Working with the Ecuadorian fishing community to reduce the mortality of sea turtles in longlines:

The First Year

March 2004-March 2005

PARTICIPATING AND SUPPORTING ORGANIZATIONS

Western Pacific Regional Fishery Management Council (WPRFMC)

Subsecretaría de Recursos Pesqueros (*SRP)*

Asociación de Exportadores de Pesca Blanca (*ASOEXPEBLA*)

Programa Nacional de Observadores Pesqueros del Ecuador (*PROBECUADOR*)

Federación Nacional de Cooperativas de Pescadores del Ecuador (*FENACOPEC*)

World Wildlife Fund (*WWF*)

The Ocean Conservancy (*TOC*)

Fundación Jatún Sacha

Escuela de Pesca del Pacífico Oriental (*EPESPO*)

Escuela Politécnica del Litoral de Santa Elena (*ESPOL*)

National Oceanographic and Atmospheric Administration (*NOAA*)

Inter-American Tropical Tuna Commission (*IATTC*)

Prepared by

E. Largacha, M. Parrales, L. Rendón
V. Velásquez, M. Orozco, and M. Hall

Participants

Subsecretaría de Recursos Pesqueros, PROBECUADOR	L. Torres
ASOEXPEBLA	G. Morán
FENACOPEC	G. Cruz
EPESPO	G. Morán, J. Martínez
NOAA Fisheries Technical Support	C. Bergmann, C. Boggs, Y. Swimmer, J. Watson
IATTC Technical Support	E. Largacha, M. Hall, M. Orozco
Program staff	M. Parrales, L. Rendón, V. Velásquez

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EXECUTIVE SUMMARY

Ecuador has led a regional effort to reduce the bycatches of endangered sea turtles in the longline fisheries of the eastern Pacific Ocean through modifications in fishing gears and techniques. Recognizing the urgent need for solution-oriented approaches to save endangered sea turtles, fishers in Ecuador have been testing modifications that had previously been demonstrated, by researchers of the U.S. National Oceanic and Atmospheric Administration (NOAA), to reduce the bycatches of sea turtles in the Atlantic Ocean. Beginning in March 2004, circle hooks of various sizes were tested on a voluntary basis on Ecuadorian fishing boats. More than 15,000 circle hooks have been exchanged for J hooks in 115 participating vessels. Instruments for handling the turtles and release techniques have also been introduced among the fishers to increase the safe release of hooked individuals. An observer program has been conducted to monitor the effectiveness of the circle hooks in reducing sea turtle hooking rates, reducing the proportion of high-mortality hookings due to location of hooks, and monitoring the catch rates of the target species.

This program brought together people sharing two simple goals: (1) nobody wants sea turtles to become extinct and (2) nobody wants fishers to be put out of work. Based on this common ground, a broad coalition was formed with the participation of many local, national, and international stakeholders, including fishers' unions and co-operatives, industry groups, government and inter-governmental bodies, and environmental groups. Technical support was provided by NOAA researchers from Pascagoula, Honolulu, and La Jolla, and by IATTC staff members from La Jolla, Ecuador, and Panama. Financial and logistic support was provided by the Western Pacific Fishery Management Council (WPRFMC), the World Wildlife Fund (WWF), NOAA, The Ocean Conservancy, national fisheries agencies involved (in the case of Ecuador, the Undersecretariat of Fishery Resources, and the Programa Nacianal de Observadores Pesqueros de Ecuador (PROBECUADOR)), the Asociación de Exportadores de Pesca Blanca (ASOEXPEBLA), the Federación Nacional de Cooperativas de Pescadores en el Ecuador (FENACOPEC), and the Escuelas de Pesca del Pacífico Oriental (EPESPO) of Manta, and the Escuela Superior Politécnica del Litoral (ESPOL) of Santa Elena.

This report describes the program and presents the results of the first year of the experiment in Ecuador. Preliminary results, based on observer trips over a single fishing season in the tuna fishery, and a smaller sample from the mahi-mahi fishery are encouraging:

- Circle hooks were found to reduce the hooking rates of sea turtles by 44 to 88% in the tuna fishery (a statistically significant difference), and by 16 to 37% in the mahi-mahi fisheries (not tested yet).
- Circle hooks were also found to result in more benign (survivable) hookings in the turtles that were hooked in both fisheries. The proportion of hookings with lower survival declined from 70% to 25% to 40% in the tuna fishery, and from 96% to 18% to 53% in the mahi-mahi fishery (statistically significant differences).
- Considering both the reductions in hookings and the expected reductions in mortality of the turtles that are hooked, and applying a range of estimates of post-hooking mortality for different scenarios, it is estimated that the total reduction in mortality could be 63 to 93% in the tuna fishery, and 41 to 93% in the mahi-mahi fishery.
- With regard to catch rates of the target species, in the tuna fishery the catch rates for the circle hooks were quite similar to those for the J hooks, but in the mahi-mahi fishery the catch rates for the circle hooks dropped by almost a third. Thus, the exchange of J hooks for circle hooks throughout the fishery will depend on achieving better target catch rates through learning or additional changes in fishing gear and methods.

These estimates do not include the additional gains that can be expected by the growing awareness of the fishers, developed through an extensive program of workshops. More than 56 workshops have been organized, with an attendance of more than 2500 fishers and their families, in 17 different locations, covering the entire coast of Ecuador.

- Caveats:
    - Larger sample sizes are needed; sampling should be conducted on more trips, on different fishing seasons, , and in all locations in which fishing takes place. In the case of the mahi-mahi fishery, so few trips were sampled that meaningful statistical tests could not be performed, so the results are very preliminary.
    - During 2004 the catches of tunas were quite low, relative to those of previous years, which may have caused shifts in fishing areas, and targeting of alternative species.
    - The changes in technology involve some learning by fishers, and it is possible that the results in the future may reflect that. We are hoping that learning to release turtles unharmed is also part of the process. In the case of the mahi-mahi fishery, catch rates in circle hooks were disappointing. A boat that made four consecutive trips with circle hooks and J-hooks went from a much better performance for the J-hooks on the first trip to the opposite on the fourth trip, during which the circle hooks clearly outdid the J-hooks.

Conclusions:

The results for the first year are quite promising, and show that programs with the characteristics of this one could result in significant reductions in sea turtle mortality. Additional data are needed to cover more than one season, since there could be significant differences in the location of fishing effort which affects catch rates and species composition of the catch, and influences the species composition of the sea turtle populations encountered. Thus additional information is needed to understand the complete picture Time is needed for the fishers to develop skills with the new circle hooks, and with sea turtle release instruments.

Combined with other actions, the changes proposed here could help us reduce sea turtle mortality, and contribute to slowing down and, eventually, reversing their population declines. But to be effective in the cases of leatherback and loggerhead turtles, the changes must take place on a large scale, and very soon. Unless we can accelerate the process of change, we may end up with too little, too late. To achieve this, we need to extend the process in the region, and outside, to the rest of the Pacific Ocean. The global efforts from the WPRFMC, the WWF, NOAA, the IATTC, The Ocean Conservancy, the Defenders of Wildlife-Mexico, and others, coupled with the interest and motivation of the governments, industries, national non-governmental organizations, and especially of the fishers involved are critical to creation of an opportunity for the turtles to recover.

Our objectives are to continue exploring with the fishers of the regions different avenues to reduce sea turtle mortality.

ACKNOWLEDGMENTS

International section

- WPRFMC - Kitty Simonds, and Irene Kinan were instrumental in the development of this project, and we thank them for their patience and vision.
- NOAA Fisheries - Rebecca Lent, John Watson, Chris Boggs, Charlie Bergmann, Yonat Swimmer, and Jeff Seminoff, participated or supported the project in many ways.
- WWF - Scott Burns, Kim Davis, Miguel Jorge, Moises Mug, Michael Valqui, and other staff members of WWF have provided personal energy, tireless motivation, and the resources to develop and extend this program, and are carrying it to the other regions of the Pacific Rim, and to other oceans.
- U.S. State Department - Dave Hogan and the staff members of the US Embassy in Ecuador were also important contributors.
- The Ocean Conservancy - Marydele Donnelly and Nina Young have also helped support the activities, and offered advice and encouragement.
- Defenders of Wildlife-Mexico - Juan Carlos Cantu has contributed generously to the efforts on many occasions and in many ways.

Ecuador section

This program exists because of the initiative and vision of Guillermo Moran, Lucia de Genna, Luis Torres, the staff of PROBECUADOR, and many others from the government and industry of Ecuador, and of Gabriela Cruz, leader of FENACOPEC.

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THE PROBLEM

Large numbers of fishing vessels operating from ports in California, Mexico, and Central and South America participate in surface longline fisheries for tunas, billfishes, sharks, mahi-mahi, and other species in the eastern Pacific Ocean. Most of the catch is retained and utilized; the proportion of individuals discarded from a sample of Ecuadorian vessels was 0.4%. Five species of sea turtles inhabit the eastern Pacific region; of these, the leatherback (*Dermochelys coriacea*), and the loggerhead (*Caretta caretta*) are in a critical situation (Figs. 1-4.)

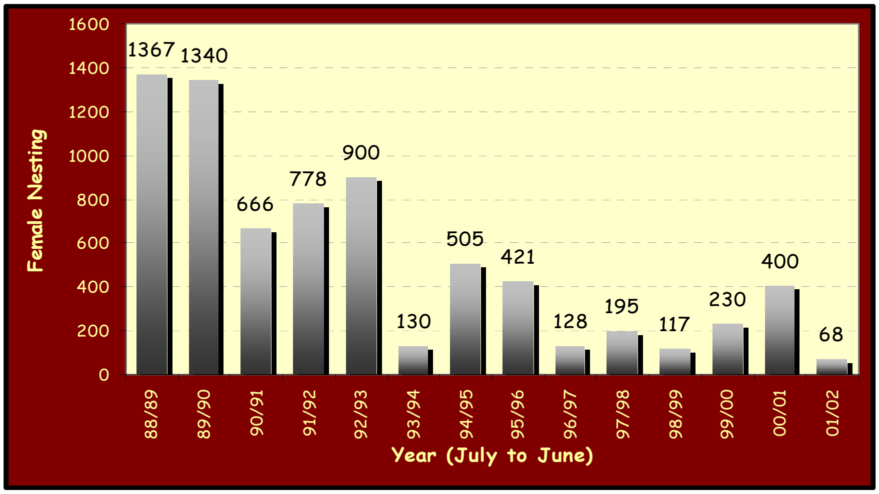


Fig. 1. Number of female leatherbacks nesting - Parque Nacional Las Baulas, Costa Rica
Steyermark, et al. 1996. and Spotila J. R. , Paladino F. V. and R. Reina (pers. comm.)

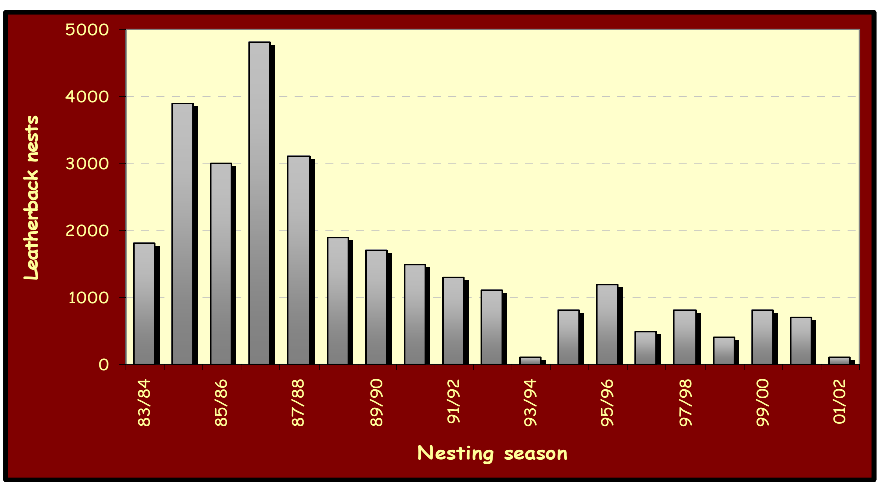


Fig. 2. Number of leatherback nests - La Playa Mexiquillo, Mexico
(Sarti et al. 1996, 2000, 2002)

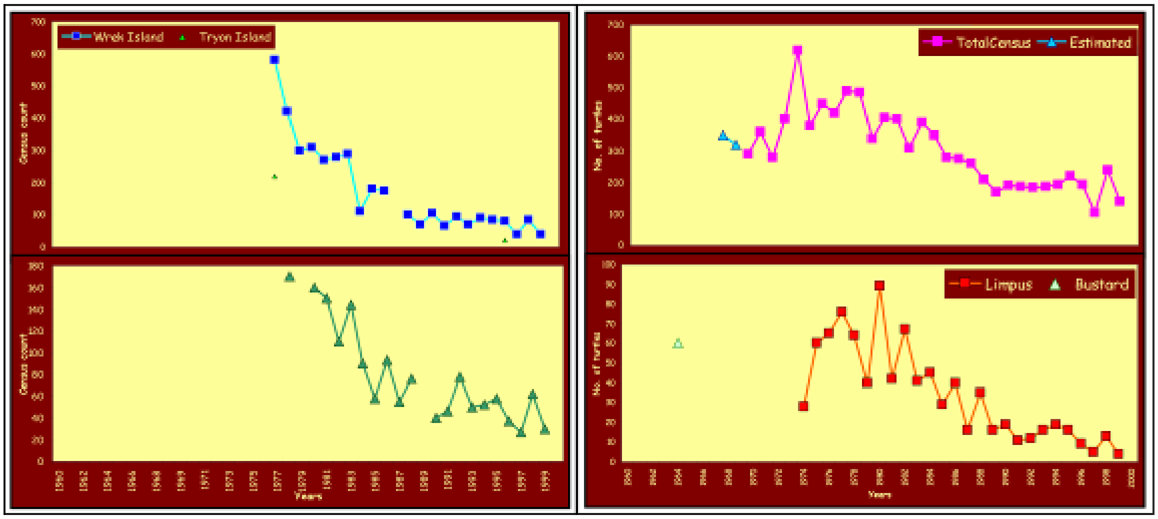


Fig. 3. Trends in loggerheads nesting in Australia *(Limpus and Limpus 2003)*

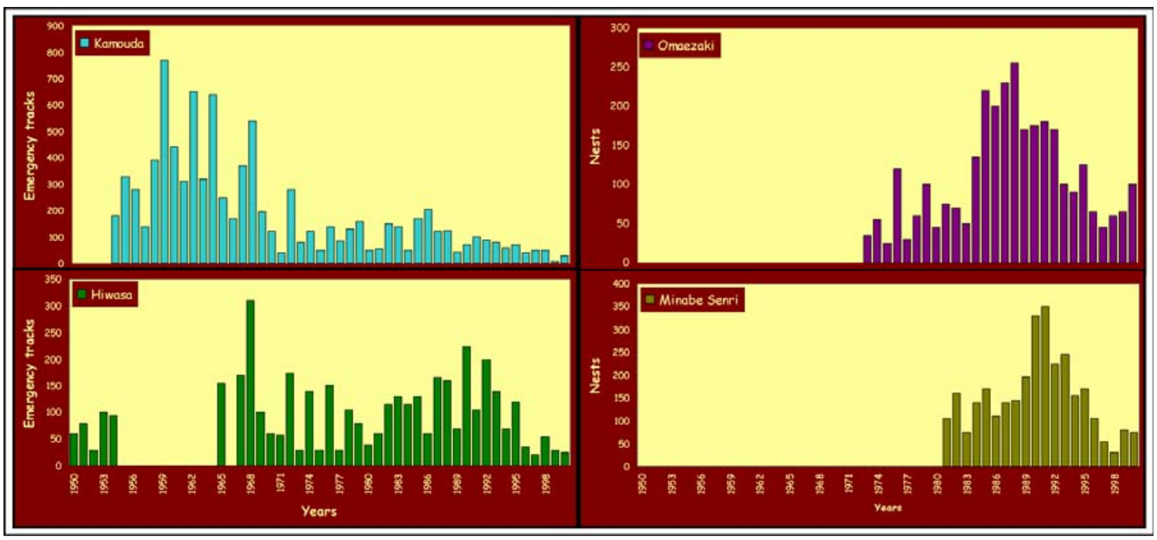


Fig. 4. Trends in loggerheads nesting in Japan *(Kamezaki et al., 2003)*

There are many reasons for these declines, but incidental mortality in fisheries is probably significant. The impact of shrimp trawls has been mitigated by the mandatory use of Turtle Excluder Devices (TEDs), although there are some difficulties with compliance. Mortality in large purse-seine nets has dropped from a high of 170 individuals per year in the late 90's, to about 20 in 2003. The vast majority of these mortalities is comprised of olive ridleys (*Lepidochelys olivacea*), the most abundant sea turtle population. Of the observed mortality, there was only one leatherback taken in the 1993-2004 period, and an average of 2 loggerheads / year in the whole eastern Pacific. There are additional unknown amounts that die entangled in the webbing hanging under the fish-aggregating devices planted by the fishers in the region.

About mortality in gillnets little is known, but it may be significant in some regions. Mortality in longlines has been documented in many regions of the world, and, as the number of hooks deployed every year in the world's oceans is very large, and the long migrations of many turtle species bring them into fishing grounds, interactions are unavoidable. The interactions involve not only hooking (*the turtle gets hooked while trying to take the bait*), but also snagging when the hook is accidentally caught in a flipper or other part of the turtle body, and entanglement (*the turtle is entangled on the fishing lines*).

