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TRIALS WITH DIFFERENT HOOK AND BAIT TYPES IN THE CONFIGURATION OF THE SURFACE LONGLINE GEAR USED BY THE SPANISH SWORDFISH (*XIPHIAS GLADIUS*) FISHERY IN THE PACIFIC OCEAN

B. García-Cortés[1], J. Ortiz de Urbina[2], A.Ramos-Cartelle[1], J. Mejuto[1]

SUMMARY

*Three hook types and two bait types were tested on two surface longline vessels targeting swordfish (*Xiphias gladius*) for 240 days at sea in areas of the SE Pacific Ocean. The use of circle hooks instead of conventional ones led to losses in swordfish catch rates of –23.1%, while moderate increases of up to +5.5% were found for the shortfin mako (*Isurus oxyrinchus*) and billfish catches rose substantially +55.5%. Few changes in catch rates were observed in the sea turtle* Caretta caretta *with the use of the circle hooks being tested. The use of squid as bait instead of mackerel would generally cause a decrease in the catch rates of most fish species with the exception of billfish and the sea turtle* Caretta caretta*, which exhibited values of up to +31.7% and +8.2%, respectively. Mean standardized CPUE data suggest that the use of the alternative hook-bait combinations tested would cause a drop in the catch rates of the target species ranging from –15.8% to –36.4%, but, in general, an increase in the catch rates of billfish up to +86.8%, as compared to the use of the traditional combination of reference. Owing to the scarce interaction on sea turtles, it was not possible to draw robust conclusions for these species. However the results do suggest that the use of squid as bait tends to increase the catch rates of sea turtles as opposed to the use of mackerel. There was no interaction with sea birds during the whole experiment.*

RÉSUMÉ

Trois types d'hameçons et deux types d'appât ont été testés sur deux palangriers de surface ciblant l'espadon (Xiphias gladius) *pendant 240 jours en mer dans les zones du sud-est de l'océan Pacifique. L'utilisation d'hameçons circulaires plutôt que conventionnels a entraîné des pertes au niveau des taux de capture d'espadon (-23,1%), tandis que l'on a découvert des augmentations modérées (à hauteur de +5,5%) en ce qui concerne le requin taupe bleue* (Isurus oxyrinchus) *et les prises d'istiophoridés ont considérablement augmenté (+55,5%). Peu de changements ont été observés dans les taux de capture de la caouane* (Caretta caretta) *lorsque les hameçons circulaires ont été testés. L'emploi du calmar au lieu du maquereau entraînerait généralement une baisse des taux de capture de la plupart des espèces de poissons, à l'exception des istiophoridés et de la caouane qui ont dégagé des valeurs de + 31,7% et +8,2%, respectivement. Les données moyennes de la CPUE standardisée suggèrent que l'utilisation des associations alternatives testées d'hameçons-appâts provoquerait une baisse des taux de capture des espèces-cibles, allant de -15,8% à -36,4% mais qu'en général, elle donnerait lieu à une augmentation des taux de capture d'istiophoridés de +86,8%, par rapport à l'utilisation de l'association traditionnelle de référence. Compte tenu de la faible interaction des tortues marines, il n'a pas été possible de tirer de solides conclusions pour ces espèces. Toutefois, les résultats suggèrent que l'emploi du calmar comme appât a tendance à augmenter les taux de capture des tortues marines par rapport à l'utilisation du maquereau. Aucune interaction n'a eu lieu avec les oiseaux marins pendant toute la durée de l'expérimentation.*

RESUMEN

*Tres tipos de anzuelos y dos tipos de cebos fueron ensayados en dos buques palangreros dirigidos al pez espada (*Xiphias gladius*) durante 240 días de mar en áreas del Océano Pacífico SE. El empleo de anzuelos circulares en vez del convencional produciría, descensos en las tasa de captura de pez espada de hasta el –23,1%, incrementos moderados de hasta el*

[1] Instituto Español de Oceanografía. P.O. Box 130, 15080 A Coruña. Spain
[2] Instituto Español de Oceanografía. P.O. Box 285, 29640 Fuengirola. Spain

*+5,5% para el marrajo dientuso (*Isurus oxyrinchus*) e incrementos más considerables de hasta el +55,5% en los peces de pico. Escasos cambios en las tasas de captura se producirían para la tortuga* Caretta caretta *con el uso de los anzuelos circulares ensayados. Usando pota como cebo en lugar de caballa, en general se producirían descensos en las tasas de captura de la mayoría de especies de peces, excepto en los peces de pico y en la tortuga* Caretta caretta*, de hasta +31.7% y +8.2%, respectivamente. Los datos de CPUE media estandarizada sugieren que el empleo de combinaciones de los anzuelos-cebos alternativos ensayados en general produciría reducciones entre el –15.8% y –36.4% de la tasa de captura de la especie objetivo pero en general incrementos de la tasa de captura de hasta +86,8% en el caso de peces de pico en relación al uso de la combinación convencional de referencia. La baja interacción ocurrida sobre las tortugas marinas no permitió obtener conclusiones robustas para estas especies, pero sugiere que el uso de pota como cebo tiende a incrementar las tasas de captura de las tortugas frente al uso de caballa. No se produjo ninguna interacción con aves marinas durante todo el experimento.*

KEY WORDS

Longline, CPUE, hook, bait, swordfish, sea turtles, sea birds

1. Introduction

Circle hooks ("G" hooks) have gained notoriety in recent years because of the supposed advantages they offer in terms of the conservation of some species as compared with other types such as "J" hooks (Watson 2004, Watson *et al*. 2002, 2005). Hence, they have been recommended for use by some forums despite the fact that the results of several studies have been rather inconsistent or even contradictory (Anon. 2008[a]). However, due to differences in environmental conditions, fishing practices, gear configurations and materials used and target species, it is unclear whether it would be appropriate to extrapolate local results to entire fisheries (Cooke and Suski 2004).

Recent studies have suggested that circle style hooks ("G") with no offset or a minor offset (about 4^{o}) cause less physical damage to fish than "J" style hooks because of the tendency of circle hooks to hook fish in the mouth rather than in the pharynx, esophagus or stomach and also because "G" hooks minimize foul hooking (external hooking) and bleeding (Prince *et al*. 2002, Skomal *et al*. 2002). However, there is no generic description of the "G" hook type. Therefore, it is difficult to promote the use of "G" hooks or a unique hook type as being a panacea for all the fisheries and species. A good knowledge of how fishes and other pelagic species get caught on the hook-bait combination and their respective catch data are essential to be able to support planning recommendations.

In this respect, several experiments were performed in different areas and Oceans where Spanish pelagic longline fleets operate. Several million hooks have already been set for testing hook-bait types. For decades, the Spanish surface longline fishery targeting swordfish in the different oceans has used traditional "J" hook types that are soaked at night traditionally with mackerel as the predominant bait. However, with the recent use of the monofilament longline style, squid has also been introduced as bait and some hook changes have been made. Experiments using different pelagic longline styles in areas of the Western Mediterranean Sea where a high incidence of sea turtles was observed suggest that there are other more important and significant factors to consider than the type of hook used ("J" or "G" hooks) to reduce the accidental capture of sea turtles and the capture of juvenile swordfish in these western Mediterranean areas (De la Serna *et al*. 2006, 2008). Experiments carried out in the Western Indian Ocean with different types of hooks did not generate any comparative results related to the respective capture of sea turtles, owing to the low interaction of these species in the fishing zone under experimentation (Ariz *et al*. 2005). The data obtained in an experiment testing 3 types of hooks and 2 different baits covering large areas of the North and South Atlantic Ocean suggest that the overall catch rates in weight and in number of the fish species in general and sea turtles respectively, were reduced for most fish and were generally found to increase for sea turtles when the alternate hooks and baits tested were used, including the G type. The interaction between bait and other factors was also significant for some species. The use of squid as bait instead of mackerel would cause an increase in the catch rates of the most prevalent sea turtles being hooked either externally or internally, regardless of the type of hook used (Mejuto *et al*. 2008).

An external consultant (MRAG Ltd.) has recently finished a private contract (EC-DG Fish-Mare, UE-FISH/2005/28-A[3]) to assess the turtle by-catch, testing circular versus traditional hooks types in several fleets of the Atlantic and Mediterranean Sea (Anon. 2008[b]). Although the number of observations was quite limited, the results do not support the promotion of a shift from the 'J' hooks used in these trials to either of the two circle hooks (16/0 0° offset and 18/0 10° offset) tested, as these circle hooks did not consistently or significantly reduce turtle catch rates and had negative impacts on swordfish catches in the regions observed. As in the case of other experiments previously cited, the greatest reduction in turtle by-catch in this experiment targeting swordfish was observed in trials where the mixed squid and mackerel bait was replaced by mackerel bait alone.

The objective of this study was to expand upon the overview of these experiments, testing the effect of different combinations of hooks and baits on the incidental by-catch of sea turtles as well as on the catch of target species and the main by-catch species. The SE Pacific areas were covered in this experiment.

2. Material and methods

Vessels / type of gear: The two boats used were long distant units belonging to the Spanish surface longline fleet. The mean characteristics of the boats are: 38.9m in length, 224.5 GRT and 634 HP. One of the boats used a mean number of around 1 184 hooks per set with the monofilament American longline type (gear ***B2***, used as reference) and the other boat used 2 688 hooks per set with the Spanish traditional longline type (gear ***B1***).

Fishing areas and duration: The fishing area was located at around 15ºS–30ºS latitude and 075ºW-115ºW longitude in the South East Pacific Ocean **(Figure 1)**. The area was analyzed considering 'zones' of 5ºx5º squares (Miyake 1990). One of the vessels began to operate in February 2007 and the other one commenced in the middle of March 2007. The experiment ended in July 2007, after each vessel had completed 120 days at sea.

Characteristics of the experimental set-up for types of hooks and baits tested: The gears were adapted to test 3 types of hooks and 2 types of bait to measure the yields of different species or groups caught. The gear was configured in sections or lengths and a combination of the hook-bait was placed on each section. The position of each hook-bait combination on the longline was rotated **(Table 1)** to prevent elements such as a specific hook–bait combination on the longline, the drift of the different longline sections, the varying duration of the soaking time of a section or other uncontrolled factors, from systematically affecting the CPUEs obtained (Mejuto *et al.* 2008).

Three types of hooks were tested **(Figure 2)**. ***A1*** *(conventional Spanish "J" style)*: Hook 16/O (10 º offset) = 70 – 40 – 35. ***A2*** *(circle style "G")*: Hook 17/O (8º offset) = 60 – 50 – 30. ***A3*** *(circle style "G")*: Hook 17/O (0 º offset) = 60 – 50 – 30. The 2 types of similar–sized bait were: **bait 1**= mackerel (*Scomber spp.*) and **bait 6**= squid (*Illex spp.*).

Species: An analysis was carried out on the results obtained for the turtle species captured: CAT (*Caretta caretta*), DER (*Dermochelys coriacea*) and QUE (*Quelonias mydas*) as well as for target and by-catch fish species or groups: SWO (*Xiphias gladius*), PGO (*Prionace glauca*), IOO (*Isurus oxyrinchus*) and BIL (Istiophoridae). In some cases the results for the sea turtle DER were not discussed because its interaction with the gear is mostly accidental and produced by flippers. The dressed weight (DW) of the fishes was estimated in kg on the basis of different size–weight relationships. Incidental catches of turtles were expressed in number of individuals.

Catch rates: Nominal CPUEs in weight (kg DW) per thousand hooks were used for SWO and the by-catch species. The nominal CPUE for the incidental by-catch of sea turtles was expressed in number of individuals. The nominal yields were obtained per hook and bait types and their combinations. The CPUE observations for standardized procedures were calculated as the aggregation of the catch and effort data by set and factor ('gear', 'hook', 'bait', 'zone').

"*Gain*" is understood to be an increase in CPUE in relation to the factor selected as a reference, and therefore, it represents increments in mortality. In sea turtles, the term "*gain*" should be interpreted as increments in incidental catch rates, and therefore, an undesirable effect on this species. The term "*loss*" should be interpreted in the opposite sense.

