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SHORT NOTE

At-sea surveys reveal new insights of fine-scale distribution and foraging behaviour of Chatham albatrosses (*Thalassarche eremita*) in central southern Peru

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The Chatham albatross (*Thalassarche eremita*) is a highly migratory species, breeding exclusively on The Pyramid, a small rocky islet, in the southern outskirts of the Chatham Islands (44°26′S, 176°14′W), located ~900 km eastward of the New Zealand South Island (ACAP 2010; Deppe 2012). Between 5,304 and 5,500 pairs breed annually (Robertson *et al*. 2003; Bell *et al*. 2017) Eggs are laid from September to October and hatch during November and December, with chicks fledging from March to April (ACAP 2010; Deppe 2014). Until the 1990s it was thought that Chatham albatrosses did not venture beyond the Central Pacific (Reid & James 1997), with some rare records south of Tasmania in Australia and on the South African coast (Reid & James 1997; Ryan 2002). However, vessel sightings and the first satellite tracking studies in the 1990s

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Figure 1. Chatham albatrosses (*Thalassarche eremita*) in southern Peru, one individual was photographed eating offal discards in the longline SSF off Ilo. Photo credits: Top Left, Cristian Moreno; others, Javier Quiñones

identified the coastal waters of Chile and Peru as regularly visited areas during their winter (Robertson *et al*. 2000; Spear *et al*. 2003; BirdLife International 2004; Latham *et al*. 2004; Nicholls & Robertson 2007).

Incidental records of Chatham albatrosses along the Peruvian coast exist since July 1988, when one individual was registered about 165 nautical miles (nm) off Chiclayo (07°54′S, 82°21′W) (Haase 1994), and in 1999, a satellite-tagged adult was caught off the coast of Chimbote (~09°S), north Peru (Jahncke *et al*. 2001). Spear *et al*. (2003), over 15 years (1980–1995), identified approximately six Chatham albatrosses in Peruvian waters, all of them south of 13°27′S. In June 2008, one adult was sighted at 57 nm off Tacna (17°40′S, 73°15′W) (Pizarro-Neyra 2010). The first studies using Global Location Sensing (GLS) confirmed the species' wide distribution off the Peruvian coast. A total of 15 Chatham albatrosses that were fitted with archival light-recording tags at The Pyramid in 2007 showed trans-Pacific migration, with the highest densities recorded in Peruvian waters between 10°S and 20°S mainly in late autumn, evidencing that these birds spent a high amount of time in these waters (Deppe 2012). In addition, an incidental bycatch (~17°S) was recorded in the Ilo longline Small Scale Fishery (SSF) targeting sharks (Mangel 2012). There is more evidence (n = 4) of the presence of adult individuals in waters off southern Peru (15°–18°S) and one individual off Callao (12°S) for the period 2005–2017 (eBird 2021). With the exception of satellite tracking studies conducted in New Zealand (Deppe 2012), reports of the presence of Chatham albatrosses in Peru have been opportunistic, and consequently, there are some limitations to explaining the recurrent presence of Chatham albatrosses in Peru. This novel information provides onboard systematic studies that evidence their fine-scale spatial distribution year-round and their foraging ecology in detail.

While there is good evidence of the general presence and distribution of the species in Peruvian waters during their wintering period (Deppe 2012), we do not have sufficient information on their fine-scale distribution. Spear *et al*. (2003) focused on their broad-scale distribution, abundance, behaviour, and seasonal patterns in the southeast Pacific. While this study is of extraordinary value, not least due to its long-term approach of 15 years, the vessel's course did not follow a regular pattern, survey tracks were more than 180 nautical miles [nm] apart, and the number of surveys comparatively small with fewer than two surveys per year (12 in autumn and 9 in spring).

