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National Report of Mexico
(Mexican National Report to the 17th ISC)[1)]

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1. INTRODUCTION

This national report describes the recent trends of the Mexican tuna fishery for the tuna and tuna-like species in ISC area

In Mexico, the National Institute of Aquaculture and Fisheries (Instituto Nacional de Acuacultura y Pesca, INAPESCA, Formerly INP), was created more than fifty years ago to systematically conduct scientific work and fisheries research with the marine resources of Mexico. The INAPESCA is responsible of providing the scientific bases for the management advice to the fisheries authorities in México and has stablished along its coastal states, in both, Pacific and Gulf of Mexico, 14 regional fisheries centers (CRIPs) which are the centers and laboratories in charge of data collecting, sampling, monitoring and assessment of the main fisheries and aquaculture activities on a regional scale. Since 1992, the INAPESCA incorporated to this effort, the work of the National Tuna-Dolphin Program (Programa Nacional de Aprovechamiento del Atún y Protección del Delfín, PNAAPD), which closely monitored and study the tuna fishery of its purse seine and longline national fleets. The data here reported is based on the combined efforts from these different and unified groups.

2. TUNAS

In this region the Mexican fleet concentrates mainly in the yellowfin (Thunnus albacares), which is the prime target tuna species. The Mexican tuna purse seine fishery is one of the largest in the (ETP) since the mid 1980's. YFT represents for its large volumes the main component of the catch by Mexico. Other tuna species which are also caught, but contrastingly in lower proportions are: the skipjack, (Katsuwonus pelamis), the black skipjack (Euthynnus lineatus) and more recently, in northerly zones of the Mexican EEZ, the bluefin (Thunnus orientalis) which is targeted by some vessels and sporadically the albacore (Thunnus alalunga). The fishing operations of the Mexican purse seine fishery comprise a vast area in the EPO, (figure 1).

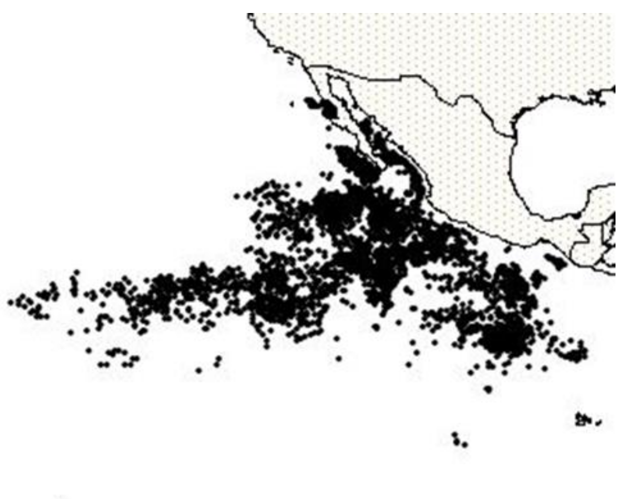

Figure 1. Fishing grounds of the Mexican purse seine. 2014

The recorded levels of tuna captures in the EPO area by the Mexican fleet from 1980 till 2016 are shown in figure 2.

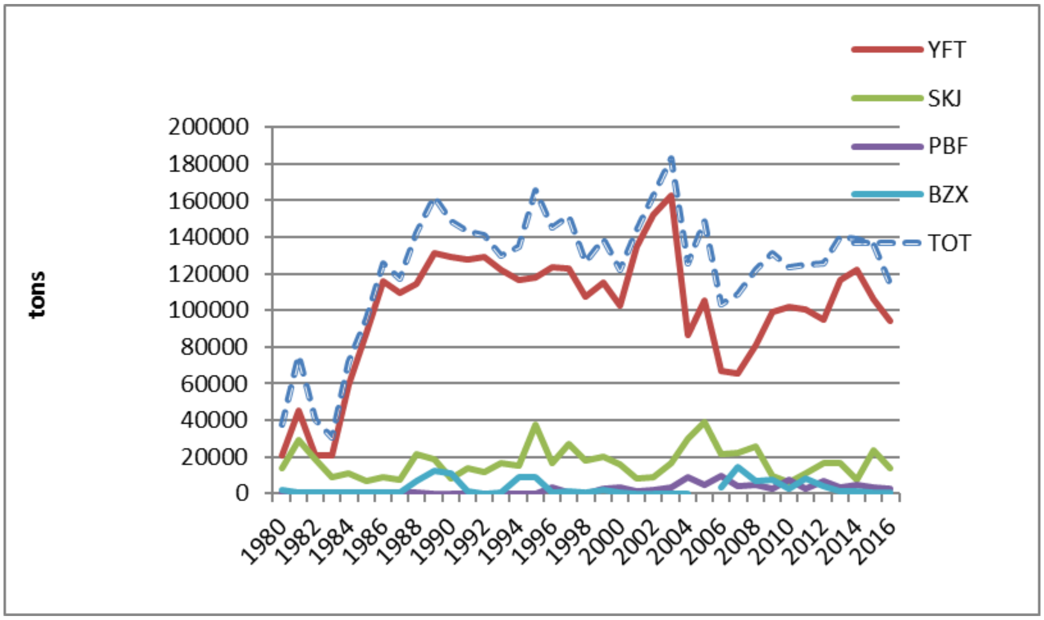

Figure 2. Mexican tuna catch of yellowfin tuna (YFT), skipjack (SKJ) and bluefin tuna (BFT), 1980-2016.

