COST BENEFIT AND FINANCIAL ANALYSES OF QUOTA MANAGED OPTIONS FOR BIGEYE AND YELLOWFIN TUNAS IN THE EASTERN PACIFIC OCEAN

FINAL REPORT

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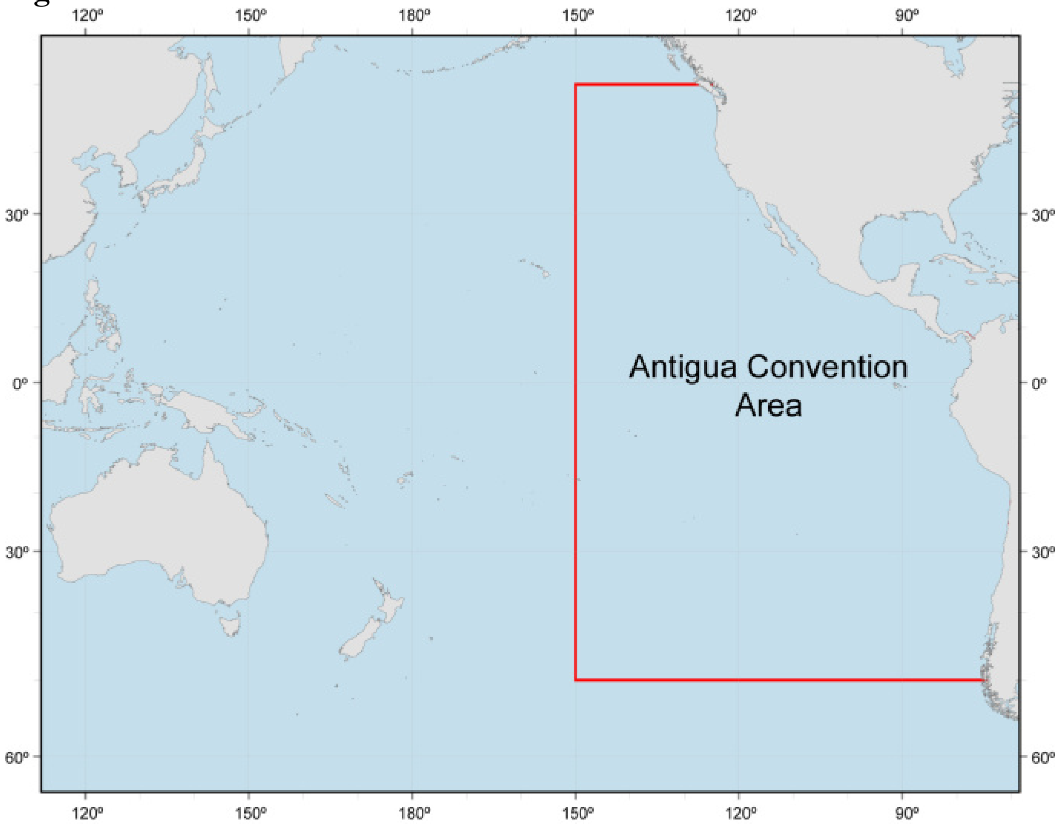
CHAPTER 1 - INTRODUCTION AND BACKGROUND

1.1. INTRODUCTION

The status and the administration of large pelagic fish stocks[1] across the globe are of concern (Pauly et. al., 1998, Jackson et. al., 2001, Baum et. al., 2003, Myers y Worm, 2003). The tuna purse seine fishery that operates in the Eastern Pacific Ocean (EPO) (Figure 1) in the area under jurisdiction of the Inter-American Tropical Tuna Commission (IATTC) is not an exception.

Figure 1. IATTC Convention Area*



Source: IATTC

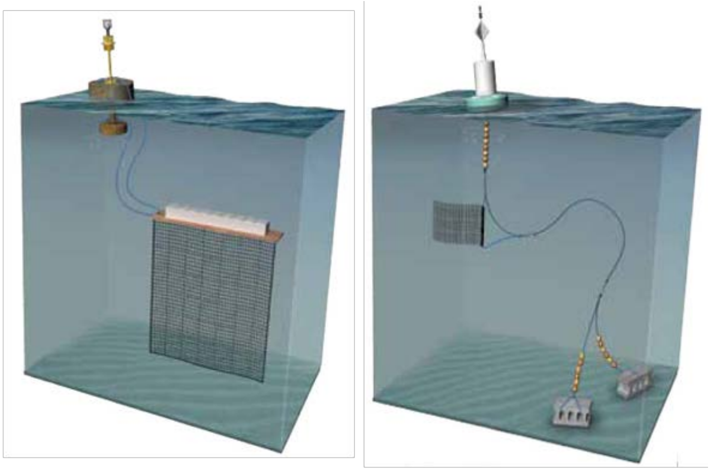
*The red box represents the area of jurisdiction of the IATTC under the terms of the Antigua Convention. The IATTC Convention Area (see map) includes waters bounded by the coast of the Americas, the 40 ° N. and 40 ° S. parallels, and the 150 ° W. meridian.

The management of the tuna fishery in the different oceans across the globe is complex due to two reasons: 1) the transnational nature of the habitat of such species, namely, tuna stocks

[1] Fish that live in the open sea, in mid-waters or near the surface; limiting their contact with the seabed or the coast.

are shared among the economic exclusive zones (EEZ) of various nations, and 2) the extension of the tuna fishing zones, which are extended up to high sea zones, beyond the EEZ, where the national jurisdictions do not apply[2].

Figure 2. Fish Aggregating Devices (FADs)



Source: The Pew Charitable Trusts

At the beginning of last year, a concern that had existed for many years was confirmed: the abundance of Bigeye tuna (BET) and Yellowfin tuna (YFT) (two of the three most important commercial tuna species exploited in the EPO) was below (or was projected below) the levels of biomass that facilitate the achievement of the maximum sustainable yield (MSY) of such species. For this reason, by mid-2016, the scientific staff from the Inter-American Tropical Tuna Commission (IATTC), regional regulatory body of tuna fishing activity in the EPO, recommended to increase the annual closed season to 25 additional days. The objective of the latter measure is to control and reduce the mortality rate of both BET and YFT so as to influence positively stock health of both species in the EPO. Because of this situation, the representatives of the tuna purse seine industry in the EPO, as well as representatives from other groups of interest related to this

[2] Around 40% of the tuna in the world is captured in high seas (Allen et. al. 2010).

fishery (e.g. governments, NGOs, among others) considered the implementation of alternative management policies to solve the problem (of excessive capacity and effort) without entailing an extension of the closed season. The management alternatives analyzed in this report include the following:

1. Establishing an individual catch quota system for BET and YFT, distributed among boats or countries; and/or
2. Options for seasonal closures.

In this report, our main objective is to evaluate quantitatively the impact of these policies on the welfare of the fishing sector that operates in the EPO. It is important to emphasize that our analysis will be conducted under the framework of the current situation of overcapacity in the EPO, which translates into a disproportionate fishing effort that has negatively affected the health of BET and YFT populations.

1.2. BACKGROUND OF THE TUNA FISHERY IN THE EASTERN PACIFIC OCEAN

The purse-seine tuna fishery that operates in the Eastern Pacific Ocean is a transboundary fishery that covers the Economic Exclusive Zones (EEZ) of various coastal states. The total tuna catch in the EPO has ranged between 500.000 and 900.000 Metric Tons and constitutes between 10% and 20% of the total global tuna catch (Allen et al., 2008).

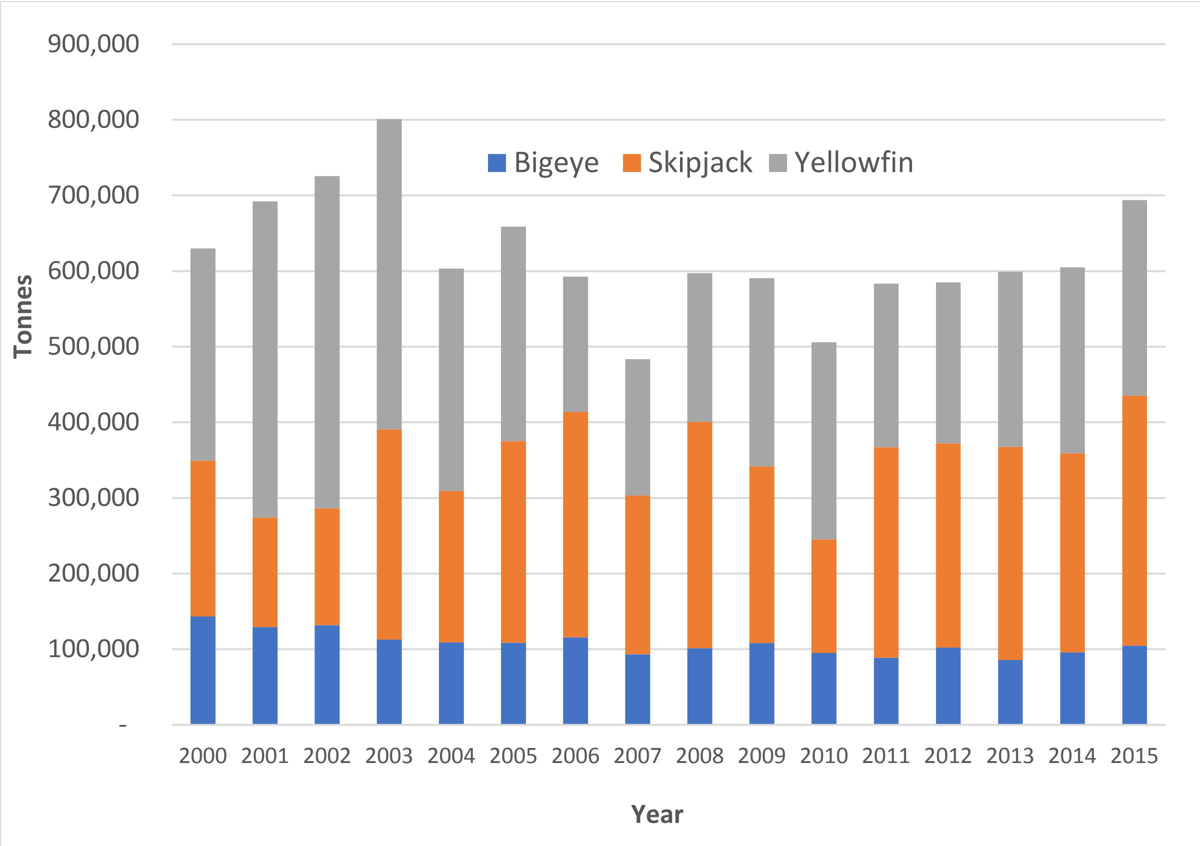
In 2015, approximately 13% of the global production of tuna came from the EPO. Total catches of Bigeye Tuna (BET), Yellowfin Tuna (YFT) and Skipjack Tuna (SJT) in 2015 in the EPO summed up to approximately 693,633 tonnes, which represents a 14.66% increase in comparison to the catch of 2014. As shown in Figure 3, the total catch has showed a negative trend since 2003 (year in which the catch of these species achieved a record level of 800,933 tonnes), reaching its minimum in 2010 (i.e. 483,660 tonnes). However, since 2011 a slow recovery of the catch is observed, which reached its peak in 2015 (though it is still 13.40% lower than the maximum catch recorded in 2003). Regarding the composition of the catch, according to the IATTC data, during the last six years (i.e. 2010-2015), approximately 44% of the total catch in the EPO was of SJT, while approximately 40% and 16% of the catch was of YFT and BET, respectively.

In the EPO, during the last six years (i.e. 2010-2015), approximately 91.4% of the catch was taken by purse-seine (PS) vessels, 8.0% was taken by long-line (LL) vessels, and the rest (i.e. 0.6%) corresponded to other types of vessels (Figure 4). The longline fleet that participates in the EPO originates mainly from Asian nations (i.e. distant waters nations), such as Japan, Korea, China and Taiwan, which operate exclusively on the high seas. On the other hand, the PS fleet operates not only in the high seas, but also in the EEZs of member countries. In the year 2015, vessels from five coastal states from Latin America (Ecuador, Mexico, Panama, Venezuela and Colombia) landed slightly more than 90% of the total tuna catch coming from the PS fleet in the EPO.

Purse-seiners catch the three commercial tuna species in the EPO by using three different types of sets; they are: dolphin (DEL), unassociated (NOA) and floating-object (OBJ). In the last six years (i.e. 2010-2015), PS vessels caught 51.6% of the tuna using OBJ sets, 28.2% using DEL sets, and the remaining 20.2% using NOA sets (Figure 5). It is important to emphasize that for each of the three commercial tuna species, the prevalence of the type of set is different. Thus, OBJ is the most important type of set for both BET (i.e. approximately 97% of the total catch) and SJT (66% of the total catch). On the other hand, DEL set is the most important for the catch of YFT (66% of the total catch).

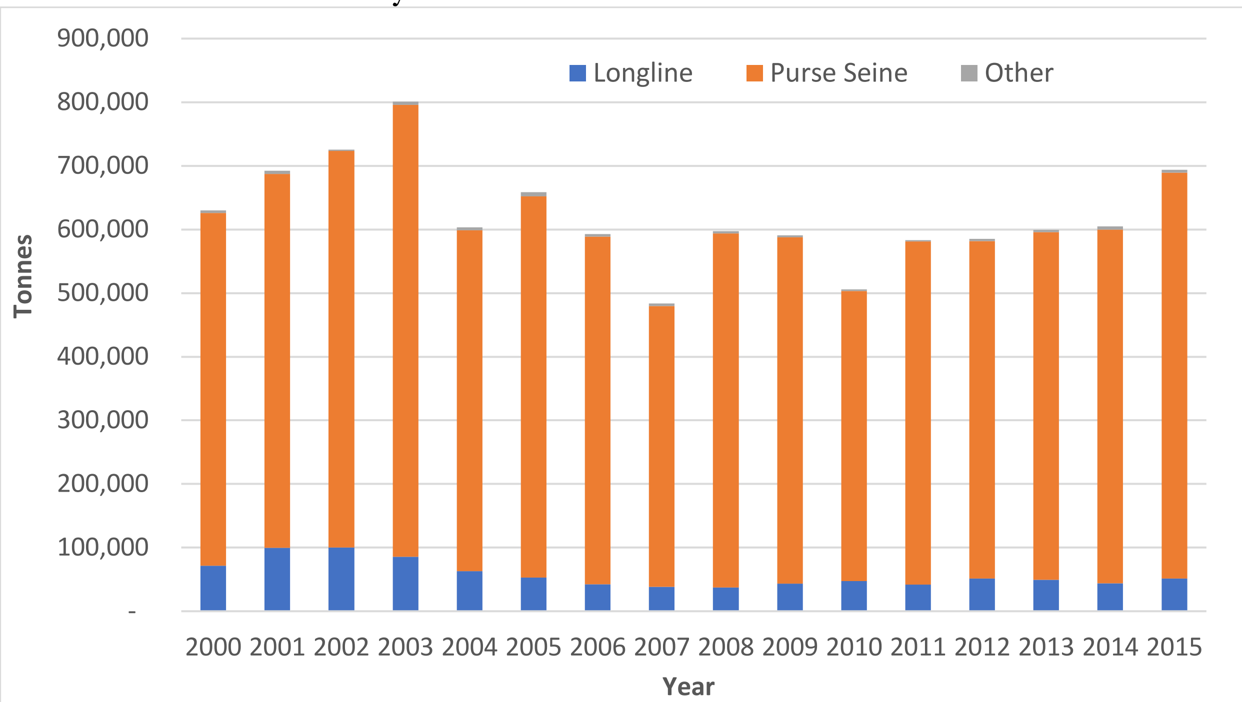
Also, we should note that the fleets that participate in the EPO specialize in a specific type of sets, and based on that specialization, PS vessels can be classified into two groups. The first one (in which Ecuador is the main participant) consists of vessels that use FADs intensively for their fishing operation. The FADs are essentially focused on the catch of SJT and, incidentally, capture smaller sizes of BET and YFT. On the other hand, the second group consists of vessels that use the technique of fishing over dolphins, and focuses especially on the catch of adult YFT and SJT. Mexico is the main participant in this second group.

Figure 3. Total Catch of Yellowfin, Bigeye and Skipjack Tuna in the Eastern Pacific Ocean from 2000 to 2015



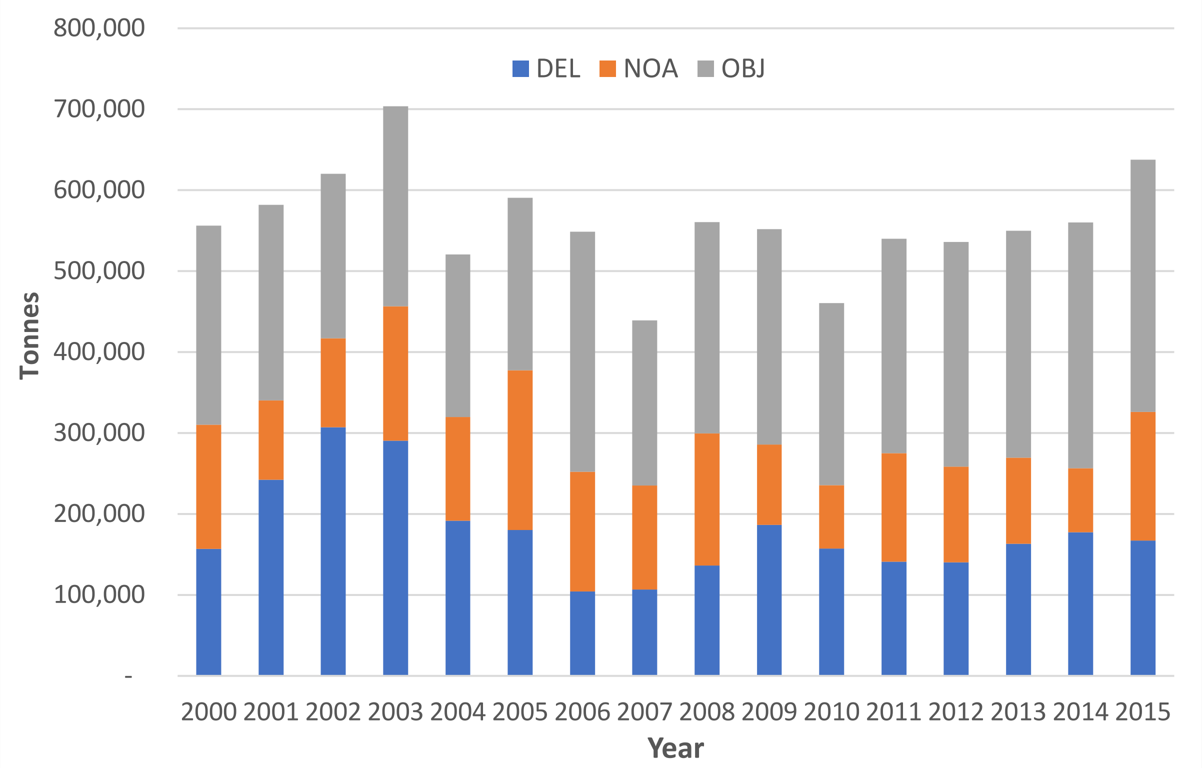
Source: IATTC. Catch Reports Data. https://www.iattc.org/CatchReportsDataENG.htm

Figure 4. Total Catch of Yellowfin, Bigeye and Skipjack Tuna in the Eastern Pacific Ocean from 2000 to 2015 classified by Gear



Source: IATTC. Catch Reports Data. https://www.iattc.org/CatchReportsDataENG.htm

Figure 5. Total Catch of Yellowfin, Bigeye and Skipjack Tuna by the IATTC's Purse Seine Tuna Fleet in the Eastern Pacific Ocean from 2000 to 2015 classified by the type of set



Source: IATTC. Catch Reports Data. https://www.iattc.org/CatchReportsDataENG.htm

1.3. GOVERNANCE, MANAGEMENT AND REGULATIONS FOR INDUSTRIAL TUNA FISHING IN THE EPO

The fishery is managed by the Inter-American Tropical Tuna Commission (IATTC), an organization that is composed by 21 members, within coastal states and countries in distant waters[3]. The IATTC is the regional institution responsible for the regulation of the tuna fisheries and of other species captured by tuna fishing vessels in the EPO. Consequently, since 2004, the IATTC has implemented measures to limit the purse seine fishing effort. These measures

[3] The members of the IATTC are Belize, the European Union, Nicaragua, Canada, France, Panama, China, Guatemala, Peru, Colombia, Japan, Taiwan, Costa Rica, Kiribati, United States, Ecuador, Korea, Vanuatu, El Salvador, Mexico and Venezuela. Bolivia, Honduras, Indonesia and Cook Islands are cooperative non-affiliated members. It is important to specify that Ecuador is part of the IATTC since 1997, date since which it has complied and adopted all the resolutions and recommendations established by the institution.

essentially consist of temporary (e.g. closed seasons) and spatial (e.g. area closures) fishing restrictions.

