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THE EASTERN PACIFIC REGIONAL PROGRAM TO REDUCE INCIDENTAL MORTALITY OF SEA TURTLES

There has been a considerable increase in longlining by small vessels based in nations adjacent to the eastern Pacific Ocean (EPO) during recent years. Sea turtles are caught incidentally by longline gear, and the populations of leatherback, loggerhead, and hawksbill turtles have been at low levels or declining in recent years. The FAO and other organizations have urged the development of programs to reduce sea turtle mortality. The Association of Fish Exporters of Ecuador, together with the Subsecretaria de Recursos Pesqueros, and fish worker's organizations from that country took the initiative, and decided to search for a solution that reduced the mortalities of sea turtles, but allowed the continuation of the fishing activities, critical to thousands of families. Some member countries from the EPOasked IATTC to help develop such a program. In response to this, the IATTC adopted a Resolution on a Three-Year Program to Mitigate the Impact of Tuna Fishing on Sea Turtles (Resolution C-04-07) at its 72nd meeting in June 2004. It then began a program, supported by the World Wildlife Fund, the U.S. Western Pacific Regional Fisheries Management Council, the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. State Department, the Overseas Fishery Cooperation Foundation (OFCF) of Japan, The Ocean Conservancy, Defenders of Wildlife (Mexico), and several national conservation, industry, and fishworker's organizations of the coastal countries of the EPO, to seek ways to reduce this mortality by (1) reducing the catches of sea turtles and (2) reducing the mortalities of sea turtles that are caught.

A program was begun in Ecuador in 2003, and expanded to other countries bordering the EPO. By the end of 2006 the program was (1) active in Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Panama, and Peru and (2) under development in Mexico and Nicaragua.

REDUCING THE CATCHES OF SEA TURTLES BY LONGLINE GEAR

Most of the small vessels use "J-hooks," a category in which we include straight J hooks (with a straight shank), and Japanese style tuna hooks (with a bent shank). It has recently been found in other areas that the use of "circle hooks" tends to decrease the catches of sea turtles without affecting those of the target species. These results might not apply to the countries bordering the EPO, however, so an experimental hook exchange program was begun in 2004. Some of the J-hooks are replaced by circle hooks on the gear of some of the vessels, in accordance with a statistically-valid design, and observers are placed aboard those vessels to record the results.

There are two principal longline fisheries conducted by small vessels in the EPO, one directed at tunas, billfishes, and sharks (henceforth called the TBS fishery) and the other directed at mahi-mahi, *Coryphaena hippurus* (henceforth called the mahi-mahi fishery). Most of the vessels in Ecuador and Peru have two sets of gear, one with larger hooks for the TBS fishery and the other with smaller hooks for the mahi-mahi fishery. In Central America, however, many vessels use the same gear, regardless of the species toward which they are directing their effort.

In the TBS fishery, large J hooks, or Japanese tuna hooks, were replaced by C16/0 and C18/0 circle hooks in Ecuador, but the C18/0 hooks proved to be too large, so the large J hooks were replaced only by C16/0 hooks after 2004. In Central America some of the vessels were already using C14/0 and C15/0 hooks, and some of the fishermen expressed interest in testing C16/0 hooks, so some of the C14/0 and C15/0 hooks were replaced by larger circle hooks. The total effort observed in the region is shown in Table 1.

Table 1. Summary of sampling effort (2004 – 2006).

Country	LL vessels sampled	Total hooks (sample size)	LL fishing trips observed	LL experimental sets	Observers
Ecuador	140	221545	341	1394	56
Peru	41	225007	73	552	24
Colombia	6	10978	35	35	4
Panama	6	324890	43	474	13
Costa Rica	24	449636	76	775	15
Guatemala	57	284957	340	929	21
El Salvador	5	7980	10	19	2
Totals	**279**	**1524993**	**918**	**4178**	**135**

More than 900 fishing trips, during which the gear was set more than 4000 times(sets) have been observed in the region. A total of 279 vessels are testing the circle hooks on their lines, and taking observers in some of their trips. The spatial distribution of the effort is shown in Figs. 1a and 1b:

