Turk. J. Fish.& Aquat. Sci. 20(12), 845-855
http://doi.org/10.4194/1303-2712-v20_12_01

Turkish Journal of
FISHERIES and
AQUATIC SCIENCES

RESEARCH PAPER

Population Aspects of Graceful Mojarra *Eucinostomus gracilis* (Perciformes: Gerreidae) in a Coastal Lagoon in the Tropical Eastern Pacific

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Article History
Received 26 June 2020
Accepted 22 October 2020
First Online 30 October 2020

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Keywords
Eucinostomus gracillis
Magdalena Bay
Size at maturity
Growth
Recruitment

Abstract

Graceful mojarra (*Eucinostomus gracilis*) is an important component of the ichthyic fauna of lagoon systems but knowledge of its population aspects is scarce. Monthly samples in the Bahía Magdalena-Almejas Lagoon system (March-August, 2014-2017) were obtained with a trawling net. Abundance was estimated using the swept area method and its spatial variation; and the maturity size was determined using the logistic method. The sex ratio for mature and immature populations, and their length-weight relationship were estimated; FISAT was used to estimate the growth and recruitment parameters. Abundance ranged from 0.6 to 203 ind-ha^{-1} with changes for each lagoon system areas and among years. Size at maturity (L_{50}) was 132 mm in total length (TL) for the population, 129 mm TL females, and 135 mm TL males. Considering the population of the total organisms, L_{50} indicated that 18% were adults and 82% were juveniles. Juvenile dominance indicated that this lagoon system is used for grow-out. The smaller ratio of adults organisms does not allow the assertion that the priority of the area is for reproduction. *E. gracilis* showed moderate growth (K=0.56 year^{-1}) with longevity of 5.4 years and asymptotic length of L_{∞}=195 mm.

Introduction

The family Gerreidae is made up of eight genera (Nelson, 2006), of which *Eugerres*, *Diapterus*, *Eucinostomus*, *Gerres* and *Ulaema* are all found in Mexican coastlines (Kobelkowsky, 2004). It is an interesting group of fish (known as mojarras) because of its great abundance and wide distribution in estuarine lagoon environments of tropical and subtropical latitudes (Castro-Aguirre *et al.*, 1999). In Mexico, besides being a commercially important group locally in coastal Mexican lagoons (Castro-Aguirre *et al.*, 1999; Arizmendi *et al.*, 2014), the species of this family also forms part of shrimp trawl bycatch (López-Martínez *et al.*, 2010).

In one stage of their life-cycle, the members of this family develop in mangrove ecosystems located in coastal zones with muddy, sandy, and rocky bottoms (Castro-Aguirre *et al.*, 1999; Nelson, 2006), and which show the typical characteristics of mixohaline and hyperhaline conditions. Therefore, the species of such families have an osmoregulation mechanism that allows them to inhabit this type of environment (Castro-Aguirre *et al.*, 1999). Some information at the family level is available; such as, exploitation, taxonomy,

Published by Central Fisheries Research Institute (SUMAE) Trabzon, Turkey in cooperation with Japan International Cooperation Agency (JICA), Japan

ecology, and its role within the lagoon ecosystems in the Tropical Eastern Pacific (Ramos-Lozano, 2010). Likewise, population studies have been published for some species; such as, *E. currani* (López-Martínez *et al.*, 2010) and *Diapterus brevirostris* (Gallardo-Cabello *et al.*, 2015). Nevertheless, there are species of which population research studies are scarce.

The Graceful mojarra (*Eucinostomus gracilis*) inhabits sandy and muddy bottoms in shallow coastal waters, including estuaries and mangroves with bathymetric distribution limit of up to 50 meters in depth (Froese & Pauly, 2018). The species is distributed from the limits of Southern Baja California Sur in the Pacific, including the Gulf of California to Ecuador, to the Northern Subtropical climate zone (Cortez Province + Sinaloan Gap), Northern Tropical zone (Mexican Province to Nicaragua + Revillagigedo), the Equatorial zone (Costa Rica to Ecuador + Galápagos, Clipperton, Cocos, Malpelo) and the North Temperate zone (Province of California and/or the northern Gulf of California) (Robertson & Allen, 2015). Despite wide distribution and knowledge of the species habitats, basic aspects of its biology are still unknown.

The objective of this research study was to describe the population dynamics (including abundance, distribution, reproduction, size at maturity, growth, and recruitment) in an effort to contribute to the biological knowledge of this species in a coastal lagoon of the Eastern Pacific, the northern limit of its distribution.

Materials and Methods

Study Area

The western coast of the Baja California Peninsula is located in northwestern Mexico (Figure 1) and is influenced by the California Current, which confers temperate-cold characteristics to this area. Bahía Magdalena-Almejas Lagoon System is located on the southwestern coast of the Baja California Peninsula, between 24° 16’ and 25° 45’ N and 111° 20’ and 112° 18’ W (Figure 1). This system is composed of three geomorphologically distinct zones: zone of navigation channels located to the northwest, Bahía Magdalena (883 km^2) situated in the central part of the complex, and Bahía Almejas (370 km^2) to the southwest. The lagoon system is comprised of almost 30% wetlands. The channel zone is connected to the ocean by two mouths (one of 1.9 and the other one of 1.7 km in width), while Bahía Magdalena is connected by one (5.6 km in width); and Bahía Almejas by two, one called Canal de Rehusa (2.5 km in its narrowest part) and the other Boca Barra Flor de Malva. The latter is temporal, and its amplitude and depth tend to vary (Figure 1). The

