Potential for Unintended Consequences in an Ecuadorian Hook Exchange Program

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Marine and Environmental Affairs

University of Washington

2012

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Program Authorized to Offer Degree: School

of Marine and Environmental Affairs

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Introduction

Policies advocating the use of conservation technologies – that is, physical devices primarily used to protect organisms and/or habitat – have the potential to improve natural resource management (Jenkins, 2006). These technologies may allow for a maximized use of land and sea resources with minimal impacts on the environment (Zimmerer, 2006). In marine-based systems, conservation technologies are being promoted as a way to mitigate the negative impacts associated with certain fisheries, while maintaining the livelihoods and lifestyles of those who participate in the fishery (Largacha, 2005; Jenkins, 2006). Bycatch reduction is one area in which conservation-based technologies are a particularly attractive and useful option. Sea Lion Excluder Devices in New Zealand and Australia, Turtle Excluder Devices in the US shrimping industry, and circle hooks in US commercial and recreational fishing industries are three examples where conservation-based technologies have been employed to reduce incidental capture of threatened or endangered species (Baird, 2005; Margavio, 1996; NOAA, 2004). However, conservation technologies may have unintended consequences when the outcome of their implementation is counter to the overall goal of conservation (Hannah et al., 1994; Williams, 2002; Zimmerer, 2006; Zimmerer, 1998).

This case study looks at a conservation initiative in Ecuador that was intended to curb the incidental capture of endangered sea turtles in surface longline fisheries. The initiative focused on exchanging the commonly used j-hooks for circle hooks. The circle hooks mitigate turtle bycatch. However, they also appear to produce higher catch rates for sharks than j-hooks. The presence of an Ecuadorian shark fishery coupled with a lucrative international shark fin market may create incentives to misuse this technology and target sharks.

Research in the North Pacific Ocean, indicates that circle hooks had a catch rate for pelagic sharks 1.6 times that of tuna hooks (Kaplan et al., 2007). The study is not definitive. Research in the same area saw a non-significant difference (p = 0.48 and 0.43, two-way ANOVA) between catch of pelagic shark with j-hooks, tuna hooks, and circle hooks (Yokota et al., 2006). In Hawaii, mandatory regulations to switch from j-hooks to circle hooks have been successful in lessening shark and turtle bycatch; however, the success seems to be dependent on a mandated switch in bait from squid to mackerel (Gilman et al., 2007).

This case study will rely upon the circle hook program's self-published reports, key-informant interviews, and a social survey conducted in Ecuador that examined fishers' perceptions and their relationship to the conservation technology. The case study is important because the Ecuadorian circle hook program represents the first step in a large-scale promotional effort in Central and South America on the Eastern Pacific Ocean (EPO). It also forwards understanding of the factors influencing the diffusion of technologies through society.

Background of the Circle Hook Project

In 2003 the World Wildlife Foundation (WWF), the Inter-American Tropical Tuna Commission (IATTC), the National Oceanic and Atmospheric Administration (NOAA), the Ocean Conservancy, the Western Pacific Regional Fisheries Management Council, and the Overseas Fisheries Cooperation Foundation of Japan initiated a joint project intended to prevent sea turtle bycatch in surface longline fisheries of the EPO. These organizations saw a pressing need to reduce the amount of sea turtle bycatch in Ecuador's artisanal longline fisheries. The project was led primarily by WWF and IATTC with technical assistance from NOAA (Mug et al., 2008).

NOAA researchers have shown that circle hooks reduce bycatch of turtles in the West

Atlantic and Gulf of Mexico (NOAA, 2004). The j-hook is the traditional hook used in longline fisheries within Latin American countries along the EPO, and closely resembles the letter from which it takes its name. Circle hooks, in contrast, curve sharply inward at the point (Figure 1).

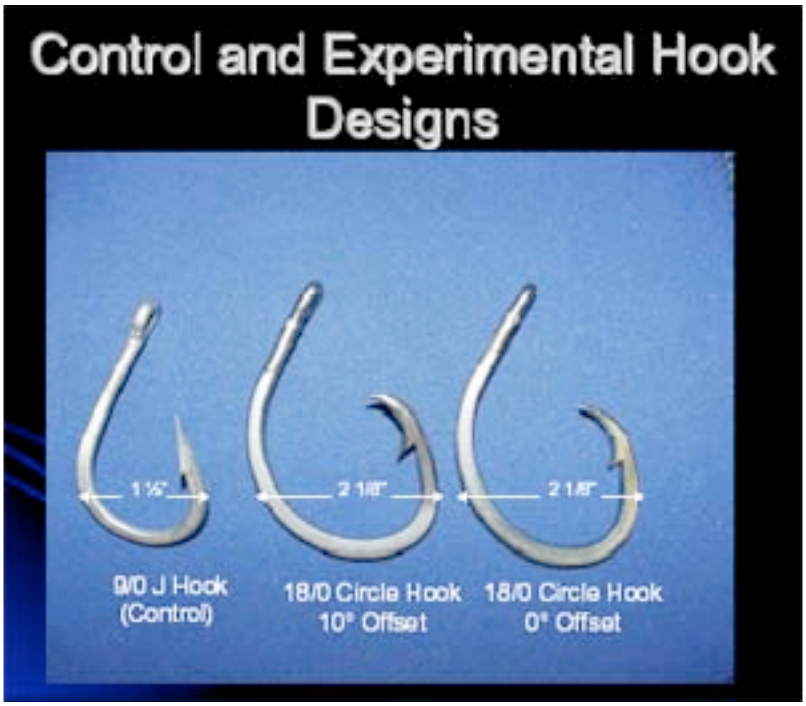

Figure 1: Circle hook and J-hook photo

The project focused on substituting circle hooks for j-hooks through an exchange program. Participating boats would change out every other j-hook on the line for a circle hook. Each participating boat was also required to take on an observer. The observer collected data in order to compare the capture rates of j-hooks with circle hooks. Specifically, the data would determine the circle hooks' effectiveness in reducing sea turtle bycatch, and whether circle hooks affected the capture of target species (Mug et al., 2008; Largacha et al., 2005).

