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# Optimum sample number for estimating shark by-catch in the Spanish Purse Seiners in the Western Indian Ocean

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## Introduction

The Food and Agriculture Organization of the United Nations (FAO) defines the term bycatch (or by-catch) as "*part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying*". Nowadays, the by-catch issue is one of the most important topics that the fishery management is facing with. It affects, to a large extent, to different countries and fisheries and, thus, it has become an issue worldwide. For example, Keller (2005) estimated that 7.5 million tons of fish are discarded annually, which represents approximately the 8% of all the captures. That has led to the question about the possible effect that by-catch can have in the different species and in the ecosystem.

In this work, we consider the bycatch as the fraction of the catch that consists of non target species (including other tuna-like species) that are captured by the Spanish purse-seine fleet operating in the Indian Ocean. The tuna purse-seine fishery has as main target species skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) but it also has an impact in other species of the pelagic ecosystem. By-catch normally depends on the structure, behaviour and spatial organisation of the different species included into the fish aggregations. Among the incidentally captured species in this fishery other tuna-like fishes, sharks, turtles, and others are included.

The main aim of this working document is to estimate the sampling level coverage needed to get accurate and reliable estimates of the shark by-catch in the Spanish purse seine fishery. In other words, our intention is to determine the number of tows to be sampled to get accurate estimates of shark total by-catch with a given confidence interval. Moreover, the working document will also describe the incidence of shark by-catch using AZTI discard sampling data in the Spanish purse-seiners in the Indian Ocean.

## Material and methods

Since 2003 AZTI-Tecnalia, in coordination with the Spanish Institute of Oceanography (IEO), carries out part of the Spanish tropical tunas sampling programme for the collection of data in the fisheries sector (PNDB) under the EU Data Collection Regulations (EC) No 1543/200, 1639/2001 and 1581/2004. This sampling program covers approximately the 5% of the total effort devoted by the Spanish purse-seine fishery. One of the objectives of the sampling program is to estimate the discards (modules E and H of the regulation) of by-catch species in the fishery.

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The information presented in this document was collected by AZTI-Tecnalia. In total, 22 sampled trips were completed in 12 different Spanish purse-seiners in the Indian Ocean between April 2003 and November 2006. The yearly sampling coverage between 2003 and 2006 is presented in Table 1. The number of sets includes null sets. Most of the sampling was carried out in the second and fourth quarter of the year. The observers collected the data according to the *ad hoc* common methodology agreed by IEO, IRD and AZTI (Delgado de Molina *et al*, 1997). These data are the following: route data; set and Fish Aggregation Device (FAD) characteristics, retained catch, discard and by catch estimations, and length distribution by species.

**Table 1. -** AZTI Discard sampling level in Indian Ocean (2003-2006).

| Project | Sampling Objective (trips) | Sampled trips | Fishing days | Total Sets |
|---|---|---|---|---|
| PNDB 2003 | 6 | 4 | 108 | 98 |
| PNDB 2004 | 6 | 4 | 149 | 92 |
| PNDB 2005 | 7 | 6 | 176 | 164 |
| PNDB 2006 | 7 | 7 | 272 | 181 |
| *Total* | 26 | 22 | 705 | 535 |

Our study will only take into account the sharks captured under the fishing FAD modality as the number of observation in the free-school fishing was low. The captures associated to FADs were considered, because only four sharks from the species (*Carcharodon carcharias*) where captured in the free schools hauls.

Assuming that the by-catch level is constant year by year and using Monte Carlo simulation techniques, we analyse whether the sampling level was sufficient enough to raise the by-catch estimates to the whole capture for that fleet segment or the whole fleet with a certain degree of confidence. In other words, the probability of calculating the by-catch with a 95 % confidence interval was estimated based on the number of samples.

We estimate the parameters of a negative binomial distribution using the data obtained in the samplings.

$$p(c) = \frac{\Gamma(c+n)}{\Gamma(n)\cdot c!}\cdot p^{n}\cdot(1-p)^{c}, \qquad \begin{matrix} c = 0,1,2,\ldots,n \\ 0 < p \le 1 \end{matrix}$$

$$\begin{cases} E(c) = \dfrac{n\cdot(1-p)}{p} \\ VAR(c) = \dfrac{n\cdot(1-p)}{p^{2}} = \dfrac{E(c)}{p} \end{cases}$$

Through Monte Carlo simulation techniques, extracting values of the obtained binomial negative function when varying the sampling intensity, we simulated the shark captures. For each iteration, we estimated the probability that the obtained value would be correct with a 95 % confidence level (Hilborn and Mangel, 1997).