The total tuna landings of Mexico in 2003 were 183199 mt. Value which represents the highest historic record for this fishery. Comparatively, the lowest recorded capture in this fishery during recent years was in the 2006 season, with only 102472 mt., value which is closer to the 1980's development phase. After 2008 catch levels recovered. The fleet has compensated partially its catches primarily with skipjack.

These high consistent reported catches are the result of the combination of the fishing experience and performance of the fleet as well as the effect of high recruitments in previous years and are not related with any significant increase in the fishing effort or a greater expansion of its carrying capacity during the corresponding years. Lower catches in 2006 and 2007 are probably related to a decrease in population levels of yellowfin tuna (lower recruitment) and excessive catches of juvenile tunas in coastal areas in the EPO.

The purse seine fleet is subdivided in purse seine vessels, most of them with observers on board all tuna fishing trips and a small quantity of pole and line vessels (Table I). The whole fleet is quite stable in number, composition and carrying capacity since the 1990´s.

Yellowfin tuna always has been the primary catch, and skipjack is always second in volume. Other tuna species have high values because the fleet has compensated lower yellowfin catches with other tunas, basically with skipjack but a slight increase is related also with Bluefin tuna catches (Table 2).

Table 1. Size, composition and carrying capacity of the active Mexican tuna fleet 2007 to 2016, in EPO and ISC area.

YEAR	No. of active tuna boats	No. of m PSeiners > 400 m3	No. of PSeiners < 400 m3	No. of active Bait Boats
2007	55	42	11	2
2008	49	39	8	2
2009	46	38	6	2
2010	42	36	3	3
2011	43	38	3	2
2012	45	39	3	3
2013	43	37	3	3
2014	47	42	3	2
2015	47	42	3	1
2016	47	42	3	1

Table 2. Total tuna landings of YFT, SKJ and other tuna species by the Mexican fishery during 2015 and 2016 in ISC area

YEAR	TOTAL LANDINGS All tuna species (mt.)	Yellowfin (mt	Skipjack (MT.)	Others Species (mt.)
2015	119243	104237	10478	4528
2016	107285	92813	10330	4142

2.1 Bluefin tuna

All the fishing zones for bluefin tuna used by the Mexican fleet are located in the Northwest side of the Baja California peninsula, inside the ZEE of Mexico (figure 3), closer to the ranching locations. Recorded catches of PBF are registered from March to September, time in which the transpacific migration of this stock is closer to the Mexican Pacific coast, due to oceanographic factors. Sea conditions together with the presence of the specie permitted the development of this new fishery predominantly related to ranching activities in the Mexican Northwestern coastal area. Temperature is an important factor defining areas were PBF is to be found. In recent years fishing season started later (May-June)

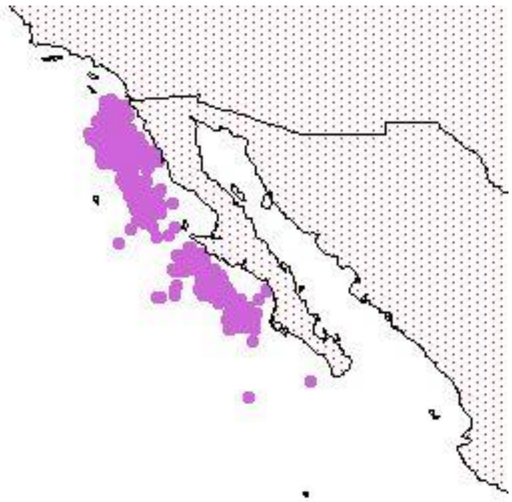

Figure 3. Fishing Zone for bluefin tuna in the Northwest region of Mexico, offshore the Baja California peninsula (several years),

The time series of bluefin tuna captured by the Mexican tuna purse seine boats from 2005-2016 is presented in Table 3 and in figure 4, the 1980-2016 catch series is shown. This catch represents only a very small proportion of the total tuna caught by the Mexican fleet with an average catch of 3612 mt for the entire period. This represents a small proportion of the Mexican tuna catch, although very valuable. The 3,700 mt reported in 1996 was the first historic highest record for this fishery and the first year bluefin tuna has been targeted by the fleet. Again, in 2004 and 2006 new records were established for this tuna specie in Mexico. In 2007 the catch returned closer to the average. In 2009 due to the international economic crisis many companies did not operate and catches were below average. In 2010 catches increased again and since 2012, management measures were implemented in IATTC area limiting the PBF catch. The catch in the Eastern Pacific nevertheless is below the historic highs observed in the 1960's and 1970's. The information provided makes clear that fishing for bluefin has not being a foremost significant activity in Mexico for many years. It also shows that even in some fishing seasons there were no captures on this stock, or those were only of low levels. Therefore, it is clear that fishing bluefin in Mexico was considered only incidental. However, more recently, in the years (1996-to present time) there has been a greater interest devoted to this species, mainly for the ranching activities developed in the Northwest region of Mexico.