This program was in effect from 2004 to 2007. Biologists and technical trainers from

WWF, IATTC, and NOAA conducted workshops. The program included training fishermen in best techniques for bringing turtles on board, resuscitating turtles, and untangling turtles from lines. Fishermen unhappy with circle hooks were allowed to exchange them for their original j-hooks (Mug et al., 2008; Largacha et al., 2005).

IATTC has recorded the occurrence of 42 promotional workshops with a total of 2,176 participants from September 2003 to October 2004 (Largacha et al., 2005). The workshops occurred in the provinces of Guayas, Manabi, and Esmeraldas. Interviews with key informants from IATTC, WWF, and the Ecuadorian Government indicate that additional promotional workshops have occurred. However, the records kept are unclear as to where and when they occurred, which organizations participated, and how many fishers attended. (Key Informants, WWF employees, December 9th, 2011; Key Informant, IATTC Biologist, December 10th, 2011; Key Informant, Government Employee, January 25th, 2011.)

There are two main fishing seasons in Ecuadorian waters. The first season targets the common dolphinfish (*Coryphaenahippurus*) from November to April, with peaks in January and February. The second season targets tuna (*Thunnus* spp.), billfish *(Istiophoridae spp.*), and shark (*Selachii spp.)* from May to October[1] (Mug et al., 2008; Largacha et al., 2005).

Each fishery tested various hook sizes. Hooks sized from 12/0 to 16/0 were exchanged in the common dolphinfish fishery, and hooks sized from 14/0 to 18/0 were tested in the tuna, billfish, and shark (TBS) fishery. A key informant from IATTC stated that the first promotional introduction of circle hooks into the fishery used a Korean-made hook that proved problematic:

So we would make the changes on lines to these ones and come back in the afternoon and

[1] See Charts in Appendix A for FAO catch statistics of each of these species/order from 2001-2010

fishermen would tell us about fish that got away and show us the broken hooks. We isolated them and stopped giving them out as a result of the adverse reaction we were receiving (Key Informant, IATTC Biologist, December, 2010).

The Korean-made hook tended to rust quickly and bend open; as a result, the IATTC and WWF switched the Korean circle hooks for stainless steel Japanese circle hooks. Hook sizes remained the same.

Program staff exchanged 330,569 j-hooks for circle hooks, during a total of 435 observed trips on 169 boats from the towns of Manta, Esmeraldas, Santa Marianita, and San Mateo in 5 years (Mug et al., 2008). The common dolphinfish fishery tested circle hooks sized 14/0, 15/0, and 16/0. These circle hooks reduced the number of turtles caught as bycatch in 18 of the 28 cases selected for study. In 8 out of the 28 cases, circle hooks outperformed j-hooks. In 20 out of 28 cases, j-hooks outperformed circle hooks. Circle hooks successfully mitigated bycatch of sea turtles, but at the expense of catch rates for the target species (Mug et al., 2008).

In the TBS fishery, circle hooks sized 14/0, 16/0, and 18/0 were tested. They reduced bycatch of sea turtles in 13 of 24 cases. Catch of target species in the TBS fishery increased in 14 of 24 cases, with the greatest increase in catch of sharks. Catch of blue shark (*Prionaceglauca*) increased with circle hooks by 1.7 times. Catch of hammerhead shark (Sphyrnidae) increased by 1.1 times. Catch of silky shark (*Carcharhinus falciformis*) increased by 1.6 times. This is in contrast to big eye tuna, of which catch increased by 1.1 times (Largacha, 2005).

Conservation Initiatives, and Unintended Consequences

Conservation technologies are an attractive option for resource management and in conservation initiatives, such as the circle hook program. However, there are challenges and trade-offs associated with conservation technologies and conservation initiatives. In terrestrial systems, soil conservation technologies, such as counter hedgerows, canals, and terraces, have suffered from low rates of adoption and abandonment of use after promotion projects are completed (Cramb, 2000). Two examples of well-intended conservation initiatives, in Mexico and Zaire, illuminate the issue of unintended consequences.

Shade-grown coffee – growing coffee trees inside high canopied forests – is seen as a conservation tool that can balance the need for maintaining wildlife habitat while providing viable economic choices for farmers. Shade-grown coffee certification programs in Mexico rely on satellite remote sensing technology. The technology allows programs to use the normalized difference vegetation index (NDVI) – a quantitative measurement for green vegetation relying on satellite readings of reflected radiation –as a grading threshold. NDVI fails to differentiate for types of vegetation, and so fails to detect the quality of the ecosystem. A coffee farm can be certified as shade-grown, and yet provide none of the benefits expected from shade-grown coffee, such as habitat protection and forest preservation (Zimmerer, 2006).

Sustainability initiatives in Zaire have encouraged rural farmers to keep bees so as to cultivate honey as a source of income and sustenance. However, the bees are more likely to pollinate flowering weedy invasive plants, to the detriment of native species (Zimmerer, 2006). In both cases, what appears to be an attractive option for resource management carries unintended consequences that affect conservation goals.

