Title

Analysis of Sport and Recreational Fishing Activities in the Los Cabos Region, Baja California Sur, Mexico

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CAPSTONE PROJECT

ANALYSIS OF SPORT AND RECREATIONAL FISHING ACTIVITIES IN THE LOS CABOS REGION, BAJA CALIFORNIA SUR, MEXICO

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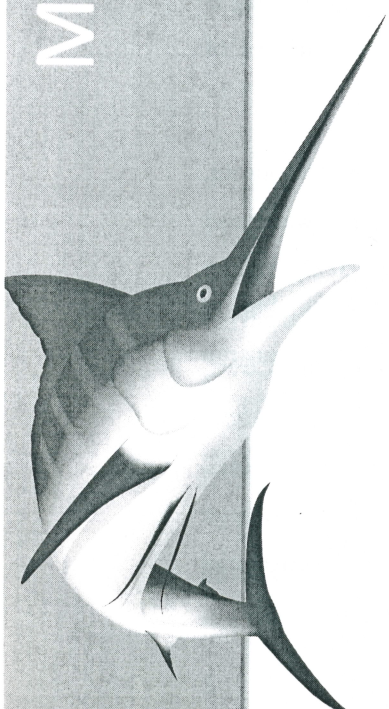

INTRODUCTION

"In the morning the Black mystery of the night was gone and the little harbor was shining and warm. The tuna Cannery against the gathering rocks of the point and a few houses along the edge of the beach were the only habitations visible. … There is indeed a light on the end of the pier… the light burns only in the day time"

John Steinbeck, 1951.

Describing his midnight maritime arrival, Steinbeck captured a moment in time when Cabo San Lucas was but a small rural town with no lights to welcome them by night, but with a warm coast replete with marine life by day. A few homes destroyed by a hurricane, the tuna Cannery and a light house (that only worked during the day because of the need of energy from the tuna Cannery) where the only signs of development in the area.

Just 58 years later Los Cabos, with 164,162 habitants (5), is the one of the fastest growing regions in México. A high economic growth and an inadequate policy of development from the local government have generated a population growth rate of 9% per year which translates into a large pressure on the local resources (Arizpe *et al.,* 2008). This amazing development has its origin in one of the most frequent leisure activities in coastal zones worldwide: Recreational and sports fishing.

Recreational and sports fisheries are usually considered those where fishing is conducted by "individuals for sport and leisure, with a possible secondary objective of catching fish for personal consumption" (Cooke and Cowx, 2006).

Although commercial exploitation is a more important threat to marine resources, new evidence of the negative consequences of recreational fishing in both freshwater and marine systems is emerging rapidly (Cooke and Cowx, 2004; Post *et al.* 2002). In the ocean, recreational fisheries often occur in critical habitats for multiple life stages of many fishes, including estuaries, reefs, mangroves, and embayments (Cooke and Cowx, 2004). The environmental damage to these places can be huge. Lloret *et al.* (2008) argue that impact of this activity can be similar to that of the commercial fishery sectors, including problems of bycatch, fisheries-induced selection, trophic changes and habitat degradation. Although some anglers practice catch and release, there can be substantial post-release mortality, as well as negative effects on growth and fitness of the fishes.

According to Cooke and Cowx (2004) this mortality is analogous to bycatch discards in commercial fisheries.

Despite these facts, marine recreational fisheries are not monitored with the same care as commercial fisheries (Lloret *et al.,* 2008). This happens mainly because recreational fishermen typically do not keep or release records of their activities (place, time and resources spent fishing) and they are highly variable both spatially and temporally (McCluskey and Lewison, 2008).

Los Cabos is one of the most important places for the development of recreational fishing in México. The "sports fishing triangle" of Los Cabos is formed by the towns of Cabo del Este, San José del Cabo and Cabo San Lucas (Billfish Foundation, 2008; Fig.1). Los Cabos lies on the southernmost tip of the Baja California Peninsula, 220 kilometers (136 miles) south of La Paz (8). It is bound to the south and east by the Gulf of California and to the west by the Pacific Ocean (23° 03´ latitude north, 109° 42´ latitude west) (9).

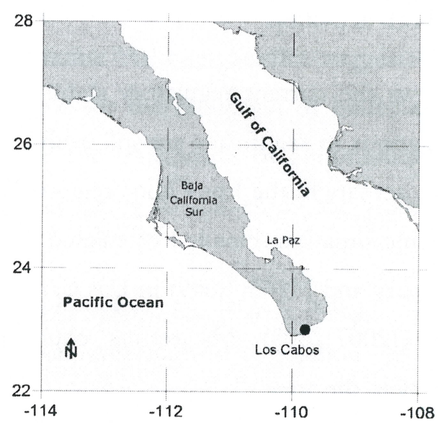

Fig. 1. Map of Baja California Sur and Los Cabos region.

It was around the mid 1950s that the practice of recreational fishing in this area started, where visitors from the US were amazed by the large quantity of billfishes, initiating the entire tourism industry in the area. Its unique striped marlin fishery generated great economic benefits to local business and the local government through tax revenues (Billfish Foundation, 2008).

This large economic growth was possible because Baja is a sports fishing destination for select skilled, high income fisherman. The most important visitors in the region are the tournament charters billfish anglers that have large annual incomes ($70,000-179,000; Ditton and Stoll, 2003). They come to this region to participate in some of the approximately 20 recreational fishing tournaments that are organized every year in the region (1). The most important is the Bisbee tournament in which the prizes total as much as $3,590,030 dollars (2).

Currently the regulation of recreational fishing is based on the idea that recreational fishing has a low impact on the environment. There is no limit for the number of permits given, permits are easy to get and the local institutions have weak or no control on the behavior of the fleet. Furthermore this activity is constantly competing with the commercial fishing for these resources and the government of México is now at a crucial juncture where it needs to decide between promoting recreational or commercial fisheries, find a sustainable way of exploiting these resources and improving the regulation of the activity. The time has come where decisions need to be made and there are two main aspects to be considered: the conservation of the species and the economic benefits of both activities.

My study reviews the current regulatory status of recreational fishing activities and evaluates the regulations to see if they are still useful for this growing fishery. To do this, I will describe this activity in the Los Cabos region. This includes a literature review of the legal and economic situation. Finally I calculated the catch-per-unit effort (CPUE) of one company (February and March 2009) in Los Cabos and analyzed catch data from two other companies (2007-2009). My results could provide guidance for future regulation of this activity in the state.