**Results and Discussion**

AZTI-Tecnalia observers, onboard Spanish purse-seiners, sampled a total of 320 fishing tows associated to FAD (Table 2 shows the yearly distribution of tows) in 22 trips (705 fishing days) during 2003-2006.

**Table 2. –** Total tows of the Spanish purse-seiners and AZTI sampled tows in fishing associated with FAD, Indian Ocean (2003-2006).

| Year | Spanish total tows | Sampled tows |
|---|---|---|
| 2003 | 1822 | 49 |
| 2004 | 1775 | 46 |
| 2005 | 2620 | 118 |
| 2006 | 3100 | 107 |
| *Total* | 8837 | 320 |

*Carcharhinus falciformis* was the species most captured by the observed purse-seiners; however, on average, less than two individuals per FAD set are captured. Table 3 shows the mean by-catch by species per FAD set, and figure 1 the distribution of this by-catch by species in percentage.

**Table 3. –** Total shark catches observed by species by FAD sets.

| Species | Mean number by FAD set |
|---|---|
| *Carcharhinidae family* | 0.30 |
| *Carcharhinus longimanus* | 0.10 |
| *Carcharihiniform order* | 0.21 |
| *Carcharodon falciformis* | 1.91 |
| *Megachasma pelagios* | 0.00 |
| *Rhincodon typus* | 0.02 |
| Non identified shark | 0.14 |

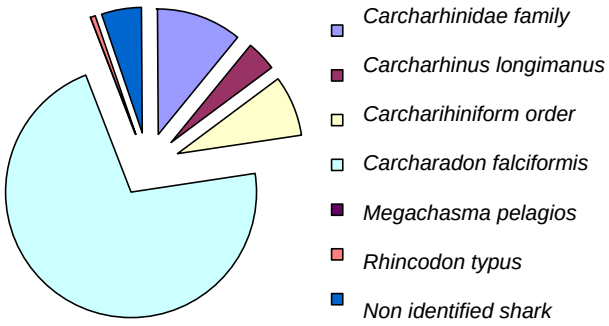


**Figure 1.-** Shark by-catch percentage by species in FAD sets.

Figure 2 shows the number of tows where different numbers of sharks per tow were captured. There were no shark catches in most of the tows but there were few tows with a significant number of shark by-catch. The binomial negative estimated from the data is also presented in figure 2 (right).

