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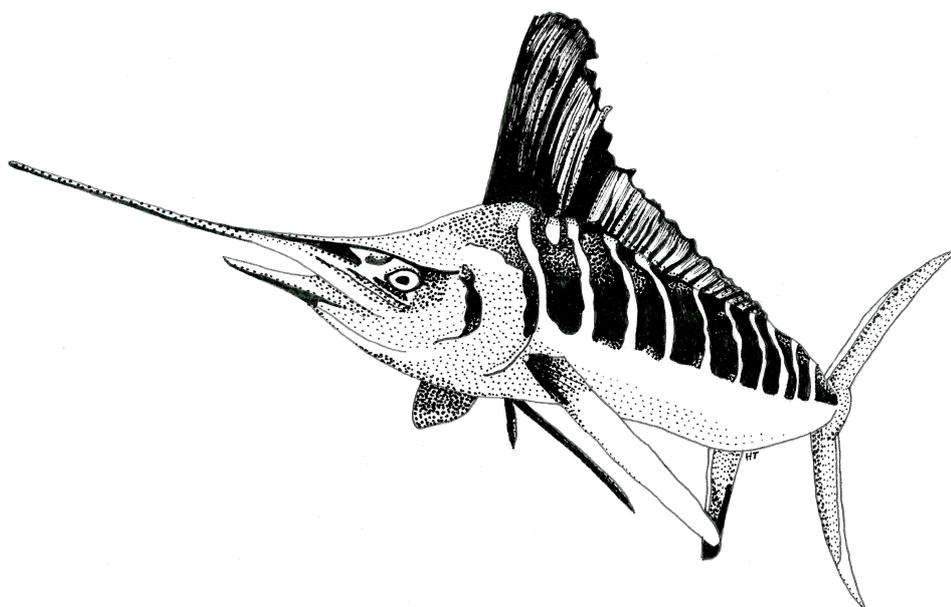
WESTERN CENTRAL
ATLANTIC FISHERY
COMMISSION

SLC/FIAP/C1125 (En)

**FAO
Fisheries and
Aquaculture Circular**

ISSN 2070-6065

THE VALUE OF BILLFISH RESOURCES TO BOTH COMMERCIAL AND RECREATIONAL SECTORS IN THE CARIBBEAN



THE VALUE OF BILLFISH RESOURCES TO BOTH COMMERCIAL AND RECREATIONAL SECTORS IN THE CARIBBEAN

by

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ISBN 978-92-5-109431-0

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PREPARATION OF THIS DOCUMENT

This document is part of a series of desk and field studies carried out under “Component 1. Generating value and conservation outcomes through innovative mechanisms” of the Caribbean Billfish Project GCP/ SLC/ 001/ WBK of the Ocean Partnership Program belonging to the Areas beyond National Jurisdictions (ABNJ) program. The project is funded by the Global Environmental Facility (GEF) and The World Bank and executed by the Western Central Atlantic Fisheries Commission (WECAFC) of the Food and Agriculture Organization of the United Nations (FAO) based at the FAO Sub Regional Office in Bridgetown, Barbados.

The study was carried out under a contract with the International Game Fish Association (IGFA) through a Letter of Agreement with FAO. Support and guidance were provided by Mr Raymon van Anrooy, Secretary of the Western Central Atlantic Fishery Commission (WECAFC) and Mr Manuel Perez Moreno, Regional Project Coordinator, during the elaboration of the report.

The preliminary findings of the study were presented at the 2nd Regional Workshop on Caribbean Billfish Management and Conservation of the WECAFC Recreational Fisheries Working Group held in November, 2015 in Panama City, Panama. In addition, the document was also reviewed by the members of the Consortium on Billfish Management and Conservation (CBMC) established in the Caribbean Billfish project. The formatting was carried out by Ms Magda Morales.

FAO. 2016.

The value of billfish resources to both commercial and recreational sectors in the Caribbean, by Brad Gentner. FAO Fisheries and Aquaculture Circular No. 1125. Bridgetown, Barbados.

ABSTRACT

The study carried out a comparison of the value estimated both in recreational and commercial fisheries for billfish in the Caribbean. The recreational value was found to be much higher than the value in the commercial sector but total estimates should be treated with caution due to the uncertainty of the raw data available. Enough value exists in recreational sector to compensate losses in commercial sector. Billfish commercial fishery responsible for much less than one percent of total Caribbean seafood value (between 0.36 percent and 0.84 percent). Most recreationally caught billfish released with high survival. In general, there is a need for better data regarding landings, effort, supply chain in both sectors.

This report develops the background on ecosystem values as they relate to billfish stocks in the Caribbean, defining the terminology and state of the art in valuation science in general and the state of billfish valuation in the Caribbean region in particular. Types of value, including market and non-market, are defined and the basic estimations techniques used to value billfish across commercial and recreational sectors are detailed and described as they related to this project. Benefit transfer, due to data and time limitations, is ultimately the only avenue available for this desk study. Caveats regarding the transfer of benefits from studies within the region and outside the region are briefly discussed. The results of an exhaustive literature search for commercial and recreational billfish values are summarized. The values identified are applied to current commercial and recreational landings demonstrating that recreational values are higher than commercial values in the region when only a limited number of countries with recreational billfish fisheries are included. There are many caveats with this analysis, however the results presented here can be used to develop more detailed value propositions when more data becomes available. It is anticipated that as the country selection process moves forward, that more detailed analyses of the value proposition can be made for those countries that may be selected for participation in the business cases.

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INTRODUCTION

The World Bank's Ocean Partnership Program (OPP) focuses on reclaiming values lost to overfishing, habitat destruction and pollution. These issues are symptoms of fishery management institutional failure. The goal of the OPP project component in the Caribbean, the Caribbean Billfish Project, which is implemented by FAO/WECAFC, is to address the open access, commons nature of the billfish fishery and increase the value of that stock in the Caribbean region to improve triple bottom line outcomes. This desk study is designed to establish the region wide value proposition to demonstrate the benefits of improving billfish stocks, demonstrate the amount of potential compensation available to enhance the transition to new management regimes and develop tools to help the Consortium on Billfish Management and Conservation (CMBC) select nations with the best value proposition for use in the business cases.

Oceanic resources in Caribbean are ecologically and economically important. The particular focus of this project is pelagic resources in general and billfish in particular. This study will focus on the human benefits of billfish supported by the pelagic ecosystem by first looking at flows of goods and services from the larger pelagic ecosystem to provide context. This report will describe the types of goods and services that are produced in the pelagic ecosystem in order to place where billfish lie in that spectrum.

The report will briefly define the concepts of human benefits and economic valuation. Next, the various methods for estimating value will be discussed briefly to provide context. Commercial fisheries values will be identified and region wide estimates of economic value will be presented. A review of the literature on economic values and expenditure estimates for recreational billfish trips will be detailed and an attempt will be made to make some crude recreational total value estimates for the region. Commercial and recreational values will be compared demonstrating a strong value proposition potential for the conservation of billfish stocks. Finally, a discussion of the potential stock gains that might be attained through conservation will be discussed.

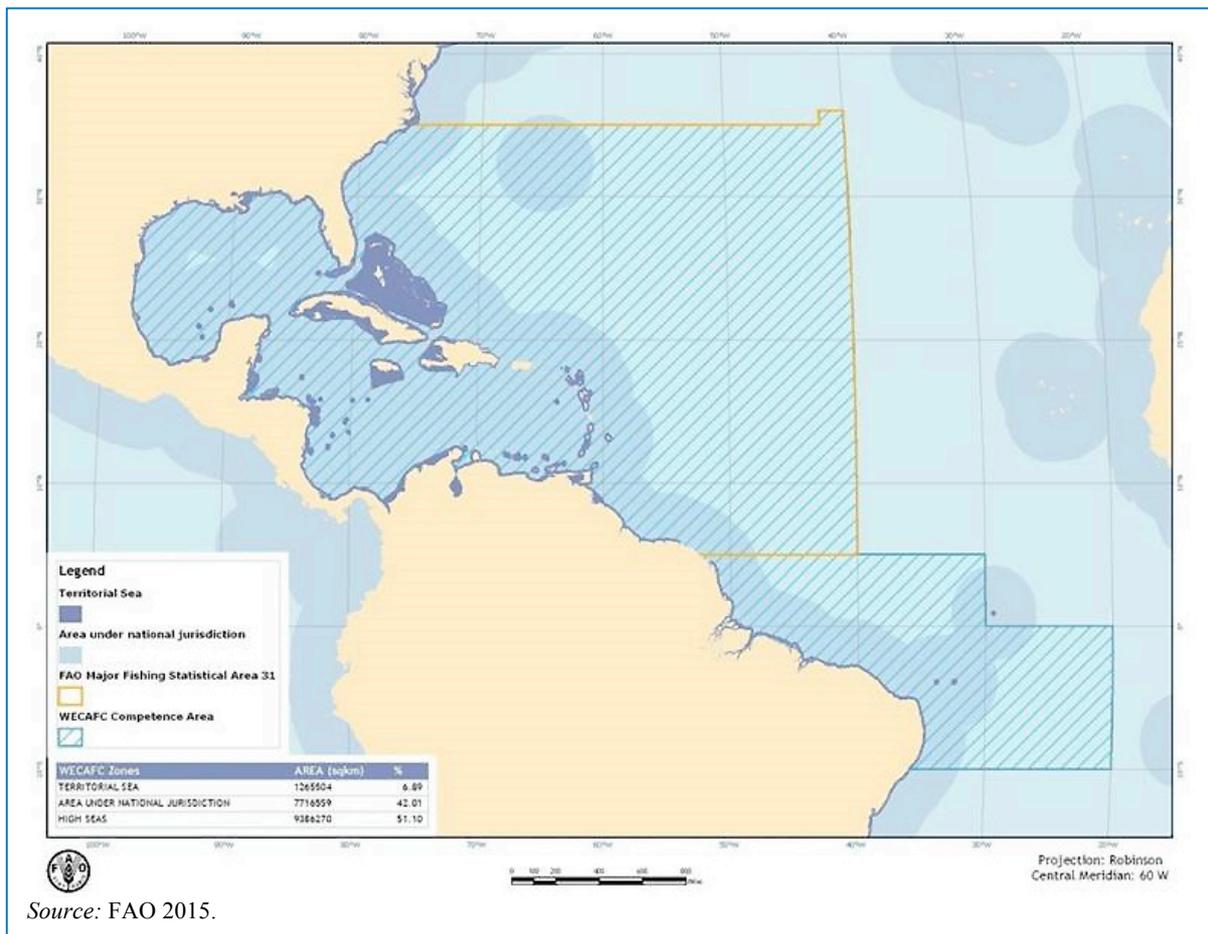
This report only focuses on the economic value component of human benefit with a brief discussion of the distributional impacts as they related to incomes and jobs provided by each sector.

HUMAN BENEFITS OF CARIBBEAN BILLFISH STOCKS

Estimating the benefits to humans of ecosystem stocks and flows generally in pelagic systems has proven difficult to quantify exactly (Pendleton *et al.*, 2014). Pelagic systems generally encompass large areas of the high seas with fluid boundaries. These areas beyond national jurisdictions are generally poorly studied with little to no data on the streams of ecosystem services. This is driven by many factors including primarily the remoteness of these flows. Their remote nature makes the link between the human system on land and the flows at sea difficult to trace. Figure 1 shows the mandate area of the Western Central Atlantic Fishery Commission (WECAFC), which encompasses FAO statistical area 1 and the WECAFC Area of Competence, which northern part of area 41. This area is larger than what would strictly be considered the Caribbean but includes flows of ecosystem services that impact the benefits that accrue to the Caribbean region. Billfish stocks utilize the pelagic waters of this region and beyond and their productivity relies on the ecosystem goods and services provided by this large marine area. The Caribbean pelagic system is no different. Little valuation work has been completed for the Caribbean specifically (Schuhman, 2012).

FIGURE 1

Western Central Atlantic statistical region and WECAFC area of competence



This report will utilize an ecosystems services approach to examine the value of billfish fisheries in the Caribbean. This technique is well established in the literature and has been used in the Millennium Ecosystem Service Assessment (MEA, 2005) and The Economics of Ecosystems and Biodiversity (TEEB, 2010). The pelagic ecosystems of the Caribbean provide many ecosystem services as detailed in Table 1. There are the provisioning services of commercial fishing, artisanal fishing and recreational fishing. There are also cultural services like tourism, research and existence or cultural values. In the Caribbean, as in other regions, there is very little research linking pelagic ecosystems to

these cultural services (Pendleton *et al.* 2014, Schuhmann 2012). Finally there are regulating and supporting services such as carbon transfer, carbon storage, atmospheric gas exchange and egg/larvae transport. Sometimes these two categories, regulating and supporting, are treated as separate flows, but they are combined here for convenience. This report will focus only on the provisioning services of commercial, artisanal and recreational fishing and the cultural services that support recreational fishing.

Table 1

Types of economic values for pelagic ecosystems in the Caribbean

Category	Final Service sector	Benefit location	Description	Contribution to the pelagic ecosystem
Provisioning	Commercial fishing	Local International	Billfish are caught as bycatch primarily by distant water long-liner fleets. Benefits accrue mostly to those distant nations	Habitat, spawning, transit.
	Artisanal fishing	Local	Some directed fisheries for billfish, especially using FADs. Generally sold in local markets	Habitat, spawning, transit.
	Recreational fishing	Local International	Tuna and billfish fisheries are well developed in the Caribbean. Many tournaments are held in the region.	Habitat, spawning, transit.
Cultural	Tourism	Local	Quality fisheries and quality water attracts and retains tourist	A healthy ocean contributes to the attractiveness of the region
	Research, education and protection	Local	The Caribbean is an important area for research.	Caribbean is host to unique biological and environmental conditions
	Existence and cultural values	Local International	Pelagic ecosystems are host to charismatic flora and fauna with high existence values	The pelagic system supports whales, sharks and billfish
Regulating and supporting ecosystem services	Carbon sequestration and atmospheric gas exchange	International	Through the food web carbon is transferred from the atmosphere and sequestered in the water and organisms.	This topic is being actively research globally.
	Egg/larvae transport	International	Pelagic currents are responsible for the wide distribution of eggs and larvae	Basis of overall fishery productivity inside and outside of pelagic ecosystem.