Sharks and the Global Markets

Shark fins are, per pound, the most lucrative portion of the shark fishery. The Food and Agriculture Organization (FAO) claims that shark finning is a $115 million industry; however, careful estimates by Clarke (2004) – a leading researcher of the shark fin trade – indicate it is closer to a $450-$500 million industry. The shark fin is one of the most expensive fish products in the world, fetching upwards of $400 per kilogram (Clarke, 2004; Vannuccini, 2002). Fins are primarily used for shark fin soup, a delicacy served at Chinese banquets and weddings, where the presence of such a luxury food indicates the wealth and generosity of the host. In addition, fins are used in medicinal tonics. Both uses date back to the Ming Dynasty (Clarke, 2004).

The economic boom in China is responsible for the increase in consumption and price of shark fins. A viable middle class is beginning to covet the status symbol that shark fin represents. Trade in the fins — which come packaged dried (as whole fins or as powder), frozen (whole or in chunks), or fresh — is strong and consistent (Vannuccini, 2002). Shark fin production more than doubled between 1984 and 2004, from 40,000 metric tons to 100,000 metric tons. Hong Kong sees 50–80 percent of that trade flow through its port en route to the Chinese mainland (Clarke 2004). A downturn in the domestic Asian markets in the fourth quarter of 1997 and the first quarter of 1998 did not bring a decrease in metric ton importation of shark fins to Hong Kong, attesting to the strength and continuity of the market (Wang, 1999). Since 2000, efforts to track the amount of fins entering China have been complicated by a change in the codification system for imports that allows frozen shark fin meat to be classified as generalized fish meat. Statistics from Hong Kong indicate that frozen shark fin meat constitutes 40-50 percent of trade into Hong Kong ports (Clarke 2006). This new classification further obfuscates the already unclear and underreported market in shark fins. Fins from many species of shark are traded. The only consumer criteria placed on the fins is length, texture, and thickness. These characteristics are used to divide fins into “black” fins or “white” fins (Vannuccini, 2002).

A number of developed countries have taken action against the importation, production, exportation, and sale of fins within their borders, even as demand for shark fins continues to increase. In the United States, a ban on the sale, production, and importation of shark fins is slowly spreading state by state (Rosenthal, 2012). Currently, the entire West Coast is closed to shark fin trade, with numerous states on the East Coast following suit. This is in addition to already stringent regulations within the United States that require sharks to be brought into port whole, or with a 5 percent fin-to-carcass ratio (Rosenthal, 2012). The European Union has strict restrictions on finning--the act of cutting off shark fins at sea and returning the shark to sea--though it still allows shark catch and finning at port (Clarke, 2006). Implementation of these regulations has reduced importation of shark and shark fin products into Hong Kong from the U.S. and the E.U. Shark fin exports to Hong Kong declined 54 percent from the U.S. and 30 percent from the E.U. in the years following the regulations (Clarke, 2006). At the same time, shark fin imports into Hong Kong have increased. The restrictions by the U.S. and the E.U. on shark finning theoretically shift fin trade either underground or to less developed countries with regulations that are loosely enforced or nonexistent (Rice, 2007; Clarke, 2006).

The growing demand for shark products, coupled with their high profitability, creates an incentive for capture. Promoting a hook that leads to increased shark catch can create unintended consequences for the environment. It is therefore important to understand if hook exchanges are desirable before promoting them and arranging more of them. Semi-structured interviews with key informants and survey data collected from villages in Ecuador that participated in the promotional efforts may provide insight into the perception that fishers have of circle hooks. Such insight can clarify how fishers relate to the hook, and how the hook may be used.

Methodology

Complementary Research Methods: Qualitative and Quantitative

In Ecuador semi-structured interviews with government officials knowledgeable about fisheries, IATTC employees, and WWF employees were conducted. Interviews were used to understand the national fishery: fisher demographics, seasonal catch, target species, and fishing gear in wide use. Key informants knowledgeable about the circle hook program were asked more in-depth questions relating to the promotion, uptake, and use of the conservation technology. Field Coordinator Michael Vina, a native Spanish speaker, carried out the Ecuadorian interviews. Additionally, Lekelia Jenkins, one of the principal investigators, conducted interviews in the United States with NOAA and IATTC officials. The U.S. interviews dealt primarily with the circle hook program, its development, and the promotional efforts surrounding the circle hook. A total of 12 interviewees mention circle hooks. Of those interviewees, nine directly mention the circle hook program in Ecuador. The nine interviewees that directly mention the Ecuadorian circle hook program will be considered for analysis. Six interviews analyzed were conducted in Ecuador, the remaining three were conducted in the United States. All interviews that were analyzed were conducted face to face, with eight out of the nine agreeing to use digital recorders.

The research team identified recurring thematic concepts in the initial interviews, then used those themes to develop surveys for the research sites. Six distinct surveys were developed for preselected sections of the population: boat captains, boat owners, deckhands, fishing leaders, community leaders, and community members. The team designed the surveys to gather data on site demographics, the fishery, the rate of diffusion for the promoted circle hook, the reasons for acceptance or rejection of the hook, and the proliferation of the hook. Each survey contained a mix of open- and closed-ended questions. Captain and deckhand surveys were designed to target working longline fishers. Owner surveys were meant for those who owned active boats. The owner, captain, and deckhand categories of actors have the most influence, and in the case of captain and deckhand, direct contact with the conservation technology. Therefore, the results section will only analyze data from those three survey types. In total, 275 surveys were analyzed: 104 captains, 53 owners, and 118 deckhands. Sixteen captains, 16 deckhands, and 8 owners were interviewed at each site. To account for the role of mother ships (described below), an additional 18 captains, 18 deckhands, and 9 owners, all connected to mother ships, were interviewed in Manta. Captains, deckhands, and owners answered questions in several categories regarding circle hooks: attributes of the technology, prevalence of use, enforcement and legality, process and nature of promotion, modification of technology, and governance.

