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Size-Structured Method Applied to the Brown Crab Fishery *Callinectes bellicosus* in the Gulf of California

Gilberto Genaro Ortega-Lizárraga [1], Horacio Alberto Muñoz-Rubí [1], Guillermo Rodríguez-Domínguez [2], Raúl Pérez-González [2], Jaime Edzael Mendívil-Mendoza [3,*] and Eugenio Alberto Aragón-Noriega [4,*]

1 Centro Regional de Investigación Acuícola y Pesquera, Instituto Mexicano de Investigación en Pesca y Acuacultura Sustentables, Calzada Sábalo-Cerritos s/n, col. Estero El Yugo, Mazatlán 82000, Sinaloa, Mexico; gilberto.ortega@imipas.gob.mx (G.G.O.-L.); horacio.munoz@imipas.gob.mx (H.A.M.-R.)
2 Facultad de Ciencias del Mar, Universidad Autónoma de Sinaloa, Paseo Claussen S/N, Mazatlán 82000, Sinaloa, Mexico; guirodom@uas.edu.mx (G.R.-D.); raulp@uas.edu.mx (R.P.-G.)
3 Departamento de Ingenierías, Campus Valle del Yaqui, Tecnológico Nacional de México, Bácum 85276, Sonora, Mexico
4 Unidad Guaymas del Centro de Investigaciones Biológicas del Noroeste, Km 2.35 Camino al Tular, Estero de Bacochibampo, Guaymas 85454, Sonora, Mexico
* Correspondence: jmendivil.mendoza@itvy.edu.mx (J.E.M.-M.); aaragon04@cibnor.mx (E.A.A.-N.)

Abstract: The crab fishery of the genus *Callinectes* is one of the most important fisheries in Mexico. Sonora and Sinaloa are the states on the eastern coast of the Gulf of California, the mainland coast. Sinaloa encompasses the greatest production in Mexico of these species, in particular the Bahía Santa Maria La Reforma (BSMR), supplying the most important catches. A mandatory administrative document for the fishery is the Management Plan of Crab. One of the main weaknesses found in it for Sonora and Sinaloa is the lack of fishery assessment in both states. For this reason, a size-structured method called CASA (Catch-at-Size Analysis) was applied in the BSMR, in the seasons 2000, 2011, and 2014, to *C. bellicosus*. The first catch size (CW50%) estimated for females was 97.5, 102.5, and 100 mm, while in males, it was estimated at 117.5, 107.5, and 102.5 mm. In the specific case of fishing mortality (F), the algorithm allowed us to find that in the larger sizes, a greater fishing pressure is applied for both females and males, yielding a weighted exploitation rate of 0.047 (2000), 0.119 (2011), and 0.426 (2014) for females and 0.045 (2000), 0.295 (2011), and 0.132 (2014) for males, all below 50% (E = 0.50). The crab *C. bellicosus* in BSMR is not at risk of overexploitation.

Keywords: Baranov's equation; CASA model; exploitation rate; fishing mortality

Key Contribution: This study was conducted using Catch-at-Size Analysis (CASA) for stock assessment of a crab fishery in Bahía Santa Maria La Reforma, Sinaloa, Mexico. The main result is that the crab fishery in Bahía Santa María La Reforma in Sinaloa state of Mexico is not at risk of overexploitation.

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1. Introduction

The incorporation and development of the swimming crab fishery in Mexico have grown gradually, due to its high export demand in its different forms [1], generated mainly by the decrease in catches of the blue crab (*Callinectes sapidus*) fishery in the United States. Reference [2] explained how the decline in blue crab catches impacted the families and economy in the East coast of USA. In the same way, Reference [3] analyzed the decrease in blue crab on the coast of Virginia and Maryland. In recent years, in Mexico, the crab fishery of the genus *Callinectes* (Stimpson, 1860) has become very relevant, reaching more than 28,000 tons in 2008 in total for the country. Sinaloa is the main producer with more than 40% in 2013 [4]. The presence of *C. toxotes* (Ordway, 1863), *C. arcuatus* (Ordway, 1863), and *C. bellicosus* (Stimpson, 1859) has been observed on the Mexican Pacific coasts; however, the latter two species generate almost the total amount of commercial catches in Sonora and Sinaloa. *C. bellicosus* accounts for 57% of catches in Sinaloa and 95% in Sonora [5]. In Sinaloa, the main landings are recorded in the fishery offices of La Reforma, Los Mochis, and Guasave, exceeding 1000 tons in 2012.

C. bellicosus, the brown swimming crab, is a portunid crustacean of high commercial value in northwestern Mexico. It has a complex life cycle in which the early larval stages are planktonic, and juveniles and adults inhabit mainly soft bottoms near the coast or in coastal lagoons and estuaries, and they are capable of swimming for short periods [6]. Along the coast of Sonora, in the eastern Gulf of California, the spawning season of *C. bellicosus* spans from March to September with a peak in June. Gravid females move from inside coastal lagoons and estuaries to nearby open marine waters where they release between one and three million eggs. Over a period of 65 to 70 days prior to settlement, swimming crab larvae are planktonic and are subjected to drift in sea currents. Reference [7] showed a clear latitudinal gradient in both genetic diversity and effective population size, as well as in the role of sites along the Sonora state coast as either sources (southern sites) or sinks (northern sites) of *C. bellicosus*. These results support the presence of a predominantly asymmetric metapopulation structure that could be explained by larval drift in the northward current along the Sonoran coast during the spawning period of the brown swimming crab in the Gulf of California.

