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Catch Composition, Effort, and Selectivity of Fishes of recreational Fishing in Yucatán, Mexico

By Gaspar Poot-Lopez, Sharix Rubio-Bueno, Harold Villegas-Hernandez, Carlos Gonzalez-Salas, Sergio Guillen-Hernandez & Raul E. Díaz-Gamboa

Autonomous University of Yucatan

Abstract- Fishing for recreational purposes is a component rarely studied. This activity represents a potential competition with artisanal fisheries, although its impact on fish stocks remains unknown in many coastal areas worldwide. Here, In this study we described the catch composition, the catch per unit effort (CPUE), size at first capture (L_{50}) and the length-weight relationship (LWR) of the fish species caught by the recreational fishing from the coastal area off Chuburna Puerto, Yucatan, Mexico. During an annual cycle a total of 1,241 specimens of 21 fish species, belonging to 13 families, were collected with hook and line, as the main fishing gear used by the recreational fishing in the region. The species *Haemulon plumieri* and *Sphoeroides nephelus* were captured all along the study period and contributed with 43.07% and 30.55% of the total biomass, respectively. Seven species are known to have a commercial interest for exploitation and 10 with minor commercial interest.

Keywords: *recreational fishing, catch composition, catch per unit effort, length-weight relationship, Haemulon plumieri, Sphoeroides nephelus, yucatan.*

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Catch Composition, Effort, and Selectivity of Fishes of recreational Fishing in Yucatán, Mexico

Gaspar Poot-Lopez [α], Sharix Rubio-Bueno [σ], Harold Villegas-Hernandez [ρ], Carlos Gonzalez-Salas [Ѡ], Sergio Guillen-Hernandez [¥] & Raul E. Díaz-Gamboa [§]

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Keywords: recreational fishing, catch composition, catch per unit effort, length-weight relationship, Haemulon plumieri, Sphoeroides nephelus, yucatan.

I. Introduction

The fishing resources are very dynamic and diverse, but the global vision of development and promotion, that once considered them as inexhaustible, has been modified by the sustainable use (Hilborn *et al.*, 2003). In recent years, a great proportion of identified species resulted as overfished. In fact, overall it is estimated that about 13.5% of marine resources are severely damaged, 26% over-exploited, 25.5% in maximum use, 5% in development and for 30% no information is available that allows a proper diagnosis (Arreguín-Sánchez & Arcos-Huitrón, 2011).

Author α σ ρ Ѡ ¥ §: Department of Marine Biology. Faculty of veterinary medicine and zootechnics. Autonomous University of Yucatan, Mexico. Section 4-116 Itzimná, km 1.5 carret. Mérida- Xmatkuil. Merida Yucatan. Mexico. e-mail: raul.diaz@correo.uady.mx

The fishing industry includes both recreational, subsistence and commercial fishing, including the extraction and commercialization of fish (FAO, 2016). However, fishing for recreational purposes is a component rarely studied, being a key outdoor activities in the United States (Ditton *et al.,* 2002). Recreational fishing means the capture of aquatic animals (mainly fish) that do not constitute the primary resource of the individual to satisfy their basic nutritional needs and the captured organisms are not sold or commercialized in the fish markets (FAO, 2012). In addition, this activity can be considered a sports activity (sportfishing tournaments), representing an enormous economic potential in several countries, including Mexico. This generates flow of jobs, foreign exchange and its effects expands to other activities and services, becoming good for development (TRAGSATEC, 2005; Ibáñez, 2011). However, that represents a potential competition with artisanal fisheries, although its impact on fish populations remains unknown in many coastal areas worldwide (FAO, 2012; Flores-Nava *et al.*, 2016)

The overexploitation of commercial fishing resources in Yucatan, Mexico is bordering fishermen for a change in economic activity towards the tertiary sector, particularly adventure tourism, such as recreational fishing (Gutiérrez-Pérez, 2014). For example, in some ports, off shore sport fishing tournaments are usually held frequently (3-10 per year), involving 30 to 50 boats, and up to 200 fishermen (Vidal-Hernández *et al.,* 2017). However, recreational fishing increases during weekends or holiday periods (spring-summer), where users hire artisanal fishermen as guides, and the payment includes boat rentals, fishing gear (hook and line) and bait (Gutiérrez-Pérez, 2014; Mugarte-Mendoza *et al.*, 2016; Vidal-Hernández *et al.,* 2017). Although there are no well-established services for recreational fishing and there are no catch records of this activity, it is a fact that is practiced by a large number of people, either with their own or rented boats. Similarly, little is known about scuba diving, spearfishing, and underwater photography in the area, all of which are linked to the incipient or potential use of natural resources (García de Fuentes *et al.*, 2011).

In the coast of Yucatan there are several fish species currently exploited by the recreational fishing, such as white grunt (*Haemulon plumieri*), grouper (*Epinephelus morio*), snappers (*Ocyurus chrysurus* and *Lutjanus* spp), porgies (*Calamus* spp), among other species (Salas *et al.,* 2006, Mexicano-Cíntora *et al.,* 2007, Fernández *et al.,* 2011). However, in sport fishing tournaments competitors seek to capture species with high commercial value, as well as the biggest and heaviest organisms (Vidal-Hernández *et al.,* 2017).

Up to date, there is a lack of information on biological-fishing issues of these un assessed species captured by the unregulated recreational fishing in this region. In this sense, studies examining the composition of the catches in a fishery are designed to know the exploitation status (e.g., catch rates and size structures) and changes in the selectivity patterns to contribute to management and conservation measures (Quiroz *et al.,* 2008). Therefore, the present study describe the composition of the catches, the catch per unit effort (CPUE), selectivity and the length-weight relationship (LWR) of the fish species caught by the recreational fishing, for the first time in the northern coast of the Yucatan.