WHY IS IT IMPORTANT TO TAKE CARE OF LARGE PELAGIC FISHES?

> "...the greatest mystery of the tuna is the mystery of life itself. Are tuna no more than marvelously efficient swimming, feeding, and breeding machines?... Does the tuna know it exists... or that it is beautiful? Does it know how to enjoy life, or feel sorrow for a loved one?"
>
> Roger Revelle, Scripps Institution of Oceanography, July 13, 1979.

Large pelagic fishes form a group of organisms that includes billfishes (families Istiophoridae and Xiphiidae), tunas (family Scombridae) and sharks (subclass Elasmobranchi) and they comprise the upper portions of marine pyramids of consumption and production (Barnes and Hughes, 1999; Eschemeyer *et al* 1983; De

Sylva *et al* 2000) (Appendix A). Billfishes act as apex predators in pelagic marine ecosystems where they play important roles as predators and act as indicators of the fisheries' impacts (Kitchell *et al.* 2006).

Tunas and billfishes occur globally in temperate and tropical waters in both mesopelagic and epipelagic waters; they inhabit the warm upper layer of the ocean known as the "mixed layer" (Joseph *et al.*, 1988; De Sylva *et al.*, 2000). As part of the nekton (organisms that are capable of controlling their movements by swimming) pelagic fishes undertake large migrations for feeding or to search for the best habitats in different stages of their life histories (Joseph *et al.*, 1988; Barnes and Hughes, 1999; Kitchell *et al.* 2006). The large pelagic fishes constitute the target of highly economically important fisheries worldwide and are a resource shared by many countries (Joseph *et al.* 1988; Me´ nard, 2000). However, due to their economic importance, the effort of these fisheries has increased, resulting in population reductions in coastal, shelf and oceanic ecosystems (Jackson, 2001; Myers and Worm, 2003).

Over-exploitation of pelagic fish populations has been documented by many authors. In 1998 the National Marine Fisheries Service suggested that commercial and recreational fishing are responsible for the reduction of billfishes in the Caribbean. In 2003, Myers and Worm analyzed the trajectories of communities of predatory fish in shelf and oceanic ecosystems. According to this study the global ocean has lost more than 90% of large predatory fishes.

The impacts of over-exploitation of larger pelagic fishes have significant implications for fisheries science. Although the position of billfishes as keystone predators (a single species that is essential to ecosystem function) is still controversial because their diets and habitats broadly overlap (Kitchell *et al.* 2006), the decline in global fisheries targets and changes in the catches of organisms that feed at lower levels of the food web are consequences of the removal of large predatory fish including billfishes, tunas and sharks (Myers and Worm, 2003). The largest organisms are selected to be harvested. The structural changes in marine communities start when larger organisms are scarce in the community, followed by the entire community being dominated by the small fishes with faster life histories (Jennings *et al.* 2001; Myers and Worm, 2003). These small organisms often feed at lower trophic levels (Jennings *et al.* 2001); eventually the fisheries shift to the harvest of these organisms and fishers start to "Fish down the food web" (Pauly *et al.,* 1998). For these reasons selective and incidental fishing has clear effects on the trophic web structure and composition. The populations of top predators have been reduced around the world, as affecting of the top-down control in the ecosystem causing the size of the prey population to increase, creating a trophic cascade (Cox *et al.* 2002).

In conclusion large pelagic fishes are showing big reductions in their population sizes, which affects the entire food chain. The main cause of this problem is the increase in the demand for their products worldwide. Seeking the most sustainable way to manage them is one of the greatest challenges at the present time for fisheries managers around the world.

ECONOMIC ANALYSIS

In order to balance the interests and control the negative impacts of commercial or recreational fishing of billfishes, the government has to consider the economic value of the two activities in addition the activities effect on the populations. Thus an economical analysis of recreational fishing is necessary based on assessments of willingness to pay (WTP; Ditton and Stoll, 2003).

In México some attempts have been made to assess the economic value of recreational billfishing. The most important study of sports fishing was done in the Los Cabos region by the Billfish Foundation (2008). They measured and reported the economic impact of recreational fishing in Los Cabos and, for some of the data, in the entire country. The project provides information about the economic impacts of the activity (i.e., benefits created by the visits of anglers to Los Cabos, such as jobs and tax revenues) and marketing information (such as the reasons why anglers chose Los Cabos as a destination). They conducted in-person interviews, surveys of local businesses, visitor surveys, visitor and angler expenditure estimates and they developed an *ad hoc* economic model. They also used existing data through interviews with many people from the government, NGO's and private organizations whose jobs were related to this activity.

The expenditures made by anglers in Mexico experience a multiplier impact. If the people or firms that receive the money directly from the angler spend it in goods and services of the region, the multiplier impact will be high. However if those expenditures are invested outside the region, the impact of billfish anglers expenditures to the local economy will be reduced (Ditton and Stoll, 2003). To include this phenomenon in the study, the billfish foundation calculated a multiplier factor for the Los Cabos region. A very low value shows that the economy of the area behaves like an island, where most investment and consumer goods are imported from outside the region. Currently the multiplier effect has a value of 1.78; if the economy were more vertically integrated, it would have a value closer to 2.7.

The billfish foundation also showed that sport fishing in Cabo generates $633.6 million dollars in retail sales, 24,426 jobs, $245.5 million dollars in local and federal tax revenues and $1.125 billion in total economic activity. At a national level it generates 34,895 jobs, contributes US$652.078 million to the GDP, and raises tax revenues of US$73.53 million.

The visitor surveys also showed interesting results. First, in 2007 the anglers that stayed in hotels and time shares spent $629,743,806 dollars. When we add this value to the expenditures of Marina-based anglers ($3,825,440), we get a total of $633,549,246 dollars. This figure represents the total quantity of money that anglers spent in Cabo. Second, policies that favor commercial fishing could have a negative impact on the anglers' decision to visit this area. Eighty-eight percent of international anglers who have fished in Cabo reported that they would be less likely to return if the commercial harvest of billfishes increases and 85% will return if commercial harvest is stopped or reduced.

