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Enabling mitigation measures in the southern Peruvian artisanal longline fleet targeting sharks to reduce the bycatch of albatrosses and petrels

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SUMMARY

The artisanal longline fishery targeting sharks in southern Peru, operates from mid-autumn to mid-spring, in this scenario there is a strong overlap with New Zealand seabirds, such as Salvin's, Buller's, Chatham, Northern Giant Petrels, Black Petrels, White-chinned petrels, Sooty Shearwaters, Cook's petrels, etc. As well as from Chile, such as Black-browed albatrosses, Pink-footed shearwaters, Juan Fernandez Petrel, Masatierra petrel, among others. Therefore, we test mitigation measures recommended by ACAP, New Zealand and Brazil, we adapted those to the Peruvian reality, building a tori line and hauling mitigation prototypes, and good practices in offal discards, and tested in this fishery. We registered seabird relative densities, species composition and behavior during longline deployment and recovery, using a "Danger area" as a bycatch proxy. In addition, we determine the characteristics of the artisanal longline targeting sharks, their characteristics, operability, and trials for testing the Peruvian Tori-lines prototype. The study area was located in offshore waters of southern Peru, between 20 to 180 nautical miles offshore, we performed 10 fishing operations and we obtained seabird species densities in each fishing area (coastal, intermediate and oceanic), seabirds behavior during longline operations during longline deployment and longline recovery, Number of seabird per species entering in the Danger Area, Conclusions and technical recommendations.

RESUMEN

La pesquería artesanal de palangre dirigida a tiburones en el sur de Perú, opera desde mediados de otoño hasta mediados de primavera, en este escenario hay una fuerte superposición con aves marinas de Nueva Zelanda, como albatros de Salvini, de Chatham, de Buller, petreles gigantes del norte, petreles barbilla blanca, pardelas grises, petrel de

Cook, etc. Procedentes de Chile, como albatros ceja negra, pardelas de patas rosadas, petrel de Juan Fernández, petrel de Masatierra, entre otros. Por lo tanto, probamos las medidas de mitigación recomendadas por ACAP, Nueva Zelanda y Brasil, las adaptamos a la realidad peruana, construyendo prototipos locales de Tori-line y mitigación lateral, así como buenas prácticas de descarte de vísceras, y las probamos en esta pesquería. Se registraron densidades relativas de aves marinas, composición de especies y comportamiento durante el despliegue y el recojo del palangre, utilizando un "área de peligro" como proxy de la captura incidental. Además, determinamos las características de esta pesquería, su operatividad y pruebas con el prototipo adaptado de Tori-line. El área de estudio se ubicó en zonas oceánicas del sur del Perú, entre 20 y 180 millas náuticas mar adentro, se realizaron 10 operaciones de pesca y se obtuvieron densidades de especies de aves marinas en cada área de pesca (costera, intermedia y oceánica), comportamiento de las aves marinas durante las operaciones de palangre durante el despliegue y la recuperación del aparejo, número de aves marinas por especie que entran en la zona de peligro, conclusiones y recomendaciones técnicas.

I. Introduction: The Northern Humboldt Upwelling System (NHUS) is the most productive marine ecosystem worldwide (Pennington et al. 2006), this system attracts many highly migratory species, such as albatrosses, petrels and shearwaters. During the whole year, a wide variety of species, breeding in different places of the Pacific Ocean basin have been recorded in Peru, for example from autumn to spring, several species of albatrosses, such as Salvin´s (*Thalassarche salvini*), Chatham (*T. eremita*), Northern Buller's (*T. bulleri platei*), Southern Buller's (*T. bulleri bulleri*) come from New Zealand; Black-browed albatrosses (*T. melanophris*) from Chile; Waved albatrosses (*Phoebastria irrorata*) from Galapagos. As well as, Giant northern petrel (*Macronectes halli*), White-chinned petrels (*Procellaria aequinoctialis*), Cook's petrel (*Pterodroma cooki*), Sooty shearwaters (*Ardenna grisea*), Black Petrel (*Procellaria parkinsoni*), Buller shearwater (*Ardenna bulleri*) among others come as well from New Zealand, and Masatierra's petrel (*Pterodroma defilippiana*), and Pink-footed shearwater (*Ardenna creatopus*) from Chile.

Within the NHUS, high levels of artisanal longline fishing effort pose a threat to different species of albatrosses, petrels and shearwaters. Artisanal longline fishing in Peru targets Mahi mahi (*Coryphaena hippurus*) from November to April, and sharks, such as Blue (*Prionace glauca*) and Mako (*Isurus oxyrhynchus*) from May to October, while hand lines with squid jigs targets giant squid (*Dosidicus gigas*) all year round. By-catch of seabirds is often associated with commercial longline tuna fishing (e.g. Alderman et al. 2011). However, it is estimated that the number of albatrosses caught annually by the Peruvian longline artisanal fishing probably represents 5 to 13 per cent of the populations of Waved and Chatham albatrosses that feed off the coast of Peru (Jahncke et al. 2001). However, the last information is not updated, and almost nothing is known regarding artisanal longline bycatch in southern Peru nowadays. Therefore, a better understanding of artisanal fishing operations in Peru and their impact on albatrosses, petrels and shearwaters, as well as the identification of viable low coast mitigation options for this fishery is urgently needed.

II. Objetive. As an initial priority we propose to characterize the operations of the artisanal longline fishery. targeting sharks in coastal and offshore waters of southern Peru, and then testing the most feasible and effective forms of by-catch mitigation. Specifically, our aim is to first characterize which species of albatross, petrels or shearwaters behaves and interact with fishing gear during deployment and recovery, and to try to quantify their species composition, relative densities, and presence in the "Danger Area" (a proxy of seabird bycatch) in coastal, intermediate and offshore waters

In addition, we will try to identify in which part of the gear (for example, mother line, snoods, wire snood, etc.) the bycatch evets or bycatch proxy mostly occur. We will also undertake a further assessment on the overlap of albatross and petrel species with the full range of artisanal fisheries in Peruvian waters to quantify the potential risk of bycatch. Based on the information collected, we will plan the implementation of the most feasible (i.e., simple and affordable) seabird bycatch mitigation measures to ensure its future implementation by local fishermen. The final objective of this project is to reduce by-catch of seabird species, focusing on vulnerable albatrosses and petrels occurring in the NHUS.

III. Methodology:

1. Prior Observations without mitigation measures: We first observed the normal operation of the artisanal longline gear in southern Peru, without using any mitigation measures, so according to Fig. 1., we registered the seabird relative densities, species composition, all in the observation area up to 100 mt radius at 360° or up to 180°, and also in the Danger area, represented by the black rectangle (Fig. 1.), this observation technique was applied during the following fishing periods:

a) during the longline deployment, starting around 03 - 04 pm more, and finishing just before the sunset.

c) during the longline recovery, from 06 am until the total gear was totally onboard, the time depends on the number of sharks captured, this is a very important period since there were a lot of offal discards, a very effective seabirds attractant.

d) During the soak time, we didn't perform any analysis since was entirely during night time.