Table 3. Bluefin tuna catch of Mexico, 2005-2016*. (*preliminary)

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
4542	9806	4147	4407	3019	7746	2731	6668	3154	4862	3082	2706*

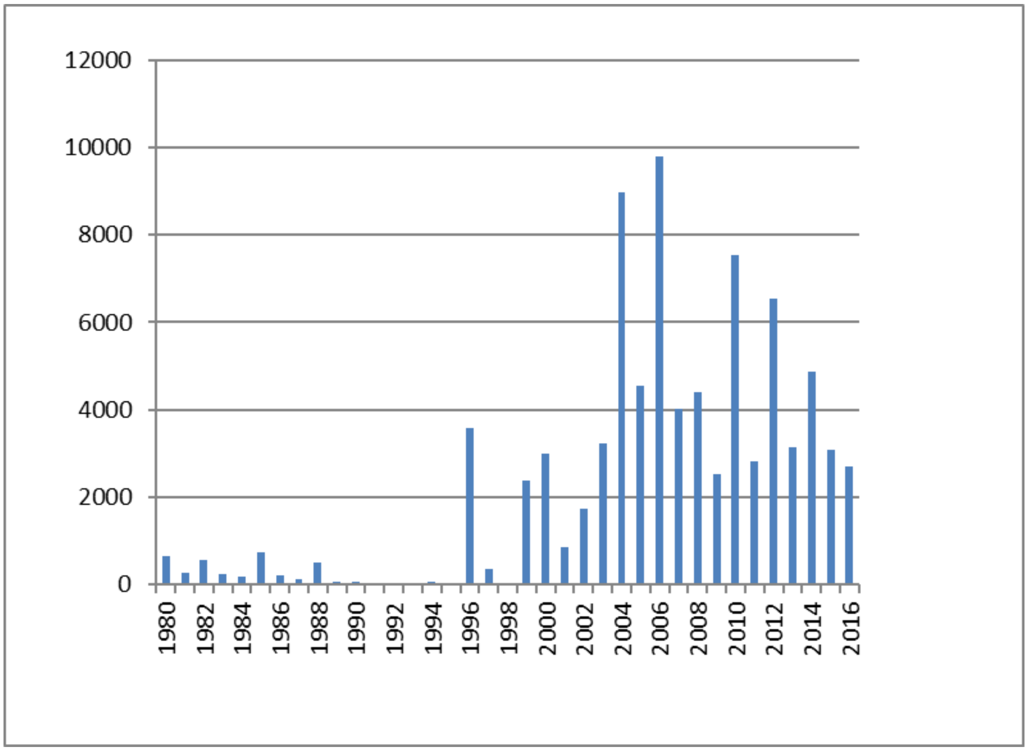

Figure 4. Mexican purse seine catch in the EPO (ISC area) from 1980 to 2016.

The catches of bluefin for ranching are performed only with commercial purse seiners (normally searching for YFT) with a deeper purse seine net. Bluefin tunas are transferred from the purse seine net to "transfer" nets then to the enclosures and fattening nets located in northern Baja California peninsula.

There is also a US sport fishery that operates in Mexican EEZ that is reported by the US.

Effort
There were six trips devoted to PBF catch in 2015 and five during 2016.

Ranching Activities
Ranching activities started in 1996 but fully developed until 2001. Catch before 2012 (quotas implemented since that year) have been variable, making evident that oceanographic conditions and the eastern distribution of the species are limiting factors for the Mexican bluefin fishery. In 2005, 2006 an estimated 80% of the catch was transported to the ranching companies and the other 20% went to the Mexican market. In recent years, basically all PBF is used in ranching activities. This represents an economic incentive for the Mexican tuna fishery and has a regional economic impact especially in northwestern Mexico.

The size composition of the PBF catch for farming is obtained from stereoscopic cameras that are used during transfer operations. Information is available, used to estimate size composition of the catch and shared with ISC as well as IATTC.

2.2 Albacore (*T. alalunga*)

The related Mexican information for this fishery has been reported constantly to ISC and IATTC. Catches are limited to a small area in northern Mexico. Table 4 shows the total catch reported for Mexico from 1980 to 2016. The main component of albacore catch in Mexican waters comes from US sport fishery (and reported by the US).

