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ALBATROSS AND PETREL DISTRIBUTION WITHIN THE WCPFC AREA

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ACAP[1]

[1] Agreement for the Conservation of Albatrosses and Petrels

Albatross and petrel distribution within the WCPFC area

Agreement for the Conservation of Albatrosses and Petrels (ACAP)

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ABSTRACT

This paper presents an analysis of the seasonal distribution of albatrosses and petrels within the WCPFC area, using remote tracking data from the Global Procellariiform Tracking Database. The WCPFC Convention Area overlaps with the distribution of 18 of the 22 species of albatross, and the Global Procellariiform Tracking Database holds relevant remote tracking data for 14 of these. This analysis highlights the high importance of WCPFC for global albatross distribution, with at 11 of these species having over 50% of their distribution in the WCPFC Convention Area in one or more seasons of the year, and 9 of these having over 40% of their distribution in one or more seasons in areas in which WCPFC longline fishing effort occurs. Fewer data are available for petrel and shearwater species, but at least Sooty Shearwater and Westland Petrel also have high overlap with WCPFC longline effort.

Seasonally, the three North Pacific albatross species (Laysan, Black-foot and Short-tailed) have a high overlap with the WCPFC Convention Area throughout the year. In the South Pacific, the distribution of some species varies markedly by season. However, species vary in the timing of these migrations, such that overlap between albatross distribution and WCPFC longline fishing effort occurs throughout the year.

The analysis indicates that the mitigation areas defined in WCPFC-CMM-2007-04 incorporates a high proportion of the distribution of albatrosses, petrels and shearwaters (the species considered most at risk of bycatch in longline fisheries) in the West and Central Pacific. Less than 20% of WCPFC longline fishing effort is distributed in these areas.

The analysis presented here is based on available remote-tracking data, and key data gaps remain. In relation to the WCPFC area, priority tracking data gaps (in terms of those species most likely to have high overlap with WCPFC longline fishing effort) include: (1) lack of tracking data for Salvin's Albatross, (2) lack of tracking data for non-breeding season for Buller's Albatross and Campbell Albatross, (3) lack of tracking data for Short-tailed Shearwater, (4) lack of tracking data for Northern Giant-petrels from the Chatham Islands, and (5) lack of tracking data from some major colonies of Laysan and Black-footed Albatross. The collection of tracking data to fill these gaps would improve the analysis. Seabird-at-sea observations are also an important source of distribution data for other seabird species within the WCPFC area.

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1. INTRODUCTION

Eighteen of the world's 22 albatross species are globally threatened with extinction (IUCN 2008), and incidental catch in fisheries, especially longline fisheries, is recognised as one of the principal threats to many of these species (Robertson & Gales 1998). Albatrosses, petrels and some shearwater species are considered particularly vulnerable to longline bycatch. In recognition of the global importance of the WCPFC area in relation to albatross distribution, and the accompanying risk of seabird bycatch in longline fisheries, WCPFC has adopted requirements for longline vessels to use seabird bycatch mitigation measures in areas of high albatross distribution, identified as being above 23ºN in the North Pacific, and below 30ºS in the South Pacific (CMM 2007-04). This paper presents an analysis of remote tracking data from the Global Procellariiform Tracking Database, updated with the most recent data available. This database has been established through a unique collaboration between scientists from around the world. The paper explores the spatial and seasonal distribution of albatrosses and petrels in the Pacific, and the overlap WCPFC longline fishing effort.

2. METHODS

Over 90% of existing albatross and petrel tracking data have been submitted to the Global Procellariiform Tracking Database, representing 20 of the 22 species of albatross, both species of giant-petrel, and several species of petrel and shearwater. Remote tracking data have the advantage of providing distribution data for birds of known life history stage and provenance. However, gaps in tracking data remain, particularly for juvenile and immature life stages of many species. Assumptions on distribution must be applied in some cases, using data on known range and other sources.

Procellariiform distribution can vary markedly with life history stage and the breeding cycle. Analysis of overlap with WCPFC longline fisheries should therefore take this seasonal variation into account, particularly given that longline fishing effort also varies seasonally. The analysis presented in this paper differs from previous analyses (e.g. BirdLife 2006) in that, rather than producing separate maps for breeding and non-breeding birds, it estimates the total distribution of each seabird species on a seasonal basis (year quarter), by combining juvenile, immature, breeding and non-breeding distributions. This allows a fuller understanding of overlap with fisheries. While there may also be variations in seabird distribution between years, studies have indicated that interannual differences in distribution are not as substantial as the variation between the different stages of the breeding cycle, and between breeding and non-breeding birds (Weimerskirch *et al.* 1993, Prince *et al.* 1998, Weimerskirch 2004, Phillips *et al.* 2004a). Table 1 gives the species names used in the text.

2.1 Processing seabird remote tracking data

When satellite tracking (PTT) data are submitted to the Tracking Database, data are processed using standardised methods agreed among data-holders. Data points are first validated using a filter based on McConnell *et al.* (1992). Where the estimated speed of travel by the bird is over the maximum velocity *vMax* (set at 100km.hr^{-1} for all species) and an alternative latitude and longitude is provided, the filter substitutes the alternative point. In an iterative process, the filter then removes the data point with the highest velocity over *vMax*, although a point with high accuracy is not removed (location classes 1, 2 and 3 with accuracies of up to 1km, Argos 1989, 1996). The velocities for the four points adjacent to the removed point are then recalculated and the process repeated, until no low quality point has a velocity above *vMax* (BirdLife International 2004). In order to convert the PTT tracking data into density distributions, the assumption is made that birds travel at constant speed and in a straight line between each pair of uplinks. The path of the bird is then resampled at hourly intervals. If the interval between two uplinks is more than 24 hours (as in the case with duty-cycled data), no resampling is conducted between these points.

Geolocator (GLS) devices are generally less accurate than PTTs and provide only two locations per day, but are ideal for tracking the wintering ranges of pelagic species and, being lighter than PTT devices, can be used on smaller birds. Data holders submit GLS data to the database in a processed form, since the variety of geolocators available made it unrealistic to develop a standardised validation. GLS data did not require resampling since the locations are available from tracked birds at regular (approximately 12-hour) intervals.

Table 1. The seabird species referred to in this paper

Common name	Scientific name	Threat status[1]
Antipodean Albatross	*Diomedea antipodensis*	Vulnerable
Black-browed Albatross	*Thalassarche melanophris*	Endangered
Black-footed Albatross	*Phoebastria nigripes*	Endangered
Buller's Albatross	*Thalassarche bulleri*	Vulnerable
Campbell Albatross	*Thalassarche impavida*	Vulnerable
Chatham Albatross	*Thalassarche eremita*	Critically Endangered
Grey-headed Albatross	*Thalassarche chrysostoma*	Vulnerable
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Endangered
Laysan Albatross	*Phoebastria immutabilis*	Vulnerable
Light-mantled Albatross	*Phoebetria palpebrata*	Near Threatened
Northern Royal Albatross	*Diomedea sanfordi*	Endangered
Salvin's Albatross	*Thalassarche salvini*	Vulnerable
Short-tailed Albatross	*Phoebastria albatrus*	Vulnerable
Shy Albatross	*Thalassarche cauta*	Near Threatened
Sooty Albatross	*Phoebetria fusca*	Endangered
Southern Royal Albatross	*Diomedea epomophora*	Vulnerable
Wandering Albatross	*Diomedea exulans*	Vulnerable
White-capped Albatross	*Thalassarche steadi*	Near Threatened
Northern Giant Petrel	*Macronectes halli*	Not Threatened
Southern Giant Petrel	*Macronectes giganteus*	Vulnerable
Black Petrel	*Procellaria parkinsoni*	Vulnerable
Grey Petrel	*Procellaria cinerea*	Near Threatened
Westland Petrel	*Procellaria westlandica*	Vulnerable
White-chinned Petrel	*Procellaria aequinoctialis*	Vulnerable
Short-tailed Shearwater	*Puffinus tenuirostris*	Least Concern
Sooty Shearwater	*Puffinus griseus*	Near Threatened

[1] Source IUCN 2008

2.2. Estimating total population distribution

To estimate total population distribution, the annual cycle of each species was split into stages, representing groups of individuals that are likely to have different distributions (Table 2). Where tracking data were available, kernel density distributions were derived for each stage (and sex if known) of a particular population. This was done in ArcGIS 8.2 using a smoothing (*h*) parameter of 1° and a grid size of 0.1° for PTT data (selected on the basis that this was likely to be the smallest practical unit for management on the high seas), and for GLS data a smoothing parameter *h* of 2°, (corresponding to the nominal resolution of the data) and a cell size of 0.5°. Data points were usually not separated into 'commuting' or 'foraging' points[1]. It is thus recognised that not all areas used by the albatrosses and petrels will be areas of foraging, although these still represent areas where there is potential interaction with fisheries. Grids were combined to produce an overall density distribution for the species for each year quarter (where Q1=Jan-March, Q2=Apr-Jun, Q3=Jul-Sept, Q4=Oct-Dec), based on the length of the stage (start/end dates rounded up to 0.5 months), the proportion of time spent at sea during the stage, and the proportion of birds in the stage.

[1] For Sooty Shearwater see notes in Appendix 1.

Estimation of total distribution requires assumptions on the population structure of each species. In albatrosses and petrels, fledged chicks do not return to their natal colony for several years, and once they do it can take several more years to form a pair-bond and start breeding. Similarly, the proportion of non-breeding adults in a population is difficult to ascertain without a long-term banding study. Non-breeding adults consist of failed breeders, those that do not attempt breeding in a given year (on 'sabbatical'), and all adults out of the breeding season ('non-breeders') (Table 2). Birds in each of these stages have differing ties to the colony and provisioning demands, which can lead to differing distributions. For the purposes of this analysis, populations were assumed to comprise 20% juveniles, 10% immatures (pre-breeders) and 70% adults. These are considered reasonable assumptions for a long-lived species with a low reproductive rate (e.g. Arnold *et al.* 2006, Inchausti & Weimerskirch 2001). Non-breeding adults outside the breeding season include 100% of adults for annual breeders and biennial breeders with a short breeding season. For those biennial breeders with a breeding season spanning most of the year (i.e. the great albatrosses) the 'non-breeding' birds all fall under the "sabbatical" grouping. In the absence of detailed studies for a large proportion of the species under consideration, it was decided to group late-failing birds with breeding birds, and sabbatical birds with early-failing birds, and assume an even number of adults falling in these two groups. If no tracking data were available for a particular stage then distribution was estimated based on the most appropriate distribution for which there were tracking data. Details of the parameters and assumptions used to create the grids for each of the species considered in this paper are given in Appendix 1.

Table 2. Annual stages for seabird species under consideration

Stage	Season	Age class	Notes	Proportion time at sea
Incubation	Breeding	Adult	The pre-egg period was included in this stage as no tracking data was available	0.5
Brood-guard	Breeding	Adult	In the case of burrowing petrels, where the brood period is very short, lasting only a few days, this stage was ignored	0.5
Post-guard	Breeding	Adult		1
Early fail	Breeding	Adult	Breeding adults that fail before brood-guard – combined with sabbaticals	1
Late fail	Breeding	Adult	Breeding adults that fail after brood-guard – combined with breeders	1
Sabbatical	Breeding	Adult	Non-breeding adults during the breeding season	1
Immatures (B)	Breeding	Immature	Pre-breeders that have returned to the colony	1
Non-breeders	Non-breeding	Adult	Non-breeding adults during the non-breeding season - in annual breeders this is all adults	1
Immatures (NB)	Non-breeding	Immature	Pre-breeders that have returned to the colony	1
Juveniles	Breeding & Non-breeding	Juvenile	Juveniles that have not returned to the colony since fledging	1

In interpreting the resulting distributions, it is important to note that density distributions may include some bias in favour of areas near to the locations at which tracking devices were deployed, particularly in the case where birds were tracked after being caught at sea ('at-sea deployments'), where the tracks are not independent samples of the species' distribution.

An additional point that applies to all tracking analyses is that care must be taken when interpreting maps which have been based on small sample sizes. Ideally, analysis would be based on at least 10-15 tracks for each breeding stage, and preferably each sex, before results would be considered to approach reliability, though the effect of sample size varies between species (BirdLife International 2004).

2.3 Overlap with WCPFC longline fishing effort data

The WCPFC area used for analysis in this paper is that defined in article 3 of the Convention. Longline effort data were obtained from the Secretariat of the Pacific Community Oceanic Fisheries Programme's public domain catch & effort data (SPC 2008). Effort data were summarised as average number of hooks per 5° grid square per year quarter (Jan-March, April-June, July-Sept, Oct-Dec) for the period 2000-2005.

For each species, the percent at-sea time spent within the WCPFC Convention Area was obtained using the seabird distribution grids produced in Section 2.2. Calculations were also made of the percentage at-sea time spent within each 5x5° grid square. In addition, the proportion of average quarterly WCPFC longline effort falling within the range defined by the seabird distribution gird for the relevant quarter was calculated. These measures of overlap should be relatively robust in relation to any uncertainty in exact magnitude of fishing effort.

3. RESULTS

The Global Procellariiform Tracking Database holds relevant remote tracking data for 14 of the 18 albatross species whose ranges overlap with the WCPFC area, as well as for three petrel species, and two shearwater species. **Figures 1 to 16** show the seasonal distribution of these seabird species within the WCPFC area (by year quarter) and their overlap with WCPFC longline fishing effort (based on WCPFC longline effort data for 2000-2005). The percent time that each seabird species is estimated to spend within the WCPFC area is summarised in **Table 3**. **Table 4** refines this to the % time spent within WCPFC 5x5 grid squares in which longline fishing effort occurred during 2000-2005.

On the maps, the 50%, 75% and 95% contours indicate the areas of highest density of seabird distribution (50% areas are highest density), while the 100% contour shows the full extent of tracked birds. In cases where sample sizes of tracking data are small, this 100% contour covers a smaller area than the estimated full range, which is shown on these maps for comparison. The full ranges are maps held by BirdLife International and have been defined using data from a variety of sources including at-sea and on-shore observations, bird band recovery data, and references such as Harrison 1989, Tickell 2000, and Robertson *et al.* 2003. In some cases, tracked birds are located outside the estimated full range, emphasising the fact that the full ranges are estimates, and continue to be updated as new data are available.

3.1 North Pacific

In the North Pacific, **Laysan Albatross** and **Short-tailed Albatross** have over 90% of their distribution in the WCPFC area throughout the year (Table 3, Figures 1 and 2). Overlap with 5x5 grid squares in which WCPFC longline fishing effort occurs is lower (around 30-40% of their distribution is in grid squares with WCPFC longline effort, Table 4), as some of their distribution occurs in regions beyond the northern limit of longline fishing effort.

Black-footed Albatross distribution also has a high (>50%) overlap with WCPFC area, though it also spends time in the East Pacific, overlapping with the IATTC area (Figure 3, Table 3). However, overlap with WCPFC longline fishing effort is as high as for the other two species (Table 4), with the greatest longline effort occurring in the Black-footed Albatross range in the fourth and first quarters of the year (September-March).

