Estimation of catches of sandbar (*Carcharhinus plumbeus*) and blacktip (*C. limbatus*) sharks in the Mexican fisheries of Gulf of Mexico (SEDAR 11-DW-06)

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SEDAR29-RD-04

SB-02-3

LCS-DW-06

DRAFT DO NOT CITE

Estimation of catches of sandbar (*Carcharhinus plumbeus*) and blacktip (*C. limbatus*) sharks in the Mexican fisheries of the Gulf of Mexico

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ABSTRACT

Stock assessment requires a complete account of all sources of mortality from the stock being analyzed. In the case of the shark fisheries of the east coast of the USA, the current assumption is that many of the stocks of large coastal sharks are shared between Mexican and US waters. In this paper we present the best possible estimation of the Mexican catches of the two main species caught in the large coastal shark fisheries of the USA, namely the sandbar and the blacktip sharks. The method used to arrive to the best possible estimates is as follows. The total catches (live weight in tonnes) of cazón (small sharks of less than 1.5 m TL) and 'large sharks' in the Mexican fisheries of the Gulf of Mexico were obtained from the official statistical yearbooks of the Mexican Government (Anuarios Estadísticos de Pesca). These data are available only for the period 1976-2000. Additional data on shark catches (live weight in tonnes) for the period 1962-1975 were obtained from the corresponding statistics published by FAO. By comparing a short time-series of Mexican statistics and FAO statistics from an overlapping period, it was possible to identify the data corresponding to 'small sharks' and 'large sharks' in the FAO statistics. Because Mexican catches of sharks are not reported by species, the contribution in weight of sandbar and blacktip sharks to the Mexican shark catches from each administrative entity (State) were estimated based on a careful and detailed analysis of available Mexican studies on the shark fisheries of the Gulf of Mexico. The proportion factors thus derived were applied to the historical statistics from each State to estimate the catches of each species for each State. These figures were transformed into estimates of total numbers caught for each species in each State using average weights for each species determined from the available studies. The constraints of information on the species composition in the Mexican fisheries and the weaknesses of the assumptions that had to be made to arrive to our estimates are discussed.

INTRODUCTION

In fisheries stock assessment, having complete information on the total removals (catches) from a population is critical for obtaining adequate estimates of the initial population size and productivity of the stock, and by extension for deriving more accurate estimates of management measures such as total allowable catches (TACs). Using underestimated total catches in stock assessment models will tend to provide underestimated virgin stock sizes and underestimated stock productivity (for a given stock abundance trend) while overestimated total catches (a less common phenomenon in most practical situations) will tend to give overestimated virgin stock sizes and overestimated stock productivity. Consequently, inaccuracies in total catch data can also lead to overestimated or underestimated TACs.

The two most important species in the US Atlantic shark fishery, sandbar (*Carcharhinus plumbeus*) and blacktip (*C. limbatus*) sharks are widely distributed sharks that are taken also in the commercial fisheries of neighboring Mexico. Both species are known to move between US and Mexican waters (Kohler et al. 1998) although our knowledge of the most important details about these movements (proportion of the stock moving,

frequency of the migration, rates of movement, exact timing and extent of the migration, number and origin of stocks involved in the movements, etc.) remains from sketchy to unknown. Nevertheless, the available evidence suggests that there is only one single stock of sandbar sharks in the NW Atlantic (Heist et al. 1995) while blacktip sharks might belong to one or several discrete management units along the NW Atlantic.

The present paper constructs estimates of the historical catches of sandbar and blacktip sharks in the Mexican fisheries of the Gulf of Mexico based on the best available information. Data sources employed include official Mexican catch statistics, Food and Agriculture Organization of the United Nations (FAO) catch statistics, and several Mexican research papers on the various artisanal fisheries in the Gulf of Mexico.

This paper does not address the issue of (stock) management unit delineation and its consequent influence on how much of the estimated Mexican catches should be incorporated into the US stock assessment process for each of the species. This will probably be done during the 2002 SEW meeting when the different hypotheses about the possible management units is discussed among all participants. It is also important to stress that the present estimates hold no official validity and are only the best estimates the authors could produce with the limited information available to them. They should therefore be used with caution for any stock assessment purpose.

BACKGROUND

Mexican shark fisheries are characterized by the following traits (Bonfil et al, 1990; Bonfil 1997; Castillo et al. 1998): shark fishing has been a traditional fishery in the southern Gulf of Mexico since at least the early 1930s although official statistics published by the Mexican government are only available from 1976 onwards; alternative statistics for the period 1962 onwards are available through the Food and Agriculture Organization of the United Nations (FAO); most of the catch is taken with small-scale vessels and various types of gears that depend on the usages of each region (usually each administrative entity, know as State), thus the species composition of the catches varies along the Mexican shore; catch statistics are only broken down into two categories, as 'small sharks' (cazón: sharks of less than 1.5 m total length [TL]) and 'large sharks' (tiburón, all sharks larger than 1.5 m TL).

METHODS

General Approach

With very few exceptions worldwide, catches in fishery statistics are reported in terms of biomass (usually tonnes). Therefore our approach was to estimate the tonnage of sandbar and blacktip sharks in the catches of Mexico based on the tonnages of unidentified sharks reported by official sources and estimates of species composition of the catch in weight. These were then converted into numbers of sharks using estimated average weights for

each species and locality. The estimations were performed on a State by State basis whenever possible because the sizes of blacktip and sandbar sharks caught in each region is known to vary due to gear selectivity and spatial segregation of the different life-stages of each species. This method provides a finer-detail in the estimates of shark numbers.