II. Material and Methods

a) Study area

Chuburna Puerto (21°15'07" N and 89°48'57" W) is on the coast of the Gulf of Mexico in the northern coastal area off the Yucatan Peninsula. Four sampling sites were chosen, with depths ranging from 4 to 5 meters (Figure 1). The average annual temperature is 25.6°C, with a maximum of 36°C. The region has a warm semi-dry climate from March to June, with intense rain from July to October, and strong northern winds and lower intensity rain the rest of the year (Ordoñez-López et al., 2013). Due to its location in the tropical zone, the study area shows three climatic periods: dry (March-June), rainy (July-October) and northerly winds (November-February), which determine the environmental and ecological dynamics of the system (Vega-Cendejas, 2004).

b) Sampling

We performed twelve samplings on a monthly basis, from October 2015 to September 2016. A 23-foot long boat with a 40 HP motor was used on each fishing trip, in which four crew members used hook and lines as fishing gearsand with tentacles of squid (*Dosidicus gigas*) as bait. The standardized catch effort was four hours/fisher/day. We stored the captured specimens in coolers, except forthose in a temporary fishing ban or not suitable for human consumption, in which cases were identified, measured, weighed and released at the time. The following morphological data were taken from each: standard length (SL in cm) and total weight (TW in gr). The species identification was carried out following the guidelines of Carpenter (2002) and Gallardo-Torres *et al.* (2014). As a complementary analysis, we catalogued each species according to their exploitation uses: commercial (C_o), minor commercial (C_m), aquarium (Aq), aquaculture (Aqc), Recreational (Rec) and livelihood fishery (LFIS), based on biological-fishery related data (i.e. regulation measures or minimum sizes of sexual maturity) available in Fish Base (Froese & Pauly, 2017) or previous published studies.

With the SL data, we constructed length frequency histograms with size class intervals of 2 cm. The cumulative frequency histogram of the lengths of each species was used to adjust the parameters of the selectivity equation, described as follows:

$$r(SL) = \frac{\exp(b_0 + b_1 SL)}{1 + \exp(b_0 + b_1 SL)} \qquad \text{(Eq.1)}$$

Where *r* (*SL*) is the probability of capture of the organism of a given standard length, and b_0 and b_1 are constants or parameters to be estimated for the logistic model. The function was adjusted using least squares method in the Statistica 6.1 software. We obtained the selectivity parameters (b_0 and b_1) and then estimated the size at first capture(L_{50}), which is defined as the size (*SL*) at which the fishing gear retained 50% of the organisms as L_{50} = - (b_0/ b_1). The parameters mentioned above were estimated at 95% confidence (Millar &Fryer 1999; Arellano-Torres *et al.,* 2006) only for those species that had more than ten specimens collected.

Based on the catches in number of individuals (n) and weight (kg), the catch per unit of effort (CPUE) was estimated on a monthly basis as well as for the climatic periods (dry, rainy and northerly winds season) according to the recommendations of Vega-Cendejas (2004) and compared with a one-way analysis of variance (ANOVA).

Length-Weight relationships (*LWR*) was estimated using the biometric information to establish the relationships between the standard length (*SL*) and the total weight (*TW*) using the potential equation:

$$TW = a(SL)^b \qquad \text{(Eq. 2)}$$

Where *a* is the ordinate to the origin (intercept) and *b* is the slope. Parameter *a* represents the condition factor or degree of individual robustness. Meanwhile, *b* is a relative growth coefficient by the length and its proportionality with the weight (Safran, 1992). Both LWR parameters were estimated by linear regression in Microsoft Excel based on the logarithms of SL and TW according to:

$$\text{Log } TW = \text{Log } a + b \log SL \qquad \text{(Eq. 3)}$$

Once estimated slope (*b*) of LWR of the selected species was statistically compared to test if it is or not different from the isometric growth, that is to say, *b* value equal to 3 (Ricker, 1975), using the one-tailed

Student's t-test (Zar, 1999). In the same way, as with the L_{50}, the LWR equation was estimated only for those species that had at least ten specimens.

III. Results

a) Catch Composition

A total of 1,241 specimens of 21 fish species were collected, belonging to 13 families. Haemulidae, Tetraodontidae, Serranidae, Balistidae, Lutjanidae, Carangidae and Sparidae were the families that contributed toa large proportion of biomass and individuals captured along the study period (Table 1). The families Ariidae, Batrachoididae, Echeneidae, Monacanthidae, Scombridae and Synodontidae, accounted for less than 0.9% of the catches, and some of them with a single specimen. Two species, *Haemulon plumieri* and *Sphoeroides nephelus*, were caught during the 12 months and contributed with 43.07% and 30.55% of the total biomass, respectively. In contrast, the contribution of *Caranx crysos* concerning total biomass was only 3.32% and captured all year. We cataloged seven species under exploitation of commercial interest (C_o), where only *Epinephelus morio* supports a strong fishery in the region (Table 1). Ten species have minor commercial importance, and recreational fisheries capture 12 species in other areas (Table 1). *Opsanus beta* and *Echeneis neucratoides* also present reports of incidental catches by recreational fisheries, while *Stephanolepis hispidus* and *Sphoeroides nephelus* are species captured by the livelihood fisheries (Table 1).

b) Size at first capture (L_{50})

