Trialling the new Hookpod-mini, configured to open at 20 m depth, in pelagic longline fisheries off southern Brazil

Dimas Gianuca[1,2], Gabriel Canani[1,2]**, Augusto Silva-Costa[1,2], Sáskia Milbratz[1] & Tatiana Neves[1]*

[1] Projeto Albatroz.
[2] BirdLife International: Albatross Task Force.
*Current: Birdlife International Marine Programme.
**Current: Waterbirds and Sea Turtles Lab, Universidade Federal do Rio Grande (FURG).

SUMMARY

Bycatch in pelagic longline fisheries is a major threat for albatrosses and petrels globally. Hookpods are an emerging bycatch mitigation technology, which capsules the point and barb of hooks to prevent seabirds from becoming hooked during line-setting. We trialled the new Hookpod-mini, configured to open at 20 m depth, in pelagic longline fisheries off southern Brazil. From July 2018 to November 2019, Projeto Albatroz and Albatross Task Force on-board observers monitored seven trips to check the effects of the Hookpod-min (attached at 3.5 m from the hook), compared to conventional gear (75 g weighted swivel attached at 3.5 m from the hook), on seabird and turtle bycatch and on target species catches. Monitored effort comprised 72 sets and 81,989 hooks, of which 45,289 (55%) were Hookpod-mini and 36,700 (45%) were conventional gear. Generalized linear models (GLM) were applied to compare turtle bycatch and target species catches between the two gears. Two seabirds (black-browed albatrosses) were caught on the conventional gear (0.05 birds/1000 hooks) and none on the Hookpod-mini gear. There was no significant effect of Hookpod-mini on turtle bycatch and target species catches. Our findings reinforce the effectiveness of the Hookpod as a seabird bycatch mitigation measure in pelagic longline fisheries, without increasing the bycatch of turtles neither reducing the catchability of target species. We recommend that the Working Group on Bycatch considers adding the Hookpod, both Hookpod-LED and Hookpod-mini, to the seabird bycatch mitigation measures recommended in Resolution C-11-02. And that it encourages further research on the performance and feasibility of Hookpods by CPCs, which shall submit to the IATTC any information derived from such efforts.

1. INTRODUCTION

Fisheries bycatch is the major threat to populations of air breathing marine megafauna, such as seabirds, sea turtles and marine mammals (Lewison *et al.*, 2014). They are particularly susceptible because of their attraction to baits and discards, and their naturally slow reproductive rates rendering them sensitive to even small increases in mortality (Lewison *et al.*, 2004, 2014). Bycatch in longline fisheries a major source of mortality threatening albatrosses and large petrel species with extinction (Phillips *et al.*, 2016; Dias *et al.*, 2019). The ACAP Advisory Committee added 'hook-shielding devices' (including the Hookpod), which physically protect the barb of the hook while it sinks, releasing it beyond the diving range of most seabirds (≥10 m depth), to their list of best practice seabird bycatch mitigation measures (ACAP, 2016, 2017).

The Hookpod is a novel hook-shielding device proven to be highly effective as standalone seabird bycatch mitigation measure (releasing the hook at 10 m depth) without affecting the catch of target species (Sullivan *et al.*, 2017). The ACAP Advisory Committee recommended more investigation on the durability or failure rates of hook-shielding devices, and on the effectiveness of the Hookpod-mini, which is lighter than the Hookpod version (now called Hookpod-LED) tested by Sullivan at al. (2017) and reviewed by the committee (ACAP, 2016). Subsequent trials with the Hookpod-mini in Brazil (Silva-Costa *et al.*, 2017) and New Zealand (Goad *et al.*, 2019) suggested high effectiveness as standalone seabird bycatch mitigation measure, aligned with previous trials with the Hookpod-LED (Sullivan *et al.*, 2017). The ACAP Advisory Committee recommended further research on the possibility of increasing depth protection of hook-shielding devices (ACAP, 2016, 2017), which could improve effectiveness in regions with high densities of medium-sized diving petrels, capable of retrieving baits from depths beyond 10 m (Jiménez *et al.*, 2012; Rollinson *et al.*, 2014, 2016; Zhou and Brothers, 2021).

In this sense, the aim of this study is to evaluate, for the first time, the effectiveness of the new Hookpod-mini, configured to open at 20 m depth, in reducing seabird and its effects on turtle bycatch and on target species catches, since an ideal mitigation measure for a species group shall not increase the bycatch of another concerning *taxa* (e.g. turtles), neither reduces target species catches (Senko *et al.*, 2014; Komoroske and Lewison, 2015). In addition, this study provides updated (2018-2019) seabird and turtle bycatch rates in PLL fisheries off southern Brazil, in the southwest Atlantic Ocean, a global hotspot for seabird and turtle bycatch (Wallace *et al.*, 2010; Lewison *et al.*, 2014; Jiménez *et al.*, 2020).

