AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS
Aquatic Conserv: Mar. Freshw. Ecosyst. **16**: 133–146 (2006)
Published online 1 August 2005 in Wiley InterScience
(www.interscience.wiley.com). DOI: 10.1002/aqc.709

Foraging areas of black-browed and grey-headed albatrosses breeding on Macquarie Island in relation to marine protected areas

ALEKS TERAUDS[a,b,*], ROSEMARY GALES[b], G. BARRY BAKER[c] and RACHAEL ALDERMAN[b]
[a] *University of Tasmania, Churchill Avenue, Sandy Bay, Tasmania, 7005, Australia*
[b] *Nature Conservation Branch, Department of Primary Industries, Water and Environment, PO Box 44, Hobart, Tasmania 7000, Australia*
[c] *Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia*

ABSTRACT

1. Although marine protected areas (MPAs) are often established to protect threatened top-order predators, there is a paucity of data that can be used to evaluate their efficacy in achieving this purpose.
2. We assessed the effectiveness of a network of MPAs around Macquarie Island in the Southern Ocean by examining the foraging areas of breeding black-browed *Thalassarche melanophrys* and grey-headed albatrosses *T. chrysostoma*.
3. During late incubation and brood periods over 90% of time spent foraging by black-browed albatrosses was contained within MPAs, principally the Economic Exclusion Zone (EEZ) around Macquarie Island. In contrast, grey-headed albatrosses spent only 34% of their time foraging in MPAs.
4. Black-browed and grey-headed albatrosses spent 30% and 15% of their respective foraging times in the Marine Park around Macquarie Island.
5. Both black-browed and grey-headed albatrosses foraged in Antarctic waters under the jurisdiction of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), accounting for 5% and 12% of the total foraging times respectively.
6. The spatial extent of MPAs around Macquarie Island appear to adequately cover much of the foraging distribution of breeding black-browed albatrosses from Macquarie Island.
7. Breeding grey-headed albatrosses spend significantly more time in waters outside the spatial extent of the surrounding MPAs and are at higher risk from fisheries activities and other threats.
8. Further information on the foraging movements both of albatrosses outside the breeding season and of juvenile albatrosses is required to more fully assess the efficacy of MPAs in protecting foraging habitats of these species.

KEY WORDS: black-browed albatrosses; grey-headed albatrosses; marine protected areas; Macquarie Island

*Correspondence to: A. Terauds, Nature Conservation Branch, Dept. of Primary Industries, Water and Environment, PO Box 44, Hobart, Tasmania 7000, Australia. E-mail: Aleks.Terauds@dpiwe.tas.gov.au.

Received 7 July 2004
Accepted 18 March 2005

INTRODUCTION

Although establishment of a system of reserves and protected areas has been an important mechanism for the conservation of terrestrial ecosystems for over a century, application of the same principle to marine ecosystems has been a relatively recent phenomenon. Reasons for the delay in establishing marine protected areas (MPAs) include conflict between the needs of resource use and conservation, incomplete biophysical information, the reluctance of managers to embrace the concepts of multiple-use in any system of marine reserves and difficulties in declaring them on the high seas where there is no national jurisdiction. As a result, marine protected areas have often been seen as measures of last resort to protect highly threatened species or areas of great beauty (Kelleher and Reccia, 1998; Hyrenbach *et al*., 2000), rather than having a more utilitarian role in maintaining ecosystem function.

Related to the difficulty of establishing MPAs is the paucity of data quantifying their effectiveness. This applies both with respect to their efficacy in conserving marine biodiversity in general, and top-order marine predators in particular. Because top-order predators have been considered to be surrogates of ecosystem function (Croxall *et al*., 1999; Croxall and Wood, 2002; Field *et al*., 2004), and are often more easily studied, it is surprising that data from studies of these taxa have not been more widely applied to assess MPA effectiveness. The application of data from the recent proliferation of satellite-tracking studies of marine mammals and birds (for example, Waugh *et al*., 1999; Nel *et al*., 2001; Huin, 2002; Robinson *et al*., 2002) provides an opportunity for determining the foraging ranges of many top-order predators and thus assessing whether their needs are adequately met by MPAs. These data may also be used to determine the overlap of such species with other marine resources and extractive operations such as fisheries and mineral exploration, providing critical information of particular value in a multiple-use environment (Croxall and Wood, 2002; Hindell *et al*., 2003; BirdLife International, 2004).

Macquarie Island is a small isolated subantarctic island situated in the Southern Ocean. The island is an important breeding site for four species of albatrosses, all of which are considered to be threatened by interactions with fishing vessels (Gales, 1993, 1998; de la Mare and Kerry, 1994). Three of these species (wandering albatross, *Diomedea exulans*, black-browed albatross *Thalassarche melanophrys*, and grey-headed albatross *T. chrysostoma*) are particularly at risk owing to the small size of the breeding populations on Macquarie Island (<100 pairs annually).

Longline tuna fisheries have been identified as the main source of albatross mortality and the distribution of these fleets was widespread throughout temperate latitudes of the southern hemisphere during the 1970s and 1980s (Tuck *et al*., 2003). The potential scale of the impact of tuna longline fisheries on albatrosses was highlighted by the work of Brothers (1991), and subsequent studies confirmed the extent and nature of the interactions (Murray *et al*., 1993; Klaer and Polacheck, 1995, 1997; Gales *et al*., 1998; Brothers *et al*., 1999). In two comprehensive reviews of the conservation status and threats of albatross populations worldwide, Gales (1993, 1998) described longline fishing as the most serious threat to the survival of albatross populations. The relatively recent advent of a large-scale fishery for Patagonian toothfish (*Dissostichus eleginoides*) in Southern Ocean waters also presents a significant threat to albatrosses foraging in these areas (Cherel *et al*., 1996; Croxall and Prince, 1996; Nel *et al*., 2002).

Macquarie Island is adjacent to a network of MPAs that may be of great significance for the albatrosses breeding there. These MPAs include Australia's 200-nautical-mile Economic Exclusion Zone (EEZ) that surrounds both Macquarie Island and the Australian continent (included because it conforms with the broad definition of an MPA adopted by the International Union for the Conservation of Nature; see Materials and Methods), the Macquarie Island Marine Park, and the waters surrounding the Antarctic continent under the jurisdiction of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). One of these MPAs, the Macquarie Island Marine Park,

was established expressly to protect top-order predators, including albatrosses (Environment Australia, 2001).

