Incorporating Recreational and Artisanal Fishing Fleets in Atlantic Billfish Management

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INCORPORATING RECREATIONAL AND ARTISANAL FISHING FLEETS IN ATLANTIC BILLFISH MANAGEMENT

By

Ayeisha A. Brinson

A DISSERTATION

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INCORPORATING RECREATIONAL AND ARTISANAL FISHING FLEETS IN ATLANTIC BILLFISH MANAGEMENT

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Atlantic billfish include sailfish (*Istiophorus platypterus*), blue marlin (*Makaira nigricans*), white marlin (*Kajikia albida*, formerly *Tetrapturus albidus*) and the spearfishes (*Tetrapturus*); these fishes are found in tropical and subtropical waters. The spearfishes include the longbill spearfish (*T. pfluegeri*), the Mediterranean spearfish (*T. belone*) and the roundscale spearfish (*T. georgii*). The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the regional fishery management organization that conducts research to determine the condition of tuna and billfish resources and supports international cooperative management. ICCAT has determined that blue marlin and white marlin are overfished; the status of sailfish and spearfish are unknown, but overfishing is thought to be occurring. Management of these resources is complicated by uncertainty in the biological models, but uncertainty about the fishers who target these resources. This dissertation studied artisanal fishing fleets that target Atlantic billfish in Venezuela and Ghana, as well as studied recreational charter boat fishing fleets in South Florida and Senegal. The information from these fleets was used to develop performance indicators that evaluate the socioeconomic performance of these fleets. An allocation model was developed to determine the optimal allocation of billfish resources among recreational and artisanal fishers in Ghana, West Africa. Finally, the
issues and challenges of managing Atlantic billfish were identified as well as a possible future framework. Results indicate that performance indicators can be used to contrast fleets with different operational objectives. Fishers do produce positive fishing profits in both artisanal and recreational fleets; however, Senegalese recreational anglers are particularly sensitive to fuel costs. Results of the allocation model suggest that the artisanal sector should be allocated 95% of the quota in Ghana. There is the possibility to over-allocate quota to the recreational sector due to methodological differences in determining benefit $f$ and the practice of catch-and-release. ICCAT’s limited purview over socioeconomics was identified as the major impediment to effective billfish management. Therefore, it is recommended that the institutional structure for billfish management be modified to include socioeconomic issues, most especially strengthening the link to local institutions in fishing communities.
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Chapter 1:

The current resource status and early socioeconomic literature for Atlantic billfish

1.1 Introduction to Atlantic billfish management and current status

Atlantic billfish include sailfish (*Istiophorus platypterus*), blue marlin (*Makaira nigricans*), white marlin (*Kajikia albida*, formerly *Tetrapturus albidus*) and the spearfishes (*Tetrapturus*). The spearfishes include the longbill spearfish (*T. pfluegeri*), the Mediterranean spearfish (*T. belone*) and the roundscale spearfish (*T. georgii*) (Anonymous, 2007, Shivji et al., 2006). Spearfishes are the least abundant of all billfish. Most of the billfish species are found throughout the tropical and subtropical waters of the Atlantic, Indian and Pacific Oceans. White marlin are endemic to the Atlantic Ocean and the Mediterranean spearfish is endemic to the Mediterranean Sea (ICCAT, 2006).

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the regional fishery management organization that conducts research to determine the condition of tuna and billfish resources and supports international cooperative management among contracting parties (nations). According to Shima (1990), ICCAT’S “…management objective is to maintain resources of tunas and tuna-like fishes at levels producing a maximum sustainable yield (MSY)”’. ICCAT’s management uses the scientific data and technical information provided by member nations to support the need for regional management interventions. Although management recommendations are made by the ICCAT Commission to the contracting states it is the member nations that are responsible for the implementation of these management measures in their own
Exclusive Economic Zone (EEZ) and wherever their vessels may fish (Shima, 1990).

According to ICCAT, the stocks of blue marlin and white marlin are overfished and continue to be suffering overfishing. However, the 2006 marlin assessment suggests that population biomass may be stabilizing (ICCAT, 2007). The case for sailfish is less clear; the last assessment for sailfish failed to obtain a conclusive evaluation of stock status for either of the two Atlantic stocks (eastern or western Atlantic). Abundance indicators, however, suggest that the eastern stock is currently overfished (ICCAT, 2007). Although ICCAT has recommended large reductions in the number of marlins caught by industrial vessels, along with other management measures aimed at reducing fishing mortality, it is too soon to know whether such reductions will help the stocks recover. It is possible that further management measures for all billfish species may be recommended by ICCAT at some point in the near future (ICCAT, 2007).

There are many reasons for this dire situation, but a contributor is that management of these resources is difficult because of the many different user groups that catch billfish. These groups differ in the reasons why they catch billfish but also in their management and conservation objectives towards these species. Billfish occupy the same spatial habitat as tuna resources; therefore, even though billfish are not typically a target of tuna fishing operations, they are often caught as bycatch by many pelagic tuna longline and purse seine fleets. In addition, other user groups, such as recreational and artisanal anglers, directly target billfish. Their distinctive size, beauty and spectacular fighting ability make billfish among the most valuable and sought after saltwater sportfishes in the world. Artisanal fisheries in the Caribbean, South America and West Africa target
billfish because they are an important source of protein and have a high commercial value in local coastal communities. A secondary contribution to the state of their stocks is the fact that, like other highly migratory fish, billfish are found in multiple fishery jurisdictions throughout the Atlantic Ocean so their management is dependent on many authorities. It is difficult to adopt and enforce policies for their recovery. Finally, management is further complicated by scientific uncertainty surrounding billfish stock status.

1.2 Early socioeconomic research

Much of the early research that was called socioeconomic did not collect social or economic data. Instead, researchers collected biological data using social science techniques (e.g., surveys) at recreational events. Fishing tournaments, especially specialized events for billfish, are a unique opportunity to collect user and biological data from the catch (Schramm et al., 1991a). Many tournament and some private recreational anglers were surveyed to determine catch rates, effort estimates and migratory patterns of the species. Biologists use these settings to survey the catch to determine size and age of landed fish, gonad morphology, etc. (Beardsley, 1990, Carter and Farber, 1994, Friedlander, 1995, Harvey, 1990, Luckhurst, 1994, Mahon et al., 1994, Martinez and Gonzalez, 1994, Mensah, 1994, Prince and Brown, 1991, Schramm et al., 1991b).

After World War II, billfish sportfishing became a popular sport even though people had been fishing for billfish since the early 1900s. The first big game recreational club started in 1905 in Avalon, CA. Billfish sportfishing became an elite activity for wealthy and affluent men. Popular folk heroes, such as Zane Grey and Ernest
Hemingway, furthered the sport’s popularity (DeSylva, 1974, Kitner and Maiolo, 1988). In the latter half of the twentieth century, recreational activity grew as Americans’ leisure time increased. This trend was evident in the billfish sportfishing community (Rockland, 1990). The sport’s popularity steadily increased and eventually a unique market for charter boats emerged (Rockland, 1990). Today, recreational billfish fishing is a global enterprise reaching all corners of the ocean.

Artisanal fishing fleets are found throughout the world. Most of these fisheries are found in developing countries (Chuenpagdee et al., 2006). Despite their predominance, there has been a tendency to overlook or ignore these fisheries (Macinko and Schumann, 2007, Schumann and Macinko, 2007). Billfish research is no exception; there has been little to no research on artisanal fisheries that target billfish (Brinson et al., 2006). Many argue that artisanal fisheries do not contribute substantially to the worldwide catch of fishery resources; therefore, there is no motivation for management (Schumann and Macinko, 2007). However, there are 39 million fishers found throughout the world and as many as 90% of these fishers are artisanal and/or live in coastal communities (FAO, 2002). Another explanation for the lack of attention to artisanal fisheries is that it is difficult to collect catch, effort and user data for these fisheries because they often use a wide range of landing sites and employ part-time workers (Salas et al., 2007).

Early socioeconomic research for artisanal fisheries focused on improving the productivity of fleets in order to further development. In the early 1970s many fishery development projects were introduced to different artisanal fleets around the world with the objective of building local industrial fleets. These fleets eventually competed with
local traditional fishing practices. Many of these projects were successful around the world, except in Africa (Pauly, 2006). In parts of Africa, the industrialization of local fleets did not materialize mostly due to the presence of distant water fleets (Atta-Mills et al., 2004). Other studies evaluated the types of gears used and promoted more efficient or modern techniques. However, the majority of these recommendations lead to overcapacity in the fleets (Pauly, 2006).

During the 1950s and 1960s there was a global expansion of industrial tuna longline operations. The fleets were able to fish further outside their historical range mostly due to technological advancement. As fleets initially entered previously unexploited areas, there were high catches of tuna and billfish. Eventually these catches declined and longline operations expanded to other areas (Myers and Worm, 2003). Industrial fishing operations represented the largest source of fishing mortality. While the longline and purse seine operations are targeting swordfish and tuna, respectively, they land billfish incidentally because billfish occupy the same spatial habitat. There has not been substantial socioeconomic research for the industrial sector. Recent research evaluated the economic impacts of reducing billfish bycatch to the tuna sector (Cox et al., 2002, Kitchell et al., 2004, Kitchell et al., 2006). However, it is important to note that these studies did not use standard econometric techniques to evaluate the change in net revenue for industrial fleets.

1.3 Research approach, goals and specific objectives of this dissertation

The overall goal of this study is to improve the knowledge about the social and economic variables that can describe the context within which fishing fleets exploit
billfish populations. Furthermore, this research aims to develop a framework that can incorporate social and economic assessments into the resource management decision-making process. The specific objectives of this study are to:

1. Evaluate the socioeconomic performance of artisanal and recreational fishers targeting Atlantic billfish.
   1.1 Evaluate fishers’ perceptions of billfish stock status and possible management strategies
   1.2 Contrast the differences or similarities across different geographical locations
2 Evaluate an optimal economic framework that allocates catch shares to recreational and artisanal fleets in Ghana, West Africa.
3 Identify the major policy issues driving Atlantic billfish management

The study fleets chosen are the South Florida recreational charter boat fleet, the Senegalese recreational charter boat fleet, the Venezuelan artisanal pelagic fleet and the Ghanaian artisanal pelagic fleet. Surveys of these fleets collected cost and earnings data, as well as information on the perception of stock status. Data from the surveys were used to compare fleet performance indicators and for the allocation model.
Chapter 2:

Contrasting socioeconomic indicators for two fisheries that target Atlantic Billfish: Southeast Florida recreational charter boats and Venezuelan artisanal gill–netters

2.1 Performance indicator background

Management of marine fishery resources attempts to achieve conflicting objectives, e.g., increase yields, maximize resource rent, rebuild overfished stocks, and/or maintain biodiversity. Governments increasingly demand that managers relate each objective to measurable performance indicators supported by scientific data in order to evaluate the success of management strategies and objectives (Cochrane, 2002). In theory, fishery management plans should clearly identify the process and performance indicators that are to be used in the evaluation (Die, 2002, FAO, 1997, Smith et al., 1999) and ideally these indicators need to explicitly incorporate uncertainty (Stokes et al., 1999).

Defining the process to be followed when evaluating management strategies can be complicated. The process varies depending on the type of fishery but typically is dictated by governmental policies at each level: local, state, national, or international. Such policies rarely prescribe the specific quantitative models or methods that are to be used to develop each performance index. More commonly, detailed operational definitions are presented in other documents and are intended to reflect technical standards. Some examples of these are the social (ICGP, 1994) and biological (Restrepo et al., 1998) guidelines for federal fisheries in the United States and the general standards for international fisheries (FAO, 1997). Ultimately, the evaluation of management

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1 Brinson et al., 2006
success is a process in which the relative importance of meeting conflicting objectives is evaluated through the political process. Moreover, actual management is often driven by objectives that are neither explicit, nor as lofty as the government policy; thus, day to day management reflects the risk-averse nature of most managers (Walters, 1986).

The open access nature of most marine resources poses an additional problem because there are few incentives for individual users to invest in fisheries conservation. In addition, open access allows users that often do not share the same management objectives to exploit the same fishery resources. Differing objectives tend to influence the relative weight given by various users to the evaluation of management performance. Commercial fishers place more weight on performance measures that relate to yield and profits; sport fishers judge the likelihood of encountering fish, especially prize-size fish; subsistence fishermen seek to harvest enough protein; non-consumptive users want to ensure exclusive access to specific sites; and, conservationists want to enhance the “intrinsic value” of a site or the conservation value of a species or stock.

Typically managers utilize the results of biological and ecological studies to implement management measures for billfishes because initially most managers were trained as ecologists (Walters, 1986). This paradigm persisted because both government and fishing interest groups agreed to work under the paradigm that “if the biology is taken care of” management will succeed, or as Walters (Walters, 1986) expressed “…with the implicit assumption that regulation and enhancement of biological harvests will also lead to economic well being”. Such management led to the development of biological indicators that were stock related (e.g., maximum sustainable yield, overfishing, and overfished criteria) and tied to management actions through explicit formulae.
Partially due to our naïve view of the ocean as an inexhaustible source of fish, more and more resources reached unsafe biological limits and remedial action was sought through biological regulations. However, any management measure restricts human use or access in order to ensure species’ sustainability.

Examination of the current literature (FAO, 1997, Restrepo et al., 1998) that presents guidelines on quantitative measures used in the evaluation of fishery management strategies reveals that there are many accepted measures to quantify and evaluate the biological consequences of management actions on the target stock. There is, however, much less agreement on how to quantify the economic, social, and ecological consequences of management strategies. We contend that this is not necessarily due to the lack of methods to obtain such quantitative measures, but rather the unwillingness of the fishery management process to accept simple indicators to measure the socioeconomic consequences. There is a need to complete social and economic studies of the users of billfish resources. These studies can produce data that can be linked to each management objective, whether the objective is biological, social or economic, and used to evaluate the performance of management strategies. This sort of evaluation would undoubtedly make the management process more transparent and responsive to the needs of all stakeholders. Moreover, it is well accepted that increased recognition of stakeholder needs improves the effectiveness of fisheries management. With a strong sense of ownership in the management decisions, stakeholders are more likely to support the implementation of management measures.
Effective management is necessary for the continued sustainability of billfish (including sailfish, *Istiophorus platypterus* (Shaw in Shaw and Nodder, 1792); blue marlin, *Makaira nigricans* Lacépède, 1802; and white marlin, *Tetrapturus albidus* Poey, 1860) populations and pelagic ecosystems. Atlantic Billfish management is complicated by all of the problems presented earlier: multiple levels of institutional control, competing users’ objectives, the tendency to use biological indicators to determine management measures, and the unwillingness of managers to accept socioeconomic indicators. Our study addresses the latter issue with the objective of providing a baseline characterization of the financial and economic performance of two fisheries that target Atlantic billfish: the artisanal fishery of Playa Verde, Venezuela and the south Florida charter fishery (Figure 2.1).

Figure 2.1. Location of case studies in the Western Atlantic Ocean: Venezuela and south Florida.
The Venezuelan artisanal fishery is a commercial and subsistence fishery; some of the catch is sold to local consumers and the remainder is for the crew’s consumption. The operations target billfish, but will land whatever by-catch species are caught. The Playa Verde fleet is limited to 35 vessels which cannot be replaced nor modified. The artisanal port is located along the Venezuelan central coast about 10–15 mi north of the port of La Guaira (Marcano et al., 2001a). The south Florida charter fishery includes charter boat operations that specifically target billfish from Miami to Stuart, Florida. This fishery is a mixed recreational and commercial fishery (some of the vessels sell their non-billfish catch when they return to the dock). The two study sites were chosen because each country (United States and Venezuela) is a contracting member of the International Commission for the Conservation of Atlantic Tunas, (ICCAT). Each nation provides catch and effort data to ICCAT.

2.2 Methods

Data collected from the surveys of boat owners or captains were used to develop financial performance indicators for the two case studies. The performance indicators were used to evaluate the performance of the billfish fleets. Four performance indicators were used in this study: gross revenue, net revenue, financial profit and economic profit (Figure 2.2). These performance indicators did not estimate the total value of billfish. Instead the purpose was to characterize and contrast the performance of the producers that target billfish (Brinson et al., 2006).
Figure 2.2. Financial performance indicators (adapted from Whitmarsh et al., 2000).

The first performance indicator was annual gross revenue, GR. Annual gross revenue measured the total amount of income generated from fish sales or fishing rentals. In charter fisheries, additional revenue was generated by referrals to the taxidermist. Gross revenue calculated the revenue accruing to the owner before accounting for any costs. Net revenue, NR, measured the difference between gross revenue and running or variable costs. Running costs were costs that change based upon the vessel’s trips. Running costs included the cost of bait, fuel and groceries. Net revenue calculated the short term revenue for the producer: the artisanal vessel owner or the charter boat owner (Brinson et al., 2006).

Financial profit was the third performance indicator and it calculated the amount of cash coming in and out of an industry (Hundloe, 2000). This financial performance indicator considered the viability of an industry in terms of its commercial profitability (Pascoe et al., 1996). Positive financial profits indicated that the revenue exceeds the
owner’s cash investment (Brinson et al., 2006, Pascoe et al., 1996, Whitmarsh et al., 2000).

Financial profit was the difference between gross revenue and all costs (running costs, fixed costs, crew payments and interest payments). Fixed costs included insurance, advertising fees, dock fees, office space, licenses, and repair/maintenance of the vessel, motor, gear and equipment. In contrast to running costs, fixed costs did not change with the number of trips taken in a year. The crew payment included any direct payment to crew members and interest payments are loan repayment schemes for vessels (Brinson et al., 2006).

In contrast to financial profit, economic profit was the value of fishing to society in terms of the resource costs of that activity (Pascoe et al., 1996). Economic profit measured the efficiency of a producer in society’s view. This performance indicator measured the real costs of inputs in comparison to the value of output, or revenue (Brinson et al., 2006, Pascoe et al., 1996, Whitmarsh et al., 2000).

Economic profit was calculated by deducting running costs, fixed costs, the opportunity cost of labor, the opportunity cost of capital goods (including economic depreciation) from gross revenue. The opportunity cost of an item was defined as the value of the next best alternative (Allen et al., 2002). We assumed that the opportunity cost of labor is equal to the current wage for persons employed in manufacturing jobs. Many times it is impossible to know the value of the capital item in the next best alternative (opportunity cost of capital goods). Instead, the rental price of the capital good was used as the opportunity cost of that capital good. We assumed that depreciation
followed a linear relationship; therefore, the rental price was the value of the capital good multiplied by the sum of interest and depreciation (Brinson et al., 2006).

The four performance measures accounted for costs in different manners. Financial profit calculations simply viewed the industry in terms of its profitability to the business owner; whereas, economic profit calculations allocated resources in the most efficient manner for society as a whole. If financial profit were positive, the industry was profitable for the owner. If economic profit was positive, then the industry was efficient and profitable for society. If economic profit was negative, then the true cost of factors of production exceed the revenue generated by the industry. If performance indicators for financial profit and economic profit conflict, this is due to the treatment of costs. Only economic performance indicators account for the opportunity cost of labor and capital. If results show positive financial profit and negative economic profit, the fishery may be commercially viable in the short term, but the fishery is not operating optimally (long-term analysis) based upon society’s view of allocating resources in the most efficient manner (Brinson et al., 2006, Hundloe, 2000, Pascoe et al., 1996, Whitmarsh et al., 2000).

Surveys were developed following Armstrong et al. (Armstrong et al., 1992) to obtain data on the fishery. Four types of information were collected from the surveys: a description of fishery operations, socioeconomic operator data, demographic data and perceptions of fishery management objectives. The questionnaire included both quantitative and open-ended questions, with the latter providing an opportunity for comment on contentious and complicated issues. After some adjustments, the final survey instrument was adopted and administered in 2003 in the two western Atlantic
study areas: south Florida, United States, and Playa Verde, Venezuela. The survey instrument in Venezuela included questions related to the social livelihoods of fishermen’s households and the instrument was administered in Spanish.

Both countries provide detailed catch and effort data that are used by ICCAT in their species’ assessments. Billfish are directly targeted by both fleets and are important for the survival of these fishermen, while other species are secondary targets. The south Florida charter boat fleet operates from Miami in the south and Stuart in north. It is a multi-species rod and reel fishery that primarily targets billfish, but also catches dolphinfish, tunas and wahoo. This fleet is a mixed recreational and commercial fishery. One-half of the fleet possesses a Florida saltwater products license that allows them to sell their catch when returning to port. There are about 350 anglers working on 100 vessels (Brinson et al., 2006).

The artisanal port of Playa Verde, La Guaira is the second study site. This fishery began in 1988 and is considered the most important artisanal fishery in Venezuela (Marcano et al., 2001b). There are approximately 28 operating licenses that allow vessels to target billfish (Brinson et al., 2006). The fleet was reduced to a maximum of 35 vessels in 2000. The number of vessels in the port is regulated, but there are no limits on fishing effort. As a result, effort has increased for a variety of reasons (Marcano et al., 2001b). Catch and effort data are collected daily by fisheries officers. It is a multi-species fishery that targets billfish, dolphinfish, wahoo, tunas and sharks. There are about 105 anglers, representing one-fifth of the entire community. Fishers fish from 33
foot wooden boats that typically have one to two 60 horsepower engines and it is a gillnet fishery. Fishing trips are overnight and last about 16 hours (Brinson et al., 2006, Marcano et al., 2001b).

Charterboat operators/captains in Martin, Palm Beach, Broward, and Miami-Dade Counties were identified through a variety of sources: internet websites, yellow pages, and personal referral. In Venezuela, vessel owners and fishers were contacted through the Playa Verde Fishermen’s Association; the Association functions as a cooperative and includes all licensed gillnet fishermen in the fleet. Standard techniques were utilized to contact and conduct personal surveys with the respondents (Dillman, 2000, Fowler, 2002). A member of the research team visited a potential respondent at their dock space, explained the purpose of the survey, and attempted to establish a meeting time to interview the captain or owner.

The research team then administered the 40-question personal survey. In-person surveys were typically conducted at the marina or in the case of Venezuela, the artisanal port of Playa Verde. Occasionally, surveys were conducted at the operator’s home or another designated meeting place. All efforts were made to minimize the amount of time taken from the operators’ schedule. Interviews were conducted from September 2002–June 2003 in South Florida; Playa Verde interviews were conducted in June and July of 2003. The research team attempted a census of all of the boat owners. The results represented the responses of all of those who chose to participate in the study. Fishermen primarily refused participation due to lack of time and/or unwillingness to reveal information about their operations. Data were obtained from 87% of the Playa Verde fishing fleet. Responses from 75% of the South Florida charter boat fleet were collected;
the response rates for the included counties were: Miami-Dade (80%), Palm Beach (85%) and Martin (90%), and Broward (60%).

2.3 Results

In Venezuela, all of the active fishermen were adults, with an average age above 30 years. Ninety-eight percent were Venezuelan, having an average of 15 years experience in fishing; 11 years on average were spent at Playa Verde alone. In South Florida, fishermen had the same level of fidelity to their sites. They worked in the charter boat industry for a median of 18 years and nine years with the same operation (Brinson et al., 2006).

In Venezuela, fishing was carried out at night about 16 days per month and depended on the weather and phases of the moon. Fishing took place during the new moon, early crescent and late waning phases. Venezuelan fishermen took about 192 trips per vessel per year. Charter fishermen took close to 15,000 trips in 2003, or 177 trips per vessel per year. They relied upon a clientele comprised of repeat (repeat–53%, mixed first-time and repeat – 28%, first-time–19%) and out-of-state customers (out-of-state–60% and Floridians–25%). The majority of operations offered half-day trips, but full-day and six-hour trips were also available (Brinson et al., 2006).

Due to the economic disparity between the nations of the two study sites, the Venezuelan study collected additional information about the family life that were not included in the south Florida surveys. Of those interviewed, 13% could not read, 14% could not write and just 26% completed the fifth grade. The results found illiteracy in the families of captains or mates, but there was no instance of illiteracy among families of
boat owners. Fishers’ family groups included 197 persons, of whom only 19% reported contributing to the family income and by an average of $87.16 per month (Brinson et al., 2006).

The median annual gross revenue for an individual vessel in the Venezuelan artisanal fleet and South Florida charter fleet were estimated to be $19,701.50 (Table 2.1) and $357,600.00 (Table 2.2), respectively. Gross revenue for the Venezuelan fleet was estimated as the sum of all fish sales in one year. Gross revenue for the South Florida fleet was estimated to be the sum of the cost of fishing charters, plus the referral revenue to the taxidermist (for vessels that landed billfish only; (Brinson et al., 2006).

Table 2.1. Gross revenue, net revenue and financial profit for a Venezuelan artisanal vessel1.

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>No. Obs</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Revenue2</td>
<td>19,701.50</td>
<td>19</td>
<td>3,068.00</td>
<td>36,219.00</td>
<td>7,888.60</td>
</tr>
<tr>
<td>Running costs3</td>
<td>6,320.00</td>
<td>19</td>
<td>4,148.00</td>
<td>26,325.00</td>
<td>4,800.97</td>
</tr>
<tr>
<td>Net revenue</td>
<td>13,362.38</td>
<td>19</td>
<td>-16,005.00</td>
<td>29,367.00</td>
<td>9,832.80</td>
</tr>
<tr>
<td>Fixed Costs4</td>
<td>2,904.69</td>
<td>19</td>
<td>1,762.50</td>
<td>6,325.00</td>
<td>1,386.68</td>
</tr>
<tr>
<td>Crew pay</td>
<td>7,388.06</td>
<td>19</td>
<td>1,151.00</td>
<td>13,582.00</td>
<td>2,958.23</td>
</tr>
<tr>
<td>Interest payments5</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Financial profit</td>
<td>1,296.82</td>
<td>19</td>
<td>-22,290.00</td>
<td>12,198.00</td>
<td>7,681.02</td>
</tr>
</tbody>
</table>

1The exchange rate used for these calculations was Bs1600=US$1
2Gross revenue included revenue from fish sales.
3Running costs included the cost of bait, fuel and groceries.
4Fixed costs included the cost of insurance, advertising fees, dock fees, office space, licenses, repair/maintenance of vessel, motor, gear and equipment.
5Financing for vessels was not available in Venezuela; therefore, all of the vessels were owned outright.
Table 2.2. Gross revenue, net revenue and financial profit for a South Florida charter boat.

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>No. Obs</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Revenue(^1)</td>
<td>357,600.00</td>
<td>84</td>
<td>22,380.00</td>
<td>1,525,500.00</td>
<td>279,896.11</td>
</tr>
<tr>
<td>Running costs(^2)</td>
<td>23,531.00</td>
<td>84</td>
<td>0.00</td>
<td>189,840.00</td>
<td>28,043.06</td>
</tr>
<tr>
<td>Net revenue</td>
<td>329,293.45</td>
<td>84</td>
<td>4,500.00</td>
<td>1,514,746.80</td>
<td>272,155.35</td>
</tr>
<tr>
<td>Fixed Costs(^3)</td>
<td>26,825.00</td>
<td>84</td>
<td>2,410.00</td>
<td>131,760.00</td>
<td>24,008.72</td>
</tr>
<tr>
<td>Crew pay(^4)</td>
<td>0.00</td>
<td>84</td>
<td>0.00</td>
<td>180,000</td>
<td>32,460.17</td>
</tr>
<tr>
<td>Interest payments</td>
<td>0.00</td>
<td>72</td>
<td>0.00</td>
<td>27,600</td>
<td>7,507.68</td>
</tr>
<tr>
<td>Financial profit</td>
<td>277,077.34</td>
<td>72</td>
<td>-149,126.00</td>
<td>1,451,746.80</td>
<td>272,891.45</td>
</tr>
</tbody>
</table>

\(^1\)Gross revenue included revenue from fishing charters and mounting referral fees.
\(^2\)Running costs included the cost of bait, fuel and groceries.
\(^3\)Fixed costs included the cost of insurance, advertising fees, dock fees, office space, licenses, repair/maintenance of vessel, motor, gear and equipment.
\(^4\)The median value for crew payments in the South Florida charter fleet was $0. On 79% (n=66) of the operations, the crew did not receive a salary; instead they worked for tips from customers.

Table 2.1 shows that in Venezuela, the median vessel earned annual net revenue of $13,362.38. Net revenue accounted for running costs. Running costs included the cost of bait, fuel and groceries. Fuel costs account for more than two-thirds of an individual trip’s running costs in both Venezuela and South Florida (Figure 2.3). Median annual running costs were estimated to be $6,320 (Table 2.1). The typical vessel in South Florida had net revenue of $329,293.45, when accounting for running costs, $23,531.00 (Table 2.2) (Brinson et al., 2006).
Financial profit was the value of the enterprise to the individual owner. Financial profit accounted for running costs, fixed costs, direct payments to the crew and any interest payments on the capital goods (vessel, gear, etc.). In Venezuela, the annual median vessel’s financial profit was $1,296.82 (Table 2.1). Running costs, fixed costs and the payments to crew were $6,320.00, $2,904.69 and $7,388.06, respectively (Table 2.1). The typical vessel’s financial profit was $277,077.34 in South Florida (Table 2.2). Running costs, fixed costs, interest payments and the payments to crew were $23,531.00, $26,825.00, $0 and $0, respectively (Table 2.2). The median annual value for crew payments in the South Florida charter fleet was $0. On 79% (n=66) of the operations, the crew did not receive a salary; instead they worked for tips from customers (Brinson et al., 2006).

Economic profit was the value of the enterprise to society as a whole. Table 2.3 shows the annual economic profit for the median Venezuelan vessel, $1,210.00. Also shown in Table 2.3 are the components of economic profit: running costs ($6,320.00), fixed costs ($2,904.69), the opportunity cost of labor ($2,001.50), the opportunity cost of

Figure 2.3. Percentage of an individual trip’s running costs.
*Values have been adjusted to reflect 2007 dollars.
capital items ($2,503.40) and depreciation ($2,937.50). Median economic profit was estimated to be $198,272.30 in South Florida (Table 2.4). Running costs, fixed costs, the opportunity cost of labor, the opportunity cost of capital items, depreciation were $23,531.00, $26,825.00, $57,782.00, $29,365.00 and $9,400.00, respectively (Table 2.4; Brinson et al., 2006).

