Economic Analysis of International Billfish Markets

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Contents

In general, billfish are pelagic apex predators which roam the tropical oceans worldwide providing unique challenges for management. Because of their highly migratory nature, their range crosses international boundaries, making management subject to negotiated actions across many nations. Worldwide, stocks are poorly understood, as very little information exists about stock structures, life histories or habitat requirements, making stock assessment difficult and uncertain. Where adequate stock assessments are in place, stocks appear imperiled. All international fishery management organizations (IFMOs) are calling for more attention to the harvest of these stocks and are working toward collecting better data on billfish biology.

Billfish Harvest

Worldwide, the majority of the billfish harvest is driven by the industrial longline and purse seine fisheries for tuna, with billfish caught as a by-product of the tuna production process. A smaller, but rapidly growing portion of the catch is from artisanal longline and drift gillnet fleets which target billfish or catch billfish as bycatch for local consumption. Because billfish is a byproduct of the industrial and artisanal tuna fisheries, billfish harvest will not respond to typical price signals and other market signals. Compounding these problems is considerable uncertainty regarding the total mortality of billfish species. Catch data are also poor, as many fisheries only report landed billfish at the point of first sale. Fish discarded at sea, alive or dead, and fish not otherwise entered into commerce are not reported consistently. The United Nation's Food and Agriculture Organization (FAO) consolidates landings data from the various IFMOs. According to FAO harvest data from 2004, the top three species harvested are:

- 26,765 metric tons (mt) of blue marlin
- 25,722mt of Indo-Pacific sailfish
- 23,658mt of billfish not elsewhere included (NEI)

Landing data also appear to be subject to manipulation to avoid regulations, as evidenced by the high level of unclassified, or NEI, harvest reported. In 1999, after new International Commission for Conservation of Atlantic Tunas (ICCAT) regulations aimed at reducing blue and white marlin landings were enacted, the reporting of unclassified/unidentified billfish spiked, while the blue and white marlin landings declined. Prior to 1997, unclassified billfish landings showed a slight upward trend but stayed below 5% of total harvest. After the regulations were implemented, unclassified billfish landings increased steadily to a peak of 33% in 2003. In 2004, that number had dropped to 11% in the ICCAT data and 26% in the FAO data. Additionally, all IFMOs recognize that illegal, unregulated and unreported billfish harvesting is occurring, but very little is known about this activity.

According to FAO data, the top five billfish harvesting countries, as measured by weight landed and averaged over 2000 -2004 are:

- Taiwan Province of China - 22,777mt/year
- Sri Lanka - 11,542mt/year
- Japan - 11,306mt/year
- Philippines – 8,010mt/year
- Iran – 5,970mt/year

Billfish Trade

Trade data are also lacking. Of the three sources of domestic trade data examined here, Urner Barry Waterborne Shipment, FAO, and United States (US) Food and Drug Administration (FDA), it is unknown which is most accurate or whether the FDA data, with the highest volume, includes the other two data sources. It is likely that while FAO data are the most complete at the international level, this data still represent an underestimate of total importation due to mislabeling of product or problems with reporting. As with most fisheries, there is no ability to track billfish from the harvester to the consumer once the product leaves the first landing or port of importation. The National Marine Fisheries Service (NMFS) does not track billfish trade.

The following rankings based on FAO data may be misleading as trade information is poorly reported to the FAO. When looking at FDA data, the quantity of US imports was 6.5 times higher and the values of imports reported were 9.6 times higher than those reported to the FAO. It is likely that import and export activity is far higher than the FAO data show and, if better data were available, it is likely that the import and export rankings would change. The top five exporters of billfish, ranked by average annual quantity imported over the period 2001-2005 in the FAO data, are (value in US dollars):

- Taiwan Province of China – 8,169mt/year and $12,652,600
- South Africa – 407mt/year and $498,800
- Maldives – 176mt/year and $238,400
- Costa Rica – 213mt/year and $193,200
- El Salvador – 25mt/year and $36,600

The top five importers of billfish, listed by average annual quantity imported over the period 2001-2005 in the FAO data, are (value in US dollars):

- United States – 166mt/year and $535,624
- Sri Lanka – 95mt/year and $98,998
- Japan – 40mt/year and $57,453
- Singapore – 36mt/year and $58,104
- France – 32mt/year and $69,304

These rankings would change if the importing countries were ranked by value as France and Singapore are buying higher priced products than Japan. It is also noteworthy that the United States is buying a relatively high value product, usually fresh or fresh frozen billfish products. Additionally, from the FDA, the US imports 1,260mt annually averaged over the period 2003-2006, again highlighting the underreporting inherent in the FAO data.

From FDA customs clearance forms, the top five exporters of billfish to the US, listed by average annual quantity over the period 2003-2006, are (value in US dollars):

- Costa Rica – 342mt/year and $1,348,512
- Ecuador – 245mt/year and $946,835
- Vietnam – 221mt/year and $830,036
- Republic of South Korea – 132mt/year and $723,783
- Philippines – 121mt/year and $374,296

The above ranking underscores the underreporting in the FAO data as the FDA has Costa Rica exporting an average of 342mt to the US alone while the FAO shows Costa Rica exporting only 213mt. It is also interesting that of the top five exporters to the US, the largest, Costa Rica, has access to both Atlantic and Pacific Coasts.

According to FAO, the top five consumers of billfish, listed by average annual quantity harvested, plus imports and minus exports, averaged over the period 2001-2005, are:

- Taiwan Province of China – 14,630mt/year
- Sri Lanka – 11,637mt/year
- Japan – 11,346mt/year
- Philippines – 8,010mt/year
- Iran – 5,970mt/year

In the case of consumption, the amount of imports and exports are small relative to a country's harvest and therefore the rankings are not likely to change with improved reporting.

In the United States, it is illegal to harvest any billfish, other than swordfish, from the Atlantic Ocean for commercial sale. According to highly migratory species (HMS) regulations 50 CFR part 635, a billfish Certification of Eligibility (COE) is required to remain in association with any billfish product throughout the chain of custody up to, but not including, the consumer to certify that billfish product was not caught in the Atlantic. The first purchaser of a billfish product is required to complete the COE. Unfortunately, there is no requirement for this form to be submitted to NMFS, any other government body or otherwise retained by dealers. The COE accompanies the product to consumption and dealers are free to dispose of the form as they see fit. If this form were to be collected and recorded by NMFS, this would be a way to track the trade patterns of billfish and billfish products once they enter the United States. Currently, there is no way to track fisheries products from the country of origin to the consumers' plates for any species. Additionally, customs officials have no responsibility to check the COE for products coming into this country.

Perhaps this small legal trade window encourages a black market for Atlantic caught billfish. There are many nations harvesting Atlantic billfish, but, since the COE is not tracked or enforced, the author suspected that illegal trade would not show up in the trade data. However, several shipments identified in the FDA imports database originated from countries with no Pacific coast access (Table 7, page 26). It is unlikely that these shipments were transshipments of product sourced from the Pacific. Without any ability to track the COE in the FDA data it is impossible to know if these were transshipments. It is also impossible to determine whether Atlantic products are being transshipped through Pacific nations to avoid this regulation. Several countries, which have both Atlantic and Pacific coasts, ship billfish products to the United States, further compounding this traceability problem (Table 8, page 27). If Atlantic products from the countries in Tables 7and 8 were either intentionally or mistakenly mislabeled as Pacific caught product on the COE, under current regulations, it would be impossible to trace.

Transhipment, in general, deserves closer scrutiny. For example, the Maldives has no harvest of billfish, as reported to FAO, yet it exported, on average, 176mt annually between 2001 and 2005. El Salvador and Nicaragua also export annually, on average, 25mt and 1mt of billfish respectively without any reported harvest of billfish. Additionally, South Africa, while it harvests 78mt on average per year, exports 407mt per year for a total potential transhipment per year of 391mt. There is no way to determine whether these export values represent underreported harvests or transhipments and, if transshipments, where the billfish was caught. These problems reflect the difficulty that exists in tracking imports back to their origin. Domestic trade is even more difficult, as there are no reporting requirements past the point of first purchase. No Atlantic billfish show up in the domestic landings data. However, without data on billfish consumption at the consumer level, total imports and total domestic production from the Pacific, it is impossible to tell if Atlantic sport caught or domestic commercial bycatch enters the market place. None of these data sets are currently available.

The 2007 Magnuson Stevens Reauthorization Act (MSRA) includes provisions to address bycatch and illegal, unregulated and unreported (IUU) fishing by penalizing nations that engage in those practices. Section 607 of MSRA requires the Secretary of Commerce to identify and biennially list nations whose fishing vessels have: been engaged in IUU or bycatch fishing during any portion of the previous two years and the relevant IFMO has failed to implement effective measures to end IUU fishing and bycatch by vessels of that nation; the nation does not belong to an IFMO; or no IFMO exists to regulate said fishing. Identification for this provision is equivalent to the provisions of the High Seas Driftnet Fisheries Enforcement Act (HSDFEA) of 1992. Under the HSDFEA, The Secretary of Commerce is responsible for identifying nations engaged in the use of the gear and engaging those nations in consultations within 30 days of identification. Under the new MSRA provisions, if the offending nation is taking action to reduce IUU and/or bycatch, a positive certification is given to that nation, but if no action is being taken, a negative certification is issued. Vessels identified vessels as participating in IUU and/or bycatch will be immediately denied entry into US ports and US navigable waters. A failure to certify or a negative certification triggers provision in the Pelly Amendment of 1995 (PA).

Under the PA, if an agreement is not reached terminating IUU or bycatch within 90 days, the offending nation will face trade sanctions, including the prohibition on the import into the United States of that nation's fish, fish products or sportfishing equipment. The PA connects the fishery management sector with the General Agreement on Tariffs and Trade administered by the World Trade Organization. The PA outlines procedures for the certification and upon that certification the President can impose trade sanctions. The advanced notice of proposed rulemaking for these new MSRA provisions were published in the federal register on Monday June 11, 2007 (Volume 72, Number 111, page 32052). These provisions may provide a method to reduce billfish landings, effectively making it illegal to import billfish without making importation expressly illegal, as long as billfish is recognized as a protected living marine resource.

Billfish Economics
No data exist on consumer purchases of billfish, precluding the estimation of demand models at the consumer level. It is this author's opinion that it would be impossible to estimate an aggregated demand model using exvessel billfish data, except perhaps in Hawaii. Hawaii harvested 2,550mt of billfish with a value of $2.7 million in 2006. Black marlin commanded the highest price at $4.96/kg but striped marlin was the most valuable species due to quantity landed at $1.4 million. Striped marlin has been the most valuable billfish fishery in Hawaii in recent times with the exception of 1995 when black marlin was the highest. In 2006, the United States imported 1,335mt of billfish with a value of $5.2 million, based on FDA customs clearances. Prices are not available from the FDA customs data, so Hawaii ex-vessel prices were used to estimate value in the remainder of this analysis on the domestic billfish import market.

All of the documented domestic harvest of billfish comes from Hawaii. The economic impacts of harvesting, processing, wholesaling, distribution and consumer sales of billfish in Hawaii for 2005 are:

- 346 jobs supported in Hawaii
- $12.5 million in income/value added generated in Hawaii
- $25 million in output

The FDA data were used for the economic impact analysis of US imports in this report. The economic impacts of importation, wholesaling, distribution and consumer sales of billfish into the United States market for 2005 are:

- 328 jobs supported on the mainland United States
- $11 million in income/value added on the mainland United States
- $19 million in output on the mainland United States

The total United States economic impacts of Hawaii harvesting and the mainland importation of billfish in 2005 are:

- 675 jobs supported nationwide
- $23.5 million in income/value added nationwide
- $44 million in output nationwide

To put these estimates in perspective, the $23.5 million in value added generated nationwide represents only 0.071% of $32.9 billion; the value added generated by all seafood industry activities in the United States for 2005.

Finally, a review of the seafood demand literature suggests that the demand for most fish species is highly elastic, although no billfish specific elasticity estimates exist. This suggests that a ban on the importation of billfish would have little consumer welfare impact and whatever welfare impact that was generated would fade quickly. Additionally, the literature found that consumers elasticity is affected by health warnings, as well as "green" or sustainability certifications, which suggests that an informational campaign related to the health impacts of eating an apex predator with high mercury levels or the inability to sustain the harvest of billfish, like the dolphin safe tuna campaign, may be an effective means to drive down consumer demand. Additionally, elastic demand means that the economic impacts of any policy that reduces billfish importation would likely be short lived if felt in the economy at all. However, because billfish are a byproduct of the tuna harvesting process, banning imports or reducing domestic demand may not reduce billfish mortality.

Introduction

In general, billfish are pelagic apex predators that roam the tropical oceans worldwide. For the purpose of this report the term billfish includes the following members of the *Istiophoridae* family: Atlantic and Pacific sailfish (*Istiophorus platyterus*), black marlin (*Istiompax indica*), blue marlin (*Makaira nigricans*), Atlantic white marlin (*Kajikia albidus*), striped marlin (*Kajikia audax*), shortbill spearfish (*Tetrapturus angustirostris*), Mediterranean spearfish (*Tetrapturus belone*), roundscale spearfish (*Tetrapturus georgii*), and longbill spearfish (*Tetrapturus pfluegeri*) (Collette et al. 2006). It does not include swordfish (*Xiphias gladius*). All billfish are listed on Annex I of the United Nations Convention on the Law of the Sea.

This grouping of species provides unique challenges for management for a number of reasons. First, they are highly migratory and their range crosses international boundaries making management subject to negotiated actions across many nations. Second, stock assessments for these species are difficult, if not impossible, to complete (ICCAT 2006; Pepperell 2000). To some extent, their highly migratory nature also makes these species difficult to study, resulting in little knowledge about their life histories, habitat requirements and stock sizes, which are vital components of a stock assessment (ICCAT 2006; ICCAT 2006; Skillman 2000). Removals, an important component for assessing stocks and fisheries for these species, present unique challenges from a catch recording and reporting standpoint

Worldwide, there are three types of fisheries for billfish: artisanal, industrial and recreational. This report will focus predominately on artisanal and industrial fisheries. In a broad sense, artisanal and industrial fisheries are both commercial fisheries. The vast majority of billfish landings come from industrial fisheries as bycatch from tuna purse seines and tuna longlining. Of these two industrial fisheries, the majority of landings come from the longliners. Historically, bycatch, particularly discarded bycatch, is poorly reported. Smaller but growing recently are the artisanal fisheries. These fisheries are characterized by day trips of small boats using longlines, drift gillnets, or other gear. Some of these fisheries are directed at billfish, while within others, billfish is bycatch. These local, coastal fisheries are poorly monitored and, until recently, did not report landings or bycatch consistently. It is generally agreed that any estimate of billfish catch is an underestimate presenting another major problem for stock assessment and management (ICCAT 2006, Uozumi and Matsumoto 2003, Goodyear 2000a, ICCAT 2003, and others).

The bycatch problem is particularly insidious. Compounding the stock assessment and management problems presented by poor reporting of catches, the bycatch issue makes it difficult to construct effective incentives to curtail billfish mortality when it is a negative output of positive, tuna, production process. Goodyear (2000) has shown that the ratio of billfish landed to tuna landed, in some fisheries, is such that even if tuna harvest is at sustainable levels, billfish harvest may be unsustainable. Controlling the bycatch of billfish, thereby reducing the ratio of billfish to tuna harvested, is a way to make billfish management sustainable.

Good management involves examining the economic components of the fishery: business profits, consumer values, and the economic impact of fishing and trade activities. To gauge business profits, data on a businesses costs and returns are needed. Very little is known about the costs and returns for billfish harvesters, and the situation is the same for fish dealers, processors, wholesalers and importers.

There are additional difficulties beyond the lack of data across the businesses harvesting and trading billfish. A problem for fisheries in general is the inability to track landings to the final consumer. This problem is particularly acute for billfish. For imported seafood, tracking information is much less available and reliable than data on the first landing. Once the fish is landed domestically or comes in as an import, there is no way to track final consumption of that fish or at what price the final transaction was made.

This report will describe the billfish stocks, billfish fishery, and trade in billfish species internationally. The market analysis will begin at the international level, and then narrow its focus on the volume, source and type of billfish products being brought into the United States (US). Particular attention will be given to discussion of data deficiencies and discrepancies which make tracking billfish harvest and trade difficult and may indicate the presence of illegal activity.

Billfish Stocks

Caveats abound when examining billfish stocks. In general, the stocks are poorly studied. There is a lack of basic life history, habitat requirements, and stock sizes. This paucity of data occurs on all sides of the stock assessment issue including both fishery dependent data, collected from the participants in the fishery, and fishery independent data, collected from sources independent of billfish removals. To avoid confusion, a few conventions will be followed in this report. A distinction will be made between landings and removals (catch and harvest). Landings are reported at the first sale of a fishery product and that convention will be used here. Removals include fish discarded at sea or not otherwise entered into either a logbook or seen by an observer. Generally, removals require some sort of statistical estimation technique to estimate total removals or they are reported as an underestimate. Typically, landings data is more reliable than removals data, but landings alone do not tell the whole story. Additionally, bycatch also has a number of definitions. For this report, bycatch includes non-target catch that is entered into commerce as well as non-target catch that is not entered into commerce and is discarded.

Currently "accurate stock assessments of (Pacific) pelagic species are not possible with existing fisheries data (Cook 2000 p.185)." Even where stock assessments exist in the Atlantic, there is significant uncertainty in the data quality, and many key biological parameters are not available. All International Commission for the Conservation of Atlantic Tunas (ICCAT) assessments have very large residuals, regardless of the assessment tool used (ICCAT 2006). A short list of assessment needs includes better biological reference points (age, growth, and habitat requirements) and better data on removals. Countries with highly variable data include: Barbados, Benin, Brazil, China, Taiwan, Cuba, Cote d'Ivoire, EC – Spain, Ghana, Grenada, Korea, Panama, USSR, Trinidad and Tobago, US, and Venezuela (ICCAT 2006). Drew et al (2006) states that the biggest reason better production models cannot be estimated for all species is the lack of age and growth data. Where the data is capable of supporting an assessment, stocks appear to have been overfished, or overfishing is occurring in most cases.

A number of abbreviations will be used to describe the status of billfish stocks in this report. Maximum Sustained Yield (MSY) or Average Maximum Sustained Yield (AMSY) describe the fishery yield, or allowable harvest, a stock can sustain into the future. Biomass describes the total size of the stock usually relative to B_{MSY}, or the biomass that generates the maximum sustained yield. Fishing mortality (F) describes the rate of removals and F_{MSY} is the rate of removals that will produce MSY. In the Billfish Stocks section, the state of the science will be described for each species in the Pacific and Atlantic Oceans.

Billfish Stocks

Pacific Billfish

Pacific billfish include black marlin, blue marlin, striped marlin, sailfish, and shortbill spearfish. These species are high migratory apex predators, and this highly migratory and solitary nature makes this group difficult to study (Pepperell 2000). These species move very long distances, some making transoceanic trips (Scott et al 1990, Squire and Suzuki 1990, Pepperell 1990). In addition, stock structures of all Pacific billfish are poorly understood. With regard to stock assessments, there are very few assessments for Pacific billfish (Skillman 2000). Regionally, the least is known about the Indian Ocean stocks as no stock assessments for any billfish in the Indian Ocean have been undertaken (IOTC 2006).

Blue Marlin

Blue marlins are epipelagic and oceanic. Recent research suggests that blue marlins constitute a single worldwide species, and that the Pacific stock is a single, Pacific wide stock (IATTC 2006). The status of Pacific blue marlin stock is uncertain at best. Skillman (1989) puts MSY at 20,000 metric tons (mt) and in 1989 viewed the stock as overfished. Suzuki (1989) held a conflicting view finding the stock to be healthy. Pepperell (2000) stated the stock was 50-90% of the unexploited stock size and that biomass and effort were near AMSY, although he pointed out that there is considerable uncertainty regarding levels of effort that would produce AMSY. Pepperell also believed the stock was at the top of its yield curve and close to fully exploited. IATTC (2006) used a Deriso-Schnute model to assess the stock using 1951-1997 data and estimated that biomass and effort were near those corresponding to AMSY. More recently, an assessment using MULTIFAN-CL found that the level of effort that produces AMSY is very uncertain, but while yield is very near full exploitation, the stock is not over-fished. In the Indian Ocean, no stock assessments have been conducted. As an indicator of abundance, blue marlin landings peaked in 1997 and have been declining since (IOTC 2006).

Black Marlin
Black marlins are epipelagic and oceanic, occurring in tropical, sub-tropical, and sometimes temperate waters (Nakamura 1985). They are also sometimes found in the Atlantic, likely coming around the Cape of Good Hope, but it is not believed that an Atlantic breeding stock exists. It is believed that they form a single Pacific wide stock, but that theory is not based on solid data (Pepperell 2000). Suzuki (1989) believed the stock to be healthy and Skillman (1989) made no determination. There has been no recent formal stock assessment of this species anywhere in its range (Pepperell 2000; IATTC 2006).

Striped Marlin
Striped marlin are epipelagic and oceanic, usually staying above the thermocline. Graves and McDowell (1994) believe that there are three distinct populations of striped marlin: a population in the Indian Ocean and two Pacific stocks separated roughly by the equator. Langley et al. (2006) maintain that stock structure is uncertain and note that there are several theories: single Pacific stock, and two stocks separated by the equator with some Eastern Pacific Ocean mixing, and a semi independent southwest Pacific stock. Because of the stock structure uncertainty, the Western Central Pacific Fisheries Commission (WCPFC) has given stock structure research a high priority (WCPFC 2007).

There have been few stock assessments of striped marlin (Langley et al. 2006; Pepperell 2000). In 1989, Suzuki reported that the south Pacific striped marlin stock was healthy and put MSY at 6,000 – 9,000mt. Suzuki also believed that the north Pacific stock was healthy but did not make an estimate of MSY. Pepperell (2000) held the current biomass to be 50-70% of unexploited biomass.

The Inter-American Tropical Tuna Commission (IATTC) has completed two stock assessments. The Pella-Tomlinson model put AMSY at 3,700 – 4,100 mt, with current biomass at about 47% of an unexploited stock (IATTC 2005). This model suggests that current biomass is greater than would produce AMSY. In this same report, IATTC also estimated a more optimistic Deriso-Schnute model which put AMSY between 8,700 and 9,200 mt with current biomass at 70% of an unexploited stock. Likewise, their estimate of current biomass is greater than would produce AMSY. Average annual catch from 2000-2003 was 2,000 mt, which is well below AMSY from either model. Annual catches have been falling and effort has also declined since 1990. Current and near-term anticipated effort is less than that corresponding to AMSY (IATTC 2005). These additional indicators agree with the two models suggesting that the stock is in good shape.