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[3] http://ec.europa.eu/fisheries/publications/studies/turtle_by-catch_2008.pdf

Statistical methods: To evaluate the significance of the factors tested (α=5%) a standardization of the CPUEs was carried out by GLM procedures. Relative indices of abundance were estimated assuming a delta–lognormal model error distribution. Under this model, both the catch rates of positive sets and the proportion of positive sets were fitted separately. The mean catch rate of positive sets (in number or weight per 1 000 hooks) was modeled assuming a lognormal distribution. The proportion of positive sets (sets with a least one individual) per combination of type of hook, type of bait and spatial stratum (zone) was assumed to be the result of ***s*** successful sets of a total ***n*** number of sets, with each one representing the execution of an independent *Bernouilli* process, and modeled assuming a binomial error distribution. The final index was the product of these two components.

Analysis: The analyses were focused on different aspects such as species composition, catch in number and dressed weight (DW), severity of the injuries caused by each type of hook in the sea turtles and other factors that enhance entanglement or hooking. The effect of gear modifications on the catch rates of target species was also assessed, allowing potential measures to identify any detrimental effect on catches of swordfish. Effects of hook and bait on other species caught during the trials as secondary target species or by-catch were also monitored. Analyses were carried out to obtain nominal and standardized catch rate data of all the species caught, except for the sea turtles QUE and DER due to the scarce number of observations obtained.

Hook location in the incidental catch of turtles: The location of the hook in each specimen of sea turtle caught was recorded during the experiment: mouth, tongue, flipper, entangled in the gear (grouped together within the category "external"). The locations stomach and esophagus were grouped together within the category "internal" (swallowed).

3. Results and discussion

Both vessels deployed a total of 356 600 hooks during a total of 183 sets. The total number of hooks set for each vessel-gear used, by hook type, bait and zone, in addition to their combinations, are presented in **Tables 2 and 3**.

The total catch in weight (kg DW) of the specimens of the different fish species captured, regardless of the use assigned to the catch, was 219 t. A total of 113 t was obtained by one of the vessels with 250 040 hooks set and 106 t by the other vessel with 106 560 hooks set **(Table 2)**. The total catch of all the fish species combined and retained on board amounted to 202 t (DW), accounting for 92.5% of the total catch of the two vessels. The catch amount retained on board the two vessels was 102 t of SWO, 33 t of PGO, 30 t of IOO, 2 t of BIL and 35 t of the total catch of other species. All fish specimens were retained on board, with the exception of 7.5% of SWO, 0.2% of PGO, 2.4% of IOO and 48.6% of BIL, which were tagged and released alive, in addition to some individuals (13.4%) belonging to the group of other species or specimens of different species that were discarded or released alive.

Table 4 reports a qualitative summary of the deviance analyses for factors affecting catch rates of positive sets for each species and the proportion of positive sets. Factor '*gear*' affected the catch rates of positive sets for all the species of fish as well as the CAT turtle. Factor '*gear*' was significant in the proportion of positive sets only for IOO and BIL. In general, factor '*zone*' seemed to affect the majority of fish species (except for BIL and CAT) in the case of catch rates of positive sets and it is the only factor affecting the proportion of positive sets for all the fish species, but it was not significant for CAT turtles. As for factors '*hook*' and '*bait*', statistical significance depended greatly on the species of fish analyzed. Nevertheless these factors were consistently not significant for CAT turtles. Regarding interactions, most of them were not significant in either model, except in the catch rate of positive sets for the CAT turtle where all the interactions proved to be significant **(Tables 5, 6)**.

The results of the standardized mean CPUE by fish species and for each of the principal factors are shown in table 7 **(Figures 3-7)**. The high variability in the CPUE between zones for the different species of fish was confirmed. This 'area' variability is very frequent and well known historically by fishermen involved in large pelagic fisheries. The mean standardized CPUE obtained for the most important fish species caught indicate yield losses per hook between -41% and -64% for the traditional Spanish gear type (B1). So catchability per hook set is much higher for the American style longline than the traditional one. The lower catchability per hook of traditional longline occurs because more hooks are set covering a similar number of nautical miles.

The "hook" factor proved to be significant for SWO. The mean standardized CPUE indicates that a change in hook type could lead to mean yield losses of between –16.0% and –23.1% in weight (for circle hooks A2 and A3, respectively) as compared to the conventional hook of reference (A1). The "hook" factor does not seem to be significant for PGO and IOO. Nevertheless a change in hook could result in slight gains for PGO when the circle type A2 hook is used (+1.8%) and slight losses with the circle type A3 (–1.7%). Moderate gains would be expected with the alternative hooks tested A2 and A3 (+5.5% and +3.2%, respectively) for IOO species. The "hook" factor proved to be significant for the BIL group and gains were suggested with either of the two alternative hooks tested, A2 and A3 (+55.5% and +1.5%, respectively) **(Table 7, Figure 8)**.

The "*bait"* factor proved to be significant only for swordfish. However the use of alternative bait 6 (squid) would result in yield losses in weight for almost all of the fish species as compared to reference bait 1 (mackerel) and yield gains for the billfish group **(Table 7, Figure 9)**.

Although the experiment attempted to standardize and balance the type and number of observations between combinations, the hook and bait factors are not easy to separate, since neither one is able to produce a catch by itself. Only the combination of the two factors enables a catch to take place, except in cases where animals become entangled in the gear or when sporadic accidents occur. The olfactory stimulus appears to be fundamental to the final decision of swordfish to make their attack on prey–bait (Mejuto *et al*. 2005). Similar behavior is also well known in other large pelagic species.

The '*hook*bait*' interaction was not significant for any of the fish species under the assumptions put forth. However, the mean standardized CPUE estimations for the hook-bait combination proved to be of some interest when compared (table 8). The combination of alternative hooks-bait in relation to the reference combination (A1/1 consisting of the conventional hook 'J' and mackerel bait) suggests losses for swordfish (–15.8% to –36.4%) and IOO (–0.6% to –13.5%) but gains for PGO, except with combinations A1/6 (–2.2%) and A3/6 (–5.9%). However, gains are mostly suggested for the BIL group (+36.4% to +86.8%). The results of the use of any of the alternative hooks with bait type 6 (squid) indicate that the catch rates in weight of the fish species would generally decrease as compared to the alternative combinations tested, except in the case of the BIL group, where possible gains were always implied.

Few cases of interaction with sea turtles have been observed in the commercial longline fishery practices in these areas of the South East Pacific Ocean. An interaction with only 44 sea turtles (34 CAT, 7 DER and 3 QUE) was reported during the whole experiment. Therefore, the conclusions related to sea turtles should be considered very shaky in comparison to similar experiments conducted previously in the Atlantic and Mediterranean areas where a much higher interaction was found. During this experiment in the Pacific all sea turtles were released alive apparently in good condition for further survival. The overall interaction rate per hook for all turtles combined was $1.23E^{-04}$ ($9.55E^{-05}$, $1.97E^{-05}$ and $8.43E^{-06}$ for CAT, DER and QUE, respectively). The mortality rate per hook during hauling back and release was null. The fishery practices and the treatment of the incidental captures were the same as the ones applied during commercial activities, with the exception of the test carried out on hooks and bait. Hence, the release rates could be assumed to come close to those that would occur in strictly commercial operations within these areas-times.

The summary of the deviance analyses for the CAT species indicates that the factor '*gear*' was important to providing an explanation for these catch rates. The "gear" in combination or interaction with some other factors also seems to be significant in some cases, but clearly less important. Any factor or interaction of factors would seem to be significant for the proportion of positive sets **(Tables 9–10)**.

Despite the scarce number of interactions with turtles during the experiment, the use of alternative bait 6 (squid) would suggest moderate increases in the incidental catch rates of the turtle CAT (+8.2%) and also with the significant interaction of A3/6 (+18.9%). Others significant interactions of factors suggested moderate losses for this species (–1.6% to –12.0%).The results indicate that the interaction of the bait with any other factor might be an important element affecting the incidental catch rates of CAT species. The combination of the different hooks tested with bait 6 (squid) generally produced higher interactions rates than those obtained using mackerel as bait **(Table 11, Figure 10)**. Because CAT catches were null in some of the areas, zone 20080 SW was used as a reference for this species. All the turtles QUE (3 specimens) were caught with alternative bait 6. A qualitative summary of catch rates, gains-losses, in weight for the fish species and in number for CAT species by '*gear', 'hook', 'bait*' and interaction '*hook*bait*' in relation to the factor taken as a reference, are shown in table 12.

Hook location in turtles: The prevalence of the different hook locations observed on the 44 turtles, regardless of the hook or bait type used, can be broken down as follows: 43.2 % by the flipper, 43.2% in the mouth (mouth+tongue), 11.3% swallowed (4.5% in the esophagus and 6.8% in the stomach) and 2.3% entangled (table 13, figure 11). As regards the specimens of CAT and QUE, 52.9% and 33.3% were hooked in the mouth while 100% of the individuals belonging to the DER species were hooked by the flippers as were 66.7% of QUE specimens. In 14.7% of CAT specimens the hooks were swallowed **(Table 13, Figure 12)**.

By hook type: The highest percentage of hooking (36.4%) took place with the A1 and A2 hooks, and 27.3% with hook A3. Eighty-nine percent of the hookings were observed on the external part of the animals (flippers+mouth+tongue+entangled), while roughly 11% were caught internally (esophagus+stomach) (table 14, figure 13). Conventional hook type A1 was mainly hooked in the in the mouth (18.2%) and flippers (9.1%). Hook A2 was primarily caught in the flippers and mouth at identical levels (15.9%). With hook A3, the greatest number of locations were in the mouth and flippers (18.2% and 6.8%), respectively.

The CAT species was mainly caught in the mouth+tongue with the conventional A1 type hook (26.4%). Two of the three QUE specimens captured were caught with hook type A2. The DER species was always observed to be caught by the flippers **(Table 14, Figure 14)**.

By bait type: The prevalence of the different hook locations of turtles species combined, by bait type would suggest that most of the interactions, 63.6%, occurred with bait type 6 (squid) and 36.4% with bait 1 (mackerel). The highest percentage of turtles hooked in the mouth+tongue (25.0%) took place with bait type 6 (squid), whereas bait type 1 (mackerel) resulted in 18.2% of turtles caught by the mouth+tongue. The percentage of animals being hooked in the flipper with bait type 6 was 34.1% and with bait 1 it was only 9.1%. Bait 6 (squid) was involved in 61.4% of the external hooking and 2.3% of the internal hooking observed. However bait 1 (mackerel) was involved in 27.3% of the external hooking and 9.1% of cases of swallowed hooks **(Table 15, Figure 15)**.

When relating hook location to bait type in each turtle species **(Table 14, Figure 16)**, we observed that CAT showed a slight preference for bait 6 (squid), 58.8% and 41.2% for bait 1 (mackerel). The only three individuals of QUE caught had an apparent preference for bait 6 (squid) **(Table 15, Figure 16)**.

By hook-bait combinations: For the total number of turtles caught, the highest percentage of hook locations was found with the combination of circle 8º offset hook–squid bait (A2/6) (25.0%) followed by the combination conventional hook–squid bait (A1/6) (22.7%) **(Table 16, Figure 17)**.

To facilitate the description, the prevalence in percentages of the different hook locations was combined and then classified into “external” (flipper+mouth+tongue+entangled) and “internal” wounds (esophagus+stomach), according to the different combinations of hooks A1, A2, A3 and baits 1 and 6 (mackerel or squid). The differences between their respective combinations were also computed **(Table 17, Figure 18)**.

The results obtained for the sea turtle species must be interpreted with caution, since their interaction during the fishing operations was relatively scarce. The small number of observations does not allow robust conclusions to be drawn for these species. There was no interaction with sea birds during the whole experiment.