Table 2.3. Economic profit for a Venezuelan artisanal vessel.

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>No. Obs</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running costs²</td>
<td>6,320.00</td>
<td>19</td>
<td>4,148.00</td>
<td>26,325.00</td>
<td>4,800.97</td>
</tr>
<tr>
<td>Fixed costs³</td>
<td>2,904.69</td>
<td>19</td>
<td>1,762.50</td>
<td>6,325.00</td>
<td>1,386.68</td>
</tr>
<tr>
<td>Labor opportunity cost⁴</td>
<td>2,001.50</td>
<td>19</td>
<td>2001.50</td>
<td>2001.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Capital items</td>
<td>2,503.40</td>
<td>19</td>
<td>1,312.50</td>
<td>3,675.00</td>
<td>647.40</td>
</tr>
<tr>
<td>Depreciation</td>
<td>2,937.50</td>
<td>19</td>
<td>1,762.50</td>
<td>7,050.00</td>
<td>1,582.15</td>
</tr>
<tr>
<td>Economic profit</td>
<td>1,210.00</td>
<td>19</td>
<td>-29,972.00</td>
<td>18,673.00</td>
<td>11,157.86</td>
</tr>
</tbody>
</table>

¹The exchange rate used for these calculations was 1600Bs= $US1.
²Running costs included the cost of bait, fuel and groceries.
³Fixed costs included the cost of insurance, advertising fees, dock fees, office space, licenses, repair/maintenance of vessel, motor, gear and equipment.
⁴The opportunity cost of labor was assumed to be equal to the minimum wage for rural workers in Venezuela for 2003 (U.S. State Department 2005).
⁵The opportunity cost of capital items was assumed to be equal to the rental price of goods; where, m = Capital item * (interest + depreciation).
Table 2.4. Economic profit for a South Florida charter boat.

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>No. Obs</th>
<th>Min</th>
<th>Max</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running costs(^1)</td>
<td>23,531.00</td>
<td>84</td>
<td>0.00</td>
<td>189,840.00</td>
<td>28,043.06</td>
</tr>
<tr>
<td>Fixed costs(^2)</td>
<td>26,825.00</td>
<td>84</td>
<td>2,410.00</td>
<td>131,760.00</td>
<td>24,008.72</td>
</tr>
<tr>
<td>Labor opportunity</td>
<td>57,782.00</td>
<td>84</td>
<td>57,782.00</td>
<td>57,782.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Capital items</td>
<td>29,365.00</td>
<td>84</td>
<td>3,962.00</td>
<td>426,300.00</td>
<td>64,035.13</td>
</tr>
<tr>
<td>Opportunity cost(^3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>9,400.00</td>
<td>84</td>
<td>0.00</td>
<td>117,500.00</td>
<td>23,248.26</td>
</tr>
<tr>
<td>Economic profit</td>
<td>198,272.30</td>
<td>84</td>
<td>-338,687.40</td>
<td>1,358,064.40</td>
<td>278,054.42</td>
</tr>
</tbody>
</table>

\(^1\)Running costs included the cost of bait, fuel and groceries.
\(^2\)Fixed costs included the cost of insurance, advertising fees, dock fees, office space, licenses, repair/maintenance of vessel, motor, gear and equipment.
\(^3\)The opportunity cost of labor was assumed to be equal to the wage for a manufacturing job in Florida for 2003 (Bureau of Labor Statistics, www.bls.gov, accessed May 26, 2004).
\(^4\)The opportunity cost of capital items was assumed to be equal to the rental price of goods; where, \(m = \text{Capital item} \times (\text{interest} + \text{depreciation})\).

In both south Florida and Venezuela, the median financial and economic profits were positive; however, there were vessels that experienced negative financial and economic profits. This indicates that while overall financial profit is positive, there are some vessel owners who are unprofitable. The results of the economic profit analyses indicate that the fleet is efficient overall, but there are some vessels owners who are inefficient because the true cost of the factors of production exceed the revenue generated by the industry. Negative economic profit indicates that the fishery is not sustainable.
based upon society’s view of allocating resources in the most efficient manner because
the indicator accounts for the opportunity costs of labor and capital.

Figure 2.4 displays the percentage of fishermen who believed that billfish catch
rates have changed since they first started fishing in the area. More than one-third (39%)
of the fishermen in Venezuela perceived that the billfish catch rates remained the same.
In contrast, close to one-half (45%) of the South Florida fishermen perceived that the
billfish catch rates were higher. In both study areas, fishermen did not perceive a change
in the size classes of billfish species (Figure 2.5) (Brinson et al., 2006).

![Figure 2.4. Percentage of survey respondents who believe that the catch rates have changed since they first started fishing the area.](image-url)
Figure 2.5. Percentage of respondents who perceived a change in the average size class of billfish.

In both Venezuela and South Florida, fishermen were committed to their respective fisheries. Only one in five Venezuelan fishermen reported that they would abandon the fleet if the billfish catch decreased by 50%. The same trend was apparent in South Florida; less than one in ten Florida fishermen reported that they would leave the fishery if catch rates were to decrease by such a level (Brinson et al., 2006).

Fishermen in Playa Verde believed that less than half (44%) of the billfish released by recreational fishermen actually survive. In fact, many (71%) of these artisanal fishermen perceived that recreational fishing drove away billfish. Charter fishermen had a different perception of their impact to billfish populations in South Florida. Charter fishermen (84%) rated the status of sailfish in the South Florida region as either good or excellent. Close to three-fourths (74%) of the fishermen interviewed practiced total catch and release for all billfish species. South Florida charter fishermen believed that sailfish had high rates (85%) of survival, post release. Despite this
perceived high rate of sailfish post-release survival, 50% were using J-hooks, 24% used both J-hooks and circle hooks and 19% used circle hooks exclusively to target sailfish (Brinson et al., 2006).

Fishermen in Venezuela and South Florida had limited support for possible management measures (Figure 2.6). Venezuelan fishermen supported size limits, gear restrictions and limiting entry into the fishery, i.e. excluding others’ access. Floridian anglers had limited support for size limits and some other management measure. The most often cited other management measure was no new regulations or a zero bag limit for recreational anglers (Figure 2.6).

![Figure 2.6. Western Atlantic Ocean fishermen’s acceptance of management measures. *The most commonly cited other management measure was to require fishers to release all billfish.](image)

Although charter fishermen made a financial profit (Table 2.2, $277,077.34), fishermen relied on other means to supplement their income. They either had other
occupations (40%) or sold their catch at the docks (46%). Charter owners who had a saltwater products license were able to sell other species that were caught while targeting billfish (the sale of Atlantic Billfish is illegal). People who had other occupations usually worked in another sector of the fishing industry (44%). The entire artisanal fleet was dependent upon fish sales at the dock for economic survival. In both Venezuela and South Florida, participation with fishing organizations was important. The majority (65%) of the charter boat fleet belonged to some sort of fishing organization. One-third (38%) participated in a local angler’s association and another 36% belonged to the International Game Fish Association. In Venezuela, 98% belonged to the Playa Verde Fishermen’s Association.

2.4 Discussion

Fisheries indicators measure the state of the fishery and can represent critical situations. In theory, indicators will help determine the biological, social, and economic effects of management strategies (Seijo and Caddy, 2000). Indicators that are linked to each other are effective tools to (1) identify where more resources are needed, (2) monitor whether resources are being used effectively, and (3) evaluate the success of management objectives (Seijo and Caddy, 2000). Biological indicators in fishery systems have been collected for many years to monitor trends in stocks; e.g., biomass, total catch, effort, spawning stock biomass, etc. The importance of maintaining similar socioeconomic performance indicator databases is recognized by many, yet a major problem exists. There are few long-term datasets that compile social and economic information for fishery systems. This partially reflects the fact that investment in the
science required to support fishery management is largely biased towards biological information on target species.

This lack of information on socioeconomic indicators is a general phenomenon across world fisheries. For instance, during 1997–2000 the European Community Fisheries Directorate invested 78% of its research budget into biological studies, 11% on studies related to regulation and harvesting, and only 2% on socioeconomic studies (European Commission, 2004). ICES, the International Council of Exploration of the Sea, the main scientific body advising European countries on fisheries matters has an almost exclusive biological focus (ICES, 1964). ICES summarizes stock status on the basis of two precautionary reference points. The first indicator measures whether the spawning stock is inside or outside safe biological limits; the second measures whether the stock is being harvested sustainably (ICES, 2002). These two measures are analogous concepts to the overfished and overfishing criteria established by the National Oceanic and Atmospheric Administration (NOAA) which manages United States’ stocks (Restrepo et al., 1998). Similarly ICCAT’s interpretation of the precautionary approach only refers to estimations of the biological status of stocks and the safe harvest levels that could maintain such status. There are no statements suggesting the inclusion of socioeconomic or ecosystem issues in these considerations (ICCAT, 1999). An analysis of the ICCAT database of scientific papers presented at ICCAT meetings reveals that most of the technical work conducted through ICCAT focuses on biological issues pertaining to target stocks. Out of a total of 2844 papers presented at ICCAT meetings only 11 papers focused on economic issues and 74 focused on environmental issues. Slightly more attention is focused on issues related to the environment, but most of the 74
papers focused on environmental issues related to oceanographic processes and only five of these focused on ecosystem issues.

The present study shows that socioeconomic indicators can be developed for vastly different fisheries and to describe and quantify the impacts of alternative management measures. The indicators are ideal tools to highlight the various impacts that certain management measures may have on different fleets. For instance, perception of stock status and commitment to the fishery were rather similar among the two fleets studied; however, economic performance and income dependency from billfish fishing were not similar. Developing and collecting information on socioeconomic indicators will integrate and improve the evaluation of management measures, because biological and ecological impacts can be evaluated alongside socioeconomic costs and benefits within a single mathematical framework. We recommend that social and economic indicators such as those used in this study be considered by both scientists and managers as alternatives for the quantitative evaluation of management performance for highly migratory fisheries.
Chapter 3:

Socioeconomic performance of West African fleets that target Atlantic billfish

3.1 Background

Managing marine resources is contentious and complicated in many fisheries around the world. Resource managers must implement policies and regulations that preserve the biological integrity of the resource, but they must also account for various socioeconomic objectives of different user groups. This issue becomes further complicated when certain sectors require special attention or consideration, e.g., artisanal or recreational fishers. Artisanal fisheries may need intervention in order to improve communities’ livelihoods. Recreational fisheries may deserve special attention because of the catch-and-release nature of the sport. Furthermore, socioeconomic issues are much more polarized and salient in developing countries, where widespread poverty among artisanal fishers coexists with fishing enterprises that attract wealthy foreign tourists, such as in West Africa.

3.1.1 Artisanal and recreational fisheries management background

There are many social factors to consider besides biological sustainability in fisheries management. Oftentimes, managers of artisanal fleets do not have any quantitative information about artisanal fishers themselves and have little information about the species they target or their harvest levels (Branch et al., 2002, Brinson et al., 2006, Garza-Gil and Amigo-Dobano, 2008, Hauck et al., 2002, Hutchings and Lamberth,

The motivations, strategies and management preferences of recreational anglers are fairly well understood in the Americas, Europe and Australia (Dendrinos, 1991, Ditton and Stoll, 2003, Maiolo and Kitner, 1989, Sutton and Ditton, 2001). There has been little research about recreational fishing on the African sub-continent, with the exception of South Africa. Often European anglers come to fish in Africa from the former colonial power because there are close economic and tourism ties with that country.

The objective of this chapter is to contrast the socioeconomic performance of two fleets that target billfish in the eastern Atlantic Ocean: one in Ghana and one in Senegal (Figure 3.1). The study uses financial indicators to contrast the performance of the Ghanaian artisanal and Senegalese recreational charter fleets. These two fleets were chosen because each nation is a member of ICCAT, which is the primary institution in
charge of managing large pelagic fish in the Atlantic Ocean. Furthermore, West African fishing fleets have substantial impacts on the billfish and tuna stocks that they share (ICCAT, 2006). The results of this chapter will be contrasted with a previous study of two fishing fleets that target Atlantic billfish in the western Atlantic (Brinson et al., 2006).

Figure 3.1. Location of study areas in the eastern Atlantic Ocean, Ghana and Senegal, along with sites where surveys were conducted.

3.2 Methods

3.2.1 Study fleets

The Ghanaian fleet is an artisanal fleet that targets billfish, particularly sailfish. The Ghanaian artisanal drift gillnet (DGN) fleet is comprised of approximately 240 vessels, with 1,700 fishers who target the billfish and tunas. The artisanal fishers use
drift gillnets to target billfish, tunas and sharks from large (10m) motorized canoes, with a crew of about four to seven men, primarily in the towns of Dixcove, Apam, Axim and Shama (Figure 3.1; Mensah and Doyi, 1994). The billfish fishery began in 1974 in Ghana and the Ghana Ministry of Fisheries has collected catch data for the International Commission for the Conservation of Atlantic Tunas (ICCAT) Enhanced Research Program for Billfish since 1989 (Mensah, 1994). The Ministry of Fishery collects data on catch, effort and value of the landed fish.

In Senegal there are six known cities that host fishing clubs or centers (Figure 3.1). There is one fishing center in Dakar, two fishing centers in N’Gor and four fishing centers in Saly. Approximately eight firms that target billfish operate in these three areas. The number of fishing centers is unknown in Saloum, Cap Skeree and St. Louis. All of the known charter boat firms belong to the Fédération Sénégalaise de pêche Sportive. The Federation recommends different rules to its members and oversees recreational fishing within Senegal. Each of the operations typically has three to four people on board: the captain or skipper, the mate, the client and maybe the owner. The crew members help the client locate and hook the fish. The charter boats use standard recreational vessels that are 10 in length with two 270 horsepower engines on board. Anglers target sailfish, swordfish and dolphinfish on eight hour trips. The West African fleets were chosen for this study because there is little information about African fisheries targeting billfish. Furthermore, these fisheries have substantial impacts on billfish stocks (ICCAT, 2006).
3.2.2 Survey methodology

Surveys were developed following Armstrong et al. (1992) and Brinson et al. (2006) to obtain data on the fishery. Four types of information were collected from the surveys: a description of fishery operations, socioeconomic operator data, demographic data and perceptions of fishery management objectives. The questionnaire included both quantitative and open-ended questions, with the latter providing an opportunity for comment on difficult and/or contentious issues. The final survey instrument was adopted and administered in 2005 (Ghana) and in 2007 (Senegal). The data were used to estimate the four performance indicators: gross revenue, net revenue, financial profit and economic profit.

Standard techniques were used to contact and conduct in-person surveys with the respondents (Dillman, 2000, Fowler, 2002). In Ghana, all owners were contacted for participation in each area where billfish are landed. If the owner was not available, then the survey was completed with the head fisherman (equivalent to captain). Fisheries officers from the Ghanaian Ministry of Fisheries conducted surveys in the local dialect exclusive to that region. The officers completed the survey form and translated survey responses. Response bias does not seem to be affected by the surveys being conducted by local fisheries officers. In Senegal, surveys were conducted at the following centers: Dakar Sportfishing Center, Espadon Club, Blue Marlin Club, Saly Fishing Club and the N’Gor Fishing Center. The owners and/or crew of the different charter operations were contacted at each site and surveyed in French.

The results from Ghana represent the responses of all owners or head fishermen who chose to participate in the study. Fishers primarily refused participation due to lack
of time and/or unwillingness to reveal information about their operations. Data were obtained from 53% (n=129) of the vessels in the Ghanaian DGN billfish fleet. However, the response rate (41.3%, n=52) in one site, Shama, was much lower than the other sites (60.7-72.4%). Respondents (individual fishers) in this location had a lower participation rate because they wanted monetary remuneration for the time taken to answer the survey. This was probably due to the fact that the primary author was present and perceived to have access to large amounts of monetary capital. The results in Senegal represent the responses (n=15, 88% response rate) of either the owner or crew member whom the interviewer was able to contact. The interviewer was not able to establish contact with one owner.

3.2.3 Performance indicators

Four performance indicators were chosen for this study: gross revenue, net revenue, financial profit and economic profit (Brinson et al., 2006, Whitmarsh et al., 2000). These performance indicators have been used previously for other artisanal and recreational fleets (Brinson et al., 2006, Garza-Gil and Amigo-Dobano, 2008, Hutchings et al., 2002, Pascoe et al., 1996, Whitmarsh et al., 2000).

The Ghana Ministry of Fisheries collects monthly harvest and effort data for species landed in the four landing sites as part of the Enhanced Billfish Research Program. The data collection also includes information about the sale price of harvested fish. The Ghanaian analysis is based upon the entire fleet’s monthly performance because the harvest database is based upon the entire fleet’s monthly landings. Therefore, the performance results are for the entire fleet rather than for individual vessels. Median vessel owners’ survey responses were used for costs in the performance
indicators’ calculations. The Senegalese data are based upon individual vessels’ performance during the year.

The performance indicators are different measures of revenue for the owner and society. The indicators increasingly account for more costs. Annual gross revenue is the total amount of revenue generated from the sale of fish or from the sale of fishing trips. Gross revenue is the amount of revenue accruing to the owner before accounting for any costs. Gross revenue \( (GR_A) \) was calculated for the Ghanaian artisanal fleet (subscript \( A \))

\[
GR_A = \pi_\beta + \pi_\theta
\]

as the sum of billfish revenue \( (\pi_\beta) \) and non billfish revenue \( (\pi_\theta) \)

\[
\pi_\beta = \sum_i (h \cdot pr), \text{ where } h \text{ represents the harvest of billfish species } i \text{ and } pr \text{ represents the sale price of species } i.
\]

\[
\pi_\theta = \sum_j h \cdot \overline{pr}, \text{ where } h \text{ represents the harvest of non billfish species } j \text{ and } \overline{pr} \text{ represents the average sale price.}
\]

Gross revenue \( (GR_R) \) was calculated as the produce of the charter fee \( (Y) \) and the number of trips \( (ER) \) for the year for the Senegalese recreational charter fleet

\[
GR_R = Y \cdot ER
\]

Net revenue \( (NR) \) is the difference between gross revenue \( (GR) \) and running costs \( (RC) \).

\[
NR = GR - RC
\]

Running costs are costs that change with the number of trips a vessel completes, including the cost of bait \( (\varphi) \), fuel \( (\delta) \) and groceries \( (\lambda) \). Net revenue is the short term revenue for either the artisanal or charter fleet producer or owner.
Financial profit is the third performance indicator, and it measures the amount of cash coming in and out of an industry (Hundloe, 2000). This financial performance indicator considers the viability of an industry in terms of its commercial profitability (Pascoe et al., 1996). Positive financial profits indicate that the revenue exceeds the owner’s cash investment (Pascoe et al., 1996, Whitmarsh et al., 2000). Financial profit (FP) is the difference between gross revenue and all costs (running costs, fixed costs and crew payments).

\[ FP = GR - RC - FC - CR \]

In contrast to running costs, fixed costs do not change with the number of trips taken in a year. Fixed costs (FC) include the annual repair costs for the gear (\(\mu\)), vessel (\(v\)), and equipment (\(\gamma\)), the cost of licenses (\(\kappa\)), dock fees (\(\psi\)), federation membership fees (\(\eta\)) and insurance (\(\iota\)).

\[ FC = \sum(\mu, v, \gamma, \kappa, \psi, \eta, \iota) \]

A monthly estimate for fixed costs was calculated for the artisanal fleet based upon the average annual estimate of fixed costs (\(\bar{FC}\)) and the fleet size (\(\Delta\))

\[ FC_\Delta = \frac{\bar{FC} \times \Delta}{12} \]

The crew payments (CR) included any direct payments to crew members for each trip.

In contrast to financial profit, economic profit is the value of fishing to society in terms of the resource costs of that activity (Pascoe et al., 1996). Economic profit is an indicator that measures the efficiency of a producer in society’s view. This performance indicator measures the real costs of inputs in comparison to output or revenue (Pascoe et
al., 1996, Whitmarsh et al., 2000). Economic profit (EP) deducts running costs, fixed costs and the opportunity costs of both capital items and labor from gross revenue.

$$EP = GR - RC - FC - Z - \Lambda$$

The opportunity cost of an item is defined as the value of the next best alternative (Allen et al., 2002, pp. 667). It is often difficult to determine the opportunity cost of capital investment ($Z$); instead, the rental price of the capital goods was used. The rental price is a function of the replacement value for the vessel ($\alpha$), gear ($o$) and equipment ($\varepsilon$).

$$Z = \frac{\sum (\alpha, o, \varepsilon) \times 0.14}{12}$$

We assumed that the opportunity cost of labor ($\Lambda$) was equal to the product of the number of trips ($E$), the minimum wage of laborers ($\Omega$), the number of hours per trip ($\omega$) and the crew size ($\tau$).

$$\Lambda = E \times \Omega \times \omega \times \tau$$

The four performance measures account for costs in different manners. Financial profit calculations simply view the industry in terms of its profitability to the owner. Economic profit evaluates profitability in terms of the greater society. If financial profit is positive, the industry is profitable for the owner. If economic profit is positive, the industry is efficient and profitable for society. If economic profit is negative, then the true cost of factors of production exceed the revenue generated by the industry. If performance indicators for financial and economic profit conflict, this is due to the manner by which costs are handled. Only economic performance indicators account for the opportunity cost of labor and capital items. Furthermore, if financial profit indicators are positive and economic profit is negative, then the fleet may be commercially viable in the short term, but not operating optimally based upon a long-term analysis of allocating
society’s resources efficiently (Brinson et al., 2006, Hundloe, 2000, Pascoe et al., 1996, Whitmarsh et al., 2000).

3.3 Results

3.3.1 Socio-demographic results

Artisanal fishers in Ghana tended to be older, the head of a large household, lacked formal education and had limited access to infrastructure. All of the active owners or captains were adults, with a median age of 48 years. In the fishing communities, polygamy was common practice and most fishers had two wives and six dependents. Most fishers had fewer than six years of formal education. The lack of formal education was apparent in the Ghanaian fishing communities: less than 30% of the fishers could read or write. The infrastructure in fishing communities was limited as well. Less than 40% of the respondents had running water and less than 20% had a functional sewer system in their households; however, the majority (95%) had electricity in their homes. Households that did not have running water or a sewer system relied upon public facilities for water (public well – 45%) and sewer systems (public pit latrine – 55%).

The Ghanaian artisanal fishers were extremely experienced and dependent upon fishing for their livelihoods. Ghanaian artisanal fishers had a median of 21 years of fishing experience; 13 years were spent at their current site alone. They were at least a third generation fisher. Only 19% practiced occupational multiplicity, which is having another occupation. Owners had two canoes, a crew of eight men and took three and a half trips per week on average.
Senegalese anglers had different demographic profiles depending on their crew position (captain/mate versus owner). Overall, anglers were middle aged, 46 years old. Crew members were more likely to have larger households than the operator or owner (median household size 11.7 people versus 3.3 people, \( t=4.08** \)) with more dependents (6.3 children versus 1.4 children, \( t=2.88^* \)). Crew members did not have the same level of access to services when compared to operators, although this relationship was not found to be statistically significant. Operators all had running water, electricity and sewer systems in their households. Crew members were less likely to be guaranteed this same level of services; 14.3% did not have running water (\( \chi^2=1.606, p=0.205 \)) or electricity (\( \chi^2=1.606, p=0.205 \)) and 27% lacked a sewer system (\( \chi^2=14.49*** \)) in their homes. A larger percentage (75% versus 29%) of operators exhibited occupational multiplicity (more than one occupation) than crew members (\( t=3.355, p=0.0670 \)).

### 3.3.2 Performance indicator results

Financial indicators for the Ghanaian DGN fleet were calculated for the entire fleet because landings data were not available for individual vessels. The median monthly gross revenue for the Ghanaian artisanal fleet was estimated to be $750,253 (Table 3.1). The median annual gross revenue for an individual vessel in the Senegalese recreational charter fleet was estimated to be $160,191 (Table 3.2). Table 3 shows that in Senegal, the median vessel earned net revenue of $73,791. Net revenue accounted for the running costs which included the annual cost of bait, fuel and groceries. Fuel costs account for more than two-thirds of a trip’s running costs in both Ghana and Senegal.
Median running costs were $86,400 in Senegal (Table 3.2). The monthly net revenue in the Ghanaian artisanal DGN fleet was $525,599, after accounting for running costs, ($272,100) (Table 3.1).

Table 3.1. Monthly gross revenue, net revenue and financial profit for the Ghanaian artisanal fleet.

<table>
<thead>
<tr>
<th></th>
<th>Median ($)</th>
<th>Sample Size</th>
<th>Min ($)</th>
<th>Max ($)</th>
<th>Std. Dev ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross revenue²</td>
<td>750,253</td>
<td>12</td>
<td>295,856</td>
<td>6,363,707</td>
<td>1,701,976</td>
</tr>
<tr>
<td>Running costs</td>
<td>272,100</td>
<td>12</td>
<td>132,428</td>
<td>731,809</td>
<td>164,841</td>
</tr>
<tr>
<td>Net revenue</td>
<td>525,599</td>
<td>12</td>
<td>-86,518</td>
<td>5,928,166</td>
<td>1,659,524</td>
</tr>
<tr>
<td>Fixed costs³</td>
<td>54,167</td>
<td>12</td>
<td>54,162</td>
<td>54,167</td>
<td>--</td>
</tr>
<tr>
<td>Crew pay⁴</td>
<td>262,780</td>
<td>12</td>
<td>-43,259</td>
<td>2,964,083</td>
<td>8,297,672</td>
</tr>
<tr>
<td>Financial profit</td>
<td>208,632</td>
<td>12</td>
<td>-97,421</td>
<td>2,909,916</td>
<td>508,111</td>
</tr>
</tbody>
</table>

1 The exchange rate for 2005 was 9000¢ = US $1; values were adjusted to 2007 values using the Inflation Calculator, www.bls.gov.
2 The data on revenue were provided by the Ghana Ministry of Fisheries. The revenue data were only available at the fleet level, not at the vessel level; therefore, no further data were available.
3 An average was used for this variable based on individual respondent’s survey responses.
4 Crew pay is based upon direct payments to the crew. Since crew members were paid a salary based upon fish, it is possible to have negative crew pay or financial profit if owners were not able to catch enough fish to cover their variable costs.
Figure 3.2. An individual trip’s running cost for bait, fuel and groceries in Ghana and Senegal, adjusted to 2007 US dollars. Responses represent the median respondent’s answer to a series of questions regarding the costs for an individual trip.

Financial profit was the value of the enterprise to the individual owner. Financial profit accounted for running costs, fixed costs and direct crew payments. In Senegal, the median vessel’s financial profit was $66,459 (Table 3.2). Running costs, fixed costs and crew payments were $86,400, $5,978 and $616, respectively (Table 3.2). Monthly financial profit for the Ghanaian artisanal DGN fleet was $208,632 (Table 3.1). Running costs, fixed costs and crew payments were $272,100, $54,167 and $262,780, respectively (Table 3.1).
Table 3.2. Annual gross revenue, net revenue and financial profit for a Senegalese recreational vessel.

<table>
<thead>
<tr>
<th></th>
<th>Median ($)</th>
<th>Sample Size</th>
<th>Min ($)</th>
<th>Max ($)</th>
<th>Std. Dev ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross revenue</td>
<td>160,191</td>
<td>7</td>
<td>62,885</td>
<td>252,568</td>
<td>72,089</td>
</tr>
<tr>
<td>Running costs</td>
<td>86,400</td>
<td>7</td>
<td>12,700</td>
<td>176,330</td>
<td>56,871</td>
</tr>
<tr>
<td>Net revenue</td>
<td>73,791</td>
<td>7</td>
<td>-13,702</td>
<td>147,840</td>
<td>53,537</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>5,978</td>
<td>7</td>
<td>10</td>
<td>53,080</td>
<td>19,063</td>
</tr>
<tr>
<td>Crew pay</td>
<td>616</td>
<td>7</td>
<td>616</td>
<td>2,497</td>
<td>810</td>
</tr>
<tr>
<td>Financial profit</td>
<td>66,459</td>
<td>7</td>
<td>-14,431</td>
<td>118,197</td>
<td>43,007</td>
</tr>
</tbody>
</table>

1The exchange rate for 2007 was 487CFA = US$1.

Economic profit was the value of the enterprise to society as a whole. Median monthly economic profit for the Ghanaian DGN fleet was estimated to be $249,866 (Table 3.3). Running costs, fixed costs, the opportunity cost of labor and the opportunity cost of capital items were $272,100, $54,167, $288,218 and $151, respectively (Table 3.3). Table 3.4 shows the annual economic profit for the median Senegalese vessel, $28,663. Also shown in Table 3.4 are the components of economic profit: running costs ($86,400), fixed costs ($5,978), the opportunity cost of labor ($1,836) and the opportunity cost of capital items ($9,487).

In both Senegal and Ghana, the median financial and economic profits were positive; however, there were vessels that experienced negative financial and economic profits. This indicates that while overall financial profit is positive, there are some vessel owners who are unprofitable. The results of the economic profit analyses indicate that the fleet is efficient overall, but there are some vessels owners who are inefficient
because the true cost of the factors of production exceed the revenue generated by the industry. Negative economic profit indicates that the fishery is not sustainable based upon society’s view of allocating resources in the most efficient manner because the indicator accounts for the opportunity costs of labor and capital.

Table 3.3. Monthly economic profit for the Ghanaian artisanal fleet.