When the turtles are hooked, there are several possible outcomes:

1) The turtle is found dead when the line is retrieved (*quite rare in shallow sets*).
2) The turtle is found alive, the line is cut, and the turtle escapes with the hook still attached.
3) The turtle is found alive, the hook is removed, and the turtle is released.
4) The turtle is found alive, but the removal of the hook results in the turtle's injury or mortality. This is especially true when the hook is lodged deep inside the animal.

A fraction of the released turtles will experience post-hooking mortality, at a rate that depends on the location of the hook, the injury, and the turtle's characteristics and condition. When the hook is left in the turtle, the rates are higher. They are also higher for individuals deeply hooked, and for those hooked in the upper jaw, rather than in the lower jaw.

When the turtles are entangled, there are also several potential outcomes:

1) The turtle may be disentangled and released unharmed
2) It may be disentangled and released with injuries of varying degrees.
3) It may die during the disentanglement process as a result of impatience, mishandling, or lack of adequate instruments.

The proportion of entangled turtles dying will depend on the injuries suffered by the animal, and on the methods use to disentangle it. Ideally, the turtles should be brought on board to remove all the fishing line, but that process may be harmful for the larger individuals, in vessels where the decks are higher in the water. Also struggling individuals may be handled roughly to expedite the process.

Leatherbacks and loggerheads in the eastern Pacific Ocean

According to tagging and genetic studies, most of the leatherbacks that we encounter in the eastern Pacific Ocean originate in nesting beaches on the American coastline, mainly in Mexico and Costa Rica (*Fig. 5*). Tagging studies of the females leaving the nesting areas show that they return to their foraging grounds southwest of the nesting beaches, and when they are south of the Equator, frequently west of the Galapagos Islands they appear to return toward the coastal zone (*Dutton et al. unpub.; Shillinger, unpub. Fig. 6*).

Fig. 5. Leatherback nesting beaches

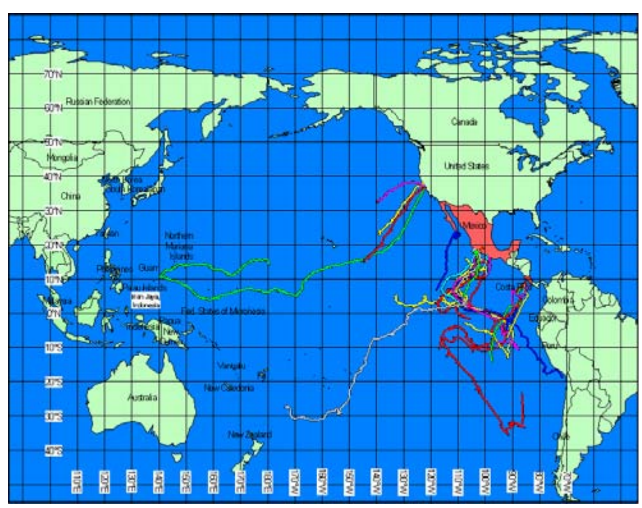


Fig. 6. Satellite tracks of leatherbacks (*Dutton, Eckert & Benson, unpublished*)

The migratory routes for the loggerhead are not well-known, but, genetic evidence (*Dutton el at. 2004*) shows that the individuals born in Australia cross the Pacific, and develop along the coast of South America, while those born in Japan are found along the Mexican coast. Some of the nesting populations of loggerheads from Japan have shown signs of recovery in recent years, but others, including those of Australia have continued to decline. The population of loggerheads nesting in Japan has declined significantly over the last decades, and there are fewer than a thousand breeding females nesting annually today. In most beaches the decline has been continuous, but in two of the main beaches there have been increases over the last 4-5 years (www.umigame.org). Integrated actions across the Pacific are needed to reverse the negative trends.

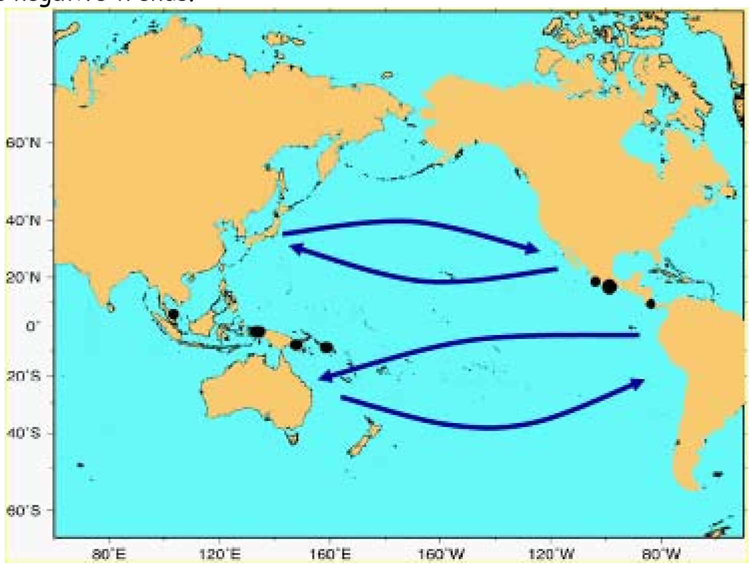


Fig. 7. Migratory routes loggerhead turtles (*inferred*)

Additional evidence of movements can be obtained from the distributions of sightings by observers in tuna boats, recorded since 1990. In particular, the distribution of sightings of dead individuals may point toward areas of interactions with fisheries (*Fig. 8*). The observer cannot attribute those deaths to any particular source, but if they coincide in areas and seasons with the operations of fisheries, these data will be helpful is developing strategies to reduce bycatches of turtles.

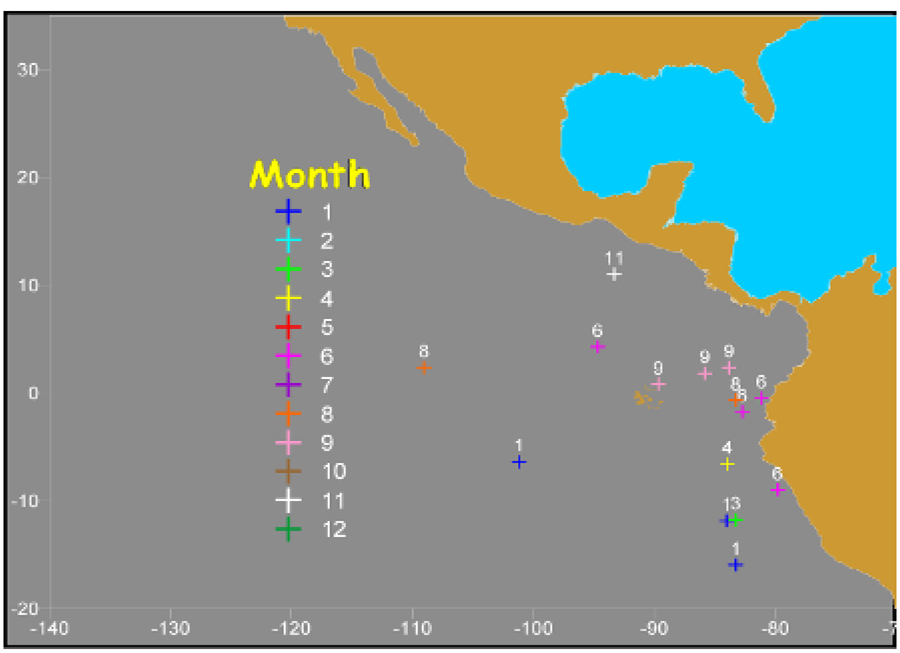


Fig. 8. Sightings of dead leatherbacks by month (*1990 - 2002*)

PROPOSED SOLUTIONS

Proposed solutions to mitigate the impact of sea turtle hookings

a) **Circle hooks**: Research conducted by NOAA with captive sea turtles has shown that the wider the hooks, the less likely that loggerhead sea turtles will attempt to swallow them (*Watson et al., 2003; Table 1, Fig. 10*). If the hook is not swallowed, then it should result in either no hooking, or hooking only in the mouth, which is more benign than deep hooking. Most hooks used in the world's longlines are of two types: J-hooks, and Japanese-style tuna hooks (*with a bent shank, and a ring*). The more common designs are shown in Fig. 9. For simplicity we'll refer to all of these, as J-hooks.

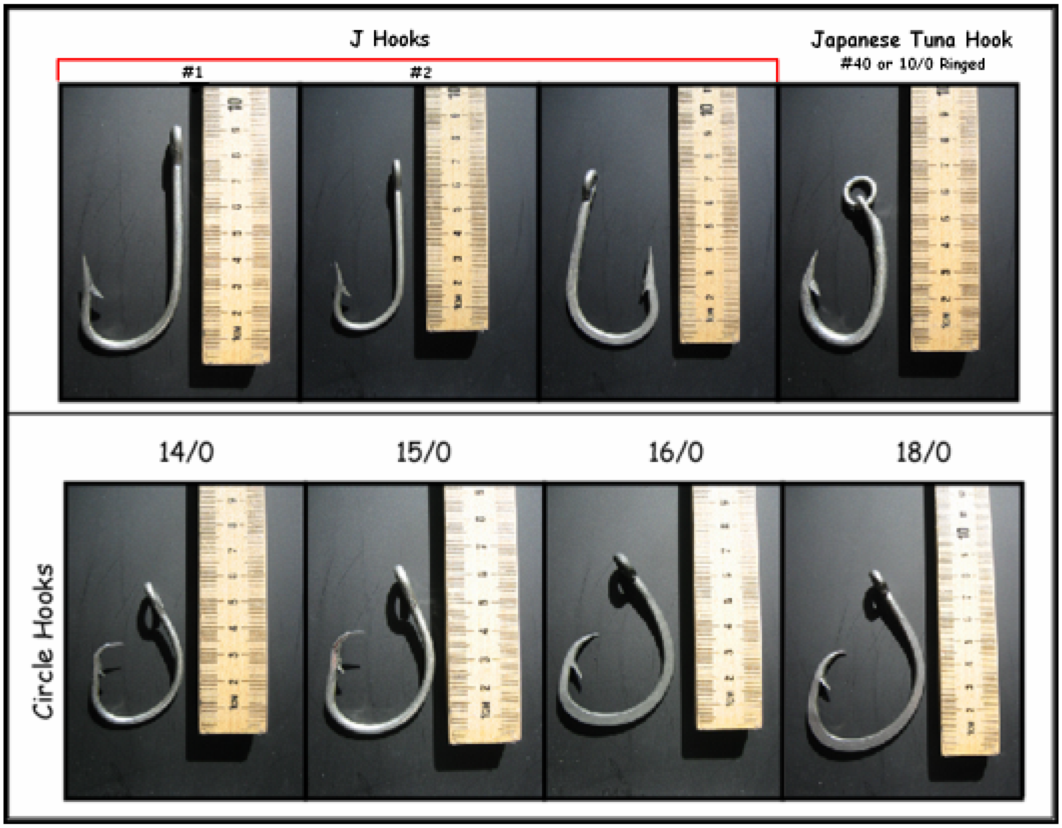


Fig. 9. Hook types

Hook Type	*Hook width*	*Hook length*
9/0 J	41 mm	78 mm
9/0 Tuna	33 mm	78 mm
10/0 Tuna	38 mm	86 mm
11/0 J	51 mm	98 mm
16/0 Circle	51 mm	73 mm
11/0 Modified J	56 mm	86 mm
18/0 Circle	57 mm	86 mm
12/0 J	57 mm	111 mm
14/0 J	63 mm	130 mm
20/0 Circle	63 mm	100 mm

Table 1. Hook dimensions

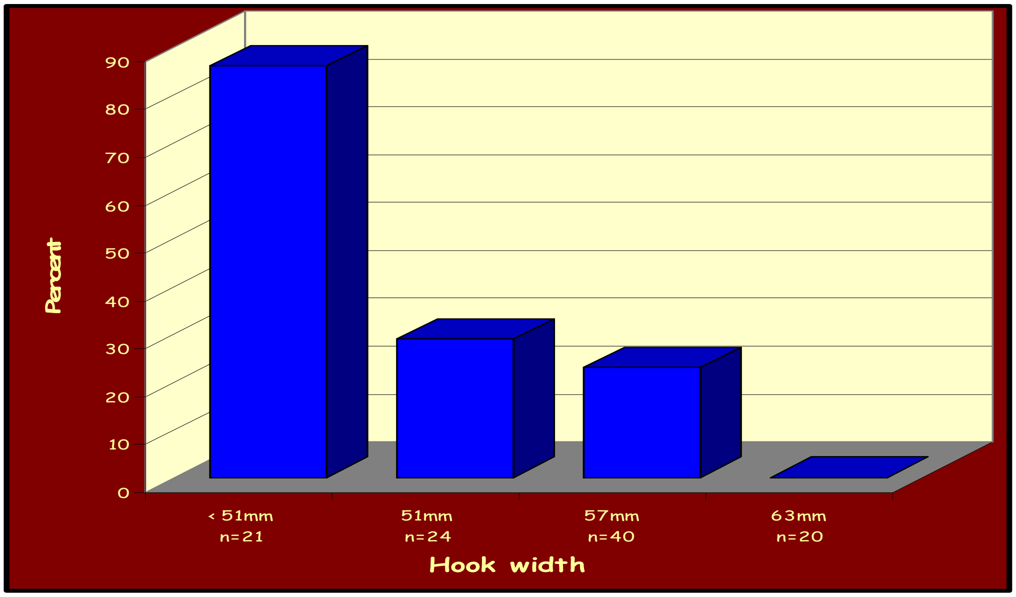


Fig. 10. Percent sea turtles that attempted to swallow hook

As a consequence of those findings, extensive field experiments were carried out in the Northwest Atlantic (*Watson et al., 2003*), these showed reductions of 60% to 90% in the hooking rates of loggerhead and leatherback turtles and increases in the catch rates of the target species (*swordfish, Xiphias gladius, and bigeye tuna, Thunnus obesus*) for at least some combinations of circle hooks and bait types, so the solution doesn't have a negative impact in the fishers' production.

b) **Hook removal**: There is a variety of instruments, called dehookers, used to remove the hooks from the turtles. Some of these are shown in
c) Fig. **11**.

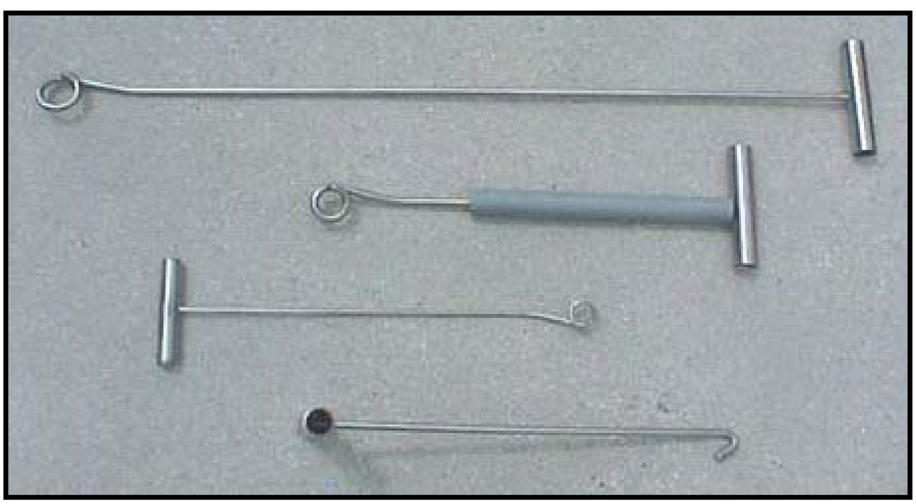


Fig. 11. Dehookers

The value of the dehookers is twofold. First, by increasing the removal of hooks, it increases the chances of survival of hooked or snagged turtles by reducing post-hooking mortality. Second, by making possible the removal of the deep hooks without harming the turtles, it reduces another important source of mortality. The PVC section shown in one of the dehookers allows the use of the instrument even when the turtle or fish is biting it.

Proposed solutions to mitigate the impact of sea turtle entanglements

a) Adequate instruments: The process of lifting turtles to high-deck boats can be facilitated by the use of dipnets, at least for many sizes of turtles. Line cutters, instruments with blades and a long handle, to assist in the removal of monofilament, can also be helpful.
b) Training on the correct techniques for disentanglement.
c) Workshops to explain the fishers the problem, and to motivate them to respond to the problem with patience and care.

IMPLEMENTATION OF THE SOLUTIONS

The program designed to implement the solutions consists of the following activities:

Hook exchange program: In order to allow the fishers to test the circle hooks, it was decided to perform an experiment during actual fishing operations. Boats owned by fishers, willing to fish with experimental gear were secured. The fishers were offered an exchange of hooks. We would replace 2/3 of their original hooks with circle hooks. The replaced hooks would remain in our possession, but they would be returned to the fishers if they wanted to reverse the exchange and return to their original hooks (*Fig. 13*). The experimental gear consisted of a line with control J-hooks paired with circle hooks of two different sizes, as shown in Fig. 12. Each line would start with a different type of hook, to avoid always placing the same type hook closer to the floats or the center of the section between floats. The sizes of circle hooks used were selected following the recommendations of Mr. Charles Bergmann, (*NOAA, Pascagoula Lab.*) according to the targets of the fisheries. For the fishery targeting tunas, billfishes, and sharks, they were Circle 16/0 and 18/0; for the fishery targeting mahi-mahi Circle 14/0 and 15/0. Observers would accompany these vessels, and record the events of importance. As of April 1, 115 vessels had volunteered to participate in the hook exchange program. The ultimate goal would be a massive replacement of the current hooks with circle hooks. Once the fishers are convinced that they can make a living with the circle hooks, and select a size that is adequate for their fisheries, it would become important to develop a financial assistance program to implement the costly replacement. Of the 115 experimental lines deployed, in only two cases were circle hooks returned and the old J hooks put back on the lines.