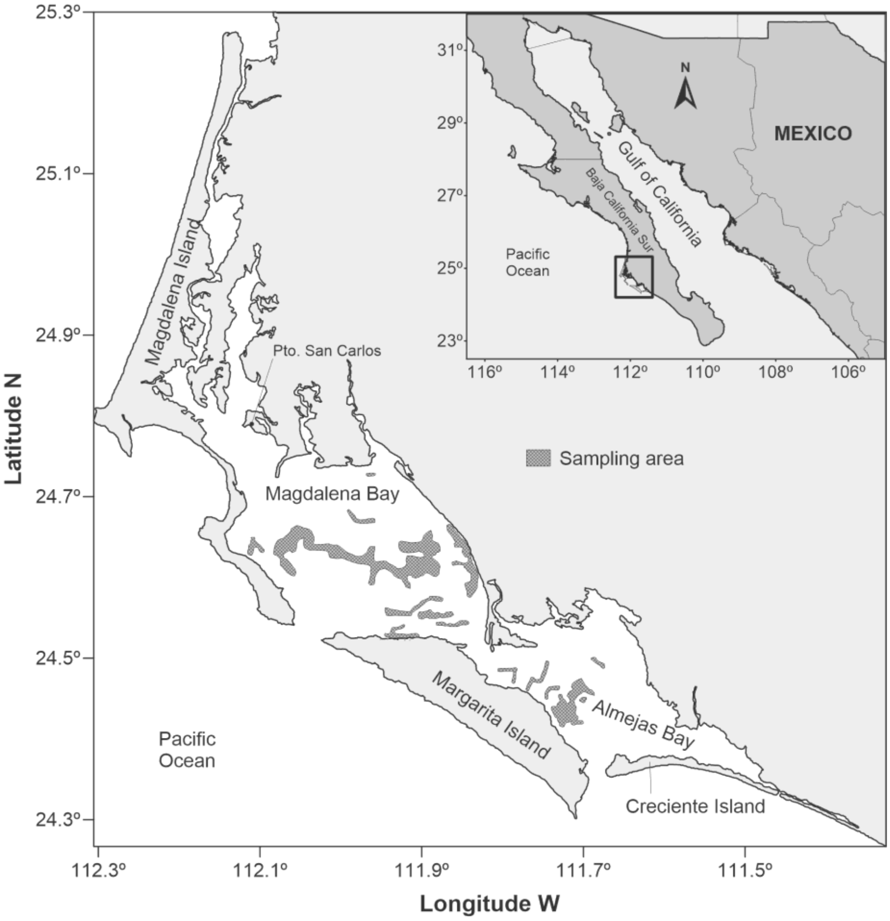

Figure 1. Location of sampling areas for *Eucinostomus gracilis* in Bahía Magdalena-Almejas Lagoon Complex, Baja California Sur, Mexico.

complex depth oscillates from 8-40 m, with the greatest depths observed in the navigation channel zone (Funes-Rodríguez *et al.*, 2007).

Samplings

Sampling was performed monthly from March to August (closed season of shrimp fishery) from 2014 to 2017 following the course detailed in figure 1. Samples were collected as part of faunal studies on board a small boat in the areas where trawling fishing could be performed. The fishing gear was a 6-17 m long headline trawl with 3.5 cm mesh opening in the body and cod-end. Trawling periods lasted 30 minutes. Once throws were performed, a maximum of 10 kg of sample was taken, even if the initial capture sample exceeded 10 kg. If the throw collected less than 10 kg, regardless of sample weight, it was recorded as a sample. The samples (fish specimens) were immediately refrigerated until subsequent processing in the laboratory. Data from throws were taken, such as duration, initial and final geographic coordinates, depth, etc.

At the laboratory, the *E. gracilis* specimens were counted and their total length (TL) and total weight (TW) were measured. Sexual maturity was determined using the morpho-chromatic scale proposed by Nikolsky (1963).

Data Analysis

Due to the fact that the various trawling nets used had different characteristics (headline length), abundance was stndardized to individuals per hectare (ind/ha^{-1}). The swept area method was used to determine the number of organisms per trawled area (Sparre & Venema, 1995). To evaluate the mean and variance of the abundance, a minimum variance unbiased estimation was followed through the Pennington Method (Pennington, 1996; Folmer & Pennington, 2000). For this analysis, the NANSIS program developed by Jeppe Kolding (Version Sept 2000) was used. The spatial analysis of abundance per year was estimated through a classed post map, using software Golden Surfer 13.

To determine the size at which 50% of the population of females and males were mature (size at maturity or $L_{50\%}$), the ratio of mature organisms was estimated by length intervals and adjusted to the logistic model (King, 2007):

$$Pi = \frac{1}{1+exp^{-r(L_i - L_{50})}};$$

here Pi is the ratio of (mature individuals)/(the total number of individuals a given size); *r* is the slope; L_i is the total length in mm and L_{50} is the length that corresponds to 50% of the mature individuals. The model was adjusted by maximizing the negative likelihood logarithm (-Log likelihood):

$$-LL = \sum_{i=1}^{n} \left[m_i ln\left(\frac{pm_i}{1-pm_i}\right) + n_i ln(1 - pm_i) + ln\left(\frac{n_i}{m_i}\right)\right];$$

where: n is the total number of individuals of class *i* and *m* is the number of mature organisms in class *i*. Confidence intervals were estimated for size at maturity based on the likelihood profiles. The x^2 distribution (Venzon & Moolgavkar, 1988) was defined as all those values of θ that satisfy the following inequality:

$$2(L(Y|\theta_{best})) < x^2_{1,1-\alpha} \text{ ; where: } L(Y|\theta_{best})$$

is the -Log-likelihood of the most probable value of θ and $x^2_{1,1-\alpha}$ is the value of x^2 with a degree of freedom at confidence level $1-\alpha$. The interval of 95 of confidence for θ extends to all the values of θ that are two times the difference between the negative likelihood of θ less than 3.84 (Haddon, 2001), using the following estimator:

$$L(Y|\theta) = L(Y|\theta_{best}) - \frac{x^2_{1,1-\alpha}}{2}.$$

The ratio male: female was estimated by month for each year. A chi-square (x^2) test was applied to determine if any statistical difference existed between the sex ratio, starting from the null hypothesis of the 1:1 ratio. To estimate the ratio of mature organisms and the size at maturity, the organisms from Phase III to V were used.