<table>
<thead>
<tr>
<th></th>
<th>Median ($)</th>
<th>Sample Size</th>
<th>Min ($)</th>
<th>Max ($)</th>
<th>Std. Dev ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running costs</td>
<td>272,100</td>
<td>12</td>
<td>132,441</td>
<td>731,809</td>
<td>164,841</td>
</tr>
<tr>
<td>Fixed costs²</td>
<td>54,167</td>
<td>12</td>
<td>54,167</td>
<td>54,167</td>
<td>--</td>
</tr>
<tr>
<td>Labor opportunity cost³</td>
<td>287,966</td>
<td>12</td>
<td>140,289</td>
<td>775,156</td>
<td>174,605</td>
</tr>
<tr>
<td>Capital items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>opportunity cost⁴</td>
<td>151</td>
<td>12</td>
<td>151</td>
<td>151</td>
<td>--</td>
</tr>
<tr>
<td>Economic profit⁵</td>
<td>249,866</td>
<td>12</td>
<td>-744,643</td>
<td>5,412,508</td>
<td>5,093,711</td>
</tr>
</tbody>
</table>

¹The exchange rate for 2005 was 9000¢ = US$1 conversion factor used; values were adjusted to 2007 values using the Inflation Calculator, www.bls.gov.
²An average was used for this variable based on individual respondent’s survey responses.
³The opportunity cost of labor was calculated as 13,500¢ per hour (http://www.thestatesmanonline.com/pages/news_detail.php?newsid=2340&section=1, accessed March 10, 2008).
⁴Depreciation was included in the calculation of the opportunity cost of capital items.
⁵The data on revenue were provided by the Ghana Ministry of Fisheries. The revenue data were only available at the fleet level, not at the vessel level; therefore, no further data were available.
Table 3.4. Annual economic profit for a Senegalese vessel\(^1\).

<table>
<thead>
<tr>
<th></th>
<th>Median ($)</th>
<th>Sample Size</th>
<th>Min ($)</th>
<th>Max ($)</th>
<th>Std. Dev ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running costs</td>
<td>86,400</td>
<td>7</td>
<td>12,700</td>
<td>176,330</td>
<td>56,871</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>5,978</td>
<td>7</td>
<td>10</td>
<td>53,080</td>
<td>19,063</td>
</tr>
<tr>
<td>Labor opportunity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cost(^2)</td>
<td>1,836</td>
<td>7</td>
<td>882</td>
<td>4,320</td>
<td>1,274</td>
</tr>
<tr>
<td>Capital items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>opportunity cost(^3)</td>
<td>9,487</td>
<td>7</td>
<td>4,312</td>
<td>48,487</td>
<td>18,252</td>
</tr>
<tr>
<td>Economic profit</td>
<td>28,663</td>
<td>7</td>
<td>-25,035</td>
<td>108,372</td>
<td>49,877</td>
</tr>
</tbody>
</table>

\(^1\)The exchange rate for 2007 was 487CFA = US$1.
\(^2\)The opportunity cost of labor was calculated as US $0.3 per hour (http://www.senegalemembassy.co.uk/cost_of_labour.html, accessed March 10, 2008).
\(^3\)Depreciation was included in the calculation of the opportunity cost of capital items.

3.3.3 Fishers’ perceptions

More than two-thirds (73\%) of the artisanal fishers in Ghana perceived that the billfish catch rates are lower compared to ten years ago (Figure 3.3). In contrast, close to one-half (40\%) of the Senegalese anglers perceived that the billfish catch rates were lower. In Senegal, the majority (60\%) did not perceive a change in the size classes of billfish species; however, Ghanaian fishers (57\%) perceived billfish to be smaller (Figure 3.4). Ghanaian fishers attributed both environmental changes and divine forces as the cause for resource fluctuation. In contrast, Senegalese anglers blamed industrial fishery operations and the proliferation of artisanal fishers for the declines of billfish.
Figure 3.3. Percentage of respondents who perceived a change in the billfish catch rates compared to ten years ago. Answers represent the percentage of people who responded that catch rates were either higher, the same or lower compared to ten years ago.

Figure 3.4. Percentage of respondents who perceived a change in the average size classes of billfish. Answers represent the percentage of people who responded that the average size of billfish were either bigger, the same or smaller compared to ten years ago.

Ghanaian and Senegalese fishers had different opinions about management measures that could be implemented in the future to improve the fishery (Figure 3.5). In
general, however fishers are unwilling to accept input controls, such as closed seasons or closed zones, and quotas limiting their catch. Ghanaian fishers are somewhat accepting of size limits or gear restrictions (Figure 3.5). In Senegal, anglers are most likely to accept quotas or size limits as management measures. Senegalese anglers are less likely to accept closed seasons, closed zones, gear restrictions or mandatory circle hook use as management measures (Figure 3.5).

![Figure 3.5. Eastern Atlantic fishermen’s acceptance of different management measures. Answers represent the percentage of people who agreed with each individual management option. Other management options included the exclusive use of circle hooks or no management at all.](image)

3.4 Discussion

Many studies for artisanal fisheries report negative profitability or revenues (Hutchings et al., 2002). However our results and others point out that this is not necessarily always the case (Brinson et al., 2006, Garza-Gil and Amigo-Dobano, 2008).
Some trends are similar between the Ghanaian artisanal fleet and the Senegalese recreational charter fleet. Both fleets appear to have positive profits, but it is uncertain whether or not this is sustainable.

Although the Ghanaian DGN fishers earn positive economic profits, they live in persistent states of poverty and the question remains as to why. The owners have positive financial profits, but these may not be substantial enough to change their living situation (i.e. lack of access to water and/or sanitation services). It is important to note that this analysis is for boat owners; crew members may live in worse conditions and be more vulnerable to poverty than the owners. It is unclear, however, whether increased income or earnings will necessarily move these fishers or owners out of poverty.

One explanation for the continued existence of poverty may have to do with the lack of banking institutions or savings knowledge in artisanal fishing communities. Artisanal fishers may not be knowledgeable about savings techniques to decrease their personal risk of poverty during periods of low catches. There are no formal banking institutions in the areas where the artisanal DGN fleets are located. Learning about savings techniques is important because it has been hypothesized that the traditional buffer to low fish catches was hunting for small mammals (bushmeat) in adjacent forest areas. There has been a decline in these terrestrial resources as well and it was shown that illegal bushmeat hunting is related to low fish catches. Artisanal fishers may not be able to rely upon this buffer for employment and/or protein (Brashares et al., 2004, Rowcliffe et al., 2005). They will need to make behavioral adjustments to reduce risk and vulnerability from low fish catches such as savings techniques. Proper savings techniques may help buffer fishers’ financial status during periods of low catches. If
management measures were to be implemented, it would be vital to simultaneously introduce workshops that train fisherfolk on savings techniques.

Another issue may be that during periods of high billfish catches there may be a market glut that lowers the fleet’s profitability. Technological storage improvements may mitigate the profit variability. Currently, processors do not have advanced technical capacity to store fish for long periods of time. If the processors were able to store fish during high catch periods and then sell the reserves during low catch periods, they may be able to stabilize their profits throughout the year. Savings schemes and the capacity to store fish for longer periods of time may reduce the vulnerability of fisherfolk and other community members.

In Senegal, the charter fleet seems to be operating sustainably, but there is no information about the number of charter fleets in Cap Skeree, St. Louis or Saloum. The majority (71%) of crew members surveyed were artisanal fishers before becoming sport fishers. The results of this study indicate that the crew pay is less than the opportunity cost of labor in Senegal, indicating that the crew’s labor is undervalued. If there is overcapacity in the artisanal sector, more fishers may enter the sport fishery. The effort and number of charter boats should be monitored to prevent overcapacity in the recreational sector.

Although the Senegalese sport fishery is small, the fleet exhibits positive economic or financial profits primarily because it is an elite recreational activity. The majority of the customers are foreign nationals, and billfish recreational fishing is part of a larger vacation experience. However, some customers travel to the fishing centers specifically to experience billfish fishing in Senegal. This is apparent at some of the
larger resorts that have a fishing fleet within the hotel. The recreational charter fleet is small and sustainable at this point. If there is overcapacity in the Senegalese artisanal sector, fishers may covet crew positions on recreational vessels. Crew positions on recreational vessels may not be available because this fleet is small. Managers will need to monitor the recreational sector to ensure that there is not increased effort or overcapacity in the Senegalese recreational sector.

In both study areas, fishers perceived a decrease in the billfish catch rate and perhaps a change in the average size of fish caught (only in Ghana). However, fishers were largely unwilling to accept management measures that were not already in place. Ghanaian fishers were somewhat supportive of size limits and gear restrictions, but this may be due to the current minimum mesh size (40 mm) regulation. This limited acceptance indicates that there may be fishers who may not make the connection that the objective of management measures is to improve the fishery. Furthermore, fishers may perceive personal risk from management measures. Most fishery operations typically undervalue the crew’s time; i.e., the crew pay is less than the national opportunity cost of labor. This was apparent in Senegal, but not apparent in Ghana (the opportunity cost of labor was greater than direct crew payments). These results may indicate that fishing is a good or profitable source of employment for otherwise unskilled workers who have few alternative sources of employment.

Table 3.5 compares performance indicators in West Africa to a previous study of similar fleets in Venezuela and Florida (Brinson et al., 2006). The indicators for Venezuela and Florida were adjusted from 2003 to 2007 values using the Bureau of Labor Statistics inflation calculator (www.bls.gov, accessed March 15, 2008). Ghanaian
performance indicators were adjusted by the estimated number of vessels in the fleet (242) to compare average individual fisher’s performance indicators.

Table 3.5. Annual performance indicators for the average artisanal and recreational vessel targeting Atlantic billfish$^{1}$.

<table>
<thead>
<tr>
<th>Location</th>
<th>Fleet type</th>
<th>Gross Revenue (Median $)</th>
<th>Net Revenue (Median $)</th>
<th>Financial Profit (Median $)</th>
<th>Economic Profit (Median $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venezuela$^{2}$</td>
<td>Artisanal</td>
<td>22,201</td>
<td>15,055</td>
<td>1,461</td>
<td>1,363</td>
</tr>
<tr>
<td>Ghana</td>
<td>Artisanal</td>
<td>37,203</td>
<td>26,063</td>
<td>10,345</td>
<td>12,390</td>
</tr>
<tr>
<td>South Florida$^{2}$</td>
<td>Recreational</td>
<td>402,965</td>
<td>371,067</td>
<td>312,227</td>
<td>223,425</td>
</tr>
<tr>
<td>Senegal</td>
<td>Recreational</td>
<td>160,191</td>
<td>73,791</td>
<td>66,459</td>
<td>28,663</td>
</tr>
</tbody>
</table>

$^{1}$ All values were adjusted with the inflation calculator to reflect 2007 US dollars, except for data from Senegal which were collected in 2007 (www.bls.gov, accessed March 15, 2008).  
$^{2}$ (Brinson et al., 2006)

All four fleets have declining values for each performance indicator as one accounts for more costs, except in Ghana. In Ghana, the economic profit was greater than financial profit (Table 3.5). This may indicate that the crew pay was greater than the opportunity cost of labor. The artisanal fleet in Venezuela has nearly equal values for economic profit suggesting that fixed costs may be more prohibitive in Venezuela because of the large difference between net revenue and financial profit (Brinson et al., 2006).
The performance indicators for the recreational fleets follow a similar decreasing trend, except for net revenue in Senegal (Table 3.5). Senegalese net revenue is nearly half the value of gross revenue. The greatest component of running costs is the cost of fuel. While all of the fleets are sensitive to the cost of fuel, fishers in Senegal are extremely sensitive to the price of fuel, which comprised 92% of the daily running costs (Figure 3.2). The surveys in Florida were conducted in 2003 and accounted for two-thirds of the running costs (Brinson et al., 2006). Given the change in the price of oil in the last five years, this result may be very different if the Florida data were updated. Other than the difference in net revenues, the performance indicators for the recreational fleets follow similar trends. The other differences in performance indicator values were due to the development differences between the United States and Senegal.

Fishers in Senegal and Ghana were unwilling to support management measures that would protect billfish even though they perceived a decline in billfish abundance. The same phenomenon was apparent in Venezuela and South Florida (Brinson et al., 2006) indicating that fishers, regardless of their geographic location or objective, do not see the connection between management regulations and sustainability-based improvements in the fishery. Managers who decide to implement restrictions for resource improvements will have to address and overcome this disconnect.

The goal of this research was to characterize the artisanal and recreational fleets in West Africa that target billfish. The socioeconomic performance indicators were able to characterize the Ghanaian artisanal and Senegalese recreational charter fleets. Another objective of this chapter was to demonstrate that these indicators are effective tools to contrast fleets in different geographic locations with different fishing objectives. The
performance indicators were useful measures of profitability for fleets that target Atlantic billfish. We suggest that others consider using measures such as these to contrast fishing fleets’ profitability and performance.
Chapter 4:
Evaluating an economically optimal allocation framework for Atlantic Billfish in Ghana, West Africa

4.1 Management background

Fish provide food, employment and recreation for many around the world. Fishing operations have expanded in the last century, including industrial, recreational and artisanal fishing operations. There have been many drivers attributed to increased fishery exploitation. Some of these drivers are increased human population, increased demand for seafood products, improved technology and increased demand for recreational activities (FAO, 1997, H. John Heinz III Center for Science, Economics and the Environment, 2000, Worm et al., 2006). Managers and scientists face a conundrum: how to account for multiple demands for fishery resources and the different objectives of users while maintaining a sustainable level of fishery resources.

There are many management strategies with the goal of reducing overfishing and maintaining healthy, sustainable fish populations. While reducing overfishing is often the goal of management, the economic and social impacts of management strategies must be reconciled (Green, 1994). There are three general objectives that management strategies try to achieve: biological, economic or social objectives. Management strategies that try to maximize biological objectives seek to ensure that “living resources are not endangered by overexploitation.” Such strategies try to “maintain or restore populations of harvested species at levels which produce the maximum sustainable yield or MSY” (Caddy and Mahon, 1995, UN, 1983). Management strategies with biological
objectives may enact restrictions that limit the amount of catch or effort for a fleet. Socially-based management strategies may try to empower users’ rights, preserve coastal communities, protect artisanal fisheries, or improve revenues for owner-operated fleets. For example, users may define or devise management plans. Management strategies with economic objectives seek to improve the economic efficiency of a sector so that fewer resources are used to catch more fish.

One method to achieve economic efficiency is through the assignment of property rights. Most resources operate under an open access regime, meaning that ownership of the resource is determined by whoever catches the fish. This lack of ownership is the most common cause of resource overexploitation (Gordon, 1953, Gordon, 1954, Hardin, 1968). Historically, the marine environment was considered common property under most national and international laws (Atta-Mills et al., 2004). Under open access the resource (fish) is an un-priced input for the operation. Fishery operators do not have ownership of the resource; therefore, there is an incentive to continuously fish. This often occurs when exploitation costs equal the fishery value. The solution is to institute property rights that provide fishers with an incentive to fish conservatively and eliminate the race to fish (Costello et al., 2008). In fact, the Law of the Seas was designed to address this lack of property rights for fisheries and the marine environment (Caddy and Mahon, 1995, UN, 1983); however, few nations have taken this one step further and allocated property rights to private citizens within the national exclusive economic zone (EEZ).

Property rights give users ownership over the resource and encourage them to exploit resources in a sustainable manner (Costello et al., 2008). Shares of the fishery
resource can be allocated through individual transferable quotas (ITQs). ITQs are an effective mechanism to instill property rights in the fishery and eventually achieve economic efficiency. Economic efficiency is achieved primarily because the quotas are transferable. This is important because users who inefficiently use (their costs outweigh the benefits from the sale of fish) their quota can sell their quota to other users who are more efficient. Over time, the fishery will achieve economic efficiency.

Co-management is often proposed as an effective management tool for artisanal fisheries due to their unique character, complexity and community importance. There is no single definition for co-management; however, the major premise is that resource management responsibilities are shared between the government and resource users, with varying levels of power sharing (NRC, 1999).

Co-management has been implemented in African fishery communities with limited success. The major challenge for African fisheries is establishing and maintaining co-management arrangements (Hara and Raakjær-Nielsen, 2003). Co-management arrangements have failed in African nations for a variety of reasons. Three basic assumptions of co-management are 1) “communities are comprised of fixed groups of families or individuals with a fishing livelihood; 2) village elders or chiefs are focused on individuals’ welfares or resource sustainability rather than tourism, better roads or increased development; and 3) the territorial use rights of the co-management structure coincide with the resource and fishers’ behaviors” (Ellis, 2000). Co-management projects often fail because these assumptions are erroneous. Donor projects that establish co-management for fishery dependent communities do not last and the government cannot maintain this level of funding (Hara and Raakjær-Nielsen, 2003, Leach et al.
The lack of long-term funding, the failure of local and/or national governments to intervene and erroneous assumptions lead to co-management disintegrating over time.

Two major arguments in resource management are determining who deserves access to the resource and what quantity that user can harvest. Once it is determined who deserves access, the quantity of initial allocation must be determined. In the case of transferable quotas, the initial allocation amount is not that crucial for economic efficiency because users can trade or sell quotas until an efficient level is reached. However, the initial quota allocation is often socially important: users may be unwilling to accept quota management if they deem their initial allocation unfair (Squires et al., 1995). If the quotas are not transferable, then the initial allocation of quota is extremely important. One strategy to allocate shares of such quota is to use an economically optimal allocation framework. This framework is vital because there is no market mechanism to reallocate shares among efficient users when the quotas are not transferable.

Allocating catch quota is important because competing users have their own personal agendas for seeking access to the same resource. Decision-makers have to choose among different allocation strategies that maximize various economic, social or biological objectives to competing users. The resource has to be redistributed and there are several methods that accomplish this goal. These methods can be based upon 1) economic efficiency, 2) historical use, 3) social equity, or 4) biological standards. Historical use allocation models divide the total allowable catch (TAC) based upon the status-quo use records. Allocation regimes that use biological indicators may suggest that allocation of the catch should be modified to improve the biological status of the
stock. Social equity goals include maximizing employment, increasing the number of jobs and/or maintaining historical occupations. Economic efficiency objectives strive to maximize the overall economic benefit (Green, 1994).

Any model based upon a specific objective will sacrifice gains in any of the other three objective areas. As a result, individual users may incur economic losses and demand a greater allocation share. Regardless of management objective used, there will be political impacts for entire sectors or some individuals. Decision-makers need flexibility to decide how to incorporate these other objectives and/or how to account for the associated tradeoffs in an objective manner (Criddle, 2004, Galeano et al., 2004). Therefore, it is important to develop a quantitative or objective system rather than relying solely upon political decisions to determine resource allocation strategies (Criddle, 2004).

4.2 Economic resource allocation

Using an economic resource allocation framework is an example of utilizing a quantitative system for resource allocation. Economic allocation of scarce resources requires reallocating resources to those users who generate the highest benefits to all of society. It is difficult to compare the benefits to society for commercial and recreational fisheries because there is no common metric. The benefits for industrial or artisanal fisheries are estimated based upon using the resource while the benefits from recreational fishing are derived from the actual recreational experience. Managers need an objective method to balance and compare these benefits (Loomis and Helfand, 2001). One such method to balance various issues is estimating the total value of a resource. Value is a monetary measure of well-being. One method of determining the value of a good is to
measure the net benefit, which is the value of the resource to society. Net benefit is measured as the difference between gross benefits and the costs to society (Green, 1994). Net benefit estimation should include both demand (consumer) and supply (producer) components (Bhat and Bhatta, 2006).

The benefits to both the producer and consumer are both essential when considering societal value and it is important to remember that producer and consumer benefits are neither synonymous nor equal. Producer surplus is the benefit that producers receive by selling their product at a higher price than the cost of production. Producer surplus is represented as the area between the actual price paid and supply curve (Figure 4.1). Producer surplus is estimated through using cost and earnings studies of commercial or artisanal fishing fleets (Brinson et al., 2006). On the demand or consumer side, consumer surplus is the total excess ‘satisfaction’ to consumers, or the difference between the price consumers are willing to pay for a good and the actual price paid (Clark, 1990). This would be represented by the area between the demand curve and the actual price paid (Figure 4.1).
Figure 4.1. The relationship between consumer and producer surplus of various goods.

Estimating the net benefits to recreational anglers is difficult because the data are either not available or difficult for researchers to obtain. Consumer surplus is the value or benefit of resources to consumers. In a perfect world, consumer surplus would be measured by deriving observable market prices, but this is not always the case because markets do not exist for many of these resource benefits, especially in the case of recreational fishing. Furthermore, expenditure data are often the only data available and subsequently are used as a proxy for the net benefits of recreational angling, but expenditures do not represent the true value of the recreational fishing experience. Expenditures are a measure of economic impact, which is the benefit to private business sectors. Expenditures often overestimate the benefit of the resource because opportunity costs are not taken into account. The net benefit or economic value measures the real value to society and accounts for resource opportunity costs. The opportunity cost is the value of the next best alternative job (Allen et al., 2002). For example, the opportunity cost of labor is often assumed to be equal to the salary of the next best employment
opportunity. Economic value is measured by consumer surplus, which is the difference between the amount that users are willing to pay and the amount they actually pay for that good (Figure 4.1) (Edwards, 1990, Green, 1994, Hundloe, 2000).

The consumer surplus of a resource can be derived through two different procedures. Revealed preference techniques, such as the Travel Cost Method, derive the amount a user is willing to pay for a good based upon their expenditures. Stated preference techniques derive the economic value for a resource from the users’ stated amount they are willing to pay for that resource. These techniques each have their associated advantages and disadvantages (e.g., great data needs and response bias, thus further complicating the economic value estimation) (Anderson, 2004, Loomis and Walsh, 1997, Loomis and Helfand, 2001). If inappropriate techniques are used and one sector is valued over another, managers may place too much of an emphasis on recreational or non-consumptive users (Laukkanen, 2001, Milliman et al., 1992).

Economically optimal allocation strategies use the equi-marginal principle (Figure 4.2) because shares of the resources are allocated at the point where the marginal benefit for each additional unit of the good is equal for each user group (Criddle, 2004, Galeano et al., 2004, Green, 1994). The marginal benefit measures the increase in benefits as additional use occurs (Green, 1994, Loomis and Walsh, 1997). If there are two user groups, resources should be allocated to where the benefits and costs are shared equally, thus each extra fish produces the same marginal benefit for either user group (Criddle, 2004, Galeano et al., 2004, Green, 1994).

Consider two user groups who seek access to a certain resource (Figure 4.2). The marginal benefit of each user group is plotted against the amount of quota each group
receives (X-axis). At EM*, the marginal benefit for each user group is equal and there is no welfare loss to society (Figure 4.2). At point EM¹, user group 2 has a higher marginal benefit than user group 1 and there is an overall welfare loss for society. At point EM², user group 1 has a higher marginal benefit than user group 2. The area under the curve represents the overall welfare loss to society. At both EM¹ and EM², there is an overall welfare loss to society because one user has a greater marginal benefit than the other user group. The quota allocation that produces equal marginal benefit for both user groups, EM*, represents the equi-marginal principle (Criddle, 2004, Galeano et al., 2004, Green, 1994).

![Figure 4.2. The equi-marginal principle for a hypothetical allocation scenario.](image-url)
4.2.1 Management and catch allocation of ICCAT billfish resources

The management conundrum of accounting for various users and maintaining sustainable resource levels is especially evident in the case of Atlantic Billfish management. The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the regional fishery management organization that conducts research to determine the condition of tuna and billfish resources. Populations of blue marlin and white marlin were considered overfished and overfishing was thought to be occurring; however, recent assessments have indicated that populations may be stabilizing (ICCAT, 2007). The status for sailfish and spearfish is less clear, but overfishing seems to be occurring in the eastern Atlantic (ICCAT, 2007). Atlantic billfish are caught as bycatch in industrial fishing operations, recreational fishers target billfish in a catch-and-release fishery and artisanal fishers target billfish for subsistence and small-scale commercial purposes.

ICCAT does not specifically allocate quota to an individual sector per se, but instead a stock wide harvest level is established for each species. The acceptable harvest level is recommended by the Standing Committee on Research and Statistics (SCRS). The Commissioners (mostly comprised of political appointees) either accept or modify the recommended total allowable catch (TAC) from the SCRS. The Commissioners in turn decide on the quantity of quota for individual member nations that will sum to achieve the stock-wide TAC. Often these decisions are driven by political objectives, but scientific information is sometimes included. ICCAT does not use ITQs as a management strategy, but instead relies upon traditional command-and-control strategies, e.g., catch limits or minimum size regulation resolutions.
Although ICCAT has used an ad-hoc allocation regime to determine the TAC for individual member nations, they have specifically protected artisanal fleets from quota reductions. This is glaringly evident in the case of Atlantic billfish management. After several recommendations by the SCRS to reduce the TAC of billfish, ICCAT eventually embarked upon an aggressive program to reduce the mortality of billfish primarily through bycatch reduction in industrial fleets (ICCAT Recommendation 97-9, 98-10, 00-13).

It is therefore plausible to assume that ICCAT has been managing billfish resources based upon three objectives. First, the industrial sector’s landings of billfish should be eliminated or reduced as close to zero as possible within realistic limitations of the fleet. The industrial sector was targeted because they had the highest source of fishing mortality and billfish were caught as bycatch, thus they were relatively unimportant to industrial operations. Second, recreational fishing should not be heavily regulated because the fishery is predominately catch-and-release. Finally, the artisanal fishery’s catch should not be constrained in order to preserve the social value of these activities and to ensure social and economic equity for developing countries. These three objectives are seen through the implementation of various ICCAT recommendations. Industrial fleets were first encouraged to reduce their landings of billfish (ICCAT Recommendation 97-9) and later required to release all live fish (ICCAT Recommendation 00-13). The artisanal sector was specifically exempted from regulations (ICCAT Recommendation 97-9). U.S. sport fishing tournaments were encouraged to cap their landings of billfish and the U.S. recreational fleet capped their billfish landings (ICCAT Recommendation 00-13).
Blue marlin and white marlin populations have stabilized and this may or may not be due to strict regulations on the industrial fishing sector (ICCAT, 2007). Unfortunately, it is apparent that these actions are not sufficient to rebuild billfish populations; therefore, ICCAT may need to reevaluate catch allocations for the artisanal and recreational sectors. Current strategies to rebuild billfish populations may not be sufficient due to a variety of factors. First, the catch from the artisanal sector may have shifted and taken over the catch previously attributed to the industrial sector. Figure 4.3 displays the historical catch by sector. This figure shows that it may be possible that artisanal fleets are increasing their catch for certain species of billfish, especially in the case of sailfish (Figure 4.3). Many artisanal fleets in West Africa and the Caribbean have shifted towards targeting pelagic resources as a strategy to deal with declining nearshore resources (Organization of Eastern Caribbean States, 1999, Perry and Sumaila, 2007). Second, the recreational harvest of billfish is underestimated because the estimated billfish post-release survival rate is probably overestimated. Three, there is an inability to determine whether the industrial sector’s reported catch is a product of their landings’ reduction or previous under-reporting of fishing mortality.
Figure 4.3. Historical catch of billfish by sector for the entire Atlantic Ocean. Panel a represents blue marlin, panel b, white marlin and panel c represents sailfish. Data source: ICCAT Task I Data.

It is evident that the allocation strategies used by ICCAT for billfish are not adequate given the complex nature of the fishery. Ignoring the issues of assessment and
real time monitoring necessary to maintain the minimum mortality for the industrial sector, the major decision for ICCAT is whether or not the artisanal sector can remain in a protected status if billfish populations can rebuild. This question translates into how the catch quota can be allocated among recreational and artisanal fisheries and which allocation method to use.

Competition between artisanal and recreational sectors is not a new phenomenon and has plagued fishery managers for many years in countries where these fleets coexist (e.g. Senegal, Venezuela). This ongoing competition for access and control over fishing grounds has led to campaigns through the political or legislative process to exclude certain users. For example, Venezuela has allocated certain portions of the La Guairá fishing grounds to recreational fishers by excluding commercial fishers. Countries like the U.S. have allocated all of the billfish stock to recreational fishers based upon the premise that there is no artisanal fishery in the U.S. (NMFS, 2004). However, there are active artisanal fishers in the U.S. Caribbean territories that compete with recreational fishers from the mainland U.S. for billfish resources. In West Africa, both artisanal and recreational fleets coexist in many nations, but the artisanal sector is much more important economically and lands a significant portion of nations’ total catches (Akrofi, 2002, Atta-Mills et al., 2004, Bannerman and Cowx, 2002, Marquette et al., 2002, Mensah and Antwi, 2002, Reid et al., 2005). In Senegal, the recreational sector may be small, but they are trying to influence national allocation decisions by promoting conservation while ensuring satisfactory access to fishery resources for themselves. Part of this competition between artisanal and recreational fishers can be attributed to political
power or lack thereof (i.e., the artisanal sector’s lack of political power and the recreational sector’s relative strength in political power and the political process).

This chapter presents a study that evaluates how an economic framework can determine the value of changing catch allocation for the artisanal and recreational fleets in Ghana, West Africa. Data from the artisanal pelagic fleet in Ghana and recreational fleets in other parts of the Atlantic and Pacific Oceans are used to parameterize the model. Exploring a hypothetical economic allocation scenario (determining EM*) in Ghana between these sectors may shed light on possible management actions for other areas of the Atlantic Ocean where the recreational and artisanal sector currently compete for access and power over billfish resources.

4.3 Methods

The following is a conceptual model that evaluated a hypothetical economically optimal allocation between recreational and artisanal billfish sectors in Ghana. Ghana has a well-developed artisanal fishing fleet located in four landing sites along the coast (Mensah and Doyi, 1994, Mensah, 1994) and an emerging recreational fishery (Anderson, October 2006, Giangio, 2001). The model used data from the case study on the Ghanaian artisanal pelagic fleet. The model explores optimal allocation for the Ghanaian billfish fishery.