In addition, we register the seabird's behavior close to the "Danger Area", as well as determining which species presented some kind of direct attack action towards the bait, both during longline deployment and recovery.

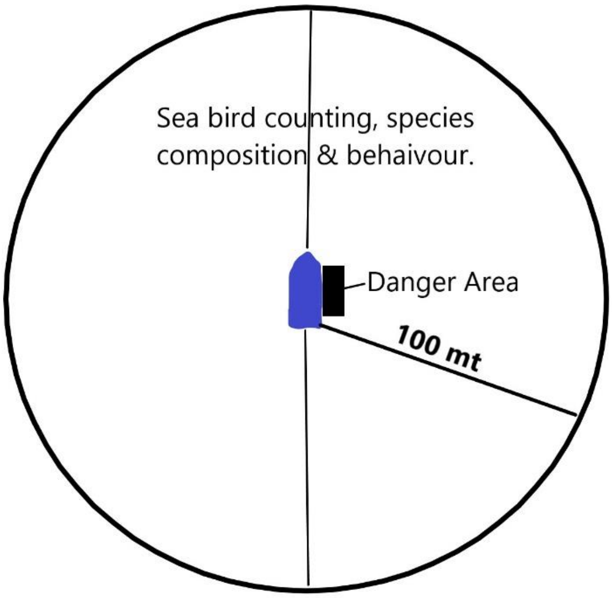

Fig. 1. Sea bird observations method in the 360° area, and in the "Danger Area" (black square), the vessel is represented by the blue polygon.

2. Proposed mitigation measures to test in the Peruvian scenario.

2.1) *Tori-lines*, we first perform the observations specified in the section 1, then in the last haul we tested the tori-line, and it worked very well, however we will test them in the second (June) and third (October) onboard operations, when the albatrosses' densities will be higher, since important numbers of Black-browed albatrosses will arrive by June.

2.2) *Hauling Mitigation*, this will be an effective tool for the Peruvian artisanal longlines, we used local very cheap materials to build them, we will start testing the trials in the second (June) and third (October) onboard operations.

2.3) *Good practices in offal discards*, we will count with and without good practices, we will store the shark offal in the fishing cages, they will be on the deck of the vessel, and because they are too smelly, they will lure seabirds anyways, so we propose to do a batch discard at the stern on the opposite side of the hauling area. As the two previous mitigation measures, we will start testing the trials in the second (June) and third (October) onboard operations

3. Mitigation methods we cannot apply to the Peruvian scenario.

3.1) *Line-weighting*, in the Peruvian longline gear targeting sharks, the snoods are between 10 / 12 mt long, and the first 9 / 11 mt are composed of polyamida multifilament material, and the last 0.5 mt section is composed by a 2 mm diameter wire (obviously weights more than the multifilament), between the two sections of the snood is a lead (Pb) weight (60 gr) with a swivel and at the final end of the wire is a "J" hook, so there is already weight on the snoods in the Peruvian artisanal longline, so they work straight downwards, so as far as we have been observing, it would no longer be necessary to use this mitigation measure since is already implemented, however we can still test some TDR's in order to test the sinking time.

3.2) *Night setting*. We already use night setting in the Peruvian scenario, since they start the deployment at 03:00 / 04:00 pm and finish just before sunset, they operate the whole night, and the recovery starts more or less around 06:00 am. So, is no longer necessary to test them. In addition, it is very difficult to change these operating procedures, since they are fully rooted in the Peruvian artisanal fishermen community.

3.3) *Hookpod mini*: is impossible to use them because is very expensive for the Peruvian fisherman budget, and also the device is activated at 20 mt depth (so is perfect for the fishing depth range for blue fin tuna longline fishery in New Zealand, but not for the Peruvian shark fishery, which operates in shallower waters (between 10 and 12 mts depth).

4. Tori-line low-coast Peruvian prototypes

The different mitigation measures we are using are the most accessible in economic terms, the cost of purchasing materials and implementation are economically accessible to the longline fishing community in southern Peru, so it can be applied to reality. Otherwise, things are just written in a paper and could never be implemented, since the economic situation in the country, and especially of the fishermen, is not the best. As follows you will see the Tori lines prototypes we already built, and the used materials (Fig. 2, 3, 4, and 5)

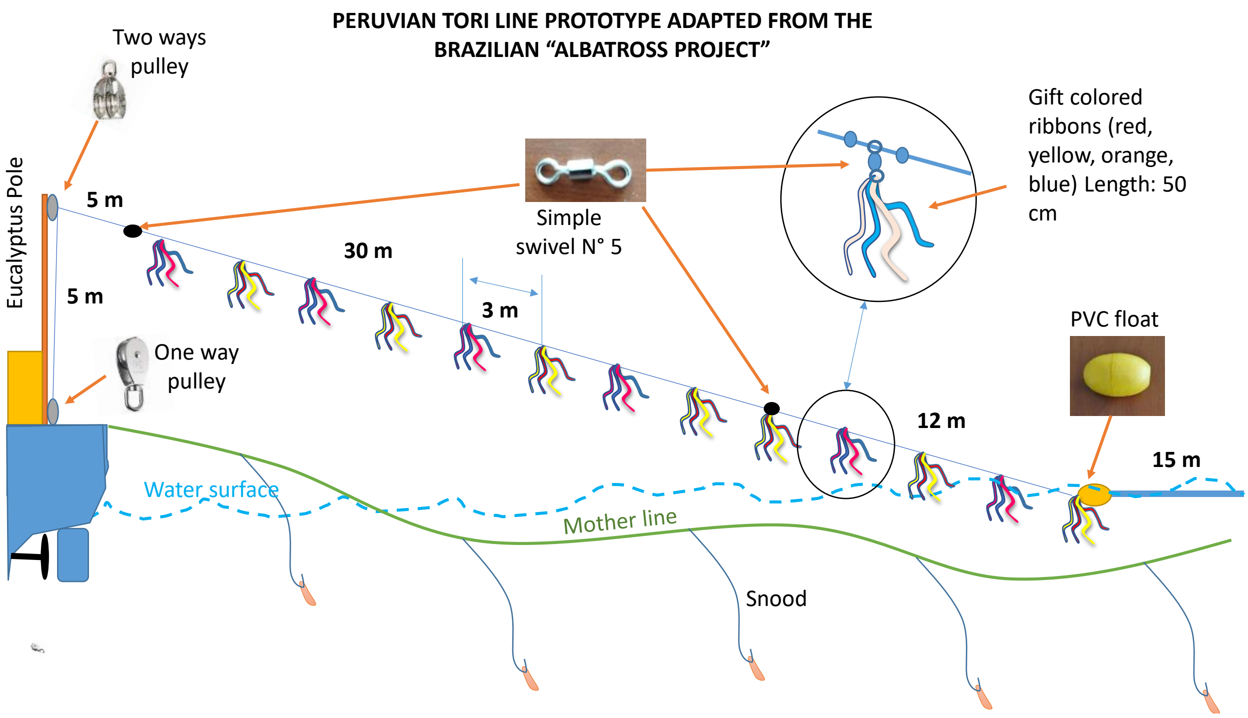

Fig. 2. Peruvian low coast prototype, adapted from the Brazilian "Albatross Project", Gabriel Canani send us the original Brazilian model used in Rio Grande do Sul.