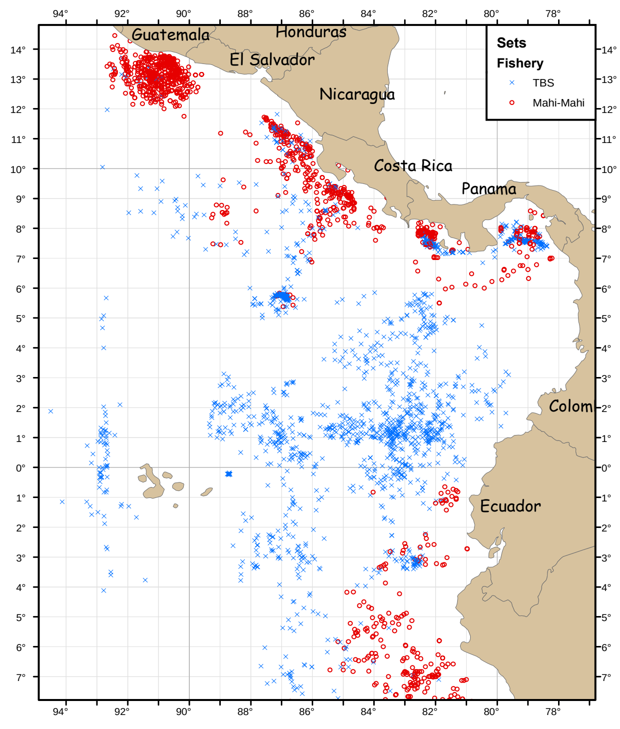

Fig. 1a: Observed longline sets, 2004 - 2006, Northern sector.

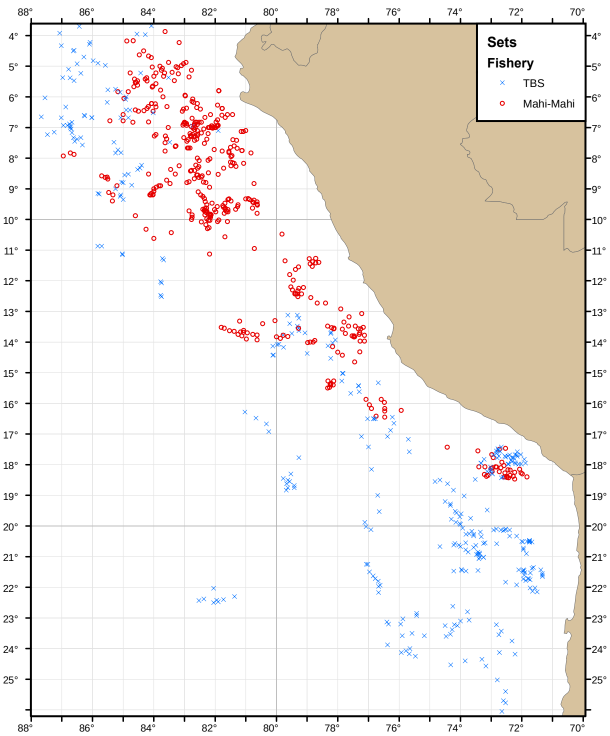

Fig. 1a: Observed longline sets, 2004 – 2006, Southern sector.

Preliminary results for the differences in hooking rates between J hooks and circle hooks are shown in Fig. 2. Each vertical bar represents a port-year combination, and each group of bars represents the years a port has been sampled. The names of the ports have been omitted because they were not needed to make the point . The values on the y-axis represent the difference in hooking rates (rate for J hooks versus rate for circle hooks). If they are positive (over the 0 (zero) line), it means that the J-hooks had higher hooking rates than the circle hooks. For instance, a value of +2.0 means that by replacing the J hooks by the circle hook tested in that case, reduces turtle entanglements by 2 individuals per 1000 hooks, or 2000 turtles per million hooks.