The estimation of Mexican catches of sandbar and blacktip sharks follows a three step approach. First, we put together a historical time-series of catches of 'small sharks' and 'large sharks' for each State in the Mexican coast of the Gulf of Mexico that went back in time as far as allowed by the data (1962). Secondly, we collated and reviewed all available reports of species composition of the shark catches for the different States. Whenever information on species composition in weight was available this was used. Otherwise composition by numbers was converted into composition by weight. This was achieved by transforming length frequency data (preferably and whenever available) to weight with the use of length-weight equations for each species and then recalculating the contributions of each species to the overall reported sample in terms of weight. Otherwise, average length for each species was used to estimate the corresponding weight for each species and this was multiplied by the numbers of that species in the sample to approximate the species composition in weight. Finally, once we arrived to the best possible estimate of species composition in weight for each State or region, this number was applied to the corresponding time-series of official catch statistics to obtain estimates of the catch in weight of sandbar and blacktip sharks in each State. The assumptions are that the species composition calculated this way from the available data is representative of the true composition in weight of the fishery catches and -more daring- that the species composition in weight has not changed over the period of study.

Blacktip sharks are caught mostly as juveniles in most States (Hernández, 1987; Marín, 1992; Rodríguez et al. 1996; Bonfil, 1997; Castillo et al. 1998) although a few large specimens are caught in some areas. Whenever information was available to estimate the amount of small and large (cut-off = 1.5 m TL) blacktips in the catch, this was used to calculate the amounts of this species caught from the reported 'small sharks' and 'large sharks' statistics. However this was possible only for Tabasco and Campeche due to data limitations. For the other States, all the blacktip catches were derived from the 'small shark' statistics.

For sandbar sharks, the available information (Hernández, 1987; Marín, 1992; Rodríguez et al. 1996; Bonfil, 1997) indicates that virtually the entire catch taken in Mexican waters consists of large juveniles over 1.5 m TL and adults. Therefore all the calculations were based on the 'large shark' fishery statistics. Furthermore, with the exception of reports of trace numbers of sandbar sharks in the landings of Tabasco and Campeche from Rodríguez et al. (1996), all other reports (Uribe, 1984; Seca and Murillo, 1985; Hernández, 1987; Bonfil 1997) indicate that this species is absent from the landings in Tabasco and Campeche. Therefore sandbar shark catch estimates were based only on fishery statistics for Tamaulipas, Veracruz and Yucatan.

Data sources

Official data on catches of 'small sharks' and 'large sharks' in each State in the Mexican east coast for the period 1976-2000 were obtained directly from the statistical yearbooks of the Mexican Government (Anuarios Estadísticos de Pesca). Additional data on shark catches in Mexican waters of the Gulf of Mexico for the period 1962-1975 were obtained from statistics published by the Food and Agriculture Organization of the United Nations (FAO) through its FishStat online database for fishery production.

Estimates of species composition in weight or in number of fish, as well as average size of weight of each species were obtained from the following sources: for Tamaulipas and Veracruz, Marín (1992), Rodríguez et al. (1996), and Castillo et al. (1998); for Tabasco and Campeche, Hernández (1987), and Rodríguez et al. (1996), for Yucatan, Bonfil et al. (1990) and Bonfil (1997); and for Quintana Roo, Bonfil (1997). Equations for converting length to weight or for converting one type of length to another (for cases where the length-weight relationship was not for TL) were selected from the published literature choosing always equations based on data from the region of interest or if from other regions, equations based on the largest amount of data points; the particular sources for each case are detailed in the corresponding tables. In a few cases also detailed in the tables, unpublished equations calculated by the senior author from a database of the Yucatan fishery were used for converting between different lengths. In a few difficult cases, similar equations available through FishBase (www.fishbase.org) were used.

RESULTS

Estimation of historical catches of 'small sharks' and 'large sharks' by State

Catches of 'small sharks' and 'large sharks' for each State in the east coast of Mexico obtained from the statistical yearbooks of the Mexican Government for the period 1976-2000 are shown on Table 1. Data on this table for the period 1962-1975 were estimated using the corresponding data published by FAO for the east coast of Mexico (Table 2). A direct comparison between the FAO data and data from the Mexican statistical yearbooks for the late 1970s revealed that what FAO reports as 'requiem sharks' corresponds exactly with Mexican reports of 'small sharks', while FAO's 'sharks, skates and rays' statistics correspond with the Mexican statistics for 'large sharks'.

The average contribution of each State to the total catch of 'small sharks' and 'large sharks' in Mexican statistics for the period 1976-2000 was used to obtain factors with which to split the FAO statistics of 'small sharks' and 'large sharks' into estimates of catches in each State for the period 1962-1975. This assumes that the average contribution of each State to the total landings of each category for 1976-2000 is representative of the catch of each State in the period 1962-1975.

Estimation of species composition in weight for Tamaulipas and Veracruz

There are two sources of information about the shark fisheries of Tamaulipas and Veracruz. Marín (1992) carried out a 3-year and 4 months study of the landings where he sampled a total of 1344 sharks. His study provides information on species composition in numbers in addition to average length and in fewer cases average weight for some of the species. On the other hand, Rodríguez et al. (1996) performed an intensive one-year study of the entire coast of the Mexican Gulf of Mexico. They sampled nearly 12,000 sharks in these two States, but provide information on the average sizes of only the 8 main species (including blacktip sharks but not sandbar sharks).

Data from both studies were used to estimate the species composition in weight for Tamaulipas and Veracruz. Table 3 presents the estimation of species composition in weight for 'large sharks' and Table 4 the estimation for 'small sharks'. Only species reported by Marín (1992) and Rodríguez et al. (1996) as having average lengths greater than 1.5 m TL in their samples of the fisheries were considered as part of the 'large shark' group for the estimation (with the exception of *Sphyrna mokarran* which had an average TL of 148.6 cm but was still considered as part of the 'large sharks' group. This follows as personal experience of the authors indicates that even only a few large individuals of this species would contribute disproportionally to the total weight of this species, thus it was thought more appropriate to discount this species from the 'large shark' category).

With the exception of the bull shark *Carcharhinus leucas*, Rodriguez et al. (1996) do not provide average sizes for any other large sharks. As they reported average sizes of 227.4 and 173.3 cm TL for the bull shark in Tamaulipas and Veracruz respectively while Marín (1992) reported 207.2 cm TL for this species in both localities, the latter value was considered representative and was used in the calculations for this species. Average lengths for five species in Table 3 were not available from the original data. Instead we used the average weights of closely related species (see table for details). After calculating the weight corresponding to the average length reported for each species this value was multiplied by the sum of the numbers of the corresponding species in the sample of Marín (1992) plus the numbers reported by Rodríguez et al. (1996; table 10) as caught in the fishery. In this way we arrived to an estimate of the species composition in weight. Overall, the contribution of sandbar sharks to the total catch in weight for 'large sharks' in the catches of Tamaulipas and Veracruz was estimated as 7.3%.

