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TRIALS USING 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

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ABSTRACT

Three types of hooks and two types of baits were tested on two swordfish longliners over a period of 240 days at sea in areas of the South East Pacific Ocean. The factor "zone" was the most important significant factor explaining the variability in the catch rates of all the species of fishes analyzed. The data would suggest that the overall catch rates in weight of the swordfish target species (Xiphias gladius) would be reduced with the alternative hooks of –23.4% and would produce increments in the shortfin mako catch rates (+7.5%) and in billfishes (+60%) and also, an increment in the catch rate of Caretta caretta more than +12%. Using the alternative bait (squid) instead the conventional(mackerel) it would reduce the catch rates in general for all fish species, except for billfish and Caretta caretta with increments of +58% and +27%, respectively. The mean standardized CPUE data also suggest that the use of alternative hook-bait combinations could decrease the catch rates of swordfish between –16% and –36% depending on the type of bait combined. Nevertheless other fishes species would increase their catch rates as well as Caretta caretta with increments of +56%. Any seabird interaction has happened during the whole experiment.

RESUMEN

Tres tipos de anzuelos y dos tipos de cebos fueron ensayados en dos buques palangreros de pez espada durante 240 días de mar en áreas del Pacífico sudeste. El factor 'zone' se mostró como el único factor estadísticamente significativo en los niveles de abundancia para todas las especies de peces analizadas. El empleo de anzuelos circulares en vez del convencional llevaría a descensos en las tasas de captura de hasta el –23.4% de la especie objetivo, pez espada (Xiphias gladius), a incrementos en las tasas de captura del marrajo dientuso (Isurus oxyrinchus) de hasta el +7.5% y de peces de pico de hasta el +60.2%, además de un incremento de más del +12% en la tasa de captura de la tortuga Caretta caretta. Empleando pota como cebo en lugar del cebo convencional caballa, se producirían descensos en las tasas de captura de prácticamente todas las especies de peces, excepto en peces de pico y Caretta caretta, donde se producirían incrementos de +58% y +27% respectivamente. Los datos de CPUE media estandarizada sugieren que el empleo de combinaciones de anzuelos-cebos alternativos produciría en general reducciones entre el –16% y –36% de la tasa de captura de la especie objetivo, pez espada (Xiphias gladius), en relación a la combinación convencional de referencia. Sin embargo para el grupo de otras especies de peces se producirían incrementos en sus tasas de captura, al igual que para la tortuga Caretta caretta pudiendo alcanzar incrementos de hasta +56%. No se produjo ninguna interacción con aves marinas durante todo el experimento.

Key words: longline, CPUE, hook, bait, swordfish, sea turtles, sea birds.

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1. INTRODUCTION

The study had as its objective an evaluation of the applicability, and an assessment of the consequences, of adopting some technical solutions to reduce the bycatch of turtles in Spanish surface longline fisheries. The specific technical solutions to be tested were the bait and type of hook used in swordfish fisheries, which in previous studies have been shown to be effective in reducing turtle bycatch.

The objective were to test the effects of different combinations of hooks and baits on catch rates of turtles and of target and main bycatch species in surface longline fisheries targeting swordfish; to identify the positive and negative consequences of modifications to hook or bait type; to identify possible solutions and make recommendations for further actions to reduce bycatch rates of sea turtles whilst maintaining economically viable surface longline fisheries.

Circle hooks ("G" hooks) have gained notoriety in recent years because of the supposed advantages they offer in terms of conservation of some species as compared with some 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 (ANONYMOUS *in press*). However, due to differences in environmental conditions, fishing practices, methods used and target species, it is unclear if it would be appropriate to extrapolate local results to entire fisheries (COOKE & 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, esophagous or stomach and also because "G" hooks minimize foul hooking (externally hooked) and bleeding (PRINCE *et al.* 2002, SKOMAL *et al.* 2002). However, there is no generic description of a "G" hook. Therefore, it is difficult to promote the use of "G" hooks or a unique hook type as being a panacea for all the fisheries. A good knowledge of how fishes and other pelagic species get caught on the hook and their respective catch data are essential to be able to support planning recommendations.

The Spanish surface longline fishery targeting swordfish in the different oceans has used for decades the traditional "J" hook types that are soaked at night predominantly with mackerel as the traditional bait. Experiments done in areas where a high incidence of sea turtles in the Western Mediterranean Sea was observed suggest that there are other more important 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 Mediterranean areas (De la SERNA *et al.* 2006). 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). Nominal CPUE data obtained in an experiment testing 3 types of hooks and 2 different baits covering the North and South Atlantic Ocean would suggest that the overall catch rates in weight and in number of the fish species in general and sea turtles respectively, were reduced for 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 were also significant for some species. The use of squid as bait instead of mackerel would cause a considerable 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).

2. MATERIAL AND METHODS.

The two boats used are long distant units belonging to the Spanish surface longline fleet. The boats have used a mean number of around 1,184 and 2,688 hooks per set, respectively. The mean characteristics of the boats are 38.9 m in length, 224.5 GRT and 634 HP.

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 'zone' of 5ºx5º squares (MIYAKE 1990). One of the vessels began to operate in last 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) (MEJUTO *et al.* 2008) 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.

Three types of hooks were tested (figure 2). ***A1 (conventional Spanish fleet)***: Hook 16/O (10^{o} offset) "J" style = 70 – 40 – 35. ***A2***: Hook 17/O (8^{o} offset) circle style "G" = 60 – 50 – 30. ***A3***: Hook 17/O (0^{o} offset) circle style "G" = 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 fish species or groups: SWO (*Xiphias gladius*), PGO (*Prionace glauca*), IOO (*Isurus oxyrinchus*) and BIL (Istiophoridae). The results for the sea turtle DER were in some cases not discussed because its interaction is mostly 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 bycatch species. The incidental bycatch nominal CPUE 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 ('hook', 'bait', 'zone') or combination of factors ('hook*bait', 'hook*zone', 'bait*zone', '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.

Statistical methods: To evaluate the significance of the factors tested (α=1%) 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 proportion of positive sets and the catch rates of positive sets were fitted separately. 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, each one being the realization of an independent *Bernouilli* process, and modeled assuming a binomial error distribution. The mean catch rate of positive sets (in number or weight per 1000 hooks) was modeled assuming a lognormal 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 target species catch rates were also assessed, allowing potential measures to be identified any detrimental effect on catches of swordfish. Effects of hook and bait on other species caught during the trials as secondary target species or bycatch were also monitored. Analyses were carried out to obtain nominal and standardized catch data of all the species captured, except in turtles QUE and DER for the type and near null interaction of them with the gear

Hook location in the incidental catch of turtles: During the experiment the location of the hook in each specimen of sea turtle caught was recorded: 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

The two vessels deployed a total of 356,600 hooks during a total of 183 sets. The total number of hooks 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)(turtles not included), 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 that were tagged and released alive and 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 summary of the deviance analyses for factors affecting catch rates of positive sets for each species and the proportion of positive sets. In general, factor '*Zone*' seemed the only one affecting the proportion of positive sets for all the species of fish. It was also significant for the catch rates of positive sets for the majority of the species of fish. As for factors *Hook* and *Bait*, statistical significance depended very much on the analyzed species of fish. Regarding the interactions, most of them were not significant in both models (catch rates of positive sets and proportion of positive sets) for species of fish (tables 5-6).

The preliminary results of the standardized mean CPUE by species of fish 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. For SWO, the mean standardized CPUE indicates that a change in hook could lead to mean yield losses in weight of between –16.0% and –23.4% for circle hooks A2 and A3, respectively, as compared to the reference conventional hook (A1). For PGO, a change in hook could lead to slightly gains when the circle type A2 hook was used (+3.7%) and slightly losses with the circle type A3 (-1.5%). For IOO this would generate moderate gains with the alternative hooks tested A2 and A3 (+7.5% and +2.7%, respectively). For BIL group gains were suggested with either of the alternative hooks tested, A2 and A3 (+60.2% and +9.5%, respectively) as compared with the conventional hook (A1) (table 7, figure 8). The use of alternative bait (squid) would result in yield losses in weight for almost all of the fish species as compared to reference bait 1 (mackerel), except for the BIL 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 capture by itself. Only the combination of the two factors enables a capture 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 in the swordfish to the final decision to attack on prey–bait (MEJUTO *et al*. 2005). Similar behaviour is also 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). If we compare gains and loss of the different hook-bait combinations in relation to the reference combination (A1/1), consisting of the conventional hook A1 ('J') and bait 1 (mackerel), we mostly obtain gains for all species except for SWO and IOO.