Table 4. Mexican albacore tuna catches from 2010-2016 (*2016 data is preliminary)

YEAR	MEXICAN CATCH
2010	25
2011	0
2012	0
2013	0
2014	0
2015	0
2016	0

Management

Management of the tuna fishery is done within the framework of the IATTC. In recent years a 62 day closure is applied for Mexican purse seiners from November 18 to January 18 the following year as a conservation measure for tropical tunas (for 2017 a quota was stablished for dolphin and log sets), and a quota has been implemented for PBF since 2011. The catch of PBF is closely monitored by 100% scientific observer's coverage on board all the fishing activities (both a national and IATTC observer programs). All information is reported and shared weekly and based on the quota and catch amount information is reported daily to ensure a quick response from managers and timing of the closure season.

Research

Since 1998 the INAPESCA and the PNAAPD have also organized an annual scientific meeting in Mexico to review the research activities developed by Mexican and other scientists. These studies are related with tunas, large pelagic and other oceanic species. Available information of those scientific meetings could be obtained directly from the authors listed in the journal "El Vigia" of the PNAAPD (see www.fidemar.org) that lists the abstracts every year, or from the INP-PNAAPD sources. That information is not a complete list of all research performed in Mexico related to those fishes and fisheries.

Mexico is participating in Close Kin sampling program. We started sampling this year but samples are from 2016 fishing. We will start collecting samples from 2017 also probably in August.

3. SHARKS

México participated in two principal activities in the Shark Working Group (SHARKWG) during 2016-2017: 1) the stock assessment of the blue shark, *Prionace glauca*, from northern Pacific during 2016-2017 and 2) the collaborative research to develop a growth curve for the shortfin mako, *Isurus oxyrinchus* from northern Pacific Ocean. For the new blue shark stock assessment Mexico submitted to working papers to the data preparative workshop hold in Busan, South Korea in November 2016 and additional paper for the final stock assessment workshop realized in La Jolla, US, in March 2017.

3.1 Blue shark stock assessment

Blue shark catches estimations for the Mexican Pacific (1976-2015)

For the stock assessment Mexico provided information on blue shark total catches by year from period 1975-2015 (Sosa-Nishizaki et al. 2016). For the period of 1975 to 2006 estimations assume that blue shark has been represented in Mexican total catches with different proportions through time. And the values of the proportions were obtained from published papers in the scientific literature or by using more detailed local statistics. In Mexico, blue sharks are caught mainly by the artisanal and middle size long-line fisheries, which target pelagic sharks or swordfish. Catches that were landed in the past by the former large size vessel long-line fisheries and the drift gill net fisheries were taken into consideration to construct the historical series. For the period of 2006-2014 we used official statistics that report specifically blue shark catches. Historically, blue shark was not an important species in past catches; however, catches have increase from levels of less than 500 t in the 1970s to around 1,000 in the 1990s, and to around 4,000 t in the second half of the 2000s, reaching the highest catch reported in 2014 (5,500 t). Estimates indicate that blue sharks are caught mainly in the western coast of the Peninsula of Baja California, and recent years off of the Revillagigedo Islands.

Spatial dynamics of blue shark stock structure

The Shark WG conducted an analysis on the spatial dynamics of blue shark size and sex, both overall for understanding stock structure and by fleet for understanding fleet dynamics and gear selectivity. Mexico provided size and sex of 23,665 blue sharks georeferenced for the analysis. That information was obtained from the Mexican shark observed program operating on board of the Ensenada longline fleet from period 2006-2015. Results of the study (Sippel et al. 2016) indicated that blue shark juveniles dominated the Mexican catches along the west coast of the Baja California Peninsula.

Standardized catch rates for blue shark in the Mexican Pacific longline

Abundance indices for blue shark in the northwest Mexican Pacific for the period 2006-2015 were estimated using data obtained through a pelagic longline observer program (Fernandez-Mendez, et al. 2016). Individual longline set catch per unit effort data, collected by scientific observers, were analyzed to assess effects of environmental factors such as sea surface temperature, distance to the nearest point on the continental coast and time-area factors. Standardized catch rates were estimated by applying generalized linear models (GLMs). Sea surface temperature, distance to the coast, year, area fished and quarter were all significant factors included in the model. The results of this analysis show a descending trend in the last years in the standardized abundance index in the period considered. This trend could be explained in terms of recent oceanographic events like the warm Blob of 2013-2015. During the final blue shark stock assessment workshop, Mexican scientists provided to the Shark WG more specific oceanographic evidences on the extraordinary ocean warm conditions experienced in 2014-2015 along the west coast of the northern Mexican Pacific that could affect the distribution and abundance of blue sharks. Additionally during La Jolla workshop was presented an informative paper (Castillo-Geniz et al. 2017) which provided detailed information on the size and sex structure of the blue shark catches observed in the two largest shark longline fleets which operate in the Mexican Pacifico: Ensenada and Mazatlán.