2. METHODS

2.1. Opportunities and constraints finding partner vessels

In Rio Grande port (Rio Grande do Sul state), one partner vessel (Vessel A) joined the project straightforward, but only one trip (Vessel B) was arranged in Itajaí port (Santa Catarina state).

Additional trips were arranged on five ‘control vessels’, not carrying Hookpods and operating normally, without direct interference of the observer on gear configuration and fishing practices, aiming to evaluate current seabird and turtle bycatch levels in the fleet.

2.2. At-sea monitoring

From July 2018 to November 2019, 12 trips on pelagic longline vessels off southern Brazil were monitored by Projeto Albatroz/ATF on-board observers, including six vessels based on Rio Grande or Itajaí ports, comprising a total monitored effort of 137 sets and 159,250 hooks **(Table 1).**

Of the total 12 trips, five were on-board ‘control vessels’, totalling 65 sets and 77,651 hooks**,** and seven trips were on-board ‘Hookpod vessels’, which deployed Hookpod branchlines and regular (control) branchlines branchlines in the longline settings **(Table 1)**. These trips served to compare the effects of Hookpod in relation to control gear, which comprised 72 sets and 81,989 hooks, of which 45,289 (55%) were Hookpod hooks and 36,700 (45%) were control hooks **(Table 2)**.

Hookpods were positioned at 3.5 m from the hook. Control gear refers to 60-75 g weighted swivel positioned at 3.5 m from the hook, in accordance with Brazilian regulations to reduce seabird bycatch (Brazil, 2014). Likewise, circle hooks were used in all monitored vessels, aligned with Brazilian regulations to mitigate turtle bycatch (SEAP/MMA, 2018).

All Hookpods were assembled in the branchlines in port and at-sea with Projeto Albatroz/ATF instructors and fishermen working together, and instructors also worked with fishermen at sea, during longline setting and hauling, to ensure the Hookpod was used properly.

Information was obtained set by set by on-board observers. Data collected for each longline set included geographic position, date, setting start and end times, fishing effort (number of hooks deployed), sea surface temperature (SST), bottom depth and bird scaring line use (yes or not); as well total seabird, turtle and target species captured and retained during hauling. On the ‘Hookpod vessels’, for each set, the fishing effort and the number of seabirds and turtles bycaught, as well as of target species caught were recorded separately for the Hookpod and the control branchlines.

2.3. Data analysis

In order to account for seasonal variations, the data was grouped according to warm (October-March) or cold (April-September) seasons, which roughly corresponds to the breeding and non-breeding periods, respectively, for albatrosses and large petrels annual breeders (Carneiro *et al.*, 2020). Bycatch and target species catches were expressed as nominal bycatch rates of seabirds (BPUE = birds/1000 hooks) and turtles (TPUE = turtles/1000 hooks), as well as catch rates of target species (CPUE = fish/1000 hooks).

2.3.1. Current seabird and turtle bycatch in PLL fisheries off southern Brazil

To evaluate current seabird and turtle bycatch rates in PLL fisheries off southern Brazil, only data from the ‘control vessels’ was used, since observers did not interfere on fishing operations, which provides a more reliable picture of the fleet standards and bycatch.

2.3.2. Hookpod effect on seabird, turtle and target species catches

To compare bycatch rates of seabirds and turtles, as well as of target species catches, between Hookpod and control gear, only data from ‘Hookpod vessels’ was considered, when both gear type were deployed simultaneously every set, under the same biotic and abiotic conditions.

Generalized linear models (GLM) were further applied to check the effect of gear treatment (HP, Hookpod vs CT, control) on turtle bycatch and on the catches of target species, which were split into four groups: Tunas (*Tunnus* spp.), Swordfish (*Xiphias gladius*), Sharks (mostly blue *Prionace glauca* and mako *Isurus oxyrinchus* sharks) and ‘Others’ (miscellaneous fish). In order to account for other potential influential factors, SST and bottom depth were included as covariates. Negative binomial distributions were used in the models as a likelihood factor to the response variable (number of fish/turtle caught), with effort (number of hooks) as log link offset. Analysis of deviance was conducted to further address the potential covariate effects on the response variables. By combining the variables gear treatment, SST and Depth, seven models were compared for each target species group. Model selection was performed using the Akaike information criterion (AIC), where the best model corresponds to the lowest AIC value.

