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Overlap between WCPFC longline fishing effort and albatross distribution in the North Pacific

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Overlap between WCPFC longline fishing effort and albatross distribution in the North Pacific

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Abstract

This paper estimates spatial and temporal overlap between the distribution of North Pacific albatrosses and Western Central Pacific Fisheries Commission (WCPFC) longline fishing effort, highlighting areas and seasons of overlap where there is a higher risk of seabird bycatch. The results highlight the importance of the WCPFC area for all the three albatross species, and their widespread use of high seas areas, in particular the Laysan and the black-footed albatrosses. Black-footed albatross has the highest overlap score. Short-tailed albatross has a more northerly distribution, but overlap occurs in the North West Pacific during the breeding season.

1. Introduction

Seventeen of the 22 albatross species are globally threatened with extinction, with the major threat to most species recognised as incidental mortality particularly in longline fisheries (Brothers 1991, Robertson & Gales 1998, Croxall et al. 1998, Baker et al 2002, Anderson et al. 2011). Overlap analyses of albatross distribution and fishing effort have been used to highlight the potential risk to albatrosses from bycatch in fisheries (Taylor et al. 2009, Birdlife International 2010), particularly in areas for which few data on seabird bycatch are available. With the exception of data reported from fisheries around Hawaii, few seabird bycatch data are available from pelagic longline fleets in the North Pacific.

In the WCPFC, seabird bycatch mitigation requirements are different for the Northwest and Southwest Pacific, following adoption of an updated measure for the Southwest Pacific in December 2012 (WCPFC 2012).

Our purpose in undertaking this overlap analysis is to investigate the areas utilised by the three albatross species which occur in the WCPFC area in the North Pacific and the overlap with fishing effort.

2. Methods

2.1 Data availability

Just three species of albatrosses overlap with longline fisheries in the WCPFC region of the North Pacific: short-tailed albatross *Phoebastria albatrus* (Vulnerable), Laysan albatross *Phoebastria immutabilis* (Near Threatened) and black-footed albatross *Phoebastria nigripes* (Vulnerable). These birds also breed within the WCPFC area of the North Pacific. Remote tracking data are available for all three species, and have been submitted to the Global Procellariiform Tracking Database (www.seabirdtracking.org). However, tracking data are not available for all colonies or breeding states and caution is required in interpreting the kernel density distributions where data is not available. Laysan albatrosses breed on islands across the tropical/subtropical north Pacific, particularly on islands in the Hawaiian chain; however tracking data are only available for birds from Tern Island (French Frigate Shoals) in Hawaii and not from the main colonies on Midway Atoll and Laysan Island. In addition, for Laysan albatross breeding on Isla Guadalupe, Mexico, data were only available for breeding birds. However, since this population probably constitutes less than 1% of the global population (ACAP, 2010) and also because its distribution during the breeding period is mostly restricted to the Eastern Pacific, primarily in the California Current region and outside the WCPFC area (Arata et al 2009), we have excluded it from the analysis. Table 1 summarises the species and colonies for which tracking data were available.

2.2 Seasonal variation

Albatross distribution is often very different depending on the breeding cycle and life stage of the bird. During chick rearing, birds will often forage closer to the breeding colony in order to provision chicks, while juveniles or non-breeding adults do not need to remain close to the breeding colony and can forage where they can achieve optimal foraging efficiency, much further afield. Analyses of overlap with fisheries need to take into account this seasonal variation, particularly as longline fishing effort also varies seasonally.

To make comparison of albatross distribution and fishing effort easier, maps have been produced of total distribution of each of the three species by season (year quarter) rather than breeding and non-breeding distributions. Differences in breeding distribution between years has been shown to be insubstantial compared to differences 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. 2004).

2.3 Data processing and calculation of density distributions

PTT and GLS data were first filtered in order to remove unrealistic positions (using the *argosfilter* R package, for PTT data, and following the procedures described in Phillips et al. 2004, for GLS data). PTT data were also re-sampled at hourly intervals, assuming that birds travel at a constant speed in a straight line between uplinks (McConnell et al. 1992 and Birdlife International 2004).

Bird tracks were then grouped into datasets that represent unique combinations of species/colony breeding stage/year quarter, as far as data availability allowed.