The overall results indicate a huge difference in the catch rates per hook between both gear types used in the experiment. The gear, in particular, and zone factors seem to be important for most species. New experiments and analyses will be warranted to clarify the most relevant factors affecting the respective higher/lower catch rates of the different species in these areas. The lack of significance in some of the factors tested must be considered when drawing conclusions. New runs with more observations will be required since the incidental interaction with sea turtles and less prevalent fish species was relatively low in these areas. Despite these circumstances, the results can be useful for comparison with similar experiments conducted in the Atlantic and Mediterranean Sea using similar methodology. The two alternative circle hooks tested could lead to overall decreases in the catch rates in weight of the fish species in comparison with the conventional hook of reference, A1. Nevertheless, slight increases in catch rates were suggested in the shortfin mako with the use of these circle hooks (type A2: +5.5% and type A3: +3.2%). The bilfish group might also tend to increase catch rates with either of the alternative circle hooks tested, A2 and A3 (+55.5% and +1.5%, respectively) in comparison with the conventional hook (A1). The use of alternative bait 6 (squid) would generally lead to a lower catch rate in weight for practically all of the fish species, as compared to bait 1 (mackerel), but it would generate an overall increase in the catch rates of billfish (+31.7%) as well as in the scarce incidental capture of sea turtles CAT (+8.19%). The use of alternative hook-bait combinations would generally lead to small changes in the catch rates in weight for most fish species, except for the target species swordfish, where it would lead to an overall decrease between –15.8% and –36.4% and to a general increase in the incidental catch of billfish (up to +86.8%). The alternate hook-bait combinations tested would suggest slight decreases in the catch rates for all sea turtles, except with the A3/6 combination which would produce CAT yield gains of +18.9%. Nevertheless we must bear in mind that gear interaction with turtles was scarce in these areas, with a very small sampling size available. The different models tested during the analysis suggest that the results are consistent in terms of gains, losses and significance for the most prevalent fish species in the catch. However the results obtained for less prevalent species with few observations or null presence in some areas, such as sea turtles stand on shaky ground for these areas. The results obtained for the most important fish species generally match those reported in similar experiments conducted in the Atlantic areas.

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Table 1. Experimental combination of three different hook types (A1, A2, A3) and two bait types (C1=bait 1, C2=bait 6) by set (lance).

				N/3				2N/3				N hooks
Lance 1	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1
Lance 2	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2
Lance 3	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1
Lance 4	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2
Lance 5	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1
Lance 6	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2
Lance 7	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1
Lance 8	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2
Lance 9	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1
Lance 10	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2
Lance 11	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1
Lance 12	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2
Lance 13	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1
Lance 14	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2
Lance 15	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1
Lance 16	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2
Lance 17	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1
Lance 18	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2
Lance 19	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1
Lance 20	A1 C2	A1 C2	A1 C2	A1 C2	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2
Lance 21	A1 C1	A1 C1	A1 C1	A1 C1	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1
Lance 21	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2
Lance 22	A2 C1	A2 C1	A2 C1	A2 C1	A3 C2	A3 C2	A3 C2	A3 C2	A1 C1	A1 C1	A1 C1	A1 C1
Lance 23	A2 C2	A2 C2	A2 C2	A2 C2	A3 C1	A3 C1	A3 C1	A3 C1	A1 C2	A1 C2	A1 C2	A1 C2

etc...

Table 2. Total number of hooks set during the experimental survey in the South East Pacific by hook type, bait type and zone, as well as average number of hooks by set, total number of sets and total catch of total fish species combined, in dressed weight.

	TOTAL # HOOKS	Vessel 1 # HOOKS	Vessel 2 # HOOKS
A1 (16/0) 'J' (10º)	118832	83312	35520
A2 (17/0) 'G' (8º)	118848	83328	35520
A3 (17/0) 'G' (0º)	118920	83400	35520
BAIT 1 (mackerel)	178976	125616	53360
BAIT 6 (squid)	177624	124424	53200
ZONE			
15075 SW	5184	5184	0
15080 SW	86336	55136	31200
15085 SW	11616	11616	0
20075 SW	2880	0	2880
20080 SW	61152	37152	24000
20085 SW	104832	80832	24000
20090 SW	28680	25080	3600
20105 SW	3600	0	3600
25085 SW	16176	16176	0
25090 SW	18864	18864	0
25110 SW	4800	0	4800
30115 SW	12480	0	12480
AVE _HOOK / SET	1926	2668	1184
TOT_HOOK	356600	250040	106560
TOT_SET	183	93	90
TOT CATCH (t)	219	113	106

Table 3. Total number of hooks set during the experimental survey, by zone and hook–bait combinations.

HOOK Type :	A1 (16/0) 'J' (10º)			A2 (17/0) 'G' (8º)			A3 (17/0) 'G' (0º)		
BAIT Type :	1	6	Tot_HOOKS	1	6	Tot_HOOKS	1	6	Tot_HOOKS
ZONE									
15075	864	864	1728	1728		1728		1728	1728
15080	15352	13368	28720	13720	15112	28832	14344	14440	28784
15085	3912		3912	960	2880	3840		3864	3864
20075	560	400	960	400	560	960	400	560	960
20080	9960	10424	20384	10760	9624	20384	9280	11104	20384
20085	15112	19792	34904	18856	16216	35072	19888	14968	34856
20090	5528	4072	9600	5008	4568	9576	4568	4936	9504
20105	800	400	1200	400	800	1200	400	800	1200
25085	3576	1848	5424	1824	3552	5376	2688	2688	5376
25090	3648	2592	6240	1824	4296	6120	3816	2688	6504
25110	800	800	1600	1200	400	1600	400	1200	1600
30115	1840	2320	4160	1920	2240	4160	2640	1520	4160
Total	61952	56880	118832	58600	60248	118848	58424	60496	118920

Table 4. Results of the statistical significance (α=5%) of deviance analyses for factors affecting catch rates (in kg for fishes and in number for CAT) of positive sets for each species (upper table) and the proportion of positive sets (lower table) (+ : indicates the importance, from low to high, of each factor considered to be significant) .

factor	levels	species				
		SWO	PGO	IOO	BIL	CAT
Gear type	B1, B2	yes+++	yes+++	yes+++	yes+++	yes+++
Hook type	A1, A2, A3	yes+	no	no	yes+	no
Bait type	1, 6	yes+	no	no	no	no
Zone	12 squares 5ºx5º	yes++	yes+++	yes+++	no	no
Hook*Bait	interaction	no	no	no	no	yes++
Hook*Zone	interaction	yes+	no	no	no	yes++
Bait*Zone	interaction	no	no	yes++	no	yes++

factor	levels	species				
		SWO	PGO	IOO	BIL	CAT
Gear type	B1, B2	no	no	yes++	yes+	no
Hook type	A1, A2, A3	no	no	yes+	yes++	no
Bait type	1, 6	no	no	yes++	no	no
Zone	12 squares 5ºx5º	yes++	yes+++	yes+++	yes+++	no
Hook*Bait	interaction	no	no	no	no	no
Hook*Zone	interaction	no	no	no	yes+++	no
Bait*Zone	interaction	no	no	no	yes+++	no

Table 5. Deviance table analysis. Logged catch rates (DW, kg) for fish species. (% of total deviance refers to that of the null model; *P(>|Chi|) refers to consecutive models)*.

species	model	Resid. df	Resid. Dev.	Change in Dev.	% total Dev.	Model % Dev.	P(>|Chi|)
SWO	NULL	521	418.75				
SWO	GEAR	520	315.17	103.58	24.74	24.74	9.86E-47
SWO	GEAR HOOK	518	309.12	6.05	1.44	26.18	2.44E-03
SWO	GEAR HOOK BAIT	517	304.28	4.85	1.16	27.34	1.90E-03
SWO	GEAR HOOK BAIT ZONE	506	268.02	36.26	8.66	36.00	4.79E-11
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK	504	267.80	0.22	0.05	36.05	8.10E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	503	265.07	2.73	0.65	36.70	2.00E-02
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	500	264.16	0.91	0.22	36.92	6.10E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	498	261.96	2.20	0.53	37.44	1.10E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	477	243.57	18.38	4.39	41.83	2.00E-02
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	467	234.73	8.84	2.11	43.95	6.00E-02
PGO	NULL	440	363.78				
PGO	GEAR	439	286.27	77.51	21.31	21.31	3.62E-31
PGO	GEAR HOOK	437	286.25	0.03	0.01	21.32	9.80E-01
PGO	GEAR HOOK BAIT	436	286.06	0.18	0.05	21.36	5.70E-01
PGO	GEAR HOOK BAIT ZONE	425	240.12	45.95	12.63	34.00	1.53E-12
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK	423	239.98	0.13	0.04	34.03	8.90E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	422	239.01	0.97	0.27	34.30	1.90E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	419	237.62	1.38	0.38	34.68	4.90E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	417	237.61	0.02	0.01	34.68	9.80E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	395	226.94	10.66	2.93	37.61	6.70E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	385	221.33	5.61	1.54	39.16	4.60E-01
IOO	NULL	319	246.77				
IOO	GEAR	318	220.71	26.06	10.56	10.56	3.93E-16
IOO	GEAR HOOK	316	220.62	0.09	0.04	10.60	8.90E-01
IOO	GEAR HOOK BAIT	315	220.44	0.18	0.07	10.67	5.04E-01
IOO	GEAR HOOK BAIT ZONE	304	128.22	92.22	37.37	48.04	4.85E-44
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK	302	127.63	0.59	0.24	48.28	4.74E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	301	127.02	0.62	0.25	48.53	2.10E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	298	126.03	0.99	0.40	48.93	4.74E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	296	125.14	0.89	0.36	49.29	3.22E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	277	117.45	7.69	3.12	52.41	4.22E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	267	105.00	12.45	5.04	57.45	4.57E-04
BIL	NULL	78	76.52				
BIL	GEAR	77	56.27	20.25	26.46	26.46	4.38E-09
BIL	GEAR HOOK	75	52.65	3.62	4.73	31.19	4.60E-02
BIL	GEAR HOOK BAIT	74	50.58	2.07	2.71	33.90	6.00E-02
BIL	GEAR HOOK BAIT ZONE	65	41.00	9.58	12.52	46.42	6.10E-02
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK	63	38.53	2.47	3.23	49.65	1.22E-01
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	62	38.09	0.44	0.57	50.22	3.87E-01
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	59	31.79	6.30	8.23	58.45	1.30E-02
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	57	31.58	0.21	0.27	58.72	8.37E-01
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	47	27.55	4.03	5.27	63.99	7.39E-01
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	42	24.69	2.86	3.74	67.73	4.32E-01

Table 6. Deviance table analysis. Response proportion of positive sets for fish species. (% of total deviance refers to that of the full model; *P(>|Chi|) refers to consecutive models)*.

species	model	Resid. df	Resid. Dev.	Change in Dev.	% total Dev.	Model % Dev.	P(>|Chi|)
SWO	NULL	91	121.60				
SWO	GEAR	90	119.40	2.20	1.81	1.81	1.00E-01
SWO	GEAR HOOK	88	118.70	0.70	0.58	2.38	7.00E-01
SWO	GEAR HOOK BAIT	87	118.40	0.30	0.25	2.63	6.00E-01
SWO	GEAR HOOK BAIT ZONE	76	58.40	60.00	49.34	51.97	9.34E-09
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK	74	58.40	0.00	0.00	51.97	1.00E+00
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	73	58.20	0.20	0.16	52.14	7.00E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	70	54.70	3.40	2.80	54.93	3.00E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	68	53.10	1.60	1.32	56.25	4.00E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	46	24.80	28.30	23.27	79.52	2.00E-01
SWO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	34	10719.30	0.00	0.00	79.52	1.00E+00
PGO	NULL	91	111.62				
PGO	GEAR	90	110.52	1.10	0.99	0.99	2.94E-01
PGO	GEAR HOOK	88	108.61	1.91	1.71	2.70	3.85E-01
PGO	GEAR HOOK BAIT	87	107.81	0.79	0.71	3.41	3.74E-01
PGO	GEAR HOOK BAIT ZONE	76	81.57	26.24	23.51	26.92	6.00E-03
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK	74	80.24	1.33	1.19	28.11	5.15E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	73	77.22	3.03	2.71	30.82	8.20E-02
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	70	73.46	3.76	3.37	34.19	2.88E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	68	71.52	1.94	1.74	35.92	3.80E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	46	53.92	17.60	15.77	51.69	7.29E-01
PGO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	35	36.74	17.18	15.39	67.09	1.03E-01
IOO	NULL	91	185.64				
IOO	GEAR	90	174.35	11.29	6.08	6.08	1.00E-03
IOO	GEAR HOOK	88	167.67	6.68	3.60	9.68	3.50E-02
IOO	GEAR HOOK BAIT	87	150.30	17.37	9.36	19.04	3.08E-05
IOO	GEAR HOOK BAIT ZONE	76	87.56	62.74	33.80	52.83	2.86E-09
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK	74	86.07	1.50	0.81	53.64	4.73E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	73	84.56	1.51	0.81	54.45	2.20E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	70	78.76	5.80	3.12	57.57	1.22E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	68	76.75	2.01	1.08	58.66	3.66E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	46	50.53	26.22	14.12	72.78	2.42E-01
IOO	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	35	38.65	11.88	6.40	79.18	3.73E-01
BIL	NULL	81	157.48				
BIL	GEAR	80	151.92	5.56	3.53	3.53	1.80E-02
BIL	GEAR HOOK	78	138.35	13.57	8.62	12.15	1.00E-03
BIL	GEAR HOOK BAIT	77	134.99	3.36	2.13	14.28	6.70E-02
BIL	GEAR HOOK BAIT ZONE	68	96.93	38.06	24.17	38.45	1.70E-05
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK	66	96.38	0.55	0.35	38.80	7.59E-01
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	65	93.08	3.30	2.10	40.90	6.90E-02
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	62	90.89	2.19	1.39	42.29	5.35E-01
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	60	85.62	5.27	3.35	45.63	7.20E-02
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	42	53.71	31.91	20.26	65.89	2.30E-02
BIL	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	33	36.55	17.16	10.89	76.79	4.60E-02