Adapted from Pendleton, 2014.

Defining human benefits

Goods and service from the ecosystem take many forms and can contribute directly or indirectly to human well-being. Measuring economic well-being is the domain of economics. Economic well-being involves the monetization of benefits less the costs of producing or providing those benefits. Economists measure well-being in terms of economic value. Generally value is defined as the amount of well-being a consumer or user retains after expending energy or money to acquire something. Value can also result from simply knowing something exists or the value of the contribution that service or good has to something that is consumed. Some of these goods and services are traded in formal markets. Those goods are relatively easy to value as value is directly measurable. Many

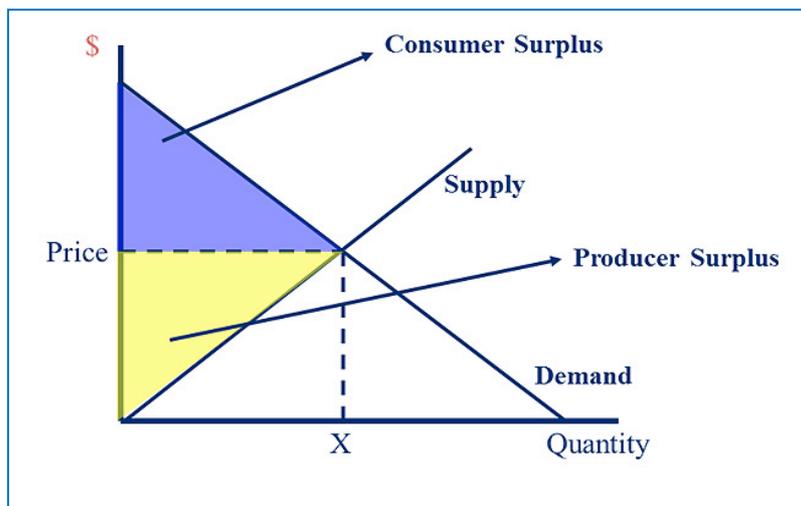
ecosystem services are not traded in formal markets and measuring their value is considerably more difficult.

Measuring economic value first and foremost requires data on stocks and flows of the goods and services produced by the ecosystem. Many of the reasons there are gaps in the values shown in Table 1 is due to the lack of basic stock and flow data. In the Caribbean little is known about the billfish stock or the flows of this stock. It is suspected that commercial catches are under-reported and only three nations reported recreational billfish harvest in 2013 thereby leaving serious gaps in the knowledge of flows as well. In addition to stocks and flows, the levels and structure of those stocks and flows are needed. They must have clearly defined and consistent units or an economic analysis cannot be conducted. This is a particular problem in the Caribbean region when trying to estimate recreational fishing values.

Value is measured by taking data on stocks, flows, levels and structures and constructing supply and demand curves for those goods. Figure 2 shows a basic supply and demand relationship. Supply and demand curves can be constructed even for goods not traded in the market, however price information is harder to obtain. Demand curves are the locus of all possible prices and quantities consumers would be willing to pay to obtain that good. Supply curves represent the schedule of prices producers would be willing to accept for bringing that good to market. In the case on non-market goods, that supplier is the ecosystem itself and, while we may know the stock and flow of that good, the ecosystem doesn't have a direct cost of production and other methods must be used to establish those costs.

Total economic value for a good or a service is the sum of both consumer and producer surplus. Producer surplus is relatively easy to define; it is essentially the amount of revenue a business gets to keep after paying productions costs. It is a firm's economic profit, which is generally less than accounting profit. Consumer surplus is slightly more difficult to describe or monetize. It is the value the consumer holds for the good above what they had to pay to acquire. It is sometimes easier to think about it as a consumer's profit. The marginal value of the good is the amount a consumer or firm would be willing to pay for the next unit of that good while total value is the aggregated value for the entire production of that good or service.

FIGURE 2
Supply, demand and their relationship to economic value



Measuring value

This study will rely on values transferred from other valuation studies. Describing the underlying valuation technique is important to understanding the values being transferred. Values from goods traded in the market, such as fish caught in the commercial sector, are the easiest to measure. The market price approach starts with dockside revenue. If cost and earnings data is available on that

sector, a full supply curve can be developed and producer surplus measured directly (Gentner *et al.*, 2010). If only limited financial information is available, accounting profit may be possible to estimate, however it typically overstates economic profit slightly. Finally, if no cost information is available, total expenditures on that fish product are sometimes the fall back. Total expenditures are always an overestimate of producer surplus because costs are not included. Sometimes total expenditures at the consumer level are reported as a proxy for the value in the entire supply chain. This may underestimate total economic value because it is not properly accounting for consumer surplus or it may overstate value because costs are not taken into account.

Economic value estimates are often used to make resource allocation decisions. Generally, the resource use that generates the highest value should be allocated the lion share of the resource, but it is not often that simple. Fisheries allocation between competing uses is a complex topic and barring any property right and a free market to trade that right between uses, managers use the equimarginal principle to allocate fish quota between users (Edwards 1990, Plummer *et al.*, 2012). The equimarginal value principle states that quota should be allocated to sectors until the marginal value of the next unit of quota is equal across all user groups. Marginal value, as compared to total value, is the value of that next unit of fish harvest, usually denominated in the weight of fish. In this document it will be useful to compare marginal values, where available, to demonstrate which direction billfish quota should be moved to increase fishery value and improve fishery livelihoods. The difference in marginal value point estimates, while not indicating optimal allocation levels, can also give a sense of where compensation levels could start while a market for that quota developed.

Sometimes economic impact models are used instead of valuation tools to examine economic value. Economic impact models trace the flow of transactions through an economy and measure that activity by the rounds of spending generated by a change in final demand. Impacts are expressed in total output, sometimes called total sales, value added, income or employment. Value added, or contribution to gross domestic product (GDP), is the closest approximation to economic profit or producer surplus but one that still overstates the true producer surplus (Schuhmann, 2012). It can be a convenient proxy if the region has readymade economic impact models for fishery sectors as it also can include the value added of the entire supply chain. Total sales, which are always higher than value added, overstates value even more and should not be used as a proxy for value.

For goods and services not traded in the market place, estimation of value gets much more complicated as non-market valuation techniques must be used. For instance, here is no market for a private recreational fishing trip. The angler does not go and buy a trip in a store. Instead that angler spends money on travel and takes time off to fish. Charter trips are slightly different in that there is a market price paid to a charter captain and his producer surplus for providing a trip can be calculated much in the same way as described above for commercial fishermen. However, the anglers on those trips also hold consumer surplus that cannot be measured by a price and transactions in the marketplace.

There are two broad categories of non-market valuation techniques that will be used in the analysis below. There are revealed preference techniques so named because they rely on observing behavior to construct valuation models. The other technique includes stated preference techniques so named because they rely on angler's stated preferences for goods and services that are then used to estimate value.

Revealed preference techniques include travel cost models and hedonic pricing models. Travel cost models use an angler's travel cost as calculated by their round trip travel distance to the fishing location. These models can be simple, using linear models or complex. The favored technique for recreational fishing, where data on individual trip taking behavior is available, are the random utility site choice models which use all the substitute sites available to the angler to value the choice made (Hicks *et al.*, 2000). Hedonic price models use the price of a good used in the act of fishing to value the fishing experience. The hedonic price approach has been used to value charter fishing trips using the charter fee as a price (Carter and Liese, 2012)

Stated preference techniques include the contingent valuation method (CVM) and stated preference choice experiments (SPCE) (Hicks *et al.*, 2000). CVM relies on asking survey respondents questions regarding how much they would be willing to pay (WTP) or willing to accept (WTA) for some change in ecosystem services. SPCE uses a complex set of paired choices in a survey instrument. Each respondent is presented with a series of paired, hypothetical fishing trips (Duffield *et al.*, 2012). These trips have combinations of attributes that include fishing trip cost (generally travel cost). Using these hypothetical choices, angler demand for fishing trips can be constructed and consumer surplus calculated. This class of models is very similar to the conjoint surveys used by the marketing industry.

Finally, benefits transfer is the most common technique used in data poor situations (Pendleton *et al.*, 2014; MEA, 2005; TEEB, 2010). Because original survey work is beyond the scope of this desk study, all of the values presented in the remainder of this report will be transferred values. Benefit transfer relies on using values estimated in different studies perhaps in different locations or for different, but similar enough, goods or services. Value transfer involves simply applying a value estimate from another study. Function transfer involves using an estimated value function and re-estimating that function with regional data. Meta-analysis involves estimating a function utilizing many valuation studies to develop a value for the ecosystem good or service in question. Finally, some categorize economic impact analysis a type of benefit transfer, although one that is not well accepted. The remainder of this desk study will use values transferred from the literature as there is too little data to estimate any value function and too few studies available to pursue a meta-analysis. Each study used below will be described according to the valuation types and estimation techniques described above.

General caveats and issues with economic valuation estimates

Marginality is a concept that means starting points matter when transferring values. The value to society of moving from zero billfish caught on a trip to one billfish caught on a trip is worth more than moving from five billfish caught on a trip to six. This is due to an economic principle called the law of diminishing marginal returns on the demand side. As a consumer consumes additional units of a good, the value of that next unit diminishes. This also holds for producer surplus when that firm is producing under constant or diminishing returns to scale, but not under increasing returns to scale.

Double counting can also be an issue with ecosystem service valuation. Some uses or value sources are mutually exclusive. For example, an analysis cannot simultaneously include the value of a good in use in one sector that would preclude the use of that good in another sector while simultaneously including that value in a separate sector. In the case of billfish, projecting commercial gains from stock recovery while projecting recreational gains from stock recovery, if those gains were the same fish, would be a case of double counting.

Additionally the distribution of costs and benefits may be out of sync temporally. The costs may be immediate and large while the benefits may be small, incremental, and may accrue well into the future. A good example is fish production. Sacrifices, or costs, that the commercial fishery makes to reduce harvest will occur immediately while it could take years for the stock to recover and provide catchable fish to the recreational sector. Also, cost may be spatially concentrated while the benefits are more spatially dispersed. This can pose a particular problem in ABNJ fisheries where a small group of nations make sacrifices while larger groups of nations reap the benefits.

Non-linearities in service or good provision may also complicate the application of ecosystem values. That is the production of an ecosystem benefit may be driven by a non-linear process. Valuing and summing single outputs ignores the interdependent nature of ecosystems. Finally, there are many pitfalls to be avoided when aggregating values from the individual to the whole. For example, existence values apply to everyone. Recreational and commercial values apply to current and future participants. Unfortunately, it is often impossible to predict how many will enter the fishery when conditions improve and vice versa. As a result the benefits of stock increases are underestimated and the costs of decreases overestimated.

Valuation studies are expensive and time consuming. As a result, very few are conducted in the developing world (Schuhmann, 2012). This is no different for the Caribbean where the limited focus has been on commercial and recreational fishing valuation (Schuhmann, 2012). Most of that focus has been on coral and reef based fishing and tourism and, as a result, pelagic fisheries are not well represented at all. The majority of the recreational studies and values presented below come from outside the Caribbean region because little work has been completed in the region for pelagic species. Because of the limitations in data described above and because the focus of this project is on billfish, the remainder of this report will focus only on benefit estimates transferred from other regions or, if within region, from a single country study.

COMMERCIAL FISHING VALUE

There is little data on commercial fisheries value in the Caribbean region and even less for billfish in particular. Even dockside revenue is hard to come by, particularly for small scale and artisanal fisheries. Total fisheries value across CRFM members was US\$583.3 million in 2010 with a three year average of US\$523.8 million (Masters, 2012). The Masters (2012) report does not break out billfish revenue as a separate category. Josupeit (2015) estimated total commercial fisheries value based on landings reported to FishStat. The WECAFC region landed US\$2.9 billion in 2012 and US\$3.2 billion worth of seafood across all fishery products in 2013. The largest single species in production WECAFC wide in 2013 was northern brown shrimp with US\$785.6 million in landed value followed by spiny lobster with US\$513.5 million in landings in 2013. Those two species alone make up over 40 percent of all WECAFC fisheries value. One highly migratory species (HMS), yellowfin tuna, makes the top 5 most valuable species in 2013. It is in fifth place and it generated US\$139.4 million in landed revenue in 2013. The top ten most valuable fisheries encompass 72.5 percent of fishery value in the region, suggesting that most other species generate small amounts for landed revenue. According to Josupeit (2015), total billfish landings in the Caribbean in 2013 were worth only US\$11.7 million dollars, or only 0.36 percent of total seafood production in the WECAFC region.

There is some limited information by country on fisheries employment, but again, it is not broken down by species or even fishery. That may be changing with the new CRFM initiative for FAD management as some nations have proposed FAD fishing log books that include landed price by species landed.¹ Overall, however, very little is known about the socioeconomics of fishing in the Caribbean (Salas *et al.*, 2011).

There are only two sources of billfish landing information for the Caribbean, ICCAT and FAO FishStat. Both represent lower bounds on actual catches due to under reporting, particularly across artisanal and recreational sectors. Additionally, some countries do not report landings at all to either FAO or ICCAT. Further compounding the problem is that some landings of billfish are reported in “tunas, bonitos, billfishes” and there is no way to separate out those species. In general that catch all category contains mostly tunas and as a result, totals from that category will not be included here. This lends more support for the lower bound nature of the landings estimates used for this report. Additionally, only the FAO data allows the compilation of the landings data within the WECAFC region. The ICCAT reporting areas either include too little or too much area. While the top ten landing flags are compiled, the remainder of the analysis focuses mainly on aggregate, region-wide measures of revenue and economic value. It would be possible, as this effort moves forward, to apply this same analysis to individual countries that are being considered for participation in the World Bank program. Figure 3 contains all landings from the Western Central Atlantic. While that includes landings in the US, it is illegal to commercially land billfish species in the US. Only FAO landings will be used for the remainder of the commercial discussion.