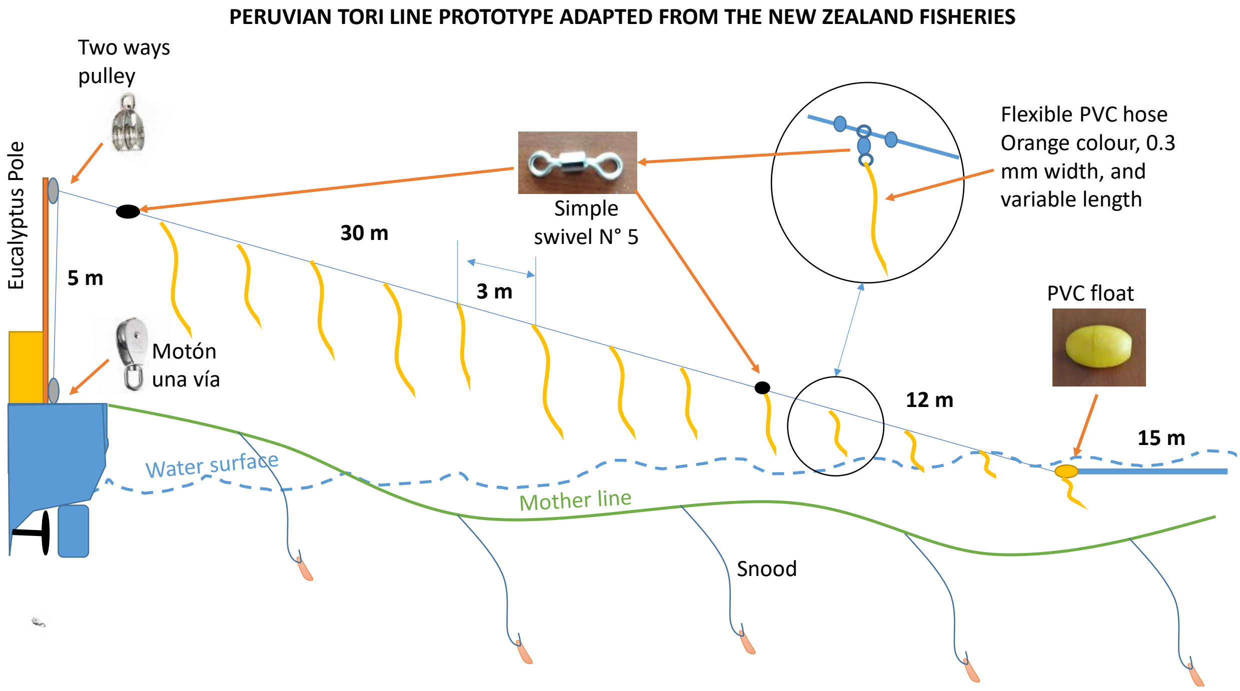

Fig. 3. Peruvian low coast prototype, adapted from the small scale New Zealand longline fisheries targeting Bluefin tuna, original sent by Dave Goad, from the Department of Conservation.

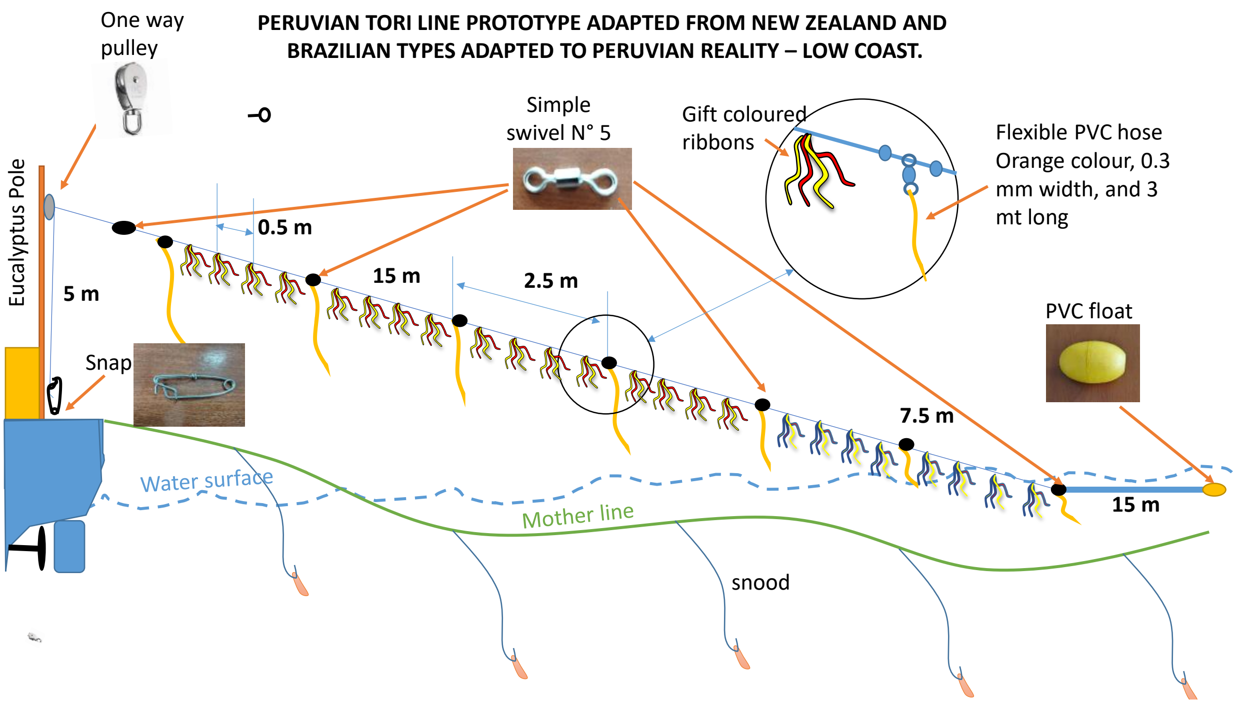

Fig. 4. Peruvian low coast prototype, adapted from the small scale Brazilian and New Zealand longline fisheries targeting swordfish and Bluefin tuna respectively, this is the final design being tested in Peru, since is well adapted to the vessels size and engine power.