3.2 Shortfin mako

Shortfin mako shark ageing

The vertebrae of shortfin mako sharks (*Isurus oxyrinchus*), collected by several Mexican research institutions (INAPESCA, CICIMAR and FACIMAR-UAS) in the Mexican Pacific Economic Exclusive Zone during 2008–2016, were used to estimate the age composition of catches. Additionally, whole vertebrae processed previously with silver nitrate by Ribot-Carballal *et al.* (2005) were re-analyzed. Providing age estimations of catches is one of the compromises of the Mexican ISC shark delegation to undertake the stock assessment of the species in the North Pacific.
All vertebrae were sectioned and growth bands observed in a microscopic with transmitted light. The precision of growth band counts from a single (intra-reader) and different readers (inter-reader) was estimated with the average percent error (APE) and coefficient of variation (CV), whereas bias was estimated with a test of symmetry and age-bias plots. Information from the age validation studies of Wells *et al.* (2013) and Kinney *et al.* (2016) for juveniles and one adult male in the Northeast Pacific, was considered to estimate age of each shark (two pairs of bands per year for the first ten years of life).

A total of 256 vertebrae were analyzed (147 collected during 2008–2016 and 109 from Ribot-Carballal *et al.* 2005). Female sharks (n= 130) ranged from 65–302 cm of total length (TL) and males (n=126) from 64–267 cm of TL. The precision of growth band counts was acceptable, whole vertebrae produced slightly more precise counts (APE= 2.66/5.77, CV= 3.70/ 8.16) than sectioned vertebrae (APE= 5.02/7.1, CV= 7.11/ 10.1) for intra and inter-reader comparison, respectively. The observed ages ranged from 0–14 years, being 0–3 years age classes the most abundant. The maximum estimated age was 14 years for a female of 302 cm TL, whereas for males was 11 years for an organism of 267 cm TL.

Collaborative work on age and growth of shortfin mako between Mexico, US, and Japan

A sub-sample of the vertebrae collected in Mexican waters were processed with different methods to determine if similar growth band counts could be obtained. The methods comparison included not stained sagittal sections, silver nitrate stained whole vertebrae, whole vertebrae observed with the shadowing method used by Semba et al. (2009), and sectioned vertebrae processed with X-ray as used by Wells *et al.* (2013).

X-rays of 78 vertebrae were obtained with the support of Dr. Suzanne Kohin and Michael Kinney during a research visit of Mr. José Alberto Rodríguez Madrigal, from the Fisheries Research Regional Center (CRIP) Bahía Banderas, INAPESCA, to the Southwest Fisheries Science Center, National Oceanic and Atmospheric Administration, La Jolla, California, USA, from September 26^{th} to 30^{th} 2016. Whereas 34 vertebrae were processed with the shadowing method following Dr Semba's protocol during a research visit of Mr Rodríguez Madrigal to the National Research Institute of Far Seas Fisheries (NRIFSF), Shimizu, Japan, from May 14^{th} to June 15^{th} 2017. The research visit of Mr Rodriguez Madrigal to Japan was mainly supported by the NRIFSF. During this visit the ageing criteria applied by Japanese and Mexican researchers to identify and count the growth bands in the vertebrae was discussed. Both research visits were very productive and successful to standardize the ageing process. Preliminary results indicate that the shadowing method produce lower growth band counts, whereas X-ray and sectioned vertebrae produce similar counts. Comparisons of growth estimations for the populations of both sides of the North Pacific Ocean are planned for the near future.

Digital images of 29 vertebrae of organisms injected with oxytetracycline and processed with X-ray were provided by the US to all the delegations of ISC to continue with the ageing standardization process among the delegations of each country. Counts of growth bands obtained by the Mexican delegation were provided before a webinar meeting on May 24^{th} 2017.the webinar was undertaken to discuss differences in counts from all the delegations. Guidance and explanations were given during the webinar by Dr Kinney when readers differ to try to bring everyone into agreement. We agreed on reread the digital images of the US OTC validated vertebra after the webinar to see if the discussion has brought each nation's readers into agreement for the counts based on a single method (i.e. the hard X-rays).