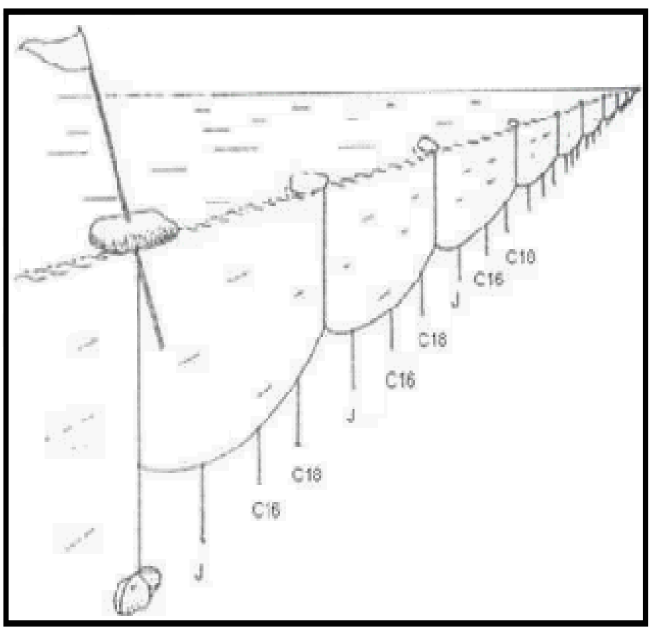


Fig. 12. Experimental line alternating J, circle 16/0 and 18/0 hooks.

Fig. 13. Bags containing the J-Hooks exchanged

Because there are two major fishing seasons, in which different sizes of hooks are utilized, the program will have to be performed in both of them. One period goes from November to April (*mahi-mahi season*), and the other from May to October (*tuna, billfish, shark season*) (*Table 2*).

Species	*Fishing type*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Mahi-mahi	Longline												
	Surface gillnet												
Tunas	Longline												
	Surface gillnet												
Billfish	Longline												
	Surface gillnet												
Swordfish	Longline												
	Surface gillnet												

Table 2. Fishing seasons by species (*prepared by J. Martínez, 2003*)

Fig. 14. Experimental longline in basket

<u>Dehooker training and distribution:</u> A donation of dehookers was received, and they were distributed to the fishers using the experimental lines and to others who attended workshops. Two sizes of dehookers, both provided with PVC bite sections, were given to every boat.

Fig. 15. Training on the use of dehookers

Observer program: Students and recent graduates of local educational institutions for fishers were trained as observers, after which they accompanied vessels with experimental lines to record hookings of the target species and of sea turtles, entanglements, and other events of relevance to the experiment. As the number of hooks per line is small, and the variability among boats is high, the observers accompany a fishing group, consisting of one large vessel and smaller vessels that fish in association with the larger ones, as in a mothership operation. As more than one of the vessels has experimental lines (usually two), the observer rotates among all of those with such lines, keeping records of the smaller vessel that he is accompanying, and, with the cooperation of the crews, records of the other smaller vessels with experimental lines. In this way, the observer promotes the use of the proper release techniques to a larger segment of the fleet, and obtains the maximum amount of data. There were no observers available with experience in this fishery, so their training and development was necessary in the first phase of the program.

Captain and crew interviews: In order to get the impressions and opinions from the fishers testing the new hooks, dehookers, and other equipment, on the advantages and disadvantages of their use, interviews were conducted after trips in which experimental lines or new equipment were tested. The questions covered preferences for size and type of hooks for the different target species, difficulties caused by the new hooks (*e.g. positioning, baiting*), and also requested suggestions for reducing mortality.

Summary of Program Objectives

- Perform experiments to compare circle hooks and J hooks in the artisanal fisheries of Ecuador.
- Promote the use of dehookers, and all available techniques and instruments to release turtles unharmed.
- Let the fishers see by themselves that they have an option to continue fishing without harming the turtles.
- Change fishers behavior and attitudes towards sea turtles.
- REDUCE SEA TURTLE BYCATCH

The origin of the program

When the status of the Pacific leatherback populations became a major conservation issue, the leaders of governments and fishing sectors of the eastern Pacific region were kept informed of the situation, and of the need for action. As part of this information, the importance of their presence at the International Fisheries Forum 2 (*IFF2*), in Honolulu, Hawaii, in June 2002, was emphasized, and the Forum was publicized at several meetings of the IATTC. Ing. G. Morán, a technical advisor to the longline exporters association of Ecuador, attended the Forum, and perceived both the seriousness of the problem, and the availability of potential solutions that could be implemented.

What the Forum brought was the realization that:

(a) It was an extensive problem, and it was not going to be solved unless everyone assumed responsibility. Many countries had already seen this, and there were efforts throughout the Pacific to solve the problem.
(b) In many places, the industry was determined to find and implement solutions.
(c) There were solutions that were simple and practical to implement, that wouldn't affect the economic viability of the fishery.
(d) There were nations and organizations that were ready to help, and the progress made by NOAA researchers could benefit all. The U.S. Western Pacific Regional Fishery Management Council was leading an effort on a scale never seen before, building a conservation program throughout the entire Pacific Ocean.
(e) There was a real threat to the longline industry, which includes shore workers, etc., in addition to fishermen.

It also connected with people working in remote areas, showing them instruments and techniques that could be applied to their fisheries.

Basically, the risks of inaction were much greater than the risks of action. In Ecuador, there are thousands of fishing vessels, and the industry produces employment for tens of thousands of families. Restrictions on fishing gear or on markets would have a major impact in a vulnerable economy. Upon Mr. Moran's return, he brought the issue up with the Under Secretary for Fisheries Resources, Mrs. Lucia de Genna, who had the courage, and the vision to launch the program in Ecuador. What started as a small project to test gear on 10 boats became a regional program covering most of the Pacific coast of the Americas. Biologists from Colombia, Costa Rica, Guatemala, Panama and Peru have gone to Ecuador to see how the program runs, how the hook exchanges are implemented, how observers are trained, etc., and they have launched programs under the sponsorship of WWF in all of those countries.

The basic approach has been to bring together people sharing these simple goals: (1) nobody wants to see sea turtles becoming extinct; and (2) nobody wants to put fishers out of work. Based on this common ground, a broad coalition was formed with the participation of many local stakeholders (*government, industry, fishers' unions and co-operatives, environmental groups*), and the support of a regional fisheries organization (*the Inter-American Tropical Tuna Commission*), with expertise in work with fishers, of a national agency of the USA with expertise on the technological solutions (*NOAA-Fisheries, Laboratories of Pascagoula, Hawaii, and La Jolla*), and international environmental groups. The financial support for the first quarter came from WWF, and for the remainder of the year the program was funded by the Western Pacific Regional Fishery Management Council, based in Hawaii.

Ecuador became the pioneer and the leader in this regional effort. The steady support of the association of exporters, the National Federation of Fishers Cooperatives of Ecuador (*led by Gabriela Cruz*), the Escuela de Pesca of Manta (*led by Ing. Guillermo Morán*), the Escuela Politécnica del Litoral (*Santa Helena*), and, on the government side, the Subsecretaría de Recursos Pesqueros, and PROBECUADOR (*led by Ing. Luis Torres*), has made a difference. The patience and understanding of the fishers themselves, and their willingness to help us find a solution, has been a source of motivation and encouragement for all participants.

As in Ecuador, the program is being advanced with many local, national and international partners and supporters including the WWF, the Western Pacific Fishery Management Council, the U.S. Agency for International Development, the U.S. Department of State, and with technical support from the IATTC and NOAA. Similar efforts are underway or under development in several countries of the western Pacific including Indonesia and the Philippines. Given the highly migratory nature of some endangered sea turtles, the urgency of the conservation challenge and the international dimension of fisheries bycatch, it is important that the efforts in Ecuador and throughout the Eastern Pacific be complemented by similar efforts in the Western Pacific.

Participants

The program was started by an initiative of the Subsecretaría de Recursos Pesqueros del Ecuador (*SRP*). It requested that the IATTC staff develop of a program to try to find a solution that would allow the continuation of the fisheries, while at the same time reducing the incidental mortality of the sea turtles. The initiative received full support from the industry, from the fishers' cooperatives, and from environmental organizations. Without the effort of the authorities and staff of the SRP, and of PROBECUADOR, this program would not have achieved its current success.

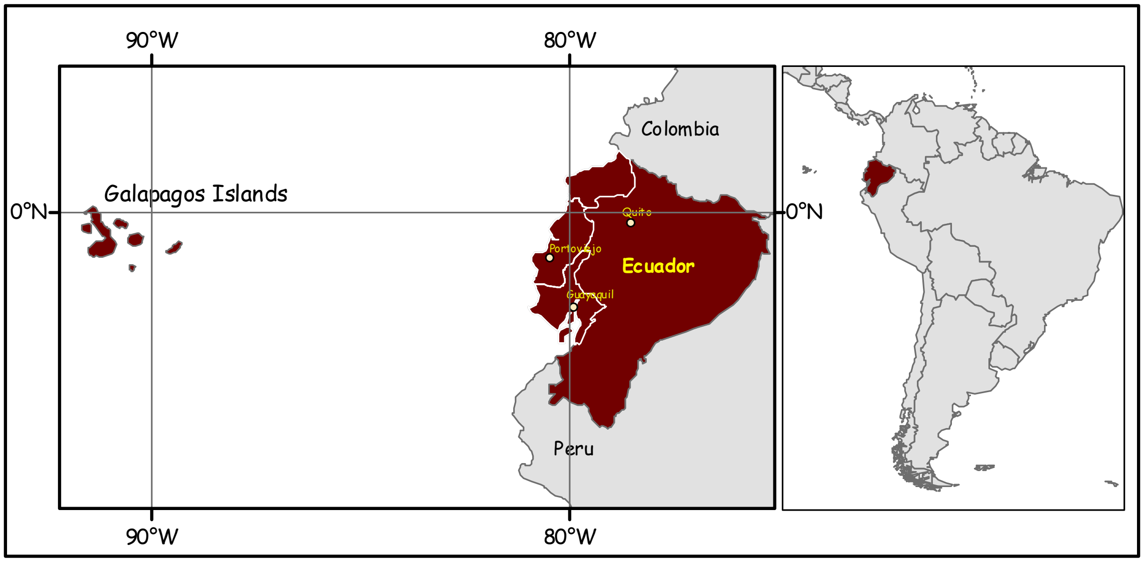


Fig. 16. Ecuador

The staff of the initial round in Ecuador were: Ing. Luis Torres, Tec. P. Cucalón, C. Sotomayor, and A. Avendaño (*SRP*), M. J. Barragán (*Fundación Jatun Sacha*), C. Bergmann, J. Mitchell, and Y. Swimmer (*NOAA*), M. Hall and IATTC field office staff in Ecuador (*E. Largacha, K. Loor, W. Paladines, C. de la A, A. Basantes, and F. Cruz*), G. Morán, and the leadership of the Asociación de Exportadores de Pesca Blanca (*ASOEXPEBLA*) were the driving forces for the initiative and the implementation. J. Martínez (*Escuela de Pesca del Pacífico Oriental*) cooperated in many ways.

The map in Fig. 17 shows the diversity of institutions and stakeholders that are participating, taking Peru and Ecuador as an example.

For subsequent stages, three researchers (Jimmy Martínez, Vanessa Velásquez, and Liliana Rendón) were hired on a full-time basis, and they cooperated very closely with Erick Largacha of IATTC-Manta. Manuel Parrales replaced Jimmy Martínez when he was appointed to a government position in Manta. All the activities of the program have been their achievement. Their professionalism and motivation have driven this program.

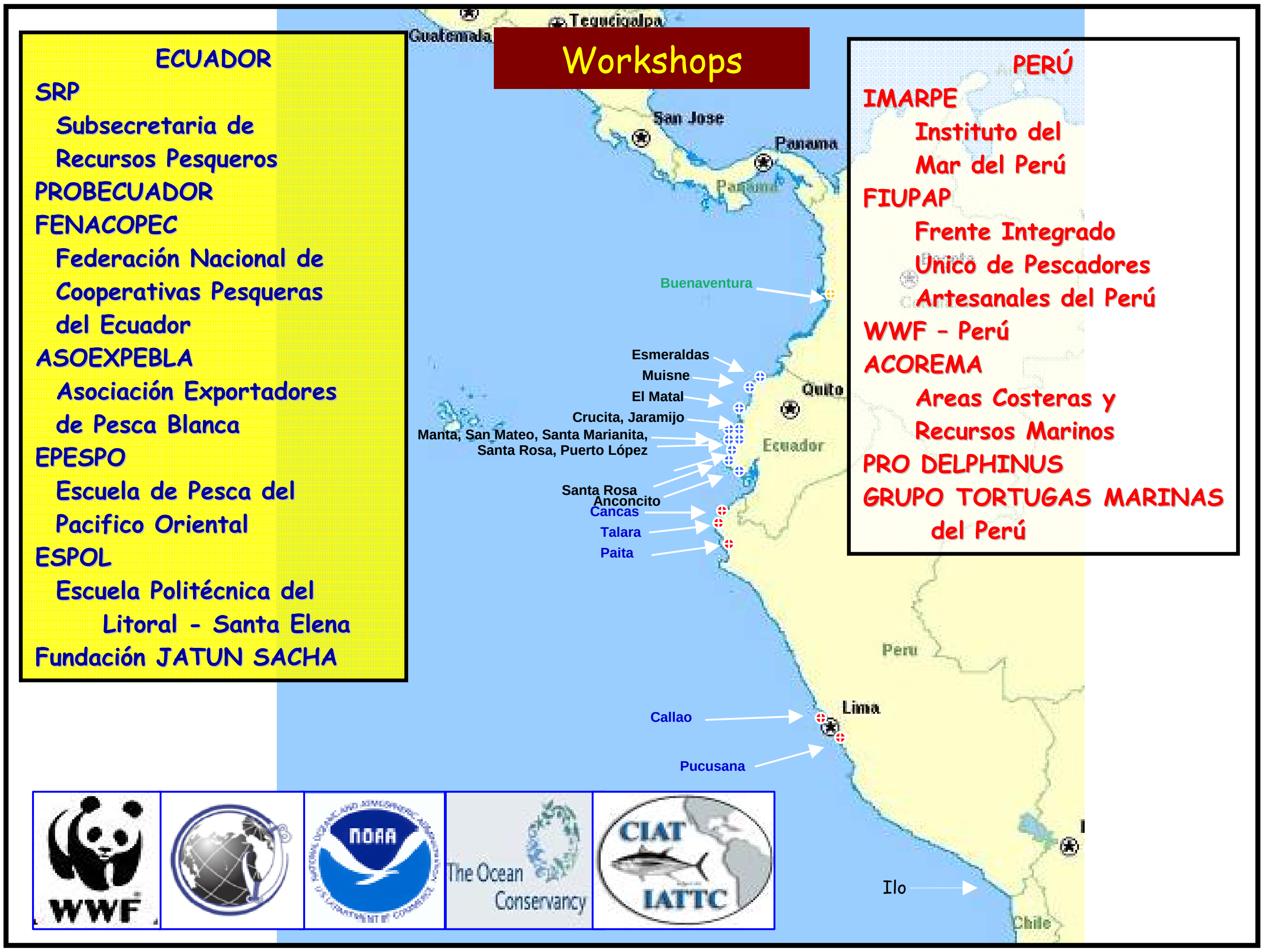


Fig. 17. Participating organizations in Ecuador and Peru, and locations of workshops

Development

The program started with a series of workshops (*Round 1, September 2003*) with the participation of representatives of all sectors, showing the commonality of purpose. In these workshops, organized with the support of all sectors, the problems, and the proposed solutions, were presented to the community of artisanal fishers. In a second stage (*Round 2*) the experiment was launched, together with the observer program. Once the experiments were under way, and as the results began to accumulate, the main subject of the workshops (*Round 3*) became discussion of those results, and the analyses of the additional steps needed to address the causes of mortality that the observer program was showing. In Ecuador, the program has reached Round 3; in Peru and Colombia Round 2 is under way; Costa Rica, El Salvador, Guatemala, Mexico and Panama are at earlier stages of development, but the process has started in all of them.