Table 7. Standardized mean CPUE by factor (kg DW x 1000 hooks^{-1}), standard error, coefficient of variation, 95% confidence limits (based on a normal approximation) and % difference with respect to reference level. Delta Method. (Gains and losses in percentage (ratio%) in relation to the type factor of reference (*REF*)).

species	factor	type	std. CPUE	Std. Err.	95%upp	95%low	CV (%)	ratio%
SWO	HOOK	A1	282.91	17.38	316.97	248.86	6.14	*REF*
SWO	HOOK	A2	237.70	15.72	268.50	206.90	6.61	-15.98
SWO	HOOK	A3	217.57	12.56	242.19	192.94	5.77	-23.10
SWO	BAIT	1	269.34	14.04	296.85	241.82	5.21	*REF*
SWO	BAIT	6	222.04	11.43	244.45	199.62	5.15	-17.56
SWO	ZONE	15075	153.60	79.40	309.22	-2.01	51.69	-22.12
SWO	ZONE	15080	268.06	16.29	299.99	236.12	6.08	35.90
SWO	ZONE	15085	326.35	37.18	399.22	253.48	11.39	65.46
SWO	ZONE	20075	109.99	32.97	174.61	45.37	29.97	-44.23
SWO	ZONE	20080	307.28	24.96	356.21	258.35	8.12	55.79
SWO	ZONE	20085	267.97	15.12	297.60	238.34	5.64	35.86
SWO	ZONE	20090	188.17	19.92	227.21	149.14	10.58	-4.60
SWO	ZONE	20105	57.14	11.06	78.81	35.46	19.35	-71.03
SWO	ZONE	25085	193.92	38.77	269.92	117.93	19.99	-1.68
SWO	ZONE	25090	137.44	26.16	188.71	86.17	19.03	-30.32
SWO	ZONE	25110	158.53	43.37	243.54	73.52	27.36	-19.63
SWO	ZONE	30115	197.24	33.30	262.51	131.97	16.88	*REF*
PGO	HOOK	A1	80.51	5.51	91.30	69.72	6.84	*REF*
PGO	HOOK	A2	81.97	5.70	93.15	70.80	6.95	1.82
PGO	HOOK	A3	79.15	6.07	91.04	67.26	7.66	-1.69
PGO	BAIT	1	81.73	4.65	90.85	72.61	5.69	*REF*
PGO	BAIT	6	79.35	5.05	89.25	69.44	6.37	-2.91
PGO	ZONE	15075	85.96	19.68	124.52	47.39	22.89	-53.28
PGO	ZONE	15080	62.12	4.56	71.05	53.18	7.34	-66.24
PGO	ZONE	15085	132.05	21.78	174.74	89.37	16.49	-28.22
PGO	ZONE	20075	63.44	21.99	106.54	20.33	34.67	-65.52
PGO	ZONE	20080	68.15	6.06	80.02	56.28	8.89	-62.95
PGO	ZONE	20085	79.88	6.20	92.04	67.73	7.76	-56.58
PGO	ZONE	20090	147.81	18.75	184.57	111.06	12.69	-19.65
PGO	ZONE	20105	109.90	25.04	158.96	60.83	22.78	-40.27
PGO	ZONE	25085	59.44	12.66	84.26	34.62	21.30	-67.69
PGO	ZONE	25090	73.04	12.79	98.11	47.97	17.51	-60.30
PGO	ZONE	25110	85.72	20.07	125.06	46.37	23.42	-53.41
PGO	ZONE	30115	183.97	25.21	233.39	134.56	13.70	*REF*

Table 7. (cont.)

species	factor	type	std. CPUE	Std. Err.	95%upp	95%low	CV (%)	ratio%
IOO	HOOK	A1	80.27	7.67	95.29	70.64	9.55	*REF*
IOO	HOOK	A2	84.71	6.73	97.90	76.02	7.94	-15.98
IOO	HOOK	A3	82.87	6.46	95.53	74.45	7.80	-23.10
IOO	BAIT	1	86.71	5.33	97.15	76.26	6.15	*REF*
IOO	BAIT	6	77.83	5.89	89.38	66.28	7.57	-17.56
IOO	ZONE	15075	31.07	16.43	63.27	-1.14	52.89	-22.12
IOO	ZONE	15080	53.20	3.94	60.92	45.49	7.40	35.90
IOO	ZONE	15085	67.51	18.67	104.10	30.91	27.66	65.46
IOO	ZONE	20075	80.94	9.05	98.68	63.21	11.18	-44.23
IOO	ZONE	20080	56.07	5.70	67.24	44.91	10.16	55.79
IOO	ZONE	20085	78.31	5.84	89.76	66.86	7.46	35.86
IOO	ZONE	20090	91.43	14.49	119.83	63.02	15.85	-4.60
IOO	ZONE	20105	126.63	31.70	188.76	64.49	25.04	-71.03
IOO	ZONE	25085	122.84	19.31	160.68	84.99	15.72	-1.68
IOO	ZONE	25090	233.38	25.70	283.75	183.01	11.01	-30.32
IOO	ZONE	25110	136.97	47.33	229.73	44.22	34.55	-19.63
IOO	ZONE	30115	293.72	30.82	354.11	233.32	10.49	*REF*
BIL	HOOK	A1	29.99	4.86	39.52	20.45	16.22	*REF*
BIL	HOOK	A2	46.62	8.40	63.09	30.15	18.02	55.48
BIL	HOOK	A3	30.44	5.62	41.45	19.44	18.45	1.52
BIL	BAIT	1	30.94	4.53	39.82	22.06	14.65	*REF*
BIL	BAIT	6	40.75	5.56	51.65	29.85	13.64	31.70
BIL	ZONE	15075	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
BIL	ZONE	15080	17.79	4.61	26.82	8.76	25.90	-68.61
BIL	ZONE	15085	38.53	8.22	54.64	22.42	21.33	-32.02
BIL	ZONE	20075	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
BIL	ZONE	20080	37.79	9.00	55.43	20.15	23.81	-33.32
BIL	ZONE	20085	37.69	5.03	47.56	27.83	13.35	-33.49
BIL	ZONE	20090	37.21	11.97	60.67	13.75	32.16	-34.34
BIL	ZONE	20105	12.84	2.80	18.34	7.34	21.84	-77.34
BIL	ZONE	25085	21.32	7.27	35.57	7.07	34.09	-62.38
BIL	ZONE	25090	11.89	2.37	16.54	7.25	19.94	-79.01
BIL	ZONE	25110	61.53	40.80	141.49	-18.42	66.30	8.58
BIL	ZONE	30115	56.67	16.17	88.36	24.98	28.53	*REF*

Table 8. Standardized mean CPUE by interactions of factors (kg DW x 1000 hooks^{-1}), standard error, coefficient of variation, 95% confidence limits (based on a normal approximation) and % difference with respect to reference level. Delta Method. (Gains and losses in percentage (ratio %) in relation to the type factor of reference (*REF*)).

species	factor	type	std. CPUE	Std. Err.	95%upp	95%low	CV (%)	ratio%
SWO	HOOK*BAIT	A1_1	325.65	25.99	376.60	274.71	7.98	*REF*
SWO	HOOK*BAIT	A2_1	274.10	26.28	325.61	222.59	9.59	-15.83
SWO	HOOK*BAIT	A3_1	219.67	17.88	254.71	184.63	8.14	-32.55
SWO	HOOK*BAIT	A1_6	245.10	19.26	282.86	207.35	7.86	-24.74
SWO	HOOK*BAIT	A2_6	207.17	16.34	239.20	175.14	7.89	-36.38
SWO	HOOK*BAIT	A3_6	216.22	16.73	249.00	183.43	7.74	-33.61
PGO	HOOK*BAIT	A1_1	81.60	7.32	95.95	67.26	8.97	*REF*
PGO	HOOK*BAIT	A2_1	82.27	7.19	96.38	68.17	8.74	0.82
PGO	HOOK*BAIT	A3_1	81.98	8.09	97.84	66.13	9.87	0.47
PGO	HOOK*BAIT	A1_6	79.80	7.86	95.20	64.40	9.85	-2.21
PGO	HOOK*BAIT	A2_6	82.05	7.56	96.87	67.24	9.21	0.55
PGO	HOOK*BAIT	A3_6	76.80	8.04	92.56	61.05	10.47	-5.88
IOO	HOOK*BAIT	A1_1	89.01	10.21	109.03	68.99	11.48	*REF*
IOO	HOOK*BAIT	A2_1	83.46	7.79	98.73	68.19	9.33	-6.23
IOO	HOOK*BAIT	A3_1	88.45	8.20	104.51	72.38	9.27	-0.63
IOO	HOOK*BAIT	A1_6	69.81	8.97	87.39	52.22	12.85	-21.57
IOO	HOOK*BAIT	A2_6	86.71	9.73	105.79	67.64	11.22	-2.58
IOO	HOOK*BAIT	A3_6	77.01	8.64	93.94	60.08	11.22	-13.48
BIL	HOOK*BAIT	A1_1	27.65	5.23	37.90	17.39	18.94	*REF*
BIL	HOOK*BAIT	A2_1	41.54	9.83	60.81	22.26	23.67	50.25
BIL	HOOK*BAIT	A3_1	26.58	6.48	39.28	13.87	24.39	-3.87
BIL	HOOK*BAIT	A1_6	37.70	7.66	52.70	22.69	20.31	36.35
BIL	HOOK*BAIT	A2_6	51.65	9.71	70.69	32.61	18.81	86.83
BIL	HOOK*BAIT	A3_6	40.25	8.85	57.59	22.90	21.99	45.58

Table 9. Deviance table analysis. Logged catch rates (number of specimens) for CAT species. (% of total deviance refers to that of the null model; *P(>|Chi|) refers to consecutive models).*

species	model	Resid. df	Resid. Dev.	Change in Dev.	% total Dev.	Model % Dev.	P(>|Chi|)
CAT	NULL	30	5.32				
CAT	GEAR	29	1.76	3.56	66.93	66.93	1.47E-24
CAT	GEAR HOOK	27	1.74	0.02	0.43	67.36	7.15E-01
CAT	GEAR HOOK BAIT	26	1.68	0.05	0.98	68.33	2.17E-01
CAT	GEAR HOOK BAIT ZONE	23	1.62	0.06	1.17	69.51	6.08E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK	21	1.60	0.02	0.34	69.84	7.69E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	20	1.57	0.03	0.63	70.47	3.21E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	18	1.57	0.00	0.05	70.52	9.64E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	16	1.24	0.33	6.15	76.67	8.20E-03
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	12	0.79	0.45	8.41	85.08	1.06E-02
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	10	0.34	0.45	8.52	93.60	1.30E-03