Specifically, the management policies applied by the IATTC up to last year (i.e. 2016) have been the following:

- 62-days closed season. All the class 5 and class 6 purse seine vessels[4] must stop their fishing activity in the EPO for a period of 62 days. Member countries, and non-member cooperating parties (CPCs) of the IATTC may decide which one of the following two periods to adhere to: from July 29 to September 28, or from November 18 to January 18. Class 4 purse seine vessels may only perform one 30-day long fishing trip during the closure periods, but if and only if they have an observer from the Observer Program of the IATTC.
- Prohibition of fishing activity for purse seiners in the zone located in the marine area known as "El Corralito", located within the 96 ° W y 110 ° W, & 4 ° N y 3 ° S, starting September 29 at 00:00 hours, until October 29 at 24:00 hours.

Class 1 to 3 purse seine vessels (182 metric tons of carrying capacity or less), longline vessels less than 24 meters long, as well as pole-and-line vessels and sports fishing vessels, are not subject to these measures.

Additionally, the IATTC has also imposed catch limits for BET caught by longline vessels whose total length exceeds 24 meters, originating from China, Japan, Korea and Taiwan. Total annual catches of BET from these fleets should not exceed the catch limits provided in Table 1.

[4] The IATTC divides the purse seine vessels in six classes, based on their storage volume in cubic meters. The classification is the following:

Class	**1**	**2**	**3**	**4**	**5**	**6**
Cubic meters	<54	54 - 107	108 - 212	213 - 318	319 – 425	>425

Table 1. Catch limits for Asian longline vessels that operate in the EPO

Country	Metric Tons
China	2,507
Japan	32,372
Korea	11,947
Taiwan	7,555

Source: IATTC

Nonetheless, all of the management policies previously mentioned have not been completely effective, especially in controlling overfishing of juvenile/small BET and YFT. For this reason, the use of complementary management policies for the tuna fishery in the EPO has been unsuccessfully explored, since 2006.

However, since 2015, and due to the threat of increasing the length of the closed season, a set of rights based management (RBM) alternatives have been discussed, such as the implementation of an individual quotas system within countries and/or seiners. Hereunder, we analyze in greater depth this initiative, the steps that have been taken for its implementation to date, as well as the pending tasks that should be fulfilled within the following months and years.

1.3.1. RIGHTS BASED MANAGEMENT

The main issue with the tuna fisheries in the EPO is overcapacity that results in excessive fishing effort, as well as an extensive use of fishing techniques that are not regulated, such as the FADs. These behaviors derive from the current environment, which facilitate the distortion of the incentives to participants, promoting the expansion of fishing capacity beyond the sustainable limits and encouraging a constant race for fishing. This situation has persisted despite efforts of the IATTC to establish limits on the number of fishing vessels registered and carrying capacity. Hence, the interest to reform the current management system, giving preference to measures that clearly define use and incentivize the “right” behavior in the fishery.

For example, an alternative is the implementation of use rights/limits over the catch. This scheme generally consists of fixing a global catch limit, and subsequently assigning quota among participants of the fishery. This removes the incentive for a "race for fishing", because every member has exclusive use of a specific quantity of fish (in this case, tuna). If transfer is allowed, the system would evolve to what is called an Individual Transferable Quota (ITQ) regime. The latter system would prompt the creation of a quota market that, at the same time, would allow a reduction of the number of fishing vessels, as the more efficient vessels would be expected to buy the quotas from the less efficient ones, and the latter, in the long term, are expected to sell definitively their ITQs and abandon the fishery, which would generate an effective reduction of fishing effort. Please note that use limits/rights can also be expressed in days at sea and limits on sets over FADs.

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1.3.2. QUOTA SYSTEM IN THE EPO – FEBRUARY 2017

As a result of the 91st Extraordinary Meeting of the IATTC (held in La Jolla, California from February 7, 2017 to February 10, 2017), annual catch limits (i.e. quotas) for BET and YFT (combined) were established for the first time, for class 4, 5 and 6 vessels that capture those species using floating objects (i.e. FADs) or over dolphins. Specifically, the IATTC resolved to establish the following as a conservation measure for the tuna fishery in in the EPO for the 2017 season (i.e. from January to December 2017):

> *The IATTC establishes a total annual catch limit of the average level observed during 2013-2015 for yellowfin and bigeye (combined) caught by capacity class 4, 5, and 6 purse-seine vessels of 97,711 t for the fishery on floating objects, and 162,182 tons for the fishery over dolphins by Class-6 vessels. These catch limits include the activation of the capacity recognized for Guatemala and Venezuela at the 88th Meeting of the IATTC. The Director shall notify CPCs when the catch of yellowfin and bigeye by capacity class 4, 5, and 6 purse-seine vessels reaches 80% of the total catch limit in sets on floating objects or over dolphins, respectively. At 90% of the total catch limit, the Director shall notify CPCs of an estimated closure date for the respective fishery, and at 100% the Director will announce the closure of the respective fishery. CPCs shall ensure that purse-seine vessels flying their flag stop making sets on floating objects or dolphins when the total limit is reached in the respective fishery.* **(Resolution C-17-01)**[5]

[5] https://www.iattc.org/PDFFiles2/Resolutions/C-17-01-Tuna-conservation-2017.pdf (Last accessed on 07/15/2017)

Unlike previous resolutions regarding tuna conservation measures which had a duration of three fishing seasons, this last one would only be applied for one season.

The delegations of Ecuador and Colombia, initially proposed not only the establishment of a global catch limit, but also of a system of individual quotas for all class 6 purse seine vessels (and class 5, included in Colombia's proposal) that capture BET (proposals of Ecuador and Colombia) and YFT (Colombia's proposal exclusively) through the use of FADs in the EPO. The proposal that Ecuador presented in October 2016 was the following:

> *From the year 2017 to the year 2018 Class-6 purse-seine vessels, that are on the IATTC Regional Vessel Register, shall limit the catches of bigeye tuna caught in sets on FADs, for which a maximum quota of 57,302 tons is established for the EPO, calculated on the basis of average of the historical catches in sets on FADs between the years 2012 and 2015 by the tuna purse-seine fleet in the Eastern Pacific Ocean with a reduction of 5%. The global quota shall be distributed for each country in accordance with its historical average 2012 to 2015 during the years that its vessels have operated minus 5%.* **(Proposal IATTC-90 G-2)[6].**

Whereas the Colombian delegation's proposal is resumed as follows:

> *IATTC Class-5 and -6 purse-seine vessels shall limit catches of bigeye and yellowfin tuna in sets on FADs, for which an annual individual-vessel catch quota is established for these species, taking as a reference the average of the catches by these vessels during the years 2013, 2014 and 2015. Taking into account the difficulty of differentiating between juveniles of bigeye and yellowfin tuna, the quota will be considered as a combination of the two species. The combined quota corresponds to the sum of the average of the catches of each of these species in sets on FADs for the years 2013, 2014 and 2015. The combined quota shall be distributed in accordance with the (IVQ) system that the Commission may establish on the basis of a recommendation from the Scientific Advisory Committee.* **(Proposal IATTC-90 G-3)[7]**

These proposals were alternatives to the scientific staff proposal to increase the closure season by an additional 25 days.

For the IATTC Extraordinary Meeting held in February 2017, Ecuador and Colombia had unified their proposal. They suggested:

> *From the year 2017 to the year 2018 Class-6 purse-seine vessels, that are on the IATTC Regional Vessel Register, shall limit the catches of bigeye and yellowfin tuna caught in sets on floating objects, for which a maximum catch limit of 89,538.60 tons is established for the entire EPO, calculated on the*

[6] https://www.iattc.org/Meetings/Meetings2016/Oct/Pdfs/Proposals/IATTC-90-PROP-G-2-ECU-Tuna-conservation-2017-2018-CLEAN.pdf (Last accessed on 07/15/2017)
[7] https://www.iattc.org/Meetings/Meetings2016/Oct/Pdfs/Proposals/IATTC-90-PROP-G-3-COL-Individual-Vessel-Quotas-IVQs.pdf (Last accessed on 07/15/2017)

basis of average of the historical catches in sets on floating objects between the years 2013 and 2015 (99,487.33 t) by the tuna purse-seine fleet in the Eastern Pacific Ocean with a reduction of 10% (9,948.73 t). The global catch limit shall be allocated for each country in accordance with its historical average of catches 2013-2015 during the years that its vessels have operated minus 10%. **(Proposal IATTC-90 G-2B)**[8]

At the end, as it was noted previously, the IATTC resolved to establish a global quota and not an individual quota/limit system, neither for vessels nor for countries. Additionally, such quota was not only established for fishing on FADs, but also on dolphins. The duration of this measure was limited to the 2017 fishing season. The danger of a global quota is the promotion of a race to fish that is especially concerning due to the degree of purse seine overcapacity in the EPO. Also, as we indicated previously, it is necessary to emphasize that the effect of a global quota over the incentive of fishery participants is completely different from other RBM systems such as an IVQ because the latter (unlike the former) does remove the incentive for a "race for fishing" since every member has exclusive right over a specific quantity of fish (in this case, tuna).

1.4. INTRODUCTION OF THE METHODOLOGY FOR THE COST AND BENEFIT ANALYSIS.

Finally, in this introductory chapter we will explain briefly the methodology of the Cost-benefit analysis (CBA) that we will apply in this report. Specifically, a CBA is a useful economic policy evaluation tool. Biological evaluation tries to determine the impact of a management policy on the health of a marine resource, considering its complete life cycle. On the other hand, economic evaluation of fishing regulation tries to assess the social desirability of a fishing policy, compared to a baseline situation or some other alternative; it can help public policy in focusing on the need for regulation, and to find the scope and design for such regulation. A CBA tries to encompass results obtained from both the economic and biological analyses.

[8] h https://www.iattc.org/Meetings/Meetings2016/Oct/Pdfs/Proposals/IATTC-90-PROP-G-2B-COL-ECU-Tuna-conservation-2017-2018.pdf (Last accessed on 07/15/2017)

CBA aims to determine the impacts of a policy in terms of benefits and costs, by transforming the impacts into monetary units. CBA has also been applied to evaluate fishery policy; examples of the application of this type of analysis are: Freese et. al. (1995), Herrick et. al. (1994), Schwindt et. al. (2000), and Brown and Macfadyen (2007).

Our proposal will solely focus on the producer side; we will not analyze the impact to consumers because of the scope of the consultancy and the limitation on time, data and resources.[9]

To analyze the welfare effect on the production side the Producer Surplus (Pr.S) is generally used as a measure, which is defined by the following equations:

$$\mathrm{Pr.S_j} = \sum_{t=1}^{n} \frac{(P_t - C_t)Q_t - A_t}{(1+r)^t} \quad \text{where } j = \text{baseline or new policy} \qquad \mathbf{(1)}$$

and
$$\Delta PS = PS_{New\ Policy} - PS_{Baseline} \qquad \mathbf{(2)}$$

where $\mathbf{Pr.S_j}$ is the producer surplus derived from the policy *j* (being *j* two possible states: status-quo/baseline or new policy), $\mathbf{P_t}$ is the price of the landed product in the time *t*, Q_t is total catch in time *t*, $\mathbf{C_t}$ is the average variable cost in time *t*, $\mathbf{A_t}$ is the total cost of fisheries management (control and monitoring)[10] in time *t* and *r* is the discount rate[11].

The Pr.S is also defined economically, as the sum between the economic profits and the fixed costs. Given that this analysis is conducted from a financial point of view we diverge a little from the economic definition of the Pr.S and we will use a more financially relevant measure; that is, we use what is known as the *financial cash flow per year*, which is defined as the net financial profits per year plus the yearly depreciation expenses. If we consider that annual depreciation expenses are a way of apportioning fixed costs of the company annually, then we can state that annual cash flow is the financial equivalent of the economic measure known as Pr.S.

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[9] A more precise way to conduct a CBA is estimating supply and demand relationships from which we would directly estimate aggregate changes in net national or regional benefits. However, the data is not rich enough (and both time and resources are too limited) for this type of analysis.

[10] Costs from changes in management are important to include. Normally, these costs are not included; the implicit assumption is that the changes in management costs are zero. In our specific case, since we are evaluating different management policies, this would be a very important component of our analysis.

[11] The choice of the appropriate rate to use for the discounting is a widely-discussed topic (see e.g. Weitzman 2001). We will make the simplified assumption that is a range that goes from the referential passive interest rate of each country to the active interest rate that each country pays for its external debt.

We will conduct this analysis for the PS fleets that operate in the EPO and with that, we will estimate the change in cash flow (i.e. financially equivalent of the change in economic Pr.S) to obtain the financial impact of the different policies on the profitability of those fleets.[12]

[12] Given our limitation on data, for the different analyses in this report we will use strong assumptions which are clearly listed in the appropriate sections below.

CHAPTER 2 - FINANCIAL BASELINE ANALYSIS

2.1. INTRODUCTION

In this chapter, first, we will provide a detailed description of both the cost and income information that have been gathered from a sample of purse-seine vessels that operate in the EPO. The information obtained from these boats will be used to define a set of representative boats for the fleets that set on FADs as well as the fleets that set on dolphins. This information will be used for the analyses conducted in this report. Finally, also in this chapter, we will provide a cash flow analysis that will be the baseline for the financial assessment analyses of a set of conservation policies, which will be conducted in the following chapters.

This section is divided into two parts. In the first part, we will provide a baseline financial analysis of the boats that set on FADs, meanwhile in the second part we will repeat this analysis for boats that set on dolphins.

As we indicated previously, the results obtained in this chapter will be used subsequently in this report. Specifically, the results will be used in Chapter 4 to estimate the financial impact of different conservation policies on the cash flow of individual PS vessels, that could be classified in the representative categories that are defined in this chapter. In addition, in the same Chapter 4, we will also use the information obtained in this chapter to extrapolate the impact of the analyzed conservation policies to the entire fleet that operates in the EPO (per year and for a 5-year period). The latter results will allow us to conclude financially what is the best conservation policy to be applied in the EPO purse-seine tuna fishery from a financial point of view.

2.2. BASELINE FINANCIAL MODEL - PURSE SEINE BOATS THAT SET ON FADs

This section (i.e. 2.2) is divided into four parts. In the first part, we will describe the financial data that were collected exclusively from Ecuadorian boats through a separate project. In this analysis, the Ecuadorian fleet will be considered as a representative case for the fleets that set on FADs.

Specifically, we will proceed to describe the operating cost that corresponds to a sample of eleven Ecuadorian purse seine boats of various tonnages (i.e. classes). Those 11 boats represent approximately 10% of the purse-seiners that belongs to the Ecuadorian fleet and 4% of all the purse-seiners that operate in the EPO. The latter information will allow us to generate financial budgets related to the fishing operation of five representative boats that set mainly on FADs, which will be used for the baseline results of this chapter as well as the analyses reported in later chapters.

In the second part, we will provide the income profile of a fleet that sets on FADs which will also be based exclusively on information obtained from the Ecuadorian fleet. Thus, the income data was built through using: 1) catch & effort data provided by the Ecuadorian Government and 2) price data obtained from interviews to boat owners and representatives of the industry.

In the third part of this section, we provide a brief discussion about the features that defined the fishing operation as well as the characteristics of the boats that composed the Ecuadorian fleet. This information will also be used for all the subsequent analyses conducted in this report.

Finally, in the fourth part, we will conduct preliminary modelling of the cash flow of the Ecuadorian PS boats that set on FADs. This will be the baseline for the policy impact analysis conducted in Chapter 4. In this final part, we will explain the analytical model assumptions and the overall design of the model to calculate the baseline results (i.e. baseline cash flows) for our analysis.

2.2.1. BASELINE COST DATA

We obtained financial data from eleven PS boats that belong to the Ecuadorian fleet through a separate grant. We assumed that the Ecuadorian fleet is representative of the fleets that set on FADs. Hence, based on the financial information of the 11 purse-seine boats we determined the main financial assumptions (Table 2) about the cost structure of purse-seiners that set on FADs that will be used in the different analyses of this report.

Table 2. Assumptions for Cost Structure of Representative Purse-Seiners that Set on FADs

AVERAGE CARRYING CAPACITY IN METRIC TONS	1,050	700	580	300	220
AVERAGE MAXIMUM AUTONOMY (Days)	75	65	65	55	45
AVERAGE NUMBER OF TRIPS PER YEAR	4	5	5	6	7
AVERAGE NUMBER OF CREW MEMBERS	24	22	20	19	19
LABOR COST (Dollars per Metric Ton) - INCLUDING LEGAL BENEFITS	245.025	230.9175	217.0125	191.97	218.025
AVERAGE USE OF FUEL PER YEAR (Gallons)	613,000	481,000	402,000	182,000	124,000
AVERAGE USE OF FUEL PER TRIP (Gallons)	153,250	96,200	80,400	30,333	17,714

Source: Ecuadorian boat owners

2.2.2. BASELINE INCOME DATA

PRICES

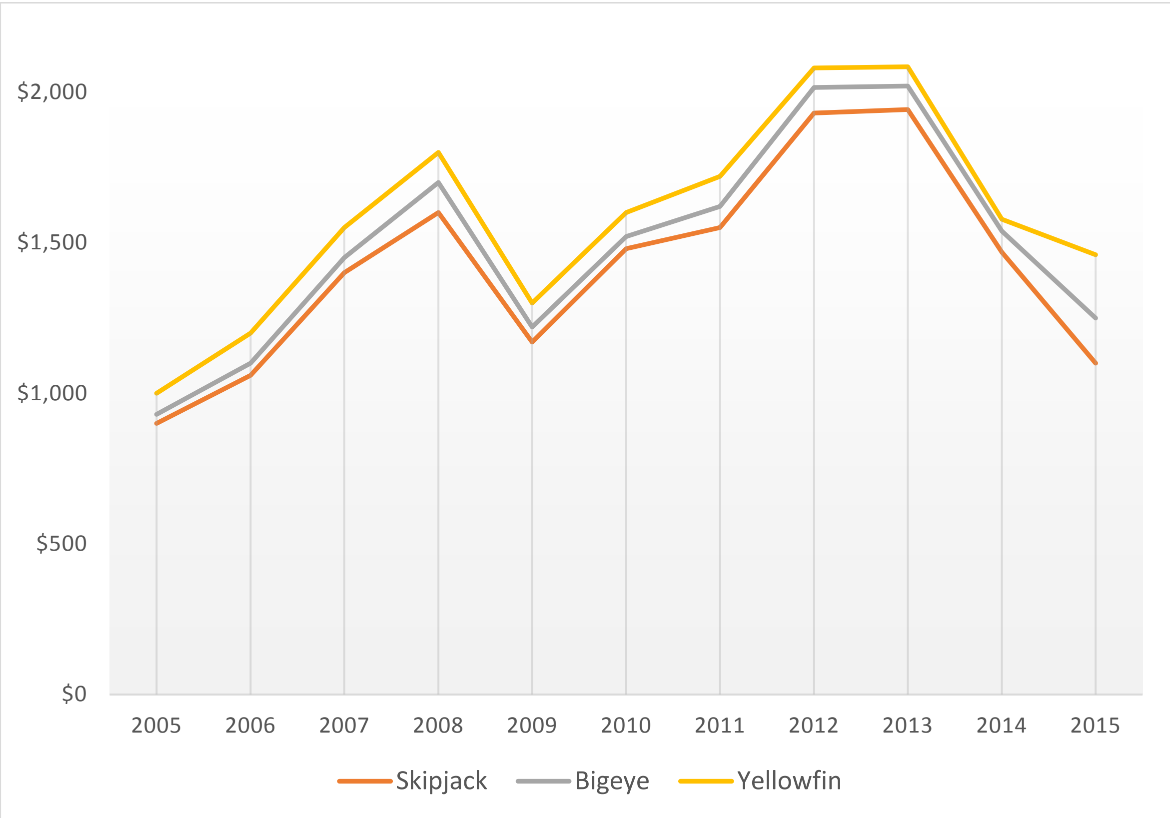
EPO tuna prices are set in relation to tuna harvesting activity and ex-vessel prices in the Western Central Pacific Ocean, the largest source of global tuna supplies. As such, EPO harvesters tend to be price takers with little bargaining power in price negotiations. The prices that are used as a reference for the ex-vessel prices in the EPO countries are the ones listed in the Bangkok Tuna Market, which have been highly volatile over the last 6 years. For this report, we use prices from Ecuador as an example of prices across the EPO region (Figure 6); and as it can be observed in Table 3 and Figure 6, the price volatility has been greater during recent years (i.e. between 2010-2015) as compared to price volatility during 2005-2010.

