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All the factors affecting a fishery resource should be analyzed to determine its status. For example in fisheries, the resource is used by a variety of fishermen all with different interest. There are people with economic interest (commercial fishermen and charter/head boats), those that do it recreationally (family trips), and those that do it as a sport (fishing tournaments). The Department of Natural and Environmental Resources of the Commonwealth of Puerto Rico has several statistics programs that collect data on the fisheries. Since 1971, the Commercial Fisheries Statistics Program (CFSP) collects and analyzes data reported by commercial fishermen. Another program is the Marine Recreational Statistics Program (MRSP) that since 1999 collects data on recreational fisheries. This program is divided on recreational fisheries and fishing tournaments.

The CFSP and the MRSP collects data the dolphinfish (*Coryphaena hippurus*). This species has a commercial value and is an important gamefish. This migratory species is reported for all over the Caribbean, where is one of the most prized specimens. On its migration route it gets fished all over, therefore the fishing pressure is high.

The economic impact of this fishery is quite high for example the commercial fishery of dolphinfish generates an average of $207,639.56 wholesale annually. Fishing tournaments generate an average of $33,247.50 on tournament's fees (17 tournaments with fee reported). Even though is illegal for recreational fishers to sell the fish

most of them sell the majority of their dolphinfish catch to finance fishing expenses.

In Puerto Rico's fishery, dolphinfish is one of the most targeted. Data collected includes landings reported and biostatistics (length and weight) for the period of 2000-2003. This data was used to determine the current trends and status of this fishery.

Total weight reported for all the activities showed a decreasing tendency of fish landed through the four years of this analysis. There is a difference on the size of the fish reported, for example commercial fishermen tend to report smaller fish both males and females.

Even though the highest fishing pressure received by the dolphin fish is from commercial fishermen, still the impact the recreational anglers make is reasonably marked. This type of analysis is fundamental for the proper management of the species.

Key words: Fishery, Dolphinfish, and Puerto Rico

Resumen

Para determinar el estatus de un recurso pesquero todos los factores que lo afectan deben ser analizados. Por ejemplo, en pesquería el recurso es usado por una variedad de pescadores cada uno distintos intereses. Hay personas con intereses económicos (pescadores comerciales/ charters), algunos pescan de manera recreativa y otros lo hacen en competencias (torneos de pesca). El Departamento de Recursos Naturales y Ambientales del Estado Libre Asociado de Puerto Rico cuenta con varios programas de estadísticas pesqueras que colectan datos de pesquería. Desde 1971, el Programa de Estadísticas de Pesca Comercial (PEPC) colecta y analiza datos de la pesca reportada por pescadores comerciales. Otro programa es el Programa de Estadísticas de Pesca Recreativa (PEPR) que desde 1999 colecta datos de la pesca recreativa. Este programa cuenta con dos componentes pesca recreativa y torneos de pesca.

El PECP y el PEPR colectan datos de pesquería del dorado (*Coryphaena hippurus*). Esta especie tiene un valor económico y es importante en la pesca recreativa. Se encuentra reportado para todo el Caribe, donde es uno de los especímenes más codiciados. En su migración por aguas caribeñas es capturado por toda el área, por lo tanto la presión al recurso es bastante alta.

El impacto económico de esta pesquería en Puerto Rico es alto. Por ejemplo la industria pesquera reporta un promedio de $207,639.56 al por mayor anual sólo en la pesca de dorado. Los torneos de pesca generan un promedio de $33,247.50 anuales en cuotas de inscripción (17 de 42 torneos visitados).

El dorado es una de las especies más pescada en la industria pesquera de Puerto Rico. Datos colectados incluyen peces abordados y su bioestadística (largo y peso) para el período de 2000-2003. Estos datos tanto de pesca comercial como de pesca recreativa se utilizaron para determinar patrones existentes y el estatus de esta pesquería.

El peso total reportado para todas las actividades muestra una tendencia de disminución a través de los años. Hay una diferencia marcada en el tamaño reportado por los diferentes pescadores; los pescadores comerciales tienden a reportar pescados más pequeños tanto hembras como machos y los recreativos tiende a pescar más peces grandes.

A pesar de que la mayor presión de pesca la reciben por parte de los pescadores comerciales, el impacto que causan los pescadores recreativos en la población del dorado es marcado. Este tipo de análisis es fundamental para el manejo apropiado de la especie.

Palabras Claves: Pesquería, Dorado, Puerto Rico

Introduction

The dolphinfish (*Coryphaena hippurus,* Linneaus 1758) is a highly migratory pelagic species distributed throughout the tropical and subtropical waters of the world. It has been reported in the Atlantic, Pacific and Indian Oceans. This species usually forms schools and feeds on almost all forms of fish and zooplankton; also feed on crustaceans and squid (Eschmeyer et al. 1983). Sexual maturity is reached in 4-5 months (3 months for captive fish) (Randall 1995). This species spawns in the open sea and probably approximate to the coast when water temperature rises (Collete 1995).