Kernel density distributions were derived from these datasets (using a projection in a Lambert Azimuthal Equal area coordinated system), using the *kernelUD* function in R (package *adehabitat*). The smoothing (*h*) parameter was set as 110000 for GLS data and 55000 for GPS or PTT data. Data points were not separated into 'commuting' or 'foraging' points; it was assumed that all locations represent areas where there is potential interaction with fisheries. A raster map (0.1x0.1^{o} resolution) with the relative probability of occurrence per cell was created for each dataset described above. Whenever data from more than one colony or one breeding stage were available for each species in each quarter, the maps were combined to produce a single map per species/year quarter. The relative contribution of each colony to the final species/quarter map was weighed by the proportion of the breeding population in that colony. Similarly, the relative contribution of each breeding stage to the final maps was based on its duration within each quarter.

The final raster maps were then converted to density distribution maps (representing the 50, 75, 90 and 100% Utilisation Distributions (UD), which indicates the areas where 50, 75, 90 and 100% of the species' time is spent during that quarter.

2.4 Overlap of bird distributions with WCPFC longline fishing effort

Longline fishing effort data is available on the WCPFC web site and we used data for the most recent five-year period available 2006-2010. Longline effort data were available for 5X5^{o} grid cells by month, except where effort constitutes less than the equivalent of two vessels (in these cases, data are not available in the public domain and are filtered out). Available effort data were calculated as the average number of hooks set per grid square per year quarter for 2006 - 2010. Overlap calculations were made based on formulas developed by the ICCAT Sub-Committee on Ecosystems (Birdlife International 2010) as follows:

Overlap Score 1: Percent seabird population distribution within the area of WCPFC geographical area;

Overlap Score 2: Percent seabird population distribution per 5X5^{o} grid square multiplied by the average longline hooks set within each 5X5^{o}, per year quarter.

The percentage of the distribution of the species (100% kernel) within EEZs was also calculated for each species and year quarter.

All the statistical analyses, including the areas estimates, were conducted in R (R Development Core Team 2010). Final maps were created in ArcGIS 8.2.

3. Results

The remote tracking data enabled us to calculate seasonal distribution of the three species of albatrosses with longline fishing effort. Maps of the distribution and overlap with WCPFC longline fishing effort by quarter year are shown in **Figures 1-3.** Results of the overlap calculations including percentage distribution within Exclusive Economic Zones (EEZs) are shown in **Table 2.**

Short-tailed and Laysan albatrosses had extremely high overlap with the WCPFC geographical area (**Figures 1-3; Overlap score 1 in Table 2**). For each quarter, 70-100% of the population occurred within the WCPFC area, and was especially high in the first two quarters when birds are rearing chicks. Black-footed albatross distribution in the WCPFC area was also high (49-63%) but lower than the other two species because its distribution extends further east into the Inter American Tropical Tuna Commission (IATTC) area.

Overlap Score 2 (**Table 2**) calculations are an indication of the intensity of overlap of fishing effort and albatross presence and hence potential interaction, and have also been expressed visually in **Figures 4-6**. There are no units for this overlap score (percent distribution x number of hooks), but the Overlap 2 score for black-footed albatross over the four quarters (10,404) was substantially higher than the total Overlap 2 scores for Laysan and short-tailed albatross (5, 786 and 6,693, respectively). The Overlap 2 score was relatively high for black-footed albatross across all four quarters, where as it was high for Laysan albatross in Q4 and Q1, and for short-tailed albatross in Q1 and Q2. Averaged cross the year, Laysan and black-footed albatross spent 70-80% of their time in high seas areas, whereas short-tailed albatross spent nearly 70% time in EEZs, the latter reflecting a preference that has been identified for using continental shelf edge habitat (ACAP, 2010).

4. Discussion

Populations of the three species of albatrosses breeding in the North Pacific Ocean were devastated by feather hunters around the turn of the 20th Century and many colonies were extirpated (ACAP, 2009, 2010a,2010b). In addition, thousands were killed in high seas driftnet fisheries until these were banned in 1992 (Arata et al. 2009). Populations of all three species have grown after removal of these threats. Unlike species in the southern hemisphere, the three species population trends are stable (Laysan albatross), stable or increasing (black-footed albatross) (Arata et al. 2009), or increasing (short-tailed albatross), (ACAP, 2009).

However, despite the relative health of the North Pacific albatross species when compared to other albatrosses, Arata et al (2009) identified bycatch in commercial fisheries as the greatest anthropogenic source of mortality (post-fledging) for both Laysan and black-footed albatross, and found that longline fishing effort before the 1980s was a 'very significant source of mortality'. Arata et al (2009) concluded that 'effective long-term conservation and management of the Laysan and black-footed albatrosses require management and monitoring at the breeding colonies and at sea'.