Used materials to build the peruvian tori line

Fig. 5. Local materials employed to the construction of the Peruvian version of the Tori Line.

V. Hauling mitigation Peruvian prototype

We construct as well a very low coast hauling mitigation, using Iridescent orange broom sticks, tarry thread, and a 5 mt long bamboo rod for use in the stern port area, which is where the longline is recovered (Fig.6).

Used materials to build the low coast Peruvian hauling mitigation

Fig 6. Low coast materials for the Peruvian version of the hauling mitigation

VI. Characteristics of the artisanal Peruvian longline targeting sharks:

This artisanal longline gear is locally called "espinel", the mother line is made of polyethylene and polyamide, having a 6 mm diameter braided green rope in "S" shape, from where equidistant snoods hang perpendicular to the main line, the separation between snoods ranges from 27 to 30 m. (17 average fathoms), these snoods are formed in 02 parts: the first one that measures 11 m in average, are made of black tarred halyard, the material is multifilament braided polyamide with soul, the second part measures 68 cm average, and is made of steel wire lined with 2 mm diameter, these two parts are separated by a swivel and a 60 gr lead weight, made of stainless steel, at the end carries a hook type "J" N°3 Mustad kirby left torsion 15° Fe galvanized, with hoop clinging with an aluminum cap. The average overall size of the snood is 11.68 m. (Fig.7.)

The bait used was frozen mackerel (*Scomber japonicus peruanus*), and this was sectioned in 3 or 4 parts with transverse cuts and cured with sea salt in order to last in the whole onboard operation. It should be noted that during phase I of the study there was no interaction with birds in any of the 10 fishing operations where there was a total catch of 2329,3 kg (1946.6 kg of shark, 382.7 of pelagic ray and 01 swordfish that due to its size could not be weighed, but exceeded 150 kg) it could only be seen that some of the birds ate the discarded bait in the "Danger area", but these did not hook, mostly the petrels and shearwaters were the ones showing a more aggressive behavior towards the baited hooks.

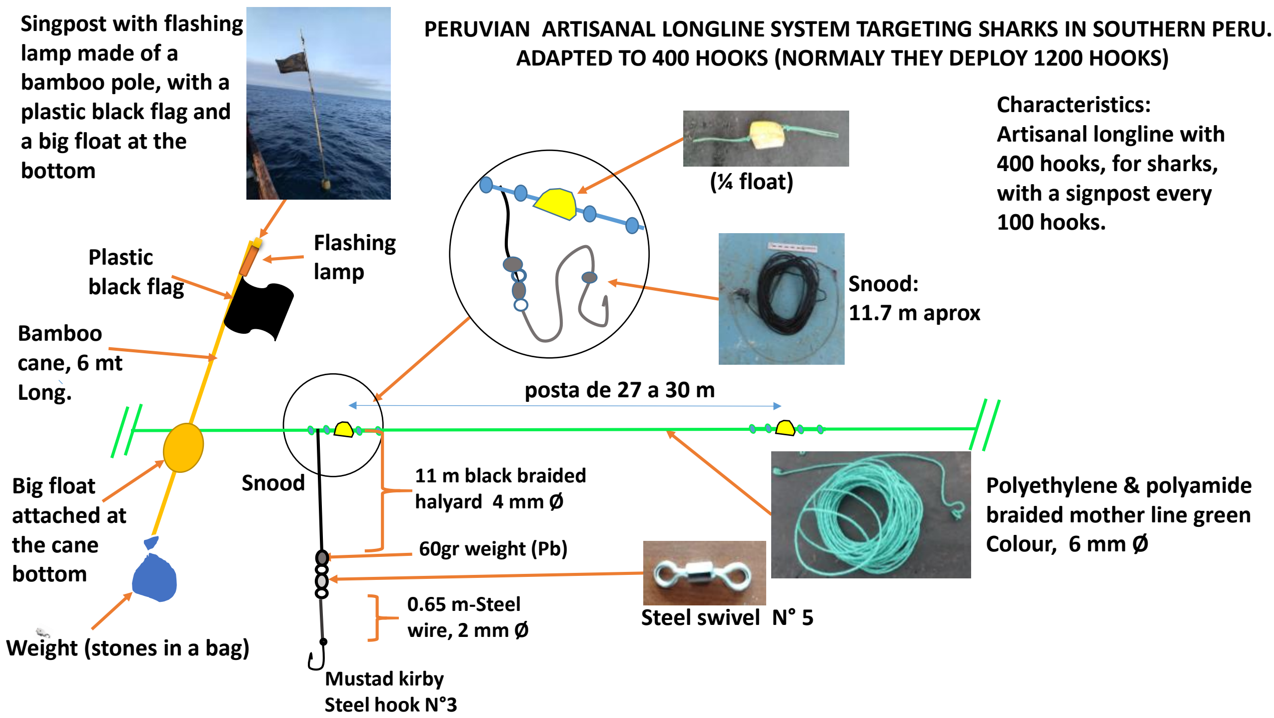

Fig. 7. Design of the artisanal Peruvian longline targeting sharks, materials, measures, and structures used by local fisherman in southern Peru.

VII. Operability of the Peruvian artisanal longline targeting sharks

Longline deployment: The operation is carried out in the afternoon, between 04:00 to 06:00 approximately, the maneuver lasts between 90 to 120 minutes at a speed between 3 to 5 knots, it is manually launched by the stern port band, and the mother line leaves by the stern of the boat, the whole gear is held in a big (6.5 m^2) metal rectangular structure at the stern, closed and surrounded by a mesh, the total number of hooks used per fishing operation was 400, separated by sets with a signpost (bamboo pole with a black flag) every 100 hooks, At the end of the line, two flashing lamps were added to the signpost, that automatically lights up in the penumbra and serves to visualize the fishing gear during the night, where the remaining of the longline begins. We tested 400 hooks, but commercially they use between 1000 to 1500 hooks.

Longline recovery: Once finished the soaking time, which lasts about 13 hours' average, the longline is manually lifted along the port band almost between the center of that band, this is raised snood by snood at a speed of between 1 to 3 knots and this stops when it is seen that a float is deepened that is warning that there is a capture, the catch is climbed onboard and continues with the recovery of the gear until the end (400 hooks in this occasion).

VIII. Peruvian Tori-line testing

A tori-line operability test was performed, our trials indicate that our device worked well, was observed that the birds in the area did not come close when the device was working, the size of the tori-line for this boat was well fitted, having a 5 mt pole over the vessel superstructure, having 7 mt overall height from the water surface. There was no entanglement between the longline mother line and the whole tori line structures (backbone, mini hoses, and gift ribbons), nor even when the signpost was already deployed (Fig. 8).