Figure 3 displays the time series of landings in the West Central Atlantic by all parties reporting to FAO in tonnes. Foreign flag reported landings have been dropping since a peak in 2008 at 1 167 tonnes. In 2013, foreign flag landings were down to 393 tonnes.² Caribbean flagged landings have been rising until 2013 when they fell off fairly dramatically. They peaked in 2012 at 1 875 tonnes and dropped off in 2013 to 1 507 tonnes. Even with the drop off in 2013, the trend in total billfish harvest is still upwards. Anecdotally, this increase is attributable to the increased use of FADs in the Caribbean. It is impossible to determine whether this separation between landing flags represents the stratification between artisanal and industrial fishing. Both sources of mortality are known to under report their landings of billfish. It is likely that the total landings of billfish, which peaked in 2008 at

¹ Agenda for upcoming discussion of FAD logbook programs ftp://ftp.fao.org/FI/DOCUMENT/wecafc/7th_sag_2015/8e.pdf Last accessed 27 October 2015.

² Foreign Flags: China, France, Japan, Other nei, Philippines, Portugal, Republic of Korea, Spain, Taiwan Province of China, United States of America, Vanuatu. Caribbean Flags: Barbados, Belize, Bermuda, British Virgin Islands, Costa Rica, Cuba, Dominica, Dominican Republic, Grenada, Martinique, Mexico, Panama, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, Venezuela (Bolivarian Republic of)

2 656 tonnes and is currently 1 900 tonnes, is a lower bound on landings. It is also likely that the Caribbean flagged landings contain some industrial landings.

Figure 4 breaks the FAO landings from Figure 3 into species totals. Blue marlin are the most landed billfish species with 898 tonnes in 2013 or 47.3 percent of all reported billfish landings. Blue marlin landings peaked in 2008 at 1 512 tonnes or 56.9 percent of billfish landings that year. Atlantic sailfish is the second highest landed billfish species with 713 tonnes in 2013 or 37.5 percent of all billfish landed that year. Atlantic sailfish landings peaked in 2012 at 955 tonnes or 37.4 percent of all billfish landings for that year. Blue marlin and Atlantic sailfish combined make up 84.8 percent of all billfish landings in 2013.

FIGURE 3

Total istiophoridae harvest volume in West Central Atlantic by flag of landing³

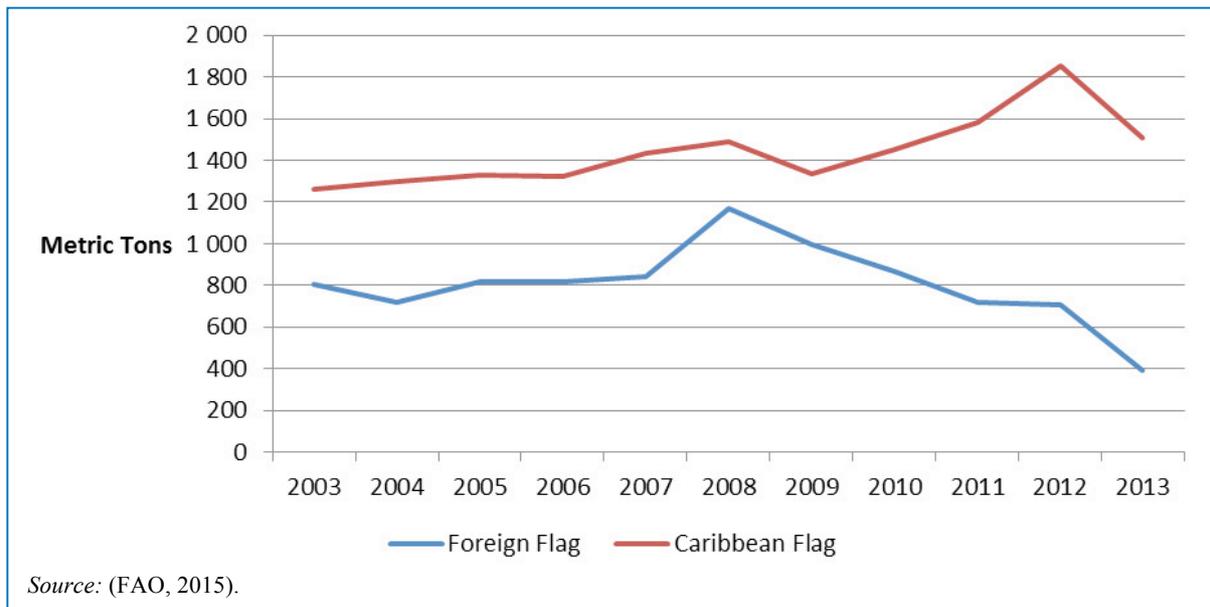
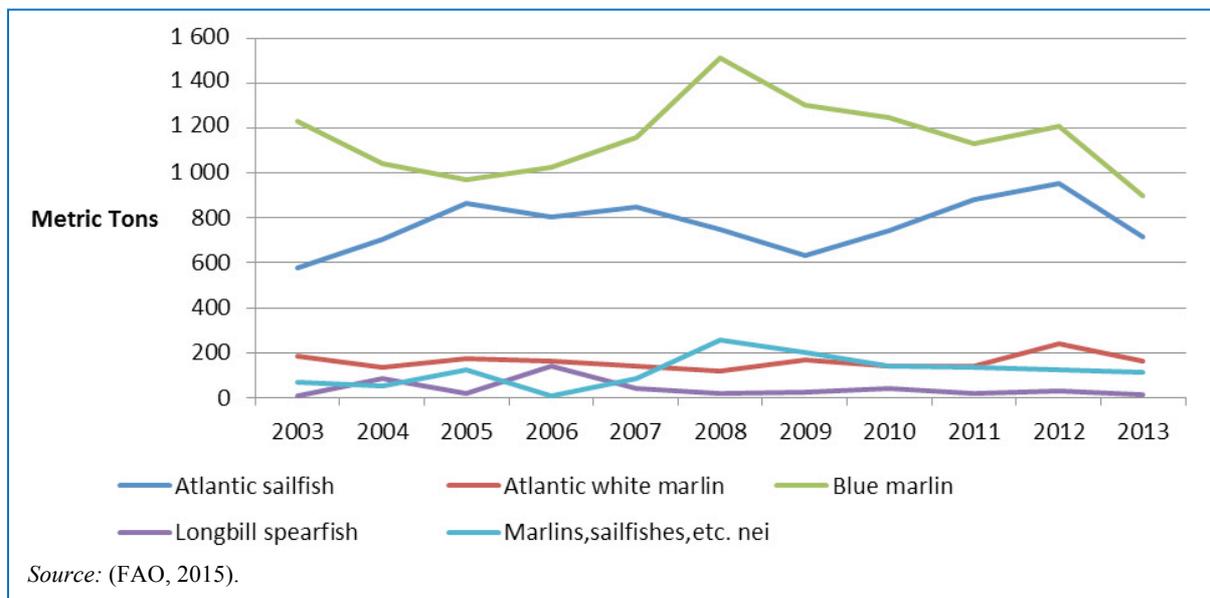


FIGURE 4

Total Istiophoridae harvest volume in West Central Atlantic by species

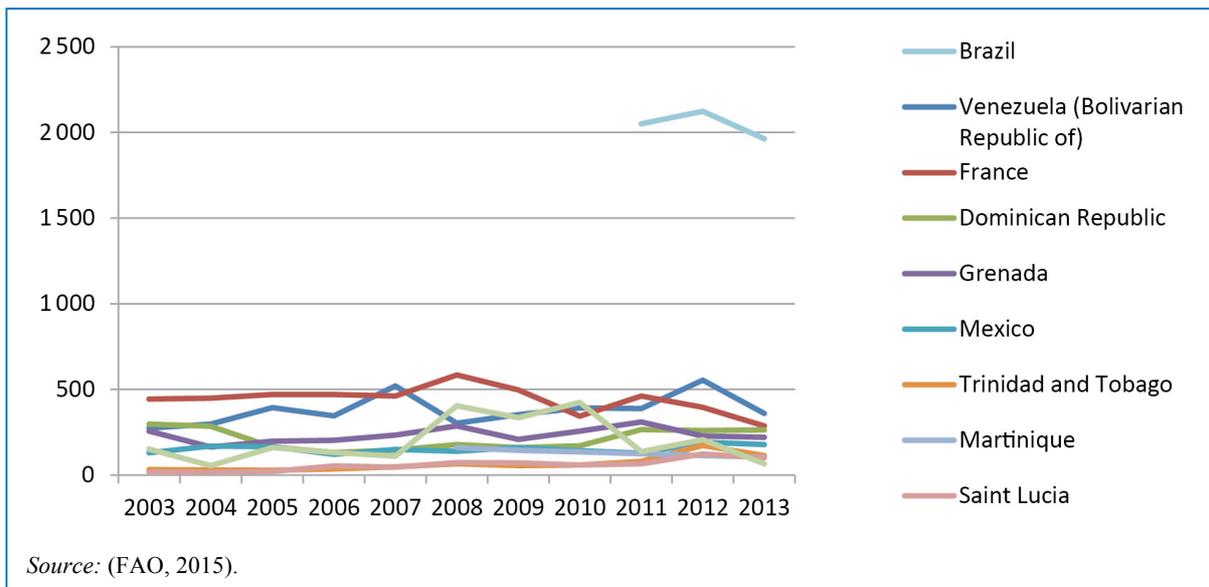


³ These figures only include Western Central Atlantic landings and, as such, do not include landings from Brazil.

Figure 5 displays the landings from the top ten countries reporting landings in the Caribbean, including Brazilian landings. Brazilian landings from 2011-2013 were provided specially for this project by Augusto (2015). The above figures do not include these updated Brazilian harvests. Brazil has only recently been able to report their landings regionally and the WECAFC area landings exceed their current FAO reported landings by a factor of six. Including the Brazilian landings more than doubles total landings for the region in 2013. It indicates further that as other countries improve reporting their totals may increase as well. FishStat reports 291 tonnes of billfish landings in Brazil for 2013 (displayed in the figures above). The recent data from Brazil contains 1 964 tonnes of billfish. If this indicates the region wide level of under reporting, total harvest in the WECAFC region may be much higher. The top ten billfish reporting countries encompass 94.8 percent of billfish landings in 2013, if Brazilian landings are included. In 2013, Venezuela reported the most landings to FAO at 361 tonnes or 19.0 percent of all billfish landings, not including Brazil. If Brazil is included, they were the top harvester in 2013 harvesting 50.8 percent of all the billfish reported in the region. With Brazil included, Venezuela landed 9.3 percent of the billfish harvest in 2013. France reported the next highest level of landings with 288 tonnes. In the last ten years, the top spot has also been shared by the Dominican Republic. Perhaps as another indicator of under reporting of landings, the largest industrial fleets in the Caribbean report very little billfish landings in the FAO data sets and also in the ICCAT data (ICCAT, 2015).⁴ Out of the top ten, eight countries are Caribbean countries.

FIGURE 5

Billfish landings by top ten countries reporting billfish including Brazil



Billfish price information is not consistently collected for any country in the Caribbean. Josupeit (2015) ran a custom query to estimate the dockside prices reported in Table 2 and those prices will be used for the remainder of this study. Table 2 also contains the price information that could be located for the region acquired solely via personal communication through various local sources as noted. The lowest price per kilogram found was in Venezuela at US\$2.23/kilogram. The highest dockside price found was from a seafood dealer in Barbados at US\$7.72/kilogram (Oxenford, 2015). The FAO prices provided by Josupeit (2015) fall within that ranges reported by local fish houses. Additionally, prices for billfish landed in Hawaii, the only port in the US where it is legal to land billfish commercially, were included for comparison's sake. Also, Hawaii has a busy market for high quality longline caught fish destined for foreign markets and is a good likely indicator of global prices industrial longliners

⁴ FAO data was used here because the ICCAT sampling areas do not conform to the WECAFC Area and even less landings are reported to ICCAT. When looking at landings in ICCAT sampling areas BIL91, 92, 93 and 94A, defined in Figure 8 below, the reported landings are roughly 25 percent of the FAO landings presented here. However, while Taiwan reports zero billfish landings to FAO in 2013, they reported nearly 7 tonnes to ICCAT over the larger area. Still less than some anecdotal estimates regarding distant water fleets.

working in the region might face for their catch delivered to ports out of the region. The FAO prices were applied to the total billfish landings to develop total dockside revenue listed in Table 3 (Josupeit, 2015).