This study quantifies the amount of time that black-browed and grey-headed albatrosses breeding on Macquarie Island spent in MPAs. Because the zoning of the Macquarie Island Marine Park includes a multiple use category that permits a commercial Patagonian toothfish fishery, we also examine the overlap between albatross foraging areas and the spatial distribution of fishing effort in the fishery. Ongoing consideration of seabird distribution in relation to fisheries activity is fundamental to the maintenance of effective management regimes designed to mitigate against bycatch. Such assessments are now routinely carried out in some major fishery management regimes (SC-CAMLR-XX11, 2003) and presentation of fine-scale information on seabird foraging activities forms a critical part of this process.

MATERIALS AND METHODS

Species and study site

Macquarie Island (54° 30′S and 158° 55′E) is a small isolated subantarctic island situated approximately 1500 km south of Australia (Figure 1). It is a Nature Reserve (including surrounding waters to 3 nm from the coast), an International Biosphere Reserve and a World Heritage Site (including waters to 12 nm from the coast). The foraging distributions of two of the four species of albatrosses that breed on the island, black-browed albatrosses and grey-headed albatrosses, were determined via satellite telemetry during the breeding season. The breeding populations of both these species on Macquarie Island are small (<100 pairs annually), and breeding occurs in the austral spring and summer. Black-browed and grey-headed

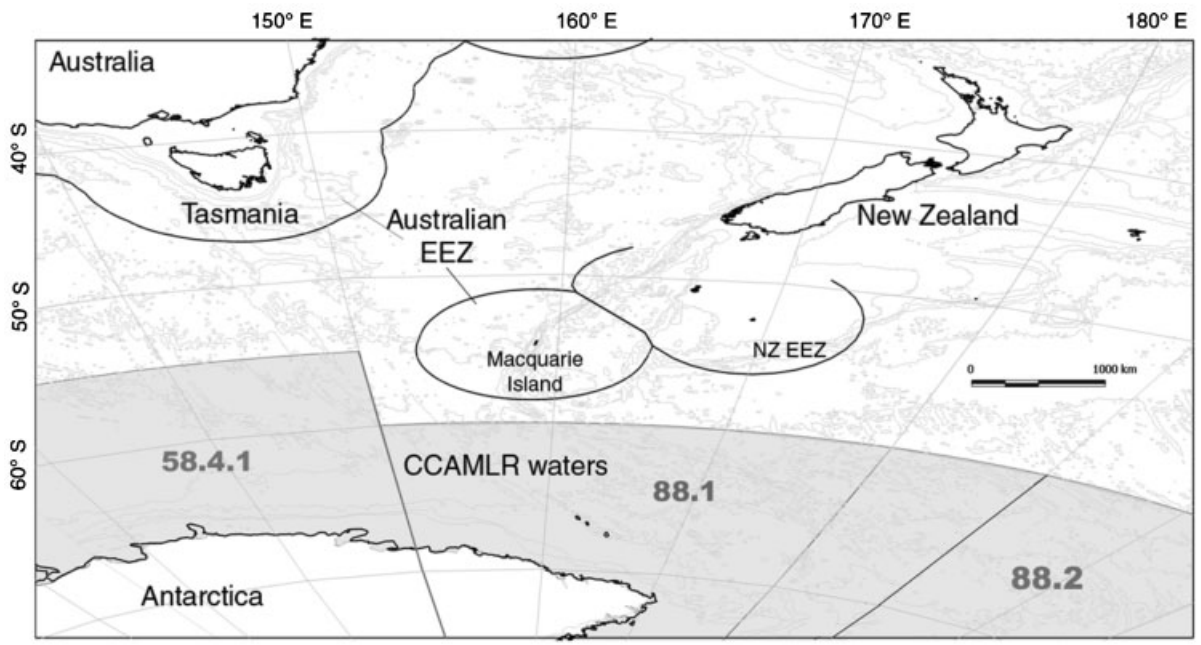

Figure 1. Location of the Australian EEZ, New Zealand EEZ and CCAMLR statistical sub-areas (grey shaded) within foraging ranges of black-browed and grey-headed albatrosses from Macquarie Island. Depth contours are 1000-m isobaths.

albatrosses on Macquarie Island lay their eggs from late September and October; chicks hatch in December and January and fledge in April and May.

Marine zones and risk prescriptions

In describing areas adjacent to Macquarie Island as MPAs we have used the broad definition adopted by the International Union for the Conservation of Nature (Anon., 1994):

> *Any area of intertidal or subtidal terrain, together with its overlying waters and associated flora, fauna, historical and cultural features which have been reserved by legislation or other effective means to protect part or all of the enclosed environment.*

Economic Exclusion Zones (EEZs)

Australia exercises a 200-nautical-mile Economic Exclusion Zone (EEZ) surrounding both Macquarie Island and the Australian continent (Figure 1). The Australian EEZ possesses the characteristics of an IUCN Category IV or VI Protected Area (Anon., 1994) by virtue of strict conservation measures prescribed by the Australian government to minimize the impact of longline fishing practices on seabirds, the key threat that albatrosses face at sea (Anon., 1998). As a result of these measures the bycatch of albatrosses has been reduced to low levels in all Australian longline fisheries (Australian Fisheries Management Authority; unpublished data). The waters within 3 nmi of the coast are managed by the state governments and on Macquarie Island no fishing is permitted within this zone.

Macquarie Island Marine Park (Environment Australia, 2001)

The Macquarie Island Marine Park is an MPA of approximately 16 million hectares embedded within the Macquarie Island Australian EEZ (Figure 2). The Marine Park is divided into three zones: a central Highly Protected Zone (HPZ, Figure 2, assigned to IUCN category Ia) and two Habitat/Species Management Zones (HSMZ, Figure 2, IUCN category IV) either side of the HPZ.

The HPZ was established to protect threatened species and migratory and foraging animals from direct human disturbance; accordingly commercial or recreational fishing, mining operations and commercial tourism activities are all prohibited in this zone. The management goals for the HSMZs permit commercial fishing. A single trawl vessel has fished in these waters in most years since 1996 under a fishing licence that imposes strict environmental conditions (AFMA, 2003). In addition, limited commercial tourism and scientific research that is compatible with the strategic objectives of the Marine Park also allowed in the HSMZs (Environment Australia, 2001).

Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

CCAMLR came into force in 1982. The agreement forms part of the Antarctic Treaty System. The area of application of the Convention includes the waters of the Southern Ocean that extend south of an approximation of the northern extent of the Antarctic Convergence (varies from latitude 45° to 60°S). CCAMLR waters possess the characteristics of an IUCN Category IV or VI protected area because the Convention has established formal measures to mitigate the incidental mortality of seabirds from fishing. These measures have virtually eliminated bycatch of albatrosses in regulated longline fisheries in the Convention area (SC-CAMLR-XXll, 2003).

Deployment of satellite tracking units

Six breeding black-browed albatrosses and seven grey-headed albatrosses were tracked between 1999 and 2002 using Microwave Telemetry PTT100 Platform Terminal Transmitters (PTTs). These units weighed

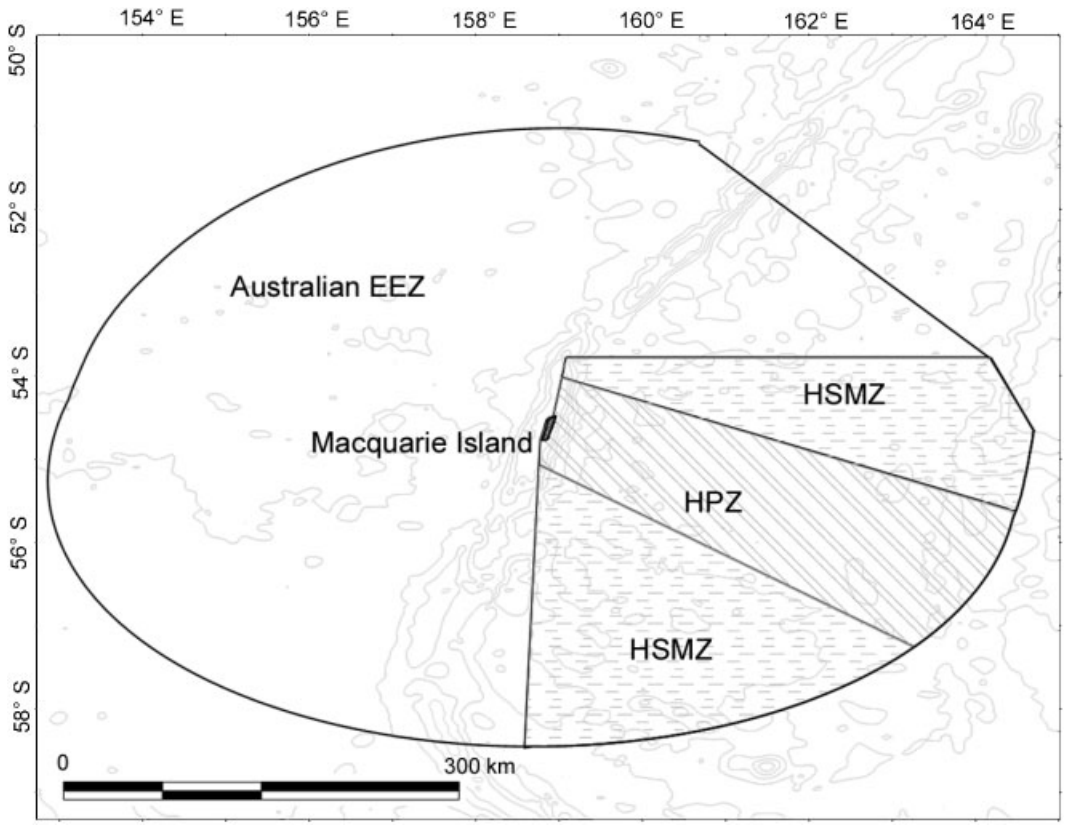

Figure 2. Macquarie Island Marine Park showing Habitat/Species Management Zones (HSMZ) and the Highly Protected Zone (HPZ).

30 g, measured $50 \times 15 \times 15$ mm and had a battery life of approximately 700 hours. They were configured to run continuously at 90 pulses per minute during deployment and were monitored using the CLS-ARGOS satellite-tracking system. In each case the units were attached prior to chick hatching to obtain information on foraging locations during the incubation and brood-guard stage. Units were attached with tape to feathers on the back of the birds just anterior to the base of the neck.

Analyses of time-spent areas and overlap

Raw location data were downloaded from ARGOS (.dat format), effectively filtered for speeds $< 100\,\mathrm{km\,h^{-1}}$ and converted to hours spent in 50 km and 20 km grid squares (time-spent squares; size depended on spatial scales examined) using custom-written Interactive Data Language (IDL) programs and Manifold 5.5 Professional Edition GIS software. These grids were overlaid on maps of the EEZs of Australia and New Zealand, the Macquarie Island Marine Reserve and CCAMLR statistical sub-areas.

As there is a fishing operation in close proximity to the breeding colonies of black-browed and grey-headed albatrosses from Macquarie Island, and both species are known to associate with fishing vessels, time-spent grids were also created for the single demersal trawler operating in the vicinity of Macquarie Island at the same time that the telemetry studies were being conducted. These grids were created from Vessel Monitoring System data supplied by the Australian Fisheries Management Authority

(AFMA). Similar fine-scale data were not available for vessels in CCAMLR waters, but the relatively low fishing effort, strict mitigation conditions (SC-CAMLR-XX11, 2003) and low bycatch (Tuck *et al.*, 2003) in the Convention area directly south of Macquarie Island suggest that the risk to albatrosses in these areas is low.