Surveys were deployed after field tests confirmed their viability. A team of 7 native Spanish speakers conducted the surveys. Every other boat was sampled to introduce an element of randomization. This method was used at every location except for Puerto Bolivar where it is believed that every boat was surveyed.

Research Sites

Six sites were identified for study: Puerto Bolivar, Santa Rosa, Manta, San Mateo, Santa Marianita, and Esmeraldas. Puerto Bolivar is situated within the Gulf of Guayaquil, and is the only site that is not located on open coastline. The six sites are located within four provinces, (listed from southernmost to northernmost): El Oro, Santa Elena, Manabi, and Esmeraldas.

Table 1: Provinces and related research sites

Province	**Site**
El Oro	Puerto Bolivar
Santa Elena	Santa Rosa
Manabi	Manta, San Mateo, Santa Marianita
Esmeraldas	Esmeraldas

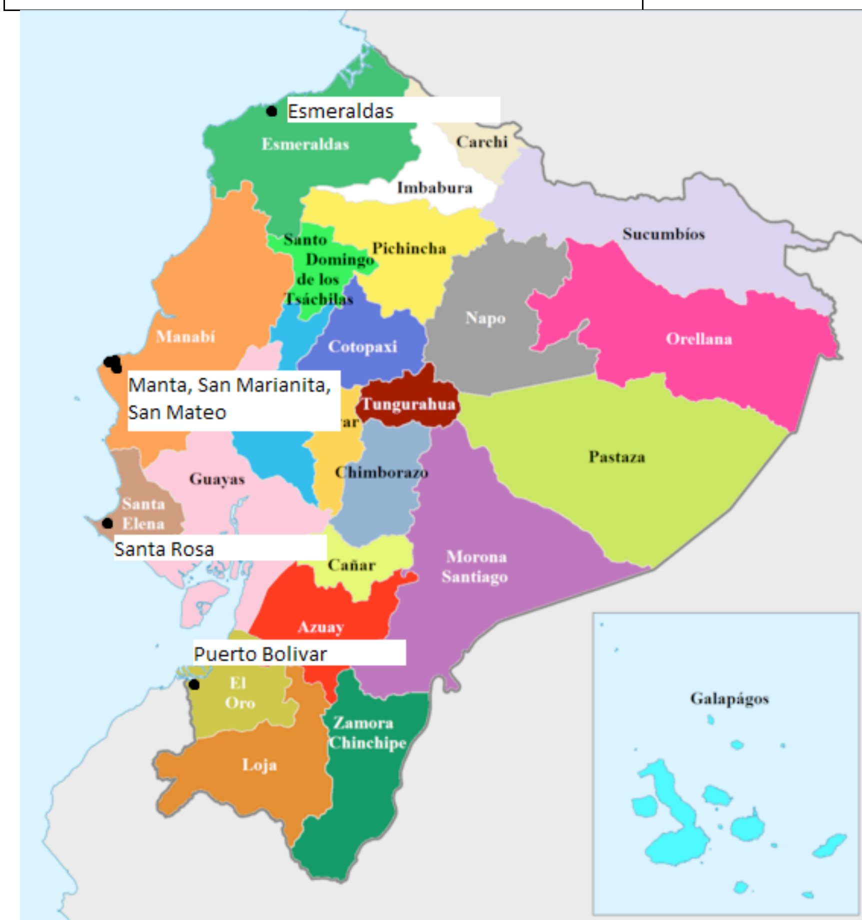

Figure 2: Province map of Ecuador with research sites

Each research site is a fishing hub for artisanal fishers who have been introduced to circle hooks through the promotional efforts of WWF, IATTC, or Instito Nacional Pesqueria (INP, National Fisheries Institute). Promotional efforts were directed towards these towns due to the pervasive use of surface longlines. The primary catch for these sites is common dolphinfish from April to October; and tuna, billfish, and shark from November to March (Largacha, 2005; Key informant, IATTC Biologist, December, 2010; Key informant, Ecuadorian government official knowledgeable on fisheries, January, 2011).

Manta and Esmeraldas are the only research sites that have an industrial fishery. Artisanal fiberglass boats (approximately 25 feet in length), large wooden-hulled ships (approximately 45 feet in length), and large steel-hulled factory ships operate from these two ports. The large wooden-hulled boats are most commonly known in Ecuador as mother ships. Mother ships tow up to 7 fiberglass boats into open water, providing storage, supplies, and support to the smaller boats. This allows for a longer fishing trip. Trips with the mother ship generally last from 15 to 30 days. (Key Informant, Ecuadorian government employee with working knowledge of fisheries, January, 2011). Artisanal fiberglass boats constitute the majority of operational boats at all other sites. These boats are powered by outboard motors.

Results and Discussion

The primary purpose of the analysis is to determine whether the initiative to promote circle hooks as a turtle conservation tool could lead to unintended consequences if the circle hooks are used instead to target sharks. Analysis of the qualitative and quantitative data will help establish the size, prevalence, and presence of a shark fishery, providing a context in which to consider the promotion of the circle hooks. Second, analysis will examine whether the use of circle hooks promoted more concentrated efforts to capture shark. Qualitative interviews were analyzed to gain insight into the shark fishery and its existence, the prevalence of circle hooks, and the manner in which circle hooks are perceived to be used. Survey questions were selected for analysis along three lines of inquiry: circle hook use, catch rate of sharks, and the relationship between circle hooks and shark catch. Significance level of p-value < .05 was used.