In SWO, the use of alternative hooks would cause losses with any combination hook-bait, with the CPUE values fluctuating between –16% and –36% in relation to the combination of reference. Hook A2 would cause mean yield losses in weight of between –32.7% and –26.1%, depending on whether it was combined with mackerel (bait 1) or squid (bait 6) and hook A3 between –36.8% and –35.1% with mackerel (bait 1) or squid (bait 6), respectively. In PGO, hook A2 could lead to yield slight loss in weight of –0.5% combined with mackerel. Hook A3 would cause the mean yield to increase with mackerel (bait 1) (+4.6%) and decrease with squid (bait 6)(–2.5%). In IOO, the use of alternative hooks and baits could lead to declining mean CPUE in all the combinations with squid (bait 6), fluctuating between –6.2% and –20.1%, according to the combination used. The use of alternative hooks combined with mackerel could bring about slight mean gains of +1.7% and +1.6% in this species. In the BIL group, the use of alternative hooks and bait could lead to increasing with any alternative combination used, between +7.0% and +132.2%.

The results of any type of alternative hook 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 BIL group, where gains were obtained in 100% of the combinations tested. The results obtained with the hook*bait*zone interaction are not included.

A very scarce interaction has been regularly observed with turtles in this commercial fishery practices in South East Pacific Ocean. An interaction on a total of 44 sea turtles (34 CAT, 7 DER and 3 QUE) was achieved in this experiment. All of them were released alive apparently in good condition for further survival. The overall interaction rate per hook for all turtles combined was $1.23E^{-05}$ ($9.53E^{-05}$, $1.96E^{-05}$ and $8.41E^{-06}$ 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 baits. Hence, the release rates could be assumed close to those that would occur in strictly commercial operations within these areas-times.

Regarding the summary of the deviance analyses for factors affecting the proportion of positive sets and catch rates of positive sets for CAT species, in general, any factor seems affecting the proportion of positive sets or the probability of catching a CAT as well the combinations of factors was not significantly different (tables 9-10).

CAT species gains were suggested with either of the alternative circle hooks tested, A2 and A3 (+12.0 and +13.5 respectively) as compared with the reference conventional hook (A1), and the use of the alternative bait would imply yield increase in the incidental catch rates of turtles CAT (+26.6%) (table 11, figure 10). All the turtles QUE (only 3 specimens) were caught with the alternative bait 6. The catch rates in number of individuals in CAT species was generally seen to increase in all the alternative combinations tested suggesting that there are increases in the mean incidental catch rate, ranging from +3.8% to +56.5% as compared to the combination of reference, except for the hook type A2 combined with mackerel (A2/1) with losses of –5.3%. Because the null catches of CAT in some of the areas, the zone 20080 SW was used as reference in this species and the interaction of the main factors (hook and bait) with zone are not presented.

The results suggest that 'bait' may be the most important factor affecting the incidental catch rates of CAT species. The data would suggest that, circle hooks A2 and A3 does not appear to reduce the incidental catch rate of the turtles species combined (table 11).

<u>Hook location in turtles</u>: The different locations of the hooks on a total of 44 turtles caught were observed. The prevalence of the different 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 12, 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 well as the 66.7% of QUE specimens. In the 14.7% of the CAT were swallowed (table 12, figure 12).

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

The CAT species was the most prevalent caught in the mouth+tongue with the conventional A1 type hook (26.4%). Two of the three QUE caught was with the hook type A2. The DER species was always found caught by flippers (table 13, 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 percentages of animals being hooked in the flipper with bait type 6 were 34.1% and with bait 1 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 swallowed (table 14, figure 15).

When relating hook location to bait type in each turtle species (table 14, figure 16), we observed that CAT indicated preference for bait type 6 (squid) with 58.8% and 41.2% for bait type 1 (mackerel). The only three individuals of QUE caught demonstrated preference for bait type 6 (squid).

By hook-bait combinations: For the total number of turtles, the highest percentage of hook locations were 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 15, figure 17).

To facilitate the description, the prevalence in percentages of the different hook locations were 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 and squid). The differences between their respective combinations were also computed (table 16, figure 18).

The results obtained for the turtle species must be interpreted with caution, since their interaction was relatively little. There was no interaction with sea birds.

4. DISCUSSION.

The results obtained in general show moderate CPUE differences between hook types alone but additional studies are needed. New experiments and analyses are probably required to clarify the most relevant factors affecting the respective upper/lower catch rates of the different species into these areas. New modelling is probably required using more observation from these fishing areas because the incidental interaction with turtles was relatively low. The introduction into the model of other elements of the gear configuration could improve further results but, at the same time, it will reduce the number of observation available by combination. Under these circumstances these results can be used as an initial approach for comparison with similar experiment previously done in the Atlantic areas with similar methodology. The two alternative circle hooks tested could lead to overall decreases in the catch rates in weight of most fish species in comparison with the reference conventional hook A1. Nevertheless, moderate increases in catch rates were observed in the shortfin mako with the use of these circle hooks (type A2: +7.5% and type A3: +2.7%). The BIL group could be also subject to increase catch rates with either of the alternative circle hooks tested, A2 and A3 (+60.2% and +9.5%, respectively) in comparison with the conventional hook (A1). Several studies have suggested that circle hooks could produce lower catch rates for turtles than J-hooks, but these have not always been statistically significant. The incidental catch rates of the most prevalent turtle (CAT) obtained in this experience suggest an increase in the overall catch rates for more than 12% using the alternative circle hooks tested. The use of alternative bait 6 (squid) would generally lead to a lower catch rates 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 BIL(+58.0%) as well as in the incidental capture of sea turtles CAT (+26.6%). The use of alternative hook-bait combinations would lead to small changes in the catch rates in weight for most fish species, except for SWO target species that would lead to a overall decrease between 16%-36% and to a general increase in the incidental capture of BIL and CAT species. The alternate hook-bait combinations tested would generally increase the catch rates as well as external hooking for all turtles combined. As in the case of other similar Atlantic experiment, the type of bait seems to be a quite important factor on incidental sea turtles catch, although the number of available observation was scarce in this experiment. The use of mackerel instead of squid could reduce this incidental catch although this effect seems to be less important that was found in the Atlantic areas where a larger sampling size was available.

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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 of deviance analyses for factors affecting catch rates of positive sets for each species and the proportion of positive sets (+ : indicates the importance, from low to high, of each factor considered to be significant) .

		Species				
FACTOR	**LEVELS**	**SWO**	**PGO**	**IOO**	**BIL**	**CAT**
Hook type	A1, A2, A3	yes++	no	no	no	no
Bait type	6	yes+	no	no	yes+	no
Zone	12 squares 5ºx5º	yes+++	yes+	yes++	yes++	no
Hook*bait	Interaction	no	no	no	no	no
Hook*zone	Interaction	no	no	no	no	no
Bait*zone	Interaction	no	no	yes+	no	no

(logged catch rates (in kg for fishes and in number for CAT)

		Species				
FACTOR	**LEVELS**	**SWO**	**PGO**	**IOO**	**BIL**	**CAT**
Hook type	A1, A2, A3	no	no	yes+	yes+	no
Bait type	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	no	no
Bait*zone	Interaction	no	no	no	no	no

Response proportion positive sets

Table 5. Deviance table analysis. Logged catch rates (RW, kg) for fish species. (% of total deviance refers to that for 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	HOOK	519	412,59	6,16	1,47	1,47	1,00E-02
SWO	HOOK BAIT	518	407,4	5,2	1,24	2,71	1,00E-02
SWO	HOOK BAIT ZONE	507	349,76	57,63	13,76	16,48	1,18E-13
SWO	HOOK BAIT ZONE HOOK*BAIT	505	347,73	2,03	0,48	16,96	2,20E-01
SWO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	484	329,33	18,4	4,39	21,35	1,60E-01
SWO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	474	318,98	10,35	2,47	23,83	1,20E-01
PGO	NULL	440	363,78				
PGO	HOOK	438	363,65	0,13	0,03573588	0,03573588	9,10E-01
PGO	HOOK BAIT	437	363,64	0,02	0,00549783	0,04123371	8,80E-01
PGO	HOOK BAIT ZONE	426	285,12	78,52	21,5844741	21,6257078	2,29E-19
PGO	HOOK BAIT ZONE HOOK*BAIT	424	285,12	2,26E-03	0,00062016	21,626328	1,00E+00
PGO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	402	274,88	10,23	2,81213921	24,4384672	8,70E-01
PGO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	392	268,77	6,12	1,68233548	26,1208027	5,40E-01
IOO	NULL	319	246,771				
IOO	HOOK	317	246,548	0,223	0,090367	0,090367	7,70E-01
IOO	HOOK BAIT	316	246,412	0,136	0,055112	0,145479	5,73E-01
IOO	HOOK BAIT ZONE	305	136,455	109,957	44,558315	44,703794	7,08E-49
IOO	HOOK BAIT ZONE HOOK*BAIT	303	135,327	1,129	0,457509	45,161303	2,67E-01
IOO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	284	128,767	6,56	2,658335	47,819638	6,99E-01
IOO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	274	116,949	11,818	4,789055	52,608694	2,00E-03
BIL	NULL	78	76,517				
BIL	HOOK	76	72,609	3,908	5,107362	5,107362	5,00E-02
BIL	HOOK BAIT	75	67,758	4,851	6,339768	11,447129	6,00E-03
BIL	HOOK BAIT ZONE	66	47,366	20,392	26,650287	38,097416	2,67E-04
BIL	HOOK BAIT ZONE HOOK*BAIT	64	47,346	0,021	0,027445	38,124861	9,84E-01
BIL	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	54	36,694	10,651	13,919783	52,044644	9,10E-02
BIL	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	48	31,307	5,388	7,041572	59,086216	2,20E-01