RESULTS

Black-browed albatrosses

The six breeding black-browed albatrosses were tracked for approximately 90 days, most of which was in the incubation stage (74 days). Black-browed albatrosses spent over 95% of their total foraging time within the MPAs surrounding Macquarie Island (Table 1, Figure 3). Most time was spent within the Australian EEZ surrounding Macquarie Island, followed by the EEZ around the Australian continent. A single black-browed albatross was tracked in 1999 on a trip into pelagic waters of high primary productivity in the Ross Sea near the Antarctic ice edge (Figure 3). This was the only trip recorded by black-browed albatross into CCAMLR-managed waters and represented 5% of the total foraging time tracked during this study (Table 1). Approximately 30% of all black-browed albatross foraging time was spent in the Marine Park around Macquarie Island and most was in the HPZ (Table 1, Figure 4). However, black-browed albatrosses also spent approximately half of the total foraging time within 200 nmi of Macquarie Island in areas not covered by the current boundaries of the Marine Park (Table 1, Figure 4).

Grey-headed albatrosses

Seven breeding grey-headed albatrosses were tracked for approximately 80 days, with 54 days in the incubation period and 26 during the brood stage. Grey-headed albatrosses spent less time in MPAs around Macquarie Island in comparison to black-browed albatrosses. Grey-headed albatrosses did not spend any time in the EEZ of continental Australia and just under one-quarter of the total foraging time was spent in the EEZ surrounding Macquarie Island (Figure 5). Grey-headed albatrosses travelled more frequently into CCAMLR waters, moving through this region in each austral summer of the study (Figure 5) and spending 12% of the total foraging time there (Table 1). Grey-headed albatrosses spent approximately 15% of all foraging time in the Macquarie Island Marine Park (Table 1, Figure 4) and most of this was in the HPZ. Overall, more than 60% of total grey-headed albatross foraging time was spent outside MPAs.

Overlap with the Macquarie Island Patagonian toothfish fishery

Black-browed albatrosses and the trawl vessel utilized very similar areas over concurrent time periods during 1999/2000 and 2000/01 (Figure 6). Both the trawl vessel and black-browed albatrosses spent time in

Table 1. Proposition of time spent foraging by black-browed ($n = 6$) and grey-headed albatrosses ($n = 7$) in marine protected areas around Macquarie Island over three austral summers (1999/2000, 2000/01, 2001/02)

Species	Total time (days)	% time in MPAs	% breakdown in MPAs			% in Marine Park	
			Aust. EEZ	MI EEZ	CCAMLR	HSMZ[a]	HPZ[b]
Black-browed albatross	87.5	96	14	77	5	3	28
Grey-headed albatross	79.7	36	0	22	12	4	11

[a] Habitat/Species Management Zones of the Macquarie Island Marine Park.
[b] Highly Protected Zone of the Macquarie Island Marine Park.

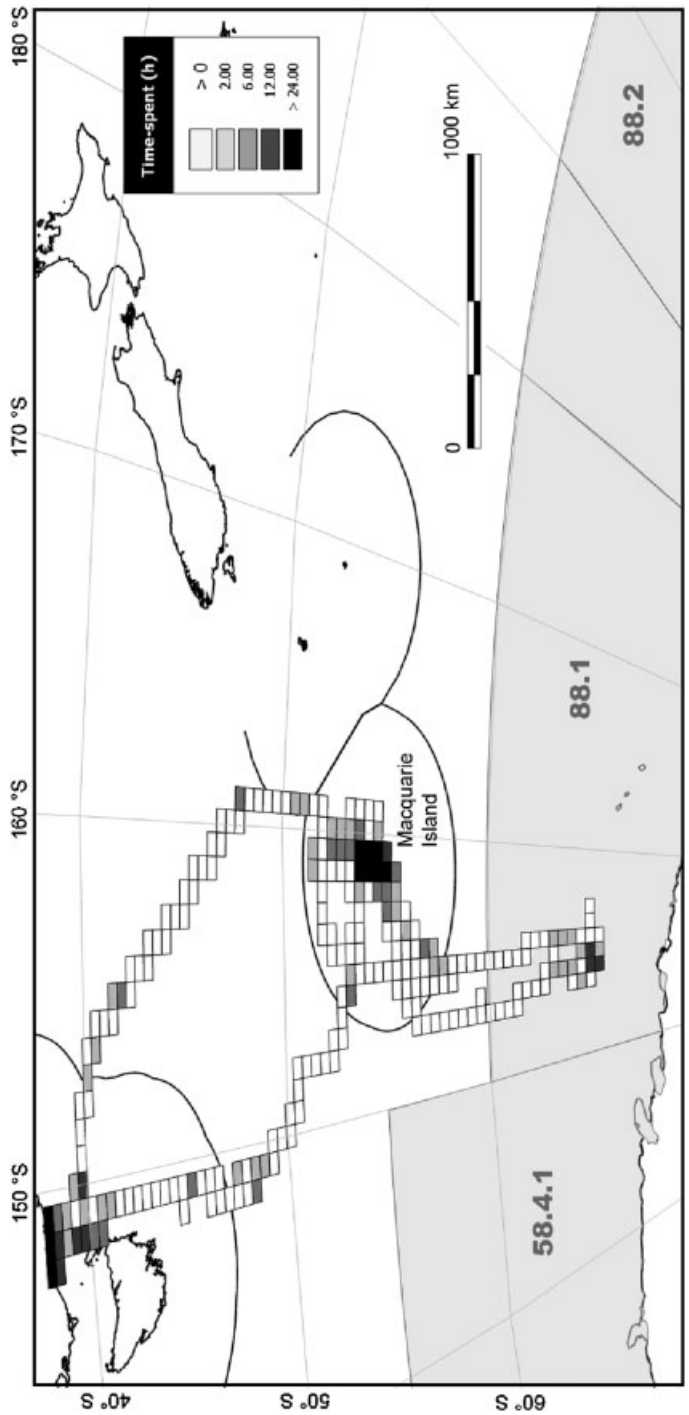

Figure 3. Foraging areas (50 km grid squares) of black-browed albatrosses in relation to Australian EEZs and CCAMLR statistical sub-areas.