Table 3. Summary statistics for referential annual prices of a MT of BET, SJT and YFT during the period 2005-2015

Period	Statistics	Skipjack	Bigeye	Yellowfin
Total Period 2000 - 2015	*Mean*	$1,418.18	$1,487.64	$1,579.27
	Volatility	$339.57	$349.08	$338.66
First Half 2000 - 2010	*Mean*	$1,268.33	$1,320.00	$1,408.33
	Volatility	$268.66	$286.98	$293.97
Second Half 2010 - 2015	*Mean*	$1,578.33	$1,660.67	$1,753.67
	Volatility	$318.55	$303.17	$267.38

Source: Ecuadorian boat owners
Note: These prices are not inflation adjusted. Volatility is defined as the standard deviation of the prices during the period.

Figure 6. Referential annual prices of a MT of BET, SJT and YFT during the period 2005-2015



Source: Ecuadorian boat owners
Note: These prices are not inflation adjusted

2.2.3. FISHING OPERATION AND BOATS CHARACTERISTICS

Using catch & effort data for the Ecuadorian PS fleet (provided by the Ecuadorian Government), and specifically information from the period 2012 to 2014 we obtained a set of variables that describes the fishing operation of that fleet. The description of these variables can be found in Tables 4 and 5. Thus, from the results shown in those Tables (i.e. 4 and 5) we can conclude the following:

a. On average, Ecuadorian purse-seiners carry out 6 trips per year;

b. The average length of a fishing trip is 36 days;

c. Ecuadorian purse-seiners make, on average, 26 sets per trip; and

d. The average catch per set is 20 metric tons.

Finally, using information from the IATTC vessel registry,[13] we obtained a description of the Ecuadorian purse-seine fleet (Table 6). From the results of Table 6 we can conclude that the average length of the Ecuadorian purse seiners is 52 meters and the average carrying capacity is 633 MT.

Table 4. Average number of trips per year and average catch (TM) per set

Number of trips per year	Percentage of Total	Catch per sets (Metric Tonnes)	Percentage of Total
less than 3	1.71%	less than 10	17.24%
3 - 5	20.96%	10 - > 20	43.26%
6 - 8	41.28%	20 - > 30	22.88%
9 - 11	29.16%	30 - > 40	9.09%
12 - 14	6.11%	40 - > 50	4.08%
greater or equal to 14	0.78%	greater or equal to 50	3.45%
Mean	6.42	Mean	20.43
Min	1.00	Min	4.53
Max	16.00	Max	82.49

Source: Ecuadorian Government

[13] https://www.iattc.org/VesselRegister/VesselList.aspx?List=RegVessels&Lang=ENG (Last accessed on 07/15/2017)

Table 5. Length of fishing trips and number of sets per trips

Length of trips (days)	Percentage of Total	Number of sets per trips	Percentage of Total
less than 20	16.51%	less than 5	1.30%
20 - < 30	23.99%	5 - < 10	5.74%
30 - < 40	22.33%	10 - < 15	10.89%
40 - < 50	16.76%	15 - < 20	13.49%
50 - < 60	9.57%	20 - < 25	16.33%
60 - < 70	6.64%	25- < 30	15.23%
70 - < 80	2.39%	30 - < 35	13.74%
80 - < 90	1.27%	35 - < 40	9.99%
greater or equal to 90	0.54%	greater or equal to 40	13.29%
Mean	35.98	Mean	26.06
Min	2.00	Min	2.00
Max	104.00	Max	47.00

Source: Ecuadorian Government

Table 6. Description of the characteristics of the purse-seine boats that composed the Ecuadorian fleet

Carrying Capacity (MT)	Percentage from Total	Boat length (meters)	Percentage from Total
less than 250	25.44%	less than 30	2.63%
250 - < 500	22.81%	30 - < 40	26.32%
500 - < 750	20.18%	40 - < 50	15.79%
750 - < 1000	11.40%	50 - < 60	23.68%
1000 - < 1250	7.89%	60 - < 70	17.54%
1250 - < 1500	6.14%	70 - < 80	9.65%
1500 - < 1750	5.26%	80 - < 90	0.88%
1750 - < 2000	0.00%	90 - < 100	0.88%
2000 - < 2250	0.00%	100 - < 110	1.75%
greater or equal to 2750	0.88%	greater or equal to 110	0.88%
Mean	633.10	Mean	51.97
Min	76.00	Min	16.15
Max	2,799.00	Max	116.00

Source: IATTC Regional Vessel Register.

In addition, we also need to highlight the following related to the Ecuadorian PS fleet: 1) It is composed of 114 PS vessels. and 2) Based on the IATTC classification the Ecuadorian PS boats can be categorized as follows: 0.88% (1 vessel) is class 2, 1.75% (2 vessels) are class 3, 20.18% (23 vessels) are class 4, 12.28% (14 vessels) are class 5 and the majority, that is, 64.91% of the boats (74 vessels) are class 6.[14]

To have a better idea about the ability of each Ecuadorian vessel to generate income, we use catch & effort data. For instance, using information from 2012 to 2014, we calculated the average catch (in Metric Tonnes) and the average number of trips per year for each Ecuadorian purse seine boat that was active during that period (i.e. 105 purse seine vessels). Subsequently, with the previous information we determined a proxy of the efficiency level of a boat; that is, the average production yield measured in metric tonnes per trip for each Ecuadorian purse-seiner by their IATTC size classes during the study period (Table 7). From Table 7 we can conclude that, on average, the production yield of class 6 boats is approximately twice that of class 3, 4 and 5 vessels.

Table 7. Summary Statistics of Production Yield (measured in Metric Tonnes per day) for Ecuadorian Purse-Seine Boats

STATISTICS	IATTC CLASSES			
	3	4	5	6
No. Boats	9	24	11	62
Mean	5.87	6.09	6.85	12.85
Std. Dev.	3.64	1.72	2.21	7.54
Minimum	2.60	3.10	3.30	0.30
Percentile 5	2.60	3.20	3.30	5.00
Percentile 25	3.50	4.90	5.20	8.80
Percentile 50	4.60	5.95	6.50	11.20
Percentile 75	6.50	7.20	8.50	13.60
Percentile 95	13.80	9.60	8.80	27.80
Maximum	13.80	9.70	11.00	43.80

In the case of class 2 vessels we do not provide the value because of confidentiality given that it is only one boat. There are 114 boats however for this table we use only those 106 boats from which we have information (107 if we count the class 2 vessel that was omitted due to confidentiality reasons),

Source: Ecuadorian Government

[14] The IATTC classification is established in cubic meters of hold volume; but there is also an equivalent classification but based on Metric Tons of carrying capacity. This classification is given as follows:

Class	1	2	3	4	5	6
Cubic meters	<54	54 – 107	108 – 212	213 – 318	319 – 425	>425
Metric Tons	<46	46 – 91	92 – 181	182 – 272	273 – 363	>363

To complement that analysis, we also examine a fundamental key process driver (KPI) of the productivity of the fishing operation of the Ecuadorian purse-seiners (Table 8). Specifically, we calculate the amount of diesel (measured in gallons) that is required to catch one metric ton of product. As it was expected the larger the boat the higher the requirement of fuel to get one unit of output (i.e. a metric ton of tuna); from a financial point of view this means that for one dollar spent in fuel it is possible to obtain a larger amount of income in smaller boats than larger ones. However, we need to remember that this is only a KPI (i.e. only one component of the fishing productivity of each boat category) and not a complete picture of the productivity profile of the vessel.

Table 8. Summary Statistics for the Key Process Driver (measured as gallons of diesel used to catch one Metric Ton of product) and return for fuel expenses (measured as dollars of income per each dollar of fuel spent).

STATISTICS	KPI				RETURN FOR FUEL EXPENSES			
	IATTC CLASSES				IATTC CLASSES			
	3	4	5	6	3	4	5	6
No. Boats	9	24	11	62	9	24	11	62
Mean	245.18	241.93	266.14	482.07	10.51	8.48	8.38	7.83
Std. Dev.	160.17	89.06	96.11	763.49	6.37	4.40	2.39	4.23
Minimum	21.70	49.70	153.20	119.90	4.33	3.16	4.48	0.38
Percentile 5	21.70	146.50	153.20	165.60	4.33	4.09	4.48	2.60
Percentile 25	163.50	191.65	195.80	237.40	5.44	6.19	5.87	5.48
Percentile 50	254.20	222.45	252.80	286.40	8.24	7.70	8.75	7.72
Percentile 75	307.60	284.55	321.30	401.70	13.75	9.45	10.59	9.27
Percentile 95	490.30	394.90	342.80	1144.40	23.42	12.20	11.65	12.75
Maximum	490.30	492.90	485.20	4325.70	23.42	26.07	11.65	30.49

In the case of class 2 vessels we do not provide the value because of confidentiality given that it is only one boat. There are 114 boats however for this table we use only those 106 boats from which we have information (107 if we count the class 2 vessel that was omitted due to confidentiality reason)

Source: Ecuadorian Government

Later in this chapter, we will use the information of this section to conduct a simulation of the baseline cash flow generated for each of the five representative Ecuadorian boats (as a representative case for the fleets that set on FADs in the EPO) and determine their sensitivity to important variables.

2.2.4 MODEL STRUCTURE

Based on the five representative boats whose budgets were analyzed in the previous section, we construct 5 different categories of PS vessels that set on FADs:

1. Between 180 MT and lower than 250MT
2. Between 250 MT and lower than 400 MT
3. Between 400 MT and lower than 600 MT
4. Between 600 MT and lower than 800 MT; and
5. Between 800 MT and 1200 MT

Thus, in this section, we will examine the cash generation capacity for the five groups of purse seiners and for that purpose we will proceed to model a baseline cash flow for each boat category.

The first step for this analysis, was to use catch & effort data of the Ecuadorian purse seine fleet during the period 2012-2014. We used that data to calculate the average catch per trip (and standard deviation) for each boat category for the three main EPO commercial tuna species (i.e. YFT, SJT and BET). We also determined the average number of trips (and standard deviation) for each vessel category.

The results of those analyses are given in Table 9 from which we can conclude that:

a. the bigger the PS vessel, the higher the catch level (for all three commercial tuna species); and,
b. the smaller the boat, the larger the number of trips the boat carries out per year.

Table 9. Average catch per trip and number of trips for each boat category

Boat Category	Statistic	Catch (Metric Tons) per Trip			Number of Trips per Year
		YFT	SJT	BET	
800 - 1200	*Mean*	92.16	493.71	164.23	4.70
	Std Dev	58.17	146.11	116.49	1.26
600 - <800	*Mean*	58.78	379.59	52.25	5.34
	Std Dev	33.53	89.91	40.40	1.52
400 - <600	*Mean*	43.09	314.09	39.95	6.12
	Std Dev	21.93	81.88	33.26	2.00
250 - <400	*Mean*	33.43	181.91	18.94	7.20
	Std Dev	18.76	75.44	24.49	2.01
180 - <250	*Mean*	23.54	116.52	10.43	8.24
	Std Dev	17.12	49.17	14.22	2.93

Source: Author's estimation

The total annual income generated for each boat category is defined by the following equation:

$$I_i = \sum_j \bar{P}_j \, \bar{Q}_j^i \bar{T}^i \quad i = \text{boat category and } j = \text{tuna species (BET, SJT and YFT)} \qquad \textbf{(3)}$$

where $\bar{\mathbf{P}}_{\mathbf{j}}^{\mathbf{i}}$ is the average price per MT for tuna species j, $\bar{\mathbf{Q}}_{\mathbf{j}}^{\mathbf{i}}$ is the average catch per trip of tuna species j for each boat category i and $\bar{\mathbf{T}}^{\mathbf{i}}$ is the average number of trips for each boat category i. We assumed that these three variables follow a log-normal distribution with a mean and standard deviation defined by the values provided in Tables 3 and 9.

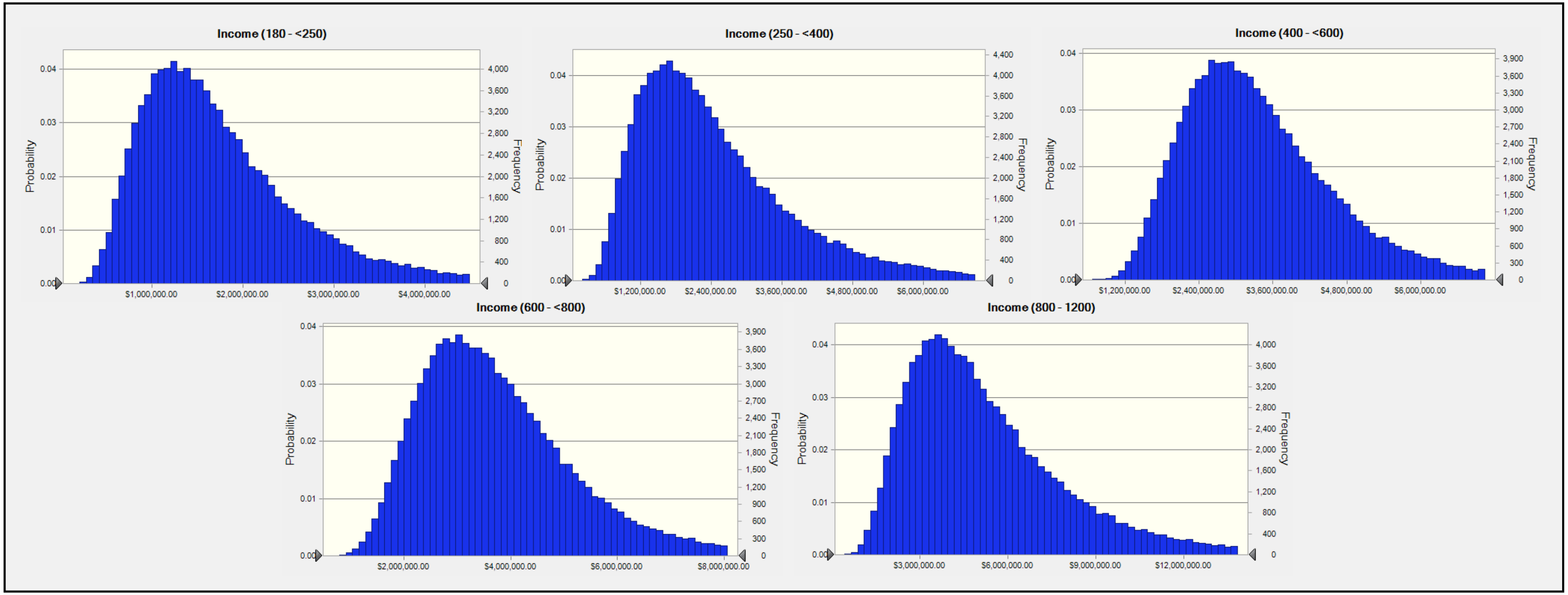
Thus, using the probability distribution of each of these three variables, we apply a Montecarlo simulation (using 100,000 replications) to generate the probability distribution of the average total income per year that each of the five boat categories could generate. The results of these simulations are given in Figure 7 and Table 10.

Table 10. Simulated average total income per year for each boat category

Boat Category	Statistic	Average Total Income
800 - 1200	*Mean*	$5,375,815.75
	Percentile 10	$2,408,850.25
	Percentile 90	$9,151,803.10
600 - <800	*Mean*	$3,788,194.14
	Percentile 10	$2,128,453.76
	Percentile 90	$5,757,720.19
400 - <600	*Mean*	$3,406,442.69
	Percentile 10	$2,011,699.51
	Percentile 90	$5,079,633.25
250 - <400	*Mean*	$2,546,340.66
	Percentile 10	$1,089,254.24
	Percentile 90	$4,411,475.11
180 - <250	*Mean*	$1,782,146.12
	Percentile 10	$823,959.00
	Percentile 90	$2,996,562.06

Source: Author's estimation

Figure 7. Probability distribution of average total income per year generated by fishing activities for each boat category



Source: Author's estimation

We can conclude from results shown in Table 10, that the larger the boat the higher its capacity to generate income. However, income is not equivalent to cash flow (even though it is a component of it). Cash flow is the net amount of cash and cash-equivalents moving into and out of the operation. It is a more accurate measure to assess the financial viability of the fishing operation; that is, how effective is the fishing operation at generating cash (i.e. liquid), which can help us to determine whether the operation is positioned to remain solvent or not. For that purpose, under a cash flow framework, it is necessary to analyze not only the capacity of the fishing operation to generate income, but also what is the cost that the operation needs to afford to generate that income. Therefore, in this part we will estimate the annual cash flow of each type of (representative) boat (CF_i) using the following equation:

$$\mathrm{CF_i} = (\mathrm{I_i} - [\mathrm{L_i} + \mathrm{Fuel_i} + \mathrm{OVC_i} + \mathrm{Dep_i} + \mathrm{ARC_i}])(1 - \text{tax rate}) + \mathrm{Dep_i} \quad \mathbf{i}\text{=boat category} \qquad \mathbf{(4)}$$

where:

- $\mathbf{I_i}$ is the total annual income generated for each boat category which is defined by Eq. 3
- $\mathbf{L_i}$ is the annual labor cost for each boat category i. This variable is constructed as follows: $\left(\sum_j \bar{Q}_j^i \bar{T}^i\right) * LcMT^i$ where $\left(\sum_j \bar{Q}_j^i \bar{T}^i\right)$ is the total quantity of tuna (of the three species) caught per year and $LcMT^i$ is the labor cost per ton for each boat category.
- $\mathbf{Fuel_i}$ is the annual cost of fuel for each boat category i. This variable is constructed as follows: $0.90\overline{F\imath d}^i\overline{Fcd}^i\bar{T}^i)$ where $\overline{F\imath d}^i$ is the average number of fishing days for boats belonging to the i category, $\overline{Fcd}^i$ is the average fuel consumption (in gallons) per day of boats in the category i and $\bar{T}^i$ is the average number of trips for each boat category i. It is necessary to highlight that the cost of a gallon of diesel in Ecuador has been kept stable since 2007, \$0.90 per gallon.

- $\mathbf{OVC_i}$ is the total amount of other variable costs per year for each boat category i. This variable is constructed as follows: $\overline{OVCt}^i\overline{T}^i$ where $\overline{OVCt}^i$ is equal to the other variable costs per trip that in average should be afforded for the operation of boats of category *i*.
- $\mathbf{ARC_i}$ is the total annual recurrent costs that are paid for the operation of each boat category i.
- $\mathbf{Dep_i}$ is the average depreciation that should be considered per year for each boat category i; and
- The **tax rate** used will be the one established in Ecuador which is equal to 25%

To generate Montecarlo simulations of the CF for each boat category we should make some assumptions about the probability distribution of each variable. Thus, we assume that both $\overline{F\iota d}^i$ and $\overline{Fcd}^i$ follow a log-normal probability distribution, whose relevant parameters are mean and standard deviation. On the other hand, we assume that $\overline{OVCt}^i$, FC_i and Dep_i follow a triangular distribution, whose relevant parameters are minimum, maximum and mean (likeliest value). In Tables 11 and 12 we show the parameters that we assume for the probability distribution of each of the variables described previously.