In the Mexican Pacific, different types of fishing gear such as traps, rings, punches, and hooks are used to catch crabs [8]; however, the Official Mexican Standard (Nom-039-PESC-2003) prohibits the use of gillnets, snoops, and cast nets to avoid harming commercially and ecologically important species such as *Sphoeroides annulatus* and *Epinephelus analogus*. In the case of Bahía Santa Maria La Reforma (BSMR), crabs are captured with a simple crab ring, and to a greater extent, the modified simple ring, which consists of a roof that acts as a trap during extraction [9]. However, a lack of fishery evaluation and biological monitoring of crabs in Sinaloa and Sonora has been identified as a major issue. Therefore, the use of size-structured methods is more relevant than age-structured models. Size-structured methods do not require information by age group, but rather by size, and they do not require long time series [10]. These methods use von Bertalanffy growth to describe changes in population abundance over time. This is incorporated into a catch-at-length algorithm with a non-linear least-squares approach to estimate relative abundance, fishing mortality, selectivity, and the parameters of maximum asymptotic length ($L\infty$) and growth rate (k) by von Bertalanffy. Then, the objective of this study was to estimate the selectivity, fishing mortality, and exploitation rate of *C. bellicosus* in BSMR, using a method structured in sizes called CASA (Catch-at-Size Analysis), to evaluate the resource in terms of size and determine the state of health in which it is found.

2. Materials and Methods

The BSMR is located on the eastern coast of the Gulf of California, between parallels 24°43′ and 25°15′ N and meridians 107°55′ and 108°23′ W (Figure 1). It has a coastline axis of more than 70 km and is the largest lagoon system in Sinaloa, covering more than 47,000 hectares [11].

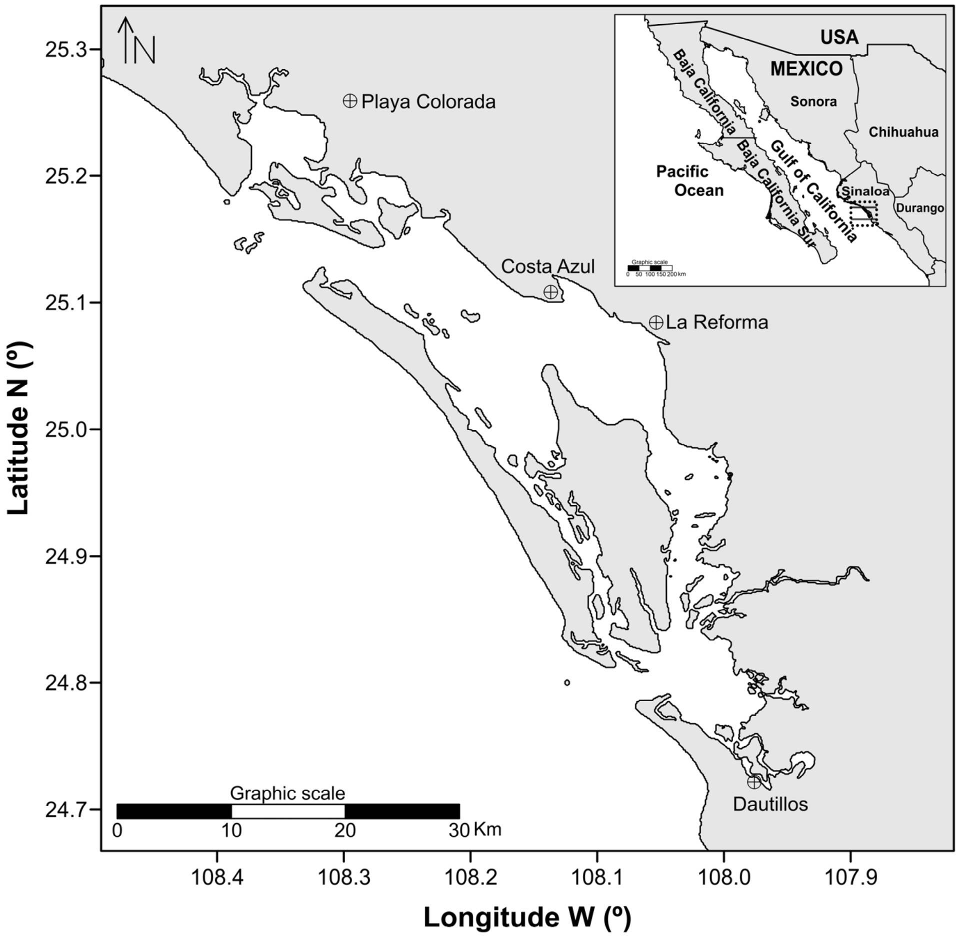

Figure 1. Study area, Bahía Santa María La Reforma, Sinaloa, Mexico.

Crab samples of *C. bellicosus* were collected in BSMR during the 2000, 2011, and 2014 fishing seasons. It is important to note that these are fishery-dependent data and do not come from a survey or experiment. The crabs were obtained on-board commercial fishing boats using a simple crab ring or the modified double ring, which has a roof that functions as a trap during extraction. Commercial fishers obtain bait in the evening prior to fishing, as they begin their activities early in the morning. Typically, only two fishers operate a small vessel and the fishing gear, which may consist of rings or traps. Occasionally, three fishers may be involved. After baiting the ring, fishers wait for approximately two hours before raising the gear. In the present study, a technician was always present on these small vessels to ensure that data were collected according to the survey plan. The organisms' size was measured, and information was collected on the crab fishery catches in the area. The method proposed by [10] was used, which refer to the relationship between catches ($C_{l,t}$) for a size class (l) over time (t) and the number of individuals in the population in that size and time class ($N_{l,t}$) through a height-based exploitation rate ($\mu_{l,t}$). So, the general Baranov's capture equations [12,13] in terms of t and l are shown as

