SEABIRD RESPONSE TO BAIT IN THE ARTISANAL LONGLINE FISHERY TARGETING SHARKS IN SOUTHERN PERU

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ABSTRACT

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This paper presents findings on the seasonal variability in numbers and the aggressive foraging behavior of procellariiform birds interacting with the southern Peruvian artisanal longline fishery that targets sharks. Information was obtained during three field campaigns (April, June, and October 2024) aboard a 12-m artisanal vessel operating out of Ilo (17°38′S, 071°20′W). Interactions were assessed across four bathymetric habitats (Upper Slope, Lower Slope, Peruvian–Chilean Trench, and Abyssal Plain), concentrating on White-chinned Petrel *Procellaria aequinoctialis*, Pink-footed Shearwater *Ardenna creatopus*, Black-browed Albatross *Thalassarche melanophris*, Buller's Albatross *T. bulleri*, Waved Albatross *Phoebastria irrorata*, and Chilean Skua *Stercorarius chilensis*. Combined across all habitats, White-chinned Petrels reached a mean of 57.9 and 47.2 individuals per observation unit in April and June, respectively, reflecting their overwhelming dominance. Black-browed Albatrosses peaked in winter (June; 8.2 = combined mean), although up to 22 were present at a single longline deployment; the species was entirely absent in April, and very few were observed in October. Aggressive bait-attack behavior during longline deployment was highest in April and June, exacerbated by intense interspecific competition during winter. Thus, seabird bycatch mitigation measures should be carried out during the austral autumn and winter seasons.

Key words: seasonal occurrence, seabird behavior, bait, longline deployment, southern Peru

INTRODUCTION

The Northern Humboldt Upwelling System supports exceptional seabird diversity, attracting migratory procellariiforms and other seabird species from breeding colonies across the South Pacific, New Zealand, and the Southern Ocean (Pitman, 1986; Quiñones, Alegre, et al., 2021; Spear & Ainley, 2008). Overlapping temporally and spatially with seabird occurrence patterns, the artisanal pelagic longline fishery in southern Peru targets sharks, predominantly blue shark *Prionace glauca* and shortfin mako *Isurus oxyrinchus* from May to October, operating in waters south of Ilo, Peru (17°38′S, 071°20′W). Several of the marine birds found in this region are listed with the Agreement on the Conservation of Albatrosses and Petrels (ACAP), meaning their conservation status is officially recognized and included in Annex 1 of the agreement. Inclusion on this list underscores the need for international conservation attention and protection. Planning cost-effective seabird bycatch mitigation practices requires understanding the seasonal structure of the overlap between seabirds and the fishery across all bathymetric habitats—from the upper slope to the abyssal plain.

Procellariiforms are particularly vulnerable to longline bycatch: due to their highly developed olfactory and visual sensory systems, they are able to locate baited hooks from considerable distances and to pursue gear and baits that are sinking below the ocean surface (Friesen et al., 2017; Gaskin et al., 2016). Petrels and shearwaters can dive to considerable depths in pursuit of prey, with shearwaters, for example, diving to over 65 m. Therefore, even partially sunken baited hooks remain accessible to them during the critical deployment window (Gaskin et al., 2016). The White-chinned Petrel *Procellaria aequinoctialis*, recognized as the procellariiform most frequently killed in Southern Hemisphere longline fisheries, possesses visual anatomical adaptations that facilitate amphibious foraging, enabling rapid underwater pursuit of baited hooks even at depth (Düssler et al., 2026).

In Chilean longline and trawl fisheries south of 40°S, Black-browed Albatross *Thalassarche melanophris* accounted for over 90% of observed captures of ACAP-listed species. White-chinned Petrel and Pink-footed Shearwater *Ardenna creatopus* were also among the most affected species, including in the present study (Richard & Adasme, 2019). Chilean Skuas *Stercorarius chilensis* are also attracted to the fishery. Yet systematic data on seabird interactions with the southern Peruvian artisanal fishing sector remain sparse. This paper distills findings from the first multi-season field effort to fill that gap (Quiñones et al., 2026), providing evidence for ACAP to consider.