Shark Fishery

Of the nine interviewees, six recognized the shark as an important and distinct portion of Ecuador's pelagic longline fishery. Two of the three interviewees who did not recognize the shark as a part of the Ecuadorian longline fishery were technicians; the questions they answered were primarily focused on promotional efforts. All 6 key informants interviewed in Ecuador considered the shark a significant enough segment of the longline fishery to nominate it as a catch. The most common answer was a variation on the following, provided by an Ecuadorian key informant who was involved in the promotional efforts for the circle hook:

> *Going back to surface longlines, we have two main seasons. One season focuses on tuna, marlin, and sharks, and that occurs between March and November depending on population numbers. (December 2010)*

Shark is a significant enough portion of the longline pelagic fishery to constitute inclusion with tuna and billfish, two important species in Ecuador (Largacha, 2005; Mug, 2008). Another key informant, a government biologist from Ecuador, echoed these statements:

> *From mid-March to December they target bigger species like albacore, marlins, and different sharks like la rabona, tiger, and thresher. (February 2011)*

Key informants consistently recognize shark as a catch; however, this recognition does not provide insight into the state of the fishery. A third, nongovernmental key informant, an expert in Ecuadorian fisheries, made the following observation about the status of the shark fishery:

> *…shark fishing has increased over the years. I don't know about incidental catch. Some fishers bring in ten sharks and one dorado (common dolphinfish). If they are not catching dorado they will definitely catch something else. At some point there won't be any sharks and they will start fishing rays. (February, 2011)*

The quantitative data from the surveys confirms the key informants' observations. Captains, deckhands, and owners were each asked to identify target species with the open-ended question: *What do you fish for?* These groups recognized 50 different species as desired catch. Of those 50 species, 14 were sharks (28%). For analysis, all species listed as desired catch were divided into two categories: shark catch and non-shark catch. (See Appendix B for a list of commonly caught sharks in Ecuadorian waters.) Crew members (captains and deckhands) reported shark as a desired catch in 73 percent of surveys. Owners reported shark as a desired catch in 66 percent of surveys. In total, 72 percent of surveys analyzed reported shark as a catch.

Landing statistics from Ecuador on shark catch are limited. For the years they are available, landing statistics indicate that sharks are a significant part of the pelagic longline fishery, confirming both the qualitative and quantitative data. Government reports for 2007 indicate that the shark fishery accounted for 21 percent of landings of large pelagic fish, specifically 4,301 tons (Diaz, 2008). By 2008, shark catch accounted for 29 percent of all pelagic catch by weight. The reported shark catch in 2008 was 6,480 tons, a 150 percent increase from 2007 (Peralta, 2009). The government estimates (Diaz, 2008; Peralta, 2009) of shark yields for 2007 and 2008 are 3.1 times higher than those reported by FAO during the same years (FAOSTAT, Fisheries Commodities Global Production and Trade, accessed last: June 3rd, 2012). It is unclear why a discrepancy exists between the government report and the statistics reported by the government to the FAO. It is noteworthy that such underreporting is common worldwide, with catch rates of pelagic sharks commonly 3 times higher than reported by FAO (Clarke et al., 2007; Clarke et al., 2004). Data from 1979 to 2005 indicates that pelagic shark catch in Ecuador may be 3.6 times higher than reported by FAO when exported fins are taken into consideration (Jaquet et al., 2008).

Reporting shark catch differed among provinces (Cramer V, $p < .001$). Eighty-three percent of surveyed fishermen in Manabi Province (Manta, Santa Marianita, San Mateo) and 88 percent in Esmeraldas Province (Esmeraldas) reported shark as catch in the pelagic longline fishery. Fishermen in the Santa Elena Province (Santa Rosa), however, only reported shark as catch 55 percent of the time. And only 16 percent of fishermen in the El Oro Province (Puerto Bolivar) reported shark as a desired catch. El Oro's lower percentage may be due to its location within the Gulf of Guayaquil, which is brackish and may not be ideal shark habitat. Because the longline artisanal sector is small in El Oro, the field team had difficulties finding informants. According to numerous local fishermen, most boats there had switched to gillnetting.

Catch statistics per port indicate that Manta, in Manabi Province—overall, the largest Ecuadorian port for landings and exports of fishery products —is clearly the most important port in Ecuador for shark landings. INP reports from 2006 indicate that 1,745 metric tons of shark were landed in Manta. Esmeraldas, in the Esmeraldas Province, had the next highest volume of shark catch at 166 metric tons (Diaz, 2008). By 2008, Manta would report 5,751 metric tons of pelagic shark catch, with Esmeraldas again recording the second highest reported catch of pelagic sharks at 239 metric tons. Shark catch accounted for 31 percent of all large pelagic catch in Manta in 2008 (Peralta, 2009).

Part of Manta's high catch rate may be due to the existence of the previously mentioned mother ships at port. One key informant explained that in Manta, mother ships go out for 15 to 30 days at a time, returning from every trip with up to 700 sharks (Government official key informant with knowledge of Manta's ports, January, 2011). No clear information is available on the size of the mother ship fleet; however, at least 41 such boats in Manta reported capture of sharks in 2007 (Diaz, 2008).