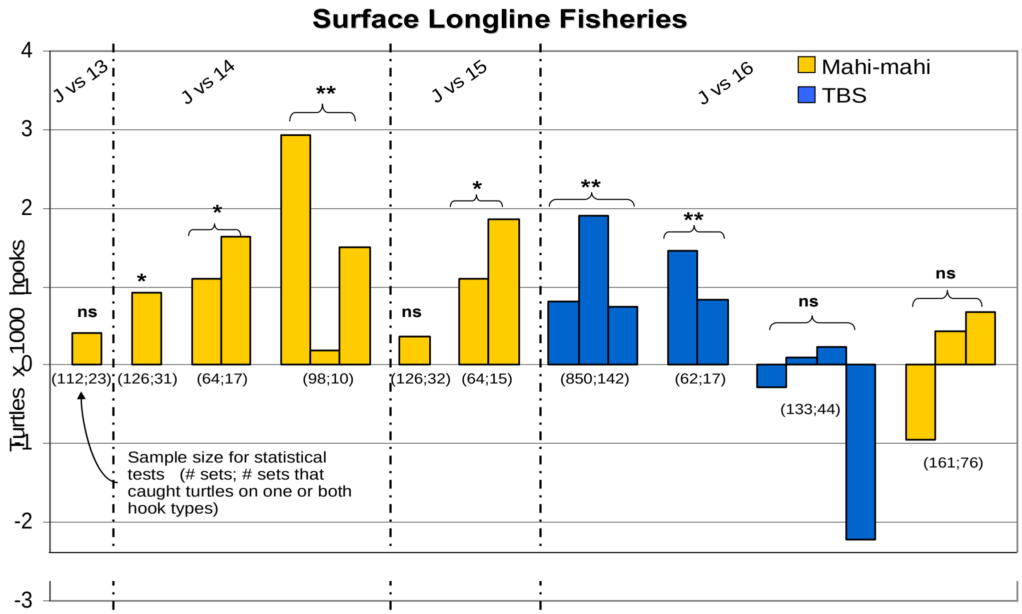

Figure 2

The y-axis shows the difference in overall hooking rates between J hooks and four types of circle hooks (*i.e.*, {[# turtles hooked on J hooks / # J hooks] – [# turtles hooked on C hooks / # C hooks]} x 1000), by fishing year, grouped according to fishery and port. 'TBS' indicates tuna, billfish and shark fisheries. Only those fisheries and ports with sufficient data for statistical tests of the difference in hook performance are shown. p-values associated with two-tailed tests of the null hypothesis of no difference in hook performance, by fishery and port, are indicated as follows: 'ns' – p-value > 0.10; '*' – p-value ≥ 0.10 but < 0.01; '**' – p-value ≤ 0.01. Statistical tests are described below.

The asterisks show that most of the values are significant with a conservative test. For some locations however, the results are less positive than for others, and there is a need to continue exploring alternatives.

Tests for differences in the performance of the different hook types (J versus 'C') were conducted as follows.

- Testing was done by fishery within ports. Tests were performed only when sufficient data were available (10 or more sets caught turtles). Data differed among ports and fisheries in terms of line characteristics, number of years of data available for analysis, and bait types.
- The main test of hook performance was based on the paired differences in the per-line hooking rates. For most fisheries and ports, many sets did not catch turtles. Thus, data used in this analysis were limited to lines that caught turtles on one or both types of hooks. This restriction was used because zero values for paired differences can arise in two ways: no turtles being caught at all on the line, or the same per-line hooking rate for the two hook types. When no turtles were caught on the line, it is not known whether no turtles were in the area (i.e., effectively no experiment was performed) or whether turtles were in the area but none were hooked.
- To test the null hypothesis of no difference in hooking rates between the two types of hooks, it was assumed that the mean difference in hooking rates could be modelled by an overall constant, and, when appropriate, a year effect and/or an 'other' hook effect (to account for any effect of multiple 'C' hooks

on the line). In addition, because of differences in mother line length between sets, which appeared to affect variability in hooking rates, it was assumed that the variance of the paired differences in hooking rates was an approximately linear function of line length. This model was fitted to the data, using generalized estimating equations (geese of geepack in the R statistical software package). P-values for a test of the null hypothesis of no difference in hook performance were based on the Wald test (two-tailed test).

