 <p>Agreement on the Conservation of Albatrosses and Petrels</p>	<p>Thirteenth Meeting of the Seabird Bycatch Working Group</p> <p><i>Swakopmund, Namibia, 26 May 2026</i></p> <p>Enabling Mitigation Measures in the Southern Peruvian Artisanal Longline Fleet Targeting Sharks to Reduce the Bycatch of Albatrosses and Petrels</p> <p><i>Javier Quiñones¹, Jairo Calderon¹, Dave Goad², Johannes H. Fischer², Igor Debski², Christian Jiménez¹, Ygor Saenz¹, Fiorella Vilela¹ & Manuel Ochoa¹</i></p> <p>¹ <i>Instituto del Mar del Perú</i> ² <i>Department of Conservation, New Zealand</i></p>
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SUMMARY

This study examined seabird bycatch in the southern Peruvian artisanal pelagic longline fishery targeting sharks and evaluated mitigation strategies across three seasonal campaigns (April, June, and October 2024) in offshore waters of southern Peru. Research was conducted aboard a 12-m wooden vessel comprising 25 fishing operations, supplemented by 24 structured skipper interviews. Seabird abundance demonstrated pronounced seasonal and spatial variation: white-chinned petrels (*Procellaria aequinoctialis*) dominated coastal habitats during autumn and winter, while black-browed albatrosses (*Thalassarche melanophris*) appeared seasonally in June, reaching peak abundances of 21 individuals in intermediate zones. Tori line deployment reduced seabird diving frequency within the danger zone (first 25 m behind the vessel) by approximately 96% during June trials (Wilcoxon $p = 0.0003984$; GLMM: $\beta = -3.219$, $p < 0.001$). Integrated hauling mitigation measures achieved approximately 95% reduction in seabird diving interactions (GLMM: $\beta = -3.0824$, $p < 0.001$). The primary recommendation is to concentrate mitigation efforts during the high-density season (autumn through winter) using the Peruvian tori line prototype during longline deployment. Skipper interviews corroborated field findings, with 73.7% of respondents reporting maximum seabird densities during winter and identifying black-browed albatrosses and white-chinned petrels as the primary bycatch species. This study demonstrates that cost-effective, seasonally targeted mitigation measures developed in close collaboration with artisanal fishermen can substantially reduce seabird bycatch while maintaining the economic viability of fishing communities and providing direct conservation benefits for critically endangered species including the waved albatross (*Phoebastria irrorata*).

RECOMMENDATIONS

We recommend that the SBWG:

1. *Note* the presented information on bycatch risks posed by the Peruvian artisanal longline fleet targeting sharks to ACAP species, particularly during the Austral autumn and winter.
2. *Note* the reduction in seabird interactions in this fishery facilitated by tori lines and integrated hauling mitigation.
3. *Incorporate* the presented results into the artisanal and small-scale mitigation advice toolbox.
4. *Recommend* that AC encourages Parties and others with jurisdiction over relevant artisanal longline fisheries to further develop and implement mitigation measures to reduce bycatch risk.
5. *Recommend* more mitigation pilot surveys in other Peruvian small scale fisheries with potential mortality in albatrosses, petrels and shearwaters.

Habilitación de medidas de mitigación en la flota artesanal de palangre del sur del Perú dedicada a la pesca de tiburones para reducir la captura secundaria de albatros y petreles

RESUMEN

Este estudio analizó la captura secundaria de aves marinas en la pesquería artesanal de palangre pelágico del sur del Perú dedicada a la pesca de tiburones y evaluó estrategias de mitigación a lo largo de tres campañas estacionales (abril, junio y octubre de 2024) en aguas de alta mar de la región. La investigación se llevó a cabo a bordo de una embarcación de madera de 12 metros en la que se realizaron 25 operaciones de pesca, y se complementó con 24 entrevistas estructuradas a los capitanes. La abundancia de aves marinas presentó una marcada variación estacional y espacial: *Procellaria aequinoctialis* dominó los hábitats costeros durante el otoño y el invierno, mientras que *Thalassarche melanophris* apareció estacionalmente en junio, alcanzando picos de abundancia de 21 ejemplares en las zonas intermedias. El despliegue de una línea tori redujo la frecuencia de inmersión de las aves marinas dentro de la zona de peligro (los primeros 25 m detrás de la embarcación) en aproximadamente un 96 % durante las pruebas realizadas en junio (p de Wilcoxon = 0,0003984; GLMM: $\beta = -3,219$, $p < 0,001$). Las medidas integradas de mitigación durante el virado lograron una reducción de aproximadamente el 95 % en las interacciones con aves marinas buceadoras (GLMM: $\beta = -3,0824$, $p < 0,001$). La recomendación principal es centrar los esfuerzos de mitigación durante la temporada de alta densidad (desde el otoño hasta el invierno), utilizando el prototipo de línea tori del Perú durante el despliegue de los palangres. Las entrevistas a los capitanes corroboraron los resultados obtenidos sobre el terreno: el 73,7 % de los encuestados informó que las densidades máximas de aves marinas se registraban durante el invierno e identificó a *Thalassarche melanophris* y *Procellaria aequinoctialis* como las principales especies afectadas por la captura secundaria. Este estudio demuestra que las medidas de mitigación rentables y adaptadas a cada temporada, desarrolladas en estrecha colaboración con los

pescadores artesanales, pueden reducir considerablemente la captura secundaria de aves marinas sin comprometer la viabilidad económica de las comunidades pesqueras y aportar beneficios directos para la conservación de especies en peligro crítico, como *Phoebastria irrorata*.

RECOMENDACIONES

Recomendamos que el GdTCS:

1. Tome nota de la información presentada sobre los riesgos de captura secundaria para las especies del ACAP que supone la flota artesanal de palangre del Perú dedicada a la pesca de tiburones, especialmente durante el otoño y el invierno australes.
2. Tome nota de la reducción de las interacciones con las aves marinas en esta pesquería obtenida con el uso de líneas tori y medidas integradas de mitigación durante el virado.
3. Incorpore los resultados presentados al conjunto de herramientas de recomendaciones sobre mitigación para pesquerías artesanales y de pequeña escala.
4. Recomiende que el Comité Asesor anime a las Partes y a otras entidades con jurisdicción sobre las pesquerías artesanales de palangre pertinentes a seguir elaborando e implementando medidas de mitigación para reducir el riesgo de captura secundaria.
5. Recomiende realizar más estudios piloto de mitigación en otras pesquerías de pequeña escala del Perú en las que exista un riesgo potencial de mortalidad de albatros, petreles y pardelas.