4.3.1 Data sources

Monthly catch and effort information from the artisanal pelagic fleet that targets billfish in Ghana (1990 – 2005) were available. The data included the monthly harvest for sailfish, blue marlin, white marlin, swordfish, the ex-vessel sale price for each species

There were no fuel consumption data available; therefore, a technical relationship between gear and fuel usage was created to estimate fuel consumption, assuming that technology had not changed over the study period time. The technical relationship between fuel use and gear were adjusted by the CPI to accurately account for currency fluctuations over the study period. The opportunity cost of labor was estimated based upon data on crew size and the Ghanaian minimum wage (Brinson et al., 2006 and Chapter 3). The minimum wage was chosen as a measure because it is a quantitative indicator of wages that an unskilled worker may expect to receive in another labor intensive occupation, similar to fishing. These data sources were used to estimate the marginal benefit of the artisanal fishing sector in Ghana. While there is considerable fluctuation in these data, the mean prices were assumed to be good measures for estimating current allocations for the artisanal sector in Ghana because it best describes the data ranges. Descriptive statistics for the variables used are displayed in Table 4.1.
Table 4.1 Descriptive statistics of the variables from the Ghanaian artisanal pelagic fleet used in analyses.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Minimum</th>
<th>Max</th>
<th>Std. Dev</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landings (kg)(^1)</td>
<td>35,586</td>
<td>11,255</td>
<td>0</td>
<td>585,403</td>
<td>74,510</td>
<td>168</td>
</tr>
<tr>
<td>Landings (kg)(^2)</td>
<td>30,078</td>
<td>11,911</td>
<td>10</td>
<td>553,113</td>
<td>57,682</td>
<td>168</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(liters/trip)</td>
<td>85</td>
<td>85</td>
<td>1</td>
<td>168</td>
<td>49</td>
<td>168</td>
</tr>
<tr>
<td>Labor usage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(hours/trip)</td>
<td>49</td>
<td>48</td>
<td>1.11</td>
<td>100</td>
<td>29</td>
<td>168</td>
</tr>
<tr>
<td>Effort (no. trips per month)</td>
<td>994</td>
<td>628</td>
<td>67</td>
<td>9,434</td>
<td>1,096</td>
<td>168</td>
</tr>
<tr>
<td>Price(^1) ($/kg)*</td>
<td>0.89</td>
<td>0.53</td>
<td>0</td>
<td>5.78</td>
<td>0.95</td>
<td>168</td>
</tr>
<tr>
<td>Price(^2) ($/kg)*</td>
<td>0.41</td>
<td>0.28</td>
<td>0</td>
<td>1.87</td>
<td>0.41</td>
<td>168</td>
</tr>
<tr>
<td>Price of fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($/kg)</td>
<td>66.755</td>
<td>66.75</td>
<td>0.79</td>
<td>133</td>
<td>38</td>
<td>168</td>
</tr>
<tr>
<td>Opportunity cost of labor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>($/trip)</td>
<td>98.5</td>
<td>98.5</td>
<td>15</td>
<td>182</td>
<td>49</td>
<td>168</td>
</tr>
</tbody>
</table>

\(^1\)Refers to the landings and price of blue marlin, respectively.
\(^2\)Refers to the landings and price of other species, respectively.
*These values have been adjusted by the CPI 2005.
4.3.2 Model estimation

The model assumes that the artisanal pelagic fleet is comprised of vessels that make trips to catch a mix of species in order to maximize profit. The generalized Leontief profit function that describes profit maximizing behavior for fishing firms is (Campbell and Nicholl, 1995, Squires and Kirkley, 1991):

\[
\pi = \sum_i \sum_j \beta_i^j (p_i p_j)^{1/2} E + \sum_i \alpha_i p_i E^2 + \gamma_i \sigma_i E + \eta_i D_i p_i E,
\]

Equation 4.1

Profit, \(\pi\), is a function of the number of trips (E), the price (p) of species \(i\), dummy variables for season (\(\sigma\)) and inter-annual variation (\(D_i\)).

Applying Hotelling’s lemma, the following output supply (Equation 4.2) and input demand (Equation 4.3) functions are obtained (Campbell and Nicholl, 1995, Squires and Kirkley, 1991). Equation 4.2 represents the output supply functions for blue marlin and other billfish species, respectively. Prices (\(p_i\)) are included in both the input demand and output supply functions because prices affect the output and inputs.

Output supply functions

\[
\frac{\partial \pi}{\partial p} = y, \text{ (Equation 4.2)}
\]

\[
Q_1 = \alpha_1 E^2 + \beta_1 E + \beta_2 E \left( \frac{p_2}{p_1} \right)^{1/2} + \beta_3 E \left( \frac{p_\text{fuel}}{p_1} \right)^{1/2} + \beta_4 E \left( \frac{p_\text{labor}}{p_1} \right)^{1/2} + \\
\gamma_1 \sigma E + \zeta_1 D90 E + \eta_1 D91 E + \tau_1 D92 E + \kappa_1 D93 E + \lambda_1 D94 E + \mu_1 D95 E + \\
\nu_1 D96 E + \xi_1 D97 E + \rho_1 D98 E + \nu_1 D99 E + \chi_1 D01 E + \psi_1 D02 E + \\
NE_1 D03 E + LA_1 D04 E
\]

\[
Q_2 = \alpha_2 E^2 + \beta_2 E + \beta_2 E \left( \frac{p_2}{p_2} \right)^{1/2} + \beta_3 E \left( \frac{p_\text{fuel}}{p_2} \right)^{1/2} + \beta_4 E \left( \frac{p_\text{labor}}{p_2} \right)^{1/2} + \\
\gamma_2 \sigma E + \zeta_2 D90 E + \eta_2 D91 E + \tau_2 D92 E + \kappa_2 D93 E + \lambda_2 D94 E + \mu_2 D95 E + \\
\nu_2 D96 E + \xi_2 D97 E + \rho_2 D98 E + \nu_2 D99 E + \chi_2 D01 E + \psi_2 D02 E + \\
NE_2 D03 E + LA_2 D04 E
\]
Input demand functions \( \frac{\partial \pi}{\partial \rho} = -x \), (Equation 4.3)

\[
-Q_3^L = \alpha_3 E^2 + \beta_{31} E + \beta_{32} E \left( \frac{p_1}{p_{\text{fuel}}} \right)^{1/2} + \beta_{33} E \left( \frac{p_2}{p_{\text{fuel}}} \right)^{1/2} + \beta_{34} E \left( \frac{p_{\text{labor}}}{p_{\text{fuel}}} \right)^{1/2} + \gamma_1 \sigma E + \zeta_0 D90E + \eta_0 D91E + \nu_0 D92E + \kappa_0 D93E + \lambda_0 D94E + \mu_0 D95E + \nu_0 D96E + \zeta_0 D97E + \rho_0 D98E + \nu_0 D99E + \chi_0 D00E + \psi_0 D02E + \text{NE}_0 D03E + \text{LA}_0 D04E
\]

\[
-Q_4^L = \alpha_4 E^2 + \beta_{41} E + \beta_{42} E \left( \frac{p_1}{p_{\text{labor}}} \right)^{1/2} + \beta_{43} E \left( \frac{p_2}{p_{\text{labor}}} \right)^{1/2} + \beta_{44} E \left( \frac{p_{\text{fuel}}}{p_{\text{labor}}} \right)^{1/2} + \gamma_4 \sigma E + \zeta_4 D90E + \eta_4 D91E + \nu_4 D92E + \kappa_4 D93E + \lambda_4 D94E + \mu_4 D95E + \nu_4 D96E + \zeta_4 D97E + \rho_4 D98E + \nu_4 D99E + \chi_4 D00E + \psi_4 D02E + \text{NE}_4 D03E + \text{LA}_4 D04E
\]

The parameters estimated were \( \hat{\alpha}_1, \hat{\alpha}_2, \hat{\alpha}_3, \hat{\alpha}_4, \beta_{11}, \beta_{22}, \beta_{33}, \beta_{44}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{23}, \beta_{24}, \beta_{34}, \gamma_1, \gamma_2, \gamma_3 \) and \( \gamma_4 \). Dummy variables (\( \zeta_1, \zeta_2, \zeta_3, \zeta_4, \eta_1, \eta_2, \eta_3, \eta_4, \iota_1, \iota_2, \iota_3, \iota_4, \kappa_1, \kappa_2, \kappa_3, \kappa_4, \lambda_1, \lambda_2, \lambda_3, \lambda_4, \mu_1, \mu_2, \mu_3, \mu_4, \nu_1, \nu_2, \nu_3, \nu_4, \chi_1, \chi_2, \chi_3, \chi_4, \psi_1, \psi_2, \psi_3, \psi_4, \text{NE}_1, \text{NE}_2, \text{NE}_3, \text{NE}_4, \text{LA}_1, \text{LA}_2, \text{LA}_3, \text{LA}_4 \)) to account for inter-annual variability were estimated as well for 1990-2004 with 2005 as the base case. The SAS code and output used are available in Appendix V. Four different models were tested based upon seasonality (low and high catch months) and year (low and high year catches).

### 4.4 Model results

The supply and demand equations (Equation 4.2 and 4.3) were estimated using the iterative seemingly unrelated regression (ITSUR) procedure. The functions were iterated until convergence, which produce equivalent parameter estimates to maximum likelihood estimation results (Squires and Kirkley, 1991). Initially heteroskedasticity was
found in the functions. Heteroskedasticity is the violation of the assumption that error terms are drawn from a distribution with equal variance (Studenmund and Cassidy, 1987). In order to account for heteroskedasticity, a weighting procedure was used for effort. Effort was weighted because it was assumed that heteroskedasticity would affect the supply functions through the use of the $E^2$ term (Campbell and Nicholl, 1995, Squires and Kirkley, 1991). The modification did not reduce some forms of heteroskedasticity (Table 4.2). Pure heteroskedasticity was not found in any of the functions (Equation 4.3). The Breusch-Pagan test for conditional heteroskedasticity was not found in three of the four supply functions: Q₂, Q₃ and Q₄ (Table 4.2) (Studenmund and Cassidy, 1987, pp. 440). The system had a good fit, indicated by the value of $R^2$ (0.99) for the system of equations (Squires and Kirkley, 1991).²

### Table 4.2. Tests for conditional (Breusch-Pagan) and pure (White) heteroskedasticity for Model 1: low year and high season.

<table>
<thead>
<tr>
<th>Equation</th>
<th>White Test $(X^2, p\text{-value})$</th>
<th>Breusch-Pagan Test $(X^2, p\text{-value})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q₁</td>
<td>139.4, 0.0971*</td>
<td>0.44, 0.8018</td>
</tr>
<tr>
<td>Q₂</td>
<td>137.3, 0.1208*</td>
<td>41.61, &lt;.0001**</td>
</tr>
<tr>
<td>Q₃</td>
<td>152.5, 0.0208*</td>
<td>72.88, &lt;.0001**</td>
</tr>
<tr>
<td>Q₄</td>
<td>136.6, 0.1283*</td>
<td>58.64, &lt;.001**</td>
</tr>
</tbody>
</table>

* Values are statistically significant at the p<0.10 level.  
**Values are statistically significant at the p<0.01 level.

²“$R^2$ was calculated as $1 - \exp\left[2(L_0-L_1)/N\right]$, where $L_0$ ($L_1$) is the sample maximum of log likelihood when all slope coefficients equal zero and $N$ is the sample size (Squires and Kirkley, 1991).”
The parameter estimates are displayed in Table 4.3. In general, the parameter estimates converged to expected signs and magnitude. The alpha parameters are hypothesized to be negative because these parameters capture the diminishing returns nature of inputs. All of the alpha parameters were negative. The beta parameters also performed as expected. The interaction beta terms were negative, with the exception of $\beta_{34}$. The beta terms for each of the four functions were positive as expected (Table 4.3).

Table 4.3. Parameter estimates from the high season and low catch year model, including dummy variables.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std Error</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1$</td>
<td>-0.014</td>
<td>0.010</td>
<td>1.44</td>
<td>0.1527</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>-0.019</td>
<td>0.001</td>
<td>-1.94</td>
<td>0.0544*</td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td>-6.000 E-5</td>
<td>0.000</td>
<td>-2.51</td>
<td>0.0132**</td>
</tr>
<tr>
<td>$\alpha_4$</td>
<td>-3.0 E-5</td>
<td>9.513 E-6</td>
<td>-2.88</td>
<td>0.0046**</td>
</tr>
<tr>
<td>$\beta_{11}$</td>
<td>104.588</td>
<td>29.161</td>
<td>3.59</td>
<td>0.0005**</td>
</tr>
<tr>
<td>$\beta_{22}$</td>
<td>300.415</td>
<td>27.717</td>
<td>10.84</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\beta_{33}$</td>
<td>0.549</td>
<td>0.097</td>
<td>5.67</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\beta_{44}$</td>
<td>0.122</td>
<td>0.075</td>
<td>1.64</td>
<td>0.1038</td>
</tr>
<tr>
<td>$\beta_{12}$</td>
<td>-3.730</td>
<td>3.054</td>
<td>-1.22</td>
<td>0.2240</td>
</tr>
<tr>
<td>$\beta_{13}$</td>
<td>-0.063</td>
<td>0.229</td>
<td>-0.27</td>
<td>0.7844</td>
</tr>
<tr>
<td>$\beta_{23}$</td>
<td>-0.2148</td>
<td>0.210</td>
<td>-1.02</td>
<td>0.3099</td>
</tr>
<tr>
<td>$\beta_{14}$</td>
<td>-0.001</td>
<td>0.170</td>
<td>-0.01</td>
<td>0.9934</td>
</tr>
<tr>
<td>$\beta_{24}$</td>
<td>-0.132</td>
<td>0.161</td>
<td>-0.82</td>
<td>0.4145</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>$\beta_{34}$</td>
<td>0.065</td>
<td>0.077</td>
<td>0.85</td>
<td>0.3976</td>
</tr>
<tr>
<td>Seasonal dummy variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>-5.764</td>
<td>14.465</td>
<td>-0.40</td>
<td>0.6909</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>-18.173</td>
<td>13.885</td>
<td>-1.31</td>
<td>0.1928</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>-0.056</td>
<td>0.033</td>
<td>-1.69</td>
<td>0.0942</td>
</tr>
<tr>
<td>$\gamma_4$</td>
<td>0.009</td>
<td>0.138</td>
<td>0.65</td>
<td>0.5196</td>
</tr>
<tr>
<td>Inter-annual dummies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\zeta_1$</td>
<td>-70.896</td>
<td>40.297</td>
<td>-1.76</td>
<td>0.0808</td>
</tr>
<tr>
<td>$\zeta_2$</td>
<td>-242.164</td>
<td>39.155</td>
<td>-6.18</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\zeta_3$</td>
<td>-0.562</td>
<td>0.113</td>
<td>-4.98</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\zeta_4$</td>
<td>-0.061</td>
<td>0.051</td>
<td>-1.20</td>
<td>0.2304</td>
</tr>
<tr>
<td>$\eta_1$</td>
<td>-80.788</td>
<td>38.094</td>
<td>-2.12</td>
<td>0.0358*</td>
</tr>
<tr>
<td>$\eta_2$</td>
<td>-248.286</td>
<td>36.528</td>
<td>-6.80</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\eta_3$</td>
<td>0.531</td>
<td>0.090</td>
<td>-5.88</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\eta_4$</td>
<td>-0.073</td>
<td>0.039</td>
<td>-1.87</td>
<td>0.0639</td>
</tr>
<tr>
<td>$\iota_1$</td>
<td>-80.848</td>
<td>37.418</td>
<td>-2.16</td>
<td>0.0325*</td>
</tr>
<tr>
<td>$\iota_2$</td>
<td>-253.133</td>
<td>35.817</td>
<td>-7.07</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\iota_3$</td>
<td>0.489</td>
<td>0.087</td>
<td>-5.61</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\iota_4$</td>
<td>-0.039</td>
<td>0.037</td>
<td>-1.06</td>
<td>0.2906</td>
</tr>
<tr>
<td>$\kappa_1$</td>
<td>-74.305</td>
<td>37.436</td>
<td>-1.98</td>
<td>0.0492*</td>
</tr>
<tr>
<td>$\kappa_2$</td>
<td>-236.225</td>
<td>36.070</td>
<td>-6.55</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\kappa_3$</td>
<td>-0.449</td>
<td>0.086</td>
<td>-5.25</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>$\kappa_4$</td>
<td>-0.054</td>
<td>0.036</td>
<td>-1.50</td>
<td>0.1358</td>
</tr>
<tr>
<td></td>
<td>( \lambda_1 )</td>
<td>( \lambda_2 )</td>
<td>( \lambda_3 )</td>
<td>( \lambda_4 )</td>
</tr>
<tr>
<td>( \lambda_1 )</td>
<td>-68.578</td>
<td>37.342</td>
<td>-1.84</td>
<td>0.0685</td>
</tr>
<tr>
<td>( \lambda_2 )</td>
<td>-240.070</td>
<td>36.476</td>
<td>-6.58</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \lambda_3 )</td>
<td>-0.442</td>
<td>0.086</td>
<td>-5.12</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \lambda_4 )</td>
<td>-0.062</td>
<td>0.037</td>
<td>-1.68</td>
<td>0.0956</td>
</tr>
<tr>
<td>( \mu_1 )</td>
<td>-61.789</td>
<td>38.119</td>
<td>-1.62</td>
<td>0.1073</td>
</tr>
<tr>
<td>( \mu_2 )</td>
<td>-239.082</td>
<td>36.981</td>
<td>-6.46</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \mu_3 )</td>
<td>-0.461</td>
<td>0.088</td>
<td>-5.22</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \mu_4 )</td>
<td>0.093</td>
<td>0.038</td>
<td>-2.44</td>
<td>0.0158**</td>
</tr>
<tr>
<td>( \nu_1 )</td>
<td>-55.640</td>
<td>7.356</td>
<td>-1.49</td>
<td>0.1387</td>
</tr>
<tr>
<td>( \nu_2 )</td>
<td>-244.497</td>
<td>36.023</td>
<td>-6.79</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \nu_3 )</td>
<td>0.381</td>
<td>0.086</td>
<td>-4.43</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \nu_4 )</td>
<td>-0.076</td>
<td>0.037</td>
<td>-2.08</td>
<td>0.0390*</td>
</tr>
<tr>
<td>( \xi_1 )</td>
<td>-3.691</td>
<td>39.014</td>
<td>-1.63</td>
<td>0.1049</td>
</tr>
<tr>
<td>( \xi_2 )</td>
<td>-250.405</td>
<td>37.532</td>
<td>-6.67</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \xi_3 )</td>
<td>-0.389</td>
<td>0.089</td>
<td>-4.35</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \xi_4 )</td>
<td>-0.052</td>
<td>0.038</td>
<td>-1.39</td>
<td>0.1673</td>
</tr>
<tr>
<td>( \rho_1 )</td>
<td>7.824</td>
<td>38.235</td>
<td>0.20</td>
<td>0.8382</td>
</tr>
<tr>
<td>( \rho_2 )</td>
<td>-180.015</td>
<td>36.690</td>
<td>-4.91</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>( \rho_3 )</td>
<td>-0.051</td>
<td>0.087</td>
<td>-0.59</td>
<td>0.5584</td>
</tr>
<tr>
<td>( \rho_4 )</td>
<td>0.134</td>
<td>0.037</td>
<td>3.67</td>
<td>0.0003**</td>
</tr>
<tr>
<td>( \upsilon_1 )</td>
<td>24.053</td>
<td>49.957</td>
<td>0.48</td>
<td>0.6310</td>
</tr>
<tr>
<td>( \upsilon_2 )</td>
<td>-171.917</td>
<td>47.929</td>
<td>-3.59</td>
<td>0.0005**</td>
</tr>
<tr>
<td>( \upsilon_3 )</td>
<td>-0.320</td>
<td>0.114</td>
<td>-2.81</td>
<td>0.0056**</td>
</tr>
</tbody>
</table>
\begin{tabular}{lccccc}
\hline
 & \(v_4\) & \(\chi_1\) & \(\chi_2\) & \(\chi_3\) & \(\chi_4\) \\
& -0.046 & 0.047 & -0.96 & 0.3378 \\
& -17.367 & 39.249 & -0.44 & 0.6588 \\
& -233.326 & 37.734 & -6.18 & \(<.0001^{**}\) \\
& -0.390 & 0.090 & -4.33 & \(<.0001^{**}\) \\
& -0.107 & 0.038 & -2.83 & 0.0054^{**} \\
& -48.344 & 37.850 & -1.28 & 0.2037 \\
\hline
\(\psi_1\) & \(-233.883\) & 36.277 & \(-6.45\) & \(<.0001^{**}\) \\
\hline
\(\psi_2\) & -0.306 & 0.087 & -3.52 & 0.0006^{**} \\
\hline
\(\psi_4\) & -0.070 & 0.037 & -1.90 & 0.0592^{*} \\
\hline
NE_1 & -64.809 & 48.526 & -1.34 & 0.1839 \\
\hline
NE_2 & -234.336 & 46.495 & -5.04 & \(<.0001^{**}\) \\
\hline
NE_3 & -0.344 & 0.111 & -3.10 & 0.0023^{**} \\
\hline
NE_4 & -0.078 & 0.046 & -1.68 & 0.0944 \\
\hline
LA_1 & 146.067 & 147.824 & 3.05 & 0.0027^{**} \\
\hline
LA_2 & -70.012 & 45.871 & -1.53 & 0.1293 \\
\hline
LA_3 & -0.294 & 0.109 & -2.70 & 0.0079^{**} \\
\hline
LA_4 & -0.052 & 0.045 & -1.16 & 0.2500 \\
\hline
\end{tabular}

*Values are significant at the p<0.05 level.

**Values are significant at the p<0.01 level.

4.4.1 Technology tests

Model structure tests for non-jointness and separability were tested by evaluating
the parameter estimates (Table 4.4). Input-output separability was rejected \((X^2=11.72, \ p<0.0196)\) for the model, meaning that changes in input (fuel, labor) prices alter the
quantity of catch composition (Jensen, 2002). Non-jointness was rejected for the overall system of output supply and demand functions. Non-jointness was rejected ($X^2=9.92$, $p<0.0193$) for one of the output supply ($Q_2$) functions, but was not rejected for the remaining functions ($Q_1$, $Q_3$, $Q_4$). Rejecting non-jointness in inputs suggests that prices will alter the catch composition (Campbell and Nicholl, 1995, Jensen, 2002). The annual dummies were found to be statistically significant, while the dummies for intra-annual variation were not (Table 4.4). This means that there were statistical differences across years, but not seasons.

Table 4.4. Model structure tests for separability, non-jointness and dummy variables for Model 1: low year and high season.

<table>
<thead>
<tr>
<th>Test</th>
<th>$X^2$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Separability</td>
<td>11.72</td>
<td>0.0196**</td>
</tr>
<tr>
<td>Overall Non-jointness</td>
<td>9.94</td>
<td>0.1270*</td>
</tr>
<tr>
<td>Non-jointness for $Q_1$</td>
<td>1.51</td>
<td>0.6808</td>
</tr>
<tr>
<td>Non-jointness for $Q_2$</td>
<td>9.92</td>
<td>0.0193**</td>
</tr>
<tr>
<td>Non-jointness for $Q_3$</td>
<td>1.35</td>
<td>0.7165</td>
</tr>
<tr>
<td>Non-jointness for $Q_4$</td>
<td>1.76</td>
<td>0.6229</td>
</tr>
<tr>
<td>Intra-annual variation (high or low catches)</td>
<td>6.38</td>
<td>0.1728*</td>
</tr>
<tr>
<td>Annual dummies</td>
<td>237.76</td>
<td>&lt;0.0001**</td>
</tr>
</tbody>
</table>

* Values are statistically significant at the $p<0.10$ level.
** Values are statistically significant at the $p<0.01$ level.
4.4.2 Price elasticity of supply

The price elasticity of supply was calculated and was found to be relatively inelastic (elasticity = 0.1473, t = 0.81, p< 0.4181). While the results are not statistically significant, something can be learned from the general relationship. This elasticity indicates that as prices rise by 10%, there is only a 1.47% change in supply of blue marlin. Prices are expected to be relatively inelastic (0<elasticity<1) in the short run because firms can only increase their supply through increasing labor. The price elasticity of supply may indicate that there are few substitutes for these fish species or that these goods are necessary for the consumers (Allen et al., 2002). These results should be interpreted with caution given that the results were not statistically significant.

4.4.3 Model simulation

The model estimated supply and demand for blue marlin (Q₁) and other billfish species (Q₂). The model was estimated for high and low catch years as well as high and low catch seasons. Simulations were run to understand the willingness to pay (WTP) for quota relationship in the artisanal pelagic billfish fleet for an entire year. It is important to understand the relationship between WTP and blue marlin quota in order to reduce the catch of billfish species.

The reduced catch for the artisanal fleet are achieved by the virtual price, \( \bar{p}_i = p_i - \tau \). The virtual price is vital because it forces firms under no regulations to behave as if there were regulations in place that limited the catch (Squires and Kirkley, 1991). The virtual price allows vessels to equate the “marginal product of effort with the unit cost of effort and vessel effort will decrease” (Campbell and Nicholl, 1995). The virtual price resembles regulations for firms because an increase in the virtual price is
equal to increasing the unit cost of effort, which leads to decreased effort and decreased landings for vessels that cannot control the species composition of the catch (Campbell and Nicholl, 1995).

Using the parameter estimates (Table 4.5), the optimal effort was calculated (Equation 4.4) and used to determine the optimal supply (Equation 4.2) for the fleet.

\[
\bar{E} = \frac{\beta_{11}(p_1 - \tau) + \beta_{12}\sqrt{p_2(p_1 - \tau)} + \beta_{13}\sqrt{p_{\text{fuel}}(p_1 - \tau)}}{2\alpha_1(p_1 - \tau)}, \text{ Equation 4.4}
\]

The WTP for quota in the Ghanaian artisanal pelagic fleet was found as the horizontal sum of the individual demands. The parameter estimates are similar in size and magnitude for the different models, except for \(\beta_{11}\) and \(\beta_{12}\). The high catch year high season model has a different estimate for the \(\beta_{12}\) parameter (price effects parameter); this may indicate that the other models are better estimates that fit all of the data. Each of the models estimated a different coefficient for the \(\beta_{11}\) parameter; however, there is not much variation among the \(\beta_{11}\) coefficients.
Table 4.5. Parameter estimates used to calculate artisanal sector’s willingness to pay for quota.

<table>
<thead>
<tr>
<th>Model</th>
<th>$\alpha_{11}$ (t, p-value)</th>
<th>$\beta_{11}$ (t, p-value)</th>
<th>$\beta_{12}$ (t, p-value)</th>
<th>$\beta_{13}$ (t, p-value)</th>
<th>$\beta_{14}$ (t, p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>-0.014</td>
<td>104.588</td>
<td>-3.731</td>
<td>-0.063</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(-1.44, 0.153)</td>
<td>(3.59, 0.001)*</td>
<td>(-1.22, 0.224)</td>
<td>(-0.27, 0.784)</td>
<td>(-0.01, 0.993)</td>
</tr>
<tr>
<td>Model 2</td>
<td>-0.014</td>
<td>87.221</td>
<td>-0.063</td>
<td>-0.063</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(-1.44, 0.153)</td>
<td>(2.87, 0.005)*</td>
<td>(-0.27, 0.784)</td>
<td>(-0.27, 0.784)</td>
<td>(-0.01, 0.993)</td>
</tr>
<tr>
<td>Model 3</td>
<td>-0.014</td>
<td>98.824</td>
<td>-3.731</td>
<td>-0.063</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(-1.44, 0.153)</td>
<td>(3.32, 0.001)*</td>
<td>(-1.22, 0.224)</td>
<td>(-0.27, 0.784)</td>
<td>(-0.01, 0.993)</td>
</tr>
<tr>
<td>Model 4</td>
<td>-0.014</td>
<td>81.457</td>
<td>-3.731</td>
<td>-0.063</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(-1.44, 0.153)</td>
<td>(2.64, 0.009)*</td>
<td>(-1.22, 0.224)</td>
<td>(-0.27, 0.784)</td>
<td>(-0.01, 0.993)</td>
</tr>
</tbody>
</table>

*Values are statistically significant at the p<0.01 level.
Model 1 refers to low year and high catch season.
Model 2 refers to high year and high catch season.
Model 3 refers to low year and low catch season.
Model 4 refers to high year and low catch season.

The WTP for quota of blue marlin from the four models based on season and high catch years are displayed in Figure 4.4. The WTP for quota will change year to year depending on the season or that year’s catch in comparison to previous years.
models are based upon season (high or low catch months) or year (high or low catch
years). All four of the models fall within one standard deviation (427 tons ± 569 tons) of
the mean Ghanaian blue marlin catch for 1990-2005. The low year high season model
will be the base model because the estimates are closest to the actual data collected in
Ghana.
Figure 4.4. The annual estimation of WTP for quota of blue marlin. Panel a represents a low year and high season. Panel b represents a high year and low season. Panel c represents a high year and high season. Panel d represents a low year and low season.
The artisanal WTP for quota must be compared to the recreational WTP for quota; however, there were no estimates of WTP for the recreational sector in Ghana or other parts of West Africa. Instead, there were estimates of WTP for fishing for sailfish on the Mexican Pacific coast (Chavez-Comparan and Fischer, 2001). This study determined the consumer surplus for sailfish fishing trips using two different methodologies: revealed and stated preference techniques to determine WTP for fishing. Based upon the revealed preference methodology, the consumer surplus for the entire recreational experience was $49.74 (adjusted to 2005 values) for a day of fishing (Chavez-Comparan and Fischer, 2001). Using the stated preference technique, the consumer surplus for catching a sailfish was $28.71 (adjusted to 2007 values). These estimates were based on one day of fishing during a trip that lasts 2.65 days. The estimates of consumer surplus were adjusted to reflect the value for the entire trip and will be compared to the marginal benefit for the entire artisanal fleet (Chavez-Comparan and Fischer, 2001).

Although the WTP estimates are from the Pacific Ocean and this study evaluates marginal benefit in Ghana, it is likely that the fishing experience in West Africa is similar to the experience in the Eastern Pacific Ocean (Prince and Goodyear, 2006). The Eastern Tropical Pacific Ocean and the Eastern Atlantic Ocean share similar habitat characteristics. There are distinct hypoxic areas that restrict the vertical movement of tunas and billfish to a shallow surface layer that may translate into increased catches and strikes for both recreational anglers and artisanal fishers (Prince and Goodyear, 2006). Therefore it is plausible to assume that the WTP for recreational billfish fishing is equal in Ghana and Mexico because 1) the fishing experiences are similar and 2) recreational
billfish anglers have similar characteristics worldwide. Recreational billfish anglers tend to be highly experienced, wealthy and typically travel from the U.S. or Europe to tropical destinations for fishing (Ditton et al., 1999, Ditton and Stoll, 2000, Ditton and Stoll, 2003, Fisher and Ditton, 1992, Graefe et al., 2005, Kitner and Maiolo, 1988).