Shark catch in other ports, such as Esmeraldas and Santa Rosa, accounted for 12 percent of large pelagic catch in 2008 (Peralta, 2009). San Mateo and Santa Marianita, two research sites, are not addressed in the INP statistics, but they are a short distance from Manta. Multiple fishermen in Santa Marianita indicated that most catch is landed at Manta (March, 2011). No statistics for shark capture in Puerto Bolivar were found.

Depending on the informant, the capture of shark is described as either incidental or intentional. Ecuadorian government key informants with ties to the agency responsible for regulation of fisheries characterized the shark fishery as incidental, meant primarily for sustenance.

> *These boats use lines with 300 to 400 hooks. So out of 300 hooks seven are shark. That doesn't seem to be a targeted species. Your answer is very clear. They are incidental. (January, 2011)*

The fact that sharks constitute such a high percentage of the catch in the pelagic longline fishery, in addition to the high shark-catch numbers reported by survey informants, indicate that the catch is not strictly incidental, as officials suggest. Still, even if shark is not an incidental catch, it is possible that shark capture is consumed primarily in country. Key informants related that catch is consumed mostly in the highlands. One non-government key informant who is an expert on Ecuadorian fisheries noted that:

Shark is consumed a lot here (in Ecuador). In the highlands it is known as corvinaquiteña (weakfish from Quito). (February, 2011)

A total of 10,483 metric tons of marine fish were consumed in Ecuador in 2007 (FAOSTAT, Consumption of Fish and Fishery products). If we accept the premise that shark catch in Ecuador is meant for consumption in country, then in 2007, 41% of marine fish consumed in Ecuador was shark (4,301 metric tons of shark landings were reported in 2007 {Diaz, 2008}). Research suggests that such a high rate of consumption for shark is unlikely. Francisco-Fabian (2001), and Revelo and Guzmon(1997), report that shark meat does not sell well on the coast because it is of poor quality and spoils quickly. It is often mislabeled as marlin, sea bass, or flounder. Fieldworkers noted that shark was apparently not consumed with any regularity on the coast despite high rates of capture, particularly in Manta (Vina, Personal Communication, February, 2011).

What is clear is that shark is caught and some shark is consumed in country. It seems unlikely that what is consumed in country is the same as the amount of sharks landed. A non-government key informant who is an expert on Ecuadorian fisheries illuminates the issue:

And why does [capture of sharks] happen? Because someone pays money for them. (February, 2011)

The key informant is hinting at the existence of a commercial fishery. Recent history can provide contextual clues to what portion of the shark fishery provides economic incentive for catch. In 2004, Luis Gutierrez, the President of Ecuador, signed a decree banning the export of shark fins from the Galapagos and the mainland (Jaques et al., 2008). The one year decree allowed incidental capture and consumption of shark to continue uninterrupted. One key informant with extensive knowledge of Latin American fisheries described the response to the decree as follows:

I've seen a mountain of tires burning in the street because [of the] …ban on fins. (January 2011)

The scene described by the key informant, and the necessity of a decree banning the sale of shark fins is incongruent with an incidental shark fishery. The violent response is indicative of a populace who participates in a shark fin industry. Part of the incentive for participation in a shark fin industry stems from the high profit on fins. A key informant IATTC biologist said:

The thing is, you have to understand this is an artisanal fishery and the average fisherman makes 30 or 40 dollars a day on a good trip. That's apart from the fish he takes home… (December, 2010)

Shark fins bring in at minimum $20/kg (Francisco-Fabian, 2001). Numerous fishermen told the field team that each set of fins could bring in $35-$45. Essentially, one set of fins is the equivalent of a fisherman's salary on a good day. WildAid, a nonprofit organization intent on eradicating illegal marine fisheries, claims that shark fins from Ecuador are commonly smuggled into Peru labeled as plastic sheeting, then sold into the international markets (Watts and Wu, 2005).

The existence of a shark fin industry, whether the fins were separated from the shark at sea or at port, is a sensitive subject. Ecuadorian law is clear that shark capture is only meant to be incidental. The existence of a commercial fishery would be illegal. Government officials and fishermen are reluctant to discuss the issue at all. The current situation merits further study to understand to what extent a shark fin industry is already operating in Ecuador.

Circle Hooks and Sharks

Survey results indicate that circle hook adoption is low; only 64 out of 273 informants (23 percent) indicated that they used circle hooks on their boats. Key informants suggest that the low uptake of circle hooks is due to their high cost and low availability, and the traditional use of j-hooks (Key informant, Ecuadorian government official, expert on fisheries, January, 2011; Key informant, IATTC biologist, January, 2011).

Qualitative analysis suggests that fishers are motivated to use circle hooks because they believe they are more effective than j-hooks at catching sharks and other large pelagic fish. Six of the 9 key informants interviewed indicated that circle hooks were good for catching sharks. One IATTC biologist key informant described the appeal of circle hooks:

> *For grueso (large fish) there is no problem. Circle hooks do not affect fishing and that is why they are well accepted for shark and marlin. (January, 2011)*

This is in sharp contrast to how interviewees viewed fishermen's reception of circle hooks for the common dolphinfish. For the common dolphinfish fishery, 6 of 9 interviewees indicated that circle hooks were rejected because they were perceived to lead to lower catch. A key nongovernment informant who is an expert on Ecuadorian fisheries explained the difference as such:

> *I have heard that circle hooks are successful for sharks and marlin and to reduce turtle hooking, but for Dorado (common dolphinfish) circle hooks are a disaster. (February, 2011)*

The qualitative analysis suggests that circle hooks are not perceived equally within all fisheries. The shark and billfish fishery prefer circle hooks. In explaining why fishermen would prefer circle hooks for larger fish, and in particular shark, a government informant with knowledge of the shark fishery and fishery regulations said:

> *They change the materials in general (between common dolphinfish season and TBS season); the hooks, the line, the wire, the type of monofilament. Everything changes. The mother line is thicker for grueso. The hooks are bigger and thicker for shark than for dorado (common dolphinfish). (January, 2011)*

Quantitative data is inconclusive regarding motivation for circle hook use. Survey informants were shown a circle hook and asked to identify it. Sixteen different names were given for the hook. “Parrot beak” hook was the most commonly given name, occurring in 26 percent of responses. Circle hook was the second most commonly given name, occurring in 18 percent of responses. “Shark” hook and “grueso” hook were the third most commonly given names, occurring in 11 percent of responses. No other names were reported in greater than 5 percent of the given responses.