Table 11. Average fishing days per trip and fuel consumption per day for each boat category

Boat Category	Statistics	Fishing days per trip	Fuel consumption per day (gallons of diesel)
800 - 1200	*Mean*	54.24	3,601.46
	Std Dev	10.58	1,455.13
600 - <800	*Mean*	47.84	2,432.50
	Std Dev	9.36	629.20
400 - <600	*Mean*	37.51	1,958.51
	Std Dev	8.29	577.21
250 - <400	*Mean*	33.84	1,467.72
	Std Dev	7.84	368.32
180 - <250	*Mean*	28.34	1,259.50
	Std Dev	7.19	376.80

Source: Ecuadorian boat owners and Author's estimation

Table 12. Average labor cost per ton of catch, other variable costs per trip, annual fixed costs and annual depreciation for each boat category

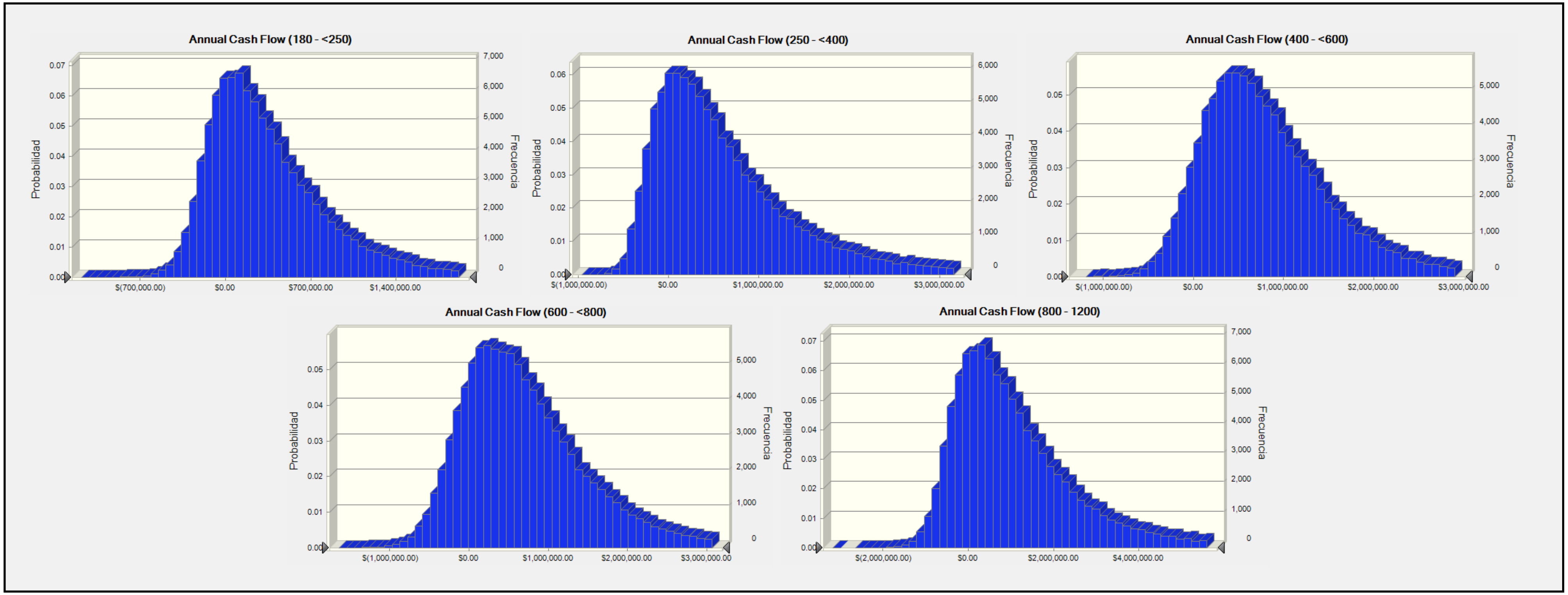
Boat Category	Statistics	Labor cost per ton of catch	Other variable costs per trip	Total fixed costs per year[15]	Total Depreciation per year
800 - 1200	*Mean*	$250	$327,823.07	$713,683.22	$1,135.600.00
	Minimum	$225	$295,040.76	$642,314.89	$900,000.00
	Maximum	$275	$360,605.38	$1,511,863.32	$1,250,000.00
600 - <800	*Mean*	$230	$210,460.54	$642,669.11	$676,739.00
	Minimum	$205	$189,414.49	$578,402.20	$540,000.00
	Maximum	$255	$231,506.60	$1,048,368.91	$750,000.00
400 - <600	*Mean*	$220	$133,278.60	$760,315.27	$652,686.00
	Minimum	$195	$119,950.74	$684,283.74	$520,000.00
	Maximum	$245	$146,606.46	$930,317.53	$720,000.00
250 - <400	*Mean*	$200	$68,827.49	$609,787.86	$149,807.00
	Minimum	$175	$61,944.74	$388,429.21	$120,000.00
	Maximum	$225	$75,710.23	$670,766.65	$165,000.00
180 - <250	*Mean*	$190	$61,740.08	$351,798.68	$167,687.60
	Minimum	$165	$55,566.07	$286,154.18	$133,000.00
	Maximum	$215	$67,914.09	$386,978.54	$185,000.00

Source: Ecuadorian boat owners, Anastacio (2017) and Author's estimation

Under those assumptions, we generate a set of Montecarlo simulations (using 100,000 replications) to build the probability distribution of the cash flow generated for each type of boat and some relevant statistics (Figure 8 and Table 13).

[15] For this cost category we do not only use the information provided by Ecuadorian boat owners but we also complement it with information used for the article "Antigüedad y Mantenimiento: Desafío para la Flota Atunera Ecuatoriana" published by the Cámara Nacional de Pesqueria (http://camaradepesqueria.com/antiguedad-mantenimiento-desafio-la-flota-atunera-ecuatoriana/?platform=hootsuite#sthash.9A5Vmd1s.arTGKRdy.dpuf). (Last accessed on 07/15/2017)

Figure 8. Probability distribution of average cash flow per year generated by fishing activities for each boat category



Source: Author’s estimation

Table 13. Simulated average cash flow per year for each boat category

Boat Category	Statistic	Cash Flow Baseline
800 - 1200	*Mean*	\$1,106,327.82
	P(CF<0)	23.06%
600 - <800	*Mean*	\$714,459.53
	P(CF<0)	17.75%
400 - <600	*Mean*	\$811,578.16
	P(CF<0)	9.47%
250 - <400	*Mean*	\$648,434.28
	P(CF<0)	21.39%
180 - <250	*Mean*	\$365,133.25
	P(CF<0)	25.46%

Source: Author's estimation

From Table 13 we can conclude that the larger the boat, the higher the cash flow; however, this is not a pure monotonic relationship because, based on our results, it is seemingly more profitable to have a boat with a capacity between 400 and 600 MT than between 600 and 800 MT. Nonetheless, the behavior of the probability of negative cash flow per capacity category is interesting, as it resembles a concave upwards function with a minimum in the boat category 400 and 600 MT (which could indicate that this boat category is the less financially vulnerable).[16]

The previous conclusions should be complemented with what we found from interviews conducted with tuna fishing experts. Specifically, they told us that most of the boats that were vulnerable to financial problems during 2015 (i.e. year in which the tuna prices were low) were class 3, 4 and 5 vessels, because of their low capacity to generate cash flow. According to the interviewed experts, both companies and individuals who own those boats were more likely to be affected by low tuna prices during 2015 because it was more difficult for their boats to generate income to cover operation costs, compared to class 6 vessels. The latter does not mean that class 6 vessels are immune to financial problems due to adverse market conditions. In fact, class 6 vessels are the most expensive to operate and each metric ton of product is more expensive to

[16] Also we should consider that the results obtained in this section could also be a factor of the sample size.

obtain through the operation of that class of boat (Table 8); however, they are less vulnerable due to their high level of fishing productivity.

We also estimated the sensitivity of each assumption variable by computing variance contribution coefficients for every assumption and every forecast while the simulation was running. Variance contribution provides a meaningful measure of the degree to which assumptions and forecasts change together. If an assumption and a forecast have a high contribution coefficient, it means that the assumption has a significant impact on the forecast (through both its uncertainty and its model sensitivity). Positive coefficients indicate that an increase in the assumption is associated with an increase in the forecast. Negative coefficients imply the opposite situation. The larger the absolute value of the correlation coefficient, the greater the sensitivity. The results of our sensitivity analysis are given in Table 14.

Table 14. Sensitivity analysis – Variance contribution.

Cost Category	Boat Category				
	180 - <250	250 - <400	400 - <600	600 - <800	800 - 1200*
Skipjack Quantity	**47.4%**	**45.4%**	**55.8%**	**44.1%**	**28.8%**
Skipjack Price	**24.5%**	**13.6%**	**25.5%**	**25.1%**	12.4%
Yellowfin Quantity	**11.7%**	9.5%	1.9%	5.6%	7.5%
Yellowfin Price	1.2%	0.5%	1.1%	1.1%	0.5%
Bigeye Quantity	1.8%	0.2%	3.0%	6.4%	**17.6%**
Bigeye Price	0.2%	0.1%	0.9%	0.8%	1.3%
Number of trips	9.6%	**29.1%**	**7.6%**	**11.7%**	**27.5%**
Daily Consumption of Fuel	-1.8%	-0.6%	-2.1%	-2.1%	-2.6%
Fishing days per trip	-1.3%	-0.5%	-1.2%	-1.4%	-0.6%

LEGEND	**Most Important**	**2nd Most Important**	**3rd Most Important**

* To keep homogeneity in the table we omit one important factor for this boat category (i.e. 800 – 1200 MT); that is, the total amount of fixed cost which has a variance contribution of -1.1%. The latter was an expected result because of the size of the boats.

Source: Author's estimation

From Table 14 we can conclude that the main driver for the generation of cash from the fishing operation of boats from different categories is the total quantity of SJT landed. The two other important drivers are: 1) the price of SJT (except for boats with a capacity between 800 and

1200 MT) and 2) the number of trips (except for boats with a capacity between 250 and less than 400 MT).

Two conspicuous results are the importance of the quantity of YFT landed for the cash flow of boats with a capacity between 250 and less than 400 MT (i.e. 3rd most important factor), and the importance of the quantity of BET landed (i.e. 3rd most important) for the cash flows of boats with a capacity between 800 and less than 1200 MT. The latter results allow us to conclude that policies that aim to restrict catch and effort applied to these two species will impact the capacity to generate profits for boats in these two categories (i.e. 250 - <400 MT of capacity and 800 – 1200 MT of capacity).

It is important to emphasize that we should be careful about generalizing the results obtained for this section to all the FAD fleets that operate in the EPO, specifically for two reasons, first, there are peculiarities of the Ecuadorian fleet that could make the results not possible to generalize to fleets of other flags, and second, the results of this section could be affected by the sample size. However, in the following sections we will adapt these estimates that would allow us to generalize the previous results to all fleets that set on FADs in the EPO.

2.3. BASELINE FINANCIAL MODEL - PURSE SEINE BOATS THAT SET ON DOLPHINS

For this analysis, we attempted to obtain financial data from PS boats that set on dolphins in the EPO. We contact with boat owners and authorities from countries whose PS boats predominantly set on dolphins. At the end, we were able to obtain the cost structure of only one boat that specializes on sets on dolphins. Specifically, we get information from a purse seiner of 1,300 MT of carrying capacity. Hence based on the previous financial information we determined the main financial assumptions (Table 18, 19 and 20) about both the catch and the cost structure of purse-seiners that set on dolphins, which will be used in the different analyses of this report. In addition, it is necessary to emphasize that given that we only have information from one boat (i.e. a very small sample) to conduct all the analyses presented in later sections we must make several assumptions that will be described in subsequent chapters.

Table 18. Assumptions for Average Annual Cost Budgets

AVERAGE CARRYING CAPACITY IN METRIC TONS	1,300
AVERAGE MAXIMUM AUTONOMY (Days)	60
AVERAGE NUMBER OF TRIPS PER YEAR	613,000
AVERAGE NUMBER OF CREW MEMBERS	4
LABOR COST (Dollars per Metric Ton) - INCLUDING LEGAL BENEFITS	24
AVERAGE USE OF FUEL PER YEAR (Gallons)	245.025
AVERAGE USE OF FUEL PER TRIP (Gallons)	153,250

Source: Panamanian boat owners

Table 19. Catch composition of the representative boat that sets on dolphins

	Catch per Trip		
	YFT	SJT	BET
Average	1,453.13	93.75	15.63

Source: Panamanian boat owners

Table 20. Assumptions for the cost structure of a vessel that sets on dolphins

	Other Costs per Trip	Other Annual Costs	Depreciation	Labor Cost per Ton of catch
Minimum	$ 353,025	$ 760,608	$ 849,421	$280
Average	$ 392,250	$ 845,120	$ 943,801	$305
Maximum	$ 431,475	$ 929,632	$ 1,544,790	$330

Source: Panamanian boat owners

Thus, using the previous assumptions we obtain the results shown in Tables 21 and Figure 9. We also conducted a sensitivity analysis for the cash flow of the representative boat that sets on dolphins (Table 22).

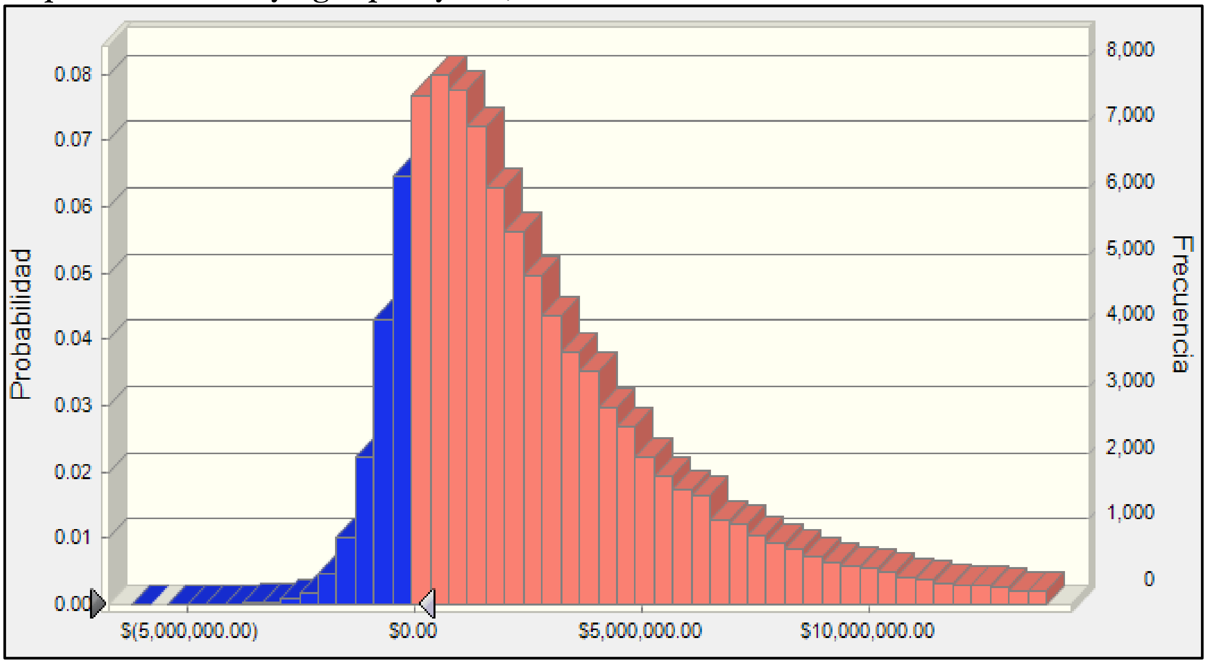
From Table 21 we conclude that on average the purse-seiner that sets on dolphins from which we obtained information has a very substantive cash flow level per year; approximately 2.5 million of dollars. This is remarkable because, based on the information previously shown, the cost structure of a boat that sets on dolphins is greater than that of those boats that set on FADs. It is important to recall that the previous results are based on information gathered from one vessel, then we must be careful about the conclusions derived from these results and their generalization to other vessels that set on dolphins.

Table 21. Simulated average cash flow per year of a representative boat that sets on dolphins with a carrying capacity of 1,300 MT

Boat Category	Statistic	Cash Flow Baseline
1,300	*Mean*	$2,481,219.40
	P(CF<0)	19.06%

Source: Author's estimation

Figure 9. Probability distribution of annual cash flow of a representative boat that sets on dolphins with a carrying capacity of 1,300 MT



Source: Author's estimation

Additionally, as we had expected, from Table 22, we could conclude that the cash flow of a vessel that sets on dolphins is highly dependent on the abundance of YFT and the price performance of that tuna species. We can also infer on the basis of the results of the sensitivity analysis that the best strategy for boats that set on dolphins to improve their cash flow is to increase the number of trips but each of these trips should be as efficient as possible (i.e. to catch more product in fewer days) so as to increase the level of catch per year and their annual income[17].

Table 22. Sensitivity analysis – Variance contribution-annual cash flow of a representative boat of 1,300 MT that sets on dolphins

Cost Category	Capacity
	1,300
Yellowfin Quantity	66.5%
Yellowfin Price	20.2%
Number of trips	9.3%
Fishing days per trip	-2.8%

Source: Author's estimation

[17] It is necessary to remember again that the results obtained in this part are based on the information obtained from a single ship, so one must be very careful in the conclusions derived from these results and the generalization of them.

CHAPTER 3 - COST OF ADMINISTRATION AND MONITORING AT SEA

In this chapter we will analyze the costs of administration, control and monitoring of the different fishery management alternatives analyzed previously. We will examine the costs of electronic monitoring systems as well as costs related to the increase of coverage and safety improvement of observers at sea.

3.1. ELECTRONIC MONITORING SYSTEM

For this section, we will use the cost estimates provided by Archipelago Marine Research Ltd., which is a Canadian consulting firm that has provided fisheries and marine biological services to both public and private sector clients since 1978. Specifically, we were able to obtain from Archipelago cost estimates for the installation and set-up of electronic monitoring systems applicable to the type of purse seiners that operates in the EPO. The main characteristic that defines the type of technology that must be used on a specific boat is the presence or not of observers.

In this section, we did not include extrapolation of the possible financial benefits that can arise from the implementation of an Electronic Monitoring (EM) System. There is evidence in other fisheries that this type of monitoring system can produce financial benefits through reducing costs or increasing efficiency (Piasente et. al. 2012, McElderry 2008, McElderry et. al. 2010, Ruiz et. al. 2015, van Helmond 2015). The main benefits from EM found in these studies are:

1. Improvement in recollection of (scientific) information; that is, the EM system fully documents the fishery, founded on a comprehensive information system which could help improve among other things the planning of future operations to reduce costs or increase catch per trip.
2. Enhancement of incident reporting with a potential impact on fishing behavior that will generate among other things a reduction of compliance risk. In other words, the 100%

monitoring approach provides a common monitoring standard across all elements of the fishery, effectively aligning the boat's crew fishing activities to more effectively comply with both fisheries regulations and the firm's management objectives.

3. Possible substitution of the observer program. If the EM system is fully adopted by the fleet and reaches a mature state that more accurately provides all monitoring information, it could be considered as a more cost efficient alternative than the observer program.

Our analyses were limited to the costs of adoption and implementation of the EM system and will be modified in the future to incorporate these potential benefits once we have feedback from the industry and or from EM trials in the Eastern Pacific purse seine fleet.

3.1.1. VESSEL HARDWARE

Archipelago recommended two types of EM System:

1) A comprehensive system for boats without observers (EM™ Observe Monitoring System – see Box 1) and
2) A simpler version for those vessels carrying observers (Marine Instruments' Electronic Eye™ system - see Box 2).

The EM system that was recommended for the surveillance on vessels carrying observers (i.e. class 6 vessels), Marine Instruments' Electronic Eye™ system, has been priced in a range that goes from \$3,700 to \$6,200, depending upon the number of cameras (i.e. 1 to 3 cameras). On the other hand, for vessels that would not carry observers (i.e. class 1 to class 5 vessels), Archipelago proposed a system with a more detailed sensor and image capture during fishing trips (EM™ Observe Monitoring System). The latter system is expected to carry 6 cameras and is priced at \$13,000. The indicative pricing that is provided in this section is based on the average length of purse-seiners and the average fishing activity of those vessels; however, other variables such as volume, are also important but they have not been incorporated in this estimation.

Box 1. Components and Specifications of Comprehensive EM™ Observe Monitoring System

EM Observe™ control centre (v5.0)

Size: 30.5 cm x 30.5 cm x 8.5 cm (12" x 12" x 3⅜")
Weight: 4.2 kg. (9.3 lbs.)
Casing: aluminum/steel anodized/powder coat
Capacity: removable SATA hard drive, expandable to 1TB
Recording time: 1,000 hours + (recording time will vary depending on configuration, frame rate etc.)
Security: tamper-evident housing, security seals
Temperature: 0-40°C

Power

DC power: 11 to 32V input voltage range
AC power (adaptor): 90 to 240 VAC
Maximum current draw: 10A at 12VDC or 5A at 24VDC (120 watts), <10 mA low-current sleep mode
Protection: 15A fuse (externally accessible)
Triple power supply: processor, sensors, and camera
Sleep mode: conserves battery (requires sensor)

Sensors, inputs, outputs

GPS receiver, power source monitor, sensors:

- 1x sleep sensor (engine oil–pressure switch)
- 4x analogue sensors
- 2x event counters
- 2x RS232 ports (for GPS and satellite modem)
- 6x USB 2.0 (2x front, 4x back)

Satellite modem: ship-to-shore communications (optional)

EM Record™ data logging software (v5.0)

Operating system: Microsoft® Windows XP Embedded®
Video compression: H264 codec support
Video display: up to eight camera views simultaneously
Interface: semi-autonomous (user configurable data recording operations based on sensor-input events)
Protection: UPS-controlled shutdown (prevents data loss), data integrity report, pre-trip system check
Encryption: Microsoft® Encrypting Files System (EFS)
Camera activation: Triggered by events including equipment sensors, port departure (GPS), port arrival (GPS), speed (GPS) and more.

User Interface

Keyboard: industrial specification
Monitor: VGA 1024x768

Cameras (digital IP)

Housing: cast aluminum, weatherproof
Power: 802.3af power-over-Ethernet
Image sensor: ¼" CMOS, 1.0 megapixels
Aiming: fixed aim; internally adjustable

Compliance

Designed and manufactured in compliance with applicable standards, including CE, RoHS, and BS EN 60945

Source: Archipelago Marine Research.