Table 1 shows the selectivity parameters (b_0 and b_1) and the size at first capture (L_{50}) for each species, whereL_{50} of species caught varied from 11.09 to 33.64 cm *SL* for *Diplectrum formosum* and *Echeneis neucratoides*, respectively. All values of b_0 and b_1 were significant ($p<0.05$). However, we did not estimate the selectivity parameters due to the low number of specimens captured (Table 1).

c) Catch per unit effort (CPUE)

The average CPUE was estimated at 2.86 kg/fisher/day, equivalent to 14.7 fish, considering 4 hours per fishing day. CPUE varied between a minimum and maximum of 1.88 (April) and 3.98 (February) kg/fisher/day. The analysis of the overall CPUE did not present significant differences between climatic periods (ANOVA, $p>0.05$)neither for weight nor the number of individuals. In terms of biomass, species of commercial interest (C_o) accounted less than 25% of the monthly catches, *E. morio* and *L. synagris* being the most important in volume, where the CPUE of commercial species presented a minimum of 0.048 (May) and a maximum of 0.895 (February) kg/fisher/day (Figure 2). We noted that *E. morio* sustains the main scale fishery in the region, due to its commercial value and volume.

Species contributing in great proportion to the catch were previously cataloged as fish with minor commercial interest (C_m) and for livelihood fisheries (LFIS), such as *Haemulon plumieri, Sphoeroides nephelus, Balistes capriscus* and *Caranx crysos*, with more than 82% of the catches in nine months along the study period (Figure 3). CPUE by weight of these species was estimated from 1.3 (April) to 3.24 (December) kg/fisher/day.

Figure 4 shows the size frequency distributions of fish species witha commercial interest (C_o), with their respective sizes of first sexual maturity reported in the literature, either furcal length (FL) or standard length (SL). Size classes that comprise the size of the first catch (L_{50}) are in blank cases (Fig. 4). *Epinephelus morio*, *Ocyurus crysurus* and *Diplectrum formosum* presented an L_{50} below their respective sizes of first sexual maturity. In spite of being a species used as human food, up to date there is no record of sexual maturity for *Calamus campechanus*. Although this later fish species commonly represents a complementary bait in recreational and artisanal fishing.

Of the species that cataloged with minor commercial interest (C_m), only *H. plumieri* showed abundant catches (Figure 5), as *Sphoeroides nephelus* did, although the livelihood fisheries (LFIS) uses the latter one. 70% of the captures of *H. plumieri* were above the size of the first maturity, meanwhile, for *S. nephelus*, no reports of their sexual maturity were found. For *Balistes capriscus*, its size of the first catch (L_{50}) matchedits reported size of the first sexual maturity (Figure 5), unlike *Caranx crysos*, affecting immature organisms.

d) Length-Weight Relationships

The results of regression models of the LWR of 12 fish species were highly significant ($p<0.001$), in which in most cases the values of the coefficient of determination (r^2) were found above 0.91 indicating that data fitted to the linear model, except for *Balistes capriscus* (Table 2). The results of the t-tests ($\hat{t}$) applied to the slopes (b) indicate that b values of *Calamus campechanus, Calamus proridens, Caranx crysos, Echeneis neucratoides* and *Epinephelus morio* show edisometric growth ($b = 3$) (Table 2).

IV. Discussion

During an annual cycle, we observed in this study that the hook and line recreational fishing on the coast of the Chuburna Puerto, Yucatan, includes at least 13 families and 21 fish species. Although in the region there are other species of fish such as catfish, croakers, snappers and even rays considered by this activity (DOF, 2012). The species composition in a fishery can be influenced by various factors, such as the kind of fishing gear used, e.g., size and design of the hook (Erzini et al., 1998), or characteristics of the fishing sites (e.g., depth), among other factors. In sportfishing tournaments (all along the coast of Yucatan), at least 20 species additional where counted respect to the present study (Vidal-Hernández *et al.,* 2017).

The depth of the selected sites was approximately 4.7 m, although some recreational fishing users can fish up to 15-20 mlooking for larger specimens. For example, in recreational fishing in a locality of the Mediterranean Sea, the site caused variability in abundance and species composition (Alós *et al.,* 2008). The variation in catches is probably due to spatial differences in fishing pressure, habitat characteristics, recruitment and timing (Agembe *et al.,* 2010). In the present study, only three species (*Haemulon plumieri*, *Sphoeroides nephelus*, and *Caranx crysos*) presented captures during all months. CPUE remained in a range of 1.88 and 3.98 kg/fisher/day, without significant differences between climatic periods.

Alós *et al.* (2009) found that in recreational fishing the type of bait might influence CPUE, as well as the size of the fish caught, the composition of the catch. Similar studies were conducted by Otway & Craig (1993), Erzini *et al.* (1996, 1998, 1999) and Halliday (2002). In the present study, it was decided to use squid (*Dosidicus gigas*) as bait all year round, since fishermen in the region prefer it than artificial ones. Similarly, local fishermen use other fish species such as *Opisthonema oglinum*, *Diplectrum formosum*, *Haemulon plumieri*, *Hemiramphus* spp, *Lutjanus synagris* and octopus (*Octopus* spp), among others.

The most important species of commercial interest captured in our study, according to their biomass, were *E. morio, L. synagris* and *O. chrysurus*, representing less than 25% of the monthly catches. However, of these, the red grouper (*E. morio*) is the most important, and also found below the size of the first reported sexual maturity (38.1 cm *SL*) in the region (Brulé *et al.,* 1999). Vidal-Hernandez *et al.* (2017) analyzed the sizes frequency of six species of fish caught in sportfishing tournaments of Yucatan, and they found that only 0.5% of the *E. morio* specimens met the estimated size of sexual maturity. That is of great importance because the stock of red grouper in Yucatan is currently classified as an overexploited resource (Burgos & Defeo, 2000, 2004, Giménez-Hurtado *et al.,* 2005). The coastal areas most wanted by recreational fishing users are often critical habitats for multiple life stages of many fish species, which use these for spawning, nursery, feeding, migration, etc. (Jackson *et al.,* 2001). Also recreational fishermen target immature stages of fish in those areas (McPhee *et al.,* 2002).