As shown in Table 3, the current area in which seabird bycatch measures are required (north of 23ºN) captures a high proportion of the distribution of these species, although the distribution of Black-footed Albatross extends to below 20ºS.

3.2 South Pacific

The South Pacific overlaps with a large number of albatross species, fifteen in all. Tracking data were available for 11 of these 15 albatross species, although of data were only partial for four of these (Table 3). Patterns of distribution vary between species, and there are several that have a very high overlap with WCPFC area in the breeding season, after which at least a proportion of their population migrates to other parts of the Pacific during the non-breeding period.

The WCPFC Convention Area has a very high overlap (>80% bird distribution) with the distribution of **Antipodean, Shy** and **Northern Royal Albatrosses**, and with at least the distribution of breeding birds of **Buller's, Campbell and Chatham Albatrosses and Westland Petrel, Northern Giant-petrel, and Sooty Shearwater** (Table 3). The latter is distributed in the South Pacific while breeding, and then migrates to the North Pacific in the non-breeding period (Shaffer *et al*. 2006, Fig. 11).

The overlap in terms of actual WCPFC longline fishing effort (Table 4) is somewhat lower than overlap with the WCPFC Convention Area, since longline fishing effort did not occur between 50-60ºS of the WCPFC Convention Area (based on 2000-2005 data). The available tracking data indicate that the species with the highest overlap with longline effort (more than 50% of their distribution in 5x5 grids in which longline effort occurred, in any year quarter) include **Antipodean, Buller’s, Chatham, Northern Royal, Shy and Southern Royal Albatrosses, Westland Petrel** and **Sooty Shearwater**.

Species with a low overlap with WCPFC longline fishing effort (mostly being distributed at higher latitudes) are Light-mantled, Sooty, Southern Royal Albatross and Wandering Albatross and Northern and Southern Giant-petrels. Black-browed Albatross has a low overlap with WCPFC longline fishing effort, and although there are several breeding sites within the WCPFC area for which no tracking data are available (Figure 14), these are small in terms of population size.

A number of species have seasonal variation in their overlap with the WCPFC area and longline fishing effort. However, the timing of this variation varies between species, meaning that overlap between bird distribution and WCPFC longline effort occurs throughout the year. However, the data indicate that there is generally a lower overlap with WCPFC longline fishing effort in the third quarter of the year (July-September).

Figures 17 and 18 indicate the ranges of the seven species of albatross, petrel and shearwater for which there are no tracking data available. Of these, at least Salvin's Albatross and White-capped Albatross and Black Petrel are likely to also have a high overlap with the WCPFC longline fishing effort. The overlaps with Campbell Albatross and Short-tailed Shearwater are also underestimated in this analysis due to data gaps.

As shown in Table 3, the current area in which seabird bycatch measures are required (south of 30ºS) captures a high proportion of the distribution of these species.

3.3. Proportion of WCPFC longline effort in areas overlapping with seabird distribution

In terms of the proportion of WCPFC longline fishing effort that occurs in the regions overlapping with seabird distribution, this is relatively low (**Table 5**). Less than 17% of WCPFC longline effort overlaps with mitigation areas (North of 23ºN and South of 30ºS) during any period of the year. This indicates that CMM-2007-04 affects a relatively low proportion of the overall fleet.

Table 3. Percent time of each seabird species that is spent within the WCPFC Convention Area, by year quarter, based on available remote-tracking data. (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec). Values in italics are derived from breeding data only. Shaded areas indicate no tracking data available for that quarter.

WCPFC area		**Q1**	**Q2**	**Q3**	**Q4**	**Average**	
Antipodean Albatross	**Total**	**96**	**97**	**97**	**97**	97	
	S of 30°S	96	96	96	96	96	
Short-tailed Albatross	**Total**	**93**	**94**	**92**	**95**	94	
	N of 23°N	93	94	92	95	94	
Laysan Albatross	**Total**	**91**	**90**	**93**	**93**	92	
	N of 23°N	89	89	92	92	91	
Shy Albatross	**Total**	**80**	**78**	**79**	**84**	80	
	S of 30°S	80	78	79	84	80	
Northern Royal Albatross	**Total**	**84**	**84**	**84**	**62**	79	
	S of 30°S	84	84	84	62	79	
Northern Giant Petrel	**Total**	**90**	**62**	**67**	**90**	77	
	S of 30°S	90	62	67	90	77	
Sooty Shearwater	**Total**	**81**	**73**	**73**	**81**	77	
	N of 23°N	0	38	66	18	31	
	S of 30°S	80	35	7	63	46	
Chatham Albatross	**Total**	**90**	**56**	**70**	**90**	77	
	S of 30°S	90	56	69	90	76	
Black-footed Albatross	**Total**	**61**	**59**	**49**	**60**	57	
	N of 23°N	58	55	48	60	55	
Southern Giant Petrel	**Total**	**15**	**14**	**12**	**13**	14	
	S of 30°S	15	14	12	13	14	
Wandering Albatross	**Total**	**12**	**12**	**12**	**12**	12	
	S of 30°S	12	12	12	12	12	
Grey-headed Albatross	**Total**	**5**	**5**	**3**	**3**	4	
	S of 30°S	5	5	3	3	4	
Black-browed Albatross	**Total**	**1**	**3**	**4**	**1**	2	
	S of 30°S	1	3	3	1	2	
Buller's Albatross	**Total**	**99**	**99**	**99**			Breeding and non-breeding from breeding season only
	S of 30°S	99	99	99			
Southern Royal Albatross	**Total**	***100***			***100***		Breeding adult data only
	S of 30°S	*100*			*100*		
Campbell Albatross	**Total**	***77***	***77***				Breeding adult data only
	S of 30°S	*77*	*77*				
Westland Petrel	**Total**			***100***			Breeding adult data only
	S of 30°S			*100*			
Light-mantled Albatross	**Total**	***52***			***45***		
	S of 30°S	*52*			*45*		
Short-tailed Shearwater	**Total**	***16***	***16***				Breeding adult data only
	S of 30°S	*16*	*16*				
Salvin's Albatross							No tracking data
Indian YN Albatross							No tracking data
Sooty Albatross							No tracking data
White-capped Albatross							No tracking data
Black Petrel							No tracking data
Grey Petrel							No tracking data
White-chinned Petrel							No tracking data

Table 4. Percent time spent within WCPFC 5x5° grid squares for which there was longline fishing effort reported during 2000-2005 within the WCPFC for each seabird species. (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec). Values in italics are derived from breeding data only. Shaded areas indicate no tracking data available for that quarter.

Species	**Q1**	**Q2**	**Q3**	**Q4**
Buller's Albatross	96	98	29	
Antipodean Albatross	61	74	47	42
Short-tailed Albatross	40	41	21	42
Laysan Albatross	34	24	49	56
Shy Albatross	55	53	< 1	50
Northern Royal Albatross	77	80	13	58
Northern Giant Petrel	2	14	1	1
Sooty Shearwater	49	50	48	31
Chatham Albatross	62	46	16	76
Black-footed Albatross	47	44	39	53
Southern Giant Petrel	< 1	1	< 1	< 1
Wandering Albatross	11	11	8	9
Grey-headed Albatross	< 1	< 1	< 1	< 1
Black-browed Albatross	1	3	3	1
Southern Royal Albatross	*73*			*12*
Campbell Albatross	*16*	*19*		
Westland Petrel			*100*	
Light-mantled Albatross	*0*			*< 1*
Short-tailed Shearwater	*7*	*9*		
Salvin's Albatross				
Indian YN Albatross				
Sooty Albatross				
White-capped Albatross				
Black Petrel				
Grey Petrel				
White-chinned Petrel				

Table 5. Percent distribution of WCPFC longline effort falling within the northern and southern seabird measures areas by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec).

	Q1	**Q2**	**Q3**	**Q4**
N of 23°N	10	4	4	12
S of 30°S	3	13	4	2

4. DISCUSSION

4.1 Importance of the WCPFC area for albatross and petrel species

The analysis has highlighted the importance of the WCPFC area for the global distribution of albatrosses. Eighteen of the 22 species of albatross overlap with the WCPFC Convention Area, and tracking data were available for 14 species. Of these, 11 had more than 50% (and up to 100%) of their distribution in the WCPFC Convention Area in one or more seasons of the year. In terms of overlap with WCPFC longline fishing effort, 9 of the 14 albatross species for which tracking data were available have over 40% of their distribution in one or more seasons in areas in which WCPFC longline fishing effort occurs.

In addition, available data confirm that the WCPFC Convention Area is important for at least Sooty Shearwater, Westland Petrel, and Northern Giant-petrel, although the latter is largely distributed in areas south of where longline effort actually occurs. No tracking data were available for Salvin’s Albatross, White-capped Albatross, Black Petrel, but all are likely to also have a high overlap with the WCPFC area and longline fishing effort. The overlaps with Campbell Albatross and Short-tailed Shearwater are also underestimated in this analysis due to data gaps.

The three North Pacific albatross species (Laysan, Black-foot and Short-tailed) have a high overlap with both the WCPFC area and longline fishing effort, throughout the year. Previous analysis of the data has indicated that up to 50% of their time is spent in high seas areas (BirdLife International 2006). A high number of albatross species occur in the South Pacific, and the distribution of some species varies markedly by season. This includes a number of species for whom at least a proportion of their population moves east across the South Pacific during non-breeding periods, to feed in the rich foraging grounds of the Humboldt Current off the coast of South America. However, species vary in the timing of these migrations, such that overlap between albatross distribution and WCPFC longline fishing effort occurs throughout the year.

The analysis indicates that the mitigation areas defined in WCPFC-CMM-2007-04 incorporates a high proportion of the distribution of albatrosses, petrels and shearwaters (the species considered most at risk of bycatch in longline fisheries) in the West and Central Pacific. Less than 20% of WCPFC longline fishing effort is distributed in these areas.

4.2 Data gaps

The analysis presented here is based on available remote-tracking data. Although the sample sizes for some species are relatively large (especially for Short-tailed, Black-footed and Laysan Albatross species in the North Pacific), they are still based on restricted numbers of birds, and relatively few colonies, and density distributions are therefore likely to underestimate the full range of each species to some extent. This limitation is offset by the ability of tracking data to provide indications of density distribution, which are highly valuable for assessment of overlap with fisheries.

Key data gaps remain. In relation to the WCPFC area, priority tracking data gaps (in terms of those species most likely to have high overlap with WCPFC longline fishing effort) include: (1) lack of tracking data for Salvin’s Albatross, (2) lack of tracking data for non-breeding season for Buller's Albatross and Campbell Albatross, (3) lack of tracking data for Short-tailed Shearwater, (4) lack of tracking data for Northern Giant-petrels from the Chatham Islands, and (5) lack of tracking data from some major colonies of Laysan and Black-footed Albatross. The collection of tracking data to fill these gaps would improve the analysis presented here. Seabird-at-sea observations are also an important source of distribution data for other seabird species within the WCPFC area.

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APPENDIX 1.

(Values in brackets are assumed from similar species or inferred from other data presented in this table)

Species	Breeding chronology								
	Return date [a,b]	**Laying period date** [a,b]	**Median egg date** [a,b]	**Incubation (days)** [a,c]	**Hatch date** [a,b]	**Brood-guard period** [a,b]	**End brood-guard date** [a,d]	**Fledging (days)** [a,c]	**Fledge date** [a,b]
Antipodean Albatross [e]	(end Dec) [f]	end Jan	25 Jan	(c. 2.5 months) [g]	end Apr	(c. 1 month) [g]	end May [h]		mid Jan
Black-browed Albatross	early Sep-early Oct	19-27 Oct	(23 Oct)	65-72; 68±1.2	most early Dec	c. 3 weeks [i]	(late Dec)	116-125 [j]	late Apr
Black-footed Albatross [k]	mid Oct	mid-late Nov		60 [l]	mid Jan-early Feb	1 month [l]	(mid Feb-early Mar)		Jun-Jul [k,l]
Buller's Albatross [m]	mid Dec-mid Jan	late Jan	3rd week Jan	69.1±1.3	2 Apr	23-25 days	(end Apr)	167±9.7	13 Sep
Campbell Albatross	Sep [n]		(Oct) [g]	(68) [g]	(Dec) [g]	(3 weeks) [g]	(Jan) [g]	(121) [g]	May [n]
Chatham Albatross [o]	(Aug) [p]	Aug-Sep		66-72	Oct-Dec	(c. 3 weeks) [g]	(Nov-Jan)		Feb-Apr
Grey-headed Albatross	early Sep-early Oct	20 Oct	20 Oct	69-78; 72±1.6	most Dec	c. 3 weeks [i]	(Jan)	141	May
Laysan Albatross [k]	early Nov	mid Nov-mid Dec		60 [l]	late Jan-mid Feb	1 month	(late Feb-mid Mar)		early Jul
Light-mantled Albatross	early Sep-mid Oct [q]	20 Oct-10 Nov [r]		66-69; 65-72 [n]; 63-67 [r]	late Dec-15 Jan [r]	3 weeks [n]	(late Jan)	140-157; 141 [r]; 140-170 [n]	mid May-mid Jun [r]
Northern Royal Albatross [s]	(Oct) [g]	Nov		79	(Nov-Jan)	(c. 1 month) [g]	Mar [t]	240	Sep
Short-tailed Albatross [u]	Oct	late Oct-late Nov		64-65	Dec-Jan	"few weeks"	Feb [v]	c. 5 months	mid May - Jun [v]
Shy Albatross [w]	(Sep)	Sep-early Oct		68-75	Dec	3 weeks	(Jan)	c. 120	Apr
Southern Royal Albatross			Dec [n]	78-80				241	Oct [n]
Wandering Albatross	Nov	10 Dec-17 Jan	24 Dec	78.4±1.2	most Mar	c. 1 month	(Apr)	278±17	most Dec

Species	Breeding chronology								
	Return date [a,b]	Laying period date [a,b]	Median egg date [a,b]	Incubation (days) [a,c]	Hatch date [a,b]	Brood-guard period [a,b]	End brood-guard date [a,d]	Fledging (days) [a,c]	Fledge date [a,b]
Northern Giant Petrel	Aug [x]	Aug-Oct [x]; 10-27 Oct [r]		57-62; 60 [x]	15 Dec-2 Jan [r]	32 days [y]	(Jan)	106-120; 108 [r]	late Feb-late Apr [r]
Southern Giant Petrel	Aug-Sep [z]	late Oct [aa]; Sep-Oct [x]; 20 Aug-6 Sep [r]		59-66; 59 [x]	late Dec [aa]; 25 Oct-12 Nov [r]	18 [z]; 21 [y] days	(mid-late Nov/Jan)	112-123; 115 [r]	early Mar-early Apr [aa]; late Jan-late Mar [r]
Westland Petrel		May [n]							Dec [n]
Short-tailed Shearwater [ab]	late Sep-early Oct	late Nov	27-28 Nov	53	mid-late Jan	2-3 days	(late Jan)		early Apr-early May
Sooty Shearwater	late Sep	mid Nov-early Dec	(end Nov)	52.7-56	24 Jan	5 days	(end Jan)	97	late Apr-mid May

[a] Assume the same for all colonies. Brooke 2004 unless otherwise stated
[b] Brooke 2004 unless otherwise stated
[c] Schreiber 2002 unless otherwise stated
[d] Inferred from hatch and brood-guard period unless otherwise stated
[e] Walker *et al.* 2002 unless otherwise stated
[f] No information - assumed the pre-egg period was 27 days, similar to congeners
[g] No information - assumed similar to congeners
[h] Imber 2005
[i] Phillips *et al.* 2004b
[j] Brooke 2004 gives 116 days
[k] Fefer *et al.* 1983 unless otherwise stated
[l] Naughton *et al.* 2007
[m] Sagar & Warham 1998
[n] Robertson 2003
[o] Robertson *et al.* 2000 unless otherwise stated
[p] No information - assumed pre-egg period c. 3 weeks similar to congeners
[q] Weimerskirch *et al.* 1986; Croxall & Prince 1987
[r] Gales *et al.* in press
[s] Gales 1998 unless otherwise stated
[t] Robertson 1998
[u] USFWS 2005 unless otherwise stated
[v] R. Suryan, pers comm.
[w] Johnstone *et al.* 1975
[x] Burger 1978; Johnstone 1978
[y] Hunter 1984
[z] Voisin 1988
[aa] Quintana *et al.* 2006
[ab] Marchant & Higgins 1990

Appendix 1 (continued).