Few data are available on seabird bycatch interactions in the North Pacific, with the exception of the Hawaiian longline fleet; however Lewison & Crowder (2003), estimated up to 10,000 black-footed albatross could be killed across all fleets. Arata et al. 2009 considered that fishery bycatch was not significantly affecting the size of the Laysan albatross population but could cause a decrease in black-footed albatross populations. While few bycatch data are available, this analysis has identified overlap between the three species and WCPFC longline fishing effort, indicating areas where interactions could be taking place.

Tracking data confirm that the distribution of the three species of albatrosses living and breeding exclusively in the North Pacific Ocean ranges from sub-Arctic waters of the Bering Sea (60-65°N), to tropical waters in the south (15-20°N). Overall, black-footed has the highest overlap with the North Pacific pelagic longline fleet, having an Overlap 2 score that is 1.5 to 1.8 times higher than short-tailed albatross and Laysan albatross, respectively(**Table 2**).

Black-footed albatross distribution overlap with fishing effort is widespread (**Figure 3, Figure 6**), with the majority (>75% distribution in each quarter) occurring in high seas areas. During chick provisioning in the first and second quarter (Jan-June), high overlap with longline fishing effort occurs relatively close to the north west of the Hawaiian Islands from 20-30°N and 155-165°W, while adult foraging is constrained. After breeding, the overlap areas move further north and west (high density areas of distribution occurring to 160°E), with relatively high overlap with fishing effort in all year quarters.

Laysan albatross is also relatively widespread across the North (**Figure 2**), and most overlap is also in the high seas (>59 % distribution in each quarter). However, overlap with WCPFC longline fishing effort is lower than for black-footed albatross because of a slightly more northerly distribution. Overlap with WCPFC longline fishing effort is highest in Q4 and Q1, when Laysan albatross foraging distribution is also most constrained in the EEZ and high seas around the breeding sites. During Q4, when birds are laying and incubating eggs, the highest area of overlap was found from 35-40°N and 160-165°W. Laysan albatrosses begin to provision chicks from January to March (Q1) and we identified high overlap with fishing effort from 20-40°N and 155-170°W. Post breeding (Q3) the population seems to move further north than black-footed albatross and this analysis found lowest overlap with fishing effort during this period.

Reports of Laysan and black-footed albatrosses bycaught in the North Pacific (Huang and Yeh, 2011; Bigelow 2011), and observations of Laysan albatrosses attacking baits (Sato et al. 2012), support this distribution analysis. Specifically Huang (2011) identifies the area between 25-40°N and 165°W and 165°E as having the highest incidental catch in the North Pacific, primarily black-footed and Laysan albatrosses. The areas of high overlap for Laysan and black-footed albatross in this analysis overlap with these high bycatch areas, particularly in the western latitudes.

Short-tailed albatross show highest overlap with WCPFC longline fishing effort in the first half of the year from January to June off Japan (**Figure 4**, Q1 and Q2). This coincides with chick provisioning when birds are foraging closer to the colony, near Japan. During the non-breeding period birds are much more dispersed along the North Pacific Rim from southern Japan to northern California, and the majority of their non-breeding distribution is north of the WCPFC longline fishing effort (**Figure 1**).

In 2012 the Conservation and Management Measure for the WCPFC was updated for the Southern Pacific, but the North Pacific requirements remained largely unchanged from the original requirements in CMM 2006-02. Vessels less than 24 m in length in the North Pacific are exempted from CMM 2006-02.

Information on the number or distribution of vessels below 24m in length, and the spatial and temporal distribution of these vessels, is not available, meaning that it is not possible to assess the overlap that these vessels have with albatross distribution. However, based on available vessel size and weight data in the WCPFC vessel database, we estimated that around 47% of all longline fishing boats registered to fish in the WCPFC area are less than 24 m. For 2% of vessels length was uncertain. Japan and Chinese Taipei account for 75% of the small vessel fleet. This suggests that this issue needs closer attention, particularly in relation to the areas identified in this study.

Given the high overlap between these North Pacific albatrosses and fishing effort, consideration should be given to the scarcity of data available on bycatch rates in the North Pacific, and to the current exemption provided to small vessels.

There are also gaps in available albatross tracking data. Data for Laysan albatross for this analysis has been limited to birds from Tern Island, French Frigate Shoals, which constitutes less than 1% of the population. Although most of the rest of the population is also on other islands in Hawaii there is a need to track birds from these large colonies Midway Atoll and Laysan Island as these birds could be distributed elsewhere.

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Table 1. North Pacific albatross remote tracking data held in the Global Procellariiform Tracking Database which overlap with WCPFC area.