$$C'_{l,t} = \mu_{l,t} N_{l,t}, \tag{1}$$

where $\mu_{l,t}$ represents the proportion of individuals of l and t that die from fishing mortality ($F_{l,t}$). Since $\mu_{l,t}$ is dependent on $F_{l,t}$ and the total mortality rate in l and t ($Z_{l,t}$), the following relationship is established:

$$\mu_{l,t} = \frac{F_{l,t}}{Z_{l,t}} (1 - e^{-Z_{l,t}}), \tag{2}$$

According to the assumption in [14], $F_{l,t}$ is a function of fishing gear selectivity and fishing effort, but as $F_{l,t}$ is not the instantaneous fishing mortality rate but rather the annual harvest rate, $F_{l,t}$ is inverted as the negative of log(1 − h) and separable as the product of size-class-specific selectivity coefficients (s_l) and the instantaneous fishing mortality rate of fully recruited organisms over time (f_t).

$$F_{l,t} = s_l f_t, \tag{3}$$

s_l is explained as the fraction of organisms of the size class exposed to the total effect of fishing mortality, represented by a logistic function [15]:

$$s_l = \frac{1}{1 + \alpha_s e^{-\beta_s l}}, \tag{4}$$

The total mortality of organisms in the size class over time ($Z_{l,t}$) is the sum of instantaneous fishing mortality rate plus natural mortality:

$$\begin{aligned} Z_{l,t} &= F_{l,t} + M_{l,t}, \\ &= s_l M_{l,t}, \end{aligned} \tag{5}$$

The relationship between the number of individuals at the time ($N_{l,t}$) and the number present at a later time ($N_{l,t'}$) is described in terms of the number of crabs, of the same size that survived, and is reduced only by mortality:

$$N_{l,t'} = N_{l,t} e^{-Z_{l,t}}, \tag{6}$$

For growth, the growth parameters of [16] calculated by [17] were used, for BSMR separated by sex. Using a gamma distribution to represent the variation in growth for its versatility and flexibility, in terms of α_Δ and β_Δ [18]:

$$g(v|\alpha_\Delta, \beta_\Delta) = \frac{1}{\beta_\Delta^{\alpha_\Delta}\Gamma(\alpha_\Delta)} v^{\alpha_\Delta - 1} e^{\frac{-v}{\beta_\Delta}}, \tag{7}$$

where v represents Δ_l (the increase in growth, which was originally in the size class). The mean of the change in length is given by $\overline{\Delta}_l = \alpha_\Delta\beta_\Delta$ and the variance is given by $\sigma_\Delta^2 = \alpha_\Delta\beta_\Delta^2 = \beta\overline{\Delta}_l$, which is proportional to the mean. In this expression, $\beta\overline{\Delta}_l = \alpha_\Delta\beta_\Delta\sigma_\Delta^2 = \alpha_\Delta\beta_\Delta^2 = \beta\overline{\Delta}_{l\Delta}$ is also the coefficient of variation which is used to incorporate the variability in the growth of the individual in the population. Given l^* and β_Δ, the parameters α, Δ, and, consequently, $\sigma_\Delta{}^2$ are a function of the parameters $L\overline{\Delta}_l$ and k of von Bertalanffy's growth model.

In a period of change, individuals in one size class may remain in the same size class or settle down to a larger size due to growth. To represent this change in growth, the following expression was used:

$$P_{l,l'} = \int_{l_1}^{l'_2} g(v|\alpha_\Delta\beta_\Delta)dx, \tag{8}$$

Any individual who enters a size class with an average height greater than the maximum cephalothorax width (CW_∞) will remain in the same size class.

$N_{l',t'}$ was then calculated from [19]:

$$N_{l',t'} = \sum\nolimits_l P_{l,l'} N_{l,t} e^{-Z_{l,t}}, \tag{9}$$

Finally, recruitment to the fishery was incorporated into the previous equation:

$$N_{l',t'} = \sum\nolimits_l P_{l,l'} N_{l,t} e^{-Z_{l,t}} + R_{l',t'}, \tag{10}$$

Recruitment to the fishery can occur over a range of size classes. Recruitment expressed in this way represents the type of recruitment observed in nature, where variation in growth, behavior, or food supply can result in individuals entering the main nucleus of the population at various sizes [20].

Recruitment was separated into a time-dependent variable (R_t) and a height-dependent variable (p_l), which represents the proportion of recruits who will go to each size class:

$$R_{l,t} = R_t p_l, \tag{11}$$

The linear transition from the number of individuals in the size class at time (t) to the number of individuals in the posterior height class (l') at a later time (t') can also be written in matrix notation:

$$\begin{bmatrix} N_{1,t'} \\ N_{2,t'} \\ \cdot \\ N_{l,t'} \\ \cdot \\ N_{n,t'} \end{bmatrix} = \begin{bmatrix} P_{1,1} & 0 & & & 0 \\ P_{1,2} & P_{2,2} & \times P_{l,l} & & \\ \cdot & \cdot & & \times & 0 \\ P_{1,n} & P_{2,n} & & P_{n-1,n} & P_{n,n} \end{bmatrix} \times \begin{bmatrix} S_{1,t} & 0 & & & 0 \\ 0 & S_{2,t} & \times & & \\ & & & S_{l,l} \times & 0 \\ & 0 & & 0 & S_{n,t} \end{bmatrix} \begin{bmatrix} N_{1,t} \\ N_{2,t} \\ \cdot \\ N_{n,t} \end{bmatrix} + \begin{bmatrix} R_{1,t} \\ R_{2,t} \\ \cdot \\ R_{n,t} \end{bmatrix}, \tag{12}$$