2.4. Gear sink rates

In order to examine the influence of additional line weighting on Hookpod sink rates, as well as to obtain sink rates of the control gear, sink profiles of baited hooks were obtained for three gear type configurations: (a) Hookpod only, (b) Hookpod + 75 g swivel and (c) 75 g swivel only (control). Eleven sink profiles were obtained for each gear treatment using time depth recorders (TDRs), Model G5 from Cefas Technology Limited. The mean depths of baited hooks after 5, 10, 20 and 30 seconds of deployment were compared using one-way ANOVA followed by a Tukey test, with a significance level of 95% ($\alpha = 0.05$).

3. RESULTS

3.1. Seabird and turtle bycatch on ‘control vessels’

In total, 10 seabirds were caught during five trips on board ‘control vessels’ (6 black-browned albatrosses, 3 white-chinned petrels and 1 wandering albatross), resulting in an overall BPUE = 0.13 (Table 3), which was higher during the cold (0.15) than warm season (0.10). All birds were caught during sets without bird scaring lines, which were deployed in only seven (11%) of the 65 sets, due to skipper’s decision. During these five trips, 39 turtles were caught (30 loggerhead, 8 leatherback and 1 green turtle), resulting in an overall TPUE = 0.50, which was similar between warm (0.49) and cold (0.40) seasons.

3.2. Hookpod effects on seabird and turtle bycatch

During the seven trips on board ‘Hookpod vessels’ there was no seabird bycatch in the Hookpod gear and two seabirds (black-browed albatrosses) were caught on the control gear (one each season), resulting in an overall BPUE = 0.05, which was slightly higher during the cold (0.07) than warm season (0.05) (**Figure 1**). Due to skipper decision, no bird scaring line was deployed across the 72 monitored sets.

A total of 90 turtles were caught, including loggerhead (*Caretta caretta*, 78%) and leatherback (*Dermochelys coriacea*, 22%). Of this total, 47 turtle were caught on the Hookpod gear (TPUE = 1.04) and 43 on the control gear (TPUE = 1.17), with contrasting effects between seasons. During the cold season, Hookpod gear showed lower bycatch rate (HP = 0.95, CT = 1.71), while during the warm season, bycatch on Hookpod gear was higher (HP = 1.14, CT = 0.79) (**Figure 1**). According to the AIC scores from the GLM models, the Hookpod effect was not significant on turtle bycatch, neither was the effect of bottom depth or SST **(Table 4).**

3.3. Hookpod effects on target species catch

In total, 2,935 individuals of target and non-target teleost and elasmobranch species were caught in the data subset used for the GLM analysis (‘Hookpod vessels’), mostly blue shark (59%), albacore (*Thunnus alalunga,* 14%), mako shark (9%) and swordfish (6%). These four target species comprised 89% of the total catch (**Figure 2, Table 5**). According to the AIC score, gear treatment (Hookpod vs control) was not significantly influential on the catches of any group of target species. The best-fit model for the Tuna, Sharks and Others included SST and depth at the fishing area as predictors of catches, while for the swordfish the best-fitted model included depth only. The list of models and respective AIC values is presented in **Table 6**.

3.4. Sink rates

On average, the control gear (75 g leaded swivel) and the Hookpod with additional 75 g swivel presented similar sink rates, which sank significantly faster than the Hookpod-only gear after 10, 20 and 30 sec of deployment (**Table 7**).

3.5. Hookpod replacement rate

Hookpod replacement rate due to damaged, malfunctioning, missing from branchlines or losses with sections of the longline was 1.34% of the total 45,289 deployments. Without considering the Hookpods lost with entire sections of the longline due to rough seas, the replacement rate was 0.50%.

4. DISCUSSION

There was zero seabird bycatch in Hookpod gear, which means 100% reduction in relation to control gear under comparable conditions (0.05 BPUE), suggesting high efficiency of the 20 m-opening Hookpod-mini for reducing seabird bycatch, aligned with the results from trials with the 10 m-opening Hookpod versions (Sullivan *et al.*, 2017; Goad *et al.*, 2019).

There was no significant effect of Hookpod on turtle bycatch, which was highly variable between trips and likely influenced by other potential factors not accounted in our analyses, e.g. oceanographic parameters, bait type, use of light attractors and spatial effects (Pons *et al.*, 2010; Gilman and Musyl, 2017; Swimmer *et al.*, 2017). There was also no significant effect of the Hookpod on the catches of target species, which supports previous studies (Sullivan *et al.*, 2017; Goad *et al.*, 2019). These are important findings, since ideal bycatch mitigation measures for a group of species should not increase the bycatch of other taxa of concern (Moore *et al.*, 2009; Senko *et al.*, 2014; Mangel *et al.*, 2018), neither reduce the catchability of target species, which is critical for the acceptance of such measures by fishermen and industry (Gilman *et al.*, 2005; Senko *et al.*, 2014; Komoroske and Lewison, 2015).