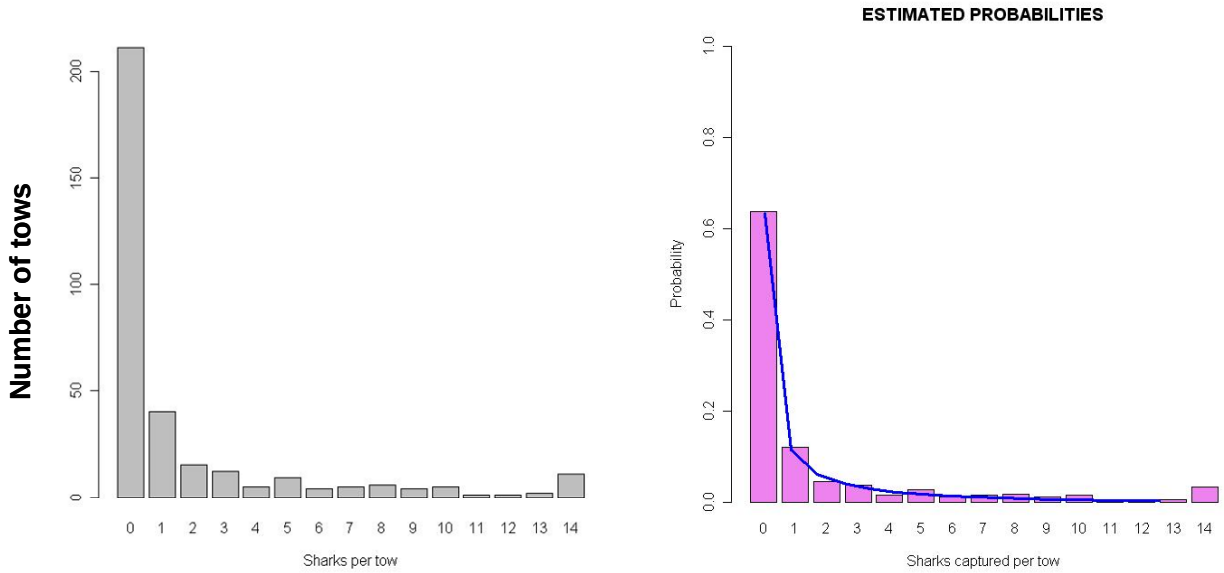


**Figure 2. –** Number of tows in which different numbers of sharks per tow were captured (left) and the estimated negative binomial distribution from sampling data.

The level of coverage obtained within the current sampling program is presented in Table 4, where the percentages of sampled tows each year are presented.

**Table 4. –** Total tows of the Spanish purse seiners and AZTI sampled ones

| Year | Spanish total tows | Sampled tows | Sampled |
|---|---|---|---|
| 2003 | 1822 | 49 | 2.7 % |
| 2004 | 1775 | 46 | 2.6 % |
| 2005 | 2620 | 118 | 4.5 % |
| 2006 | 3100 | 107 | 3.5 % |
| *Total* | 8837 | 320 | 3.4 % |

The samplings simulations following a Binomial Negative distribution estimated from the data (Figure 2, right), allowed to obtain the probability to estimate the total number of shark by-catch with 95% confidence level depending on the number of samples (Figure 3). As we can observe from the figure to obtain a 95 % confidence level with 90 % probability around 650 tows should be sampled, which corresponds to around 25 % of the total tows (taking into account 2003-2006 average in tow numbers).

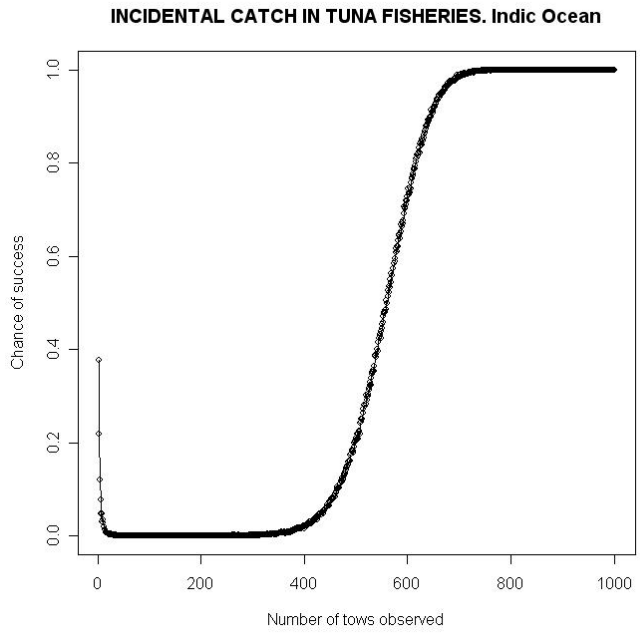


**Figure 3. –** Probability of obtaining a shark total by-catches prediction with a 95% confidence level, depending on the tows observed

Therefore, it can be concluded that to obtain an optimum sampling level it is necessary to sample around 25% of the tows of the Spanish purse seine fleet. Thus, the actual level of sampling coverage is very low, especially taking into account the relatively uncommon presence of sharks in the catch. This conclusion is in agreement with other studies carried out in relation to by-catch sampling coverage which stated that 20-33% of sampling coverage was needed for reasonable by-catch estimation (Lennert-Cody, 2001). The required high sampling coverage obtained in this study can be expected due to the fact that shark by-catch showed high variability. In other words, most of the tows do not catch shark while a few tows catch most of the shark by-catches.

In conclusion, it is clear that the actual level of coverage to estimate sharks by-catch accurately is very low and that efforts should be devoted to increased the sampling coverage. Moreover, it would be interesting to extend this exercise to other data set of the European purse seine.

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