Recently, the WCPFC completed a stock assessment of striped marlin in the southwest Pacific (Langley et al. 2006) using the MULTIFAN-CL model, and another one is planned for the North Pacific sometime in 2007 (WCPFC 2007). In the Southwest Pacific, catches and size of fish have been declining across longline, purse seine and recreational fisheries, suggesting a declining stock and motivating Australia to fund the stock assessment. For this assessment, the southwest pacific covers the area south of the equator to latitude 40ºS and from longitude 140ºE tow 130ºW. Estimates of MSY ranged from 2,555mt to 3,003mt, B_{MSY} ranged from 8,831mt to 15,610mt, and current biomass ranged from 18% to 57% of the unexploited stock biomass. These ranges represent different assumptions about the underlying stock parameters that rely on uncertain data. Variation in these estimates was driven by sensitivity analysis of the assumptions made about uncertain stock parameters including: age and growth, age-at-maturity, spawning frequency, length weight relationships, migratory patterns, catch, retention and discard data, and historic size data. The striped marlin fishery in the southwest Pacific has supported harvests around 2,400mt per year, within the range of MSY estimated, for the last 20 years with stable effort, and there is no indication that current harvest levels are damaging the stock. However, the sensitivity analysis also produced plausible estimates of current mortality that exceed $F_{MSY,}$ and biomass estimates that are below B_{MSY}. The authors suggest therefore that effort and mortality should not be allowed to increase.

There have been no formal stock assessments for striped marlin in the Indian Ocean. However examination of abundance and catch per unit effort indicate downward trends in both, suggesting potential overexploitation in the Indian Ocean (Bromhead et al. 2004; IOTC 2006).

Sailfish
Sailfish are epipelagic and oceanic usually occurring above the thermocline. Because they congregate near landmasses, it is believed that the stocks may be separate, but very little data exists to establish this claim (Nakamura 1985). Skillman (1989) believed the stock to be healthy while Pepperell (2000) found that no recent assessment had been conducted. Overall there is very little information on this species. In the Indian Ocean, no stock assessments have been conducted. As an indicator of abundance, sailfish landings have been rising dramatically since the early 1990s and continue to increase. (IOTC 2006).

Shortbill Spearfish
Shortbill spearfish are epipelagic and oceanic occurring above the thermocline (Nakamura 1985). The stock structure for shortbill spearfish is poorly understood. It is believed that there is little mixing between the Eastern Pacific Ocean (EPO) and the Western Pacific Ocean (WPO). The EPO stock may be split into an Ecuador and Mexican stock and a Hawaii and North-central Pacific stock,

but the data does not support a definitive separation (IATTC 2005). No formal stock assessment exists for this species (Pepperell 2000). In fact, very little data is available for this species in general.

Issues for Discussion
Skillman (2000) believes that, because billfish is primarily a bycatch species in tuna fishing operations, very little emphasis has been given to assessment of billfish stocks. In general stocks seem healthy, but all assessments, except for striped marlin, are more than 10 years old. Overall, even old assessments struggle with data quality and most are qualitative; based on trends in the data and not production models. Assessments have been sporadic, not consistent, and conducted in isolation. Poor quality commercial removals data is all that is available, and recreational and subsistence harvest has generally been ignored. Because billfish harvest is a by-product of a higher volume and higher value fishery, even when assessments are conducted, they are not directed at a fishery problem, but are produced as a byproduct as well.

Atlantic Billfish
Atlantic billfish include blue marlin, white marlin, sailfish, Mediterranean spearfish, longbill spearfish and roundscale spearfish. The data and research on Atlantic billfish stocks is much better than the assessments of billfish in the Pacific. The better data is due to the International Commission for the Conservation of Atlantic Tunas (ICCAT), a strong international fishery management organization (IFMO). Since 1969, ICCAT has been collecting data, formulating management recommendations and conducting research on tuna and related fisheries. Data on the biology and status of these stocks is taken from ICCAT (2005) unless otherwise noted.

In general, stocks of blue marlin and white marlin are imperiled. In 1998, ICCAT responded to this situation by recommending a 25% reduction in1996 level of landings by 1999. It later amended this recommendation to a 50% reduction in the 1996 or 1999 blue marlin landings and a 33% reduction in the 1996 or 1999 white marlin landings, whichever value is greater. Additionally, all blue and white marlin landed alive had to be released alive. This rule did not apply to dead marlin or marlin not to be sold or entered into commerce.

Blue Marlin
Blue marlin stocks are transatlantic and Trans-Equatorial, ranging in tropical and temperate waters of the Atlantic and adjoining seas. There are two schools of thought on the size of the stock: one an Atlantic wide stock and the other a two stock model with northern and southern stock divided arbitrarily at 5 degrees north. Currently, ICCAT recommends the one stock model based on tagging and DNA analysis (ICCAT 2007).

Stock assessments were conducted in 1996, 2000 and updated in 2007. The 1996 assessment put biomass at 25% of B_{MSY} and mortality about three times F_{MSY}, with overfishing occurring for 30 years and MSY at 4,500mt. The 2000 assessment put biomass at about 40% of B_{MSY} and mortality about four times F_{MSY} with overfishing occurring over the last 10-15 years. This assessment found that the stock was less productive than previously assumed, putting MSY at 2,000mt. In 2007, the assessment was updated with unfavorable results. Biomass had fallen below the 2000 level. Mortality had declined below the replacement (the level needed to recover the stock) and was probably larger than the F_{MSY} from the 2000 assessment. Over the 2001 -2005 time period, several indicators suggest the decline in the stock may have been halted, but other indicators suggest the slide continues. There is still a great deal of uncertainty in the blue marlin data with some sensitivity analysis suggesting more optimism is possible, but additional data is needed.

Overall, research indicates that overfishing of blue marlin stock is occurring and stock productivity is lower than previously estimated. If mortality continues higher than the estimate of replacement yield, the stock will decline further. Uncertainty in the data exists, and although it will be costly to reduce this uncertainty, habitat requirements and verification of historical data are both priorities. ICCAT recommends reducing catch as much as possible by releasing fish alive where feasible, reducing effort fleet wide, improving estimation of dead discards, increasing observer time, and pursuing time/area closures. Additionally, ICCAT recommended in 2000 that a minimum size for the recreational fishery be set at 251cm lower jaw fork length (LJFL). The stock is unlikely to recover if landings contemplated by the 1996 ICCAT report continue. Currently it is too early to tell if the 1998 regulations amended in 2000 are working.

White Marlin

Little is known about the species age, growth and reproductive biology; therefore, no quantitative estimates of these population parameters are available for stock assessments. White marlin are thought to form a single Atlantic wide stock, which was previously believed to be split into northern and southern stocks, similar to blue marlin. Recent research by Shivji et al. (2006) show that roundscale spearfish, a genetically different but morphologically incredibly similar species to white marlin, occurs in the western Atlantic. This finding is likely to confound future assessments by casting doubt on identification of historic landings based solely on morphology.

Although ICCAT's 2000 stock assessment indicated the stock was overfished, there was significant uncertainty about the stock status. A new assessment was undertaken in 2002, but landings, discards, and stock data had not improved significantly since 2000. The 2002 assessment indicated that the stock had been overfished for the previous 20 years. In the 1990s, biomass was about 15% of B_{MSY} and mortality was increasing, reaching more than five times F_{MSY}. In 1996, MSY was estimated at 2,200mt, but that was revised downward to 1,300mt in 2000. In 2007, ICCAT updated these figures and concluded that estimates of biomass were well below the B_{MSY} estimated in 2002. Additionally, mortality is less than replacement mortality and also larger than the 2002 F_{MSY}. Currently, some indices indicate recovery while some indicate continued decline (ICCAT 2006a).

ICCAT recommended that the maximum landings for 2002 and beyond be set at 600mt. Lower catch should increase biomass and stabilize landings long term. Substantial uncertainty surrounds the data used in these assessments, but correcting the problems in the data will be expensive. This fishery needs better monitoring and compliance to meet ICCAT's new harvest goals. It is likely that landings will have to be lowered below the current 600mt limit, but ICCAT recommends waiting for better data. Replacement yield is currently estimated at 222mt (ICCAT 2006a).

Sailfish/Spearfish
Until recently and where landings are concerned, sailfish and spearfish have been treated as one group of fish, and therefore, these two fish are discussed together. Sailfish inhabit the upper water column and form high concentrations in coastal waters, more than any other istiophorid. No transatlantic movements have been recorded for sailfish, suggesting no mixing between the eastern and western Atlantic stocks. Spearfish, on the other hand, occur more offshore, with Mediterranean shortbill spearfish confined to the Mediterranean Sea. The roundscale spearfish was thought to occur only in the east Atlantic and Mediterranean, but recent evidence suggests that they occur in the western Atlantic. Shivji et al. (2007) also found that roundscale spearfish are morphologically very similar to white marlin, and it is likely that these species have been misidentified in the landings data.

In 1991, a combined assessment of all species indicated the stock was at least fully exploited and that fishing mortality had stabilized since the 1980's at a level near MSY. However, the 1994 assessment suggested overfishing. Significant uncertainty surrounded both assessments, because of an inability to separate spearfish from sailfish caught by offshore longline fleet, and a limited number of reliable abundance indices were available. While Japan started separating landings into sailfish and spearfish in 1994, all other nations reported combined landings until recently (ICCAT 2002). As a result, some landings have ended up being unclassified, and, in general, stock assessments have been difficult.

In 2001, some of the data could be separated using ratios developed from the Japanese that had been recording catches separately since 1994. Separate stock assessments were then made, with the western stock assessment deemed more reliable than the eastern stock assessment. Unfortunately, none of the quantitative assessment models stabilized or were able to predict catch per unit effort (CPUE) or catch. Instead qualitative assessments were made. The combined western sailfish/spearfish assessment indicated the harvest may be sustainable as catches and CPUE have remained stable. However, it is not known if the stock is at, above, or below MSY. For the western sailfish only assessment, harvests have been stable around 700mt annually for the past 20 years. Additionally, abundance indices have remained relatively stable, but MSY is undetermined. For the eastern sailfish only assessment, it appears that abundance is decreasing and catches have fallen as well; therefore, there are concerns about sustainability. There have been no assessments for longbill spearfish or Mediterranean spearfish.

More research needs to be done looking at the use of formulas to split sailfish and spearfish catch. It is unknown if the stock is overfished or if overfishing is occurring in the western or eastern Atlantic. Currently, the only reliable way to judge the status of the stocks is to examine CPUE and catch trends. For the western stock, CPUE was highest in the 1960's and decreased until the 80's with CPUE stabilizing since. Additionally catch has remained stable for the last 20 years, so current mortality is viewed as sustainable. For the eastern stock, abundance indices and catch are down; therefore, concern is warranted and regulations may be needed if trends continue. Currently there are no sailfish or spearfish regulations in place.

Billfish Fishery

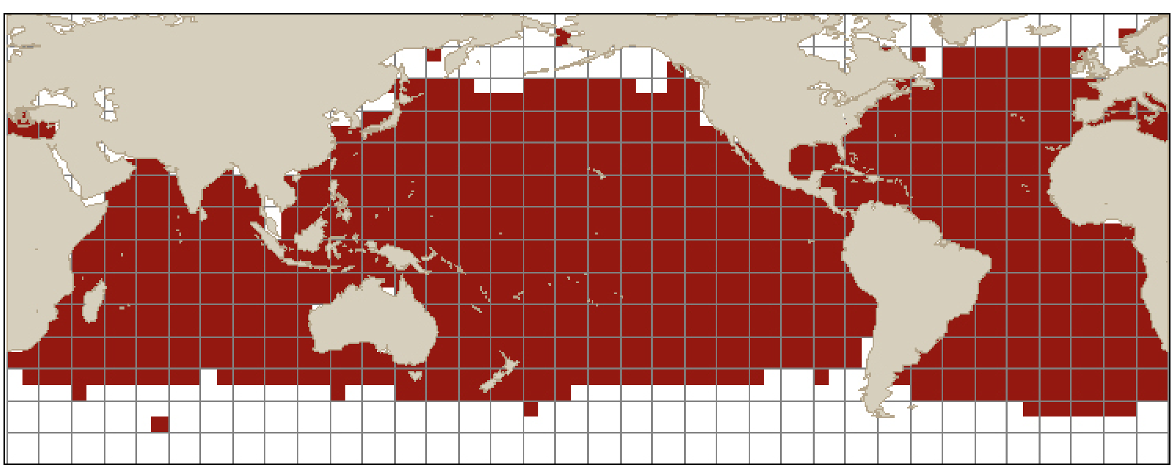
There are two types of commercial billfish fisheries: industrial and artisanal. Industrial fisheries can be characterized by highly capitalized boats fishing multiple day trips on the high seas to produce fish for the global market. None of the industrial fisheries target billfish, but catch billfish as bycatch in the pursuit of tuna or other pelagic species. The majority of the billfish bycatch from industrial fisheries comes from tuna longline fisheries and the second highest removals come from the tuna purse seine fisheries (Pepperell 2000, Skillman 2000). Longline effort occurs worldwide in tropical, sub-tropical and temperate waters, Figure 1. Purse seine fisheries cover much less water geographically, Figure 2. It is thereby impossible to discuss billfish harvest without discussing the tuna fisheries.

By in large, purse seine harvested tuna are destined for the cannery, and longline caught tuna are destined for high grade product for the sashimi or fresh seafood market (Heberer 2000). Because tuna is the primary target, it is often the only species reported. Often billfish is only recorded when it is landed and much billfish is discarded dead. Therefore, billfish removals by the longline fleet are generally underestimates. Purse seine fleets have historically had much better observer coverage, so discard/bycatch data for the purse seine fleet is much better than the longline fleet. However, because observer coverage is not 100%, bycatch is still only estimated in this fishery and likely an underestimate.

Artisanal fleets, on the other hand, consist of small vessels fishing primarily day trips in coastal waters producing fish for local consumption. Artisanal fleets target billfish in some cases, but also catch billfish mostly as bycatch of drift gillnets, longlines, and hand gear. Reporting by artisanal fisheries is very inconsistent but getting better.

In recent years, offshore longlining has been expanding, both in numbers of vessels and geographical scope, particularly in the western, eastern, and southern

Figure 1. Global Distribution of Longline Effort.Carocci and Majkowski 1998.

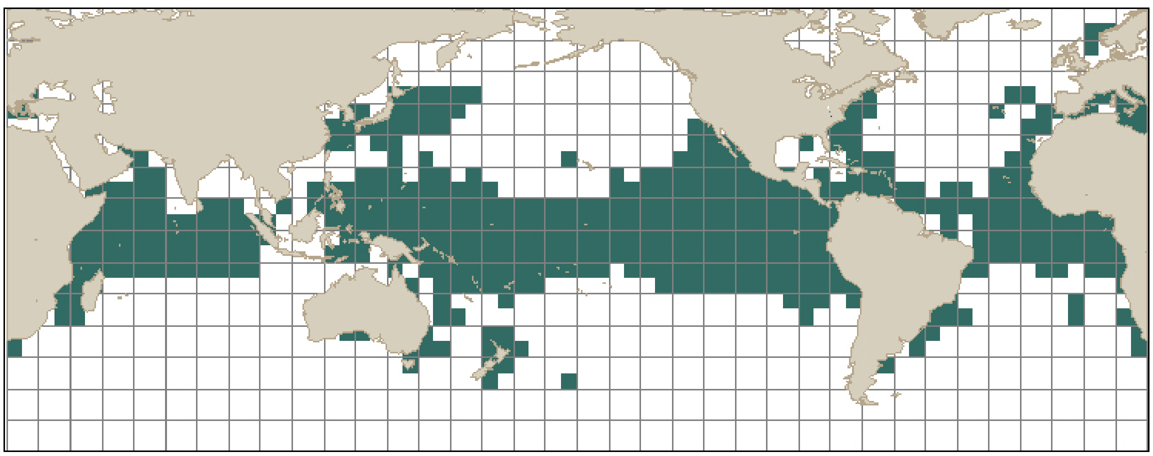


Atlantic Ocean, the Caribbean Sea, and West Central Pacific Ocean (ICCAT 2005; Langley et al. 2006). This intensification is being driven by increasing demand for tuna and increasing regulation of nations' exclusive economic zones (EEZ). As EEZ regulations tighten, fishing is moving farther offshore (Pepperell 2000). It is expected that unless market for billfish strengthens, CPUE of billfish should decline with better targeting of tuna.

continue due to the improvements in sportfishing technology and the expansion of the locales offering recreational billfish fishing opportunities.

In the remainder of this section, the character of billfish harvest will be detailed by Pacific and Atlantic regions. The most complete source for billfish landings data is the Food and Agriculture Organization's

Figure 2.Global Distribution of Purse Seine Effort.Carocci and Majkowski. 1998.



Artisanal fisheries are on the rise as well, and recent coastal gillnet landings have become important (ICCAT 2002). Coastal gillnets are low cost and very widespread in artisanal fisheries. Therefore they are virtually impossible to closely monitor (Hall and Williams 2000). Table 1 shows the level of gillnet vessels fishing in 1999 by country and the number is substantial. Most gillnet bycatch are dolphins, but billfish are a significant constituent of bycatch in some fisheries (Hall and Williams 2000).
Finally, recreational effort has also been on the rise. This rise is expected to

Table 1. Number of Gillnet Vessels by Country in 1999. Hall and Williams 2000.

Country	Number of Vessels
India	>150,000
Indonesia	48,000
Iran	2,600
Korea	14,000
Malaysia	11,700
Peru	>2,500
Portugal	11,000
Sri Lanka	3,500
West Africa	40,000

(FAO) Fishstat database. FAO warehouses global billfish landings supplied by the various IFMO's, including the ICCAT Task 1 data. FAO data will be used in the remainder of this report when referring to landings unless otherwise noted.

In 2004, 26,765mt of blue marlin was harvested, making it the most harvested species of billfish worldwide. The second most harvested species was Indo-Pacific sailfish at 25,722mt. Billfish that were not classified or not elsewhere included (NEI) constitute the third most caught species at 23,658mt. Figure 3 shows the harvest of all species of billfish by species for 2004, the last year of complete data from the FAO.

Since 1984, blue marlin has been the most caught species, except 1997, 1998 and 1999 when billfish NEI was the most caught. This was likely due to regulations put in place by ICCAT, which will be discussed in greater detail below. Pacific sailfish harvest is on the rise, most likely due to the increasing effort from coastal, artisanal fleets. Figure 4 shows a time trend of billfish landings by species.

Table 2 contains the top ten billfish harvesters, ranked by average mt landed during 2000-2004. Historically, Japan landed the most billfish, but they have been surpassed by Taiwan and Sri Lanka in recent years. Taiwan has been expanding its longline fleet in recent years and, on average, lands 22,777mt per year. Sri

Figure 3. Composition of Billfish Catch by Species from FAO Data in 2006 .

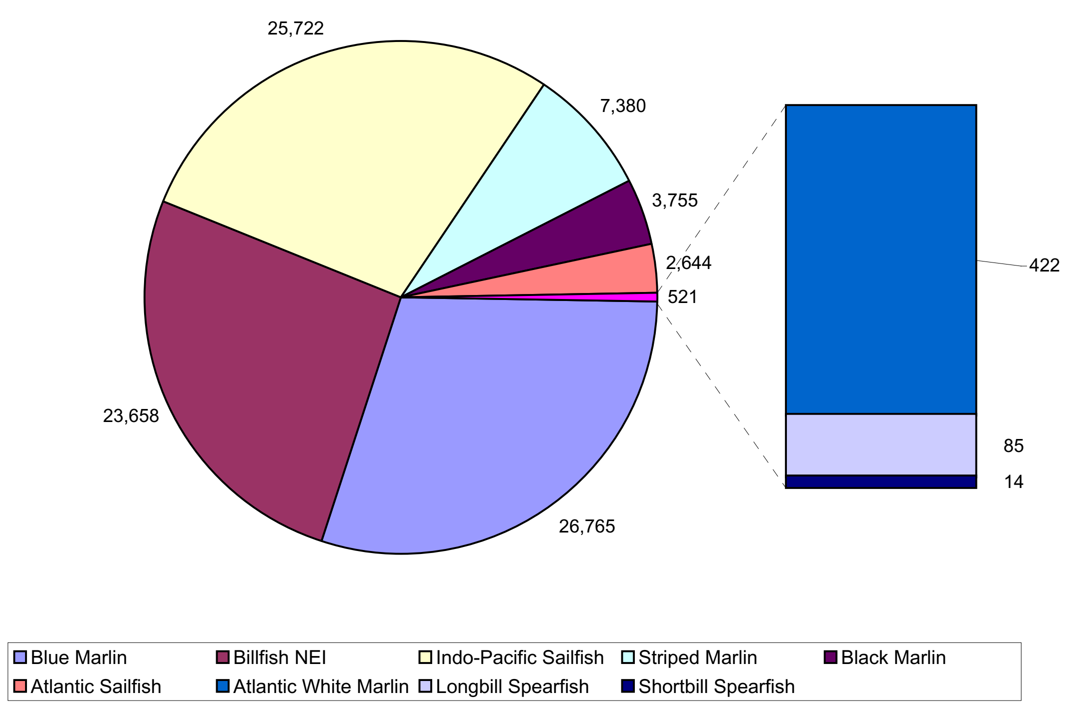
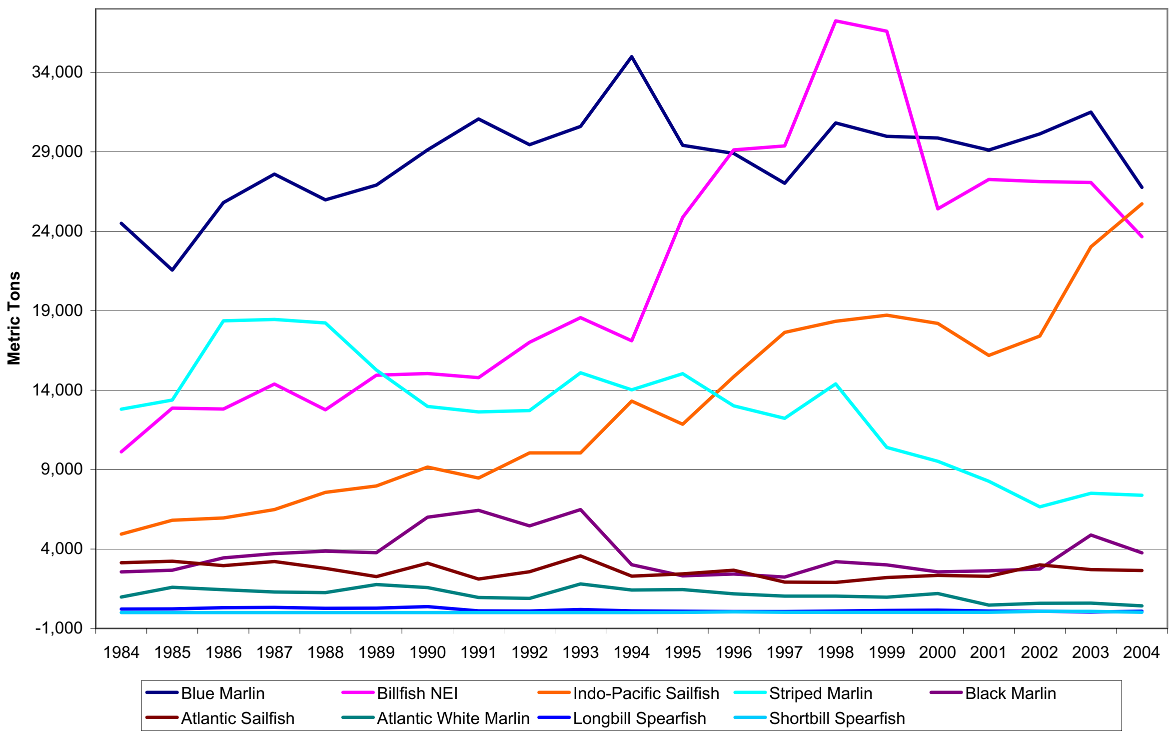


Figure 4. Billfish Landings by Species from FAO Data, 1984-2004.



