	95%	Range
	75%	-200 m
	50%	-1000 m

Sample size (bird days) in each month
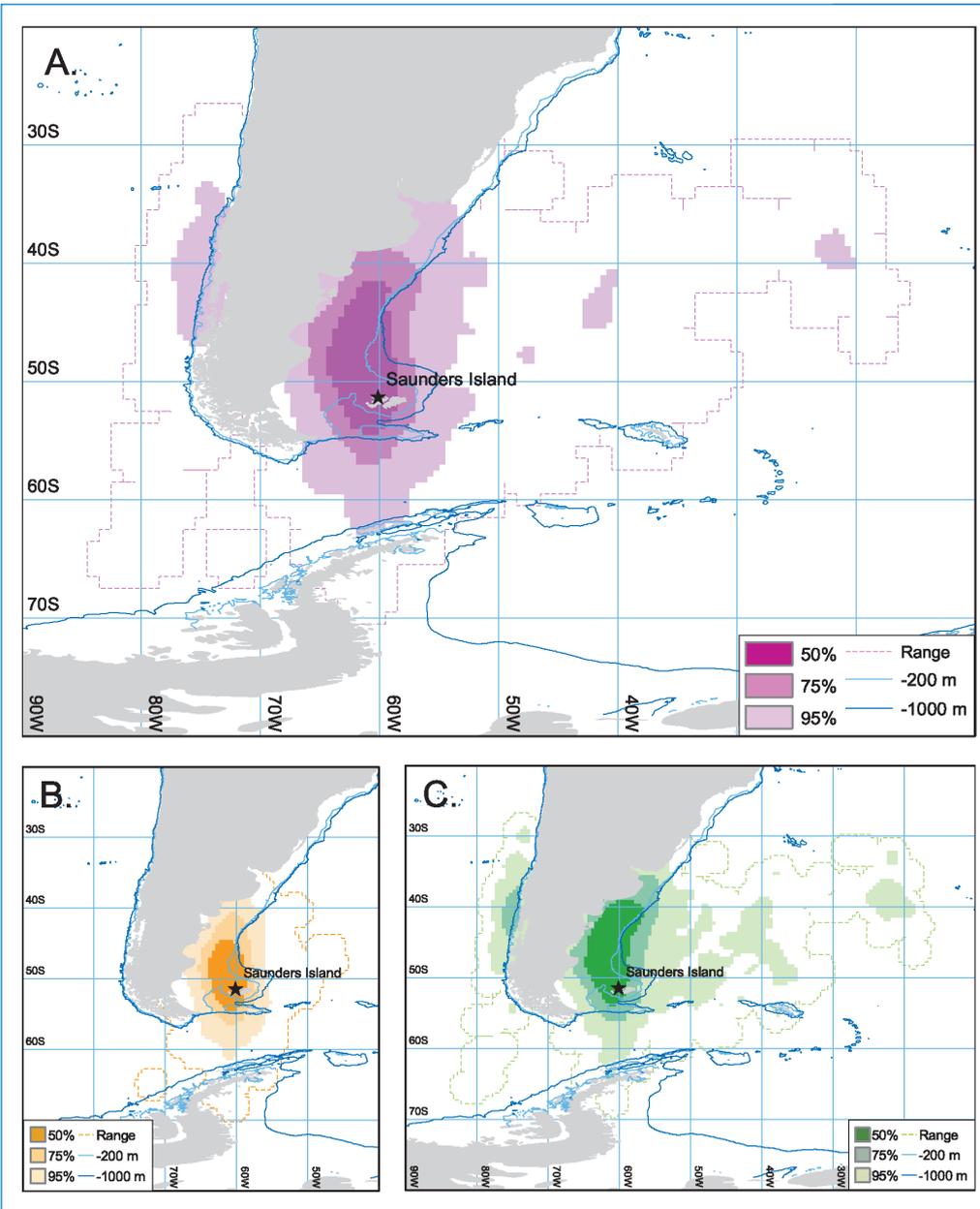
Figure 3.28. Utilisation distribution maps for Black-browed Albatrosses tracked from Saunders Island (Falklands Islands/Malvinas) during the non-breeding season. A. all birds (n=27 indivs); B. males only (n=16 indivs); C. females only (n=11 indivs).
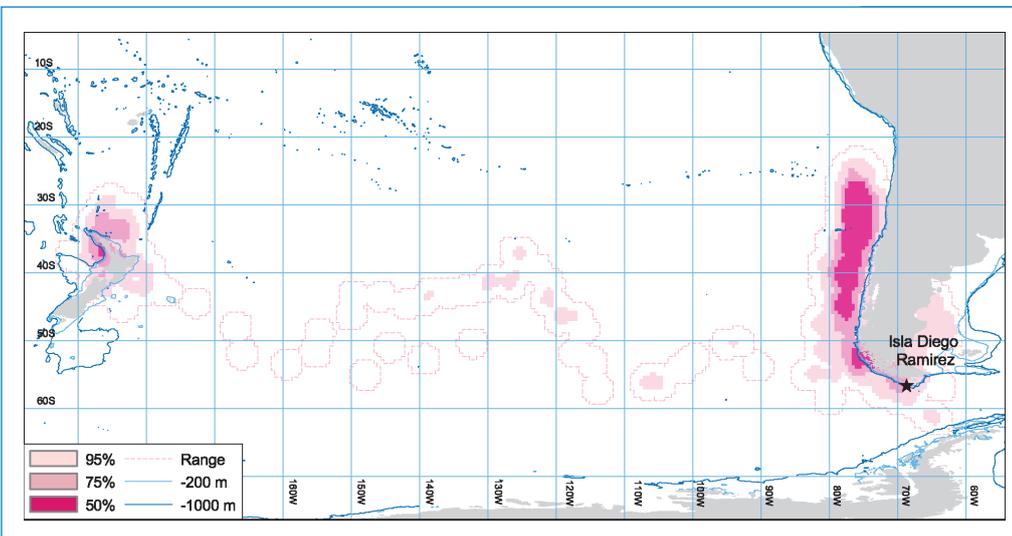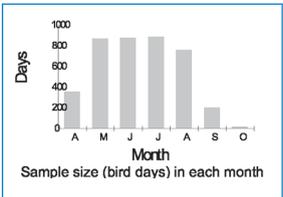
Figure 3.29. Utilisation distribution maps for Black-browed Albatrosses tracked from Diego Ramirez, Chile during the non-breeding season (n=5 indivs).
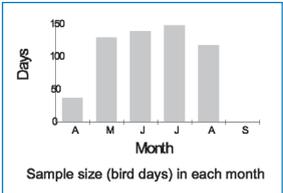
**Grey-headed Albatross *Thalassarche chrysostoma*
– South Georgia**

During the 18-month non-breeding period, Grey-headed Albatrosses have a circumpolar distribution mainly between 30°S and 60°S (Figure 3.30). Outside their foraging range in the south-west Atlantic while breeding (see Figure 3.12), they spent most time in core areas on the Patagonian Shelf and southern Indian Ocean (two areas in the west and one in the east), and tended to be more widely dispersed whilst in the Pacific Ocean. Although only the staging area in the south-west Indian Ocean (Figure 3.30) coincides with one of the primary tuna longline fishing grounds (Tuck *et al.* 2003), their migration routes traverse most of the key tuna fishing areas south of 30°S as well as others exploited for Patagonian Toothfish. Adequate protection of non-breeding Grey-headed Albatrosses would therefore require mitigation measures to be adopted in virtually all longline fisheries south of 30°S.