These results apparently favor recreational fishing over commercial fishing in the decision-making process. However we need to know the economic impacts of commercial fisheries to get to a conclusion. Also this analysis has to be taken into account with care because a company dedicated to recreational fishing was responsible of the study. My intention is not to doubt the ethical integrity of the study, but their results can be biased by the interests of the company. Furthermore the benefit-cost analysis of marine resources are often made by the calculation of the willingness to pay (WTP) that might vary depending on type, policy context, angler characteristics and the scope of the study. According to Johnson *et al.* (2006), WTP is also affected by the methodologies used to reveal the public's preferences. Low values of willingness to pay are associated with stated preference methods compared with revealed preference approaches. In this study we they used mostly revealed preference approaches which can show higher values for the activity than the real ones. For example surveys made by telephone are related to high values of WTP. Also WTP relates positively with factors like time (due to changes in angler's preferences, experiences and purchasing power), the number of trips (if the angler has done more trips the WTP will be higher) and negatively with others like quantity of people answering the survey (when more people answer the survey, the value of the WTP is lower) and catch rate (high catch rates reduce the WTP). Furthermore the WTP is highly related to the species of fish targeted; billfishes that constitute the main target in Los Cabos' recreational fishing show a high WTP.

Even if the Billfish foundation study is biased, it is unlikely that the economic value of commercial billfishing will exceed that of the recreational fisheries in the Los Cabos region. If sports fishing is truly the best option for the government of México, changes in the regulation of the activity need to be implemented to ensure its sustainability.

REGULATORY SITUATION OF RECREATIONAL FISHING IN MEXICO

Currently in Mexico the regulation of this activity is based on the idea that recreational fishing has a low impact on the environment. Both seawater and freshwater recreational fishing are regulated by the Nom-017-Pesc-1994. This regulation states that the exploitation of marlin, sailfish, dolphin fish, roosterfish and tarpon is exclusive of recreational fishing, inside a 50 mile area around the coast. Each fisherman can capture 10 organisms, with the following composition of species:

- No more than five organisms of the same species.
- No more than one organism per fisherman per day of Marlin, sailfish, swordfish and sharks. This quantity is equivalent to five organisms of other species.
- One fisherman can only take two organisms if it is a dolphin fish, roosterfish or tarpon. This quantity is equivalent to five organisms of other species.

The main problem with this law is that there is no way of monitoring these quantities in each one of the boats that practice this activity. This is due to two main reasons. The first one is that firms that offer recreational fishing services with boats with outboard motors are not obligated to keep records of their activities. The second one is the high density of boats dedicated to this activity. During the year 2008 just in the Los Cabos region 42,712 fishing individual permits (licenses) were distributed with a value of $6,147,718 Mexican pesos.

Monitoring this activity became an even more difficult objective in 2008 when the section 191D of the "*Ley federal de derechos*" changed and a permit for the boats given by the fisheries agency was no longer required. The cost of these permits was $60,000 Mexican pesos for a boat capacity of 30 tons. This change reflects the interest of the Mexican government in promoting this activity as an alternative to commercial fishing, since it makes the process cheaper and faster for the boat operator. The main consequence of this change is that the agency that controls the fisheries in the region (SGARPA) no longer has a record of the number of boats dedicated to recreational fishing. Thus, the problem is that although they know how many individual permits have been distributed, they do not know how and where they operate.

Furthermore the debates for the right on the resources between commercial fisheries and recreational fisheries have became stronger since the Mexican Legislation changed and the official Mexican norm NOM-029-PESC-2006 was published on February 14, 2007. Named "Responsible fishing of rays and sharks, Specifications for their catch," the law allowed commercial longline fishers to capture billfishes as by-catch. Before this law, the longline fishing boats with permits for commercial fishing of sharks legally operated only 50 miles beyond the coastline. Under the new law these boats can fish inside this area, which facilitates the capture of billfishes as by-catch inside a region that before was exclusive to recreational fishing (3).

Although the Nom-029 intends to regulate catches of sharks and rays, because of the high proportion of by-catch in these fisheries, this regulation is commonly seen by the people involved in recreational fishing as a mask for the commercial fishery of billfishes because the only legal way to sell billfishes in México is if they are caught as by-catch.

OBJECTIVES

The primary objective of this project is to provide information for the regulation of pelagic sport fishing in Baja California Sur. A secondary objective is to calculate the CPUE of four sports fishing boats in Los Cabos.

CPUE AND SEASONALITY

METHOD

Field Work

I collected catch data from three sports fishing companies: A, B and C (Table I). Catches from companies A and B provide an overview of the complement of pelagic fishes caught in the Los Cabos area and information on their seasonality.

Table I. Companies used for this study

COMPANY	NO. OF BOATS	TYPE OF DATA	SIZE OF THE BOATS (M)	DATES OF DATA
A	8	Monthly	8.53, 8.53, 8.83, 9.44, 9.44, 9.44, 9.44, 9.44	10/2007 – 03/2009
B	5	Monthly	9.44, 10.05, 10.05, 10.05, 12.19	10/2007 – 03/2009
C	4	H. hours	10.05, 11.58	03/2009

Companies A and B are among the largest in the region so they keep records of their activities for publicity. They provided monthly data of their catches from October 2007 to March 2009.

Data from company C provide a more in depth analysis of the dynamics of the recreational fishery on pelagic fishes in the Los Cabos area. In order to obtain data of their catches, I created a sheet (Appendix B) to record the fishing effort and fish captured in 19 nonconsecutive days during February and March 2009.

Data for each boat were recorded by observers. The sheets include:

- General information:
    - Boat and captain's name, time of departure and arrival, location of departure and arrival, number of fishermen and general information on them (age, nationality, sex, number of recreational fishing trips that they plan to make in the region in that season), sea conditions (Beaufort), atmospheric conditions, boat size and type of motor.
- Effort data:
    - Time out, time spent trolling (time spent with the hooks underwater), position at the beginning and end of trolling, number of lines (hooks underwater).
- Catch data
    - Species, estimated length, time and location, gear used, fate of the fish, and photograph of the specimen.

Tissue samples and the remoras attached to the organisms were preserved and sent to a research center in La Paz (CIBNOR) for further studies.