Box 2. Components and Specifications of Marine Instruments' Electronic Eye™ system

- **Remote Electronic Monitoring system** for bycatch control based on high definition still images taken on board.
- **High quality still images** to distinguish:
  1. Species
  2. Catch quota
  3. Fishing techniques used during the fishing trip
- **Storage of images** in a internal hard drive with up to 6 months capacity.
- Autonomous and fully intregrated: **GPS, Iridium communications modem and batteries**inside the equipment. Tamper-proof.
- Visualization of images **at the bridge in real time** from a computer.
- **Georeferenced and encripted HD images** with date and time information.
- High resolution **IP cameras.**
- Possibility to connect two **IP cameras to the same base.**
- Easy **USB download** of images.
- **VMS system** with Iridium global coverage.
- **2 step installation:** Just needs to be connected to the boat's power supply.
- Two operating modes:
  - **On deck:** Automatic depending on the vessel speed
  - **On hold:** With external sensor, depending on the movementof the conveyor belt, winch, etc.
- **Rugged design,** developed for the marine environment: stainless steel outer casing, totally sealed, protected against tampering.
- Four **security levels.**

BELUGA SOFTWARE

Exclusive Marine Instruments software to enable the visualization and analysis of the images:

- Automatic selection of **fishing activities.**
- Easy to **zoom** images, make **turns, notes,** etc.
- Playback of image sequencies **at different speeds.**
- **Boat's tracking** associated to the images.
- Possibility to export **notes, images, GPS positions, etc.** to write a fishing trip report.
- **Night/Day** identification.

Source: Archipelago Marine Research

It is estimated that the installation costs of the EM system on vessels with observers will be approximately $2,000 and for boats without observers the cost will be approximately $3,500. Installation ranges from 6 to about 20 hours depending upon system complexity. The annual maintenance cost will be approximately $2,000 for the Marine Instruments' Electronic Eye™ System hardware and $3,000 for the EM™ Observe Monitoring System hardware. In addition, the average service life of both EMs is 5 years approximately, after that time the system is expected to be replaced[18]. The details of the estimated costs per year of each of the two EM vessel systems are given in Table 23 (boats with observers) and Table 24 (boats without observers).

Table 23. Estimated cost for the Marine Instruments' Electronic Eye™ system hardware

Vessel with observers	Year 1	Years 2-5*
Electronic Eye™ Monitoring System (with 3 cameras)	$6,200	
Installation Cost	$ 2,000	
Estimated maintenance costs based on experience of costs incurred for operational and technical support		$2,000

Source: Archipelago Marine Research.
* The figure in this column is a cost in each year of the specified period. It is not a cumulative value for the whole period.

Table 24. Estimated cost for the Comprehensive EM™ Observe Monitoring System hardware

Without observers	Year 1	Years 2-5*
EM™ Observe Monitoring System (with 6 cameras)	$13,000	
Installation Cost	$3,500	
Estimated maintenance costs based on experience of costs incurred for operational and technical support		$3,000

Source: Archipelago Marine Research.
* The figure in this column is a cost in each year of the specified period. It is not a cumulative value for the whole period.

18 In many instances vessels have used their equipment for much longer than the five years lifespan provided it is properly maintained.

While the estimated cost for the entire fleet that operates in the EPO (i.e. 199 class 6 vessels and 67 vessels of other classes) is given in Table 25. We reiterate that Archipelago recommends a simpler system for vessels carrying observers and a more comprehensive system for class 5 and smaller vessels. This suggestion is grounded in the assumption that observer data is the main data source for observed trips, and the EM system is the data source for no observer trips. However, if the assumption is that complimentary datasets from EM are needed on observer trips, Archipelago recommends the more comprehensive system for both vessels (i.e. this would increase the cost of the EM program for class 6 vessels to $3,832,740).

Table 25. Estimated cost for the Marine Instruments' Electronic EyeTM system and EM™ Observe Monitoring System hardware for purse seine fleet that operates in the EPO

ITEMS*	Year 1	Years 2 to 5**
CLASS 6 VESSELS (i.e. 182 boats)		
Marine Instruments' Electronic Eye™ system (with 3 cameras)	$1,128,400	
Installation Cost	$364,000	
Estimated maintenance costs based on experience of costs incurred for operational and technical support		$364,000
CLASS 1 TO 5 VESSELS (i.e. 59 boats)		
EM™ Observe Monitoring System (with 6 cameras)	$767,000	
Installation Cost	$206,500	
Estimated maintenance costs based on experience of costs incurred for operational and technical support		$177,000
TOTAL COST FOR THE FLEET PER YEAR	$2,465,900	$541,000

Source: IATTC and Author's estimation

*This calculation did not include the US vessels because for the extrapolation exercise presented subsequently in Chapter 4 this fleet will not be considered.

** The figures in this column are costs that should be afforded in each year of the specified period. It is not a cumulative value for the whole period.

3.1.2. DATA ANALYSIS SERVICES

For the data analysis services, we examined, together with Archipelago, what would be the best data analysis alternative for the Ecuadorian fleet. Therefore, the latter cost analysis will be extrapolated to three locations that include Manta. Further, it will be assumed that data analysis of information from EM system of the entire PS fleet that operates in the EPO will be carried out at these three locations.

Manta Case Study

Archipelago suggested constituting one of the headquarters of the program in Manta, with Guayaquil/Posorja considered as a satellite port. It is recommended that the whole program be managed under a single organizational structure with administration, field technical services, and data analysis all under the same leadership. Most of the project staff would be based in Manta, with a group of two or three people to service vessels in Guayaquil/Posorja receiving and transporting equipment, hard drives and other program supplies to the head office in Manta.

The operation of the Ecuadorian tuna fleet has several advantages such as: limited ports, high fleet activity, large numbers of vessels, and extended duration at sea on fishing trips. Because of the previous characteristics, this EM program would have a lot of potential to achieve high economies of scale for the Ecuadorian fleet. This may not be the case for purse seine fleets from other countries, and therefore, a case-by-case analysis is required for the other fleets; then this cost analysis is just an example for the other countries. However, to simplify the analysis that will be conducted in the final section of this chapter (i.e. to provide a cost estimation for the entire fleet), we assume that it is possible to extrapolate the Ecuadorian results to two other possible locations. Thus, the latter simplification would allow us to estimate the total cost of implementation of an EM system for the entire EPO fleet.

Returning to the case of the Ecuadorian fleet, after a careful analysis of the specificities of the fishing operation of this fleet, we concluded that an approach of using different providers for the delivery of the service previously described is not a good alternative. If one of the goals of the monitoring program is to create a cost effective integrated information system, this becomes more difficult when the program is partitioned among different technology and service groups.

Unlike VMS (i.e. vessel monitoring system) programs, EM programs are labor intensive, and the specification approach often used for the VMS technology would not adequately address all the necessary service elements. Open, transparent competition where the private sector is involved is still necessary but it should be at the program level, not at program subcomponents level.

Moreover, it is important to plan extra program training and support time during the first few years of this new program; this is because when a new EM program is set up all the participants (i.e. agency, industry, program staff, public, etc.) are in a learning phase. Therefore, during the first years of the program, we expect at all levels, questions, discussions, debates, etc. The latter die out after approximately three years, as the routine becomes established. For that reason, it is necessary to budget training and customer services for a period of three years.

The details of the costs related to Data Analysis Services are given in Tables 26 to 28. We divided these costs into two categories: those that are paid yearly and those that are fully paid from the beginning of the program (investment) and renewed after a period of 5 or 7 years.

Variable Annual Costs

It is budgeted that the total cost per year for the Data Analysis Services will be approximately $520,800, equivalent to $5.62 for each cubic meter of fish hold volume in the Ecuadorian fleet.[19]

Table 26. Labor cost of the EM program

Personnel Cost	Units	Unit Cost	Monthly Cost	Annual Cost
Manta	18	$ 2,000	$ 36,000	$ 432,000.00
Guayaquil	2	$ 2,000	$ 4,000	$ 48,000.00
Total Cost				$ 480,000.00
Cost per hour of labor				$ 11.54

Source: Archipelago Marine Research and Author's estimation

Table 27. Other annual costs for the EM program

[19] This value was estimated using the IATTC information which indicates that the entire Ecuadorian fleet has a total fish hold volume of 92,675 m3

Other Annual Costs		
Rent & Public Services - Manta	$	16,800.00
General expenses - Manta	$	9,600.00
General expenses - Guayaquil	$	14,400.00
Total Cost	$	40,800.00

Source: Author's estimation

Equipment costs and other expenses paid at the beginning of the program and recurring after 5 or 7 years

Besides the costs that must be paid every year for the operation of the EM program, it is necessary to budget some initial investments in equipment. Those initial costs are detailed in Table 28.

The item *Equipment Headquarter* corresponds to hardware, software and furniture for the headquarters office in Manta while the item *Vehicles* is related to the acquisition of two vehicles to transport the personnel that gathers information in Guayaquil to Manta. It is assumed that the equipment should be replaced after 5 years of operation and the vehicle should be replaced after 10 years of operation.

The total costs for the *Data Analysis Services* per year for the Ecuadorian program during a period of 7 years is given in Table 29. To construct the latter table, we assumed that annual costs will grow 3% per year, and the cost of both equipment and vehicles, in their year of renewal, will increase in 25%

Table 28. Initial investments for the operation of the program

Equipment Cost and other Investments	Total Cost
Headquarter Equipment – Manta (Renewed every 5 years)	$ 110,000.00
Vehicles – Guayaquil (Renewed every 7 years)	$ 70,000.00
Training Personnel and Customer Service for 3 years	$ 120,000.00
Total Cost	$ 300,000.00

Source: Archipelago Marine Research and Author's estimation

Table 29. Data analysis costs per year

ITEMS	1	2	3	4	5	6	7
Annual Costs							
Personnel - Manta	$432,000	$444,960	$458,309	$472,058	$486,220	$500,806	$515,831
Personnel - Guayaquil	$48,000	$49,440	$50,923	$52,451	$54,024	$55,645	$57,315
Rent and Public Services - Manta	$16,800	$17,304	$17,823	$18,358	$18,909	$19,476	$20,060
General Expenses - Manta	$9,600	$9,888	$10,185	$10,490	$10,805	$11,129	$11,463
General Expenses - Guayaquil	$14,400	$14,832	$15,277	$15,735	$16,207	$16,694	$17,194
Investment							
Equipment - Manta	$110,000					$137,500	
Transport - Guayaquil	$70,000						
Training Personnel and Customer Service for three years	$120,000						
Total Cost	$820,800	$536,424	$552,517	$569,092	$586,165	$741,250	$621,863

Source: Author's estimation

3.1.3. ADDITIONAL CONSIDERATIONS BEFORE THE IMPLEMENTATION OF AN EM SYSTEM

It is not only necessary to consider the costs of implementation and functioning of the system, but some aspects should be taken care of, such as the followings:

1. Every element of the system to be implemented in the no-observer fleet will be more complex and costly. As a starter, it is important to determine if buy-in from the boat owners can be achieved. If the level of cooperation from this group is low, EM could fail (this is a very key issue). The program design needs to incorporate both outreach and a very detailed program specification, which includes EM system obligations and onboard catch handling protocols. Data analysis is much more complex because the important activities to watch occur at multiple cameras. The analysis group needs to have tight feedback loop with fleets to respond to problems and help improve data quality.
2. Engagement is required, not only from the no-observer fleet, but also from all the stakeholders of this fishery. Stakeholders include industry, managers, scientists, regulators, service providers, NGOs and experts in IT (information technology). Input from all

stakeholders will shape the design choices. For this reason, stakeholder engagement is in many ways the single biggest factor affecting the design of the program. The biggest single issue is resolving needs versus costs.

3. The program must be optimized to fit within the fishery characteristics. These include how the fishery operates, vessel characteristics, biological characteristics of target and non-target species, catch composition and the fishery socioeconomics.
4. The monitoring objectives will drive the design process. Stakeholders may have specific objectives to meet their needs. Having objectives clearly laid out will facilitate the design process by being able to weigh the advantages and disadvantages of different options. It is also important to forecast changes in monitoring needs to ensure the initial monitoring package has the built-in adaptability or flexibility to meet changing requirements.
5. Given that some design options will require more industry engagement than others, the level of fleet receptiveness to monitoring needs to be assessed and considered to guide the design.
6. The state of current technology will limit what is possible from a technical point of view. Technology is constantly being improved; however, it is important to build a program based on feasible options now and evolve the program as technology becomes available, rather than delay implementation. For example, in terms of no observer trips, the weaknesses of an EM system will be around catch composition, both at the level of major target species (i.e. bigeye/skipjack) and at the level of minor bycatch species. With respect to the former, if the tuna species are mixed in brails, there will need to be some control point where the composition can be distinguished. With the minor bycatch species, Archipelago's experience showed that these are removed at several points along the way, so enumeration at any point would be incomplete. Both these issues speak to a need for more clearly defined catch handling protocols, which are best done in collaboration with vessel crews.

7. Finally, it is necessary to emphasize that for the success of the EM program, it is essential to conduct a detailed design phase in order to work through all the critical decision points and better understand costs, to fully optimize the implementation of the EM system.

3.2. OBSERVERS PROGRAM COVERAGE

In recent years, there have been numerous discussions on increasing the observers' program coverage to all PS vessels that operate in the EPO. This increase in observer coverage is a beneficial alternative, regardless of whether the new conservation measure applied is an increase in the number of days of closure or the implementation of a system of individual quotas.

In 2015, the cost of the observers' program was $3,036,662. If the coverage is increased to all vessels that operate in the EPO regardless of their size classification, the cost of the observers' program is expected to increase by approximately $1,022,393.74 (i.e. an increment of 33% of the current cost).

3.3. IMPROVEMENT IN OBSERVERS SECURITY[20]

In almost all countries, observers cannot board without security training. Until a few years ago, observers were reimbursed for the cost of these courses, ranging from US $ 300 to US $ 500, but observers now must pay for the training.

At sea, observers depend on the ship's personnel for their communications, either by e-mail, radio or radiotelephone, and there is no protocol allowing them to confidentially inform any event of antagonism, interference, harassment, attempted bribery, or other hostile or difficult situation. Observers are only instructed to add notes about such cases into their reports after the end of the trip, if they believe that doing so during the trip may represent a danger to their physical

[20] This section is based on the information provided by IATTC in their report coded as: IATTC-90 INF C Observer safety at sea.

or moral integrity. As such, an independent communication system is expected to greatly reduce the likelihood of observers being subjected to external pressure.

The last element to consider is the case in which an observer falls into the water and the ship's personnel does not notice. Currently, the observer does not have security features that help them to survive and be located at sea. Hence the improved security system for observers is composed of the following components:

1. **InReach SE.** It is a bidirectional communication system that uses the Iridium satellite system and allows text communications to any mobile phone, as well as geographical location at intervals of 2 to 10 minutes. Cost estimates are based on an operations plan that allows an unlimited number of message texts in both directions. The apparatus is not completely waterproof, but is resistant to immersion at 1 meter in the water for 30 minutes. This system could be an important complement for the monitoring and catch report enhancement objectives that the EM system wants to attain.

2. **ResQ Link.** It is an Emergency Personal Indicator Locator Beacon. This equipment, unlike the previous one, does not allow two-way communications. Its use is exclusively confined to emergency notification. When activated by the user, the device transmits a

signal via satellite to a land station that identifies the device and its geographical location. The device is waterproof at 5 meters for an hour, and has a long-range strobe light.

3. **Imperial 409 series.** It is a group of immersion suits made of neoprene, which provide flotation and increase the time a person can be in the water without suffering hypothermia.

In Table 31 we provide the estimated budget for implementing the security improvement system in the purse seine fleet that operates in the EPO, assuming an increase of the coverage of the observers' program for the entire fleet.

Table 31. Estimated cost to improve security of current and future observers for the entire fleet that operates in the EPO

Total cost of equipment for security training and improvement of observer security	Unit Cost	Quantity	Total Cost 1st year	Annual cost including replacement
Training				
Initial	$ 500	100	$ 50,000	$ 60,000
Upgrading	$ 200	260	$ 52,000	$ 48,000
Locator and communication equipment				
• *InReach SE (bi-directional communication equipment)*	$ 300	360	$ 108,000	$ 21,600
• *InReach SE (Setup)*	$ 20	360	$ 7,200	$ 1,440
• *InReach (Annual operation)*	$ 600	360	$ 216,000	$ 43,200
• *ResQ Link (Emergency Personal Indicator Locator Beacon)*	$ 360	360	$ 129,600	$ 25,920
Flotation and Lifesaving equipment				
• *Imperial1409 Series*	$ 300	360	$ 108,000	$ 10,800
Total			$ 670,800	$ 210,960
Cost per Boat			$ 2,522	$ 793

Source: IATTC and Author's estimation

3.4. PLAN OF IMPROVEMENT OF MONITORING AND CONTROL OF THE TUNA FISHERY IN THE EASTERN PACIFIC OCEAN

A *Plan of Improvement of Monitoring and Control of the Tuna Fishery in the EPO* can be described by the following five (cost) components:

1. Adoption and Implementation of EM Systems in the entire purse seine fleet
2. Analysis of data gathered by the EM system in three regional headquarters along North, Central and South America,
3. Increase of coverage of observers in the purse-seine fleet
4. Improvement of the security of current and new observers.

It is necessary to specify that for the policy options that will be analyzed in the next chapter not all the costs will be relevant. In analyzing the policy option of increasing days of closure, most likely the plan of increasing the coverage and security of observes and their costs will be pertinent. On the other hand, if an IVQ is planned to be implemented, it would not only be necessary to increase the coverage and security of observers and possibly a phase in of improved control and monitoring mechanisms through the implementation of EM technology for all the purse seine fleet that operates in the EPO. When we proceed to compare the financial impact of both policies (i.e. to increase days of closure versus to implement an IVQ system) the only relevant monitoring and control costs for deciding between one policy or another, are those costs related to the EM system.

Table 32. Additional costs for the implementation of the Plan of Improvement of Monitoring and Control of the Tuna Fishery in the Eastern Pacific Ocean

	Years					NPV*
	1	2	3	4	5	
Implementation EM - All the purse-seine fleet	$2,465,900	$541,000	$541,000	$541,000	$541,000	$3,870,265
Data Analysis in 3 regional headquarters**	$2,462,400	$1,609,272	$1,657,551	$1,707,276	$1,758,495	$7,245,887
Increase of Observers Coverage	$1,022,394	$1,022,394	$1,022,394	$1,022,394	$1,022,394	$3,976,756
Improvement of security of current and new observers	$670,800	$210,960	$210,960	$210,960	$210,960	$1,242,432
Total cost of adopting and implementing an EM system+ (a)	$4,928,300	$2,150,272	$2,198,551	$2,248,276	$2,299,495	$11,116,151
Total cost of Increasing both the Observers Coverage and Security++ (b)	$1,693,194	$1,233,354	$1,233,354	$1,233,354	$1,233,354	$5,219,189
Total cost considering all the cost components (a)+(b)	$6,621,494	$3,383,626	$3,431,905	$3,481,630	$3,532,849	$16,335,340

* We use a discount rate of 9% to estimate the Net Present Value of each cost component and the total control and monitoring cost.
** To provide a cost estimation for the entire fleet, we used the Data Analysis Cost estimated for the Ecuadorian fleet to extrapolate for the two other possible locations that could be implemented in the EPO.
+We exclude the US fleet for the extrapolation of the implementation and adoption of EM system.
++We extrapolate this cost component for all the PS fleets that operate in the EPO (included the US fleet)

In Table 32 we will provide the estimation of the total cost for all components of the monitoring and control improvement program. We conducted the cost analysis for a five-year period applying a net present value for each component. The discount rate that has been selected for the Net Present Value (NPV) analysis is 9%.

If we calculate the NPV of the cost per boat of improving both the monitoring and control of the fishery activities of the PS fleet in the EPO, we determine that:

1. The NPV of the total cost per boat for adopting and implementing an EM system for a period of five years is approximately $13,467 for vessels with observers and $24,054 for vessels without observers.
2. The NPV of the total cost per boat for increasing the observer coverage and improving their security calculated for the same period of five years is $19,621.

Therefore, the NPV of the total cost per boat of both enhancing the observer program and implementing an EM system for a period of five years could range between $33,088 and $43,675 per boat.