Table 6. Deviance table analysis. Response proportion of positive sets for fish species. (% of total deviance refers to that for 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	67	114,18				
SWO	HOOK	65	113,5	0,68	0,6	0,6	7,12E-01
SWO	HOOK BAIT	64	113,17	0,33	0,29	0,88	5,65E-01
SWO	HOOK BAIT ZONE	53	51,01	62,16	54,44	55,33	3,67E-09
SWO	HOOK BAIT ZONE HOOK*BAIT	51	49,51	1,5	1,31	56,64	4,73E-01
SWO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	29	25,25	24,27	21,25	77,89	3,33E-01
SWO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	18	7,98	17,27	15,12	93,01	1,00E-01
PGO	NULL	67	73,506				
PGO	HOOK	65	71,599	1,907	2,59434604	2,59434604	3,85E-01
PGO	HOOK BAIT	64	70,804	0,795	1,08154436	3,6758904	3,73E-01
PGO	HOOK BAIT ZONE	53	47,437	23,367	31,7892417	35,4651321	1,60E-02
PGO	HOOK BAIT ZONE HOOK*BAIT	51	45,753	1,684	2,29096944	37,7561015	4,31E-01
PGO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	29	28,678	17,075	23,2293962	60,9854978	7,59E-01
PGO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	18	12,363	16,315	22,195467	83,1809648	1,30E-01
IOO	NULL	67	148,857				
IOO	HOOK	65	142,319	6,538	4,392135	4,392135	3,80E-02
IOO	HOOK BAIT	64	125,354	16,965	11,396844	15,788979	3,81E-05
IOO	HOOK BAIT ZONE	53	58,794	66,56	44,714054	60,503033	5,48E-10
IOO	HOOK BAIT ZONE HOOK*BAIT	51	57,163	1,631	1,095682	61,598716	4,42E-01
IOO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	29	32,278	24,884	16,716715	78,31543	3,03E-01
IOO	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	18	20,855	11,423	7,673808	85,989238	4,09E-01
BIL	NULL	57	122,204				
BIL	HOOK	55	108,769	13,434	10,993094	10,993094	1,00E-03
BIL	HOOK BAIT	54	105,438	3,331	2,72577	13,718864	6,80E-02
BIL	HOOK BAIT ZONE	45	68,911	36,526	29,889365	43,608229	3,20E-05
BIL	HOOK BAIT ZONE HOOK*BAIT	43	63,906	5,005	4,095611	47,703839	8,20E-02
BIL	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE	25	33,484	30,422	24,894439	72,598278	3,40E-02
BIL	HOOK BAIT ZONE HOOK*BAIT HOOK*ZONE BAIT*ZONE	16	13,899	19,585	16,02648	88,624759	2,10E-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	315,38	20,41	355,38	275,38	6,47	*REF*
SWO	HOOK	A2	264,89	18,45	301,05	228,73	6,97	-16,01
SWO	HOOK	A3	241,72	15,40	271,90	211,53	6,37	-23,36
SWO	BAIT	1	301,10	16,13	332,72	269,47	5,36	*REF*
SWO	BAIT	6	245,99	13,07	271,61	220,37	5,31	-18,30
SWO	ZONE	15075	114,49	56,73	225,67	3,31	49,55	-66,89
SWO	ZONE	15080	313,59	22,64	357,97	269,21	7,22	-9,31
SWO	ZONE	15085	236,40	25,26	285,90	186,89	10,68	-31,64
SWO	ZONE	20075	192,04	56,05	301,89	82,19	29,18	-44,46
SWO	ZONE	20080	375,07	34,06	441,84	308,30	9,08	8,47
SWO	ZONE	20085	278,75	17,92	313,87	243,63	6,43	-19,39
SWO	ZONE	20090	170,79	22,17	214,23	127,34	12,98	-50,61
SWO	ZONE	20105	100,69	18,54	137,03	64,36	18,41	-70,88
SWO	ZONE	25085	140,17	28,60	196,23	84,12	20,40	-59,46
SWO	ZONE	25090	99,88	18,72	136,57	63,18	18,74	-71,12
SWO	ZONE	25110	276,39	74,52	422,44	130,33	26,96	-20,07
SWO	ZONE	30115	345,78	59,86	463,10	228,47	17,31	*REF*
PGO	HOOK	A1	85,92	6,55	98,76	73,07	7,63	*REF*
PGO	HOOK	A2	89,11	6,78	102,40	75,81	7,61	3,71
PGO	HOOK	A3	84,60	6,93	98,19	71,02	8,19	-1,53
PGO	BAIT	1	86,53	5,36	97,04	76,02	6,20	*REF*
PGO	BAIT	6	86,41	5,89	97,96	74,87	6,82	-0,14
PGO	ZONE	15075	61,92	14,26	89,87	33,97	23,03	-79,66
PGO	ZONE	15080	69,48	5,68	80,61	58,35	8,18	-77,18
PGO	ZONE	15085	95,20	15,65	125,87	64,53	16,44	-68,73
PGO	ZONE	20075	103,63	35,96	174,12	33,14	34,70	-65,96
PGO	ZONE	20080	75,63	7,76	90,85	60,42	10,26	-75,16
PGO	ZONE	20085	79,72	6,37	92,20	67,25	7,98	-73,81
PGO	ZONE	20090	133,50	19,33	171,38	95,62	14,48	-56,15
PGO	ZONE	20105	180,51	42,27	263,37	97,66	23,42	-40,70
PGO	ZONE	25085	43,08	9,67	62,03	24,14	22,44	-85,85
PGO	ZONE	25090	52,06	8,88	69,47	34,66	17,06	-82,90
PGO	ZONE	25110	141,25	33,20	206,32	76,18	23,50	-53,60
PGO	ZONE	30115	304,43	42,73	388,18	220,68	14,04	*REF*

Table 7.(cont.)