Common name	Scientific name	Population	Breeding pairs/total pairs globally	Global population breeding in WCPFC Area	% of Global population on tracked islands	Threat Status	Data submitted: Status (no. Tracks)
Short-tailed albatross	*Phoebastria albatrus*	Torishima Island, Japan	418/470	100%	89%	VU	Breeding (11PTT), non-breeding (40PTT)
Laysan albatross	*Phoebastria immutabilis*	Hawaiian Islands: (French Frigate Shoals- Tern Island)	2988/591,356	99.9%	0.51%	NT	Breeding (134PTT),non-breeding (28GLS)
Black-footed albatross	*Phoebastria nigripes*	Hawaiian Islands: (French Frigate Shoals- Tern Island and Midway Atoll)	28,272/61,307	100%	46%	VU	Breeding (129PTT, 24 GLS), Non-breeding (10PTT, 24GLS)

Table 2. Three albatross species overlap scores calculated per quarter: Overlap Score 1: percent seabird population distribution within the area of the WCPFC longline effort, per year quarter; Overlap Score 2: percent seabird population distribution per 5x5^{o} grid square multiplied by the average longline effort in hundreds of hooks set within each 5x5^{o} grid square, per year quarter

	Overlap Score 1 (%)				Overlap Score 2 (No Unit)				Total overlap score	Percentage of the distribution within EEZs			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4
Short-tailed albatross	100	100	86	70	3717	2883	80	13	6693	80	49	87	53
Laysan albatross	93	96	96	88	2107	724	337	2618	5,786	15	22	41	32
Black-footed albatross	59	49	62	63	2993	1439	1827	4145	10,404	23	23	20	19

Figure 1. 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 2006-2010 (average number of hooks set per 5X5^{o} grid square per quarter per year). The highest densities of birds are shown in dark orange and the 100% contour indicates the full extent of the distribution of tracked birds.