Several snapper species has been the main component of the small scale fishery (artisanal) of coastal areas of the Yucatan Peninsula (SAGARPA, 2005, DOF, 2012). However, due to the decrease in the catches of the red snapper *Lutjanus campechanus*, some lutjanids such as *Lutjanus synagris* and *Ocyurus chrysurus* recently acquired greater commercial, due to international demand (DOF, 2012). In the present study, at least 80% of *O. chrysurus*'s catches were located before or until the size of the first sexual maturity of 21.3 cm (Freitas *et al.,* 2011; Trejo-Martínez *et al.,* 2011).In contrast, *L. synagris* showed that size at first catch (L_{50}) similarly matched its size of the first sexual maturity at 18.67 cm *SL*(Freitas *et al.,* 2011). This agrees with that reported by Vidal-Hernandez *et al.* (2017), who determined that *L. synagris* in fishing tournaments were made up of 97% of adult organisms, unlike *O. crysurus*, with 58% of mature fish. Regarding *Calamus proridens*, the size of the first maturity of 13.2 cm of *FL*(Tyler-Jedlund, 2009) was inferior to that observed in our study. Although *Diplectrum formosum*, whose L_{50} matched size atthe first maturity equivalent to 12.5 cm *SL* (Darcy, 1985), is classified in some regions of the Caribbean as a commercial fishing species, in the Gulf of Mexico it is only associated with the catfish fishery (DOF, 2012). Also, these species are complementary bait in both artisanaland recreational fishing.

Recreational fishing can directly contribute to the decline of global fisheries through catches mortality, it can also alter the function and quality of ecosystems (Cooke & Cowx, 2004, Arlinghau & Cooke, 2009). In the present study, most of the catches were species of minor commercial interest, but that serve as food or as a source of complementary income for the fishermen's families. An example of this is the white grunt *H. plumieri,* which supports an artisanal fishery in the northern coast of the Yucatan Peninsula, being up to date a non-regulated resource without maximum catch rates and unspecified catch size limits (Villegas-Hernández *et al.,* 2014). The size of the first maturity of this species was 16.8 cm *FL* in Brazilian waters (Shinozaki-Mendes *et al.,* 2013). The fishery of *H. plumier* is very important because is available all year round, representing an exploitation alternative that would serve as an "opportunity for recovery" to other species that are subject to a higher level of exploitation. This resource is considered as moderately abundant and with an intermediate distribution (Courtenay, 1961, Gaut& Munro, 1974, Domínguez-Viveros & Avila-Martínez, 1996).

Another resource that presented abundant catches throughout the year is the puffer fish *Sphoeroides nephelus*. *S. nephelus* is a species discarded for fishermen and associated with artisanal multispecies fisheries in the Yucatan Peninsula (DOF, 2012). There is evidence that the ancient Mayans used individuals of *Sphoeroides* spp as food (Herrera-Flores and Markus-Götz, 2014). However, their consumption has only been documented in the United States, where their meat is appreciated, despite its toxicity (Abbott et al., 2009; DSSH, 2011). Regarding *C. crysos* and *B. capriscus*, although their catches in number were not abundant, they contributed with 3.32% and 5.31% of the total biomass, respectively. The size of first catch of *C. crysos* found below the first sexual maturity, may vary (22.5-26.7 cm) depending on the estimation measure (*FL* or *SL*) (Berry, 1959; Goodwin & Finucane, 1985), similarly for *B. capriscus* whose size at first maturity has been estimated at 16.9 cm *FL* (Bernardes & Dias, 2000).

The values of parameter *b* in the LWR of 12 fish species varied between 2.3522 and 3.1982, where *Balistescapriscus* had the lowest one and *Echeneis neucratoides* the highest. The specimens of the families Haemulidae, Lutjanidae, Tetraodontidae, Balistidae and Batrachoididae showed an allometric growth, as well as *Diplectrum formosum* of the Serranidae family. At present, there is little information on the LWR of the species captured in this study, particularly in the Gulf of Mexico and the Yucatan Peninsula. Regarding the species *Caranx crysos* and *Echeneis neucratoides*, there was no information of these parameters. LWR of *C. campechanus* was presented for the first time by Poot-López *et al.* (2017), but *S. nephelus, B. capriscus, C. proridens* and *D. formosum* have limited information. For example, *S. nephelus* has been reported for Yucatan Peninsula (Amador-del Angel et al., 2012; Poot-López *et al.,* 2017). In the present study, the value of *b* (2.35) for *Balistes capriscus* was lower than that reported by Burton *et al.* (2015) in the Southeast of the United States (2.98), whose sample was 20,431 specimens. Similarly, different *b* values have been reported for other species, such as *Calamus proridens* (Tyler-Jedlund, 2015) in the eastern Gulf of Mexico and *Diplectrum formosum* in the northern Gulf of Mexico (Bortone, 1971). Variations in the LWR are mainly due to differences between sexes, size or age of the individuals, feeding history caused by food availability, gonadal developmental state, the season of the year in which were captured or to different fishing sites (Ricker, 1975; Csirke, 1980). Haimovici and Velasco (2000) also mention other factors that affect the accuracy of LWRs such as sample size and adjustment methods.