Table 2

Caribbean billfish dockside prices per kilogram (2015 US dollars)

Country	Species	Price per kilogram	Source
Barbados	Billfish	\$7.72	Oxenford 2015
	Atlantic sailfish	\$5.51	J&H Quality Fish 2015
Grenada	Atlantic sailfish	\$4.41	J&H Quality Fish 2015
	Atlantic sailfish	\$5.79	Masters 2015
	Blue marlin	\$5.81	
	White marlin	\$6.04	
WECAFC region wide averages	Atlantic sailfish	7.00	Josupeit 2015
	Atlantic white marlin	6.00	
	Blue marlin	5.80	
	Marlins, sailfishes, etc. nei	5.00	
Venezuela	Sailfish/white marlin	\$2.23	Arocha 2015
US, Hawaii	Billfish	\$5.42	NMFS 2015

Table 3 combines the FAO landings presented above with the prices from Table 2. The highest price from the Table 2 prices from FAO was used to create the upper bound and the lowest price, for “Marlins, sailfishes, etc. nei” was used to create the lower bound (Josupeit, 2015). The other prices in Table 2 have been provided to highlight that local conditions and local markets are different and it is precisely these sorts of differences that should be taken into consideration when selecting countries with the best value proposition. It is assumed that foreign flagged vessels landed their billfish at prices similar to those found in the Caribbean. This appears to be a reasonable assumption as Hawaiian prices fall right into line with the average Caribbean prices from FAO. In 2013, foreign flagged vessels landed between US\$1.7 and US\$3.0 million in billfish. In 2013, Caribbean flagged vessels landed between US\$17.4 and US\$24.3 million in billfish. Caribbean wide, between US\$19.1 and US\$27.3 million US dollars in billfish were landed in 2013. Again, even the upper bound probably underestimates total commercial landings due to under reporting from the region. If Brazilian value is included in the total billfish value calculation, billfish production still only represents between 0.59 percent and 0.84 percent of the total WECAFC production.

To establish value, a literature review was conducted to find cost and earning surveys of artisanal fisheries in the Caribbean. The results of this effort have been condensed into Table 4 with the cost and earnings data distilled into estimates of percent profit, or other metric, relative to total revenue. This metric works only if you assume that dockside prices, and therefore total revenue, has inflated at the same rate that costs have in these countries. Grant (2006) conducted a survey in the Grenada longline industry. The Grenada fishery as surveyed was small scale and targeted pelagic and reef fish. Yellowfin tuna, Atlantic white marlin and blue marlin made up their top three catches. The fishery fished mostly from small open boats. Grant (2006) did not calculate economic profit only income across three different common vessel types in this fishery. From Table 4, for every one dollar in dockside revenue open pirogues take home US\$0.565 in income, cabin pirogues take home US\$0.514 in income and launchers take home US\$0.729. Launchers, a much larger type of vessel than either of the other two vessel classes earned a much high percentage of income.

Table 3
Dockside revenue for billfish using FAO FishStat data (2015 US Dollars)

Year	Foreign Flag		Caribbean Flag		Total Caribbean	
	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
2008	\$9 004 770	\$5 145 583	\$10 423 000	\$7 445 000	\$19 427 770	\$12 590 583
2009	\$7 677 589	\$4 387 194	\$9 331 000	\$6 665 000	\$17 008 589	\$11 052 194
2010	\$6 689 919	\$3 822 811	\$10 164 000	\$7 260 000	\$16 853 919	\$11 082 811
2011	\$5 555 642	\$3 174 653	\$25 445 547	\$18 175 391	\$31 001 189	\$21 350 043
2012	\$5 447 616	\$3 112 923	\$27 818 288	\$19 870 206	\$33 265 904	\$22 983 129
2013	\$3 032 455	\$1 732 831	\$24 293 940	\$17 352 814	\$27 326 395	\$19 085 645

Schuhmann *et al.* (2010) used a survey of the Barbados longline fishery to estimate the costs and earnings for that fleet. This was the only study that calculated true economic profit in addition to both gross and net value added. Gross value added includes profit before paying wages whereas net value added is gross value added less depreciation. The target of the Barbadian longline fleet is tunas, which make up 27–47 percent of their catch. The second highest landed species is flyingfish and the third highest is dolphinfish. The price data used for the effort came from many sources including dockside queries, documents prepared by the Barbados Agricultural and planning unit and other publications. Per trip costs from their survey were on average US\$5 625/trip with a median of US\$4 108/trip. Total revenue for the longline fleet is highly variable. Percent metric values in Table 4 were taken from the highest revenue year in the time series, 2005, and reflect the highest profits estimated by Schuhmann *et al.* (2010). For each one dollar in revenue, economic profit per trip is US\$0.224, gross value added is US\$0.471 and net value added is US\$0.421. This is an excellent example of how value added as a proxy for economic profit or producer surplus overstates economic value. Profit per vessel in this fishery was US\$5 000 in 2002 and US\$26 000 in 2005, before depreciation. Profit per trip was US\$3 700 in 2005 and crewmember share was between US\$400 and US\$700/trip.

Brinson (2009) and Brinson *et al.* (2006), conducted a cost and earnings survey across billfish charters in Senegal, artisanal billfish fishermen in Ghana and the Venezuelan gillnet fleet that catches billfish regularly. Brinson found that the Ghana artisanal fleet had an economic profit ratio of 33.3 percent of revenue and, as seen in Table 4, Venezuelan gillnet fleet had a profit ratio of 6.1 percent of total dockside revenue. On the recreational side, Brinson found that Senegalese charter vessels had a 17.9 percent profit ratio while South Florida, US charter operators had a 55.5 percent profit ratio to total charter revenue.

Table 4 uses the profit, and other metric ratios, to estimate the potential range of economic value generate by the billfish harvest sector in the Caribbean. Again even these ranges presented here represent the lower bound on total regional billfish value from commercial harvesting due to under reporting of billfish landings. The ratios presented in the table are applied to the estimated total dockside revenues presented in Table 3. While other metrics are provided for context, only the estimates for economic profit for Barbados and Venezuela represent estimates of the economic value of billfish resources in commercial production (Schuhmann *et al.*, 2010, Brinson *et al.*, 2006).

Using the Barbadian fleet profits, the foreign flag vessels generate between US\$700 000 and US\$1.2 million in economic value and the Caribbean flagged vessels generate between US\$4.5 and US\$6.2 million in economic value, region wide. In total, across both fleets, billfish landings generate between US\$5.2 and US\$7.5 million in economic value. For these estimates, it is assumed the foreign flagged vessels have a similar profit ratio to the Barbadian fleet. This may or may not hold, however profit ratios for industrialized commercial fleets tend to run between 40 percent and 60 percent (Gentner *et al.*, 2010). Using the Venezuelan metric, foreign flagged vessels generate between

US\$191 000 and US\$334 000 and Caribbean flagged vessels generate between US\$1.2 and US\$1.7 million for a region wide total between US\$1.4 and US\$2.0 million.

While this total value estimate for the regional commercial harvest of billfish may be a lower bound, it is possible to use the information in Table 2 and Table 4 to develop a value per kilogram, or marginal value, metric. Using the Venezuelan prices and the Venezuelan profit ratio, the lower bound marginal value would be US\$0.50/kilogram. Using the higher Barbadian prices and higher profit ratio, the upper bound marginal value would be US\$1.73/kilogram. It is important to reiterate the marginality caveat mentioned above. These values only hold for small changes in the harvest of billfish and the farther one reduces commercial harvest, the more the next unit of billfish will be worth to commercial fishermen and vice versa. That caveat aside, calculating the per kilogram value of billfish will be useful when more and better data becomes available as this project moves forward.

These numbers presented in Table 4, particularly the percent profit metrics, give a good indication for future use in this project, what potential compensation schemes might cost. For instance, if it could be assumed that the Caribbean flagged vessels represented all the small scale landings in the Caribbean and a scheme could be developed to end their harvest of billfish in favor of leaving those fish for the recreational sector, a compensation scheme would cost between US\$1.2 and US\$6.2 million. These estimates of course assume that the landings from Table 3 are the true landings of billfish in the Caribbean. Alternately, the value per kilogram estimates could also be used as a starting point for individual negotiations at the country level. However, as the business cases move forward, it is hoped that the selected nation will either already have a better estimate of their billfish landings or the business case itself will provide for better estimates. With better estimates in hand, it will be a simple matter to estimate potential compensation amounts using this data.

Table 4

Billfish economic value and other metrics (thousands of 2015 US dollars)

Location	Vessel/ gear	Metric	Ratio of metric to revenue	Caribbean flag		Foreign flag		Total		Source
				Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	
Grenada	Open pirogue	Income	56.5%	\$15 703	\$11 217	\$3 075	\$1 757	\$18 779	\$12 974	Grant 2006
	Cabin pirogue		51.4%	\$14 290	\$10 207	\$2 798	\$1 599	\$17 089	\$11 806	
	Launcher		72.9%	\$20 285	\$14 489	\$3 972	\$2 270	\$24 257	\$16 759	
Barbados	Longline	Economic Profit	22.4%	\$6 242	\$4 459	\$1 222	\$699	\$7 465	\$5 157	Schuhmann <i>et al.</i> , 2010
		Gross Value Added	47.1%	\$13 089	\$9 349	\$2 563	\$1 465	\$15 652	\$10 814	
		Net Value Added	42.1%	\$11 700	\$8 357	\$2 291	\$1 309	\$13 992	\$9 667	
Venezuela	Gillnet	Economic Profit	6.1%	\$1 708	\$1 220	\$334	\$191	\$2 042	\$1 411	Brinson 2009

Net economic value (NEV) is not calculated here as NEV equals economic rent less subsidies (Pendleton *et al.*, 2014). There are numerous subsidies in fisheries worldwide and the Caribbean is no different (Shrank, 2003). Subsidies can take many forms. Direct government payments include price supports, vessel funding or the funding of FADs. Tax waivers or tax deferrals are also a type of subsidy widely used in the Caribbean. Government loans, loan guarantees and government subsidized insurance are also used. Finally, implicit payments like discounted fuel or payments for fishing rights are also types of subsidies. In an exhaustive search of the literature, no fishery specific estimates of Caribbean wide, or even country specific estimates, could be found. It is important to recognize, however, that any compensation scheme indicated in the business case should estimate local subsidies and take those into account when planning a compensation scheme.

Billfish supply chain and foreign trade

In addition to the value generated in the harvest sector, billfish harvest generates value regionally as the billfish moves through the rest of the seafood supply chain. Even less is known about the economics of the fishery supply chain in the Caribbean than the harvest sector. The only supply chain information in the regions is contained in the FAO data on imports and exports. The FAO FishStat data on imports and exports of billfish do little more than highlight the reporting problems in the region, however. Figure 6 details the billfish import value by country. For an example of the reporting issues, Costa Rica exports 18 tonnes more than it harvests and exports 15 more tonnes more than imports plus harvests. Most of that billfish is likely coming from Costa Rica's Pacific Coast fisheries which points out the difficulty of tracing value using import and export data when the origin of the billfish cannot be traced. Additionally, while import/export values are included in the FishStat database, the prices implied by the value data is troubling. All import prices are lower than dockside prices by an order of magnitude. For example, the highest import price is US\$1.44/kilogram in Brazil in 2011 while the import price for 2011 in Costa Rica is US\$0.25/kilogram. That isn't necessarily an issue as it could be that imports are lower priced than local production for any number of quality or other typical trade reasons. It is however slightly troubling when import and export weights are for processed product which would translate into heavier whole weights and even lower whole weight prices at the dock.

The export prices implied in Figure 7 should likewise be higher than dockside prices in the same country unless those prices are reflection of re-exporting less expensive imported product. It stands to reason, however that there would be at least some value added in country before the product was exported. Export prices are as low as US\$0.63/kilogram from Suriname, a country not reporting any billfish landings nor reporting any billfish imports. Brazil reported import prices of US\$6.47/kilogram which is more consistent with import prices and dockside prices from other countries. No dockside prices could be found for Brazil in the published literature.

FIGURE 6
Import value by country

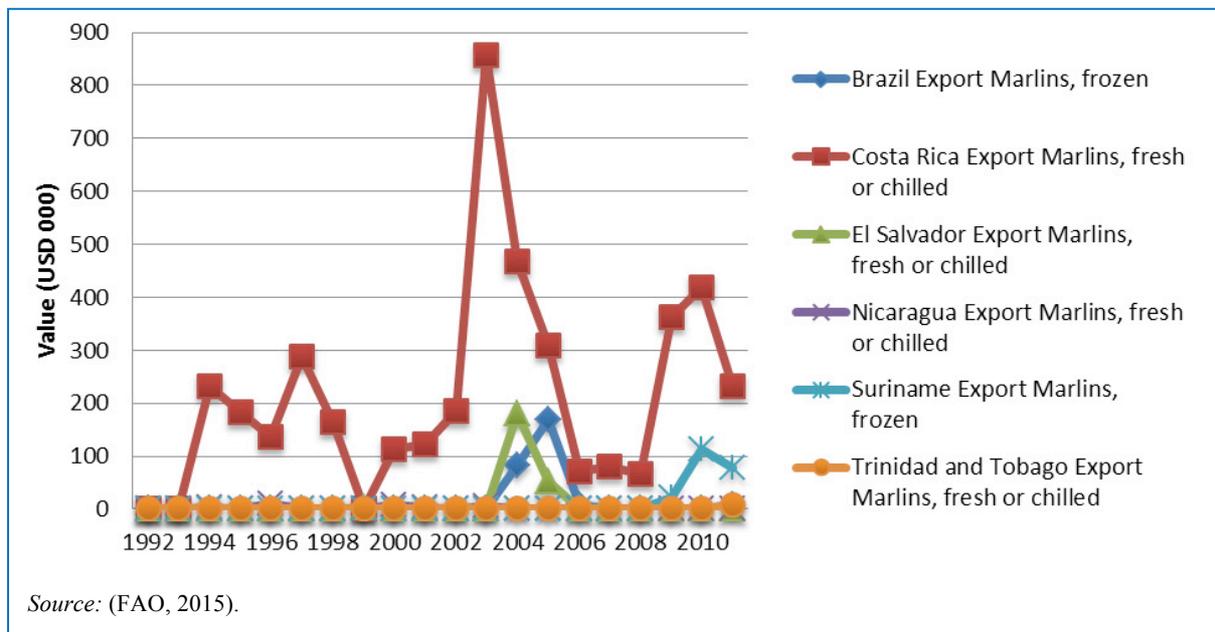
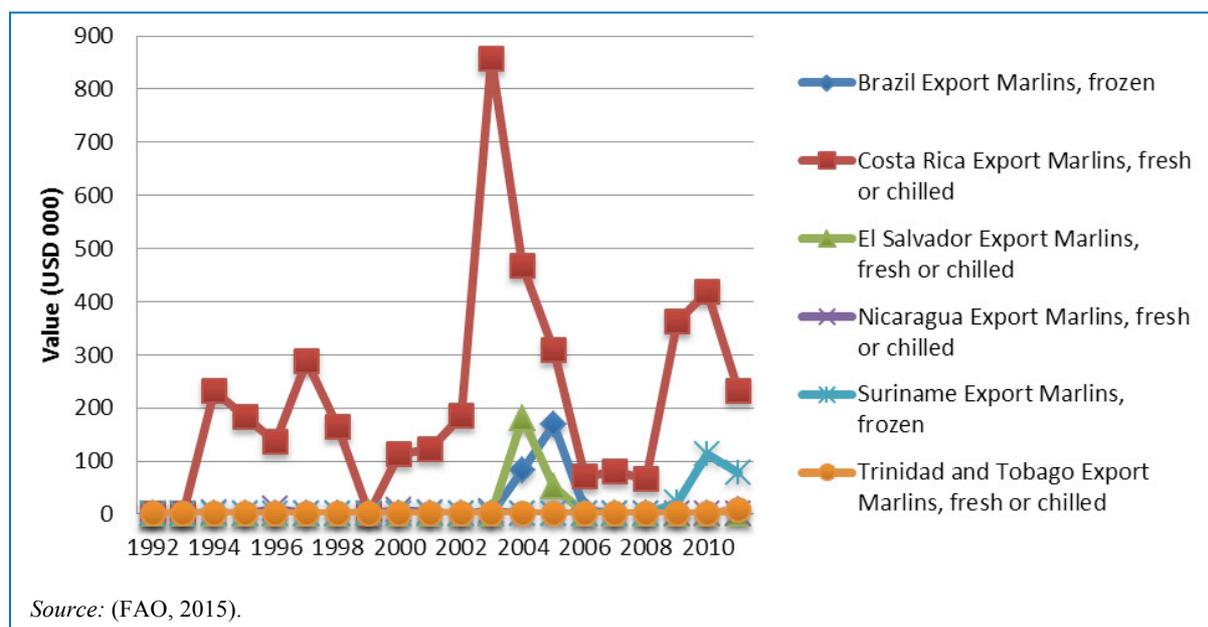