For the estimate of species composition in weight of the 'small sharks' in Tamaulipas an Veracruz (Table 4), Marín (1993) gives data on average TL or average weight for most species from samples taken in both States and pooled together. In addition there were additional data on average TL for most of the species separately for Tamaulipas and Veracruz from Rodríguez et al. (1996). Thus it was possible to calculate estimated species composition in weight separately for Tamaulipas and Veracruz based on the data of Rodriguez et al. (1996) and for both States pooled together from all the data of Marín (1992) and Rodriguez et al. (1996) pooled together. The corresponding estimates of percentage contribution in weight of blacktip sharks to the total catch of 'small sharks' was 57.4% for Tamaulipas, 59% for Veracruz, and 59.9 % for both localities pooled

together. For the rest of the calculations, the estimated values for each separate State were used.

Estimation of species composition in weight for Tabasco and Campeche

The fishing grounds of Tabasco overlap with those of Campeche by at least 50% and the species caught in both localities are roughly the same. (Rodriguez et al. 1986; Fig. 72 and Tab. 10). Because the study of Hernández (1987) provides detailed information on the length frequency of all the species in the catch, his study was chosen as the basis of the analysis in Tabasco and Campeche. This allowed not only for more accurate estimation of the species composition of the catch in weight but also allowed proper breakdown of the catch of each species into the 'small shark' and 'large shark' categories.

Table 5 shows the original length frequency data of Hernández (1987) with the parameters of the L-W relationships used for each species at the bottom. Table 6 presents the estimated mean weights for each size class and species based on the corresponding L-W relationship. Table 7 shows the estimated total weight of each size class and species, i.e. the product of Tables 5 and 6. Finally, Table 8 gives the estimated proportion by weight of each species in the catches of 'small sharks' and 'large sharks'. According to this, the blacktip shark represents 12.3% and 18.1% of the catch in weight for 'small sharks' and 'large sharks' respectively in the catches of Tabasco and Campeche.

Estimation of species composition in weight for Yucatan

Bonfil et al. (1990) provide direct estimates of the species composition in weight of the catches of 'large sharks' and 'small sharks' for the State of Yucatan. Sandbar sharks represent 7% of the catch of 'large sharks' in weight, while blacktip sharks represent less than 1.2% of the catch of 'small sharks'. These two values were used in the corresponding calculations.

Estimates of time series of total weight and total numbers of sandbar sharks in Mexican fisheries

Table 9 present the estimated historical catches in tonnes of sandbar sharks for each State in Mexican waters of the Gulf of Mexico. The estimated total numbers of sandbar sharks caught in each State since 1964 are presented in Table 10. Overall, the estimated take of sandbar sharks in Mexican fisheries during the 1990s ranges approximately between 7,000 and 11,000 fish per year.

Estimates of time series of total weight and total numbers of blacktip sharks in Mexican fisheries

The estimated catches in tonnes of small blacktip sharks in each State are shown in Table 11 while Table 12 presents the corresponding estimates for numbers of fish. Similar data for large blacktip sharks are presented in Tables 13 and 14. The total estimated number of blacktip sharks (small and large) caught in Mexican fisheries ranges between approximately 110,000 and 280,000 fish per year.

DISCUSSION

The present estimates of historical catches of blacktip sharks in Mexican waters are much higher than previously thought (NOAA 1998). Two factors account for this, first that while we present estimates considering all the States of the Gulf of Mexico coast of Mexico, the SEW report of 1998 based its estimates only in the fishery statistics of Tamaulipas and Veracruz. The discussion of which Mexican-caught blacktips should be considered in the US stock assessment is beyond the scope of this paper but even considering only our estimates for Tamaulipas and Veracruz our numbers are at least double of what was estimated during the SEW of 1998. The second factor to be taken into account is that the average lengths used for our estimates of blacktip sharks in Tamaulipas and Veracruz are probably overestimates of the mean size of 'small' blacktips in those States. This is due to the inclusion of an unknown number of blacktip sharks larger than 1.5 m TL in the mean size calculations. This was inevitable due to the lack of detailed information on the size frequencies for blacktip sharks from these two States in the original studies (Marín, 1992 and Rodríguez et al. 1996). Length frequency information would have allowed us to split the catches into 'small' and 'large' blacktip sharks and arrive to better estimates of the mean weights of blacktip sharks in each category. This would have decreased the proportion of blacktip sharks in the 'small shark' category while increasing only slightly the proportion of blacktip sharks in the 'large shark' category. Given that Tamaulipas and Veracruz both report very large catches of 'small sharks' the overall effect of these two things combined might have somehow inflated our final estimates of total blacktip numbers. However, it is also likely that if the blacktip contribution to the 'large shark' category for these States could be calculated, the total numbers would be still larger than previously estimated. Redoing the present analysis with the original data from Marín (1992) and Rodríguez et al. (1996) should be pursued in order to obtain more accurate estimates of the real numbers of blacktip sharks caught in Mexican fisheries.

Although we tried to obtain the best possible estimates, several constraints in available information precluded more reliable results. Our usage of average weights mostly derived from average lengths could be biasing the results either positively or negatively. Also, our assumption that the contribution of each species to the total catch has remained constant for nearly 40 years is very unlikely.

Gaining access to the original raw data from some of the studies used here as baseline information could yield much better estimates of the contribution in weight of each species to the catch of 'small sharks' and 'large sharks' in each State. This might in fact be feasible in the future through collaborations with Mexican researchers.

ACKNOWLEDGEMENTS

Leonardo Castillo (Instituto Nacional de la Pesca) kindly offered valuable information and useful discussions about the original data, and together with Sonia Soriano (Instituto Nacional de la Pesca) provided some of the Mexican catch statistics.