Species	Distribution data used[1] - see Appendix 2 for colonies tracked and sample sizes. (Shaded cells indicate no data)							
	Incubation	Brood-guard	Post-guard	Sabbatical	Immatures (B)	Non-breeders	Immatures (NB)	Juveniles
Antipodean Albatross	PTT tracking (also pre-egg)	PTT tracking	PTT tracking	Breeders	Breeders	PTT tracking		
Black-browed Albatross	PTT tracking	PTT tracking	PTT tracking	Breeders	Breeders	PTT & GLS tracking[2]		
Black-footed Albatross	PTT tracking	PTT tracking	PTT tracking	Non-breeders	Non-breeders	PTT & GLS tracking[2]		
Buller's Albatross	PTT tracking (also pre-egg)	PTT tracking	PTT tracking	Breeders	Breeders			
Campbell Albatross		PTT tracking						
Chatham Albatross	Breeders	PTT tracking		Breeders	Breeders	PTT tracking		
Grey-headed Albatross	PTT tracking	PTT tracking	PTT tracking	Breeders	Breeders	GLS tracking	Non-breeders	Non-breeders
Laysan Albatross	PTT tracking	PTT tracking	PTT tracking	Non-breeders	Non-breeders	PTT & GLS tracking[2]	Non-breeders	Non-breeders
Light-mantled Albatross	PTT tracking	PTT tracking						
Northern Royal Albatross	PTT & GPS tracking	PTT tracking		Breeders	Breeders	PTT tracking		
Short-tailed Albatross	Breeders	Breeders	PTT tracking	Non-breeders	Non-breeders	PTT tracking		
Shy Albatross	PTT tracking	PTT tracking	PTT tracking	Breeders	Non-breeders	PTT tracking	PTT tracking	
Southern Royal Albatross	PTT tracking							
Wandering Albatross	PTT & GPS tracking	PTT & GPS tracking	PTT & GPS tracking	Breeders	Breeders	PTT tracking		

Species	Distribution data used[1] - see Appendix 2 for colonies tracked and sample sizes. (Shaded cells indicate no data)							
	Incubation	**Brood-guard**	**Post-guard**	**Sabbatical**	**Immatures (B)**	**Non-breeders**	**Immatures (NB)**	**Juveniles**
Northern Giant Petrel	Breeders	PTT tracking		Breeders	Breeders	Juveniles	Juveniles	PTT tracking
Southern Giant Petrel	PTT & GLS tracking[2]	PTT & GLS tracking[2]	PTT & GLS tracking[2]	Breeders	Breeders	PTT & GLS tracking[2]		
Westland Petrel			PTT tracking					
Short-tailed Shearwater		PTT tracking						
Sooty Shearwater	GLS tracking	GLS tracking		*See notes*	*See notes*	GLS tracking	*See notes*	*See notes*

Appendix 1 (continued)

	Notes
Antipodean Albatross	Separate breeding/non-breeding grids were created for each colony and weighted by colony size. The pre-egg-laying period was modelled separately from incubation as tracking data were available. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole. All non-breeding tracks (adults and juveniles) were pooled to create the non-breeding distribution as juvenile sample sizes were small.
Black-browed Albatross	Separate breeding/non-breeding grids were created for each colony and weighted by colony size. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole.
Black-footed Albatross	All non-breeding tracks (from adults, juveniles and immatures) were pooled to create the non-breeder distribution[2]. As this species has a restricted range without long migration routes to over-wintering grounds, it was assumed that non-breeders during the breeding season would follow the same distribution as during the non-breeding season.
Buller's Albatross	Data available for Solander/Snares Is only. Separate breeding/non-breeding grids were created for each colony and weighted by colony size. The pre-egg-laying period for the Snares was modelled separately from incubation as tracking data were available. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole. No data for non-breeding period, or for juveniles.
Campbell Albatross	Only chick-rearing data were available, so overlaps were only calculated for quarters when birds were rearing chicks.
Chatham Albatross	Breeding data only consisted of chick-rearing tracks, and these were not separated into brood-guard and post-guard stages. Thus all breeding tracks were pooled and used to model the breeding distribution irrespective of breeding stage. Non-breeding birds (except juveniles) during the breeding season were assumed to have the same distribution as breeders. All non-breeding tracks (adult and juvenile) were pooled to create the non-breeder distribution as sample sizes were small.
Grey-headed Albatross	Separate breeding/non-breeding grids were created for each colony and weighted by colony size. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole.
Laysan Albatross	Separate breeding grids were created for each colony and then combined, weighted by colony size. All non-breeding tracks were pooled to create the non-breeder distribution[2]. As this species has a restricted range without long migration routes to over-wintering grounds, it was assumed that non-breeders during the breeding season would follow the same distribution as during the non-breeding season.
Light-mantled Albatross	Only incubation and brood-guard data were available, so overlaps were only calculated for quarters when birds were incubating/brooding.
Northern Royal Albatross	Chick-rearing tracks were not separated into brood-guard and post-guard stages; these were thus pooled. Separate breeding/non-breeding grids were created for each colony and weighted by colony size. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole. All non-breeding tracks (adults and juveniles) were pooled to create the non-breeding distribution as sample sizes were small.
Short-tailed Albatross	Only post-guard tracks were available for breeding, but as these showed a very restricted breeding range, even during late chick-rearing, it was assumed that the incubation and brood-guard stages would follow a similar distribution. All non-breeding tracks (from adults and juveniles) were pooled to create the non-breeder distribution. Although there appeared to be a general west-east migration by post-breeders, it is unsure whether this applies to all non-breeders as at-sea tracking from the Aleutians was only performed after the breeding season. It was thus assumed that non-breeders during the breeding season would follow the same distribution as during the non-breeding season, except that the distribution was restricted to no further north than the South Bering Sea/Aleutian Island chain from January to April (R. Suryan, pers comm.)

	Notes
Shy Albatross	Separate breeding grids were created for each colony and weighted by colony size. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole. Non-breeding adults from all colonies were pooled as sample sizes were small. Separate immature/juvenile grids were created from pooled data from all colonies. Assumed immatures during the breeding season were distributed as non-breeding adults.
Southern Royal Albatross	Only incubation data were available, so overlaps were only calculated for quarters when birds were incubating.
Wandering Albatross	Separate breeding grids were created for each colony and weighted by colony size. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole. Non-breeding data from all colonies were pooled as sample sizes were small and a large proportion of the birds were of unknown provenance.
Northern Giant Petrel	Breeding data only consisted of chick-rearing tracks, and these were not separated into brood-guard and post-guard stages. Thus all breeding tracks were pooled and used to model the breeding distribution irrespective of breeding stage. Only fledgling data were available to model non-breeder distribution.
Southern Giant Petrel	Separate breeding/non-breeding grids were created for each colony and weighted by colony size. It was assumed that non-breeders (except juveniles) during the breeding season were distributed as for breeders as a whole.
Westland Petrel	Only chick-rearing data were available, so overlaps were only calculated for quarters when birds were rearing chicks.
Short-tailed Shearwater	Only chick-rearing data were available, so overlaps were only calculated for quarters when birds were rearing chicks.
Sooty Shearwater	Breeding and non-breeding GLS data from two colonies in New Zealand were available; these were pooled as tracking shows that there are no colony-specific differences in distribution (Shaffer *et al.* 2006). Chick-rearing tracks were pooled as the brood-guard period is very short. Post-breeders performed a fairly synchronous migration from the south-west Pacific to the northern and eastern Pacific in April and May, returning to the colonies in October. The birds performed an incredibly fast transit of the central Pacific, during which they did not stop to forage (Shaffer *et al.* 2006). These transit points were thus separated out by selecting all points during April, May and October with a velocity, averaged over the preceding and following 24 hours, of 22 $km.hr^{-1}$, which corresponds to the lower limit of the migration rate given in Shaffer *et al.* (2006). The paths of the tracked birds, outside the range of the foraging areas, were then calculated by assuming a straight line between successive points. The remaining points were used to generate kernel density distributions of foraging areas. To model the post-breeder distribution during the non-breeding season the tracking points were grouped by date. However non-breeders (juveniles, immatures and adults on sabbatical), may have a slightly different migration schedule as they are not constrained by breeding. Harrison (1989) places this species in the northern portion of its range from June to November, and in the south from September to April. Separate distributions were thus produced from the northern and eastern portion of the post-breeders' range, and also from the south-western portion, and were used to model non-breeder distribution during these two periods.

[1] Merged cells indicate where tracks from different phases were pooled
[2] Separate grids were produced for PTT and GLS data, and then combined, weighting them by the number of hours of tracking in each grid - see methods

APPENDIX 2.

Remote tracking data held in the Global Procellariiform Tracking Database for species addressed in this paper.

Species	Site	Annual Breeding Pairs	Global popn (%)	Data submitted: Status (Number of tracks) All tracks are PTT unless otherwise specified.
Antipodean Albatross	Antipodes Is	5,148	41%	Breeding (79 tracks), non-breeding (including post-breeding and juveniles) (33 tracks)
(Gibson's Albatross)	Auckland Is	7,319	59%	Breeding (43 tracks), post-breeding (22 tracks)
Black-browed Albatross	Chile	122,870	20%	Breeding (165 tracks), post-breeding (5 GLS)
	Falkland Is (Malvinas)	380,000	62%	Breeding (206 tracks), post-breeding (1 PTT, 38 GLS), juveniles (3 tracks)
	Iles Kerguelen	4,270	1%	Breeding (26 tracks)
	Macquarie Island	182	0%	Breeding (7 tracks), fledgling (2 tracks)
	South Georgia	100,332	16%	Breeding (365), post-breeding (3 PTT, 49 GLS)
	at-sea deployment			Non-breeding adult (2) and juveniles (6 tracks)
Black-footed Albatross	Midway Atoll	21,830	35%	Non-breeding juvenile (10 tracks)
	Tern Island (FFS)	4,259	7%	Breeding (99), non-breeding (24 GLS, 1 PTT)
	At-sea deployment			Non-breeding adult (20) and immature (13)
Buller's Albatross	Snares Is	8,465	27%	Breeding (180) and non-breeding (including juveniles) (97 PTT, 19 GPS, all during breeding season)
	Solander Is	4,800	15%	Breeding (49 tracks), non-breeding (including post-breeding) (137 tracks, all during breeding season)
Campbell Albatross	Campbell Is	21,000	100%	Breeding (10 tracks)
Chatham Albatross	Chatham Is	4,000	100%	Breeding (16 PTT, 3 GPS), non-breeding (including post-breeding and juveniles) (19)
Grey-headed Albatross	Campbell Island	6,400	6%	Breeding (5 tracks)
	Chile	16,408	15%	Breeding (67 tracks), post-breeding (1 track)
	Macquarie Island	84	0%	Breeding (9 tracks)
	Prince Edward Is	7,717	7%	Breeding (6 tracks)
	South Georgia	61,582	58%	Breeding (299), post-breeding (4 PTT, 22 GLS)
Laysan Albatross	Isla Guadalupe	337	< 1%	Breeding (118 tracks)
	Tern Island (FFS)	3,226	1%	Breeding (105), non-breeding (8 PTT, 28 GLS)
	At-sea deployment			Non-breeding (18 tracks)
Light-mantled Albatross	Macquarie Is	1,250	6%	Breeding (14 tracks)

Species	Site	Annual Breeding Pairs	Global popn (%)	Data submitted: Status (Number of tracks) All tracks are PTT unless otherwise specified.
Northern Royal Albatross	Chatham Is	2,060	99%	Breeding (28 tracks), post-breeding (15 tracks)
	Taiaroa Head	18	1%	Breeding (3 PTT, 50 GPS), non-breeding (including post-breeding and juveniles) (16)
Short-tailed Albatross	Torishima	325	84%	Breeding (8), post-breeding (14), juvenile (1)
	at-sea deployment			Non-breeding adult (3) and juvenile (6 tracks)
Shy Albatross	Albatross Island	5,128	40%	Breeding (58), juvenile (3), fledgling (10)
	Mewstone	7,358	58%	Breeding (2), failed (3), fledgling (11)
	Pedra Branca	268	2%	Breeding (4), failed (2), fledgling (5)
Southern Royal Albatross	Campbell Is	8,400	99%	Breeding (7 tracks)
Wandering Albatross	Iles Crozet	2,062	26%	Breeding (204 tracks)
	Iles Kerguelen	1,094	14%	Breeding (11 tracks)
	Macquarie Island	11	< 1%	Breeding (4 tracks), fledgling (2), immature (2)
	Prince Edward Is	2,707	34%	Breeding (20 tracks), post-breeding (3 tracks)
	South Georgia	2,001	25%	Breeding (222 PTT, 66 GPS), post-breeding (4)
	At-sea deployment			Non-breeding (5 tracks)
Northern Giant Petrel	Macquarie Is	950	9%	Breeding (4 tracks), fledgling (5 tracks)
Southern Giant Petrel	Argentina	2,542	5%	Breeding (16 tracks), non-breeding adult (6) and juvenile (4)
	Macquarie Is	2,150	5%	Breeding (6 tracks), juvenile/fledgling (7)
	South Georgia	4,654	10%	Breeding (11 PTT, 127 GLS), non-breeding (55 GLS)
Westland Petrel	Punakaiki	2,000	100%	Breeding (20 tracks)
Short-tailed Shearwater	Australia (French Is , Montague Is)	15,600	?%	Breeding (4 tracks)
Sooty Shearwater	New Zealand (Codfish, Mana)	?	?%	Breeding (32 GLS) non-breeding (25 GLS)