Table 10. Deviance table analysis. Response proportion of positive sets for CAT species. (% of total deviance refers to that of the full model; *P(>|Chi|) refers to consecutive models*

species	model	Resid. df	Resid. Dev.	Change in Dev.	% total Dev.	Model % Dev.	P(>|Chi|)
CAT	NULL	47	48.58				
CAT	GEAR	46	46.36	2.22	4.56	4.56	1.37E-01
CAT	GEAR HOOK	44	45.43	0.94	1.93	6.50	6.25E-01
CAT	GEAR HOOK BAIT	43	44.49	0.94	1.93	8.42	3.33E-01
CAT	GEAR HOOK BAIT ZONE	40	40.18	4.31	8.86	17.28	2.30E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK	38	38.96	1.22	2.51	19.80	5.43E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT	37	37.28	1.68	3.47	23.26	1.94E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE	34	35.36	1.93	3.96	27.23	5.88E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT	32	34.41	0.95	1.95	29.17	6.23E-01
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE	26	23.17	11.24	23.14	52.31	8.10E-02
CAT	GEAR HOOK BAIT ZONE GEAR*HOOK GEAR*BAIT GEAR*ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	23	19.20	3.97	8.17	60.48	2.65E-01

Table 11. Standardized mean CPUE by factor and by interactions of factors (number x 1000 hooks^{-1}), standard error, coefficient of variation, 95% confidence limits (based on a Normal approximation) and % difference with respect to reference level. Delta Method. (Gains and losses in percentage (ratio %) in relation to the type factor of reference (*REF*).)

species	factor	type	std. CPUE	Std. Err.	95%upp	95%low	CV (%)	ratio%
CAT	HOOK	A1	0.83	0.07	0.97	0.69	8.70	*REF*
CAT	HOOK	A2	0.81	0.06	0.93	0.69	7.74	-2.41
CAT	HOOK	A3	0.86	0.15	1.15	0.57	17.23	4.04
CAT	BAIT	1	0.79	0.07	0.93	0.65	8.81	*REF*
CAT	BAIT	6	0.85	0.08	1.01	0.69	9.52	8.19
CAT	ZONE	15075	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	15080	0.83	0.06	0.96	0.71	7.42	0.14
CAT	ZONE	15085	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	20075	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	20080	0.83	0.08	1.00	0.67	10.19	*REF*
CAT	ZONE	20085	0.83	0.11	1.05	0.61	13.33	-0.30
CAT	ZONE	20090	0.66	0.05	0.76	0.55	8.18	-20.93
CAT	ZONE	20105	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	25085	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	25090	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	25110	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	ZONE	30115	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*	*not estim.*
CAT	HOOK*BAIT	A1_1	0.85	0.12	1.08	0.62	14.00	*REF*
CAT	HOOK*BAIT	A2_1	0.78	0.07	0.91	0.65	8.54	-8.42
CAT	HOOK*BAIT	A3_1	0.75	0.09	0.92	0.58	11.59	-11.96
CAT	HOOK*BAIT	A1_6	0.82	0.07	0.97	0.68	8.92	-2.93
CAT	HOOK*BAIT	A2_6	0.84	0.08	1.00	0.67	9.85	-1.63
CAT	HOOK*BAIT	A3_6	1.01	0.30	1.59	0.43	29.23	18.91

Table 12. Qualitative comparison of catch rates gains-loss in weight for the fish species-groups and in number for sea turtles species, by gear, hook, bait and interactions hook-bait.(–: loss and +:gains in relation to the factor of reference (*ref*)).

		SWO	PGO	IOO	BIL	CAT
`gear'	B1	– – –	– – –	– –	– – –	– –
	B2	*ref*	*ref*	*ref*	*ref*	*ref*
`hook'	A1	*ref*	*ref*	*ref*	*ref*	*ref*
	A2	–	+	+	+++	–
	A3	– –	–	+	+	+
`bait'	1	*ref*	*ref*	*ref*	*ref*	*ref*
	6	–	–	–	+	+
*`hook*bait'*	A1/1	*ref*	*ref*	*ref*	*ref*	*ref*
	A2/1	–	+	–	+++	–
	A3/1	– –	+	–	–	–
	A1/6	– –	–	– –	++	–
	A2/6	– –	+	–	+++	–
	A3/6	– –	–	–	++	+

Table 13. Prevalence (%) of each hook location within each sea turtle species and species combined.

Location	%CAT	%DER	%QUE	%Total
Mouth	50	0	33,3	40,9
Tongue	2,9	0	0	2,3
Esophagus	5,9	0	0	4,5
Stomach	8,8	0	0	6,8
Flipper	29,4	100	66,7	43,2
Entangled	2,9	0	0	2,3

Note: decimals are in Spanish (, = .)

Table 14. Prevalence (%) of each hook location within each sea turtle species and species combined, by hook type.

Location	Hook type	%CAT	%DER	%QUE	%Total
Mouth	A1	23,5	0	0	18,2
Tongue	A1	2,9	0	0	2,3
Esophagus	A1	2,9	0	0	2,3
Stomach	A1	2,9	0	0	2,3
Flipper	A1	2,9	42,9	0	9,1
Entangled	A1	2,9	0	0	2,3
Mouth	A2	17,6	0	33,3	15,9
Tongue	A2	0		0	0
Esophagus	A2	2,9	0	0	2,3
Stomach	A2	2,9	0	0	2,3
Flipper	A2	8,8	42,9	33,3	15,9
Entangled	A2	0	0	0	0
Mouth	A3	8,8	0	0	6,8
Tongue	A3	0	0	0	0
Esophagus	A3	0	0	0	0
Stomach	A3	2,9	0	0	2,3
Flipper	A3	17,6	28,6	33,3	18,2
Entangled	A3	0	0	0	0

Note: decimals are in Spanish (, = .)

Table 15. Prevalence (%) of the hook locations within each sea turtle species and species combined, by bait type.

Location	Bait type	%CAT	%DER	%QUE	%Total
Mouth	1	23,5	0	0	18,2
Tongue	1	0	0	0	0
Esophagus	1	5,9	0	0	4,5
Stomach	1	5,9	0	0	4,5
Flipper	1	5,9	28,6	0	9,1
Entangled	1	0	0	0	0
Mouth	6	26,5	0	33,3	22,7
Tongue	6	2,9	0	0	2,3
Esophagus	6	0	0	0	0
Stomach	6	2,9	0	0	2,3
Flipper	6	23,5	71,4	66,7	34,1
Entangled	6	2,9	0	0	2,3

Note: decimals are in Spanish (, = .)

Table16. Prevalence (%) of the hook location within each sea turtle species and species combined, for each combination hook-bait used.

Location	Hook/Bait	%CAT	%DER	%QUE	%Total
Mouth	A1/1	8,8	0	0	6,8
Tongue	A1/1	0	0	0	0
Esophagus	A1/1	2,9	0	0	2,3
Stomach	A1/1	2,9	0	0	2,3
Flipper	A1/1	0	14,3	0	2,3
Entangled	A1/1	0	0	0	0
Mouth	A1/6	14,7	0	0	11,4
Tongue	A1/6	2,9	0	0	2,3
Esophagus	A1/6	0	0	0	0
Stomach	A1/6	0	0	0	0
Flipper	A1/6	2,9	28,6	0	6,8
Entangled	A1/6	2,9	0	0	2,3
Mouth	A2/1	5,9	0	0	4,5
Tongue	A2/1	0	0	0	0
Esophagus	A2/1	2,9	0	0	2,3
Stomach	A2/1	0	0	0	0
Flipper	A2/1	5,9	0	0	4,5
Entangled	A2/1	0	0	0	0
Mouth	A2/6	11,8	0	33,3	11,4
Tongue	A2/6	0	0	0	0
Esophagus	A2/6	0	0	0	0
Stomach	A2/6	2,9	0	0	2,3
Flipper	A2/6	2,9	42,9	33,3	11,4
Entangled	A2/6	0	0	0	0
Mouth	A3/1	8,8	0	0	6,8
Tongue	A3/1	0	0	0	0
Esophagus	A3/1	0	0	0	0
Stomach	A3/1	2,9	0	0	2,3
Flipper	A3/1	0	14,3	0	2,3
Entangled	A3/1	0	0	0	0
Mouth	A3/6	0	0	0	0
Tongue	A3/6	0	0	0	0
Esophagus	A3/6	0	0	0	0
Stomach	A3/6	0	0	0	0
Flipper	A3/6	17,6	0	33,3	15,9
Entangled	A3/6	0	0	0	0

Note: decimals are in Spanish (, = .)

Table17. Accumulated prevalence (%) of hook location in turtles, classified as external hooking (flipper+mouth+tongue+entangled) and internal hooking (esophagous+stomach) resulting from the different combinations of hook types A1, A2, A3 and bait types 1 and 6 (mackerel and squid) and the differences found between the respective combinations, according to data summarized from table 15 **(see Figure 18).**

Hook/bait	Hooked	%CAT	%DER	%QUE	%Total
A1/1	external	8,8	14,3	0	9,1
A1/1	internal	5,9	0	0	4,5
A1/6	external	23,5	28,6	0	22,7
A1/6	internal	0	0	0	0
A2/1	external	11,8	42,9	66,7	20,5
A2/1	internal	2,9	0	0	2,3
A2/6	external	14,7	0	0	11,4
A2/6	internal	2,9	0	0	2,3
A3/1	external	8,8	14,3	0	9,1
A3/1	internal	2,9	0	0	2,3
A3/6	external	17,6	0	33,3	15,9
A3/6	internal	0	0	0	0
(A1/6)-(A1/1)	external	**14,7**	**14,3**	0	**13,6**
(A1/6)-(A1/1)	internal	*-5,9*	0	0	*-4,5*
(A2/1)-(A1/1)	external	**2,9**	**28,6**	**66,7**	**11,4**
(A2/1)-(A1/1)	internal	*-2,9*	0	0	*-2,3*
(A2/6)-(A1/1)	external	**5,9**	*-14,3*	0	**2,3**
(A2/6)-(A1/1)	internal	*-2,9*	0	0	*-2,3*
(A3/1)-(A1/1)	external	0	0	0	0
(A3/1)-(A1/1)	internal	*-2,9*	0	0	*-2,3*
(A3/6)-(A1/1)	external	**8,8**	*-14,3*	**33,3**	**6,8**
(A3/6)-(A1/1)	internal	*-5,9*	0	0	*-4,5*

Note: decimals are in Spanish (, = .)

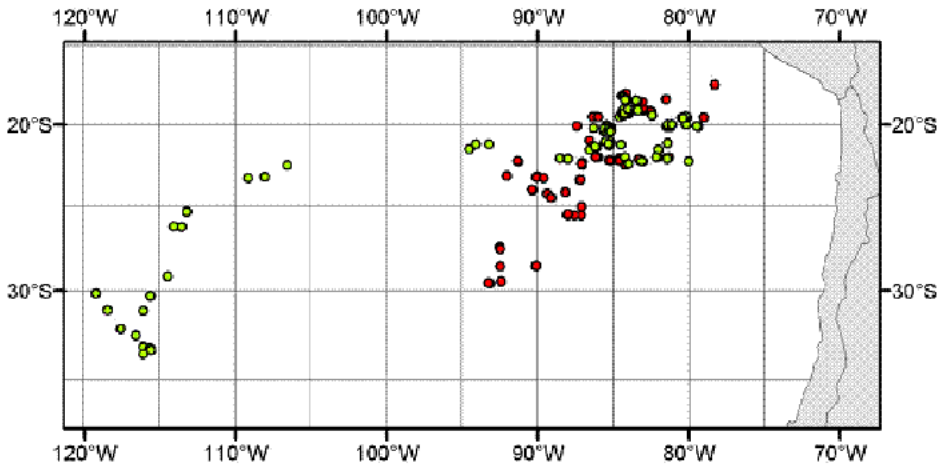


Figure 1. Map of the fishing areas in the South East Pacific where the sets were carried out (green dots: gear ***B2***, red dots: gear ***B1***).