CHAPTER 4 - COST-BENEFIT ANALYSIS OF MANAGEMENT POLICIES

As we have indicated previously, the main objective of this study is to develop a cost-benefit analysis for different management alternatives for the purse seine fishery in the Eastern Pacific Ocean (EPO)[21]. For that purpose, we will analyze the financial impact of two types of conservation policies; they are:

1. Increase of the length of the closure period;
2. A quota-managed program for BET (and/or YFT), which involves its allocation to Members and Co-operating Non-Members of the Commission (CPCs), as well as individual vessels and/or organizations (group quotas) in these countries.[22]

Using as reference the baseline results of the previous chapter we will analyze the short-term impact of the implementation of these two conservation policies for the purse seine tuna fishery in the EPO.

First, we analyze the impact of these policies on the PS boats that set on FADs. For that purpose, we will use the baseline results of the Ecuadorian fleet as a representative case for the entire FAD fleet. Finally, using the baseline results presented in section 2.3 we will analyze the financial impact of the conservation policies on the fleet that sets on dolphins.

4.1. POLICY IMPACT ANALYSIS IN FLEETS THAT SET ON FADs

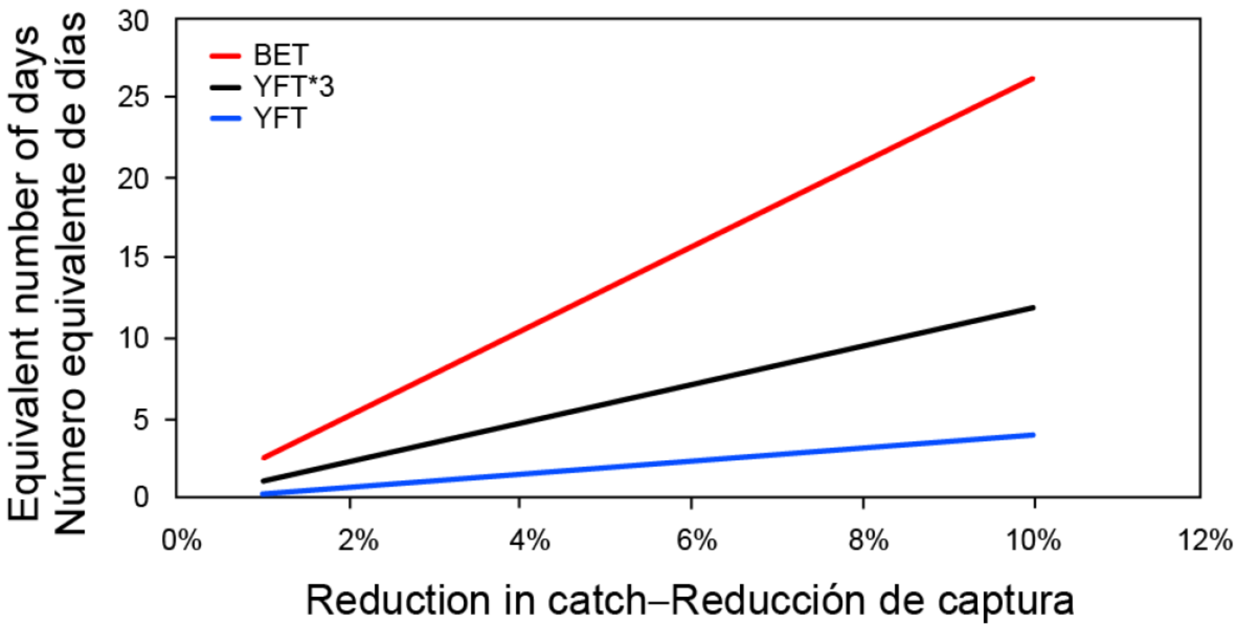
To model the impact of these two management policies we first use the baseline assumptions that were applied for the financial analysis conducted in section 2.2. Also, it is necessary to specify that for this policy analysis we will assume that even though all the boats that set on FADs in the EPO do not have a similar cost structure to the Ecuadorian purse-seine boats, the differential impact of the conservation policies on their cash flow (in percentage and dollars) will be equivalent.

[21] Another type of analysis that can be carried out with the information that we have available in this report is the financial valuation of the boats and their capacity permits. This analysis can be found in Annex 1 of this report.
[22] It is important to emphasize that in this section we are modeling the IVQ as a limit rather than as a time limited or permanent quota program. Therefore, the asset value of a time limited or permanent quota is not part of this cost benefit analysis.

Therefore, given that we are interested in this differential impact, we proceed to assume that the impact of the conservation policies on the profitability of the Ecuadorian fleet can be extrapolated to the other purse-seine fleets that participate in the EPO and set on FADs.

Finally, for each of the two conservation policies that we are interested in (i.e. increase of the closure days and the implementation of an individual vessel quota), we will compare them using equivalent policies. The equivalence of the policies is provided in a technical report prepared by the IATTC Scientific Advisory Commission (IATTC-91-03a Addendum 1) and results are summarized in Figure 10.

Figure 10. Equivalent days of closure for different reductions in catch on floating objects by Class-6 vessels, as described in the Colombia-Ecuador proposal, by species. BET: bigeye; YFT: yellowfin.



Source: IATTC

Hence, based on the results of the IATTC document (Figure 10) we will compare the impact of the following "equivalent" policies:

1. Increase of closure by 25 days compared with:

a. an IVQ for the BET established at 10% below the historical catch level and

b. an IVQ for both, BET and YFT, established at 10% below the historical catch level for each of the two species.[23]

2. Increase of closure by 10 days compared with:

   a. an IVQ for the BET established at 4% below the historical catch level,

   b. an IVQ for the YFT established at 8% below the historical catch level and

   c. an IVQ for both, BET and YFT, established at 4% and 8% below the historical catch level for each of the two species respectively.[24]

4.1.1. ASSUMPTIONS FOR SIMULATION OF SCENARIOS

For each conservation scenario, we will make specific assumptions to capture the impact of those policies on the profitability of the fishing operation of purse seiners that set on FADs. Those assumptions will be succinctly explained in the following paragraphs:

POLICY ALTERNATIVE 1: Increase of days of closure.

For this specific policy alternative, we will analyze two possible simulation scenarios:

a. **Scenario 1:** We assume that additional days of closure will be reflected as a proportional reduction of the cash flow of the operation in a fraction equivalent to the percentage reduction of fishing days. Implicitly we are assuming: 1) that fishing days are equivalent to fishing opportunities and 2) that there is a linear relationship between the cash flow generated by the operation and the fishing opportunities. Thus, for the case of the increase of 10 days of closure the proportional reduction in the cash flow

[23] This joint IVQ is modelled as a weighted average of imposing individual quotas for each species, which is approximately the mean of imposing a joint quota to both species (i.e. a system that considers both species as a one and only aggregate species).
[24] Idem.

is assumed to be 3.30% approximately; and for the 25 days closure the reduction is approximately 8.25%.

b. **Scenario 2:** According to the analysis conducted by the IATTC Scientific Advisory Committee (IATTC-75-07b REV), it is assumed that an additional 10 days of closure, will produce a reduction in the fishing effort of approximately 5%; and in the case of a 25 days closure this reduction in the fishing effort will be 12% approximately. In fact, in our simulations we assumed that this effort reduction derived from the additional days of closure will follow a triangular distribution, with the parameters given in Table 33.

Table 33. Assumptions about equivalence between additional days of closure and reduction of effort

Days of closure	Minimum	Likeliest	Maximum
10 days	-2%	-5%	-10%
25 days	-8%	-12%	-16%

Source: IATTC

POLICY ALTERNATIVE 2: Implementation of an Individual Quota

To analyze the impact of this policy we will assume that a quota is set based on the historical catch level of each boat. As we previously explained in a detailed manner, our analysis is based on a group of boats that belong to a specific capacity category. It is expected that there should be some level of heterogeneity among the boats that belong to each capacity category. For that purpose, to consider the effect of heterogeneity among boats we will generate the probability distribution of the catch per trip for each boat category and we will use that distribution to conduct the policy simulations.

An additional assumption that we imposed to our analysis is that boat owners are rational agents, therefore they would adjust their fishing operation to the catch limit determined by the individual quota. In our specific case, we assume that the adjustment will be reflected as a shift of the probability distribution (or specifically a displacement of the mean of the probability distribution) of the catch level per trip in a proportion equivalent to the quota which is imposed as a percentage reduction with respect to the historical catch.

For this policy alternative, we will also consider a second scenario in which boat owners adjust their effort and consequently their operation costs to the new reality, they will also try to compensate the contraction in the catch of BET and/or YFT with a higher catch level of SJT. This would require an increase in their effort to obtain the compensated catch. Thus, for each policy the increase of effort to compensate with a higher catch of SJT, will follow a triangular distribution with the parameters provided in Table 34.

Table 34. Assumptions about increase of effort to increase catch level of SJT to compensate contraction of catch of other commercial species

IVQ TYPE	Minimum	Likeliest	Maximum
BET IVQ at 10% below of historical catch level	0%	3%	6%
BET and YFT IVQ at 10% below of historical catch level for each of these two species	1%	5%	9%
BET IVQ at 4% below of historical catch level	0%	2%	4%
YFT IVQ at 8% below of historical catch level	0%	2%	4%
BET and YFT IVQ at 4% and 8% below of historical catch level respectively for each of these two species	1%	4%	7%

Source: Author's assumption

The results obtained from our simulations will be the estimated percentage contraction with respect to the baseline cash flows or the cash flow of the BAU scenario (i.e. current situation) which were estimated in Chapter 2. It is also necessary to specify that any type of IVQ policy will only be applied for class 6 and 5 vessels; therefore, we will simulate this policy for all the boat categories except for the 180 - <250 category.

Finally, to complete all the possible boat categories in the Ecuadorian fleet we reconstructed a boat category that was missing from the data that we obtained from boat owners in Ecuador. Specifically, we are referring to purse-seine vessels greater than 1,200 Metric Tons. For that purpose, we used catch and effort data for that boat category from a database provided by the Ecuadorian Government and we reconstructed their cost structure extrapolating the information provided by boat owners for smaller boat categories that are also used in our analysis.

4.1.2. RESULTS OF SIMULATIONS

It is important to emphasize that in this section we are modeling the IVQ as a limit rather than as a time limited or permanent quota program. Therefore, the asset value of a time limited or permanent quota is not part of this cost benefit analysis. The results of our simulations of the impact of conservation policies are given in Tables 35 and 36. From those tables we can infer that immediately after applying any of the two policy alternatives (i.e. increase of days of closure and IVQ), the cash flow of each boat category decreases. However, a system of individual vessel quota (IVQ) provides the possibility of a less negative impact on the profitability of the fishing operation compared to the alternative of increasing the days of closure. This is because an IVQ system is flexible and allows the operator to adjust their fishing decisions; among these, to change their target fisheries to species that are not bounded by the quota (i.e. SJT), in order to reduce the impact of this conservation policy on the profitability of the operation. In other words, the IVQ allows the owner to re-optimize his fishing operation to dilute the financial effect of the catch restriction; either through a reduction of costs or through an increase in income by the capture of more SJT. On the other hand, a policy that implies an increase of the days of closure is a straitjacket that prevents the re-optimization of the operation or the re-diversification of the catch portfolio. Therefore, the impact of this conservation policy on the cash flow will always be greater.

It is necessary to emphasize also that there is some heterogeneity on the impact of the IVQ policy among boat categories, specifically in the case of a BET IVQ. We observe in results from Tables 35 and 36 that larger boats are more dependent on BET than smaller ones; for that reason, larger boats will be more impacted by this policy. However, if we consider that boats will compensate with additional catch from other species, we found that larger vessels are better off with the IVQ compared to a closed season[25].

Table 35. Simulated average financial impact on the cash flow per year because of the implementation of equivalent conservation policies: 1) increase in 25 days of the annual closure, 2) BET IVQ at 10% below of the historical catch level, and 3) BET and YFT IVQ at 10% below the historical catch level for each of these two species.

Boat Category	Increase of closure days - 25 days		IVQ - BET 10% below historical catch		IVQ - BET & YFT 10% below historical catch	
	Proportional	No Proportional	Without compens.	With compens.	Without compens.	With compens.
>1200	-8.25%	-7.69%	-9.38%	-1.69%	-13.83%	-3.82%
800 - 1200	-8.25%	-10.31%	-5.57%	-1.83%	-10.08%	-3.71%
600 - <800	-8.25%	-12.33%	-2.95%	-1.63%	-8.04%	-3.49%
400 - <600	-8.25%	-14.48%	-2.32%	-0.64%	-5.47%	-2.20%
250 - <400	-8.25%	-13.38%	-1.17%	-0.38%	-5.53%	-1.78%
180 - <250	-8.25%	-12.90%	0.00%	0.00%	0.00%	0.00%

Source: Author's estimation

Table 36. Simulated average financial impact on the cash flow per year because of the implementation of equivalent conservation policies: 1) increase in 10 days of the annual closure, 2) BET IVQ at 4% below of the historical catch level, 3) YFT IVQ at 8% below of the historical catch level, and 3) BET and YFT IVQ at 4% and 8% below the historical catch level respectively for each of these two species.

Boat Category	Increase of closure days - 10 days		IVQ - BET 4% below historical catch		IVQ - YFT 8% below historical catch		IVQ - BET & YFT 4% and 8% below historical catch respectively	
	Proportional	No Proportional	Without compens.	With compens.	Without compens.	With compens.	Without compens.	With compens.
>1200	-3.30%	-4.62%	-3.00%	-1.15%	-2.44%	-1.18%	-6.88%	-2.46%
800 – 1200	-3.30%	-4.07%	-2.14%	-0.37%	-2.44%	-0.87%	-5.76%	-2.46%
600 - <800	-3.30%	-5.13%	-0.54%	-0.38%	-3.22%	-1.40%	-5.57%	-3.19%
400 - <600	-3.30%	-6.15%	-0.75%	-0.12%	-2.55%	-1.00%	-3.53%	-1.65%
250 - <400	-3.30%	-5.91%	-0.61%	-0.22%	-2.00%	-0.50%	-4.16%	-1.81%
180 - <250	-3.30%	-5.39%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Source: Author's estimation

[25] We warned again to use the results of this chapter carefully since they are based on a limited sample of Ecuadorian boats exclusively.

4.2. POLICY IMPACT ANALYSIS ON FLEETS THAT SET ON DOLPHINS

In this section, we will examine the financial impact of the two proposed conservation policies on the cash flow of vessels that set on dolphins. It is necessary to recall that for the baseline results of vessels that set on dolphins, presented in section 2.3., we used cost information from only one boat. In the case of catch information, we used information provided by the boat owner of that unique vessel as well as aggregate catch data from the fleets from Mexico, Colombia and Venezuela.

Because of the data limitation previously explained, for the analyses of this part we need to make the strong assumption that the differential impact calculated for this unique boat could be: a) extrapolated directly for all vessels that set on dolphins with a carrying capacity equal to or greater than 800 MT and b) extrapolated proportionally to those boats below 800 Metric Tons.

Unlike the case of boats that set on FADs, for boats that set on dolphins we do not have an explicit equivalence between days of closure and catch reductions (of either BET and YFT) when set on dolphins. For that reason, we conducted some simulations so as to derive our own equivalence, which need to be in some degree congruent with the equivalence used in the previous section for boats that set on FADs. Thus, based on our simulation results, we will compare the impact of the following "equivalent" policies:

1. Increase of closure in 25 days compared with:
    a. an IVQ for the BET established at 10% below the historical catch level and
    b. an IVQ for both, BET and YFT, established at 10% below the historical catch level for each of the two species[26].
2. Increase of closure in 10 days compared with:
    a. an IVQ for the BET established at 4% below the historical catch level,

[26] This joint IVQ is modelled as a weighted average of imposing individual quotas for each species, which is approximately the mean of imposing a joint quota to both species (i.e. a system that considers both species as a one and only aggregate species).

b. an IVQ for the YFT established at 4% below the historical catch level and
c. an IVQ for both, BET and YFT, established at 4% below the historical catch level for each of the two species[27].

4.2.1. ASSUMPTIONS FOR SIMULATION OF SCENARIOS

For each conservation scenario, we will make specific assumptions to capture the impact of those policies on the profitability of the fishing operation of purse seiners that set on dolphins.

Unlike the analysis conducted previously, for vessels that set on FADs, for this specific case (i.e. purse seiners that set on dolphins) we have an important limitation on the available information, for that reason we will not estimate distribution functions of the impacts of the different policies.

Specifically, given that for this case we have scarce information, we will proceed to calculate the impact of the different policies on the profitability of the fishing operation of that boat. That is, we will carry out a financial-accounting analysis of the impact of the different policies on the cash flow of the one boat.

We will assume that this impact will be equivalent to all boats that: 1) operate in the EPO, 2) set on dolphins and 3) have a carrying capacity equal to or greater than 800 MT. This assumption will give us an idea of the possible impacts of the studied conservation policies on this type of boat. In the case of small boats (i.e. less than 800 MT) the adjustment will be proportional as it is later described in section 4.3.1

Even to analyze financially the impact of conservation policies using one observation (and without resorting to probability distribution functions), it is necessary to make some assumptions which are detailed below:

[27] Ídem.

POLICY ALTERNATIVE 1: Increase of days of closure.

For this specific policy alternative, we will analyze two possible simulation scenarios:

a. **Scenario 1:** We assume that additional days of closure will be reflected as a proportional reduction of the cash flow of the operation in a fraction equivalent to the percentage reduction of fishing days. Implicitly we are assuming: 1) that fishing days are equivalent to fishing opportunities and 2) that there is a linear relationship between the cash flow generated by the operation and the fishing opportunities. Thus, for the case of the increase of 10 days of closure the proportional reduction in the cash flow is assumed to be 3.30% approximately; and for the 25 days closure the reduction is approximately 8.25%.

b. **Scenario 2:** According to the analysis conducted by the IATTC Scientific Advisory Committee (IATTC-75-07b REV), it is assumed that an additional 10 days of closure, will produce a reduction in the fishing effort by approximately 5%; and in the case of a 25 day closure this reduction in fishing effort will be 12% approximately. We assumed that this effort reduction directly affects the average number of fishing days that vessels planned to be at the sea.

POLICY ALTERNATIVE 2: Implementation of an Individual Quota

To analyze the impact of this policy we will assume that a quota is set based on the historical catch level of the boat. For this case, we use as a proxy of fishing activity for the one boat that we were able to get information from complemented by aggregate information from the fleets that set on dolphins. Thus, we get the results presented in Table 20 from which we conclude that the average catch composition of a vessel that sets on Dolphins is 93% YFT, 6% SJT and 1% BET. Then, given that we observed a clear bias of the catch composition towards YFT, it is expected that an IVQ for that species will have an important financial impact on this type of boat.

For this analysis, we assume that the IVQ will produce an immediate reduction in the catch level by a percentage equal to the limit established by the IVQ.

As in the previous section we assume two scenarios: one in which boat owners would only adjust their fishing operation to the catch limit determined by the individual quota; and a second scenario in which boat owners adjust their effort (and consequently their operation costs) to the new reality (i.e. a limit in the catch of some species) and they will try to compensate for the contraction in the catch of BET and/or YFT with a higher catch level of SJT.

Hence, as in the previous section, the results obtained from our simulations will be the estimated percentage reduction with respect to the baseline cash flows or the cash flow of the BAU scenario (i.e. current situation), which were estimated in Chapter 2.

4.2.2. RESULTS OF SIMULATIONS

The results of our simulations about the impact of conservation policies on the cash flow of representative purse seiners that set on dolphins are given in Tables 37 and 38.

Table 37. Simulated average financial impact on the cash flow per year because of the implementation of equivalent conservation policies: 1) increase in 25 days of the annual closure, 2) BET IVQ at 10% below of the historical catch level, and 3) BET and YFT IVQ at 10% below the historical catch level for each of these two species.

Boat Category	Increase of closure days - 25 days		IVQ - BET 10% below historical catch		IVQ - BET & YFT 10% below historical catch	
	Proportional	No Proportional	Without compens.	With compens.	Without compens.	With compens.
>1200 - 1600	-8.25%	-27.43%	-0.27%	-0.01%	-26.79%	-2.72%

Source: Author's estimation

Table 38. Simulated average financial impact on the cash flow per year because of the implementation of equivalent conservation policies: 1) increase in 10 days of the annual closure, 2) BET IVQ at 4% below the historical catch level, 3) YFT IVQ at 8% below the historical catch level, and 3) BET and YFT IVQ at 4% and 8% below the historical catch level respectively for each of these two species.