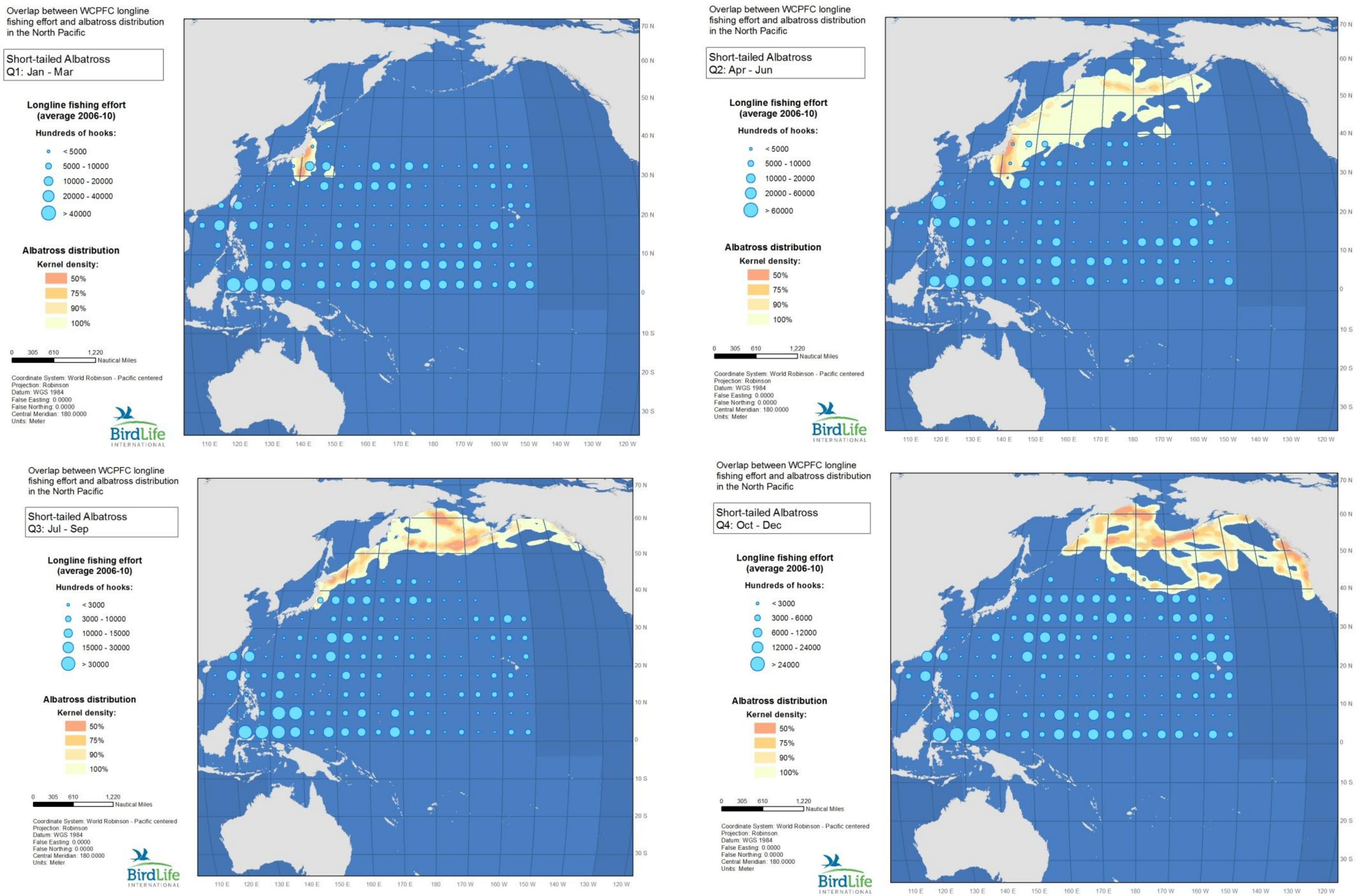
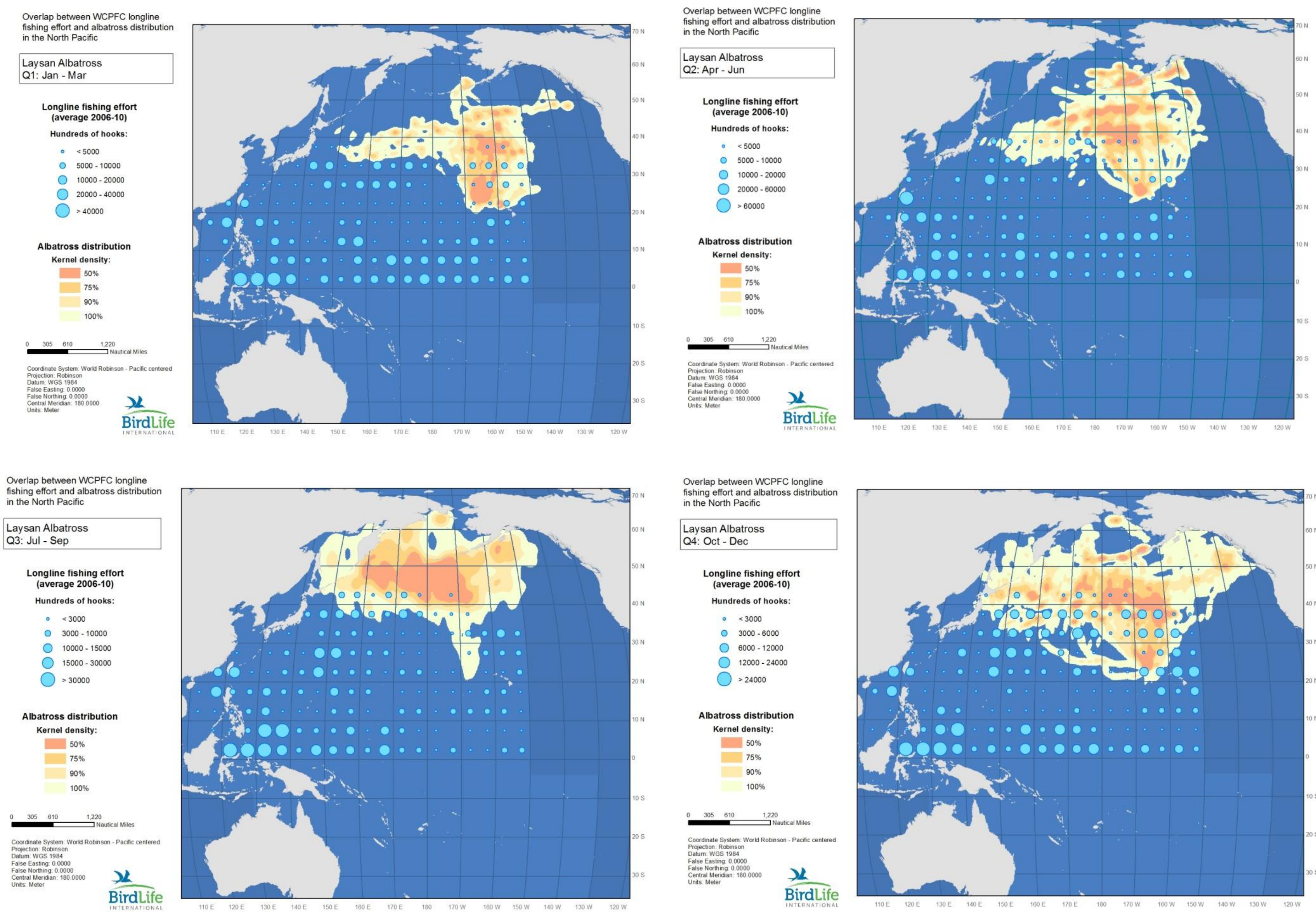