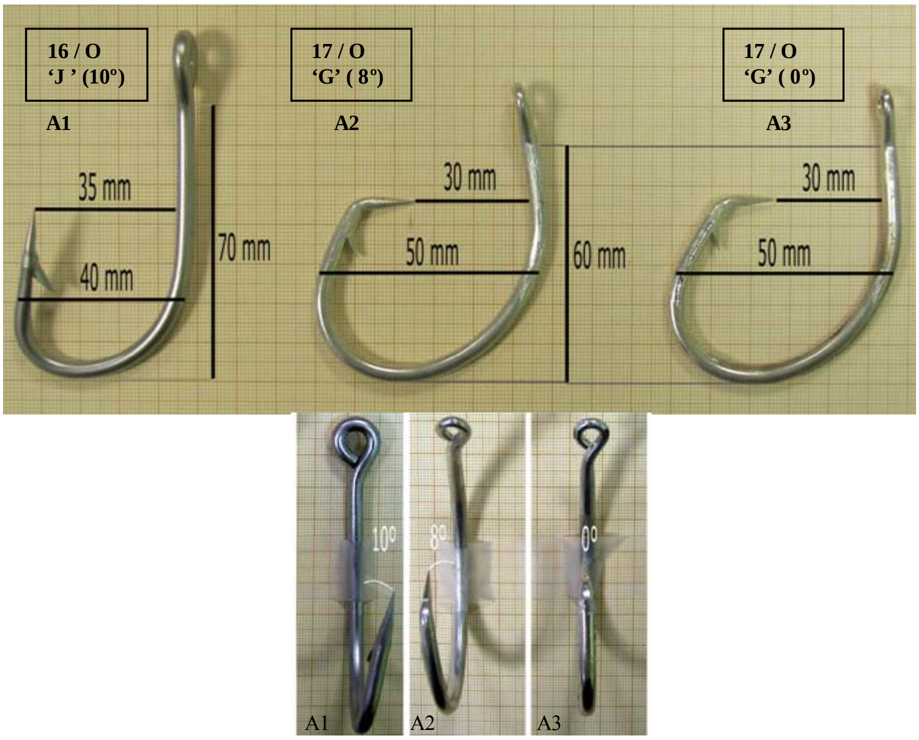


Figure 2. Three types of hooks tested during the survey, sizes (mm) and offset (degrees). ***A1***: Conventional "J" hook 16/O (10º offset) "J" = 70 – 40 – 35. ***A2***: Circle "G" hook 17/O (8º offset) = 60 – 50 – 30. ***A3***: Circle "G" hook 17/O (0º offset) = 60 – 50 – 30.

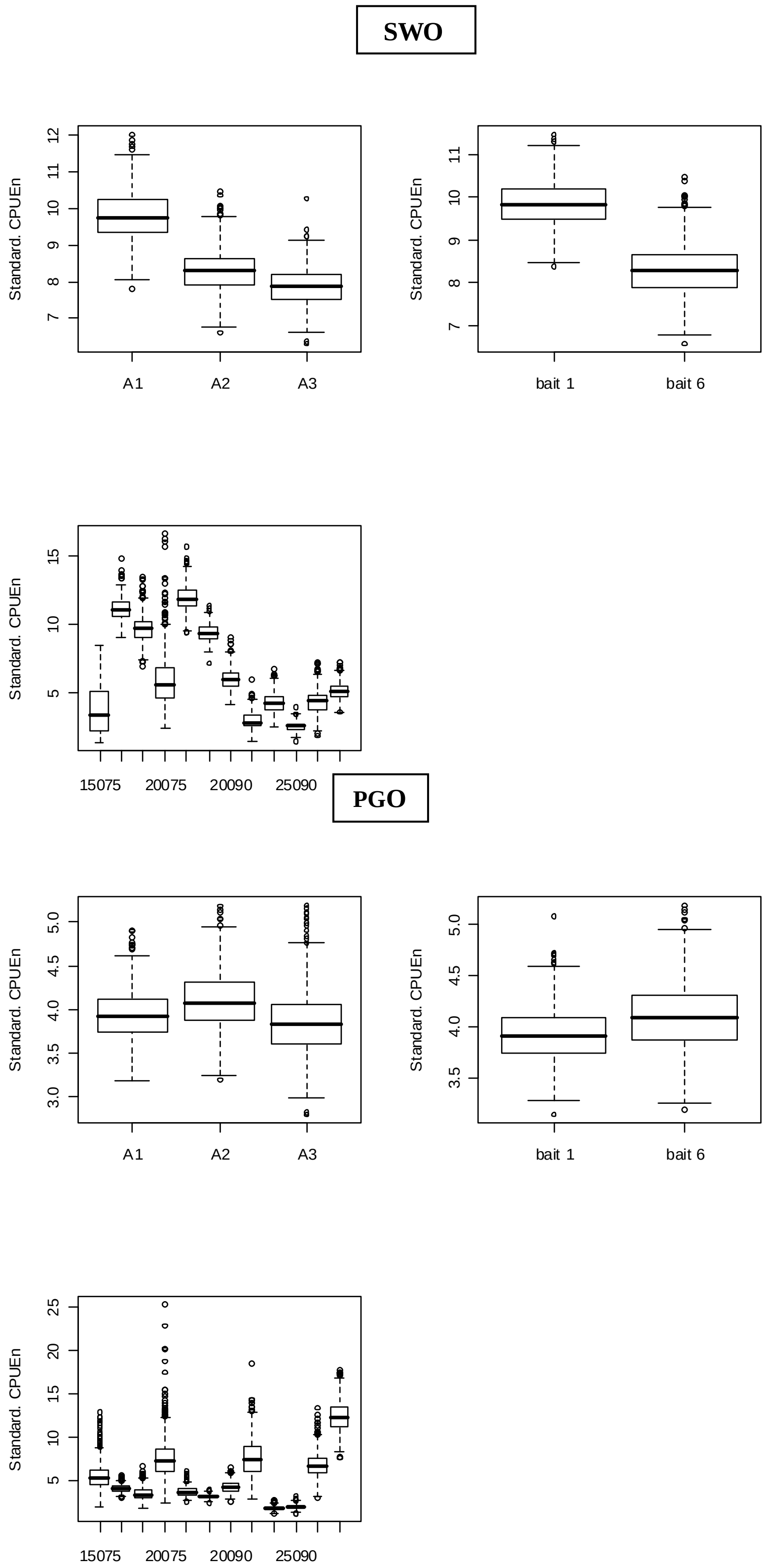
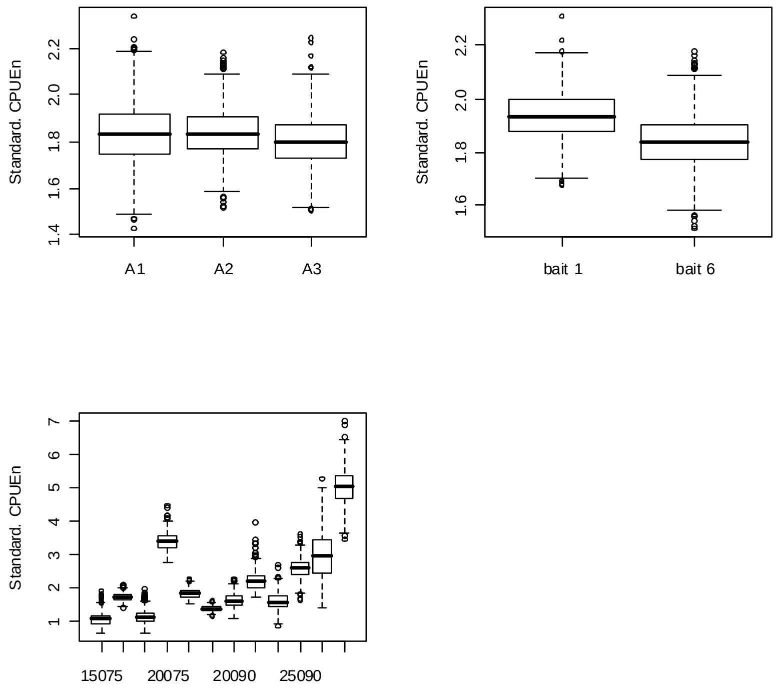


Figure 3. Standardized CPUE (number of fish x 1000 hooks^{-1}) by hook, bait and zone with approximate 95% confidence intervals for SWO and PGO.

IOO



BIL

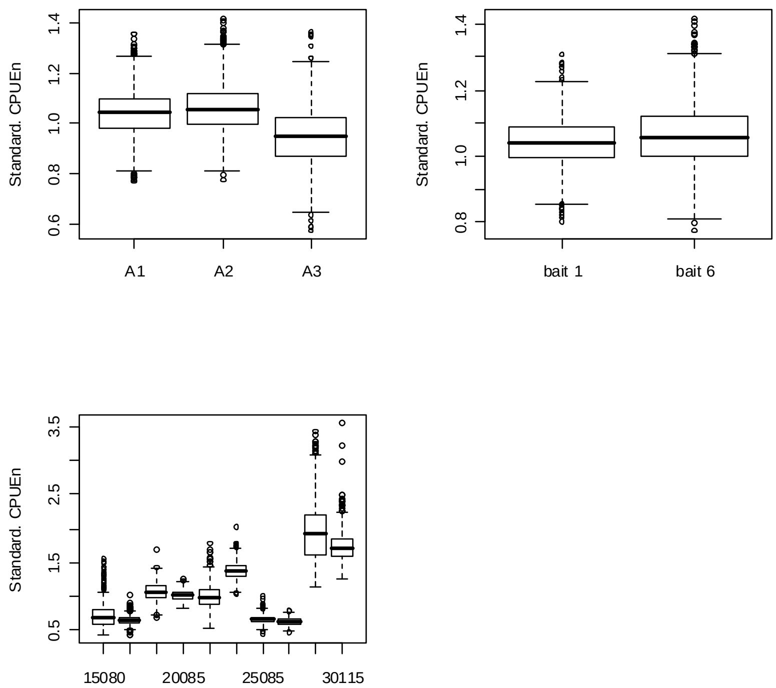


Figure 4. Standardized CPUE (number of fish x 1000 hooks^{-1}) by hook, bait and zone with approximate 95% confidence intervals for IOO and BIL.

CAT

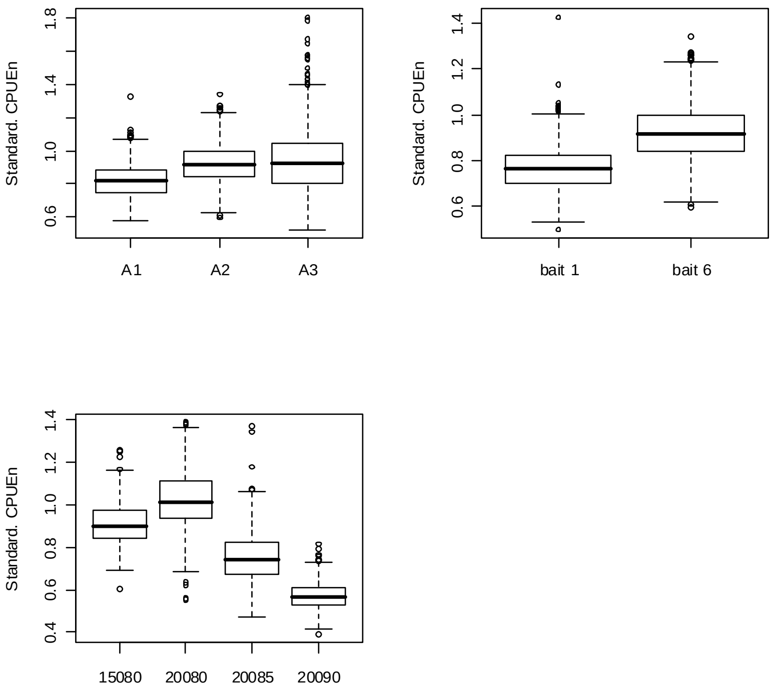


Figure 5. Standardized CPUE (number of individuals x 1000 hooks^{-1}) by hook, bait and zone with approximate 95% confidence intervals for CAT.