This paper synthesizes field data from three seasonal campaigns conducted in southern Peru during 2024, as part of the ACAP Small Grants project "Enabling mitigation measures in the southern Peruvian artisanal longline fleet targeting sharks to reduce the bycatch of albatrosses and petrels" (Quiñones et al., 2026). It focuses on procellariiform abundance across four bathymetric habitat zones and on aggressive foraging behavior toward baited hooks during longline deployment, with an emphasis on the six most affected species. This systematic assessment of albatross, petrel, and shearwater behavior toward bait during active longline setting represents one of the first studies of its kind in small-scale fisheries in western South America. Therefore, the acquired information constitutes a critical input needed for designing evidence-based conservation measures.

METHODS

Research was conducted aboard the artisanal vessel *San Martín III* (a 12-m wooden vessel), representative of the Ilo shark-targeting longline fleet. The study area encompassed four bathymetric zones: the Upper Slope (10–30 nautical miles from shore, depth of ~1,500 m), Lower Slope (31–65 nautical miles, 1,500–4,500 m), Peruvian–Chilean Trench (66–93 nautical miles, > 4,500 m), and Abyssal Plain (94–200 nautical miles, depth of > 5,500 m to the 200-nautical-mile exclusive economic zone boundary). Three seasonal campaigns were conducted (Fig. 1): Campaign 1 (April 2024, early autumn, n = 10 fishing sets, baseline without seabird bycatch mitigation measures); Campaign 2 (June 2024, austral winter, n = 10 operations, mitigation trials); and Campaign 3 (October 2024, early spring, n = 5 operations, low-density validation). Species density data during longline recovery observations were used for spatial and temporal analysis, as recovery periods yielded greater species diversity and higher abundance. Seabird diving within defined "danger areas" during deployment served as the primary bycatch proxy. The danger area corresponded to the aerial section in which baited hooks remained accessible before sinking below the attack depth of surface-foraging species.

Seabird observations were conducted using standardized 360° surveys at 10-min intervals during longline deployment and at 100-hook intervals (~3 km) during recovery. This translates to five systematic observation efforts during both longline deployment and recovery, using a hybrid of scan sampling and strip transect methodology adapted from Altmann (1974) and Tasker et al. (1984, Table 1 therein). At each 100-hook survey point, all procellariiforms within a 300-m radius were counted and identified to species, with mean density expressed as individuals per observation unit (10-min, 360° count). Data were aggregated by bathymetric zone and campaign; combined means were calculated as the arithmetic mean ± standard deviation (SD) of zone-specific means. In June and October, the Abyssal Plain was not surveyed due to operational constraints; combined means for those campaigns, therefore, reflect three zones only. Bold values in Table 1 indicate notable mean values per season and species (Quiñones et al., 2026). Research effort emphasized the six species most frequently encountered.

The behavioral data summarized in Table 2 were collected during longline deployment using a dedicated stern-observation protocol. A trained observer at the vessel stern documented all bird entries into the danger area—an 8 m × 25 m rectangle centered on the hook entry point—recording species identity, dive type (deep plunge, shallow dive ≤ 1.5 m, or kleptoparasitic), and approximate dive depth (Quiñones et al., 2026). This approach drew on the framework developed in controlled bait-interaction trials for albatrosses, petrels, and shearwaters. This effort demonstrated that stern-based observation effectively characterizes species-specific diving repertoires and interspecific competitive dynamics around baited hooks (Gaskin et al., 2016). Dive-type categories in Table 2 are consistent with established behavioral categories. Seabird aggressiveness—defined as competitive behavior among individuals toward the bait during longline deployment—was scored semi-quantitatively per deployment using a four-point scale (absent/low/moderate/high), based on the number of diving events within the danger zone and the intensity of interspecific interactions. These two components were integrated to produce risk classifications (Table 2). Under control conditions (no tori line for bird deterrence), a total of 22 danger-zone dive events were recorded during April and June, with no events observed in October.