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Table 1 MEXICAN CATCHES GULF OF MEXICO (from Mexican yearly statistical books except where stated otherwise)

All data in tonnes

	CAZON (small sharks)							TIBURON (large sharks)						
	Tamaulipas	**Veracruz**	**Tabasco**	**Campeche**	**Yucatán**	**Quintana Roo**	**Total**	**Tamaulipas**	**Veracruz**	**Tabasco**	**Campeche**	**Yucatan**	**Quintana Roo**	**Total**
1962	*644*	*504*	*200*	*510*	*115*	*27*	**2000**	*0*	*0*	*0*	*0*	*0*	*0*	**0**
1963	*580*	*454*	*180*	*459*	*103*	*24*	**1600**	*0*	*0*	*0*	*0*	*0*	*0*	**0**
1964	*838*	*656*	*259*	*663*	*149*	*35*	**2600**	*10*	*31*	*6*	*24*	*25*	*4*	**100**
1965	*967*	*757*	*299*	*765*	*172*	*41*	**3000**	*10*	*31*	*6*	*24*	*25*	*4*	**100**
1966	*838*	*656*	*259*	*663*	*149*	*35*	**2600**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1967	*967*	*757*	*299*	*765*	*172*	*41*	**3000**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1968	*967*	*757*	*299*	*765*	*172*	*41*	**3000**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1969	*902*	*706*	*279*	*714*	*161*	*38*	**2800**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1970	*258*	*202*	*80*	*204*	*46*	*11*	**800**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1971	*258*	*202*	*80*	*204*	*46*	*11*	**800**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1972	*322*	*252*	*100*	*255*	*57*	*14*	**1000**	*20*	*63*	*12*	*47*	*51*	*8*	**200**
1973	*515*	*403*	*160*	*408*	*92*	*22*	**1600**	*98*	*314*	*58*	*235*	*253*	*42*	**1000**
1974	*450*	*352*	*139*	*356*	*80*	*19*	**1396**	*176*	*563*	*103*	*422*	*454*	*75*	**1793**
1975	*445*	*348*	*138*	*352*	*79*	*19*	**1381**	*159*	*510*	*94*	*382*	*411*	*68*	**1623**
1976	266	474	169	627	172	39	**1747**	75	234	92	468	213	200	**1282**
1977	575	654	189	544	154	32	**2146**	155	190	358	817	251	63	**1834**
1978	439	358	204	377	94	26	**1498**	133	667	309	1037	369	81	**2596**
1979	733	627	228	429	61	24	**2102**	203	738	193	640	121	55	**1950**
1980	889	706	274	491	160	49	**2569**	371	1351	182	391	277	75	**2647**
1981	2486	1036	407	441	91	80	**4541**	703	3676	181	758	679	215	**6212**
1982	1044	1309	392	847	154	83	**3829**	286	3461	148	706	1939	248	**6788**
1983	1019	1493	311	2013	212	65	**5113**	423	2719	374	1741	2139	320	**7716**
1984	1291	2433	500	2005	62	79	**6370**	466	3133	397	1839	2012	403	**8250**
1985	1479	1144	442	1582	96	84	**4827**	378	1239	414	1249	2025	487	**5792**
1986	1382	991	438	1174	173	57	**4215**	372	1935	812	1754	2078	301	**7252**
1987	1583	777	467	1390	165	41	**4423**	494	1425	669	2671	1377	215	**6851**
1988	1744	838	477	1363	140	54	**4616**	631	2283	372	2573	1486	223	**7568**
1989	1917	1254	410	1128	156	59	**4924**	573	1617	252	1400	1741	244	**5827**
1990	2352	1254	667	1209	475	78	**6035**	666	1823	380	2022	2509	366	**7766**
1991	1692	1137	802	1003	363	63	**5060**	551	1670	400	1802	2019	224	**6666**
1992	1907	1135	678	2414	322	62	**6518**	622	1823	482	2163	2095	273	**7458**
1993	2154	1464	571	1745	428	64	**6426**	593	1731	326	1785	1942	297	**6674**
1994	2052	1266	489	1273	288	56	**5424**	707	1685	438	1808	1752	241	**6631**
1995	1655	1162	449	1115	298	60	**4739**	1136	1683	325	1543	1881	244	**6812**
1996	1775	1355	515	1066	392	72	**5175**	1044	2047	328	1637	2014	258	**7328**
1997	825	1739	331	489	358	42	**3784**	697	2381	148	615	1023	131	**4995**
1998	1229	972	421	821	492	56	**3991**	981	1519	136	641	1006	170	**4453**
1999	882	736	419	738	426	78	**3279**	784	1414	188	483	1578	295	**4742**
2000	928	532	372	851	382	42	**3107**	729	1652	199	519	1037	234	**4370**
AVG tonnes 76-00	1372	1074	425	1085	245	58		551	1764	324	1322	1423	235	
AVG %	0.322	0.252	0.100	0.255	0.057	0.014		0.098	0.314	0.058	0.235	0.253	0.042	

Above numbers in Italics (1962-1975) are estimated catches by state based on FAO total catches for Mexican Gulf and the AVG % contribution of each state to the total for the period 1976-2000

Table 2 FAO FISHSTAT statistics for sharks skate and rays, landed in the Atlantic coast of Mexico

	requiem sharks	sharks, skates and rays
1962	2000	
1963	1800	
1964	2600	100
1965	3000	100
1966	2600	200
1967	3000	200
1968	3000	200
1969	2800	200
1970	800	200
1971	800	200
1972	1000	200
1973	1600	1000
1974	1396	1793
1975	1381	1623

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Table 3. Estimation of species composition in WEIGHT for large sharks (tiburón) in Tamaulipas and Veracruz based on mean size and numbers in catch of Rodriguez et al. (1996) and Marin (1992)