Data Analysis

The data from the companies A and B were used to determine the seasonality of the catch of Marlin, Dolphinfish and Yellowfin tuna. I also compared the seasonality of striped Marlin with the presence of tourists in the area and the number of hotel rooms occupied from October 2007 to December 2008 (6) using a linear regression.
With the data obtained from Company C, I calculated:

a) The weight of the organisms using the species' weight–length relationship information for these species available at http://www.fishbase.org/.
b) The fishing effort of a typical boat, using the formulas from Table II: Average hook hours per day per boat; Total hours fished; Total hours at sea; Total number of hooks fishing; Effort; Average effort of a boat per day;
c) Total catch and per unit effort as number of organisms/hook-hour and Kg/hook-hour (Table VI)

d) Number of organisms caught with each type of bait

e) Fate of the catch.

RESULTS

The catches of pelagic fishes in the region by Companies A and B comprised mainly by 12 species (Table III) with Marlin, Dolphinfish and Yellowfin tuna presenting the highest numbers in catches. For company A the catches of Marlin, Dolphinfish and Yellowfin present totals of 12,723, 6,092 and 6,490 fishes in 18 months respectively (Table IV). Catch of Marlin, Dolphinfish and Yellowfin tuna show a strong seasonal component. Catches of Marlin peak from October to February, while those of Dolphinfish peak from August to November (Fig 2 and 3). Yellowfin peaked from February to April 2008, but this abundance was not evident in 2009 (Fig. 4).

The number of marlin caught by Company A from October 2007 to December 2009 was not correlated with the number of hotel rooms rented in the region ($R^2 = 0.05$, $P = 0.17$; Fig 5).

Data from Company C, although collected over a short time interval, document a clear change in effort between February 16-March 14 (season 1) and March 25-March 27 (season 2) (Table V). Based on Fig. 2, we can conclude that the data from company C were obtained at the end of the striped marlin season. From February 16 to March 14 (season 1), some captures of Marlin where still present (Table VI) and the effort is lower (average effort= 3.27 hook hrs/day). From March 25 to March 27 (season 2) the abundance of striped marlin is less and the effort is higher (average effort= 11.2 hook hrs/day.).

A change in the type of bait is also evident between the two seasons. With the reduction in the abundance of marlins, the use of Macarela (*Scomber japonicus* Houttuyn, 1782) as bait was also reduced. During the first season the percentage of fishes caught with Bigeye scad, Macarela and trolling lure are approximately 25%, 30% and 45% respectively, while in the second season the same baits resulted in values of 60%, 0% and 40% (Fig. 7).

In this small company (C) the absence of a catch-and-release culture is evident. Of the 13 marlin caught in 19 boat days, only three were released and the rest were kept.

In some cases it was possible to register organisms as being sold. Both of the sharks caught where released, while not a single Dolphinfish was released (Table V).

During both seasons all the boats were 121 hours at sea. The hooks were underwater only 103.5 hours, resulting in an average of 1.36 hours per day per boat. The average effort of one boat per day is 4.75 and the total catch per unit effort of one boat is 0.045 fishes/hook hour or 1.10kg of fish/hook hour (Table IX).

Table II. Formulas used for the data analysis.

CONCEPT	FORMULA
N_B	No. Boats company C
N_{TB}	Total No. of boats of the entire fleet
N_F	No. Of organisms
N_H	No. Of hooks
N_T (Hours)	No. Of hours
N_w (Kg)	Total weight of the catch
Effort (E) (Hook Hours)	$\sum(N_H \cdot N_T)$
Mean Effort (E_m)	E/N_B
CPUE (Organisms/Hook Hour)	N_F/E
$CPUE_w$ (Kg/Hook Hour)	N_w/E
Total Catch of the fleet	$N_{TB} \cdot E_m \cdot CPUE$
Mean CPUE($CPUE_m$) (Organisms/Hook Hour)	$CPUE/N_B$
Total CPUE (fleet)	$CPUE_m \cdot N_{TB}$

Table III. English, Spanish and scientific name of the targeted species by sport and recreational fishing in Los Cabos B. C. S. Local names are those used in the Los Cabos region (7).

English name	Spanish name	Local name	Scientific name
Striped marlin	Marlin Rayado	Marlin Rayado	*Tetrapturus audax* (Philippi, 1887)
Dolphinfish	Dorado	Dorado	*Coryphaena hippurus* Linnaeus, 1758
Yellowfin tuna	Atún Aleta amarilla	Atún Aleta amarilla	*Thunnus albacares* (Bonnaterre, 1788)
Yellowtail jack	Medregal rabo amarillo	Jurel	*Seriola lalandi* Valenciennes, 1833
Skipjack tuna	Barrilete listado	Barrilete	*Katsuwonus pelamis* (Linnaeus, 1758
Pacific sierra or Mackerel	Sierra del Pacífico	Sierra	*Scomberomorus sierra* Jordan & Starks, 1895
Sailfish	Pez vela	Pez vela	*Istiophorus platypterus* (Shaw, 1792)
Wahoo	Peto	Barracuda	*Acanthocybium solandri* (Cuvier, 1832)
Blue marlin	Marlin azul	Marlin azul	*Makaira nigricans* Lacepède, 1802
Pacific bonito	Bonito del Pacífico oriental	Bonito	*Sarda chiliensis* (Cuvier, 1832)
Roosterfish	Papagallo	Pejegallo	*Nematistius pectoralis* Gill, 1862
Hammerhead shark	Cornuda	Cornuda	*Sphyrna* sp

Table IV. Catch from companies A and B.

	Company A			Company B		
	Marlin	Dolphinfish	Yellowfin Tuna	Marlin	Dolphinfish	Yellowfin Tuna
Oct-07	777	1547	368	96	394	115
Nov-07	1228	445	355	112	95	98
Dec-07	1167	75	305	265	31	181
Jan-08	889	67	91	222	26	54
Feb-08	254	27	909	42	5	121
Mar-08	110	122	2161	13	13	556
Apr-08	332	81	1023	76	12	206
May-08	315	128	196	103	25	59
Jun-08	304	59	61	88	24	3
Jul-08	110	88	173	30	23	11
Aug-08	117	276	371	43	76	174
Sep-08	206	1347	194	131	340	26
Oct-08	1357	690	106	146	104	9
Nov-08	2045	386	113	619	56	14
Dec-08	1201	258	30	309	29	6
Jan-09	945	107	6	411	37	1
Feb-09	809	251	9	76	112	10
Mar-09	557	138	19	38	6	0
Total	12723	6092	6490	2820	1408	1644
Total/No. Of Boats	1817.57	870.28	927.14	705	352	411
Total/No. Of boats/No of months	100.98	48.35	51.51	39.17	19.55	22.83