Figure 2. Laysan albatross distribution in the WCPFC area by year quarter (Q1= Jan – Mar, Q2= Apr-Jun, Q3= July-Sep, Q4 = Oct-Dec), and overlap with WCPFC longline fishing effort 2006-2010 (average number of hooks set per 5X5° grid square per quarter per year). The highest densities of birds are shown in dark orange and the 100% contour indicates the full extent of the distribution of tracked birds.



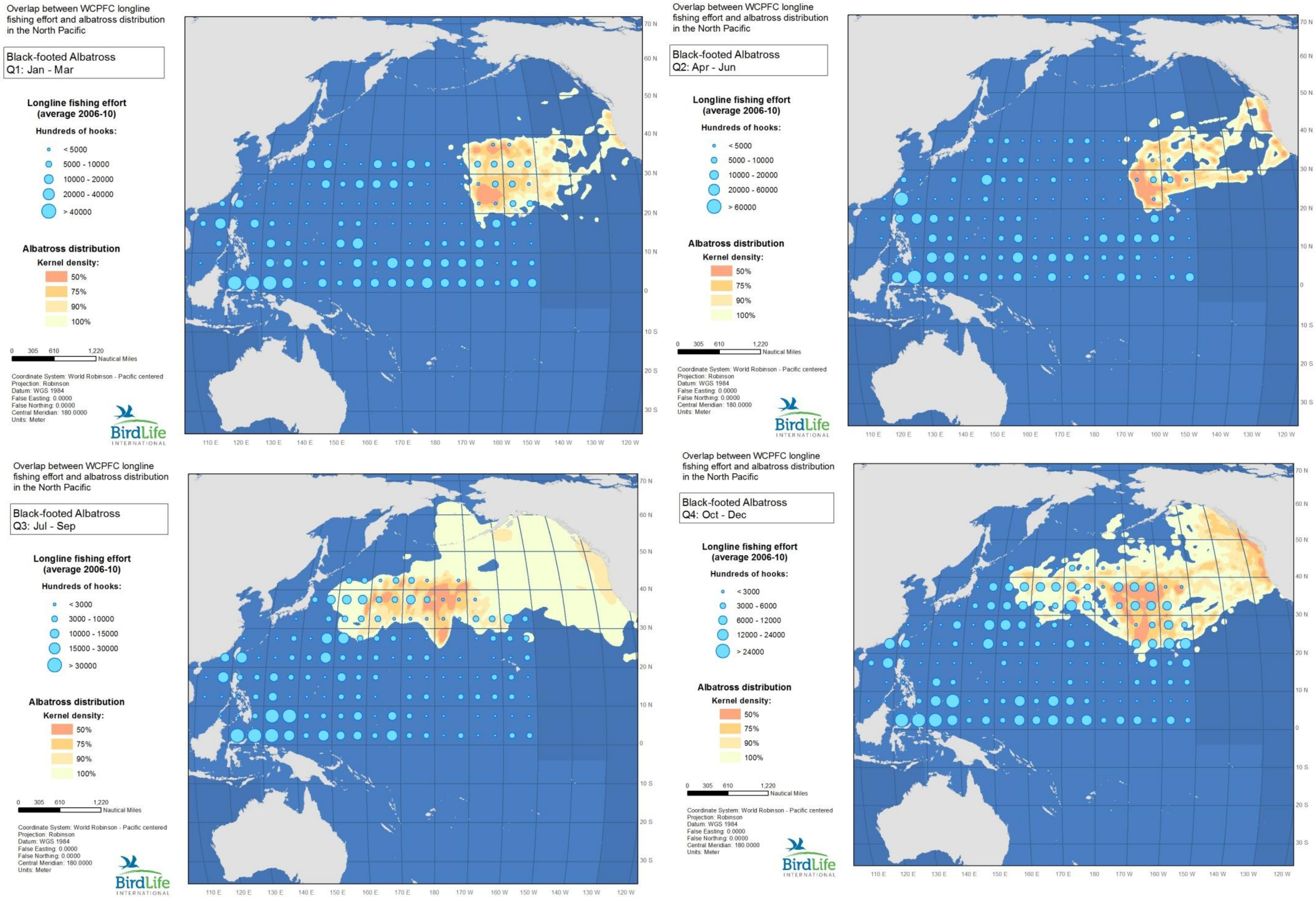


Figure 3. Black-footed albatross distribution in the WCPFC area by year quarter (Q1= Jan – Mar, Q2= Apr-Jun, Q3= July-Sep, Q4 = Oct-Dec), and overlap with WCPFC longline fishing effort 2006-2010 (average number of hooks set per 5X5^{o} grid square per quarter per year). The highest densities of birds are shown in dark orange and the 100% contour indicates the full extent of the distribution of tracked birds.