where $S_{l,t}$ represents exponential survival ($e^{-Z_{l,t}}$). In the same way, the capture equation can be expressed in matrix form:

$$\begin{bmatrix} C_{1,t} \\ C_{2,t} \\ \cdot \\ C_{l't} \\ \cdot \\ C_{n,t} \end{bmatrix} = \begin{bmatrix} \mu_{1,t} & 0 & & & 0 \\ 0 & \mu_{2,t} & \times & & \\ & & & \mu_{l,t} \times & 0 \\ 0 & & & 0 & \mu_{n,t} \end{bmatrix} \times \begin{bmatrix} N_{1,t} \\ N_{2,t} \\ \cdot \\ N_{n,t} \end{bmatrix}, \tag{13}$$

The model parameters were estimated using an approximation that minimizes the square residuals of the target function:

$$RSS_{captura} = \sum\nolimits_{l,t} \left(C'_{l,t} - C_{l,t}\right)^2 \tag{14}$$

where $C'_{l,t}$ is the catch at the estimated size and $C_{l,t}$ is the catch at the observed size over time (t). The observed data are the captures in number of organisms by specific size classes, taken at equal time intervals. The parameters were obtained by minimizing the squared residuals by means of Newton's direct search algorithm [10,21].

3. Results

Figure 2 shows the CASA model fitted to the catch-at-size: the observed frequencies of catches of the artisanal fleet of BSMR, for females and males in 2000, 2011, and 2014, and the frequencies estimated with the model. For the 2000 harvesting season, more females than males were caught in the size range of 87.5 to 127.5 mm, although males dominated in sizes greater than 127.5 mm. The beta value of the growth transition matrix (βΔ) is small, showing narrow size ranges on which fishing pressure is exerted. The values of this parameter ranged from 0.47 for females to 0.38 for males. Size ranges for the 2011 capture season were wider in females than in males (between 85 and 132 mm); yet, recorded catches were higher for males. The βΔ parameters were higher in females than in males, ranging from 1.54 to 0.146, respectively. During the 2014 season, the size range in males was wider than in females with values between 75.5 and 172.5 mm and between 77.5 and 137.5 mm, respectively. However, females had higher capture rates than males between 99 and 125 mm. A higher βΔ was determined in females than in males, between 0.928 and 0.753, correspondingly.

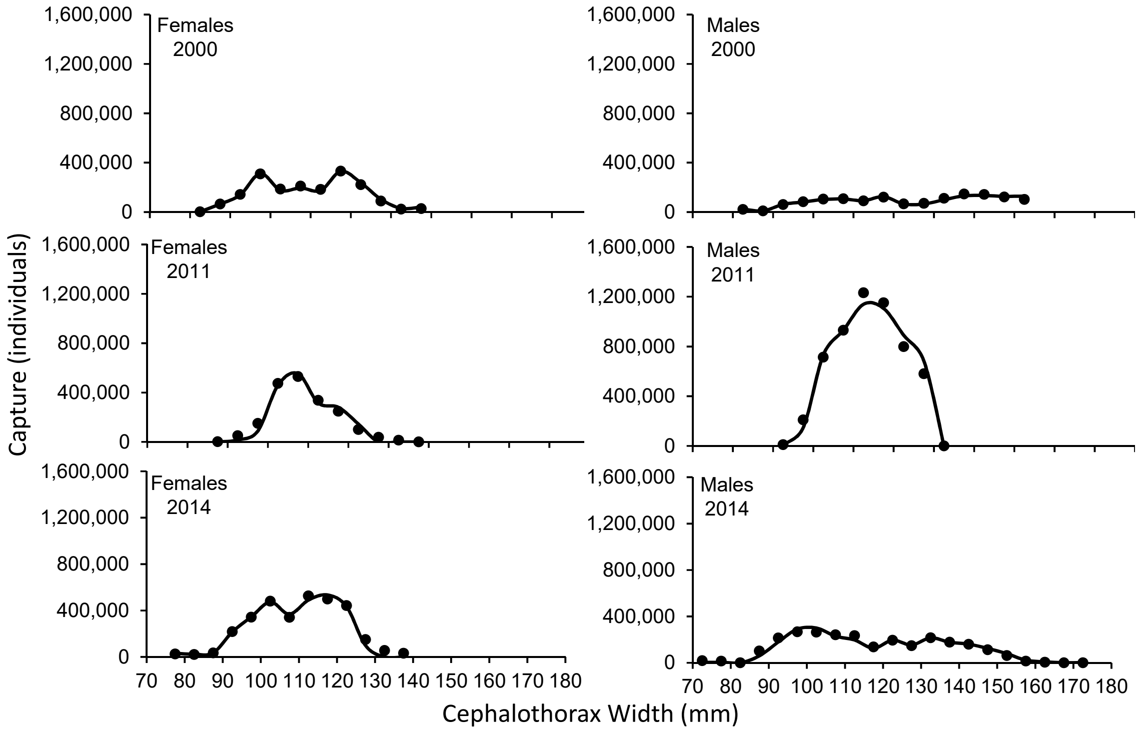

Figure 2. CASA model (line) fitted to the observed catch data (points) of *Callinectes bellicosus* in the artisanal fishery of the Bahía Santa María La Reforma, Sinaloa. Left column are females and right column males. The rows are ordered from top to bottom from 2000 to 2014. In text is an explanation for each subplot.