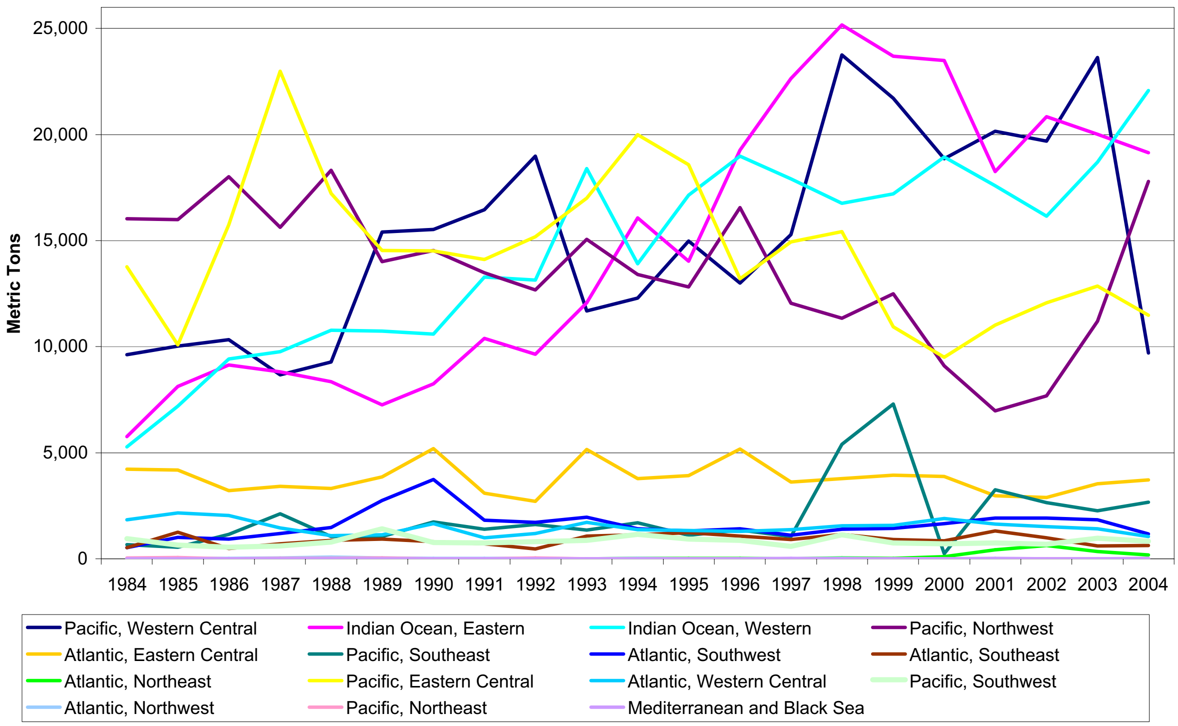
Lanka and Japan land 11,542mt and 11,306mt annually, and these countries have swapped second and third place a number of times in the last five years.

Figure 5 shows a time trend of the regional harvest of billfish. In 2004, the western Indian Ocean harvested the most billfish of any region, but in recent years the western central Pacific and eastern Indian Ocean have consistently landed the most billfish. Through the 1980s, the east central and northwest Pacific landed the most billfish, but the landings from these areas have been on a slight downward trend since, except for the northwest Pacific, which jumped to the third highest landings in 2004. Since 1984, most Atlantic billfish harvests came from the eastern central Atlantic followed by the southwest Atlantic, the southeast

Table 2. Top Ten Billfish Harvesters Ranked by Average Landings (mt) from FAO Data During 2000-2004.

Country	2000-2004 Total (mt)	2000-2004 Average (mt)
Taiwan	113,887	22,777
Sri Lanka	57,710	11,542
Japan	56,531	11,306
Philippines	40,052	8,010
Iran	29,850	5,970
India	20,867	4,173
Indonesia	20,640	4,128
Korea, Republic of South	18,771	3,754
Costa Rica	10,447	2,089
Ecuador	7,500	1,500

Figure 5. Volume (mt) of Billfish Landings by Region from FAO Data, 1984-2004.



Atlantic, and the northeast Atlantic respectively. Overall, Atlantic landings are far lower than landings from the Pacific. In 2004, the total Pacific yield was 83,677mt and in the Atlantic it was 6,753mt.

Pacific Fishery

Longline bycatch in the Pacific produces the majority of the billfish landings. Table 3 shows the relative amounts of bycatch in metric tons across gear types in the Eastern Pacific Ocean (EPO). From this table, longlines in the Pacific took 48% of the billfish landings in 2004 and the purse seine fleet took 38%, with miscellaneous gears taking the remainder. Unfortunately, data on longline bycatch in the Pacific is very sparse, and unless the fish enters the commercial landings, it is generally not recorded. That is changing for the better with increases in observer coverage for this fleet.

The purse seine fleet in the Pacific also lands a significant amount of billfish. In the tropical Pacific, black, blue, and striped marlin, sailfish and shortbill spearfish are abundant in the catch of purse seine vessels, occurring at the rate of at least one fish per set. In the purse seine fishery there are three types of sets: log sets associated with floating debris, school sets where an identified school is encircled, and dolphin sets where dolphins are used to indicate a school of tuna. In the subtropical pacific, black and blue marlin, sailfish, and shortbill spearfish are abundant in catch, occurring at the rate of at least one per set on average. Striped marlin in the sub-tropical pacific are often target species and usually abundant in sets, if not targeted. In the temperate Pacific, black, blue and striped marlins, sailfish and shortbill spearfish are seldom caught and

Table 3. Number of Pacific Billfish Caught as Bycatch by Gear Type. IATTC 2005.

Species	Object	Purse Seine Unassociated School	Dolphin	Pole & Line	Longline	Other	Total
Blue Marlin	308	12	8	0	416	73	817
Striped Marlin	8	4	8	0	214	33	267
Black Marlin	99	8	16	0	4	0	126
Sailfish	3	19	45	0	48	87	202
Shortbill Spearfish	<1	<1	<1	0	0	0	<1
Total Billfish	418	43	77	0	682	193	1412

are considered rare with one taken every few months. Usually bycatch is associated with a season or an area in temperate regions. Across the entire Pacific 71% of all purse seine sets contain bycatch, and about 2.4mt of each set is discarded with 2% of that bycatch being billfish (Hall and Williams 2000). In the EPO Pacific sailfish are by far the most abundant in dolphin and school sets with blue, black and striped marlin distant followers (Hall and Williams 2000). EPO log sets are the opposite with blue and black marlin most abundant (Hall and Williams 2000). Blue and black marlin are the most common in Western Pacific Ocean (WPO) school and log sets (Hall and Williams 2000).

Hall and Williams (2000) summarized billfish bycatch by the EPO and WPO, which is displayed in Table 4 by pounds per set and in Table 5 by number of billfish per 1,000mt of marketable tuna. In Table 4, log sets are responsible for the majority of the bycatch across all species, with the exception of sailfish that is predominantly caught in school sets. Table 5 expresses the same conclusions as Table 4, but relates bycatch to the tuna fishery that drives the catch of billfish as bycatch. Australian fisheries have logbooks that record billfish catch, and in 1994 their fleets caught 182,280 billfish, or 6.6% of the nation's purse seine catch, with striped

Table 4. Pounds of Pacific Billifish Purse Seine Bycatch per Set. Hall and Williams 2000.

	Eastern Pacific Ocean			Western Pacific Ocean	
Species	Dolphin	School	Log	School	Log
Blue Marlin	0.006	0.022	0.165	0.062	0.071
Black Marlin	0.007	0.02	0.148	0.063	0.079
Striped Marlin	0.007	0.02	0.148	0.063	0.079
Shortbill Spearfish	0.002	0	0.001	0	0
Unclassified	0.004	0.006	0.055	0	0
Sailfish	0.052	0.114	0.014	0.01	0.006
Swordfish	0.001	0.003	0.013	0.006	0
Total Billfish	0.079	0.185	0.544	0.204	0.235

Table 5. Number of Pacific Billfish Caught as Bycatch per 1,000mt of Marketable Tuna. Hall and Williams 2000.

	Eastern Pacific Ocean			Western Pacific Ocean	
Species	Dolphin	School	Log	School	Log
Blue Marlin	0.4	1.5	5	2.4	2
Black Marlin	0.4	1.3	4.5	2.4	2.2
Striped Marlin	0.4	1.3	2	0	0.1
Shortbill Spearfish	0.1	0	0	0	0
Unclassified	0.2	0.4	1.7	0	0
Sailfish	3	7.8	0.4	0.4	0.2
Swordfish	0	0.2	0.2	0	0
Unidentified	0.1	0.2	0.4	0.2	0
Total Billfish	4.6	12.7	14.2	5.4	4.5

marlin (34%) making up the majority of the billfish bycatch (Hall and Williams 2000). Observers had the total billfish caught at 186,624, or 6.7% of the purse seine catch, with about 30% of the shortbill spearfish, 20% striped marlin, a relatively good match with the logbook data (Hall and Williams 2000). New Zealand fisheries average catching 678 billfish with their domestic fleet and the Japanese fleet averages 1,446 billfish, as reported in their New Zealand logbook. In the Western Tropical Pacific purse seine fisheries, billfish make up 15.8% of the total catch, including swordfish (Hall and Williams 2000). 5.6% of the catch is blue marlin and 6.2% is swordfish (Hall and Williams 2000). The Western sub-Tropical Pacific purse seine catch is 3.1% shortbill spearfish, and 3.1% striped marlin. Logbook data is not complete in this fishery, and estimates should be considered lower bounds at best (Hall and Williams 2000). In the past, Japan has dominated the landings of Pacific billfish, but in recent years, Taiwan has greatly expanded their longlining operations, surpassing Japan as the largest harvester of billfish in the Pacific (Langley 2006).

The IOTC reports that 70% of the marlins are caught on longlines while 20% are caught in drift gillnets in the Indian Ocean. The remaining 10% of marlin landings come from troll and hand lines. The bulk of the Indian Ocean marlin landings comes from the Taiwanese and Japanese fleets, although Indonesia and several other not elsewhere included (NEI) fleets catches are on the rise. For sailfish and shortbill spearfish in the Indian Ocean, 99% of the landings are sailfish. The sailfish are mostly harvested from drift gillnets (80%), 10% from troll or hand lines and 7% from longlines. Shortbill spearfish are all caught using longlines. Sailfish landings have increased dramatically since the 1980s, due mainly to Sri Lanka's expansion into gillnetting and longlining. It is likely that both sailfish and shortbill spearfish are underreported because of their low relative value. Overall the IOTC indicates that reporting for nations fishing in the Indian Ocean is poor (IOTC 2006).

The US operates a large fleet in the western and central Pacific Ocean, mainly ported in Hawaii and California (NOAA 2006). Purse seine vessels make up 82%

Table 6. Hawaiian Billfish Landings by Volume (kg), Value (US Dollars) and Species 2002-2006.

Year	Species	Volume in kg	Price/kg	Value (US Dollars)
2002	Billfish	44	$3.31	$147
2002	Marlin, Blue	397,201	$2.56	$1,018,654
2002	Marlin, Black	3,664	$2.56	$9,382
2002	Marlin, Striped	278,954	$3.53	$982,496
2002	Spearfish	142,477	$1.90	$269,238
2002	Sailfish	4,993	$3.09	$15,415
2003	Billfish	974	$3.02	$2,936
2003	Marlin, Blue	435,350	$1.90	$825,183
2003	Marlin, Black	1,846	$2.36	$4,374
2003	Marlin, Stripped	622,934	$1.85	$1,155,931
2003	Spearfish	234,814	$1.12	$265,367
2003	Sailfish	1,584	$1.70	$2,678
2004	Billfish	310	$2.91	$906
2004	Marlin, Blue	407,166	$2.73	$1,111,304
2004	Marlin, Black	3,216	$3.44	$11,039
2004	Marlin, Striped	423,960	$3.17	$1,347,960
2004	Spearfish	200,978	$2.14	$430,870
2004	Sailfish	3,439	$2.84	$9,758
2005	Billfish	143	$2.23	$318
2005	Marlin, Blue	421,949	$2.31	$972,110
2005	Marlin, Black	1,063	$2.58	$2,740
2005	Marlin, Striped	541,260	$2.84	$1,536,412
2005	Spearfish	212,167	$1.98	$420,144
2005	Sailfish	3,366	$2.51	$8,480
2006	Billfish	28	$4.96	$137
2006	Marlin, Blue	399,928	$2.25	$902,553
2006	Marlin, Black	3,468	$2.54	$8,799
2006	Marlin, Striped	593,331	$2.43	$1,435,002
2006	Spearfish	151,886	$2.34	$356,008
2006	Sailfish	8,168	$1.85	$15,084

of the harvest in this fishery. From this fishery, tuna is landed frozen in American Samoa and billfish is transshipped to foreign markets, but usually not to the US. Longline harvest makes up 14% in this fishery, producing mostly fresh product for Hawaiian consumption. Although a small portion is transshipped to other US markets, another small portion is exported to foreign countries. The distant water troll fleet lands only 1% of the catch in this fishery, which is mostly albacore for the US market. Finally, the small-scale boats take 3% of the harvest and these participants can best be described as Hawaiian artisanal fishermen taking day trips to catch local fresh product with some effort directed at billfish. With fuel prices continuing to rise and tuna prices stable, the purse seine and distant water troll fleets will continue to decline. See Table 6 for landings of billfish in Hawaii.

In the Pacific, the majority of the landings come from northwest of Australia. Figure 6 shows the catch distribution of both Pacific and Atlantic blue marlin. The majority of black marlin harvests come from areas north of Australia and east of Indonesia. Figure 7 shows the catch distribution for black marlin. The majority of striped marlin harvest is taken just west of Central America. Figure 8 shows the catch distribution for striped marlin. There is little geospatial information for Pacific sailfish or shortbill spearfish catch. Overall, consistent and complete data on the removals of billfish in the Pacific is lacking.

Atlantic Fishery

Data on the Atlantic fishery is far better than the data on the Pacific fishery. Even so, catch estimates are believed to be underestimates due to underreporting of dead discards (ICCAT 2005). The majority of the bycatch in the Atlantic is from high seas longlining. Japan is by far the biggest player in this industry, setting 100 million hooks annually and taking 10% of all the white marlin and 35% of all blue marlin (ICCAT 2006).

For white and blue marlin, sailfish and spearfish, most of the landings are incidental take from offshore longlining by Brazil, Cuba, Japan, Korea, Taiwan and others. There are directed recreational fisheries for white and blue marlin off the US, Venezuela, Bahamas, Brazil, and many other countries off West Africa and in the Caribbean Sea (ICCAT 2005). White marlin are also subject to an artisanal fishery in the Caribbean and West Africa (ICCAT 2005). Sailfish and spearfish landings have a major artisanal component and the size of that fishery is increasing. Tropical purse seining also generates incidental catch, particularly with log sets. In 2001, the US instituted time/area closures to reduce interaction with blue marlin. It is suspected that there are some Illegal Unregulated and Unreported (IUU) landings of all Atlantic billfish, but no available market data allows an estimate like bigeye or bluefin tuna.

The blue marlin commercial fishery developed in the 1960s peaked in 1963 with 9,000mt. It decreased to 2-3mt from 1967 – 1977, increased between 1978 and 1996 and has decreased thereafter (see Figure 4). Figure 9 displays the spatial distribution of blue marlin catch by gear type. This figure indicates that the majority of harvest comes from longline gear and occurs off the coast of South America. In this figure, the other (OTH) gear type is artisanal drift gillnets, for the most part, indicating that this gear makes up a significant portion of mortality in many regions, particularly West Africa.

The white marlin commercial fishery developed in the 1960's, peaked at 5,000mt in 1965. It declined to 1,000mt a year between 1977-1982, fluctuated between 1,000mt and 2,000mt through 1999, and has remained at less than 1,000mt since 2000. For white marlin, there has been a shift in landings to the southern hemisphere; see Figure 10. White marlin catch follows the same general patterns as blue marlin: longline gears predominate, most of the catch is off South America and artisanal fisheries play an important role in some regional fisheries.
Figure 11 shows the distribution of sailfish and spearfish catches combined. Much of the sailfish is caught east of South America

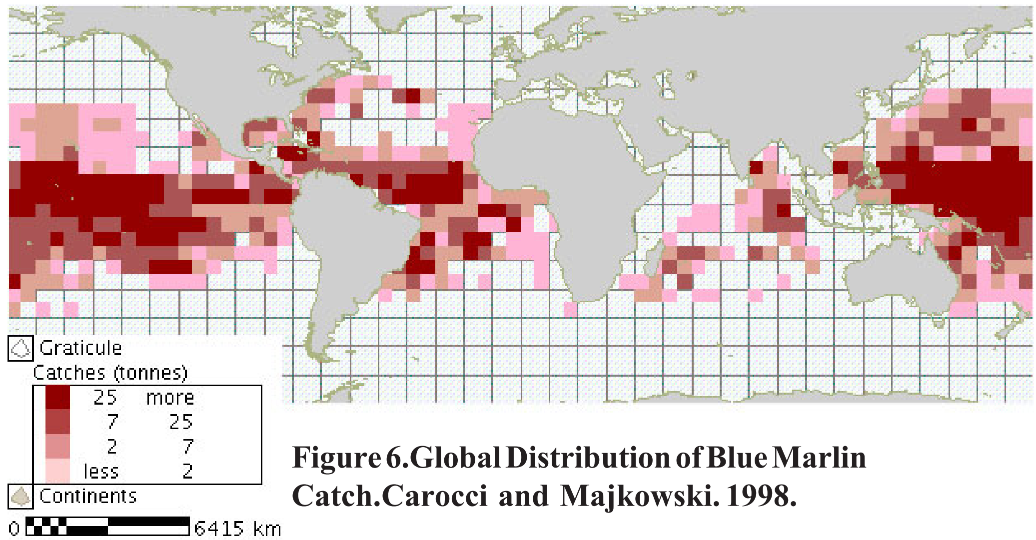


Figure 6.Global Distribution of Blue Marlin Catch.Carocci and Majkowski. 1998.

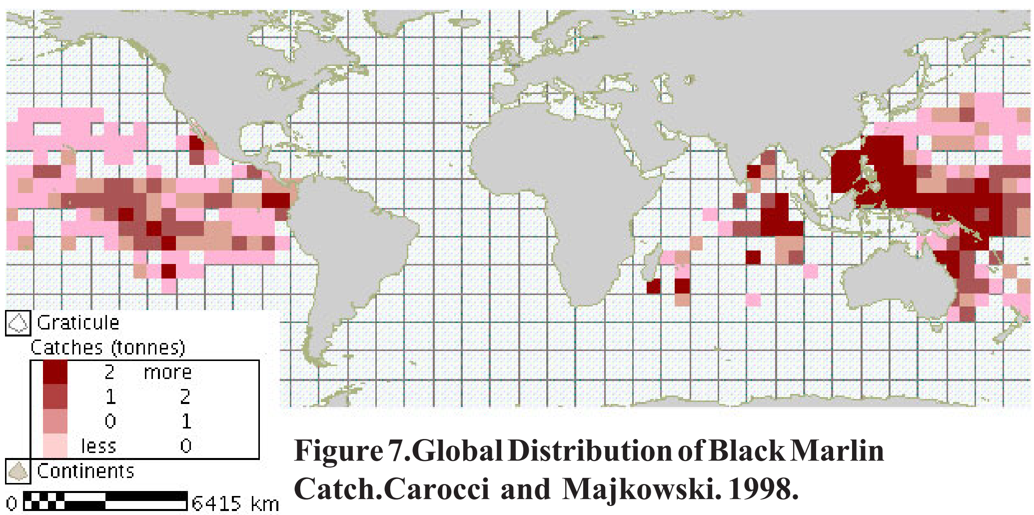


Figure 7.Global Distribution of Black Marlin Catch.Carocci and Majkowski. 1998.

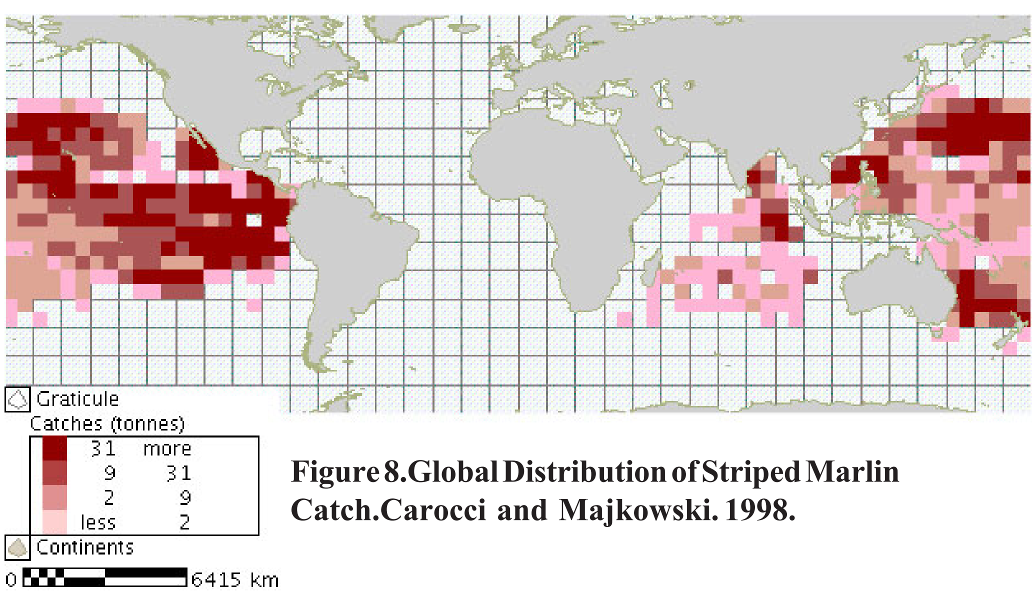


Figure 8.Global Distribution of Striped Marlin Catch.Carocci and Majkowski. 1998.