The marginal benefit for the artisanal sector is based upon WTP per quota (kg) and the marginal benefit for the recreational sector is based upon the WTP per trip. These estimates are not even metrics of WTP. Equation 4.4 was used to create an even metric that is based upon WTP per trip for the artisanal sector.

\[ MB = \tau \times \frac{avg\text{landings}}{avgE}, \text{ Equation 4.4} \]

The marginal benefit per trip for both sectors is shown in Figure 4.5. The figure shows two estimates of marginal benefit for the recreational sector (Chavez-Comparan and Fischer, 2001) and the artisanal sector’s marginal benefit per trip (Equation 4.6) for one year. The larger estimate ($131.81) for the recreational marginal benefit corresponds to the entire quota being allocated to the recreational sector. The second estimate corresponds to 5% of the total quota (919 tons) being allocated to the recreational sector and the remaining 95% to the artisanal sector (Figure 4.5).
Figure 4.5. The marginal benefit schedule for the artisanal sector compared to the marginal benefit for the recreational sector. The recreational estimate is based upon the WTP of a fishing trip for billfish on the Pacific coast of Mexico (Chavez-Comparan and Fischer, 2001).

4.5 Discussion

Some of the differences in benefit estimation for recreational fishing may be attributed to methodology. The recreational benefit estimates were based upon two different methodologies that estimate the WTP: revealed preference (Travel Cost Method – TCM) and stated preference (Contingent Valuation Method – CVM). Methodology is known to influence WTP estimates for recreational experiences, especially when using stated preference methods (Johnston et al., 2006, Mitchell and Carson, 1989). Other studies corroborate that TCM estimates tend to be greater than CVM estimates (Mitchell and Carson, 1989). The difference in WTP estimates is most likely due to the
methodology, but in the case of the Mexican study the TCM estimate corresponded to the entire recreational experience while the CVM estimate was based upon catching a sailfish (Chavez-Comparan and Fischer, 2001, Johnston et al., 2006). Other variables tend to lower WTP estimates, such as using mail surveys, more experienced anglers, higher survey response rates, changes in preferences and purchasing power (Johnston et al., 2006). Any one or a combination of these factors could have affected either of the WTP estimates.

The two different estimates of recreational benefit have very different outcomes in terms of quota allocation. The greater recreational benefit estimate translates into the entire quota being allocated to the recreational sector. The other recreational estimate translates into 5% quota allocation for the recreational sector. If the artisanal fishers were prohibited from fishing, there would be large direct impacts to the local community and many secondary impacts in terms of employment, gender equality, food security and poverty alleviation (Béné and Merten, 2008, Brashares et al., 2004, Rowcliffe et al., 2005, Salas et al., 2007, Thorpe et al., 2004, Thorpe et al., 2005, Walker, 2001). If the entire quota were allocated to the recreational sector, the Ghanaian government would have to provide some sort of subsidy to the artisanal fishers and their dependents as well as offset the secondary impacts to surrounding communities. This cost may present a hardship to a nation that has a per capita GDP of $368 (African Development Bank (ADB) and Organisation for Economic Cooperation and Development (OECD), 2008).

The optimal economic allocation analysis indicates that the recreational sector should be allocated either 100% or 5% of the TAC. An allocation of 5% to the recreational sector would be more realistic and potentially achievable the nature of the
recreational catch-and-release fishery. The average (2000-2005) recreational proportion of total catch for the Atlantic Ocean was 0.7% (Figure 4.3; ICCAT Task I Data). This estimate assumes that there is 100% survival of the fish released in the recreational fishery.

There is limited evidence that the post-release mortality for certain billfish species is much greater than the current assumption of zero post-release mortality (Horodysky and Graves, 2005, Kerstetter and Graves, 2006). While it is certain that the impacts to billfish populations from catch-and-release fisheries are not well understood (Pine et al., 2008), there have been some estimates of the post-release mortality for white marlin. Post-release survival varies depending upon the angler’s experience, fight and resuscitation time, hook or bait type and hook offsetting (Graves and Horodysky, 2008, Horodysky et al., 2007, Horodysky and Graves, 2005, Kerstetter and Graves, 2006).

Post-release mortality is important because there are cascading effects to stock assessment and the efficacy of management strategies. In a catch-and-release fishery like billfish, as post-release mortality increases, the gains from minimum size regulations in preventing recruitment overfishing can be lost (Pine et al., 2008). Based upon a conservative estimate of 35% post-release mortality for the recreational sector (Horodysky and Graves, 2005), the total white marlin fishing mortality may have been underestimated by 89% for 1992-2001 (Kerstetter and Graves, 2006). This conservative estimate of 35% post-release mortality (Horodysky and Graves, 2005) may not be enough for most billfish populations. At survival rates of 75%, size limit regulations were only effective for populations where overfishing is occurring (Pine et al., 2008). Given these
results, the quota allocated to the recreational sector should be conservative in order to account for underestimation of fishing mortality for released fish.

There have been claims that billfish should be reserved for recreational fishing and ecotourism because the clientele practice catch-and-release and the profit from recreational fishing is greater than the profit from the artisanal fishery (Holland et al., 1998). Many use economic expenditure estimates as indicators of net value for the recreational fishing experience and thus support for the recreational sector (Bohnsack et al., 2002, Clark et al., 1993, Ditton and Stoll, 2000, Ditton, 2005, Fisher and Ditton, 1992, Lucy et al., 1990, Rhodes and Iverson, 1998, Stoll et al., 2002). Expenditure estimates grossly overstate benefits or values expenditures measure the benefit to private business sectors, rather than the value to all of society (Edwards, 1990, Green, 1994, Hundloe, 2000). Given the results and the justifications for billfish as ecotourism (Holland et al., 1998), it seems that angling for billfish is not an appropriate ecotourism venture.

4.5.1 Caveats in economic allocation

Social or distributional issues are important in all fisheries, particularly in the case of developing countries. Developing countries may need extra consideration if decision-makers decide that social equity is a priority. Social equity or poverty reduction may be particularly important for many developing countries.

Eliminating a sector or reducing the number of users within a sector may be economically justified; however, the costs are serious for those specific individuals and the community (Bhat and Bhatta, 2006, Laukkanen, 2001). Benefits are greatest to all of society, but at least one user will think that this optimal solution is inferior in their
personal opinion (Criddle, 2004). While there have been advances in quantifying non-market values for natural resources this is still a difficult and often contentious undertaking (Sumaila et al., In Press). One of the main explanations is that it is difficult for economic optimal allocations methods to capture non-market values for the resource. The non-market value loss is probably non-economic and the effects are difficult to quantify, but nonetheless need to be considered when evaluating allocation regimes (Green, 1994, Milliman et al., 1992). Other effects of allocation decisions could include massive unemployment in some communities or urban population expansion (when members of a community move to an urban center searching for new employment), loss of welfare, loss of community institutions or disruption of family structures (Perry and Sumaila, 2007).

Allocation decisions may have unanticipated biological consequences as well. An analysis of the economically optimal allocation of cod landings between the coastal fleet (primarily artisanal) and trawl fleets determined that an economically optimal allocation does not necessarily equal biological success (Armstrong, 1999, Armstrong and Sumaila, 2001). In this fishery, the coastal fleet targets the mature portion of the cod stock and the trawl fleet targets the juvenile portion. If the portion of TAC allocated to the artisanal fleet decreased, there would be increased availability of mature cod. An increase in mature cod increased their cannibalism on the younger sub-stock thus effectively reducing the biomass available to the trawl sector. A decrease in the artisanal catch of the mature sub-stock did not translate into an increased catch (or revenues) for the industrial sector due to biological interactions within the stock (Armstrong, 1999, Armstrong and Sumaila, 2001). This demonstrates that economically optimal allocations
do not always produce the desired outcome and there may be unanticipated biological interactions.

4.5.2 Model limitations

The major limitation of this model is the lack of certainty in data and the model. This model did not address the benefits or losses to consumers of billfish, i.e., the consumer surplus for the artisanal sector. Arguably, there may be considerable impacts to local communities if the optimal economic allocation methodology is implemented for Ghanaian billfish resources. The proposed allocation reduces the overall landings of billfish for the Ghanaian artisanal pelagic fleet, thus affecting food availability in the surrounding communities. Furthermore, the model uses estimates of WTP from private fishing boats in Mexico. The Mexican estimates are good proxies for the Ghanaian fishing experience, but the true WTP is still unknown in Ghana. Therefore, the model may incorrectly allocate quota based upon an uncertain estimate of WTP for recreational billfish experiences. This model utilizes a static relationship which may have two important impacts. Benefits from fishing may change as management regulations change and the model does not account for changes in the stock size.

The optimal allocation between recreational and artisanal billfish fishers can be better understood if there are three major improvements to this hypothetical model. Firstly, the data sources from the artisanal fishing fleet should be improved. Secondly, implementing a CVM or TCM study in Ghana would also better the model. Finally, a dynamic model that incorporates changes in the stock and changes in (artisanal and recreational) WTP, given management changes would greatly improve the allocation model.
4.6 Conclusions

The objective of this chapter was to evaluate a hypothetical optimal economic allocation between the recreational and artisanal sectors targeting billfish in Ghana. The results suggest that caution must be used when setting policies that maximize economic benefits. The optimal economic allocation analysis suggested that the recreational sector should be allocated 5% of the total billfish catch in Ghana. However, the recreational sector grossly underestimates the post-release mortality of billfish. This means that fishery managers and ICCAT should not allocate greater proportions of the total catch to the recreational sector. While the recreational sector in Ghana is under-developed, there are many other regions that have a well-established recreational sector that demand greater proportions of the total catch. Fishery managers in these areas should consider restricting recreational fishing effort and improving the post-release survivorship of billfish. This chapter does demonstrate, however, that it is possible to develop, assess and compare optimal economic allocation models across two very different fishery sectors.
Chapter 5: The issues and challenges of managing Atlantic billfish

5.1 Background

Billfish, including the marlins, sailfish and spearfishes, are in a precarious state throughout the Atlantic. The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the regional fishery management organization (RFMO) with jurisdiction over the Atlantic Ocean for the study of tuna and tuna-like species (billfish). ICCAT has determined that blue marlin and white marlin are overfished and overfishing is thought to be occurring (ICCAT, 2007, Die, 2006). In the case of the spearfishes and sailfish, scientists are unsure of the status for these fishes, but they think that overfishing is likely occurring. There are multiple drivers affecting the management and eventual recovery of these species. The following is an analysis of these drivers affecting billfish management policies. Finally, key recommendations needed for improving the current decision-making process and improving the likelihood that they will be efficacious.

The fishery management system which includes these drivers is comprised of four components: policy and planning, fishery development, fishery research and fishery management (Charles, 2001; Figure 5.1). Policy and planning for fisheries is the strategic management component of the fishery system. Policy and planning includes the system’s objectives, which may often conflict. The policy component also includes the institutional and legislative framework for the fishery. Fishery development is comprised of the actual steps needed to improve the institutional or technical capabilities of the
system. The fishery research component aims to understand the natural and human systems involved by collecting, analyzing and disseminating information. The management component of the fishery system includes identifying the research and data gaps and the management measures employed in the fishery system (Charles, 2001; Figure 5.1).

Figure 5.1. A schematic representing the Atlantic billfish fishery management system which includes policy and planning, fishery development, fishery research and fishery management.

The dominant paradigm for natural resource management has been to focus on the biological or ecological issues affecting species’ sustainability. Fisheries management is no exception: management plans aim to reverse a stock’s decline typically focus on rebuilding stocks and ignored the socioeconomic implications of management actions (Hilborn, 2007). Part of the reason for this biological focus in resource management is that the majority of scientists initially involved were biologists. Therefore, the majority
of the institutions that were established focused on the biological aspects of resource management, e.g., ICCAT.

The majority of the billfish research has focused on species identification, understanding growth, abundance and distribution of billfish resources. For example, of the 36 articles and notes published from the 4th International Billfish Symposium, only four addressed socioeconomic topics (Bulletin of Marine Science, Vol. 79 (3), 2006). Issues such as alternative livelihoods, food security or employment generation are not well understood in the context of billfish. ICCAT is ill-equipped to address this broad set of challenges. The following chapter identifies the prevailing issues and challenges of managing Atlantic billfish, including a suggested framework for future management.

5.2 Analysis of current issues and policies

The drivers of research and management of billfish can be loosely grouped by disciplines: biological, economic and social or institutional drivers. The issues for billfish management do not exist in isolation, i.e., there are many cross-linkages across the areas, but they are rarely considered in a comprehensive fashion.

5.2.1 Biological issues

Two species of billfish (blue marlin and white marlin) are overfished and overfishing is thought to be occurring. Assessments for other billfish species have been either inconclusive (sailfish), or have not been conducted because of the paucity of data (spearfishes), but overfishing is probably occurring because they share the same habitat and have similar biological characteristics as the marlins. Recent assessments for blue
and white marlin (2006) suggest that it is possible that these stocks are stabilizing (ICCAT, 2007). Part of this uncertainty over recovery status is that there is disagreement over the historical ‘virgin’ status of billfish. Therefore it has been difficult to quantitatively assess the degree of overfishing (Die, 2006).

Catch statistics are one of the main sources of uncertainty in billfish stock assessments (Die, 2006). Catch statistics may be biased due to illegal, unreported and unregulated fishing, misidentified and unidentified catches, uncertainty over post-release survival and/or biases from fishery-dependent data. Newly-identified species may also contribute to the uncertainty in assessments; for example, the newly-identified roundscale spearfish may have contributed to the overestimation of white marlin due to morphological similarities between these two species (Shivji et al., 2006).

The industrial sector has historically been the greatest source of billfish mortality and therefore regulations have focused on this sector (ICCAT Recommendation 96-9, 97-9, 98-10, 00-13, 01-10, 02-13, National Marine Fisheries Service Fisheries Management Plan 1988, 1999, 2004). In return, the industrial sector has complied with these regulations and there has been a reduction in fishing mortality attributed to the industrial sector. Yet, this conclusion is subject to uncertainty. It is unknown whether the catch reduction a result of 1) previous underreporting of billfish catches, 2) underreporting of recent catches, or 3) compliance with ICCAT regulations?

Another key factor producing uncertainty is the true proportion of mortality for released billfish. Some have disputed this assumption and suggest that 35% is a more realistic estimate of post-release survival (Horodysky et al., 2007, Horodysky and Graves, 2005, Kerstetter and Graves, 2006). ICCAT has not recommended regulations
for the recreational sector because the sector claims that it should be immune to regulations because it self-regulates through catch-and-release. Industrial fishers are required to release all live billfish because it was assumed that reducing fishing mortality could best be realized through this strategy. The uncertainty over post-release mortality estimates may translate into the possibility that white marlin populations have been underestimated by 89% for 1991-2004 (Kerstetter and Graves, 2006). Management strategies such as catch-and-release assume that 1) the industrial and recreational sectors are significant sources of fishing mortality and 2) releasing live fish substantially decreases fishing mortality. If the second assumption is false or overestimated, then simply requiring the release of billfish for industrial and recreational sectors may not be a substantial regulation to facilitate billfish recovery (Pine et al., 2008). Revised estimates of post-release survival will affect predicted impacts of these regulations and may require ICCAT to identify other management strategies to help in the recovery of billfish.

Assessment models are also affected by uncertainty from illegal, unreported (including under-reporting) and unregulated (IUU) fishing. Most IUU fishing discussions focus on IUU fishing from the industrial fishery (Sumaila et al., 2007, Sumaila et al., 2006). Low profitability in official fisheries, high prices for illegal catches, low detection probabilities and low penalties are incentives for fishers to engage in IUU fishing (Gallic and Cox, 2006, Sumaila et al., 2006). These incentives for IUU fishing may be greater for the artisanal and recreational sectors than the industrial sector. Most IUU fishing models consider food security to be negligible given substitutes, but issues of food security may lead artisanal fishers to engage in IUU fishing (Gallic and Cox, 2006, Sumaila et al., 2006).
Many of these incentives for IUU fishing can be linked to fishers’ resilience and vulnerability. Artisanal fishers can have reduced resilience and increased vulnerability to unstable resources for a variety of resources. For example, unstable political environments, food shortages and/or price/catch fluctuations may affect fishers’ resilience and vulnerability (e.g., Chapter 3). Understanding their vulnerability is important because if this vulnerability can be reduced then it may be possible to increase the likelihood that fishers will fish resources in a sustainable manner. Conversely, management regulations to limit catch may be ineffective if vulnerable fishers or those with low resilience are driven towards engaging in IUU fishing as a coping mechanism to ensure they meet their catch needs in the short term.

5.2.2 Economic issues

ICCAT does not explicitly consider economics, but there are economic considerations in rebuilding plans. In order to achieve the goal of rebuilding billfish stocks, ICCAT management strategies have focused upon reducing fishing mortality in the industrial sector. These strategies have focused on technical or output controls to manage billfish resources (Table 5.1). Management strategies such as ICCAT Recommendation 00-13 (requiring the release of all live billfish from industrial operations) were chosen for both biological and economic reasons. First, the industrial sector is responsible for the largest portion of mortality; therefore, a landings reduction in this sector would have the greatest biological impact to the entire stock. Second, the regulations were thought to have an insignificant economic impact because billfish are bycatch in tuna and swordfish operations, thus billfish have a low value for the sector. A
few ICCAT member nations (U.S. and Brazil) furthered this strategy by prohibiting the sale of billfish within their domestic markets (NMFS, 2004, White Marlin Biological Review Team, 2007).
Table 5.1. Key ICCAT management regulations and the type of management measures for Atlantic billfish.

<table>
<thead>
<tr>
<th>Year</th>
<th>Measure</th>
<th>Type of measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Promote use of monofilament leaders</td>
<td>Technical control</td>
</tr>
<tr>
<td>1998</td>
<td>Provisions do not apply to artisanal fisheries</td>
<td>--</td>
</tr>
<tr>
<td>1999</td>
<td>Marlin landings should be no more than levels required to achieve MSY by 1999</td>
<td>Output control</td>
</tr>
<tr>
<td>2001</td>
<td>All marlins brought to longline or purse seine vessels should be released in a manner that maximizes survival</td>
<td>Output control</td>
</tr>
<tr>
<td>2001</td>
<td>US limit recreational landings to 250 marlins</td>
<td>Output control</td>
</tr>
<tr>
<td>2001</td>
<td>Establish domestic minimum sizes for marlin landings</td>
<td>Technical control</td>
</tr>
<tr>
<td>2001</td>
<td>Require nations to maintain records (catch/effort) of marlin landings</td>
<td>Technical control</td>
</tr>
<tr>
<td>2001</td>
<td>Encourage research on technological gear improvements</td>
<td>Technical control</td>
</tr>
<tr>
<td>2003</td>
<td>Annual harvest should be no more than 50% (blue marlin) or 33% (white marlin) of 1996/1999 landings</td>
<td>Output control</td>
</tr>
<tr>
<td>2007</td>
<td>Monitor and report artisanal effort and catches of billfish</td>
<td>Output control</td>
</tr>
</tbody>
</table>

1Resolution (96-9) by ICCAT regarding the release of live billfish caught by longline.
2Recommendation (97-9) by ICCAT regarding Atlantic blue marlin and Atlantic white marlin.
3Recommendation (98-10) by ICCAT regarding Atlantic billfishes.
4Recommendation (00-13) by ICCAT to establish a plan to rebuild blue marlin and white marlin populations.
5Recommendation (02-13) by ICCAT to amend the plan to rebuild blue marlin and white marlin populations.
6Recommendation (06-09) by ICCAT to further strengthen the plan to rebuild blue marlin and white marlin populations.
Management strategies such as these have had limited success for a few reasons. First, market values have been lowered considerably due to these domestic and international regulations; however, there still exists an incentive to fish for highly migratory species. This incentive exists because there is a large benefit from tuna and swordfish operations and many countries still allow the sale of billfish. Secondly, strategies that require catch reductions are effective only if fleets can successfully control the species composition of the catch, i.e., fleets must be able to effectively target their catch (Campbell and Nicholl, 1995). If fishing fleets are unable to target their catch, then only management strategies that require effort reductions will successfully achieve the goal of reducing billfish fishing mortality (Campbell and Nicholl, 1995).

In contrast, it has been widely thought that the recreational and artisanal sectors have large economic values for billfish populations. Therefore, management has prioritized social (artisanal sector) and economic (recreational and artisanal sectors) objectives over biological objectives. One of the uncertainties is that the magnitude of this economic value is not well understood or is overstated for both the recreational and artisanal sectors.

Fishing access agreements such as those negotiated by the distant water fishing nations (DWFN) can be categorized as subsidies for industrial fishing fleets to continue targeting pelagic resources where billfish are found (Kaczynski and Fluharty, 2002, Pauly et al., 2005, Sumaila et al., 2007). These agreements can be categorized as subsidies because the foreign nation negotiates and pays for access to the fishing grounds on behalf of fishing fleets. The fishing fleets can in turn generate greater profits without paying the true cost of access to fishing. Another issue is the access agreements themselves:
oftentimes, these agreements are considered development aid and are subject to confidentiality agreements. The funds from these access agreements are important for the nation with the fishery resources (often a developing country in need of hard currency) because the funds are typically deposited to the general treasury rather than to the fishing department (Kaczynski and Fluharty, 2002). These agreements are recognized as threats to the social and economic stability of local communities who rely upon fishery resources for their livelihoods (Atta-Mills et al., 2004, Kaczynski and Fluharty, 2002, Ovetz, 2007).

The issue of subsidies is pervasive for industrial fishing around the world (Sumaila et al., 2007). Currently $30 billion dollars per year in subsidies are given to fishing fleets (Sumaila et al., 2007). These subsidies exacerbate overcapacity and overfishing; for example, two-thirds ($20-26 billion) of all subsidies are overfishing subsidies. Subsidies that lead to overfishing are those that fund vessel construction, fuel subsidies, or ambiguous subsidies (e.g. unclassified agreements) that lead to increased fishing effort (Sumaila et al., 2007). Nations that have valuable fishery resources within their exclusive economic zone (EEZ) are aware of this disparity and seek to solve this problem by making the DWFNs pay the real resource rent for access (Conrad and Adu-Asamoah, 1986). This is problematic because these nations often depend heavily on DWFNs for foreign currency exchange and the individual fishing fleets are unlikely to have the funds equal to the government’s budget (Sumaila et al., 2007). More importantly, the countries with the fishery resources may lack the power to unilaterally negotiate more ‘equitable’ agreements with DWFNs (Kaczynski and Fluharty, 2002, Pauly et al., 2005, Sumaila et al., 2007).
Even though artisanal fleets were protected from ICCAT regulations until 2007 (see section 5.2.3), the impact or importance of artisanal billfish fleets is not well understood. Results from analyses of this issue find that despite high variability, artisanal fleets are often quite profitable (chapters 2 and 3). It is important to note that these profits are highly variable and reflect the owner’s profits, rather than the crew’s income. While there are positive profits, the issue of sustainability in the long run is a different issue. The profits and fisheries are probably not sustainable in the long run due to the open access nature of the fishery, rent dissipation, the declining nature of the resource and the overcapacity in the fleets. Other studies conclude that the fishing fleets may be economically efficient and produce positive profits; however, this may not be enough to support livelihoods in fishing communities (Robards and Greenberg, 2007). The occurrence of impoverished conditions (e.g., lack of access to running water or sanitation services) within the artisanal fishing fleets in Ghana and Venezuela, as well as within the crew of the Senegalese recreational fleet, provides evidence that fishing is not enough to support sustainable livelihoods (e.g., Chapters 2 and 3). If current fishing operations are inadequate to support sustainable livelihoods in these communities, what is the outlook for such communities, given the uncertainty in the recovery of these stocks and the possibility that managers may need to implement catch restrictions for artisanal catches?

The question of outlook for fishing communities is exacerbated in the face of declines of other fishery resources. Many nations, especially those in the Caribbean have promoted the use of fish aggregating devices (FADs) by artisanal fishers to attract coastal pelagics and oceanic pelagic fishery resources, like billfish. The development and promotion of FADs is a strategy to counterbalance the decline of nearshore fishery
resources, the traditional target of Caribbean artisanal fishers. The result has been that FAD usage has increased without proper monitoring and/or control of fishing effort and fishing mortality. This result has further impacts to the estimation of billfish catches in the Caribbean. FAD usage has increased the fishing mortality of many pelagic resources and added to the uncertainty in catch estimation for billfish, particularly for blue marlin and sailfish (Reynal et al., 2006).

Many argue that recreational fishing generates economic benefits for local communities and should be encouraged because there is a conservation focus (due to the catch-and-release nature) (Holland et al., 1998). Often the benefit of recreational fishing is overstated due to the tendency to use expenditure data as a proxy for net benefit (see section 4.5 for a discussion on expenditures). The results of an analysis of optimal economic allocation between the recreational and artisanal fishing sectors in Ghana indicate that the recreational sector should not be allocated a greater portion of the entire catch (Chapter 4). Despite these results, the claims to benefit generation and the conservation focus of recreational fishing may cause managers and policy-makers to resist imposing regulations on this sector.

While it may seem attractive from conservation motivated management position, it is important to note that encouraging artisanal fishers to switch to recreational fishing ventures is unviable for three reasons. First, artisanal fishers are unlikely to have the capital investment necessary for recreational fishing. Secondly, it is unlikely that there will be enough positions in the recreational sector to accommodate all of the artisanal fishers. Lastly, there are issues of food security and/or food availability if artisanal fishers are required or encouraged to enter the recreational sector because they typically
consume part of their catch at home. Furthermore, the existing infrastructure is unlikely to support a large recreational fishing sector.

5.2.3 Social issues

Artisanal fishing sectors have been shielded from management regulations (ICCAT Recommendation 97-9, 06-09) in order to maintain social equity and/or promote economic development for developing countries. Social equity is a constraint to economic efficiency (Robards and Greenberg, 2007) and has been seen as employment generation by economists (Panayotou, 1982). However, employment generation is not synonymous with economic development, which usually aims to alleviate poverty. Poverty, a multi-dimensional, complex phenomenon, can be assessed by many measures such as income, nutrition levels, or employment levels, but it is not equivalent to these measures (Thorpe, 2004). The symptoms of poverty in developing countries may include the lack of opportunities outside the fishery, low levels of literacy, poor sanitation services or low education levels. There was evidence of poverty in the artisanal fishing communities in Venezuela and Ghana, as well as with the crew of the recreational fleet in Senegal (Chapters 2 and 3).

Poverty alleviation is often considered beyond the realm of fisheries management but poverty issues eventually drive many management decisions (e.g., historical protection of artisanal fisheries). The opposite is also true: many nations’ poverty reduction strategies do not explicitly include fisheries in their action areas (Thorpe et al., 2004, Thorpe et al., 2005). What types of information are needed to make these regulations better informed or more effective for poverty reduction and fishery
management? It is evident that fisheries management may need to take a broader scope and include strategies that better understand and address poverty alleviation and the interaction with fisheries. One such method of doing so is through the use of the sustainable livelihoods approach (Allison and Ellis, 2001, Allison and Horemans, 2006, Ellis, 2000). This approach recognizes that institutions are the underlying cause for people living in impoverished conditions (Béné, 2003, Béné, 2004). Thus, institutions are the key for improved livelihoods and ultimately poverty alleviation are institutions themselves (Allison and Ellis, 2001, Allison and Horemans, 2006).

Obviously, the livelihoods approach and the promotion of alternative livelihoods will not solve all resource and poverty management problems. For example, alternative occupations may only be viable for a short period of time (Robards and Greenberg, 2007) or they may have also impacts on other resource management issues (e.g., urban sprawl, population expansion) (Perry and Sumaila, 2007, van Oostenbrugge et al., 2004). Improving fishers’ livelihoods or impoverished status may be suboptimal in terms of economic efficiency (Robards and Greenberg, 2007). Furthermore, alternative livelihoods will likely never completely replace fishing revenues (van Oostenbrugge et al., 2004). Incorporating a livelihoods approach is unlikely to solve all problems of resource management and poverty alleviation, but the approach may be a mechanism to better incorporate these issues and move towards improvement in both the status of the fish stock and its users.

Social issues such as gender inclusion are also important for billfish management. In West Africa, women maintain considerable economic power primarily because the societies follow a matrilineal succession pattern and women are able to amass capital by
controlling agricultural production (Walker, 2002). While men produce goods, women are responsible for selling and marketing these goods. As a result, women generally dominate markets for trade of goods, especially agricultural products, including fish. These markets are well organized and this system evolved out of a long standing history of trans-Atlantic and trans-Saharan trade (Overà, 2006).

In fisheries, West African women have occupied the fish monger position, or fish mammi, since the early 1900s (Walker, 2002). In this role, women functioned as bankers, marketing executives, processors, shipping agents and managers. The fish mammi position typically was determined through inheritance (Walker, 2001). Women were the main source of credit for male fishermen (Aryeety, 2002, Bennett, 2005); they provide the men with capital to purchase fuel, groceries and bait for fishing trips. When fish are landed, women reserve a portion of the catch for themselves (to account for advances made to the men) and pay the men the remainder (Aryeety, 2002). After acquiring the fish, women process the catch and sell it at the markets. As a result, women control the capital coming in and out of the industry.

Many women have moved beyond the traditional fish mammi role and have become boat owners themselves. If women do not own canoes directly, they often loan men the money to buy canoes, thus becoming indirect boat owners. As the controllers of capital, women are major stakeholders in the fishing trade and potentially can influence daily practices. Fishers and fish mammis are part of an intricate socioeconomic and cultural network in the fishing industry. Without this complementary network, neither the individual fisher nor fish mammi have chances of success (Aryeety, 2002, Bennett, 2005, Walker, 2002).
Although women have a strong position in the local traditional fishing community and control the capital, there are no governmental policies to include women in policy development. As a result, women often lack power over the actual resource and their role is diminishing and disrupting traditional roles and norms. The chief fisherman is recognized by the fisheries department and outside agencies (e.g., in negotiations for credit facilities for outboard motors). This is not the case for the chief *fish mammi*; she has little influence beyond the females working as fish traders (Overå, 2001). Little work or investment in strengthening the marketing or processing capabilities of women has occurred. Credit facilities are only available for technological improvements (Aryeety, 2002, Bennett, 2005, Walker, 2002). Furthermore, the role of the chief *fish mammi* is decreasing in importance as more and more fishermen are able to increase their wealth by buying canoes (Overå, 2001). Yet, women’s roles have changed with the natural progression of technology. For example, the advent and proliferation of mobile phones in Africa have strengthened women’s roles as marketers of fishery products (Overå, 2006).