In general, $\mu_{l,t}$ increases with crab size in both sexes. However, in 2011 females and 2014 males, the exploitation rate increased with size, but then decreased at the largest sizes recorded. The $F_{l,t}$ also tended to increase with the size of the crabs in both sexes, and then decrease towards the larger sizes recorded (Appendix A Table A1).

For the s_l of *C. bellicosus* in the 2000, 2011, and 2014 seasons, a reduction in the size of the first capture of males was observed between 2000 and 2014, while in females, it increased from 2000 to 2012 and then decreased again around 2014 (Figure 3). Fishing pressure was exerted on the largest sizes, in both sexes and during the three seasons analyzed. The average fishing mortality for females in 2000 was F = 0.112, while for males, it was F = 0.117. For the 2011 season, the average fishing mortality for females was F = 0.257, while in males, it was F = 0.560. In the 2014 season, F = 1.639 and 0.287 were determined for females and males, respectively (Figure 4).

The exploitation rate for 2000 indicates that the highest extraction is found in the size ranges of 117.5 to 137.5 mm (female–male) and 137.5 to 152.5 mm (female–male), with $\mu_{l,t}$ less than 50% for both females and males. However, for the 2011 season, the highest catch is found in the size ranges of 117.5 to 137.5 mm (female–male) and 112.5 to 132.5 mm (female–male), with $\mu_{l,t}$ greater than 50% for males between 127.5 and 132.5 mm. For the 2014 fishing season, females with size ranges between 112.5 and 135 mm had higher catches and a $\mu_{l,t}$ greater than 50%. In males, sizes between 122.5 and 172.5 reveal higher catches without reaching a $\mu_{l,t}$ greater than 50% (Figure 5). The weighted exploitation rate of all size groups in each season was 0.047 (2000), 0.119 (2011), and 0.426 (2014) in females and 0.045 (2000), 0.295 (2011), and 0.132 (2014) in males.

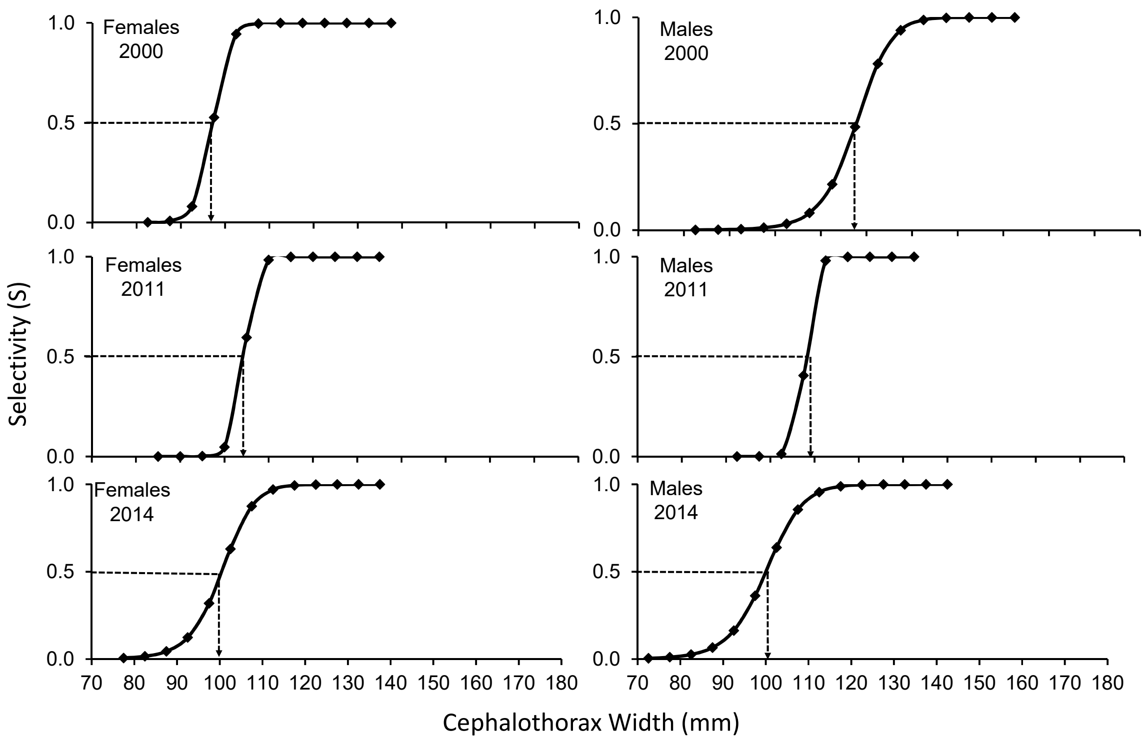

Figure 3. Selectivity of *Callinectes bellicosus* in artisanal fishing of the Bahía Santa María La Reforma, Sinaloa. Left column are females and right column males. The rows are ordered from top to bottom from 2000 to 2014. In text is an explanation for each subplot.