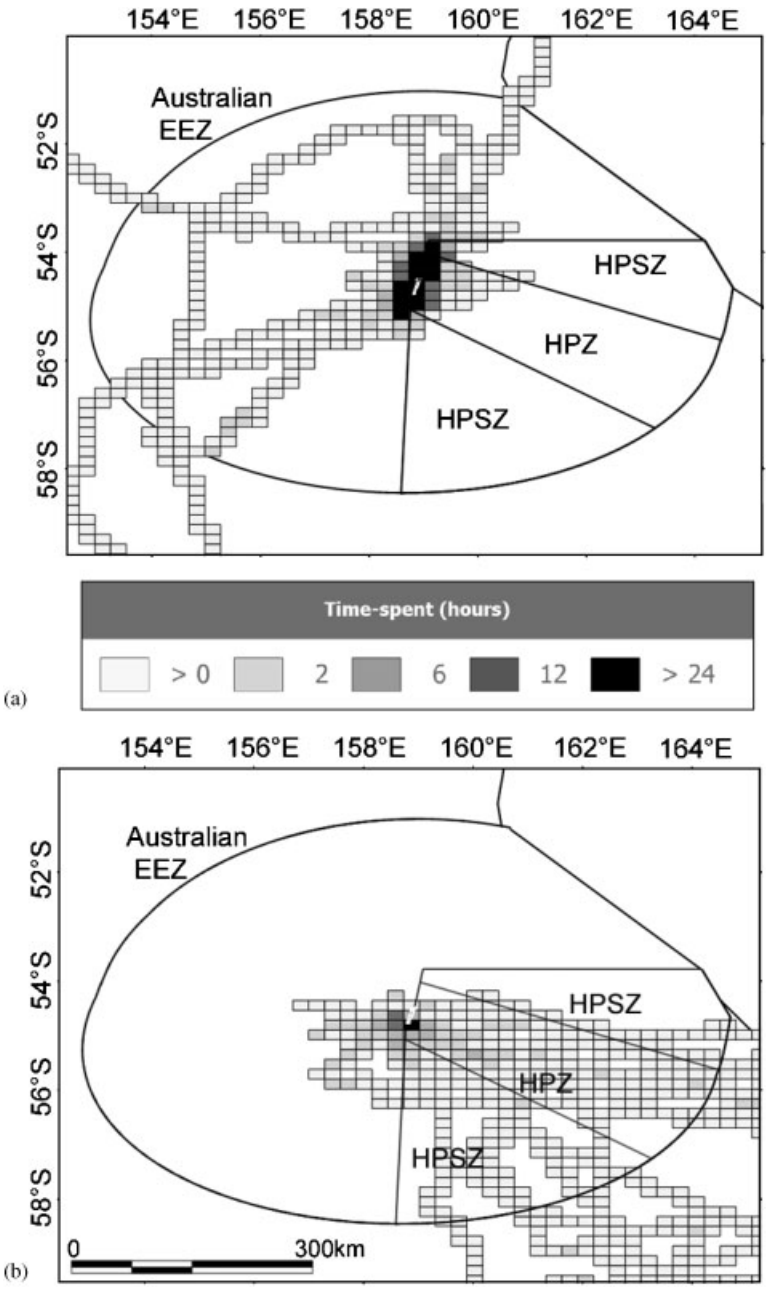

Figure 4. Foraging areas (20 km grid squares) of (a) black-browed and (b) grey-headed albatrosses from Macquarie Island in relation to the EEZ and Marine Park boundaries.

the areas above the ridge complexes to the north and, to a lesser extent, south of Macquarie Island and there was significant overlap in these areas (Figure 6(b,d)). Approximately 50% of the foraging time of the black-browed albatross was spent in the same area as the fishing vessel in 1999/2000 and this figure increased to 70% in the 2000/01 summer season (Figure 6). Satellite tracking of black-browed albatrosses in

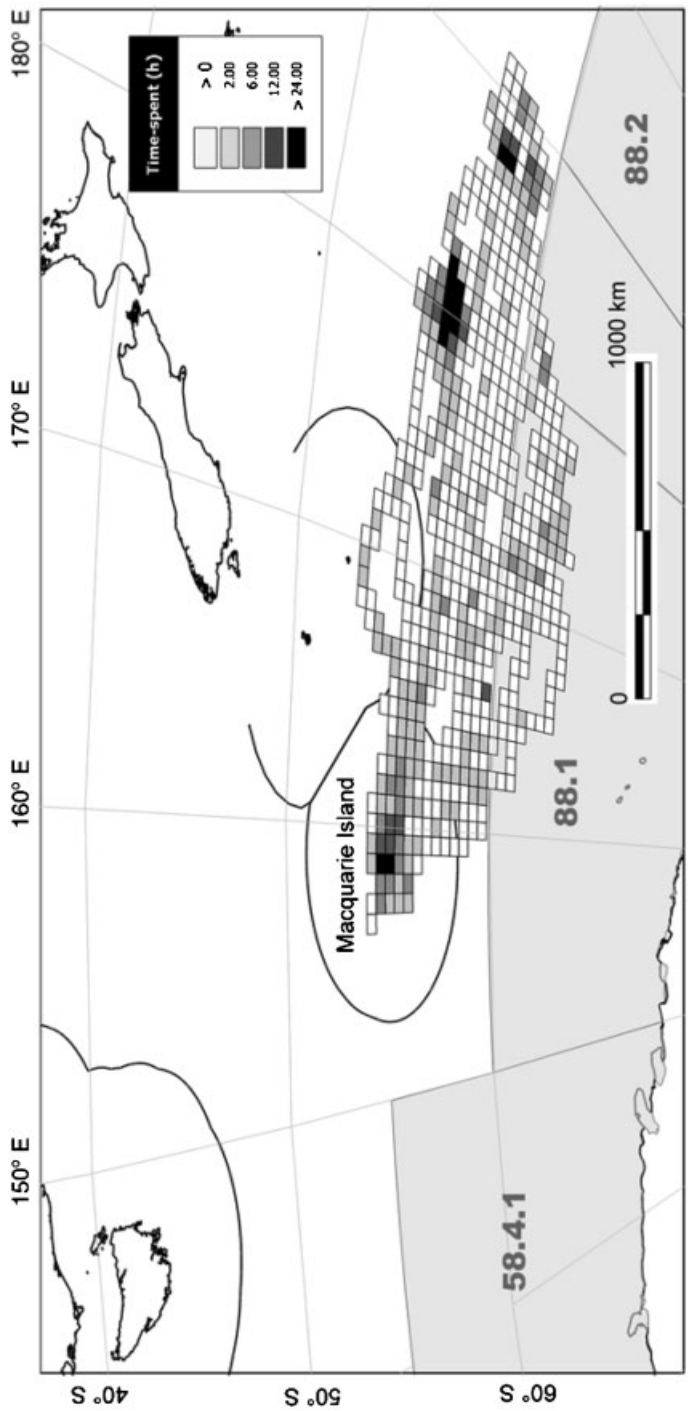

Figure 5. Foraging areas (50 km grid squares) of grey-headed albatrosses in relation to Australian EEZs and CCAMLR statistical sub-areas.