Global fisheries resources face several threats attributed to commercial exploitation (Jackson et al., 2001, Hilborn et al., 2003, Pauly et al., 2003, Watson et al., 2003). However, some authors consider that recreational fishing is also responsible, indeterminately, for the degradation of fish stocks. Cooke & Cowx (2004) highlighted the potential of this activity to contribute to the decline of fisheries so that future fisheries management approaches should distinguish between categories of fishing activity and variations in the effort, either full-time, time partial, subsistence and recreational, although this requires data availability (FAO, 2016).

It should not be forgotten that recreational fishing could offer socioeconomic benefits in coastal regions, as an option for tourism (Ditton *et al.,* 2002, TRAGSATEC, 2005, Ibáñez, 2011). However, it is necessary to evaluate the impacts of capture rates, the extraction of specimens in times of reproduction, sub-lethal damage to fish (use of hooks and spears), and contamination, to offer more specific management measures for each region (Arlinghaus & Cooke, 2009). In this sense, it is necessary to provide baseline information such as our results of the fish species caught by the recreational fishing from the northern coast of the Yucatan. However, future research is encouraged to carry out in the same matter in other coastal locations along the Yucatan Peninsula to establish management strategies for these unassessed fish species which are up to date subject of unregulated exploitation.

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Table 1: Catch composition of the recreational fishing (hook and line) in the coastal area off the Chuburna Puerto in Yucatan (Mexico)

Family	Species	N	% (n)	Total Weight (g)	% (g)	Use	b_0	b_1	L_{50} (SL in cm)
Ariidae	*Ariopsisfelis*	1	0.08%	293.0	0.12%	C_m, Rec	ID	ID	ID
Balistidae	*Balistescapriscus*	25	2.01%	12,726.1	5.31%	C_m, Rec	-8.99	0.543	16.55
Batrachoididae	*Opsanus beta*	9	0.73%	3,776.3	1.57%	Inc	-9.87	0.367	26.89
Carangidae	*Caranxcrysos*	37	2.98%	7,949.5	3.32%	C_m, Rec	-11.56	0.577	20.03
Echeneidae	*Echeneisneucratoides*	11	0.89%	2,350.3	0.98%	Inc	-12.38	0.344	33.64
Haemulidae	*Anisotremus virginicus*	2	0.16%	852.2	0.36%	C_m, Rec, Aq	ID	ID	ID
	Haemulon aurolineatum	42	3.38%	2,473.4	1.03%	C_m, Aq	-30.78	2.565	12.00
	Haemulon plumieri	544	43.84%	103,285.9	43.07%	C_m, Rec, Aq	-10.29	0.568	18.13
	Orthopristischrysoptera	3	0.24%	222.4	0.09%	Cm, Aq	ID	ID	ID
Lutjanidae	*Lutjanus synagris*	32	2.58%	6,155.3	2.57%	C_o, Rec, Aq	-10.08	0.563	17.90
	Ocyurus chrysurus	25	2.01%	3,225.5	1.35%	C_o, Rec, Aq, Aqc	-8.99	0.543	16.55
Monacanthidae	*Stephanolepishispidus*	1	0.08%	60.0	0.03%	LFIS, Aq	ID	ID	ID
Scombridae	*Scomberomorusregalis*	2	0.16%	386.5	0.16%	C_m, Rec	ID	ID	ID
Serranidae	*Diplectrum formosum*	37	2.98%	1,295.7	0.54%	C_o, Rec, Ba	-8.348	0.752	11.09
	*Epinephelus morio**	43	3.46%	13,841.1	5.77%	C_o, Rec, Aq	-12.56	0.578	21.71
Sparidae	*Archosargus probatocephalus*	1	0.08%	248.4	0.10%	C_o, Rec, Aq	ID	ID	ID
	Calamuscampechanus	15	1.21%	1,762.3	0.73%	C_o	-14.48	1.023	13.96
	Calamusproridens	20	1.61%	3,192.2	1.33%	C_o	-20.94	1.328	15.76
	Lagodonromboides	6	0.48%	518.2	0.22%	C_m, Rec, Ba	ID	ID	ID
Synodontidae	*Synodusintermedius*	1	0.08%	61.3	0.03%	C_m, Aq	ID	ID	ID
Tetraodontidae	*Sphoeroides nephelus*	384	30.94%	73,258.6	30.55%	LFIS	-10.41	0.624	16.69
Total		1241		237,934.3					

**Sub-family: Epinephelinae, C_o= Commercial, C_m= Minor Commercial, Rec=Recreational, Aq=Aquarium, Aqc= Aquaculture, LFIS=Livelihood fishery, Ba=bait, Inc= Incidental, DI= Insufficient Data,*

Table 2: Length-weight relationship of 12 species of fish caught by recreational fishing (hook and line) in the coastal area offChuburna Puerto, Yucatan, Mexico. The coefficient of determination (r^2) that measures the fit of the data to the regression model and the calculated statistic ($\hat{t}$) of the Student's t test is shown to accept that b=3 (isometric growth) or $b \neq 3$ (allometric growth*)