Richard Phillips, Janet Silk and John Croxall
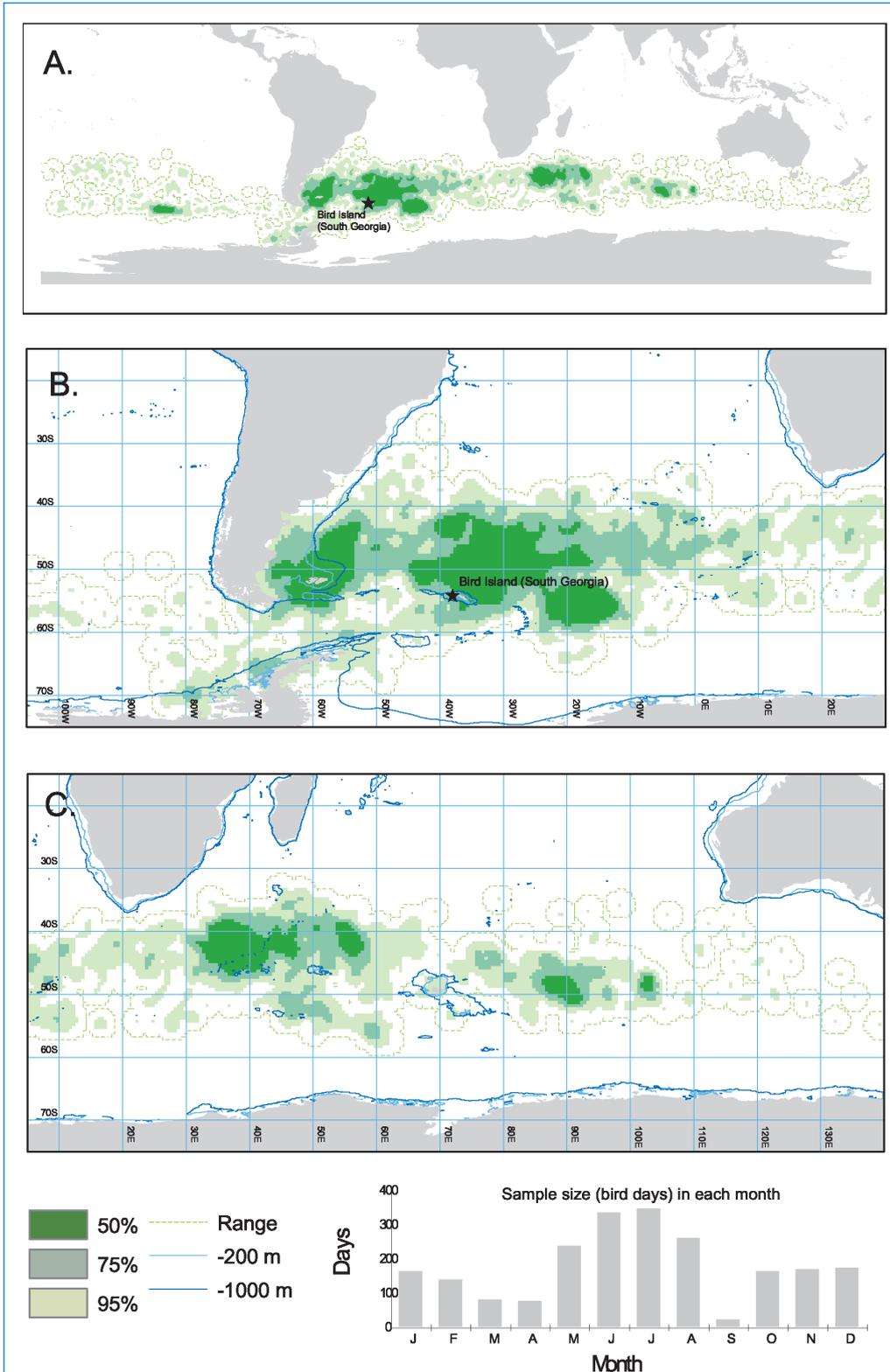
Figure 3.30. Utilisation distribution maps for Grey-headed Albatrosses (a biennial breeder) tracked from Bird Island, South Georgia in the 18 months between breeding attempts (n=6 indivs). A. Overall distribution; B. South Atlantic; C. Southern Indian Ocean.

4 REGIONAL SUMMARIES

4.1 SOUTH-WEST ATLANTIC AND SOUTHERN SOUTH AMERICA

4.1.1 Breeding

Composite distribution maps for the south-west Atlantic and South American sector illustrate very effectively the location of core areas of overlap in foraging ranges of the target albatrosses and petrels breeding in the region. Considering the maximum extent of foraging ranges (Figures 4.1A and 4.1B), breeding birds obviously travel over a vast area. Nevertheless, the 95% utilisation distributions (Figure 4.1C), illustrate that much of this habitat (particularly waters >1000m deep) is exploited only by single species. This is particularly apparent in the south-east Pacific, where the inclusion of chick-rearing tracks from the large Black-browed Albatross and small Southern Giant-petrel colonies in Chile (see Tables 4.1– 4.2) is unlikely to change the picture.

In terms of identifying key areas for the greatest number and diversity of threatened seabirds, all composite maps highlight more or less the same core regions, even though each was derived using different criteria. Interestingly, comparatively few sites appear to be important for multiple species (Figure 4.1D), perhaps reflecting the diversity of feeding strategies and high level of niche specialisation in albatrosses and petrels. However, here the lack of tracking data from populations of Southern Giant-petrels breeding in the Falkland Islands (Malvinas) and in the southern Scotia Sea (see Table 4.2) is unfortunate, as their inclusion would no

Table 4.1. PTT datasets included in the summary of breeding birds in the South-west Atlantic and South American region.

Site	Colony	Breeding stage	Year(s)	No. of hours	No. of indivs	No. of tracks	Contributor(s)
Black-browed Albatross							
Chile	Isla Diego de Almagro	incubation	2001	2,654	?	13	Graham Robertson
	Islas Diego Ramirez	incubation	1997–2001	10,103	?	62	Graham Robertson (97), Javier Arata (99–02)
		brood	1999–2001	5,367	?	32	
		early breeding	1997–1999	1,642	?	9	
		post guard	2001–2002	6,083	12	23	
	Islas Ildefonso	incubation	2001	5,014	?	26	Graham Robertson
Falkland Islands (Malvinas)	Beauchêne Island	incubation	2000	2,653	4	11	Nic Huin
		post guard	2000	3,397	4	48	
	Saunders Island	incubation	1998	2,759	7	22	
		post guard	1999	4,587	6	117	
South Georgia	Bird Island	incubation	1996	2,402	10	10	British Antarctic Survey
		chick	1993–1994	5,316	12	74	
		Total		**51,977**	**?**	**447**	
Grey-headed Albatross							
Chile	Islas Diego Ramirez	incubation	1997–2001	12,663	?	37	Graham Robertson (97), Javier Arata (99–02)
		brood	2000–2002	5,250	18	18	
		post guard	2001–2002	3,803	11	11	
	Islas Ildefonso	incubation	2001	572	1	1	Graham Robertson
South Georgia	Bird Island	incubation	1993–1995	953	4	5	British Antarctic Survey
		chick	1991–2001	24,264	35	239	
		Total		**47,505**	**?**	**311**	
Tristan Albatross							
Gough Island		incubation	2001	3,070	17	21	Richard Cuthbert
		brood guard	2001	1,017	9	28	
		post guard	2001	7,364	12	79	
		Total		**11,451**	**38**	**128**	
Wandering Albatross							
South Georgia	Bird Island	incubation	1991–2000	7,440	42	52	British Antarctic Survey
		chick	1990–2002	30,272	89	155	
		Total		**37,712**	**115**	**207**	
Northern Giant-petrel							
South Georgia	Bird Island	incubation	1998	3,921	18	18	British Antarctic Survey
		Total		**3,921**	**18**	**18**	
Southern Giant-petrel							
Argentina	Isla Arce	brood	2001–2002	4,014	5	5	Flavio Quintana
	Isla Gran Robredo	incubation	1999–2000	2,692	2	2	
		brood	2000	1,582	2	2	
South Georgia	Bird Island	incubation	1998–1999	3,352	11	11	British Antarctic Survey
		Total		**11,640**	**20**	**20**	
White-chinned Petrel							
South Georgia	Bird Island	incubation	1996–1997	1,074	4	4	British Antarctic Survey
		chick	1998	2,240	6	19	
		Total		**3,314**	**9**	**23**	

Figure 4.1. Regional summary of breeding albatrosses, giant-petrels and petrels in the South-west Atlantic and South American region.