Semi-structured interviews were conducted with experienced and reliable skippers of artisanal shark-targeting longline vessels, selected with the support of Instituto del Mar del Perú (IMARPE) staff in Ilo. A total of 30 interviews were carried out across the ports of Ilo, Morro Sama, and Arica (Chile), as well as onboard vessels, during June and December 2024; six interviews were discarded, as they referred to the mahi-mahi *Coryphaena hippurus* fishery, yielding 24 valid responses. The following data were recorded using a structured interview instrument: vessel characterization, fishing operations, seasonal and spatial distribution of seabirds,

TABLE 1
Mean seabird densities[a] of the six main procellariiform species encountered, combined across all bathymetric habitats[b]

Species	Early autumn (April 2024)	Winter (June 2024)	Spring (October 2024)
White-chinned Petrel *Procellaria aequinoctialis*	**57.9 ± 79.4**	**47.2 ± 27.2**	0.9 ± 0.2
Pink-footed Shearwater *Ardenna creatopus*	**2.9 ± 2.5**	**2.7 ± 3.3**	0.0 ± 0.1
Black-browed Albatross *Thalassarche melanophris*	Absent	**8.2 ± 3.1**	0.1 ± 0.2
Buller's Albatross *Thalassarche bulleri*	1.0 ± 1.5	**1.4 ± 1.5**	0.2 ± 0.0
Waved Albatross *Phoebastria irrorata*	0.8 ± 1.6	0.1 ± 0.2	Absent
Chilean Skua *Stercorarius chilensis*	**5.2 ± 6.4**	3.4 ± 2.3	0.3 ± 0.4

[a] Individuals/observation unit ± standard deviation (SD).
[b] Values are the arithmetic mean ± sample SD of the habitat-specific means (Quiñones et al., 2026). Bold values indicate notable mean values per season. SD reflects inter-habitat variability. "Absent" = not recorded in any habitat during that campaign. April includes four habitats (Upper Slope, Lower Slope, Peruvian–Chilean Trench, Abyssal Plain); June and October include three habitats (Abyssal Plain not surveyed).

incidental capture rates by species and fishing zone, timing and location of bycatch events, and place of the hook in the seabird; species identification was facilitated through photographic guides. In addition to data collection, the interviews served as a community outreach tool, raising awareness among skippers about high-risk bycatch seasons and the most vulnerable species, encouraging the voluntary adoption of mitigation measures.

RESULTS AND DISCUSSION

Seasonal Variability in Species Abundance

Seabird assemblages showed pronounced seasonal and spatial variation across all three campaigns (Table 1). When combined across bathymetric habitats, White-chinned Petrels attained a mean density of 57.9 ± 79.4 individuals per observation unit in April—the highest combined value of any species and season—driven by their overwhelming dominance in waters of the Upper Slope (170.5 ± 86.0), alongside lower but still substantial densities on the Lower Slope (57.1 ± 37.7). There were much lower densities in the Peruvian–Chilean Trench (2.5 ± 3.3) and Abyssal Plain (1.5 ± 2.8). By June, the combined mean declined to 47.2 ± 27.2, and by October, it fell to 0.9 ± 0.2—a decline of more than 60-fold from April. The large standard deviation in April directly reflects the extreme contrast in White-chinned Petrel abundance between the productive upper-slope habitats and the deeper offshore zones.

Pink-footed Shearwaters showed a combined mean of 2.9 ± 2.5 individuals per observation unit in April, distributed across all four habitats. A similar value was evident in June (2.7 ± 3.3), largely attributable to elevated densities on the Upper Slope. By October the species was virtually absent (0.0 ± 0.1).

Black-browed Albatrosses, entirely absent in April, reached a combined mean of 8.2 ± 3.1 in June—the highest combined albatross density of any campaign (with a peak count of 22 birds during one deployment)—distributed across the Upper Slope (5.0 ± 2.6), Lower Slope (11.2 ± 5.6), and Trench (8.3 ± 4.3), before declining to 0.1 ± 0.2 by October.