The Hookpod-mini (48 g) tested here showed slower sink rate than the control gear (75 g swivel positioned 3.5 m off the hooks), which can be explained by the higher mass and lower volume of the leaded swivel compared to the Hookpod-mini. This is aligned with previous comparisons between the Hookpod-mini and two control gear types (38 g at 0.5 m and 60 g at 1 m from the hook) (Goad *et al.*, 2019), and contrasting with the faster sink rate of the heavier (65 g) Hookpod-LED in relation to the control gear (60 g swivel 3.5 m from the hook) (Sullivan *et al.*, 2017). Fishermen in Brazil prefer to use the Hookpod with additional line weighting (Gianuca *et al.*, 2018), owing concerns that the Hookpod alone is too light and thus can enhance entanglements or affect fishing depths, although there was no evidence of that. Even so, if fishers prefer to use additional weight, this will not affect the Hookpod mechanism and can provide further protection by increasing sink rates and reducing the risk of birds getting entangled in the branchlines, which is not solved with the hook-shielding devices (Sullivan *et al.*, 2017; Goad *et al.*, 2019).

The Hookpod, including both 10m- and 20m-oppening models, is highly efficient and feasible standalone mitigation measure to reduce seabird bycatch. However, if incorporated into national regulations and international recommendations, its correct utilization and wide adoption requires specific training for fishers and on-board observers programs or Remote Electronic Monitoring (REM) systems to ensure compliance, likewise other seabird bycatch mitigation measures (Gilman and Kingma, 2013; Winnard *et al.*, 2018; Gilman *et al.*, 2020).

Acknowledgements

This research was conducted by Projeto Albatroz, sponsored by Petrobras through the *Programa Petrobras Socioambiental*, in collaboration with the Albatross Task Force, a BirdLife International project sponsored by the Royal Society for the Protection of Birds (RSPB). Additional financial support was provided by the Agreement on the Conservation of Albatrosses and Petrels (ACAP Small Grant 2018-05) and the Hookpod LTDA. We also thank the skippers that joined the project and the following on-board observers, Giuliano Müller Brusco, Charles Cabral Salame, Gabriel Bini and Bruno Buchaim.

REFERENCES

ACAP. 2016. ACAP Review and best practice advice for reducing the impact of pelagic longline fisheries on seabirds. In *Ninth Meeting of the Advisory Committee* Agreement on the Consertavion of Albatrosses and Petrels: La Serena;

ACAP. 2017. ACAP Review and best practice advice for reducing the impact of pelagic longline fisheries on seabirds. In *Tenth Meeting of the Advisory Committee* Agreement on the Conservation of Albatrosses and Petrels: Wellington;

Brazil. 2014. Instrucao Normativa Interministerial MPA/MMA nº 7, de 30 de outubro de 2014 (INI07/2014). : 47–48.

Carneiro APB, Pearmain EJ, Oppel S, Clay TA, Phillips RA, Bonnet-Lebrun A-S, Wanless RM, Abraham E, Richard Y, Rice J, et al. 2020. A framework for mapping the distribution of seabirds by integrating tracking, demography and phenology. *Journal of Applied Ecology* **57**: 514–525.

Dias MP, Martin R, Pearmain EJ, Bur IJ, Small C, Phillips RA, Yates O, Lascelles B, Garcia P, Croxall JP. 2019. Threats to seabirds: A global assessment. *Biological Conservation* **237**: 525–537.

Gianuca D, Costa AS, Canani G, Neves T. 2018. Hookpod trials in Brazilian pelagic longline fishery, from 2011 to 2017. In *Sub-committee on Ecosystems Meeting* International Comission for the Conservation of the Atlantic Tuna - ICCAT: Madri; SCRS/2028/86.

Gilman E, Kingma E. 2013. Standard for assessing transparency in information on compliance with obligations of regional fisheries management organizations: Validation through assessment of the Western and Central Pacific Fisheries Commission. *Ocean and Coastal Management* **84**: 31–39.

Gilman E, Musyl M. 2017. Captain and Observer Perspectives on the Commercial Viability and Efficacy of Alternative Methods to Reduce Seabird Bycatch during Gear Haulback in the