Species	N	Standard Length (SL in cm)		Total Weight (TW in g)		Parameters of the LWR Regression		Confidence Limits		r^2	$\hat{t}$
		Min	Max	Min	Max	*a*	*b*	95% CL of *a*	95% CL of *b*		
*Balistescapriscus**	24	19.0	27.5	294.6	730.0	0.2985	2.3522	0.0976-0.9123	2.00-2.71	0.891	3.781
Calamuscampechanus	15	9.8	17.0	37.2	198.8	0.0476	2.9035	0.0152-0.1492	2.48-3.33	0.943	0.473
Calamusproridens	20	12.9	18.5	63.0	202.0	0.0333	3.0086	0.0120-0.0860	2.67-3.51	0.950	0.053
Caranxcrysos	31	17.0	28.2	121.4	518.2	0.0398	2.7988	0.0166-0.0955	2.51-3.09	0.917	1.409
*Diplectrum formosum**	37	7.50	15.0	10.1	76.9	0.0343	2.8333	0.0234-0.0505	2.67-2.99	0.967	2.122
Echeneisneucratoides	11	23.2	38.5	59.5	302.2	0.0027	3.1982	0.0006-0.0115	2.78-3.62	0.970	1.073
Epinephelus morio	43	15.5	29.1	115.9	753	0.0219	3.0580	0.0127-0.0379	2.88-3.23	0.967	0.665
*Haemulon plumieri**	544	9.5	26.5	31.5	426.0	0.0978	2.5626	0.0809-0.1183	2.50-2.63	0.917	13.22
*H. aurolineatum**	42	10.2	14.4	32.6	75.3	0.0729	2.6032	0.0401-0.1324	2.37-2.84	0.927	2.691
*Lutjanus synagris**	32	13.3	27.0	72.1	447.8	0.0811	2.6358	0.0439-0.1496	2.43-2.85	0.956	3.450
*Ocyurus chrysurus**	24	13.2	25.0	60.2	294.8	0.0783	2.5575	0.0311-0.1975	2.23-3.88	0.920	2.828
*Opsanus beta**	9	13.2	36	58.5	816.4	0.0724	2.5889	0.0348-0.1507	2.37-2.81	0.991	4.356
*Sphoeroides nephelus**	384	11.5	25.3	52.0	530.0	0.0698	2.7505	0.0592-0.0824	2.69-2.81	0.959	8.401

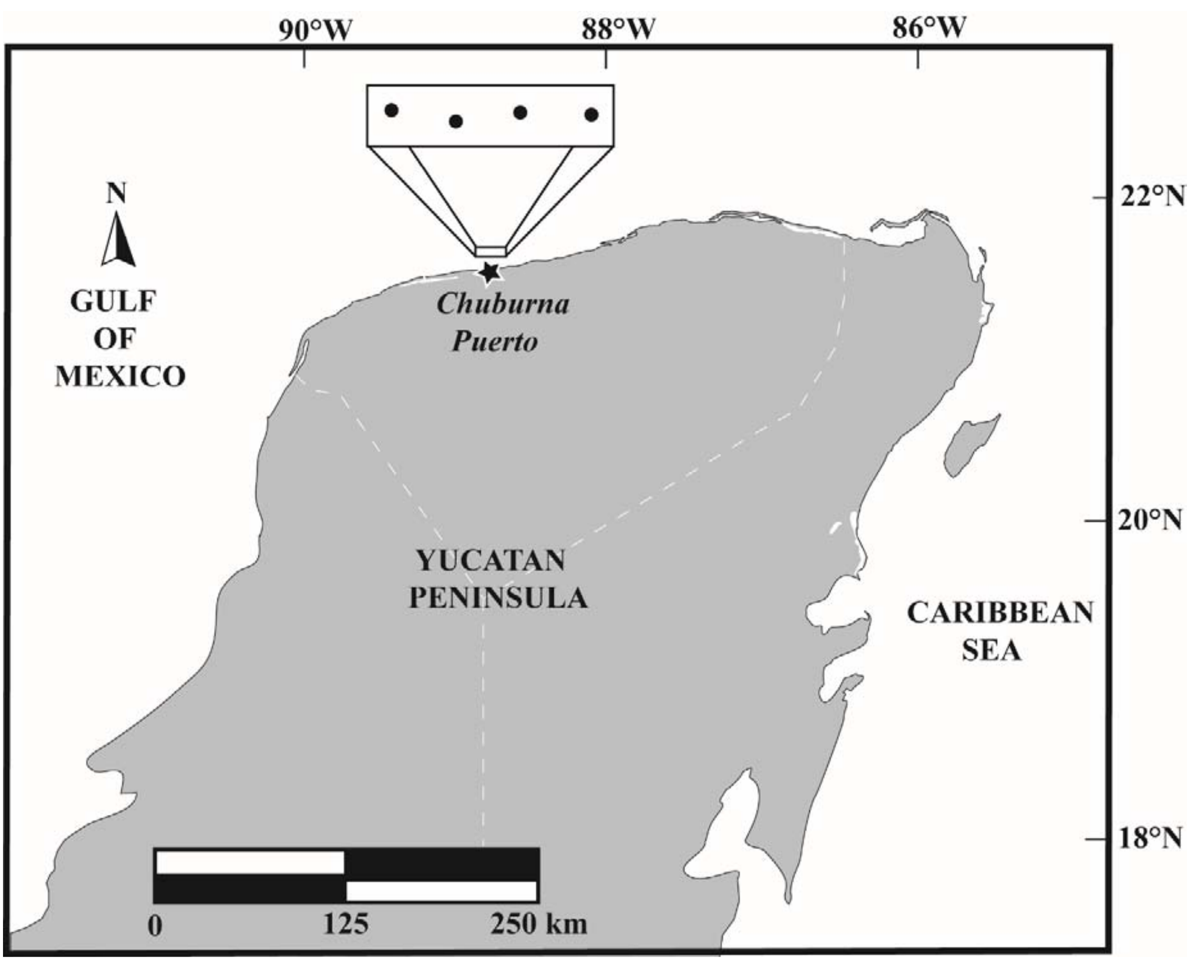

Figure 1: Location of the study area and the fishing sites along the coast offChuburna Puerto, Yucatan, Mexico.