The dolphinfish color is striking with golden hues on the sides, metallic blues and greens on the back and sides, with white and yellow on the under parts. Small specimens have pronounced vertical bars on the sides of the body. Mature males have a prominent bony crest in front of the head. Maximum length reported has been 210 cm TL (male/unsexed Collete 1999) and the maximum weight 40.0 kg (Allen and Steene 1988) One of the characteristics of the species is its high reproduction rate, it has been reported that the population doubling time is less than fifteen (15) months (Allen and Steene 1988).

Due to its gregarious behavior, its high growth rate and its high reproductive success is a very important species for the fisheries industries. The dolphinfish has a prominent commercial value worldwide. This species is one of the principal target species for commercial as well as recreational fishers worldwide. In Puerto Rico, is the number one targeted species for recreational and the number nine reported for commercial fishers.

The two main hypothesis states that two different migratory stocks visit the coastal waters of Puerto Rico, therefore there are two-dolphinfish season. For the northern stock, that comes from the Atlantic, the season starts in October and ends in March. The southern stock that ranges in the Caribbean is close to Puerto Rican waters from March to June (Oxenford and Hunte 1984). These stocks are highly exploited by commercial and recreational fishers.

Data analyzed came from three sources the Commercial Fisheries Statistics Program (CFSP), the Marine Recreational Statistics

Program (MRST) and the Fishing Tournaments Statistics Program (FTSP), all under the DNER.

In the present paper, it is compare and analyzed landing and biostatistical data for commercial and recreational fisheries to describe tendencies in this fishery resource.

Methods

Commercial

Commercial Landings Data

Commercial fishery landing data were collected from voluntary fishers, fish buyers and fishing associations from around Puerto Rico. Four port samplers and the principal investigator visited the 42 coastal municipalities including the islands of Vieques and Culebra, and the 88 identified fishing centers (Matos-Caraballo 2003). The data collection occurred from January 2000-December 2003. Data were collected using a landing trip ticket system (Matos-Caraballo 2004) on a biweekly or monthly basis. Special boxes were placed in most fishing centers to enable port samplers to collect trip tickets from fishers.

Catch per unit of effort (CPUE) was evaluated in two ways: 1) for landings data by calculation of total pounds per trip, making a sub sample by month, using only those landings trip tickets that clearly indicated a single trip (Matos-Caraballo 2004).

Commercial Biostatistical Data

Port samplers collected biostatistical data from finfish three days per week. Each individual was identified by species to determine catch composition. Finfishes were measured in fork length (FL) both in millimeters (mm), and weighed in grams. For the purpose of this analysis the weight recorded was converted to kilograms. Data were recorded on the field and copied in the biostatistical data sheets using the format shown in (Matos-Caraballo 2004). Biostatistical CPUE data was handled as follows: catch is total capture expressed in pounds.

Recreational

The Marine Recreational Fisheries Program is divided on three main projects, the Recreational Anglers Program, the Telephone Surveys, and the Fishing Tournaments Program. The main objective of these is to generate statistically valid estimates of catch and fishing effort of marine anglers in Puerto Rico. The Recreational Anglers program collects data on charters, rental boats, sport fishers and shore modes. A standardized form developed by MRFSS and adapted for Puerto Rico was used (Marine Recreational Fisheries Statistics Program Final Report 2003). Telephone household interviews were carried out in counties within 25 miles of ocean coastline. The information asked in these

interviews is mainly regarding the fishing trips itself and not the biological characteristic of the species (i.e. measurements, weight etc) therefore this part is not discussed in this paper.

Samplers that intercept fishers at the docks or boat ramps collected the biostatistical data. Recreational fishing data included catch, species identification, length, weight, effort, location, bait, and fishing gear) and basic socioeconomic data (Marine Recreational Fisheries Statistics Program Final Report 2003).

For the fishing tournament program the project staff attended each tournament and collected the landings and/or releases data as well as total effort information from records (logbooks) and also collected biometrical data. These include information on sex (whenever possible), length, weight and species identification. The information was annotated to determine size and weight frequencies by species. These data was used to determine Catch per Unit effort (CPUE) for takes and for fishing activity. All measurements were taken in a straight line from the fish lower jaw (LJ) to the fork length (FL) (Rodríguez-Ferrer and Rodríguez Ferrer 2004).

Results

Commercial

Data from the landings trip ticket system collected by the port samplers were combined to analyze this fishing mode. Of the 1,163 active commercial fishermen 842 reported dolphinfish as one of the landed species (Matos-Caraballo et al 2002). A steady decrease on the fish reported from 1990-2003 is noted (Figure 1). For this analyzes we will emphasize the 2000-2003 reported data. For the four from the four years combined, a total of 188,306 kg (Table 1) and an average mean weight of 5.72 kg were reported as landed by commercial fishers (Figure 2). The south and west coasts are the ones with the most total weight reported (Figure 3). The price per pound ranged from $1.96-$2.07 with an average income of $207,639.56 wholesale a year for this fishery (Table 2).

Most fish measured between 414-1100mm (Figure 4) for the four years. When we compared the size difference between the fishing zones (i.e. north, south, east, west) there is quite a significant difference between several of the zones. Both the south and west coast reported significantly larger fishes than the north coast (Kolmogorov-Smirnov Dmax= 0.58) for the south coast (Kolmogorov-Smirnov D Max 0.62) for the west coast. Between the north and east coast, the north coast has significantly larger individuals (Kolmogorov-Smirnov D max= 0.93). There was not significant difference between the east and west and between east and south. The difference between fish sizes of the south

versus the west coast is slightly significant (Kolmogorov-Smirnov D max= 0.13).