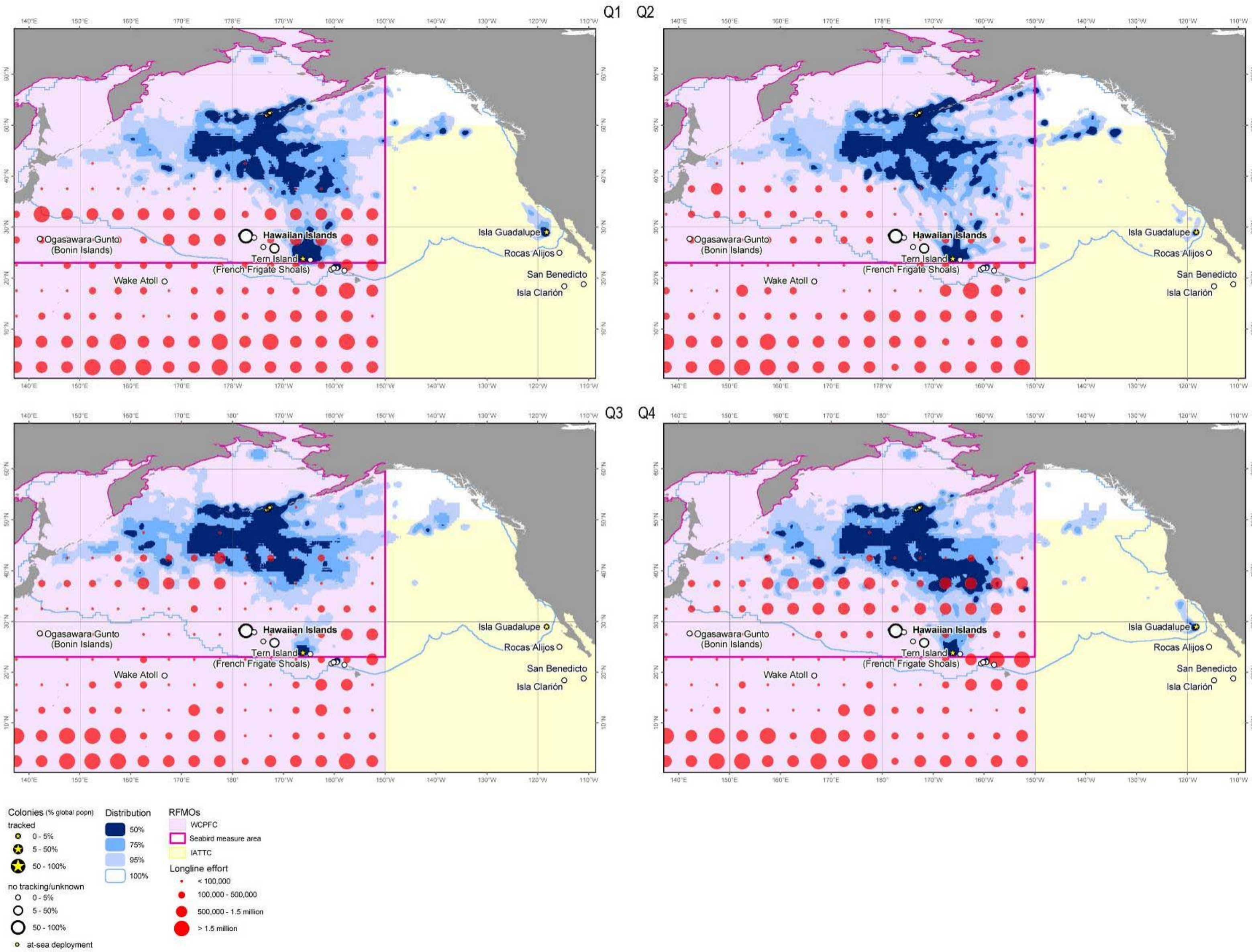

Figure 1. Laysan Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown

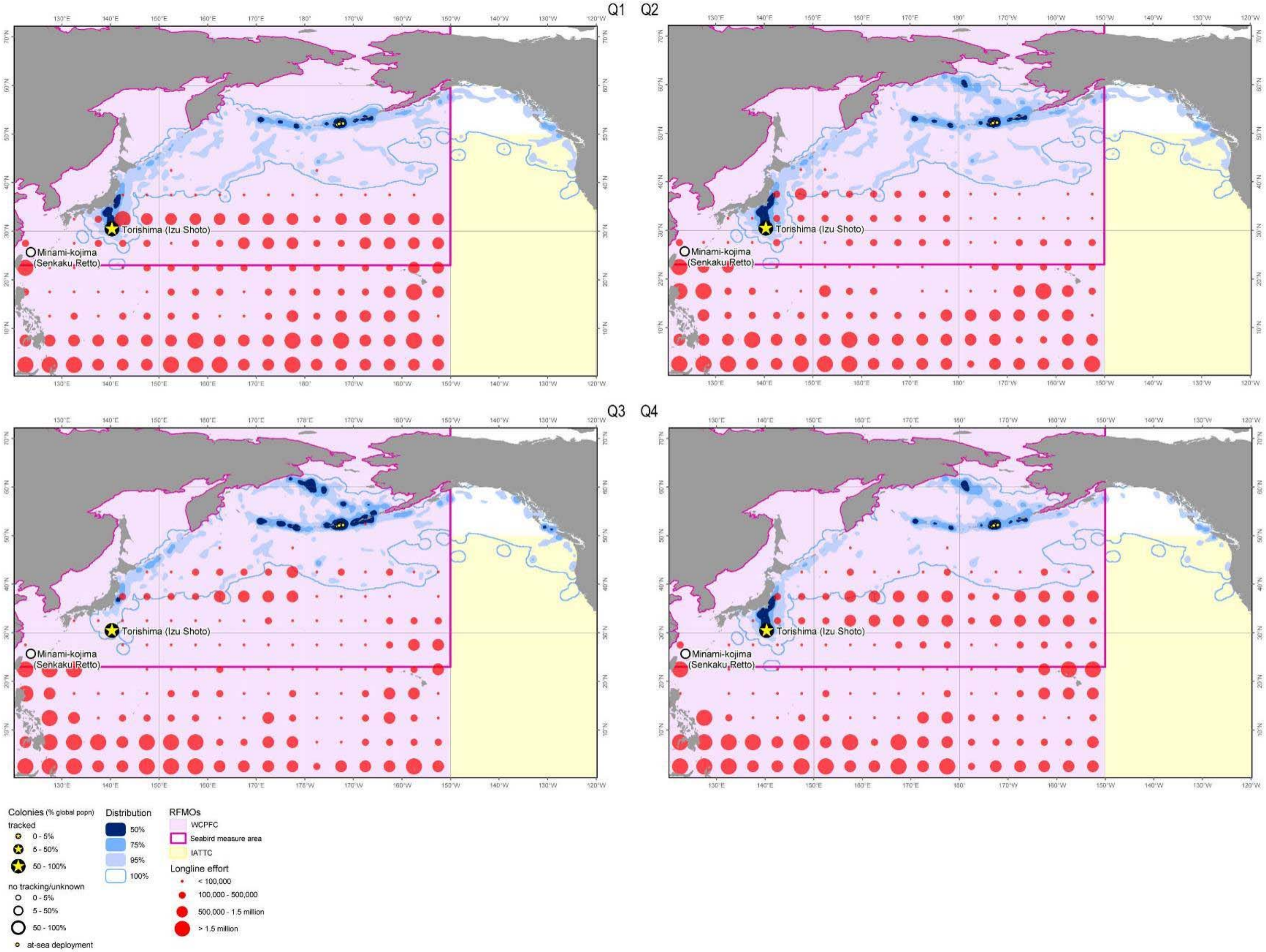

Figure 2. Short-tailed Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

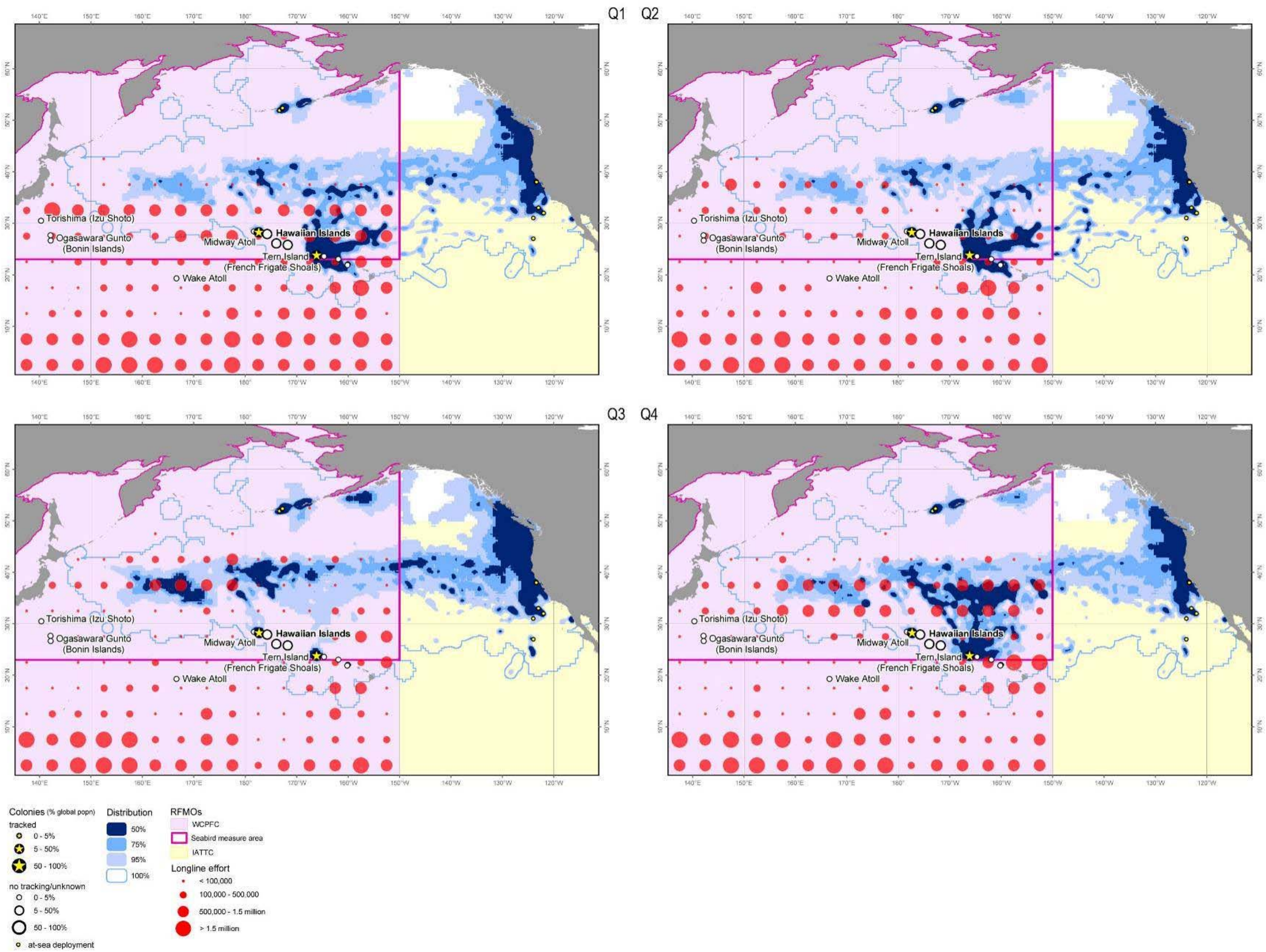

Figure 3. Black-footed Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

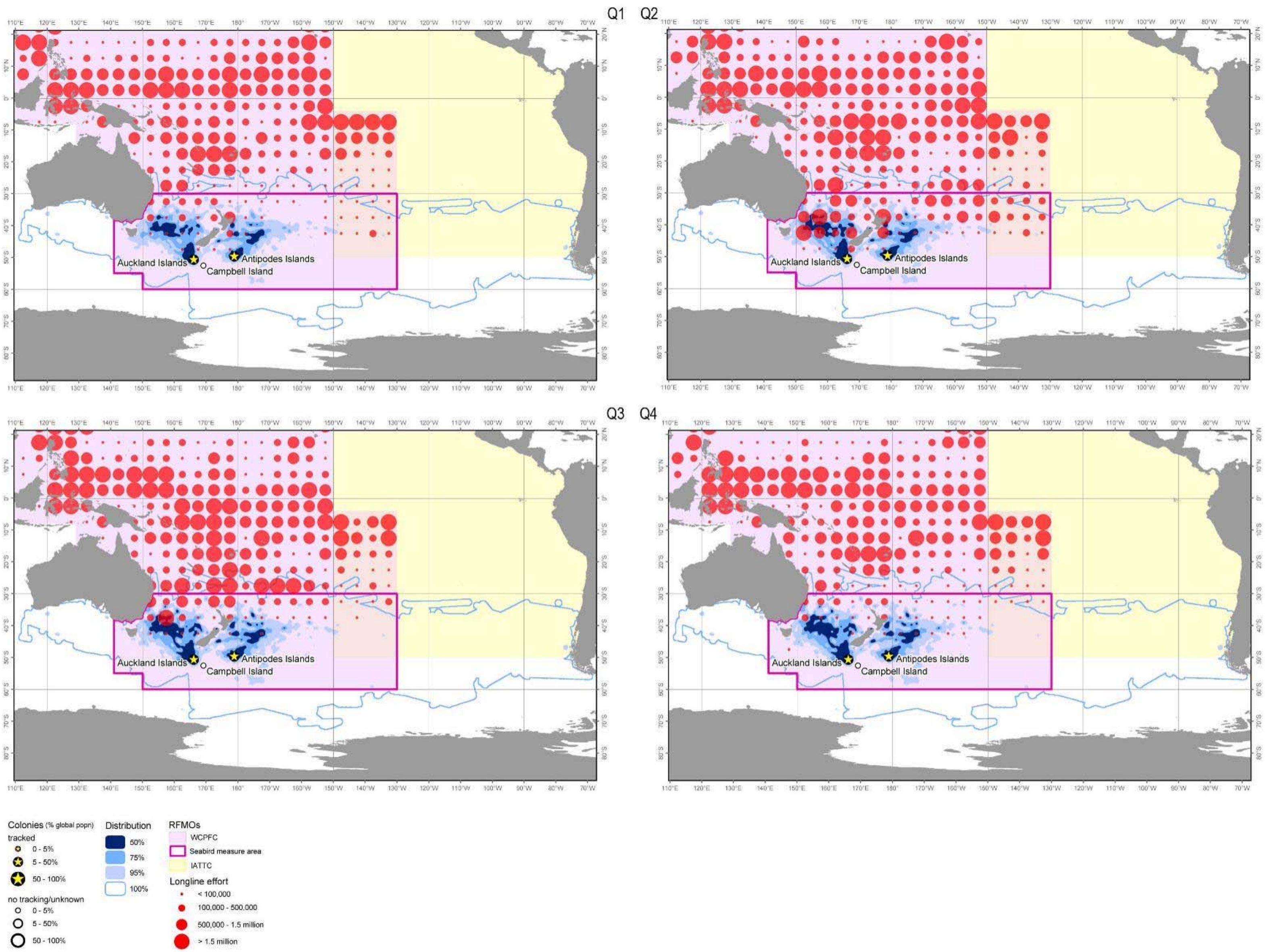

Figure 4. Antipodean Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

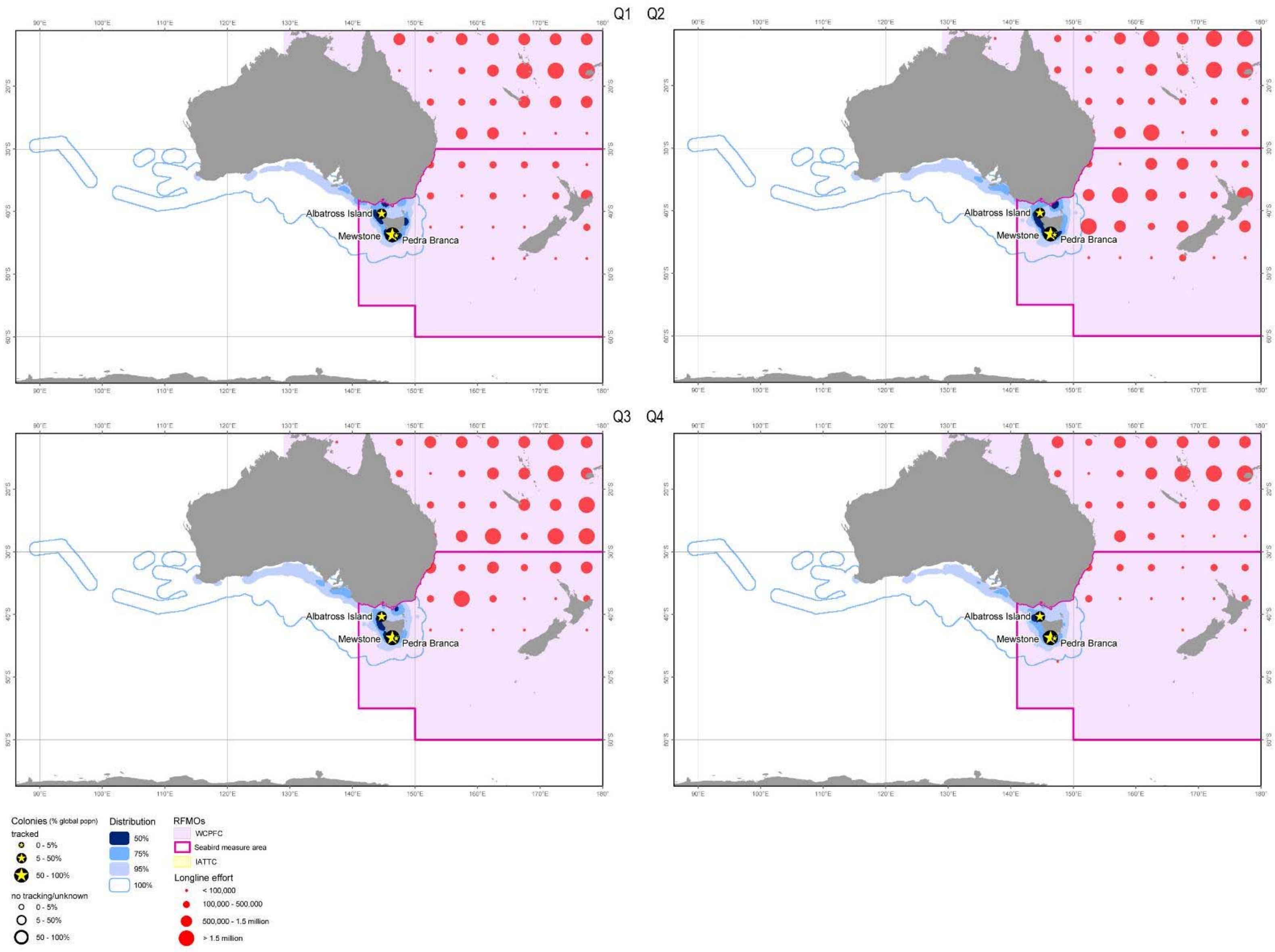