SPECIES	***FACTOR***	***TYPE***	***std. CPUE***	***std. Err***	***95% upp***	***95% low***	***CV (%)***	***Ratio%***
IOO	HOOK	A1	83,69	8,37	100,10	67,27	10,01	*REF*
IOO	HOOK	A2	89,99	7,14	103,98	75,99	7,93	7,53
IOO	HOOK	A3	85,94	6,93	99,53	72,35	8,07	2,69
IOO	BAIT	1	91,02	5,50	101,80	80,23	6,05	*REF*
IOO	BAIT	6	81,23	6,24	93,46	69,01	7,68	-10,75
IOO	ZONE	15075	26,40	14,00	53,84	-1,05	53,04	-93,61
IOO	ZONE	15080	55,20	4,27	63,57	46,82	7,74	-86,64
IOO	ZONE	15085	56,47	16,18	88,18	24,76	28,65	-86,33
IOO	ZONE	20075	115,23	11,10	136,98	93,48	9,63	-72,11
IOO	ZONE	20080	64,63	6,65	77,66	51,61	10,28	-84,35
IOO	ZONE	20085	78,07	5,99	89,82	66,33	7,67	-81,10
IOO	ZONE	20090	87,64	15,99	118,99	56,30	18,24	-78,78
IOO	ZONE	20105	179,92	45,81	269,70	90,14	25,46	-56,45
IOO	ZONE	25085	102,47	16,89	135,57	69,38	16,48	-75,20
IOO	ZONE	25090	194,01	21,04	235,26	152,76	10,85	-53,04
IOO	ZONE	25110	192,74	64,60	319,34	66,13	33,52	-53,35
IOO	ZONE	30115	413,12	41,27	494,01	332,23	9,99	*REF*
BIL	HOOK	A1	32,90	5,79	44,25	21,54	17,61	*REF*
BIL	HOOK	A2	52,71	10,87	74,02	31,41	20,62	60,25
BIL	HOOK	A3	36,03	6,46	48,69	23,38	17,92	9,54
BIL	BAIT	1	32,27	4,63	41,34	23,20	14,34	*REF*
BIL	BAIT	6	51,01	9,02	68,69	33,33	17,68	58,05
BIL	ZONE	15075	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
BIL	ZONE	15080	19,25	8,01	34,96	3,55	41,61	-81,65
BIL	ZONE	15085	30,21	8,07	46,02	14,40	26,70	-71,21
BIL	ZONE	20075	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
BIL	ZONE	20080	39,11	8,03	54,86	23,36	20,54	-62,73
BIL	ZONE	20085	40,92	5,84	52,37	29,47	14,28	-61,01
BIL	ZONE	20090	37,06	15,48	67,41	6,72	41,77	-64,68
BIL	ZONE	20105	28,12	5,62	39,14	17,10	19,99	-73,21
BIL	ZONE	25085	16,07	4,83	25,53	6,61	30,04	-84,69
BIL	ZONE	25090	10,29	2,09	14,39	6,18	20,35	-90,20
BIL	ZONE	25110	122,42	89,73	298,30	-53,45	73,30	16,66
BIL	ZONE	30115	104,94	30,92	165,54	44,35	29,46	*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	358,83	32,31	422,15	295,50	9,00	*REF*
SWO	HOOK * BAIT	A1_6	298,34	31,08	359,25	237,44	10,42	-16,86
SWO	HOOK * BAIT	A2_1	241,26	22,03	284,45	198,08	9,13	-32,76
SWO	HOOK * BAIT	A2_6	265,04	24,63	313,31	216,76	9,29	-26,14
SWO	HOOK * BAIT	A3_1	226,78	21,90	269,70	183,85	9,66	-36,80
SWO	HOOK * BAIT	A3_6	232,71	20,62	273,12	192,30	8,86	-35,15
PGO	HOOK * BAIT	A1_1	84,69	8,19	100,74	68,64	9,67	*REF*
PGO	HOOK * BAIT	A1_6	87,34	8,58	104,16	70,53	9,82	3,13
PGO	HOOK * BAIT	A2_1	84,25	8,92	101,73	66,76	10,59	-0,53
PGO	HOOK * BAIT	A2_6	84,73	9,05	102,47	66,99	10,68	0,05
PGO	HOOK * BAIT	A3_1	88,62	9,48	107,20	70,04	10,70	4,64
PGO	HOOK * BAIT	A3_6	82,57	9,80	101,78	63,37	11,87	-2,50
IOO	HOOK * BAIT	A1_1	90,08	10,49	110,63	69,52	11,64	*REF*
IOO	HOOK * BAIT	A1_6	84,47	8,38	100,90	68,04	9,92	-6,22
IOO	HOOK * BAIT	A2_1	91,63	8,80	108,88	74,38	9,60	1,73
IOO	HOOK * BAIT	A2_6	72,00	9,55	90,73	53,28	13,27	-20,07
IOO	HOOK * BAIT	A3_1	91,51	10,94	112,96	70,07	11,96	1,59
IOO	HOOK * BAIT	A3_6	75,60	9,05	93,34	57,85	11,98	-16,08
BIL	HOOK * BAIT	A1_1	27,05	5,57	37,97	16,13	20,59	*REF*
BIL	HOOK * BAIT	A1_6	37,10	10,12	56,93	17,27	27,27	37,15
BIL	HOOK * BAIT	A2_1	28,95	7,81	44,26	13,65	26,97	7,02
BIL	HOOK * BAIT	A2_6	43,39	12,32	67,53	19,25	28,39	60,38
BIL	HOOK * BAIT	A3_1	62,83	14,85	91,93	33,72	23,64	132,25
BIL	HOOK * BAIT	A3_6	46,59	9,01	64,25	28,92	19,35	72,21

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

Species		Resid. Df	Resid. Deviance	Change in deviance	% of total deviance	model % deviance	P(>|Chi|)
CAT	NULL	30	5.317				
CAT	HOOK TYPE	28	5.197	0.121	2.268.111	2.268.111	6.76E-01
CAT	HOOK TYPE BAIT TYPE	27	4.729	0.468	8.801.625	11.069.736	8.14E-02
CAT	HOOK TYPE BAIT TYPE ZONE	24	4.078	0.650	12.230.121	23.299.857	2.39E-01
CAT	HOOK TYPE BAIT TYPE ZONE / HOOK *BAIT	22	3.782	0.296	5.568.720	28.868.577	3.83E-01
CAT	HOOK TYPE BAIT TYPE ZONE / HOOK *BAIT / HOOK *ZONE	18	2.949	0.833	15.668.021	44.536.598	2.48E-01
CAT	HOOK TYPE BAIT TYPE ZONE / HOOK *BAIT / HOOK *ZONE / BAIT *ZONE	16	2.466	0.483	9.079.967	53.616.565	2.09E-01

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

Species		Resid. Df	Resid. Deviance	Change in deviance	% of total deviance	model % deviance	P(>|Chi|)
CAT	NULL	23	33.104				
CAT	HOOK TYPE	21	32.169	0.934	2.821.411	2.821.411	6.27E-01
CAT	HOOK TYPE BAIT TYPE	20	31.242	0.927	2.800.266	5.621.677	3.36E-01
CAT	HOOK TYPE BAIT TYPE ZONE	17	28.145	3.097	9.355.365	14.977.042	3.77E-01
CAT	HOOK TYPE BAIT TYPE ZONE / HOOK *BAIT	15	27.569	0.576	1.739.971	16.717.013	7.50E-01
CAT	HOOK TYPE BAIT TYPE ZONE / HOOK *BAIT / HOOK *ZONE	9	17.422	10.147	30.651.885	47.368.898	1.19E-01
CAT	HOOK TYPE BAIT TYPE ZONE / HOOK *BAIT / HOOK *ZONE / BAIT *ZONE	6	14.691	2.731	8.249.758	55.618.656	4.35E-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	0,82	0,09	1,01	0,64	11,43	*REF*
CAT	HOOK	A2	0,92	0,11	1,14	0,70	12,43	12,01
CAT	HOOK	A3	0,93	0,18	1,28	0,58	19,14	13,53
CAT	BAIT	1	0,77	0,09	0,94	0,60	11,34	*REF*
CAT	BAIT	6	0,97	0,10	1,17	0,77	10,42	26,64
CAT	ZONE	15075	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	15080	0,90	0,09	1,08	0,72	10,24	-11,97
CAT	ZONE	15085	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	20075	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	20080	1,03	0,13	1,27	0,78	12,42	*REF*
CAT	ZONE	20085	0,75	0,12	0,99	0,52	15,80	-26,58
CAT	ZONE	20090	0,56	0,06	0,68	0,45	10,56	-44,93
CAT	ZONE	20105	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	25085	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	25090	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	25110	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	ZONE	30115	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*	*non estimable*
CAT	HOOK * BAIT	A1_1	0,76	0,02	0,80	0,72	2,88	*REF*
CAT	HOOK * BAIT	A1_6	0,79	0,02	0,83	0,75	2,45	3,89
CAT	HOOK * BAIT	A2_1	0,72	0,03	0,77	0,67	3,55	-5,34
CAT	HOOK * BAIT	A2_6	0,83	0,01	0,86	0,81	1,48	9,40
CAT	HOOK * BAIT	A3_1	1,03	0,02	1,07	0,98	2,37	34,70
CAT	HOOK * BAIT	A3_6	1,19	0,11	1,41	0,97	9,53	56,54

Table 12. Prevalence (%) of each hook location within each sea turtle species and sea turtles 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

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

Table 14. Prevalence (%) of the hook locations within each sea turtle species and turtles 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

Table 15. 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

Table 16. 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*

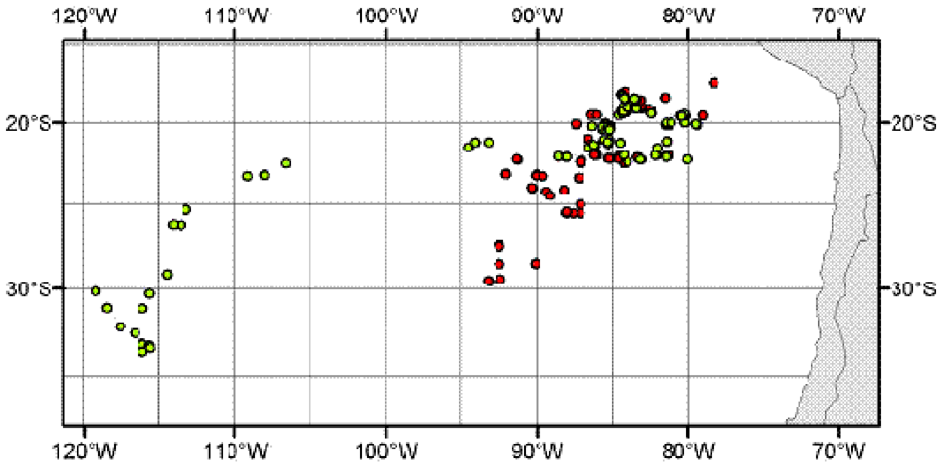


Figure 1. Map of the fishing areas in the South Pacific where the sets were carried out.