Recreational

Tournaments

A total of 155 fishing tournaments were visited on the period 2000-2003 of which 35 or 22.5% of tournaments the target species were dolphinfish. Regarding participation 3,695 fishers took part in this activity (18,468 fishers for all tournaments, n=155 tournaments between 2000-2003, n=4,617 fishermen sd=606.26) Table 3. The tournament fee ranges $33,247.50 in 20 of 35 tournaments visited. The average fee per boat is $280.00 and the average income the marina gets from the tournament fee only is about $7,054.50.

A total of 32,261.02 Kg of dolphinfish were boarded during fishing tournaments for all three years (Table 1). The mean weight for tournaments is 7.60 kg (Figure 5). Most fish measured between 800-1149 mm (n=3909 fish measured) (Figure 6). These fishes where mostly mature individuals as previous research has determined the size for sexual maturity as 820 mm for males and 900 for females (Pérez et al. 1992). The differences in sizes between the zones is as follows. Contrary to our expectations there was not a significant difference between the north and south coast (Kolmogorov-Smirnov.0,5 D max=0.01). Between north, east, and north, west coast there was not a significant difference between sizes reported (ie. Kolmogorov-Smirnov Dmax=0.01 for north versus east and Dmax=0.02 for north versus west). Contrary to commercial data there is a marked differences between the west and east coast having the west coast the largest individuals (Kolmogorov-Smirnov D0.05=0.08, Dmax=0.86). The south coast reported larger dolphinfishes than the east or west coasts (Kolmogorov-Smirnov Dmax=0.62 for the south versus east coasts and Dmax=0.11 for the south versus west coasts).

Regarding the sex composition of the fish boarded, females still dominated as the most sex boarded for all years (Figure 7). Contrary to the commercial fishers data the south coast is the one with the most weight reported for fishing tournaments (Figure 8).

Non Tournaments

Only the biostatistical data collected by the data samplers was used on this analysis. Port samplers on fish caught recreationally for the four years measured a total of 4, 311.38 kg of dolphinfish (Table 1). The mean weight for this mode was 5.78 kg (Figure 9)

Relatively mature individuals were reported as being caught by recreational fishers (i.e. 700-1100 mm) by port samplers (Figure 10).

There was a significant difference on the length between the north and south coast (Dmax=0.31) (Figure 11). For the rest of the zones

there was no significant difference between the lengths of the dolphinfish reported.

Samplers did not determine the sex of the individuals therefore no analysis on the fishing preferences regarding sex and sexual maturity was not done for this activity.

Comparison between fisheries

Due to the nature of sampling the data set for the fishing tournament (N=3452) is larger than both the commercial fishers (N=792) data and the non-tournament recreational data (N=804).

Commercial versus tournaments

When we compared the reported commercial landings with the tournaments landings, there is significant difference on the size of the fish landed (Kolmogorov-Smirnov D max= 1). Where the tournament fishers had the largest fishes.

In tournaments, participants outnumbered the commercial fishermen that reported dolphinfish as a target species. Regarding fishing tournaments the south coast is the zone with the most participation (Table 3), the most fishing tournaments celebrated with dolphinfish as a target species specifically and is the zone with the highest number in total weight reported (Fig. 8). For commercial fishermen in 2000 also the south coast was the zone with the highest total weight then the following years it shifted to the west coast (Fig. 9).

Commercial versus recreational non-tournaments

Recreational fishers tend to report larger fishes when we compared to commercial fishers (Kolmogorov-Smirnov Dmax=1, average length for recreational fishers 887.12mm vs. 877.10 mm for non tournament fishers).

Recreational non-tournaments versus tournaments

There is a high tendency for the tournament fishers to land larger individuals (Kolmogorov-Smirnov, Dmax=3.29).

Discussion

Even though the commercial fishery reports the highest total weight recreational fishing is an important activity and is clearly affecting this species also.

The peak in captures reported by commercial fishermen, recreational fishers, and the tournaments celebrated coincide with the dolphinfish migration pattern (Oxenford and Hunte 1984).

The differences on fishing zone (i.e. the commercial fishers report mainly form the west coast and the recreational from the south coast) could be due to the nature of the commercial fishery report system because fishermen report the fishing center where they landed and not

the fishing area. This is something that will be fixed with the new ticketing system developed by the Department of Natural and Environmental Resources Department.

When the reported fork length for 2000-2003 is compared with previous studies the specimens are relatively smaller than in earlier years (i.e. 381-1479 mm Pérez et. al. 1992 vs. 414-1149 mm). This could mean a sign of fishery exploitation due to the fact that even though is not a marked difference a trend is noted and this trend could increase in the near future.