Date	Province	Location	Attendance
9/22/2003	GUAYAS	Guayaquil (Universidad Politecnica)	95
9/23/2003	GUAYAS	Playas	88
9/24/2003	GUAYAS	Anconcito	72
9/25/2003	GUAYAS	Santa Rosa	28
9/26/2003	MANABI	Manta	45
9/29/2003	ESMERALDAS	Esmeraldas	47
9/30/2003	MANABI	Santa Rosa	129
9/30/2003	MANABI	San Mateo	110
1/26/2004	MANABI	San Mateo	36
3/3/2004	MANABI	Jaramijó	30
3/3/2004	MANABI	San Mateo	20
3/4/2004	MANABI	San Mateo	30
3/5/2004	MANABI	Jaramijó	60
3/6/2004	GUAYAS	Santa Rosa	8
3/6/2004	GUAYAS	Chulluype	300
3/14/2004	MANABI	Santa Marianita	70
4/26/2004	MANABI	Santa Marianita	50
4/26/2004	MANABI	San Mateo	70
4/27/2004	MANABI	Arenales de Crucita	35
4/28/2004	MANABI	Los Esteros	47
4/28/2004	MANABI	Puerto López	40
4/29/2004	MANABI	El Matal	80
4/30/2004	ESMERALDAS	Esmeraldas	28
5/1/2004	ESMERALDAS	Muisne	6
5/3/2004	GUAYAS	Anconcito	36
5/5/2004	GUAYAS	Santa Rosa	148
5/8/2004	ESMERALDAS	Esmeraldas	18
7/30/2004	MANABI	Santa Marianita	42
9/10/2004	GUAYAS	ANCONCITO	11
9/15/2004	MANABI	Tarqui	25
9/16/2004	MANABI	Manta	10
9/18/2004	MANABI	Puerto Lòpez	60
9/21/2004	MANABI	Muelle de Manta B/P Buenos Aires	26
9/25/2004	MANABI	Tarqui	27
9/27/2004	MANABI	Manta	75
9/27/2004	MANABI	Tarqui	22
9/29/2004	ESMERALDAS	UPROCOPES (La Poza)	13
9/29/2004	ESMERALDAS	Muisne	12
10/16/2004	MANABI	Puerto López	15
10/20/2004	MANABI	Tarqui	27
10/27/2004	GUAYAS	Anconcito	45

Table 3. Workshops organized in Ecuador

DATA SUMMARIES

Ecuadorian artisanal fishery: fleet, gear, and fishery description

a) Fisheries: There are two major fishing seasons (*Table 2*) for the Ecuadorian artisanal fleet, and for many of the other floats operating in the southeastern Pacific: a "warm water" fishery, during the period November to April, but peaking in January-February, with mahi-mahi (*Coryphaena hippurus*) as the main target, and a "cold water" fishery from May to October, targeting mainly bigeye tuna (*Thunnus obesus*), but with a variety of targets including several species of billfishes, sharks, etc.

b) Vessels: There are two main sizes of vessels that participate in both fisheries: small units, called "fibras" because of their fiberglass construction, and the larger ones called "botes." When fishing is very close to the coast, fibras can operate independently, but the vast majority of the time they operate with a bote which tows a number of fibras, acting as a mothership. The bote receives and stores the catch, carries supplies, and, in general, supports the fishing by the fibras. Fibras pay for the support service with a portion around 45% of the catch. The main characteristics of fibras and botes, and of the fishing operations, are summarized in box plots that show the center of the distribution (*median, 25th and 75th percentile*), and give an idea of the overall variability. The symbols are in Appendix 1.

c) Fishing areas: Figure 18 shows the location of the sets for the tuna fishery. Mahi-mahi sets tend to occur in more southly locations, during the period of the year when a warm water mass is present in the area.

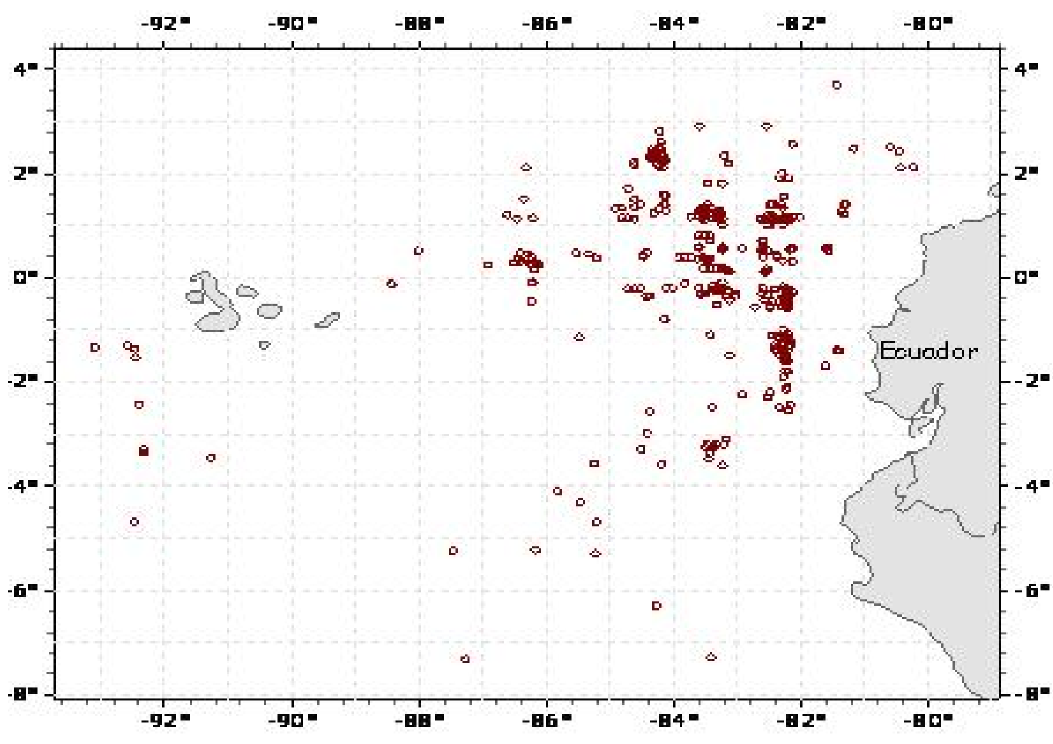


Figure 18. Spatial distribution of longline sets in the tuna fisheries.

Some rounding off of positions is apparent, which results from the lack of GPS systems in many of the fibras.

Vessel length

Fibras have a very narrow range of lengths. The vast majority ranging from 7.5 m to 7.7 m. They are also similar in, color, design, etc. Predominant outboard motors are Yamaha 75 HP. The hooks are carried in most cases on fixed wooden partitions, but in other cases in removable baskets.

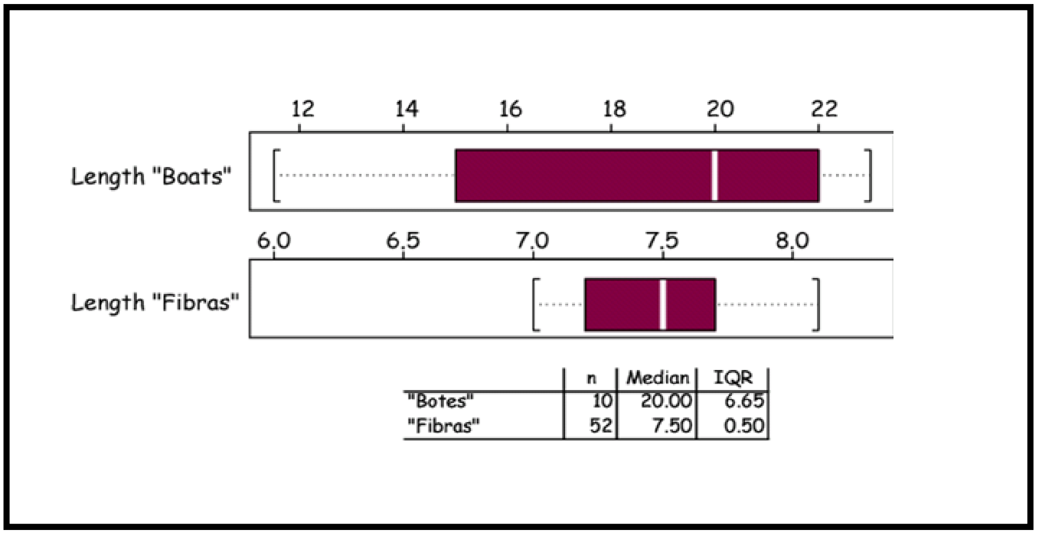


Fig. 19. Vessel length distribution for botes and fibras (in meters)

Length of fishing lines

Most botes use lines 2.5 to 6 nautical miles in length; fibras tend to have shorter lines, generally less than 4.5 nautical miles.

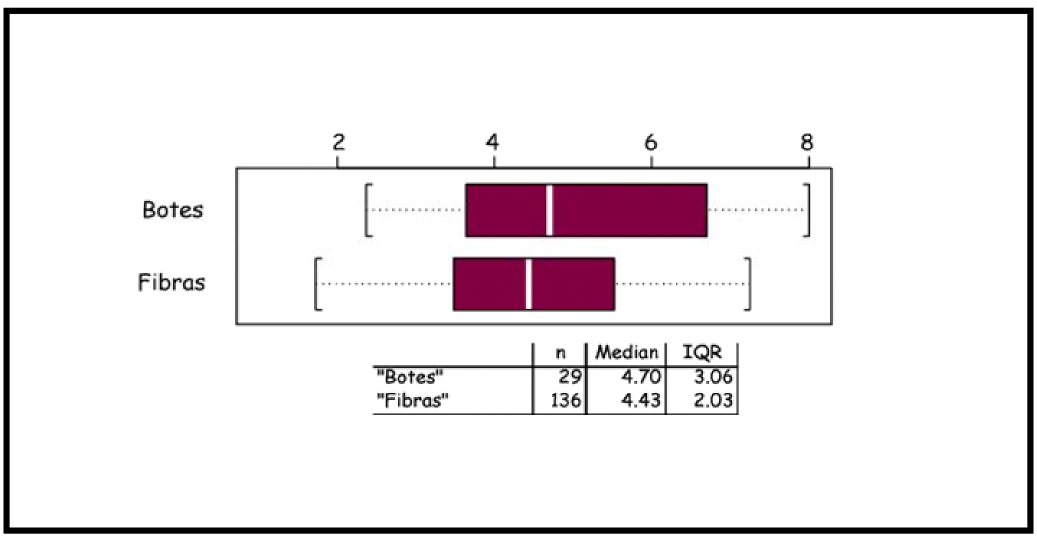
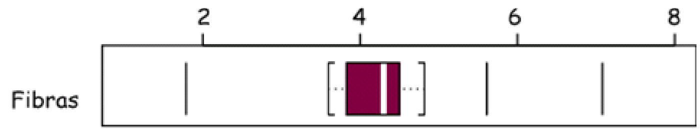


Fig. 20. Distribution of lengths of fishing lines in nautical miles (nm) - tuna fishery

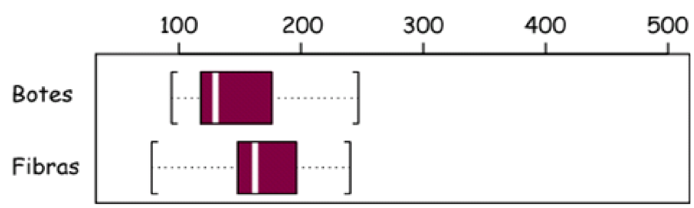


	n	Median	IQR
"Botes"	1	1.79	
"Fibras"	18	4.30	0.64

Fig. 21. Distribution of lengths of fishing lines in the mahi-mahi fishery (in nm)

<u>Number of hooks per line</u>

In the tuna fishery, and in spite of the longer lines, botes deploy fewer hooks per line than fibras (*median of 163 for fibras versus 130 for botes*)



	n	Median	IQR
"Botes"	29	130.00	58.00
"Fibras"	136	162.50	47.25

Fig. 22. Number of hooks per line tuna fishery

In the mahi-mahi fishery there are data for 20 lines over two seasons. The number of hooks is much greater than in the tuna fishery, and there appears to be some inter-annual variability, but the sample sizes are not adequate for testing.

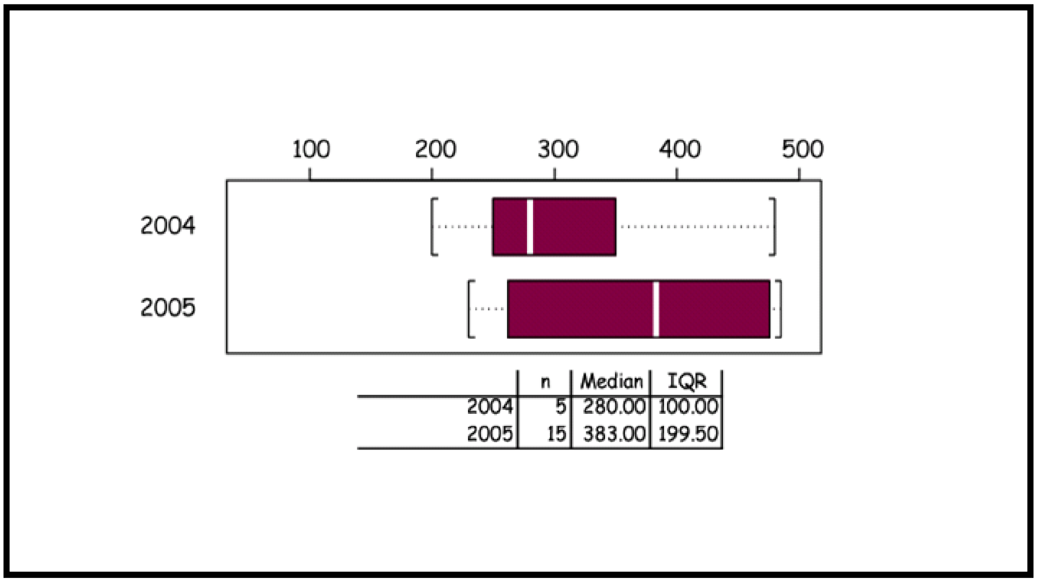


Fig. 23. Number of hooks per line mahi-mahi fishery

Number of fibras towed per bote

In order to save fuel, and to extend the geographical range of the fibras, they operate associated with a larger bote. The number of fibras towed by bote is shown in the following histogram:

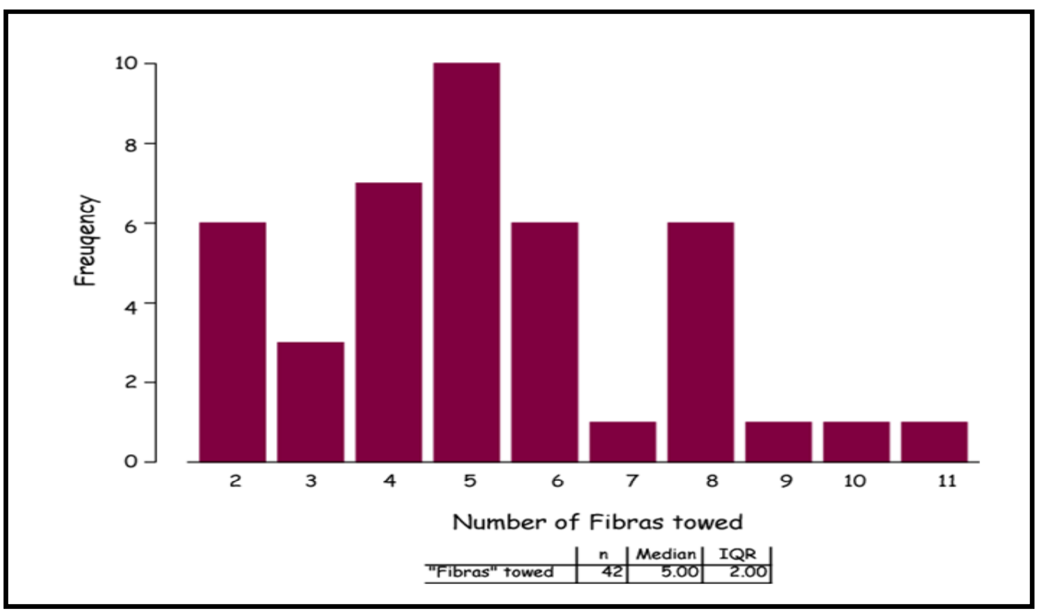


Fig. 24. Number of fibras towed per bote tuna fishery

In the mahi-mahi fishery the numbers observed range from 4 to 8.