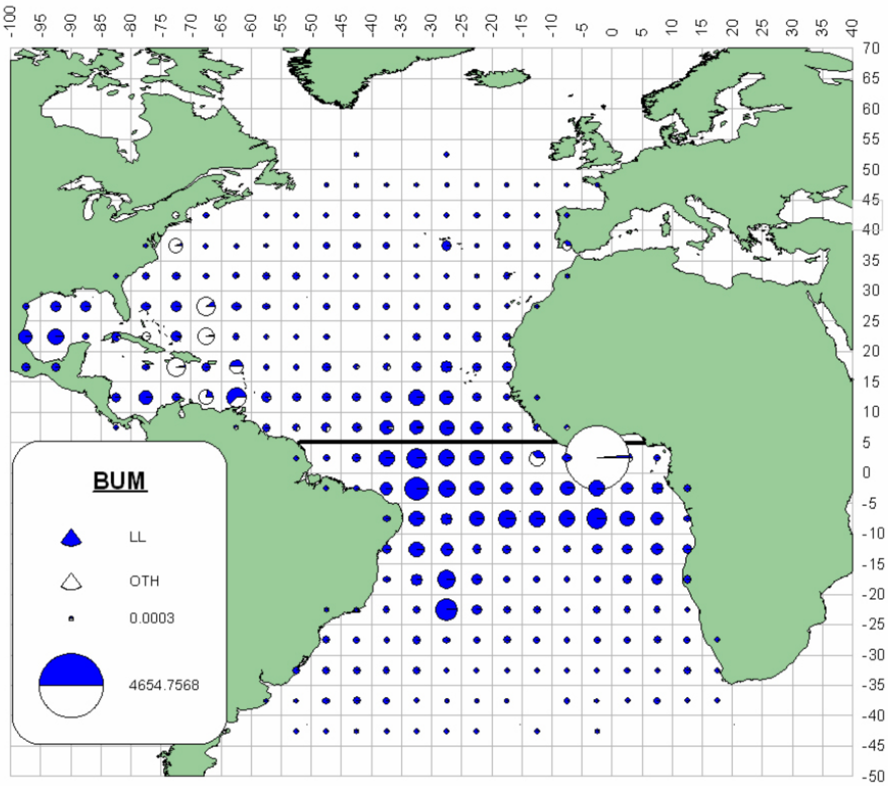


Figure 9. Distribution of Atlantic Blue Marlin Catch by Gear Type. ICCAT 2006a.

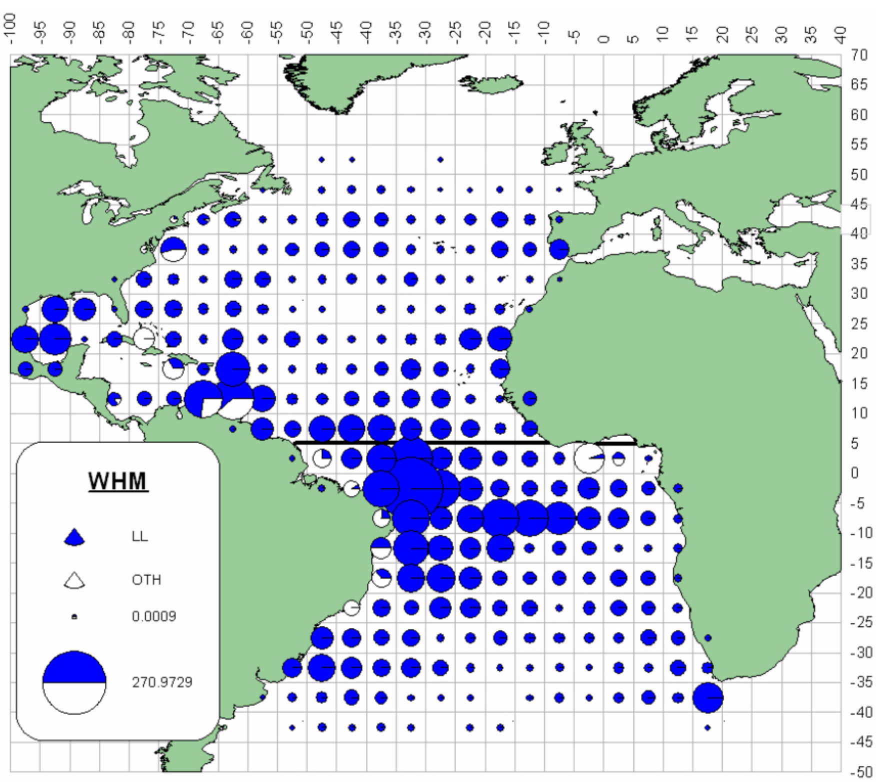
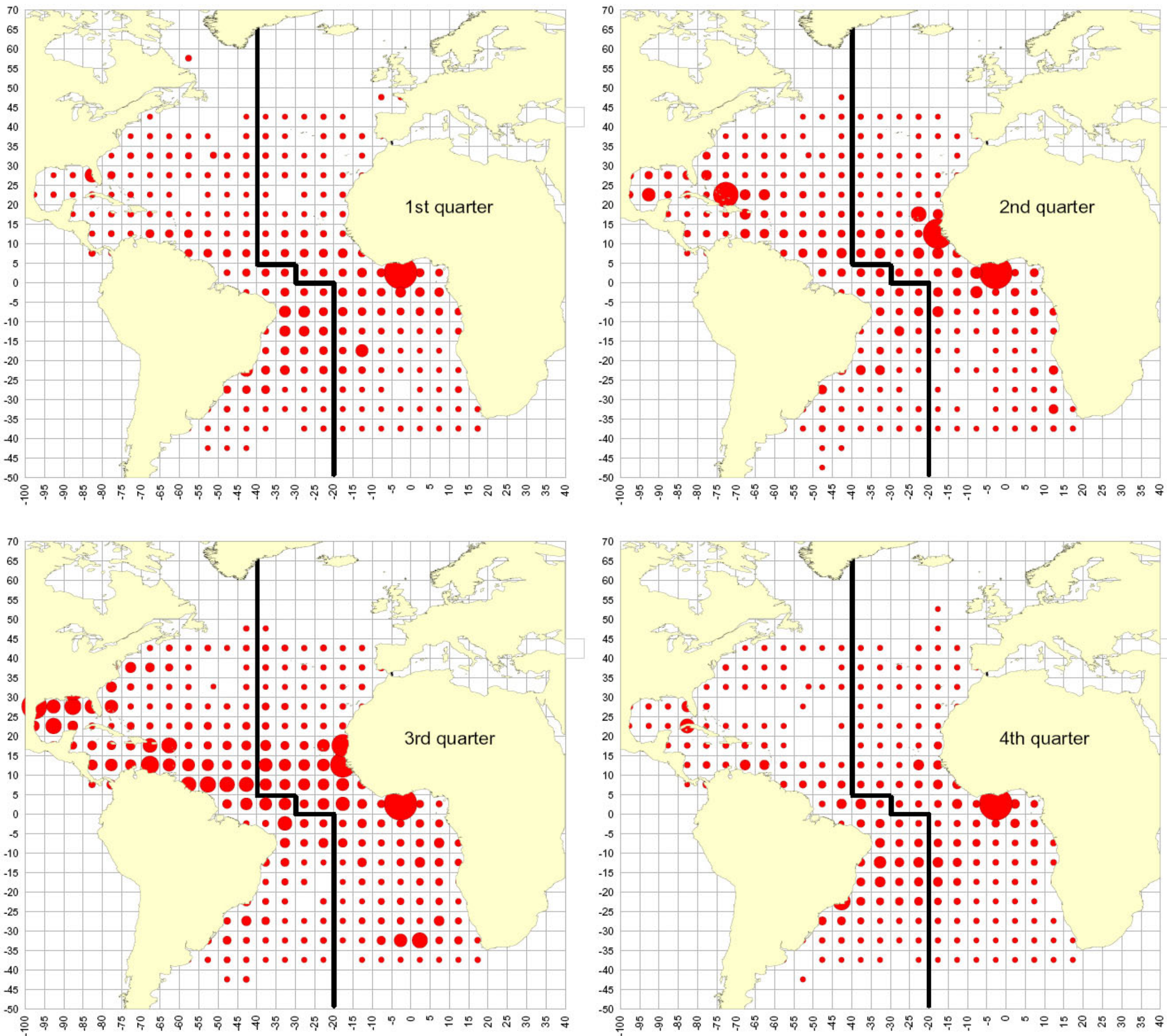


Figure 10. Distribution of White Marlin Catch by Gear Type. ICCAT 2006a.

Figure11.Global Distribution of Sailfish/Spearfish Catch by Quarter. ICCAT 2007.



and west of Africa. Again these stocks are harvested heavily by West African nations in their artisanal fleets.

Additionally, for all Atlantic billfish, gear changes, tightening of regulations and the falling market importance of billfish may have led to fewer landings being reported in recent years. Also, very little discard data has existed in these fisheries until recently. Spain has reported that 16.3% of billfish caught are released dead, 2.5% are released alive and 2.4% are tagged and released (ICCAT 2006a). Japanese longline discards from observer data show that their fleets land 45% of blue marlin alive and less than 30% of white marlins alive (ICCAT 2006a). The Japanese logbook program does not record releases. Catch of Gulf of Mexico longliners is 16% billfish, including swordfish. Of that 16%, 10% is white marlin and 3% is swordfish (ICCAT 2006a).

Recreational Fishery

The recreational billfish fishery developed in the late 19th century and was popularized by Zane Grey and Ernest Hemingway. The billfish are highly esteemed sportfish and have a place of status in the recreational psyche as evidenced by the use of billfish images in logos and advertisements (Pepperell 2000). Recreational mortality peaked in the period of time between 1920 and 1950. During the 1960's a tag and release ethic became prevalent and mortality has been on the decrease since. Unfortunately, recreational catch and effort data is very spotty, even in Australia, which is known for its good commercial record keeping (Pepperell 2000). It is generally accepted that recreational harvest is dwarfed by commercial harvest, except in some sailfish fisheries when it is possible to separate out sailfish catch from spearfish catch (ICCAT 2006a). The US has collected data on the Pacific Coast since 1969 using end of season catch cards that also collect effort information. It is voluntary and therefore likely overestimates catch as more successful anglers are more likely to report. In 1992, the US started a similar program on the East Coast in the states of Maine through Virginia. Trends in the fishery indicate decreasing catch and CPUE, which may indicate declines in the stock (ICCAT 2006a).

Laws and Legality

Because stocks of billfish are highly migratory, nations must collaborate in IFMOs to achieve conservation goals for these species. The single most important international treaty giving IFMOs the authority to manage straddling stock is the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (hereinafter UN Straddling Stocks Treaty). This treaty set out a series of conservation strategies including (Spear 2000):

•Establish precautionary thresholds that will help prevent overfishing and trigger recovery measures in depleted fisheries.

•Minimize pollution, waste, discards, catch by lost or abandoned gear, catch of non-target species, and impacts on associated or dependent species.

•Develop and use to the "extent practicable" selective fishing gear to reduce waste and by-catch.

•Adopt plans necessary to conserve non-target species of fish, marine birds, and other marine wildlife that are inadvertently caught and killed in fishing gear, including protection of habitats of special concern and protection of biodiversity in the marine environment.

The treaty also contains provisions for data collections including: a time series of catch and effort statistics by fishery and fleet, total catch by species (target and non-target species), discards by species, effort by gear, effort location, date and time fished, and other data as appropriate. It is clear from the information shortfalls noted in both the stock and fishery sections of this report that these provisions are not being followed sufficiently. As stated above, FAO warehouses all of this data at the international level. The treaty requires several things from participating nations: cooperate with one another if there is no existing IFMO, allow only nations cooperating in an IFMO to participate in that IFMO's fisheries, and authorize individual states to enforce IFMO rules and provisions. The enforcement provisions are far reaching, allowing nations and IFMO enforcement staff to board vessels suspected of violating IFMO rules and allowing detention of violating vessels and requiring compulsory binding dispute resolution as set forth in the Laws of the Sea Convention (LOS). Additionally, flag states must ensure their fleet adheres to the IFMO rules, putting the discovery burden and enforcement burden on the flag states. Re-flagging vessels to avoid IFMO regulations violates the treaty. As of June 2007, only 66 nations have ratified this treaty; and many nations landing billfish in this report have not ratified this treaty.

Currently, the list of IFMOs in the Pacific include: IATTC, South Pacific Permanent Commission, South Pacific Forum Fisheries Agency, South Pacific Commission, Commission for the Conservation of Southern Bluefin Tuna, Asia-Pacific Fishery Commission, Indian Ocean Tuna Commission (IOTC), Indian Ocean Fisheries Commission, and recently, the West Central Pacific Fisheries Commission. A geographic gap in the IFMO coverage exists in the Northwest Pacific Ocean, which in 1990 landed 57% of the striped marlin, 87% of the black marlin, and 84% of Pacific sailfish. There are also a number of functional gaps in these IFMOs. For example, IATTC is one of the best at collecting data consistent with the UN Straddling Stocks Treaty, but it still does not follow all of the provisions including adhering to the precautionary principle, or enforcement and flag state responsibilities. For the Atlantic, ICCAT is the only IFMO responsible for tuna and other highly migratory species. Because the Atlantic is smaller than the Pacific and is governed by only one mature IFMO, ICCAT does a much better job adhering to the UN Straddling Stocks Treaty than any IFMO in the Pacific.

After four years of negotiation, the convention to start the WCPFC was open for signature in 2000 and became a functioning IFMO in June 2004, covering the western and central Pacific. The WCPFC has 25 members and three participating territories. Scientific data management functions are, temporarily, housed within the Secretariat for the Pacific Community. While the youngest IFMO, it has taken on an impressive regulatory and scientific agenda.

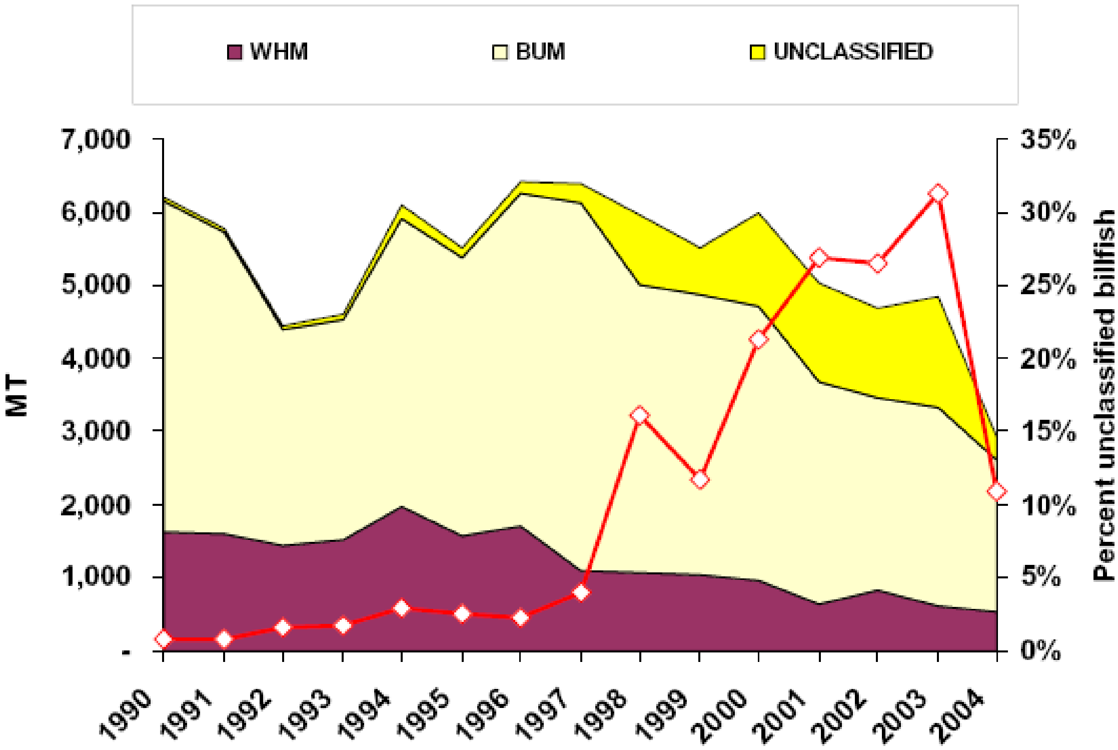
For the Atlantic, ICCAT has passed new strict rules regarding blue and white marlins (ICCAT 2006b). In 1998, ICCAT called for a 25% reduction in blue marlin and white marlin landings from purse seine and longline vessels from the 1996 or 1999 levels, whichever is higher. These rules were amended in 2000 to include a 50% reduction in blue marlin landings from purse seine and longline vessels from the highest of 1996 or 1999 levels and a 33% reduction in white marlin levels using the same period as a reference. All fish landed alive are to be released alive unless the fish is entered into commerce. This measure is an attempt to reduce dead discards. All purse seine and longline vessels are to maintain daily records of live and dead releases of blue and white marlin by 5x5 degree fishing area and be verified with 5% observer coverage of all sets. All billfish tournaments are to be monitored with 5% coverage, and the US is to maintain 10% coverage. The US is to limit recreational landings to 250 blue and white marlin combined annually through 2010. Recreational fisheries are to set a minimum size for marlin: blue marlin at 251cm LJFL minimum size and white marlin at 168cm LJFL minimum size.

Additionally, all contracting parties, non-contracting parties, entities and fishing entities are required to record weight or number of blue and white marlin. For the same parties, catch and effort data is required for all landed marlin with size measured and recorded for 50% of landed marlin. All efforts are to be made to reduce post release mortality through the use of circle hooks. Artisanal fisheries must submit documentation of fisheries and cap landings at 2006 levels by 2008. All fisheries must develop plans to limit bycatch. A new stock assessment is planned for 2010, and these rules will be evaluated. After 2010, rebuilding efforts are to continue until F_{MSY} can be achieved.

The more stringent 2000 ICCAT blue and white marlin regulations appear to have been successful; the 2001-2004 blue marlin harvest was 49% of the 1996-1999 average, which is slightly under the regulatory target. For white marlin, landings from 2001-2004 were 59% of the 1996-1999 average, putting landings considerably over target. Unfortunately, the data show a sharp increase in the reporting of unclassified marlin (Figure 12), which may indicate fishing fleets trying to meet these caps without actually reducing the harvest of blue marlin and white marlin. From Figure 12, reports of unclassified billfish increased with a slight upward trend staying below 5% of the total harvest through 1997. In 1998, unclassified marlin jumped to nearly 15%, while blue marlin and white marlin landings fell. In 2003, reports of unclassified billfish climbed to nearly 33%, but then fell in 2004 to just over 11%. FAO data show in 2004 that unclassified or billfish NEI landings were 26% of the total harvest (Figure 3). Unclassified billfish harvests steadily increased in the FAO data to a peak of 36% in 1999. Bromhead et al. (2004) also discuss this trend in Pacific fisheries as well. In the 1990s, Sri Lanka, India and Pakistan reported the most unidentified billfish harvest, and, in recent years, the Philippines, Korean, Ecuador and French Polynesia have been responsible for the increases in unidentified billfish landings. This raises important questions about reporting and tracking of fish species with direct bearing to the true estimate of imports and the impact of trade in any single species. Reports of unclassified billfish harvests should be monitored closely into the future.

The WCPFC has also adopted the precautionary measure suggested by Langley et al. (2006) in the first regional striped marlin stock assessment to limit striped marlin effort (WCPFC 2006). This restriction caps the number of fishing vessels allowed to be fishing for striped marlin "in the Convention Area south of 15 ° S to the number in any one year between the period 200-2004." Commission members, cooperating non-members, and participating territories (CCM's) will supply the number of vessels fishing this

Figure 12. Volume (mt) of Blue Marlin, White Marlin and Unclassified Marlin Including Percentage Unclassified Landings 1990-2004. ICCAT 2006a.



area to the WCPFC by July 1, 2007, and the WCPFC will determine the maximum number of vessels permitted in the area. These regulations do not apply to CCM's that have already undertaken moratoriums on the harvest of marlins. However, limiting the number of vessels does not effectively control effort if the vessels have become more efficient harvesters, or if those vessels now have more harvesting capacity. That said, it is an attempt to reduce effort. Additionally, the WCPFC is committed to tracking transshipments to reduce and discourage IUU fishing. Article 29 of their Convention and Annex III, Article 4 require identification of designated transhipment ports so these activities are easier to track and regulate. Additionally, transhipment guidelines will be developed prior to the fourth WCPFC meeting in December 2007.

In the US, it is illegal to commercially harvest any billfish, other than swordfish, for commercial sale in the Atlantic Ocean. According to HMS regulations at 50 CFR part 635, a billfish Certification of Eligibility (COE) is required to remain in association with any non-Atlantic billfish product throughout the chain of custody up to, but not including, the consumer. This form is to be completed by the first purchaser of the billfish product. Unfortunately, there is no requirement for this form to be submitted to the National Marine Fisheries Service (NMFS) or any other government body or to be otherwise retained by dealers. The COE accompanies the product to consumption and dealers are free to dispose of the form as they see fit. If this form was collected by NMFS, this would be a way to track the trade patterns of billfish once the product enters the US. Currently there is no way to track fisheries products from the country of origin to the consumer's plate for any species. Additionally, customs officials have no responsibility to check the COE for products product sourced from the Pacific, but without any ability to track the COE in the FDA data, it is impossible to know. It is also impossible to know if Atlantic product is being transshipped through a Pacific nation to avoid this regulation. Several countries that have both Atlantic and Pacific coasts ship billfish products to the US, further compounding this traceability problem. See Table 8 for a list of coun-

Table 7. Volume (mt) and Value (US Dollars) of US Billfish Imports from Countries with No Access to the Pacific Ocean from FAO Trade Data, 2003-2006.

Year	Origin	Product	Volume in kg	Value (US Dollars)
2003	Dominican Republic	Raw, Fresh, Refrigerated	132	$475
2003	Guatemala	Raw, Fresh, Refrigerated	360	$1,291
2003	Italy	NEC	44	$158
2003	Martinique	Raw - Fresh, Frozen, Natural State	460	$1,651
2003	Trinidad & Tobago	Raw, Fresh, Refrigerated	3,450	$12,384
2004	Dominican Republic	Packaged Food	2,449	$6,596
2004	Dominican Republic	Raw, Fresh, Refrigerated	103	$279
2004	France	Cultured/Cured	55	$147
2005	France	Cultured/Cured	90	$533
2005	Spain	Packaged Food	39	$228
2006	France	Cultured/Cured	43	$166
2006	Trinidad & Tobago	Raw, Fresh, Refrigerated	*	*

*** A shipment was reported, but no quantity information available**

coming from countries with an Atlantic coastline.