Mise en œuvre de mesures d'atténuation dans la flotte palangrière artisanale du sud du Pérou ciblant les requins afin de réduire les captures accessoires d'albatros et de pétrels

RÉSUMÉ

Cette étude a porté sur les captures accessoires d'oiseaux marins dans la pêche artisanale à la palangre pélagique du sud du Pérou ciblant les requins et a évalué les stratégies d'atténuation mises en œuvre au cours de trois campagnes saisonnières (avril, juin et octobre 2024) dans les eaux au large du sud du Pérou. Les recherches ont été menées à bord d'un navire en bois de 12 mètres, comprenant 25 opérations de pêche, et complétées par 24 entretiens structurés avec les capitaines. L'abondance des oiseaux marins a présenté des variations saisonnières et spatiales marquées : les pétrels à menton blanc (*Procellaria aequinoctialis*) dominaient les habitats côtiers en automne et en hiver, tandis que les albatros à sourcils noirs (*Thalassarche melanophris*) apparaissaient de manière saisonnière en juin, atteignant des pics d'abondance de 21 individus dans les zones intermédiaires. La mise en place de lignes d'effarouchement des oiseaux (lignes tori)

a réduit la fréquence des plongées des oiseaux marins dans la zone de danger (les 25 premiers mètres derrière le navire) d'environ 96 % lors des essais menés en juin (test de Wilcoxon, $p = 0,0003984$; GLMM : $\beta = -3,219$, $p < 0,001$). Les mesures intégrées d'atténuation lors du halage ont permis de réduire d'environ 95 % les interactions de plongée des oiseaux marins (GLMM : $\beta = -3,0824$, $p < 0,001$). La principale recommandation consiste à concentrer les efforts d'atténuation pendant la saison de forte densité (de l'automne à l'hiver) en utilisant le prototype péruvien de ligne tori lors de la mise à l'eau des palangres. Les entretiens menés auprès des capitaines ont confirmé les observations de terrain : 73,7 % des répondants ont indiqué que la densité d'oiseaux marins était maximale en hiver et ont identifié l'albatros à sourcils noirs et le pétrel à menton blanc comme principales espèces capturées accidentellement. Cette étude démontre que des mesures d'atténuation rentables et adaptées aux saisons, élaborées en étroite collaboration avec les pêcheurs artisanaux, peuvent réduire considérablement les captures accessoires d'oiseaux marins tout en préservant la viabilité économique des communautés de pêcheurs et en apportant des bénéfices directs en matière de conservation pour des espèces en danger critique d'extinction, notamment l'albatros des Galápagos (*Phoebastria irrorata*).

RECOMMANDATIONS

Nous recommandons que le SBWG :

1. Prenne note des informations présentées concernant les risques de captures accessoires que représente la flotte péruvienne de palangriers artisanaux ciblant les requins pour les espèces de l'ACAP, en particulier pendant l'automne et l'hiver australs.
2. Prenne note de la réduction des interactions avec les oiseaux marins dans cette pêcherie, rendue possible grâce à l'utilisation de lignes tori et à des mesures d'atténuation intégrées lors du halage.
3. Intègre les résultats présentés dans la boîte à outils de conseils en matière d'atténuation destinée aux pêcheries artisanales et à petite échelle.
4. Recommande que le Comité consultatif encourage les Parties et les autres entités ayant compétence sur les pêcheries artisanales à la palangre concernées à poursuivre l'élaboration et la mise en œuvre de mesures d'atténuation visant à réduire le risque de captures accessoires.
5. Recommande de mener d'autres études pilotes sur les mesures d'atténuation dans d'autres pêcheries artisanales péruviennes susceptibles d'entraîner la mortalité d'albatros, de pétrels et de puffins.

1. INTRODUCTION

The Northern Humboldt Upwelling System (NHUS) is recognised as the most productive marine ecosystem in the world (Pennington et al. 2006), attracting a rich diversity of highly migratory seabirds from breeding colonies distributed across the South Pacific, the Southern Ocean, and New Zealand. Throughout the year, numerous species breeding in different regions of the Pacific Ocean basin are recorded in Peruvian maritime domain (*i.e.* waters within 200 nautical miles). From autumn to spring, several albatross species migrate from New Zealand, including Salvin's albatross (*Thalassarche salvini*), Chatham albatross (*T. eremita*), northern and southern Buller's albatross (*T. bulleri platei* and *T. bulleri bulleri*) (Quiñones et al, 2021a) Black-browed albatross (*T. melanophris*) migrates from Chile (Quiñones et al, 2021b) and the waved albatross (*Phoebastria irrorata*) from the Galápagos Islands. Additional species from New Zealand include the white-chinned petrel (*Procellaria aequinoctialis*), black petrel (*Procellaria parkinsoni*), and pink-footed shearwater (*Ardenna creatopus*), among others. (Rexer-Huber et al, 2025; Fischer et al, 2023; Felis et al, 2019)

Within the NHUS, high levels of artisanal pelagic longline fishing effort pose a significant threat to albatrosses, petrels, and shearwaters. Artisanal longline fishing in Peru targets common dolphinfish (*Coryphaena hippurus*) from November to April, and sharks — including blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*) — from May to October. It is estimated that albatrosses caught annually by this fleet represent 5 to 13% of the waved albatross and Chatham albatross populations foraging off the coast of Peru (Jahncke et al. 2001). Despite the scale of this overlap, quantitative assessments of bycatch and mitigation efficacy in this fleet had remained largely absent prior to the present study. Previous work by Mangel (2012) reported mean capture rates of 0.076 ± 0.065 seabirds per 1,000 hooks, with black-browed albatross, white-chinned petrel, and Buller's albatross as primary bycatch species.