Owners and captains were asked directly: Which of these reasons for using circle hooks is most important to you: [1] Catch more shark [2] Conserve turtles [3] Neither. The circle hook was promoted as a conservation technology, helping to protect turtles. It had no significant history of prior use in Ecuador. The promotional efforts demonstrated the benefit of a circle hook as a conservation tool. It was expected that a significant number of respondents would have indicated that circle hook use is important for the conservation of turtles. In fact, results for a chi-squared analysis were non-significant (Pearson chi squared value: $p = .694$). Captains (41%) and owners (37%) were just as likely to value circle hooks to catch more sharks as they were to value circle hooks for the conservation of turtles. Individuals who valued the circle hook for its ability to capture sharks were significantly more likely to use circle hooks to capture sharks ($n=92$, Pearson chi-squared value: $p = .01$). A subset of the population is motivated to use circle hooks to capture more sharks.

Informants were just as likely to report shark capture whether j-hooks or circle hooks were used. J-hook users (74%) reported shark as a capture as often as circle hook users did (78%). The adoption rates of the circle hook are low, and there remains a prominent shark fishery. With no clear statistics on individual boat-landings, and the gear used on those boats, it is difficult to determine whether circle hooks are encouraging the targeting of sharks. Further, the surveys were not designed to make such a determination. As such, only one question directly mentioned sharks and circle hook.

Recommendations

Ecuador has a prominent shark fishery as indicated by a review of catch statistics, qualitative data, and social survey results. The existence of such a fishery may provide an incentive for the use of the circle hooks to target shark. While the exchange program intends to combat the incidental capture of sea turtles, it could be inadvertently providing a tool for fishermen to capture more sharks, resulting in unintended harm to the ecosystem. The shark is an apex predator with slow growth rates whose removal from ecosystems has documented negative consequences (Dulvy et al., 2007; Pauly et al., 1998). In one instance in the Atlantic Northwest, the removal of sharks contributed to declines in other fish populations (Baum, 1998).

The lucrative trade in shark fins and the established shark fishery in Ecuador provide incentive to use the circle hook to target sharks. There is no easy solution to this problem. Ecuador, and those at IATTC and WWF, are in the unenviable position of trying to decide with uncertain science whether to promote a hook that may save sea turtles but put sharks at risk.

Before these organizations extend promotional efforts for the circle hook program, both in Ecuador and along the Eastern Pacific countries, they must gather more information. First, they must gain a clearer understanding of how circle hooks are used. Do fishermen using circle hooks attempt to target more sharks? While the survey results indicated that sharks were a target species, regardless of hook, it does not reveal the quantity of shark caught. It is possible that circle hook users target shark and bring more sharks to shore than j-hook users. Observers on board boats that use circle hooks and on board boats that use j-hooks would help managers understand whether the circle hook is leading to more sharks being caught.

Second, these organizations should investigate the effect of a shark fishery on Ecuadorian ecoystems. More systematic study on the status of shark populations and role sharks play in the regional marine ecosystem could provide important information; currently few such studies exist. It is possible that increased shark catch is an acceptable outcome of policies that reduce turtle bycatch.

Third, these organizations should develop policy alternatives that seek to conserve both the sea turtle and the shark. Such policy alternatives must consider whether there is, in fact, a targeted shark fishery. Depending on whether the shark fishery is incidental or targeted, the types of effective policy for management change drastically.

If the shark fishery is incidental, with insignificant numbers of fishermen targeting shark, then Ecuador can employ policies of gear modification similar to the circle promotion initiatives. Initiatives can include education on changing the depths of lines to below 100 meters, avoiding shark hot spots, and promoting the use of whole fish bait instead of squid–methods that have been shown to reduce shark bycatch by 30%. Coincidently, setting lines deeper than 100 meters and switching to full fish bait has also been shown to reduce sea turtle bycatch by 55-90% (Gilman, 2012). But switching to fish bait can increase operation costs in comparison to squid

(Gilman et al., 2007), discouraging fisher participation, in turn making it difficult to monitor policies that seek to implement changes in line depth. Fisher participation would be required for success in both initiatives (Gilman, 2012).

If, as the research indicates, Ecuador does have a targeted shark fishery, then the previously mentioned policy efforts would be ineffective. Such policy assumes that the shark is bycatch and that reduction in catch would not be an undesirable outcome of gear and fishing behavior modification (Gilman, 2012). In a targeted shark fishery such measures are unlikely to interest fisher. Policy would be better directed at finding ways to create a sustainable shark fishery. Understanding the motivation for shark capture will allow for more direct management. For example, if fins are the primary motivation for shark capture, and finning the predominant practice, then the establishment of ratio-based capture rates could be effective. Ratio-based rates of capture make it illegal to have more than a 5 percent fin-to-carcass ratio on board at all times (Clarke, 2006). Such a policy could limit the number of sharks that are finned and left to die at sea. Its effectiveness is dependent on finning being a prominent practice. If finning is not occurring in a significant way, other policy alternatives must be considered, even if the motivation for shark capture arises from the sale of fins.