Figure 4. Short-tailed albatross overlap maps between WCPFC longline fishing effort and black-footed albatross distribution. Overlap score 2: percentage albatross distribution multiplied by fishing effort (average longline hooks set within each 5x5^{o} grid square, per year quarter

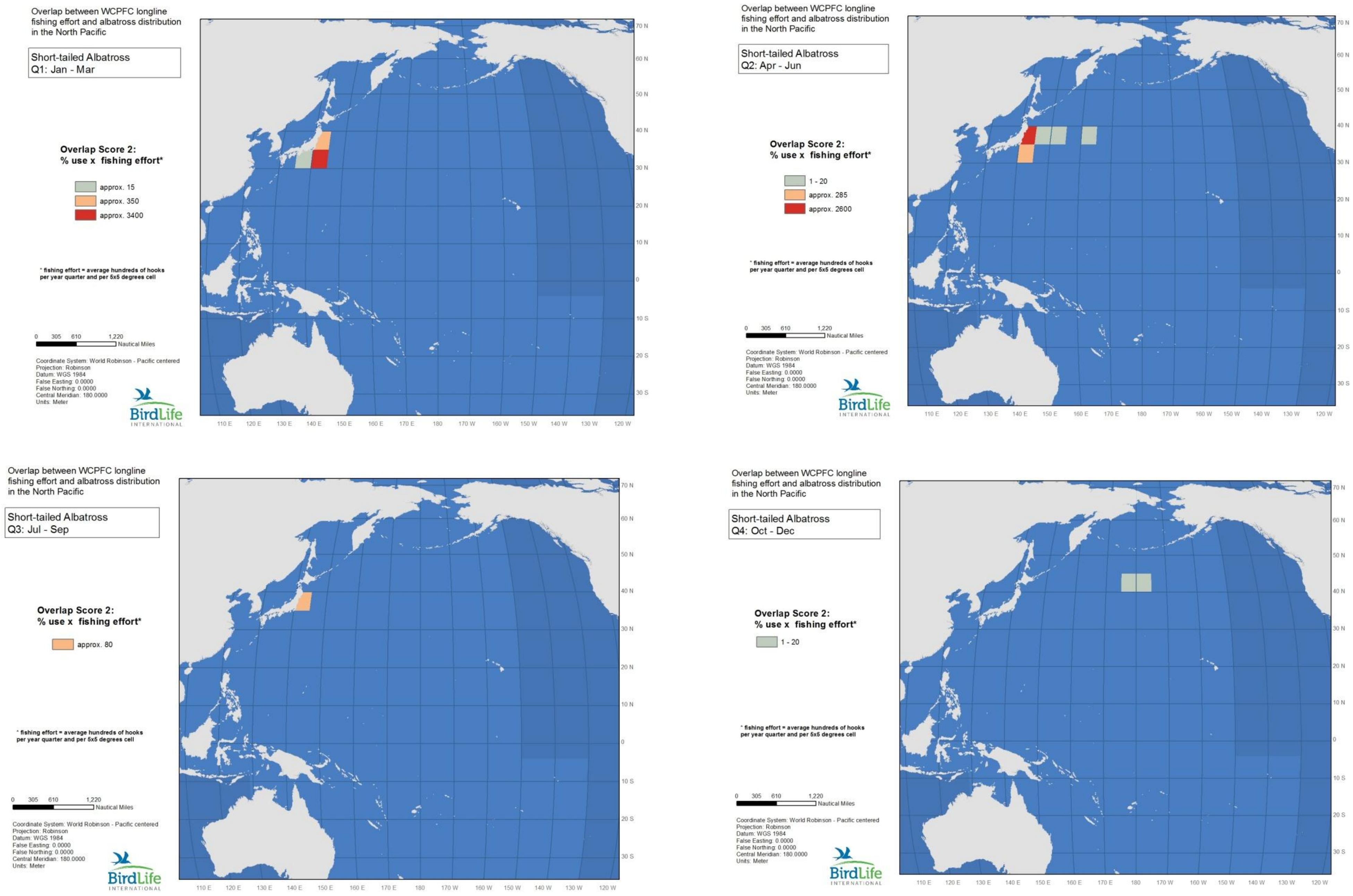


Figure 5. Laysan albatross overlap maps between WCPFC longline fishing effort and black-footed albatross distribution. Overlap score 2: percentage albatross distribution multiplied by fishing effort (average longline hooks set within each 5x5^{o} grid square, per year quarter