Another social issue to consider is food security and its impact on other resource management issues. In coastal areas, artisanal fishers have a vital role for nutrition, trade and economic activity (Marquette et al., 2002). The artisanal fleet is the largest sector in Ghana and they provide the majority of the national catch (Atta-Mills et al., 2004, Brashares et al., 2004, FAO, 2002). This catch is important for employment and for the provision of protein throughout the country, especially in coastal areas. Nationally, the per capita fish consumption is 31 kg/year with 19% of the total protein diet coming from fish (http://earthtrends.wri.org/text/coastal-marine/country-profile-72.html, accessed June
More than half of the nation’s population lives within 100 km of the coast. In these areas, up to 25% of the local diet can be comprised of locally-caught fish (Brashares et al., 2004).

Marine fishery management is further complicated because it is intertwined with terrestrial natural resource management. Fish are the primary source of animal protein and wild terrestrial mammals are the secondary source in Ghana. Management of terrestrial and marine resources is connected because in times of low fish catches, fishers switch to bushmeat hunting for sources of protein and income and vice versa (Brashares et al., 2004, Cowlishaw et al., 2005). Both wildlife and fishery resources have declined, thus threatening the traditional food buffer system. If fish stocks cannot supply the additional demand that arises from reduced availability of bushmeat, then what are the alternatives? Management policies for fishery and/or wildlife resources must consider the socioeconomic interactions between these protein sources (Rowcliffe et al., 2005). Managers must also evaluate the implications of limiting access to fishery resources (e.g., increased exploitation of declining terrestrial resources).

Unlike artisanal fishers, recreational anglers have often had a strong influence and effective power in management decisions. Recreational billfish anglers tend to be wealthy and highly educated (DeSylva, 1974, Ditton et al., 1999, Graefe et al., 2005, Kitner and Maiolo, 1988) and well-connected (Gillis and Ditton, 2002). They are also a relatively homogenous (Ditton et al., 1999) and a unique subculture of general saltwater anglers (Fisher and Ditton, 1992, Maiolo and Kitner, 1989).

The characteristics of recreational billfish anglers from the U.S. seem to have translated into political power that can be used to steer political decisions in both national
and international arenas. For example, the recreational sector was able to steer national management decisions by having the billfish fishery reserved for the recreational fishery in the U.S. (NMFS, 2004). Internationally, it is possible that the majority of the strong ICCAT recommendations are at least partially attributed to the recreational sector’s lobby and influence on U.S. representatives to ICCAT who may in turn have steered ICCAT’s recommendations (Webster, 2006). The U.S.’s influence on ICCAT management of billfish can be seen by the participants attending billfish assessment workshops (Table 5.1) versus participants attending swordfish workshops (Table 5.2). On the other hand, artisanal fishers who lack power are typically not part of the management or decision-making processes (Caballero Miguez et al., 2008).
Table 5.2. Participants by nation in ICCAT billfish workshops and assessments.

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<td>Other</td>
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Table 5.3. Participants by nation in ICCAT swordfish assessment meetings.

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<td>U.S.</td>
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<td>Ghana</td>
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<td>Non-governmental organization</td>
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<td>Other</td>
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5.2.4 Institutional issues

Billfish are highly migratory and transboundary; therefore, they are a shared resource for many nations and international management is necessary. The Food and Agricultural Organization (FAO) of the United Nations (UN) authorized a Conference (Conference of Plenipotentiaries on the Conservation of Atlantic Tunas, Rio de Janeiro, May 1966) that established a Commission for conservation of tuna and tuna-like species in the Atlantic Ocean in 1965 (ICCAT, 2007). This Commission is ICCAT, a regional fishery management whose study areas include 1) abundance, biometry and ecology of fishes, 2) oceanography of the surrounding environment and 3) the effects of natural and human factors on abundance. ICCAT may collect and analyze statistical information relating to the current conditions or trends for these species. The study of these fishes is to ensure maintenance of populations and that catches will maximize the sustainable yield (ICCAT, 2007).

ICCAT’s study and management of billfish lagged behind the response for other core species such as bluefin tuna, swordfish or yellowfin tuna. While the first billfish workshop was held in 1981, the first billfish stock assessment was not completed until 1996 (Restrepo et al., 2003). Furthermore, the number of ICCAT Standing Committee on Research and Statistics (SCRS) papers on billfish are much lower than the number of papers on core ICCAT species (Figure 5.2). ICCAT’s response was initially slow for billfish and other bycatch species, but this may have cascading effects in terms of compliance with management recommendations. Figure 5.3 displays the reported catch of cooperating and non-cooperating ICCAT parties. Obviously there are fewer catch reports from non-cooperating ICCAT parties. This demonstrates that ICCAT has limited
capacity to impact actions from non-cooperating parties. The good news is that there is an increasing trend in the number of cooperating parties (Figure 5.4).

Figure 5.2. The number of ICCAT SCRS papers grouped for tunas 1 (bluefin tuna and albacore), tunas 2 (skipjack, bigeye, yellowfin and general tunas), marlins (blue and white marlin), swordfish and billfish (sailfish, spearfish and general billfish papers) from 1973-2006.
Figure 5.3. Reported catch of ICCAT Cooperating and Non-cooperating parties. Panel a displays blue marlin (BUM) and billfish (BIL) from 1981 – 2007 and panel b displays white marlin (WHM) and sailfish/spearfish (SAI/SPF) from 1956 – 2007.
International management is obviously necessary for highly migratory, shared resources like billfish. However, international management strategies may conflict with national priorities and thus affect how member nations enact ICCAT recommendations. For example, in Ghana, artisanal fishing makes a substantial contribution to the national income with $56 million in exports and $380 million to the national economy (Atta-Mills et al., 2004, Thorpe et al., 2004). Artisanal fishing is important in terms of food supply: the artisanal fish catch supplies 70-80% of the total domestic catch (Akrofi, 2002, Bannerman and Cowx, 2002, Mensah and Antwi, 2002). The sector is also nationally important in terms of employment: in 1996, 1.5 million people were employed in fishing and 27% were directly employed in the sector as fishers (Atta-Mills et al., 2004). Despite the economic importance of fisheries, this is still one of the poorest sectors (Mensah and Antwi, 2002). Nationally, managers and politicians may seek to develop strategies that reduce poverty by increasing the range and profitability of artisanal fishing fleets. These
national objectives probably conflict with ICCAT’s recommendations and may conflict with some member nations’ goals for their distant water fleets.

Management of fishery resources also proceeds at the national level and each fishing nation in the Atlantic has its national fisheries department. In the U.S., National Oceanographic and Atmospheric Administration’s (NOAA) National Marine Fisheries Service (NMFS or NOAA Fisheries) is the “lead federal agency responsible for the stewardship of the nation's offshore living marine resources and their habitat” (www.noaa.gov/fisheries, accessed 23 October 2008). Highly migratory species (HMS), like billfish are managed under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and the Atlantic Tunas Convention Act (ATCA). Under the MSFCMA, fisheries are managed to maintain optimum yield consistent with national standards. Under the ATCA, however, fisheries are managed under international agreements on which the U.S. is a signatory, but management must reflect traditional participation (White Marlin Biological Review Team, 2007).

U.S. billfish management over the last 30 years has had the same focus as ICCAT: reducing fishing mortality in the industrial sector. Table 5.3 lists the various fishery management plans (FMPs) that established various management measures regarding billfish. Early on, management focused on eliminating fishing mortality from the industrial fishing sector. Once billfish were reserved for the recreational sector (1988 FMP), management has focused on improving 1) the post-release survival of billfish and 2) the statistics on recreational fishers, especially non-tournament users.
Table 5.4. Key U.S. legislation for Atlantic billfish (White Marlin Biological Review Team, 2007).

<table>
<thead>
<tr>
<th>Plan</th>
<th>Year</th>
<th>Objective</th>
<th>Management measures</th>
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<tr>
<td>Preliminary FMP for Atlantic Billfish and Sharks (43 FR 3818)</td>
<td>1978</td>
<td>Reduce conflict between foreign and domestic industrial vessels</td>
<td>Prohibited sale of billfish from foreign fleets within the U.S.</td>
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<tr>
<td>Billfish FMP</td>
<td>1988</td>
<td>Reserve billfish for traditional use: recreation</td>
<td>Prohibited sale of billfish, established minimum size</td>
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<tr>
<td>Amendment 1 to 1988 FMP (64 FR 29090)</td>
<td>1999</td>
<td>Adopt precautionary approach</td>
<td>Logbook reporting system for charter boats</td>
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<tr>
<td>Amendment 1 to Atlantic tunas, swordfish, shark FMP (64 FR 77434)</td>
<td>2000</td>
<td>Reduce bycatch in industrial operations</td>
<td>Time/area closures in various locations</td>
</tr>
<tr>
<td>67 FR 77434</td>
<td>2002</td>
<td>Recreational billfish monitoring program</td>
<td>Permit required for anglers targeting HMS</td>
</tr>
<tr>
<td>68 FR 711</td>
<td>2003</td>
<td>Recreational billfish monitoring program</td>
<td>Mandatory reporting for non-tournament recreational landings</td>
</tr>
<tr>
<td>Consolidated HMS FMP (71 FR 58058)</td>
<td>2006</td>
<td>Reduce post-release mortality of billfish</td>
<td>Tournaments vessels must deploy non-offset circle hooks</td>
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FMP: Fishery Management Plan
HMS: Highly migratory species
There are other federal (U.S.) laws that may affect billfish management; for example, in 2001 NMFS received a petition to list the white marlin as a threatened or endangered species under the Endangered Species Act (ESA). Agencies must determine whether a species deserves listing based upon assessment of factors (in section 4(a)(1) of the ESA) leading to a species decline. These factors are 1) present a threatened destruction, modification or curtailment of habitat or range; 2) overutilization from commercial, recreational, scientific, or education purposes; 3) disease or predation; 4) inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting continued existence of species (White Marlin Biological Review Team, 2007). Upon analysis of these five factors, the NMFS Biological Review Team determined that white marlin are not threatened and do not warrant listing under the ESA (White Marlin Biological Review Team, 2007).

Other nations, especially developing countries, may not have an extensive regulatory framework for billfish management, but there is some national institutional structure. In Ghana, the Fisheries Act of 2002 established the Fisheries Commission (Ministry of Fisheries under Department of Agriculture). The objective of the Fisheries Commission is to regulate and manage the utilization of fishery resources and to coordinate relevant policies (Ghana Fisheries Act 2002 Act 625). The Fisheries Act does not specifically address billfish, but it does require all vessels to have a fishing permit, prohibits fishing for marine mammals, provides protection for various crustaceans or juvenile fish, prohibits pollution and fishing or dredging in marine reserves (Ghana Fisheries Act 2002 Act 625). Few nations have implemented specific regulations for billfish; for example, the sale of white marlin and blue marlin caught within the Brazilian

In addition to the governmental fishery organizations there are local fisher organizations as well, as seen in the different study fleets covered in this study. In Venezuela, for instance, all of the billfish fishers were members of the Asociación de Pescadores Artesanales Playa Verde (Playa Verde Fishermen’s Association), a local cooperative. In Senegal, the Fédération Sénégalaise de pêche Sportive (Senegalese Sportfishing Federation) is a locally-organized association for fishers. The Federation collects dues from members and enacts certain rules and guidelines for fishers. In Ghana there was evidence that the government established organizations consisting of the chief fisherman, the fishery officer and local government officials. These organizations eventually disintegrated as members expected a direct governmental salary in return for participation (P. Bannerman, pers. comm.). In South Florida, 65% of the anglers were members of a fishing organization; one-third of these anglers were members of the International Game Fish Association, a local angler’s association, or The Billfish Foundation. It is clear that social institutions are important, but their efficacy is more apparent in fleets with a small number of vessels.

Socioeconomic considerations are not explicitly mentioned in the ICCAT convention. However, many of these issues play important roles in fisheries management and eventually influence management strategies. While ICCAT does not overtly consider issues such as the users’ political power (or lack thereof) or food security issues (see section 5.2.3), these issues at least partially drive management decisions. For example,
requiring the live release of marlins from industrial operations was the main strategy chosen to reduce fishing mortality. Biologically speaking, fishing mortality needs to be reduced for all sectors; however, fishery and social considerations determined that regulations on the artisanal sector would not be a good strategy.

Understanding the social motivations of stakeholders is important because it influences the efficacy of management strategies. Oftentimes, management regulations are implemented based upon biological or political motivations, but these motivations typically do not converge with users’ expectations and probably do not encourage compliance (Caballero Miguez et al., 2008). Results indicate that there is disagreement among the study fleets as to whether or not catch rates have declined, but there appears to be consensus that there have been no changes in the average size of billfish landed during the last decade. The results further indicate that there was no general agreement or preference among recreational and artisanal fishers on possible management strategies that would improve billfish resources (Brinson et al., 2006, chapters 2 and 3). This lack of agreement may reflect the operational objectives of the fleets, but most importantly it suggests that there is no single management strategy that can satisfy the interests of all stakeholders. The general unwillingness of fishers to accept management measures suggests an inability to make the connection that management measures translate into fishery improvements.

5.3 How does management proceed?

There are obviously many unknowns for Atlantic billfish management and many issues that need consideration beyond the typical range of those considered in fisheries
management. The important question is whether there is a framework that can be incorporated that better accounts for the range of important issues and uncertainty surrounding billfish management. The strategy that will most likely have the greatest effect is to improve institutional support and management of Atlantic billfish. These institutions must be developed by both officials and stakeholders at multiple levels and scales (Mahon et al., 2008, Ostrom, 2008). The overall goal for billfish management should be to incorporate social and economic values as well as biological stock optimization in the assessment process. Institutions should be modified from the current framework to focus on two objectives: 1) reducing the risk of billfish overexploitation and 2) increasing fishers’ resilience.

Currently ICCAT’s strategy is to improve the biological understanding of billfish species by focusing on better reporting of catch statistics, improved methods of estimating catch per unit (CPUE) and better understanding of biological parameters, such as age and growth. Progress is being made on these study areas. For example, in the 4th International Billfish Symposium (Bulletin of Marine Science, Volume 79, 2006), many papers were presented on each of these topics. Also, technological advancements are furthering scientific understanding of billfish movement, life history and behavioral patterns. Further progress or understanding can occur if there is increased coverage of artisanal fishing fleets, rather than focusing exclusively on industrial and recreational sectors.

The first objective of reducing billfish exploitation can be achieved by continuing many of ICCAT’s current initiatives: increased participation by member nations from developing countries. The increased participation by these nations can also translate into
improved biological understanding of billfish. Participation should not be limited to simple data sharing, but should technology and knowledge transfers. Many of these initiatives have been implemented to further increase member nations’ participation. In the last year, ICCAT has made significant progress on improving the provision and subsequent analyses of billfish fisheries data from artisanal fleets in West Africa. While the landings from artisanal fleets contribute an important component (marlin) or majority (sailfish) of the total catch, these data have not contributed much to our overall knowledge on stock status until very recently (D. Die, pers. comm.). International institutions like ICCAT must continue and further strengthen these types of collaborations with national institutions.

Although ICCAT does not explicitly study or provide advice on social or economic issues, the management strategies do implicitly incorporate these issues. An example is the policy to exempt artisanal fisheries from management regulations. There is some evidence that artisanal fleets are increasing their portion of the total Atlantic billfish catches (Figure 4.3); therefore, the special protection from regulation provided to artisanal fleets may not be able to be sustained for much longer. How then can management reduce catches in the artisanal sector? Simply implementing management regulations (such as closed seasons, catch limits, or closed zones) will probably not be an efficacious policy because artisanal fishers are unlikely to realize the connections between management regulations and fishery improvements (Chapters 2 and 3). Furthermore, artisanal fishers are likely to be concerned with day-to-day fishery operational issues such as food security or income generation and are not capable of
investing in long term sustainability by embracing fish stock conservation measures in the near term.

Institutions should simultaneously focus on 1) reducing the risk of overexploitation for billfish and 2) collaborating with local institutions with the goal of improving fishers’ resilience and adaptive capacity. This second strategy is important because fishers often cannot invest in long-term fish conservation efforts because they are vulnerable and lack resilience. Vulnerability can be determined by the community’s ability to respond to environmental changes (Budreau and McBean, 2007). Vulnerability can be exacerbated due to shocks to the system (e.g., extreme weather events, high cost of inputs or political instability), trends in the community (resource fluctuations or declines, disease prevalence) or the seasonality nature of the fishery (Allison and Ellis, 2001, Allison and Horemans, 2006).

While some of the factors affecting vulnerability are beyond the control of fishers, management can focus on improving the adaptive capacity of fishers so that they are able to handle these extreme events. Adaptive capacity is the ability of fishers to be able to adjust and prepare for different scenarios and events associated with environmental fluctuations (Budreau and McBean, 2007). Adaptive capacity can be measured by gear diversity, occupational multiplicity, occupational mobility, social assets, physical assets and human assets (K. Brown, Presentation at Coping with global change in marine social-ecological systems symposium, July 2008). Fishers may be able to adjust to long-term conservation strategies if they have increased resilience and the adaptive capacity to handle conservation strategies. It is important to note that successful adaptive capacity
policies are dependent on whether they are implemented proactively, rather than reactively (Budreau and McBean, 2007).

Local institutions are best equipped to handle issues of adaptive capacity and fisher resilience. In some nations (e.g., Venezuela and Senegal), the local institutions were strong and were able to impact fishers’ actions. One explanation for their strength may have been the relatively small number of fishers involved in targeting billfish. While these local institutions do not have the same objectives as ICCAT, they can complement ICCAT’s management strategies. The primary goal of these local institutions should be to augment ICCAT management strategies by working to increase the number of employment opportunities outside the fishery. The local institutions do not necessarily need to be recognized as ICCAT members because this is contrary to ICCAT’s organizational structure; however, ICCAT can encourage and recommend member nations to collaborate with these local institutions. These local institutions will need support from the national government in order to ensure the success and efficacy of the local institutions and the fishers themselves.

ICCAT and local institutions should focus on the following research to fill in data gaps. Research is needed on 1) improving property rights in these fleets, 2) utilizing the Sustainable Livelihoods Approach to reduce fishers’ dependence on fishery resources and 3) understanding fishers’ adaptive capacity. ICCAT should also implement a monitoring program for recreational and artisanal fleets targeting billfish. This monitoring program should collect catch, effort and sale price information for artisanal fleets. Recreational fishing fleets should also report their catch, effort and charter fees to the monitoring program. These data can be collected through the ICCAT Task II data collection
program. A subset of fleets should be required to submit more detailed information for recreational and artisanal fleets. These detailed data should include information on operations, capital and gear investments and returns to the owner.
General Conclusions

2.1 Fishers in South Florida and Venezuela were experienced at saltwater fishing (15-18 years fishing).

2.2 Family members of the crew were most likely to be illiterate in Venezuela.

2.3 Venezuelan profits are most sensitive to direct crew payments and fixed costs. This may be due to the relative low cost of fuel.

2.4 South Florida profits are sensitive to fuel and fixed costs.

2.5 Crew members of South Florida charter boats do not typically receive a direct salary; instead, they work for tips from customers. Crew members augment their wages through a referral fee from the local taxidermist for encouraging charter customers to mount their landed fish.

2.6 Some vessels (South Florida and Venezuela) have negative financial profit and economic profit. This indicates that there is great variability in the fleets.

2.7 Close to one-half of the South Florida anglers perceived that the billfish catch rates were higher.

2.8 Less than one in ten South Florida anglers would leave the fishery if catch rates declined by 50%.

2.9 In Venezuela, fishers perceive that recreational fishing is the cause of billfish declines.

2.10 The majority of South Florida anglers practice total catch-and-release. By their own estimates, they believe that there is an 85% post-release survival for sailfish.
2.11 Despite this high estimate of post-release survival, one-half of anglers use J-hooks to target sailfish.

2.12 The most popular management measure chosen in South Florida to improve billfish populations was no new regulations or a zero bag limit.

3.1 Fishers in Ghana had the lowest level of occupational multiplicity, 19%.

3.2 Artisanal fishers in Ghana fished for more than 20 years.

3.3 Senegalese charter boat operators had higher occupational multiplicity than crew members.

3.4 Running costs and crew pay were the most prohibitive costs for Ghanaian boat owners.

3.5 Running costs, especially the cost of fuel were the most prohibitive in Senegalese charter boats.

3.6 There was high variability in profits for the Ghanaian fleet.

3.7 In Ghana, the economic profit was greater than financial profit. This may indicate that the direct crew pay was greater than the opportunity cost of labor and fishing is a profitable source of income.

3.8 The majority of Ghanaian fishers perceived a declining catch rate; while, close to one-half of Senegalese anglers perceive a declining catch rate.

3.9 Ghanaian fishers attributed environmental changes and divine forces as the cause for resource fluctuation.

3.10 Senegalese anglers blamed industrial fishery operations and the proliferation of artisanal fishers for billfish declines.
Ghanaian fishers were more likely to accept management measures that were already in place.

The recreational sector should be allocated 100% of the billfish quota in Ghana.

The artisanal sector should be allocated 95% of the billfish quota in Ghana.

The differences in these results may be attributed to methodological differences in how the recreational benefit was determined.

The results of the optimal allocation analysis are subject to a great deal of uncertainty.

There is uncertainty in the post-release survival of billfish.

There is data uncertainty for both the artisanal and recreational data sources.

The lack of data for the recreational sector means that the slope of the WTP for quota is unknown.

The economic optimal allocation framework is useful to determine quantitatively the most equitable allocation of billfish resources and to evaluate tradeoffs.

ICCAT has focused on technical and output measures to reduce the fishing mortality for billfish.

The U.S. has dominated billfish assessment meetings, whereas there was more equal representation from many nations during swordfish assessment meetings.

ICCAT has focused on economically important species like the tunas and swordfish. The study of billfish has lagged in comparison.

Non-cooperating ICCAT nations are less likely to report their catches of billfish.
General Recommendations

Overall

1. There was great variability in profits in all of the study sites. Research and management should focus on understanding this phenomenon. A lack of property rights may explain this trend; however, there are property rights in the Venezuelan fleet. Are those fishers (in Venezuela) with negative profits the ones who exhibit occupational multiplicity or those who will be exiting the fishery soon?

2. ICCAT should require member nations who have artisanal fleets to report economic data including the sale price of fish. Pilot programs can be started in Ghana because the fishery officers currently collect price information along with catch and effort data, but the price information is not reported.

3. A monitoring program should be implemented that identifies recreational and artisanal fishers in different locations. At the very minimum the program should identify the fishers and collect catch and effort information. A more detailed program would monitor the fishers’ investments in gear and capital and their profit levels.

4. As recreational billfish fishing increases in popularity and as other fishery resources are degraded more artisanal fishers will enter the billfish fishery. Conflict may ensue, thus, necessitating the importance of allocating billfish resources among these users. A multi-country assessment of allocation alternatives between recreational and artisanal fishers should be completed.
Venezuela

1. Venezuelan fishers may be negatively impacted if there is a regime change in national politics. Managers should monitor national politics and the fishers to determine if fuel shortages or fuel price increases negatively affect fishers’ livelihoods. Political turmoil may cause fishers to further their catches of billfish or fish in areas that are currently prohibited. Managers should focus on the Sustainable Livelihoods Approach to improve fishers’ status.

2. Strategies should focus on improving the education level of crew members and their respective family members because they are the group with the highest rates of illiteracy.

South Florida

1. Crew members of South Florida charter boats may be more inclined to encourage anglers to keep the fish caught instead of releasing billfish because many receive a bonus from the local taxidermist in return for referring clients. Management should target this group and encourage them to release a larger proportion of fish or use gear configurations that reduce billfish mortality.

2. If very few recreational anglers in South Florida are willing to leave the fishery, what are the alternative management measures possible to reduce overcapacity? Are the anglers unwilling to exit the fishers the ones who exhibit occupational multiplicity? Managers should investigate the alternatives that fishers have if billfish populations do decrease.
Ghana

1. Fishers in Ghana had the lowest levels of occupational multiplicity. Managers should apply the Sustainable Livelihoods Approach in these areas to encourage fishers to diversify their economic interests and reduce their dependence on fishing.

2. A lack of property rights is probably the cause of profit variability. Management should focus on improving property rights in Ghana. Managers should team with local chief fishermen and the chief fish mammi to devise plans that improve property rights in the Ghanaian artisanal pelagic fishery.

Senegal

1. Senegalese operators were more likely to exhibit occupational multiplicity than crew members. Crew members should be encouraged to seek alternative occupations. The Sustainable Livelihoods Approach can also be used with crew members because they were more likely to live in impoverished conditions than the operators.

2. The interaction and conflict among recreational and artisanal fishers needs to be better understood. The recreational sector is currently small; however, artisanal fishers may have an incentive to enter the recreational fishery if fish catches decline.
References


---, 2002. World Economic Indicators. The World Bank, Washington, D.C.


---, 2000. World Development Indicators. The World Bank, Washington, D.C.

---, 1999. World Development Indicators. The World Bank, Washington, D.C.


Appendix I: South Florida Charter boat survey questionnaire

Name of operation/operator_________________________
Address_________________________________________________________________
Phone___________________________________

BACKGROUND INFORMATION

1. Please circle the description that best describes your current position.
   Owner   Owner/operator   Captain

2. How many years have you:
   a. Worked on this operation _____ years
   b. Worked in charterboating _____ years

3. How many persons work in this operation?
   a. Mates/captains _____/_______
   b. Part-time personnel ______________

4. Do you belong to any fishing organizations?
   ______YES     ______NO
   If YES, then please list separately below:
   __________________________________________
   __________________________________________
   __________________________________________
5. What is your primary docking site (marina)?
__________________________________

6. Do you dock at the primary site:

   _______ All year     _______ 6 months     _______ 3 months     _____ less than 3 months

7. Where else do you dock?_______________________

8. Do you fish in other countries or states? ______YES     ______NO

   If YES, then which one(s)?___________________

   ________________________________

BOAT INFORMATION

8. Please provide the replacement value of the following items you utilized in charterboat fishing last season:

   a. ___ Vessel(s)                   $___________
   b. Electronic equipment on board   $___________
   c. Gear (rods, reels, nets)       $___________

9. Please provide the best estimate for the following annual expenses:

   a. Licenses                        $___________
   b. Boat payments                  $___________
   c. Dockage                        $___________
   d. Repair/maintenance:
      - Vessel(s)                     $___________
      - Gear                         $___________
10. Off boat income:
   a. Do you have another occupation apart from this charterboat operation?
      ______YES ______NO
   b. If YES, then please list the occupation__________________________
   c. If YES, then what percentage of your total income is derived from the charterboat operation: ____________%

11. Do you have a Saltwater Products License (SPL)?
    ______YES ______NO

    If YES, then which endorsements do you have?
    ____________________________

12. What percentage of your customers would you state are out of town (FL)/ out of state visitors? ______/______%

13. On which of the following type of clientele do you MOST rely for your trips?
   a. First time visitors
   b. Repeat customers

14. Do most visitors make trips to this region specifically for charter fishing or also for other activities?
   a. Charter fishing
   b. Mixed trips
FISHERY INFORMATION

15. How many trips did you take last year? ________trips
   a. Percentage full-day trips _________%
   b. Percentage ¾ day trips _________%
   c. Percentage half-day trips _________%
   d. Percentage multi-day trips _________%

16. What percentage of those trips that TARGETED:
   a. Sailfish _________%
   b. Reef fish _________%
   c. Other pelagics _________%
   d. Other (____________) _________%

17. On the trips from last year, what was the AVERAGE catch in numbers OR poundage per trip of:
   a. Sailfish _________
   b. Reef fish _________
   c. Pelagics _________
   d. Other (____________) _________

18. Of the total sailfish that you caught last year, what percentage OR number did you land? _________
   a. How many were mounted _________
   b. How many were consumed _________
19. On a typical trip last year, what were your costs on the following items:

<table>
<thead>
<tr>
<th></th>
<th>Sailfish</th>
<th>Reef fish</th>
<th>Other pelagics</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel/oil</td>
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<tr>
<td>Bait (L/A)</td>
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<tr>
<td>Supplies</td>
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<tr>
<td># of crew</td>
<td></td>
<td></td>
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<tr>
<td>Crew share</td>
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</tbody>
</table>

20. What type of hook types did you use last year (for sailfish)?

- _____J-hooks
- _____circle hooks
- _____other hook type

SAILFISH INFORMATION

21. In your opinion, what is the status of sailfish in the region?

- _____excellent
- _____good
- _____fair
- _____poor
- _____Don’t know

22. What are the trends in sailfish catch rates, compared to when you first started fishing?

- _____much higher
- _____somewhat higher
- _____the same
- _____somewhat lower
- _____much lower
- _____Don’t know
23. What are the trends in sailfish sizes (or the average size caught), compared to when you first started fishing?