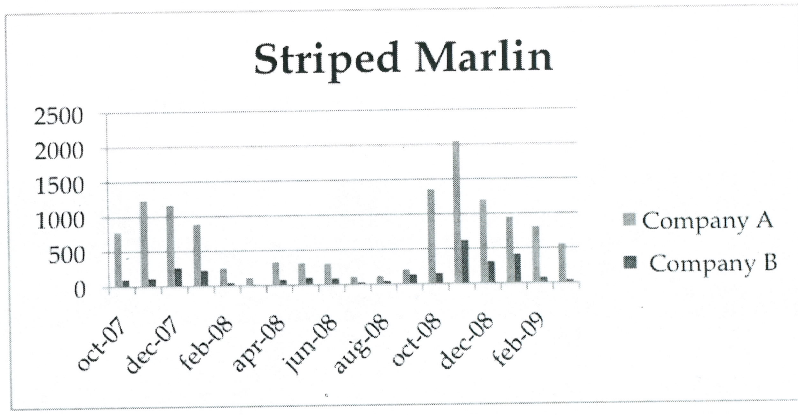

Fig. 2 Seasonality in the abundance of Striped Marlin

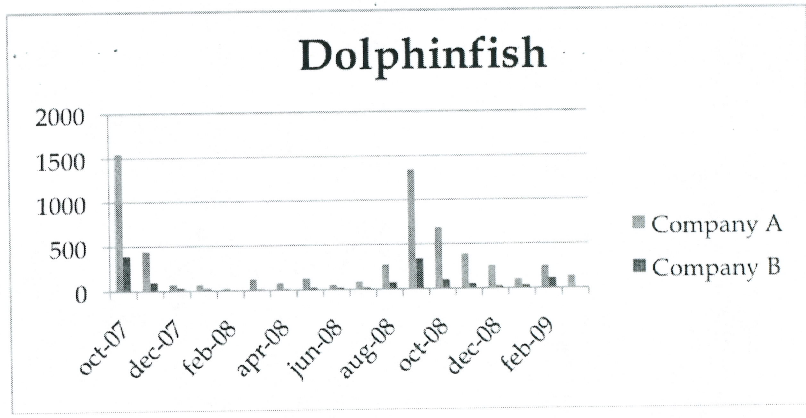

Fig. 3 Seasonality in the abundance of Dolphinfish

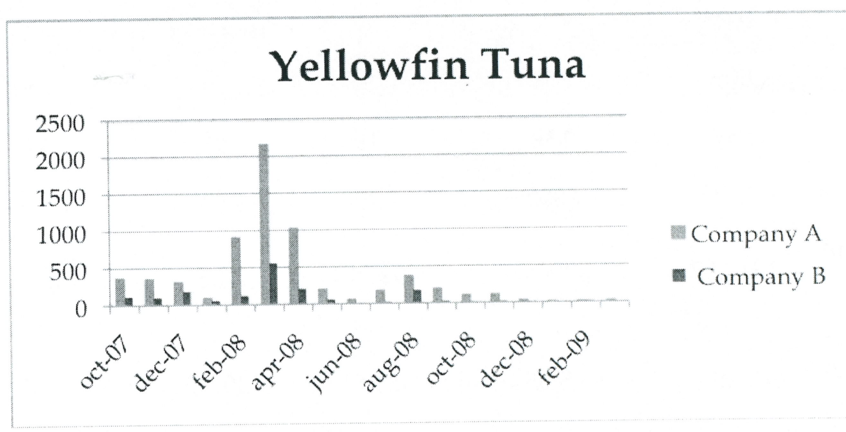

Fig. 4 Seasonality in the abundance of Yellowfin Tuna.

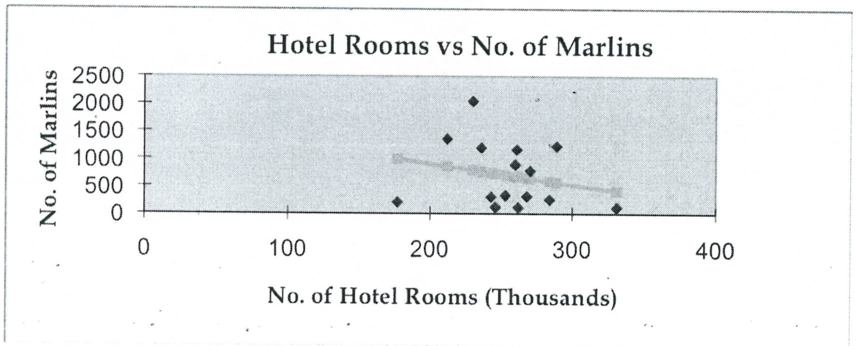

Fig. 5 Linear regression between the catch of marlin from company A and the number of Hotel rooms rented.

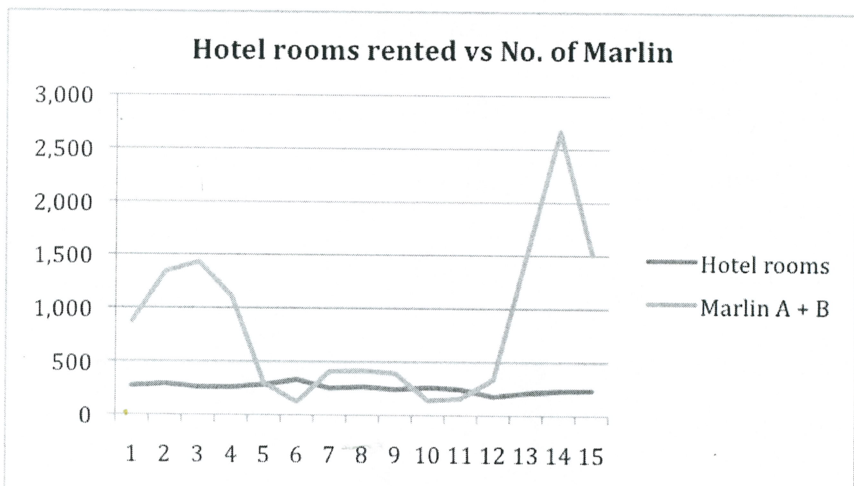

Fig. 6. Seasonality on Striped Marlin catches of companies A and B and seasonality in the number of hotel rooms rented.