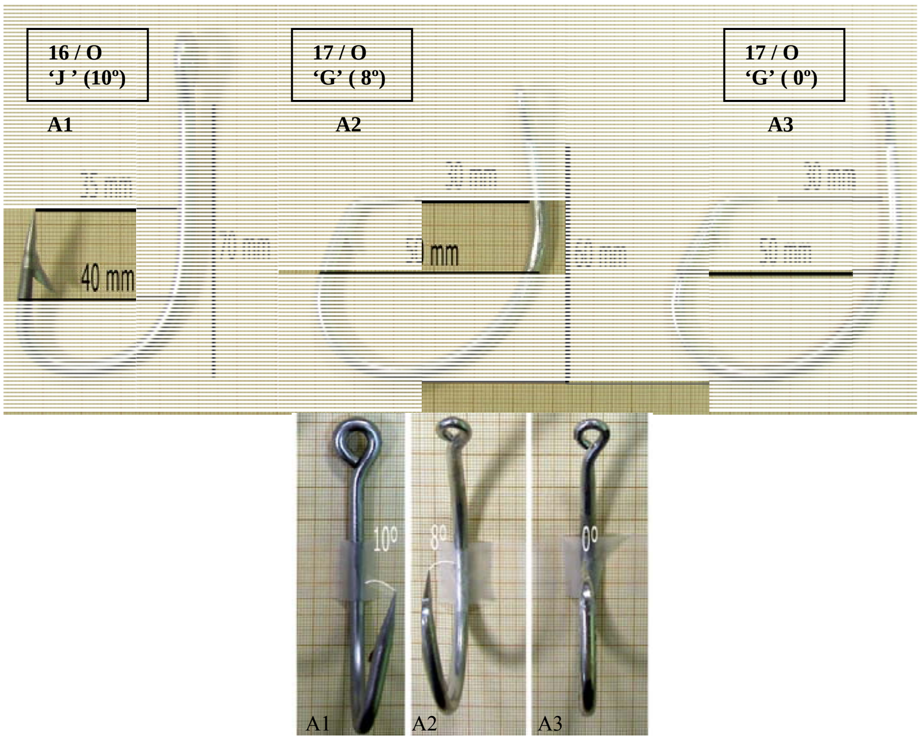
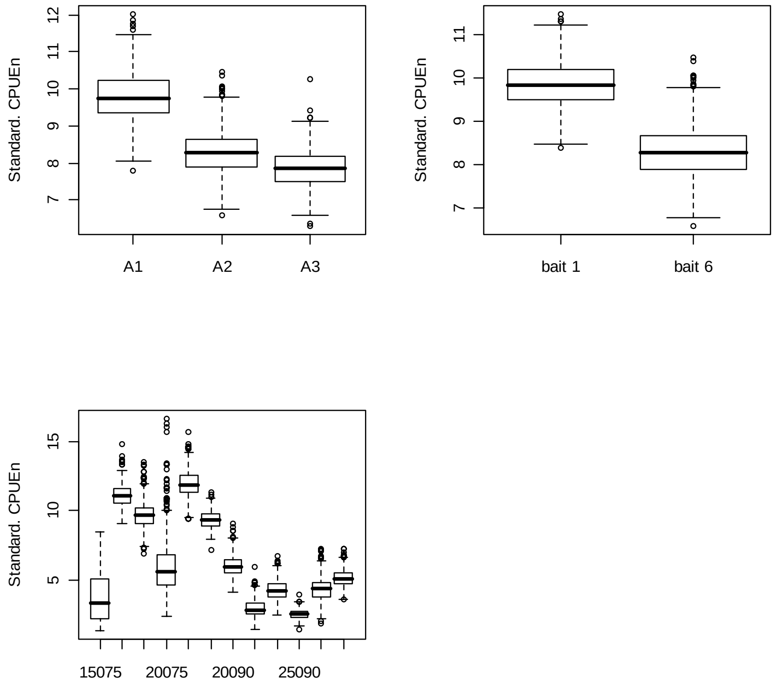


Figure 2. Three types of hooks tested during the survey, sizes (mm) and offset (degrees). ***A1***: Conventional "J" hook 16/O (10º offset) "J" = 70 – 40 – 35. ***A2***: Circle "G" hook 17/O (8º offset) = 60 – 50 – 30. ***A3***: Circle "G" hook 17/O (0º offset) = 60 – 50 – 30.

SWO



PGO

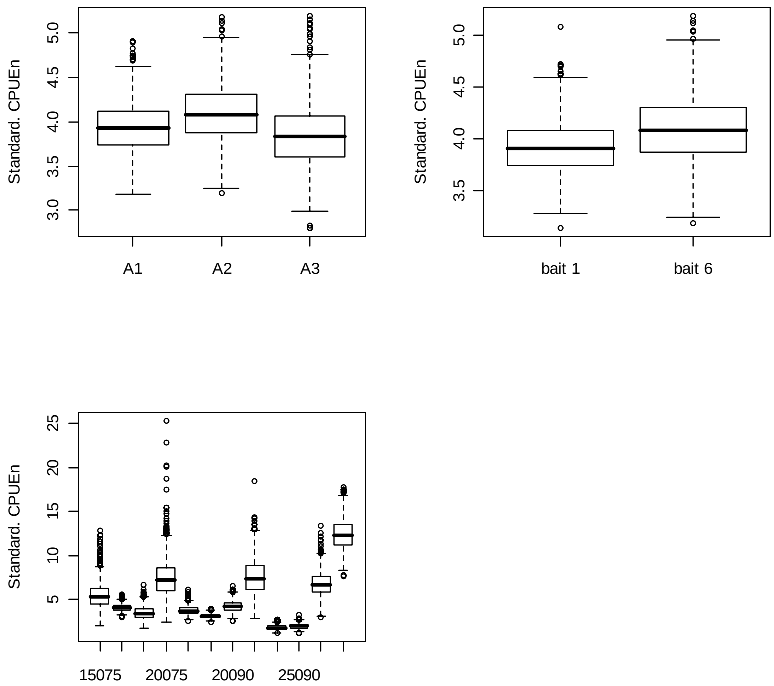
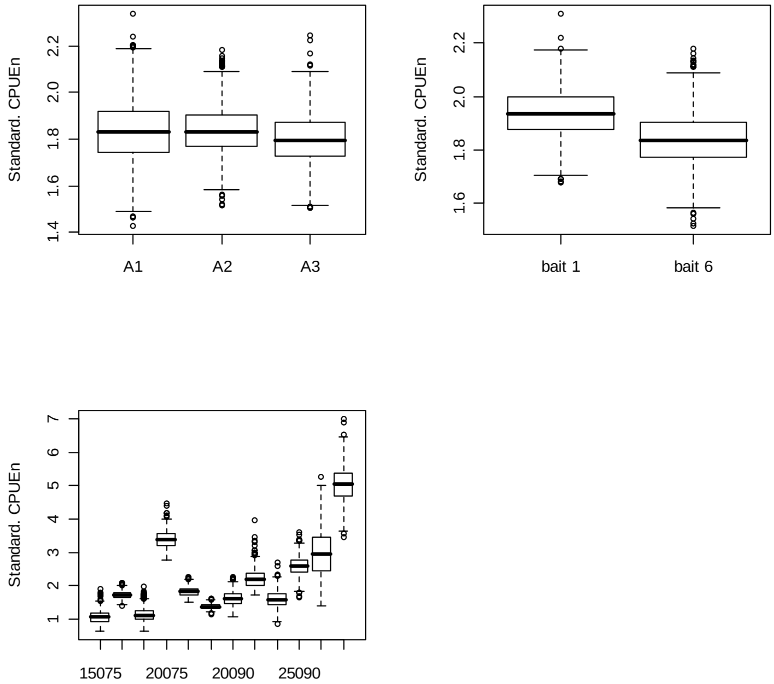


Figure 3. Standardized CPUE (number of fish x 1000 hooks^{-1}) by hook, bait and area with approximate 95% confidence intervals. SWO and PGO.

IOO



BIL

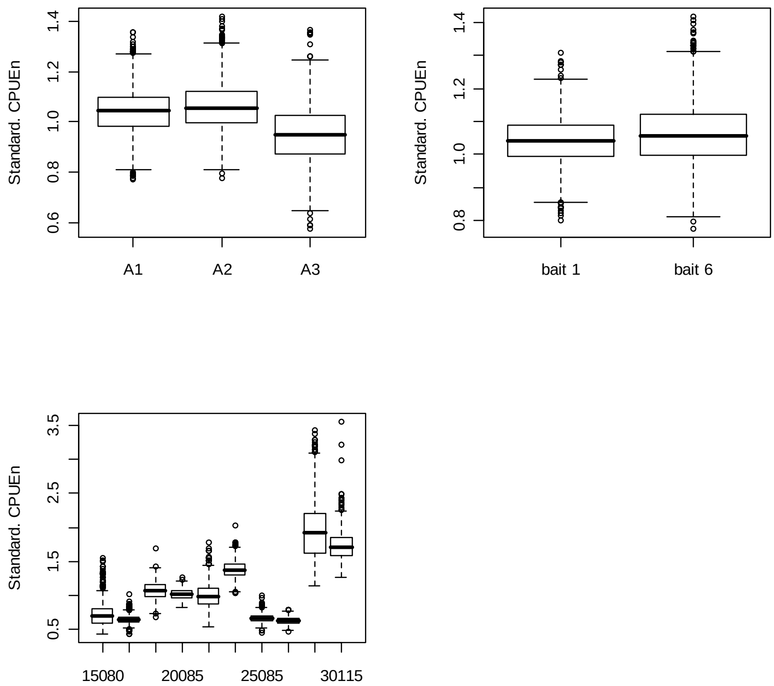


Figure 4. Standardized CPUE (number of fish x 1000 hooks^{-1}) by hook, bait and area with approximate 95% confidence intervals. IOO and BIL.