Fishing trips

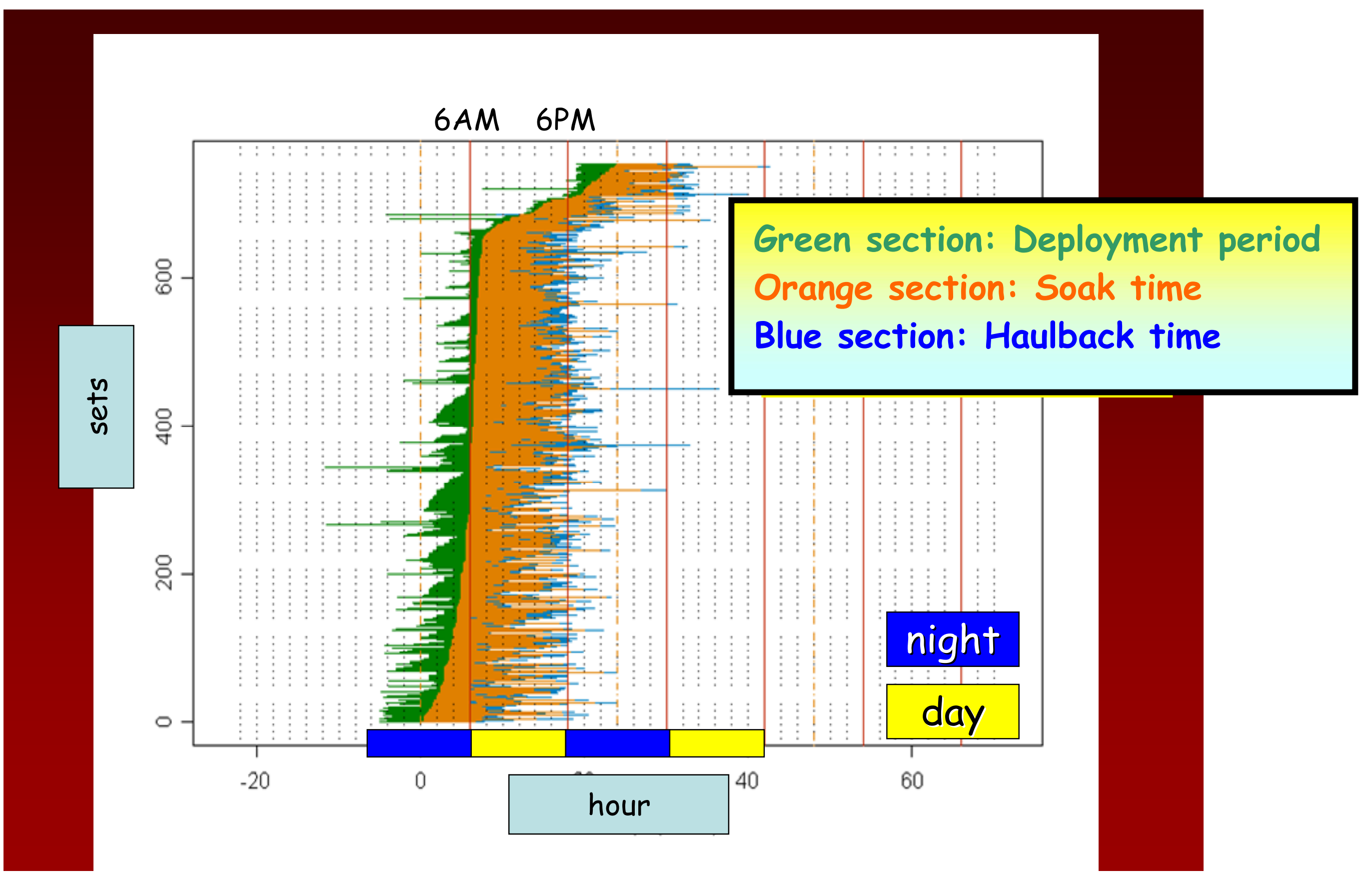
The vast majority of the trips in the tuna fishery take 13 to 17 days, during which time they typically make 8 to 9 sets. Botes and fibras are very similar in this respect. The fibras bring their catch to the "mothership" for storage, and receive supplies from it. Most of the fishing in this period took place in an area half way between Galapagos Islands and the continent, as shown in the map (*Fig. 18*). Mahi-mahi trips are somewhat shorter, around 9 to 10 days, and the average number of sets is 7 per trip. It is much more common during the mahi-mahi fishing season to see trips lasting only one day, because of the proximity of the fishing grounds to the coastal zone.

Fishing period

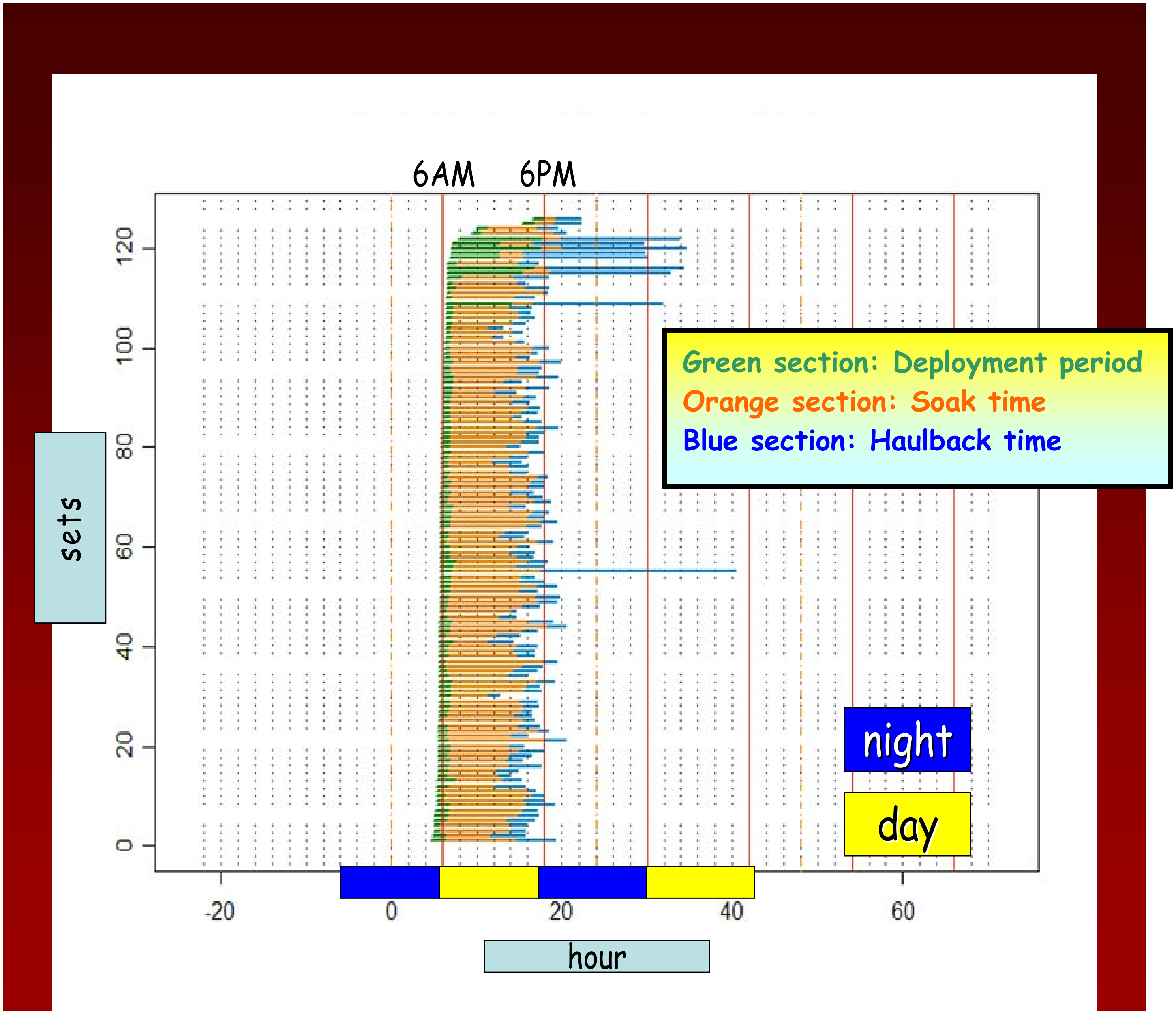
Close to 80% of the sets in the tuna fishery occur during daylight. This is in part conditioned by the need to fish for bait, which in some cases takes place at night (*Figure 25*). All mahi-mahi fishing occurs during the day.

Figure 25. Timing of sets for the tuna and mahi-mahi fisheries. Each horizontal line is a set (*direct or secondary observations*). Green section is time of deployment, orange section is soak time, blue section is haulback time. Vertical red lines indicate 6AM and 6PM each day.

Timing of longline sets tuna fishery



Timing of longline sets mahi-mahi fishery



Sea turtle interactions

The table below summarizes the interactions remaining after the full set of quality controls described in the next section has been applied. The table to the right shows the complete set of interactions for the tuna fishery without any quality control. Table entitled Tuna Fishery All includes, in addition to the data recorded directly by the observer, all reports by fishers on vessels with experimental gear, trips with unbalanced designs, etc. The four records of leatherbacks by C18 hooks came from fishers from a single trip, and could not be confirmed,

Total number of turtle interactions

	Tuna fishery				Mahi-mahi fishery				Tuna fishery ALL			
	Hooked			Entangled	Hooked			Entangled	Hooked			Entangled
	J	C16	C18		J	C14	C15		J	C16	C18	
Olive ridley	8	3	1	20	13	10	14	17	19	8	2	92
Black	2	2		12	5		4	25	7	5		61
Hawksbill					6	5	1	6	3	1		23
Loggerhead									4	1		19
Leatherback				1							4?	1
Unidentified									3	1		
Total	10	5	1	33	24	15	19	48	37	16	6	196

Table 4. Number of interactions by species and by hook type for tuna and mahi-mahi fishery.

PRELIMINARY RESULTS

Databases, and data quality controls

Data from observer trips constitute the database. In a typical trip, a bote will tow 4-6 fibras, and, of these, probably two would have experimental lines. The observer would make direct observations on one of the fibras, and sometime during the trip he would switch to the other fibra to get data there. During the trip, the observer can collect or receive a fair amount of information from the other fibra with circle hooks, and even from fibras with only J hooks. Our hopes of using these data to augment the database were quickly abandoned when we compared the sea turtle hooking rates, which were considerably lower in the "secondary" observations than on the direct data set. So from then on, all estimations of sea turtle hooking rates were based only on direct observations. However, these secondary observations could be useful for some purposes, such as determining the species composition of the catch (*which can be verified by the observer during transfer to the bote*), or other variables, such as the location of hookings in the turtle, etc., on the grounds that once the crew reports the event, there is no point in misreporting the details. Thus a limited use can be made of the secondary observations, but we have relied only on direct observations for the critical pieces of information. Early in the program, some observers produced data for which it could not be ascertained whether they were direct observations, so those data were excluded.

Notation for the circle-hooks: The different sizes of circle hooks that we used were C14, C15, C16, and C18. The C14 and C15 are made by MUSTAD (*catalog Nr 399660*), with no offset. We also tested a reinforced MUSTAD triple strength (3X, *catalog 39966*), two stainless steel circle hooks made by a Korean manufacturer and distributed by Lindgren-Pitman (*a 16/0 and an 18/0 stainless steel hooks with a flat forge*), and a 16/0 Carbon-Steel hook, also from Lindgren-Pitman (*LP-CIR-HK-BL-0*), all with 10°offset.

Performing these tests on regular fishing boats during their operations has a huge advantage because not only are we collecting statistical data for analyses, but the fishers are getting a demonstration of the performance of the hooks,. The downside of this approach is that the fishers have control of the operations, and in many cases they rearrange the hooks to fit their perceived needs. The difficulty of the crewman baiting hooks that constantly change in shape and size frequently leads to regrouping of hooks of similar characteristics, which destroys the experimental design selected. The data for all sets with hooks regrouped were eliminated from the analyses. Finally, preferences for some circle hook sizes, or, more commonly, rejection of a size considered to be too large, resulted in some cases in crews replacing or eliminating circle hooks of some sizes. When the hooks were initially placed in the line, the proportion of the three hook types (*J, C16, and C18*) was 1:1:1, and this operation was always witnessed and assisted by program staff. As fishing progresses, it is to be expected that there will be alterations of these proportions (*e.g. hooks lost and replaced with the wrong type, etc.*), but we set limits on these ratios, and eliminated the data for all sets for which any of the ratios (J hooks/C16 hooks, and J hooks/C18 hooks) went below 0.5 or above 2.5. A set had to meet both constraints, for the data to be retained.

The inexperience of the observers was a source of data quality issues, especially at the beginning of the program. One of the main problems was the failure to clearly identify direct and secondary observations, and in the absence of certainty the data were not used.

Occasionally, the boat would fish with hook and lines, but in a modality called "a la rueda" (as a wheel), that consisted in deploying a small number of hooks, mostly in a vertical setting, and retrieve and re-bait them constantly. Sometimes this way of fishing was associated with floating objects found adrift. The data for these sets were also eliminated.

All these quality controls resulted in considerable losses of data, and in quite a few cases no data for a trip were used, but it was considered better to work on a relatively small, but clean, data set than on a larger one with biases of different kinds. The database originally contained data for 66 observer trips, but after the quality controls were applied, the remainder were data for 41 observer trips in the tuna fishery, which sampled 185 sets in 136 different platforms (botes or fibras), producing data for 20,570 hooks. The major source of data loss was vessels with unbalanced designs, including a few that were only willing to test one of the sizes of circle hooks. In the mahi-mahi fishery 18 observer trips on 7 different platforms (1 bote and 7 fibras) produced data for 126 sets using 32,200 hooks.

Also, the limitations of the data did not allow us to standardize the results, so all figures are simply nominal hooking rates. In the future, we'll try to explore improvements on this aspect, to obtain better estimates of the rates. However, from the point of view of the comparison between hooks, it is expected that the experimental design will overcome most of the problems. As the objective of the observer program was to document the results of the experiment, rather than to estimate bycatch rates or total bycatches, no attempt was made to place observers randomly with regard to port or period of departures, type of platform, etc, or in proportion to the different strata present in the fishery. Important fishing regions (Esmeraldas to the north and Anconcito-Santa Rosa de Salinas to the south) are absent or poorly represented in the data.

As the program is in progress, the statistical analyses of the results will be continued over the next fishing season for each fishery. For the tuna fishery, this particular season did not produce large catches of tunas or swordfish normally the most desirable targets, so the fishing areas, mode of operation, and species composition of the catch may not be representative of the results in a season with good catches of the main target species. In the case of the mahi-mahi fishery, the sample size, in terms of number of trips or vessels sampled, is clearly insufficient, and the very short seasons are making it difficult to produce larger samples because of the catch rates of the circle hooks (*to be discussed later*). However, some preliminary results should be presented because of the urgency of the situation, and the need to share information with other researchers undertaking these types of experiments. It is important to answer the question as to whether these hooks can produce a significant reduction in sea turtle mortality, so that we don't end up pushing for a solution that is not effective. The data for the mahi-mahi fishery should be considered as very preliminary; all those results should be taken as a first indication that may change significantly with more coverage.

There are two basic questions to answer to help the managers assess the options:

1) <u>Does the use of circle hook result in a significant **reduction** is sea turtle mortality</u>?

This question really contains two component questions:

a) Do circle hooks reduce the hooking rates of sea turtles?
b) Do circle hooks change the location of hooks in hooked turtles in a way that results in higher survival?

2) <u>Does the use of circle hooks result in target catch rates that are **not less** than those with hooks</u>?

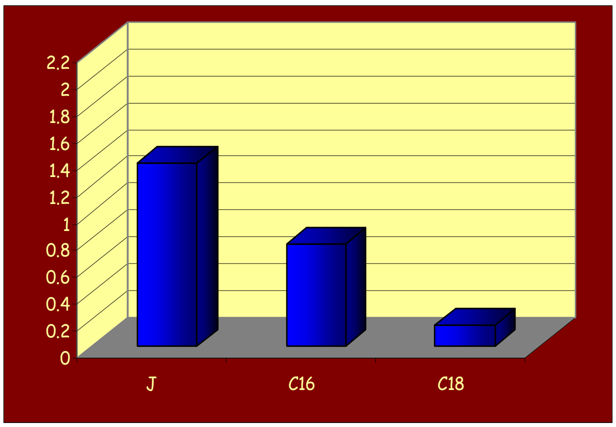
From the point of view of management, we need to "prove" with an adequate null hypothesis that circle hooks are better than J hooks in the sense of reducing sea turtle mortality. From the point of view of the fishers, the question is: Could they keep fishing without decreasing their catches, without losing their economic viability? In some cases, the use of circle hooks has resulted in higher catch rates for the target species, which would help improve their acceptance by the fishers. However we think that even if the catch rates remain at the same level as before, the replacement would be a positive step if it reduces sea turtle mortality. A WIN--TIE outcome is good enough. The full answer to this question goes beyond the catch rates. The species and size composition of the catch affect the economic results of the fishery, and the evaluation that the fishers will make of the performance of the hooks will be driven by this broader answer.

Sea turtle hooking rates

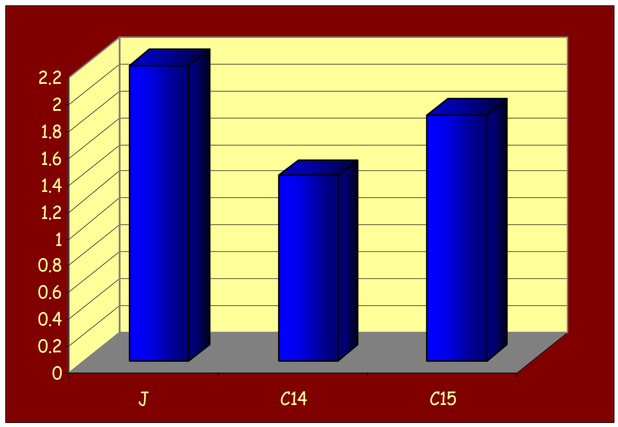
QUESTION:

DO CIRCLE HOOKS REDUCE THE HOOKING RATES OF SEA TURTLES ?

A comparison of hooking rates (per 1000 hooks) by fishery, type and size of hook is shown in Fig. 26.



Tuna fishery



Mahi-mahi fishery

Fig. 26. Sea turtle hooking rates (*per 1000 hooks*)

Note: In the tuna fishery, the control hook is most commonly a Japanese tuna hook Nr. 9 or 10. In the mahi-mahi fishery the control J hook is most commonly a Nr 4-5 J hook, or a Japanese tuna hook Nr. 7 or similar.

In the tuna fishery, C16 hooks cut hooking rates of sea turtles by 44%, and C18 by 89%, using the data for all time periods, and 60% and 87%, respectively, if we use only the predominant day set data (Table 5 below).