Hawaii-based Pelagic Longline Swordfish Fishery. : 1–24.
Gilman E, Brothers N, Kobayashi DR. 2005. Principles and approaches to abate seabird by-catch in longline fisheries. *Fish and Fisheries* **6**: 35–49.
Gilman E, Beverly S, Musyl M, Chaloupka M. 2020. Commercial viability of locating pelagic longline branchline weights at the hook to reduce seabird bycatch. *Endangered Species Research* **43**: 223–233.
Goad D, Debski I, Potts J. 2019. Hookpod-mini: a smaller potential solution to mitigate seabird bycatch in pelagic longline fisheries. *Endangered Species Research* **39**: 1–8.
Jiménez S, Domingo A, Abreu M, Brazeiro A. 2012. Bycatch susceptibility in pelagic longline fisheries: Are albatrosses affected by the diving behaviour of medium-sized petrels? *Aquatic Conservation: Marine and Freshwater Ecosystems* **22**: 436–445.
Jiménez S, Domingo A, Winker H, Parker D, Gianuca D, Neves T, Coelho R, Kerwath S. 2020. Towards mitigation of seabird bycatch: large-scale effectiveness of night setting and Tori lines across multiple pelagic longline fleets. *Biological Conservation* **247**: 108642.
Komoroske LM, Lewison RL. 2015. Addressing fisheries bycatch in a changing world. *Frontiers in Marine Science* **2**: 1–11.
Lewison RL, Crowder LB, Read AJ, Freeman SA. 2004. Understanding impacts of fisheries bycatch on marine megafauna. *Trends in Ecology and Evolution* **19**: 598–604.
Lewison RL, Crowder LB, Wallace BP, Moore JE, Cox T, Zydelis R, McDonald S, DiMatteo A, Dunn DC, Kot CY, et al. 2014. Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. *Proceedings of the National Academy of Sciences of the United States of America* **111**: 5271–6.
Mangel JC, Wang J, Alfaro- J, Pingo S, Jimenez A, Swimmer Y, Godley BJ. 2018. Illuminating gillnets to save seabirds and the potential for multi-taxa bycatch mitigation. *Royal Society Open Science* **5**: 180254.
Moore JE, Wallace BP, Lewison RL, Žydelis R, Crowder LB. 2009. A review of marine mammal, sea turtle and seabird bycatch in USA fisheries and the role of policy in shaping management. *Marine Policy* **33**: 435–451.
Phillips RA, Gales R, Baker GB, Double MC, Favero M, Quintana F, Tasker ML, Weimerskirch H, Uhart M, Wolfaardt A. 2016. The conservation status and priorities for albatrosses and large petrels. *Biological Conservation* **201**: 169–183.
Pons M, Domingo A, Sales G, Niemeyer Fiedler F, Miller P, Giffoni B, Ortiz M. 2010. Standardization of CPUE of loggerhead sea turtle (Caretta caretta) caught by pelagic longliners in the Southwestern Atlantic Ocean. *Aquatic Living Resources* **23**: 65–75.
Rollinson DP, Dilley BJ, Ryan PG. 2014. Diving behaviour of white-chinned petrels and its relevance for mitigating longline bycatch. *Polar Biology* **37**: 1301–1308.
Rollinson DP, Dilley BJ, Davies D, Ryan PG. 2016. Diving behaviour of Grey Petrels and its relevance for mitigating long-line by-catch. *Emu - Austral Ornithology* **116**: 340–349.
SEAP/MMA. 2018. Portaria Interministerial SEAP/MMA Nº 59-A, de 9 de novembro de 2018. : 1.
Senko J, White ER, Heppell SS, Gerber LR. 2014. Comparing bycatch mitigation strategies for vulnerable marine megafauna. *Animal Conservation* **17**: 5–18.
Silva-Costa A, Neves T, Marques C, Gianuca D, Winnard S, Yates O. 2017. The performance of Hookpods under commercial fishing conditions in the Brazilian pelagic longline fleet. In *Eighth Meeting of the Seabird Bycatch Working Group* Agreement on the Conservation of Albatrosses and Petrels: Wellington; SBWG8 Inf 08.
Sullivan BJ, Kibel B, Kibel P, Yates O, Potts JM, Ingham B, Domingo A, Gianuca D, Jiménez S, Lebepe B, et al. 2017. At-sea trialling of the Hookpod: a ‘one-stop’ mitigation solution for seabird bycatch in pelagic longline fisheries. *Animal Conservation* **21**: 159–167.
Swimmer Y, Gutierrez A, Bigelow K, Barceló C, Schroeder B, Keene K, Shattenkirk K, Foster DG. 2017. Sea Turtle Bycatch Mitigation in U.S. Longline Fisheries. *Frontiers in Marine Science* **4**: 260.
Wallace BP, Lewison RL, Mcdonald SL, Mcdonald RK, Kot CY, Kelez S, Bjorkland RK, Finkbeiner EM, Helmbrecht S, Crowder LB. 2010. Global patterns of marine turtle bycatch. *Conservation Letters* **3**: 131–142.
Winnard S, Hochberg T, Miller N, Kroodsma D, Small C, Augustyn P. 2018. A new method using AIS data to obtain independent compliance data to determine mitigation use at sea.

In *Thirteenth Meeting of the CCSBT Compliance Committee* CCSBT: Noumea; CCSBT-CC/1810/Info/3/Rev1.
Zhou C, Brothers N. 2021. Interaction frequency of seabirds with longline fisheries: risk factors and implications for management. *ICES Journal of Marine Science* **fsab014**: fsab014.