More traditional management methods, such as the establishment of quotas or size limits, could be better suited to manage the stock in a sustainable manner. Quotas or size limits are easier to enforce than policy on gear modification for bycatch reduction (Gilman, 2012). Creating policy that permits a targeted shark fishery would allow circle hook promotional efforts to continue. Even though the circle hooks could promote an increase in shark capture, that increase could be mitigated by policy designed to create a sustainable catch.

Any policy in Ecuador looking to reduce shark capture must consider fisher participation, political feasibility, conservation goals, enforceability, and social equity. Without fisher participation, managers will have difficulty monitoring and controlling fisheries, meaning policy measures are likely to fail (Gilman, 2012). The short-lived ban on shark fin exports in 2004 highlights the need to have politically feasible solutions. Achieving conservation goals through policy requires the consideration of multiple species groups (at minimum sharks and sea turtles) and Ecuador-specific solutions (Gilman, 2012). Any solution must consider how it will be enforced and at what cost, and whether it is feasible. Lastly, a policy's effectiveness can depend on who bears the cost. In the case of the circle hook initiative in Ecuador, key informants indicated that the higher cost of the circle hooks was a reason for low adoption rates (Key informant, Ecuadorian government official, expert on fisheries, January, 2011; Key informant, IATTC biologist, January, 2011).

The largest gaps in knowledge arise from attempting to understand the political feasibility of a policy and the potential for fisher participation. More research is needed in these areas. Also, if conservation must consider both sharks and sea turtles, it is clear that a solution depends on whether the shark fishery is incidental or targeted.

Suggested recommendations for further research:

- Research into the effects of a shark fishery on the regional marine ecosystem.
- Research to determine whether the shark fishery is incidental or targeted.
- Research into the political feasibility of policy alternatives.
- Research on the potential for fisher participation in policy alternatives.

Acknowledgements:

Patrick Christie

Lekelia Jenkins

Michael Vina

Nancy Benetiz

the Ecuadorian survey team

Richard Pollnac

Nikita Gabor

Barbie Clabots

Mary Bacha

My Family

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Appendix A: Catch Statistics from major Ecuadorian fisheries

Year	Billfish capture (metric tons)	Tuna capture (metric tons)	Pelagic shark capture (metric tons)	Common Dolphinfish Capture (metric tons)
2001	617	151,126	2,656	5,266
2002	508	145,693	2,064	5,473
2003	263	232,005	1,379	4,756
2004	N/A	184,466	1,209	4,838
2005	127	224,496	1,094	2,300
2006	2126	226,729	1,708	3,638
2007	3,503	186,234	1,731	3,865
2008	3305	252,326	1,884	13,491
2009	1688	229,916	4,941	6,920
2010	491	201,560	5,514	6,728

Sources: FAOSTAT, Fisheries Commodities Global Production and Trade, accessed last: June 3rd, 2012

Note: For Shark, FAO statistics were used, though estimates by field reseachersindicate that actual catch may be 3.6 times higher (Jaquet et al., 2008; Diaz, 2008; Peralta, 2009)

Appendix B: List of commonly caught sharks in Ecuadorian Waters

Common name	Scientificname	ListedonIUCN redlist
Scallopedhammerheadshark	Sphyrnalewini	Endangered
Pelagicthresher	Alopiaspelagicus	Vulnerable
Bigeyethresher	Alopiassuperciliosus	Vulnerable
Oceanicwhitetipshark	Carcharhinuslongimanus	Vulnerable
Shortfinmako	Isurusoxyrinchus	Vulnerable
Longfinmako	Isuruspaucus	Vulnerable
Galapagosshark	Carcharhinusgalapagensis	Lowerrisk(nearthreatened)
Blueshark	Prionaceglauca	Lowerrisk(nearthreatened)
Silkyshark	Carcharhinusfalciforims	Lowerrisk
Blacktipshark	Carcharhinuslimbatus	Lowerrisk(nearthreatened)
Bullshark	Carcharhinusleucas	Lowerrisk(nearthreatened)
Dusky shark	Carcharhinusobscurus	Lowerrisk(nearthreatened)
Tigershark	Galeocerdocuvier	Lowerrisk(nearthreatened)
Lemon shark	Negaprionbrevirostris	Lowerrisk(nearthreatened)
Crocodile shark	Pseudocarchariaskamoharai	Lowerrisk(nearthreatened)
Pacificangelshark	Squatinacalifornica	Lowerrisk(nearthreatened)
Bonnetheadshark	Sphyrnatiburo	Lowerrisk
Smooth hammerheadshark	Sphyrnazygaena	Lowerrisk(nearthreatened)
Smalltailshark	Carcharhinusporosus	Data deficient
Nurse shark	Ginglymostomacirratum	Data deficient
Mexican hornshark	Heterodontusmexicanus	Data deficient
Sharptoothsmoothhound	Mustelusdorsalis	Data deficient
Scoopheadhammerheadshark	Sphyrnamedia	Data deficient
Brownsmoothhound	Mustelushenlei	Not evaluated
Sicklefinsmoothhound	Musteluslunulatus	Not evaluated
Whitenoseshark	Nasolamiavelox	Not evaluated
Pacificsharpnoseshark	Rhizoprionodonlongurio	Not evaluated

Sources:Aguilaretal.2007;IUCN 2007;Martinez-Ortiz2007.