Buller's Albatrosses *Thalassarche bulleri* maintained a low, but consistent, combined presence across April (1.0 ± 1.5) and June (1.4 ± 1.5), primarily concentrated on the Lower Slope and Trench.

Waved Albatrosses *Phoebastria irrorata* were present mainly in April, where their combined mean of 0.8 ± 1.6 reflects their restriction to the Upper Slope (3.3 ± 5.0), with absence from all other habitats. In April very few individuals were recorded (0.1 ± 0.2). Waved Albatrosses are of particular concern, since there was overlap of this critically endangered species with Peruvian longline effort during its prime foraging season, making any mortality disproportionately significant at the population level.

Chilean Skuas reached a combined mean of 5.2 ± 6.4 in April and 3.4 ± 2.3 in June, declining to 0.3 ± 0.4 by October.

By October, all seabird species densities strongly diminished to negligible numbers per observation unit, and Waved Albatrosses were completely absent (Table 1), indicating that spring presents negligible bycatch risk.

Seabird Behavior During Longline Operations

Seabirds diving into the danger zone during longline deployment served as the principal bycatch proxy. Twenty-two fishing sets recorded danger-zone dive events under control conditions (no tori line) during April and June 2024. No danger-zone dives were recorded during October, while April baseline operations documented high bird attendance but a qualitatively different aggression profile, dominated by petrels and shearwaters rather than albatrosses (Table 2).

TABLE 2
Aggressive foraging behavior toward baited hooks during longline deployment by six key species across three seasonal campaigns[a]

Species	Dive type	Interaction risk		
		April 2024	June 2024	October 2024
White-chinned Petrel *Procellaria aequinoctialis*	Deep plunge dive	**High (dominant attacker)**	**High (13 danger-zone dives; strong competition with all other birds)**	Very low/ absent
Pink-footed Shearwater *Ardenna creatopus*	Deep plunge dive	**High (aggressive, competes with petrels)**	Low	Absent (they are already in the Northern hemisphere)
Black-browed Albatross *Thalassarche melanophris*	Shallow dive (≤ 1.5 m)	Absent	**High (8 danger-zone dives)**	Absent
Buller's Albatross *Thalassarche bulleri*	Shallow dive (≤ 1.5 m)	Moderate (occasional dives)	Moderate (competes with Black-browed Albatross)	Very low
Waved Albatross *Phoebastria irrorata*	Shallow dive (≤ 1.5 m)	Low (attending vessel)	Occasional	Absent
Chilean Skua *Stercorarius chilensis*	Kleptoparasitism/ shallow dive	Moderate (1 danger-zone dive)	Low (1 danger-zone dive)	Absent

[a] Danger-zone dives refer to entries into the 8 m × 25 m stern danger area (bycatch proxy). Risk categorized as High (red; greatest interaction risk), Moderate (yellow; intermediate risk), or Low/Absent/Occasional (white). All 22 recorded danger-zone entries in June 2024 occurred under control conditions (no tori line). Interspecific competition was evidenced during high seabird densities in fishing sets only in April 2024 (between White-chinned Petrels and Pink-footed Shearwaters) and June 2024 (especially between Black-browed Albatrosses and White-chinned Petrels).