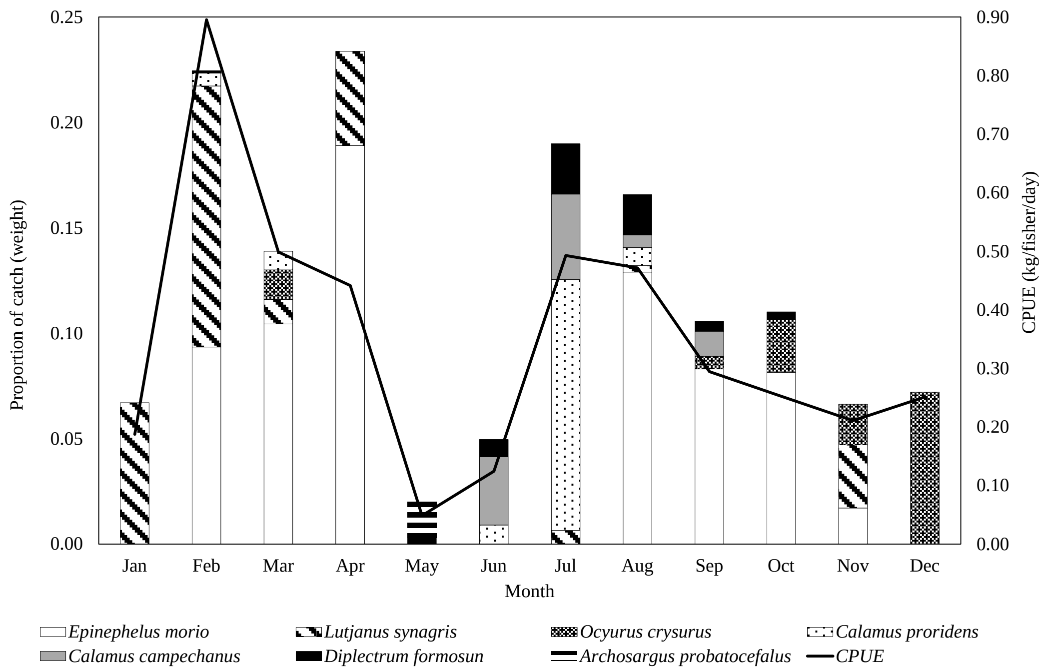

Figure 2: Monthly proportion of the catch and CPUE in weight of the species with commercial interest (C_o) obtained by the recreational fishing during an annual cycle in the coast of the Chuburna Puerto, Yucatan, Mexico.

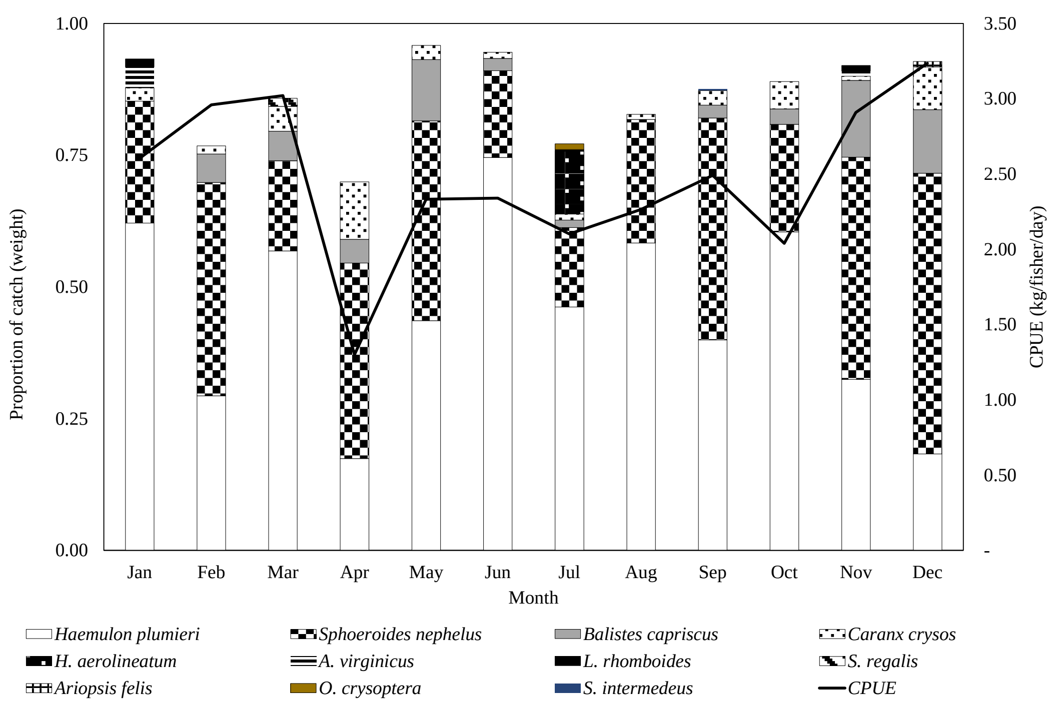

Figure 3: Monthly proportion of the catch and CPUE in weight of species with minor commercial interest (C_m) and for livelihood fishery (LFIS) obtained by the recreational fishing during an annual cycle in the coast of Chuburna Puerto, Yucatan, Mexico