- Because the analysis of paired differences excluded lines that caught no turtles, which may exclude useful information, a second test of differences in hooking rates was also performed using logistic regression to model the log of the odds that a hook caught a turtle (year and ‘other’ hook effects included, as appropriate). Tests of the null hypothesis were based on a t statistic (two-tailed test). Although results of this analysis were consistent with those of the tests of the paired differences in hooking rates, the logistic regression model used in these preliminary analyses has the shortcoming that it does not explicitly take into account the pairing of hooks on the line, nor any effect of main line length on variability in the data. Future work will explore modelling these data with zero-inflated mixed-effect models.
- Neither analyses above accounts for any effects of bait on hook performance, nor does either account for the grouping of sets within trips and vessels. Accounting for bait effects is made difficult because the proportions of the different baits were not known when several bait types were used. To address this issue, the above analyses were repeated for sets that only used squid bait. This could only be done for a few ports and fisheries. However, the results were consistent with those of the analyses performed on the larger data sets. Accounting for the grouping of sets within trips and vessels was not done in these preliminary analyses because not all trips/vessels were represented in the data by more than one set. Of the two, it is believed that vessel effects may be more important, and this will be explored in the future.
- For the reasons stated in the previous paragraphs, because of the diversity and variability of the fisheries involved, and because of the number of variables (not always controlled) that appear to have the potential to affect the results, these should be considered very promising, but still preliminary.

PROPORTION OF HOOKS SWALLOWED

Circle hooks also reduce the proportion of hooks swallowed deeply by the turtles which may lead to additional mortality. In this case, the statistical tests are performed after pooling years, since there is no reason to expect interannual effects in what basically is a physical process. Figure 3 summarizes the results for comparisons of J hooks versus C16 hooks in some cases, and versus C14 in another case.