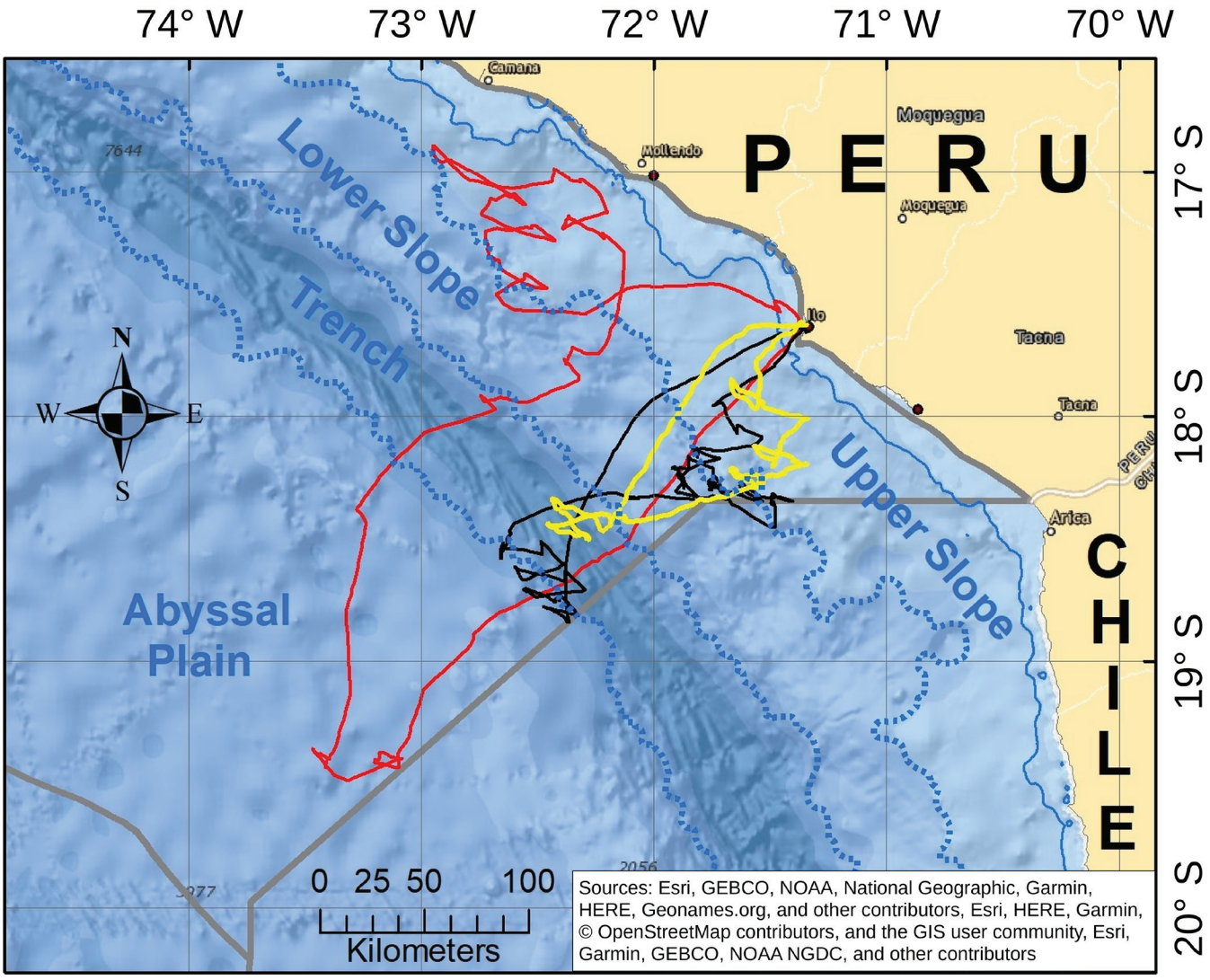


Fig. 1. Study area, showing the fishing vessel track during the three seabird observation campaigns: April 2024 (red), June 2024 (black), and October 2024 (yellow). Dashed blue lines delimit the four bathymetric habitat zones (Upper Slope, Lower Slope, Peruvian–Chilean Trench, and Abyssal Plain); the continuous blue line close to the coast represents the continental shelf break; and the thick gray line is the oceanic boundary between Peru and Chile.

White-chinned Petrels were the most aggressive species across both the April and June campaigns. They executed rapid deep plunge dives targeting hooks within seconds of bait entry into the water. Their combination of high combined abundance, dive speed, and penetration depth places them at the highest risk for entanglement on weighted hooks during deployment. Pink-footed Shearwaters showed comparable attack behavior in April, frequently competing directly with White-chinned Petrels at the hook entry point and executing deep dives. Both species' capacities to dive well below the surface render them vulnerable during the initial sinking phase of the longline set—the critical window of bycatch risk during deployment. In June (winter), the arrival of Black-browed Albatrosses introduced a qualitatively different dynamic. They performed shallow surface dives (≤ 1.5 m) and, being substantially larger than petrels, were able to displace smaller procellariids from bait.