FIGURE 7
Export value by country and product type



As a result of the data anomalies/discrepancies discussed above, this report does not include any valuation estimates for the supply chain. Nothing is known about in-country supply chains. It is advisable that once a country is selected for the business case, the supply chains in that country should be traced and values developed such that compensation schemes can adequately compensate those businesses that will be impacted by reduced landings. It is likely that billfish sold for local consumption is marked up very little from the dockside value and that billfish product likely passes through a very simple supply chain locally. In searching for price data, consumer market price for billfish was reported from one fish market in Barbados. They reported a price of US\$8.82/kg for the consumer. This represents a small, 12.5 percent markup from the dock to the consumer suggesting very little value added. In dollar terms, that is a US\$1.10/kg mark up. That market has to process the fish, pay for inputs, including labor, and make a profit out of that US\$1.10/kg. If the economic profit margin is even 50 percent, the economic value per kilogram embodied by the entire supply chain would be US\$0.55/kg. A small amount compared to the US\$1.73/kg value generated by the harvesters in Barbados and described in Table 4.

RECREATIONAL VALUATION AND IMPACT STUDIES

This section will focus on estimates of recreational expenditures and non-market valuation studies from the recreational fishing literature. Recreational landings information is poor to non-existent in the WECAFC region as no nation has recreational data collection efforts outside of Puerto Rico, which has run a version of the US Marine Recreational Information Program (MRIP) study sporadically. As discussed above, it is essential to have estimates of the resource stock and flows in order to estimate economic value. Because very little catch information and no effort data exists either region wide or for individual countries, the most reliable estimates of value will be non-market values for individual countries and/or events like tournaments. This information will be used to extend these per trip or per fish economic values to the larger Caribbean, but it is important to note that these values will be extreme lower bounds on the current recreational value in the region. While several studies that examine the impact of changes in billfish stocks on catch rates and recreational fishing effort, there is not enough information in the Caribbean to estimate how reductions in commercial harvest will improve values in a quantifiable way.

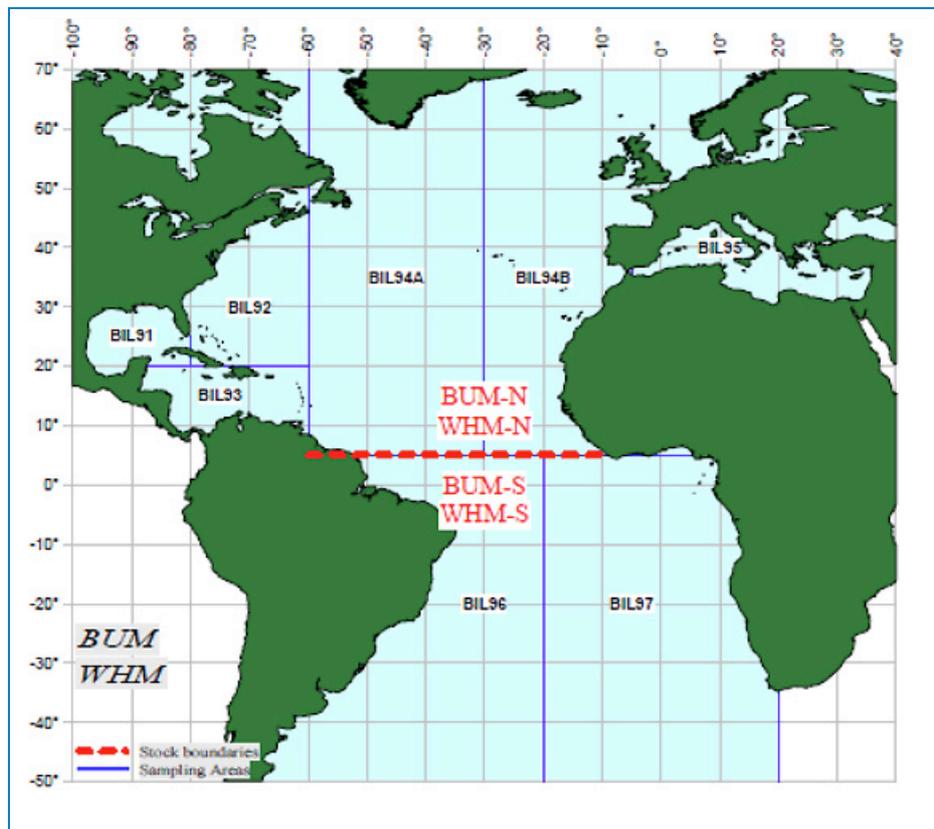
Table 5 contains the rod and reel and handline landings for the Caribbean region as taken from the ICCAT Task 1 data (ICCAT, 2015). The landings were filtered by Sample Area BIL91, BIL92, BIL93 and BIL94A in Figure 8, in the ICCAT queries. US and Canada harvests were then filtered out manually for Table 5. As one can see, this area is not the same as the FAO defined WECAFC area; it encompasses too much territory to the east and not enough territory to the south. There are no continuous recreational data collection efforts in the Caribbean region. The origin of this data is unclear and currently Gentner Consulting Group is pursuing better information on these statistics. The Dominica landings are a bit troubling in their size, but they may be capturing an artisanal handlining commercial fleet or may simply be miscoded. Before ending reporting in 2012, the 2011 Dominica recreational landings were 58.9 tonnes. Barbados reports the second highest landings in 2011 at 10.2 tonnes with an increase in 2012 to 16.7 tonnes falling in the last year of reporting to 4.7 tonnes. Bermuda and Trinidad and Tobago were the only other nations reporting recreational landings to ICCAT in 2013. The one thing that is certain about this landings data is it indicates the need to improve recreational landings in the region.

Table 5

Recreational harvest by country all billfish combined (tonnes)(ICCAT, 2015)

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Dominica			42.28	23.94	88.33	47.38	75.68	58.86		
Trinidad and Tobago	0.79	0.15	0.29	0.76	0.03	0.03	0.03		0.51	0.49
UK.Bermuda	2.50	2.50	3.40	2.95	2.72	0.40	1.39	2.39	1.99	2.90
UK.Turks and Caicos	0.08		0.15		0.09			0.00		
Barbados							5.41	10.18	16.67	4.68
Caribbean total	3.37	2.65	46.11	27.65	91.18	47.81	82.50	71.43	19.17	8.07

FIGURE 8
 ICCAT billfish sample areas



Impact studies

The Billfish Foundation has funded a number of studies to estimate billfish angler expenditures and economic impacts of billfish tourism in a number of locations in the region such as Panama, Costa Rica and Mexico. However, these studies have focused on the fisheries on the Pacific Coast of these nations. All three studies used similar methodologies (Southwick *et al.*, 2008, Jimenez *et al.*, 2010, Southwick *et al.*, 2013). All three used in-person interviews conducted at airports sampling fishermen on their way back home. Industry linkages and industry production functions, necessary for the creation or augmentation of economic impact models, were constructed using samples of convenience of local sport fishing and tourism related businesses. The expenditure estimates in all three studies included all expenditures for those whose trip was primarily for fishing and only included fishing expenditures for those tourists in country for multiple tourism purposes. Standard statistical techniques were used to estimate mean and total expenditures. More detailed methodologies can be found in the manual developed for the FAO for rapidly assessing expenditures (Southwick and Gentner, 2014).

The most recent expenditure effort was in Panama (Southwick *et al.*, 2013). The estimates produced by this survey are displayed in Table 5 and Table 6. During the survey year, 86 250 visitors fished in Panama spending 17.2 days in Panama on average and fishing 5.2 days per trip. Those fishing targeted “mostly highly migratory species” on those trips. Each angler spent US\$216.55 on each trip with a sales impact of US\$379.98/trip contributing US\$55.19/trip to GDP and generating 0.0212 jobs per trip. In total, across all anglers and all trips, fishing for HMS species in Panama generated US\$97.1 million in total expenditures, US\$170.4 million in total sales, US\$24.8 million in gross value added and supported 9 503 jobs. As discussed above, gross value added or contribution to GDP is often used as a proxy for economic value. In this case, then, a proxy for the economic value of HMS angling on the Pacific Coast of Panama would be US\$24.8 million. The Southwick surveys all contained many contingent behavior questions that, while not quantitative, indicate that anglers would

prefer better billfish angling opportunities. 65.4 percent of respondents in this survey stated that the quality of fishing was the major reason why they visited Panama and 89.5 percent ranked fishing quality as a somewhat to important reason for selecting Panama as a fishing destination. Respondents to this survey were very aware of the commercial/recreational conflicts with 37.1 percent not likely to return if commercial harvest increased. Also, 50.6 percent stated they would be likely to return if commercial fishing was restricted or shut down.

The Costa Rica study (Jimenez *et al.*, 2010) also surveyed anglers mostly on trips targeting HMS species where the majority of the anglers expected to catch billfish in the Pacific. In the year of the survey, 283 783 visitors fished in Costa Rica. On average their trips were 8.5 days long and they spent 3.1 days fishing. Visitors spent US\$539.33/day fishing which generated US\$703.71 in GDP per day and supported 0.074 jobs per day. Overall, billfish fishing tourism in Costa Rica generated US\$467.7 million in expenditures, US\$599.1 million in GDP contribution and supported 63 000 jobs. Using GDP as a proxy for value, the value of billfish angling in Costa Rica was US\$599.1 million. Quality of fishing ranked the highest in terms of visitor motivations for travel to Costa Rica. Anglers were aware of the commercial/recreational conflicts in Costa Rica and 58.5 percent said they would be less likely to return if commercial harvest increased and 50.9 percent said they would be likely to return if commercial fishing were restricted. Overall, respondents were both aware of Costa Rica's efforts to protect billfish and it factored heavily in their choice to visit Cost Rica.

The first evaluation conducted by Southwick was done in Cabo San Lucas, Mexico (Southwick *et al.*, 2008). Cabo San Lucas is a very popular billfish fishing destination and most of the trips were HMS targeting trips. Looking at the responses from the visiting anglers, this study was the most HMS oriented study of the three. 354 013 visitors visited the region on trips that averaged 8.3 days per visit. Those visitors fished 5.4 days per trip on average. These visitors spent US\$331.42 generating US\$558.61/trip in total sales, US\$341.10 in GDP and supporting 0.0128 jobs per day trip. Over all trips, HMS angling in just this one location generated US\$633.6 million in total spending, US\$1.2 billion in total sales, US\$652.1 million in GDP contribution and supported 24 426 jobs. Quality of fishing ranked as the highest motivator for selecting this destination. This region, for various biological reasons, is considered a "core area" for billfish productivity in the region. Because of various direct and indirect actions that positively impacted the billfish stock, billfish catch rates have been high and increasing, driving the popularity of this destination (Squire and Au, 1990). 71.4 percent stated they would be likely to return to Cabo San Lucas because of their commercial billfish regulations. Also, if billfish were managed to maximize fishing quality, 89.6 percent of respondents said they would return to the area. Finally, 37 percent stated that "fishing is better in Cabo" was their most important factor in selecting Cabo San Lucas as a fishing destination.

The final report in Tables 5 and 6 are from a recent report of US expenditures on HMS fishing trips (Hutt *et al.*, 2014). This survey was conducted in the Northeast US and Mid-Atlantic primarily and covered private anglers fishing from private boats using a permit base sampling frame. The US requires all angler targeting HMS species to obtain a HMS Angling Category permit that does not allow commercial sale. Hutt *et al.* (2014) surveyed 3 796 permit holders out of a possible total of 14 206 permits using a mail survey. They estimated that there were 55 864 HMS trips taken with 5 123 specifically targeting billfish. On average, HMS permit holders spent US\$900.25/day trip generating US\$1 321 in total sales, US\$747.62 in GDP contribution and supporting 0.0091 jobs per day trip. Across all trips, billfish trips in the Northeast and Mid-Atlantic generated US\$4.6 million in expenditures, US\$6.8 million in total sales, US\$3.8 million in contribution to GDP and supported 47 jobs. This represents a small portion of HMS effort in the US as a significant amount of effort occurs south of the Mid-Atlantic states. In terms of proxy for value, each billfish trip generated US\$747.62 in contribution to GDP.