Dolphins are caught in the Island year round and all over the area. With the seasonal peaks and aggregations areas there are zones where the specimens are more abundant. It is a popular believe that the south coast has the largest specimens and the highest total weight. With this analysis we established that the total weight and the dolphin size is larger in the south coast. When we compared sizes between fishing activities recreational fishers reported larger individuals than the commercial fishers. Before the fish reach maturity they are already economically valuable (Fishery Management Plan for the dolphin and wahoo fishery of the Atlantic 2003) therefore commercial fishers will target all sizes available to increase profits. On the other hand, recreational fishers are targeting larger individuals principally in tournaments because they will guarantee a prize. It is worth mentioning, that on tournaments where total fishing weight is used to determine the winner fishermen tends to bring as many individuals as possible ignoring the sizes.

Dolphinfish landings have increased in recent years in the Atlantic (Fishery Management Plan for the dolphin and wahoo fishery of the Atlantic 2003). It was established by genetic studies that dolphin from the Gulf of Mexico, US Atlantic, including Puerto Rico, the Virgin Islands, Mid Atlantic and New England is a single stock (Wingroove R in: Fishery Management Plan for the dolphin and wahoo fishery of the Atlantic 2003). If this is the case, special attention should be place on this species that is being fished all over its migratory route. Even though Prager (2000) suggested that the species may be able to withstand a relatively high rate of exploitation Mahon and Oxeford (1999) warns there is a high risk of stock depletion given that the fishery may remain feasible at low stock levels because of high tendency of the species to aggregate.

In Puerto Rico there is competition between recreational and commercial fishers for the resource. This can lead to a localized depletion of stocks and a "shift in the historical levels of catch between commercial and recreational fishers"; as it happened in the Atlantic and

Gulf of Mexico (Fishery Management Plan for the dolphin and wahoo fishery of the Atlantic 2003).

Beginning in 2005 a new fishing regulation (DNER 6768) will be established in Puerto Rico. For the first time a bag limit will be established for recreational fishers, 5 dolphins per fishermen per fishing day. Consequently the dynamics of the recreational fisheries specially the tournaments will have to change. It is imperative that data on the specimens continues to be recorded to determine the impact of this regulation in both the species and on the fishermen.

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List of Figures Captions

Table 1. Landings reported (Kg) for the three fishing activities in Puerto Rico during 2000-2003 .

Fishing Activity	**2000**	**2001**	**2002**	**2003**	**Total reported**
Commercial	63,555.45	50,488.64	45737.27	29,476.36	189,258
*Recreational	1,214.19	937.65	782.65	1,376.89	4,311.38
Fishing Tournaments	7,322.01	9,049.65	9,553.16	6,336.2	32,261.02
Totals kg reported	72,091.65	60,475.94	56,073.08	37,189.45	225,830.4

*Only the fish measure by the port samplers

Table 2. Total income reported in commercial landings (wholesale) on dolphinfish (*Coryphanea hippurus*) fishery in Puerto Rico 2000-2003.

Year	Average price/pound	Pounds	Total
2000	2.04	139,822	$285,236.88
2001	1.89	111,075	$209,931.75
2002	2.07	100,622	$208,287.54
2003	1.96	64,848	$127,102.56
		Average	$207,639.56

Table 3. Total number and participation in dolphinfish tournaments in Puerto Rico during 2000-2003.

	North		South		East		West	
Year	Number of Tournaments	# Of fishers	Number of Tournaments	# Of fishers	Number of Tournaments	# Of fishers	Number of Tournaments	# Of fishers
2000	NR	236	NR	NR	NR	NR	NR	NR
2001	4	381	4	430	2	192	2	215
2002	2	172	4	424	1	215	2	220
2003	4	444	4	486	1	100	1	72

Figure 1. Commercial landings of dolphinfish (Coryphaena hippurus) for 1990-2003 reported in kilograms

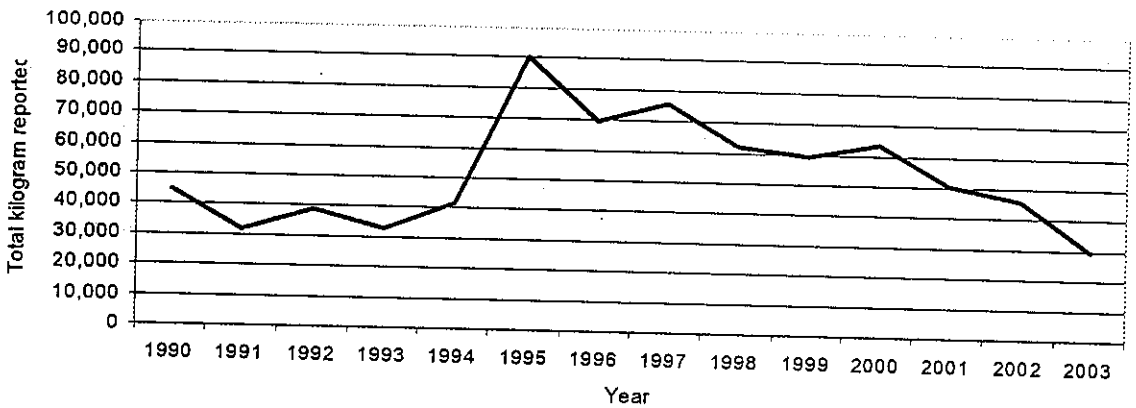

Figure 2. Total weight reported by commercial landings (kg).