Table V. Fishing effort of company C in 19 boat days.

	Average hook hours per day per boat	Number of Hooks underwater	Total Time at sea (Hours)	Effort (E) (Hook hours)	Mean Effort per day (Hook Hours)
Both seasons	1.36	68	121	323	4.25
Season 1	1.21	48	92	183	3.27
Season 2	2.8	20	29	112	11.2

Table VI. Catch of each species for company C during season 1 and season 2.

	Season1		Season2	
Species	Total Quantity	Quantity/effort	Total Quantity	Quantity/effort
Striped marlin	11	0.060	2	0.018
Dolphinfish	9	0.049	16	0.143
Yellowfin tuna	3	0.016	2	0.018
Yellowtail jack	0	0	4	0.036
Skipjack tuna	0	0	2	0.018
Pacific sierra or Mackerel	2	0.011	4	0.036
Hammerhead	1	0.005	1	0.009

Table VII. Quantity of organisms caught with each type of bait.

Species	Caballito (bigeye scad) *Selar crumenophthalmus* (Bloch, 1793)	Macarela (Chub mackerel) *Scomber japonicus* Houttuyn, 1782	Trolling Lure (Currican)
Striped marlin	5	7	1
Dolphinfish	12	0	14
Yellowfin tuna	0	0	2
Yellowtail jack	4	0	0
Skipjack tuna	1	0	4
Pacific sierra or Mackerel	2	0	4
Hammerhead shark	1	1	0

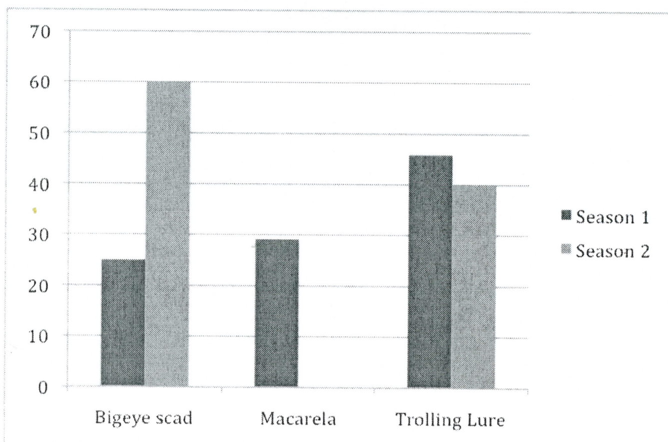

Fig. 7 Percentage of catches using Bigeye, Macarela and Trolling lure as baits

Table VIII. Fate of the catch

Species	Total Released	Sold	Kept (Fate unknown)	Consumed	Total KEPT (Sold, Fate unknown and consumed)
Striped marlin	3	5	0	5	10
Dolphinfish	0	0	16	9	25
Yellowfin tuna	0	0	2	0	2
Yellowtail jack	0	0	4	0	4
Skipjack tuna	2	0	3	0	3
Pacific sierra or Mackerel	0	0	6	0	6
Hammerhead shark	2	0	0	0	0

Table IX. Catch per unit effort

Species	Total	Total weight (kg)	Average weight (kg)	CPUE (Organisms/Hook Hour)	CPUEw (Kg/Hook hour)	Mean CPUE (Organisms/ hook hour)	Mean CPUEw (Kg/hook hour)
Striped marlin	13	881.59	67.81	0.04	2.73	0.0101	0.6823
Dolphinfish	26	410.37	17.10	0.08	1.27	0.0201	0.3176
Yellowfin tuna	2	11.39	5.69	0.01	0.04	0.0015	0.0088
Yellowtail jack	4	49.50	12.37	0.01	0.15	0.0031	0.0383
Skipjack tuna	5	33.64	8.41	0.02	0.10	0.0039	0.0260
Pacific sierra or Mackerel	6	8.84	1.47	0.02	0.03	0.0046	0.0068
Hammerhead shark	2	23.40	23.40	0.01	0.07	0.0015	0.0181

Discussion

Seasonality

According to González-Armas *et al.* (2006) during the winter and spring Striped marlin is present. In summer and fall he reports there is Dolphinfish and Yellowfin Tuna. My results coincide with this statement for Dolphinfish that follows the highest seawater temperatures (26 to 29° C) provided by equatorial countercurrent during the summer and the autumn. Dolphinfish also find concentrations of floating objects that provide them with shelter and food during this period (Zúñiga et al , 2008).

However I found a higher abundance of striped Marlin during the Fall-Winter season and low catches during the spring. This could be due to changes in the sea currents since striped marlin has a strong preference for waters 20–25°C (Domeier, 2006).

For Yellowfin Tuna the highest pick occurred from February to May 2008. This pick was absent in 2009. Two small picks are visible from July to December. The reason for this could be that this species is truly more abundant in the fall-winter season and that the pick observed in 2008 is a result of mistakes made by the fishermen during the identification of the species, since in many cases the record sheets had only the word "Tuna". Another explanation could be that the catch of tuna only occurs when marlin and dolphin fish are less abundant since the months of February to May are the low season for these species.

No correlation was shown between the presence of tourist and the seasonality in the catch of Striped Marlin. Although the number of hotel rooms occupied in the Los Cabos area does not show a strong seasonal component, the catches of pelagic fishes in the area do. Therefore the seasonality is the result of the natural behavior of the Striped marlin. In contrast to the temporal stay of the fish, Los Cabos is characterized by the presence of tourists all year round because of the existence of target species in every month of the year (Zúñiga Flores *et al.* 2008).

Regarding the catch of both companies, since company A has a larger number of boats it presents higher catches than company B (in the case of striped marlin company A captured 12,723 while company B caught 2820). Furthermore new fishing technologies are being developed according to the understanding of fish behavior, increasing catch ability (Parrish, 1999). Company A is a big modern company with boats equipped with GPS, Fish Finder, Radar and Water Temperature Gauges while company B has GPS only on some of the boats (4).

Catch per unit effort

Previous calculations of the CPUE in the Los Cabos region are higher than the values found in this study. For billfishes the SWFC calculated a CPUE of 0.77 billfishes per day, while González-Armas *et al.* (2006) reported 0.45 fish per trip. For Dolphinfish, Zuniga-

Flores *et al* (2008) calculated 1.33 dolphinfish per day. This differs greatly from my results of 0.17 marlins/day and 0.34 dolphinfish/day. There are several reasons why my results show such low values. First of all, my data only includes Striped Marlin as compared to the previous studies that include all the billfishes. Secondly the previous studies used data from an entire year, while my calculation only includes the catch from the end of the striped Marlin season. And finally I based the calculation of the CPUE in the catches of small company.