A. Combined utilisation distribution map for 7 species of breeding albatross, giant-petrel and petrel tracked in the region of the South American continent. (See Table 4.1 for the list of species and datasets included). Each species has been given equal weighting.

B. Combined utilisation distribution map for the above 7 species of breeding albatross, giant-petrel and petrel, where each species has been weighted according to their IUCN threat status: Black-browed Albatross (E); Grey-headed Albatross (V); Northern Giant-petrel (NT); Southern Giant-petrel (V); Tristan Albatross (E); Wandering Albatross (V); White-chinned Petrel (V). The weights used were: NT (Near Threatened) = 1; V (Vulnerable) = 2; E (Endangered) = 3; CE (Critically Endangered) = 4.

C. Species density distribution map including the above 7 species. Only the range included in the 95% utilisation distribution of each species was used to calculate the number of species in each area.

D. Species density distribution map including the above 7 species. Only the range included in the 50% utilisation distribution of each species was used to calculate the number of species in each area.

**E.** Locations of colonies from which breeding birds were tracked.
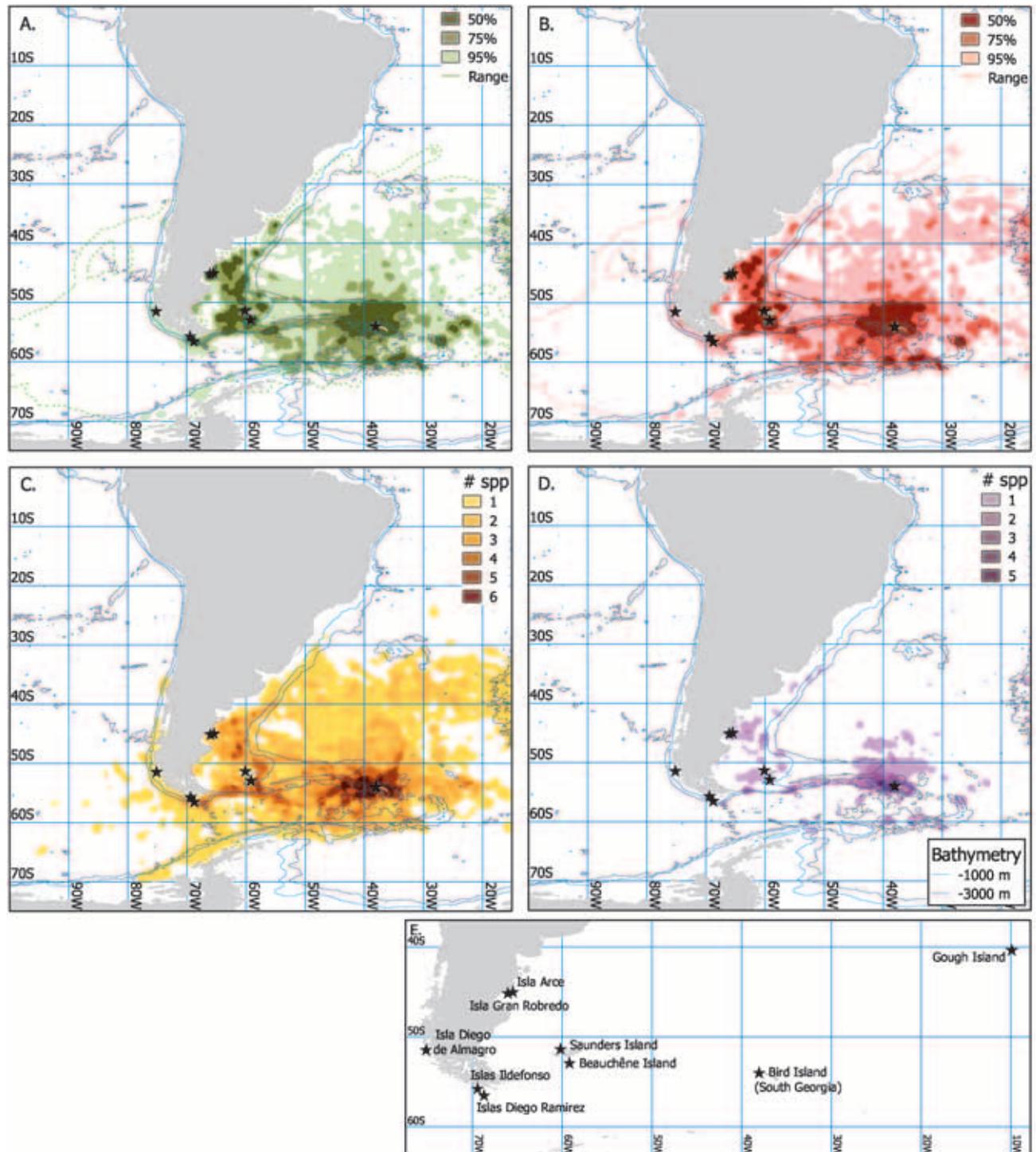
Table 4.2. Gap analysis of breeding PTT tracking data for the South-west Atlantic and South American region.

Species	Site	Annual no. breeding pairs	% regional population	PTT tracking data No. of hours	PTT tracking data No. of individuals	PTT tracking data No. of tracks	% tracking data (in hours)
Atlantic Yellow-nosed Albatross	Gough Island	7,500	23%				
	Tristan da Cunha Islands	25,750	77%				
Black-browed Albatross	Chile	122,870	16%	30,863	?	165	59%
	Falkland Islands (Malvinas)	548,584	71%	13,396	18	198	26%
	South Georgia	100,332	13%	7,718	21	84	15%
Grey-headed Albatross	Chile	16,408	21%	22,288	?	67	47%
	South Georgia	61,582	79%	25,217	36	244	53%
Light-mantled Albatross	South Georgia	6,250	100%				
Sooty Albatross	Gough Island	5,000	65%				
	Tristan da Cunha Islands	2,747	35%				
Tristan Albatross	Gough Island	798	100%	11,451	38	128	100%
	Tristan da Cunha Islands	3	0%				0%
Wandering Albatross	South Georgia	2,001	100%	37,712	115	207	100%
Northern Giant-petrel	South Georgia	4,310	100%	3,921	18	18	100%
Southern Giant-petrel	Antarctic Continent	290	1%				0%
	Argentina	1,350	6%	8,288	9	9	71%
	Chile	290	1%				0%
	Falkland Islands (Malvinas)	3,100	15%				0%
	Gough Island	50	0%				0%
	Palmer Station	6,500	31%				0%
	South Georgia	4,650	22%	3,352	11	11	29%
	South Orkney Islands	3,400	16%				0%
	South Sandwich Islands	1,550	7%				0%
White-chinned Petrel	Falkland Islands (Malvinas)	2,500	0%				0%
	South Georgia	2,000,000	100%	3,314	9	23	100%

doubt change the emphasis, resulting in more cores highlighted on the Patagonian Shelf and along the Scotia Arc.