Another way to examine expenditures and value in the region is to look at the spending at billfish tournaments in the Caribbean. These estimates are not included in the tables. Fisher and Ditton (1992) found that anglers spent US\$3 347 per angler for a 2.6 day billfish tournament. Ditton *et al.* (2000) estimated the total expenditures at North Carolina's Pirates Cove Billfish tournament to be US\$3.0 million, not including registration fees. Of this amount, over 80 percent was from outside the

region which translates into increases in economic activity and incomes in the region. Thailing *et al.* (2001) estimated the total expenditures for Virginia's Red, White and Blue tournament to be US\$623 274. NMFS requires registry of all HMS tournaments in US territorial waters. As of September 2015, there were 23 tournaments registered in the US territories in the Caribbean (NMFS, 2015a). Alvarez (2015) has six billfish tournaments planned in the Caribbean in 2015; three in the Dominican Republic, two in the USVI and one in Puerto Rico. Netting out the overlap with the NMFS list, that is a total of 26 tournaments in the region and that is likely a lower bound estimate. Using these expenditure estimates per tournament, these events alone could generate between US\$16.2 million and US\$78.0 million dollars with little impact on billfish stocks. There are other tournaments planned in the Caribbean in 2015, but queries regarding those tournaments are as yet unanswered.

Table 6

Per Day Trip expenditures and economic impact estimates from the literature

Region	Species target	Expenditures per day trip	Sales impact per trip	GDP contribution per trip	Employment impact per trip	Source
Atlantic Coast US	Billfish	\$900.25	\$1,321	\$747.62	0.0091	Hutt <i>et al.</i> , 2014
Panama	Mostly HMS	\$216.55	\$379.98	\$55.19	0.0212	Southwick <i>et al.</i> , 2013
Costa Rica	Mostly HMS	\$549.33	n/a	\$703.71	0.0740	Jimenez <i>et al.</i> , 2010
Cabo San Lucas, Mexico	Mostly HMS	\$331.42	\$588.61	\$341.10	0.0128	Southwick <i>et al.</i> , 2008

Table 7

Total expenditure and impact estimates from the literature

Region	Species target	Total expenditures	Total sales	Contribution to GDP	Total employment	Source
Atlantic Coast US	Billfish	\$4 611 977	\$6 766 521	\$3 830 037	47	Hutt <i>et al.</i> , 2014
Panama	Mostly HMS	\$97 120 908	\$170 423 000	\$24 753 700	9 503	Southwick <i>et al.</i> , 2013
Costa Rica	Mostly HMS	\$467 673 300	n/a	\$599 100 000	63 000	Jimenez <i>et al.</i> , 2010
Cabo San Lucas, Mexico	Mostly HMS	\$633 569 246	\$1 125 218 980	\$652 078 000	24 426	Southwick <i>et al.</i> , 2008

Valuation studies

A number of billfish valuation studies have been conducted both in the Caribbean region, in adjacent regions and globally. Whitehead *et al.* (2013) conducted a survey of North Carolina, US charter and headboat anglers. Anglers were intercepted during the course of the MRIP survey and asked if they would participate in the follow-up telephone survey. 1 317 anglers completed the field survey in 2007 in North Carolina and 1 204 were contacted for the phone survey. 71 percent of charters fished in federal waters (beyond three miles) and the average charter involved five anglers. Whitehead *et al.* (2013) estimated a single trip random utility model, a type of revealed preference travel cost model. The survey contained 15 fishing alternatives; state or federal waters, charter or headboat, five

aggregated port sites and whether the primary trip purpose was recreational angling. They stratified the model between anglers that traveled primarily to fish versus those that fished incidental to other travel. The first choice node in the model was between fishing mode (charter/headboat) and fishing area (state/federal) combinations. The next choice node was one of five port sites. Costs for the trip included the round trip travel cost plus the charter/head boat fee. Trip quality was measured as the catch rate at each port location. All estimates below are presented in 2015 US dollars.⁵

Very few of the anglers were on day trips. Most were at least on overnight trips to North Carolina. Those who took the trip to the coast primarily to fish took three charter trips in the last year and those in the region for other purposes took two charter trips in the previous year. The top three primary species targets for respondents were tuna, wahoo and dolphin. Top secondary species targets were billfish and tuna, Spanish mackerel and dolphin. Only 50 percent of primary and 25 percent of secondary targeters actually had a targeting preference.

Whitehead *et al.* (2013) estimated from this model that secondary billfish targeters were willing to pay US\$2 114.74 for one more harvested billfish and primary targeters were willing to pay US\$2 579.10 for additional harvest billfish over their current harvest. Given the typical catch and keep rates for billfish, which are typically quite low, this represents a very large, non-marginal increase in harvest. If a model existed predicting the changes in recreational catch rates in the Caribbean for changes in commercial harvests, the value of this additional harvest could be calculated. The other valuation measure they estimated was willingness to pay for the trip they took, regardless of catch. They estimated that value at US\$717.22/angler. With an average of five anglers per trip, that is every charter trip has an economic value of US\$3 568.08, regardless of whether a billfish is harvested or not. If total charter effort estimates existed in the Caribbean, this value could be used to estimate the current value of the fishery. Both of these results strongly demonstrate the higher value that exists in the charter fishery considering that the vast majority of trips in the US release all marlin (Ditton, 1998), and, even if kept, a 200kg marlin would be worth roughly as much as US\$13/kg which is significantly higher than the value per kg of commercially harvested fish demonstrated above.

Duffield *et al.* (2012) conducted a state preference choice experiment in Hawaii using the MRIP intercept survey, Hawaiian commercial marine license (CML) and volunteer sign up at tackle shops to generate a sampling frame for a mail follow up survey. Anglers were presented a set of paired trip choices that included blue marlin catch, yellowfin tuna catch, other pelagic catch, season of trip and cost per day. The survey had a low response rate with only 21.4 percent responding however, Hawaiians are very anti-authority, particularly mainland authority, and this survey was fielded during talks to implement a recreational fishing license. 580 names and addresses were gathered from the MRIP survey, 1 500 were sampled from the CML database and 525 names and addresses were gathered at local tackle shops. The CML database generated the best response rate by far. The CML was used because it is an open access fishing license that allows commercial sales. Many or most Hawaiian anglers obtain one so that they can occasionally sell catch to cover trip costs. Only 480 surveys were returned.

This effort was unique in that it included more marlin encounter options besides catch. Seeing one more blue marlin in the spread, without hooking them, would generate US\$310 across all anglers, US\$475 for each charter angler and US\$185 for private anglers. Hooking but losing one more marlin would generate US\$229 across all anglers, US\$352 for charter patrons and US\$143 for private boat anglers. Interestingly, they would rather see and not hook an additional marlin than hook and lose an additional marlin. The willingness to pay for the catch and release of one more marlin was US\$423 across all anglers, US\$577 for charter anglers and US\$306 for private boat anglers. The interesting result from this study is anglers are willing to pay for increased quality, even when that increased quality doesn't result in catch or even harvest, recalling that Whitehead *et al.* (2013) estimated the value of an additional harvested marlin.

⁵ Bureau of Labor Statistics CPI calculator. <http://data.bls.gov/cgi-bin/epicalc.pl>

Bob Ditton and a series of collaborators conducted a series of contingent valuation surveys across the region in the 80s and 90s. These studies are all summarized in Ditton (1998) (Ditton and Grimes, 1995; Ditton *et al.*, 1999; Ditton and Stoll, 2003). This report was prepared for ICCAT in response to the allocation debates in the then new ICCAT billfish fishery management plan. These studies contain a lot of human dimensions and demographic information that will not be summarized here. These studies all contained the same contingent valuation questions. The first was angler's willingness to pay to maintain the current population levels. Anglers on the US Atlantic coast were willing to pay US\$410/person. Puerto Rican anglers were willing to pay US\$439/person. Costa Rican anglers were willing to pay US\$885/person and anglers in Southern Baja were willing to pay US\$343/person. The next question asked anglers to value a 25 percent increase in billfish populations, regardless of whether or not that increase changed catch rates. US Atlantic anglers would be willing to pay US\$701/person, Puerto Rican anglers would be willing to pay US\$554/angler, Costa Rican anglers would be willing to pay US\$516/angler and Southern Baja anglers would be willing to pay US\$541/angler. Not including the US estimates, the in region estimates are all very similar. It is important to note that the Costa Rican estimates and the Southern Baja estimates came from surveys conducted with anglers in the Pacific. Only the Puerto Rican estimates come from the Caribbean.

Three of these studies also estimated the consumer surplus for the current trip. In Puerto Rico, the value of access was US\$859/trip, in Costa Rica it was US\$1 841 per trip and in Southern Baja it was US\$856/trip. Ditton extrapolated these values to total economic value of billfish in those same three locations. In Puerto Rico, the total economic value was US\$28.3 million, in Costa Rica it was US\$6.3 million and in Southern Baja it was US\$24.2 million. In addition to value, these studies asked questions about billfish retention rates. In the US Atlantic, 89 percent of all billfish are released, in Puerto Rico, 72 percent of billfish caught by resident tournament anglers were released and 87 percent of billfish caught by non-resident tournament anglers were released. In Southern Baja, 66 percent of billfish caught on charter boats in Cabo San Lucas were released and 74 percent of the billfish caught by panga anglers out of East Cape were released.

Cox (2012) conducted a stated preference choice experiment across a small sample of convenience (26 completes) on Isla Mujeres, Mexico. This was a preliminary study with a low response rate. Isla Mujeres is a region of high Atlantic sailfish catch rates. His estimate of the economic value of an additional sailfish caught and release was US\$89.41 per angler. This makes sense with high catch rates in comparison to the Whitehead *et al.* (2013) study where per trip catch rates are less than one. Because of the low response rate, these estimates are not particularly reliable.

Can total current value be estimated?

As discussed above, harvest estimates for the Caribbean are not reported consistently as there are no recreational data collections in the region. However, there are some reported landings. An attempt was made below to transfer CPUEs from the US, which has a well developed recreational data collection, to make a rough estimate of Caribbean effort based on Caribbean recreational catches reported to ICCAT. In exploring the US data, it was found that, for the last four years, 96.3 percent to 99.0 percent of all white marlin, blue marlin and sailfish caught on the US East Coast were released (MRIP, 2015). In 2014, only 213 white marlin, blue marlin and sailfish were harvested in 9 081 vessel trips or 48 129 angler trips on the US Atlantic Coast (Salz, 2015).

NMFS collects and estimates harvest rates and billfish directed effort using a combination of the MRIP and Large Pelagic Survey (LPS). Table 8 contains the harvest levels, effort levels and CPUE for all billfish (white marling, blue marlin and sailfish) combined for the US Atlantic coast as reported in the MRIP and LPS queries (MRIP, 2015). Harvest in kilograms estimates presented in Table 8 were derived using a combination of techniques. Sailfish data came from the online MRIP queries which directly estimate harvested weight (MRIP, 2015). One of the reason for the LPS survey's existence is that the MRIP survey encounters very few harvested large pelagics. Because the MRIP was unsuitable for these rare event landings, the LPS was designed. However, because so few billfish are harvested and because billfish are too large to weigh by dockside samplers, no weights are taken for white and blue marlins and very few lengths can be captured. During the 2010–2013 time frame, only four blue

marlin and 14 white marlin were length sampled. As a result, the LPS does not estimate harvested weight and only estimates the total numbers of fish harvested. Total harvested weights for these species for numbers present in Table 8 was derived by estimating average weights from average lower jaw lengths for both species from 2010–2013 provided by Salz (2015). Using a weight calculator that estimates both girth and then weight, the average weight of a harvest blue marlin and white marlin used for the data in Table 8 were 205.9kg and 49.0kg respectively.⁶ The weights estimated for both blue marlin and white marlin are based on very small sample sizes and should be used with this caveat in mind. Additionally, these weights will not correspond to the totals reported to ICCAT as sailfish are included and NMFS uses a different source for ICCAT reporting for white and blue marlin than the method used here. These estimates were used for this effort in order to be consistent with the way directed effort was estimated.

Table 8

US billfish harvests, effort and harvest per unit effort (MRIP 2015, Salz 2015)

Year	Harvest in kilograms	Vessel trips		Angler trips		Vessel trips		Angler trips	
		Caught or targeted	Caught only	Caught or targeted	Caught only	HPUE caught or targeted	HPUE caught	HPUE caught or targeted	HPUE caught
2010	25 981	9 633	5 934	51 055	31 450	2.70	4.38	0.51	0.83
2011	22 677	9 909	7 093	52 518	37 593	2.29	3.20	0.43	0.60
2012	56 106	10 313	7 665	54 659	40 625	5.44	7.32	1.03	1.38
2013	43 845	9 081	5 768	48 129	30 570	4.83	7.60	0.91	1.43

Directed effort estimates were estimated as a custom query run for this project by the MRIP and LPS staff (Salz, 2015). Directed effort is defined as both trips that caught and/or targeted billfish and those trips that only caught billfish. The custom effort queries were used to estimate harvest per unit effort (HPUE) under the two definitions of trips that caught and/or targeted billfish and only trips that caught billfish. Vessels very rarely harvest billfish on the Atlantic coast. Because of the high release rates in the US, kilograms of harvested billfish per vessel trip range from 4.8 to 7.6 depending on the definition of directed effort in 2013. That is, for trips that either targeted and did not catch fish or caught billfish, their HPUE in kilograms was 4.8 kg. For only those trips where a billfish was caught, only 7.6kgs was harvested, averaged across all trips. With 5.3 anglers per vessel on average, harvest per angler was between 0.9 and 1.4 kilograms per angler per trip (Salz, 2015).