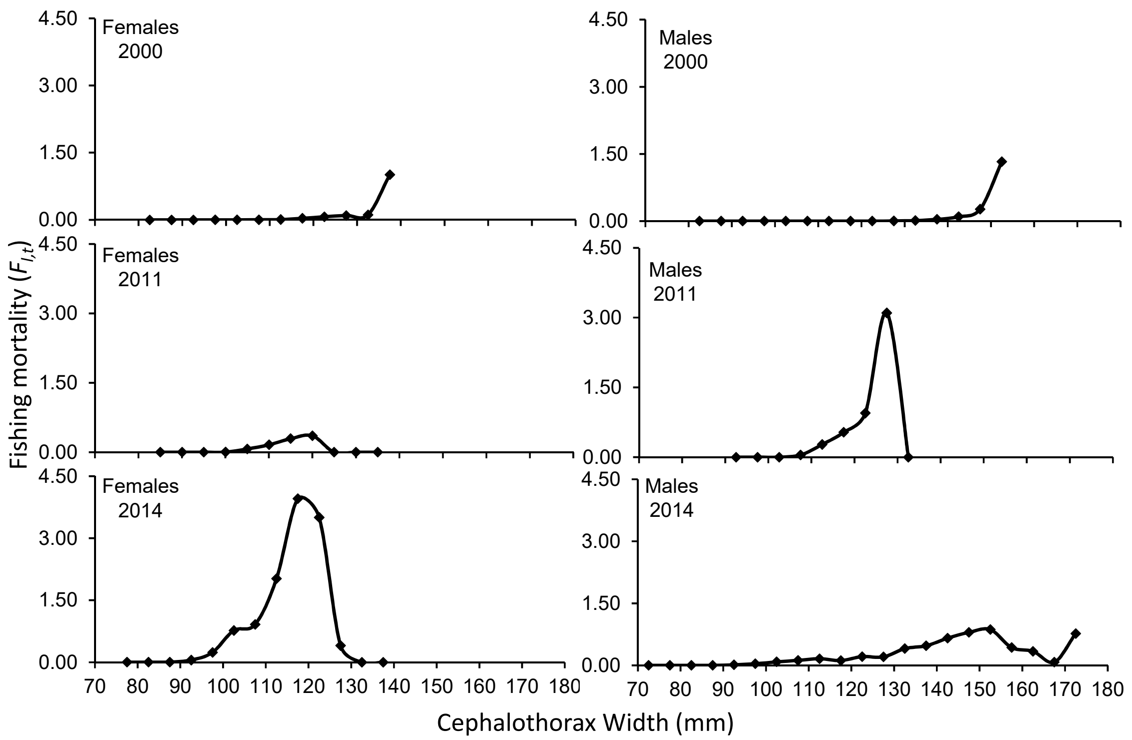

Figure 4. Instantaneous fishing mortality rate at size of *Callinectes bellicosus* in artisanal fisheries of the Bahía Santa María La Reforma, Sinaloa. Left column are females and right column males. The rows are ordered from top to bottom from 2000 to 2014. In text is an explanation for each subplot.

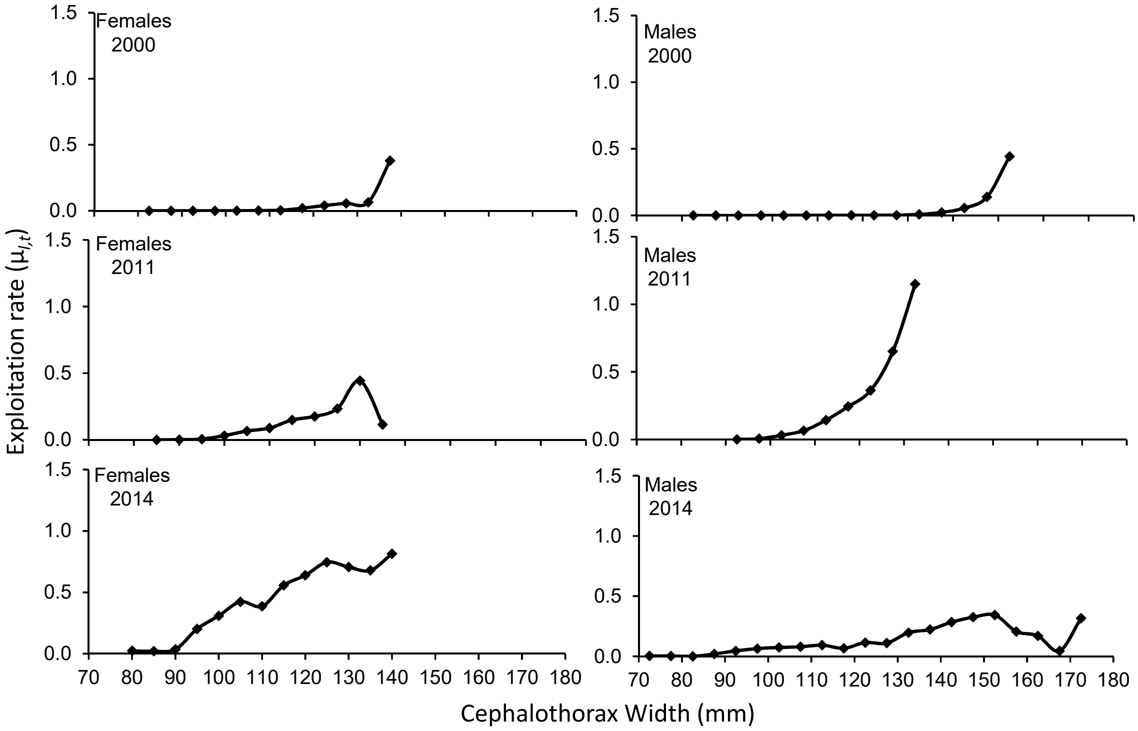

Figure 5. Exploitation rate at size of *Callinectes bellicosus* in artisanal fishing of the Bahía Santa María La Reforma, Sinaloa. Left column are females and right column males. The rows are ordered from top to bottom from 2000 to 2014. In text is an explanation for each subplot.