It is thought that perhaps this small legal trade window encourages a black market for Atlantic caught billfish. There are many nations harvesting Atlantic billfish, but since the COE is not tracked or enforced, it had been initially thought that illegal trade would not show up in the trade data. However, several shipments identified in the Food and Drug Administrations (FDA) imports database originated from countries with no Pacific coast access (see Table 7). It is unlikely that these shipments were transshipments of tries and the volume and value of product shipped into the US. If Atlantic product from these countries were either intentionally or mistakenly mislabeled as Pacific caught product on the COE, it would be impossible to trace. These problems reflect the difficulty that exists in tracking imports back to their origin. Domestic trade is even more difficult as there are no reporting requirements past the point of first purchase. No Atlantic billfish show up in the landings data. However, without data on billfish consumption at the consumer level, total imports and total domestic production from the Pacific, it is impossible to tell if sport caught or domes-

Table 8. Volume (mt) and Value (US Dollars) of US Billfish Imports from Countries with Atlantic and Pacific Coastlines.

Year	Origin	Product	Volume in kg	Value (US Dollars)
2003	Canada	Raw, Fresh, Refrigerated	108	$389
2003	Costa Rica	Cultured/Cured	7,653	$27,467
2003	Costa Rica	Packaged Food	200,221	$718,593
2003	Costa Rica	Raw - Fresh, Frozen, Natural State	20,703	$74,303
2003	Costa Rica	Raw, Fresh, Refrigerated	291,338	$1,045,611
2003	Costa Rica	Raw, Fresh, Refrigerated	2,814	$6,831
2003	Mexico	Raw, Fresh, Refrigerated	0	$1
2003	Nicaragua	Packaged Food	5,777	$20,733
2003	Nicaragua	Raw, Fresh, Refrigerated	2,411	$8,653
2003	South Africa	Raw - Fresh, Frozen, Natural State	13,722	$49,248
2003	South Africa	Raw, Fresh, Refrigerated	11,222	$40,276
2004	Colombia	Raw, Fresh, Refrigerated	865	$2,331
2004	Costa Rica	Cultured/Cured	17,234	$46,411
2004	Costa Rica	Packaged Food	131,012	$352,816
2004	Costa Rica	Raw - Fresh, Frozen, Natural State	10,496	$28,266
2004	Costa Rica	Raw - Fresh, Frozen, Natural State	100	$30
2004	Costa Rica	Raw, Fresh, Refrigerated	151,735	$408,621
2004	Costa Rica	Raw, Fresh, Refrigerated	6,844	$24,029
2004	Nicaragua	Packaged Food	807	$2,174
2004	Nicaragua	Raw, Fresh, Refrigerated	693	$1,865
2004	Nicaragua	Raw, Fresh, Refrigerated	309	$1,320
2004	Panama	Packaged Food	317	$854
2004	Panama	Raw - Fresh, Frozen, Natural State	7,649	$20,599
2004	Panama	Raw, Fresh, Refrigerated	1,586	$4,272
2004	South Africa	Raw - Fresh, Frozen, Natural State	8,589	$23,130
2005	Colombia	Raw, Fresh, Refrigerated	1,926	$11,396
2005	Costa Rica	Cultured/Cured	4,703	$27,828
2005	Costa Rica	Packaged Food	175,521	$1,038,558
2005	Costa Rica	Packaged Food	388	$1,699
2005	Costa Rica	Raw - Fresh, Frozen, Natural State	13,462	$79,655
2005	Costa Rica	Raw, Fresh, Refrigerated	108,783	$643,670
2005	Costa Rica	Raw, Fresh, Refrigerated	814	$3,150
2005	Guatemala	Packaged Food	61	$360
2005	Nicaragua	Packaged Food	776	$4,592
2005	Nicaragua	Packaged Food	118	$393
2005	Nicaragua	Raw - Fresh, Frozen, Natural State	4,352	$25,751
2005	Panama	Raw, Fresh, Refrigerated	459	$2,713
2006	Colombia	Packaged Food	475	$1,837
2006	Colombia	Raw, Fresh, Refrigerated	248	$959
2006	Costa Rica	Packaged Food	136,441	$527,635
2006	Costa Rica	Raw - Fresh, Frozen, Natural State	10,821	$41,846
2006	Costa Rica	Raw, Fresh, Refrigerated	76,810	$297,033
2006	Guatemala	Packaged Food	180	$695
2006	Guatemala	Raw, Fresh, Refrigerated	261	$1,010
2006	Nicaragua	Packaged Food	57	$220
2006	Panama	Raw - Fresh, Frozen, Natural State	39,710	$153,563
2006	Panama	Raw, Fresh, Refrigerated	675	$2,610
2006	South Africa	Raw, Fresh, Refrigerated	1,314	$5,082

tic commercial bycatch enters the market place. None of these data sets is currently available.

Similarly for Australia, it is illegal for commercial fishermen to retain black or blue marlin. Currently, there are proposals to include striped marlin in this restriction due to decreasing recreational catches of striped marlin and increasing fishery interactions between recreational fishermen and longlining vessels, particularly foreign vessels. At this time, the Australian government is researching these interactions (Ward and Bromhead 2005). Also, New Zealand has prohibited the commercial harvest of black, blue, and striped marlin by domestic and foreign fleets within the Auckland Fishery Management Area since 1988.
The 2007 Magnuson Stevens Reauthorization Act (MSRA) in the US includes provisions to address bycatch and IUU fishing by penalizing nations that engage in those practices. Section 607 of MSRA requires the Secretary of Commerce to identify and biennially list nations whose fishing vessels have: been engaged in IUU fishing during any portion of the previous two years, and the relevant IFMO has failed to implement effective measures to end IUU fishing by vessels of that nation; the nation does not belong to an IFMO; or no IFMO exist to regulate said fishing. Identification for this provision is equivalent to the provisions of the High Seas Driftnet Fisheries Enforcement Act (HSDFEA) of 1992. Under the HSDFEA, The Secretary of Commerce is responsible for identifying nations engaged in the use of driftnets and engaging those nations in consultations within 30 days of identification. Under the new MSRA provisions, if the offending nation is taking action to reduce IUU or bycatch, a positive certification is given to that nation, but if no action is being taken, a negative certification is issued. Vessels identified as participating in IUU or bycatch will be immediately denied entry into US ports and US navigable waters. A failure to certify or a negative certification triggers provisions of the Pelly Amendment of 1995 (PA).

If an agreement is not reached terminating IUU or bycatch within 90 days, the offending nation will face trade sanctions, including the prohibition on the import into the US of that nation's fish, fish products, or sport fishing equipment under the PA. The PA connects the fishery management sector with the General Agreement on Tariffs and Trade (GATT) administered by the World Trade Organization (WTO). The amendment set about procedures for the certification, and upon that certification the President can impose trade sanctions. The advanced notice of proposed rulemaking for these new MSRA provisions was published in the federal register on Monday June 11, 2007 (Volume 72, Number 111, page 32052). These provisions may provide a method to reduce billfish landings, effectively making it illegal to import billfish without making importation expressly illegal, as long as billfish is recognized as a protected living marine resource.

Fishery Summary
Tracking billfish harvest and trade in billfish is a difficult task given the paucity of data. It is thought that IUU is occurring, but no information is available to estimate its extent. In the industrial sector

of commercial fishing, billfish harvest is bycatch. In fisheries in general, bycatch is poorly reported, therefore all billfish landings must be thought of as an underestimate (Lewis 2000, Uozumi and Matsumoto 2003, ICCAT 2006). There is no longline catch time series in the following countries: Barbados, Venezuela, Cuba, Trinidad and Tobago, Korea, Panama, USSR, Argentina, Brazil, US, Mexico, Uruguay, Portugal, Spain, Belize, Honduras, China, Philippines, and Canada (ICCAT 2006a). Additionally, many nations do not report dead discards. For example, the Japanese Atlantic fleet is one of the most heavily observed fleets in the world. The observer data for this fleet indicates that only 50% of the catch of white marlin and sailfish observed onboard the vessel was ever reported. Blue marlin data turns out much better with 90% of observed being reported. Spearfish fares much worse with only 20% of the observed fish being reported. These ratios varied by vessel and by fishery with some vessels reporting 100% and some reporting 0% (Uozumi and Matsumoto 2003). Additionally, the Spanish longline fleet did not begin reporting billfish catch at all until 2003 (Goodyear 2000a, ICCAT 2006a). Atlantic purse seine catches of billfish are seldom reported in commercial logbooks even though most are bound for African fish markets (ICCAT 2006a). As a result, European Union purse seine billfish landings are estimated using observer data from 1991-2000. To compound this reporting problem, the observers focus during these years was bigeye tuna, so it is likely that the species of billfish was incorrectly identified (ICCAT 2003). In the Indian Ocean, species aggregation, mislabeling, underreporting, and non-reporting are widespread problems (IOTC 2006)

Catch by East and West Atlantic artisanal fleets has increased with little monitoring (ICCAT 2006). In the East Atlantic, Cote d'Ivoire, Ghana, Senegal, and Sao Tome did not start reporting billfish landings until 2005, and even then the data are highly suspect. It is noteworthy that Cote d'Ivoire's fishing effort has doubled in 2002-2003. In the Western Atlantic, Netherlands Antilles, EC-France (Martinique & Guadeloupe), Barbados and Venezuela have been reporting billfish catches sporadically. A new fish aggregating device (FAD) fishery has developed in the Caribbean with significant catches being reported by Martinique and Guadeloupe, although there is no formal reporting requirement in those countries (ICCAT 2006). Artisanal fisheries do not have to adhere to the landings reductions

Billfish Economics

Markets for billfish are confounded by the fact that billfish is an undesirable output from the production of tuna. Generally, demand for the species was once high but has fallen for a number of reasons discussed below. In a normal market, as demand falls, prices will fall, profits will fall, and businesses will produce less of the goods, or in this case catch fewer billfish. Additionally, as stocks decline and CPUEs fall, increasing the effort needed to catch the same amount of fish, fishing costs go up, profits go down and the harvest of billfish would also be expected to fall. Unfortunately, because the ratio of billfish caught in the production of tuna is fixed, at least in the short term, the billfish market cannot respond to changes in demand for billfish or changes in the cost structure in the fishery.

All billfish are marketed internationally in a variety of product forms. Nakumara (1985) summarized the various billfish products that are brought to market. Striped marlin's flesh is considered the best among the billfish for sashimi and sushi. It is marketed, mostly frozen, but sometimes as a fresh smoked product. Black marlin flesh is perceived as good quality and marketed fresh or frozen, and prepared as sashimi in Japan. Blue marlin is also considered to have good quality flesh, marketed mostly frozen but sometimes fresh for the sashimi market. In Japan, it is also prepared into sausages, but demand for this product has declined in recent years. Atlantic white marlin is considered to have excellent quality flesh and is marketed fresh and frozen. Spearfish is marketed frozen for the sashimi market, and processed into fish cakes and sausages in Japan. Atlantic sailfish is utilized fresh, frozen, and canned, and is generally eaten steamed in Japan. Finally, Pacific sailfish is marketed fresh and frozen for the sashimi market, and is sometimes smoked. Sailfish is also eaten broiled or baked.

These billfish markets began in the late 1940's when the Japanese longline fleet began its expansion. The market grew steadily at a relatively slow rate (see Figure 4), until the late 1980's when demand for fresh tuna increased dramatically. This pushed tuna prices up in Japan, the US, and Europe, while costs remained stable, driving tuna profits higher as well (King 1989). Increased profits in the tuna fishery increased the harvest of billfish. Additionally, territorial sea regulations pushed fleets farther out into the open access seas, also increasing this harvest. Recent trends in Japan suggest a decline in price and demand for billfish products, which is noteworthy given that Japan is one of the largest consumers of billfish. Worldwide, fish prices have remained stable or declined in real terms while costs have started to rise after being relatively stable for a long time. In economic terms, these forces should act to drive harvest down, but harvests have continued to rise, with the exception of the set of ICCAT regulations in the Atlantic.

Below is a discussion of billfish markets. It begins with a discussion of the development of a market for billfish and its interrelatedness with the tuna market since its very inception. Current international and domestic consumption and price trends are discussed. International trends in trade are explored with particular attention to US imports of billfish. This leads to a qualitative discussion of billfish demand analysis and better data are needed to undertake a welfare analysis of billfish importation. To further examine consumer preferences for billfish relative to other fish a review of the seafood substitution elasticity literature is included. Finally, the economic impacts of domestic production and importation are estimated.

History and Current Trends
Japan pioneered the development of distant water longlining as boat technology and refrigeration technology improved immediately after the end of World War II. These early boats harvested tuna and billfish for the market, but found that billfish discolored less and maintained quality better under poor freezing conditions than did tunas (Saito et al 2001). Therefore, billfish came to be seen as an analog to tuna in sausages and other processed products (King 1989). In the 1960s, development of negative 40º Celsius holds enabled boats to transport sashimi grade billfish from distant waters. This improvement in technology greatly reduced the price and stimulated demand for sashimi. By the mid 1970s, striped marlin fetched higher prices in Japan than all non-bluefin tuna, and all billfish went to the sashimi market (Saito et al 2001). Before the deep freezer was invented in the late 1950s, all bigeye tuna went to the canneries because a poorly frozen marlin was much higher quality than a poorly frozen tuna. With the development of more sophisticated freezing capabilities, both prices shot up dramatically. In the 1980s, the price of marlin began falling, and fell to 50% of its 1970s price by 1990 (Uozumi and Matsumoto 2003).

The market structure has changed in Japan in the 1990s. Increasing fuel prices, post WWII economic growth, and declining stocks pushed fishermen into the lower cost purse seine fishery, which has a lower bycatch of billfish (King 1989). Cuba, Taiwan, Korea, China, Sri Lanka, and other countries with relatively fewer land based economic opportunities expanded into longlining. As a result, catches did not decline, and now Taiwan and Sri Lanka catch more billfish than Japan (Table 2). Taiwan's and Sri Lanka's rapid expansion into longlining in recent years has been driven by increased demand for fresh and frozen fish for export (IOTC 2006). During this same time, swordfish fisheries exploded with their attendant billfish bycatch. Through the 1990's, swordfish harvest grew in size more than 10 fold (King 1989).

The Japanese market continues to change. Prices for frozen product are falling dramatically due to changes in regulations and Japanese preferences for large fish (Uozumi and Matsumoto 2003). In Japan, larger fish command higher prices, and, due to stock declines, the average size of billfish landed has decreased. Currently there is less incentive to keep and sell billfish, unless they are large specimens. A billfish less than 30kg is worth about half as much as a fish over 30kg. That alone is driving the higher reporting for blue marlin, which are bigger fish and therefore worth bringing to the dock for reporting and sale. Basically, any billfish under 30kg will be discarded, dead or alive, and this is one reason why spearfish, a relatively small billfish, are rarely reported. Before the 1990s, few fish were ever discarded, but with decreasing prices and increasing regulations, more billfish are now being discarded (Uozumi and Matsumoto 2003).

Historically billfish supply (harvest) was extremely insensitive to price, which is true for many fish species (King 1989, Kirkley 2006). Fisherman harvest as much as they can, when they can, regardless of price because they have little control over product mix brought in by their gear or quotas and other regulations set by fishery management bodies. In addition, billfish is a byproduct of tuna production. While the tuna market has stagnated somewhat, billfish catch has not declined due to increases in swordfish and artisanal fisheries (King 1989, Uozumi and Matsumoto 2003). Typically, dockside prices for billfish are higher than for tuna (FUS 2005).

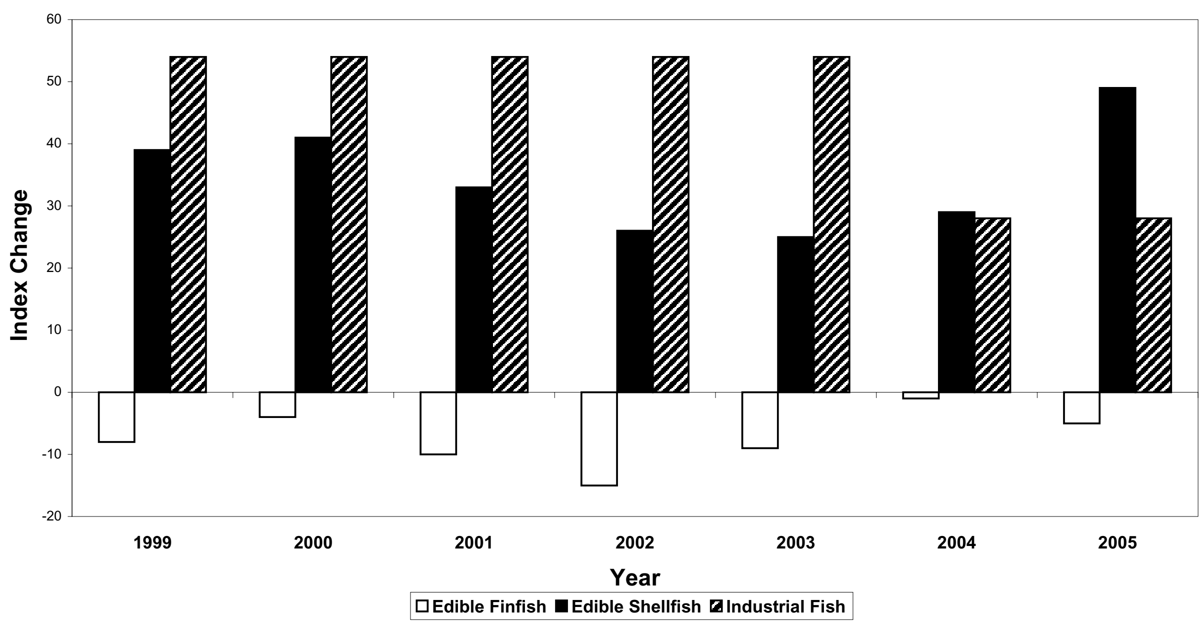
Until 1986, fishing prices increased faster than fishing costs, and billfish prices increased faster than other finfish prices (King 1989). Since then, billfish prices have fallen, as have prices for most seafood. Figure 13 shows the ex vessel price index for US fisheries products as reproduced from Fisheries of the United States (FUS 2005). This figure shows the prices, in real terms, for edible finfish are below the index year (1982) and have been for the period shown on the graph. The index reached its lowest value in 2002, increased in 2003 and 2004, but was back down again in 2005. Between 1979 and 2003 the real (2004 constant dollar) ex vessel price of all finfish and shellfish dropped from $.76/ pound (lb) to $.35/lb (FUS 2005). Due to these decreases in nominal prices and increases in relative income, US demand for seafood has increased.

The US ranks third in total consumption of seafood, behind China and Japan, and 72nd in per capita consumption (FUS 2005, Kirkely 2006). Per capita consumption has gone up since 1929 from 11.8lb to 16.3lb annually. Most of the seafood consumed is shrimp at 4lb per person per year, followed by canned tuna at 3.4lb per person per year (Kirkley 2006). As mentioned above, nominal prices are falling; canned tuna has dropped from $2.55/lb in 1980 to $1.78/lb in 2004. Overall, the majority of these price reductions are driven by increased imports from China, Thailand, and Vietnam, particularly for aquaculture shrimp and finfish produced with very low costs.

Non-price factors driving the US consumption of fish include an increasing health consciousness among US consumers. Additionally, US consumers like fish, but not "fishy" tasting fish. Billfish imports into the US have been growing since 1986 due to increasing incomes and demand for high quality fresh product suitable for sashimi.

Retail level price or demand data on any specific species are nearly impossible to quantify because of multiple problems in attempting to obtain this information. The most significant problem is the absence of seafood product tracking once it leaves

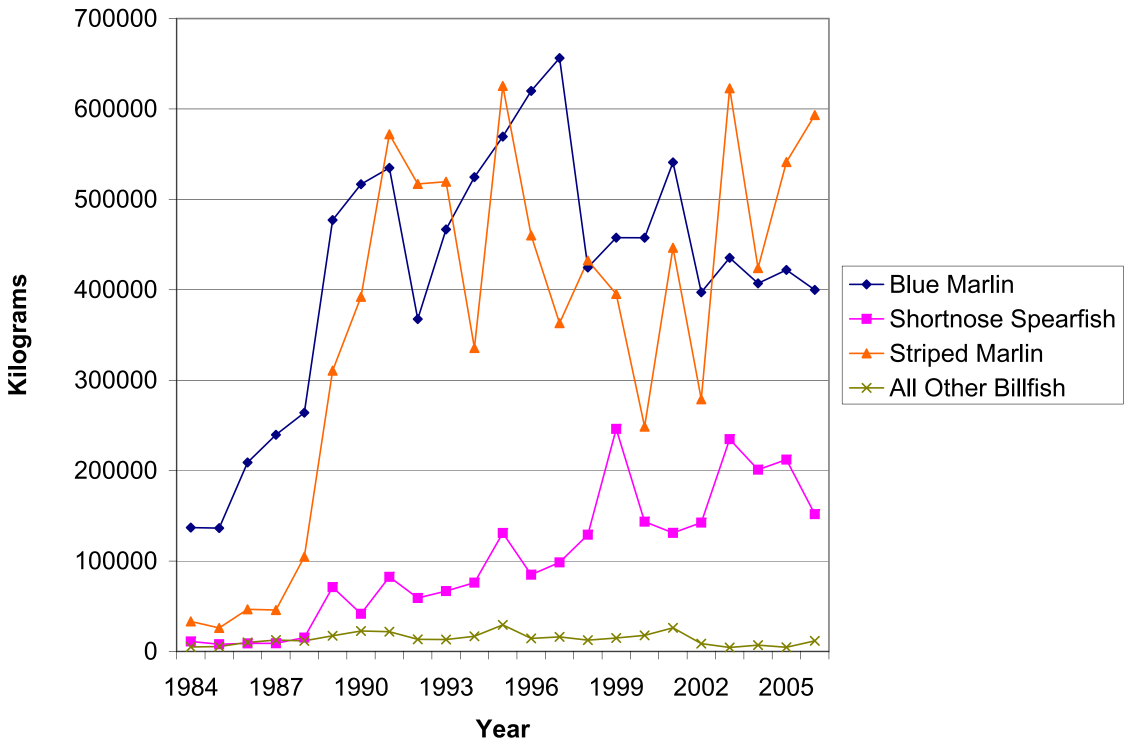
Figure 13. US 2005 Exvessel Price Index. FUS 2005.



the dock of first purchase. Compounding this problem at the retail level is the potential mislabeling of fish. Even if retail transaction data could be obtained, it would difficult to verify the species sold as being the same species that was landed. Foulke's (1993) FDA white paper about US Customs inspections of mislabeled seafood points to three reasons for this problem. Fish may be incorrectly identified dockside, with the mistake carried forward; there may be regional name confusion; and dealers, wholesalers, and retailers may be committing fraud. Fraud is sometimes undertaken to avoid tariffs, to achieve a better price, to meet high consumer demand for a particular fish, to use more attractive names for the consumer, to avoid consumption advisories, to avoid green lists, or to avoid regulations, like the COE for billfish. Compounding this problem is the lack of FDA and US Customs inspectors. There are only 1,350 inspectors nationwide and only 85 work primarily with seafood. As a result, there have been cases in some US markets of billfish being mislabeled and marketed as tuna.