Assuming that recreational HPUEs are similar in the Caribbean as the HPUE's presented in Table 8, a crude estimate of recreational effort in the Caribbean can be derived. Table 9 displays estimates of Caribbean effort and total economic value for the current level of trips using per trip valuation estimates detailed above. If the highest per trip per angler values are applied to the estimates of effort from Table 9, the fisheries in Barbados, Trinidad and Tobago and the Turks and Caicos alone could be as much as US\$16.3 million in 2013 (Ditton, 1998). If the Puerto Rican per trip per angler values are applied, total economic value in Barbados, Trinidad and Tobago and the Turks and Caicos could be as high as US\$7.6 million in 2013 (Ditton, 1998). If the North Carolina per trip, per angler values are applied to the effort estimates from Table 9, the Barbados, Trinidad and Tobago and the Turks and Caicos fisheries could be worth as much as US\$6.4 million in 2013 (Whitehead *et al.*, 2013).

Table 10 displays the potential level of expenditures being generated by this rough estimation effort. This table uses the more liberal effort estimates from Table 9. The expenditure estimates come from those in Table 6 and the columns are labeled by the country the expenditures where the expenditures were estimated. From the table, potential spending and contributions to a nation's GDP could be significant from current levels of billfish effort. On the high side, billfish angler could be generating as much as US\$8.0 million and on the low side, US\$1.9 million in just these three nations.

⁶ Weight calculator used: www.csgnetwork.com/fishsaltwtcalc.html Last accessed 5 October, 2015.

Table 9

Estimated total economic value of currently reported billfish fishing (Millions of US Dollars)

Year	Angler trips		Total Value, Whitehead <i>et al.</i> , 2013		Total value, Puerto Rico		Total value Costa Rica	
	CPUE caught or targeted	CPUE caught	CPUE caught or targeted	CPUE caught	CPUE caught or targeted	CPUE caught	CPUE caught or targeted	CPUE caught
2010	162 128	99 872	\$116.28	\$71.63	\$139.27	\$85.79	\$298.48	\$183.86
2011	165 432	118 419	\$118.65	\$84.93	\$142.11	\$101.72	\$304.56	\$218.01
2012	18 676	13 881	\$13.40	\$9.96	\$16.04	\$11.92	\$34.38	\$25.55
2013	8 855	5 625	\$6.35	\$4.03	\$7.61	\$4.83	\$16.30	\$10.35

Table 10

Potential recreational spending and GDP contributions

Year	Panama estimates		Costa Rica estimates		Cabo San Lucas estimates		US Atlantic estimates	
	Spending	GDP	Spending	GDP	Spending	GDP	Spending	GDP
2010	\$35.11	\$5.51	\$89.06	\$114.09	\$53.73	\$55.30	\$145.96	\$121.21
2011	\$35.82	\$6.54	\$90.88	\$116.42	\$54.83	\$56.43	\$148.93	\$123.68
2012	\$4.04	\$0.77	\$10.26	\$13.14	\$6.19	\$6.37	\$16.81	\$13.96
2013	\$1.92	\$0.31	\$4.86	\$6.23	\$2.93	\$3.02	\$7.97	\$6.62

It is hard to say if the estimates in Table 9 and 10 are upper or lower bound estimates for the countries included. The Dominica landings seem to be too high to be real, and it is those landings that are driving the very high effort and value in 2010 and 2011. Another caveat with this very rough estimation technique is it assumes very low harvest rates per trip, estimated from the US data. As mentioned above, US release rates in 2013 were 99 percent. This is supported by Goodyear and Prince (2003) who estimated white marlin release rates to be 99 percent. If harvest rates are higher in the Caribbean, these estimates over estimate effort and value in these countries.

On the other hand, the estimates in Table 9 and 10 are likely lower bound estimates for the entire region. First, using HPUE estimates, which are very small numbers in the US, the total number of trips will be underestimated if the majority of Caribbean trips are either unsuccessful or release fish at higher rate. The trend is moving to more and more catch and release fishing for billfish (Ditton, 2003) and even in the 90s recreational anglers in Puerto Rico released 72 percent to 87 percent of all billfish caught in tournaments. If the harvest per unit effort is much higher in the Caribbean, due to higher catch rates or less release, these estimate may overestimate Barbados and Trinidad and Tobago values. However, with only those two countries reporting landings that in themselves are likely lower bounds on their own landings, it is likely that Caribbean wide values are much higher.

As a result, very little confidence should be placed in these estimates. They are really more of a proof of concept. However, proof of concept or not, these estimates likely overestimate individual country values but likely understate Caribbean wide values for recreational billfish trips and these estimates are not predicated on the catch or harvest of billfish; simply based on the access to the experience. If better information on release rates, CPUE and/or landings became available it would be a quick matter to enhance the accuracy of these estimates.

Predicting changes in recreational catch rates: the key to estimating value propositions

The key to developing the value propositions for individual countries, after estimating basic catch and effort data, is to develop how much catch rates might change when commercial harvest is reduced and

how much additional effort might be attracted to the fishery. This is the double bottom line impact of increasing stocks for recreational angling. Not only are current anglers willing to pay more for better fishing, as detailed in the section above on values, but new anglers will be attracted to the region to enjoy better fishing. Very few studies have been done on this topic and none have been conducted in the Caribbean. Ideally, a full bioeconomic model would be useful for this project but is likely beyond the scope of this effort.

Several studies show that closures in Southwest Pacific have impacted recreational catch rates (Campbell *et al.*, 2002, Holdsworth *et al.*, 2003, Langley *et al.*, 2006). However the only publication to quantify the biological response to restricting the commercial harvest of billfish and the follow on increases in angler catch is Jensen *et al.* (2010). Their article is related to the concept of Core Area Management that will be discussed in greater depth in the Rights Based Desk Study as it could play a prominent role in the business cases selected for this project. This paper demonstrates that even a commercial closure that doesn't cover the entire range of the species but covers a "Core Area" can increase stocks and improve recreational catch rates.

Much of the drop in Mexican billfish mortality was the result of de facto closures. In 1976, Mexico claimed a 200 mile EEZ and began enforcing the EZZ against Japanese longliners in 1977 (Squires and Au, 1990). At the time, Japanese longline catches were 30–50 percent of all striped marlin catch globally, which had a huge impact on the striped marlin stock. In 1980, joint venture Mexican longline boats began fishing, which created a three year de facto closure. This small closure may have had an impact as there was a slight rise in striped marlin CPUE, but CPUEs in the area swing with sea surface temperatures. In 1984 and 1985, the Mexican government withheld longline permits creating another de facto closure. Then in 1990, Mexican longline vessels were prohibited from targeting billfish, and, while they are still allowed to sell billfish, there remains only a little bycatch in the tuna/shark longline fishery. In 1998, Mexico began closing areas to commercial longlining formally.

Baja has a unique concentration of striped marlin with higher recreational and commercial catch rates than anywhere in the world (Jensen, 2010). Squire and Au (1990) showed that temporary closures resulted in rapid stripe marlin recoveries. Genetic research has shown limited exchange with other regions (McDowell and Graves, 2008). Striped marlin are the target of one of the most valuable recreational fishery in the Baja region of Mexico (Ditton and Stoll, 2003). These factors combined suggest that perhaps the waters off Baja are a "core area" for the species.

Science has shown that fish with higher movement rates benefit less from reserves, in general (Gerber *et al.*, 2003 and Walters *et al.*, 2007). The effects of reserves on billfish related to the assumption regarding the rates and drivers of movement (Martell *et al.*, 2005). Pop up tags deployed in the Baja region show relatively restricted movements of striped marlins (Domeier, 2006). This suggest that reserves could be effective in the Caribbean region if a "core area" could be found for one or more species of billfish. If such a core area existed, this study shows that by eliminating, or greatly reducing, billfish mortality in that area, the stock would increase and recreational catches could improve. It would not be necessary to close all fisheries, but only those with heavy commercial mortality of billfish

Jensen *et al.* (2010) used data for the recreational fishery going back to the 1930s. Release rates in the region were 75 percent and survival rates in at 75 percent (Domeier *et al.*, 2003). This translates into a 50 percent mortality for every recreationally caught fish and that estimate is used in their model. For the commercial sector they use Japanese longline CPUE from 1963 to 1998 in five minute by five minute cells. Catch rates for this fleet are typically 20 times higher than elsewhere in the North Pacific (ISC, 2006). Recreational CPUE comes from the US billfish survey conducted by the NMFS Southwest Fishery Science Center which has estimated annual catch and effort since 1969 (Squire, 1987). The Jensen *et al.* (2010) modeling effort used the "Baja California" and "Mazatlan" reporting areas combined.

Jensen *et al.* (2010) used stock reduction analysis to estimate abundance trends and population dynamic parameter for the period from 1953 to 2002. This is not a complete population model but a

model conditioned on catch. They modeled catchable billfish from the vulnerable individuals in the model under three modeling scenarios; observation error only, 25 percent process error and 50 percent process error. The authors analyzed a four year closure, a two year closure and a 100 percent recreational release policy. They used lure only recreational release survival rates with 10 percent mortality under the 100 percent recreational release policy. This is likely optimistic according to Domeier *et al.* (2003). The four year closure increased the number of vulnerable billfish between 12 percent and 22 percent based on the error assumptions. The two year closure increased the number of vulnerable individuals from between 6 percent and 12 percent depending on the error scenarios. The 100 percent recreational release policy generated between 2.8 percent and 7.5 percent more vulnerable individuals. Under all model results the observation error results only produced the highest change in vulnerability. These results suggest that a closure is more effective, even when the entire range of white marlin cannot be closed, than mandating 100 percent recreational release. Additionally, recruitment is slightly better under all scenarios suggesting there will be stock growth. This result runs counter to claim that reserves don't work for highly migratory species.

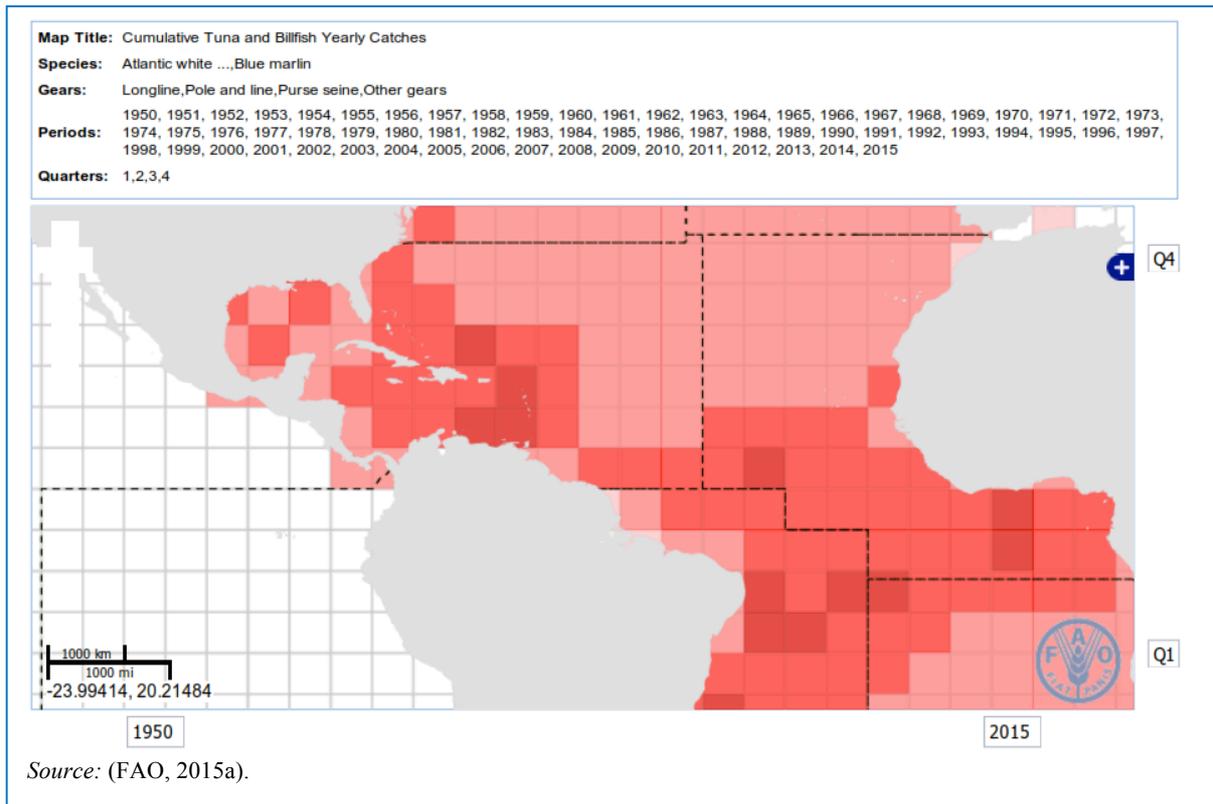
Some of the recovery in the region is not explained by the model and may be driven by weather or other climatic factors. There are caveats. The catch data is uncertain. Artisanal panga fleet catches striped marlin but landings are not reported. Additionally, industrial longliners may have become more resistant to providing data and may be under reporting striped marlin harvest. It is important to point out that tag recoveries have shown that this stock does not move as much as other striped marlin stocks as 90 percent of 306 tag recaptures have occurred within 1 000 kilometers. It is important to point out that mixing rates and spatial distribution of temporary migrants matter for closures to work. The authors suggest that management and conservation efforts should focus more locally. Their modeling strategy does not need stock structure and all stock structures showed rapid increases in abundance resulting from closures.