The combined 50% utilisation distributions may help pinpoint the core sites (Figure 4.1D). Close to the huge seabird colonies at South Georgia, these are: (a) the shelf that surrounds the archipelago and extends westwards to Shag Rocks, exploited by most locally-breeding procellariiforms; (b) the somewhat deeper waters (1000–3000 m) between Shag Rocks and the Burdwood Bank along the North Scotia Ridge, utilised particularly by Wandering Albatrosses; (c) the Antarctic Polar Frontal Zone, which runs in an east-west axis to the north of South Georgia and (d) several areas of deep, sub-Antarctic waters at around c. 45–48°S, which are favoured feeding grounds of Black-browed, Grey-headed and Wandering Albatrosses.

Figure 4.1D also highlights the importance of several discrete patches of shelf habitat south of 55 ºS along the Scotia Arc, extending from the Antarctic Peninsula to the South Sandwich Islands. Of these, the more westerly areas tend to be exploited by albatrosses and the most north-easterly by both giant-petrel species from South Georgia. The addition of tracking data from Southern Giant-petrels from other sites would presumably further emphasise the importance of these shelf areas.

On the Patagonian Shelf there are clearly many hotspots located around the Falkland Islands (Malvinas), to the south-east at the Burdwood Bank, and to the east and north-east of Peninsula Valdez (see Sections 3.1.1 and 3.1.5). Despite being relatively inshore, several sites near to Peninsula Valdez are key areas not just for Black-browed Albatrosses from the Falkland Islands (Malvinas) and Southern Giant-petrels from Argentina, but also for White-chinned Petrels and female Northern Giant-petrels commuting during incubation from as far away as South Georgia. Similarly, other important sites on the shelf break relate to foraging White-chinned Petrels and Wandering Albatrosses from South Georgia.

Although not particularly apparent from Figure 4.1D, the small Chilean shelf is of considerable importance to local Black-browed Albatrosses. Finally, in the central South Atlantic, there are apparently several core areas on the mid-Atlantic Ridge utilised by Tristan Albatrosses. Coverage in this region, however, is rather poor, with no data available for the other three local target species; Southern Giant-petrel, Atlantic Yellow-nosed and Sooty Albatrosses (Table 4.2).

Although coverage was generally good, it should be noted that data were missing entirely for three species (Light-mantled, Sooty and Atlantic Yellow-nosed Albatrosses), for most breeding populations of Southern Giant-petrel, and for chick-rearing birds at several sites (Tables 4.1–4.2). The inclusion of additional information from these taxa would undoubtedly result in some changes of emphasis, and should therefore be a target for future research. However, many of the core areas highlighted here are dependent on bathymetry, or associated with relatively constant hydrodynamic or oceanographic features such as tidal or oceanic frontal systems where prey aggregations are to an extent predictable. As such, it is unlikely that these would alter a great deal from year to year, and there are clearly a number of candidate sites for marine IBA status. It is also important to note that tracking data from non-breeding birds indicates the existence of further areas on the Patagonian Shelf and on the west coast of South America that may be critical for species when wintering (see Section 4.1.2).

Richard Phillips, Javier Arata, Richard Cuthbert, Nic Huin, Flavio Quintana and Graham Robertson

4.1.2 Non-breeding (includes migrating failed breeders, post-breeders and non-breeders)

Maps of combined utilisation by 5 species of non-breeding albatrosses show two major areas of intensive use by those species, one extending along the Humboldt Current (7–50ºS) and from there westwards into the southeast Pacific (40–50ºS), the other over the Patagonian Shelf south of 35ºS (Figure 4.2). More localised patches of intensive use are also found around South Georgia and over oceanic waters to the north and north-west (38–48ºS). Similar patterns are obtained when weighting species equally or according to IUCN threat status.

Figure 4.2. Regional summary of non-breeding albatrosses in the South-west Atlantic and South American region.

A. Combined utilisation distribution map for 5 species of non-breeding albatross tracked in the region of the South American continent. (See Table 4.3 for the list of species and datasets included). Each species has been given equal weighting.

B. Combined utilisation distribution map for the above 5 species of non-breeding albatross, where each species has been weighted according to their IUCN threat status: Antipodean Albatross (V); Buller's Albatross (V); Chatham Albatross (CE); Northern Royal Albatross (E); Wandering Albatross (V). The weights used were: NT (Near Threatened) = 1; V (Vulnerable) = 2; E (Endangered) = 3; CE (Critically Endangered) = 4.

C. Species density distribution map including the above 5 species. Only the range included in the 95% utilisation distribution of each species was used to calculate the number of species in each area.

D. Species density distribution map including the above 5 species. Only the range included in the 50% utilisation distribution of each species was used to calculate the number of species in each area.

E. Locations of colonies from which non-breeding birds were tracked.


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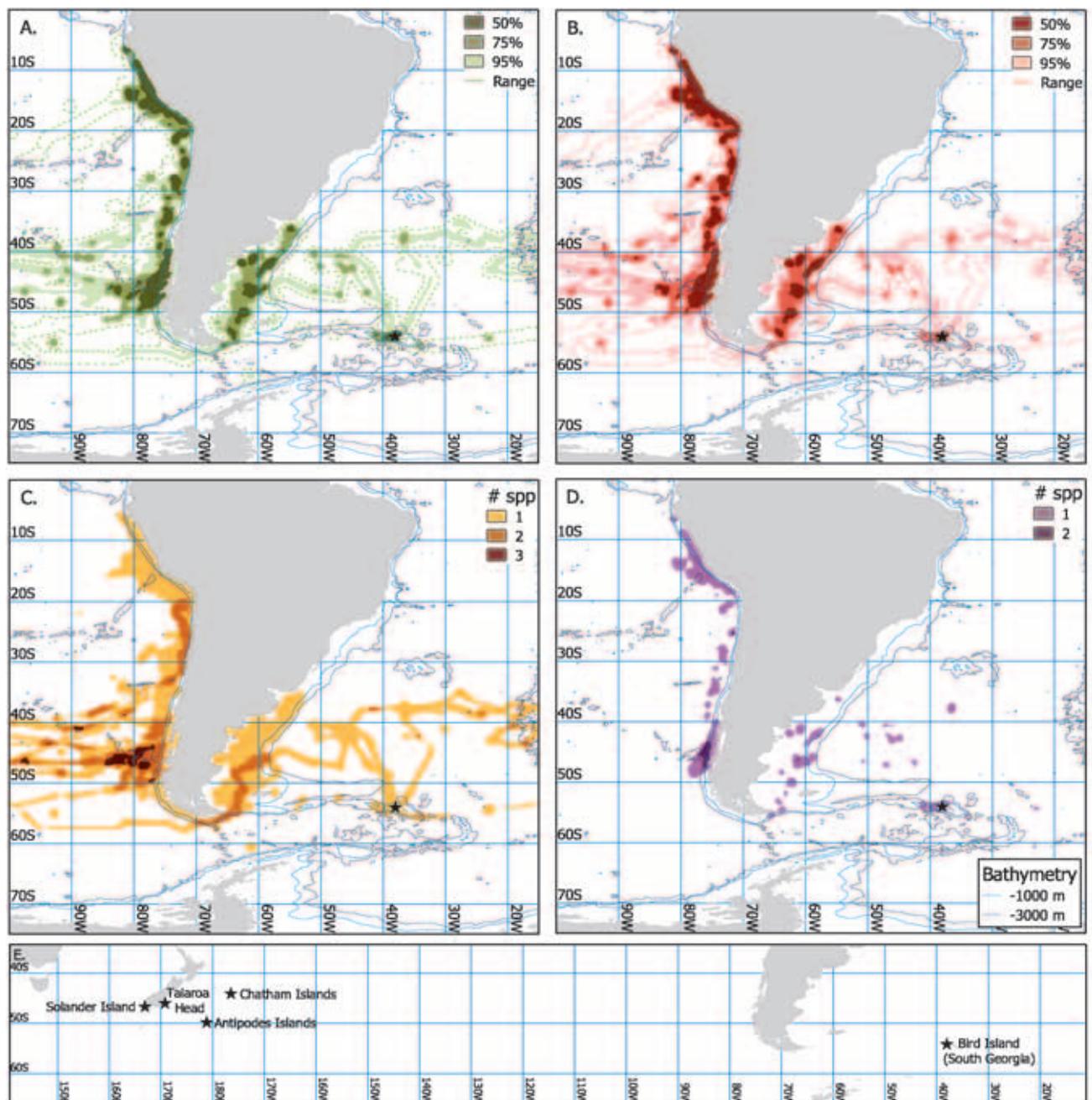
Table 4.3. PTT tracking datasets included in the summary of migratory non-breeding birds in the South-west Atlantic and South American region.