With support from the ACAP Small Grants Programme and the expertise of the Department of Conservation of New Zealand, the present study was carried out to examine seabird species composition across different habitats in southern Peru, their spatial and temporal distribution in oceanic waters south of Ilo port, and their interactions with the artisanal longline fishery (Quiñones et al, 2026). The simultaneous application of three internationally recognised best practices — branch line weighting, and bird-scaring lines (tori lines), and hauling mitigation — represents the most effective approach to reducing seabird bycatch, potentially reducing mortality by 72–93% compared to individual measures alone (Bell et al. 2025).

2. METHODOLOGY

2.1 Study Area and Field Campaigns

Three seasonal field campaigns were conducted aboard the research vessel *San Martín II*, a 12-m wooden artisanal longline vessel based at Ilo Harbour (17°38'S; 71°20'W), southern Peru. The vessel has a 4.5-m beam and is representative of the regional artisanal shark-targeting fleet. The study area encompassed offshore waters in the southernmost extreme of the national territory, spanning coastal (10–30 nm), intermediate (35–75 nm), and oceanic (160–180 nm) habitats (Fig. 1).

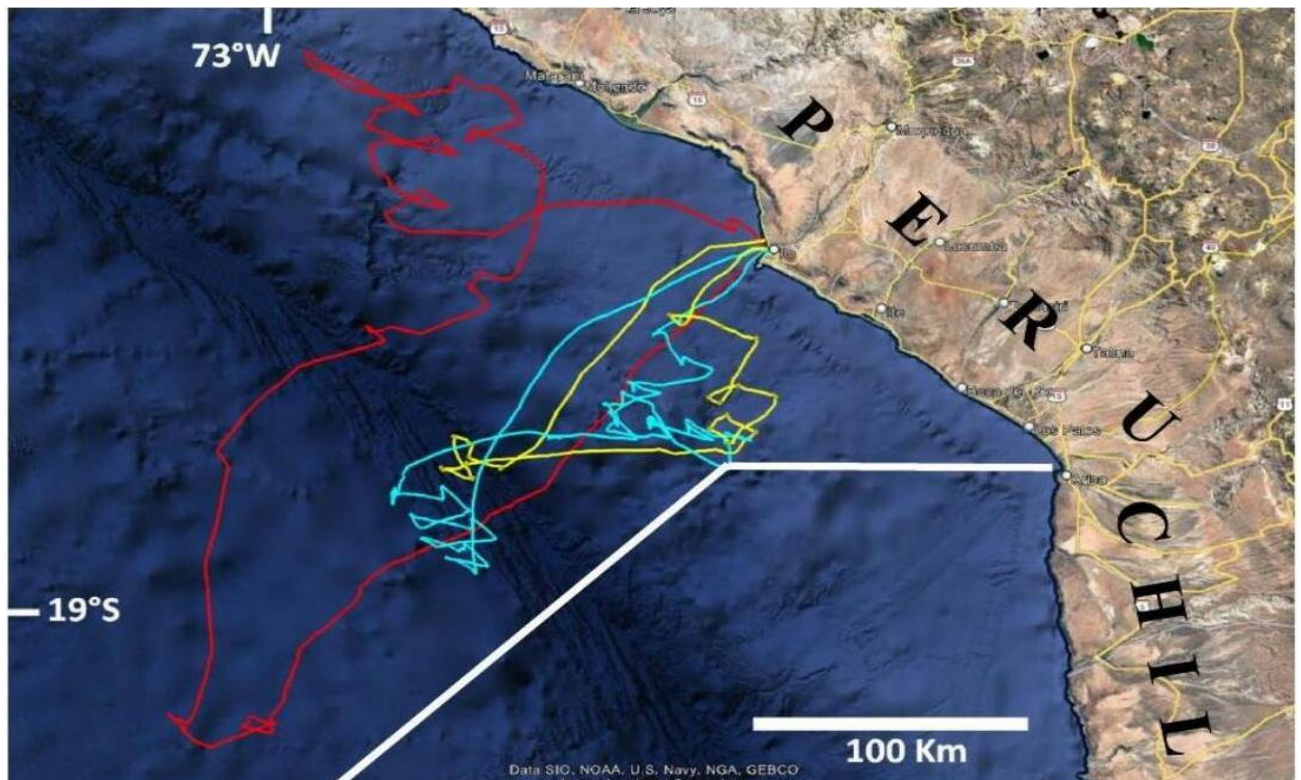


Fig. 1. Study area during the three campaigns: April 2024 (red), June 2024 (light blue), and October 2024 (yellow). The thick white line is the oceanic boundary between Peru and Chile.

Campaign 1 (April 2024, early autumn) comprised ten fishing operations dedicated to baseline characterisation of seabird composition and behaviour, without implementing mitigation measures. Campaign 2 (June 2024, late autumn/austral winter) comprised ten fishing operations coinciding with the seasonal arrival of black-browed albatrosses and peak seabird densities, during which full tori line and integrated hauling mitigation trials were conducted. Campaign 3 (October 2024, early spring) comprised five fishing operations conducted under substantially reduced seabird abundances, confirming the seasonal nature of bycatch risk.

2.2 Fishing gear and operational characteristics

The artisanal longline gear ('espinel') consisted of a 6-mm diameter braided green polyethylene–polyamide mainline with snoods at 27–30-m intervals. Each snood comprised an 11-m proximal polyamide section, a 60-g lead weight with stainless-steel swivel, and a 68-cm steel wire terminal section ending in a Mustad Kirby J-hook (size 3). Average snood length was 11.68 m. Frozen chub mackerel (*Scomber japonicus peruanus*) or giant squid (*Dosidicus gigas*) served as bait. Deployment commenced between 16:00 and 18:00 h at 3–5 knots, with an approximately 13-hour soak time and morning recovery at approximately 06:00 h at 1–3 knots. Experimental trials standardised at 400 hooks per set (200 control, 200 treatment); commercial operations typically deploy 1,000–1,500 hooks.