In this study, we undertook systematic vessel-based survey observations of Chatham albatross occurrence along the Peruvian coast. Seven at-sea pelagic surveys were conducted during 2018–2020 (three in the austral summer, three in spring, and one in autumn) onboard the *BIC Humboldt* and *Jose Olaya*, both research vessels of the Peruvian Marine Research Institute (IMARPE). The surveys were part of the biannual Pelagic Anchovy Surveys and covered a latitudinal range for almost the entire Peruvian coast from 04°00′S (Punta Sal, Tumbes) to 18°20′S (border with Chile) except in autumn 2019 from 06°57`S (Isla Lobos de Tierra, Lambayeque) to 18°20′S. Distances covered during the surveys ranged from 3.5 km to 180 km (100 nm) offshore (Fig. 2), encompassing 45 parallel transects, each separated by 15 nm. Birds were sighted with the aid of 10 x 50 binoculars within a 300 m strip-transect by two observers on both sides of the bridge. Observations were continuous from civil dawn to dusk (approximate 0530 h – 1830 h local time, GMT – 0500 h) at a cruise speed of 10 knots. Transects were partitioned every 6 minutes or 1 nm for density calculation purposes.

Three additional sources of information were added to the IMARPE vessel-based surveys. First, we obtained information from a reliable observer network led by the NGO ProDelphinus, which was working onboard the longline SSF fleet of Ilo (17°38′S, 71°20′W) and Salaverry (08°13′S, 78°58′W). This fishing fleet operates throughout the year from the continental slope to the border of the Exclusive Economic Zone (EEZ) at 200 nm (370 km) offshore. In summer and early autumn they target dolphinfish (*Coryphaena hippurus*), and during late autumn, winter, and spring they target blue sharks (*Prionace glauca*) and mako sharks (*Isurus oxyrhynchus*). It should be noted that part of the Ilo fleet during the summer moves to Pucusana (12°28′S, 76°47′W), located more than 1,000 km to the north. The information obtained consisted of sightings of Chatham albatrosses that were

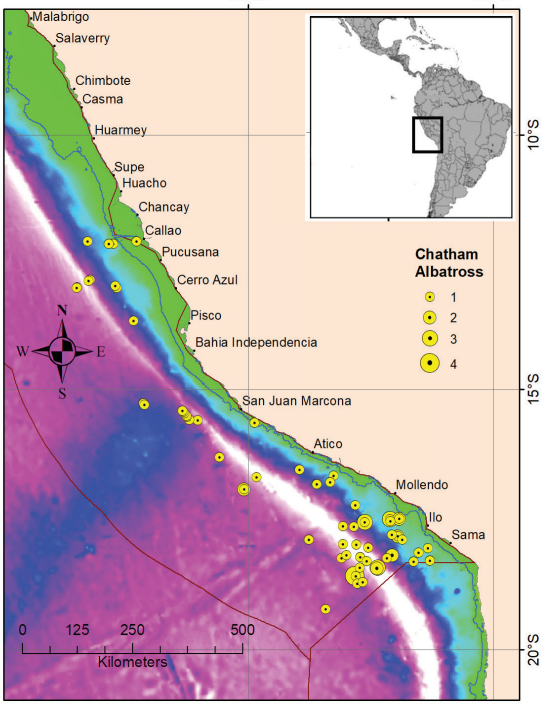

Figure 2. Spatial distribution and abundances of Chatham albatrosses (*Thalassarche eremita*) during 2004–2021 (solid yellow circles). The continuous blue line represents the 200 m isobaths (continental shelf break) and the continuous brown line represents the Exclusive Economic Zone boundaries.

identified during fishing operations from 2004 to 2010. Second, observations were also made by IMARPE personnel in the SSF commercial fleet targeting jumbo squid (*Dosidicus gigas*), between Lomas, Arequipa (15°34'S) and Mollendo (17°S) up to 210 km offshore, during 16 fishing trips from spring 2015 until autumn 2017, covering all seasons. Third, sightings were carried out by the Universidad Científica del Sur (UCSUR) in conjunction with IMARPE in two trips (29 May – 6 June 2021 and 1–9 July 2021) in the longline SSF targeting sharks in The Hague Triangle (18°36′S, 72°49′W) between the 180 km and 250 km offshore. In combination, the IMARPE, ProDelphinus, and IMARPE-UCSUR data provided sufficient information to analyse the spatial distribution, seasonal variability, and habitat preference of the Chatham albatross in the Peruvian sea.