Figure 5. Shy Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

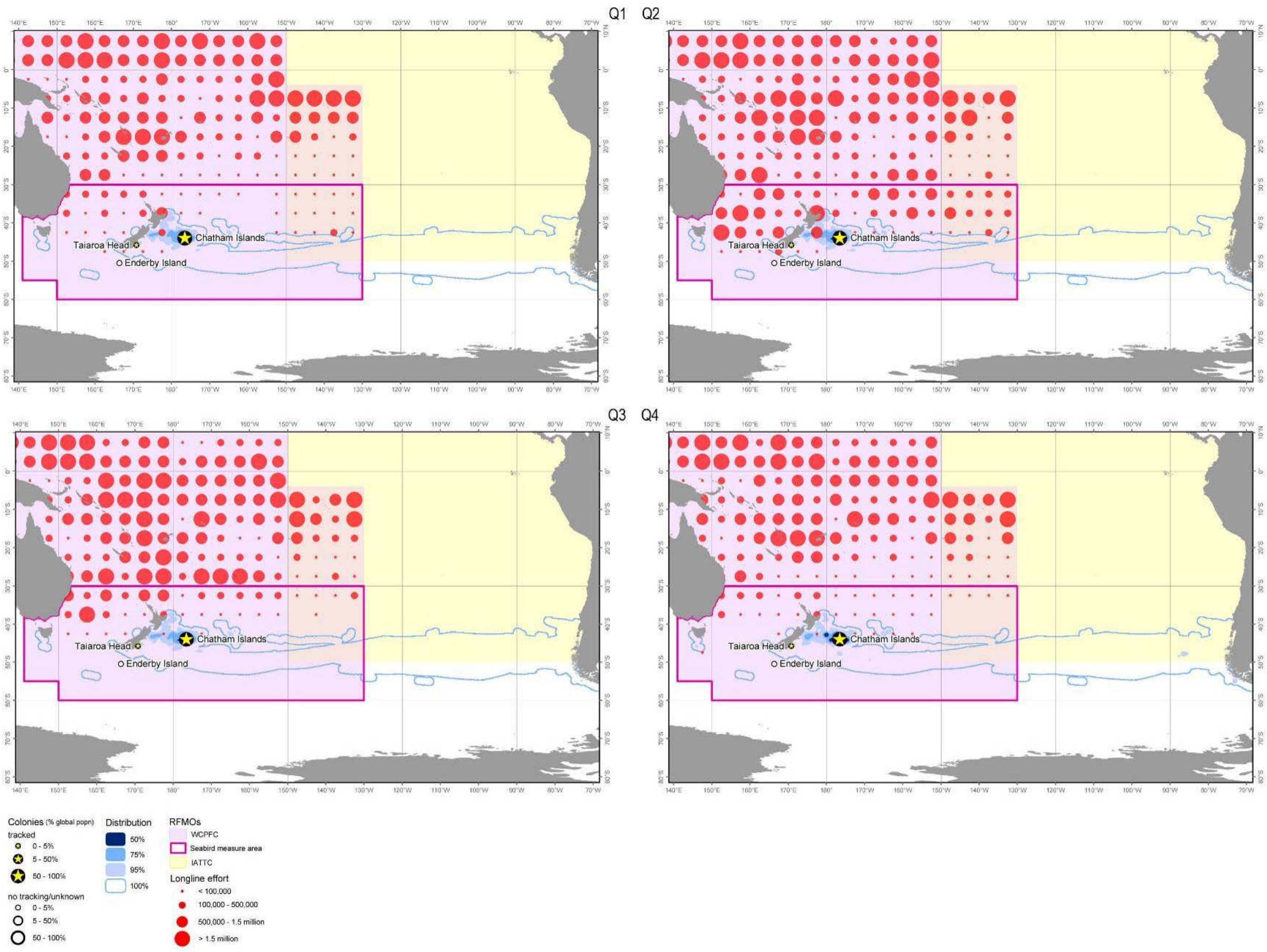

Figure 6. Northern Royal Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

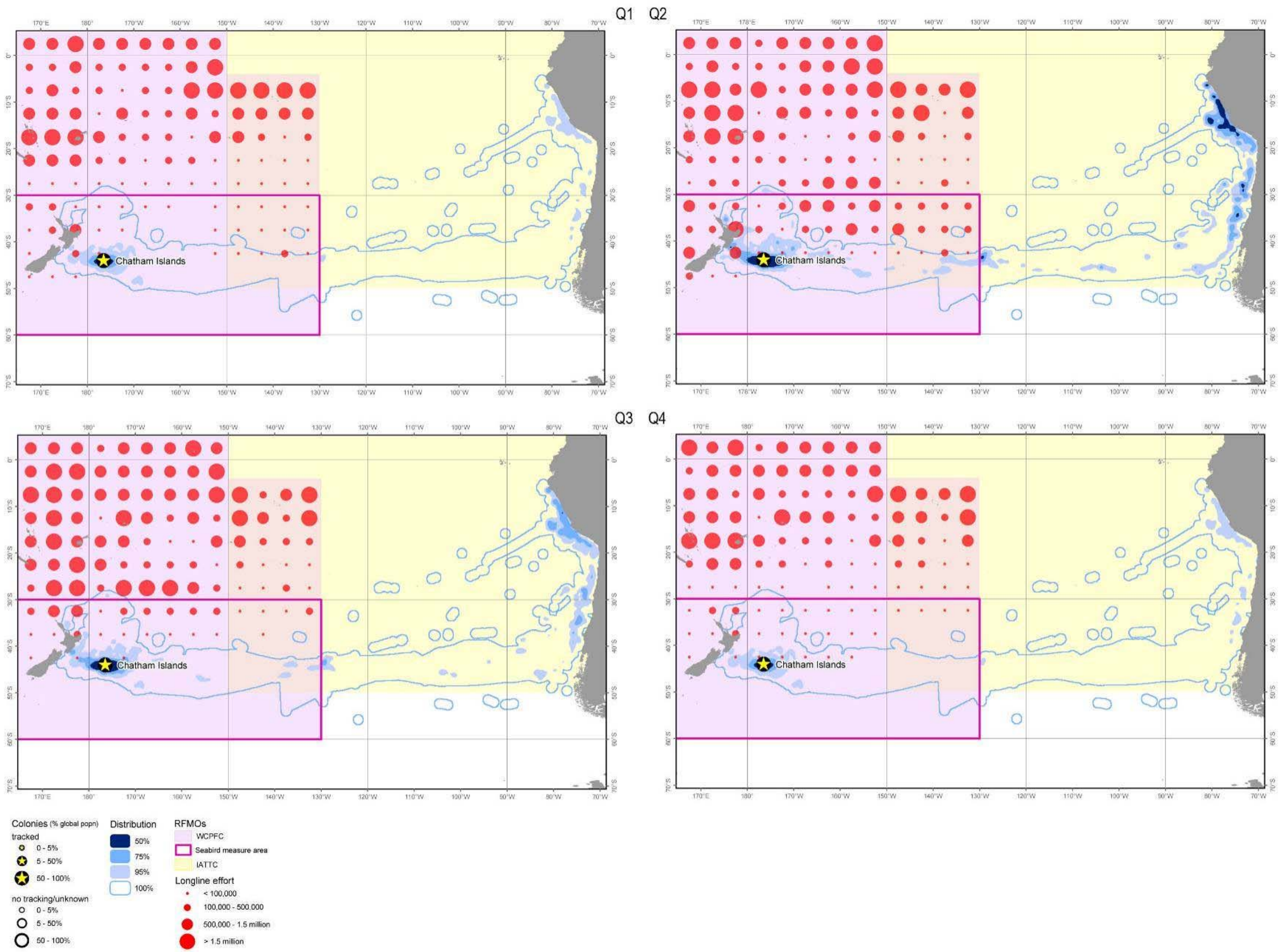

Figure 7. Chatham Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown

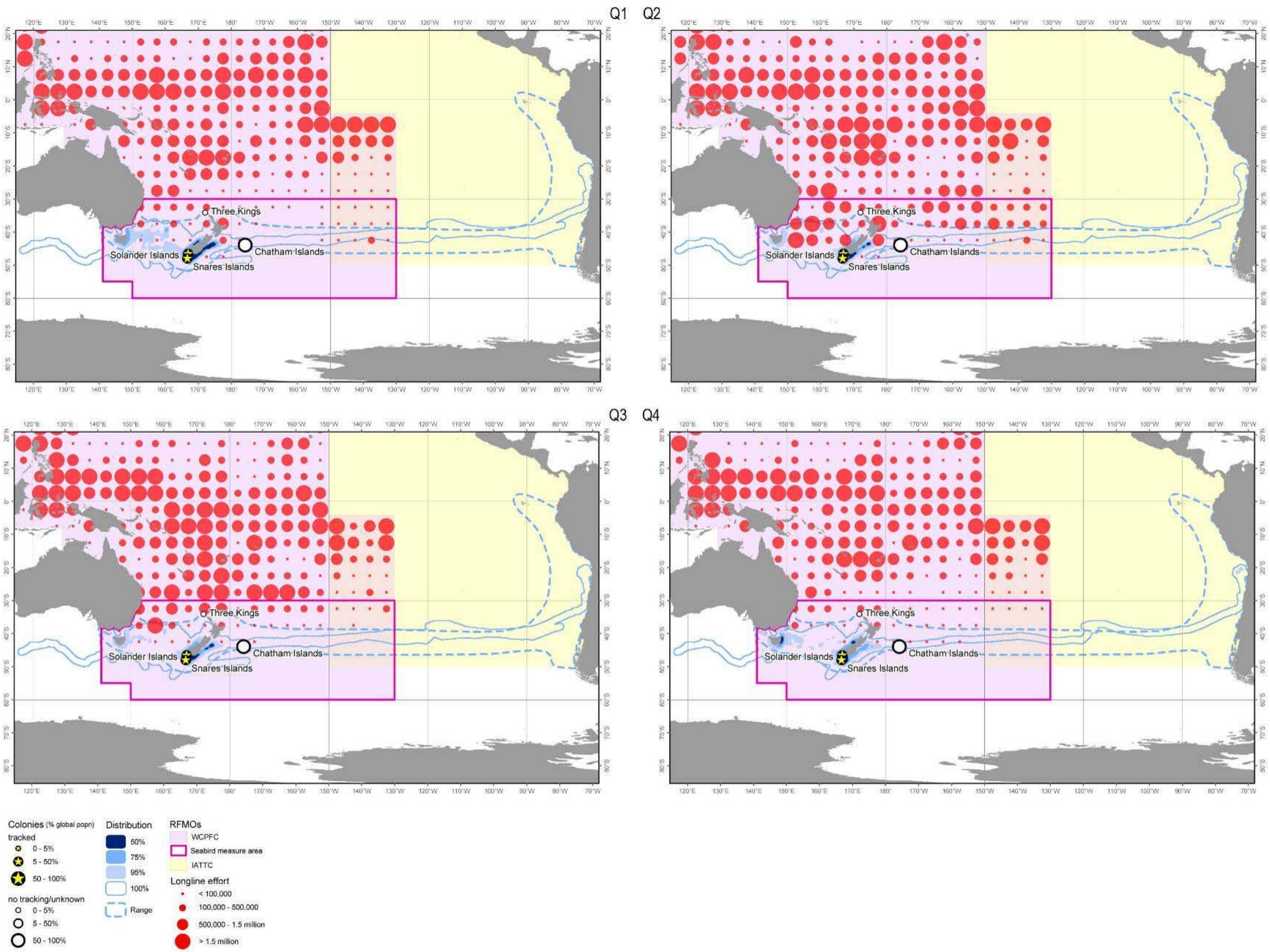

Figure 8. Buller's Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds, and full range (estimated from other sources) is shown for comparison. The seabird measures area is also shown.