To test the results statistically, given the high number of trips with zeroes for turtle hookings for all types of hooks (*and therefore lacking information for the comparison*), a process was used dropping from the analyses sets and trips in which the hooking rates for the hooks compared were both zeroes, grouping the sets per trip into a single data point, and performing a one-tailed paired-t test, and a sign test. A similar process was used for the target catch rate comparisons. The one-tailed characteristic of the test comes from the managers' questions presented earlier. The results of the tests are quite encouraging, in spite of the limited sample size; the reductions in sea turtle hooking rates are significant, or quite close to significant, for the usual 5% standards, and they are significant if we use the relaxed standards more commonly applied to ecological experiments with low level of control, etc. Comparing J with C16 hooks, the paired-t test yields $p = 0.139$, and the sign test $p = 0.035$, with an average paired difference of 0.009 per hook; the comparison against the C18 yields a paired-t value of $p = 0.019$, a sign test value of $p = 0.062$, with an average paired difference of 0.018 per hook.

There are several statistical issues that should be addressed in the future, including:

-- a) The development of a weighting system for trips with different numbers of sets (or of hooks).

-- b) The heterogeneity of the controls. Under the category of J-hooks, there is a mixture of Japanese-style tuna hooks, J-hooks, all in different sizes and materials.

-- c) The heterogeneity of the treatment hooks; the 18/0 hooks are all similar, but 3 different types of 16/0 hooks were used in the experiment. All the 16/0s were of similar shape, but the materials were different, Are there differences between hooks of the same size and shape, but made out of carbon-steel, duratin, or stainless steel?

-- d) The lack of control of the baiting operations: heterogeneity and recording difficulties.

Table 5. Sea turtle hooking rates (*nominal per 1000 hooks*) in the tuna fishery, by type and size of hooks, percent change with respect to the J hooks, tests values for the dataset for ALL time periods combined, and estimates for day sets only. The upper p value in the cell is the paired t-test result; the lower is for the sign test.

TIME PERIOD	J	J vs C16	C16	J vs C18	C18	TRIPS
ALL	1.36		0.76		0.15	41
% Change		-44.1		-89.0		
J vs. Hook		p = 0.139 *p (sign) = 0.087*		p = 0.019 *p (sign) = 0.062*		
DAY SETS	1.68		0.68		0.22	34
% Change		-59.5		-86.9		

In the mahi-mahi fishery, the number of trips was quite limited, and statistical tests may be premature. One of the problems is that, of the 18 trips for which data are available, 4 were made by the same boat, so the variability among vessels is poorly represented. Still, some preliminary information can be discussed. First of all, the J hook that is the control in this fishery is not the same as in the tuna fishery. They are much smaller; for the Japanese "tuna style" hooks the sizes are usually around Nr. 7, compared to the Nr. 10 used in the tuna fishery. For the J hooks, the numbers are variable, but Nrs. 4 and 5 are quite common. The preliminary hooking rates were 2.20 turtles per 1000 hooks for the J hooks, 1.38 turtles/1000 hooks on the C14 hooks, and 1.83 turtles/1000 hooks on the C15 hooks. The percent reduction in the hooking rate was 37% for the C14 versus the J, and 17% for the C15 versus the J. There is no reason to believe that the C15 (*the larger one*) would have a higher capture rate than the C14, and this is probably a consequence of the very low sample size. The sea turtle hooking rates are considerably higher than for the tuna fishery. At this point, we can't say whether this difference is due to area differences, sea turtle density differences, or gear differences (*e.g. smaller hooks are swallowed more easily*). More data are needed to explore these possibilities. All sets in the database are diurnal, which reflects the nature of the fishery.

Table 6. Comparison of hooking rates for sea turtles in the tuna and mahi-mahi fisheries, and percent changes with respect to the control J hooks.

HOOK	J	J vs C16	C16	J vs C18	C18
Tuna Fishery	1.36		0.76		0.15
% Change		-44.1		-89.0	
HOOK	J	J vs C14	C14	J vs C15	C15
Mahi-mahi Fishery	2.20		1.38		1.83
% Change		-37.3		-16.8	

ANSWER:

YES, BY A LARGER AMOUNT IN THE TUNA FISHERY, AND BY A SMALLER, BUT STILL IMPORTANT AMOUNT, IN THE MAHI-MAHI FISHERY.

Location of hook in the turtle

QUESTION

DO CIRCLE HOOKS RESULT IN MORE BENIGN (SURVIVABLE) HOOKINGS ?

Turtles can be hooked in many parts of their bodies. There are several possibilities:

- Accidental hookings: the turtle just gets snagged by a moving line, or gets hooked by chance while swimming near the line. These are frequently on the flippers, but they could be almost anywhere.
- Turtle gets hooked while taking the hook, usually trying to get the bait.
  - Mouth hooking
    - Upper jaw
    - Tongue
    - Lower jaw
  - Deep hooking (*bait and hook are swallowed*): hooks lodge past the mouth, in the esophagus, or deeper.

The most dangerous hooking is the deep one, followed by the upper jaw and upper part of the mouth, considered dangerous because of the proximity to the brain of the turtle. Turtles hooked in the lower jaw are believed to have much greater survival rates. External hookings on flippers, etc., may have even less impact on survival. Our objective is to reduce to the minimum possible the "bad hookings" which include deep hookings, upper jaw hookings, and tongue hookings. To produce a simple statistical test, we will compare the proportion of "bad hookings" for the different hooks. Only data showing clearly the location of hooking could be used, so the sample size was further reduced to 10 hookings on J hooks and 4 on C16 hooks in the tuna fishery, and to 25 on J hooks, 15 on C14 hooks and 17 on C15 hooks in the mahi-mahi fishery. The impacts of all hookings are considerably reduced if hook and line are recovered completely prior to the release of the turtle. The danger of the different hooking locations comes from two sources: the physical impact of the hooking injury on the individual, and the additional damage that can be caused by attempts to recover the hook without adequate instruments.

Changes in hooking location Tuna fishery		
	% ("bad hookings")	Simple test of proportions vs J (one-tailed)
J hooks	70%	
C16	25%	$p < 0.05$
C18	40%	$0.1 < p < 0.2$
Caveat: Small number of hookings		

Table 7. Changes in hooking location by type and size of hook tuna fishery.

Changes in hooking location Mahi-mahi fishery		
	% ("bad hookings")	Simple test of proportions vs J (one-tailed)
J hooks	96%	
C14	53%	$p < 0.01$
C15	18%	$p < 0.001$
Caveat: Small number of hookings		

Table 8. Changes in hooking location by type and size of hook Mahi-mahi Fishery.

ANSWER:

YES. FOR THE COMPARISON C16 VERSUS J, THE PROPORTION OF BAD HOOKINGS WENT FROM 70% TO 25%, A HIGHLY-SIGNIFICANT CHANGE. THE COMPARISON WITH THE C18 HOOKS IS COMPLICATED BY THE SMALL NUMBER OF HOOKINGS.

YES. IN THE MAHI-MAHI FISHERY, THE DIFFERENCES ARE VERY CLEAR. THE PROPORTION OF SWALLOWED OR UPPER JAW HOOKS GOES FROM 96% OF ALL J HOOKS, TO 53% OF THE C14 HOOKS, TO 18% OF THE C15 HOOKS.

In spite of the limited sample sizes, the impact of the circle hooks in changing the location of the hookings is consistent, and of considerable magnitude. As the location of the hooking is one of the determinants of post-hooking survival, and the reduction in "bad hookings" is very large, we can expect a reduction in sea turtle mortality from this source.

Estimating the total impact of circle hooks to reduce sea turtle mortality

As stated earlier, circle hooks can affect sea turtle mortality in two different ways: (*1*) they can affect the hooking rate, and (*2*) they can affect the location of hooks in hooked turtles. The reduction in hooking rate translates directly into lower mortality; fewer turtles hooked, fewer deaths. To assess the impact of the changes in the location of hooks in hooked turtles requires an additional piece of information to try to quantify its significance. It is not easy to estimate post-hooking survival of sea turtles, and scientists have been compiling information from different sources to get the best estimates. A recent report (*Epperly and Boggs, 2004*), produced a table that is reproduced here:

Nature of Interaction	**Released with hook and with line greater than or equal to half the length of the carapace**	**Release with hook and with line less than half the length of the carapace**	**Released with all gear removed**
Category	Hardshell (Leatherback)	Hardshell (Leatherback)	Hardshell (Leatherback)
I Hooked externally with or without entanglement	20 (30)	10 (15)	5 (10)
II Hooked in upper or lower jaw (not adnexa[1]) with or without entanglement	30 (40)	20 (30)	10 (15)
III Hooked in cervical esophagus, glottis, jaw joint, soft palate, or adnexa (and the insertion point of the hook is visible when viewed through the mouth) with or without entanglement	45 (55)	35 (45)	25 (35)
IV Hooked in esophagus at or below level of the heart (includes all hooks where the insertion point of the hook is not visible when viewed through the mouth) with or without entanglement	60 (70)	50 (60)	n/a[2]
V Entangled Only	Released Entangled 50 (60)	Released Entangled 50 (60)	Fully Disentangled 1 (2)
VI Comatose / resuscitated	n/a[3]	70 (80)	60 (70)

Table 9. Post-hooking mortality estimates (from Epperly and Boggs 2004).

Using the estimates from Table 9, it is possible to compare the expected mortality resulting from the different distributions of hooking patterns. The post-hooking mortality of deeply-hooked turtles with all gear removed is not given in the table (*because removing it is not recommended*), so a conservative value of 50% was used. The set of values with and without the gear removed was used to construct two basic scenarios, a best-case, and a worst-case. Only data for which the location of the hook was clearly stated and documented were used. In the absence of adequate data for the C18 hooks, it was decided to compare only the distribution from the C16 hooks, and use these values later.

	Post-Hooking Mortality Scenarios Tuna Fishery									
Hook	WORST CASE					BEST CASE				
Location										
	% Mort.	J	Mort.	C16	Mort.	% Mort.	J	Mort.	C16	Mort.
Deep	60%	4	2.40	0	0	50%?	4	2	0	0
Upper Jaw	45%	3	1.25	1	0.45	25%	3	0.75	1	0.25
Lower Jaw	30%	2	0.60	2	0.60	10%	2	0.20	2	0.20
External	20%	1	0.20	1	0.20	5%	1	0.05	1	0.05
		10	4.45	4	1.25		10	3	4	0.50
Scaling		100%	44.5%	100%	31.2%		100%	30%	100%	12.5%
Reduction				-32%					-58%	

Table 10. Post-hooking mortality scenarios for the tuna fishery. The worst-case scenario is based on the fishers' leaving the gear in and on the turtle, while the best-case scenario is based on the full removal of all gear.

Note: Upper jaw includes hookings in the upper jaw, tongue, and jaw joint. External hookings include fins, and axila.

	Post-Hooking Mortality Scenarios Mahi-mahi Fishery													
Hook	WORST CASE							BEST CASE						
Location														
	% Mort.	J	Mort.	C14	Mort.	C15	Mort.	% Mort.	J	Mort.	C14	Mort.	C15	Mort.
Deep	60%	20	12	5	1	1	0.2	50%?	20	10	5	2.5	1	0.5
Upper Jaw	45%	3	1.35	2	0.9	2	0.9	25%	3	0.75	2	0.5	2	0.5
Tongue	45%	1	0.45	1	0.45	0	0	25%	1	0.25	1	0.25	0	0
Lower Jaw	30%	0	0	5	1.5	8	2.4	10%	0	0	5	0.5	8	0.8
External	20%	1	0.2	2	0.4	6	1.2	5%	1	0.05	2	0.1	6	0.3
		25	14	15	4.25	17	4.7		25	11.05	15	3.85	17	2.1
Scaling		100%	56%	100%	28%	100%	28%		100%	44%	100%	26%	100%	12%
Reduction				-50%		-50%					-40.9%		-72.7%	

Table 11. Post-hooking mortality scenarios - mahi-mahi fishery. The worst-case scenario is based on the fishers' leaving the gear in and on the turtle, while the best-case scenario is based on the full removal of all gear.

The tables show a reduction in mortality in the tuna fishery of 32% to 58% of the hooked turtles, so these gains come after the gains from the reduction in hooking rate, and their effect should be combined with the previous one. In the mahi-mahi fishery the reductions were even larger, in the range of 41% to 73% of the hooked turtles.

The simplest form of combination is a sequential approach: starting with a given number of turtles hooked by J-hooks (*say 100 individuals*), we estimate the numbers of turtles that would have been hooked by the different sizes of circle hooks, applying the reductions in hooking rates observed in our experiment. To these numbers of hooked turtles, we apply the second set of reductions, and compute estimates of the mortalities expected to occur for the different types of hookings. Comparing these figures with those expected with circle hooks should give us a crude approximation to the reductions we can achieve.

Impact Comparison (best–worst)
Tuna fishery

	J Hooks	Circle 16/0	Circle 18/0
Initial Nr Turtles	100	100	100
Hooked	100	56	11
Post hooking mortality (best-worst)	30 - 46	7 - 17	2 - 4
Reduction in mortality		63% - 77%	91% - 93%

Table 12. Estimation of the impact of the replacement of J hooks by circle hooks in sea turtle mortality under both scenarios in Table 10 for the tuna fishery.

Impact Comparison (best–worst)
Mahi-mahi fishery

	J Hooks	Circle 14/0	Circle 15/0
Initial Nr Turtles	100	100	100
Hooked	100	63	83
Post hooking mortality (best-worst)	44 - 56	16 - 18	10 - 23
Reduction in mortality		41% - 71%	91%-93%

Table 13. Estimation of the impact of the replacement of J hooks by circle hooks in sea turtle mortality under both scenarios in Table 11 for the mahi-mahi fishery.

Entanglements

The number of turtles entangled is very significant for both fisheries. Turtles probably get entangled while swimming near lines, especially when these are not taut. The paddling action of the turtle may create or encounter a loop in the line, and from there on the attempts to disentangle may result in a worsening of the situation if not successful. In fibras, the fishers are very close to the water surface, and have relatively easy access to the struggling individuals; in botes, the vertical distance makes the situation more difficult, and in a few cases, the observer reported that injuries or mortality resulted from mishandling of an entangled turtle. Lacking dipnets, or other adequate instruments, the fishers utilize gaffs, which are the usual instruments to manipulate their catch, but the intention is not to release their target species alive. For shelled turtles, it is possible that with a high level of skill a gaff may be used without causing major injuries, but for leatherbacks that is apparently not the case, and even for many shelled turtles injuries may result from the process. In one case, a leatherback was lifted to a bote without adequate instruments, and the injury sustained was probably fatal. In two other cases, the attempts to immobilize an animal resulted in injuries. To reduce these impacts, dipnets that allow lifting many of the turtles would help, and their addition to the gear on board is probably necessary for the higher-decked boats. Line cutters, facilitating the release of those turtles too heavy to bring on board, could also contribute to the release of entangled individuals. And last but not least, fishers education and awareness that patience and care on their part is a prerequisite for any solution to work. One of the objectives for the coming months is to put a dipnet in each bote of the Ecuadorian fleet (*and, as means allow, to each bote of the Peruvian, Colombian, and other fleets*.)

A longline is composed of a series of floats connected by lines. Even though floats have more volume, the length of the line sections between floats provides a much larger "target" for entanglements. In other words, if the entanglement of a turtle is a random process, simply depending on the probability of the turtle encountering some portion of the line, then the chances of entanglement in lines should be much higher than the chances of entanglement in the immediate vicinity of the floats. The data for entanglement were grouped into three categories: "Float or floatline," "Lines," and "Both."

In the tuna fishery, the proportion of black or hawksbill turtles entangled in line sections is 14 to 17 times the number entangled near floats, as expected. But for olive ridleys, it is three times the number in the float sections, and for the loggerheads it is 1:1. These data suggest that the latter two species may be attracted to floats (*or alternatively that the former two avoid the floats or are attracted to the line sections, most likely to the bait or hooks*).

The data from the mahi-mahi fishery show similar patterns of preference for the floats for olive ridleys and hawksbill, but the proportion for black turtles has changed considerably, and they appear to also associate with the floats. This difference should be explored with more data.

Several fishers have expressed the view that sea turtles get entangled when they approach the floats "to play with them." Whatever the reasons for the approach, the observation is interesting, and we may develop some experiments to modify the characteristics of floats, or gear around them, to reduce the problem. The observation seems to apply to olive ridleys, and perhaps loggerheads, more than to the others, but the sample sizes of some of the others are not adequate. The most common response from the fishers to the question "How to reduce turtle mortality?" was to suggest modifications of the color, shape, or materials of the floats, or the use of stiffer lines near them. It is clear that an important proportion is entangled near the floats, so the concept deserves exploration.

The distribution of entanglements for each species, and for three sections of the gear (*motherline, gangions, and near floats*) is shown in the following tables:

Entanglements tuna fishery

	Olive Ridley	Black	Hawks bill	Logger head	Leather back	Total
AROUND FLOATS *By Floats + Float line*	23	2	1	6	0	32
LINES *Main + Gangion + Both*	7	35	14	6	1	63
FLOATS AND LINES	10	7	0	2	0	19
Total	40	44	15	14	1	114

Entanglements mahi-mahi fishery

	Olive Ridley	Black	Hawks bill	Logger head	Leather back	Total
AROUND FLOATS *By Floats + Float line*	17	20	6	0	0	43
LINES *Main + Gangion + Both*	0	4	0	0	0	4
FLOATS AND LINES	0	1	0	0	0	1
Total	17	25	6	0	0	48

Table 14. a) Entanglements tuna fishery by species and by location on the line. b) Entanglements mahi-mahi fishery by species and by location on the line.

Interactions, by species and sizes of the turtles

A broad range of sizes is hooked or entangled in the lines, from individuals less than 30 cm, to about 1.0 m in carapace length. The histograms below show the distributions observed in both fisheries. The interactions include both entanglements and hookings.