Species	Avg TL from Marin (1992)	Est. weight at length	# in Tamaulipas fishery, Rodriguez et al (1996)	# in Veracruz fishery, Rodriguez et al (1996)	# both sites, Marin (1992)	total specimens Marin + Rodriguez et al	Estimated catch in weight both studies pooled (#s times avg w)	% weight contribution by species	L-W parameters a	b	L-W source
A vulpinus	376.4	123.0	0	5	1	6	738	0.003			Marin 1992
H griseus	310	166.4	0	1	1	2	333	0.002	used weight of G. cuvieri		
C obscurus	273.7	111.8	123	168	74	365	40801	0.185	4.8459E-06	3.021	Bonfil et al 1990
G cuvieri	213.8	49.9	8	58	23	89	4444	0.020	0.00141	3.24	Branstetter et al 1987
C leucas	207.2	65.5	209	691	114	1014	66386	0.301	0.000011074	2.9234	Bonfil et al 1990
G cirratum	205	50.9	1	65	7	73	3716	0.017	0.0105	2.892	Bonshack and Harper 1989
C altimus	197.7	49.6			3	3	149	0.001	0.001	3.461	Kohler et al 1995
S lewini	196.7	44.1	637	416	53	1106	48730	0.221	0.004	3.07	Hernandez 1987
C brevipinna	186.1	41.3	334	302	22	658	27175	0.123	0.0075	2.97	Branstetter 1987
C plumbeus	**184.8**	**38.0**	**17**	**276**	**134**	**427**	**16214**	**0.073**	4.9181E-07	3.4798	Bonfil et al 1990
S mokarran	148.6	14.9	102	130	31	263	3911	0.018	0.0041	3.02	Hernandez 1987
S zygaena		*44.1*	0	1		1	44	0.000	used avg weight for S lewini		
Alopias spp		*123.0*	0	1		1	123	0.001	used avg weight for A vulpinus		
A superciliosus		*123.0*	0	2		2	246	0.001	used avg weight for A vulpinus		
C longimanus		*49.6*	0	2		2	99	0.000	used avg weight for C altimus		
Carcharhinus spp		*49.6*	13	143		156	7738	0.035	used avg weight for C altimus		

Table 4. Estimation of species composition in WEIGHT for small sharks (cazón) in Tamaulipas and Veracruz based on mean size and numbers in catch of Rodriguez et al. (1996) and Marin (1992)

Species	Avg TL from Marin (1992)	Est. weight at length	Avg TL Tamps from Rodriguez	Avg TL Ver from Rodriguez	Est weight at length Tamps	Est. weight at length Ver	# in Tamaulipas Rodriguez et al (1996)	# in veracruz Rodriguez et al (1996)	# in both sites, Marin (1992)	Estimated catch in W Tamps from Rodriguez	Estimated catch in W Ver from Rodriguez	% contribution in weight Tamps	% contribution in weight Veracruz	total specimens Marin + Rodriguez et al	Estimated catch in weight both studies pooled	% contribution in weight both studies pooled	L-W a	parameters b	L-W source
C granulosus	151	24.8						3	2		74		0.001	5	124	0.001	avg W taken from author's unpub. data		
I oxyrinchus	124.8	15.1						106	14		1600		0.020	120	1811	0.016	0.00521 [1]	3.141	Kohler et al 1995
C falciformis	114	7.0	88.7	113.0	3.1	6.8	38	1098	201	113	7439	0.002	0.093	1335	9303	0.084	1.899E-06	3.1915	Bonfil et al 1990
C limbatus	110.7	8.7	**110.8**	**118.7**	**8.75**	**10.77**	**2975**	**4378**	**230**	26045	47156	**0.574**	**0.590**	**7583**	**66205**	**0.599**	0.00614	3.01	Garcia-Arteaga et al. 1997
C signatus	102	5.6						553	43		3089		0.038	596	3308	0.030	0.0029 [2]	3.247	Kohler et al 1995
M canis	98.6	2.6						165	32		433		0.005	197	517	0.005	1.1832E-06 [3]	3.1828	Bonfil et al 1990
H perlo	94.4	2.3						45	1		103		0.001	46	105	0.001	used *H nakamurai*[4]		
H nakamurai	89.6	1.9					1	66	3	2	126	0.000	0.002	70	133	0.001	0.0012 [5]	3.474	Brouard and Grandperrin 1984
C isodon	88.7	4.3					234	231	33	1006	993	0.022	0.012	498	2141	0.019	used *C acronotus*		
C acronotus	77.7	2.8	104.9	81.7	7.3	3.3	430	789	78	3123	2827	0.069	0.033	1295	3678	0.033	0.0038	3.12	Hernandez 1987
N brevirostris	78.2	2.1					2	12	1	4	25	0.000	0.000	15	31	0.000	0.0053 [6]	3.16	Claro and Garcia-Arteaga 1994
R terraenovae	70.5	1.3	91.2	71.7	2.7	1.3	5519	9993	209	14807	13354	0.327	0.167	15721	20006	0.181	5.6223E-06	2.8973	Bonfil et al 1990
S dumeril	67.2	2.2						470	20		1034		0.013	490	1078	0.010	avg W given in Marin 1992		Marin 1992
Sphyrna tiburo	58.9	0.6	87.4	67.7	2.4	1.0	73	39	3	179	40	0.004	0.001	115	74	0.001	8.9532E-07	3.3718	Bonfil et al 1990
S cubensis	53.1	0.8	0.0	53.3		0.8		1470	12		1103		0.014	1482	1112	0.010	avg W given in Marin 1992		Marin 1992
Hexanchus spp		*1.9*						7			13		0.000	7	13	0.000	used avg weight for *H. nakamurai*		
I paucus		*15.1*						9			136		0.002	9	136	0.001	used avg weight for *I oxyrinchus*		
S retifer		*0.5*						14			7		0.000	14	7	0.000	used a guess of .500 kg		
Squalus spp		*0.8*						21			17		0.000	21	17	0.000	used avg weight for *S cubensis*		
Mustelus spp		*2.6*						24			82		0.001	24	82	0.001	used avg weight for *M canis*		
M norrisi		*2.6*					23	70		60	182	0.001	0.002	93	242	0.002	used avg weight for *M canis*		
S asper		*0.8*						72			58		0.001	72	58	0.001	used avg weight for *S cubensis*		
C porosus		*2.2*		*77.5*				154			336		0.004	154	336	0.003	used avg weight from Hernandez (1987)		