It is noteworthy that the Hawaiian data have the best detail of any of the other data sets used for this project. Hawaii is the only domestic harvester of billfish; the vast majority of this fish stays in Hawaii for consumption there. Table 9 (in Trade Data Appendix) details the annual total harvest for all species combined, in kilograms (kg) and the value of that product at the first sale, or ex vessel value. Figure 14 details those landings by species. Blue marlin landings peaked in 1997 at around 656mt and have fallen to just over 400mt in 2006. Striped marlin has competed with blue marlin as the most landed species in the past, but surpassed blue marlin in 2003 with landings of 623mt and has stayed ahead of blue marlin since. The situation is similar for the value of

Figure 14. Volume (kg) of Hawaiian Billfish Landings by Species.



these fish (see Figure 15). Striped marlin is the most valuable billfish landed in Hawaii over the last few years. Hawaiian billfish prices have remained relatively stable over the last twenty years, with the exception of black marlin that spiked in 1995 at almost $6/kg (see Figure 16). Currently the price for black marlin is the highest at $2.54/kg.

World Trade and Importation

Data on billfish trade are very sparse and difficult to obtain. NMFS does not maintain any record of billfish trade, and the only billfish harvest reported in disaggregated form is reported from Hawaii. Other trade data sets are available; however, no one source contains all transactions for billfish. FAO keeps track of trade between countries and its data will be examined here. Additionally, the commercial service Urner Barry publishes seafood market data as reported on ship manifests. This data only contains information on waterborne shipments and is therefore an underestimate of total trade. This data can be obtained by subscription and is examined below. Within the last few years (2003), the US Food and Drug Administration (FDA) began entering their custom clearance tickets into a database. This source appears to be the most complete information on billfish importation. Again, domestic retail sales data are very difficult to obtain for individual species, or groups of species like billfish, for many reasons including renaming to improve sales and incorrect classification, as stated above. No retail trade data were available for this analysis.

The Urner Barry data are less than ideal for the purposes of this analysis. Table 10 (in Trade Data Appendix) details all waterborne shipments of billfish products into the US by volume, value and country of origin. The Urner Barry data does not contain prices or value because ship manifests rarely contain that information. Instead the FAO prices by product type were used. While the author of this report feels the Hawaii price data are higher quality, the entire Hawaii product is delivered fresh at first sales and does not reflect the product types being imported via water transportation. There is some correspondence with the FAO data, as the biggest exporters are Costa Rica and the Maldives in both the Urner Barry and FAO data sets.

The volume of waterborne imports into the US is fairly volatile, with peaks in 2002 and 2005, but relatively low volume thereafter. Table 11 (in Trade Data Appendix) summarizes all waterborne imports into the US. Overall, all the product types in waterborne shipments are lower quality frozen products because they spend considerably more time in transit. As a result, lower quality product usually ends up going by boat, while higher quality frozen and fresh product goes by faster transport modes such as air transport.

There are several caveats with the Urner Barry data. The product classifications as provided by the shipper vary widely from either the FAO or FDA data. Additionally, two non-fish shipments were found in the data: one a pallet of stainless steel marlin chairs and one a case of marlin jackets. Additionally, many of the product types in the data base are mixtures of various species, as shown in Table 12 (in Trade Data Appendix). In 2005, over a

Figure 15. Value (US Dollars) of Hawaiian Billfish Landings 1984 -2005.

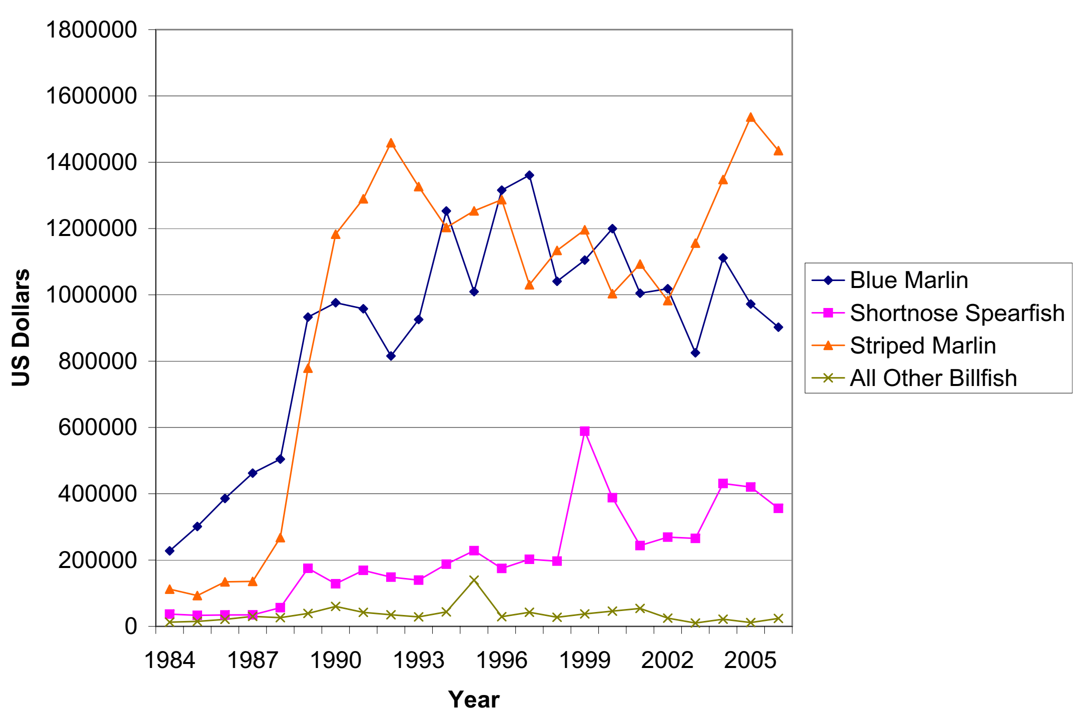
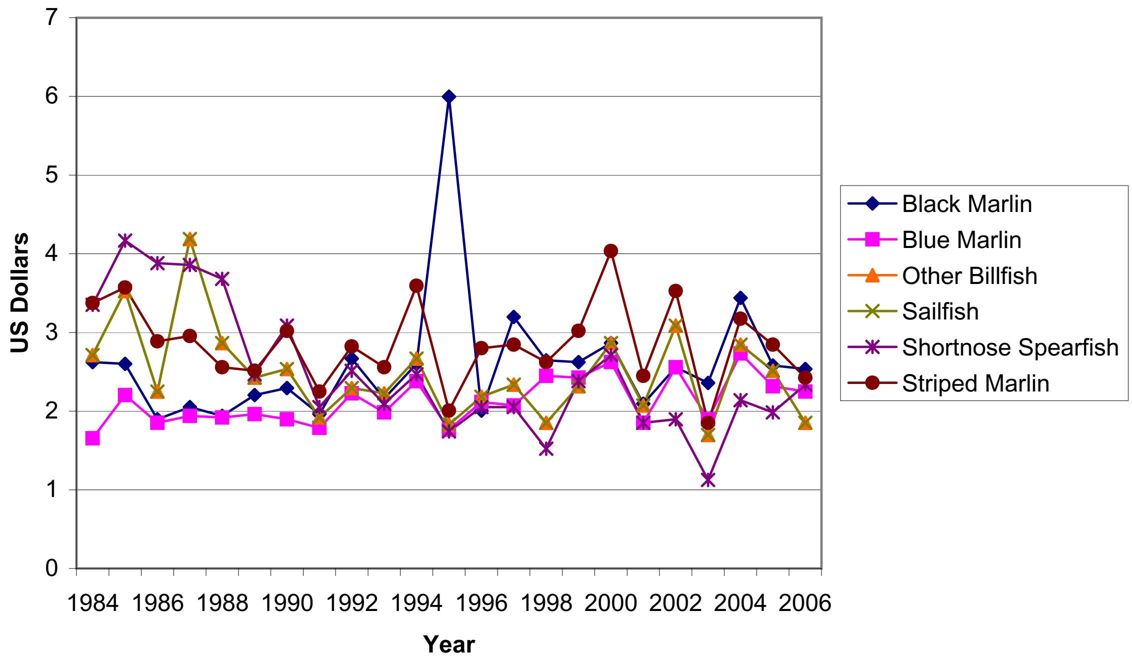


Figure16. Hawaiian Billfish Prices per KG (US Dollars), 1984-2005.



100mt of product was mixed product. Product aggregation and mislabeling of product is a persistent problem in landings and trade data, increasing the difficulty of tracking trade products (IOTC 2006).

While the FAO trade data are a very rich data set with regards to characterizing global landings, it has some deficiencies in the area of global trade in billfish that were only discovered after examining the FDA data. The FDA data contains the most volume and value of any other source, as shown in Figure 17. In every year, the FDA totals are at least three times either the FAO or Urner Barry data. The following rankings, based on FAO data, may be misleading, as trade information appears to be poorly reported to the FAO, at least for the US. When looking at FDA data, the quantity of US imports was 6.5 times higher and the value of imports reported was 9.6 times higher than those reported to the FAO (Figure 17). It is likely that import and export activity is far higher than the FAO data shows for other countries as well, and, if better data were available, it is likely that the import and export rankings would change.

Table 13 (in Trade Data Appendix) lists the top exporters of billfish products worldwide, as reported to the FAO. These countries were ranked based on the average volume of landings. There are only six countries in this list, and from the FDA data on US imports it is evident that there are far more exporters of billfish worldwide.

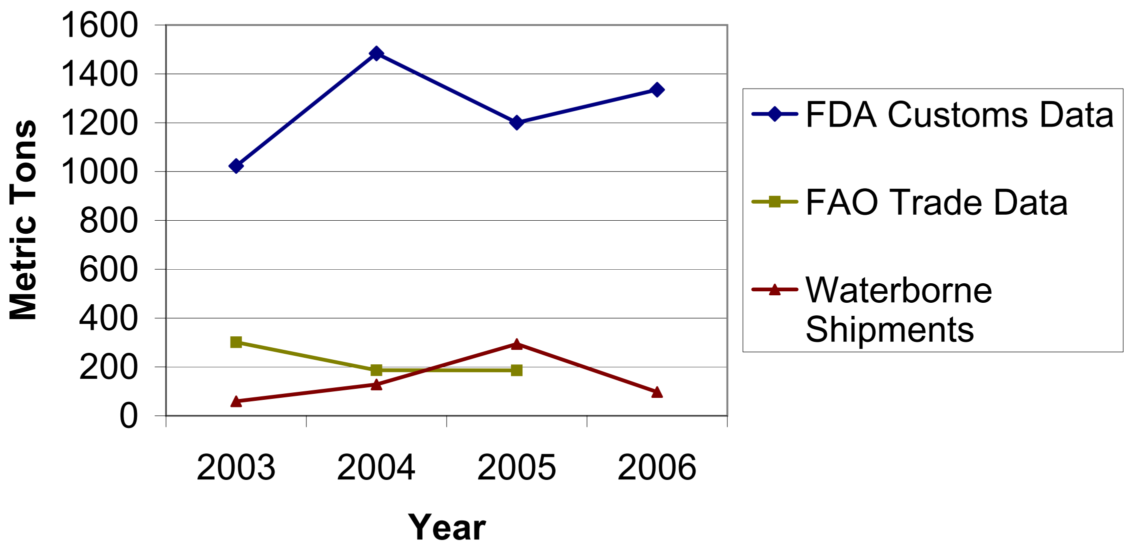
Table 14 ranks the top ten importers of billfish products by average volume over the period 2001-2005 in the FAO trade data. These rankings would change if the importing countries were ranked by value as France, Singapore, and Spain are buying higher priced products relative to the other countries. It is also noteworthy that the United States is buying relatively high value products, usually fresh or fresh frozen billfish. Additionally, from the FDA, the US imports 1,260mt annually, averaged over the period 2003-2006, again highlighting the underreporting inherent in the FAO data.

In the FAO trade data, the US takes the three highest import totals by year with its 2003, 2004, and 2005 imports greater than any other country and any other year. The US also takes sixth place for its 2002 importation volume. Table 15 (in Trade Data Appendix) summarizes the volume and value imported from all importers of billfish products since 2002, according to the FAO trade data.

According to FAO in 2005, the majority of the US product is coming from Costa Rica with 803mt, followed by El Salvador with 24mt, Nicaragua with 4mt, and the Maldives with 176 kg. Table 16 (in Trade Data Appendix) summarizes the destination of billfish product by exporting country during 2005. Finally, although the year 2000 is missing in the FAO trade data, the volume and value grew to a peak in 2003 with 301mt. It has since fallen to 186mt in 2005. Table 17 (in Trade Data Appendix) details the total volume and value of billfish entering the US since 1999, according to FAO trade data.

From FDA customs clearance forms, the top ten exporters of billfish to the US, ranked by average annual quantity exported to the US over the period 2003-2006, are listed in Table 18 (in Trade Data Appendix). The ranking in Table 18 underscores the underreporting in the FAO data, as the FDA has Costa Rica exporting an average of 342mt to the US alone, while the FAO shows Costa Rica exporting only 213mt worldwide (Table 13). It is also interesting that of the top

Figure 17. Volume (mt) of Billfish Imports by Data Source, 2003-2006.



five exporters to the US, the largest, Costa Rica, has access to both Atlantic and Pacific Coasts.

Table 19 (in Trade Data Appendix) details the entire volume and value billfish product imported into the US in 2006 by product type and country of origin from FDA customs clearances. The 2006 import information is highlighted here to give an idea of the product mix that enters the US. In 2006, the biggest shipment included a 534mt shipment from Vietnam followed by 136mt from Costa Rica and 107mt from Ecuador. The majority of the billfish products entering the US are processed packaged product that is usually frozen. After packaged products, raw refrigerated or fresh frozen product is the most commonly imported product.

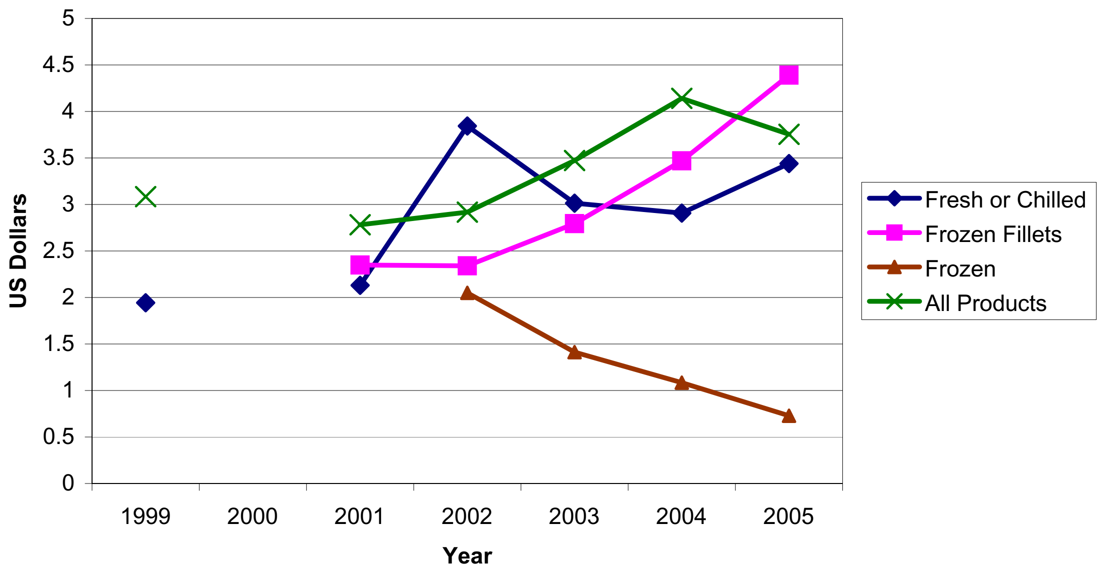
Table 20 (in Trade Data Appendix) summarizes the volume and value of all imports by year. The volume of imports was particularly high in 2003 and 2005, with 18,285mt in 2003 alone. Upon examining the data, a few outliers appear to be data entry errors, either by the shipper's agent filling out the form or by the FDA. These shipments include 17,263mt of raw product from Indonesia, 2,807mt of raw product from Micronesia, and 1,254mt of raw product from Vietnam. Raw product has to be shipped by air, and is it highly unlikely that this much product was shipped by air. The FDA representative working with the author could not track down any problems on the FDA side and recommended removing these three shipments from the analysis. Table 21 (in Trade Data Appendix) then summarizes the total volume and value of imports after those outliers were removed, and Figure 17 was drawn using the data after outlier removal. The highest volumes come from packaged product, product that has already been fully processed, and raw or fresh/frozen product. Also a small but important amount of cured product is likely smoked product. Finally Table 22 (in Trade Data Appendix) summarizes the volume and value of imports by product type and year.

Figure 18 details the prices for billfish products averaged across all product types, and from the FAO trade data, the price trend for all products is up, peaking in 2004 at $4.15/kg. The price for frozen fillets is also upward trending with no peak on the graph. The 2005 price for this product is $4.89/kg. It is interesting to note that the fresh or chilled product price is lower than the frozen fillet price, but as expected, the frozen category, whole loins and whole eviscerated fish, is the lowest of all four.

Table 23 (in Trade Data Appendix) expands the exports summary in Table 13 detailing the US imports of billfish products since 1999 by country of origin and product type. Frozen and fresh chilled products predominate and Costa Rica is the largest exporter of marlin products in the FAO trade data. There is no information regarding what type of marlin is being traded in the FAO trade Data.

Table 24 ranks the top ten billfish consuming countries by average country consumption in the FAO data during 2001-2005. For this table, consumption equals total landings, plus imports, minus exports. In the case of consumption, the amount of imports and exports are small relative to a

Figure 18. FAO Billfish Prices/kg by Product, 1999-2005.



country's harvest; therefore, the rankings are not likely to change with improved reporting. When creating this table, several apparent discrepancies emerged. For example, the Maldives has no harvest of billfish, as reported to FAO, yet it exported, on average, 176mt annually between 2001 and 2005 (Table 13). El Salvador and Nicaragua also export annually, on average, 25mt and 1mt of billfish respectively, without any reported harvest of billfish. Additionally, South Africa, while it harvests 78mt on average per year, exports 407mt per year, for a total potential transshipment per year of 391mt. There is no way to determine whether these export values represent underreported harvests or transshipments, and if transshipments, where the billfish was caught. These problems reflect the difficulty that exists in tracking imports back to their origin. Transshipment, in general, deserves closer scrutiny.

It is the author's judgment that the FDA data includes at least the Urner Barry data, as waterborne shipments are required to clear customs. Due to the correspondence between the FAO and Urner Barry data, it is assumed that the FAO data is constructed using either transshipment data or some other form of waterborne shipment data. It is likely an underestimate due to potential mislabeling and underreporting. As with the Urner Barry data, customs forms do not ask for product value, so price and value information was taken by product type from the FAO data. For the remainder of the economic analysis, the FDA data will be used along with FAO price information.

Demand Analysis

Demand analysis enables economists to quantify consumer preferences in models allowing the examination of consumer responses to changing prices or quantities in the marketplace. Policy makers are particularly interested in how external stimuli like regulations or international trade policies affect prices or quantities. Additionally, demand models allow economists to examine changes in consumer and producer welfare, or value, when policies change. For decades, economists have been using the concept of value, also known as net benefits or welfare, to answer the question, "Is society better or worse off after a policy change?" The first component, producer welfare, is the amount of revenue the producer retains above and beyond what it cost to produce the goods. Although the economic definition of profits differs slightly from the accounting definition of profits, producer welfare can be likened to a business' profit. Government policies change the size of these profits. When they go up, they are a "benefit" to society and when they go down, they are a "cost." Consumer benefits are a little more abstract. Consumer benefit is the amount of enjoyment or value, described in monetary terms, that a person gets to retain above and beyond what they pay for the good. Government policies change this value, too. When they go up, it is a "benefit" to society and when they go down they are a "cost". The decision rule for economists is then to balance the benefits and costs of a regulation and, in a perfect world, select policies that maximize benefits or minimize costs. The US government uses this economic reasoning, requiring the comparison of benefits and costs when making policies.

In order to examine economic changes stemming from changes in the product mix allowed into US, changes in benefits to harvesters, wholesalers, processors, and retailers (restaurants, grocery, fish markets, and consumers) must be examined. Retail and wholesale prices, quantities by species, and costs and revenues from harvesters, processors, importers, and dealers/wholesalers are required to construct demand and supply models. As mentioned above, consumer expenditures on fish by species at the retail level, does not exist, nor does data regarding quantities of fish sold at retail. Cost and return data from harvesters, fish dealers, processors, wholesalers, importers and other related businesses do not exist either. It is therefore impossible to build a system of demand and supply equations to estimate consumer and producer welfare (Edwards 1992). Additionally, this author is not aware of any studies that have analyzed the billfish fishery or a similar fishery to use in a meta analysis or benefit transfer study. Very little demand work on fish products in general has been done since the early 1990s, other than with salmon and whitefish, and these studies use dockside or wholesale prices. Additionally, very little demand work has been performed at all with disaggregated fish species, even at the wholesale level. Following the work of Capps and Schmitz (1991), Park et al (2004), Kinnucan et al (1997), Huang (2000), it may be possible to construct a demand model using ex vessel prices for several species of fish including billfish, but given the data problems with billfish outlined in this report, it would be difficult at best.

In addition to the examination of welfare, demand analysis is useful in the examination of substitution; particularly how consumers will substitute one good for another as prices or quantities change. Economists refer to substitution in terms of elasticities that show the responsiveness of consumer demand to exogenous shocks. Elasticity can be used to refer to a good itself, or to refer to the demand for that good. An elastic good is a good for which large quantity changes have small price change implications. An inelastic good is a good for which small quantity changes have large price change implications. The more and closer the substitutes exist for a good in the marketplace, the more elastic demand will be in response to a change in price. That is, the more readily people will substitute away from the elastic good in the face of a price or quantity change. Necessities tend to have a more inelastic demand curve, whereas luxury goods and services tend to be more elastic. Finally, demand tends to be more elastic in the long run rather than in the short run. Even for inelastic goods, if price rises high enough, consumers will substitute away from that good making the demand more elastic over time.