Interspecific competition between White-chinned Petrels, Black-browed Albatrosses, and Buller's Albatrosses during June operations was intense and directly elevated the frequency of danger-zone entries (Figs. 2–4). In periods of high mixed-species aggregation at the stern, aggressive interactions—including chasing, wing-spreading, and bill-grappling—were observed to cause multiple simultaneous dive attempts by several individuals of different species, amplifying instantaneous bycatch risk beyond what would be expected from any single species alone. This interspecific competitive effect represents an additive risk factor concentrated exclusively in the winter season.

Hook placement data from skipper interviews (n = 24) corroborate these observations: 75% of respondents reported bycatch events during deployment, with hook placements predominantly in the throat (43%) and bill (34%), consistent with birds attacking sinking baited hooks. Respondents identified Black-browed Albatross as the most frequently bycaught species (47.6%), followed by White-chinned Petrel (31.0%), Buller's Albatross (11.9%), Chatham Albatross *Thalassarche eremita* (7.1%), and Salvin's Albatross



Fig. 2. Pink-footed Shearwaters *Ardenna creatopus* showing aggressive behavior toward each other for procuring bait, which was frozen chub mackerel *Scomber japonicus*. Photo taken in April 2024, ~80 km off Matarani, southern Peru. Photo credit: Javier Quiñones



Fig. 3. White-chinned Petrel *Procellaria aequinoctialis* and Black-browed Albatrosses *Thalassarche melanophris* competing for bait during longline deployment in June 2024, ~60 km off Ilo, southern Peru. Photo credit: Javier Quiñones



Fig. 4. White-chinned Petrel *Procellaria aequinoctialis*, Black-browed Albatrosses *Thalassarche melanophris*, and northern Buller's Albatross *Thalassarche bulleri platei* competing for bait during longline deployment in June 2024, ~60 km off Ilo, southern Peru. Photo credit: Javier Quiñones

Thalassarche salvini (2.4%). Higher bird attendance was also reported during recovery, primarily driven by olfactory and visual attraction to shark offal—liver and intestines were identified as the most preferred components—with Chatham and Black-browed Albatrosses frequently dominant upon arrival.

CONCLUSIONS

According to our findings, bycatch risk in the southern Peruvian artisanal shark longline fishery is seasonally influenced. The seasonal presence of mollymawk albatrosses from New Zealand and southern Chile has been noted previously (Quiñones, Alegre, et al., 2021; Quiñones, Manrique, and Arata 2021).

These results, corroborated by skipper interviews, provide the empirical foundation needed to integrate the Peruvian longline artisanal fleet into ACAP's regional bycatch mitigation framework (Quiñones et al., 2026). During bycatch mitigation trials held by ACAP in 2024, the Peruvian tori line prototype—which achieved ~96% reduction in danger-zone diving during June trials (generalized linear mixed model [GLMM]: $\beta = -3.219$, $p < 0.001$; see Quiñones et al., 2026)—is the primary recommended tool, to be used during longline deployment exclusively in April–June. Nevertheless, further mitigation trials should be conducted, with a greater number of replicates to achieve higher statistical certainty. This seasonally targeted approach could maximize conservation benefit for the ACAP-listed species identified here, while minimizing economic burden on the ~200-vessel Ilo fleet, helping to ensure that mitigation remains operationally feasible and voluntarily adopted across the artisanal fishing community (Quiñones et al., 2026).

The pronounced seasonal pattern of procellariiform occurrence in southern Peru directly determines the temporal window of highest bycatch risk: April–June. Accordingly, I recommend concentrating mitigation efforts for ACAP-listed species in the artisanal Peruvian shark longline fishery during the austral autumn–winter season, when procellariiform densities and aggressive interaction rates are highest.

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ETHICS STATEMENT

This study was based entirely on observational records of free-flying seabirds at sea. No birds were captured, handled, or disturbed, and no eggs or nests were accessed. Ethical approval and animal care committee certification were, therefore, not required.

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