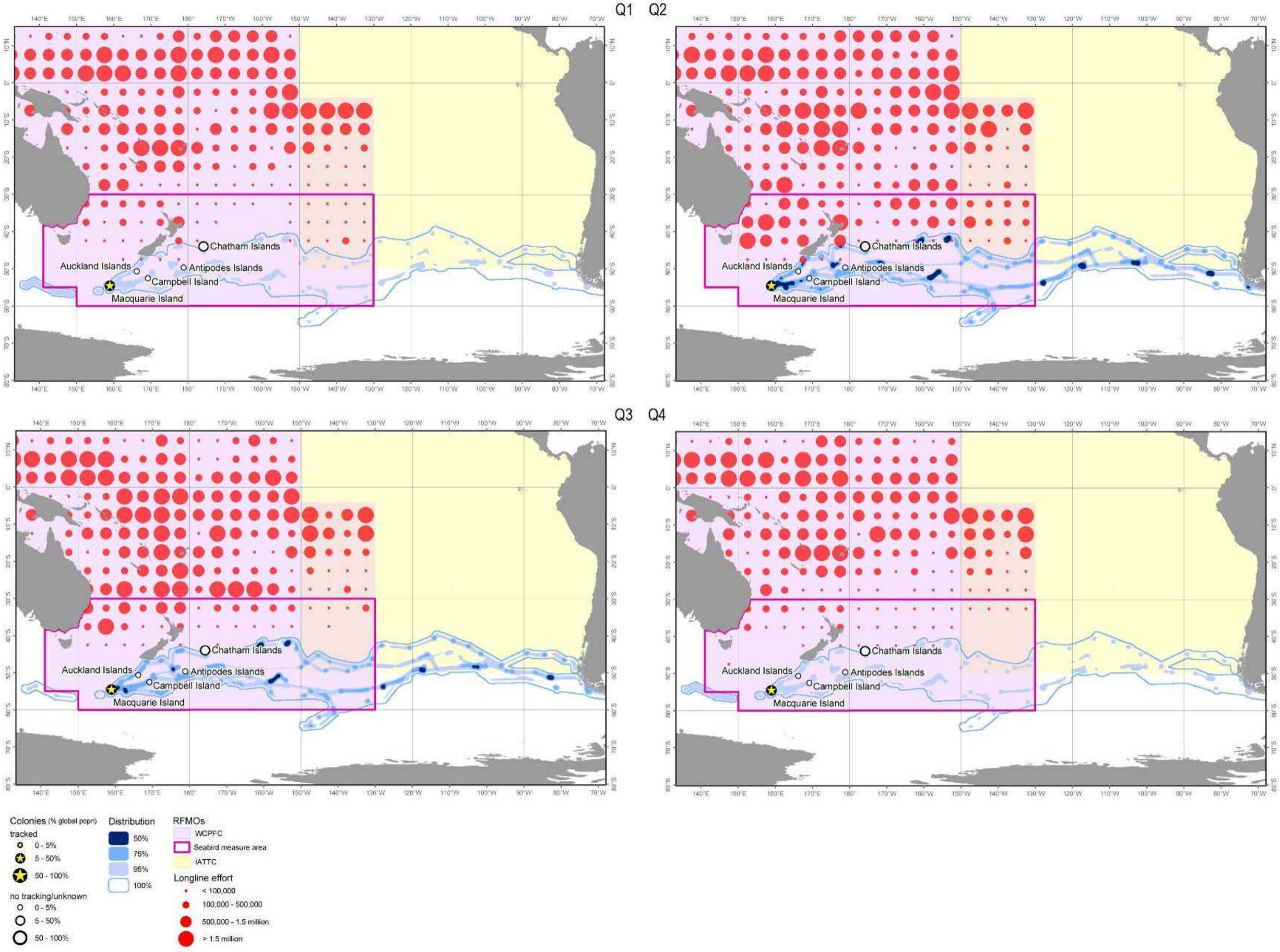

Figure 9. Northern Giant Petrel distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

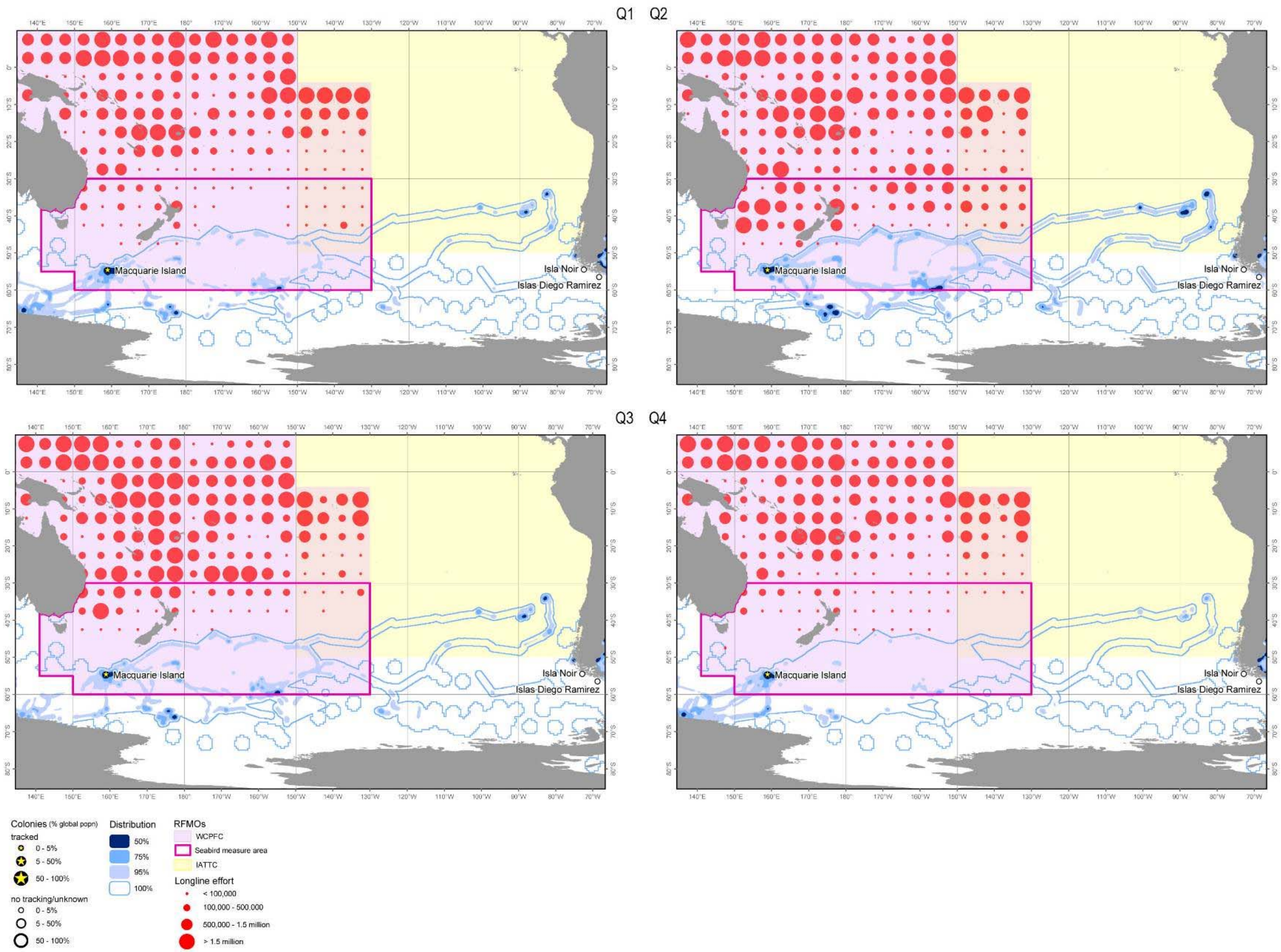

Figure 10. Southern Giant Petrel distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown

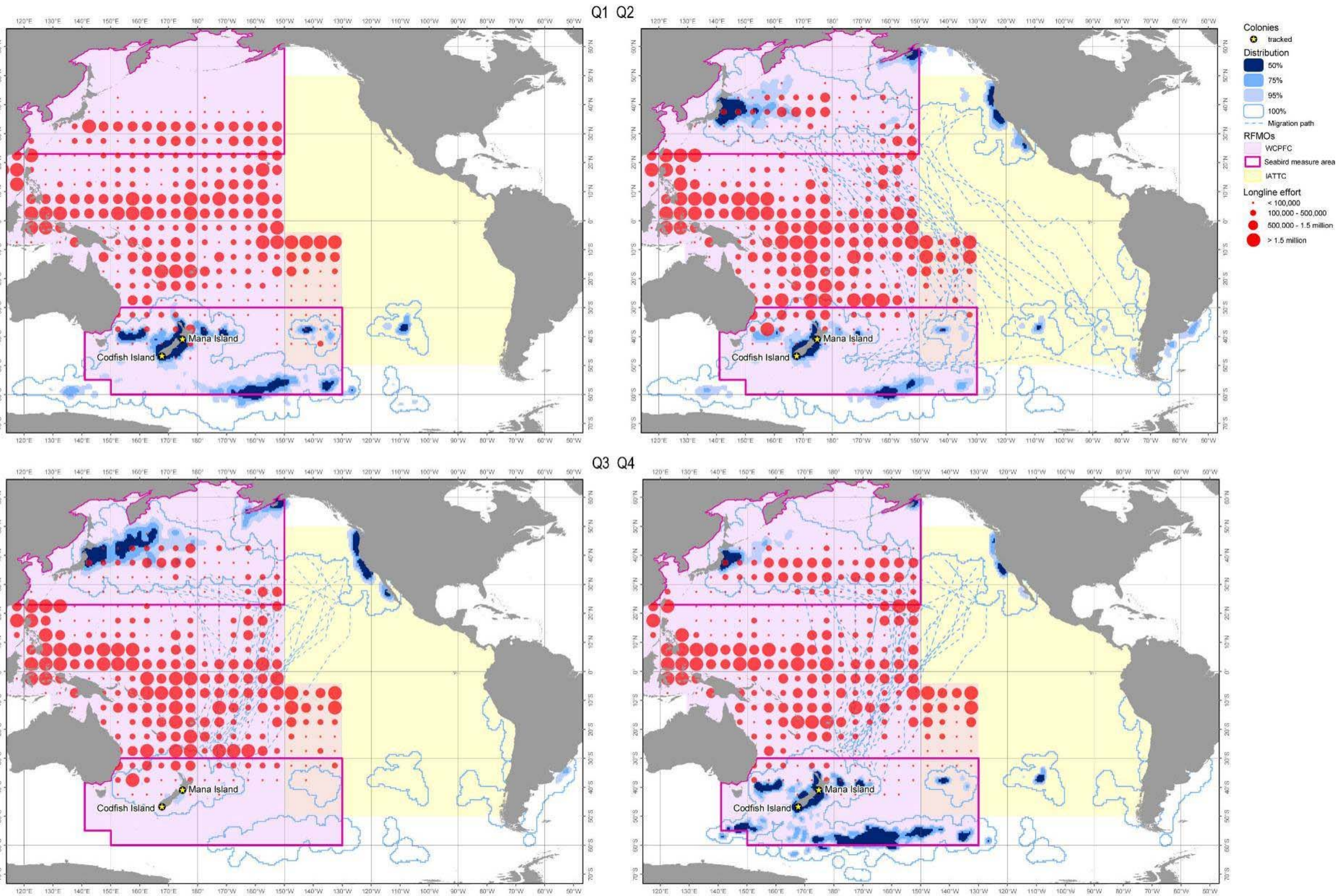

Figure 11. Sooty Shearwater distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds, and migration paths are shown as dotted lines. The seabird measures area is also shown.