Site	Colony	Status	Year(s)	No. of hours	No. of indivs	No. of tracks	Contributor(s)
Antipodean Albatross							
Antipodes Islands		failed/migration	1996	1,009	1	1	David Nicholls
		non-breeding	1996	243	1	1	
		Total		**1,252**	**2**	**2**	
Buller's Albatross							
Solander Islands	North-West Headland	failed/migration	1997	982	2	2	Jean-Claude Stahl, Paul Sagar
		Total		**982**	**2**	**2**	
Chatham Albatross							
Chatham Islands	The Pyramid	failed/migration	1997–1999	11,149	8	8	Christopher Robertson, David Nicholls
		non-breeding	1998	570	1	1	
		Total		**11,719**	**9**	**9**	
Northern Royal Albatross							
Chatham Islands		failed/migration	1996–1998	2,225	4	6	Christopher Robertson, David Nicholls
New Zealand	Taiaroa Head	failed/migration	1998	3,671	1	1	
		non-breeding	1998	1,481	2	2	
		Total		**7,377**	**7**	**9**	
Wandering Albatross							
South Georgia	Bird Island	failed/migration	1992–1998	3,617	4	4	British Antarctic Survey
		Total		**3,617**	**4**	**4**	

Over the Humboldt Current and its south-western approaches, species density obtained from 95% utilisation distributions is highest in the south (40–50ºS, up to 3 species; mostly Antipodean, Northern Royal and Chatham Albatrosses), intermediate in the central region (20–40ºS, up to 2 species; mostly Chatham and Buller's Albatrosses), and low in the north (7–20ºS, Chatham Albatross only). All areas north of 40ºS are dominated by a single species when using 50% utilisation distributions, although this may merely reflect the limited number of Buller's Albatross locations, all of which were within 32–41ºS during the eastward migration (southeast Pacific) and 20–32ºS over the wintering area (Humboldt Current; Stahl and Sagar 2000a). Inclusion of Salvin's Albatross (abundant and widely distributed between 10–40ºS (Spear *et al.* 2003)) and Black-browed Albatross (abundant south of 40ºS during the non-breeding season (Jehl 1973)) would have presumably increased species density in all areas, but probably without altering the pattern of south to north decrease in species density.

Over the Patagonian Shelf and in the southwest Atlantic, areas of extensive use are mostly dominated by one species (Northern Royal and Wandering Albatross respectively); overlap between the 95% utilisation distributions of the two species over the southern Patagonian Shelf reflects the track of a Wandering Albatross commuting over that area. The distribution of Northern Royal Albatrosses over the Patagonian Shelf, however, largely overlaps that of non-breeding Black-browed Albatrosses from the Falkland Islands (Malvinas) (Grémillet *et al.* 2000), not included in the analysis.

Jean-Claude Stahl, Paul Sagar, John Croxall,
David Nicholls and Christopher Robertson

4.2 INDIAN OCEAN

4.2.1 Breeding

The combined utilisation distribution maps for all the species of albatrosses and petrels tracked in the Indian Ocean (Figure 4.3) show that the overall range covers the entire western part of the south Indian Ocean. The eastern part is almost unexploited, not even by albatrosses from Kerguelen and Amsterdam that have the potential range to go much further east than they actually do.

The 95% utilisation distribution shows that it is mainly the sub-tropical and sub-Antarctic waters that are exploited. The Antarctic waters are not regularly visited by albatrosses, only White-chinned Petrels foraging there in summer. The 50% utilisation distribution shows that birds mainly concentrate in the vicinity of the breeding grounds, but also in some sectors such as the seamounts between the Prince Edwards and Crozet islands, or the sub-tropical front areas north of Crozet. Weighting each species according to its conservation status leads to the same conclusions.

In terms of the species distribution maps, the Crozet sector appears as a hotspot but this is due to the fact that the most species have been tracked from this site. Hotspots for multi-site origin are the Tropical Convergence Zone north of Crozet where birds from different species come from Crozet, but also Amsterdam Island, Marion Island and the seamount zone between Marion and Crozet.

In terms of hotspots for populations and species in the Indian Ocean, several sectors can be identified. First the vicinity of islands, that generally encompass the large shelf and shelf-edge waters around the islands, is the major zone of concentration of species and individuals. However this is not only due to the presence of the shelves, since around Amsterdam and Marion Island the shelf extent is very limited, but also to the proximity of islands. However, some species are specialised in exploiting shelf edges, such as Black-browed Albatrosses throughout the breeding season, or Wandering Albatrosses and White-chinned Petrels during short trips in the chick-rearing period. The effect of the proximity of islands is partly due to the bias arising from the tracking of central place foragers whose density decreases with the distance from the breeding island. Other hotspots, not influenced by the close vicinity of islands, are apparent: seamounts, such as those between Marion and Crozet are possible areas of enhanced production, but also could be recent areas of illegal fishing for Patagonian Toothfish. A last hotspot, well known for its enhanced production, is the zone of the Subtropical Convergence north of Marion and Crozet where, in addition

Figure 4.3. Regional summary of breeding albatrosses and petrels in the southern Indian Ocean.

A. Combined utilisation distribution map for 7 species of breeding albatross and petrel tracked in the southern Indian Ocean. (See Table 4.4 for the list of species and datasets included). Each species has been given equal weighting.

B. Combined utilisation distribution map for the above 7 species of albatross and petrel, where each species has been weighted according to their IUCN threat status: Amsterdam Albatross (CE); Black-browed Albatross (E); Grey-headed Albatross (V); Sooty Albatross (E); Wandering Albatross (V); Indian Yellow-nosed Albatross (E); White-chinned Petrel (V). The weights used were: V (Vulnerable) = 2; E (Endangered) = 3; CE (Critically Endangered) = 4.

C. Species density distribution map including the above 7 species. Only the range included in the 95% utilisation distribution of each species was used to calculate the number of species in each area.

D. Species density distribution map including the above 7 species. Only the range included in the 50% utilisation distribution of each species was used to calculate the number of species in each area.