Fig. 8. Peruvian tori line being tested in offshore waters of southern Peru.

IX.Logistics

We arrived to Ilo Harbour (17°38'S; 71°20'W) in southern Peru on April 16th 2024, and we took at least two days to purchase all the nurseries, food, petroleum, we purchase 500 gr frozen chub mackarell (*Scomber japonicas peruanus*), four tons of ice, and we store all on board the research vessel "San Martin III" a wooden made artisanal vessel of 12 meters long and 4.5 meters wide, we depart from the Ilo harbor on April 18th 2024, and we sailed for about 45 hours to arrive to our destination in offshore waters at 180 nautical miles southeast Ilo, which corresponds to 190 nautical miles northwest Iquique (Chile), in the southwest corner of the Hague Triangle in the southeastern most part of Peru.

X. Study area

The onboard operation lasted 15 days, we surveyed three different fishing areas: 1) the first one in offshore waters over the Abyssal plain, between 160 and 180 nautical miles offshore, in this area we performed two fishing operations; 2) the second one in an intermediate zone over the deepest part of the continental slope and the shallower part of the Peru – Chilean trench, between 30 and 70 nautical miles offshore, in this area we performed dour fishing operations and 3) third, a coastal area over the shallower part of the continental slope between 10 to 30 nautical miles offshore, where additional four operations were carried out, the latitudes of the working area ranged from 16°50'S to 19°30'S and the longitudes from 72°W to 73°40'W (Fig. 8.).

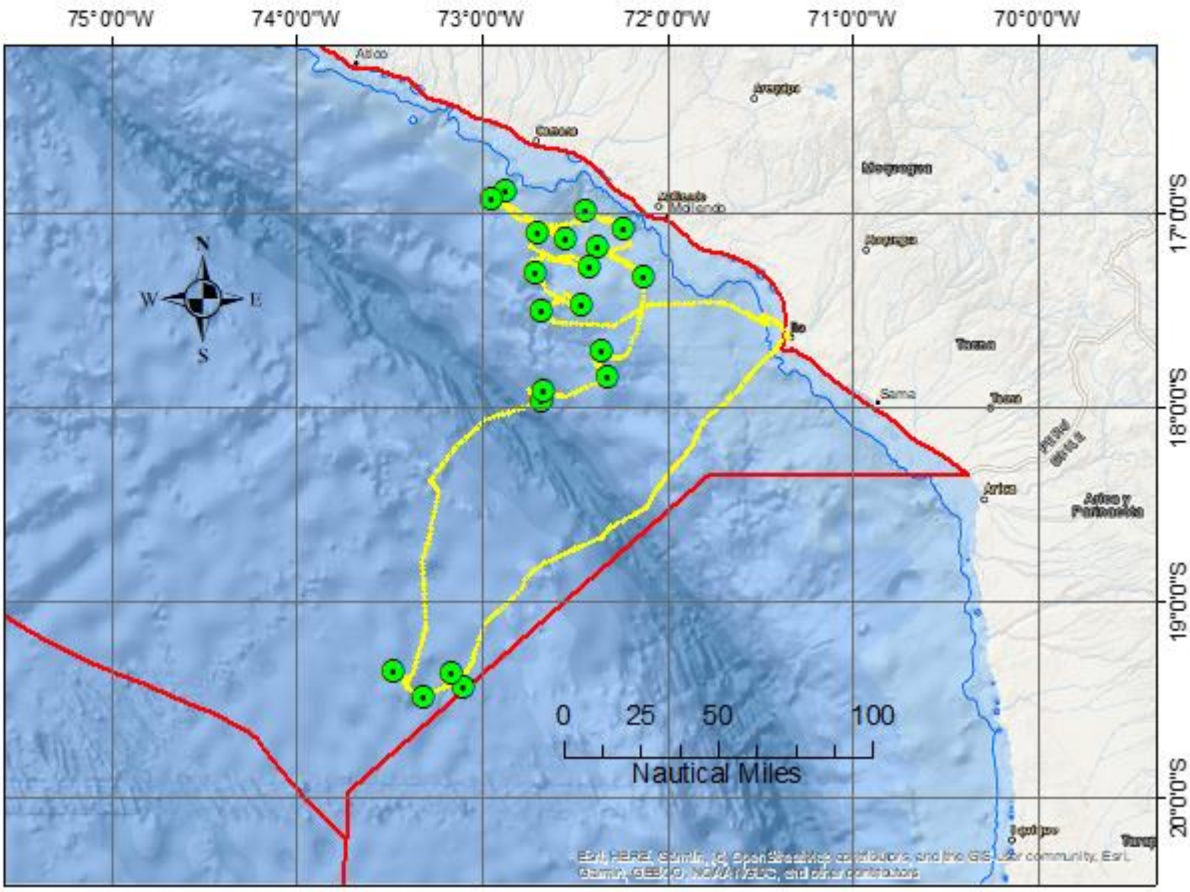

Fig. 8. Map of the fishing operations (deploy and recovery) represented by green circles, the fishing track by the yellow line; the EEZ Peruvian limits with Chile, represented by a red solid line, and the shelf break area by a thin blue line close to the coast.

XI. Fishing operations

Table 1: Fishing operations carried out in an artisanal longline vessel targeting sharks in southern Peru

Haul	Date	Hour	SST	DC	Reference	Lat (°)	Minutes	Long (°)	Minutes
1 deploy	20/04/2024	14:58	23.7	162	Morro Sama	19	26.14	73	5.78
1 haul	21/04/2024	07:40	22.9	164	Morro Sama	19	22.219	73	9.866
2 deploy	21/04/2024	14:22	23.3	176	Morro Sama	19	29.148	73	19.094
2 haul	22/04/2024	07:47		179	Morro Sama	19	21.631	73	28.295
3 deploy	23/04/2024	15:38		72	Pta Bombon	17	58.416	72	40.725
3 haul	24/04/2024	07:55	23.6	69	Pta Bombon	17	55.374	72	39.677
4 deploy	24/04/2024	15:12	23.8	56	Sur Pta. Bonbon	17	50.711	72	19.158
4 haul	25/04/2024	06:12	23.6	47	Pta Bombon	17	43.173	72	21.285
5 deploy	25/04/2024	15:33	22.5	19	Mejia	17	19.818	72	7.668
5 haul	26/04/2024	07:12	22.6	19.7	Norte Matarani	17	10.762	72	22.191
6 deploy	26/04/2024	16:30	20.5	9.8	Matarani	17	4.935	72	14.372
6 haul	27/04/2024	05:44	19.7	12.4	Honoratos	16	59.347	72	26.179
7 deploy	27/04/2024	16:02		17.7	Camana	16	53.464	72	52.105
7 haul	28/04/2024	06:43	20.7	22.5	Camana	16	55.929	72	56.588
8 deploy	28/04/2024	16:33		23.2	Honoratos	17	8.425	72	32.687
8 haul	29/04/2024	07:40	20.4	29.2	Quilca	17	6.429	72	41.999
9 deploy	29/04/2024	16:04		26.6	Matarani	17	16.926	72	25.307
9 haul	30/04/2024	07:38	22.9	38	Honoratos	17	18.751	72	42.871
10 deploy	01/05/2024	16:04		38.8	Molloendo	17	28.728	72	27.474
10 haul	01/05/2024	05:50	23.6	46.8	Norte Matarani	17	30.55	72	40.325

* SST = Sea Surface Temperature; DC= Distance to the Coast; (°) = Latitudinal degrees all in the southern hemisphere.