Table 1. Monitored fishing effort (number of hooks) on control and Hookpod vessels according to season (Warm = October-March or Cold = April-September).

	Warm season	Cold season	Total effort
Control vessels	38,462	39,189	77,651
Hookpod vessels	42,465	39,524	81,989
Total effort	80,927	78,713	159,250

Table 2. Monitored fishing effort (number of hooks) on Hookpod vessels only, according to treatment (Control or Hookpod) and season (Warm = October-March or Cold = April-September), including the percentage of Hookpod branchlines in relation to the total effort.

	Warm season	Cold season	Total
Control effort	21,465	15,235	36,700
Hookpod effort	21,000	24289	45,289
Total effort	42,465	39,524	81,989
% Hookpod effort	49	61	55

Table 3. Summary of seabird and turtle bycatch across five trips on-board 'control vessels' (65 sets and 77,651 hooks), including information on species and respective conservation status (IUCN), number caught (N) and capture rate (BPUE: Birds/1000 hooks or TPUE: Turtles/1000 hooks).

	Species	Status	N	BPUE/TPUE
Seabirds				
Total			10	0.13
Black-browed albatross	*Thalassarche melanophris*	LC	6	0.08
White-chined petrel	*Procellaria aequinoctialis*	VU	3	0.04
Wandering albatross	*Diomedea exulans*	VU	1	0.01
Turtles				
Total			39	0.05

Loggerhead turtle	*Caretta caretta*	VU	30	0.39
Leatherback turtle	*Dermochelis coriacea*	VU	8	0.10
Green turtle	*Chelonia mydas*	EN	1	0.01

Table 4. List of models compared to address the effect gear treatment (Hookpod vs control), sea surface temperature (SST) and depth at the fishing area (Depth) on turtle bycatch, including models description and respective AIC values.

Model description	AIC
Capture~Depth+Offset	206.1
Capture~SST+Depth+Offset	207.2
Capture~Treatment+Depth+Offset	208.1
Capture~Treatment+SST+Depth+Offset	209.1
Capture~SST+Offset	216.6
Capture~Treatment+Offset	217.1
Capture~Treatment+SST+Offset	218.6

Table 5. Total catches (N) and nominal CPUE (N/1000 hooks) for each target species group, named Sharks (mostly blue and mako sharks), Tunas (*Thunnus* spp.), Swordfish (*Xiphias gladius*) and Others (miscellaneous fish).

Target species group	**HP catches**	**CT catches**	**HP CPUE**	**CT CPUE**
Sharks	1,079	930	23.82	25.34
Tunas	301	187	6.65	5.10
Swordfish	110	77	2.43	2.10
Other	144	107	3.18	2.92

Table 6. List of models, including models description and respective AIC values, compared to address the effect gear treatment (Hookpod vs control), sea surface temperature (SST) and depth at the fishing area (Depth) on the catches of each target species group: Sharks (mostly blue and mako sharks), Tunas (*Thunnus* spp.), Swordfish (*Xiphias gladius*) and Others (miscellaneous fish).

Model description	**AIC**
Tuna	
Capture~SST+Depth+Offset	499.4
Capture~Depth+Offset	499.9
Capture~Treatment+SST+Depth+Offset	500.9
Capture~Treatment+Depth+Offset	501.3
Capture~Treatment+Offset	523.5

Capture~SST+Offset	524.1
Capture~Treatment+SST+Offset	525.4
Swordfish	
Capture~Depth+Offset	329.7
Capture~SST+Depth+Offset	330.3
Capture~Treatment+Depth+Offset	331.7
Capture~Treatment+SST+Depth+Offset	332.2
Capture~SST+Offset	343.8
Capture~Treatment+SST+Offset	345.8
Capture~Treatment+Offset	346.4
Sharks	
Capture~SST+Depth+Offset	671.0
Capture~Treatment+SST+Depth+Offset	672.4
Capture~Depth+Offset	702.5
Capture~Treatment+Depth+Offset	703.7
Capture~SST+Offset	718.7
Capture~Treatment+SST+Offset	719.9
Capture~Treatment+Offset	753.5
Others	
Capture~SST+Depth+Offset	332.4
Capture~Treatment+SST+Depth+Offset	333.6
Capture~Depth+Offset	338.5
Capture~Treatment+Depth+Offset	340.2
Capture~SST+Offset	355.6
Capture~Treatment+SST+Offset	356.6
Capture~Treatment+Offset	361.1