4. Discussion

The size structures of *C. bellicosus* captured during the 2000, 2011, and 2014 seasons differed, resulting in variations in exploitation rates, instantaneous fishing mortality rate, and selectivity. A decrease in the number of larger organisms was observed during the male capture seasons from 2000 to 2011, which appeared to be due to overfishing of growth, specifically the capture of young organisms. During the 2000, 2011, and 2014 seasons, the estimated selectivity for females in the fishing period revealed that the size of the first catch (CW50%) was determined at 97.5 mm CW. This indicates that the captured organisms have not yet reached the size of first maturity (CW50% = 103.73 mm) in the BSMR, as reported by [22]. Therefore, there is a high risk of growth overfishing [23], which occurs when juveniles of the target species are captured before reaching size-at-maturity. In males, the effect of CW50% in the 2000 and 2011 seasons began after reaching the first maturity height proposed by [22] (117.5 and 107.5 mm, respectively), which was higher than the CW50% determined at 102.5 mm in the 2014 season. However, studies on *C. bellicosus* have shown that they can mature to smaller sizes ranging from 51 and 112.4 mm on the Mexican Pacific coasts [17,22,24], which could have a significant impact on the stock of broodstock and, therefore, the resource's capacity to renew. The average instantaneous fishing mortality rate for the 3-year period was 0.67 for females (F_{2000} = 0.112, F_{2011} = 0.257, F_{2014} = 1.639) and 0.32 for males (F_{2000} = 0.117, F_{2011} = 0.560, F_{2014} = 0.287), which was lower than that reported by [22,25] at an estimated instantaneous fishing mortality rate between 1.1 and 1.37, 1.92 and 1.13, and 1.06 and 1.62, respectively. However, the instantaneous fishing mortality rate by size range reaches up to 4.85 (122.5 mm) in females and 3.10 in males (127.5 mm), which are the main contributors to catches in 2011. The exploitation rates of over 70% and 60% in each age group initially caused a negative effect on the length at first maturity [26]. In the 2014 season, the weighted exploitation rate was 0.426, which is similar to the rate reported by [22] for the same region in females, but differs in males (0.132) with a higher exploitation rate (0.34). Similarly, in BSMR, the predictive model developed by [27] was utilized to determine the maximum sustainable yields and assess overfishing by analyzing the yield and biomasses at different levels of fishing mortality. This study found that female crabs (*C. bellicosus*) were above their maximum sustainable yield. In the present work, the exploitation rate exceeded 0.5, resulting in a decrease in population size [28]. Male crabs were found to be below the maximum sustainable yield (E < 0.5). It is worth mentioning that the catches of *Callinectes* sp. during the 2003 season in BSMR were no more than 300 tons, which is lower than the reported amount in 2014 (3978 tons). The authors of [22] conducted studies in regions such as Bahía Navachiste and BSMR using various methods and concluded that these areas are relatively healthy [6], which is consistent with the findings of this study.

In the studies of [6,22], prior values of r were between 0.6 and 1.5, which are default values suggested by [29] for highly resilient species. This method is known as Catch-MSY, which is characterized by being a simple method for estimating MSY and defining a reasonable prior range for the parameters of the Schaeffer model. In the studies of [6,22], prior values of r were between 0.6 and 1.5, which are default values suggested by [29] for highly resilient species. Although no estimates of r for *C. bellicosus* exist, some reported life history parameters, such as age at 50% maturity ($L_{50\%}$) and growth rate (k) from a von Bertalanffy Model, are consistent with those of a resilient species. According to FishBase, highly resilient fishes are classified as those with $k > 0.3$ year^{-1} and $L_{50\%} < 1$ year. Therefore [6], it can be concluded that the crab fishery in Sinaloa state is at its limit of sustainability, while [6,22] mentioned that the crab fishery is at risk of overexploitation. The latter argument is consistent with the findings of the present study which concluded similar results using a different method, the CASA model. This is because the values of the weighted exploitation rate did not exceed 0.5 (E < 0.5).

All methods used to manage fishery stocks have limitations, and assessing stock biomass can be expensive. Therefore, studies such as the present crab stock assessment can be conducted using fishery-dependent data collections. Fishery-independent and fishery-dependent data are the two important sources of information used by fishery scientists for stock assessment. However, fishery-dependent data are determined by where fishers choose to fish. It is important to note that the data presented in this study may not be representative, due to the collection method used. Fishery-dependent data are influenced by fishery behavior, which can lead to potential issues [6]. To manage crab fisheries in the Gulf of California, where data-poor stocks are common and sustainability is desired, a simple method such as the Catch-MSY method proposed by [29] can be useful [22]. In the present study, the CASA method was applied to the crab fishery in BSMR. The results indicated that the crab fishery in this coastal lagoon in Sinaloa state, Mexico, was not at risk of overexploitation. After conducting a literature review, we support the use of the CASA method because it employs structured sizes instead of age for a robust biomass analysis. References [6,22] mentioned that the management strategy for a crab fishery is the catch quota. Thus, a catch quota of 5500 tons was recommended for the fishery in Sinaloa; however, because the stock biomass was below B_{MSY}, a lower catch quota was recommended until the crabs' biomass recovered above the benchmark. Precautionary catch quotas of 3500 tons and 1171 tons are recommended for the Sonoran stock and for BSMR, respectively. Reference [22] mentioned that if the recommended catch quota for the Sinaloa stock is divided by zones based on how catches contributed to the overall production of the state, a catch quota of 1100 tons would correspond to a BSMR like that obtained in the stock assessment for BSMR separately. This finding is significant for the management of crab fisheries in the region and nationally. To prevent overfishing, knowledge of population biology is fundamental. The results presented in this study support the conservation of the species under study, making it relevant to fisheries' biologists, managers, and decision makers. This study shows that the fishery was healthy from 2000 to 2014. Any future study analyzing years after the period presented here should note the absence of overfishing problems during that time. It is important to remember that in organisms with short life cycles and high fishing pressure, the biological processes of a particular year determine the stock's abundance in subsequent years. This principle applies to crabs of the Portunidae family in the Gulf of California. Since 1982, the brown crab C. bellicosus has become the focus of an important commercial fishery in Mexico, particularly in the eastern Gulf of California, where a small-scale fishery for these crabs has been established [22]. To reduce the risks of adverse economic and social effects in this fishery, it is essential to continue gathering biological studies, even if they are assessed from fishery-dependent data.