Elasticities suggest the size of the welfare loss stemming from welfare decreasing policies. If a good is inelastic, welfare losses tend to be larger and persist longer, and if a good is elastic, welfare losses tend to be small and short lived. Substitution elasticities have bearing on economic impact analysis as well. By construction, economic impact measures are static and do not deal with consumers' responsiveness to change. If demand for billfish is elastic, consumers will quickly and readily substitute away from billfish if the price increases, and the economic impact of the policy that caused the price increase will fade quickly or may not even register in the economy in the first place. Elasticities require the same data that demand models require because they are a derivative of demand models. As stated above, the billfish data cannot support these kinds of models. Unlike the above, lack of demand models that have calculated welfare that could be used in a meta analysis or benefit transfer, there are a number of studies focusing of different fish species and elasticities, as outlined below. However, none focus on billfish.

Moschini and Meilke (1989) found that beef and pork are more elastic than chicken and fish. Fish is a weak substitute for beef, chicken, and pork, but fish is a weak enough substitute to suggest that fish and all other meats are independent products. In addition, consumer preferences for poultry and fish have increased for reasons related to health (Moschini & Meilke 1989; Moschini 1991; Edwards 1992). Billfish, being apex predators, bioaccumulate mercury. Issuing and publicizing a strong consumption advisory against billfish may cause consumers to readily substitute away from billfish voluntarily, with fewer welfare implications than if a change in import polices were mandated.

Existing research points overwhelmingly to the elasticity of demand for fish. Cheng and Capps (1988) alone claim that fish demand is inelastic; meaning policy changes that reduce quantity will have large welfare impacts. Park et al (2004) found that, typically, fish consumed at home is price elastic using species specific models with far less aggregation across species than Cheng and Capps (1988). In a review of existing literature on substitution elasticity for seafood products, Asche et al (2005) found that seafood demand is elastic, and in many cases highly elastic.

Retail demand is less elastic than elasticities constructed using ex vessel prices. However, they found that pelagic fish have received little attention in the literature. Additionally, research on substitution between fish and other meats is limited (DeVoretz and Salvanes 1997, Durham and Wessells 1998). According to Asche et al (2005) "Although it is difficult to generalize, it is clear that most seafood products have substitutes," (p.26) which is supported by Johnson et al (1998) and Eales and Wessells (1999). Substitutability increases between similar species and similar product types, as discussed regarding the growth in the Japanese sashimi market above (see *History of Market and Current Trends*). In the sashimi market, the Japanese switched between tuna and billfish based on price and quality (Uozumi and Matsumoto 2003). In recent years cod (whitefish) and salmon have received almost all the disaggregated species demand modeling attention because the data exists in those fisheries.

High value fishery products substitute readily with other high value products while lower value products substitute with lower value products, but low value products are not substitutes for high value products (Gordon et al 1993). One of the few studies investigating tuna found Japanese tuna demand to be elastic, supporting the idea that it has many substitutes (Wessells and Wilen 1994). This study revealed that substitutes for tuna in southern Japan include fresh salmon, salted cod roe, horse mackerel, yellowtail, and sea bream; and in northern Japan includes fresh salmon, salted salmon, cuttlefish, salted cod roe, horse mackerel, shrimp and lobster, shellfish, and other fish. Eales et al (1997) found that high value fresh fish, medium value fresh fish, and low value fresh fish were all elastic, with low value fresh fish being the most elastic. In a demand analysis of reef species in the South Atlantic, Parks et al (2004) found that demands were very elastic for the groups of fish analyzed and there was a high degree of substitutability between species groups. In their analysis of red snapper quota reductions, they also found little change in price with change in quantity. The price before the policy change proved to be a good proxy for price after the policy, and therefore quantity, change.

With regards to substitution of imports, Lopez and Pagaloutos (2002) found that if the elasticity of substitution between foreign and domestic goods is near one, then changes in the world prices would be fully absorbed by changes in import volumes. As a result, there would be little impact on the domestic economy. If elasticities are large, changes in import prices should have a direct impact on domestic factor prices, particularly low skill wages. They found that welfare impacts of trade barriers are inversely proportional to the elasticities of substitutions. Thereby, if the import elasticity of substitution is high, the domestic welfare impact will be low. Lopez and Pagaloutos found the import substitution elasticity for canned and cured fish and seafood to be 2.025, and prepared fresh or frozen seafood to be 0.882, suggesting welfare impacts of trade sanctions would be low for these products.

In summary, most fish species have highly elastic demands; therefore, it is likely that consumers will readily and quickly substitute away from billfish in the event of a reduction in either quantity imported or a health advisory. Perhaps the same would hold true for a "green" advisory like the dolphin safe tuna campaign aimed at reducing US consumption of billfish. As a result, any welfare impact of a quantity reduction will likely be small and short lived. The same statement can be made for the welfare impact on imported goods. Finally, if consumers will readily substitute other fish for billfish, as the studies here for other fish species have suggested, the economic impacts presented in the next section are likely to fade quickly, if they are noticed at all.

Economic Impacts

Where welfare analysis answers the question, "Is society better off as the result of a policy?" economic impacts outline "Who specifically wins and who specifically looses and by how much?" Economic impact models are essentially an accounting of all the transactions in an economy. Economic impacts begin with a consumer purchase or final demand. Those initial expenditures constitute the direct impact. To supply those goods, the store purchases its inventory and labor while inventory suppliers purchase inputs like raw materials and labor as well. When businesses and suppliers import goods from outside the economy, the money spent, called a leakage, leaves the economy and is not considered in further calculations. Tracking purchases of supplies and labor by business continues until all the original purchase amount is exhausted by leakages. The sum of all this economic activity is called the indirect impact. In turn, laborers and business owners purchase goods and services in the economy using wages and business owner's profits from the indirect phase. That round of spending and the economic activity generated is defined as the induced impact. The sum of direct, indirect, and induced impacts describes the total impact, also known as total output, of consumer expenditures in an economy. These impacts can be denominated by the number of jobs supported, the total output in an economy, and the amount of personal and business income generated, sometimes called value added or contribution to Gross Domestic Product (GDP). The purpose of an economic impact analysis is to outline the relationships within an economy between the production of goods and their final consumers, outlining both the sectors involved and the magnitude of their involvement.

As stated, economic impact models are formulated using final demand or consumer purchase of a good or service. Unfortunately, retail data on consumer purchases of seafood is impossible to ascertain, particularly from restaurants. Because the only data generally available in commercial fisheries is dockside value of landed product, examination begins with the harvester section backwards. To examine economic impact forward of the harvesters sector, margins for the sectors forward in the chain must be known. Kirkley et al (2004) describes the availability of the margins for primary dealers and processors, and for secondary wholesalers and distributors which are incorporated into the model used in this report. The Kirkley et al (2004) model is based on data supplied by IMPLAN;

however, commercial fisheries activities are not well described by the standard input/output data for IMPLAN and must be augmented by more complete data on the costs and earning of commercial harvesters, processors, and dealers. This lack of comprehensive IMPLAN data was the initial impetus for construction of Kirkley's national impact model. Unfortunately, cost and earnings data are limited as discussed previously. All models are representations of reality, limited by their abilities to accurately capture reality, due to data or model limitations. Uncertainty in national seafood input/output (i/o) model stems from the quality of the cost and earning data used in the model. That said, Kirkley's model is the best representation of the seafood economy which currently exists at the national level.

There are two distinct segments of billfish product flow in the US: domestic production plus consumption in Hawaii, and imported product consumption on the mainland US. Three models were used to calculate the economic impacts in this report; the national seafood i/o model, the Kearney/Centaur model, and IMPLAN. The national seafood i/o model was used to calculate the impacts on harvesters, primary dealers and processors, and the secondary wholesalers and distributors of Hawaiian production (see Table 9 in Trade Data Appendix), as well as for the secondary wholesalers and distributors for the imports, since the imported product enters the country already processed (Kirkley et al 2004). The national model i/o was built using national average production functions by gear type and species, which may not reflect the conditions on the ground in Hawaii. However, no other model specific to the Hawaiian fishing economy exists to this author's knowledge. Currently the national seafood input/output model does not include the retail trade or seafood import sectors, so those effects had to be calculated outside the national model (Kirkley et al 2004).

To calculate the impacts of retail trade from grocery stores and fish markets (hereinafter retail markets) and restaurants, a source for the margins added to products purchased wholesale in both sectors was needed. These margins have not been consistently developed for the nation since NMFS commissioned Kearney/Centaur (1989) to develop them. Again, this is due to the lack of information on the price and quantities of fishery products purchased by consumers, a situation particularly acute for the restaurant trade. Currently, the Kearney/Centaur model is used by NMFS to calculate the value added, or contribution to GDP, of the entire fishing industry (FUS 2005). This model does not have margins for billfish trade, so a suitable analog needed to be selected. Both tuna and swordfish were examined and swordfish margins were selected because more swordfish products go to restaurants than tuna products. In this author's opinion, it is likely that the retail and restaurant market for billfish is more similar to the swordfish market than to the tuna market, as the margining in the Kearney/Centaur (1989) model for tuna includes a significant amount of low value product which goes directly to household consumption. The author acknowledges that these margins are dated and taken from a similar fishery, but currently, this is the only source for this information. The margins from secondary wholesaling/distribution forward to retail markets and restaurants were applied to the amount of imported product from customs clearance forms, (see Table 21 in Trade Data Appendix), to calculate the consumer expenditures on billfish in retail markets and restaurants. Additionally, the value of product captured from the national i/o model in the secondary wholesaling/distribution sector was then applied to the billfish margin to calculate the consumer expenditures on billfish products in Hawaii.

The level of purchases in stores and restaurants was then run as an impact in IMPLAN (MIG 2000). The IMPLAN model was constructed using the US national data sets, and the activity already captured by the national seafood model was netted out of the model, thereby only capturing the transactions generated by the retail and restaurant trade. This avoids double counting the harvesting, processing, and wholesaling activity already captured through the national i/o model. Table 25 contains the economic impact results of harvesting, processing, wholesaling, distribution, and final consumption for the Hawaiian billfish market. Table 26 contains the results the economic impact results from the importation, wholesaling, distribution, and final consumption of billfish in the US mainland billfish market. Table 27 contains the total US economic impacts of US billfish trade obtained by summing the values in Table 25 and Table 26.

In Hawaii, The harvesting of billfish supported slightly more than 45 jobs in 2005 and generated $1.9 million in income and $5.5 million in total output. Billfish trade supported slightly more than 30 jobs, $1.3 million income impacts and $3.7 million in total output from the primary dealer/processor sector. Secondary wholesaling/distributing of billfish product in Hawaii generated 33 jobs, $1.4 million in income, and $3.9 million in total economic output. Retail store sales supported 143 jobs and generated $4.8 million in income and $6.9 million in total output. Restaurant sales generated 95 jobs, $3 million in income, and $4.9 million in total output. In total, billfish harvesting and sales generated 346 jobs, $12.5 million in income, and $24.9 million in total output. When compared to the value added, income or contribution to GDP for all commercial fishing in the US (FUS 2005) of $32.9 billion, this represents only 0.038% of national value added from commercial fishing. The estimates of the economic impact of domestic harvest are detailed by year and sector in Table 25 (in Economic Impact Appendix), for 2003-2005. See Table 25 (in Economic Impact Appendix) for the results in thousands of 2005 US dollars.

On the mainland US, secondary wholesaling/distribution, the entry point in the economy for billfish imports, generated 82 jobs, $3.4 million in income, and $9.4 million in total output in 2005. Retail store trade in billfish generated 151 jobs, $5 million in income, and $5.6 million in total output, while restaurant activity generated 95 jobs, $2.7 million in income, and $3.5 million in total output. In total, importation of billfish generated 328 jobs, $11 million in income, and $18.5 million in total output. When compared to the total income or value added generated from all seafood harvesting and sale activity in the US, this represents 0.033% of the total. The results of the economic impact evaluation for the import flows are shown in Table 26 (in Economic Impact Appendix). Unlike Hawaii, this amount is spread over the entire US economy and a cessation of billfish imports would likely result in very little felt economic hardship. The total economic impacts of Hawaiian production and consumption plus the economic impacts of domestic importation and consumption are detailed in Table 27 (in Economic Impact Appendix). The impact on the harvesting sector and the primary dealers/processors is the same as the Hawaii production in Table 25 (in Economic Impact Appendix). In total, all billfish activity in the secondary wholesaling/distribution sector for 2005 generated 115 jobs, $4.8 million in income, and $13.4 million in total output. Retail trade in billfish generated 294 jobs, $9.8 million income, and $12.5 million in total output, while restaurant sales generated 190 jobs, $5.7 million in income, and $8.4 million in total output. For all sectors of the entire US, billfish trade generated 675 jobs, $23.5 million in income and $43.4 million in total output. When compared to the income generated by all commercial fishing and seafood trade activity in the US, this represents 0.071%.

Most of the economic impact is generated by the retail and restaurant sectors, which is common for many products. Retail and restaurants mark-up their products more than many other sectors, typically because they are labor intensive, whereas commercial harvesting is more technology intensive. Unless a restaurant or fish market is specialized in selling only billfish, it will likely not be affected if billfish becomes unavailable, unless consumer demand for billfish is inelastic. From the examination of the elasticity literature, it is unlikely that billfish demand is inelastic. If billfish demand is highly elastic, consumers will likely continue going to the same restaurants and markets, but substitute different products. Consequently, most of the economic activity would not be affected in the long term. On the other hand, billfish makes up a small but non-trivial portion of the seafood economy in Hawaii. Landed value of billfish in Hawaii has ranged from 1.3% to 4.7% of total landed value in Hawaii over the past 20 years, which, while small, is non-trivial and potentially important to their economy. Additionally, billfish may be culturally significant; therefore, Hawaiian demand for billfish may be less elastic than the literature above suggests. If Hawaiian demand is less elastic, or inelastic, the economic impacts of a change in the quantity of billfish available would have a larger and longer lasting impact in Hawaii than it would have on the mainland

Discussion

Worldwide, billfish stocks are poorly understood, mainly due to poor quality data. Very little information exists about stock structures, life histories or habitat requirements making stock assessment difficult and fraught with uncertainty. Where adequate stock assessments are in place, stocks appear imperiled, so much so that ICCAT has instituted drastic reductions in landings of blue and white marlin in the Atlantic, and the WFCPFC is following suit for striped marlin in the Pacific. All IFMOs are calling for more

Discussion

attention to the harvest of these stocks and are working towards collecting better data on billfish biology.

The fisheries for billfish can be characterized as either industrial or artisanal fisheries. Worldwide, the majority of the market for billfish is driven by the industrial longline and purse seine fisheries for tuna, with billfish being a by-product of the tuna production process. A smaller, but rapidly growing portion of the catch is from artisanal longline and drift gillnet fleets that either catch billfish as bycatch or target billfish for local consumption. Because billfish, in general, is a by-product of the industrial and artisanal tuna fisheries, its harvest will not respond to typical price signals and natural market incentives. Compounding these problems is considerable uncertainty regarding the total mortality of billfish species. Catch data are poor, as many fisheries only report the billfish landed at the point of first sale. Fish discarded at sea, alive or dead, and fish not otherwise entered into commerce are not reported consistently, although this is improving with increased observer coverage and IFMO mandates for better discard information. Some nations fail to report or sporadically report landings. It also appears that landing data is subject to manipulation to avoid regulations, as is evidenced after recent ICCAT blue and white marlin regulations. The year after these regulations were enacted, the reporting of unclassified/unidentified billfish spiked, while the blue and white marlin landings fell.

Trade data is also lacking. Of the three sources of trade data examined here, it is unknown which is most accurate, or whether the FDA data, which contains the highest volume, includes both the FAO and Urner Barry data sources. This FDA data was used for the economic impact analysis in this report even though it is likely that it is an underestimate of total importation due to mislabeling of product or problems with reporting. As with most fisheries, there is no information on where fisheries products go once they leave the first landing or port of importation. No data exists on consumer purchases of billfish, precluding the estimation of demand models at the consumer level. It is this author's opinion that it would be impossible to estimate an aggregated demand model using ex vessel billfish data, except perhaps in Hawaii. It is also possible that there is a black market for Atlantic caught billfish, which are banned for trade in the US. Multiple shipments were documented in the FDA data origination from countries with only an Atlantic coast and also from nations with both Atlantic and Pacific coasts. It is impossible to know if a COE accompanied those shipments, as COE forms are not entered into a data set or linked to FDA customs clearances. It is absolutely impossible to determine if domestic caught billfish, either through sportfishing or through commercial bycatch, is entering the marketplace. Without better tracking of the chain of custody for billfish and entry of the COE forms into a database, it will never be possible to examine a potential black market for billfish. Several discoveries in the data suggest greater attention should be paid to the transhipment of billfish products.

Finally, a review of the seafood demand literature suggests that the demand for most fish species is highly elastic. However, no billfish specific elasticity estimates could be found. This suggests that a ban on the importation of billfish would have little welfare impact, and that any welfare impact generated would fade quickly. Additionally, research indicates that consumer elasticity is affected by health warnings as well as "green" and sustainability certifications, which suggests that an informational campaign related to the health impacts of eating an apex predator with high mercury levels or the inability to sustain the harvest of billfish, like the dolphin safe tuna campaign, may be an effective means to drive down consumer demand. If demand naturally falls, there may be no need to pursue import limitations, and if pursued, the welfare impacts would be much less severe. Additionally, elastic demand means that the economic impacts of any policy that reduces billfish importation would likely be short lived if felt in the economy at all.

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Appendices

Table 9. Volume (kg) and Value (US Dollars) of All Hawaiian Billfish Landed 1987-2006.

Year	Volume in kg	Value (US Dollars)
1984	410,642	$389,979
1985	387,681	$442,401
1986	605,494	$575,680
1987	676,944	$662,629
1988	872,621	$854,951
1989	1,931,350	$1,925,638
1990	2,145,991	$2,347,849
1991	2,670,379	$2,459,229
1992	2,110,306	$2,457,749
1993	2,350,488	$2,420,363
1994	2,101,119	$2,687,526
1995	2,987,939	$2,630,748
1996	2,600,102	$2,806,690
1997	2,499,875	$2,636,582
1998	2,201,840	$2,399,175
1999	2,456,137	$2,927,544
2000	1,912,597	$2,637,314
2001	2,523,712	$2,395,624
2002	1,823,955	$2,295,332
2003	2,860,499	$2,256,469
2004	2,290,751	$2,911,837
2005	2,601,337	$2,940,204
2006	2,550,325	$2,717,583

Table 10. Volume (kg) and Value (US Dollars) for Waterborne Shipments of Billfish by Country of Origin from the Urner Barry Data, 2000-2007.

Year	Origin	Volume in kg	Value (US Dollars)
2000	Costa Rica	14,170	$38,231
2000	Ecuador	97,140	$262,088
2000	Indonisia	19,168	$51,717
2000	Singapore	15,961	$43,063
2001	Costa Rica	72,949	$178,724
2001	Nicaragua	25,770	$55,900
2002	China	103,671	$311,947
2002	Costa Rica	132,204	$314,433
2002	Maldives	47,166	$140,102
2002	Singapore	35,742	$107,548
2003	Costa Rica	80,891	$218,085
2003	Maldives	107,167	$238,944
2003	Nicaragua	10,713	$38,449
2004	Costa Rica	63,957	$159,937
2004	El Salvador	66,509	$118,817
2004	Maldives	4,621	$11,103
2004	Nicaragua	1,013	$4,465
2005	Costa Rica	132,441	$538,190
2005	Maldives	124,410	$342,642
2005	Nicaragua	38,933	$127,010
2006	Costa Rica	10,252	$39,646
2006	Indonisia	25,646	$99,177
2006	Korea, Republic of (South)	25,012	$96,727
2006	South Asia	450	$1,738
2006	Vietnam	36,232	$140,114
2007	Indonisia	20,574	$81,880
2007	Singapore	20,994	$83,552
2007	Vietnam	9,953	$39,611

Table 11. Volume (kg) and Value (US Dollars) of Waterborne Shipments of Billfish into the US from the Urner Baryy Data 2000-2006.

Year	Volume in kg	Value (US Dollars)
2000	146,438	$395,099
2001	61,568	$171,251
2002	215,112	$627,590
2003	59,502	$206,632
2004	128,500	$532,181
2005	293,790	$1,103,036
2006	97,592	$377,403

Table 12. Volume (kg) and Value (US Dollars) of Waterborne Shipments Labeled as Mixed Product Included in Table 17 from the Urnen Barry Data, 2000-2005.

Year	Product	Volume in kg	Value (US Dollars)
2000	Frozen Blue Marlin Etc.	26,839	$72,412
2000	Frozen Striped Marlin Loins Etc.	11,806	$31,852
2000	**Total**	**38,644**	**$104,264**
2001	Frozen Marlin Loin & Wahoo Fillet	18,576	$51,668
2002	Frozen Blue Marlin Loins Swordfish	21,258	$62,019
2002	Frozen Marlin & Yellowfin Steak	16,494	$48,120
2002	Atun Marlin Pez Espana	69,499	$202,763
2002	Frozen Marlin Loin & Yellowfin Loin	19,249	$56,158
2002	Frozen Swordfish Blue Marlin	18,410	$53,710
2002	**Total**	**144,908**	**$422,770**
2004	Blue Marlin	11,900	$49,282
2004	Frozen Blue Marlin	25,377	$105,098
2004	Frozen Marlin	9,155	$37,917
2004	Frozen Marlin Congelado	348	$1,443
2004	Frozen Marlin Tuna & Mahi Mahi Etc.	24,993	$103,508
2004	Frozen Shrimp Codfish Sailfish Ball	20,949	$86,761
2004	**Total**	**92,722**	**$384,009**
2005	Frozen Marlin Loin Wahoo Yellowfin	20,033	$75,215
2005	Frozen Marlin Swordfish	21,634	$81,225
2005	IQF Swordfish IQF Marlin Etc	20,578	$77,261
2005	Marlin Loins & Oilfish Fillet	18,586	$69,781
2005	Marlin Loins Mahi Fillets	19,704	$73,977
2005	**Total**	**100,535**	**$377,460**

Table13. Top Exporters of Billfish Products, Worlwdide, Ranked by Average Quantity Exported (mt) in the FAO Data During 2001-2005.

Country	2001-2005 Average Exports (mt)	2001-2005 Average Value
Taiwan	8,169	$12,652,600
South Africa	407	$498,800
Maldives	176	$238,400
Costa Rica	213	$193,200
El Salvador	25	$36,600
Nicaragua	1	$3,800

Table14. Top Ten Importers of Billfish Products Worlwdide, Ranked by Average Quantity Imported (mt) in the FAO Data from 2001-2005.

Country	2001-2005 Average Imports (mt)	2001-2005 Average Value
United States	166	$535,624
Sri Lanka	95	$98,998
Japan	40	$57,453
Singapore	36	$58,104
France	32	$69,304
Taiwan	22	$14,951
Spain	20	$106,184
Costa Rica	12	$12,176
Vietnam	11	$10,831
United Kingdom	7	$26,972

Table 15. Volume (kg) and Value (US Dollars) of Worldwide Billfish Imports by Importing Country from FAO Trade Data, 2002-2006.