XII. Seabirds species densities in each fishing area:

The oceanic area (160 – 180 nm offshore) was dominated by storm petrels, mainly by Hornby's storm petrels (*Hydrobates hornbyi*) and peruvian storm petrel (*Halocyptena tethys*), however the relative densities (N° of birds / 1000 mt), were more than five times during longline recovery compared to deployment. Gadfly petrels were also a very important component of this area, mainly represented by the Juan Fernandez petrel (*Pterodroma externa*), showing the same density pattern, being 5 times more abundant during longline recovery than deployment. however, Masatierra petrel (*Pterodroma defilippiana*) had similar relative abundances during deploy and recovery. Regarding big albatrosses the only one present were adults Chatham albatrosses (*Thalassarche eremita*) showing an opposite pattern, being almost three times more abundant during longline deployment than recovery.

The Intermediate area (35 – 75 nm offshore) was dominated by White-chinned petrels (*Procellaria aequinoctialis*) being 7.5 times more abundant during longline recovery compared to deployment, the Juan Fernandez petrel and the Pink Footed shearwater (*Ardenna creatopus*) were four and eight times more abundant during longline recovery compared to deployment respectively. In this area more big albatrosses came on the scene, such as Buller's albatross (*Thalassarche bulleri*) mainly adult northerns, and adult Chatham albatrosses, the same pattern was registered being four and five times more abundant during longline recovery than deployment respectively. Salvin's albatrosses (*Thalassarche salvini*) were as well registered, but very few numbers and mainly juveniles. Another seabird taxonomic group was also recorded in this area, represented mainly by the Chilean skua (*Catharacta chilensis*) and South Polar skua (*Catharacta maccormickii*), with the same pattern being six and two times more abundant during longline recovery than deployment respectively. Storm petrels also showed the same pattern, being four times more abundant during longline recovery than deployment.

The coastal area (10 – 30 nm offshore), was absolutely dominated by the White-chinned petrels, being 45 times more abundant during longline recovery compared to deployment, mean abundances during recovery were 106 birds / 1000 mt. The critically endangered waved albatross (*Phoebastria irrorata*), was a very important seabird in this area, having 15 times higher abundances during recovery compared to deployment, Chatham and Buller's albatrosses were as well present in this area, showing the same pattern, being more abundant during longline recovery. Surprisingly storm petrels had very similar relative abundances in both longline deployment and recovery in this area. The Chilean skua was six times more abundant during longline recovery. The swallow-tale seagull (*Creagrus furcatus*), exhibit a slightly higher relative abundances during recovery compared to deployment. For more detailed information regarding specific relative abundances and other species in each tested area please see Tables 2 and 3.

Table 2. Average main seabird relative densities (N° birds/1000 mt) during longline deploy, the average velocity was 3.75 knots, in 10 minutes 1.16 km were covered

Seabird species	Oceanic Area (160 – 180 nm offshore) (n=32)	Intermediate Area (35 – 75 nm offshore) (n=50)	Coastal Area (10 – 30 nm offshore) (n=48)
Albatrosses			
Phoebastria irrorata			0.17 (0 – 2)
Thalassarche eremita	0.19 (0 – 2)	0.1 (0 – 1)	0.03 (0 – 1)
Thalassarche bulleri		0.37 (0 – 3)	0.03 (0 – 1)
Thalassarche salvni		0.03 (0 – 1)	
Petrels			
Procellaria aequinoctialis		5.7 (0 – 45)	2.33 (0 – 15)
Pterodroma externa	0.51 (0 – 3)	0.28 (0 – 3)	
Pterodroma defilippiana	0.37 (0 – 2)	0.06 (0 – 1)	
Pterodroma neglecta			
Shearwaters			
Ardenna creatopus		0.36 (0 – 2)	0.09 (0 – 2)
Ardenna grisea		0.04 (0 – 1)	0.22 (0 – 2)
Storm petrels			
Halocyptena tethys	7.34 (2 – 26)	3.39 (0 – 11)	4.33 (0 – 16)
Hydrobates hornbyi	2.14 (0 – 6)	3.85 (0 – 15)	2.59 (0 – 18)
Hydrobates markhami	0.16 (0 – 2)	0.09 (0 – 2)	0.02 (0 – 1)
Oceanites gracilis			0.09 (0 – 1)
Stercorariidae			
Catharacta chilensis		0.82 (0 – 4)	1.18 (0 – 5)
Catharacta maccormicki		0.06 (0 – 1)	0.03 (0 – 1)
Stercorarius pomarinus		0.01 (0 – 1)	
Sulidae			
Sula dactylatra	0.05 (0 – 1)		
Sula leucogaster			0.06 (0 – 2)
Sula variegata			
Laridae			
Creagrus furcatus	0.02 (0 – 1)	0.03 (0 – 1)	
Larosterna inca			0.05 (0 – 1)
Larus belcheri			
Onychoprion Sp.			0.02 (0 – 1)