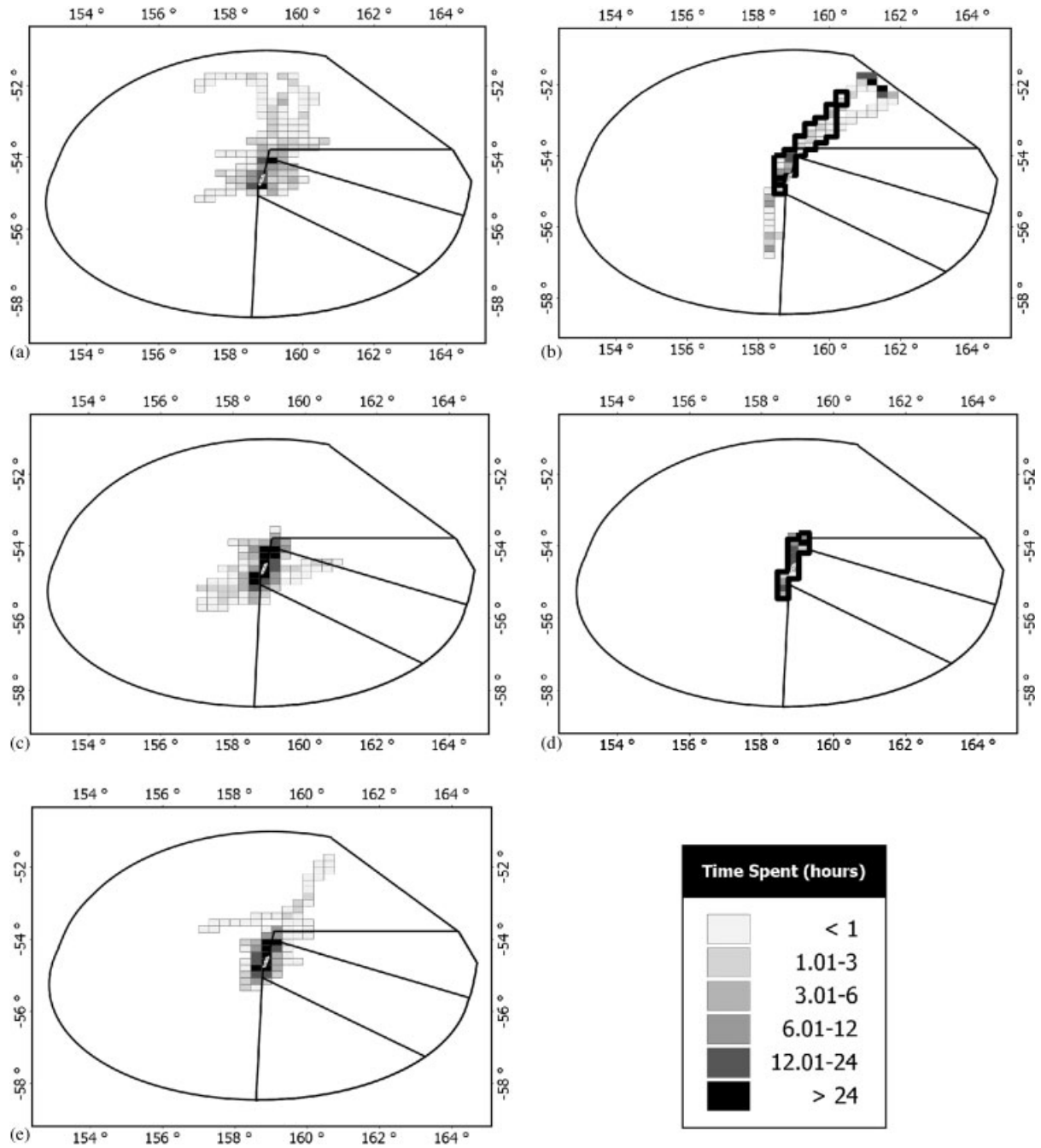

Figure 6. Foraging areas (20 km grid squares) of black-browed albatrosses and fishing areas of the demersal trawler during three austral summers around Macquarie Island. EEZ, Australian Economic Exclusion Zone; HPZ, Habitat Protection Zone of the Macquarie Island Marine Park; HSMZ, Habitat Species Management Zone of the Macquarie Island Marine Park. (a) Black-browed albatross 26/12/1999–20/1/2000. (b) Fishing area of trawler 7/1/2000–31/1/2000. (c) Black-browed albatross 29/11/2000–24/12/2000. (d) Fishing area of trawler 25/12/2000–31/12/2000. (e) Black-browed albatross 2/12/2001–29/12/2001.

2001/02, in the absence of the trawl vessel showed that black-browed albatrosses foraged in similar areas to previous summers (Figure 6(e)).

Grey-headed albatrosses spent little time foraging in the area utilized by the licensed trawl vessel. This region was only used whilst commuting to and from their pelagic foraging grounds and therefore detailed analyses are not presented here.

DISCUSSION

Although there are extensive MPAs adjacent to Macquarie Island, because of differences in the spatial use of these zones there are stark contrasts in the level of protection these areas provide to the two albatross species. During late incubation and early brood stages, black-browed albatrosses spent most of their foraging time within MPAs whereas grey-headed albatrosses spent less than 35% of their total foraging time within these zones. Although management prescriptions within these zones are variable, they are sufficient to protect both the black-browed and grey-headed albatrosses during the times that they are present in these areas.

Although most of the time that grey-headed albatrosses spent within the Australian EEZ was within the Macquarie Island Marine Park boundaries, in the context of total foraging time this proportion was very small. It is notable that the Marine Park boundaries were declared prior to studies of albatross foraging movements, and in light of the management goals that aim to 'protect foraging marine mammals and seabirds from direct human disturbance' the extent of the Marine Park and the zone boundaries may need to be re-assessed if this purpose is to be achieved. Although a relatively small number of both species was tracked during this study, the amount of time that these species spend in waters not protected by MPAs suggest a review of the current Marine Park, its zone boundaries and management prescriptions may be timely. Such a review could also incorporate more recent data on the foraging areas of other marine mammals and seabirds on Macquarie Island (e.g. Field *et al*., 2004).