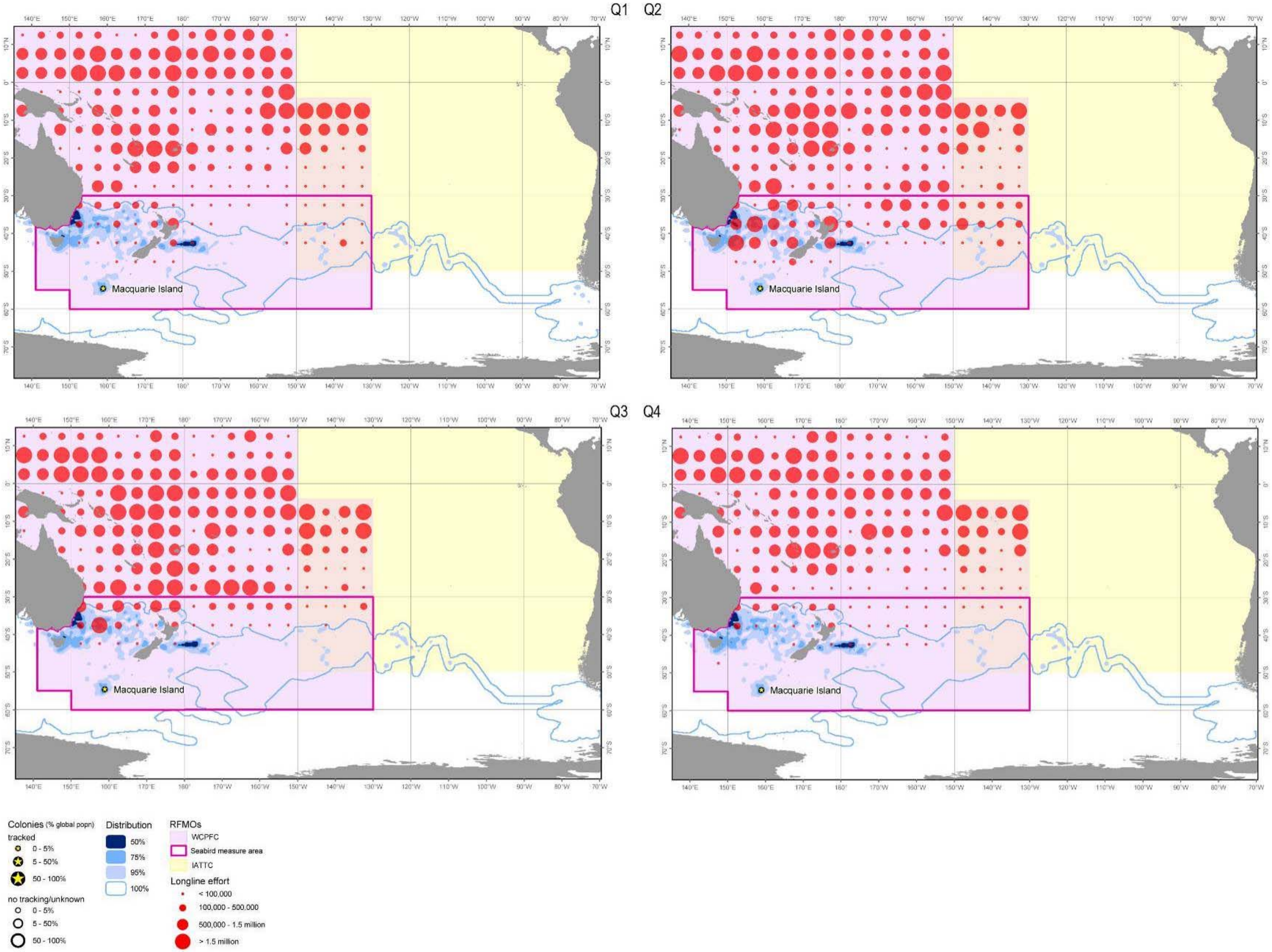

Figure 12. Wandering Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

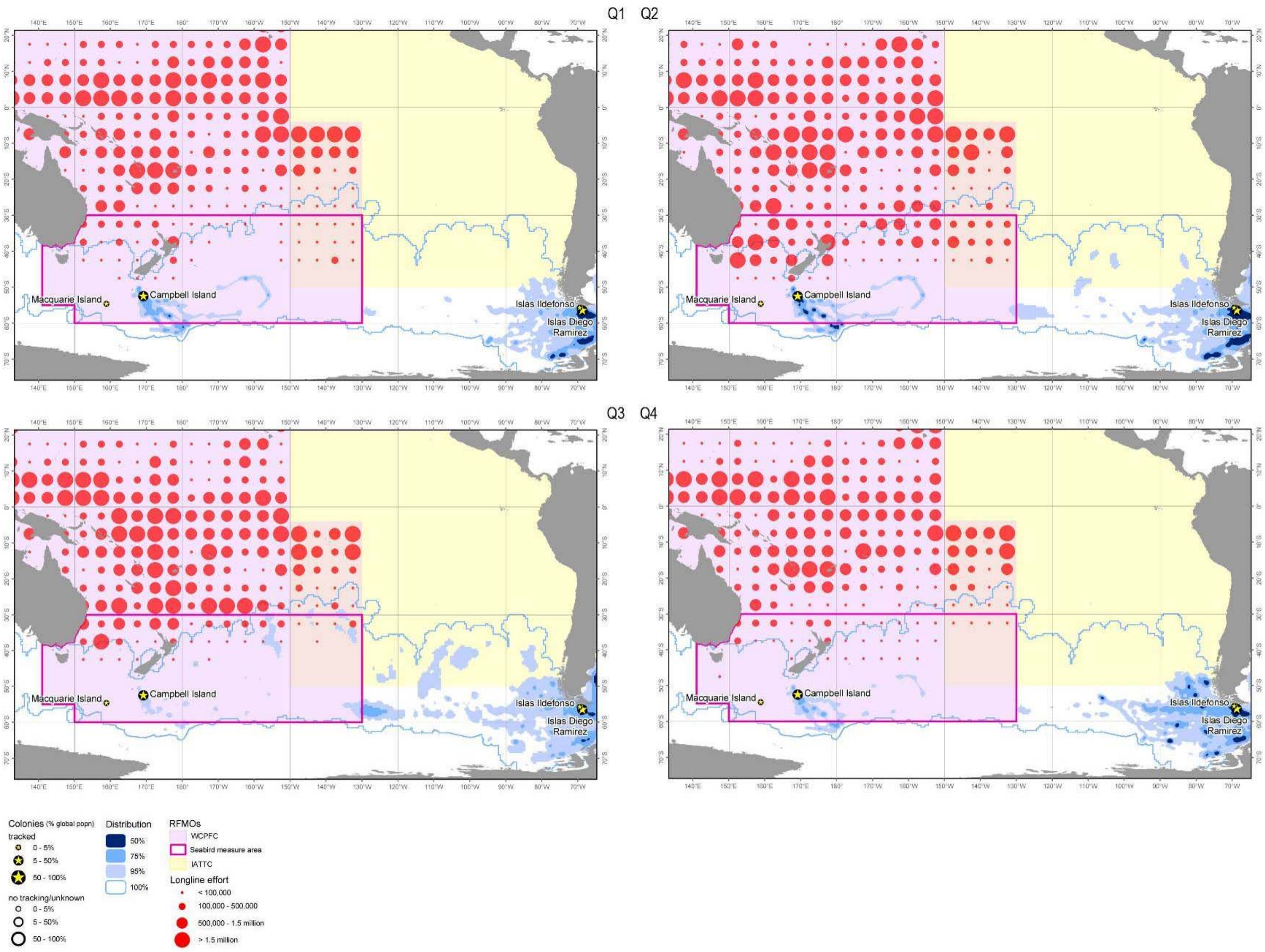

Figure 13. Grey-headed Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

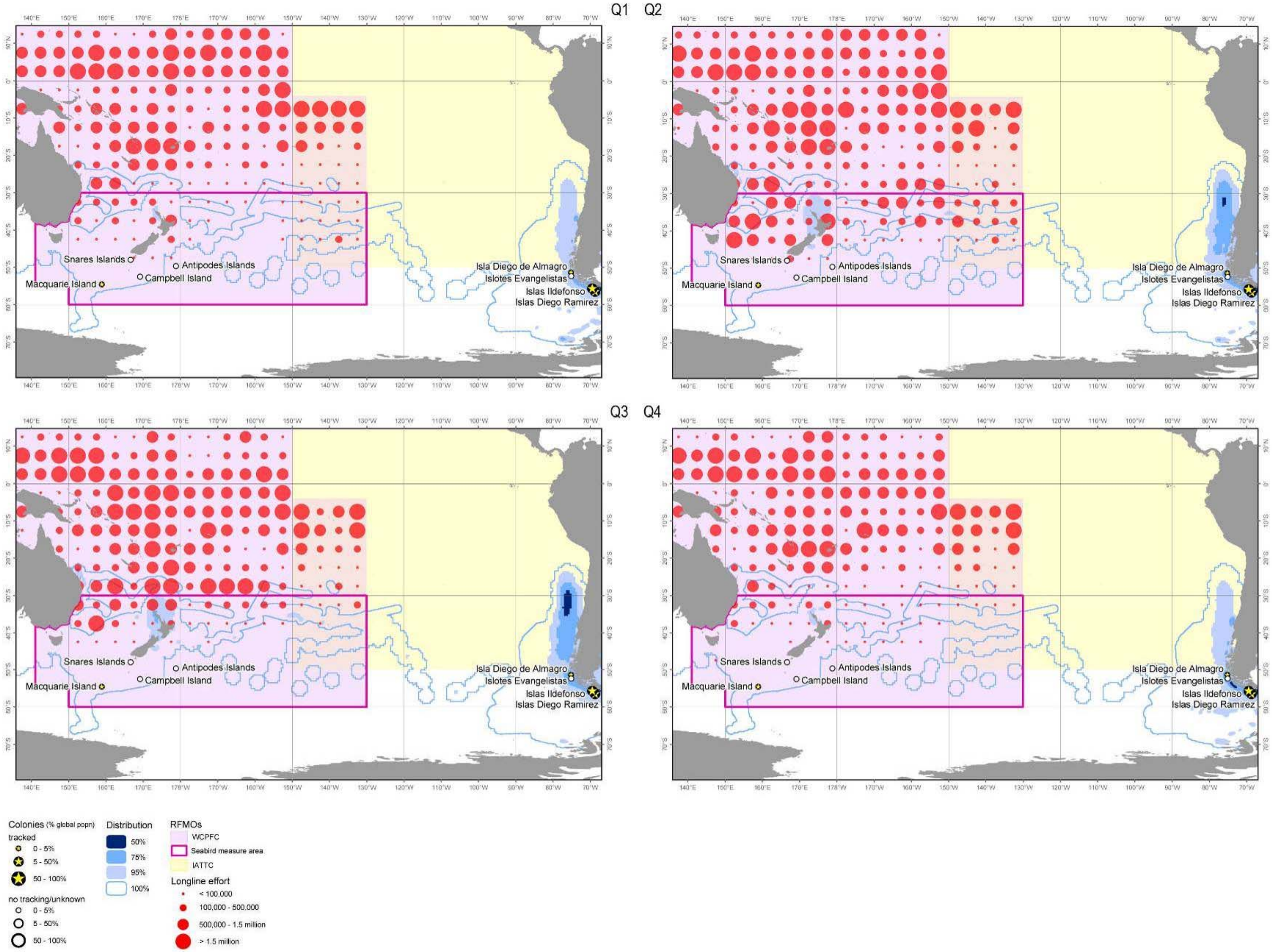

Figure 14. Black-browed Albatross distribution in the WCPFC area by year quarter (Q1=Jan-Mar, Q2=Apr-Jun, Q3=July-Sep, Q4=Oct-Dec), and overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year). Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds. The seabird measures area is also shown.

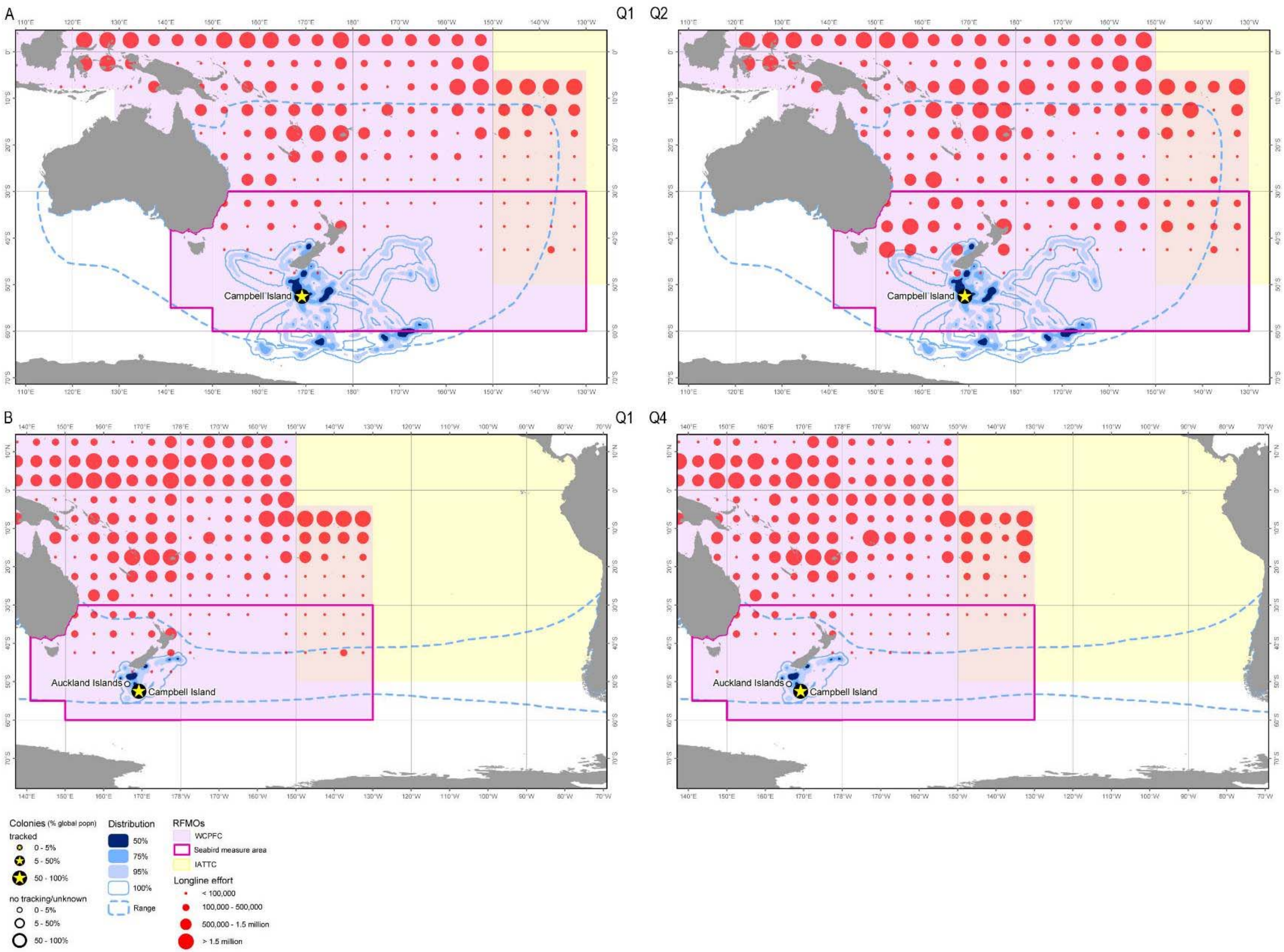

Figure 15. Breeding distribution and range maps of albatross species for which limited breeding and no non-breeding data are held in the database, and their overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year) during the relevant sections of the breeding season. Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds, and full range (estimated from other sources) is shown for comparison. The seabird measures area is also shown.. A = Campbell Albatross and B = Southern Royal Albatross.