Table 3. Average main seabird relative densities (N° birds/1000 mt) during longline recovery, the average velocity was 1.75 knots, in 10 minutes 0.54 km were covered			
Seabird species	**Oceanic Area (160 – 180 nm offshore) (n=48)**	**Intermediate Area (35 – 75 nm offshore) (n=50)**	**Coastal Area (10 – 30 nm offshore) (n=48)**
Albatrosses			
Phoebastria irrorata			**2.52 (0 – 4)**
Thalassarche eremita	**0.07 (0 – 1)**	**0.53 (0 – 2)**	**0.99 (0 – 3)**
Thalassarche bulleri		**1.49 (0 – 3)**	**0.08 (0 – 1)**
Thalassarche salvni		**0.27 (0 – 1)**	
Petrels			
Procellaria aequinoctialis	**0.86 (0 – 4)**	**45.1 (0 – 80)**	**106 (10 – 122)**
Pterodroma externa	**2.45 (0 – 6)**	**1.14 (0 – 4)**	
Pterodroma defilippiana	**0.43 (0 – 2)**		**0.04 (0 – 1)**
Pterodroma neglecta	**0.07 (0 -1)**		
Shearwaters			
Ardenna creatopus	**0.43 (0 – 3)**	**2.86 (0 – 6)**	**2.96 (0 – 4)**
Ardenna grisea		**0.11 (0 – 1)**	**0.12 (0 – 1)**
Storm petrels			
Halocyptena tethys	**33.4 (2 – 40)**	**13.3 (0 – 35)**	**4.65 (0 – 12)**
Hydrobates hornbyi	**12.1 (0 – 16)**	**15.4 (0 – 55)**	**3.74 (0 – 19)**
Hydrobates markhami	**0.43 (0 – 2)**	**0.27 (0 – 3)**	
Oceanites gracilis			**0.04 (0 – 1)**
Stercorariidae			
Catharacta chilensis		**4.69 (0 – 7)**	**7.06 (0 – 9)**
Catharacta maccormicki		**0.11 (0 – 1)**	**0.2 (0 – 4)**
Stercorarius pomarinus		**0.04 (0 – 1)**	
Sulidae			
Sula dactylatra		**0.08 (0 – 1)**	
Sula leucogaster			**0.06 (0 – 2)**
Sula variegata			
Laridae			
Creagrus furcatus		**0.15 (0 – 2)**	**0.12**
Larosterna inca			**0.08 (0 – 2)**
Larus belcheri			**0.04 (0 – 1)**
Onychoprion Sp.		**0.23 (0 – 4)**	**0.12 (0 – 4)**

In general, during longline recovery, there were more birds registered, that is due to the effect of the expectancy of the seabirds towards the shark offal discards, being those, one of their preferred food items for sea birds in general. In addition, the bait discards, in this occasion was frozen chub mackarell (*Scomber japonicus peruanus*), those were being discarded while recovering the longline, since in many occasions the hooks where without capture, and the fishermen discard this used bait, attracting seabirds very close to the "danger area".

XIII Seabirds behaviour during longline operation:

During deployment

One of the most aggressive seabirds, meaning a really fast direct attack to the bait, and even diving towards the hooked bait, where the Pink-footed shearwaters, in the second place where the White-chinned petrels performing in some occasions deep dives towards the bait, and in third case the

Chilean skuas, however this last ones exhibit activity on the surface, performing only shallow dives up to 1 mt deep. In the case of the storm petrels, mainly Peruvian storm petrel (*Halocyptena tethys*) and Ringed storm petrel (*Hydrobates hornbyi*), showed a close encounter towards the "Danger Area" when small pieces of the bait where ripped of the main bait chunk, while the fishermen were hooking the bait synchronously during deployment. Big albatrosses were less attracted to the vessel during deployment, being only the Chatham Albatrosses, the ones approaching more to the "Danger Area" but only occasionally, Buller's and Salvin's were shyer, and the Waved albatrosses were the most shyer, only gliding in the peripheric area.

During recovery

During recovery there was a big expectation of all seabirds, mostly due to the shark offal discards, the most required part of the offal was the liver, and the intestines a little bit less. When the offal was discarded by the fishermen, the first to arrive were mostly the White-chinned petrels and Chilean skuas in the intermediate area and in the coastal area, and the Juan Fernandez petrel in the oceanic area, then these birds had a lot of noisy fights for the offal, then the pink footed shearwaters arrive, even being smaller they compete very strongly with the WCP, then was very common to suddenly observe the Chatham albatrosses arrived to the discard area and outcompete all the other seabirds, even Salvin's and Northern Buller's, and eating big pieces of liver alone, the Waved albatrosses performed a more cautious behaviour even during shark offal. However, when the area was cleared of other molly mawks they became more active and stole the liver to the WCP. Storm petrels were always waiting at the perimeter of the big fights, searching for small pieces of offal being ripped out by the bigger seabirds, in order to start feeding. An important issue to mention is that shark offal produces a lot of bubbles and they always remain floating at the surface without sinking, currents normally drift them slowly apart, distracting the great majority of seabirds away from the "Danger area".

XIV. Seabirds entering in the "Danger Area"

In general, we had more Storm petrels entering in the "Danger Area" in the oceanic area during longline deployment, for instance the Peruvian storm petrel averaged 15.5 bird per haul, compared to only 2 birds during recovery. In the intermediate area, the WCP entered in the "Danger Area" during longline recovery, registering 2.8 birds per fishing operation, and none during deployment. A similar pattern was registered in the coastal area, where the WCP entered 8 times higher in the "Danger Area" during longline recovery compared to deployment, the only big albatross species registered entering in the "Danger Area" was the Waved albatrosses (0.5 birds / fishing operation) during longline recovery. For specific details for other species please see Table 4 and 5.

The registered numbers were very low, we didn't even record any bycatch event during the whole on-board activity neither during longline deployment, nor during recovery. We still need to perform more trials during the winter season, when the albatross and petrels densities are higher, and we will try to see, if with this higher densities the bycatch is increased or not, in the next field work will be in June 2024 in offshore waters of southern Peru.

Table 4. Average seabirds entering in the "Danger Area" (N° birds/fishing operation) during longline deploy.

Seabird species	Oceanic Area (160 – 180 nm offshore), n=2	Intermediate Area (35 – 75 nm offshore), n=3	Coastal Area (10 – 30 nm offshore), n=5
Albatrosses			
Phoebastria irrorata			
Thalassarche eremita			

Thalassarche bulleri			
Thalassarche salvni			
Petrels			
Procellaria aequinoctialis			**1.2**
Pterodroma externa	**1**		
Pterodroma defilippiana			
Pterodroma neglecta			
Shearwaters			
Ardenna creatopus		**0.7**	**0.8**
Ardenna grisea			
Storm petrels			
Halocyptena tethys	**15.5**	**0.7**	
Hydrobates hornbyi	**0.5**	**0.7**	
Hydrobates markhami			
Oceanites gracilis			
Stercorariidae			
Catharacta chilensis		**0.3**	**0.6**
Catharacta maccormicki			
Stercorarius pomarinus			
Sulidae			
Sula dactylatra			
Sula leucogaster			
Sula variegata			
Laridae			
Creagrus furcatus	**0.5**		
Larosterna inca			
Larus belcheri			
Onychoprion Sp.			

Table 5. Average seabirds entering in the "Danger Area" (N° birds/fishing operation) during longline recovery.