Species identification was determined using Shirihai (2008), Howell & Schmitt (2018), and Howell & Zufelt (2019). The intense sampling design allowed us to determine the use of different habitats by Chatham albatrosses over short periods, i.e. a snapshot of their distribution in different seasons. We characterized habitat use by this species according to ocean depth: continental shelf (0 to 200 m isobath); continental slope (201–4,500 m); Peru-Chile Trench (>4,500 m), and the Abyssal plain (offshore, beyond the Peru-Chile Trench). Habitat classification was an adaptation of Wakefield *et al*. (2011) for the specific bathymetric zones off the Peruvian coast.

A total of 7,215 observation hours were completed for all surveys. A total of 82 Chatham albatrosses were sighted from Callao (12°S) to the oceanic border with Chile (19°S) and 12–290 km offshore (Fig. 2). Most of the sightings (71%, n = 58) occurred in autumn, followed by winter (21%, n = 17) and spring (5%, n = 4). Very few birds (4%, n = 3) were observed during summer, despite the large survey effort during this season (three scientific cruises and five Jumbo squid trips by IMARPE and 30% of the longline effort by ProDelphinus). In autumn, birds occurred between 12°50′S and 19°15′S, 44–290 km offshore. In winter, birds were sighted between 12°S and 18°26′S, 32–145 nm. In spring, birds were recorded between 12°S to 15°36′S, 15–105 km, and finally in summer very few individuals at 13°40′S, 15°17′S and 16°50′S, 65–150 km (Fig. 2). No Chatham albatrosses were sighted north of 12°S.

The majority of sightings were over the continental slope (55%, n = 49), followed by the Abyssal plain (28%, n = 25) and the Peru–Chile Trench (15%, n = 13). Finally, only two individuals were sighted over the continental shelf (2%) (Table 1). The highest concentrations were in oceanic waters offshore the area between Mollendo (17°S) and the southern part of the Hague Triangle (18°50′S), at 50–220 km offshore. In this area, 52 Chatham albatrosses were observed, representing 63% of all sightings (Fig. 2). The mean distance of Chatham albatross sightings was 110.9 km offshore (range: 12.4–293.2 km, n = 68, Fig. 2). On three occasions, groups ≥3 Chatham albatrosses were observed. In autumn and winter 2016, during an "*El Niño*" year, these birds were observed gathered among highly active multispecies bird flocks (≥10 birds and ≥3 species), such as large groups (>30 individuals) of waved albatrosses (*Phoebastria irrorata*), Salvin's albatrosses (*Thalassarche salvini*), white-chinned petrels (*Procellaria aequinoctialis*), sooty shearwaters (*Ardenna grisea*), Hornby's storm petrels (*Oceanodroma hornbyi*), and Cape petrels (*Daption capense*). During autumn 2021, a group of four Chatham albatrosses was registered in The Hague Triangle. On this occasion these birds gathered with black-browed albatrosses (n = 10), white-chinned petrels (n = 25), Buller's albatrosses (*Thalassarche bulleri*) (n = 4), Chilean skuas (*Catharacta chilensis*) (n = 2), De Filippi's petrel (*Pterodroma delfilippiana*) (n = 2), Hornby's

Table 1. Habitat use of Chatham Albatross (*Thalassarche eremita*) off Peru. Habitat was characterized according to depth: Continental Shelf (0–200 m isobath), Continental Slope (201–4,500 m), Peru-Chile Trench (>4,500 m), and Abyssal plain (offshore the Peru Trench).