E. Locations of colonies from which breeding birds were tracked.
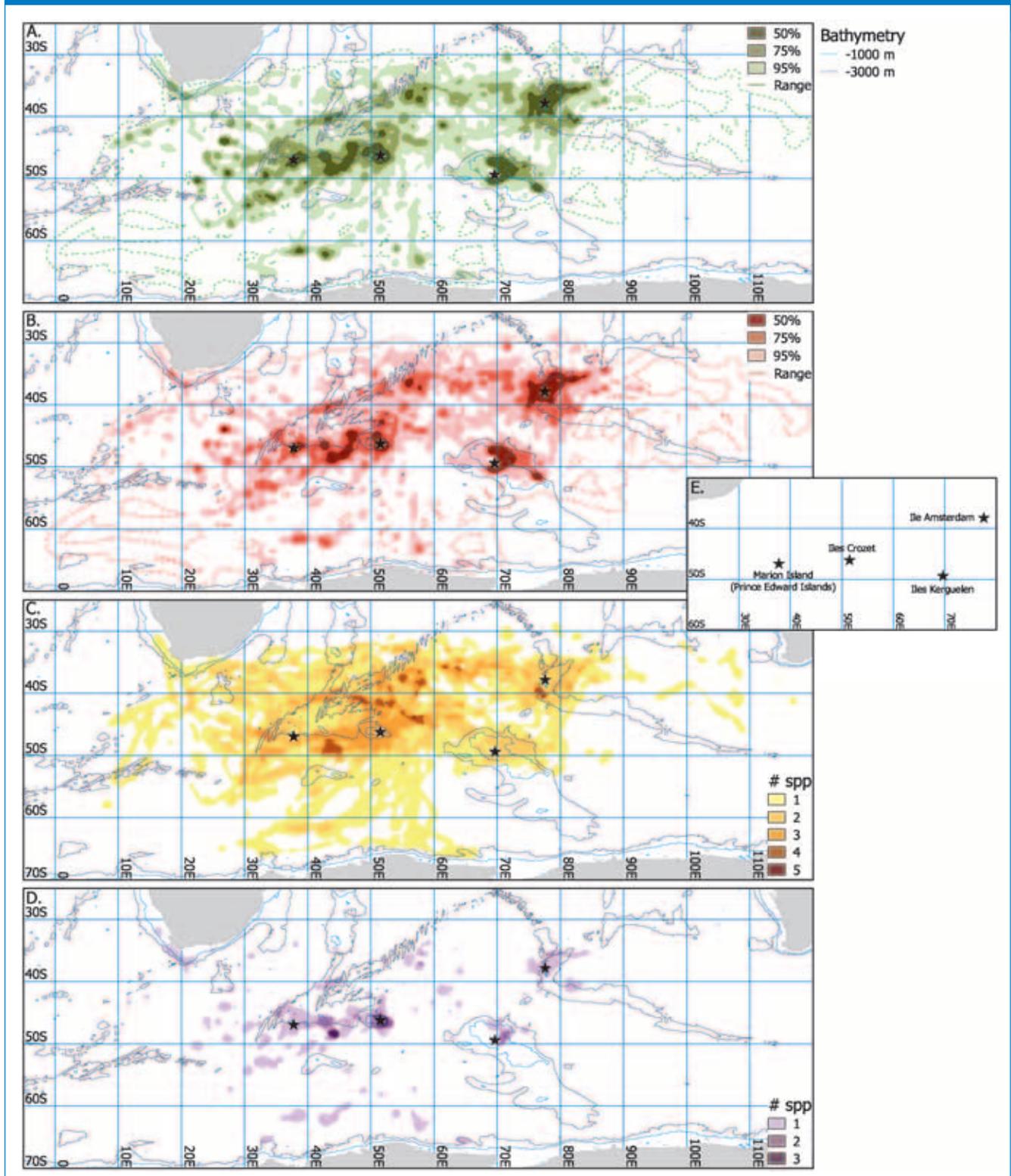
Table 4.4. PTT tracking datasets included in the regional summary of breeding birds in the Indian Ocean.

Site	Colony	Breeding stage	Year(s)	No. of hours	No. of indivs	No. of tracks	Contributor(s)
Amsterdam Albatross							
Ile Amsterdam		incubation	1996–2000	5,160	?	15	Henri Weimerskirch
		Total		**5,160**	**?**	**15**	
Black-browed Albatross							
Iles Kerguelen		incubation	1999	1,782	8	8	Henri Weimerskirch
		chick	1994–1995	5,896	?	18	
		Total		**7,678**	**?**	**26**	
Grey-headed Albatross							
Prince Edward Islands	Marion Island	incubation	1997	1,343	4	4	Deon Nel
		chick	1998	551	2	2	
		Total		**1,894**	**?**	**6**	
Sooty Albatross							
Iles Crozet		early breeding	1992–1995	8,194	?	26	Henri Weimerskirch
		Total		**8,194**	**?**	**26**	
Wandering Albatross							
Iles Crozet		incubation	1989–2001	38,011	?	157	Henri Weimerskirch
		chick	1990–1999	10,859	?	47	
Iles Kerguelen		chick	1998–1999	1,742	?	11	
Prince Edward Islands	Marion Island	incubation	1998	1,751	4	4	Deon Nel
		brood guard	1997	2,481	8	8	
		post guard	1997	3,910	8	8	
		Total		**58,754**	**?**	**235**	
Indian Yellow-nosed Albatross							
Ile Amsterdam		incubation	2000	4,229	?	9	Henri Weimerskirch
		chick	1995–2001	6,297	?	25	
		Total		**10,526**	**?**	**34**	
White-chinned Petrel							
Iles Crozet		incubation	1996	2,350	?	9	Henri Weimerskirch
		chick	1997	2,255	7	7	
		Total		**4,605**	**?**	**16**	

Table 4.5. Gap analysis of breeding PTT tracking data for the southern Indian Ocean.

Species	Site	Annual no. breeding pairs	% regional population	PTT tracking data No. of hours	No. of individuals	No. of tracks	% tracking data (in hours)
Amsterdam Albatross	Ile Amsterdam	17	100%	5,160	?	15	100%
Black-browed Albatross	Iles Crozet	880	17%				0%
	Iles Kerguelen	4,270	83%	7,678	?	26	100%
Grey-headed Albatross	Iles Crozet	5,940	28%				0%
	Iles Kerguelen	7,905	37%				0%
	Prince Edward Islands	7,717	36%	1,894	?	6	100%
Indian Yellow-nosed Albatross	Ile Amsterdam	25,000	70%	10,526	?	34	100%
	Iles Crozet	4,430	12%				0%
	Iles Kerguelen	50	0%				0%
	Prince Edward Islands	6,000	17%				0%
Light-mantled Albatross	Iles Crozet	2,421	36%				
	Iles Kerguelen	4,000	60%				
	Prince Edward Islands	241	4%				
Salvin's Albatross	Iles Crozet	4	100%				
Sooty Albatross	Ile Amsterdam	350	7%				0%
	Iles Crozet	2,248	42%	8,194	?	26	100%
	Iles Kerguelen	4	0%				0%
	Prince Edward Islands	2,755	51%				0%
Wandering Albatross	Iles Crozet	2,062	35%	48,870	?	204	83%
	Iles Kerguelen	1,094	19%	1,742	?	11	3%
	Prince Edward Islands	2,707	46%	8,142	17	20	14%
Northern Giant-petrel	Iles Crozet	1,060	35%				
	Iles Kerguelen	1,400	47%				
	Prince Edward Islands	540	18%				
Southern Giant-petrel	Iles Crozet	1,060	37%				
	Iles Kerguelen	4	0%				
	Prince Edward Islands	1,790	63%				
White-chinned Petrel	Iles Crozet	50,000	?%	4,605	?	16	100%
	Iles Kerguelen	200,000	?%				0%
	Prince Edward Islands	?	?%				0%

to the convergence, a succession of semi-permanent eddies occur as a result of the retroflection of the Agulhas Current meeting the Southern Ocean wind-driven westerly current.