The relationship length-weight was estimated by population and sex (females and males) adjusting the potential model ($TW = a \times TL^b$), where TW is total weight (g); TL is total length; a is the intercept (condition factor) and b is the allometric coefficient. To identify data out of range before the regression analysis, the length/weight pairs of data were log-transformed (ln). Once the anomalous data were located, they were excluded from the analysis. An adjustment criterium, R^2 determination coefficient was used. A confidence level of 95% was estimated for b, and a t-student test (Zar, 2009) was performed to determine isometry (H_0: b = 3, α = 0.05). To evaluate significant differences between sexes in the relationships, a one-way analysis of covariance (ANCOVA) was performed after the assumptions of homoscedasticity of the slopes (parallelism) were found with the log-transformed data (Zar, 2009).

The average individual growth of *E. gracillis* (combined sexes) was obtained from an analysis based on sizes (TL), adjusting the Von Bertalanffy model where individual growth was a function of the parameters L_∞, *K,* and t_0. Asymptotic length (L_∞) and growth constant (*K*) were obtained through the Electronic Length Frequency Analysis II (ELEFAN II) (Gayanilo *et al.*, 1995). The parameter t_0 was obtained from Pauly's (1980) empirical equation. To emphasize the confidence of the estimated growth parameters obtained in this study and compare them with other studies of the same species, the growth function index phi prima ($\emptyset'$) was applied by the equation of Pauly and Munro (1984),

$$\emptyset' = Log10(K) + 2Log10(L_{\infty})$$

where L_{∞} and K are the estimated growth parameters.

The recruitment pattern was estimated with the ELEFAN II method, which consisted of a projection of the size frequencies backward in the time axis. This generated recruitment patterns that could be used to obtain information related to spawning season length, as well as its relative magnitude (Pauly, 1987).

Results

Abundance

A total of 1,682 specimens of *E. gracilis* were analyzed with an abundance range between 0.605 to 203.7 ind-ha^{-1}. The spatial and interannual analyses showed that this species tended to show changes in abundance depending on lagoon system zone and years. The greatest abundance was obtained in 2014 (203.7 ind-ha^{-1}) (Figure 2). Pennington distribution showed that in 2014, the months with highest abundance were March (18.7±10.6 ind-ha^{-1}) and August (12.99±7.58 ind-ha^{-1}); in 2015, July (14.88±8.15 ind-ha^{-1}) and August (12.55±7.08 ind-ha^{-1}); in 2016, May (18.1±15.2 ind-ha^{-1}) and August (17.81±12.59 ind-ha^{-1}); in 2017, April (9.88±9.64 ind-ha^{-1}) and August (15.79±12.41 ind-ha^{-1}) (Figure 3).

Reproduction and Size Structure.

E. gracilis showed an overall size range between 70-192 mm TL with an average value of 121.7±15 mm (S.D.). In females, the size range was 78-192 mm TL, with an average value of 123.3±15 mm TL and in males 80-165 mm TL, with an average value of 123.4±13.6 mm TL (Figure 4 and 5b).

The size at maturity (L_{50}) obtained for the population was L_{50} = 132.1 mm TL (Figure 4A), while the likelihood profile showed that L_{50} could be found from 130 to 134 mm in TL (Figure 4B). Size by sexual maturity showed high frequency of maturity in females of 129 mm TL (Figure 4C) with the value of L_{50} oscillating from 125.6-132 mm TL (Figure 4D). Males reached L_{50} at a