Year	Destination	Volume in kg	Value (US Dollars)
2002	France	29,613	$78,140
2002	Germany	29	$156
2002	Japan	42,457	$73,520
2002	Singapore	2,138	$6,433
2002	Spain	22,780	$30,548
2002	Sri Lanka	82,134	$152,359
2002	UK	8,562	$47,639
2002	USA	123,387	$309,386
2003	Canada	2,863	$8,197
2003	France	29,648	$50,507
2003	Germany	125	$523
2003	Ireland	27	$45
2003	Japan	51,394	$56,966
2003	Singapore	107,702	$164,676
2003	Spain	27,880	$75,192
2003	Sri Lanka	138,829	$146,690
2003	Taiwan, Republic of China	38,040	$36,063
2003	UK	10,589	$37,308
2003	USA	301,309	$865,948
2003	Vietnam	32,115	$46,655
2004	Algeria	8,463	$10,079
2004	Canada	749	$3,800
2004	Costa Rica	61,000	$60,878
2004	Ecuador	5,000	$11,000
2004	France	32,852	$71,413
2004	Germany	155	$121
2004	India	1,095	$3,111
2004	Italy	1,120	$4,551
2004	Japan	45,619	$48,007
2004	Mexico	13,002	$23,412
2004	Netherlands	403	$3,770
2004	Singapore	53,788	$97,302
2004	Sri Lanka	140,269	$102,239
2004	Taiwan, Republic of China	25,247	$7,574
2004	UK	9,758	$32,169
2004	USA	186,228	$669,444
2004	Vietnam	25,000	$7,500
2005	Canada	2,387	$14,072
2005	China	2,880	$723
2005	France	2,534	$11,900
2005	Germany	371	$1,061
2005	Japan	60,136	$105,991
2005	Malaysia	4,829	$1,212
2005	Other NEI	68	$19
2005	Singapore	16,981	$22,109
2005	Spain	49,954	$425,182
2005	Sri Lanka	116,166	$93,700
2005	Taiwan, Republic of China	22,050	$7,718
2005	Thailand	225	$232
2005	UK	3,168	$12,111
2005	United Arab Emirates	822	$897
2005	USA	186,082	$738,238

Table 16. Volume (kg) and Value (US Dollars) of International Trade in Billifish by Exporter and Destination Country from the FAO Trade Data, 2005.

Origin	Destination	Volume in kg	Value (US Dollars)
Costa Rica	Algeria	8,463	$10,079
Costa Rica	Canada	5,999	$26,069
Costa Rica	France	155,065	$318,824
Costa Rica	Italy	1,120	$4,551
Costa Rica	Japan	1,603	$2,780
Costa Rica	Mexico	1,408	$1,812
Costa Rica	Spain	100,614	$530,922
Costa Rica	Taiwan, Republic of China	98,297	$51,192
Costa Rica	UK	13,637	$46,040
Costa Rica	United Arab Emirates	822	$897
Costa Rica	USA	802,539	$2,583,218
Costa Rica	Vietnam	636	$2,081
El Salvador	Costa Rica	61,000	$60,878
El Salvador	Ecuador	5,000	$11,000
El Salvador	Mexico	11,594	$21,600
El Salvador	USA	23,529	$82,358
El Salvador	Vietnam	25,000	$7,500
Maldives	China	2,880	$723
Maldives	France	4,702	$27,693
Maldives	Germany	680	$1,861
Maldives	India	1,095	$3,111
Maldives	Ireland	27	$45
Maldives	Japan	199,606	$284,483
Maldives	Malaysia	4,829	$1,212
Maldives	Netherlands	403	$3,770
Maldives	Singapore	180,609	$290,521
Maldives	Sri Lanka	477,398	$494,988
Maldives	Taiwan, Republic of China	13,040	$23,563
Maldives	Thailand	225	$232
Maldives	UK	21,001	$88,822
Maldives	USA	176	$216
Maldives	Vietnam	31,479	$44,574
Nicaragua	Other NEI	68	$19
Nicaragua	USA	3,658	$12,328

Table 17. Volume (kg) and Value (US Dollars) of Imports of Billfish into the US from FAO Trade Data, 1999 - 2005.

Year	Volume in kg	Value (US Dollars)
1999	20,400	$62,934
2001	32,896	$95,103
2002	123,387	$309,386
2003	301,309	$865,948
2004	186,228	$669,444
2005	186,082	$738,238

Table 18. Top Ten Exporters of Billfish Products Into the US by Exporting Country, Ranked by Average Quantity Exported (mt) from FDA Customs Clearances, 2003-2006.

Country	2003-2006 Average Imports to US (mt)	2003-2006 Average Import Value
Costa Rica	342	$1,348,512
Ecuador	245	$946,835
Vietnam	221	$830,036
Korea, Republic Of South	132	$723,783
Philippines	121	$374,296
Indonesia	52	$193,032
Marshall Islands	26	$117,408
Singapore	25	$91,968
El Salvador	13	$52,893
Panama	13	$46,777

Table 19. Volume (kg) and Value (US Dollars) of Imports from FDA Customs Clearances by Country of Origin and Product Type in 2006.

Origin	Product	Volume in kg	Value (US Dollars)
American Samoa	Raw, Fresh, Refrigerated	1,529	$5,911
Australia	Packaged Food	699	$2,703
Australia	Raw, Fresh, Refrigerated	3,383	$13,083
Canada	Raw, Fresh, Refrigerated	871	$3,368
Colombia	Packaged Food	475	$1,837
Colombia	Raw, Fresh, Refrigerated	248	$959
Costa Rica	Packaged Food	136,441	$527,635
Costa Rica	Raw - Fresh, Frozen, Natural State	10,821	$41,846
Costa Rica	Raw, Fresh, Refrigerated	76,810	$297,033
Ecuador	Packaged Food	83,627	$323,398
Ecuador	Raw - Fresh, Frozen, Natural State	47,925	$185,332
Ecuador	Raw, Fresh, Refrigerated	107,470	$415,601
El Salvador	Raw, Fresh, Refrigerated	275	$1,063
Fiji	Cultured/Cured	564	$2,181
Fiji	Packaged Food	198	$767
France	Cultured/Cured	43	$166
French Polynesia	Cultured/Cured	1,001	$3,872
Guatemala	Packaged Food	180	$695
Guatemala	Raw, Fresh, Refrigerated	261	$1,010
Indonesia	Packaged Food	35,654	$137,879
Korea, Republic Of (South)	Packaged Food	454	$1,754
Korea, Republic Of (South)	Raw - Fresh, Frozen, Natural State	90,000	$348,042
Kyrgyzstan	Raw, Fresh, Refrigerated	185	$715
Maldives	Raw - Fresh, Frozen, Natural State	22,746	$87,962
Marshall Islands	Packaged Food	32,168	$124,399
Marshall Islands	Raw, Fresh, Refrigerated	18,504	$71,557
New Zealand	Raw, Fresh, Refrigerated	186	$719
Nicaragua	Packaged Food	57	$220
Panama	Raw - Fresh, Frozen, Natural State	39,710	$153,563
Panama	Raw, Fresh, Refrigerated	675	$2,610
Papua New Guinea	Raw, Fresh, Refrigerated	1,638	$6,334
Philippines	Cultured/Cured	18	$70
Philippines	Packaged Food	20,515	$79,333
Philippines	Raw - Fresh, Frozen, Natural State	2,793	$10,802
Philippines	Raw, Fresh, Refrigerated	4,242	$16,406
Singapore	Packaged Food	65	$253
Singapore	Raw - Fresh, Frozen, Natural State	19,838	$76,718
South Africa	Raw, Fresh, Refrigerated	1,314	$5,082
Taiwan, Republic Of China	Packaged Food	14,159	$54,754
Taiwan, Republic Of China	Raw - Fresh, Frozen, Natural State	3	$12
Taiwan, Republic Of China	Raw, Fresh, Refrigerated	1,250	$4,834
Tonga	Raw, Fresh, Refrigerated	345	$1,334
Trinidad & Tobago	Raw, Fresh, Refrigerated	*	*
Vietnam	NEC	11,775	$45,537
Vietnam	Packaged Food	534,415	$2,066,655
Vietnam	Raw - Fresh, Frozen, Natural State	290	$1,121
Vietnam	Raw, Fresh, Refrigerated	9,224	$35,669

*** A shipment was reported, but no quantity information available**

Table 20. Total Volume (kg) and Value (US Dollars) of US Imports from FDA Customs Clearances by Year, 2003-2006.

Year	Volume in kg	Value (US Dollars)
2003	18,285,360	$65,586,055
2004	1,483,360	$3,993,294
2005	5,261,129	$31,122,727
2006	1,335,043	$5,162,793

Table 21. Total Volume (kg) and Value (US Dollars) of US Imports from FDA Customs Clearances by Year, with Outliers Removed, 2003-2006.

Year	Volume in kg	Value (US Dollars)
2003	1,022,727	$3,630,468
2004	1,483,360	$3,993,294
2005	1,200,316	$7,094,898
2006	1,335,043	$5,162,793

Table 22. Volume (kg) and Value (US Dollars) of US Imports from FDA Customs Clearances by Product Type, Outliers Removed, 2003-2006.

Year	Product	Volume in kg	Value (US Dollars)
2003	Commercially Sterile	180	$646
2003	Cultured/Cured	8,275	$29,699
2003	NEC	100	$358
2003	Packaged Food (Not Commercially Sterile)	365,880	$1,313,144
2003	Raw - Fresh, Frozen, Natural State	131,196	$470,862
2003	Raw, Fresh, Ambient	164	$589
2003	Raw, Fresh, Refrigerated	516,932	$1,815,169
2004	Commercially Sterile	768	$2,068
2004	Cultured/Cured	18,176	$48,949
2004	Packaged Food (Not Commercially Sterile)	847,961	$2,277,312
2004	Raw - Fresh, Frozen, Natural State	307,983	$829,159
2004	Raw, Fresh, Refrigerated	308,472	$835,806
2005	Cultured/Cured	5,740	$33,962
2005	NEC	19,792	$117,109
2005	Packaged Food (Not Commercially Sterile)	441,798	$2,608,413
2005	Raw - Fresh, Frozen, Natural State	530,675	$3,140,007
2005	Raw, Fresh, Refrigerated	202,311	$1,195,407
2006	Cultured/Cured	1,626	$6,289
2006	NEC	11,775	$45,537
2006	Packaged Food (Not Commercially Sterile)	859,107	$3,322,282
2006	Raw - Fresh, Frozen, Natural State	234,126	$905,396
2006	Raw, Fresh, Refrigerated	228,409	$883,289

Table 23. Volume (kg) and Value (US Dollars) of Billfish Products Imported into the US by Country of Origin and Product Type from the FAO Trade Data, 1999 - 2005.

Year	Origin	Product	Volume in kg	Value (US Dollars)
1999	El Salvador	Fresh or Chilled Marlin	320,400	$302,934
2001	Costa Rica	Fresh or Chilled Marlin	61,172	$121,644
2001	Costa Rica	Frozen Fillets of Marlin	65,227	$134,924
2001	Nicaragua	Fresh or Chilled Marlin	1,490	$4,360
2001	Nicaragua	Frozen Fillets of Marlin	291	$546
2002	Costa Rica	Fresh or Chilled Marlin	90,788	$185,934
2002	Costa Rica	Frozen Fillets of Marlin	81,719	$213,357
2002	Maldives	Fresh or Chilled Marlin	113,445	$267,399
2002	Maldives	Frozen Marlin	25,148	$31,491
2003	Costa Rica	Fresh or Chilled Marlin	332,639	$857,287
2003	Costa Rica	Frozen Fillets of Marlin	62,113	$180,928
2003	Maldives	Fresh or Chilled Marlin	130,690	$148,495
2003	Maldives	Frozen Marlin	213,675	$297,022
2003	Nicaragua	Fresh or Chilled Marlin	1,404	$5,039
2004	Costa Rica	Fresh or Chilled Marlin	154,479	$467,559
2004	Costa Rica	Frozen Fillets of Marlin	78,814	$223,391
2004	El Salvador	Fresh or Chilled Marlin	125,672	$181,151
2004	El Salvador	Frozen Fillets of Marlin	451	$2,185
2004	Maldives	Fresh or Chilled Marlin	83,819	$115,992
2004	Maldives	Frozen Marlin	166,281	$165,137
2004	Nicaragua	Fresh or Chilled Marlin	97	$594
2004	Nicaragua	Frozen Fillets of Marlin	135	$364
2005	Costa Rica	Fresh or Chilled Marlin	81,466	$308,009
2005	Costa Rica	Frozen Fillets of Marlin	181,786	$885,432
2005	Maldives	Fresh or Chilled Marlin	63,441	$130,911
2005	Maldives	Frozen Marlin	141,651	$109,367
2005	Nicaragua	Fresh or Chilled Marlin	309	$1,445

Table24. Top Ten Consumers of Billfish Products Worlwdide, Ranked by Average Quantity (mt) Harevested, Minus Average Quantity Exported, Plus Average Quantity Imported from the FAO Data During 2001-2005.

Country	2001-2005 Harvest Average (mt)	2001-2005 Imports Average (mt)	2001-2005 Exports Average (mt)	2001-2005 Harvest Average (mt)
Taiwan	22,777	22	8,169	14,630
Sri Lanka	11,542	95	0	11,637
Japan	11,306	40	0	11,346
Philippines	8,010	0	0	8,010
Iran	5,970	0	0	5,970
India	4,173	219	0	4,392
Indonesia	4,128	0	0	4,128
Korea, Republic of South	3,754	0	0	3,754
Costa Rica	2,089	12	238	1,864
Ecuador	1,500	1	0	1,501

Table 25. Employment, Income and Output Economic Impacts Generated from the Harvest, Processing and Consumption of Billfish in Hawaii (Thousands of 2005 dollars).

	2003				2004				2005			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Harvesters												
Employment Impacts (FTE jobs)	12.7	6.2	18.9	37.8	15.8	7.8	23.6	47.1	15.1	7.4	22.6	45.2
Income Impacts (000 of 2005$)	527.1	338.3	750.3	1615.7	656.6	421.5	934.7	2,012.8	629.9	404.3	896.7	1,930.8
Output Impacts (000 of 2005$)	1482.1	1017.3	2123.3	4622.8	1,846.5	1,267.3	2,645.3	5,759.1	1,771.3	1,215.7	2,537.5	5,524.6
Primary dealers/processors												
Employment Impacts (FTE jobs)	5.7	3.4	16.2	25.3	7.1	4.3	20.2	31.6	6.8	4.1	19.4	30.3
Income Impacts (000 of 2005$)	268.3	186.6	641.7	1096.6	334.2	232.5	799.4	1,366.2	320.6	223.0	766.9	1,310.5
Output Impacts (000 of 2005$)	731.5	517.2	1811.9	3060.5	911.3	644.3	2,257.2	3,812.8	874.2	618.1	2,165.3	3,657.6
Secondary Wholesalers/Distributors												
Employment Impacts (FTE jobs)	7.3	4.4	16.1	27.7	9.0	5.4	20.0	34.5	8.7	5.2	19.2	33.1
Income Impacts (000 of 2005$)	323.0	224.0	637.2	1184.2	402.4	279.1	793.8	1,475.3	386.0	267.7	761.5	1,415.3
Output Impacts (000 of 2005$)	885.5	608.3	1800.6	3294.3	1,103.1	757.8	2,243.2	4,104.1	1,058.2	726.9	2,151.8	3,937.0
Retail Stores												
Employment Impacts (FTE jobs)	64.1	14.5	10.7	89.4	81.5	18.6	14.2	114.3	104.3	23.1	15.2	142.7
Income Impacts (000 of 2005$)	1590.9	1109.1	1196.3	3896.4	2029.9	1413.5	1539.0	4982.4	1619.8	1624.0	1573.0	4816.8
Output Impacts (000 of 2005$)	2117.6	1394.7	898.6	4410.9	2718.8	1787.6	1203.6	5709.9	2711.2	2904.7	1324.0	6939.9
Restaurants												
Employment Impacts (FTE jobs)	52.9	11.2	10.9	75.0	67.1	14.2	13.9	95.2	66.8	14.2	14.0	95.0
Income Impacts (000 of 2005$)	783.1	789.2	808.7	2381.0	995.0	1001.8	1028.8	3025.7	996.8	1001.5	1033.6	3031.9
Output Impacts (000 of 2005$)	1365.9	1407.0	1089.6	3862.4	1737.3	1788.0	1388.3	4913.7	1744.5	1791.8	1399.5	4935.9
Total Economic Activity												
Employment Impacts (FTE jobs)	142.6	39.7	72.9	255.2	180.5	50.3	91.9	322.6	201.7	54.1	90.4	346.3
Income Impacts (000 of 2005$)	3492.4	2647.3	4034.1	10173.8	4418.2	3348.4	5095.7	12862.3	3953.1	3520.6	5031.6	12505.3
Output Impacts (000 of 2005$)	6582.5	4944.5	7723.9	19250.9	8316.9	6245.1	9737.6	24299.6	8159.4	7257.3	9578.2	24994.9
Percent of 2005 Total Value Added				0.031%				0.039%				0.038%

Table 26. Total US Employment, Income Output Economic Impacts Generated from the Importation of Billfish into the Mainland US (Thousands of 2005 dollars).

	2003				2004				2005			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Secondary Wholesalers/Distributors												
Employment Impacts (FTE jobs)	11.7	7.0	25.9	44.6	12.4	7.5	27.5	47.3	21.4	12.9	47.4	81.6
Income Impacts (000 of 2005$)	504.9	350.2	996.0	1851.0	536.1	371.9	1,057.6	1,965.6	924.6	641.3	1,823.9	3,389.8
Output Impacts (000 of 2005$)	1384.0	950.8	2814.4	5149.2	1,469.7	1,009.6	2,988.6	5,468.0	2,534.6	1,741.2	5,153.9	9,429.7
Retail Stores from IMPLAN												
Employment Impacts (FTE jobs)	49.7	10.2	1.2	61.1	53.9	11.2	1.9	67.0	122.4	24.9	3.9	151.2
Income Impacts (000 of 2005$)	1146.8	826.0	732.4	2705.2	1251.8	899.7	812.1	2963.6	1696.4	1827.5	1442.8	4966.6
Output Impacts (000 of 2005$)	1280.5	879.0	14.3	2173.9	1416.8	968.7	43.8	2429.3	2447.5	2982.4	147.1	5577.1
Restaurants from IMPLAN												
Employment Impacts (FTE jobs)	42.7	7.4	0.6	50.8	46.3	8.1	0.4	54.8	80.7	14.2	0.5	95.4
Income Impacts (000 of 2005$)	532.7	574.4	276.2	1383.3	580.2	623.6	307.8	1511.6	1016.7	1090.8	547.0	2654.5
Output Impacts (000 of 2005$)	791.4	940.8	109.3	1841.5	866.9	1025.3	98.5	1990.6	1524.7	1797.5	149.9	3472.0
Total Economic Activity from Importation												
Employment Impacts (FTE jobs)	104.1	24.7	27.7	156.4	112.6	26.7	29.8	169.1	224.5	51.9	51.8	328.2
Income Impacts (000 of 2005$)	2,184.5	1,750.5	2,004.6	5,939.5	2,368.1	1,895.2	2,177.5	6,440.8	3,637.6	3,559.6	3,813.7	11,010.9
Output Impacts (000 of 2005$)	3,456.0	2,770.6	2,938.0	9,164.6	3,753.4	3,003.6	3,130.9	9,887.9	6,506.8	6,521.0	5,451.0	18,478.8
Percent of 2005 Total Value Added				0.018%				0.020%				0.033%

Table 27. Total US Employment, Income Output Economic Impacts Generated from Hawaiian Harvest of Billfish and the Mainland Importation of Billfish Products (Thousands of 2005 dollars).

	2003				2004				2005		
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced
Harvesters											
Employment Impacts (FTE jobs)	12.7	6.2	18.9	37.8	15.8	7.8	23.6	47.1	15.1	7.4	22.6
Income Impacts (000 of 2005$)	527.1	338.3	750.3	1615.7	656.6	421.5	934.7	2,012.8	629.9	404.3	896.7
Output Impacts (000 of 2005$)	1482.1	1017.3	2123.3	4622.8	1,846.5	1,267.3	2,645.3	5,759.1	1,771.3	1,215.7	2,537.5
Primary Dealers/Processors											
Employment Impacts (FTE jobs)	5.7	3.4	16.2	25.3	7.1	4.3	20.2	31.6	6.8	4.1	19.4
Income Impacts (000 of 2005$)	268.3	186.6	641.7	1096.6	334.2	232.5	799.4	1,366.2	320.6	223.0	766.9
Output Impacts (000 of 2005$)	731.5	517.2	1811.9	3060.5	911.3	644.3	2,257.2	3,812.8	874.2	618.1	2,165.3
Secondary Wholesalers/Distributors											
Employment Impacts (FTE jobs)	18.9	11.4	42.0	72.3	21.4	12.9	47.5	81.9	30.1	18.1	66.6
Income Impacts (000 of 2005$)	827.9	574.2	1633.2	3035.3	938.6	651.0	1851.4	3441.0	1310.6	909.0	2585.4
Output Impacts (000 of 2005$)	2269.5	1559.1	4615.0	8443.6	2572.8	1767.4	5231.8	9572.1	3592.8	2468.1	7305.8
Retail Stores											
Employment Impacts (FTE jobs)	113.8	24.7	11.9	150.4	135.4	29.7	16.0	181.2	226.8	48.0	19.1
Income Impacts (000 of 2005$)	2737.8	1935.1	1928.7	6601.6	3281.7	2313.2	2351.0	7945.9	3316.2	3451.5	3015.8
Output Impacts (000 of 2005$)	3398.1	2273.8	912.9	6584.8	4135.5	2756.3	1247.4	8139.2	5158.8	5887.1	1471.1
Restaurants											
Employment Impacts (FTE jobs)	95.7	18.6	11.5	125.8	113.4	22.3	14.3	150.0	147.5	28.4	14.5
Income Impacts (000 of 2005$)	1315.9	1363.6	1084.9	3764.3	1575.2	1625.4	1336.6	4537.2	2013.5	2092.3	1580.6
Output Impacts (000 of 2005$)	2157.3	2347.8	1198.9	5704.0	2604.2	2813.3	1486.8	6904.4	3269.2	3589.3	1549.4
Total Economic Activity											
Employment Impacts (FTE jobs)	246.7	64.4	100.5	411.7	293.2	77.0	121.6	491.7	426.3	106.0	142.2
Income Impacts (000 of 2005$)	5676.9	4397.8	6038.7	16113.4	6786.3	5243.6	7273.2	19303.1	7590.8	7080.2	8845.3
Output Impacts (000 of 2005$)	10038.5	7715.1	10662.0	28415.6	12070.3	9248.7	12868.5	34187.5	14666.2	13778.3	15029.2
Percent of 2005 Total Value Added				0.049%				0.059%			