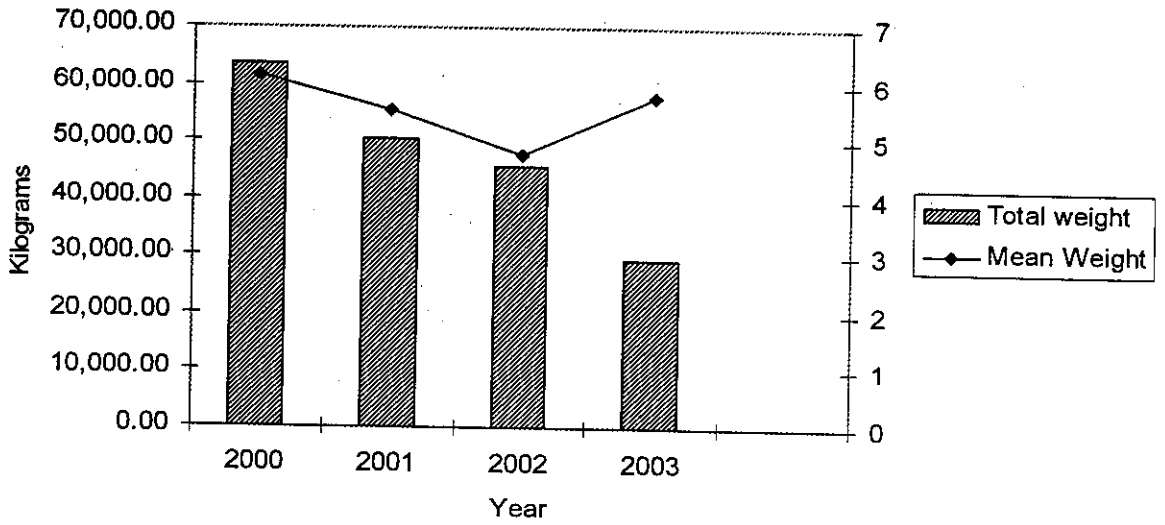

Figure 3. Landings reported by coast in Puerto Rico 2000-2003

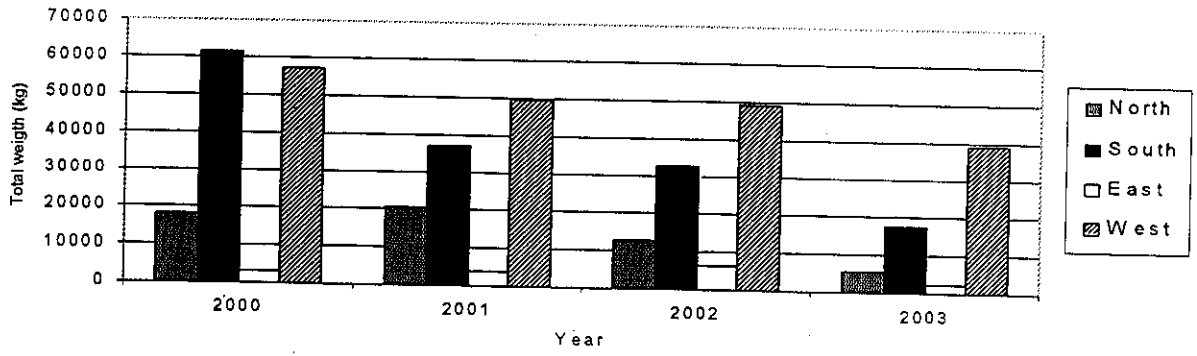

Figure 4. size Frequency Distribution Commercial fisheries