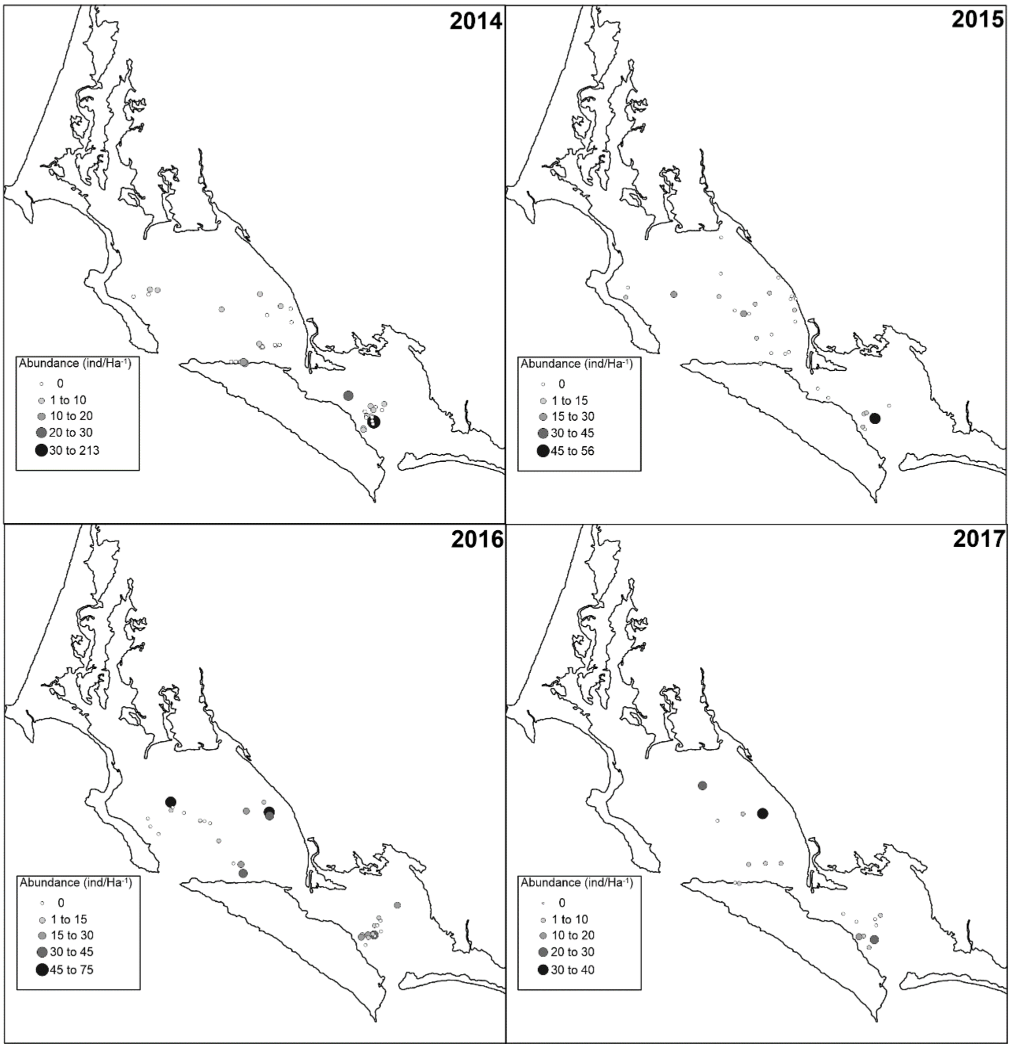

Figure 2. Spatial distribution of *Eucinostomus gracilis* abundance from 2014-2017 in Bahía Magdalena-Almejas Lagoon Complex, Baja California Sur, Mexico.

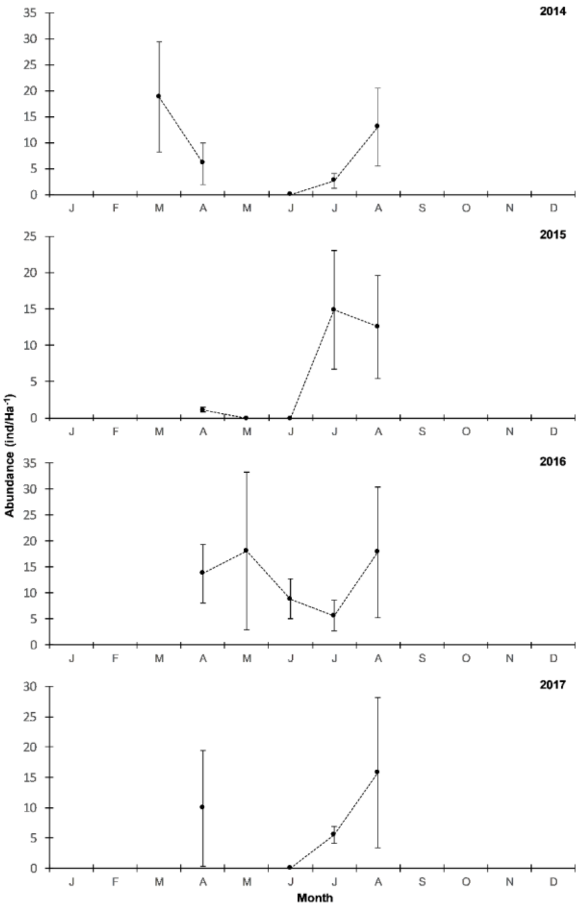

Figure 3. Abundance seasonality of *Eucinostomus gracilis*, during 4-year study period in Bahía Magdalena-Almejas Lagoon Complex, Baja California Sur, Mexico (no sampling was performed in months without data).