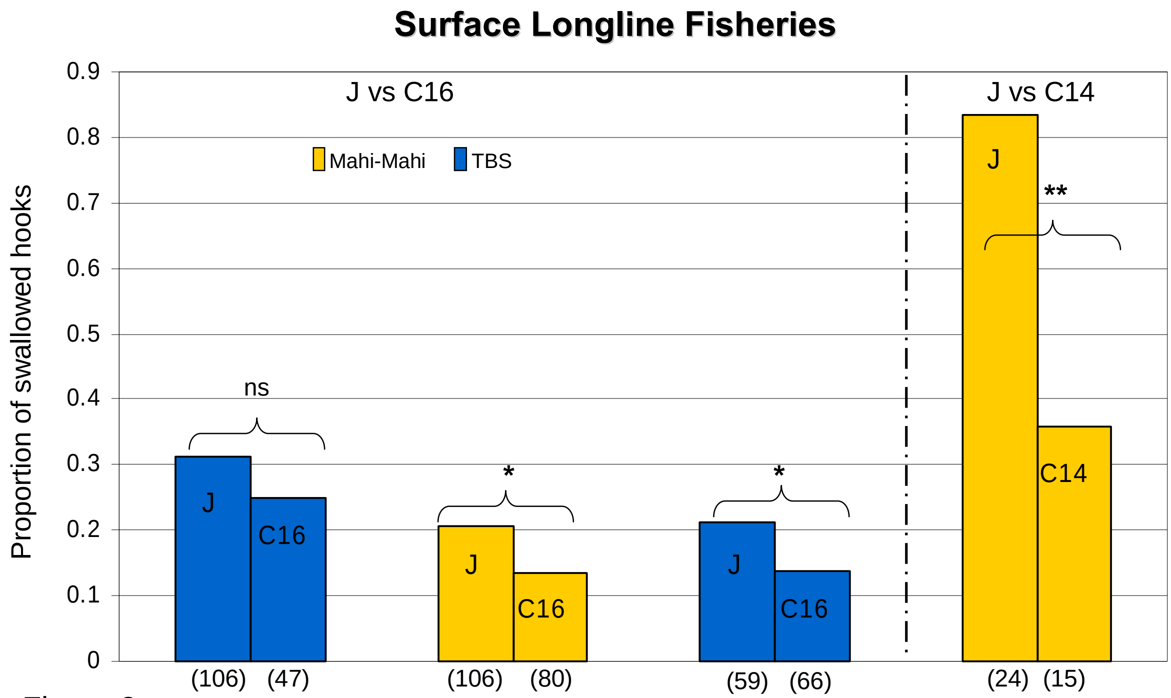

Figure 3

Proportion of hooked turtles that swallowed the hook, by fishery and port (data pooled over years), for J hooks and two types of circle hooks ('C'). 'TBS' indicates tuna, billfish and shark fisheries. Only those fisheries and ports with sufficient data are shown. p-values associated with two-tailed tests of a 'hook-type effect,' by fishery and port, are as follows: 'ns' – p-value > 0.10; '*' – p-value ≥ 0.10 but < 0.01; '' – p-value ≤ 0.01. Sample sizes for statistical tests (# turtles) are shown in parentheses. Statistical tests are described below.**

CATCH RATES FOR THE TARGET SPECIES

The catch rates for the target species were about the same for the large J hooks and the C16/0 hooks in the TBS fisheries. In the mahi-mahi fishery based in Peru and Ecuador, however, the catch rates were lower with circle hooks, which is hampering the exchange of hooks. We have began testing hooks with an added wire in the side opposite the point as an additional option to reduce deep hookings.

HANDLING OF HOOKED SEA TURTLES

"Dehookers," which make it easier and less traumatizing to remove the hooks from the turtles, have been distributed to fishermen, including those who have not had observers aboard their vessels, and they have been instructed in their use.In a recent experiment sponsored by the OFCF, a veterinarian was invited to examine the procedures used, and the impacts on the turtles of the hooks and of the dehooking process. This knowledge will be used to improve the guidelines given to observers and fishers to retrieve the hooks.

ESTABLISHMENT OF AN OBSERVER DATA BASE AND QUALITY CONTROL OF THE DATA

The observer database has been continuously improved to reflect our increasing knowledge and understanding of the conditions prevailing in the fishery and of the factors that are relevant to the analysis of causes of hookings or entanglements. The database has been standardized throughout the region, and they are also completely consistent.

Summaries of the data have been prepared, and the results have been discussed with the participants in each country. Especially important is the understanding of the similarities and differences among fisheries with respect to gear, mode of operation, *etc*.

FUTURE DEVELOPMENTS

The bottom-up approach to change, trying to convince fishermen to fish sustainably and increase the selectivity of their fishing operations is proving successful. The model shows real life evidence, coming from fishermen's own fishing trips, of the benefits of the gear substitution and best practices for the turtles, and also the absence of negative impacts on the target catches. This approach seems to match fishers' own cultural and social learning process and the way they adopt innovations in gear and techniques. Based on this assessment, the future of the program is projected along the same methodological and "philosophical" lines, building on the trust developed over the initial years, on the voluntary basis that has prevailed, and on the basic premises that give us a common ground.

- From the scientific point of view, there are many improvements that should be made to the data collection process, going from observer training to variable definition. In future data exploration, analysis, and experimental design we need to pay special attention to issues such as hook type (variations within the broad types of circle hooks, J and Japanese tuna hooks, affecting size and shape), and try to improve the handling of some variables of obvious importance but very difficult to control and track (bait type, size).
- Explore other models that account for differences in variance associated with length of fishing gear.
- Adding a wire to a hook on the side opposite the tip, with an angle of around 45 degrees from the shank, makes the hook wider without affecting the biting end. This has reduced gut hooking in fishes, and it may help also to reduce deep hooking in sea turtles. As the initial experiments were promising, the exploration of hooks with added wires, will continue.
- Continue the study of sea turtle entanglements, and their mitigation options, especially the replacement of line materials in the sections near the floats.
- Integrate new on-board turtle handling techniques with recommendations obtainedfrom wildlife veterinarians.
- Commence the planning for full implementation of the changes already tested in some fishing locations, as a pilot project for the general change at the regional level.