1 Equation is for fork length; used FL = -1.71 + .9286 TL form Casey and Kholer 1992for conversion
2 Equation is for fork length: used FL= 0.503 + .839 TL from Kohler et al. 1995 for conversion
3 Used length-weight equation for *Mustelus norrisi*
4 Equation is for standard length: used TL= 1.47 SL for *H. perlo* from FishBase to convert
5 Equation is for standard length: used TL= 1.47 SL for *H. perlo* from FishBase to convert
6 Equation is for standard length: used SL= 0.775 TL from FishBase to convert

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Table 5. Species composition and length frequency data from Hernandez (1987) for the Campeche and Tabasco shark fishery

Midpoint TL	*Sphyrna liburo*	*Sphyrna lewini*	*Carcharhinus limbatus*	*Sphyrna mokarran*	*Carcharhinus acronotus*	*Rhizoprionodon terraenovae*	*Carcharhinus leucas*	*Carcharhinus porosus*	*Carcharhinus brevipinna*	*Ginglymostoma cirratum*	*Carcharhinus obscurus*	*Galeocerdo cuvier*
37.5	2	12				1						
52.5	5	99			11	4		12				
67.5	366	49	39	8	20	26	2	11				
82.5	625	19	38	28	29	32	1	7	7		1	
97.5	484	6	26	42	29	19	1					
112.5	41	7	2	31	15	1	1					
127.5			3	12			2	1				
142.5			24	3						1		
157.5			45	2			2					
172.5			3	2			7					
187.5		1	2	1			31			1		1
202.5		1					17			1		
217.5		2		1			4			1		
232.5		1					5			1		
247.5				1			1					
262.5				1			1					
277.5												
292.5				1								
307.5				1								
322.5				1								
337.5												
352.5												
367.5				1								
382.5				1								
397.5												
412.5												
427.5				1								
Length-weight parameters												
a	6.9532E-07	0.004	0.00614	0.0041	0.0036	5.8223E-06	0.000011074	0.0036	0.0075	0.0105	4.8459E-06	0.00141
b	3.3718	3.07	3.01	3.02	3.12	2.8973	2.9234	3.12	2.97	2.692	3.021	3.24
source	Bonfil et al 1990	Hernandez 1987	Garcia-Arteaga et al. 1997	Hernandez 1987	Hernandez 1987	Bonfil et al 1990	Bonfil et al 1990	used L-W rel. for C acronotus	Branstetter 1987	Bohnsack, J.A. and D.E. Harper, 1988. Length-	Bonfil et al 1990	Branstetter et al 1987

Table 6. Estimated mean weights by species and size class for data from table 5

Midpoint TL	*Sphyrna liburo*	*Sphyrna lewini*	*Carcharhinus limbatus*	*Sphyrna mokarran*	*Carcharhinus acronotus*	*Rhizoprionodon terraenovae*	*Carcharhinus leucas*	*Carcharhinus porosus*	*Carcharhinus brevipinna*	*Ginglymostoma cirratum*	*Carcharhinus obscurus*	*Galeocerdo cuvier*	
37.5	0.141	0.272	0.336	0.232	0.293	0.204	0.442	0.293	0.355	0.374	0.276	0.177	Small sharks (Cazón)
52.5	0.439	0.764	0.924	0.642	0.838	0.542	1.183	0.838	0.964	0.991	0.782	0.528	
67.5	1.024	1.652	1.970	1.372	1.835	1.122	2.467	1.835	2.033	2.049	1.628	1.192	
82.5	2.014	3.059	3.603	2.515	3.433	2.007	4.435	3.433	3.689	3.661	2.965	2.283	
97.5	3.538	5.109	5.958	4.165	5.781	3.256	7.227	5.781	6.059	5.935	4.945	3.923	
112.5	5.731	7.927	9.165	6.418	9.034	4.929	10.981	9.034	9.266	8.977	7.619	6.237	
127.5		11.641	13.358	9.363			15.833	13.350	13.441	12.892	11.120	9.356	
142.5		16.376	16.670	13.101			21.916			17.784	15.561	13.415	
157.5		22.270	25.234	17.724			29.365			23.753	21.055	18.553	
172.5		29.444	33.182	23.329			38.312			30.902	27.715	24.912	
187.5		38.034	42.646	30.009			48.887			39.329	35.654	32.639	
202.5		48.171		37.861			61.222			49.133	44.987	41.883	
217.5		59.987		46.980			75.445			60.412	55.826	52.794	
232.5		73.617		57.462			91.686			73.263	68.287	65.528	
247.5				69.403			110.073						Large sharks (tiburón)
262.5				82.900			130.734						
277.5				98.048									
292.5				114.943									
307.5				133.683									
322.5				154.363									
337.5				177.080									
352.5				201.932									
367.5				229.013									
382.5				258.423									
397.5				290.257									
412.5				324.612									
427.5				361.585									

Table 7. Estimated weight for each length frequency (mean weight for each class times number of individuals)

Midpoint TL	*Sphyrna tiburo*	*Sphyrna lewini*	*Carcharhinus limbatus*	*Sphyrna mokarran*	*Carcharhinus acronotus*	*Rhizoprionodon terraenovae*	*Carcharhinus leucas*	*Carcharhinus porosus*	*Carcharhinus brevipinna*	*Ginglymostoma cirratum*	*Carcharhinus obscurus*	*Galeocerdo cuvier*	
37.5	0.282	3.262				0.204							Small sharks (Cazón)
52.5	2.194	75.611			9.217	2.167		10.055					
67.5	374.725	80.950	76.813	10.974	36.708	29.170	4.933	20.189					
82.5	1258.822	58.120	136.924	70.410	99.549	64.210	4.435	24.029	25.824		2.985		
97.5	1712.205	30.652	154.898	174.915	167.647	61.860	7.227						
112.5	234.987	55.488	18.330	198.896	135.516	4.929	10.981						
127.5			40.075	112.358			31.665	13.350					
142.5			448.087	39.303						17.784			
157.5			1135.522	35.449			58.731			0.000			Large sharks (tiburón)
172.5			99.546	46.657			268.183			0.000			
187.5		38.034	85.297	30.009			1515.508			39.329		32.639	
202.5		48.171					1040.774			49.133			
217.5		119.975		46.980			301.782			60.412			
232.5		73.617					458.432			73.263			
247.5				69.403			110.073						
262.5				82.900			130.734						
277.5													
292.5				114.943									
307.5				133.883									
322.5				154.363									
337.5													
352.5													
367.5				229.013									
382.5				258.423									
397.5													
412.5													
427.5				361.585									