2.3 Mitigation Measures

Tori Lines

Tori line prototypes were developed based on designs from the New Zealand Department of Conservation and the Brazilian 'Albatross Project', adapted to Peruvian operational conditions using locally available, low-cost materials. The final Peruvian prototype (Fig. 2) incorporates PVC floats, flexible orange hoses (~3 m), coloured gift ribbon streamers (50 cm, multiple colours), a 6-mm polyethylene–polyamide mainline, eucalyptus poles, one-way pulleys, and standard swivels. During trials, the tori line was applied to 200 of the 400 deployed hooks per set (alternating design) to enable direct within-set comparison.

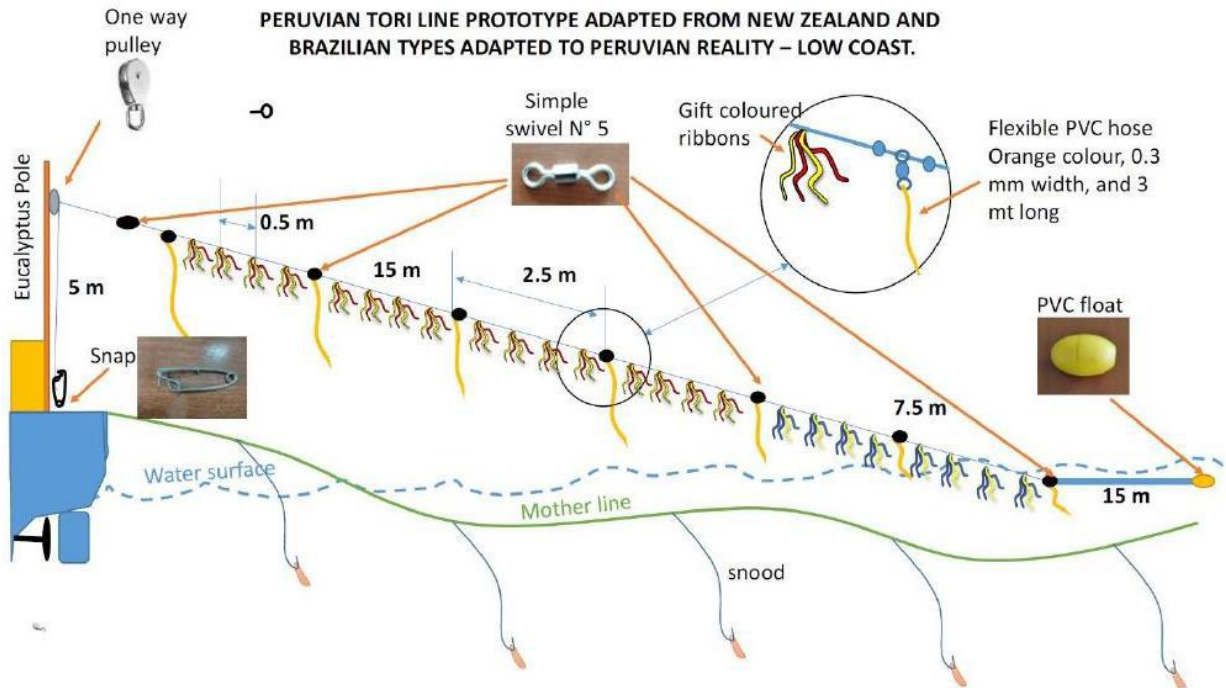


Fig. 2. Peruvian low-cost tori line prototype (final design), adapted from New Zealand and Brazilian longline fisheries and adapted to Peruvian vessel size and engine power. Key components include coloured ribbons, flexible orange PVC hose, a one-way pulley, eucalyptus pole, PVC floats, and standard swivels.

Integrated Mitigation Measures During Longline Recovery

Three complementary measures were applied simultaneously during the recovery (hauling) phase as Integrated Mitigation Measures (IMM): (i) **Hauling mitigation device:** an iridescent orange broomstick suspended from a 5-m bamboo pole secured at the port-stern hauling station, providing visual and tactile deterrence (Fig. 3); (ii) **Offal retention:** all shark offal (liver, intestines) was retained in a dedicated on-deck container and discarded only upon completion of hauling operations, eliminating the olfactory and visual attraction to seabirds during active gear retrieval; and (iii) **Used bait retention:** all unused bait removed from unproductive hooks was collected in a container rather than discarded overboard, preventing bait-associated bird aggregation near active gear.

Used materials to build the low cost Peruvian hauling mitigation



Fig. 3. Low-cost hauling mitigation device deployed at the port-stern of the artisanal longline vessel during longline recovery, constructed from a 5-m bamboo pole with hanging iridescent orange broomsticks (left: components; right: deployed on vessel).

2.4 Seabird Observations, Bycatch Proxies, and Data Analysis

Seabird observations were conducted using standardised 360° surveys at 5-minute intervals during longline deployment and at 100-hook intervals (~3 km) during recovery. Seabird diving and submersion activities within defined ‘Danger Areas’ served as bycatch proxies (Fig. 4). The Danger Area during deployment was defined as an 8 m × 25 m rectangle at the vessel stern, corresponding to the aerial section of the tori line’s effective protection zone. During recovery, a 4 m × 10 m rectangle at the port-stern was used.