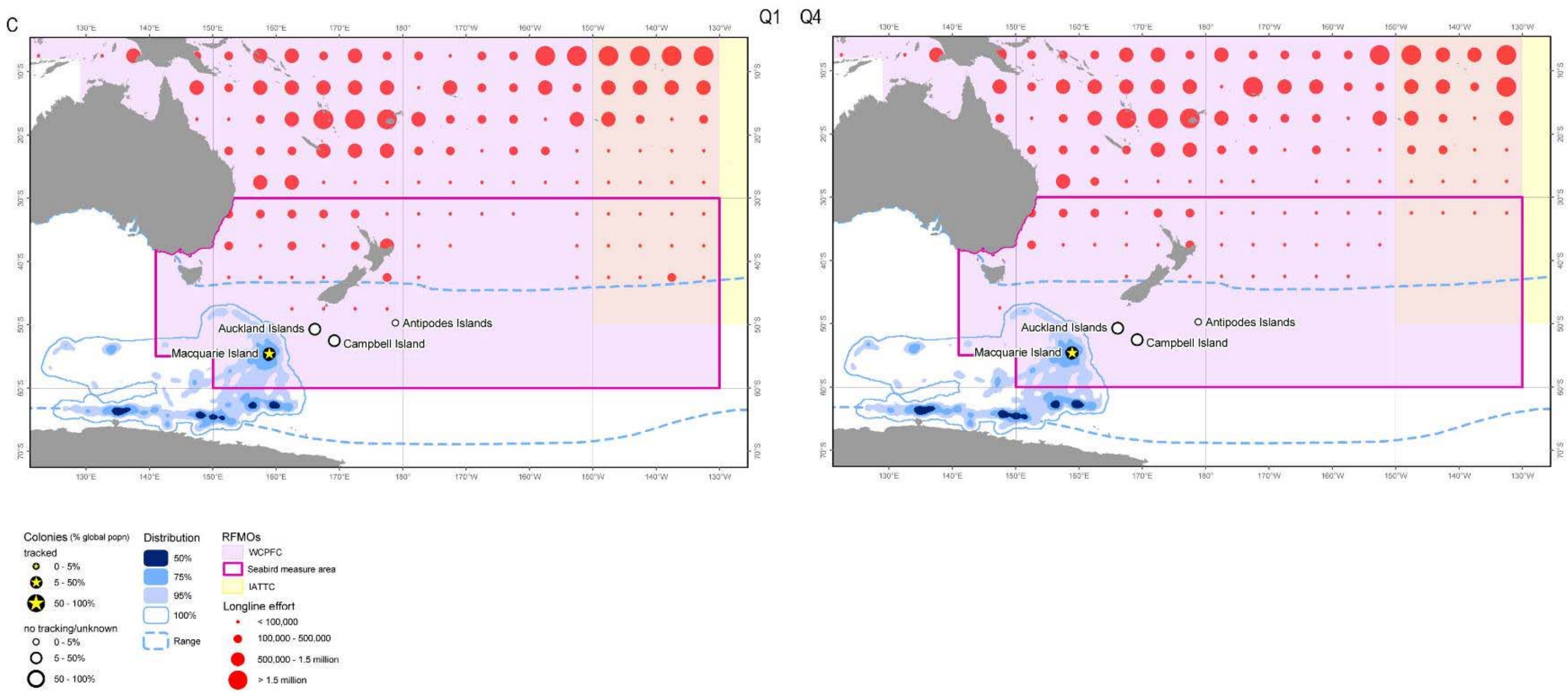

Figure 15 cont. Breeding distribution and range maps of albatross species for which limited breeding and no non-breeding data are held in the database, and their overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year) during the relevant sections of the breeding season. Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds, and full range (estimated from other sources) is shown for comparison. The seabird measures area is also shown.. C = Light-mantled Albatross

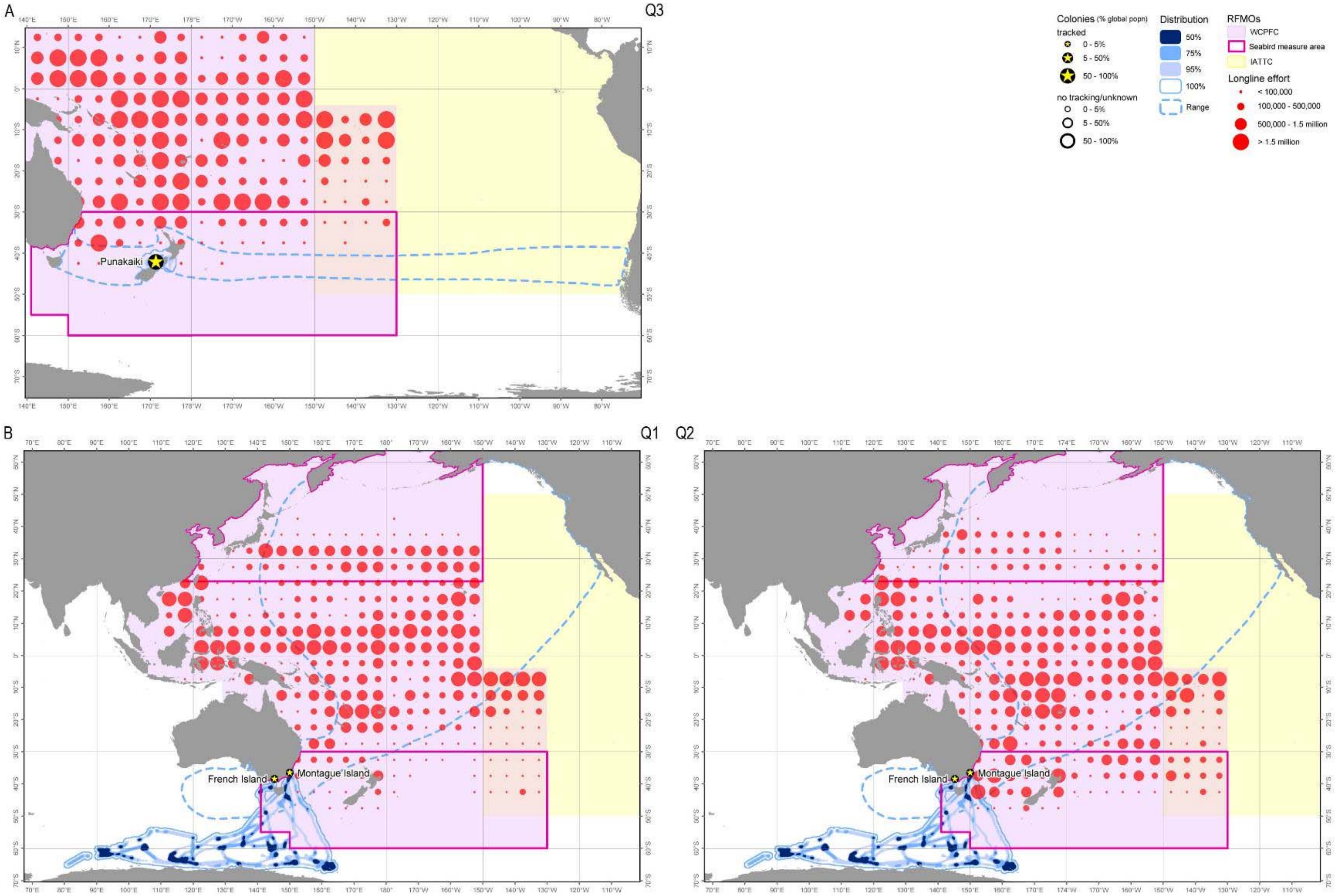

Figure 16. Breeding distribution and range maps of petrel and shearwater species for which limited breeding and no non-breeding data are held in the database, and their overlap with WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per quarter per year) during the relevant sections of the breeding season. Highest densities of bird distribution are shown in dark blue. The 100% contour indicates the full extent of the distribution of tracked birds, and full range (estimated from other sources) is shown for comparison. The seabird measures area is also shown.. A = Westland Petrel and B = Short-tailed Shearwater.

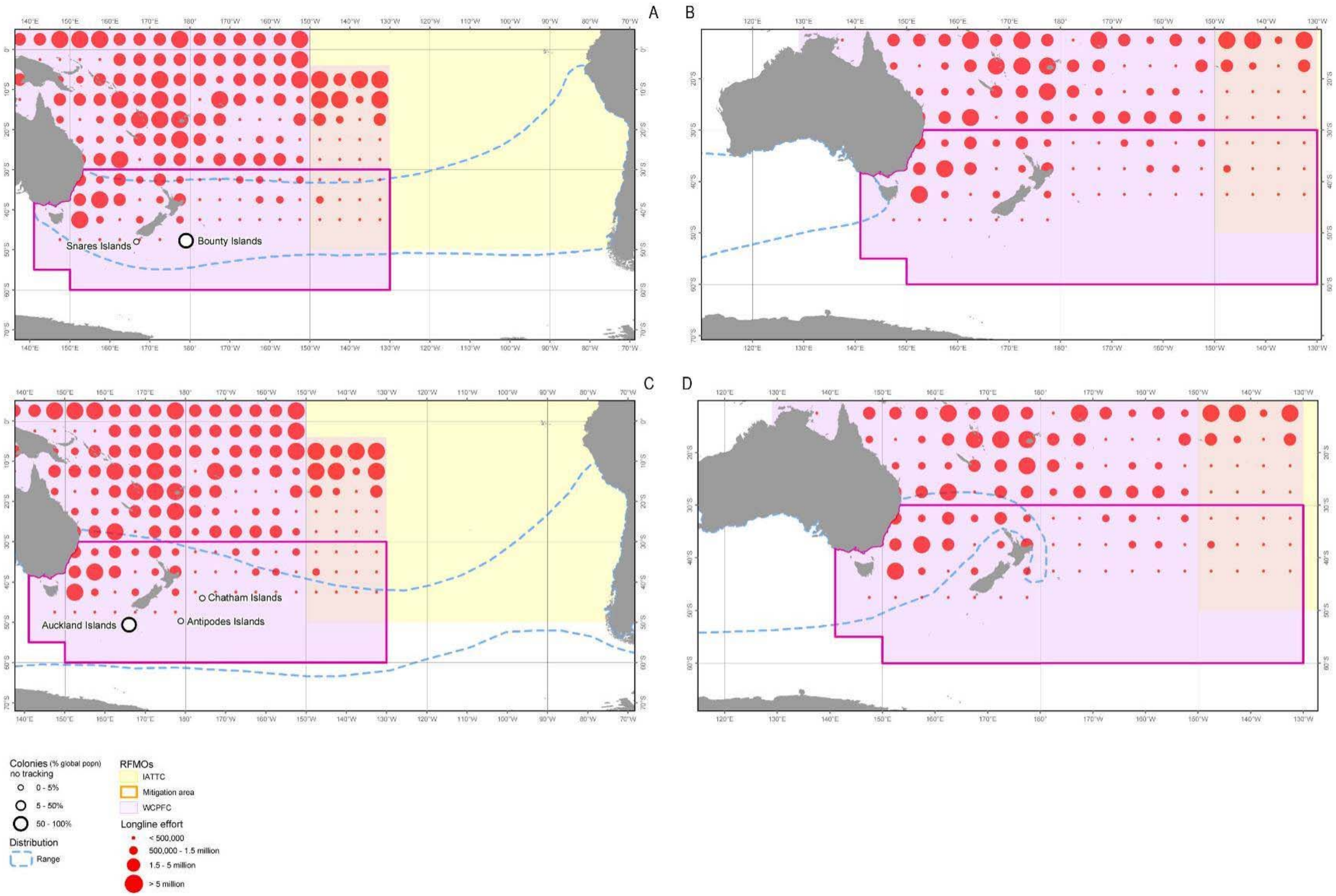

Figure 17. Range maps of albatross species for which no relevant tracking data are held in the database, and their overlap with the WCPFC area and WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per year). A = Salvin's Albatross, B = Sooty Albatross, C = White-capped Albatross and D = Indian Yellow-nosed Albatross.

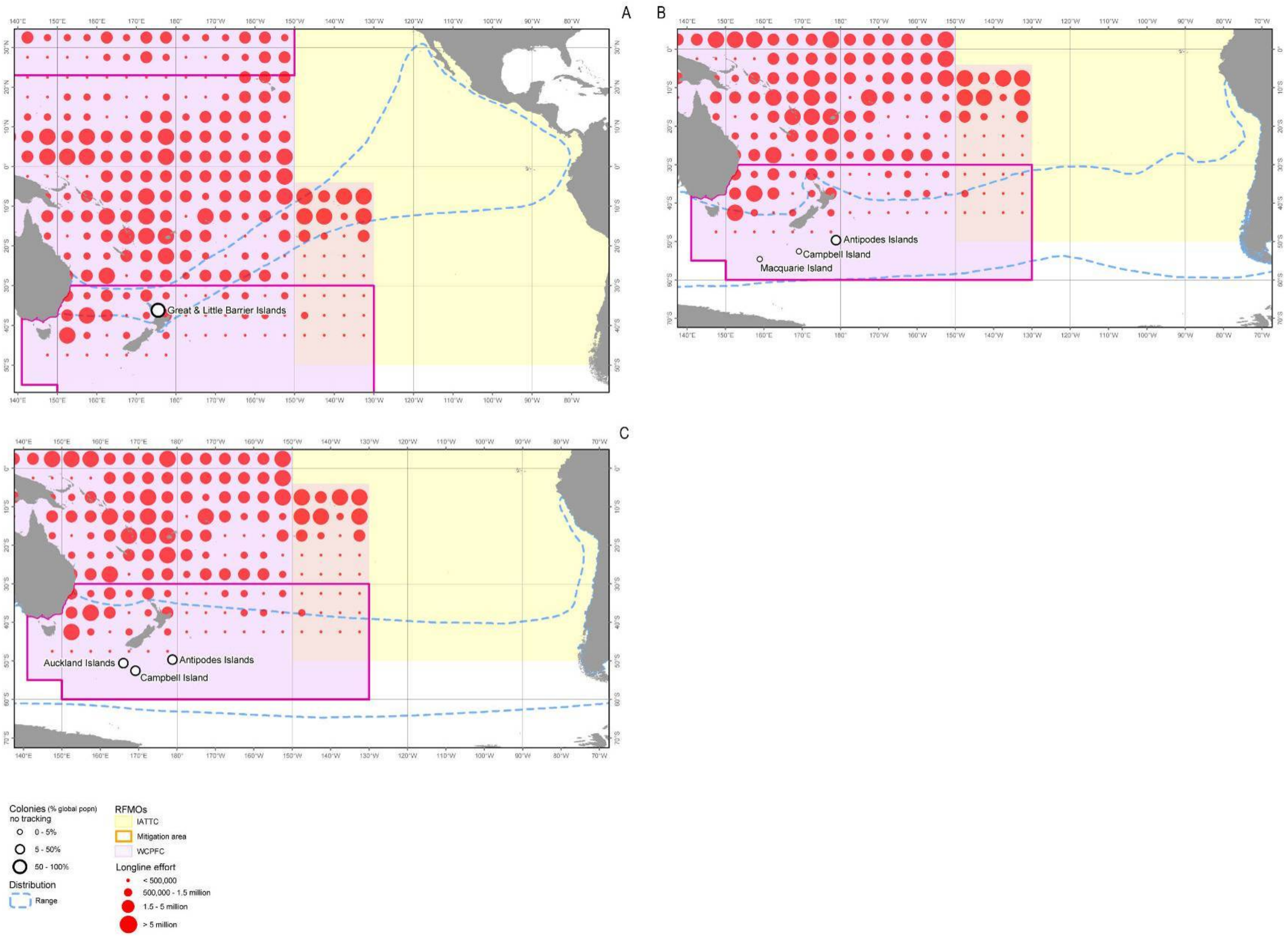

Figure 18. Range maps of petrel species listed under ACAP for which no relevant tracking data are held in the database, and their overlap with the WCPFC area and WCPFC longline fishing effort 2000-2005 (average number of hooks set per 5° grid square per year). A = Black Petrel, B = Grey Petrel and C = White-chinned Petrel