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4. BILLFISHES

Billfish retained catches in recreational fisheries of Mexico: 1990 – 2016

Fisheries on billfish in the Pacific Mexican EEZ has more than fifty years history where both, recreational and commercial fleets have gotten benefits. Origins of recreational fisheries started by 1930, when US-anglers aboard their own boats used to come to Mexican waters, mainly near Cabo San Lucas and La Paz, off the southern Baja California peninsula (Talbot and Wares 1975). As communication ways developed another sites as Guaymas, Mazatlan and Acapulco became attractive centers for anglers (mainly US citizens) who lacked private vessels and could access to the Gulf of California and the southern Mexican Pacific coast. Nowadays, most recreational fleets concentrate at the mouth of the Gulf of California, just in the proximity of the main population center of striped marlin in the eastern Pacific, whereby recreational fisheries depend to a large degree on the abundance of this species in the region. Despite the eight decades long history, it was until 90’s beginning that recreational fisheries in Mexico had a noticeable effort and catch increment (Figure 1). In the other side, commercial exploitation, started after Japanese longline fleets expanded their fishing grounds to the Eastern Pacific at the end of 50’s, around the equatorial fringe until 10° N. In 1963, the fleets expanded to the north reaching the vicinity of southern Baja California peninsula, where catches of striped marlin, as well as sailfish and swordfish, were abundant even as much as tuna catches (Kume and Schaefer, 1966; Talbot and Wares, 1975). By 70’s decade, Mexico decreed its own EEZ while a transition to Mexican fleets focused on tuna, shark and finfish occurred and billfish were an important proportion of incidental catches. In 1983, it was decreed a 50 nautical miles fringe contiguous to the coastal line, where billfish along with dolphinfish and roosterfish, were reserved for recreational fisheries. In 1984, the first commercial permits were issued for billfish in Mexico, and striped marlin composed most of the catches. In 1987, two additional exclusion areas were implemented where commercial billfish fishing was not allowed. One of them is at the mouth of the Gulf of California (which extends northward, just along the western coast of Baja California peninsula) and the other is at the Gulf of Tehuantepec (Figure 2). By 1991, billfish commercial permits were not issued anymore and those fleets focused to spearfish commercial fishing. Eventually, most of the vessels turned to shark fishing, so that billfish (other than spearfish) is only incidentally caught by these fleets since the beginning of 90’s.

Data Sources

Since 1987 INAPESCA through the Monitoring Program for Recreational Fisheries, systematically collects catch and effort records of recreational fleets operating in three sites:

Cabo San Lucas and Buenavista in Baja California Sur and Mazatlan in Sinaloa. Because we have no access to the whole fleets, total catch in each site was estimated with the next equation:

$$C_{TOT} = CPUE_{rec} \cdot \hat{f}$$

where C_{TOT} is the estimated total catch in a specific month at one particular site; $CPUE_{rec}$ is the mean catch rate of those vessels recorded during monthly sampling at each site and $\hat{f}$ is the total effort in number of trips in the same month at the same site. Effort from Cabo San Lucas, was obtained from monthly records of the Port administration; when these records were not available, $\hat{f}$ was estimated with the mean number of daily trips recorded during sampling and multiplied by the number of days the port was open for fishing after Port reports. Effort from Buenavista, was estimated as the mean number of daily trips after fleets' reports, multiplied by the number of days the port was open for fishing. Effort data from Mazatlán were used directly after fleets' reports.

Estimated Retained Catches

Historical records (1990 – 2016) of recreational fleets operating around the mouth of the Gulf of California indicate multispecies composition of catches and billfish are an important proportion of them, about 22% in number of organisms (Figure 3). Six species account for 90% of catches, two of them are billfish: striped marlin (*Kajikia audax*) (17%) and sailfish (*Istiophorus platypterus*) (~ 4%). The other four are: common dolphinfish (*Coryphaena hippurus*) (~ 35%), yellowfin tuna (*Thunnus albacares*) (29%), Pacific sierra (*Scomberomorus sierra*) (~ 5%) and roosterfish (*Nematistius pectoralis*) (1%). Other tunids such as skipjacks and bonitas (*Katsuwonus pelamis, Euthynus lineatus y Sarda spp.*) (~ 4%) and blue marlin (*Makaira mazara*) (1%) account for aditional 5%. Other species such as wahoo (*Acanthocybium solandri*), yellowtail amberjack (*Seriola lalandi*), along with a variety of sharks and demersal fish (snapper, grouper and bass) contribute with about 3% while other billfish such as black marlin (*Makaira indica*), swordfish (*Xiphias gladius*) and shortbill spearfish (*Tetrapturus angustirostris*) represent less than 0.1% of the catch.

This species composition figure is based on total catch, which takes into account both catch-retained individuals (landed at harbor) and catch-released individuals. Catch and release practice in recreational fisheries is of paramount importance for billfish because it represent most of the catch records. Catch and release proportion is variable depending on the year and the species. On average the highest proportion of catch and release is found in striped marlin (~ 82%), followed by sailfish (~ 78%), blue marlin (~ 62%), black marlin (~ 51%) and swordfish (~ 33%). It should be considered, however, that little is known about survival of released individuals. The paper of Domier *et al*. (2003) is the only known document which reports an estimated survival rate of 74 – 91% for striped marlin. These results indicate that even in released individuals there is a marginal mortality, which must be added to retained catches for population variability analysis. Under this context, table 1 shows the retained catch (and landed) during 1990 – 2016.