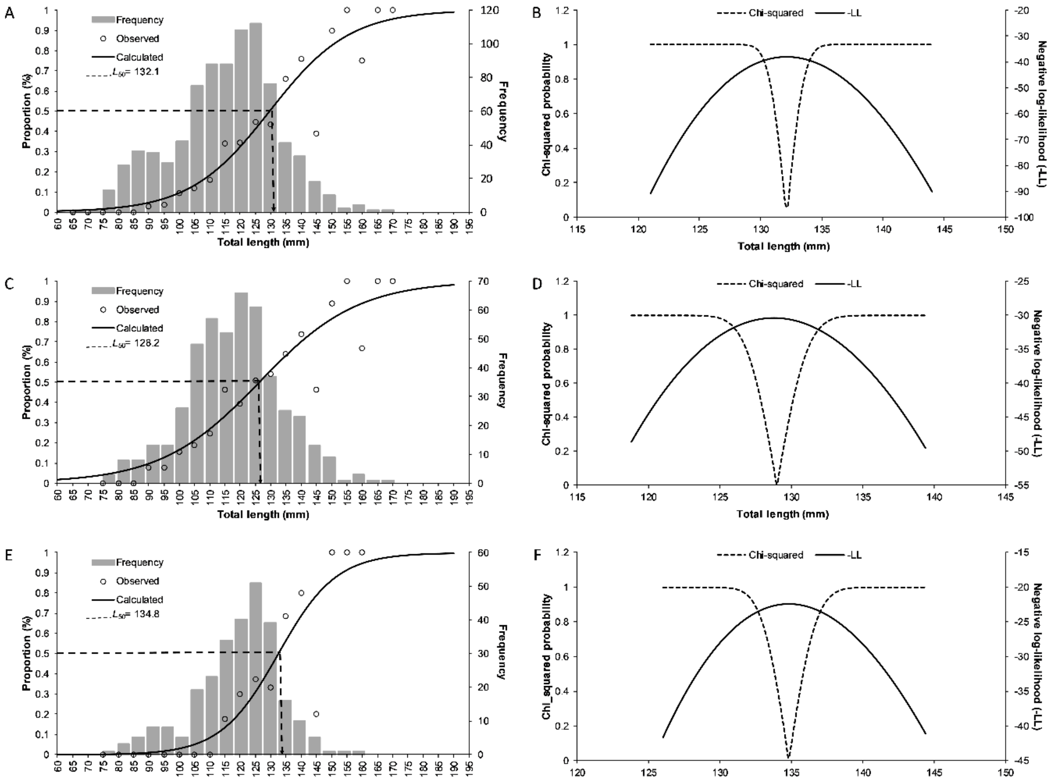

Figure 4. Size at maturity and likelihood values, Chi square and confidence intervals (95%) for *Eucinostomus gracilis* (A) and (B) both sexes, (C) and (D) females, (E) and (F) males from 2014-2017 in Bahía Magdalena-Almejas Lagoon Complex, Baja California Sur, Mexico.

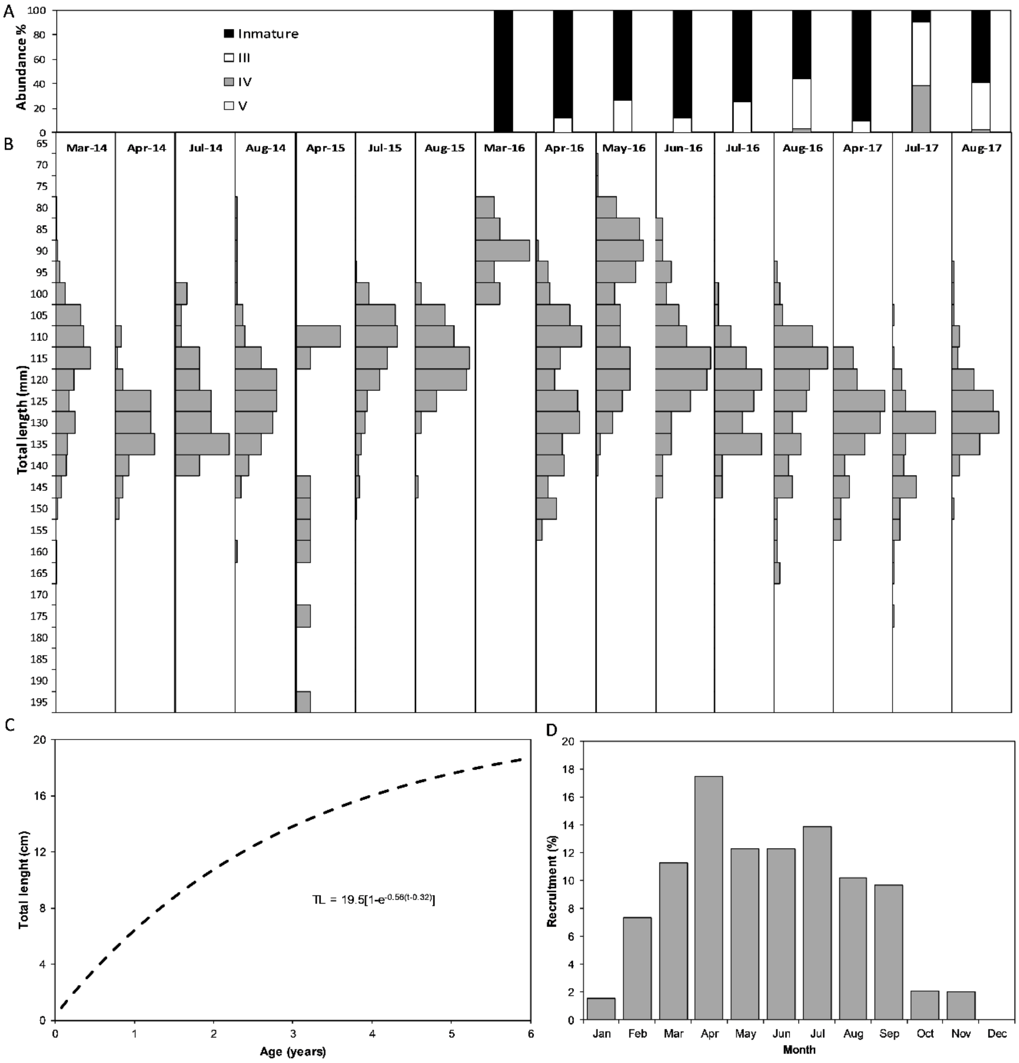

Figure 5. Abundance ratio of *Eucinostomus gracilis* in maturity stage 2016-2017 (A), size structure behavior during the whole study period (B), Growth curve (both sexes) adjusted to the von Bertalanffy model (C), and monthly recruitment pattern (D), in Bahía Magdalena-Almejas Lagoon Complex, Baja California Sur, Mexico.

greater size (134.8 mm TL) (Figure 4E) even though size at maturity could oscillate from 132 to 137.6 mm TL (Figure 4F). Considering the estimated sizes at maturity (Figure 4) of the total organisms analyzed, 18.4% were adults and 81.6% juveniles. A marked juvenile dominance was obvious during the four months from 2014 to 2017 (Table 1), but there was only a slight dominance of adults recorded in April 2015 (Table 1).