Habitat	Mean depth (range) (m)	Mean coast distance (km)	No. of birds (%)	No. of flocks	Mean no. of birds per flock
Continental Shelf	53 (52–54)	37.1	2 (2)	0	0
Continental Slope	2,267 (634–6,721)	84.8	49 (55)	6	2.3
Peru-Chile Trench	5,663 (4,589–6,773)	136.6	13 (15)	1	3
Abyssal plain	4,327 (3,132–5,527)	155.4	25 (28)	2	3

storm petrels (n = 10), and Elliot's storm petrels (*Oceanitis gracilis*) (n = 8). Single birds composed the majority (>72%) of sightings on this trip. A total of nine groups were recorded, each with a mean of 2.6 individuals (range: 2–4 birds) (Table 1).

All the surveys carried out by IMARPE (Research cruises and the jumbo squid observer program), all the UCSUR-IMARPE surveys, and the eBird sightings, included additional observations (including photographic captures), allowing us to determine the age-class composition and behavioural patterns of the Chatham albatross. Most individuals were adults (76.5%, n = 39), and the remainder were sub-adults (23%). During the non-breeding period in autumn, 15% were sub-adults (n = 5), while during the time when adult birds were at their colonies (winter – summer) sub-adults increased to 39%. Fifty-three percent (n = 27) of the birds were observed flying, 27% (n = 14) were on the water, 8% (n = 4) exhibited pelagic feeding and 12% (n = 6) were feeding on shark offal discards.

The capture of live prey by one first-year Chatham albatross was observed in autumn 2019 when the bird glided slowly at about 1m above the water at 98 km off Punta Caballas (15°30'S, 76°15'W) and landed in the middle of a multispecies bird flock. The flock was composed of more than 20 white-chinned petrels, more than 15 sooty shearwaters, 12 Hornby's storm petrels, and five Inca terns (*Larosterna inca*). We photographed this Chatham albatross feeding on a medium-size cephalopod, probably a giant squid (*Dosidicus gigas*). In addition, a couple of adult Chatham albatrosses were also observed feeding on offal discards in autumn 2016 at 71 km off Ilo (17°50'S, 71°57'W) in the middle of another multispecies bird flock composed of 40 sooty shearwaters, 13 white-bellied storm petrels (*Fregetta grallaria*), 12 white-chinned petrels, eight Hornby's storm petrels, seven wedge-rumped storm petrels (*Oceanodroma tethys*), four Salvin's albatrosses, and two black-browed albatrosses (*Thalassarche melanophris*).

The occurrence of Chatham albatrosses in central and southern Peru is the result of a vast trans-Pacific migration of ~11,000 km from The Pyramid in the Chatham Islands. It is known that they disperse towards central Chile at the end of the breeding season around March–April each year (ACAP 2010; Deppe 2012). According to 45 individuals tracked in 2008–2010 using GLS loggers, all birds traverse the South Pacific Ocean at a mean latitude of 40°S, with a latitudinal extension from 30°S to 50°S (Deppe 2012). Juveniles and sub-adults tend to disperse great distances from their breeding colonies, often with an eastward movement driven by the strong prevailing westerly winds that dominate the Southern Ocean between 30°S and 60°S (Weimerskirch *et al*. 2000). The influence of winds on albatrosses and petrel migrations is well documented (Weimerskirch *et al*. 2000; Suryan *et al*. 2008). The majority of our sightings (65%) were in autumn, coinciding with post-breeding timing. During this season the Subtropical Jet Stream (STJ) in the south Pacific Ocean is not fully developed (Nakamura & Shimpo 2004). Still, Chatham albatrosses traverse the Southern Pacific Ocean on both post- and pre-breeding migrations probably using low-pressure systems to progress rapidly downwind and slowing when caught up in a high-pressure ridge as was registered in southern Buller's albatrosses (Stahl & Sagar 2000). After traversing the Southern Pacific Ocean they are probably arriving in Chile at offshore waters in latitudes between Talca (35°S) and Puerto Aysen (45°S) and then shifting northward toward Peru, where in May they are mainly congregated off central and southern Peru in offshore pelagic waters (Quiñones *et al*. 2021). The Chatham albatross concentration in front of Mollendo appeared to indicate an important core area, as in this zone there were similar aggregations during 1997–1999, even in years influenced by strong "*El Niño*" events (Pashkow 2020), which means that the species continues to use those areas regardless of strong environmental changes.