In addition to EEZs, both species, but particularly the grey-headed albatrosses, foraged in waters managed by CCAMLR (Statistical Sub-area 88.1) within and to the north of the Ross Sea. This region is classified as 'low–average risk' (risk level 1 to 2) against a five-point scale of potential risk of interaction between albatrosses, and longline fisheries (SC-CAMLR-XXll, 2003). Even though the number of hooks set in this region has increased significantly over the last five years, no seabird bycatch has been reported by regulated fisheries in CCAMLR Statistical Sub-area 88.1 in the last seven years (SC-CAMLR-XX11, 2003). Both Tuck *et al*. (2003) and SC-CAMLR-XX11 (2003) estimate that the number of hooks set, and hence seabird bycatch levels, in Illegal, Unreported and Unregulated (IUU) fisheries in this area are likely to be low.

Although the sample size is small, the consistent data presented here shows significant overlap between the tracked black-browed albatross foraging areas and the Macquarie Island Patagonian toothfish fishery. This overlap is attributable to a combination of two factors. Firstly it seems likely that both albatrosses and Patagonian toothfish exploit the same highly productive areas (Goldsworthy *et al*., 2001). Secondly, several studies have shown that black-browed albatrosses, like many species of seabird, are attracted to fishing vessels (Cherel *et al*., 1996; Gales *et al*., 1998; Weimerskirch *et al*., 2000) and observer reports from the trawl vessel in the region indicate that black-browed albatrosses from Macquarie Island are second only to northern giant petrels (*Macronectes halli*) as the most abundant seabird attending the vessel (AFMA fisheries observers, pers. comm.).

Observations of fishing operations around Macquarie Island have reported no deaths or serious injuries to seabirds (Weinecke and Robertson, 2002), but data have not been collected during towing, when birds interacting with trawl warps are likely to be lost (Bartle, 1991; Weimerskirch *et al*., 2000) or unobserved (Sullivan and Reid, 2003). As discussed by Baker *et al*. (2002), reliable data on the levels of seabird bycatch

during trawl operations will only be obtained when observer programmes are established to focus on this issue. The fishing company that has operated in this fishery has demonstrated a high level of environmental responsibility in its fishing operation. Nevertheless, the overlap identified here supports the cautious approach taken by the Australian Government in its management of this fishery. Restricting effort to a single trawl vessel, prohibition of offal discharge, 100% observer coverage and the utilization of trawl mitigation measures all serve to assist in the reduction of the threats posed by this fishery to albatrosses from Macquarie Island. These mitigation measures are more effectively enforced within an MPA and it is unlikely that such stringent measures would be in place outside of these areas.

The foraging data presented here have implications for all the marine protected areas in which these populations forage. Breeding grey-headed albatrosses from Macquarie Island spend relatively little time in MPAs and the level of risk that they face on the high seas (from both legal and illegal fisheries) remains unknown. The current MPA system may be inadequate to ensure their long-term survival in the face of expanding fisheries in the Southern Ocean. In contrast, black-browed albatrosses are currently well served by the MPA network adjacent to Macquarie Island, but the level of protection afforded this species could be improved. The formation of a Marine Park within the Macquarie Island EEZ was a progressive move to protect top-order predators, but ongoing assessment is required as additional foraging information is obtained.

This study has only addressed the distribution of two albatross species during their incubation and brood periods. Further evaluation of the effectiveness of the existing MPA network for black-browed and grey-headed albatrosses requires detailed information on the areas used by both species later in the breeding season whilst chick rearing and during the non-breeding season, to identify key foraging areas at other times of the year. Information on the areas used by young albatrosses prior to breeding is also critical for further evaluation. Collection of these data, together with long-term monitoring programmes that investigate demographic trends and foraging ecology, are essential to the ongoing management of these small and vulnerable populations.

ACKNOWLEDGEMENTS

This project was jointly funded by Department of Environment and Heritage (formerly Environment Australia), the Antarctic Scientific Advisory Committee (ASAC_751) and an Australian Postgraduate Award (through the University of Tasmania). We thank Nigel Brothers, Catherine Bone, Jason Hamill and Sam Thalmann for assistance in deploying the satellite trackers. Alastair Richardson provided useful comments on draft versions of this manuscript and Colin Galbraith and John Cooper provided comments that greatly improved a more recent draft. We thank Guan Oon (ARGOS Australia) for his assistance with the satellite data. Thanks go also to Martin Excel (Austral Fisheries), Martin Scott (AFMA), Stuart Fitch (AFMA) and Thim Skousen (AFMA) for assistance in processing and providing the fisheries-location data. Thanks also to Michael Sumner (University of Tasmania) for processing the satellite data and adapting the processing software originally written by Dave Watts (Australian Antarctic Division).

REFERENCES

AFMA. 2003. Antarctic Fisheries Bycatch Action Plan. Australian Fisheries Management Authority (AFMA), Canberra, Australia.

Anon. 1994. *Guidelines for Protected Area Management Categories*. IUCN and the World Conservation Monitoring Centre: Gland, Switzerland, and Cambridge, UK.

Anon. 1998. Threat Abatement Plan for the incidental catch (or by-catch) of seabirds during oceanic longline fishing operations. Prepared by the Biodiversity Group — Environment Australia, in consultation with the Threat Abatement Team: Canberra, Australia.

Baker GB, Gales R, Hamilton S, Wilkinson V. 2002. Albatrosses and petrels in Australia: a review of their conservation and management. *Emu* **102**: 71–97.