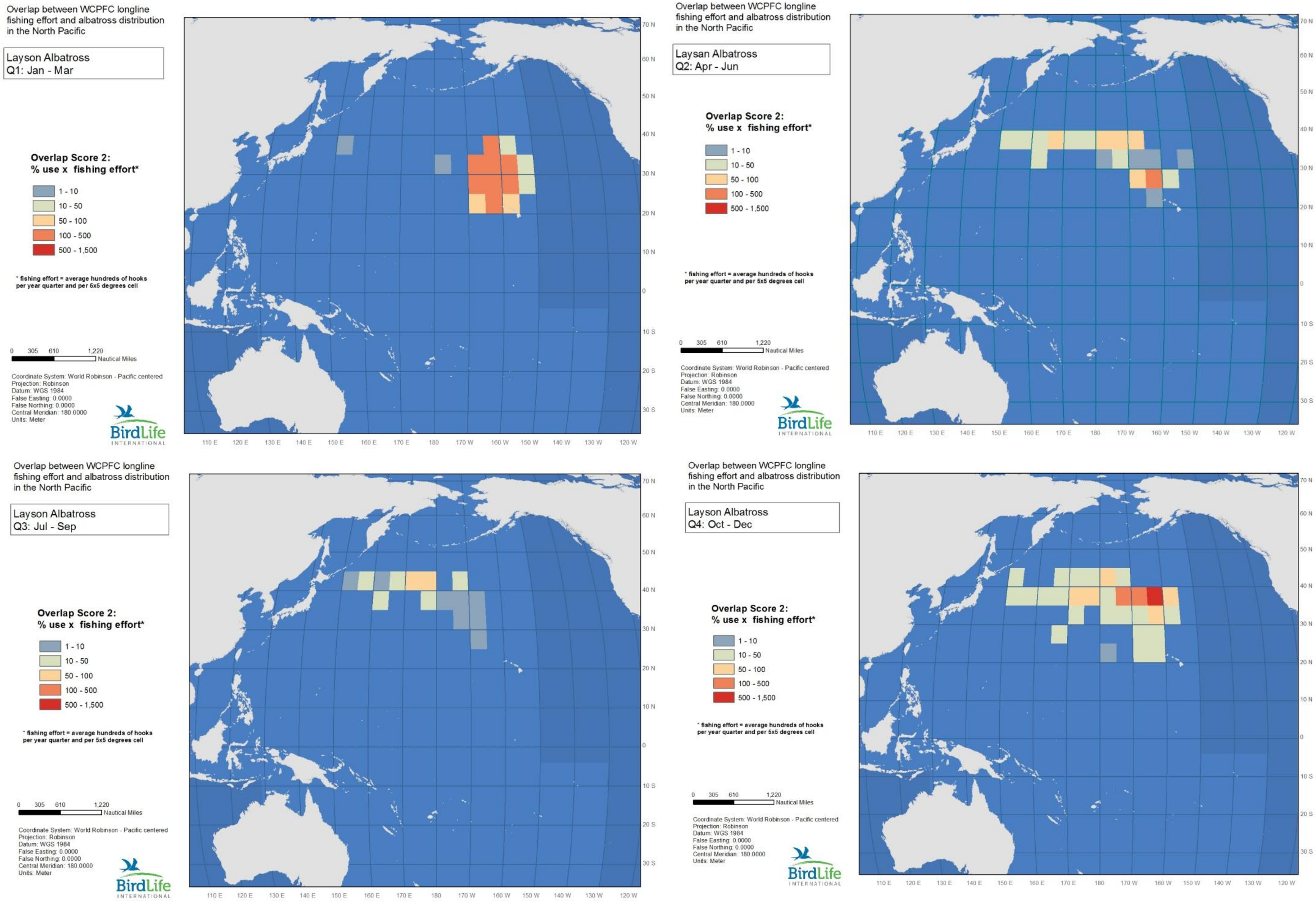


Figure 6. Black-footed albatross overlap maps between WCPFC longline fishing effort and black-footed albatross distribution. Overlap score 2: percentage albatross distribution multiplied by fishing effort (average longline hooks set within each 5x5^{o} grid square, per year quarter