Although the number of species studied in the zone is relatively high, it must be noted that one species, the Wandering Albatross is over-represented in terms of the number of individuals tracked (three sites (Marion, Crozet and Kerguelen) and over 11 seasons for some sites (e.g. Crozet)). Otherwise, no species has been tracked at more than one site. It will be of great interest to see whether different populations of other species forage in the same sectors, for example Grey-headed Albatrosses from Crozet and Kerguelen, or Yellow-nosed Albatrosses from Prince Edward or Crozet. Every species of resident albatross has been tracked at least from one site in the Indian Ocean, but some species only in limited numbers, such as the two *Phoebetria* species from Crozet. On the other hand, giant-petrels have not been tracked in the Indian Ocean, and this is a future requirement, in view of the relatively small size of the populations, and relatively high susceptibility to longline fisheries in the sector. The species most threatened locally by toothfish longline fisheries,

White-chinned Petrels and Grey Petrels, should be a major focus for future tracking studies. Only White-chinned Petrels have been tracked at the Crozet Islands showing that, while breeding, they are in contact with fisheries off South Africa, with subtropical oceanic fisheries, as well as neritic fisheries for toothfish. The tracking of White-chinned and Grey Petrels from Kerguelen would be important since it is around this island that a major legal longline fishery, killing substantial numbers of both species, is still operating.

Henri Weimerskirch and Deon Nel

4.3 AUSTRALASIA

4.3.1 Breeding

Maps of combined utilisation by 9 species of breeding albatrosses highlight the importance of the vicinity of breeding grounds as major foraging areas for breeding birds in this region (Figure 4.4). Thus areas of intensive use

Figure 4.4. Regional summary of breeding albatrosses around New Zealand and Australia.
A. Combined utilisation distribution map for 9 species of breeding albatross tracked in the region of New Zealand and the Australian continent. (See Table 4.6 for the list of species and datasets included). Each species has been given equal weighting.
B. Combined utilisation distribution map for the above 9 species of breeding albatross, where each species has been weighted according to their IUCN threat status: Antipodean (Gibson's) Albatross (V); Black-browed Albatross (E); Buller's Albatross (V); Chatham Albatross (CE); Grey-headed Albatross (V); Light-mantled Albatross (NT); Northern Royal Albatross (E); Southern Royal Albatross (V); Shy Albatross (NT). The weights used were: NT (Near Threatened) = 1; V (Vulnerable) = 2; E (Endangered) = 3; CE (Critically Endangered) = 4.
C. Species density distribution map including the above 9 species. Only the range included in the 95% utilisation distribution of each species was used to calculate the number of species in each area.
D. Species density distribution map including the above 9 species. Only the range included in the 50% utilisation distribution of each species was used to calculate the number of species in each area.
E. Locations of colonies from which breeding birds were tracked.
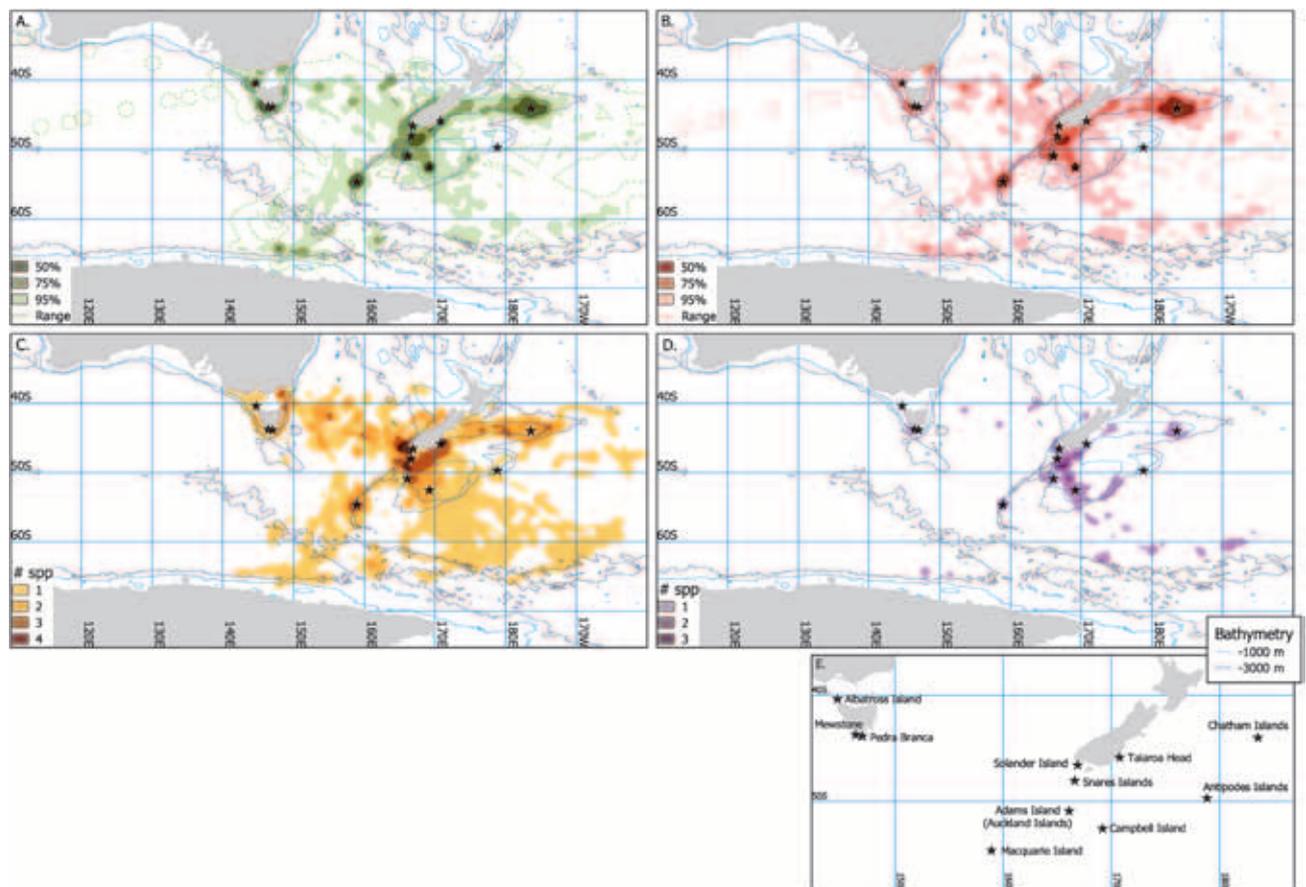
surround the breeding localities of most of the tracked birds, including Albatross Island, Mewstone and Pedra Branca off Tasmania (Shy Albatross), Macquarie (Black-browed, Grey-headed and Light-mantled Albatrosses), Campbell (Southern Royal, Grey-headed Albatrosses), Auckland (Antipodean (Gibson's) Albatross), Snares (Buller's Albatross) and Chatham Islands (Northern Royal and Chatham Albatrosses) in the New Zealand region (Brothers *et al.* 1998, Robertson and Nichols 2000, Stahl and Sagar 2000a and b, Hedd *et al.* 2001, Nichols *et al.*

2002, Waugh *et al.* 2002, Robertson, C. *et al.* 2003b, R. Gales unpublished data). Beyond those foraging zones, areas of most intensive use are located over shelf and slope areas around the South Island of New Zealand (Antipodean (Gibson's), Northern Royal, Southern Royal, and Buller's Albatrosses) and over the Chatham Rise (Northern Royal and Chatham Albatrosses). Over oceanic waters, areas of most intensive use are located over subtropical waters of the Tasman Sea between 40–46ºS (Antipodean (Gibson's) and Buller's Albatrosses), over the