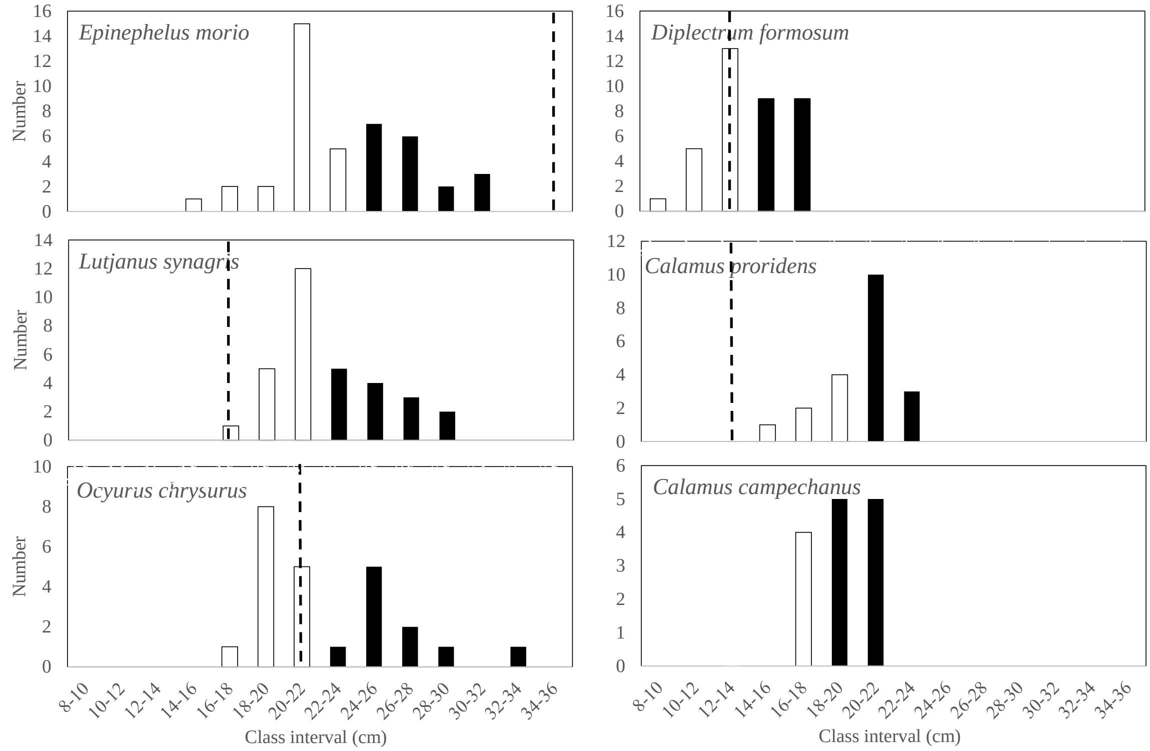

Figure 4: Size-frequency distribution in standard length (SL) of species of commercial interest (C_o) captured by the recreational fishing during an annual cycle in the coast of Chuburna Puerto, Yucatan,Mexico. The dotted vertical line indicates the size of first sexual maturity according to bibliographic references. The blank classes include the size at first capture (L_{50}).

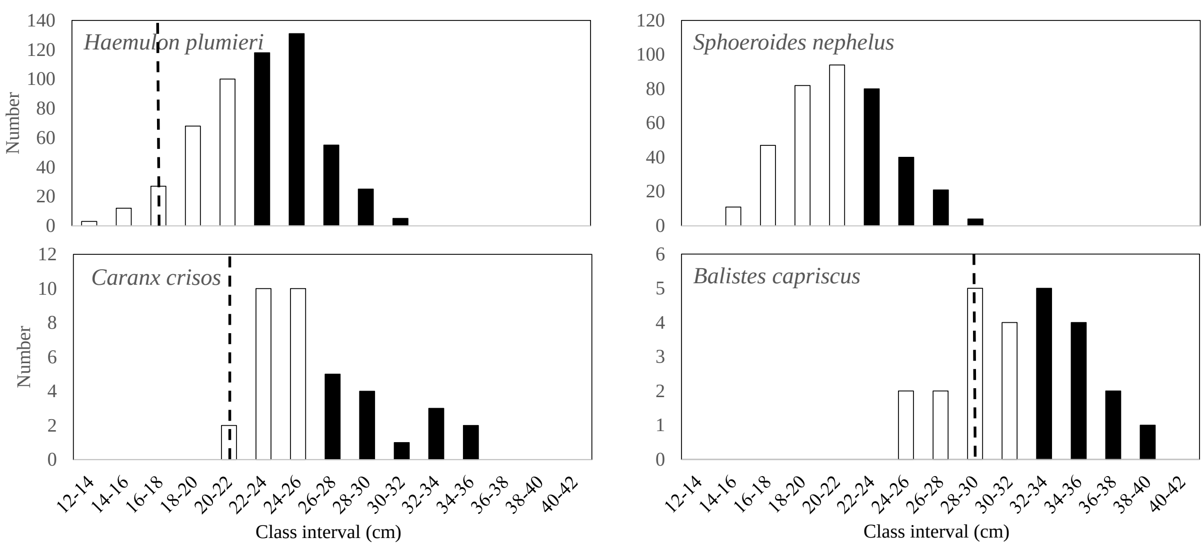

Figure 5: Size-frequency distribution in standard length (SL) of species of minor commercial interest (C_m) captured by the recreational fishing during an annual cycle in the coast of Chuburna Puerto, Yucatan,Mexico. The dotted vertical line indicates the size of first sexual maturity according to bibliographic references. The blank classes include the size at first capture (L_{50}).