The Jensen *et al.* (2010) results do not go so far as to convert increased vulnerability to recreational catches. They would need to link their model to a model of angler and commercial fisher behavior creating a bioeconomic model. Without specific estimates of the increase in catch rates it is difficult to estimate the value proposition offered by restricting commercial billfish harvest. Fortunately, Ditton (1998) asked anglers what they would be willing to pay for a 25 percent increase in billfish stocks regardless to the impact on catch rates. The Jensen *et al.* (2010) result shows a four year closure would increase the vulnerable portion of the stock as much as 22 percent. US Atlantic anglers would be willing to pay US\$701/person, Puerto Rican anglers would be willing to pay US\$554/angler, Costa Rican anglers would be willing to pay US\$516/angler and Southern Baja anglers would be willing to pay US\$541/angler. While there are no current estimates on the number of billfish anglers for the region, the number of anglers visiting a prospective country could be estimated with the economic impact assessment manual developed by Southwick and Gentner (2014). These numbers could then be applied to the Ditton (1998) value estimates to develop the value proposition for an individual country.

Figure 9 displays the cumulative harvests of Atlantic white marlin and blue marlin in the WECAFC area (FAO, 2015a). The darker red the cell, the higher the harvests. From this figure, several areas of high harvests emerge. If these areas correspond with areas of importance for stock spawning or other areas important to the billfish life cycle, it may prove beneficial to focus on countries in that region. However, blue marlin and white marlin are generally more mobile than striped marlin in the Baja region of Mexico. Further research on billfish regional movements and billfish life cycles will be needed before deciding if core area management could be successful in the region.

FIGURE 9

Cumulative Atlantic White Marlin and Blue Marlin harvests since 1950 in the WECAFC area



Several caveats are warranted regarding the use of this study to transfer benefits to the Caribbean. First, blue marlin and white marlin are likely far more mobile and it is likely unrealistic to think that protecting a small area in the Caribbean would produce similar gains for billfish in the Caribbean. Besides the relative mobility of these species, as mentioned above, many of these countries have very small EEZs because of their close proximity. In the Mexico example above, the entire core area was within the Mexico EEZ. As a result, even if a core area for blue and white marlin could be found in the Caribbean, it still may involve agreements between multiple sovereign nations for harvest reductions to be meaningful and produce stock gains. Again, this result is presented as more of a proof of concept. It shows that even under perfect conditions, increases in vulnerable (or catchable) billfish may be modest but still have the potential to generate substantial value.

DISCUSSION

There are many caveats with benefit transfer analyses such as the analysis presented here. Many assumptions were made that may or may not hold. If they don't hold it calls into question the absolute magnitude of the estimates presented. Additionally, the values presented here are the current values at the current harvest levels and do not hold the farther any future analysis moves beyond current harvest levels. Additionally, recreational values assume that stock and therefore abundance conditions are similar between the Caribbean and the region where the values were estimated. However, the relative magnitude of these estimates reflects a substantial potential increase in value. Under the best case scenario, the economic rent for the entire commercial billfish fishery is US\$7.5 million US dollars on total revenues of US\$27.3 million. The lowest recreational value of access presented above is US\$4.8 million dollars and the highest is US\$16.3 million across only three countries that reported recreational landings. This does not include the producer surplus that accrues to local charter captains engaged in taking tourists fishing. If those rents are included, the total recreational economic rent would be still higher. Those estimates are based on very optimistic release rates but only cover a small portion of the total recreational landings in the Caribbean. Looking at estimated billfish tournament spending in 2015, between US\$16.2 million and US\$78.0 million will be spent during tournaments in the region. While those are expenditures and not economic value, the economic value embodied by those tournaments alone may be more than the economic rent from commercial fishing, perhaps by a wide margin.

While the results in the document were developed for the region as a whole, some limited conclusions can be drawn from the country specific results. Table 11 displays the dockside revenue, commercial value, recreational expenditures and recreational value for the countries that reported recreational billfish landings. Using the crude recreational effort estimation technique, anglers in Barbados took 5 137 trips on the upper bound worth US\$9.5 million in 2013, in terms of economic value or rent. This level of effort would have generated between US\$2.8 million dollars in total expenditures. This value was generated by 4.7 tonnes of recreational landings in 2013. In contrast, the Barbados commercial fishery caught 54 tonnes of billfish. Using the FAO prices listed above, this generated US\$378 000 in landed revenue. Using economic rent estimates from Schuhmann *et al.* (2010) specific to the Barbados longline fleet, this level of revenue generated US\$84 823 in value for the Barbadian people. Commercial value is several orders of magnitude lower in Barbados than recreational value. Across all countries examined in Table 11, recreational value far exceeds commercial value.

Table 11

Comparing total revenues, economic value and expenditures derived in this report

Country	Commercial		Recreational Value	
	Revenue	Economic value	Expenditures	Economic value
Trinidad and Tobago	\$805 000	\$180 642	\$479 285	\$980 131
UK.Bermuda	\$21 000	\$4 712	\$689 834	\$5 864 621
Barbados	\$378 000	\$84 823	\$2 822 071	\$9 457 762
Totals	\$1 204 000	\$270 178	\$3 991 189	\$16 302 514

If the recreational release rates transferred from the US prove to be too high and therefore the harvest per trip estimates prove too low then the rough recreational effort estimation technique presented here will overestimate values for those individual countries. However, for total regional values, the estimates presented here are likely extreme lower bounds as they cover only three countries. It is not hard to believe that Caribbean wide there were more than between 5 625 to 8 855 recreational billfish trips in the region in 2013. However, the comparison can also be made without effort estimates. Current commercial marginal value, or economic rent per kilogram, was US\$1.73 as estimated in the commercial value section above. To compare this to the recreational values per kilogram, focus on the value of an additional harvested fish from Whitehead *et al.* (2013) of US\$2 579.10, the only such number found in the literature. That billfish would have to weigh more than 1 490 kilograms for it to

be of lower value than the commercially caught fish. That is higher than the largest billfish of any species ever caught on a rod and reel. Even if Caribbean anglers value the next harvested billfish significantly less than North Carolina anglers, it is hard to imagine the Caribbean values being low enough to change that comparison. To put this another way, translating the North Carolina value from Whitehead *et al.* (2013) to a marginal value using an average size harvested blue marlin in the US blue marlin (205kgs) implies a marginal value per pound of US\$12.53/kg. That is over seven times higher than the commercial marginal value of US\$1.73/kg.

The strongest conclusion from this limited desk study is there exists enough billfish value in the region to compensate the commercial sector for their loss of billfish harvest and still leave the recreational anglers better off, perhaps by a seven-fold margin. While this is true for the region as a whole, it may not be true at the individual country level and therein lies the heart of the next phase of this project. The Consortium on Billfish management and Conservation (CMBC) should be looking for countries where recreational value exceeds commercial value. This desk study provides tools to analyze those values quickly and easily as long as commercial landings and, at the very least, recreational effort can be obtained. The other key is insuring that commercial reductions will translate into recreational increases. Jensen *et al.* (2010) show that is possible under one certain set of circumstances. Finding the nexus between a good value proposition and an ability to improve recreational catch will be the keystone to success in the business cases. It also may be enough, even if increased stock size cannot be guaranteed, to pursue compensation strategies for reducing user conflict and increasing local recreational catch rates using compensation and rights schemes to FAD fishing.

Finally, a note on recreational expenditures estimated here. While it is not appropriate to use economic impacts for valuation purposes, they often get abused for that purpose. Instead, expenditure estimates can be used to examine distributional impacts and how incomes and livelihoods can be impacted in the individual countries as the allocation of billfish switches between commercial and recreational sectors. In 2013, the upper bound on total revenues attributable to billfish in the region was US\$14.6 million dollars. This does not include the entire supply chain, but it is likely the supply chain for billfish is very short and involves little additional value added at the local level. Using the rough recreational effort estimation routine above for Barbados, recreational expenditures are between US\$1.1 million and US\$4.6 million dollars while commercial total revenues are only US\$416 673. Therefore, in addition to valuation criteria support the business case notion, expenditures and economic activity are also higher on the recreational side. Stock improvements, if they flow to the recreational sector, will support more income and more jobs than those same fish harvested in the commercial sector.

Billfish landings represent between 0.36 percent, without the updated Brazilian landings, and 0.84 percent, with the updated Brazilian landings at the upper bound price, demonstrating that billfish production represents a small fraction of total WECFC seafood production. The analysis shows that recreational value far exceeds this small fraction produced commercially suggesting that it would be possible to compensate commercial fishermen, preserve commercial fishing livelihoods and enhance overall values in countries that pursue billfish management reform. Additionally, most billfish caught are released to be caught again. Release rates from the literature discussed here range from a low of 72 percent in Puerto Rico to a high of 99 percent in the US. Billfish also survive capture well with survival rate of 75 percent or better. Not only does recreational fishing generate more value and support more incomes per caught fish, the majority of those fish remain in the water to generate even more value through additional recreational trips and through their continued contribution to the stock of billfish as they can spawn again and again. A commercially harvested fish is gone forever. It generates no value in the future. Finally, with recreational fishing, the thicker the stock, the better fishing gets. Better fishing drives higher values in two ways. First, recreational anglers are willing to pay more for higher quality fishing. Second, as quality improves, more recreational fishing trips will be taken, generating even more value and incomes. Overall, moving fish from the commercial sector to the recreational sector represents a strong opportunity to improve value, incomes and strengthen livelihoods in the WECAFC area.

Recommendations

The single biggest issue hampering examination of commercial and recreational fisheries value is a lack of data. For both sectors, landings data is under-reported and perhaps severely so. Looking at the updated Brazilian landings used for this analysis, the amount they report to FAO is six times less than their updated landings data provided for this effort. The situation is even worse for recreational landing data. Only three countries reported recreational landings in 2013. With no ongoing recreational landings reporting systems in the entire region, it is unclear where these country estimates originate. As a result, caution is warranted in using the total value estimates used here as they are likely incomplete because landings data is likewise incomplete.

However, far more confidence is warranted with the marginal value estimates, because they do not rely on landings data. On the commercial side, these marginal value estimates would be much improved with better reported prices and data on cost and earnings for the fishing vessels participating at the local level. Economic rent used in this document comes from a relatively recent study in Barbados and inasmuch as that study is representative of other regions cost structures, fairly high confidence can be placed in those estimates. Currently, FAO has cost and earnings data collections under way in the WECAFC region.

On the recreational side, better estimates would also require a survey of anglers that focused on estimating total effort and collected either revealed preference or stated preference recreational demand data. Generally speaking it is easier and quicker to collect stated preference data and it would be the recommendation to initiate a stated preference choice experiment in the countries interested in improving their recreational estimates. However, that type of effort would take considerable time and money and rapid assessments could improve on the estimates presented here by collecting better data on recreational landings and recreational effort. Better landings and effort data could be generated fairly quickly using a rapid assessment tool administered to for-hire fishing operators.

If better data were available, marginal value could be modelled more precisely. The marginal values presented here are simply ratios taken from the literature and not directly modelled for the specific fisheries. While revenue functions on the commercial side and demand functions on the recreational side would be beneficial to this project it is unlikely that they are within the scope of the OPP for this region.

It is also important to examine both the commercial and recreational supply chain. The values presented here do not capture the values generated in the supply chain. While it is not uncommon in allocation analyses to ignore the seafood supply chain, the fairness and equity of changes in billfish management will be improved by gathering better information on the supply chain. Inasmuch as seafood purchasers, processors and retailers would be disadvantaged by a loss of billfish harvests, their livelihoods and incomes should also be accounted for and compensated as necessary. Tempering this is the extremely small percentage billfish value constitutes in seafood production in the region and is unlikely that supply chain impacts are very large.

Examining the supply chain on the recreational side is also important. It is very important to determine if tourism dollars stay in local communities or leave the region as payments to offshore investors. Tourism dollars, from an economic development standpoint, can be better for local economies than local spending as it represents new money being brought into a local economy whereas locals spending their incomes on locally caught fish is re-spending of money already in a local economy. As long as enough of the tourism dollars stay in the local community, additional tourism dollars will raise incomes and improve livelihoods more than commercial fishing revenues.

In conclusion, the value proposition and livelihood concerns inherent in moving from current management regimes to reformed regimes that focus on improved value could be addressed better with some basic data collections in countries under consideration for inclusion in reforms. Many of these gaps could be filled with some rapid assessment work. That is not to say that longer term, more

accurate data collections would not be beneficial, but projects such as the OPP do not always have that luxury.

Finally, this report is one small piece in a larger process that involves governance and biological factors as well. While this report does not focus on governance issues, governance issues will be very important for a successful transition to the more valuable recreational sector. The reform has to be bottom up and has to involve all stakeholders. If the reform is not fair, equitable and improve all livelihoods, it will not be successful, which has been born out time and again. Another desk study is currently underway to more fully develop these guidelines for rights based management reform. The reform has to involve some sort of compensation scheme to leave commercial fishermen at least as well off as prior to the change. It will be important to select countries with strong differences in marginal values between sectors. It will also be important select countries with well developed, locally owned fishing tourism industries. This report also indicates that it will be important to focus on regions where commercial restrictions can be effective from a stock standpoint. Identifying and focusing on a core area for billfish may enhance success by reducing the number of sovereign states that need to be included for billfish harvest reductions to be successful.

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This document develops the background on ecosystem values as they relate to billfish stocks in the Caribbean, defining the terminology and state of the art in valuation science in general and the state of billfish valuation in the Caribbean region in particular. Types of value, including market and nonmarket, are defined and the basic estimations techniques used to value billfish across commercial and recreational sectors are detailed and described.

This background study was funded by the GEF/ World Bank Caribbean Billfish Project, for which the Western Central Atlantic Fishery Commission is the executing agency.



ISBN 978-92-5-109431-0 ISSN 2070-6065



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I6178E/1/09.16