The ratio male:female showed a female dominance of 1:1.7 (x^2 = 96.4; P<0.05) in the time period analyzed (Table 1). Only a greater number of males were observed in April 2014 and July 2016, but x^2 did not show significant differences.

In 2017, the percentage of mature organisms in Phases III and IV was greater from May to August, with mature organisms in phase IV being most abundant in August (Figure 5a), indicating large scale reproduction during spring-summer. In 2016, presence of juvenile organisms was detected in March and May, while in 2015, greater sized organisms were observed in April compared with the other months (Figure 5b).

Growth, Longevity and Recruitment

The relationship TL/TW, for both sexes, with females alone and for males alone, showed a potential relationship (R^2 > 0.93). Slope *b* values were in the range of 3.07 to 3.16, which denoted a type of isometric growth in the three cases analyzed (P>0.05). The ANCOVA showed statistically significant differences in the relationship TL/TW between females and males (P<0.05). A moderate growth was observed in *E. gracilis*, *K* = 0.56/year, which corresponded to species longevity of 5.4 years (longevity = 3/*K*), L_∞ = 195 mm; t_0 = -0.32 (Figure 5c), and $\emptyset' = 4.33$. Recruitment was continuous from January to November (Figure 5d) with two maximums, one in April (17.5%) and the other one in July (13.9%).

Table 1. Ecological parameters of *Eucinostomus gracilis* in Bahía Magdalena-Almejas Lagoon Complex, Baja California Sur, México

Year	Month	N	Juv%	Adu%	M	F	M:F	x^2*Calc*	*P*
2014	March	313	85.6	14.4	89	144	1:1.6	13.0	*P=0.16**
	April	77	61.0	39.0	35	23	1:0.7	2.5	*P=0.01*
	July	37	70.3	29.7	10	24	1:2.4	5.8	*P=0.18**
	August	112	80.4	19.6	35	55	1:1.6	4.4	*P=0.25**
2015	April	11	45.5	54.5	4	5	1:1.3	0.1	*P=0.00*
	July	189	92.6	7.4	42	142	1:3.4	54.3	*P=1.03**
	August	70	98.6	1.4	34	35	1:1	0.01	*P=0.03*
2016	March	23	100.0	0.0	0	0	0:0	0.0	*P=0.01*
	April	165	71.5	28.5	53	100	1:1.9	14.4	*P=0.18**
	May	169	98.2	1.8	29	86	1:3	28.3	*P=0.40**
	June	73	89.0	11.0	16	55	1:3.4	21.4	*P=0.16**
	July	59	78.0	22.0	30	28	1:0.9	0.1	*P=0.00*
	August	91	74.7	25.3	32	54	1:1.7	5.6	*P=0.09**
2017	April	55	65.5	34.5	12	43	1:3.6	17.5	*P=0.25**
	July	72	51.4	48.6	19	53	1:2.8	16.1	*P=0.18**
	August	85	78.8	21.2	62	18	1:0.3	24.2	*P=0.36**
	Total	1601			502	865	1:1.7	96.4	*P=1.81**

Abundance (N), juvenile percentage (Juv%), adult percentage (Adu%), male abundance (M), female abundance (H), ratio male:female (M:H) calculated x^2 values (x^2 *Calc*) and *P* values (*significant diferences).

Discussion

Relevant information about some members of the family Gerreidae is available in estuarine lagoon environments. In the case of *E. gracilis* there have been studies on length-weight relationship (Ruíz-Ramírez *et al.*, 1997; Aguirre *et al.*, 2008; De la Cruz-Agüero *et al.*, 2011), however, this is the first study in the western coast of the Baja California peninsula, which contributes to knowledge of population dynamics of this species.

Species of the Gerreidae family are considered important for their richness and abundance within the lagoon ecosystems in Mexico (Ordóñez-López & García-Hernández, 2005). In a coastal lagoon in the State of Sonora, Padilla-Serrato *et al.* (2017) reported a total of five species, *Diapterus brevirostris* and *E. entomelas* were the first and third most abundant species from a total of 95 fish species reported but *E. gracilis* was not reported. In other investigations performed in the coastal lagoon of Rancho Bueno in Baja California Sur (BCS), Rodríguez-Romero *et al.* (2011) reported the Gerreidae family as one of the most important with five species. *E. gracilis* was the second most abundant from a total of 68 and showed a wide distribution within the lagoon. It is important to mention that Rancho Bueno is a coastal lagoon located in the southernmost region of the Bahía Magdalena-Almejas lagoon system, which is why the importance of this species stands out within the complex. In the mangrove system of Bahía de La Paz, BCS, during a sampling year, *E. gracilis* was considered a common species in three sequiential months and its family was found to be the most abundant (Ramos-Lozano, 2010).

Spatial distribution and abundance of Gerreidae seem to be directly linked to a characteristic habitat-type: soft-bottom areas (sandy and muddy) with mangrove presence (Robertson & Allen, 2015). Affinity towards this type of habitat makes *E. gracilis* distribution nonhomogeneous within the Bahía Magdalena-Almejas lagoon system. This distribution will depend on sediment characteristics (fine) and proximity to mangrove systems because of their food contribution (Funes-Rodríguez *et al.*, 2007). This is similar to other species such as *Eucinostomus melanopterus* and *Diapterus auratus* which distribution and spatial abundance are also influenced by food availability (Castillo-Rivera *et al.*, 2005).

On the other hand, in a bay south of Brazil, *Diapterus rhombeus* displayed adult segregation behavior with reproductive purposes in specific areas (Rodríguez da Costa *et al.*, 2012). It is possible that the spatial distribution and movements of *E. gracilis* in Bahía Magdalena-Almejas lagoon system follow similar patterns depending on other biological processes such as areas adults breeding grounds and juvenils feeding grounds.