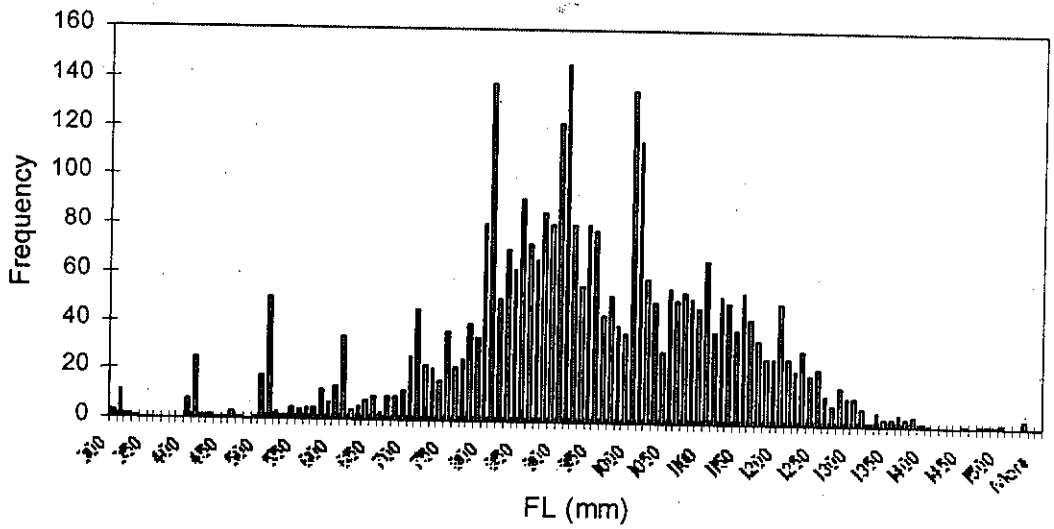

Figure 5. Total weight reported by tournaments landings 2000-2003

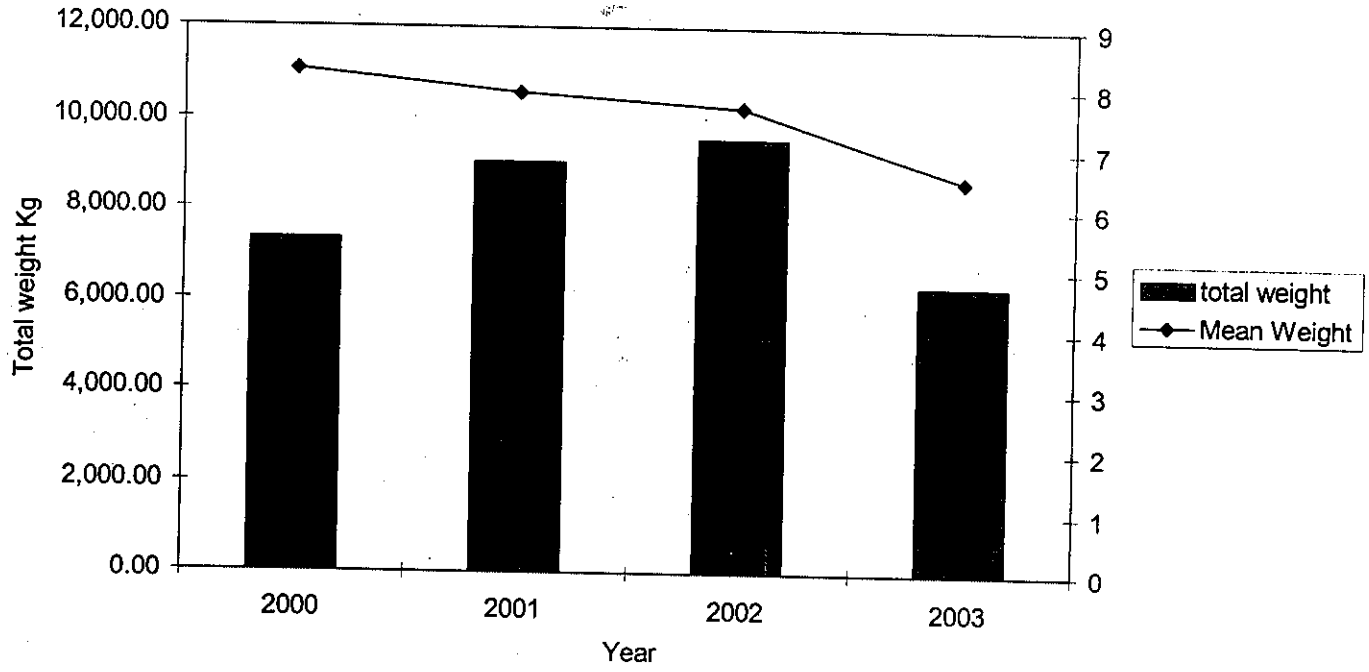

Figure 6. Size Frequency Distribution for Puerto Rico's Fishing Tournamnets 2000-2003