Table 8. Calculation of species composition in weight for the shark fisheries of Tabasco and Campeche from data in table 7

	Sphyrna tiburo [1]	*Sphyrna lewini*	*Carcharhinus limbatus*	*Sphyrna mokarran*	*Carcharhinus acronotus*	*Rhizoprionodon terraenovae* [1]	*Carcharhinus leucas*	*Carcharhinus porosus*	*Carcharhinus brevipinna*	*Ginglymostoma cirratum*	*Carcharhinus obscurus*	*Galeocerdo cuvier*
Total weight in sample of small sharks (cazón)	4479	304	875	607	449	203	59	68	26	18	3	0
Proportion of each species in the total weight of small sharks	0.632	0.043	0.123	0.086	0.063	0.029	0.008	0.010	0.004	0.003		
Total weight in sample of large sharks (tiburón)	0	280	1320	1563	0	0	3884	0	0	222	0	33
Proportion of each species in the total weight of large sharks		0.038	0.181	0.214			0.532			0.030		0.004

1 Values obtained from calculations based on table 7 were multiplied by 1.25 because L-W relationship for these species were for gutted fish

Table 9. Estimated sandbar catch in tonnes (sandbars caugh in Mexico are always large sharks, thus calculation is based only on Mexican statistics for 'large' sharks (tiburon)), proportions for each state from table 3 and Bonfil et al. (1998)

	Tamaulipas	Veracruz	Tabasco	Campeche	Yucatan	Quintana Roo
sandbars as %	0.073	0.073	0	0	0.07	0
Year						
1962	0	0	0	0	0	0
1963	0	0	0	0	0	0
1964	1	2	0	0	2	0
1965	1	2	0	0	2	0
1966	1	5	0	0	4	0
1967	1	5	0	0	4	0
1968	1	5	0	0	4	0
1969	1	5	0	0	4	0
1970	1	5	0	0	4	0
1971	1	5	0	0	4	0
1972	1	5	0	0	4	0
1973	7	23	0	0	16	0
1974	13	41	0	0	32	0
1975	12	37	0	0	29	0
1976	8	17	0	0	15	0
1977	11	14	0	0	18	0
1978	10	49	0	0	26	0
1979	15	54	0	0	8	0
1980	27	99	0	0	19	0
1981	52	270	0	0	46	0
1982	21	254	0	0	136	0
1983	31	200	0	0	150	0
1984	34	230	0	0	141	0
1985	28	91	0	0	142	0
1986	27	142	0	0	145	0
1987	36	105	0	0	96	0
1988	46	168	0	0	104	0
1989	42	119	0	0	122	0
1990	49	134	0	0	178	0
1991	40	123	0	0	141	0
1992	46	134	0	0	147	0
1993	44	127	0	0	136	0
1994	52	124	0	0	123	0
1995	83	124	0	0	132	0
1996	77	150	0	0	141	0
1997	51	175	0	0	72	0
1998	72	112	0	0	70	0
1999	58	104	0	0	110	0
2000	54	121	0	0	73	0

Table 10. Estimated catch of sandbar sharks in number of fish

	Tamaulipas	Veracruz	Tabasco	Campeche	Yucatan	Quintana Roo	Total
Mean weight of sandbars (kg)	38[1]	38[1]	–	–	29.6[2]	–	
	-	-			-		-
	-	-			-		-
	19	61			60		139
	19	61			60		139
	38	121			120		279
	38	121			120		279
	38	121			120		279
	38	121			120		279
	38	121			120		279
	38	121			120		279
	38	121			120		279
	189	607			598		1,394
	340	1,088			1,073		2,500
	307	984			971		2,263
	145	452			503		1,100
	299	367			593		1,260
	257	1,289			672		2,418
	392	1,426			286		2,104
	717	2,810			855		3,982
	1,358	7,102			1,605		10,065
	553	6,687			4,582		11,822
	617	5,253			5,055		11,125
	900	6,053			4,755		11,708
	730	2,394			4,786		7,910
	719	3,739			4,911		9,368
	954	2,753			3,254		6,962
	1,219	4,411			3,512		9,142
	1,107	3,124			4,114		8,346
	1,287	3,522			5,929		10,738
	1,065	3,227			4,771		9,063
	1,202	3,522			4,951		9,675
	1,146	3,344			4,589		9,080
	1,366	3,256			4,140		8,762
	2,195	3,252			4,445		9,892
	2,017	3,955			4,760		10,732
	1,347	4,600			2,418		8,364
	1,895	2,935			2,377		7,208
	1,515	2,732			3,729		7,976
	1,408	3,192			2,451		7,051

1 from Marin (1992)

2 R. Bonfil unpubl. data from the shark fishery of Yucatan, based on 210 measured individuals

Table 11. Estimated catch of small blacktips (tonnes); percentage of blacktips for each state from tables 3 and 8, landings of small sharks from table 1