Major abundances of the species within the lagoons have been reported monthly without a defined pattern during October and November in one study (Ramos-Lozano, 2010) and in January, May and November in another (Ayala-Pérez, 1992). In this study, the maximum abundance was between April-May and August. However, these studies are not directly comparable to more recent ones due to differences in their sampling time periods. Thus, the need to carry out studies (size and sex) that can cover the annual cycle, both within and outside of the lagoons. This will aid in, more precisely defining the pattern of presence of the species within the lagoon.

Although the size structure observed for *E. gracilis* showed the presence of juvenile and adult organisms within the lagoon system, a dominance of juveniles was observed in all the months during the 4-year research period. This behavior emphasizes the importance of the bay and lagoons as breeding areas of many fish species and members of the Gerreidae family (Tsai *et al.*, 2015; Padilla-Serrato *et al.*, 2017). Based on observations, the young organisms of *E. gracilis* use Magdalena-Almejas lagoon primarily as a nursery zone. This coincides with the findings of González-Acosta *et al.* (2005), which state that members of this family are commonly observed in lagoon systems with mangroves ecosystems which use them as nurseries and feeding areas.

As previously mentioned, not much information exists on population dynamics of *E. gracilis*, which highlights the need of generating basic knowledge for adequate management of the species. This need is emphasized in the Convention on International Trade in Endangered Species Wild Fauna and Flora (CITES https://www.iucnredlist.org/species/183543/8131874) where the need for updating species information is mentioned. Basic knowledge, such as reproductive biology, is scarce. Our study was able to note a sexual dimorphism for this species in which females were greater in length than males. Nevertheless, males mature at a greater size (Figure 4e). The size at sexual maturity reported to date for the species was 135 mm TL (Froese & Pauly, 2018), which is slightly greater than that estimated in our study (132 mm TL).

Female dominance had not been reported in *E. gracilis* even though it was reported in *Diapterus rhombeus* associated with seasonality and environmental parameters (Aguirre-León & Díaz-Ruiz, 2006). A higher sex ratio for females could potentially be the result of migration to refuge areas as a survival strategy to avoid predators or in search of greater food quantity in preparation for reproduction. In crustaceans, a greater number of females have a longer life expectancy than males, and they also tend to school in areas with greater food resources (de Souza Alves-Teodoro *et al.*, 2014).

The high percentages of mature organisms in the spring and summer of 2016 and 2017 coincide with studies of the Gerreidae family, in which reproduction tends to occur during these two seasons (Kanak & Tachihara, 2008; López-Martínez *et al.*, 2010). In some cases, reproduction is associated with high temperature and the beginning of the rainy season (Mexicano-Cintora, 1999). However, Gallardo-Cabello *et al.* (2015) recorded mature organisms of *Diapterus brevirostris* during the whole year along the coasts of Colima and Jalisco, Mexico, with a massive spawning in September and another one in February. Thus, it can be stated that *E gracilis* reproduction likely take place from April to August, which coincides with the maximum temperature of the region. López-Martínez *et al.* (2010) suggested that in the Gulf of California, the great

Table 2. Life history of *Eucinostomus spp* in some ocean regions (some lengths were converted (TL mm) when necessary)

Species	Oceanic region	Source	Sex	Length data	Min Length (mm)	Max Length (mm)	$L\infty$ (mm)	K (annual)	t_0 (yr-1)	Ø′	Sex ratio (F:M)	L50 (mm)	Life Span
E. argenteus	AO	Silva et al. 2014	F-M	TL	11.0	269.0	283.1	0.61	-0.57	2.69	ND	ND	4.9‡
E. argenteus	CS	García and Duarte, 2006	F-M	TL	55.0	164.0	205.0	0.58	ND	2.39	ND	ND	5.2‡
E. gula	CS	García and Duarte, 2006	F-M	TL	62.0	178.0	223.0	0.29	ND	2.19	ND	ND	10.3‡
E. gula	GM	Mexicano-Cintora, 1999	F-M	FL	53.0	164.0	202.6	0.41	-0.23	4.22	1.5:1	110.0	7.3‡
E. gula	GM	Aguirre-León et al. 1989	F-M	TL	ND	ND	201.0	0.50	ND	2.31	ND	ND	6.0‡
E. spp	CS	Valentine-Rose et al. 2011	F-M	SL	19.0	100.0	207.0	0.43	ND	4.3*	ND	ND	7.0‡
E. argenteus	AO	Rodrigues da Costa et al. 2018	F-M	TL	46.0	210.0	221.1	0.47	-0.38	2.36	ND	135.0	6.4‡
E. argenteus	GM	Bonilla-Goméz et al. 2013	F-M	TL	17.0	120.0	136.5	0.54	-0.37	2.00	ND	ND	5.6‡
E. gula	GM	Bonilla-Goméz et al. 2013	F-M	TL	17.6	123.3	126.0	0.68	-0.28	2.03	ND	ND	4.4‡
E. currani	GC	López-Martínez et al. 2011	F-M	TL	46.0	210.0	218.0	0.85	-0.22	4.6*	ND	142.0	3.5‡
E. argenteus	P-AO	Frose and Pauly, 2018	F-M	TL	ND	ND	202.0	0.50	-0.36	4.3*	ND	124.0	5.6
E. currani	PO	Frose and Pauly, 2018	F-M	TL	ND	ND	221.0	0.68	-0.26	4.5*	ND	135.0	4.2
E. dowii	PO	Frose and Pauly, 2018	F-M	TL	ND	ND	211.0	0.72	-0.25	4.5*	ND	129.0	3.9
E. entomelas	PO	Frose and Pauly, 2018	F-M	TL	ND	ND	190.0	0.66	-0.28	4.4*	ND	118.0	4.3
E. gracilis	PO	Frose and Pauly, 2018	F-M	TL	ND	ND	221.0	0.68	-0.26	4.5*	ND	135.0	4.2
E. gula	AO	Frose and Pauly, 2018	F-M	TL	ND	ND	214.0	0.34	-0.53	4.2*	ND	131.0	8.3
E. harengulus	AO	Frose and Pauly, 2018	F-M	TL	ND	ND	159.0	0.65	-0.30	4.2*	ND	100.0	4.3
E. havana	AO	Frose and Pauly, 2018	F-M	TL	ND	ND	190.0	0.79	-0.23	4.5*	ND	118.0	3.6
E. jonesii	AO	Frose and Pauly, 2018	F-M	TL	ND	ND	211.0	0.72	-0.25	4.5*	ND	129.0	3.9
U. lefroyi (*E. lefroyi*)	AO	Frose and Pauly, 2018	F-M	TL	ND	ND	242.0	0.63	-0.27	4.6*	ND	146.0	4.5
E. melanopterus	AO	Frose and Pauly, 2018	F-M	TL	ND	ND	315.0	0.49	-0.33	4.7*	ND	185.0	5.8
E. gracilis	NWPM	Present study	F-M	TL	70.0	192.0	195.0	0.56	-0.32	4.3	1:1.7	132.1	5.4