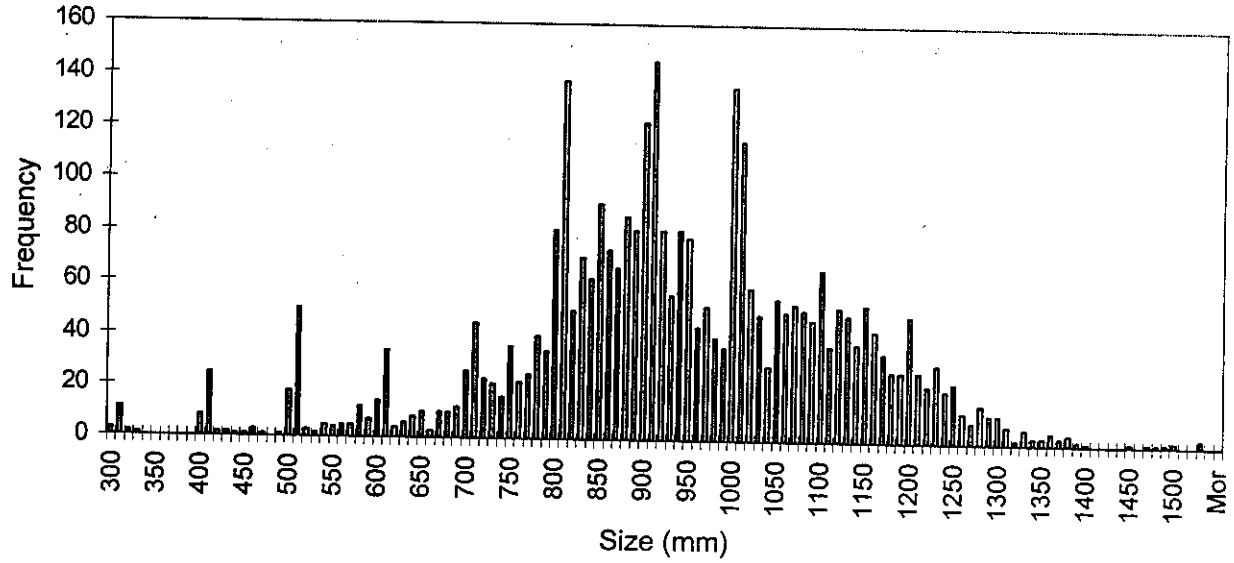

Figure 7. Reported Dolphinfish by sex in Fishing Tournaments 2000-2003

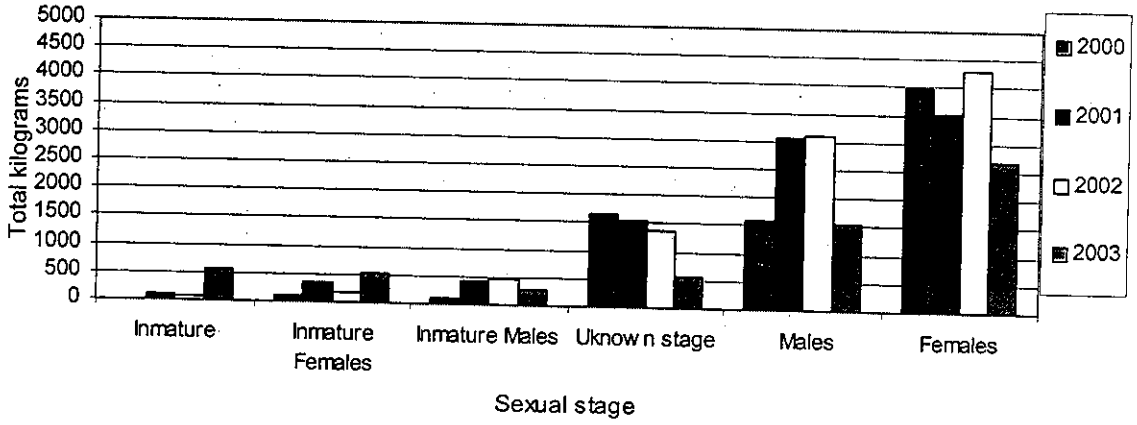

Figure 8. Total Weight by coast Fishing Tournaments in Puerto Rico (2000-2003).