CAT

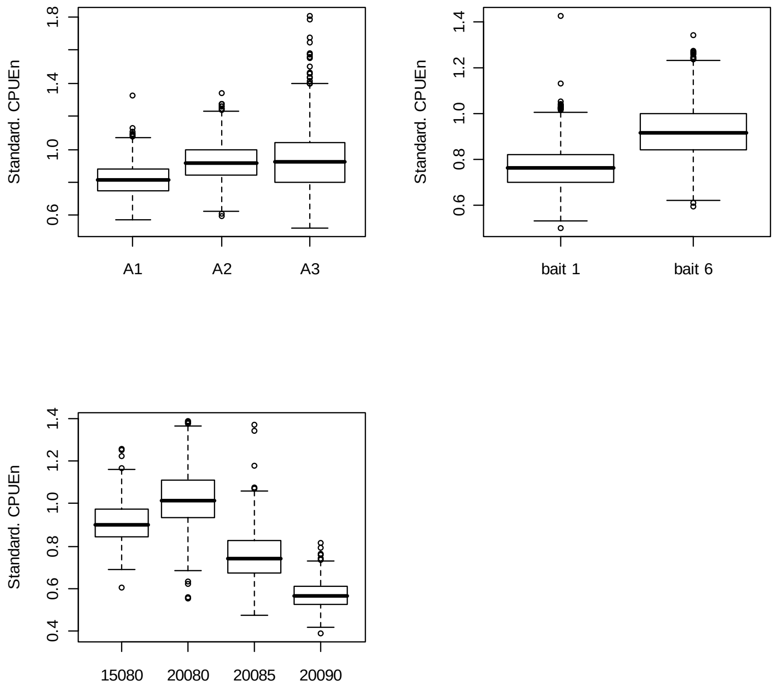
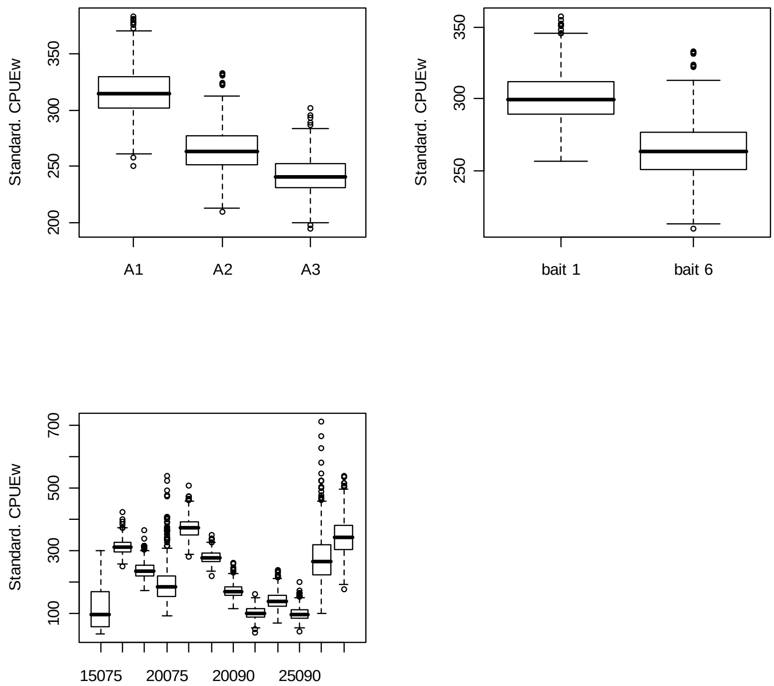


Figure 5. Standardized CPUE (number of individuals x 1000 hooks^{-1}) by hook, bait and area with approximate 95% confidence intervals. CAT.

SWO



PGO

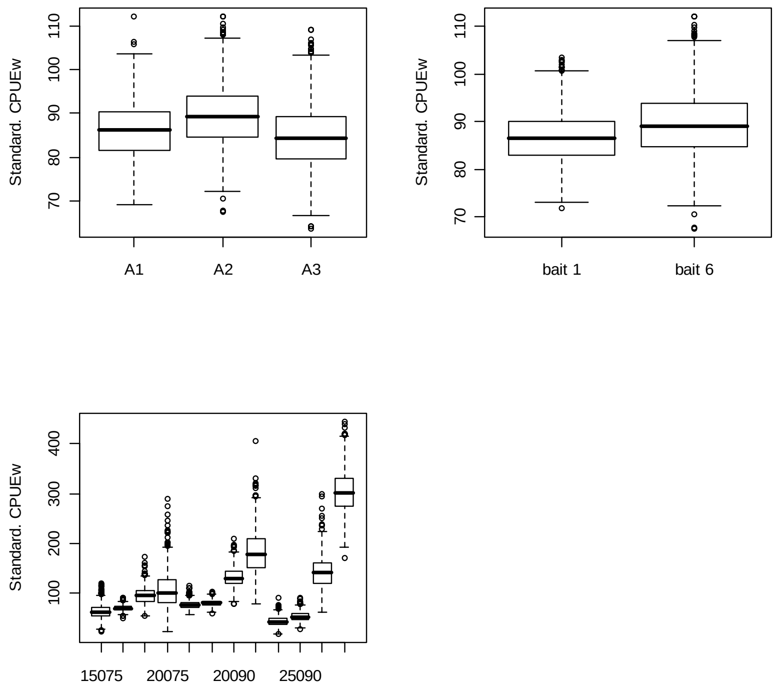
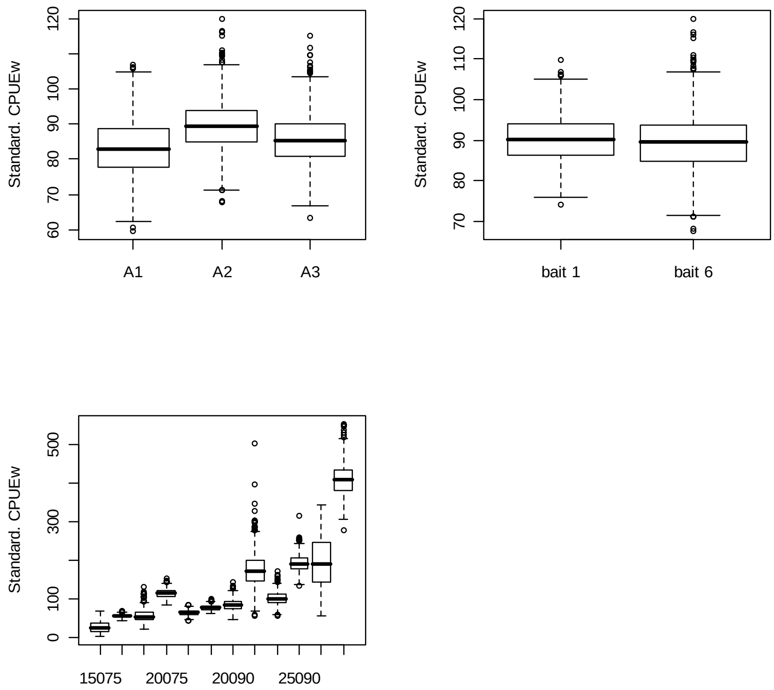


Figure 6. Standardized CPUE (kg RW x 1000 hooks^{-1}) by hook, bait and area with approximate 95% confidence intervals. SWO and PGO.

IOO



BIL

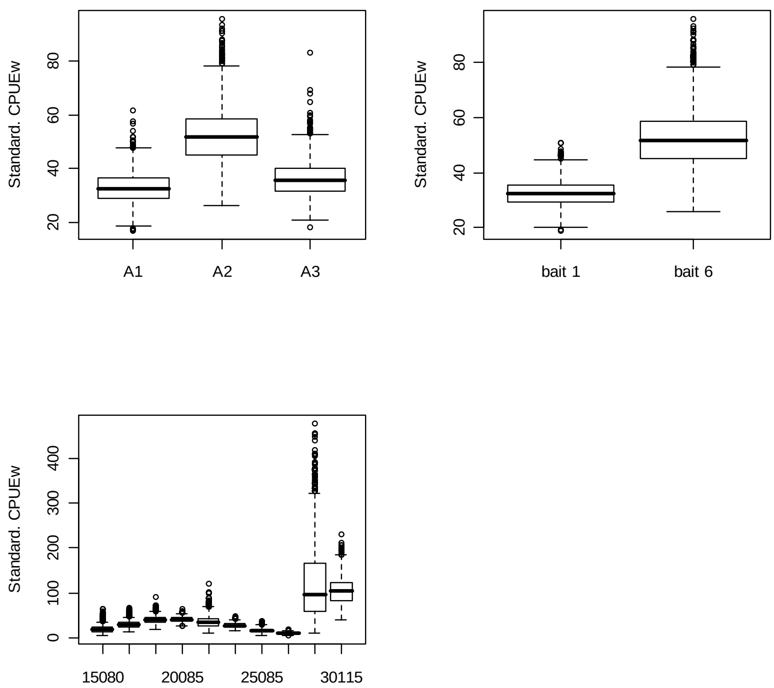


Figure 7. Standardized CPUE (kg RW x 1000 $hooks^{-1}$) by hook, bait and area with approximate 95% confidence intervals. IOO and BIL.