Despite our observation effort, we did not see any Chatham albatross north of Callao (12°S), probably due to a mix of the prevailing environmental conditions, lack of food availability,

and intraspecific competition with other albatross species. The highest aggregations of these birds (57% of our sightings) were in autumn in an area characterized by a complex interaction between the northward, cold and fresher Humboldt Current System (HCS) and the poleward subtropical Peru-Chile Undercurrent (PCUC), whose interaction forms eddy-like structures offshore the Peruvian shelf and shelf-slope, 15°S to 17°S (Chaigneau *et al*. 2013). In the south east Pacific eddies can extend the propagation of high primary productivity to offshore waters far from the coastal upwelling (Chaigneau *et al*. 2008). This productivity influx towards more oceanic waters in central and southern Perú coincides with the offshore spatial distribution of our observations of Chatham albatrosses, occurring in higher densities at an average distance of 107 km from the coast which is in the range where individuals have been recorded in their northward movements through the continental slope between isobaths 500–5,000m (BirdLife International 2004). In far oceanic waters, there is evidence of small-sized giant squid (Alegre *et al*. 2014) being more suitable prey for this albatross species. Finally, the presence of other albatross species during autumn, such as the more frequently observed Salvin's albatrosses and waved albatrosses (*Phoebastria irrorata*), both of which are particularly numerous in oceanic waters of the northern and central coast (Spear *et al*. 2003; Awkerman *et al*. 2006; Quiñones *et al*. 2021) and, consequently, probably outcompeting Chatham albatrosses.

In southern Perú, we observed several SSF fishing vessels targeting giant squid using squid jigs mainly over the continental slope, and targeting blue sharks (*Prionace glauca*) and shortfin mako sharks (*Isurus oxyrinchus*) using longlines, mainly over the Peru–Chile Trench and the Abyssal Plain (Adams *et al*. 2016). Both SSF are very common in oceanic waters in southern Perú (Adams *et al*. 2016; Csirke *et al*. 2018). In autumn, there is a spatial overlap of Chatham albatrosses with the SSF targeting giant squid in southern Peru (15°45′S – 18°S) (Sueiro & de la Puente 2013). One Chatham albatross was hooked by a squid jig in autumn 2016 and was safely released in Peruvian waters. In southern Peru, medium- and large-sized giant squids are distributed in oceanic waters (Paredes & de la Puente 2014). This was evidenced by a photo of a juvenile Chatham albatross feeding on a medium-size squid at ~100 km offshore at 15°30′S, 76°15′W in autumn 2019.

The longline SSF targeting sharks in Peru is active between March and November (Doherty *et al*. 2014). In southern Peru, the higher CPUE hot spots of both shark species occur in offshore waters over the Peru-Chile Trench and the Abyssal plain in the 16°–19°S and over the continental slope in the 17°30′S – 18°30′S (Adams *et al*. 2016). This spatially overlaps with 61% of our sightings of Chatham albatrosses. Due to the strong overlap of SSF and this albatross species in southern Perú, they are likely feeding in offal discards. For instance, when we used information with onboard observers on SSF, such as on the giant squid fishery (16 fishing trips), and the pelagic longline targeting sharks (two fishing trips), we register that in 37% of the cases, the Chatham albatrosses fed on offal discards, preferably eating the liver, after the sharks and giant squids were butchered. Apart from being a possible anthropogenic influence on species distribution in the region, this behaviour could also produce interactions or even bycatch. It is, therefore, a priority to identify the spatial overlap of the areas used by the birds and by the fishery to identify potential species conservation and management measures. Given the vast size of the small-scale fleets operating in Peru (Alfaro-Shigueto *et al*. 2010) and the overlap of fishing grounds with species distribution, the potential negative impacts on albatross and petrels are very high. The provided information both demonstrates and confirms the importance of offshore waters in central and southern Peru for adult and juvenile Chatham albatrosses during autumn. The fine-scale resolution of the observational data presented as well as the behavioural studies are giving new insights for the proper management of this vulnerable species.

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