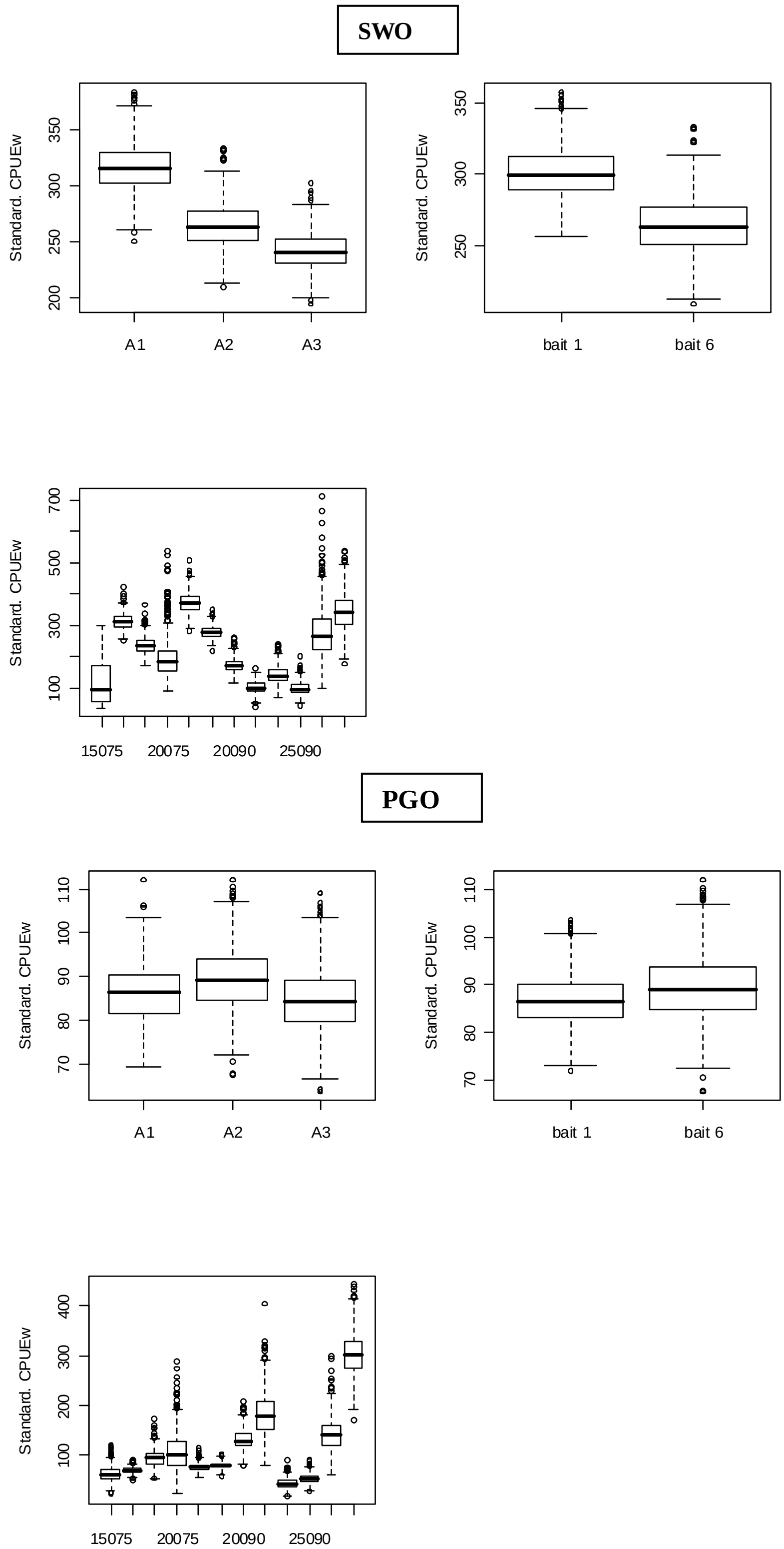


Figure 6. Standardized CPUE (kg DW x 1000 hooks^{-1}) by hook, bait and zone with approximate 95% confidence intervals for SWO and PGO.

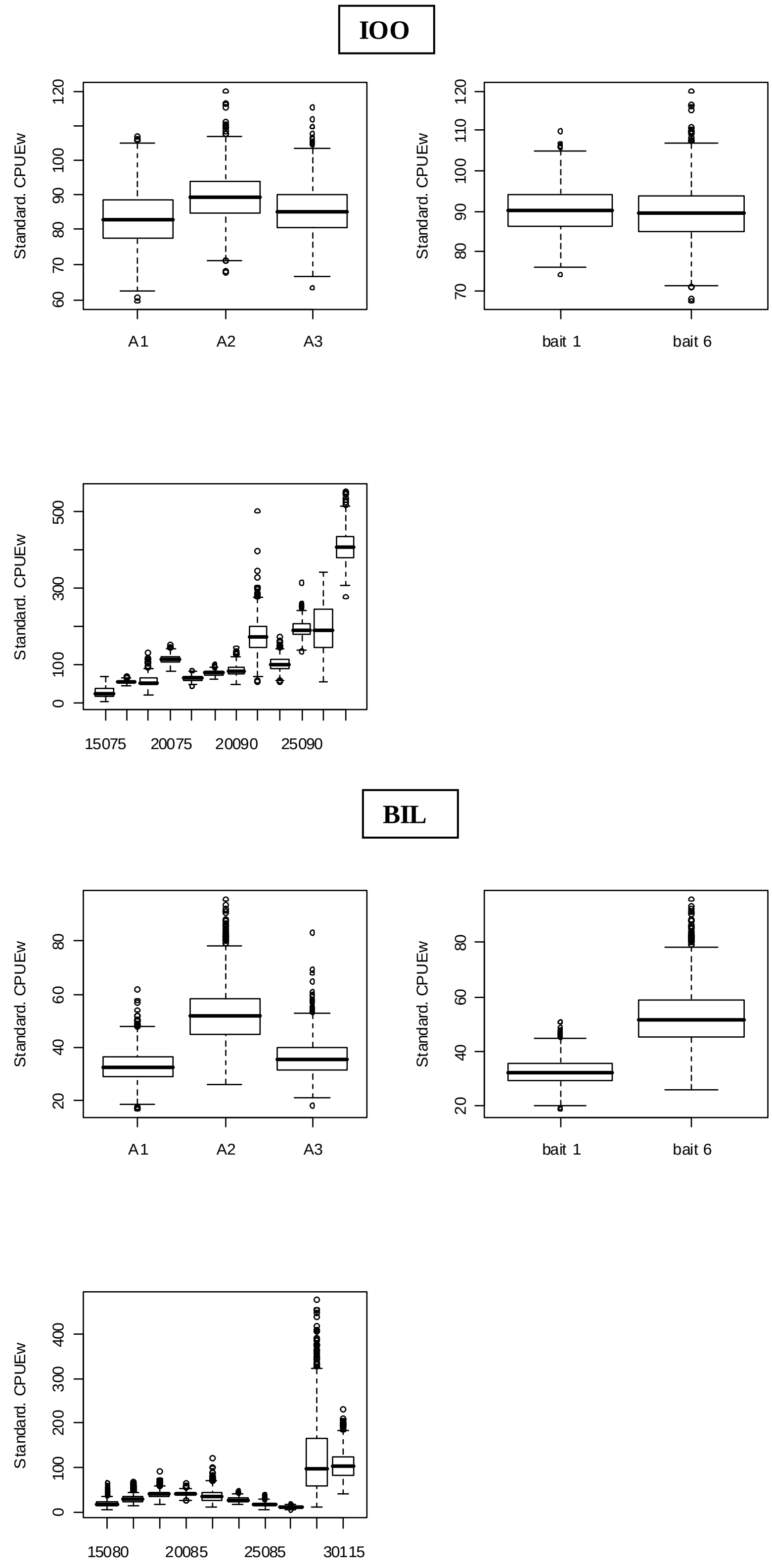


Figure 7. Standardized CPUE (kg DW x 1000 hooks^{-1}) by hook, bait and zone with approximate 95% confidence intervals for IOO and BIL.

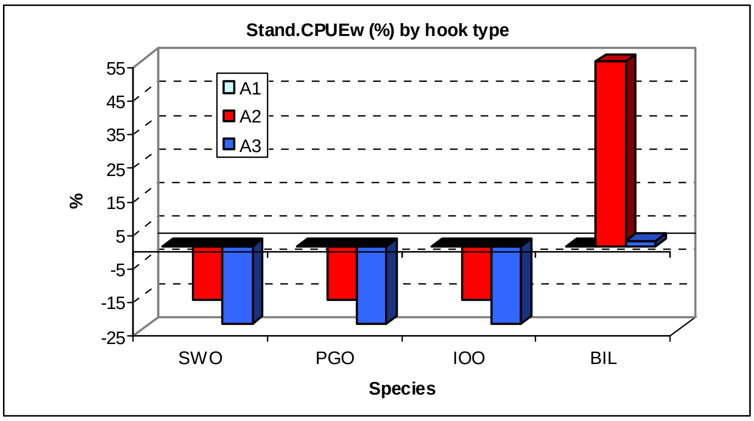


Figure 8. Gains and losses in catch rates in weight for fish species caused by type A2 and type A3 hooks (circle hooks), as compared to hook type A1 ('J' conventional) used as a reference.

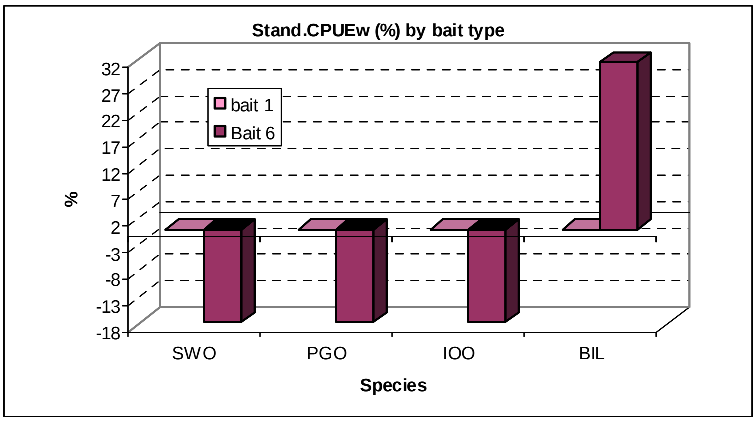


Figure 9. Gains and losses in catch rates in weight for fish species caused by bait type 6 (squid) as compared to bait 1 (mackerel) used as a reference.

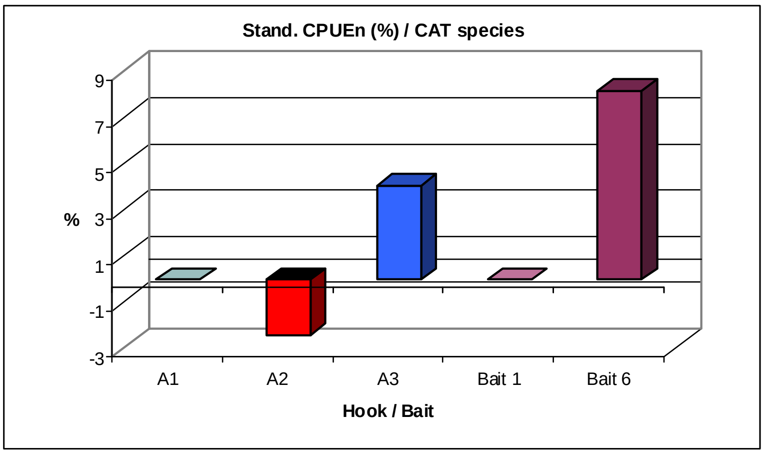


Figure 10. Gains and losses in catch rates in number of CAT turtles caused by hook type (A2, A3) and by bait type 6 (squid) as compared to hook type A1 ('J' conventional) and bait 1 (mackerel) used as a reference.

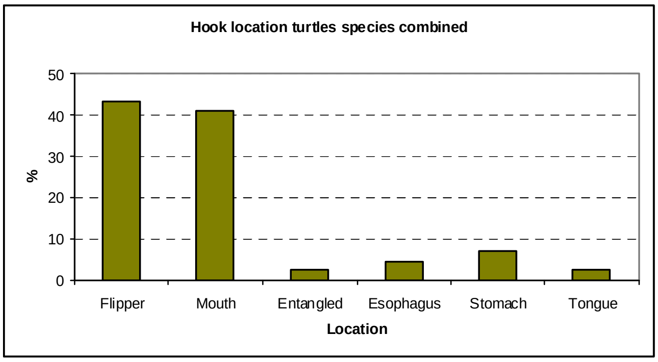


Figure 11. Prevalence (%) of each hook location for all sea turtles species combined.