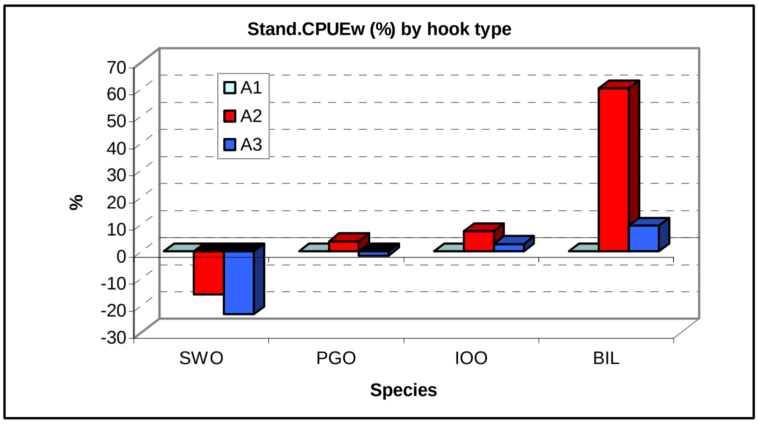


Figure 8. Gains and losses in catch rates in weight for fish species caused by type A2 and type A3 hooks (circle hooks), as compared to hook type A1 ('J' conventional) used as a reference.

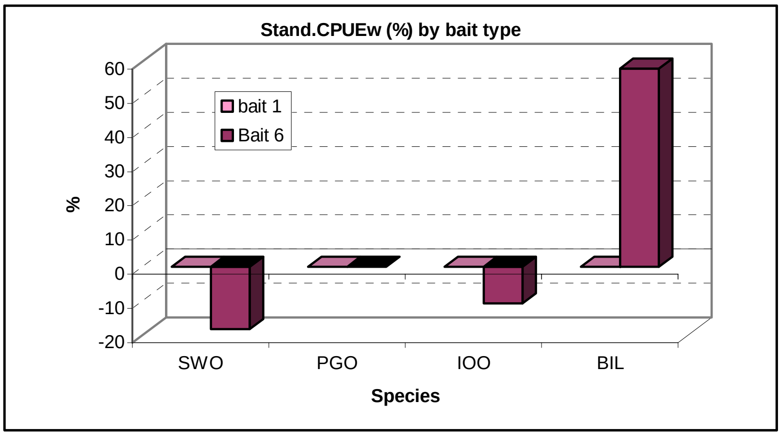


Figure 9. Gains and losses in catch rates in weight for fish species caused by bait type 6 (squid) as compared to bait 1 (mackerel) used as a reference.

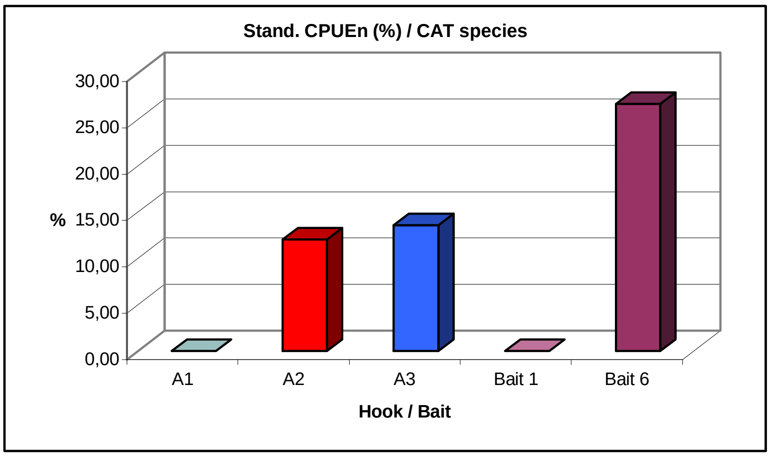


Figure 10. Gains and losses in catch rates in number of CAT turtles caused by hook type (A2, A3) and by bait type 6 (squid) as compared to hook type A1 ('J' conventional) and bait 1 (mackerel) used as a reference.

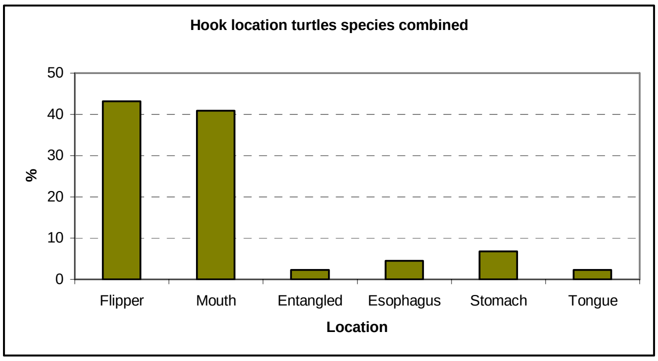


Figure 11. Prevalence (%) of each hook location for all turtles species combined.

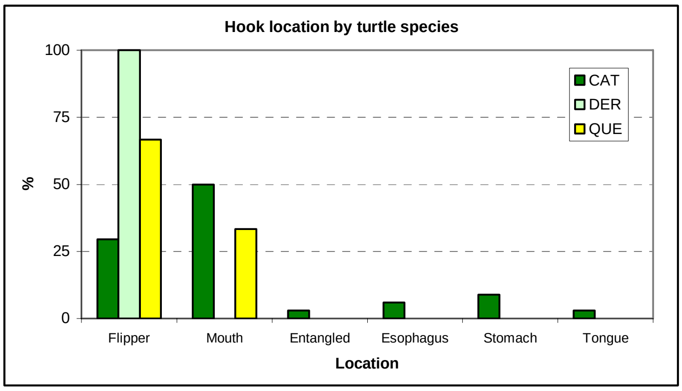


Figure 12. Prevalence (%) of each hook location by species of turtle. The lack of vertical bar indicates null catch.

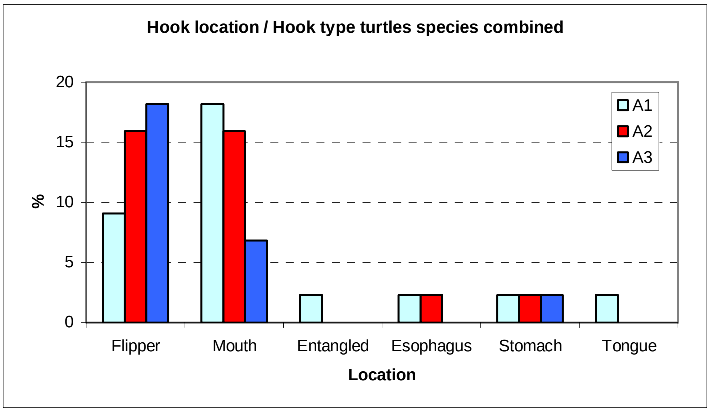
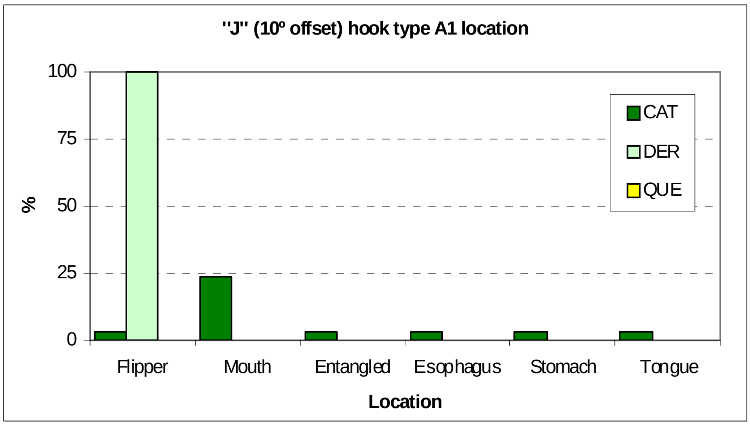
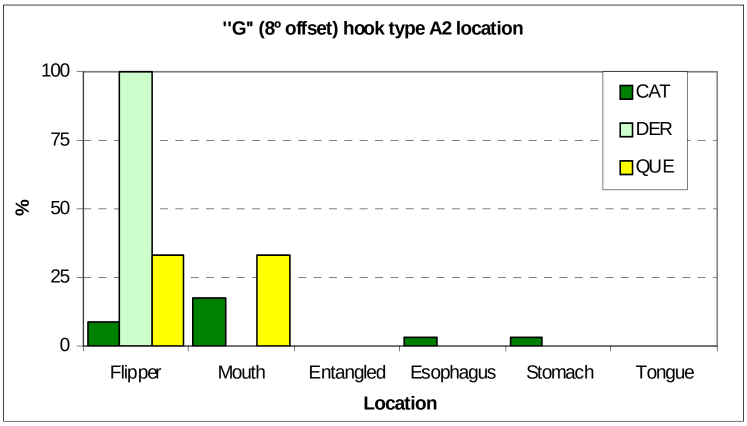


Figure 13. Prevalence (%) of each hook location for all turtles species combined, by hook type. The lack of vertical bar indicates null catch.