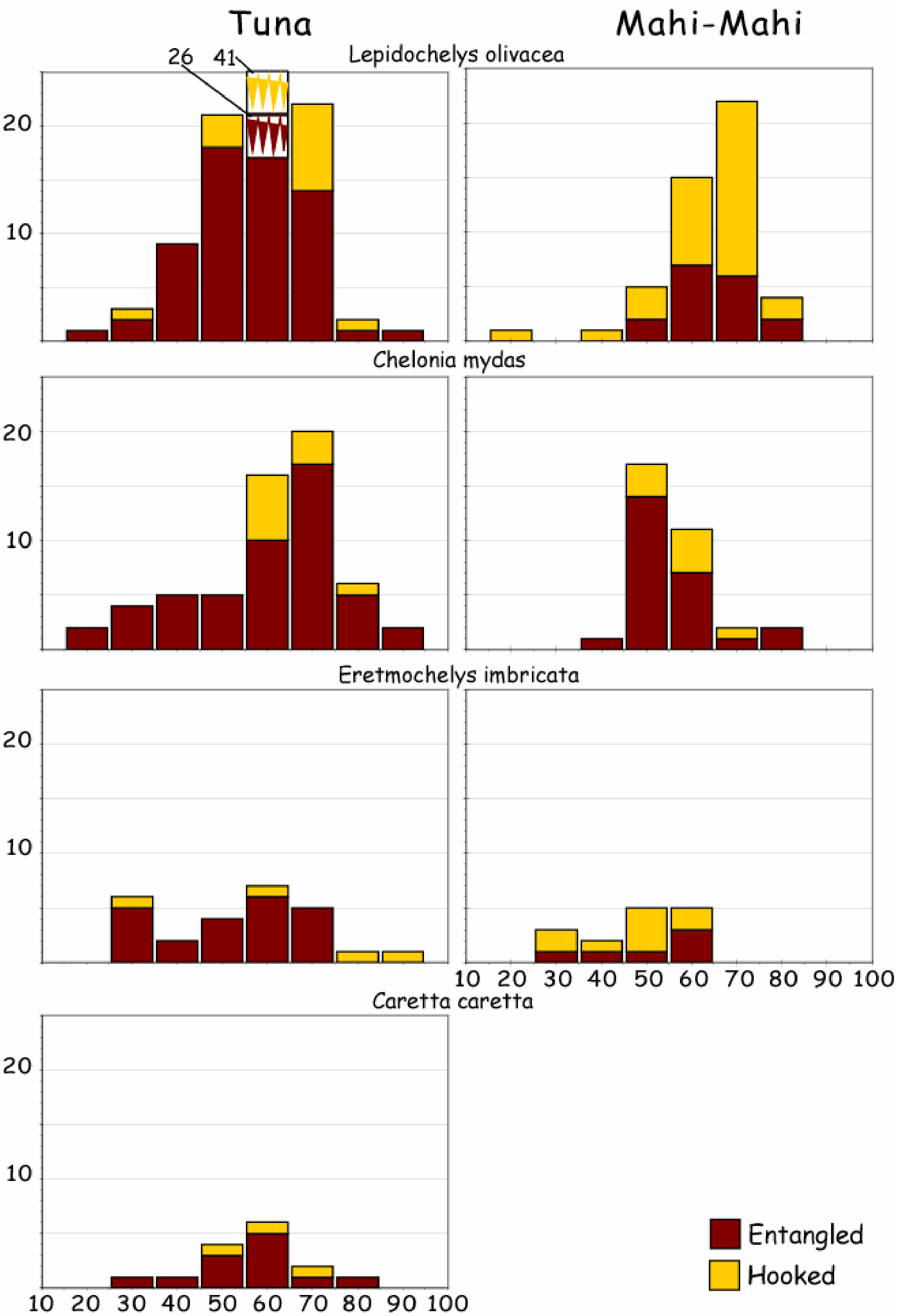


Figure 27. Length frequency distributions of sea turtles interacting with fishing gear in the tuna and mahi-mahi fisheries.

Overall target catch rates

QUESTION:

1. ***DO CIRCLE HOOKS CATCH AS MUCH AS J-HOOKS?***

a) Tuna fishery hooking rates:

The results from a single season should not be considered to provide a definitive answer, and the 2004 season was not a typical one, yielding less than normal tuna catches, according to those familiar with the fishery. In the absence of previous years' data, we could not verify the statement, or quantify its magnitude. The following tables show the catch rates by hook type. The figures show a 6% reduction with the C16, and an almost 10% decline for the C16 and C18 hooks, respectively, with respect to the control J hook. A consequence of this difference is the preference of the majority of the fishers for the C16 hooks over the C18's. The durability of the stainless steel hooks was a decisive factor. More samples are needed over more seasons to make a more complete assessment of the productivity of the hooks, especially since the hooking rates must be analyzed jointly with the species and size composition of the catch. Statistically, the p-values (*one-tailed*) are close to being significant. In addition to the numbers, most fishers' perception was that C18 hooks were "too large." This answer may be influenced by the type or size of bait used, which in most cases was squid, caught during the fishing trips; the larger hook may have a higher rate of bait loss, or it may be too visible for the target species. In any case, the 10% reduction in catch rate was sufficient to steer the fishers away from the C18 hook. The species composition of the catches may be another factor of economic significance, affecting their decision. We intend to discuss in depth the issue of species composition of the catches after another season has been sampled.

Tuna Fishery 2004:
Target Species Hooking Rates

TIME PERIOD	J	J vs C16	C16	J vs C18	C18	TRIPS
ALL	13.9		13.0		12.6	41
% Changes		-6.1		-9.5		
J vs. Hook		p = 0.102		p=0.156		

Table 15. Catch rates per species/group of species (*per 1000 hooks*)

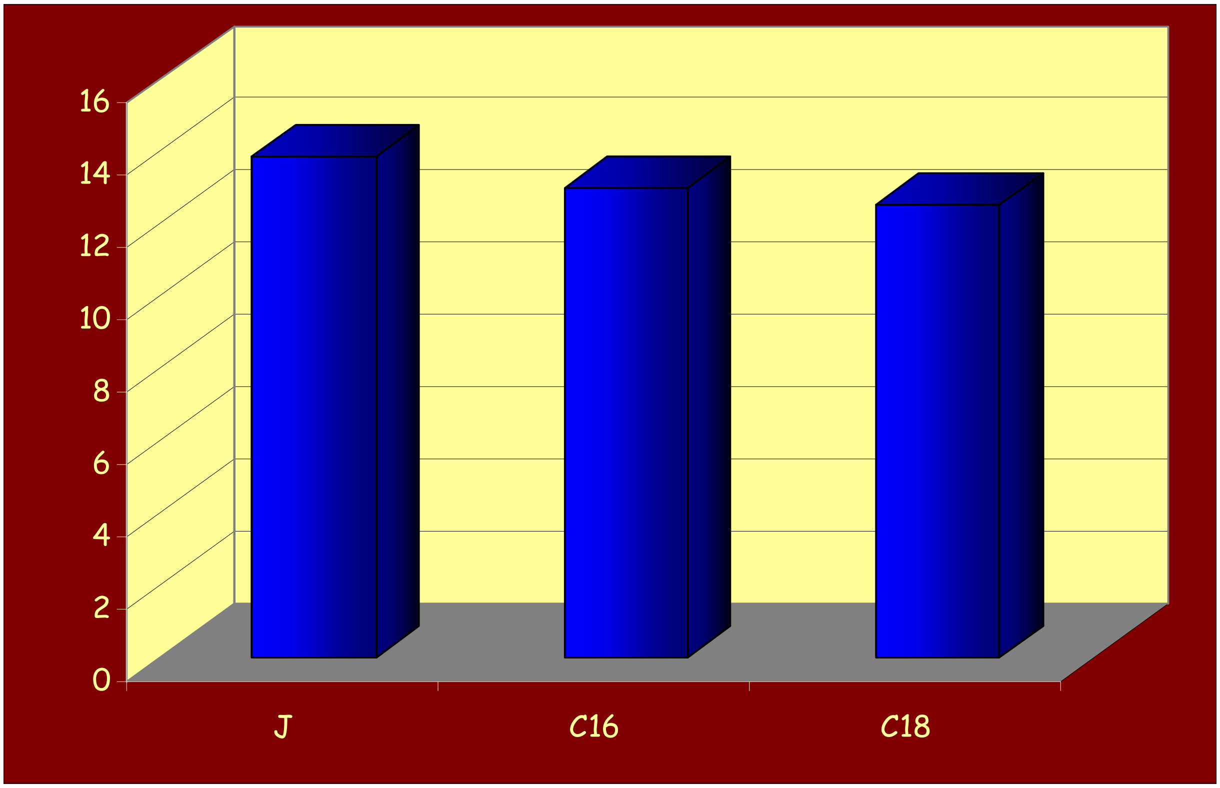


Fig. 28. Catch rates all targets by hook type (*per 1000 hooks*)

b) <u>Mahi-mahi Fishery hooking rates:</u>

The number of trips is insufficient to provide a complete picture of the catches of the hooks. The predominance of mahi-mahi in the catches is very obvious, with just a few individuals of other species being taken, with thousands of mahi-mahi. The catch rate, in fish per 1000 hooks, was more than 10 times that for the tuna fishery. Unfortunately, the catches of the C14 and C15 hooks were 30%-35% less than those of the J-hooks, and the fishers were not satisfied with that performance. It appears that it will be difficult to convince them to continue testing the hooks under these conditions. While in the tuna fishery, the hooks are easier to replace as the experiment progresses, here we are faced with the opposite result. For this fishery, we need to find an alternative way to proceed, and experimental fishing is the obvious choice. In selected trips, experimental lines may be fished, offering the fishers a guarantee to make up for the economic losses suffered (*e.g. pay them for the difference between their catch rates and the averages of similar boats*). Alternatively the entire trip could be a charter trip. In these experiments, different types of hooks, baits, or other changes, would be introduced, in attempts to find an acceptable combination before pushing for more hook exchanges. Only when the right combination is found, would we be able to develop a meaningful exchange program.

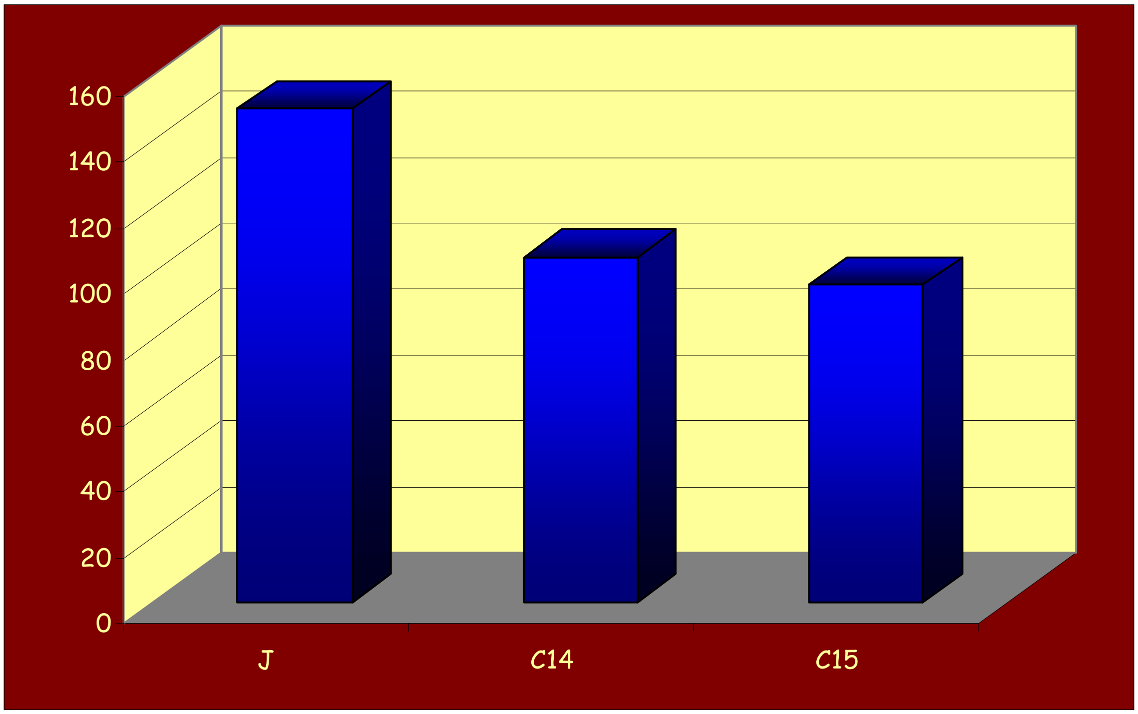


Fig. 29. Catch rates by hook type mahi-mahi fishery (*per 1000 hooks*)

HOOK	J	J vs C16	C16	J vs C18	C18	TRIPS
Tuna Fishery	13.9		13.0		12.6	41
% Change		-6.1		-9.5		
HOOK	J	J vs C14	C14	J vs C15	C15	TRIPS
Mahi-mahi Fishery	149.8		104.9		96.3	18
% Change		-30.0		-35.7		

Table 16. Comparative catch rates per 1000 hooks by fisheries

Species catch rates

The preferred target of the tuna fishery is the bigeye tuna. Swordfish is also a very desirable target in the infrequent years when it is not scarce, however, most of the other species caught are also retained and utilized. Less than one out of every thousand fish caught is discarded. When the target abundances are low, the fishers catch a mixture of species. Many of these are much less valuable than the main targets. Mahi-mahi, billfishes, wahoo, oilfish, and blue, thresher, hammerhead, and other sharks are also found in the region, and they contribute a significant part of the catch in the absence of tuna; the meat from all species is consumed or exported, and all products of value (including fins, jaws, cartilage, skins, etc.), are also utilized. From the economic point of view, the production of the fishery in years, such as 2004 with low target abundance, is low, and the conditions make it difficult for fishers to make a living.

The differences in catch rates for individual species or groups shown below should not be interpreted as more than indications. We have not performed statistical tests, so even large differences may not be significant. With the very low catch rates observed in many cases, much larger samples, over more seasons, will be needed to ascertain whether the differences are due to factors other than random fluctuations. Another factor that will affect catch rates is the learning process. While the fishers have spent many years fishing with J hooks, they have yet to develop the techniques to operate with circle hooks, so we can expect to see improvements in their catch rates with circle hooks in the future. Only species for which the hook rates (for any of the types of hooks) exceeds 0.5 will be discussed.

a) Tuna fishery

Bigeye tuna: This is the most important species for the fishery, and the rates were:

J	C16	C18
0.68	0.76	0.60

The preliminary results show that circle hooks are very competitive with J hooks for this, the primary target. Catch rates were low for all hooks.

Yellowfin tuna; circle hooks have lower catch rates than J hooks.

J	C16	C18
0.82	0.15	0.30

Mahi-mahi, wahoo; Even though this is not the mahi-mahi season, it is always a highly-valued species. The 16/0s were very even with the J hooks.

J	C16	C18
2.04	1.97	0.91

Oilfish; This is another highly-valued species, but the catch rates are low.

J	C16	C18
0.68	0.45	0.60

Marlins: This group includes striped, blue, and black marlins. The catch rates for the circle hooks were almost 1/3 less than those of the J hooks.

J	C16	C18
2.86	1.97	1.96

Blue shark: The catch rates of blue shark increased considerably with circle hooks. This is by far the most abundant shark in the tropical Pacific Ocean, but it is not a desirable target because of its low value.

J	C16	C18
1.36	2.27	2.42

Thresher sharks: This group includes the pelagic thresher, the bigeye thresher, and other unidentified *Alopias spp.*, all species of economic significance. The rates are slightly greater for circle hooks, but the differences are probably not significant.

J	C16	C18
3.12	3.48	3.48

Carcharinid sharks: This group includes the silky shark, lesser amounts of blacktip sharks, and unidentified *Carcharinus spp.* Circle hooks have higher catch rates.

J	C16	C18
0.68	1.06	1.05

Hammerhead sharks: This group includes the scalloped and the smooth hammerheads; circle hooks have lower catch rates.

J	C16	C18
0.68	0.30	0.15

b) Mahi-mahi fishery

Mahi-mahi: Its rates are, by far, the highest of any specie caught in these longline fisheries. Circle hooks produce catch rates that are about 1/3 less than those of J hooks.

J	C14	C15
147.0	100.4	91.8

Bigeye tuna: In this fishery, circle hooks outperformed J hooks, but all the hooks are different from those used in the tuna fishery.

J	C14	C15
0.18	1.19	0.67

Yellowfin tuna: The catch rates were, higher for circle hooks than for J hooks.

J	C14	C15
0.18	0.28	0.39

Skipjack tuna: The catch rates were higher for circle hooks.

J	C14	C15
0.37	1.28	0.77

Pelagic stingray: The catch rates were less for circle hooks.

J	C14	C15
1.28	0.37	0.96

Blue shark: The catch rates were lower for circle hooks.

J	C14	C15
1.28	0.37	0.96

Wahoo: The 15/0 circle hooks produce the highest catch rates.

J	C14	C15
0.0	0.18	0.58

The remaining species or groups: marlins, thresher sharks, and hammerhead sharks, all have catch rates of 0.2 or less.