Boat Category	Increase of closure days - 10 days		IVQ - BET 4% below historical catch		IVQ - YFT 4% below historical catch		IVQ - BET & YFT 4% below historical catch	
	Proportional	No Proportional	Without compens.	With compens.	Without compens.	With compens.	Without compens.	With compens.
>1200 – 1600	-3.30%	-11.43%	-0.11%	-0.01%	-11.43%	-1.17%	-11.54%	-1.17%

Source: Author's estimation

From the results presented in Tables 37 and 38 we can conclude the following:

1. A system of individual vessel quota (IVQ) seems preferable than an increase of days of closure because the range of losses derived from the implementation of the former conservation policy showed the possibility of less negative financial impact than the latter. This is because an IVQ system is flexible and allow operators to adjust their fishing decisions. Among these, boat owners can change their target fisheries to species that are not bounded by the quota (i.e. SJT), and reduce the financial impact of this conservation policy on the profitability of the fishing operation. Boat owners can also adjust fishing operations to reduce costs. On the other hand, a conservation policy that implies an increase of the days of closure is a straitjacket that prevents the re-optimization of the operation or the re-diversification of the catch portfolio. However, this possibility that boat owners will decide to increase their catch of SJT to compensate the reduction of YFT and BET is not so simple to apply in this case. Thus, we should be prudent with our expectations about the extent of the catch adjustment to cancel out (or attenuate) the losses derived from the IVQ.
2. Although the range of losses derived from the IVQs are somehow preferable to the range derived from an increase in the days of closure (because of the possibility of mitigating these losses with additional catches of SJT and cost reduction), the financial losses because of the implementation of any IVQ system on the fleet that focuses solely on YFT are

considerable (and sometimes greater than those derived from increasing the days of closure). This is because of the high dependence of the income of this fleet with respect to the catch of this species. It is also important to highlight the very small impact of the implementation of IVQs for BET (logically due to the almost null importance of this species in the catch portfolio of these boats, approximately 1%).

4.3. FINANCIAL IMPACT OF CONSERVATION POLICIES ON THE ENTIRE PURSE-SEINE FLEET THAT OPERATES IN THE EPO

4.3.1. ASSUMPTIONS FOR EXTRAPOLATION

In this section, we will extrapolate the results obtained previously for all purse seine fleets operating in the EPO. For this purpose, we will have to make several assumptions and simplifications, some of which have already been enunciated throughout this document, but which we will recount in the following paragraphs.

Fleets that set on FADs

Although we know that there is a high level of heterogeneity in terms of the cost structure of vessels fishing on FADs in the EPO (among these differences, the most important are the dissimilar cost levels in each of the countries), we will assume that the differential financial impact of each conservation policy (with respect to the baseline) on the profitability of the fishing operation of all vessels fishing on FADs in the EPO will be very similar to the financial impact calculated for the Ecuadorian fleet. In other words, we will assume that the difference in cash flows between different conservation policies and the baseline that has been calculated for Ecuadorian vessels may be extrapolated directly to vessels of other flags, if these are properly classified in each of the categories defined in previous chapters. Therefore, based on this assumption the composition of the purse-seine fleet that sets on FADs in the EPO can be expressed through the following boat distribution, which will be used for the extrapolation of our results:

Table 39. Boats that set on FADs classified by size categories

Size Category	Frequency
>1200	30
800 - 1200	33
600 - <800	12
400 - <600	21
250 - <400	30
180 - <250	31
Total	**157**

Source: Author's estimation
Note: From those 157 boats, 114 are Ecuadorian and the rest (i.4. 43 boats) are from other flags.
Source: Author's estimation

It is necessary to emphasize that in the distribution previously shown (Table 39), the US fleet does not appear. This is because we assume that it will not be affected by any of the two conservation policies analyzed in this report, since they have limited access for their fishing operations in the EPO. Specifically, US flag vessels are authorized to make only one trip not exceeding 90 days per calendar year, with an observer on board and without authorization to make dolphin sets. Finally, it should be pointed out that the fleets considered for this analysis that set on FADs are: Ecuadorian, Salvadorian, Spanish, Nicaraguan,[28] Panamanian and Peruvian. We will assume homogeneity within each of the countries and that each purse seiner belonging to the fleet of any of the countries listed previously is characterized by an intensive use of sets on FADs.

Fleet that set on Dolphins

In the case of the fleet fishing on dolphins the situation is more complex and the assumptions that must be made are much stronger as we only have information from a single ship. This boat has a

[28] Some experts classify Nicaragua fleet as fishing over dolphins; however, during the period 2013-2015 (2014-2015) 60% (55%) of the Nicaraguan fleet sets were made on FADs. For this reason, for this study we will classify the Nicaraguan fleet as a fleet that sets predominantly on FADs.

carrying capacity of 1300 MT. Based on that, we have assumed that the financial impact of conservation policies that was calculated for that boat could be extrapolated directly to all vessels that fish on dolphins in the EPO and that their carrying capacity is equal to or greater than 800 MT. For those boats whose carrying capacity is below that limit we assume that the financial impact will be proportional to their size (with respect to the capacity of the 1300 MT type boat). Thus, when we look at the number of boats that sets on dolphins we find that there are 84 boats of that type in the EPO. From those boats, 65 have a carrying capacity equal to or greater than 800 MT and 19 ships have a capacity below 800 MT. By making the proportional adjustment indicated above we can find that these 19 boats of less than 800 MT are equivalent to 6 boats with a carrying capacity equal to or greater than 800 MT. Therefore, for our analysis we will assume that we have 71 ships with a tonnage equal to or greater than 800 MT for which the financial results calculated in section 4.2.2 can be directly applied.

Additionally, it should be emphasized that the fleets that we considered for this analysis that set on dolphins are: Mexican, Colombian and Venezuelan. We will assume homogeneity within each of the countries and that each ship in the fleet of the countries listed previously is characterized by fishing intensively on dolphins.

In the case of Venezuela, we will assume, we will specifically assume that prices within that country are not distorted and therefore that extrapolation can be performed without any additional financial adjustment. This is a very strong assumption given the current political and economic conditions in that country, but due to the difficulty of obtaining information we must restrict ourselves to this strong assumption, recognizing that the results derived from this analysis must be treated with great care.

4.3.2. RESULTS OF EXTRAPOLATION

We estimated the annual loss of cash flow for each of the conservation alternatives but we also estimated the NPV of the total loss for a period of 5 years, assuming a discount rate of 9% and a growth rate of 1% as well as uniformity of the cash flow during that period. Then the results of our estimations are given in Tables 40 to 43.

Table 40. Loss of Cash Flow per year and during a period of 5 years derived from 10 additional closure days

Boat Category	Increase of closure days - 10 days	
	Proportional	No Proportional
FAD fleet	$ (4,402,868.96)	$ (6,604,370.23)
Dolphins fleet	$ (5,676,312.42)	$ (19,657,761.93)
Total (Annual)	$ (10,079,181.38)	$ (26,262,132.16)
Total (5 years)	$ (39,928,120.32)	$ (104,035,985.95)

Table 41. Loss of Cash Flow per year and during a period of 5 years derived from 25 additional closure days

Boat Category	Increase of closure days - 25 days	
	Proportional (Lower Bound)	No Proportional (Upper Bound)
FAD fleet	$ (11,006,071.79)	$ (14,469,501.43)
Dolphins fleet	$ (14,190,781.06)	$ (47,178,628.64)
Total (Annual)	$ (25,196,852.85)	$ (61,648,130.07)
Total (5 years)	$ (99,815,940.81)	$ (244,215,662.07)

Table 42. Loss of Cash Flow per year and during a period of 5 years derived from IVQ schemes equivalent to 10 additional closure days

	IVQ - BET 4% below historical catch for both fleets		IVQ - YFT 8% below historical catch for FAD fleet and 4% for FAD fleet		IVQ - BET & YFT 4% and 8% below historical catch respectively for FAD fleet and 4% for both species for Dolphin fleet	
	Without compensation (Upper Bound)	With compensation (Lower Bound)	Without compensation (Upper Bound)	With compensation (Lower Bound)	Without compensation (Upper Bound)	With compensation (Lower Bound)
FADS	$ (2,287,817.13)	$ (696,722.37)	$ (2,980,424.97)	$ (1,183,506.03)	$ (6,776,686.65)	$ (2,803,227.42)
Dolphins	$ (184,838.82)	$ (8,629.73)	$ (19,657,241.94)	$ (2,005,102.04)	$ (19,842,080.75)	$ (2,013,731.77)
Total (Annual)	$ (2,472,655.95)	$ (705,352.10)	$ (22,637,666.91)	$ (3,188,608.07)	$ (26,618,767.40)	$ (4,816,959.19)
Total (5 years)	$ (9,795,289.96)	$ (2,794,213.37)	$ (89,677,867.03)	$ (12,631,494.76)	$ (105,448,776.76)	$ (19,082,117.77)

Table 43. Loss of Cash Flow per year and during a period of 5 years derived from IVQ schemes equivalent to 25 additional closure days

	IVQ - BET 10% below historical catch for both fleets		IVQ - BET & YFT 10% below historical catch for both fleets	
	Without compensation (Upper Bound)	With compensation (Lower Bound)	Without compensation (Upper Bound)	With compensation (Lower Bound)
FADS	$ (6,707,473.65)	$ (1,676,251.29)	$ (13,606,800.03)	$ (7,924,556.82)
Dolphins	$ (462,097.05)	$ (21,574.32)	$ (46,084,325.00)	$ (4,675,188.64)
Total (Annual)	$ (7,169,570.70)	$ (1,697,825.61)	$ (59,691,125.03)	$ (12,599,745.46)
Total (5 years)	$ (28,401,858.29)	$ (6,725,842.37)	$ (236,463,094.71)	$ (49,913,195.67)

It should be recalled that in addition to the direct budgetary impact of conservation policies, the changes required in terms of control and monitoring costs must be included to fully understand the impact of the conservation policies analyzed. For this purpose, it is necessary to recall results in Chapter 3. Specifically, in that chapter we indicated that there are two types of control and monitoring costs, those related to the increase of coverage and security for observers; and a second group related to the implementation of an EM system.

Thus, in Chapter 3, we argued that costs related to the enhancement of both observers' program coverage and observers safety should be implemented regardless of whether the selected conservation policy was an increase of the days of closure or the implementation of an IVQ system. Therefore, the increase of this type of cost of monitoring and control is not differential between the two conservation alternatives, since they should be carried them out regardless of the selected policy.

On the other hand, the costs of implementing an electronic monitoring (EM) system will be specific and make more sense when the policy selected is to implement an IVQ system. Hence, this cost could be classified as differential because it will appear in one conservation alternative (i.e. IVQ system) but not in the other (i.e. increase in the days of closure). For this reason, we proceeded to adjust the NPV related to the implementation of an IVQ system so as to include the cost of implementing an EM system. The results of this adjustment are given in Tables 44 and 45.

Table 44. Net Present Value of the loss of Cash Flow adjusted by changes in the cost of monitoring and control because of the implementation of IVQ schemes equivalent to 10 additional closure days

	IVQ - BET 4% below historical catch for both fleets		IVQ - YFT 8% below historical catch for FAD fleet and 4% for FAD fleet		IVQ - BET & YFT 4% and 8% below historical catch respectively for FAD fleet and 4% for both species for Dolphin fleet	
	Without compensation (Upper Bound)	With compensation (Lower Bound)	Without compensation (Upper Bound)	With compensation (Lower Bound)	Without compensation (Upper Bound)	With compensation (Lower Bound)
Total (5 years)	$(20,911,441.16)	$(13,910,364.58)	$(100,794,018.24)	$(23,747,645.96)	$(116,564,927.96)	$(30,198,268.97)

Table 45. Net Present Value of the loss of Cash Flow adjusted by changes in the cost of monitoring and control because of the implementation of IVQ schemes equivalent to 25 additional closure days

	IVQ - BET 10% below historical catch for both fleets		IVQ - BET & YFT 10% below historical catch for both fleets	
	Without compensation (Upper Bound)	With compensation (Lower Bound)	Without compensation (Upper Bound)	With compensation (Lower Bound)
Total (5 years)	$(39,518,009.50)	$(17,841,993.57)	$(247,579,245.92)	$(61,029,346.87)

If we compare the results shown in Tables 40 and 41 (which are related to a policy of increasing the number of days of the seasonal closure) with the results of Tables 44 and 45 (related to the implementation of an IVQ system including the adoption of an EM system) we can conclude the following:

1. When a policy of establishing additional 10 days of fishing closure is adopted instead of its equivalent rights-based management policies, it is estimated that the purse-seine fleet operating in the EPO will lose on average 21 million dollars (NPV for a period of five years); that is, approximately $ 87,000 per boat;
2. When a policy of establishing additional 25 days of fishing closure is adopted instead of its equivalent rights-based management policies, it is estimated that the purse-seine fleet operating in the EPO will lose on average 80.5 million dollars (NPV for a period of five years); that is, approximately $ 334,000 per boat.

Therefore, on average, accepting one additional day of closure instead of adopting its equivalent rights-based management policies will produce an average loss (for the fleet operating in the EPO) that ranges from 2 million to 4 million dollars per additional day of closure (NPV for a period of five years); that is, an equivalent of $ 9,000 to $ 16,000 per boat.

Hence, based on the previous results we can conclude that it is preferable to adopt a rights-based management system, such as the establishment of an IVQ rather than a more restrictive system such as the extension of the closure period. Specifically, an IVQ system is more financially advantageous because it is elastic enough to allow ship-owners to correct their fishing operations and catch decisions to mitigate the negative effects of this management policy.

To sum up, it can be said that an IVQ system has a significant flexibility characteristic which allows ship-owners to limit their losses and because of that this type of policy becomes a superior alternative compared to increasing the days of closure, which is a rigid alternative whose financial impact is difficult or impossible to mitigate.

CHAPTER 5 - CONCLUSIONS

The main objective of this study was to develop a cost-benefit analysis for different management alternatives for the purse seine fishery in the Eastern Pacific Ocean (EPO). For that purpose, we analyzed the financial impact of two types of conservation policies; they are:

1. Increase of the days of the closure period;
2. A quota-managed program for BET (and/or YFT), which involves its allocation to Members and Co-operating Non-Members of the Commission (CPCs), as well as individual vessels and/or organizations (group quotas) in these countries[29].

In this report, we focus in determining the short-term impact of the implementation of these two conservation policies for the purse seine tuna fishery in the EPO and compare them financially. Based on that comparison we were able to conclude that an IVQ system is a superior alternative compared to increasing the days of closure. Specifically, we estimated that on average, accepting one additional day of closure instead of adopting any equivalent IVQ scheme will produce (for the fleet operating in the EPO) an average loss that ranges from 2 million to 4 million dollars per additional day of closure (NPV for a period of five years); that is, an equivalent of $9,000 to $16,000 per boat.

The reason of the financial advantage of the IVQ system over the increase of the closure period is because the former is a flexible scheme that allows fishing operators to adjust their fishing decisions (among these, to change their target fisheries to species that are not bounded by the catch limit), in order to reduce the impact of this conservation policy on the profitability of the operation. In other words, an IVQ system allows the owner to re-optimize his/her fishing operation to dilute the financial effect of the catch restriction; either through a reduction of costs or through an increase in income through the capture of other species.

[29] It is important to emphasize that in this section we are modeling the IVQ as a limit rather than as a time limited or permanent quota program. Therefore, the asset value of a time limited or permanent quota is not part of this cost benefit analysis.

On the other hand, any policy that implies an increase of the days of closure is a straitjacket that prevents the re-optimization of the operation or the re-diversification of the catch portfolio. Therefore, the negative impact of this type of conservation policy on the cash flow will always be greater.

REFERENCES

Allen, R., J. Joseph and D. Squires. 2010. Conservation and management of transnational tuna fisheries. Wiley-Blackwell. Ames, Iowa, USA

Anderson, J., C. Anderson, J. Chu, Meredith, F. Asche, and G. Sylvia, et. al. 2015. The Fishery Performance Indicators: A Management Tool for Triple Bottom Line Outcomes. PLoS ONE 10(5): e0122809. doi: 10.1371/journal.pone.0122809

Baum, J., R. Myers, D. Kehler, B. Worm, S. Harley, and P. Doherty. 2003. Collapse and conservation of shark populations in the northwest Atlantic. Science 299: 389–392.

Bjørndal, T. and G. Munro. 2012. The Economics and Management of World Fisheries, Oxford, Oxford University Press.

Brown, J. and G. Macfadyen. (2007). Ghost fishing in European Waters: Impacts and management responses, Marine Policy (31):488-504.

Campling, L., E. Havice, and P. Howard. 2012. The political economy and ecology of capture fisheries: market dynamics, resource access and relations of exploitation and resistance. Journal of Agrarian Change 12:177–203.

Gréboval, D. and G. Munro. 1998. Overcapitalization and Excess Capacity in World Fisheries: Underlying Economics and Methods of Control, in Managing Fishing Capacity: Selected Papers on Underlying Concepts and Issues. FAO - Fisheries Technical Paper. No. 386. FAO, Rome.

Freese, S., J. Glock, and D. Squires. 1995. Direct allocation of resources and cost-benefit analysis in fisheries: an application to pacific whiting. Marine Policy (19): 199-211.

Hall, M. and M. Roman. 2013. Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world. FAO Fisheries and Aquaculture Technical Paper No. 568. FAO, Rome

Herrick, S., I. Stand, D. Squires, M. Miller, D. Lipton, J. Walden, and S. Freese. (1994). Application of Benefit-Cost Analysis to Fisheries Allocation Decisions: The Case of Alaska Walleye Pollock and Pacific Cod. North American Journal of Fisheries Management (14): 726-741.

Inter-American Tropical Tuna Commission. 2011. Multiannual Program for the Conservation of Tuna in the Eastern Pacific Ocean during 2011-2013. Inter-American Tropical Tuna Commission 82th Meeting, La Jolla, (USA), 4-8 July 2011 C-11-01, 4 pp.

Inter-American Tropical Tuna Commission. 2012. Recommendations by the Staff for the Conservation of Tunas and Sharks in The Eastern Pacific Ocean, 2012-2013. Inter-American Tropical Tuna Commission 83rd Meeting. La Jolla, California, USA.

Inter-American Tropical Tuna Commission. 2013. Individual-Vessel Quotas for Purse-Seine Vessels that Fish on Fish-Aggregating Devices (FADS) (SAC-04-11). Scientific Advisory Committee Fourth Meeting. La Jolla, California, USA.

Inter-American Tropical Tuna Commission. 2013. Management Options: Total Allowable Catch (TAC) Scheme (SAC-04-INF D). Scientific Advisory Committee Fourth Meeting. La Jolla, California, USA.

Inter-American Tropical Tuna Commission. 2013. Multiannual Program for the Conservation of Tuna in the Eastern Pacific Ocean during 2014-2016. Inter-American Tropical Tuna Commission 85th Meeting, Veracruz, (Mexico), 10-14 June 2013 C-13-01, 4 pp.

Inter-American Tropical Tuna Commission. 2015. Fishery Status Report—Informe de la Situación de la Pesquería No. 13. Tunas and Billfishes in the Eastern Pacific Ocean in 2015. La Jolla, California, USA.

Jackson, J., M. Kirby, W. Berger, K. Bjørndal, L. Botsford, B. Bourque, R. Bradbury, R. Cooke, J. Erlandson, J. Estes, T. Hughes, S. Kidwell, C. Lange, H. Lenihan, J. Pandolfi, C. Peterson, R. Steneck, M. Tegner, and R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629–638.

Maguire, J., M. Sissenwine, J. Csirke, and R. Grainger. 2006. The state of the world highly migratory, straddling and other high seas fish stocks, and associated species. FAO - Fisheries Technical Paper No. 495. FAO, Rome.

Mansfield, B. 2011. Modern industrial fisheries and the crisis of overfishing. In: Peet R., Robbins P., Watts MJ, editors. Global political ecology. London and New York: Routledge.

McElderry, H. 2008. At-Sea Observing Using Video-Based Electronic Monitoring. Electronic Monitoring Workshop. Archipelago Marine Research Ltd, British Columbia.

McElderry, H., M. Beck, M.J. Pria, and S. Anderson. 2010. Electronic Monitoring In The New Zealand Inshore Trawl Fishery: A Pilot Study. Working Paper. Archipelago Marine Research Ltd, British Columbia.

Miller, T., and A., Kim. 2016. 2016 Index of economic freedom. Promoting economic opportunity and prosperity. The Heritage Foundation and Dow Jones & Company, Inc. Washington, DC.

Munro, G., and U. Sumaila. 2002. The impact of subsidies upon fisheries management and sustainability: the case of the North Atlantic. Fish and Fisheries, 3: 233-250.

Myers, R. and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423: 280–283.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, and F. Torres. 1998. Fishing down marine food webs. Science 279: 860–863.

Pauly, D., V. Christensen, S. Guénette, T. Pitcher, U. Sumaila, C. Walters, R. Watson, and D. Zeller. 2002. Towards sustainability in world fisheries. Nature, 418: 689-695.

Piasente, M., B. Stanley, T. Timmiss, H. McElderry, M.J. Pria, and M. Dyas (2012). Electronic onboard monitoring pilot project for the Eastern Tuna and Billfish Fishery. FRDC Project 2009/048. Australian Fisheries Management Authority 105 pp.