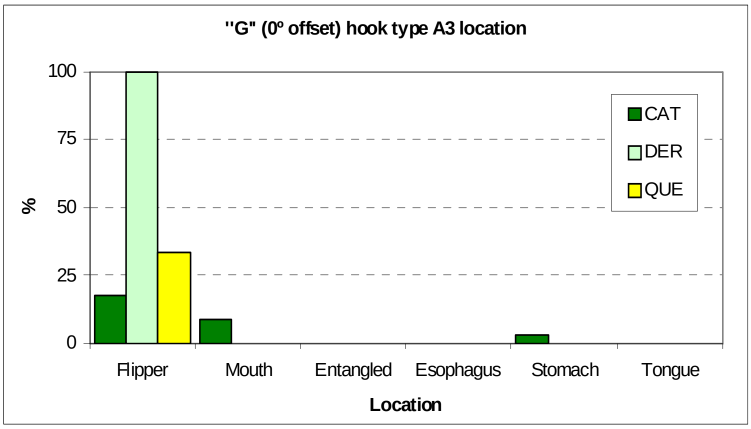


Figure 14. Prevalence (%) by hook type of each hook location by species of sea turtle. The lack of vertical bar indicates null catch.

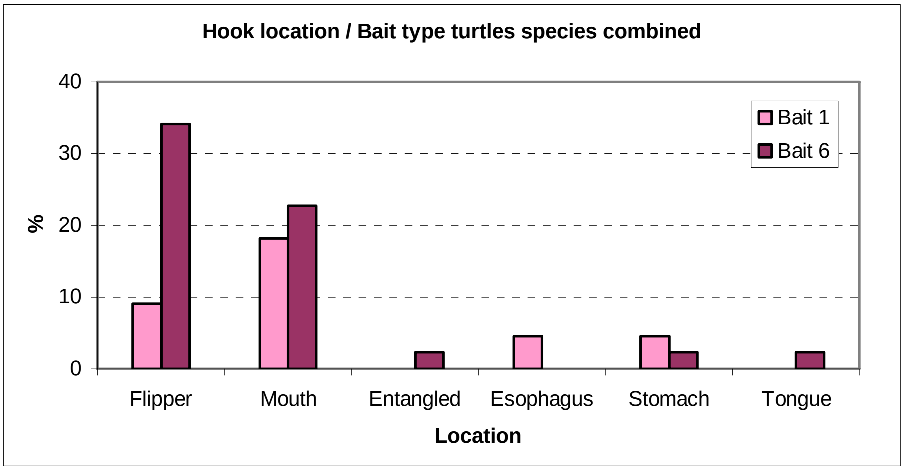
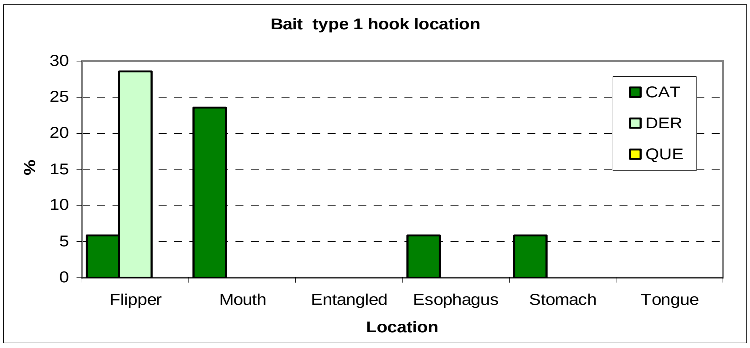


Figure15. Prevalence (%) of each hook location for all turtles species combined, by bait type. The lack of vertical bar indicates null catch.



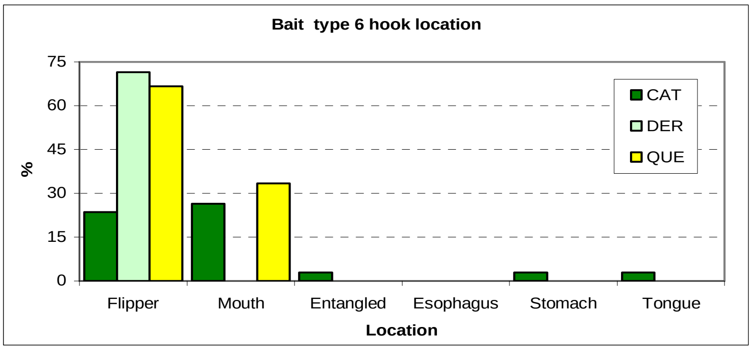


Figure16. Prevalence (%) by bait type of hook locations by species of turtles. The lack of vertical bar indicates null catch.

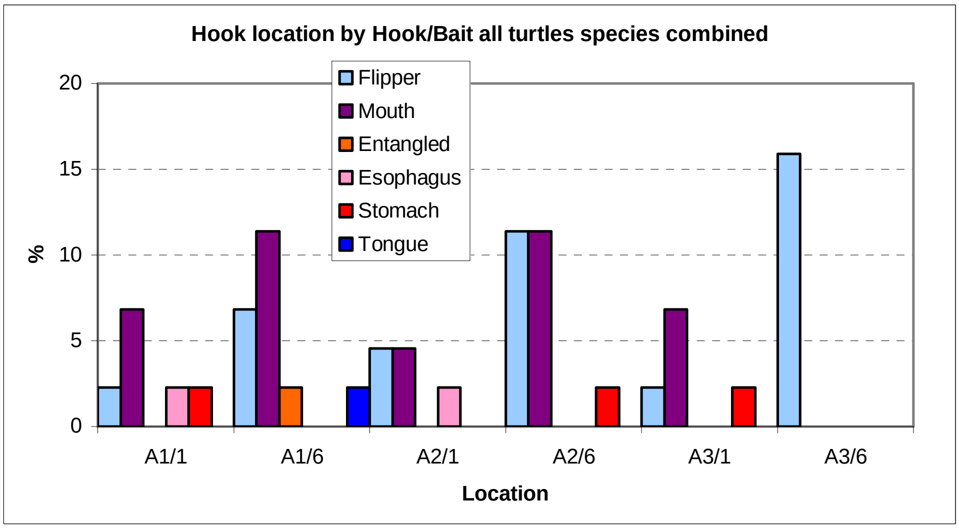


Figure 17. Prevalence (%) of hook locations for all sea turtles species combined, by different hook-bait type combinations. The lack of vertical bar indicates null catch.

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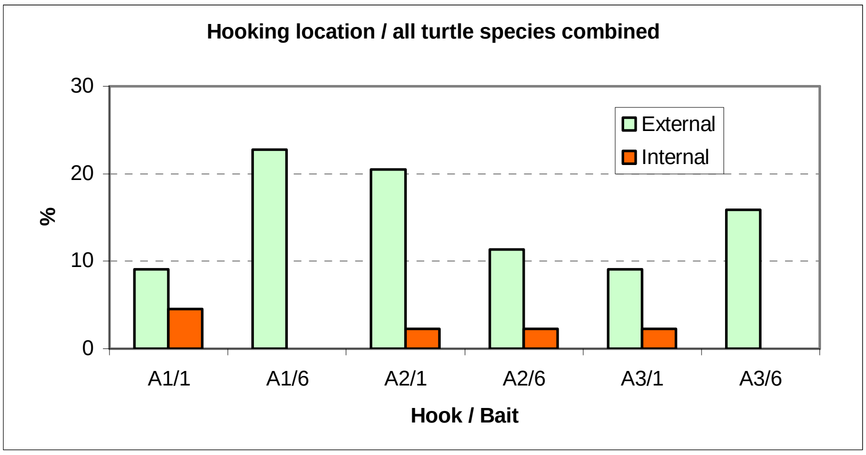

Figure 18. Prevalence (%) of each group of hook location (external or internal) for all the sea turtles species combined by hook and bait combinations. The lack of vertical bar indicates null catch.