________ much higher  _________ somewhat higher  ______ the same

________ somewhat lower  _________ much lower  ______ Don’t know

24. Please rank the following to determine how you decide to target sailfish on a trip?

a. By season  _____  
b. Request of customer  _____  
c. Sea state/climate  _____

25. What is your catch-and-release policy for sailfish?

a. Release all  
b. Retain all legal sized sailfish  
c. Retain only at the request of customer  
d. Other: _________________________

26. In your opinion, what percentage of sailfish that are released survive? _____ %

27. If there were a decrease in the catch rates of sailfish by 50%, how would affect your income?

a. By $\frac{3}{4}$  
b. By $\frac{1}{2}$  
c. By $\frac{1}{4}$  
d. Minimally
28. Please rank the activities in which you most likely engage if sailfish catch rates decreased by 50%:

a. Target other species ________

b. Fish harder for sailfish ________

c. Increase off boat work ________

d. Leave charterboating ________

FISHERY MANAGEMENT OPINIONS

29. From which of the following sources do you receive information on fishery management? Which is the most reliable?

a. Government agency literature and/or personnel ()

b. Fisheries meetings ()

c. Industry literature and/or personnel ()

d. Popular media ()

e. Marina and local fishermen ()

f. Other__________________________()

30. What would be the MOST effective way for you to be informed on fishery management issues?

a. Visits by government agency representatives

b. Surveys

c. Information via mail/internet

d. Popular media

e. Other__________________________
31. How well informed would you say you are on fishery management issues (such as current regulations and proposed changes)?
   ______ Very informed    ______ Somewhat informed    ______ Uniformed

32. How effective would you say that government agencies are in managing fisheries in general?
   ______ Very effective    ______ Somewhat effective    ______ Not effective

33. How effective would you say that government agencies are in managing sailfish fisheries?  _____ Very effective    _____ Somewhat effective    ______ Not effective

34. How would you measure the success of sailfish management regulations to your operation? Please select the MOST important outcome:
   a. Greater catch rates
   b. Larger fish
   c. More customers (business)
   d. Longer fishing season
   e. Other:_____________________________

35. What management options would you most favor to protect billfish fishery and improve catch rates (select all that apply)?
   a. Size limits
   b. Closed season
   c. Closed zones
   d. Quotas
   e. Gear restrictions
   f. Other__________________________
36. Which of the following groups MOST affects the billfish fishery, in terms of the total resource and catch rates?
   a. Commercial fishery
   b. Recreational fishery
   c. Charterboat fishery

37. How often (on average) do you see the Coast Guard/FWCC (law enforcement) when you are out billfishing? _________# of times

38. If there were another angler illegally harvesting undersized billfish, how likely is it that the angler would be caught and penalized by the authorities?
   a. Always
   b. 2 out of 3
   c. 1 out of 3
   d. 1 out of 10
   e. 1 out of 100 or less

39. In general, how often do you believe that other anglers illegally harvest undersized sailfish or take more than the legal limit?
   a. Always
   b. 2 out of 3
   c. 1 out of 3
   d. 1 out of 10
   e. 1 out of 100 or less
Appendix II: Encuesta de la pesca artesanal de Playa Verde, Venezuela

Fecha: _____________

I. Datos del encuestado

1. Nombre: ________________  Apellidos: _________________

2. Edad: _________________  Nacionalidad: ______________

3. Estado civil: _____________  Tiempo viviendo en La Guiara o alrededores______

4. Desempeño:
   ______Dueño  ______Dueño y patron  ______Patrón
   ______Motorista  ______Marino  ______Otro

5. Años trabajando en pesca en Playa Verde: __________

6. Años de trabajo en pesca: _______________________

7. Pertenece a aluguna asociación (cooperative) de pesca:
   _______Si  _______No
   Si su repuesta es afirmativa, indique cual/es: _____________________

II. Nivel educativo

8. Sabe leer: _______

9. Sabe escribir: _______
10. Nivel alcanzado:

______Ninguno _______Primaria _______Secundaria
______Técnica _______Universitaria

11. Nivel completado

__1  ____2  ____3  ____4  ____6  ____7
__8  ____9  ____ completo

III. Datos del grupo familiar

<table>
<thead>
<tr>
<th>Parentesco</th>
<th>Edad</th>
<th>Lee</th>
<th>Escribe</th>
<th>Nivel est.</th>
<th>Estudia</th>
<th>Trabaja</th>
<th>Tipo de Trabaja</th>
<th>Ingreso (Bs mes)</th>
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IV. Servicios básicos que dispone en la vivienda

12. Tipo de vivienda

_____Cuarto  ____Quinta  ____Apartamento
____Sin vivienda  ____Casa  ____Rancho  ____Otro

_____Número de habitaciones

13. Material de construcción

_____Zinc  _____Madera  _____Bloque  _____Tierra  ____Otro

14. Tenencia
<table>
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<tr>
<th></th>
<th>Propia</th>
<th>Alquilada</th>
<th>Prestada</th>
<th>En crédito</th>
<th>Otros</th>
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<td></td>
<td>Pública</td>
<td>Planta en comunidad</td>
<td>Planta propia</td>
<td>Otro</td>
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<td>16. Agua</td>
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<td>Tubería</td>
<td>Tanque propio</td>
<td>Tanque común</td>
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<td></td>
<td>Pipote</td>
<td>Cisterna</td>
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<td>Otros</td>
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<td>17. Tiene algún:</td>
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<td>Cloaca</td>
<td>Teléfono</td>
<td>Celular</td>
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<td>TV</td>
<td>Nevera</td>
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V. Información de la embarcación

18. Nombre de embarcación: ___________________________

19. Numero de tripulantes durante faena de pesca (si comparte oficio poner ½)

   | Patrón | Motorista | Marinos | Otros |
|---|--------|----------|---------|-------|
|   |   |   |   |   |

20. Zona de desembarco

   | A | B |
|---|---|---|
|   |   |   |

Características de la embarcación y los artes (chequear con lista y anotar cambios). Sólo patrón o dueño.

   | Cambios | Sin cambios |
|---|----------|-------------|
|   | Permisos | Peces de pico | Volapie |
|   | Capitanía | Especial | Otros |
VI. **Información económica (Sólo patrón o dueño)**

21. Por favor, provea el valor de los equipos actuales de su embarcación (valor de reemplazamiento) (Bs)
   
   a. Embarcación: __________
   
   b. Equipo (GPS, celular): __________
   
   c. Aparejos: __________
   
   d. Motor(es): __________

22. Por favor, provea los mejores estimados de los siguientes gastos anuales de mantenimiento:
   
   a. Permisos: __________
   
   b. Créditos: __________
   
   c. De amarre en puerto: __________

23. Por favor, provea los mejores estimados de los siguientes gastos anuales de reparación:
   
   a. Aparejos (redes…): __________
   
   b. Motor: __________
   
   c. Pintura: __________
   
   d. Otros gastos emb. __________
24. Salario de la tripulación (numero de partes).

Desucuentá gastos de viaje primero: _______ Si  _______ No

______ Dueño  _______ Patrón  ____ Motorista

___ Total marinos  _______ Otros

25. Otros gastos Bs. Por viaje

   a. Combustibe litros: ________
   b. Aceite litros: _________
   c. Alimentos: ___________
   d. Otros: ___________

26. Tiene otro oficio a parte de la actividad de pesca? _______ Si  _______ No

Si su respuesta es afirmativa, diga cual es la actividad y si la ejerce el porcentaje de sus ingreso que proporciona:

Actividad: __________________  La ejerce: __________________

Porcentaje de ingresos: __________________

27. Certificado de salud: _______ Si  _______ No

VII. Información pesquera

27. Cuantos viajes realizó el mes pasado? ______

28. Desembarcan todos las agujas que caen en la red o tiran al mar ejemplares pequeños/estropeados (por tiburones). _____ Desembarcan todos  ____ Tiran alguno
Información sobre el pez vela/agujas

29. Comparadas con el primer año que pescó las capturas de aguja de este año han sido.
   _____Mayores _____Iguales _____Menores _____No se

30. Comparadas con el primer año que pescó las tallas de las agujas son.
   _____Mayores _____Iguales _____Menores _____No se

31. La decisión de salir a pescar aguja depende de:
   a. Estado del mar y clima
   b. Fase de la luna
   c. Otros (describir): ______________

32. Si existiera una disminución de ½ en las capturas de agujas, seguirían pescando?
33. Si existiera una disminución de ¾ en las capturas de agujas, seguirían pescando?
34. Si dejara de pescar agujas que haría?
   a. Pescar otros especies
   b. Dejar la actividad de pesca
VIII. Destino de la captura

<table>
<thead>
<tr>
<th></th>
<th>Familiar</th>
<th>Venta directa</th>
<th>Cavero</th>
<th>Otros</th>
<th>Precio por kg</th>
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<td>A. blanca</td>
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<td>Tiburones</td>
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<td>Atún</td>
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<td>Pez espada</td>
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<td>Carachana</td>
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<td>Otros</td>
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IX. Opiniones sobre las regulaciones de la pesquería

35. De cual de las siguientes fuentes usted recibe información de las regulaciones de la pesquería? Y cual es la mas confiable?

   a. SARPA
   b. INIA (FONIAP)
   c. Pescadores
   d. Otros ___________________________

36. Cuan efectivo considera usted las regulaciones pesqueras?

    _______Muy efectivas _________Efectivas _______Nada efectivas
37. En qué te fijas para saber si las regulaciones están mejorando las pesca?
   a. Aumento en las capturas
   b. Peces más grandes
   c. Mejores precios
   d. Otros (describir) ___________________________

38. De las regulaciones actuales cuáles son mejor(es) para las pesca de las agujas?
   a. Límite en las tallas
   b. Uso exclusivo del placer para Play Verde y deportistas
   c. Uso exclusivo del tenedor
   d. Tamaño y entre nudo del tenedor
   e. Prohibición de mejora de embarcaciones
   f. Prohibición de transferencia de licencia
   g. Límite en número de licencias
   h. Prohibición de venta de agujas por los deportivos

39. Piensa que hay otras regulaciones que podrían mejorar la pesca de la aguja?
   a. Límite en el número de Charter
   b. Cierre de la pesca por temporadas
   c. Límite en el número o peso total de agujas desembarcadas
   d. Límite en el número de agujas ‘strikes’ pegadas por lancha y día en los deportivos
   e. Límite en el número de torneos
   f. Otro ___________________________
40. Cuál de los siguientes grupos afecta más el recurso de agujas (número de capturas y promedio de tallas) que usted pesca?

   a. Pesca industrial
   b. Pesca deportiva
   c. Pesca de charter
   d. Otros

41. Cuál es el porcentaje que supervivencia de las agujas soltados por los deportivos?

42. Cuan a menudo se te acerca la Guardia Costera cuando estás pescando?

   a. Siempre
   b. Frecuentemente
   c. Raramente
   d. Nunca

43. Cuan a menudo se te acerca la Guardia Nacional o SARPA cuando estás desembarcando?

   a. Siempre
   b. Frecuentemente
   c. Raramente
   d. Nunca
44. Qué tan frecuente es que los multen por incumplimiento de permisos o regulaciones de pesca?

a. Siempre
b. Frecuentemente
c. Raramente
d. Nunca
Appendix III: Ghanaian Survey Questionnaire

Name: ______________

Location: ______________

Vessel Name: ____________

I. BACKGROUND INFORMATION

1. Age: ______

2. # Children: _______ # Children in school: __________

3. # Wives __________

4. Crew size: _______

5. What is your position?
   ________ Head fishermen    ______ Crew    ______ Owner

6. # years working this boat? ______

7. # years fishing? ______

8. What generation fishermen are you?
   ______________________________________________________________________

9. How many family members are involved in fishing (relationship)?
   ______________________________________________________________________

10. Do you fish other sites? _____YES    ______NO
    Where?________________________________________________________

11. How many times do you fish in a week?____________________________________

12. Are you a migrant from another area?____________________________________
    ______YES    ______NO    If yes, where? _______________
BOAT INFORMATION

13. What is the replacement value for?
   a. Vessel ______________
   b. Gear ______________
   c. Equipment __________
   d. Length of boat: ________

14. How much are the following annual expenses?
   a. Licenses _________
   b. Gear repair ________
   c. Vessel repair ________
   d. Equipment repair ________
   e. Management committee __________
   f. Insurance _______________

15. What is the crew share for each trip?
    _______________________________________

16. How is this distributed? ___________________

17. On a typical trip, what are the costs:
   a. Bait __________________
   b. Fuel __________________
   c. Groceries ______________
   d. Average earnings per trip: ______________
II. SOCIAL INFORMATION

18. Do you have another job?
   _____YES     _____NO

19. List your other occupation and the percentage of time and income from this occupation. __________________________________________________________

20. Can you read?     YES     NO

21. Can you write?     YES     NO

22. What type of sewer system does your home have? ___________________________

23. Do you have running water at home?     _____YES     _____NO

24. If no, what type of water system do you have? _______________________________

25. Do you have electricity at home?     _____YES     _____NO

III. STAKEHOLDER PERCEPTION

26. What is the status of billfish?
   _____Excellent     _____Good     _____Fair     _____Poor     _____Don’t know

27. Has the catch rate of billfish changed in the last 10 years?
   _____much higher     _____somewhat higher     _____same

   _____somewhat lower     _____much lower     _____Don’t know

28. Has the size of billfish changed in the last 10 years?
   _____Much bigger     _____Somewhat bigger     _____Same

   _____Somewhat smaller     _____Much smaller     _____Don’t know
29. Why are catch rates up or down? __________

30. What management option would you most favor to improve catch rates?
   a. Size limits
   b. Closed season
   c. Closed zones
   d. Catch quota
   e. Gear restrictions
   f. Other ____________________

31. What are the conflicts in the drift gill net fishery? How are they solved?
   ______________________________________________________________________

32. How are women involved in the distribution or actual fishing process(es)?
   ______________________________________________________________________
Appendix IV: Enquête Pêche Sportive Senegal

Nom: _____________________________

Lieu: _____________________________

Nombre Bateaux: ___________________

Nom Bateau: _______________________

I. INFORMATION DEMOGRAPHIQUE

1. Âge: ______

2. Niveau d’instruction: _______________

3. Combien de personnes habitent dans votre (la) maison? ________________

4. # Enfants: _______________________

5. # Enfants à l’école: ________________

6. Ecoles accessibles zone: ____OUI  ____NON

7. Hôpital accessibles zone : ____OUI  ____NON

II. INFORMATION de BATEAU

8. Nombre de matelots/pécheurs: ______

9. Poste?                      _____Matelot    _____Capitaine/skipper     _____ Propriétaire

10. Etes-vous pécheur artisanal avant de travailler dans la pêche sportive?

      _____OUI      _____NON
11.
   a. Nombre d’années que vous avez travaillé comme pécheur? ______
   b. Nombre d’années que vous avez travaillé sur ce bateau? ______

12. Combien de générations (père, grand-père) de votre famille étaient des pécheurs? ___

13. Combien de membres de votre famille travaille dans la pêche (qui sont il?)
   _______________________________________________________________

14. Est-ce que vous pêchez en dehors de votre région?  ____OUI  ____NON
       _____Au nord    _____Au centre     _____Au Sud

       Ou d’autres pays? ________________

15. Combien de sorties effectuez vous par semaine?
   
   De Mai à Octobre ________________
   De Novembre à Avril ________________

16. Dans quelle zone du pays êtes vous né?
    _____Au nord    _____Au centre     _____Au Sud

    Ou d’autres pays? ________________

III. L’INFORMATION ECONOMIQUE

17. Longueur du bateau ________________
       Puissance du moteur ________________

18. Coût de remplacement?
    a. Bateau ________________
    b. Engin de pêche ________________
    c. Equipement ________________
19. Cout annuel pour les?
   a. Licences/permis __________
   b. Réparations du bateau ______
   c. Réparation engin de pêche _____
   d. Réparation Equipement ______
   e. Droits de ports _____________
   f. Fédération Sénégalaise de Pêche Sportive ____________
   g. Assurances ________________

20.
   a. Est-ce que vous recevez un salaire?  ____OUI  ____NON
   b. C’est combien le salaire? ______
   c. Comment est il payé? Par voyage? Par semaine? Par mois?
     _______________________________________________________________________

21.
   a. Est-ce que vous recevez des primes les jours de pêche?
     ____OUI  ____NON
   b. C’est combien les primes? ______
   c. Comment sont elles payée? Elles sont données en fonction de quoi (eg, nombre de
      poissons pêchés ou relachés, nombres de touches)? _________________

22. Dans un sortie, quels sont les couts de:
   a. L’appât _____________________
   b. Carburant pour la grande pêche __________________________
   c. Aliments ___________________
23. Quel est le prix du client par sortie? _________________________

24. Quelle est la durée dès sorties? _____________________________

25. Pendant les tournois/sortie typique, combien avez-vous de :

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26. Vendez vous les poisson porte épée?
   ____ OUI    ____ NON

27. Quel est la prix des espèces de

   **Voilier** ________________
   **Espadon** ________________
   **Marlins** ________________
   **Autres** __________________

28. Vendez vous les autres poissons que vous pêchez (non inclus le poisson porte épée)?

   ___________________________
   ___________________________
IV. INFORMATION SOCIAL

29. Avez-vous un autre travail? ____OUI   ____NON

30. Dites quel est l’autre travail et quel pourcentage de votre temps il vous occupe.
____________________________________________________________________

31. Pouvez vous lire? ____OUI   ____NON

32. Pouvez vous écrire? ____OUI   ____NON

33. Avez-vous de l’eau courante chez vous? ____OUI   ____NON

34. Si non, quelle sorte de système d’eau avez-vous? _________________

35. Quel système d’égouts avez-vous? _________________

36. Avez-vous de l’électricité? ____OUI   ____NON

PERCEPTION DE LES ACTEURS CONCERNÉS

37. Quelle est la situation des populations de poisson porte épée en comparaison ; à
     quand vous avez commencé à pêcher?
     a. Excellent
     b. Bon
     c. OK
     d. Pauvre/médiocre
     e. Ne savez pas
38. Est-ce que le nombre de touches par sortie a changé dans les 10 dernières années?
   a. Beaucoup
   b. Légèrement
   c. Pareil
   d. Un peu moins
   e. Beaucoup moins
   f. Ne savez pas

39. Est-ce que les tailles des voiliers/marlin ont changé dans les 10 dernières années?
   a. Beaucoup
   b. Légèrement
   c. Pareil
   d. Un peu plus petits
   e. Beaucoup plus petits
   f. Ne savez pas

40. Les captures sont-elles plus basses maintenant, pourquoi? ______________________
41. Quelles seraient les mesures de gestion qui peuvent améliorer l’état des populations de marlins/voiliers?

a. Taille minimale
b. Fermeture saisonnière
c. Zones ferme à la pêche
d. Quotas
e. Contrôle des engins
f. Obligatoire hameçon circulaire
g. Autres ______________________

42. Quels sont les conflits dans la pêche? Comment sont ils résolus?

______________________________________________________________
______________________________________________________________
/* testing the high year = 2001 and high season*/

proc model data=DATASET3;
   inv=1/Effort2;
   q1 = (alpha1*Effort2) + (beta11*Effort) + (beta12*Effort*sqrt(P2/P1)) +
       (beta13*Effort*sqrt(PF/P1)) + (beta14*Effort*sqrt(PL/P1)) +
       (gamma1*Os*Effort) + (zeta1*D90*Effort) + (eta1*D91*Effort) +
       (iota1*D92*Effort) + (kappa1*D93*Effort) + (lambda1*D94*Effort) +
       (mu1*D95*Effort) + (nu1*D96*Effort) + (xi1*D97*Effort) +
       (rho1*D98*Effort) + (upsilon1*D99*Effort) + (psi1*D02*Effort) +
       (new1*D03*Effort) + (woryr1*D04*Effort) + (lasyr1*D05*Effort);
   q2 = (alpha2*Effort2) + (beta22*Effort) + (beta12*Effort*sqrt(P1/P2)) +
       (beta23*Effort*sqrt(PF/P2)) + (beta24*Effort*sqrt(PL/P2)) +
       (gamma2*Os*Effort) + (zeta2*D90*Effort) + (eta2*D91*Effort) +
       (iota2*D92*Effort) + (kappa2*D93*Effort) + (lambda2*D94*Effort) +
       (mu2*D95*Effort) + (nu2*D96*Effort) + (xi2*D97*Effort) +
       (rho2*D98*Effort) + (upsilon2*D99*Effort) + (psi2*D02*Effort) +
       (new2*D03*Effort) + (woryr2*D04*Effort) + (lasyr2*D05*Effort);
\[ q_3 = (\alpha_3 \cdot \text{Effort}^2) + (\beta_{33} \cdot \text{Effort}) + (\beta_{13} \cdot \text{Effort} \cdot \sqrt{\frac{P_1}{P_F}}) + (\beta_{23} \cdot \text{Effort} \cdot \sqrt{\frac{P_2}{P_F}}) + (\beta_{34} \cdot \text{Effort} \cdot \sqrt{\frac{P_L}{P_F}}) + (\gamma_3 \cdot \text{Os} \cdot \text{Effort}) + (\zeta_3 \cdot D_{90} \cdot \text{Effort}) + (\eta_3 \cdot D_{91} \cdot \text{Effort}) + (\iota_3 \cdot D_{92} \cdot \text{Effort}) + (\kappa_3 \cdot D_{93} \cdot \text{Effort}) + (\lambda_3 \cdot D_{94} \cdot \text{Effort}) + (\mu_3 \cdot D_{95} \cdot \text{Effort}) + (\nu_3 \cdot D_{96} \cdot \text{Effort}) + (\xi_3 \cdot D_{97} \cdot \text{Effort}) + (\rho_3 \cdot D_{98} \cdot \text{Effort}) + (\upsilon_3 \cdot D_{99} \cdot \text{Effort}) + (\psi_3 \cdot D_{02} \cdot \text{Effort}) + (\text{new}_3 \cdot D_{03} \cdot \text{Effort}) + (\text{woryr}_3 \cdot D_{04} \cdot \text{Effort}) + (\text{lasyr}_3 \cdot D_{05} \cdot \text{Effort}); \]

\[ q_4 = (\alpha_4 \cdot \text{Effort}^2) + (\beta_{44} \cdot \text{Effort}) + (\beta_{14} \cdot \text{Effort} \cdot \sqrt{\frac{P_1}{P_L}}) + (\beta_{24} \cdot \text{Effort} \cdot \sqrt{\frac{P_2}{P_L}}) + (\beta_{34} \cdot \text{Effort} \cdot \sqrt{\frac{P_F}{P_L}}) + (\gamma_4 \cdot \text{Os} \cdot \text{Effort}) + (\zeta_4 \cdot D_{90} \cdot \text{Effort}) + (\eta_4 \cdot D_{91} \cdot \text{Effort}) + (\iota_4 \cdot D_{92} \cdot \text{Effort}) + (\kappa_4 \cdot D_{93} \cdot \text{Effort}) + (\lambda_4 \cdot D_{94} \cdot \text{Effort}) + (\mu_4 \cdot D_{95} \cdot \text{Effort}) + (\nu_4 \cdot D_{96} \cdot \text{Effort}) + (\xi_4 \cdot D_{97} \cdot \text{Effort}) + (\rho_4 \cdot D_{98} \cdot \text{Effort}) + (\upsilon_4 \cdot D_{99} \cdot \text{Effort}) + (\psi_4 \cdot D_{02} \cdot \text{Effort}) + (\text{new}_4 \cdot D_{03} \cdot \text{Effort}) + (\text{woryr}_4 \cdot D_{04} \cdot \text{Effort}) + (\text{lasyr}_4 \cdot D_{05} \cdot \text{Effort}); \]

\[ \text{fit } q_1 \ q_2 \ q_3 \ q_4 \ / \ \text{itsur nestit outs=rest outest=fin2 converge =.00001} \]

\[ \text{maxit = 1000 out=resid outresid white breusch=(1 effort effort2);} \]

\[ \text{parms alpha1 alpha2 alpha3 alpha4 beta11 beta22 beta33 beta44 beta12 beta13 beta14 beta23 beta24 beta34 gamma1 gamma2 gamma3 gamma4 zeta1 zeta2 zeta3 zeta4 eta1 eta2 eta3 eta4 iota1 iota2 iota3 iota4 kappa1 kappa2 kappa3 kappa4 lambda1 lambda2 lambda3 lambda4 mu1 mu2 mu3 nu1 nu2 nu3 nu4 xi1 xi2 xi3 xi4 rho1 rho2 rho3 rho4 upsilon1 upsilon2 upsilon3 upsilon4 psi1 psi2 psi3 psi4 new1 new2 new3 new4 woryr1 woryr2 woryr3 woryr4} \]
lasyr1 lasyr2 lasyr3 lasyr4;

weight inv;

test alpha1, alpha2, alpha3, alpha4;

test beta11, beta22, beta33, beta44;

test beta12, beta13, beta14, beta23, beta24, beta34;

test beta12, beta13, beta14;

test beta12, beta23, beta24;

test gamma1, gamma2, gamma3, gamma4;

test zeta1, zeta2, zeta3, zeta4, eta1, eta2, eta3, eta4, iota1, iota2,
    iota3, iota4, kappa1, kappa2, kappa3, kappa4, lambda1,
    lambda2, lambda3, lambda4, mu1, mu2, mu3, mu4, nu1,
    nu2, nu3, nu4, xi1, xi2, xi3, xi4, rho1, rho2, rho3, rho4,
    upsilon1, upsilon2, upsilon3, upsilon4, psi1, psi2, psi3, psi4, new1,
    new2, new3, new4, woryr1, woryr2, woryr3, woryr4, lasyr1, lasyr2,
    lasyr3, lasyr4;

Estimate 'Price supply elasticity for blue marlin'

(-0.5) *(( beta12*sqrt(P2/P1)) + (beta13*sqrt(PF/P1)) +
    (beta14*sqrt(PL/P1)))* (628.5/11285 )

run;

quit;
The MODEL Procedure

Model Summary

Model Variables          4
Parameters              74
Equations                4
Number of Statements    94

NOTE: The parameter beta12 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta13 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta14 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta23 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta24 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta34 is shared by 2 of the equations to be estimated.

The 4 Equations to Estimate

\[ Q1 = F(\alpha1(Effort2), \beta11(Effort), \beta12, \beta13, \beta14, \gamma1, \zeta1, \eta1, \iota1, \kappa1, \lambda1, \mu1, \nu1, \xi1, \rho1, \upsilon1, \psi1, \text{new1, woryr1, lasyr1}) \]
\[ Q2 = F(\beta12, \alpha2(Effort2), \beta22(Effort), \beta23, \beta24, \gamma2, \zeta2, \eta2, \iota2, \kappa2, \lambda2, \mu2, \nu2, \xi2, \rho2, \upsilon2, \psi2, \text{new2, woryr2, lasyr2}) \]
\[ Q3 = F(\beta13, \beta23, \alpha3(Effort2), \beta33(Effort), \beta34, \gamma3, \zeta3, \eta3, \iota3, \kappa3, \lambda3, \mu3, \nu3, \xi3, \rho3, \upsilon3, \psi3, \text{new3, woryr3, lasyr3}) \]
\[ Q4 = F(\beta14, \beta24, \beta34, \alpha4(Effort2), \beta44(Effort), \gamma4, \zeta4, \eta4, \iota4, \kappa4, \lambda4, \mu4, \nu4, \xi4, \rho4, \upsilon4, \psi4, \text{new4, woryr4, lasyr4}) \]
Observations will be weighted by \( \text{inv} \)

NOTE: At ITSUR Iteration 8 CONVERGE=0.00001 Criteria Met.

WARNING: At ITSUR Iteration 8 a total of 39 execution errors occurred for 13 observations.