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Table 1. Annual effort and retained catch by species in recreational fisheries from the mouth of the Gulf of California región (Cabo San Lucas, Buenavista y Mazatlán)

		No. of individuals				
Year	**Effort (trips)**	**Striped Marlin**	**Blue Marlin**	**Sailfish**	**Black Marlin**	**Swordfish**
1990	31,514	2,649	492	7,734	7	68
1991	35,334	3,097	442	6,953	10	34
1992	30,023	1,809	946	4,212	13	1
1993	29,243	2,014	687	3,596	20	1
1994	29,227	2,154	478	3,109	14	20
1995	25,306	2,452	336	2,620	7	5
1996	29,048	5,735	792	4,674	22	18
1997	32,625	4,525	512	3,532	31	99
1998	34,932	5,450	1,126	3,710	39	39
1999	40,042	4,269	987	3,797	32	54
2000	41,844	5,368	965	3,480	39	65
2001	38,034	3,489	689	2,227	17	39
2002	44,355	3,769	709	1,934	8	5
2003	47,634	4,335	514	2,543	32	7
2004	48,863	4,948	473	2,312	22	31
2005	56,767	7,646	628	2,310	16	32
2006	55,975	6,456	706	1,334	32	12
2007	55,453	7,896	393	1,032	12	13
2008	50,128	4,654	285	1,268	9	10
2009	43,309	3,827	316	761	9	6
2010	39,817	2,717	217	533	13	9
2011	38,310	3,365	302	316	14	4
2012	38,540	2,323	221	508	5	24
2013	39,469	11,102	297	1,677	9	4
2014	37,172	4,634	419	566	27	0
2015	36,879	6,008	645	1,082	12	-
2016	35,072	3,720	515	126	18	-

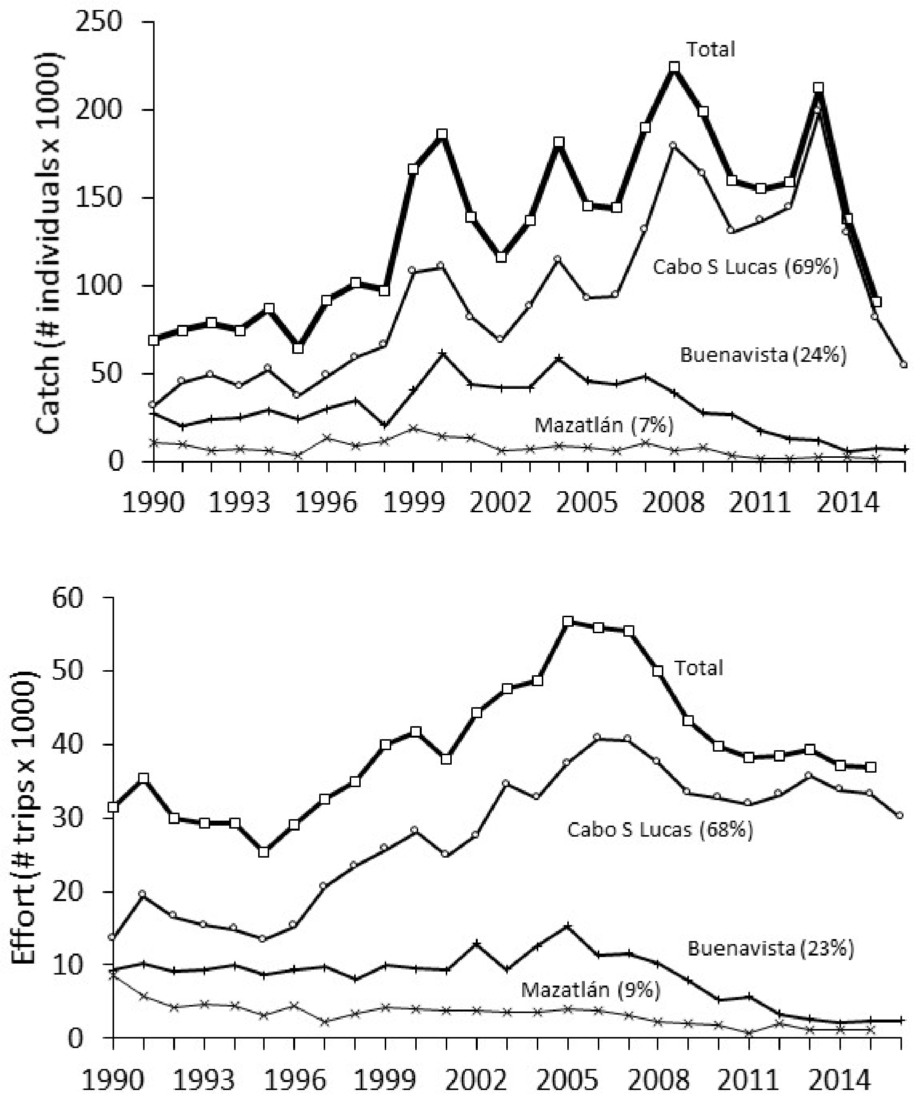

Figure 1. Total catch (retained + released) and effort of recreational fleets in the mouth of the Gulf of California: 1990 – 2016.