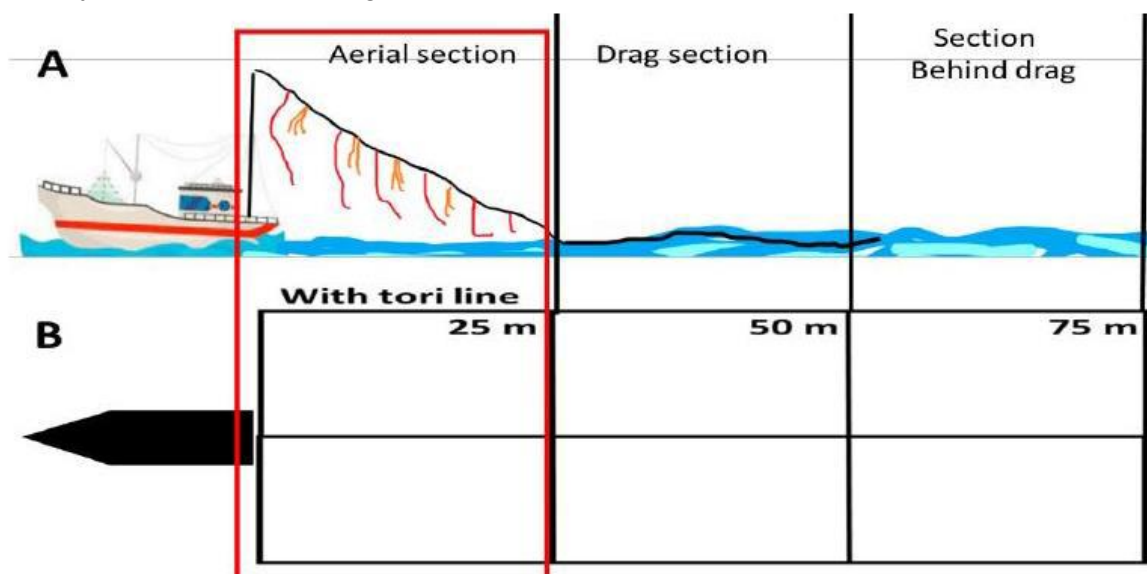


Fig. 4. Schematic representation of the Danger Area (red square) during longline deployment, represented by the first 25 m behind the stern of the vessel. A) Lateral view showing the aerial, drag, and section-behind-drag zones; B) Plan view from above.

Proxy behaviours recorded comprised deep dives by petrels (white-chinned petrel, pink-footed shearwater, sooty shearwater), shallow surface dives (≤ 1.5 m) by albatrosses (black-browed, Buller’s, Chatham, and Salvin’s albatrosses), and shallow dives by skuas (Chilean and south

polar skuas). Wilcoxon signed-rank tests were used for paired comparisons between control and mitigation conditions within individual sets. Generalised linear mixed models (GLMM) with negative binomial error distributions were fitted using the glmmTMB package in R v4.x, with fishing set as a random effect. Model selection employed the corrected Akaike Information Criterion (AICc).

3. RESULTS

3.1 Fishery Characterisation

The artisanal Peruvian longline fishery targeting sharks in southern Peru employs a gear locally known as "espinel," consisting of a braided polyethylene-polyamide mainline arranged in an "S" shape, to which snoods are attached perpendicularly at intervals of 27–30 m. Each snood, averaging 11.68 m in total length, is composed of an 11-m polyamide proximal section and a 68-cm steel wire distal section, joined by a stainless-steel swivel and a 60-g lead weight, and terminated with a size 3 Mustad Kirby galvanized iron "J" hook (between 500 – 1200 hooks) secured with an aluminium sleeve. The primary bait used is frozen, salt-cured mackerel (*Scomber japonicus peruanus*), sectioned into 3–4 pieces, while additional baits include bullet tuna (*Auxis rochei*), giant squid (*Dosidicus gigas*), and various flying fish species.

3.2 Seabird Densities, Behaviour, and Seasonality

Seabird assemblages showed pronounced spatial and seasonal variation across all three campaigns (Table 2). White-chinned petrels dominated upper-slope habitats during April 2024 with a mean density of 170.5 individuals per observation unit, declining to 17.3 in June and to 1.0 by October — a more than 170-fold decrease across the study period. Black-browed albatrosses, entirely absent in April, appeared in substantial numbers during June (mean: 5.0–11.2 individuals across habitats) before declining to virtual absence by October. During late autumn (June), white-chinned petrels, black-browed albatrosses, and Chilean skuas were 8, 33, and 5 times more abundant, respectively, compared to early spring (October). In contrast, Elliot’s storm petrel (*Oceanites gracilis*) showed the inverse pattern, being substantially more abundant during spring, while large seabirds of conservation concern were concentrated during the autumn–winter period.

Species	April 2024	June 2024	October 2024
White-chinned petrel (<i>Procellaria aequinoctialis</i>)	170.5 ± 86	17.3 ± 14.9	1.0 ± 0.7
Black-browed albatross (<i>Thalassarche melanophris</i>)	Absent	5.0 ± 2.6	Absent
Waved albatross (<i>Phoebastria irrorata</i>)	3.3 ± 5.0	0.3 ± 0.5	Absent
Chatham albatross (<i>T. eremita</i>)	1.4 ± 3.0	Absent	0.2 ± 0.4
Buller’s albatross (<i>T. bulleri</i>)	0.8 ± 1.9	1.2 ± 1.0	0.2 ± 0.4
Chilean skua (<i>Catharacta chilensis</i>)	13.2 ± 11.2	3.8 ± 1.7	Absent
Elliot’s storm petrel (<i>Oceanites gracilis</i>)	0.1 ± 0.2	5.8 ± 3.0	18.2 ± 10.0
Peruvian storm petrel (<i>Hydrobates tethys</i>)	13.8 ± 17.1	Absent	Absent

Higher seabird abundances were consistently recorded during longline recovery compared to deployment, primarily attributable to attraction to shark offal and bait discards. Shark liver and intestines were the most preferred offal components, generating strong inter-specific competition — with Chatham albatrosses frequently dominant upon arrival — and elevated numbers of birds around active gear. Prevailing currents dispersed floating offal progressively away from the vessel, effectively drawing seabirds away from the danger area over time.

3.3 Tori Line Mitigation During Longline Deployment

During late autumn trials (June 2024; n = 10 sets, 4,000 hooks total), seabird dives within the danger area ranged from 0–7 events per set under control conditions but were consistently zero during tori line deployment. Across all late autumn hauls, 22 seabirds entered the danger area (5.5 seabirds per 1,000 hooks), all exclusively under control conditions. Species composition comprised 13 white-chinned petrels, 8 black-browed albatrosses, and 1 Chilean skua. In >90% of observations, both long streamers (red tubing) and short streamers remained above the water surface throughout trials, confirming effective deployment under prevailing mild sea states.

Fig. 5 presents the tori line trial results per fishing haul for the danger area (0–25 m astern) during June 2024. Tori line deployment significantly reduced seabird diving activity in five of ten hauls (S3, S4, S7, S8, and S10). In the remaining five hauls, no reduction was observed because seabird presence was minimal or absent during both control and mitigation periods, precluding meaningful comparison. Fig. 6 presents equivalent data for the drag section (25–50 m astern), where reductions were observed in eight of ten hauls; however, reductions at this distance likely reflect natural hook depth rather than tori line efficacy.