Ruiz, J., A. Batty, P. Chavance, H. McElderry, V. Restrepo, P. Sharples, J. Santos, and A. Urtizberea. 2015. Electronic monitoring trials on in the tropical tuna purse-seine fishery. ICES Journal of Marine Science, 72: 1201–1213

Schwindt, R., A. Vining and S. Gloverman. (2000). Net Loss: A Cost-Benefit Analysis of the Canadian Pacific Salmon Fishery. Journal of Policy Analysis and Management (19), 23-45.

Shrader, J., and D. Squires. (2012). Fishing Capacity and Efficient Fleet Configuration for the Tuna Purse-Seine Fishery in the Eastern Pacific Ocean: An Economic Approach. Document SAC-04-INF B. IATTC Scientific Advisory Committee La Jolla, California (USA).

van Helmond, A., C. Chen, and J.J. Poos. 2015. How effective is electronic monitoring in mixed bottom-trawl fisheries? ICES Journal of Marine Science, 72: 1192–1200

Weitzman, M. (2001). Gamma Discounting. American Economic Review (91): 160-171

Young, J. 2011. Compendio de normas pesqueras de la República de Panamá. Fundación Marviva. Panamá, Panamá.

Zuleta, L., and A., Becerra. 2013. El mercado del atún en Colombia. FEDESARROLLO. Bogota, Colombia.

ANNEX 1 – FINANCIAL VALUATION OF PURSE SEINE BOATS

A1.1. FINANCIAL VALUATION OF PURSE SEINE BOATS WITH A COST STRUCTURE SIMILAR TO THE ECUADORIAN BOATS

The analysis that was conducted in Chapter 2 will allow us to answer an interesting question, especially relevant for a buyback program; that is: what is the approximate purchase value of both the scrapping of a boat and its underlying capacity quota?

To answer the previous question, we will apply a Discounted Cash Flow (DCF) analysis, which is a valuation technique that uses future cash flow projections and discounts them to arrive at a present value estimate of an asset. These results are used to evaluate the potential for investment in that asset. Specifically, we will apply the following formula:

$$\textbf{Valuation of boat + capacity quota} = \sum_{t=1}^{\infty} \frac{CF_t}{r-g} \qquad \textbf{(A1.1.)}$$

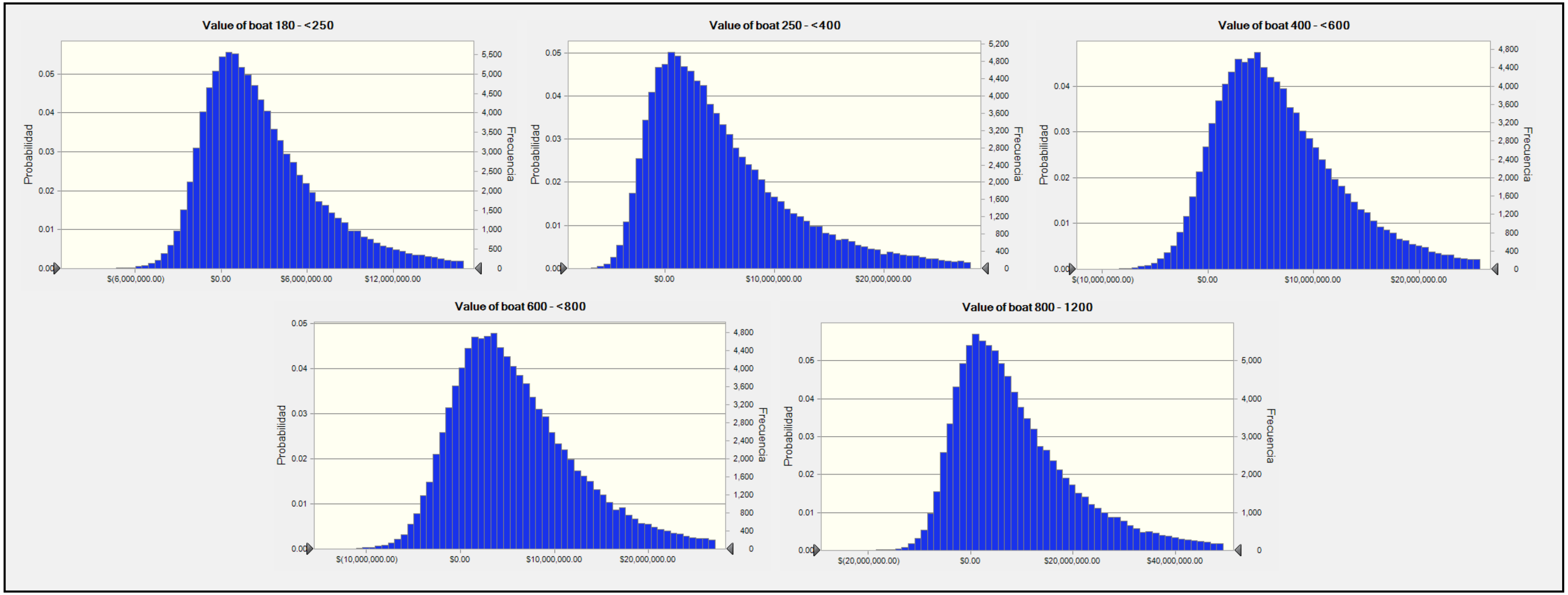
where CF_t is the cash flow generated by the boat at time t, r is the discount rate and g is the average long term growth of the cash flows.

Therefore, in addition to the assumptions that we applied in Chapter 2 to construct the Cash Flow of the boats, we need to adopt two additional assumptions for this specific analysis:

1. The discounted rate will follow a triangular distribution with a minimum equal to 10%, a maximum value of 14% and most likely a value of 12% (which is the official discount rate in Ecuador).
2. The growth of the DCF with respect to the baseline case will be assumed constant and will follow a triangular distribution with the following parameters: a minimum value of -3%, likeliest value of 1% and a maximum value of 3%.

The series of statistics resulting from the Montecarlo simulation (using 100,000 replications) are given in Table A1.1. We also obtained a set of probability distribution functions for the Net Present Value of a representative boat for each of the five boat categories defined in Chapter 2 (Figure A1.1.)

Figure A1.1. Probability distribution of net present value of a representative boat for each boat category



Source: Author's estimation

Table A1.1. Simulated net present value of a representative boat (i.e. scrapping and capacity quota) for each boat category

Boat Category	Statistics	Value of the Boat
800 - 1200	*Median*	$6,357,424.55
	Lower Bound	$3,870,169.02
	Upper Bound	$9,197,008.06
600 - <800	*Median*	$4,858,180.48
	Lower Bound	$3,373,178.06
	Upper Bound	$6,534,384.54
400 - <600	*Median*	$5,863,252.98
	Lower Bound	$4,507,147.35
	Upper Bound	$7,363,415.43
250 - <400	*Median*	$3,650,533.98
	Lower Bound	$2,271,577.79
	Upper Bound	$5,246,750.69
180 - <250	*Median*	$2,076,978.46
	Lower Bound	$1,202,155.89
	Upper Bound	$3,094,520.99

Note: For this table, the Lower Bound is the percentile 40 of the simulation and the Upper Bound is the percentile 60. We decided to use a narrow range to reduce the effect of the high dispersion in the simulation process. The latter is also the reason of why we decided to use the Median instead of the Mean.
Source: Author's estimation

From the results in Table A1.1. we are able to estimate the average value of one metric ton of capacity for purse seiners that: 1) set on FADs, 2) have a cost/income structure similar to boats that belong to the Ecuadorian fleet, and 3) has a carrying capacity that can be classified into any of the five categories that were defined in this study.

Thus, we estimate that the value of one ton of capacity should be between $3,870 and $16,143. In fact, we determine that it is likely that 50% of boat owners will find adequate a selling price of $9,183 for each metric ton of capacity, where the vessel is scrapped and the capacity quota is removed from the vessel register. These costs were calculated using data from highly efficient vessels that operate in the Eastern Pacific and therefore biased upward compared to the average vessel in the EPO.

A1.2. FINANCIAL VALUATION OF PURSE SEINE BOATS WITH COST STRUCTURE DIFFERENT FROM THE ECUADORIAN BOATS

In this part, we make an approximation for the cash flow generated for other fleets that set on FADs such as: Panama, Peru, Nicaragua and El Salvador. For that purpose, we will need to make some additional assumptions:

1. The discounted rate will follow a triangular distribution, with a minimum equal to 8%, a maximum value of 12% and an average value of 10% (The World Bank).
2. The corporate tax rate among the subset of countries for this section has an average of 27%, with a minimum of 25% and a maximum rate of 30%. We assume a uniform probability distribution for this variable[30].
3. The fuel (i.e. diesel) price for this group of countries will have a maximum of \$3/gallon, a minimum of \$2.3/gallon and an average value of \$2.7/gallon[31].

The results of the Montecarlo simulation of the average cash flow of the boats (using 100,000 replications) are shown in Table A1.2. and Figure A1.2.

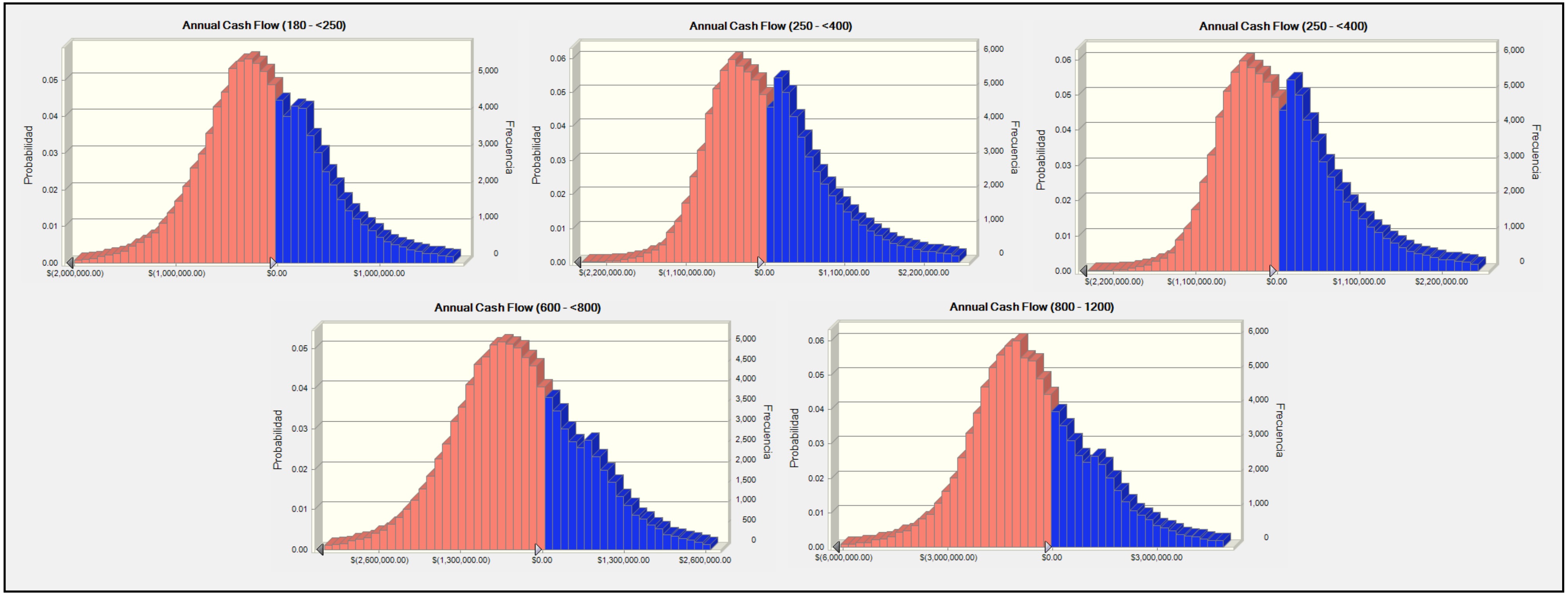
Table A1.2. Simulated average cash flow per year for each boat category for vessels with cost structures different from Ecuadorian boats

Boat Category	Statistic	Value of the Boat
800 - 1200	*Mean*	-\$581,925.10
	P(CF<0)	67.64%
600 - <800	*Mean*	-\$398,573.23
	P(CF<0)	67.11%
400 - <600	*Mean*	\$28,501.45
	P(CF<0)	50.48%
250 - <400	*Mean*	\$72,918.61
	P(CF<0)	52.91%
180 - <250	*Mean*	-\$134,855.31
	P(CF<0)	61.56%

Source: Author's estimation

[30] https://home.kpmg.com/xx/en/home/services/tax/tax-tools-and-resources/tax-rates-online/corporate-tax-rates-table.html (Last accessed on 07/15/2017)
[31] http://data.worldbank.org/ (Last accessed on 07/15/2017)

Figure A1.2. Probability distribution of average cash flow per year generated by fishing activities for each boat category



Source: Author’s estimation

The results obtained in Table A1.2. and Figure A1.2. allow us to conclude that for purse seine boats (that set on FADs) from non-Ecuadorian fleets, the probability of negative cash flows is very high (i.e. more than 50%). However, we need to emphasize that the latter conclusion is grounded in the assumption that the only difference in the cost structure between Ecuadorian boats and boats from other countries are the discount rate, the fuel price and the corporate tax rate.

It is implicitly assumed that the behavior of the other cost components is the same as for the Ecuadorian fleet. However, there is evidence that for some countries such as Panama, the labor cost is higher than the Ecuadorian labor cost and in countries like Peru that labor cost is lower than in Ecuador.

In addition, we found that the difference in results for the non-Ecuadorian fleets is driven by the higher importance of the fuel cost on the cash flow of the boats. This can be observed in Table A1.3., in which we show the contribution of this variable on the variance of the cash flow of the boats for each category.

Table A1.3. Sensitivity analysis – Variance contribution.

Cost Category	Boat Category				
	180 - <250	250 - <400	400 - <600	600 - <800	800 - 1200*
Skipjack Quantity	**44.8%**	**44.2%**	**27.8%**	**24.6%**	**21.9%**
Skipjack Price	**21.7%**	**16.6%**	**41.8%**	**37.7%**	13.9%
Bigeye Quantity	2.5%	0.6%	4.5%	4.7%	**14.3%**
Yellowfin Quantity	6.8%	8.1%	2.8%	4.1%	6.9%
Bigeye Price	0.2%	0.6%	0.7%	0.8%	1.4%
Yellowfin Price	1.0%	0.6%	0.9%	0.9%	0.5%
Number of trips	0.1%	**17.7%**	0.1%	0.3%	13.4%
Fishing days per trip	-9.2%	-4.9%	-7.0%	-8.9%	-5.2%
Daily Consumption of fuel	**-13.4%**	-6.4%	**-13.0%**	**-16.9%**	**-21.3%**

LEGEND	Most Important	2nd Most Important	3rd Most Important

Source: Author's estimation

Therefore, because of this lower capacity of the other fleets that set on FADs to generate cash, we expect a lower potential of capitalization on the value of each metric ton of capacity (i.e. boats plus capacity quota); thus, we estimate that for these boats, a value of $3,870 per MT will probably induce approximately 72.34% of boat owners to sell their boats+capacity, while a value of $16,143 will increase that percentage to 92.36%. On average, we expect that 70% of the boat owners will be enticed to sell when they are offered $2,750 per MT. The latter values are low compared to the ones obtained for the Ecuadorian boats, this is because of the lower capacity of income generation for other countries' purse seiners that set on FADs. However, we should treat these results carefully because, as we indicated previously, we are assuming that the only cost differences are the ones related to fuel, taxes and discount rate.

A1.3. FINANCIAL VALUATION OF PURSE SEINE BOATS THAT SET ON DOLPHINS

In this section, we proceed to estimate the value per metric ton of capacity of purse seine vessels fishing on dolphins. Recall, that for the analysis of these boats we face a scarcity of information. Specifically, the financial information used throughout this report for the analysis of purse-seine vessels fishing on dolphins came from a single ship and aggregate information from IATTC. Hence, as for the other results provided in this report, we have a high degree of uncertainty about the results derived from this analysis. As in the case of vessels fishing on FADs, we will use the assumptions used in Chapter 2 used to construct vessel cash flows, but we will also consider the following two additional assumptions:

1. The discounted rate will follow a triangular distribution with a minimum equal to 7%, a maximum value of 10% and most likely a value of 8.5%.
2. The growth of the DCF with respect to the baseline case will be assumed constant and will follow a triangular distribution with the following parameters: a minimum value of -3%, the likeliest value of 1% and a maximum value of 3%.

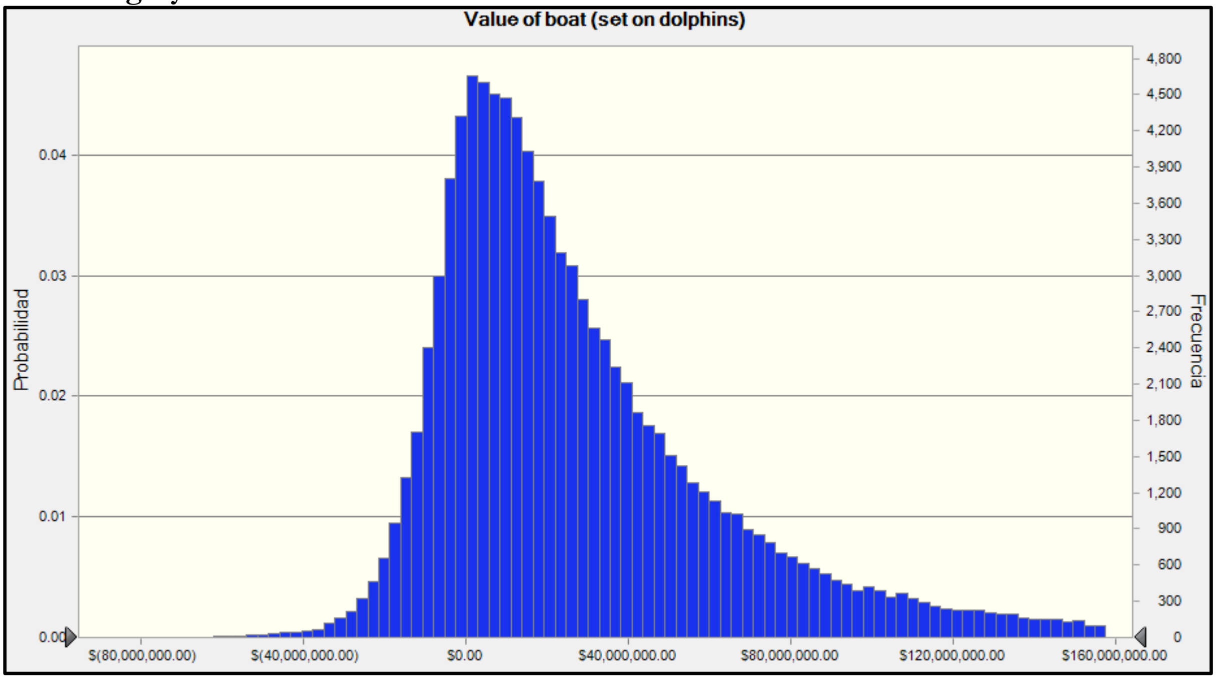
The statistics resulting from the Montecarlo simulation (using 100,000 replications) are given in Table A1.4. We also obtained a probability distribution function for the Net Present Value of the representative boat that sets on dolphins (Figure A1.3.)

Table A1.4. Simulated net present value (i.e. scrapping and capacity quota) of a representative boat of 1,300 MT that sets on dolphins

Boat Category	Statistics	Value of the Boat
	Mean	$19,910,873.64
1,300	*Lower Bound*	$12,550,348.83
	Upper Bound	$28,689,803.16

Note: For this table, the Lower Bound is the percentile 40 of the simulation and the Upper Bound is the percentile 60. We decided to use a narrow range to reduce the effect of the high dispersion in the simulation process. The latter is also the reason of why we decided to use the Median instead of the Mean.
Source: Author's estimation

Figure A1.3. Probability distribution of net present value of a representative boat for each boat category



Source: Author's estimation

From the results in Table A1.4. we are able to estimate the average value of one metric ton of capacity for purse seiners that set on dolphins. Specifically, the value of each metric ton of capacity (when jointly evaluating the boat scrapping and the capacity quota elimination from the vessel register) ranges from $9,654.11 per MT to $22,069.08 per MT. This is a fairly high range, which should be adjusted when we obtain more financial information on the purse-seiners that set on dolphins in the EPO.

We want to emphasize our reservations about these results as they are based on only one observation. However, this analysis is a good first step and we plan to obtain feedback from stakeholders of the tuna fishery that sets on dolphins in the EPO to provide more and better information to increase the reliability of our results in future analyses.