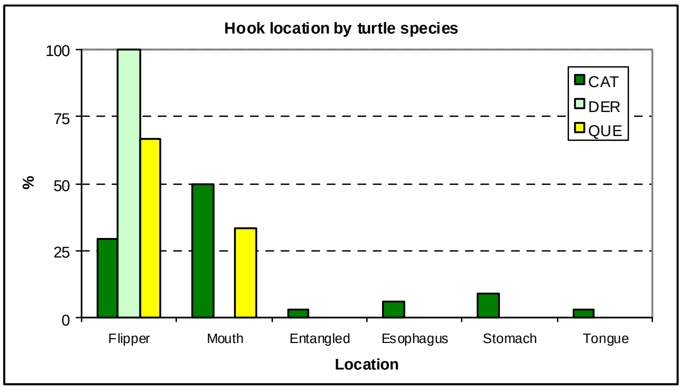


Figure 12. Prevalence (%) of each hook location by species of sea turtle. The lack of a vertical bar indicates null catch.

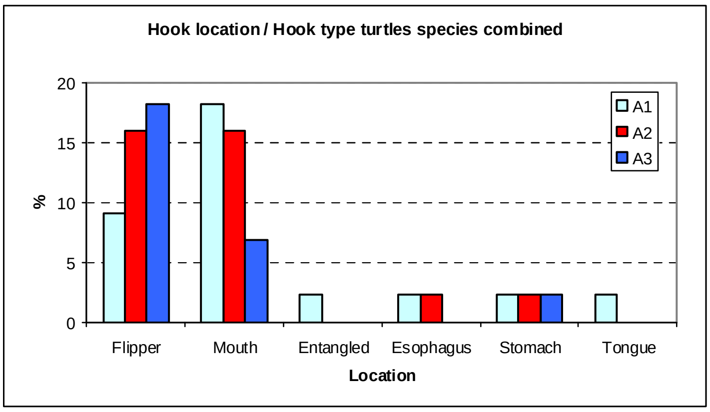


Figure 13. Prevalence (%) of each hook location for all sea turtles species combined, by hook type. The lack of a vertical bar indicates null catch.

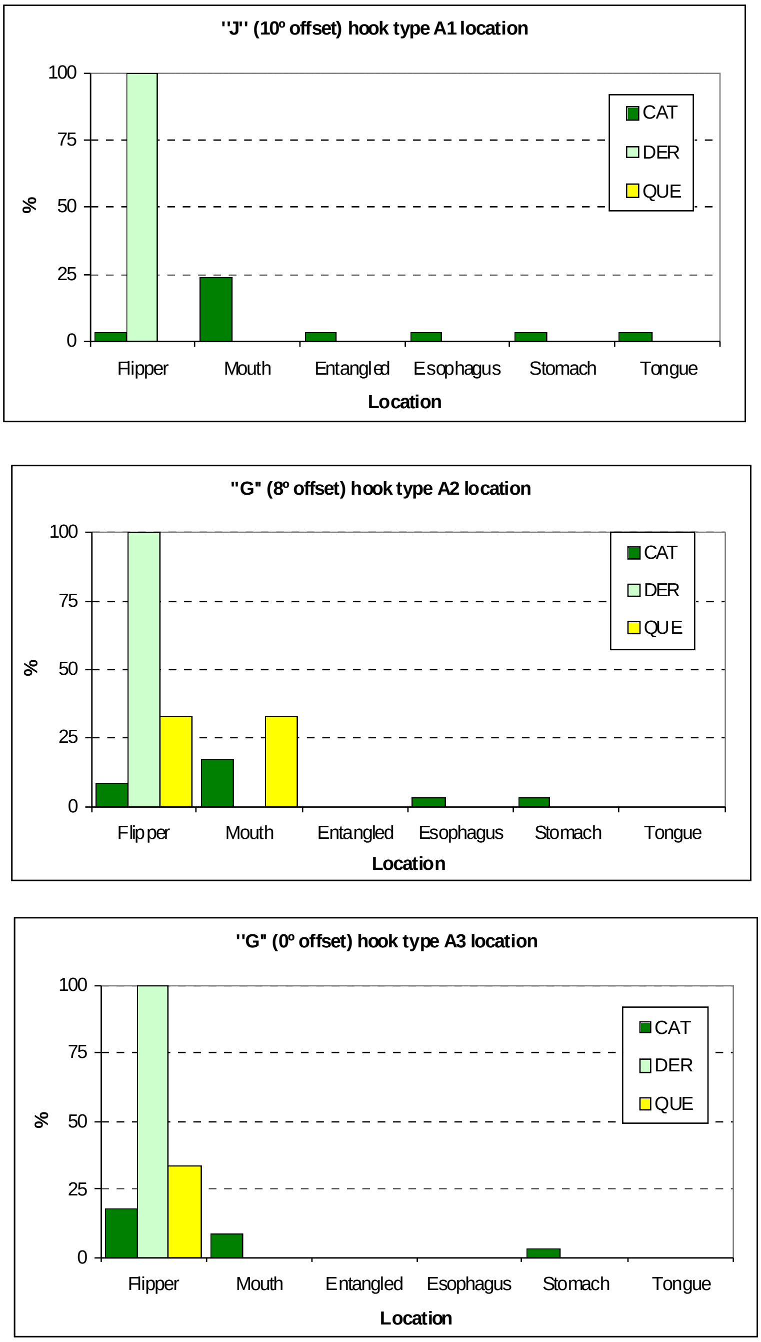


Figure 14. Prevalence (%) by hook type of each hook location by species of sea turtle. The lack of a vertical bar indicates null catch.

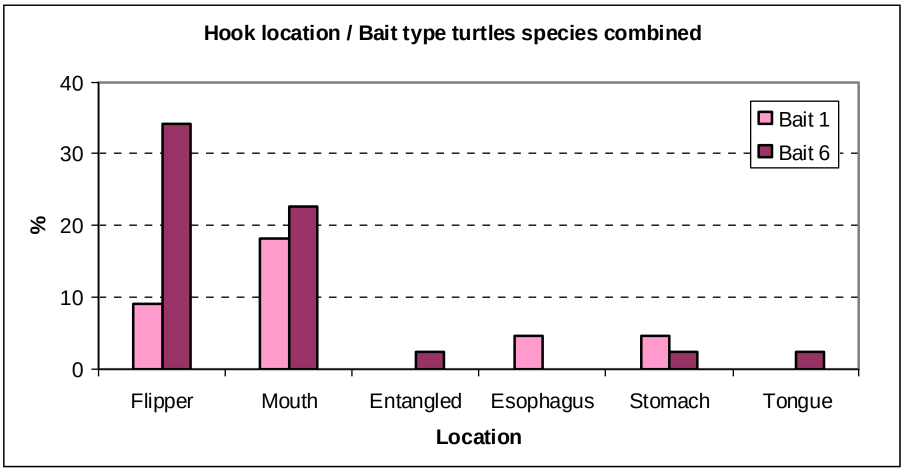
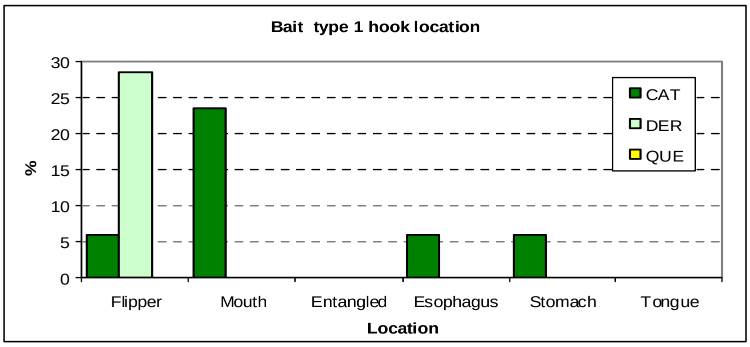


Figure15. Prevalence (%) of each hook location for all sea turtles species combined, by bait type. The lack of a vertical bar indicates null catch.



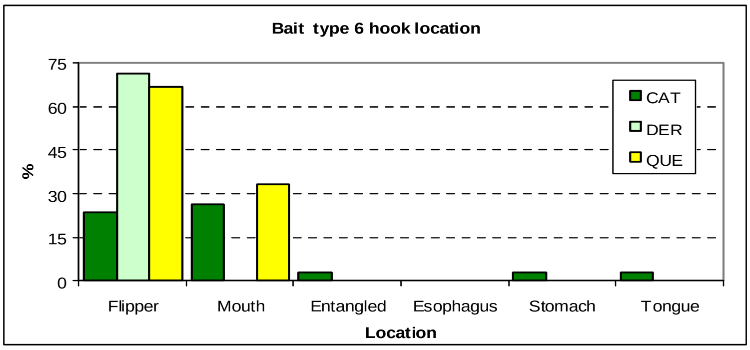


Figure16. Prevalence (%) by bait type of hook locations by species of sea turtle. The lack of a vertical bar indicates null catch.

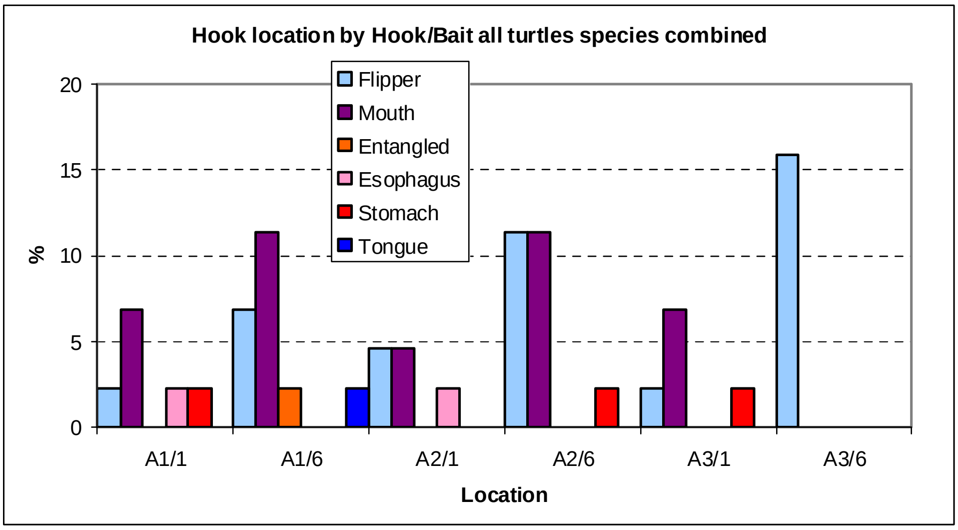


Figure 17. Prevalence (%) of hook locations for all sea turtles species combined, by different hook-bait type combinations. The lack of a vertical bar indicates null catch.

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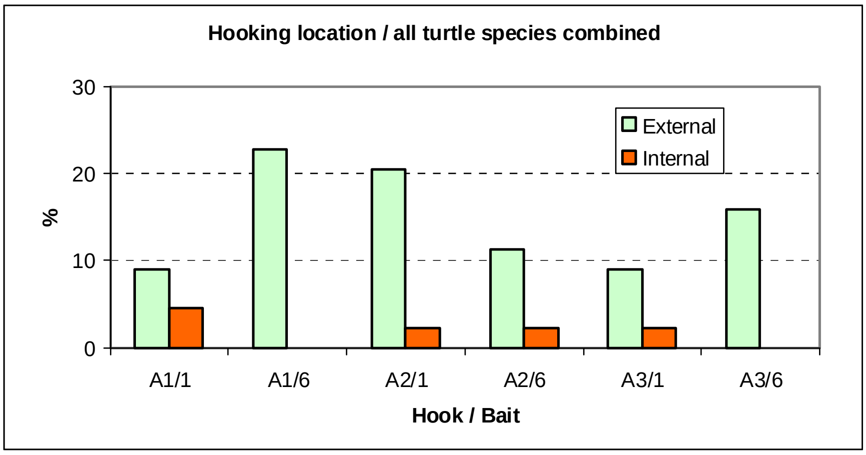

Figure 18. Prevalence (%) of each group of hook location (external or internal) for all the sea turtles species combined by hook and bait combinations. The lack of a vertical bar indicates null catch.