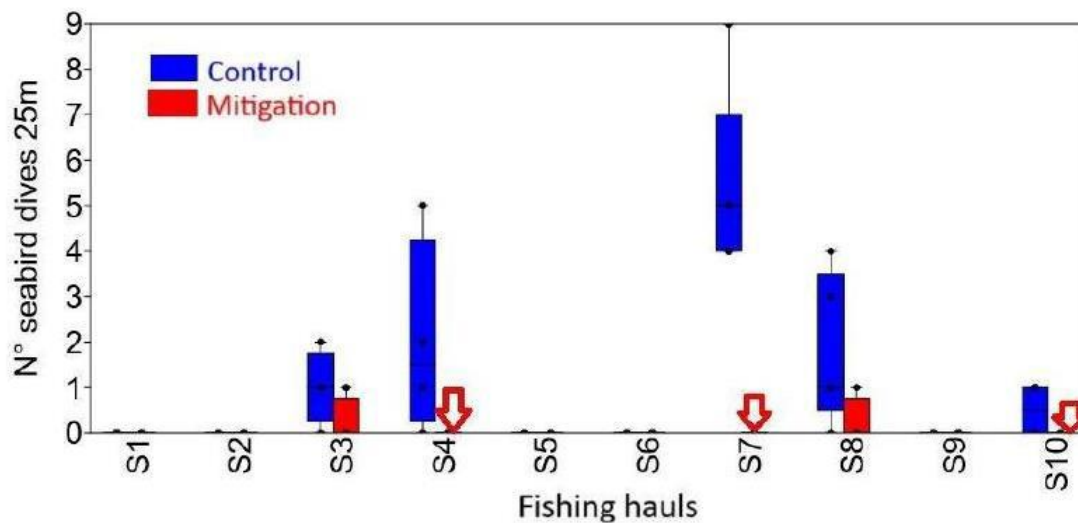


Fig. 5. Tori line trials during late autumn (June 2024) operations in southern Peru, based on seabird dives within the Danger Area (0–25 m behind the vessel stern). Blue bars: control (no tori line); red bars: mitigation (tori line). Red arrows indicate seabird reduction to zero.

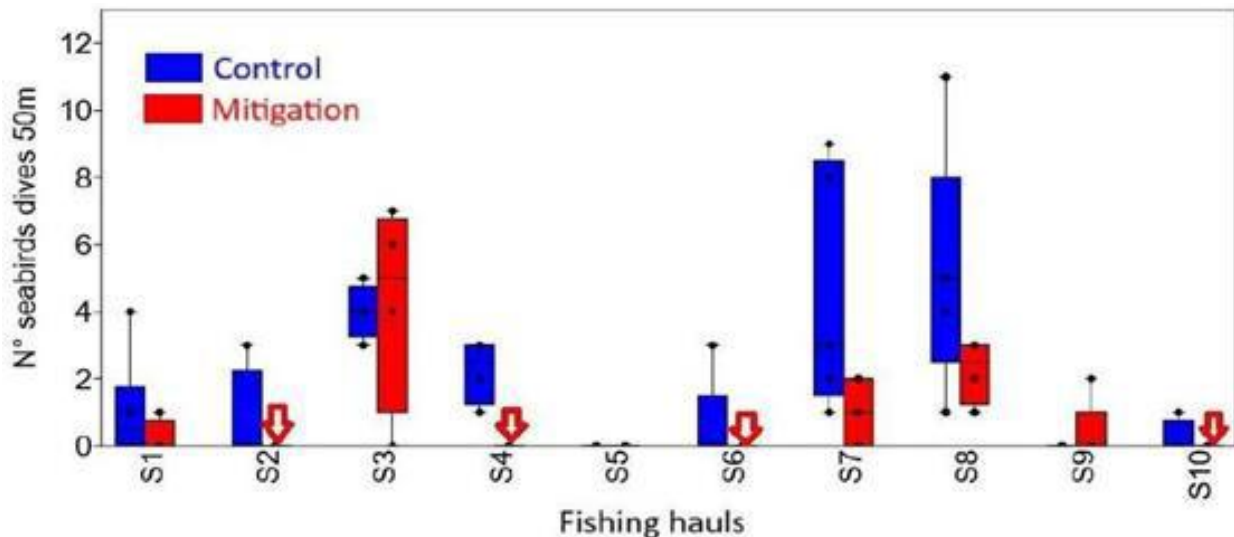


Fig. 6. Tori line trials during late autumn (June 2024) operations in southern Peru, based on seabird dives within the Drag Section (25–50 m behind the vessel stern). Blue bars: control; red bars: mitigation. Note: reductions in this zone likely reflect natural hook depth rather than mitigation efficacy.

Wilcoxon signed-rank analysis confirmed a highly significant difference between control and mitigation datasets ($p = 0.0003984$). GLMM results (Table 1) demonstrated a robust and highly significant reduction in seabird diving activity, corresponding to an estimated 96% reduction in dangerous interactions. During early spring trials (October 2024; $n = 5$ sets), seabird abundance was too low to permit meaningful assessment, with only 2 Dominican gulls recorded under control conditions and zero under mitigation.

Table 1. GLMM results for tori line mitigation during longline deployment (June 2024)	
Parameter	Value
Model type	Negative Binomial GLMM
Observations / Hauls	88 / 10
Treatment effect ($\beta \pm SE$)	-3.219 ± 0.727
z-value / p-value	$-4.428 / <0.001^{***}$
Estimated bycatch reduction	~96%
AICc ($\Delta AICc$ vs. null)	124.82 (>40)

3.4 Integrated Mitigation Measures During Longline Recovery

During late autumn (June 2024) recovery trials ($n = 10$), IMM significantly reduced large seabird diving activity within the port-stern danger area ($10\text{ m} \times 4\text{ m}$). Fig. 7 presents the number of seabird dives into the danger area under control and mitigation conditions across all ten recovery hauls. Reductions were observed in nine of ten hauls (all except S4). Fig. 8 presents seabird entries into the danger area from the water from astern, showing strong reductions under IMM conditions across all hauls except S4, which exhibited a slight increase. These results corresponded with relatively high seabird abundances documented in 360° surveys conducted during recovery operations.