Although my calculations are definitely not representative of the real CPUE, it is still valuable information because this is the first time that the CPUE is calculated using hook hours as a unit instead of fishing days. The time the hook is underwater varies greatly with the presence of marlin in the area. If we calculate the daily catch per unit effort we would not observe the change in effort when the marlin is absent.

Furthermore the method for calculating the CPUE improved in this study because the data were directly obtained from the field and not through the fishermen. In many cases, they have the incentive of providing inflated catch values to advertise themselves as good fishers. With this work we created a better method for calculating the effort of the sports fishing fleet therefore setting the basis for future research.

The population status of Striped Marlin for this region is uncertain. Hinton and Bayliff (2002) calculated the status of the striped marlin population in the eastern Pacific Ocean and found that the stock near or at the level of the MSY (range: 4,300 to 4,700 mt/year). They also reported a decreasing fishing effort and an increase in biomass harvested. On the other hand, the SWFSC reports an almost constant behavior of the CPUE from 1969 to 2006 with some increase since 2003. This information can be misleading for several reasons. Some species of tunas, billfishes and sharks form schools, mostly during spawning. Marlin form small groups near the coast, in many cases composed of up to five males and one female, but occasionally form larger groups in open water (Joseph *et al.* 1988). Schooling behavior may make these species more susceptible to fishing with resulting negative conservation impacts. For example, schools can give the impression of high fish abundance, hiding the real over-exploitation of the species. By the time that the decline in school size is evident the population may be depleted to the extent that social interactions leading to reproduction are reduced (Parrish, 1999). Thus the population in the eastern Pacific may be in poorer condition than what Hinton and Bayliff (2002) proposed. McGettigan (2001) calculated a reduction of 40-50% in the striped marlin core aggregation area through interviews with fishers of the area.

Fishing effort and catches by Company C differed greatly between season 1 and season 2. This appeared to be the result of the reduction in striped marlin density. Their catches changes from 11 in the first season to only 2 striped marlins during the second season resulting in a change on effort from 3.27 to 11.2 hook hours. During season 1, the boats fished primarily at the Golden Gate Bank where they first localize the fish by sight and then throw the hooks to the water to capture them. However in season 2, when marlin density is lower, the boats fish closer to shore by trolling with their hooks underwater most of the time, resulting in an increase in the fishing effort.

There appears to be a relationship between the end of the marlin season and the absence of chub mackerel. The reason for this is that *S. japonicus,* which constitutes one of the most important prey of Striped Marlin (28% of the Index of relative importance) (Abitia-Cárdenas, 2002), is present in Los Cabos waters from November to April for spawning, but during the spring it migrates towards northern feeding grounds (Isla Tiburón and Isla Angel de La Guarda) (Gluyas-Millán and Quiñonez-Velázquez, 1997). This event coincides with the end of the Marlin season in the Los Cabos region. These findings support the idea that the sea mounts in this region (Gorda, San Jaime, and Golden Gate Banks) are a feeding ground of striped marlin (Abitia-Cárdenas, 2002).

RECOMMENDATIONS

From an ecological point of view, sport fishing seems to be less harmful than commercial fishing of billfishes because there is often a stronger interest in conservation measures among anglers. Although many fishers support the creation of conservation measures, there are still cultural differences among them and education programs are clearly needed. For example, it has been shown that the practice of catch and release is not related to the level of education of the fisherman, but rather it depends on how often the angler goes fishing (Ditton and Stoll, 2003). Therefore finding ways to inform the angler how to practice responsible fishing is highly important.

During fieldwork for this study, we observed the interest of most anglers in conserving the different species and practicing responsible fishing methods. However they lack the information about effective management and were larger unaware of Mexican laws. Even some of those that practice catch-and-release did so incorrectly. For these reasons we created a pamphlet that could be distributed in hotels and tourism centers in Los Cabos. This pamphlet contains information about the Mexican regulation and how to practice recreational fishing responsibly (Appendix C).

However caution must be taken in considering recreational fisheries as an activity with low impact on the environment. From my point of view, expectations of this activity as an ecologically friendly one (e.g., Holland *et al.* 1998) are highly dangerous. Recreational fishing is just another way of exploiting marine resources that must rely on effective management based on sound scientific knowledge of the targeted species.

If the government of Mexico plans to promote sports fishing over other activities the following recommendations should be considered:

1) Set an overall catch limit for the region and consequently a limit on the number of permits.

2) Demand reports of their activities to firms that offer recreational fishing services.

3) Conduct studies on the biology and life history of the species targeted by recreational fisheries.

4) Make accurate calculations of the CPUE. To accomplish this it is important to return the control of records of the boats operating in the area to SAGARPA-CONAPESCA.

5) Invest in a monitoring system of the activity.

6) Have better control over the catch and release activities.

7) Promote the realization of economic studies, avoiding the participation of agencies with economic interests in the activity.

8) The new economic surveys must contain a better description of the fisher's profile. This should include information that could indicate why some fishers practice catch and release and some decide not to and how they choose the places to fish. Understanding the behavior of the fisher will provide the government with the tools to educate other anglers about sustainable ways of conducting billfish fishing (Ditton and Stoll, 2003).

Finally it is also important to consider the impact of the promotion of this activity in the community. We most avoid inequities in the distribution of benefits affecting the local poor people who in many cases are excluded from planning and decision-making (Sepiteri and Nepal, 2006).

Especially in the case of tourism, the benefits are mostly felt at the national and international levels. The local people usually don't get the best paid jobs that are given to outsiders who have the necessary skills and education (Sepiteri and Nepal, 2006). Thus it is important to ask what will be the role of the local people in this growing activity and how is it going to benefit them. The local residents and their opinions have to be included in the decision making.

The solutions for these problems have to involve both the change in regulation and the use of economic incentives.

In relation to regulations I believe that the use of a NMX is a good option. An NMX is an agreement among the people involved in the activity. The rules of this agreement are then sent to the federal government to become a law. Therefore the law is created by the community, including their own knowledge about the resources and worries about its conservation.