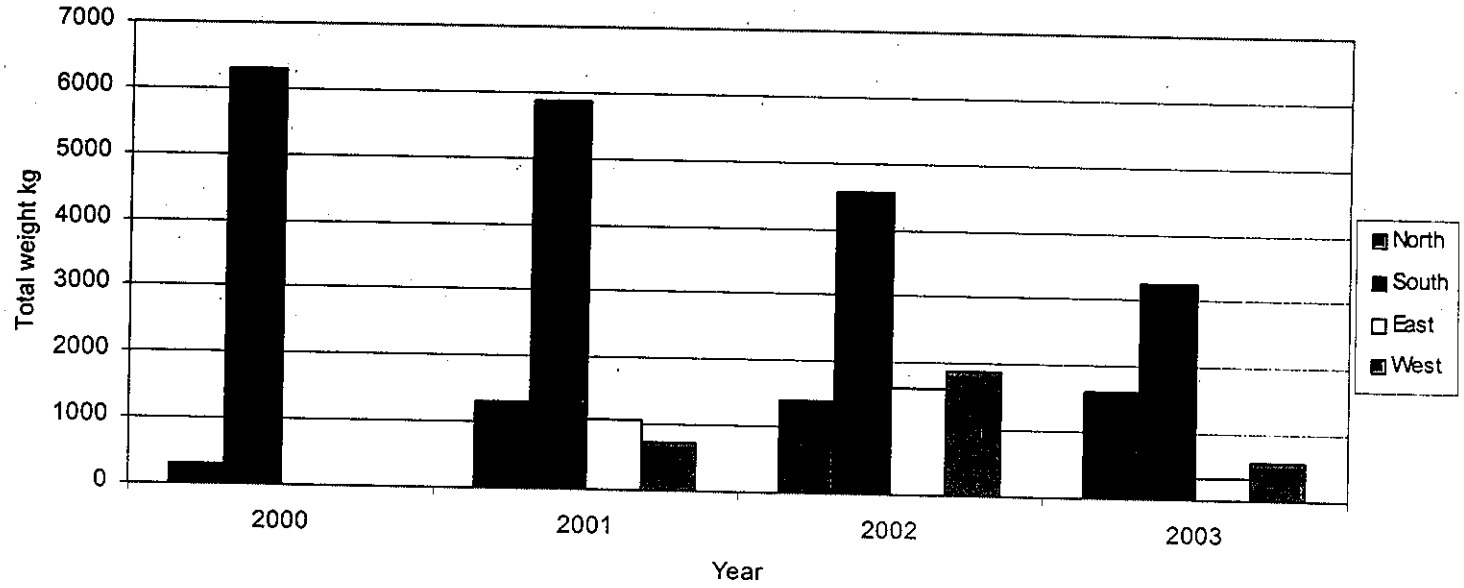

Figure 9. Total weight reported by ports sampler's interviews

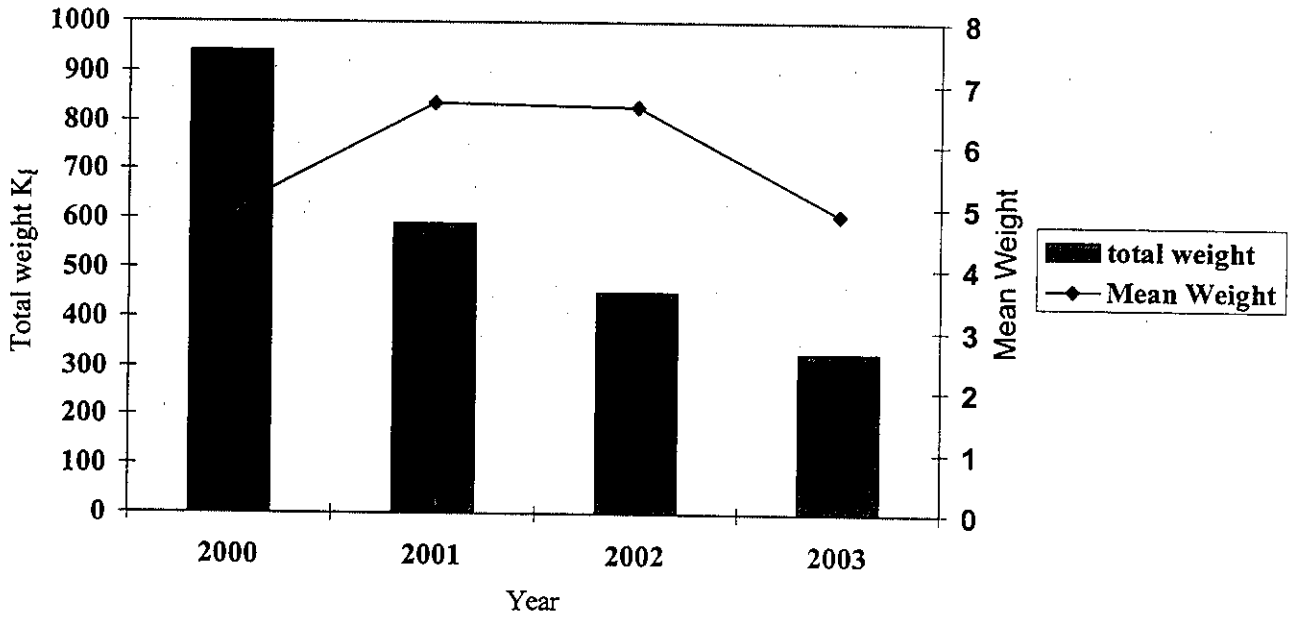

Figure 10. Size Frequency Distribution Recreational Fisheries 2000-2003

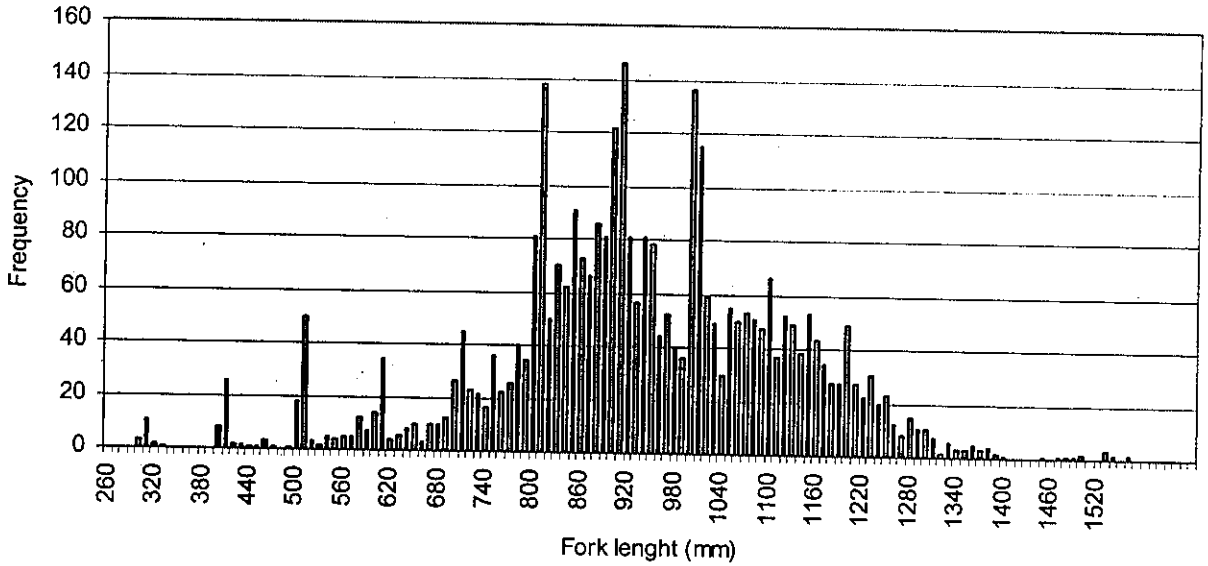

Figure 11.Total weight by coast non-tournaments 2000-2003