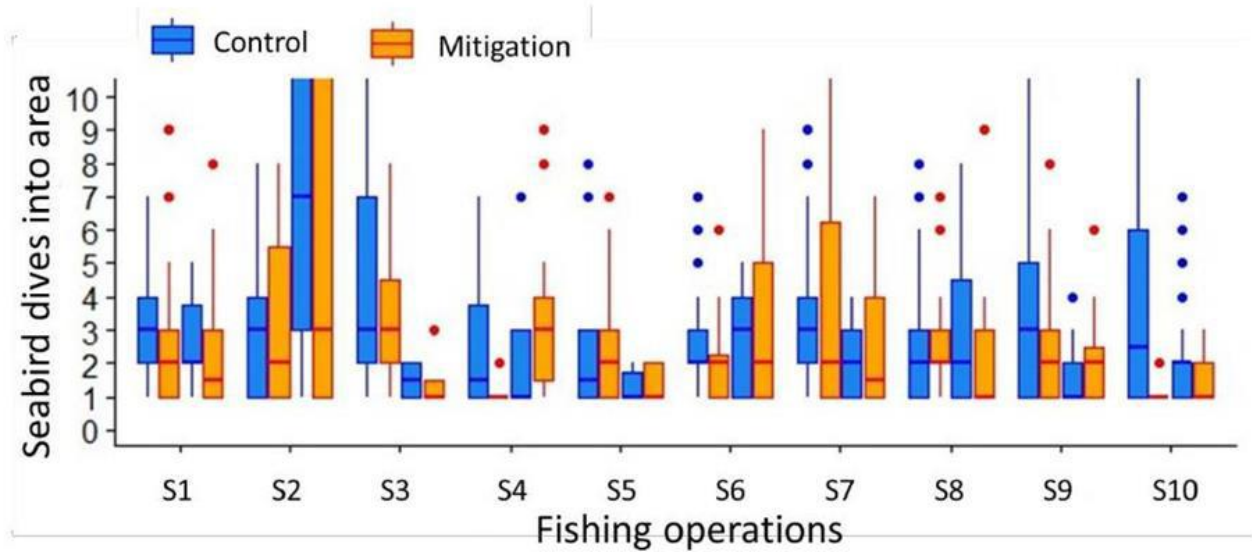


Fig. 7. Mitigation during longline recovery in late autumn (June 2024): seabird dives into the port-stern Danger Area. Blue bars: control; orange bars: integrated mitigation measures (IMM). Dots represent individual observation points; bars represent median values.

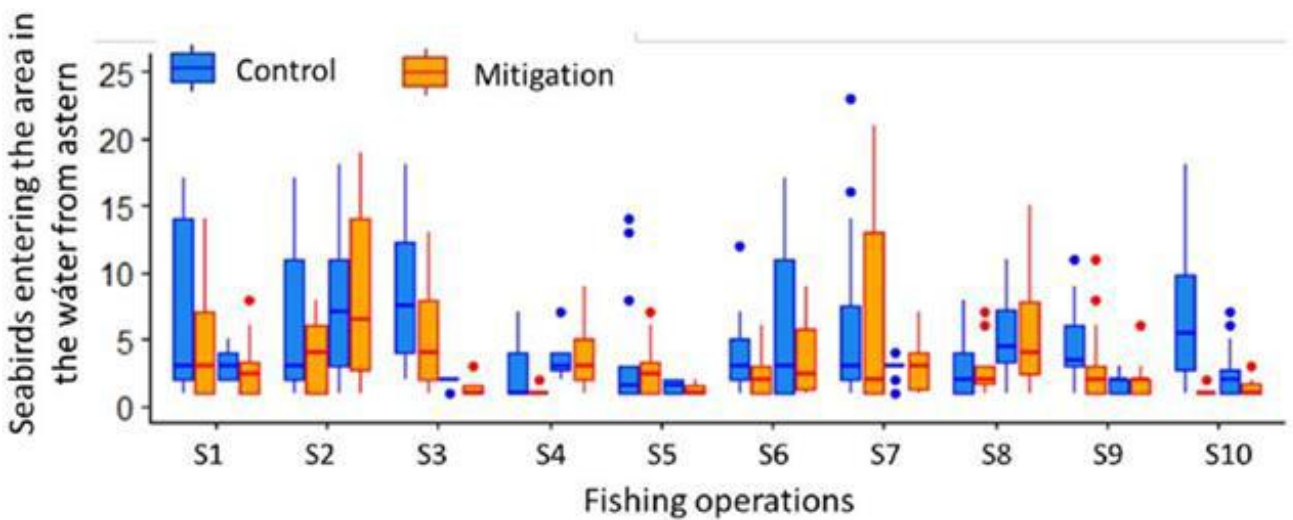


Fig. 8. Mitigation during longline recovery in late autumn (June 2024): large seabirds entering the Danger Area from the water from astern. Blue bars: control; orange bars: IMM.

During early spring (October 2024) recovery trials (n=5), no meaningful reduction was observed under IMM conditions, as seabird densities were extremely low. The absence of effect during this period reflects insufficient bird abundance rather than mitigation failure. GLMM analysis (Table 3) confirmed a highly significant treatment effect across the full recovery dataset, corresponding to approximately 95% reduction in seabird diving interactions.

Table 3. GLMM results for Integrated Mitigation Measures during longline recovery (June 2024)	
Parameter	Value
Model type	Negative Binomial GLMM
Observations / Hauls	397 / 12
Treatment effect ($\beta \pm SE$)	-3.0824 \pm 0.2225
z-value / p-value	-13.852 / <0.001***
Estimated bycatch reduction	~95%
AICc ($\Delta AICc$ vs. null)	914.42 (>280)

4. SKIPPER INTERVIEWS

A total of 30 interviews were conducted; 6 were excluded for reporting on the dolphinfish (*Coryphaena hippurus*) fishery, yielding 24 valid responses. Interviews were conducted at Ilo harbour (71%), Morro Sama, and at sea, during June and December 2024. The surveyed fleet was predominantly composed of large vessels (71%), with fishing operations reported across the Peruvian waters within 200 nm (44.4%), adjacent international waters off Peru (14.8%), southern fishing areas extending beyond the Peruvian maritime boundary (25.9%), and areas beyond national jurisdiction (ABNJ) adjacent to the Southern Humboldt Current System (14.8%), extending as far south as 33°S.