Regarding economic incentives, the creation of a Certificate for green companies is a good option since many of the companies already advertise them selves as ecologically friendly. To do this it is necessary to create a monitoring system.

The legal and the economic approach are not mutually exclusive, for example one of the conditions to obtain the certificate could be to participate in the creation of the NMX.

CONCLUSIONS

The problems related to recreational fishing need to become part of the daily agenda in the Mexican government and organizations dedicated to conservation. This activity can have a great impact on the ecosystem therefore we need to change the current open access system under which they are operating.

Furthermore, the economic growth of the Los Cabos region is occurring at a fast rate requiring a more severe and strict control of the activities developed in the area. The decisions made by the current government will greatly affect this region's destiny. These decisions should be based on the sound scientific information that in many cases are currently lacking.

Los Cabos is no longer the place that John Steinbeck once visited. Although the ecosystems in this region are already negatively impacted by the tourism industry, it is possible to change this pattern. Great efforts from scientists, economists and politicians have to be made to manage this region in a sustainable way to recover and perpetuate the beauty of this Mexican paradise.

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APPENDIX A. FISHES INCLUDED IN THE LOS CABOS RECREATIONAL FISHERY

BILLFISHES: Istiophoridae and Xiphiidae (Eschmeyer *et al.* 1983)

These are relatives of tunas that occur in tropical seas, with a few species entering temperate waters. They are among the largest and fastest swimming fishes; many migrate long distances. They can change depths quickly, but are usually found near the surface. They eat other fishes, squids and crustaceans and are often found near floating objects that attract prey. All billfishes are commercially fished to some extent, especially by the Japanese. Usually 10 species are recognized (some with sub-species).

MACKERELS AND TUNAS: Family Scombridae (Eschmeyer *et al.* 1983)

These are fast moving, schooling pelagic fishes with a sleek, streamlined, cigar-shaped body. They occur worldwide in temperate and tropical seas, both inshore and offshore. Many species migrate long distances. Some support major commercial fisheries. About 47 species.

SHARKS: Subclass Elasmobranchi (Eschmeyer *et al.* 1983)

These are cartilaginous fishes with 5 to 7 gill slits on each side, and an elongate fleshy copulatory organ (clasper) one each pelvic fin of males. They are mainly marine, although some enter freshwater species. 800 species (18 orders, 29 families).

Page

APPENDIX B

RECREATIONAL FISHING LOS CABOS

Record Sheet

Observer	
Date	

Boat	Captain	Motor	Size of the boat

	Time	GPS	Beaufort	Atmospheric Conditions
Departure				
Arrival				

Fisherman number	Nationality	Age	Sex	# Of trips this season

Date	Page

TROLLING NO. ☐

	Time	GPS	Number of lines
Start			
End			

CATCH

No.	Time	GPS	Species	Weight	Size	Photograph	Line/hook	Bait

Released ☐ Kept ☐ Consumed ☐ Sold ☐

No.	Time	GPS	Species	Weight	Size	Photograph	Line/hook	Bait

Released ☐ Kept ☐ Consumed ☐ Sold ☐

No.	Time	GPS	Species	Weight	Size	Photograph	Line/hook	Bait

Released ☐ Kept ☐ Consumed ☐ Sold ☐

No.	Time	GPS	Species	Weight	Size	Photograph	Line/hook	Bait

Released ☐ Kept ☐ Consumed ☐ Sold ☐

Appendix C Pamphlet for anglers

Fishing in Los Cabos

Los Cabos is a unique fishing paradise famous due to the presence of beautiful fishes such as Striped, Black and Blue Marlin.

To maintain these resources we encourage you to be a responsible, informed tourist.

PLEASE READ THIS PAMPHLET and help us to preserve these wonderful fishes.

We need to prevent the overexploitation of marine resources.

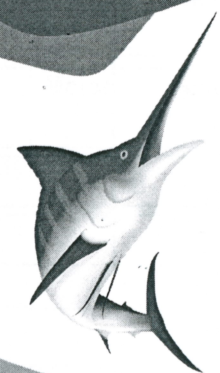
Let's take care of fish now. We want to go fishing with you and your grandchildren in the future!

The information about *Catch and Release* was based on the recommendations of the Florida Sea Grant College Program. Please visit: http://catchandrelease.org/

Questions?
cabosportsfishing@gmail.com

Designed by Alejandra Garcia

Welcome Fisherman!



Please read this IMPORTANT information

Follow The Rules

Mexican Federal Government regulations state that a fisherman can catch **no more than 10 organisms** per day and **no more than 5 fishes** of the same species. With stringent quotas for the following:

- Marlin, sailfish, sharks and swordfish: No more than **ONE** organism per fisherman.
- Dolphinfish (dorado), tarpon or roosterfish: No more than **TWO** organisms per fisherman.

These rules are implemented through a point system. Each species caught is worth a certain number of points. The designated points (p) for 1 organism of each species are:

- Marlin, sailfish, sharks and swordfish: **5 p**
- Roosterfish, tarpon and dolphinfish: **2.5 p**
- Other fishes: **1 p**

In one day, a fisherman cannot exceed a total of **10 p.**

The organisms should not be filleted onboard or sold after their catch.

To Practice Responsible Catch and Release

- Inform the boat's captain about your intentions to practice *catch and release.*
- Try **not to remove** the fish from the water. If you need to do it:
  - Handle it as little as possible.
  - Do not take it out of the water using the line.
  - Do not touch its eyes or gills.
  - Handle it with wet hands. Do not use fabrics or towels.
  - Support the weight of the fish horizontally. Do not lift it from its jaw.
  - If the hook is deep in its throat or stomach, do not take it out, it will dissolve eventually (especially if it is non-stainless steel). Cut the line as close to the fish as possible.
- Before releasing the fish, drag it with your hands in the water to make water go through the fish's gills.

Use the right gear for Catch and Release

- Use **heavy tackle** to avoid extended fighting with the fish thereby reducing its exhaustion.
- Use **non-**stainless steel circle hooks to avoid hooking the stomach.
- Use **natural bait** dead or alive.
- Insert the hook in **soft areas** of the baits body (skin and muscle) to avoid to avoid hooking the stomach or throat of the fish.
- Be patient! **Do not set the hook**; let the hook set by itself when the fish swallows the bait.
- Use a **dehooking device.**
- Learn how to use a **venting tool** for fishes with bloated swim bladder.