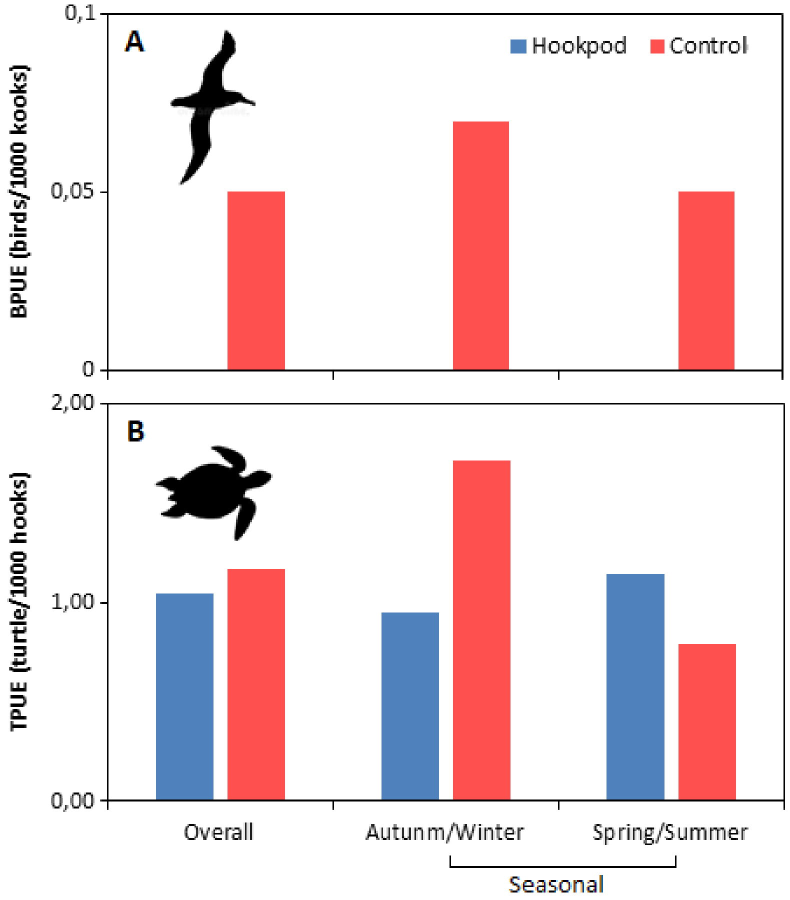

Figure 1. Nominal bycatch rates of seabirds (A) and turtles (B) per season and gear treatment (Hookpod vs control) on 'Hoopod vessels', when both Hookpod and control gear were deployed simultaneously every set.

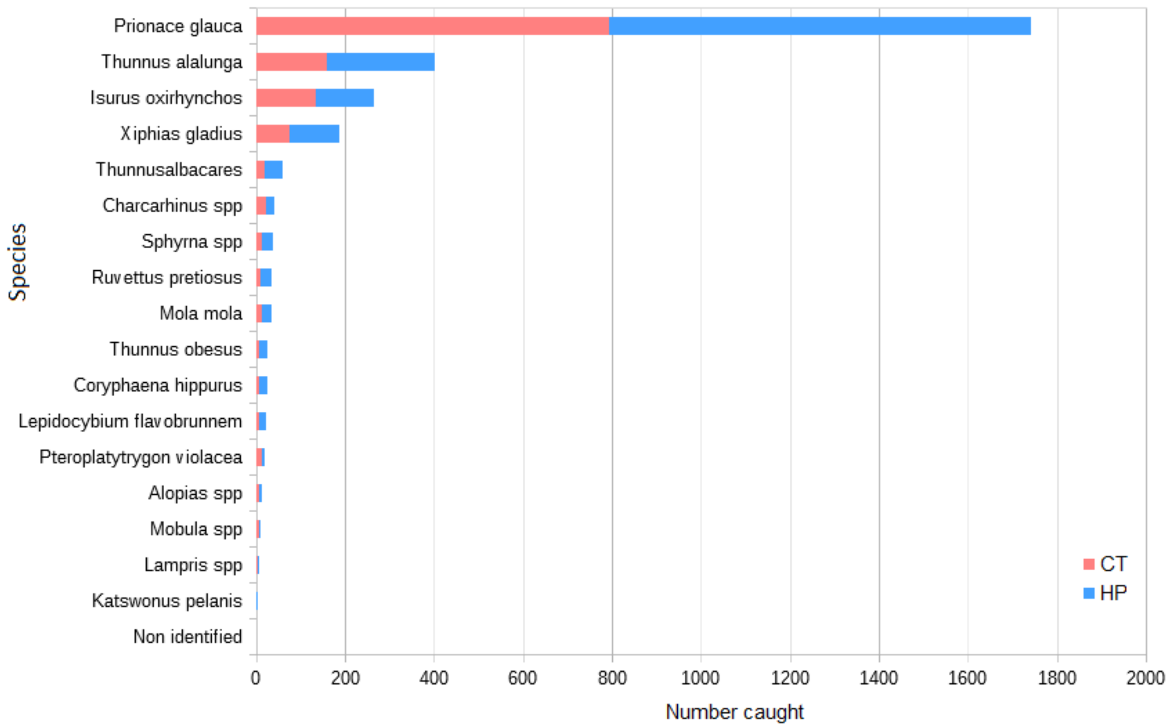

Figure 2. Total catches (number of individuals, X axis) for each teleost and elasmobranch species (Y axis) caught on Hookpod (HP) or control (CT) gear.