4.1 Seasonal Occurrence

The vast majority of respondents (73.7%) reported maximum albatross and petrel abundances during the austral winter, with lower abundances in autumn (15.8%) and minimal presence in spring (5%). Vessels operating in distant offshore waters (300–600 nm, beyond the Peruvian waters) encountered minimal albatross and petrel densities; only storm petrels and tropical seabird species were recorded at these distances. In contrast, vessels operating within the Peruvian waters (30–200 nm) encountered substantially higher abundances. Seabird densities increased progressively southward, with albatross and petrel abundances in southern waters beyond Peruvian boundary, being more than double those recorded in southern part of the Peruvian maritime domain.

4.2 Bycatch Species, Rates, and Hook Locations

Respondents identified the black-browed albatross as the most frequently bycaught species (47.6%), followed by the white-chinned petrel (31.0%), Buller’s albatross (11.9%), Chatham albatross (7.1%), and Salvin’s albatross (2.4%), using colour photographs of major species. Bycatch rates were substantially higher in southern operational areas (Table 3). Regarding timing, 75% of respondents reported bycatch events occurring during longline deployment, 20% during recovery, and 5% reported no bycatch. Hook placements were predominantly in the throat (43%) and bill (34%), collectively accounting for 77.3% of events, consistent with birds attacking baited hooks during deployment.

Seabird species	Peruvian maritime domain & beyond westward	Southern waters beyond Peruvian maritime boundary
Black-browed albatross	1.7 ± 1.1 birds (0–4, n=12)	3.3 ± 2.6 birds (1.5–10, n=9)
White-chinned petrel	1.1 ± 1.4 birds (0–3, n=8)	4.0 ± 3.8 birds (1–10, n=6)
Buller’s albatross	0.3 ± 0.6 birds (0–1.5, n=6)	1.3 ± 2.3 birds (0–4, n=3)

The majority of respondents (61.9%) reported higher albatross and petrel abundances in inshore waters (30–100 nm offshore), with intermediate abundances (28.6%) at 100–200 nm, and very few birds (9.5%) in far offshore waters (>200 nm). These spatial patterns corroborate the field observations and reinforce the recommendation to concentrate mitigation efforts in inshore and mid-offshore zones during the austral winter.

5. DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Discussion

The pronounced seasonal and spatial variation in seabird assemblages documented across three campaigns provides a robust empirical basis for targeting mitigation efforts. The Peruvian tori line prototype, constructed from locally available low-cost materials and adapted from New Zealand and Brazilian designs, achieved approximately 96% reduction in seabird diving interactions within the danger zone during June 2024 trials. This result is consistent with international evidence: Domingo et al. (2017) demonstrated significant reductions in seabird bycatch through tori line use in pelagic longline fisheries, and Melvin et al. (2014) identified bird-scaring lines as a cornerstone of best-practice bycatch mitigation. The simultaneous application of tori lines, branch line weighting, and night setting has been shown to reduce seabird mortality by 72–93% (Bell et al. 2025).

The use of locally sourced materials represents a critical adaptation: economic accessibility and operational compatibility are the most significant barriers to voluntary adoption in artisanal contexts. Integrated mitigation during the recovery phase achieved approximately 95% reduction in seabird diving frequency, demonstrating the value of combined offal management, bait retention, and physical deterrents during hauling. The effectiveness of offal retention in particular reflects the strong olfactory and visual attraction of procellariiform seabirds to fish discards.

The convergence of independent observer data and local ecological knowledge — from skipper interviews — substantially strengthens confidence in the seasonal management recommendation. Skipper-reported bycatch rates were notably higher in southern higher-latitude fishing areas, consistent with documented southward increases in seabird densities. The conservation implications are significant: this artisanal fleet represents a potentially significant source of mortality risk for the critically endangered waved albatross (*Phoebastria irrorata*), for white-chinned petrels (*Procellaria aequinoctialis*), Chatham albatross (*Thalassarche eremita*), Buller albatross (*Thalassarche bulleri*), and for the pink-footed shearwater (*Ardenna creatopus*). This study provides an evidence-based foundation for integrating the southern Peruvian artisanal fishery into regional bycatch mitigation frameworks under ACAP.

5.2 Primary Recommendation: Seasonally Targeted Mitigation

The most significant finding is that seabird bycatch risk demonstrates pronounced seasonality, with peak risk concentrated during the austral autumn through winter. We recommend that mitigation efforts focus on longline deployment using the Peruvian tori line prototype **exclusively during the high-density season (autumn through winter)**. During periods of

markedly reduced seabird densities (spring and summer), active mitigation may be unnecessary and economically inefficient. This seasonally targeted approach optimises resource allocation and is more likely to achieve voluntary adoption across the approximately 200 vessels in the Ilo fleet.

5.3 Additional Recommendations

- Continue use and refinement of the Peruvian tori line prototype, maintaining construction from low-cost, locally available materials to facilitate voluntary adoption at scale.
- Implement Integrated Mitigation Measures (hauling deterrents, offal retention, bait retention) during the high-density season, given their demonstrated ~95% reduction in dangerous diving interactions during recovery.
- Engage fishing communities through IMARPE and established organisations to promote awareness of seabird bycatch, seasonal risk patterns, and species identification.
- Establish a systematic onboard observer programme to generate reliable bycatch data across the fleet. The current absence of such a programme represents the most significant data gap for this fishery.
- Extend seasonal monitoring in Southern Humboldt Current Ecosystem, where skipper-reported bycatch rates are approximately double those in Peruvian maritime domain.
- Integrate the southern Peruvian artisanal fishery into regional bycatch mitigation frameworks under ACAP, with nationally coordinated and economically feasible measures developed in close collaboration with fishing communities.
- Deploy time-depth recorders (TDRs) on snoods to verify sink rates and confirm that the existing gear configuration provides adequate hook depth without supplementary line weighting.

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