Bartle S. 1991. Incidental capture of seabirds in the New Zealand subantarctic squid trawl fishery, 1990. *Bird Conservation International* **1**: 351–359.
BirdLife International. 2004. Tracking ocean wanderers: the global distribution of albatrosses and petrels, results from the Global Procellariiform Tracking Workshop, 1–5 September, 2003, Gordons Bay, South Africa. BirdLife International: Cambridge, UK.
Brothers N. 1991. Albatross mortality and associated bait loss in the Japanese long line fishery in the Southern Ocean. *Biological Conservation* **55**: 255–268.
Brothers NP, Cooper J, Loekkeborg S. 1999. The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. FAO Fisheries Circular 97. Food and Agriculture Organization of the United Nations: Rome.
Cherel Y, Weimerskirch H, Duhamel G. 1996. Interactions between longline vessels and seabirds in Kerguelen waters and a method to reduce seabird mortality. *Biological Conservation* **75**: 63–70.
Croxall JP, Prince PA. 1996. Potential interactions between wandering albatrosses and longline fisheries for Patagonian toothfish at South Georgia. *CCAMLR Science* **3**: 101–110.
Croxall JP, Reid K, Prince PA. 1999. Diet, provisioning and productivity responses of marine predators to differences in availability of Antarctic krill. *Marine Ecology Progress Series* **177**: 115–131.
Croxall JP, Wood AG. 2002. The importance of the Patagonian Shelf for top predator species breeding at South Georgia. *Aquatic Conservation*: *Marine and Freshwater Ecosystems* **12**: 101–118.
de la Mare WK, Kerry KR. 1994. Population dynamics of the wandering albatross (*Diomedea exulans*) on Macquarie Island and the effects of mortality from longline fishing. *Polar Biology* **14**: 231–241.
Environment Australia. 2001. Macquarie Island Marine Park Management Plan. Department of Environment and Heritage: Canberra, Australia.
Field IC, Bradshaw CJA, Burton HR, Hindell MA. 2004. Seasonal use of oceanographic and fisheries management zones by juvenile southern elephant seals (*Mirounga leonina*) from Macquarie Island. *Polar Biology* **27**: 432–440.
Gales R. 1993. *Co-operative Mechanisms for the Conservation of Albatross*. Parks and Wildlife Tasmania: Hobart, Australia.
Gales R. 1998. Albatross populations: status and threats. In *Albatross*: *Biology and Conservation*, Robertson G, Gales R (eds). Surrey Beatty & Sons: Chipping Norton; 20–45.
Gales R, Brothers N, Reid T. 1998. Seabird mortality in the Japanese tuna longline fishery around Australia, 1988–1995. *Biological Conservation* **86**: 37–56.
Goldsworthy S, He X, Tuck GN, Lewis M, Williams R. 2001. Trophic interactions between the Patagonian toothfish, its fishery, seals and seabirds around Macquarie Island. *Marine Ecology Progress Series* **218**: 283–302.
Hindell MA, Bradshaw CJA, Sumner MD, Michael KJ, Burton HR. 2003. Dispersal of female southern elephant seals and their prey consumption during the austral summer: relevance to management and oceanographic zones. *Journal of Applied Ecology* **40**: 703–715.
Hyrenbach KD, Forney KA, Dayton PK. 2000. Marine protected areas and ocean basin management. *Aquatic Conservation*: *Marine and Freshwater Ecosystems* **10**: 437–458.
Huin N. 2002. Foraging distribution of the Black-browed albatross, *Thalassarche melanophrys*, breeding in the Falkland Islands. *Aquatic Conservation*: *Marine and Freshwater Ecosystems* **12**: 89–99.
Kelleher G, Reccia C. 1998. Editorial: Lessons from marine protected areas around the world. *Parks* **8**: 1–4.
Klaer N, Polacheck T. 1995. Japanese longline seabird bycatch in the Australian Fishing Zone April 1991–March 1994: catch and catch rates by area and season and an evaluation of the effectiveness of mitigation measures. Commonwealth Scientific and Industrial Research Organization: Hobart, Australia.
Klaer N, Polacheck T. 1997. By-catch of albatrosses and other seabirds by Japanese longline fishing vessels in the Australian Fishing Zone from April 1992 to March 1995. *Emu* **97**: 150–167.
Murray TE, Bartle JA, Kalish SR, Taylor PR. 1993. Incidental capture of seabirds by Japanese southern bluefin tuna long line vessels in New Zealand waters, 1988–1992. *Bird Conservation International* **3**: 181–210.
Nel DC, Lutjeharms JRE, Pakhomov EA, Ansorge IJ, Ryan PG, Klages NTW. 2001. Exploitation of mesoscale oceanographic features by grey-headed albatross *Thalassarche chrysostoma* in the southern Indian Ocean. *Marine Ecology Progress Series* **217**: 15–26.
Nel DC, Ryan PG, Nel JL, Klages NTW, Wilson RP, Robertson G, Tuck GN. 2002. Foraging interactions between Wandering Albatrosses *Diomedea exulans* breeding on Marion Island and long-line fisheries in the southern Indian Ocean. *Ibis* **144**: 141–154.
Robinson SR, Goldsworthy SG, van den Hoff J, Hindell MA. 2002. The foraging ecology of two sympatric fur seal species *Arctocephalus gazella* and *A. tropicalis* at Macquarie Island during the austral summer. *Marine Freshwater Research* **53**: 1071–1082.

SC-CAMLR-XXll. 2003. Report of the twenty-second meeting of the Scientific Committee for the Conservation of Antarctic and Marine Living resources, R. Holt (ed.). Hobart, 22–26 October, 2003.
Sullivan BJ, Reid T. 2003. *Seabird Mortality and Trawlers in Falkland Island Waters*. Seabirds at Sea — Falklands Conservation: Falkland Islands.
Tuck G, Polacheck T, Bulman C. 2003. Spatio-temporal trends in long-line fisheries of the Southern Ocean and implications for seabird by-catch. *Biological Conservation* **114**: 1–27.
Waugh SM, Weimerskirch H, Cherel Y, Shankar U, Prince PA, Sagar PM. 1999. Exploitation of the marine environment by two sympatric albatrosses in the Pacific Southern Ocean. *Marine Ecology Progress Series* **177**: 243–254.
Weimerskirch H, Capdeville D, Duhamel G. 2000. Factors affecting the number and mortality of seabirds attending trawlers and long-liners in the Kerguelen area. *Polar Biology* **23**: 236–249.
Weinecke B, Roberston G. 2002. Seabird and seal — fisheries interactions in the Australian Patagonian toothfish *Dissostichus elagonoides* trawl fishery. *Fisheries Research* **54**: 253–265.