All the target catch rate results should be interpreted very carefully because the fishers are just learning to use the new hooks, and there are adaptations in baiting techniques, etc., that may affect their catching success. In spite of the poor results in the mahi-mahi fishery, a boat that made four consecutive trips, started with very low catch rates with its circle hooks, but finished with the circle hooks producing more than the J-hooks, and the captain expressed interest in continuing to use circle hooks, and even to replace all the hooks in his line. This is anecdotal information, but it may be an indication that the learning period for this fishery may be longer than for the tuna fishery.

ANSWER:

YES. IN THE TUNA FISHERY CATCH RATES IN NUMBER OF FISH PER 1,000 HOOKS ARE QUITE SIMILAR BETWEEN J AND CIRCLE HOOKS

NO. IN THE MAHI-MAHI FISHERY CATCH RATES IN CIRCLE HOOKS ARE CONSIDERABLY LOWER THAN THOSE IN J HOOKS.

CAVEATS:

- *These data are limited to one season, and in the case of the tuna fishery, the abundance of the main target species was very low.*

- *Catch rates need to be statistically compared for each of the individual targets, and given the sample sizes those tests were not attempted.*

INTERACTION WITH FISHING COMMUNITIES

The availability of alternative technologies and adequate instruments to release sea turtles gives us the tools to reduce the impacts if the fishery, but without the understanding on the part of the crews of the need to use them, and to change all the behaviors that may result in harm to sea turtles, it would not be enough. Given the large number of vessels, and their distribution along the Ecuadorian coast, it was decided to organize workshops in each of the main fishing communities, and to maintain a continuous flow of information through the season. In this way, a large number of individual crews would be reached, and there would be opportunities to communicate the results of the experiment, and the mortality factors identified by the observer program. The workshops also provide an opportunity to receive feedback from the fishers on the technology, and techniques, as well as on other possible approaches to the problem. The format adopted was the following:

- Introduction:
  - The current situation of sea turtles. Trends in nesting counts.
  - Factors responsible for the decline.
  - Possible consequences of a failure to halt the declines.
- Sea Turtles:
  - Identification and aspects of their distribution, ecology, and behavior relevant to the bycatch issue.
  - Migrations of the turtles and their overlap with fishing areas.
- Solutions available:
  - Experiments with circle hooks in other regions, and local results when available.
  - Instruments and techniques to remove hooks.
  - Dealing with entanglements.
  - Demonstration of the use of dehookers.
  - Recovery of sea turtles
- Proposed program:
  - Exchange of hooks.
  - Distribution of dehookers.
  - Observer program.
  - Sharing of results.
  - Workshops.

These workshops evolve, and incorporate the experiences collected in the previous periods. The fishers are asked for evaluations of the gear, and for suggestions of other steps that could be taken to reduce mortality.

Several thousand fishers and other components of the community have attended these workshops, and they have become an essential part of the program, or have received information through national and regional newspapers.

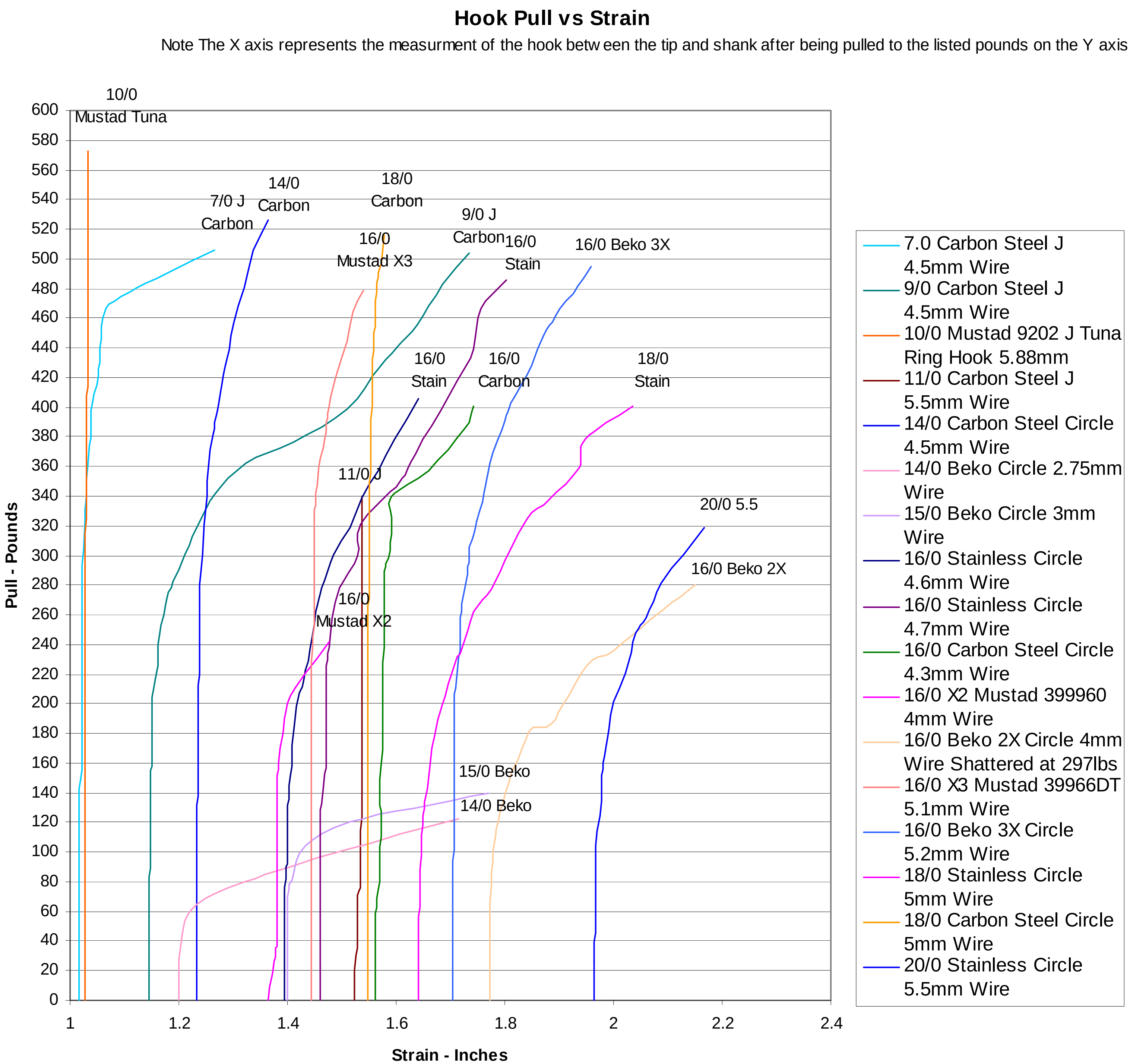
ISSUES FOR THE FUTURE

HOOKS: In spite of the good performance of the circular hooks in the tuna fishery, we should be cautious about claiming a complete victory. The good results for the C16 in the tuna fishery cannot be extrapolated to other seasons when the main targets may be others, or they may have different characteristics in size, etc. Larger and more samples from most areas and in different seasons are required to consolidate the picture. But mortality reductions of the order of more than 70% are very encouraging. This figure doesn't include the potential gains coming from the overall growing awareness of the fishers, which should be added to the technological impacts.

Even though some fishers prefer the 18/0 hooks, the vast majority lean towards the size 16/0. The overall statistics show that the reduction in prey items with the 18/0 is considerable, especially in view of the low catches of the fishery. Of the materials tested, the initial 16/0 hooks were made of a carbon-steel alloy that unfortunately has a tendency to break under strain, and they also rust very rapidly. The curves below show the problem. The x axis shows the distance between the tip of the hook and the shank after being subjected to the level of pressure shown on the y-axis. The almost straight vertical line for the Mustad 10/0 hook shows the incredible strength of this hook. The carbon-steel hooks are very strong, but past a threshold they break. The curves for the stainless steel hooks are quite similar to the carbon-steel hook, but they deform rather than break. The examination of the curves suggests that there are other interesting possibilities to find the hook with the characteristics required, and we should explore them to keep our options open (*e.g. if some other shape of circle hook is better for tunas*). We briefly tested the Mustad Triple Strength (*3X*), that had shown a good response up to 100 lb more than the stainless steel 16/0, but it rusted rapidly in the eye, and that resulted in lower acceptance. Finally, a 16/0 stainless steel hook with the same characteristics as the 18/0s the fishers were testing was introduced, and this one became a runaway favorite. We plan to continue the experiments for another season, but at the same time we would like to start making complete line changes to the fishers that have been participating from the very beginning. We also plan to test other models of circle hooks from other makers, and from other materials. Another possibility is to produce reinforced stainless steel hooks, and work on developing new models until we come up with the right one. Two manufacturers have expressed willingness to work towards the development of a hook with the desired characteristics. The fishers prefer the stainless steel material, because even though the stainless steel hooks may open, they retain the catch, and they can be reshaped.

The changes in hook materials show the importance of the fishers' participation in the process, expressing their preferences and opinions. These opinions are very heterogeneous, reflecting the differences in performance between trips. Even though the catch rates are normally presented as a unified statistical value, fishers do not respond to the averages, but to their individual perceptions, and experiences.

Fig. 30. Hook pull vs. strain. Note the X axis represents the measurement of the hook between the tip and shank after being pulled to the listed pound on the Y axis.



Dehookers and Dipnets: The dehookers will have to become part of the gear carried by every boat, regardless of size. Most of the fibras will be adequately covered with the pair of sizes currently being provided, but higher decked boats will require longer handles. For some Peruvian boats the length should be 6-7 feet. Dipnets will also have to be adopted for all high-decked boats because they have a role to play to facilitate the release of turtles. Improper handling of a leatherback sea turtle with a gaff from a bote resulted in a probably lethal injury. There are several designs of dipnets that could be used, and we need to test them all. A future addition is the line cutter that could help with larger sea turtles.

Educational campaigns and interactions with the fishing communities: These activities should continue, to reach more fishers and to include the new issues and results from the early part of the program. There should be shorter presentations, but extended to more fishing villages. The next extension will be to the northern area, in the province of Esmeraldas. The preparation of training videos that the fishers can watch while they are at sea is on the agenda. But the main evolution of this activity is the incorporation of knowledge and ideas from the fishers themselves, and a higher level of feed-back.

Floats and other parts of the fishing line: Many suggestions have been made to test other types of floats to make them less attractive to turtles. These experiments could be carried on in the coming months, and could include tests of colors, material, reduction in the number of floats, addition of swivels, stiffer lines in some section of the line, etc. The list of suggestions provided by the fishers and included below is a good starting point.

SUGGESTIONS FROM ECUADORIAN FISHERS TO REDUCE SEA TURTLE MORTALITY

In response to the questionnaires used for the captains of boats carrying experimental gear, we obtained this list of suggestions (the number in brackets is the number of captains that suggested that point.

- **Modify floats: color, materials (e.g. cork) fewer flotas (14 votes)**
- **Educate the fishers (12 votes)**
- **Use dehooker to remove hooks without hurting the turtles (4 votes)**
- **Do not fish during the day (2 votes)**
- **Use circle hooks (2)**
- **Check gear more frequently (1)**
- **Use live squid for bait (1)**
- **Put more swivels (1)**

Educational materials: with the cooperation of many scientists from the region and from other areas, the development of a basic set of instructions to identify and release sea turtles is quite advanced. The brief set of instructions is being prepared with the idea of providing it to al vessels, as a reminder of the desired procedures to improve sea turtle's survival following Epperly et al., 2004. The association of exporters produced a poster with a message to the fishers that saving the turtles is needed to save their jobs (*Poster image included in the back of the report*).

PERSONNEL DEVELOPMENT

Three Ecuadorian scientists (*J. Martinez, V. Velásquez, and L. Rendón*) were initially hired to carry on this project together with the IATTC representative in Ecuador; a former fisher, Manuel Parrales replaced Jimmy Martinez for the second half of the work. The group has developed professionally in a very satisfactory way, and the success of the program reflects their competence and motivation.

Biologists from Colombia, Costa Rica, Guatemala, Panama, and Peru, have traveled to Manta in several occasions to be trained in the methods and process, and they are now part of the teams kick-starting the program in those countries. The program in Peru started with 6 workshops in June 2004, and it was also supported by Erick Largacha from the Manta team. The participating institutions are listed on the map in Fig. 17. Workshops and other program activities have also started in all the countries mentioned, and also in El Salvador and Mexico.

The development of these types of teams to address conservation problems is quite an achievement in itself, and it should be credited to the team members' attitude and openness.

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APPENDIX

Symbols

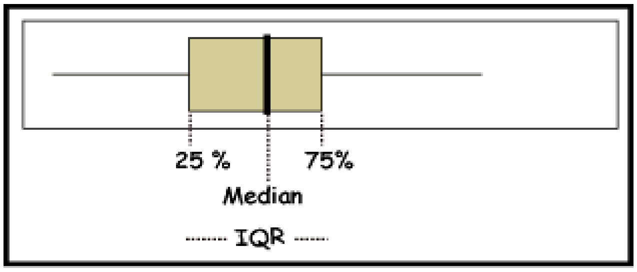

Fig. 31. Symbols for the box plots

Specie type	*Scientific name*	*Common Name*
Tunas	Thunnus obesus	Bigeye tuna
	Thunnus albacares	Yellow fin tuna
Big fishes	Coryphaena hippurus	Mahi-mahi
	Lepidocybium flavobrunneum	Oilfish
	Acanthocybium solandri	Wahoo
Billfishes	Tetrapturus audax	Striped marlin
	Makaira nigricans	Blue marlin
	Istiophorus platypterus	Sailfish
	Xiphias gladius	Swordfish
	Makaira indica	Black marlin
Sharks	Prionace glauca	Blue shark
	Alopias superciliosus	Bigeye thresher shark
	Carcharinus falciformis	Silky shark
	Alopias pelagicus	Pelagic thresher shark
	Sphyrna spp.	Hammerhead sharks
	Alopias spp.	Unid. Thresher shark
	Carcharinus spp.	Other sharks
Manta rays	Manta spp. Mobula sp.	Manta
Turtles	Chelonia agassizii	Black turtle
	Dermochelys coriacea	Leatherback
	Lepidochelys olivacea	Olive ridley
	Eretmochelys imbricata	Hawksbill
	Caretta caretta	Loggerhead

Table 17. Species used

Examples of forms used

VESSEL - GEAR

MUESTREO: ____________________

REGISTRO DE APAREJOS PALANGREROS

Fecha Salida		**Puerto Salida**		**Hora Salida**	
Fecha Llegada		**Puerto Llegada**		**Hora Llegada**	
Nombre Capitán		**Nombre del Armador**		**Nombre de la Fibra**	
Capacidad (t)		**Eslora**		**Nombre del Bote**	

<table>
<tr><th colspan="3">Características</th><th>Cantidad</th><th>Material (*)</th><th>Diámetro</th><th>Longitud</th><th>Color (*)</th><th>Distancia entre anz.</th><th>Observaciones</th></tr>
<tr><td colspan="3">Línea madre</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Reinal superior</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Reinal inferior</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Profundidad de los anzuelos</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Saca Vueltas</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Anzuelos</td><td colspan="2">J</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>C</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>C</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Orinque</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Boya</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Bandera</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Flotador</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Candil o mechero</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

SETS

MUESTREO: ____________________ **EMBARCACION:** _____________________

REGISTRO DE LANCE PALANGRERO

	POSICION				Número de anzuelos														
	HORA Y POSICION DEL LANCE		HORA Y POSICION DE LA RECOGIDA		Mar			Bote			Perdidos			Cebo nuevo			Tiempo/ Arte/ Agua	Temp ° C	Comentarios
	Inicio	Fin	Inicio	Fin	J	C	C	J	C	C	J	C	C	J	C	C			
No. Lance	LAT / LON	LAT / LON	LAT / LON	LAT / LON															
Fecha					DESCRIBA QUE TIPO DE CARNADA SE USO Y EL PORCENTAJE DE LA MISMA EN LOS DIFERENTES ANZUELOS														
HORA →																			
Fecha					DESCRIBA QUE TIPO DE CARNADA SE USO Y EL PORCENTAJE DE LA MISMA EN LOS DIFERENTES ANZUELOS														
HORA →																			
Fecha					DESCRIBA QUE TIPO DE CARNADA SE USO Y EL PORCENTAJE DE LA MISMA EN LOS DIFERENTES ANZUELOS														
HORA →																			
Fecha					DESCRIBA QUE TIPO DE CARNADA SE USO Y EL PORCENTAJE DE LA MISMA EN LOS DIFERENTES ANZUELOS														
HORA →																			

HOOKINGS

MUESTREO: ____________________ **EMBARCACION:** _____________________

REGISTRO DE ESPECÍMENES INDIVIDUALES

Lance No.	ESPECIE		Longitud	Estado (*)	Lugar Enganche (*)	Tipo Anzuelo	Destino (*)	Observaciones
	Nombre	Sexo						

ENTANGLEMENTS

MUESTREO: ______________________ **EMBARCACION:** _______________________

FORMULARIO DE TORTUGAS ENREDADAS

OBSERVADOR:											
FECHA	**LANCE**	**ESPECIE**	**SEXO**	**LCC***	**ACC***	**LINEA MADRE**	**REINAL**	**BOYA***	**COLOR BOYA**	**FLOTADOR***	**COLOR FLOTADOR**
POSICION:		**LATITUD**				**LONGITUD**			**HORA**		
OBSERVACIONES											

ESQUEMA CON RELACION AL ARTE	**ESQUEMA DE TORTUGA ENREDADA**
ACC: Ancho curvo caparazón BOYAS: material sintetico o chino	LCC: Largo curvo caparazón FLOTADOR: galones o pomas

LIBERALAS VIVAS