Oceanic regions: AO, Atlantic Ocean; CS, Caribbean Sea; GM, Gulf of Mexico; GC, Gulf of California; PAO, Pacific and Atlantic Ocean; PO, Pacific Ocean; NWPM, Northwestern Pacific Mexican (* Estimated using $Ø' = \text{Log}10(K) + 2\text{Log}(L_\infty)$, ‡ Longevity=(3/$K$), ND= not determined).

majority of fish species that are part of shrimp bycatch are synchronic in reproduction and associated with the maximum temperatures of spring and summer.

The results on the TL/TW relationship for *E. gracilis* coincide with those reported by Aguirre *et al.* (2008) and De la Cruz-Agüero *et al.* (2011) despite the smaller number (548) of data used by De la Cruz-Agüero *et al.* (2011), compare our study (1 681). In both cases, as with López-Martínez *et al.* (2010), the species shows an isometric growth. This is the first report where the TL/TW relationship has been estimated by separate sexes. In the case of females, the value of *b* was at the maximum limit of isometric growth, which was most likely because of the effect the reproductive stage has on the gonad, causing a variation in weight. This phenomenon has been observed in other groups, such as penaeidae shrimps (Fontaine & Neal, 1971). For *E. gracilis*, it is obvious that the gonad in females is greater in size than that of males; moreover, the size range was greater in females, which could influence these differences between sexes.

In the estimated growth parameters, the values of L_∞ and *K* were less than those reported in FishBase L_∞= 22.1 cm de TL and *K* = 0.68 (Froese & Pauly, 2018). The differences in both parameters were a reflection of the absence of organisms with large sizes and a dominance of small sizes, which influenced the estimations for L_∞ and *K*. According to López-Martínez *et al.* (2014), the absence of small sizes could generate an overestimation of L_∞ or a underestimation of *K*. For *E. currani*, López-Martínez *et al.* (20101) obtained a greater value for L_∞ in comparison with other studies of the same species, as a result of the presence of large sizes organisms.

Using the information of FishBase, the growth function index was calculated, obtaining a value of $\emptyset'$= 4.5, similar to that obtained ($\emptyset$ = 4.3) in our study. López-Martínez *et al.* (2011) calculated $\emptyset'$= 4.6 for *E. currani* in the Gulf of California. Pauly and Munro (1984) mentioned that this index tends to be similar among species that are close taxonomically. *Eucinostomus gula* geographically isolated with *E. gracilis* and *E. currani* showed a value of $\emptyset'$= 4.2 (Table 2), which supports the hypothesis that theese species are closely related. There are factors that could create marked differences between the index $\emptyset'$, such as habitat, the methods used to determine growth parameters, sample size, catch technique and selectivity of fishing gear, among others (Rosas-Correa & de Jesus-Navarrete, 2008).

The results of the recruitment pattern coincide with the gonad maturity data obtained in our study. The data can be used to support and confirm the reproductive period because recruitment starts in March and continue until September. The greater peak in July coincide with a greater ratio of mature organisms in July 2017. López-Martínez *et al.* (2010) used the recruitment pattern to define the reproductive period of *E. currani*, which was very similar to that obtained for *E. gracilis* (March-September). The use of recruitment to define the reproductive period is logical because recruitment and spawning are two related biological process the occurrence of new individuals in a population is maintained through recruitment as a response to reproduction.

Conclusion

The dominance of juvenile organisms of *E. gracilis* indicates that Bahía Magdalena-Almejas lagoon is used for growth purposes. The smaller ratio of adult organisms does not allow assertion that the priority of the area is for reproduction. Further studies are necessary to compare the presence of adults of *E. gracilis* and their maturity stage outside the lagoon during the months of maximum spawning. *E. gracilis* presents a reproductive period between spring and summer with greater activity in July and August, which is supported by the the recruitment pattern.

Acknowledgments

The authors appreciate the support of Instituto Nacional de Pesca y Acuacultura, specifically the Project Camarón de Baja California Sur 2014-2018 in CRIAP La Paz, B.C.S. for the funds provided to carry out this research study. JLM is grateful for the Project SEP CB 2015- 256477. JGPS is grateful to the Cátedras-CONACYT program. D. Fischer provided translation and English editorial services. JDM is appreciative of Karen Link's English editorial services.

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