Table 4.6. PTT tracking datasets included in the summary of breeding birds in the Australasian region.							
Site	Colony	Breeding stage	Year(s)	No. of hours	No. of indivs	No. of tracks	Contributor(s)
Antipodean (Gibson's) Albatross							
Auckland Islands	Adams Island	incubation	1994	1,345	2	2	David Nicholls
		guard	1994	366	1	1	
		Total		**1,711**	**3**	**3**	
Black-browed Albatross							
Macquarie Island		incubation	1999–2001	3,525	6	6	Alex Terauds, Rosemary Gales
		brood guard	2000	431	1	1	
		Total		**3,956**	**6**	**7**	
Buller's Albatross							
Solander Islands	North-West Headland	incubation	1997	2,711	6	11	Jean-Claude Stahl, Paul Sagar
		guard	1997	971	3	18	
		post guard	1997	3,796	5	20	
Snares Islands	Mollymawk Bay	pre-egg	2001–2002	1,575	2	16	
		incubation	1995–2002	5,575	18	22	
		guard	1996	1,859	5	29	
		post guard	1996	6,004	6	31	
	Punui Bay	pre-egg	2001–2002	1,050	2	16	
		incubation	1999–2002	1,768	5	8	
		guard	1999	420	4	11	
		post guard	1999	2,042	4	9	
	Razorback	incubation	1999	1,029	4	4	
		guard	1999	753	4	25	
		post guard	1999	540	3	4	
	Unknown	incubation	1995	1,448	5	5	Henri Weimerskirch
		Total		**31,541**	**47**	**229**	
Chatham Albatross							
Chatham Islands	The Pyramid	chick	1997–1999	8,136	9	16	Christopher Robertson, David Nicholls
		Total		**8,136**	**9**	**16**	
Grey-headed Albatross							
Campbell Island		chick	1997	1,271	5	5	Henri Weimerskirch
Macquarie Island		incubation	1999–2001	2,777	5	6	Alex Terauds, Rosemary Gales
		brood guard	1999–2000	1,236	3	3	
		Total		**5,284**	**13**	**14**	
Light-mantled Albatross							
Macquarie Island	Bauer Bay	incubation	2002–2003	1,224	3	3	Rosemary Gales
		brood guard	2002–2003	493	2	2	
	Hurd Point	incubation	2002–2003	1,207	3	3	
		brood guard	2002–2003	738	2	2	
		Total		**3,662**	**7**	**10**	
Northern Royal Albatross							
Chatham Islands		early breeding	1994–1996	6,370	13	28	Christopher Robertson, David Nicholls
New Zealand	Taiaroa Head	early breeding	1993–1998	885	3	3	
		Total		**7,255**	**16**	**31**	
Southern Royal Albatross							
Campbell Island	Campbell Island	incubation	1999	2,973	7	7	Henri Weimerskirch
		Total		**2,973**	**7**	**7**	
Shy Albatross							
Tasmania	Albatross Island	incubation	1993–1996	10,751	?	41	Rosemary Gales
		brood guard	1997	1,371	2	2	
		post guard	1994–1995	4,094	?	15	
	Mewstone	incubation	1997–1998	2,521	2	2	
	Pedra Branca	incubation	1997	2,906	4	4	
		Total		**21,643**	**?**	**64**	

Table 4.7. Gap analysis of breeding PTT tracking data for the Australasian region.

Species	Site	Annual no. breeding pairs	% regional population	PTT tracking data No. of hours	No. of individuals	No. of tracks	% tracking data (in hours)
Antipodean Albatross	Antipodes Islands	5,148	100%				
	Campbell Island	6	0%				
Antipodean (Gibson's) Albatross	Auckland Islands	7,319	100%	1,711	3	3	100%
Black-browed Albatross	Antipodes Islands	115	37%				0%
	Campbell Island	16	5%				0%
	Macquarie Island	182	58%	3,956	6	7	100%
	Snares Islands	1	0%				0%
Buller's Albatross	Chatham Islands	18,150	58%				0%
	Three Kings	20	0%				0%
	Snares Islands	8,465	27%	24,063	37	180	76%
	Solander Islands	4,800	15%	7,478	10	49	24%
Campbell Albatross	Campbell Island	26,000	100%				
Chatham Albatross	Chatham Islands	4,000	100%	8,136	9	16	100%
Grey-headed Albatross	Campbell Island	6,400	99%	1,271	5	5	24%
	Macquarie Island	84	1%	4,013	6	9	76%
Light-mantled Albatross	Antipodes Islands	169	2%				0%
	Auckland Islands	5,000	57%				0%
	Campbell Island	1,600	18%				0%
	Macquarie Island	2,000	23%	3,662	7	10	100%
Northern Royal Albatross	Chatham Islands	2,060	99%	6,370	13	28	88%
	Taiaroa Head	18	1%	885	3	3	12%
Salvin's Albatross	Bounty Islands	76,352	99%				
	Snares Islands	587	1%				
Shy Albatross	Antipodes Islands	18	0%				0%
	Auckland Islands	72,233	85%				0%
	Chatham Islands	1	0%				0%
	Tasmania	12,250	14%	21,643	?	64	100%
Southern Royal Albatross	Auckland Islands	72	1%				0%
	Campbell Island	7,800	99%	2,973	7	7	100%
Wandering Albatross	Macquarie Island	10	100%				
Northern Giant-petrel	Antipodes Islands	300	8%				
	Auckland Islands	100	3%				
	Campbell Island	240	6%				
	Chatham Islands	2,150	55%				
	Macquarie Island	1,110	28%				
Southern Giant-petrel	Macquarie Island	2,300	100%				
White-chinned Petrel	Antipodes Islands	50,000	?%				
	Auckland Islands	50,000	?%				
	Campbell Island	?	?%				
	Macquarie Island	?	?%				

Polar Frontal Zone and Antarctic waters (60–67ºS) from 145ºE to 165ºW (Grey-headed and Light-mantled Albatrosses), and sub-Antarctic and Antarctic waters southwest of Macquarie (Light-mantled Albatross) and south-east of Campbell (Grey-headed Albatross). Similar patterns are obtained when weighting species equally or according to IUCN threat status.

Species density obtained from 95% utilisation distributions was highest south and south-east of New Zealand (up to four species, see above), over the central Chatham Rise, around Macquarie and in the western Tasman Sea west to Bass Strait (up to three species). Species overlaps of 50% utilisation contours were mostly confined south and south-east of New Zealand (up to three species), and around Campbell and Macquarie (up to two species).

Jean-Claude Stahl, Paul Sagar, Rosemary Gales,
David Nicholls, Christopher Robertson, Alex Terauds
and Henri Weimerskirch

4.3.2 Non-breeding (includes non-breeding adults and immatures, and migrating and resident failed and post-breeders)

Maps of combined utilisation by non-breeders of 7 albatross species (Figure 4.5) reveal a more diffuse distribution pattern than that of breeding birds, albeit partly derived from foraging locations of central-foraging birds (colony attending prebreeders, adult non-breeders and failed breeders). Areas of most intensive use also tended to be more concentrated over shelf and slope areas than in breeders (except in the western Tasman Sea), and located in more northerly waters, although both possibly reflecting differences in species composition among foraging locations obtained for breeders and non-breeders.

Off Australia, areas of most extensive use are located over shelf and slope areas south of Australia from Cape Leeuwin to Bass Strait (migrating Wandering, Northern Royal and Shy Albatrosses, over-wintering Shy Albatrosses),

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