	Tamaulipas	Veracruz	Tabasco	Campeche	Yucatan	Quintana Roo
blacktips as %	0.574	0.59	0.123	0.123	0.012	--
years						
1962	370	298	25	63	1	
1963	333	268	22	56	1	
1964	481	387	32	82	2	
1965	555	446	37	94	2	
1966	481	387	32	82	2	
1967	555	446	37	94	2	
1968	555	446	37	94	2	
1969	518	417	34	88	2	
1970		119	10	25	1	
1971	148	119	10	25	1	
1972	185	149	12	31	1	
1973	296	238	20	50	1	
1974	258	208	17	44	1	
1975	255	205	17	43	1	
1976	153	280	21	77	2	
1977	330	386	23	67	2	
1978	252	211	25	46	1	
1979	421	370	28	53	1	
1980	510	417	34	60	2	
1981	1,427	611	50	54	1	
1982	599	772	48	104	2	
1983	585	881	38	248	3	
1984	741	1,435	62	247	1	
1985	849	675	54	195	1	
1986	793	585	54	144	2	
1987	909	458	57	171	2	
1988	1,001	494	59	168	2	
1989	1,100	740	50	139	2	
1990	1,350	740	82	149	6	
1991	971	671	99	123	4	
1992	1,095	670	83	297	4	
1993	1,236	864	70	215	5	
1994	1,178	747	60	157	3	
1995	950	686	55	137	4	
1996	1,019	799	63	131	5	
1997	474	1,026	41	60	4	
1998	705	573	52	101	6	
1999	506	434	52	91	5	
2000	533	314	46	105	5	

Table 12. Estimated catch of small blacktips in number of fish

	Tamaulipas	Veracruz	Tabasco	Campeche	Yucatan
Mean weight of small blacktips (kg)	8.75[1]	10.77[1]	6.63[2]	6.63[2]	4.65[3]
1962	42,264	27,626	3,701	9,454	296
1963	38,037	24,863	3,331	8,509	267
1964	54,943	35,914	4,811	12,291	385
1965	63,395	41,439	5,551	14,182	444
1966	54,943	35,914	4,811	12,291	385
1967	63,395	41,439	5,551	14,182	444
1968	63,395	41,439	5,551	14,182	444
1969	59,169	38,676	5,181	13,236	415
1970	-	11,050	1,480	3,782	118
1971	16,905	11,050	1,480	3,782	118
1972	21,132	13,813	1,850	4,727	148
1973	33,811	22,101	2,961	7,564	237
1974	29,500	19,283	2,583	6,599	207
1975	29,183	19,076	2,555	6,528	205
1976	17,448	25,964	3,134	11,629	444
1977	37,716	35,824	3,505	10,089	397
1978	28,795	19,610	3,783	6,992	242
1979	48,079	34,345	4,229	7,956	157
1980	58,312	38,672	5,082	9,106	413
1981	163,063	56,749	7,548	8,179	235
1982	68,479	71,703	7,270	15,709	397
1983	66,839	81,782	5,768	37,334	547
1984	84,680	133,272	9,273	37,186	160
1985	97,011	62,665	8,198	29,340	248
1986	90,649	54,284	8,123	21,774	446
1987	103,833	42,562	8,661	25,780	426
1988	114,393	45,903	8,847	25,279	361
1989	125,741	68,690	7,604	20,920	402
1990	154,274	68,690	12,370	22,423	1,225
1991	110,983	62,281	14,874	18,602	936
1992	125,085	62,172	12,574	44,771	830
1993	141,286	80,193	10,590	32,364	1,104
1994	134,596	69,347	9,069	23,610	743
1995	108,556	63,651	8,327	20,679	769
1996	116,427	74,222	9,551	19,771	1,011
1997	54,114	95,257	6,139	9,069	923
1998	80,613	53,243	7,808	15,227	1,269
1999	57,853	40,316	7,771	13,687	1,099
2000	60,870	29,141	6,899	15,783	985

1 from table 4

2 calculated from data on table 7

3 from personal database from the shark fishery of Yucatan, based on 141 measured individuals

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Table 13. Estimated catch of large blacktips (tonnes); percentage of large blacktips for each state from table 8

		Tabasco	Campeche
%	blacktips as years	0.181	0.181
	1962	0	0
	1963	0	0
	1964	1	4
	1965	1	4
	1966	2	9
	1967	2	9
	1968	2	9
	1969	2	9
	1970	2	9
	1971	2	9
	1972	2	9
	1973	10	43
	1974	19	76
	1975	17	69
	1976	17	85
	1977	65	148
	1978	56	188
	1979	35	116
	1980	33	71
	1981	33	137
	1982	27	128
	1983	68	315
	1984	72	333
	1985	75	226
	1986	147	317
	1987	121	483
	1988	67	466
	1989	46	253
	1990	69	366
	1991	72	326
	1992	87	392
	1993	59	323
	1994	79	327
	1995	59	279
	1996	59	296
	1997	27	111
	1998	25	116
	1999	34	87
	2000	36	94

Table 14. Estimated catch of large blacktips in numbers

	Tabasco	Campeche	Estimated total Mexican catch of small and large blacktips
Average weight of large blacktips (kg)	26.41[4]	26.41[4]	
	-	-	**83,341**
	-	-	**75,007**
	40	161	**108,544**
	40	161	**125,213**
	79	323	**108,745**
	79	323	**125,413**
	79	323	**125,413**
	79	323	**117,079**
	79	323	**16,833**
	79	323	**33,738**
	79	323	**42,072**
	395	1,613	**68,681**
	709	2,892	**61,773**
	642	2,618	**60,807**
	630	3,207	**62,456**
	2,453	5,598	**95,583**
	2,117	7,106	**68,646**
	1,323	4,386	**100,475**
	1,247	2,679	**115,511**
	1,240	5,194	**242,208**
	1,014	4,838	**169,409**
	2,563	11,930	**206,762**
	2,720	12,602	**279,892**
	2,837	8,559	**208,857**
	5,564	12,019	**192,859**
	4,584	18,303	**204,148**
	2,549	17,631	**214,963**
	1,727	9,593	**234,678**
	2,604	13,856	**275,441**
	2,741	12,348	**222,765**
	3,303	14,822	**263,557**
	2,234	12,232	**280,002**
	3,001	12,389	**252,755**
	2,227	10,573	**214,782**
	2,248	11,217	**234,447**
	1,014	4,214	**170,730**
	932	4,392	**163,484**
	1,288	3,310	**125,323**
	1,364	3,556	**118,599**

4 Calculated from data on table 7