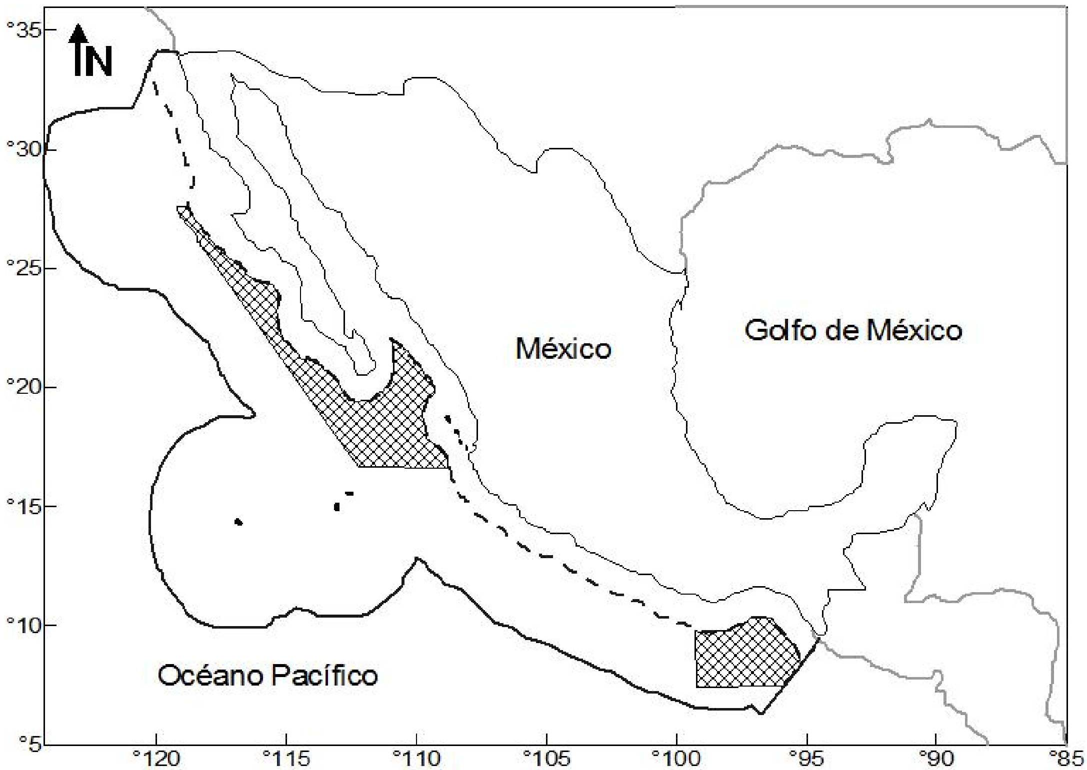

Figure 2. Exclusion zones of commercial billfish fishing. Dashed line represents the 50 nm fringe where billfish along with dolphinfish and roosterfish, are reserved for recreational fisheries. Grid areas represent exclusion zones of commercial fleets focused on billfish after 1987 Agreement (Diario Oficial de la Federación, 28 August 1987). Continuous line points out the limit of Mexican EEZ.

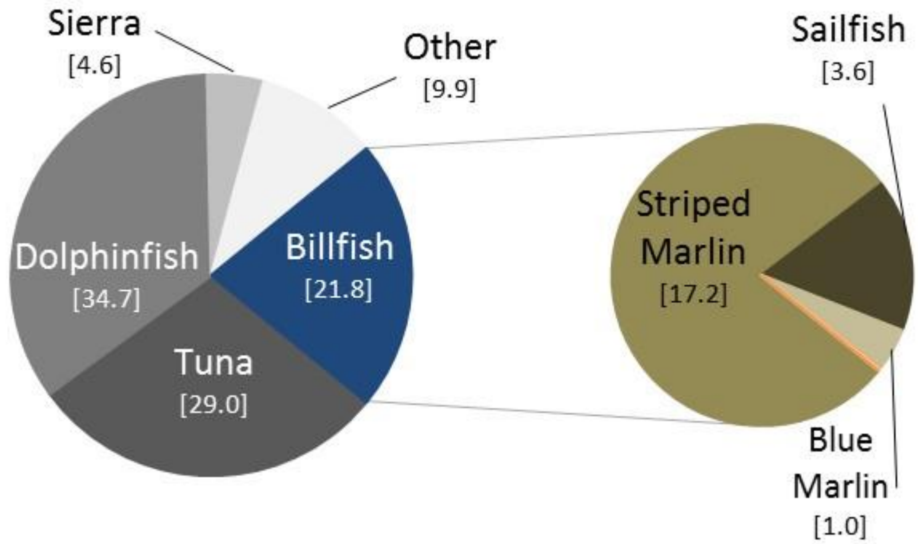

Figure 3. Historical species composition (1990-2016) of recreational fisheries catches at the mouth of the Gulf of California (Cabo San Lucas, Buenavista and Mazatlan).