Seabird species	Oceanic Area (160 – 180 nm offshore), n=2	Intermediate Area (35 – 75 nm offshore), n=4	Coastal Area (10 – 30 nm offshore), n=4
Albatrosses			
Phoebastria irrorata			**0.5**
Thalassarche eremita			
Thalassarche bulleri		**0.5**	
Thalassarche salvni			
Petrels			
Procellaria aequinoctialis	**1**	**2.8**	**9.5**
Pterodroma externa	**1.5**		
Pterodroma defilippiana			
Pterodroma neglecta			
Shearwaters			
Ardenna creatopus		**0.5**	**1.3**
Ardenna grisea			
Storm petrels			
Halocyptena tethys	**2**		

Hydrobates hornbyi			
Hydrobates markhami			
Oceanites gracilis			
Stercorariidae			
Catharacta chilensis		**0.3**	**1.3**
Catharacta maccormicki			
Stercorarius pomarinus			
Sulidae			
Sula dactylatra			
Sula leucogaster			
Sula variegata			
Laridae			
Creagrus furcatus	**0.5**		**0.3**
Larosterna inca			
Larus belcheri			
Onychoprion Sp.			

XV. Conclusions

*We didn't register any bycatch event so far, however we still had some seabirds entering in the "Danger Area", although numbers were very low, even more than expected.

*Seabirds relative densities were between 2 to 6 times lower during longline deployment compared to recovery, they were higher during recovery due to the shark offal discards, however they float very well and drifts away at the surface, distracting seabirds away from the "Danger Area"

*Regarding seabird's relative densities, without considering the storm petrels, the highest densities in the oceanic area were the Juan Fernandez petrel, WCP, Masatierra petrel and Pink-footed shearwaters; In the intermediate area, the WCP by far, followed by the Chilean skua, Pink-footed shearwaters and Buller's albatrosses. Finally, in the coastal areas, the WCP, followed by the Chilean skua, Pink-footed shearwaters, and Waved and Chatham albatrosses.

*Our conclusions are preliminary, since we didn't find any Black-browed albatrosses, which are the ones that show up in important numbers during late autumn and winter seasons, in the coming field trip in June we will perform more trials during a scenario with way higher albatrosses' and petrels densities

XVI. Technical DOC recommendations for mitigation measures

1. To keep the proposed mitigations treatments simple, we will combine it with batch discarding of offal. Similarly, when managing offal (likely holding and batch discarding on the non-hauling side) try and do the same with discarded baits as well. This way we can just have two treatments: a) Normal operation and no hauling mitigation, and b) Hauling mitigation droppers with no continuous discarding of anything, and retaining and batch discarding of both baits and offal.

2. If seabirds are used to a food source it may take some time for behavior to change, so if you stop discarding continuously they may chase baited hooks more aggressively. Monitoring contacts with baited hooks and altering the frequency of batch discards may help minimize this risk.

3. Regarding the "danger areas", the area during recovery would be where hooks are shallow enough for birds to access. During deployment the area should be behind the vessel - how far will be determined by how fast the hooks sink but you will get some idea from bird behaviour during the 'no mitigation' treatment.

4. To assess how well the tori line is working, we should look at bird abundance and behavior relative to the tori line. For example, if birds are diving on baited hooks behind the tori line then you would benefit from a longer tori line. If birds are diving beside the tori line, then it may need to be moved sideways or a second one deployed, and If the tori line is working well you will have lower bird counts in the danger area and few dives recorded compared to the no mitigation treatment.

5. In New Zealand fishers should use tori lines for all sets, and in most cases they will deploy tori lines before any fishing gear is deployed. However, if they have difficult weather conditions and are concerned about tangles with end marker floats they may deploy the end market float and then deploy the tori line before hooks are attached. Similarly, they may recover the tori line immediately before the last float is attached

XVII Operability recommendations for the next onboard operation

1. Fort the second stage (June 2024), we should allow the skipper to choose the fishing areas, that would be the ones that other skippers of this artisanal fishery are going according to their local knowledge or highest reported captures.

2. The “Danger Area” for this kind of vessels would be at the stern starboard, being an imaginary 10 x 5 mt rectangle, since in the Peruvian artisanal system, the longline is deployed at the stern starboard and is recovered at starboard in the quarter side closer to the stern, so during recovery the danger area will be displaced 5 mt towards the bow.

3. In the next onboard operation, we will test alternatively the tori-lines and the hauling mitigation according to where observed seabirds densities mostly occur, we will perform the mitigation measures in the same fishing operation, starting the trials in the first half, and the second half without mitigation and vice versa.

4. Is highly recommended to bring onboard squid jigs, to allow the night capture of Humboldt squid (*Dosidicus gigas*), or gillnets to capture flying fish (xxx sp.), since eventually the fishermen change the frozen bait for a fresh one in order to better attract the objective fish species, sharks in this fishery.

5. Discard the shark offal without stopping or delaying the recovery manoeuvres, in order to represent this discards the closest possible as reality without observers, or people that are not normally present during the fishing activity.

6. Observe carefully, and without distraction the bait discards when recovering the longline, since that with higher seabird densities the situation would be different than the observed one during this first onboard operation, pay special attention to diving species, such as petrels and shearwaters during both deployment and recovery activities.

7. We will include more eyebolt along the eucalypt wooden pole, on top of the superstructure located close to the stern of the vessel, as well as snaps allowing that the tori-line backbone will be close attached to the pole, in order to prevent some entanglements during the tori-line deployment and recovery, and also to allow a faster manoeuvre.

8. To keep the proposed mitigations treatments simple, we will combine it with batch discarding of offal. Similarly, when managing offal (likely holding and batch discarding on the non-hauling side) try and do the same with discarded baits as well. This way we can just have two treatments: a) Normal operation and no hauling mitigation, and b) Hauling mitigation droppers with no continuous discarding of anything, and retaining and batch discarding of both baits and offal.

XVIII Acknowledgements

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ANNEXES

Table 6. Captures of the objective fishing during the first onboard operation onboard an artisanal longline vessel targeting sharks in offshore waters of southern Peru (April 2024).

Date	haul	Cost distance	Blue Shark	Mako Shark	Pelagic Ray	Hammer head Shark	Sword fish	Mobula Ray	SUB TOTAL	%
20/04/2024	**1**	**Ilo 146 mn.**	113		33				145	**5.4**
21/04/2024	**2**	**Ilo 157 mn.**	48	7	16		90		161	**6.0**
23/04/2024	**3**	**Matarani 66 mn.**	270	23					293	**11.0**
24/04/2024	**4**	**Pta. De Bombon 49 mn.**	103	7	26				136	**5.1**
25/04/2024	**5**	**Pta. De Bombon 19 mn.**	735	9	40			40	823	**30.9**
26/04/2024	**6**	**Matarani 10 mn.**	175		12	2			188	**7.1**
27/04/2024	**7**	**Camana 21 mn.**	62		7	4			73	**2.8**
28/04/2024	**8**	**Quilca 25 mn.**	77	31	16				124	**4.7**
29/04/2024	**9**	**Matarani 26 mn.**	348	9	229				585	**22.0**
30/04/2024	**10**	**Matarani 39 mn.**	115	10	9				134	**5.0**
			2045	95	386	6	90	40	2662	**100.0**