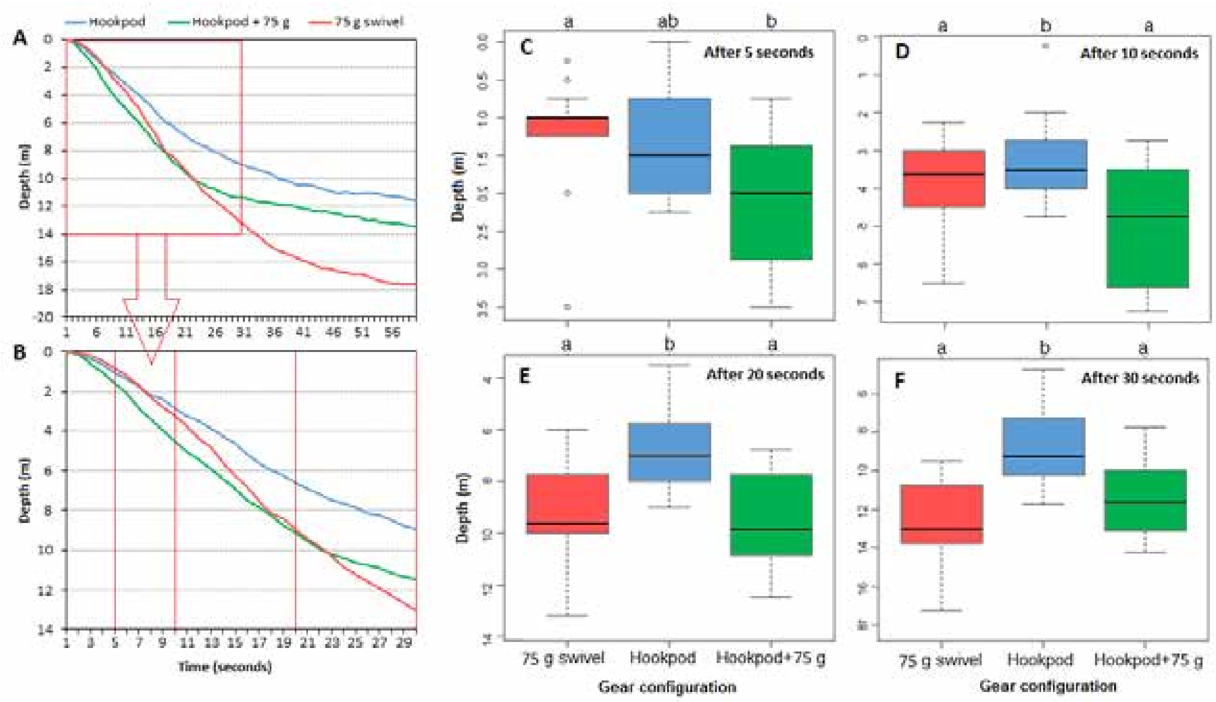

Figure 3. Average sinking profiles of baited hooks with 75 g leaded swivels (red), Hookpod only (blue) or Hookpod plus 75 g leaded swivel (green, A), and detail of the first 30 seconds after deployment, with the 5, 10, 20 and 30 seconds thresholds highlighted with red vertical lines (B). The boxplots show the depth distribution (median and the 25th and 75th percentiles, whiskers indicate values within 1.5 times of the interquartile range, and black circles indicate outliers) of baited hooks of each gear treatment after 5 (C), 10 (D), 20 (E) and 30 (F) seconds of deployment. Boxplots not sharing the same lower-case letters denote statistically distinct treatments ($P < 0.05$, Tukey test).

Table 7. Replacement rate of the Hookpo-mini due to damaged, malfunctioning, missing from branchlines or losses with entire sections of the longline.

Fate	Number	% of total hookpods used (n=1,580 pods)	% of total hookpod deployments (n=45,289 hooks)
Broken	37	2,34	0,08

Don't oppening	137	8,67	0,30
Don't closing	29	1,84	0,06
Missing from gear	22	1,39	0,05
Lost with gear	380	24,05	0,84
Total	605	38,29	1,34
Total without lost gear	225	14,24	0,50