The SAS System 15:08 Tuesday, September 16, 2008

The MODEL Procedure

ITSUR Estimation Summary

Data Set Options

\[ \text{DATA=} \quad \text{DATASET3} \]
\[ \text{OUT=} \quad \text{RESID} \]
\[ \text{OUTEST=} \quad \text{FIN2} \]
\[ \text{OUTS=} \quad \text{REST} \]

Minimization Summary

Parameters Estimated 74

Method Gauss

Iterations 8

Final Convergence Criteria

\[ \text{R} \quad 7.103E-6 \]
\[ \text{PPC(beta14)} \quad 0.01735 \]
\[ \text{RPC(beta14)} \quad 0.01735 \]

Object 0

Trace(S) 14575.06

Objective Value 3.522581
Observations Processed

Read  168
Solved 168
Used  155
Missing  13

The MODEL Procedure

Nonlinear ITSUR Summary of Residual Errors

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lasyr4  0.106956  0.0379  2.83  0.0054

Price supply elasticity for blue  0.147345  0.1814  0.81  0.4181 (-0.5)

*(((beta12*sqrt(P2/P1)) + (beta13*sqrt(PF/P1)) + (beta14*sqrt(PL/P1)))* (628.5/11285))

Test Results

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Number of Observations  

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### Heteroscedasticity Test

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/* testing the high year = 2001 and low catch season*/

**proc model** data=DATASET3B;

    inv=1/Effort2;

    q1 = (alpha1*Effort2) + (beta11*Effort) + (beta12*Effort*sqrt(P2/P1)) +
        (beta13*Effort*sqrt(PF/P1)) + (beta14*Effort*sqrt(PL/P1)) +
        (gamma1*Os*Effort) + (zeta1*D90*Effort) + (eta1*D91*Effort) +
        (iota1*D92*Effort)+ (kappa1*D93*Effort) + (lambda1*D94*Effort) +
        (mu1*D95*Effort) + (nu1*D96*Effort) + (xi1*D97*Effort) +
(rho1*D98*Effort) + (upsilon1*D99*Effort) + (psi1*D02*Effort) +
(new1*D03*Effort) + (woryr1*D04*Effort) + (lasyr1*D05*Effort);

q2 = (alpha2*Effort2) + (beta22*Effort) + (beta12*Effort*sqrt(P1/P2)) +
(beta23*Effort*sqrt(PF/P2)) + (beta24*Effort*sqrt(PL/P2)) +
(gamma2*Os*Effort) + (zeta2*D90*Effort) + (eta2*D91*Effort) +
(iota2*D92*Effort) + (kappa2*D93*Effort) + (lambda2*D94*Effort) +
(mu2*D95*Effort) + (nu2*D96*Effort) + (xi2*D97*Effort) +
(rho2*D98*Effort) + (upsilon2*D99*Effort) + (psi2*D02*Effort) +
(new2*D03*Effort) + (woryr2*D04*Effort) + (lasyr2*D05*Effort);

q3 = (alpha3*Effort2) + (beta33*Effort) + (beta13*Effort*sqrt(P1/PF)) +
(beta23*Effort*sqrt(P2/PF)) + (beta34*Effort*sqrt(PL/PF)) +
(gamma3*Os*Effort) + (zeta3*D90*Effort) + (eta3*D91*Effort) +
(iota3*D92*Effort) + (kappa3*D93*Effort) + (lambda3*D94*Effort) +
(mu3*D95*Effort) + (nu3*D96*Effort) + (xi3*D97*Effort) +
(rho3*D98*Effort) + (upsilon3*D99*Effort) + (psi3*D02*Effort) +
(new3*D03*Effort) + (woryr3*D04*Effort) + (lasyr3*D05*Effort);

q4 = (alpha4*Effort2) + (beta44*Effort) + (beta14*Effort*sqrt(P1/PL)) +
(beta24*Effort*sqrt(P2/PL)) + (beta34*Effort*sqrt(PF/PL)) +
(gamma4*Os*Effort) + (zeta4*D90*Effort) + (eta4*D91*Effort) +
(iota4*D92*Effort) + (kappa4*D93*Effort) + (lambda4*D94*Effort) +
(mu4*D95*Effort) + (nu4*D96*Effort) + (xi4*D97*Effort) +
(rho4*D98*Effort) + (upsilon4*D99*Effort) + (psi4*D02*Effort) +
(new4*D03*Effort) + (woryr4*D04*Effort) + (lasyr4*D05*Effort);
fit q1 q2 q3 q4 / itsur nestit outs=rest outest=fin2 converge = .00001
maxit = 1000 out=resid outresid white breusch=(1 effort effort2);
parms alpha1 alpha2 alpha3 alpha4 beta11 beta22 beta33 beta44 beta12
beta13 beta14 beta23 beta24 beta34 gamma1 gamma2 gamma3 gamma4
zeta1 zeta2 zeta3 zeta4 eta1 eta2 eta3 eta4 iota1 iota2 iota3 iota4 kappa1
kappa2 kappa3 kappa4 lambda1 lambda2 lambda3 lambda4 mu1 mu2
mu3 mu4 nu1 nu2 nu3 nu4 xi1 xi2 xi3 xi4 rho1 rho2 rho3 rho4 upsilon1
upsilon2 upsilon3 upsilon4 psi1 psi2 psi3 psi4 new1 new2 new3 new4
woryr1 woryr2 woryr3 woryr4 lasyr1 lasyr2 lasyr3 lasyr4;
weight inv;

test alpha1, alpha2, alpha3, alpha4;
test beta11, beta22, beta33, beta44;
test beta12, beta13, beta14, beta23, beta24, beta34;
test beta12, beta13, beta14;
test beta12, beta23, beta24;
test gamma1, gamma2, gamma3, gamma4;
test zeta1, zeta2, zeta3, zeta4, eta1, eta2, eta3, eta4, iota1, iota2,
iota3, iota4, kappa1, kappa2, kappa3, kappa4, lambda1,
lambda2, lambda3, lambda4, mu1, mu2, mu3, mu4, nu1,
nu2, nu3, nu4, xi1, xi2, xi3, xi4, rho1, rho2, rho3, rho4,
upsilon1, upsilon2, upsilon3, upsilon4, psi1, psi2, psi3, psi4, new1,
new2, new3, new4, woryr1, woryr2, woryr3, woryr4, lasyr1, lasyr2,
lasyr3, lasyr4;
Estimate 'Price supply elasticity for blue marlin'

\(-0.5\) \* ((\(\beta_{12}\) * \(\sqrt{P_2/P_1}\)) + (\(\beta_{13}\) * \(\sqrt{PF/P_1}\)) + (\(\beta_{14}\) * \(\sqrt{PL/P_1}\))) * (628.5/11285);

run;

quit;

The SAS System Output     15:08 Tuesday, September 16, 2008

The MODEL Procedure

Model Summary

Model Variables          4
Parameters              74
Equations                4
Number of Statements    94

NOTE: The parameter \(\beta_{12}\) is shared by 2 of the equations to be estimated.
NOTE: The parameter \(\beta_{13}\) is shared by 2 of the equations to be estimated.
NOTE: The parameter \(\beta_{14}\) is shared by 2 of the equations to be estimated.
NOTE: The parameter \(\beta_{23}\) is shared by 2 of the equations to be estimated.
NOTE: The parameter \(\beta_{24}\) is shared by 2 of the equations to be estimated.
NOTE: The parameter \(\beta_{34}\) is shared by 2 of the equations to be estimated.

The 4 Equations to Estimate

\(Q_1 = F(\alpha_1(\text{Effort2}), \beta_{11}(\text{Effort}), \beta_{12}, \beta_{13}, \beta_{14}, \gamma_1, \zeta_1, \eta_1, \iota_1, \kappa_1, \lambda_1, \mu_1, \nu_1, \xi_1, \rho_1, \upsilon_1, \psi_1, \text{new1}, \text{woryr1}, \text{lasyr1})\)
\[ Q_2 = F(\beta_{12}, \alpha_2(\text{Effort}), \beta_{22}(\text{Effort}), \beta_{24}, \gamma_2, \zeta_2, \eta_2, \iota_2, \kappa_2, \lambda_2, \mu_2, \nu_2, \xi_2, \rho_2, \psi_2, \text{new}_2, \text{woryr}_2, \text{lasyr}_2) \]

\[ Q_3 = F(\beta_{13}, \beta_{23}, \alpha_3(\text{Effort}), \beta_{33}(\text{Effort}), \beta_{34}, \gamma_3, \zeta_3, \eta_3, \iota_3, \kappa_3, \lambda_3, \mu_3, \nu_3, \xi_3, \rho_3, \psi_3, \text{new}_3, \text{woryr}_3, \text{lasyr}_3) \]

\[ Q_4 = F(\beta_{14}, \beta_{24}, \beta_{34}, \alpha_4(\text{Effort}), \beta_{44}(\text{Effort}), \gamma_4, \zeta_4, \eta_4, \iota_4, \kappa_4, \lambda_4, \mu_4, \nu_4, \xi_4, \rho_4, \psi_4, \text{new}_4, \text{woryr}_4, \text{lasyr}_4) \]

Observations will be weighted by \( \frac{1}{\text{inv}} \)

NOTE: At ITSUR Iteration 8 CONVERGE=0.00001 Criteria Met.

WARNING: At ITSUR Iteration 8 a total of 39 execution errors occurred for 13 observations.

ITSUR Estimation Summary

Data Set Options

DATA= DATASET3B

OUT= RESID

OUTEST= FIN2

OUTS= REST

Minimization Summary

Parameters Estimated 74

Method Gauss

Iterations 8

Final Convergence Criteria

R 7.103E-6

PPC(\beta_{14}) 0.01735
RPC(beta14)         0.01735
Object             2.52E-16
Trace(S)           14575.06
Objective Value    3.522581
S                         0

Observations Processed
Read       168
Solved     168
Used       155
Missing     13

Nonlinear ITSUR Summary of Residual Errors

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<th>SSE</th>
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Nonlinear ITSUR Parameter Estimates

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psi4            0.037004      0.0356       1.04       0.3005
new4            0.028791      0.0457       0.63       0.5302
woryr4          0.054569      0.0456       1.20       0.2337
lasyr4          0.106956      0.0379       2.83       0.0054

Price supply elasticity for blue        0.147345   0.1814    0.81    0.4181 (-0.5)
*(((beta12*sqrt(P2/P1)) + (beta13*sqrt(PF/P1)) + (beta14*sqrt(PL/P1)))* (628.5/11285) )

Test Results

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<th>Pr &gt; ChiSq</th>
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Number of Observations        Statistics for System

Used                   155  Objective   3.5226
Missing                 13  Objective*N  546.0000
Sum of Weights       0.001092

Heteroscedasticity Test

<table>
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<tr>
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<th>Statistic</th>
<th>DF</th>
<th>Pr &gt; ChiSq</th>
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/* low year = 2005 and high catch season */

proc model data=DATASET3;
inv=1/Effort2;
  q1 = (alpha1*Effort2) + (beta11*Effort) + (beta12*Effort*sqrt(P2/P1)) +
  (beta13*Effort*sqrt(PF/P1)) + (beta14*Effort*sqrt(PL/P1)) +
  (gamma1*Os*Effort) + (zeta1*D90*Effort) + (eta1*D91*Effort) +
  (iota1*D92*Effort) + (kappa1*D93*Effort) + (lambda1*D94*Effort) +
  ...
(\mu_1 \cdot D^{95} \cdot \text{Effort}) + (\nu_1 \cdot D^{96} \cdot \text{Effort}) + (\xi_1 \cdot D^{97} \cdot \text{Effort}) +
(\rho_1 \cdot D^{98} \cdot \text{Effort}) + (\upsilon_1 \cdot D^{99} \cdot \text{Effort}) + (\chi_1 \cdot D^{101} \cdot \text{Effort}) +
(\psi_1 \cdot D^{102} \cdot \text{Effort}) + (\new_1 \cdot D^{103} \cdot \text{Effort}) + (\woyr_1 \cdot D^{104} \cdot \text{Effort});

q_2 = (\alpha_2 \cdot \text{Effort}^2) + (\beta_2^2 \cdot \text{Effort}) + (\beta_1^2 \cdot \text{Effort} \cdot \sqrt{P_1/P_2}) +
(\beta_2^3 \cdot \text{Effort} \cdot \sqrt{PF/P_2}) + (\beta_2^4 \cdot \text{Effort} \cdot \sqrt{PL/P_2}) +
(\gamma_2 \cdot \text{Os} \cdot \text{Effort}) + (\zeta_2 \cdot D^{90} \cdot \text{Effort}) + (\eta_2 \cdot D^{91} \cdot \text{Effort}) +
(\iota_2 \cdot D^{92} \cdot \text{Effort}) + (\kappa_2 \cdot D^{93} \cdot \text{Effort}) + (\lambda_2 \cdot D^{94} \cdot \text{Effort}) +
(\mu_2 \cdot D^{95} \cdot \text{Effort}) + (\nu_2 \cdot D^{96} \cdot \text{Effort}) + (\xi_2 \cdot D^{97} \cdot \text{Effort}) +
(\rho_2 \cdot D^{98} \cdot \text{Effort}) + (\upsilon_2 \cdot D^{99} \cdot \text{Effort}) + (\chi_2 \cdot D^{101} \cdot \text{Effort}) +
(\psi_2 \cdot D^{102} \cdot \text{Effort}) + (\new_2 \cdot D^{103} \cdot \text{Effort}) + (\woyr_2 \cdot D^{104} \cdot \text{Effort});

q_3 = (\alpha_3 \cdot \text{Effort}^2) + (\beta_3^3 \cdot \text{Effort}) + (\beta_1^3 \cdot \text{Effort} \cdot \sqrt{P_1/PF}) +
(\beta_2^3 \cdot \text{Effort} \cdot \sqrt{PF/2}) + (\beta_3^4 \cdot \text{Effort} \cdot \sqrt{PL/2}) +
(\gamma_3 \cdot \text{Os} \cdot \text{Effort}) + (\zeta_3 \cdot D^{90} \cdot \text{Effort}) + (\eta_3 \cdot D^{91} \cdot \text{Effort}) +
(\iota_3 \cdot D^{92} \cdot \text{Effort}) + (\kappa_3 \cdot D^{93} \cdot \text{Effort}) + (\lambda_3 \cdot D^{94} \cdot \text{Effort}) +
(\mu_3 \cdot D^{95} \cdot \text{Effort}) + (\nu_3 \cdot D^{96} \cdot \text{Effort}) + (\xi_3 \cdot D^{97} \cdot \text{Effort}) +
(\rho_3 \cdot D^{98} \cdot \text{Effort}) + (\upsilon_3 \cdot D^{99} \cdot \text{Effort}) + (\chi_3 \cdot D^{101} \cdot \text{Effort}) +
(\psi_3 \cdot D^{102} \cdot \text{Effort}) + (\new_3 \cdot D^{103} \cdot \text{Effort}) + (\woyr_3 \cdot D^{104} \cdot \text{Effort});

q_4 = (\alpha_4 \cdot \text{Effort}^2) + (\beta_4^4 \cdot \text{Effort}) + (\beta_1^4 \cdot \text{Effort} \cdot \sqrt{P_1/PL}) +
(\beta_2^4 \cdot \text{Effort} \cdot \sqrt{P_2/PL}) + (\beta_3^4 \cdot \text{Effort} \cdot \sqrt{PL/PL}) +
(\gamma_4 \cdot \text{Os} \cdot \text{Effort}) + (\zeta_4 \cdot D^{90} \cdot \text{Effort}) + (\eta_4 \cdot D^{91} \cdot \text{Effort}) +
(\iota_4 \cdot D^{92} \cdot \text{Effort}) + (\kappa_4 \cdot D^{93} \cdot \text{Effort}) + (\lambda_4 \cdot D^{94} \cdot \text{Effort}) +
(\mu_4 \cdot D^{95} \cdot \text{Effort}) + (\nu_4 \cdot D^{96} \cdot \text{Effort}) + (\xi_4 \cdot D^{97} \cdot \text{Effort}) +
(\rho_4 \cdot D^{98} \cdot \text{Effort}) + (\upsilon_4 \cdot D^{99} \cdot \text{Effort}) + (\chi_4 \cdot D^{101} \cdot \text{Effort}) +
(psi4*D02*Effort) + (new4*D03*Effort) + (woryr4*D04*Effort);

fit q1 q2 q3 q4 / itsur nestit outs=rest outest=fin2 converge = .00001

maxit = 1000 out=resid outresid white breusch=(1 effort effort2);

parms alpha1 alpha2 alpha3 alpha4 beta11 beta22 beta33 beta44 beta12
beta13 beta14 beta23 beta24 beta34 gamma1 gamma2 gamma3
gamma4 zeta1 zeta2 zeta3 zeta4 eta1 eta2 eta3 eta4 iota1 iota2
iota3 iota4 kappa1 kappa2 kappa3 kappa4 lambda1 lambda2
lambda3 lambda4 mu1 mu2 mu3 mu4 nu1 nu2 nu3 nu4 xi1 xi2 xi3
xi4 rho1 rho2 rho3 rho4 upsilon1 upsilon2 upsilon3 upsilon4 chi1
chi2 chi3 chi4 psi1 psi2 psi3 psi4 new1 new2 new3 new4 woryr1
woryr2 woryr3 woryr4;

weight inv;

/* Separability test for alphas */
test alpha1, alpha2, alpha3, alpha4;
test beta11, beta22, beta33, beta44;

/*non-jointness test for overall system */
test beta12, beta13, beta14, beta23, beta24, beta34;

/*non-jointness test for Q1*/
test beta12, beta13, beta14;

/*non-jointness test for Q2*/
test beta12, beta23, beta24;

/*non-jointness test for Q3*/
test beta13, beta23, beta34;
/* non-jointness test for Q4 */

test beta14, beta24, beta34;

/* non-jointness test for seasonal dummies */

test gamma1, gamma2, gamma3, gamma4;

/* non-jointness test for annual dummies */

test zeta1, zeta2, zeta3, zeta4, eta1, eta2, eta3, eta4, iota1, iota2,
   iota3, iota4, kappa1, kappa2, kappa3, kappa4, lambda1, lambda2, lambda3,
   lambda4, mu1, mu2, mu3, mu4, nu1, nu2, nu3, xi1, xi2, xi3, xi4, rho1, rho2,
   rho3, rho4, upsilon1, upsilon2, upsilon3, upsilon4, chi1, chi2, chi3, chi4, psi1,
   psi2, psi3, psi4, new1, new2, new3, new4, worry1, worry2, worry3, worry4;

Estimate 'Price supply elasticity for blue marlin'

(-0.5) * (( beta12*sqrt(P2/P1) + beta13*sqrt(PF/P1) + beta14*sqrt(PL/P1)) * 
          (628.5/11285)) ;

run;

quit;
Equations 4

Number of Statements 102

NOTE: The parameter beta12 is shared by 2 of the equations to be estimated.

NOTE: The parameter beta13 is shared by 2 of the equations to be estimated.

NOTE: The parameter beta14 is shared by 2 of the equations to be estimated.

NOTE: The parameter beta23 is shared by 2 of the equations to be estimated.

NOTE: The parameter beta24 is shared by 2 of the equations to be estimated.

NOTE: The parameter beta34 is shared by 2 of the equations to be estimated.

The 4 Equations to Estimate

Q1 = F(alpha1(Effort2), beta11(Effort), beta12, beta13, beta14, gamma1, zeta1, eta1,
    iota1, kappa1, lambda1, mu1, nu1, xi1, rho1, upsilon1, chi1, psi1, new1, woryr1)

Q2 = F(beta12, alpha2(Effort2), beta22(Effort), beta23, beta24, gamma2, zeta2, eta2,
    iota2, kappa2, lambda2, mu2, nu2, xi2, rho2, upsilon2, chi2, psi2, new2, woryr2)

Q3 = F(beta13, beta23, alpha3(Effort2), beta33(Effort), beta34, gamma3, zeta3, eta3,
    iota3, kappa3, lambda3, mu3, nu3, xi3, rho3, upsilon3, chi3, psi3, new3, woryr3)

Q4 = F(beta14, beta24, beta34, alpha4(Effort2), beta44(Effort), gamma4, zeta4, eta4,
    iota4, kappa4, lambda4, mu4, nu4, xi4, rho4, upsilon4, chi4, psi4, new4, woryr4)

Observations will be weighted by \( \text{inv} \)

NOTE: At ITSUR Iteration 8 CONVERGE=0.00001 Criteria Met.

WARNING: At ITSUR Iteration 8 a total of 39 execution errors occurred for 13 observations.
ITSUR Estimation Summary

Data Set Options
DATA= DATASET3
OUT= RESID
OUTEST= FIN2
OUTS= REST

Minimization Summary
Parameters Estimated  74
Method Gauss
Iterations  8
Final Convergence Criteria
R  7.103E-6
PPC(beta14)  0.01735
RPC(beta14)  0.01735
Object  2.52E-16
Trace(S)  14575.06
Objective Value  3.522581
S  0

Observations Processed
Read  168
Solved  168
Used 155
Missing 13

Nonlinear ITSUR Summary of Residual Errors

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<tr>
<th>Equation</th>
<th>Model</th>
<th>Error</th>
<th>SSE</th>
<th>MSE</th>
<th>Root MSE</th>
<th>R-Square</th>
<th>R-Sq</th>
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<td>87.1227</td>
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<tr>
<td>Q2</td>
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<td>136.5</td>
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<td>0.2856</td>
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<td>0.0825</td>
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Nonlinear ITSUR Parameter Estimates

<p>| Parameter | Estimate | Std Err | t Value | Pr &gt; |t| |
|-----------|----------|---------|---------|------|---|
| alpha1    | -0.0144  | 0.0100  | -1.44   | 0.1527 | |
| beta11    | 104.588  | 29.1608 | 3.59    | 0.0005 | |
| beta12    | -3.73046 | 3.0540  | -1.22   | 0.2240 | |
| beta13    | -0.06269 | 0.2287  | -0.27   | 0.7844 | |
| beta14    | -0.00141 | 0.1698  | -0.01   | 0.9934 | |
| gamma1    | -5.764   | 14.4657 | -0.40   | 0.6909 | |
| zeta1     | -70.8957 | 40.2972 | -1.76   | 0.0808 | |
| eta1      | -80.7883 | 38.0941 | -2.12   | 0.0358 | |
| iota1     | -80.848  | 37.4179 | -2.16   | 0.0325 | |</p>
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<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>p-Value</th>
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Price supply elasticity for blue  

\[
\frac{\beta_{12}\sqrt{P_2/P_1} + \beta_{13}\sqrt{PF/P_1} + \beta_{14}\sqrt{PL/P_1}}{628.5/11285}
\]
## Test Results

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### Number of Observations

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### Statistics for System

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### Heteroscedasticity Test

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Breusch-Pagan 0.44 2 0.8018 1, Effort, Effort2

Q2 White's Test 137.3 119 0.1208 Cross of all vars

Breusch-Pagan 41.61 2 <.0001 1, Effort, Effort2

Q3 White's Test 152.5 119 0.0208 Cross of all vars

Breusch-Pagan 72.88 2 <.0001 1, Effort, Effort2

Q4 White's Test 136.6 119 0.1283 Cross of all vars

Breusch-Pagan 58.64 2 <.0001 1, Effort, Effort2

/*low year = 2005 and low catch season */

**proc model** data=DATASET3B;

  inv=1/Effort2;

  q1 = (alpha1*Effort2) + (beta11*Effort) + (beta12*Effort*sqrt(P2/P1)) +
      (beta13*Effort*sqrt(PF/P1)) + (beta14*Effort*sqrt(PL/P1)) +
      (gamma1*Os*Effort) + (zeta1*D90*Effort) + (eta1*D91*Effort) +
      (iota1*D92*Effort) + (kappa1*D93*Effort) + (lambda1*D94*Effort) +
      (mu1*D95*Effort) + (nu1*D96*Effort) + (xi1*D97*Effort) +
      (rho1*D98*Effort) + (upsilon1*D99*Effort) + (chi1*D01*Effort) +
      (psi1*D02*Effort) + (new1*D03*Effort) + (woryr1*D04*Effort);  

  q2 = (alpha2*Effort2) + (beta22*Effort) + (beta12*Effort*sqrt(P1/P2)) +
      (beta23*Effort*sqrt(PF/P2)) + (beta24*Effort*sqrt(PL/P2)) +
      (gamma2*Os*Effort) + (zeta2*D90*Effort) + (eta2*D91*Effort) +
      (iota2*D92*Effort) + (kappa2*D93*Effort) + (lambda2*D94*Effort) +
      (mu2*D95*Effort) + (nu2*D96*Effort) + (xi2*D97*Effort) +
      (rho2*D98*Effort) + (upsilon2*D99*Effort) + (chi2*D01*Effort) +
      (psi2*D02*Effort) + (new2*D03*Effort) + (woryr2*D04*Effort);
(iota2*D92*Effort) + (kappa2*D93*Effort) + (lambda2*D94*Effort) +
(mu2*D95*Effort) + (nu2*D96*Effort) + (xi2*D97*Effort) +
(rho2*D98*Effort) + (upsilon2*D99*Effort) + (chi2*D01*Effort) +
(psi2*D02*Effort) + (new2*D03*Effort) + (woryr2*D04*Effort);
q3=(alpha3*Effort2) + (beta33*Effort) + (beta13*Effort*sqrt(P1/PF)) +
(beta23*Effort*sqrt(P2/PF)) + (beta34*Effort*sqrt(PL/PF)) +
(gamma3*Os*Effort) + (zeta3*D90*Effort) + (eta3*D91*Effort) +
(iota3*D92*Effort) + (kappa3*D93*Effort) + (lambda3*D94*Effort) +
(mu3*D95*Effort) + (nu3*D96*Effort) + (xi3*D97*Effort) +
(rho3*D98*Effort) + (upsilon3*D99*Effort) + (chi3*D01*Effort) +
(psi3*D02*Effort) + (new3*D03*Effort) + (woryr3*D04*Effort);
q4=(alpha4*Effort2) + (beta44*Effort) + (beta14*Effort*sqrt(P1/PL)) +
(beta24*Effort*sqrt(P2/PL)) + (beta34*Effort*sqrt(PF/PL)) +
(gamma4*Os*Effort) + (zeta4*D90*Effort) + (eta4*D91*Effort) +
(iota4*D92*Effort) + (kappa4*D93*Effort) + (lambda4*D94*Effort) +
(mu4*D95*Effort) + (nu4*D96*Effort) + (xi4*D97*Effort) +
(rho4*D98*Effort) + (upsilon4*D99*Effort) + (chi4*D01*Effort) +
(psi4*D02*Effort) + (new4*D03*Effort) + (woryr4*D04*Effort);
fit q1 q2 q3 q4 / itsur nestit outs=rest outest=fin2 converge = .00001
maxit = 1000 out=resid outresid white breusch=(1 effort effort2);
parms alpha1 alpha2 alpha3 alpha4 beta11 beta22 beta33 beta44 beta12
beta13 beta14 beta23 beta24 beta34 gamma1 gamma2 gamma3 gamma4
zeta1 zeta2 zeta3 zeta4 eta1 eta2 eta3 eta4 iota1 iota2 iota3 iota4 kappa1
kappa2 kappa3 kappa4 lambda1 lambda2 lambda3 lambda4 mu1 mu2 
mu3 mu4 nu1 nu2 nu3 nu4 xi1 xi2 xi3 xi4 rho1 rho2 rho3 rho4 upsilon1 
upsilon2 upsilon3 upsilon4 chi1 chi2 chi3 chi4 psi1 psi2 psi3 psi4 new1 
new2 new3 new4 woryr1 woryr2 woryr3 woryr4;

weight inv;

test alpha1, alpha2, alpha3, alpha4;

test beta11, beta22, beta33, beta44;

test beta12, beta13, beta14, beta23, beta24, beta34;

test beta12, beta13, beta14;

test beta12, beta23, beta24;

test gamma1, gamma2, gamma3, gamma4;

test zeta1, zeta2, zeta3, zeta4, eta1, eta2, eta3, eta4, iota1, iota2, 
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lambda2, lambda3, lambda4, mu1, mu2, mu3, mu4, nu1, 
mu2, nu3, nu4, xi1, xi2, xi3, xi4, rho1, rho2, rho3, rho4, 
upsilon1, upsilon2, upsilon3, upsilon4, chi1, chi2, chi3, chi4, 
psi1, psi2, psi3, psi4, new1, new2, new3, new4, woryr1, woryr2, woryr3, 
woryr4;

Estimate 'Price supply elasticity for blue marlin'

(-0.5) *(( (beta12*sqrt(P2/P1)) + (beta13*sqrt(PF/P1)) + (beta14*sqrt(PL/P1)))* 
(628.5/11285) ));

run;

quit;
The SAS System      15:08 Tuesday, September 16, 2008

The MODEL Procedure

Model Summary

Model Variables          4
Parameters              74
Equations                4

Number of Statements    94

NOTE: The parameter beta12 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta13 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta14 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta23 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta24 is shared by 2 of the equations to be estimated.
NOTE: The parameter beta34 is shared by 2 of the equations to be estimated.

The 4 Equations to Estimate

Q1 = F(alpha1(Effort2), beta11(Effort), beta12, beta13, beta14, gamma1, zeta1, eta1, kappa1, lambda1, mu1, nu1, xi1, rho1, upsilon1, chi1, psi1, new1, woryr1)
Q2 = F(beta12, alpha2(Effort2), beta22(Effort), beta23, beta24, gamma2, zeta2, eta2, kappa2, lambda2, mu2, nu2, xi2, rho2, upsilon2, chi2, psi2, new2, woryr2)
Q3 = F(beta13, beta23, alpha3(Effort2), beta33(Effort), beta34, gamma3, zeta3, eta3, kappa3, lambda3, mu3, nu3, xi3, rho3, upsilon3, chi3, psi3, new3, woryr3)
Q4 = F(beta14, beta24, beta34, alpha4(Effort2), beta44(Effort), gamma4, zeta4, eta4, kappa4, lambda4, mu4, nu4, xi4, rho4, upsilon4, chi4, psi4, new4, woryr4)
Observations will be weighted by inv

NOTE: At ITSUR Iteration 8 CONVERGE=0.00001 Criteria Met.

WARNING: At ITSUR Iteration 8 a total of 39 execution errors occurred for 13 observations.

ITSUR Estimation Summary

Data Set Options
DATA= DATASET3B
OUT= RESID
OUTEST= FIN2
OUTS= REST

Minimization Summary
Parameters Estimated 74
Method Gauss
Iterations 8
Final Convergence Criteria
R 7.103E-6
PPC(beta14) 0.01735
RPC(beta14) 0.01735
Object 2.52E-16
Trace(S) 14575.06
Objective Value 3.522581
S 0

Observations Processed
Nonlinear ITSUR Summary of Residual Errors

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<tr>
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<th>Error</th>
<th>SSE</th>
<th>MSE</th>
<th>Root MSE</th>
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Nonlinear ITSUR Parameter Estimates

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|-----------|----------|---------|---------|------|------|
| alpha1    | -0.0144  | 0.0100  | -1.44   | 0.1527 |
| beta11    | 98.82404 | 29.7959 | 3.32    | 0.0012 |
| beta12    | -3.73046 | 3.0540  | -1.22   | 0.2240 |
| beta13    | -0.06269 | 0.2287  | -0.27   | 0.7844 |
| beta14    | -0.00141 | 0.1698  | -0.01   | 0.9934 |
| gamma1    | 5.763995 | 14.4657 | 0.40    | 0.6909 |
| zeta1     | -70.8957 | 40.2972 | -1.76   | 0.0808 |
| eta1      | -80.7883 | 38.0941 | -2.12   | 0.0358 |</p>
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<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
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rho2  -180.015  36.6904  -4.91  <.0001
upsilon2  -171.917  47.9286  -3.59  0.0005
chi2  -233.326  37.7340  -6.18  <.0001

The MODEL Procedure

psi2  -233.883  36.2771  -6.45  <.0001
new2  -234.336  46.4951  -5.04  <.0001
woryr2  -70.0115  45.8710  -1.53  0.1293
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beta33  0.492828  0.0999  4.93  <.0001
beta34  0.065487  0.0772  0.85  0.3976
gamma3  0.055746  0.0331  1.69  0.0942
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Price supply elasticity for blue: 0.147345 0.1814 0.81 0.4181 (-0.5)

*(((beta12*sqrt(P2/P1)) + (beta13*sqrt(PF/P1)) + (beta14*sqrt(PL/P1)))* (628.5/11285) )
Test Results

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Number of Observations

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Heteroscedasticity Test

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VITA

Ayeisha Alba Brinson was born in Jeddah, Saudi Arabia, on September 19, 1978. Her parents are Albert Carl Brinson and Amy D’sa Brinson. She received her elementary education at North Miami Elementary School and her secondary education at Horace Mann Middle School, North Dade Junior High School and North Miami Senior High School. In July 1996 she entered the College of Agriculture and Life Sciences at the University of Florida from which she graduated with the B.S. degree in May 2000. Ayeisha completed her M.S. degree in Fishery and Wildlife Biology at Colorado State University in 2002. She was employed as an ecologist at the U.S. Geological Survey from 2000-2004. In August 2003 she was admitted to the Graduate School of the University of Miami, where she was granted a Ph.D. degree in December 2008.

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