5. Conclusions

The fishing mortality of the brown crab *C. bellicosus* was relatively low during the sampling seasons, which had a favorable impact on the reproductive stock and the renewal capacity of the resource. As a result, the crab fishery in Santa María La Reforma Bay in the state of Sinaloa, Mexico, was not at risk of overfishing during the 2000–2014 fishing period. This statement is relevant for stock assessment because future studies for years after the reported period (2000–2014) may yield different results. It is important to note that during this period, the fishery was healthy.

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Appendix A

Table A1. Outputs of the CASA model for *Callinectes bellicosus* from the Bahía Santa María La Reforma, Sinaloa, where CW is the carapace width, $\mu_{l,t}$ is the exploitation rate, $F_{l,t}$ is fishing mortality, and s_l is the coefficient of selectivity.

2000						
	Females			Males		
Size (CW)	$\mu_{l,t}$	$F_{l,t}$	s_l	$\mu_{l,t}$	$F_{l,t}$	s_l
82.5	0.000	0.000	0.001	0.000	0.000	0.001
87.5	0.000	0.000	0.008	0.000	0.000	0.002
92.5	0.000	0.000	0.080	0.000	0.000	0.004
97.5	0.001	0.001	0.527	0.000	0.000	0.011
102.5	0.001	0.001	0.945	0.000	0.000	0.029
107.5	0.002	0.003	0.997	0.000	0.001	0.080
112.5	0.004	0.007	1.000	0.001	0.001	0.215

Table A1. *Cont.*

2000						
	Females			Males		
Size (CW)	$\mu_{l,t}$	$F_{l,t}$	s_l	$\mu_{l,t}$	$F_{l,t}$	s_l
117.5	0.020	0.034	1.000	0.001	0.002	0.484
122.5	0.040	0.069	1.000	0.001	0.002	0.782
127.5	0.056	0.098	1.000	0.003	0.004	0.940
132.5	0.064	0.114	1.000	0.008	0.014	0.987
137.5	0.380	1.012	1.000	0.023	0.040	0.998
142.5				0.056	0.098	1.000
147.5				0.139	0.268	1.000
152.5				0.444	1.325	1.000
Average	0.047	0.112		0.045	0.117	
2011						
Size (CW)	$\mu_{l,t}$	$F_{l,t}$	s_l	$\mu_{l,t}$	$F_{l,t}$	s_l
87.5	0.000	0.000	0.000			
92.5	0.001	0.002	0.000	0.000	0.000	0.000
97.5	0.006	0.010	0.002	0.006	0.010	0.000
102.5	0.032	0.055	0.047	0.031	0.054	0.012
107.5	0.067	0.118	0.595	0.065	0.116	0.405
112.5	0.089	0.161	0.985	0.143	0.277	0.981
117.5	0.149	0.292	1.000	0.244	0.535	1.000
122.5	0.176	0.354	1.000	0.363	0.947	1.000
127.5	0.235	0.509	1.000	0.651	3.101	1.000
132.5	0.444	1.325	1.000	1.149	0.000	1.000
137.5	0.115	0.000	1.000			
142.5						
147.5						
Average	0.119	0.257		0.295	0.560	
2014						
Size (CW)	$\mu_{l,t}$	$F_{l,t}$	s_l	$\mu_{l,t}$	$F_{l,t}$	s_l
72.5				0.003	0.004	0.005
77.5	0.024	0.041	0.006	0.002	0.004	0.011
82.5	0.021	0.035	0.016	0.000	0.000	0.026
87.5	0.036	0.062	0.044	0.019	0.033	0.066
92.5	0.201	0.419	0.124	0.045	0.079	0.163
97.5	0.308	0.740	0.319	0.064	0.114	0.362
102.5	0.423	1.216	0.631	0.073	0.131	0.639
107.5	0.386	1.044	0.874	0.079	0.143	0.856
112.5	0.556	2.081	0.970	0.092	0.168	0.956
117.5	0.639	2.932	0.994	0.067	0.120	0.989
122.5	0.745	4.852	0.999	0.113	0.212	0.997
127.5	0.705	3.976	1.000	0.110	0.205	0.999
132.5	0.679	3.504	1.000	0.196	0.406	1.000
137.5	0.814	0.402	1.000	0.223	0.475	1.000
142.5				0.284	0.658	1.000
147.5				0.324	0.797	1.000
152.5				0.343	0.866	1.000
157.5				0.206	0.432	1.000
162.5				0.170	0.339	1.000
167.5				0.045	0.079	1.000
172.5				0.316	0.768	1.000
Average	0.426	1.639		0.132	0.287	

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