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Research Article

Size structure and sexual maturity of the golden crab (*Chaceon chilensis*) exploited off Robinson Crusoe Island, Chile

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ABSTRACT. Golden crab (*Chaceon chilensis*) specimens were analyzed after being caught with traps by artisanal fishermen off Robinson Crusoe Island, Juan Fernández Archipelago, Chile. Of the 13,027 individuals caught between 300 and 1,000 m depth, 97.9% were male (12,754) and the rest female (273). The carapace length (CL) of the sampled crabs was measured and, on average, the males (CL: 118.9 mm) were larger than the females (CL: 94.3 mm). On the north side of the island, the specimens presented lower average sizes (112.2 mm) whereas, in the remaining zones, the average carapace lengths were similar (CL: 117.1-119.5 mm). In bathymetric terms, an increasing trend was seen between average size and depth, with sizes over 123 mm CL found beginning at 750 m depth. A comparison of linear regressions between the carapace length and chela length of males revealed physical maturity at 100 mm CL, whereas a numerical analysis showed the size at first sexual maturity ($SSM_{50\%}$) to be 109 mm CL.

Keywords: golden crab, *Chaceon chilensis*, size distribution, maturity, Juan Fernandez Archipelago, Chile.

Estructuras de tallas y madurez en el cangrejo dorado (*Chaceon chilensis*) explotado alrededor de la isla Robinson Crusoe, Chile

RESUMEN. Se analizaron ejemplares de cangrejo dorado (*Chaceon chilensis*) capturados mediante trampas por pescadores artesanales en torno a la isla Robinson Crusoe del archipiélago de Juan Fernández (Chile), entre 300 y 1.000 m de profundidad. Se midió la longitud cefalotorácica (LC) de 13.027 individuos de los cuales 12.754 correspondieron a machos y únicamente 273 a hembras, con un claro predominio de machos (97,9%), fueron de talla promedio superior a las hembras (118,9 y 94,3 mm de LC, respectivamente). En el sector norte de la isla, se encontraron ejemplares con menor talla media (112,2 mm) que en las zonas restantes, la longitud cefalotorácica media presentó valores similares (117,1 a 119,5 mm de LC). Se encontró una tendencia creciente entre la talla media y la profundidad, registrándose a partir del estrato de 750 m tallas promedio superiores a 123 mm de LC. Mediante la comparación de regresiones lineales entre la longitud cefalotorácica y la longitud de la quela, en machos se estableció la talla de madurez física a los 100 mm de LC y mediante análisis numérico la talla de primera madurez sexual ($TMS_{50\%}$) a los 109 mm de LC.

Palabras clave: cangrejo dorado, *Chaceon chilensis,* distribución de tallas, madurez, archipiélago de Juan Fernández, Chile.

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INTRODUCTION

The golden crab (*Chaceon chilensis* Chirino-Gálvez & Manning, 1989) is a crustacean belonging to the family Geryonidae. This crab is distributed in the Juan Fernández underwater mountain range and off San Félix and San Ambrosio islands (Retamal, 1981; Chirino-Gálvez & Manning, 1989). Occasionally, this species has been detected off the central coast of Chile (Báez & Andrade, 1977; Andrade & Báez, 1980; Andrade, 1985, 1987). Moreover, Parin *et al.* (1997) reported the presence of a geryonid in the Nazca underwater mountain range that could correspond to *C. chilensis*; nonetheless, this finding has not been ratified. Golden crabs are generally distributed to 2,000 m depth (Dawson & Webber, 1991). Around Robinson Crusoe and Santa Clara islands, however, they have been found inhabiting muddy-sandy bottoms (Arana & Vega, 2000) from 100 m to 1000 m, the maximum depth explored off these islands (Arana, 2000a). Fishing activities are normally carried out between 450 and 550 m depth, where these crustaceans are most abundant (Arana *et al*., 2006).

As a result of the exploratory fishing campaigns carried out (by the Pontificia Universidad Católica of Valparaíso) around Robinson Crusoe and Santa Clara islands in 1996 and 1997 (Arana, 2000a, 200b; Arana & Vega, 2000), *C. chilensis* was catalogued as a potential target resource for artisanal fishing in the Juan Fernández Archipelago. Because of its abundant, large specimens, the crab became an option for the island fishers, who are economically dependent on lobster (*Jasus frontalis*) extraction. Thus, regular artisanal fishing of the golden crab began in 2000; annual landings from 2000 to 2006 varied between 2 and 49 tons a year, with an average of around 17 tons a year (SERNAPESCA, 2008).

In spite of the development of the fishery, knowledge on the golden crab population off Juan Fernández is still scarce. The data available was recorded during one exploratory and another experimental fishing trip done in 1996/1997 (Arana, 2000a; Arana & Vega, 2000). These campaigns revealed a scant presence of females in the catches and, on average, large-sized specimens. Thus, new biological-fishing data on *C. chilensis* is necessary in order to examine possible changes in its population structure and to expand understanding of this resource. Therefore, our objective for the present study is to determine the structure of the exploited golden crab stock around Robinson Crusoe Island in terms of its distribution of size frequencies, sexual proportion, and size at first sexual maturity.

MATERIAL AND METHODS

General aspects

The study was carried out around Robinson Crusoe Island in the Juan Fernández Archipelago, located approximately between 33º35´S and 33º50´S and between 78º40´W and 79º50´W. The information was gathered between July 2005 and May 2006 by sampling the specimens caught during the commercial fishing operations of artisanal fishers using 9-m-long wooden boats and rectangular traps (40x70x130 cm) built with native woods and set between 300 and 1,000 m depth. The operations were carried out in the fishing areas used by the fishers, which are located to the north (La Vaquería, Bahía Cumberland), northeast (Puerto Francés), southeast (Playa Larga), and south (Bahía Villagra) of the island (Fig. 1).

Structure of the exploited stock

To establish the size structure of the golden crab, the sampled specimens were separated by sex and then measured for the carapace length (CL; ± 1.0 mm), or the straight-line distance over the mid-dorsal axis from the post-ocular ridge to the posterior limit of the carapace. The size frequency distribution of *C. chilensis* was made by grouping the carapace length measurements in 1-mm intervals. In addition, the average size, variance, and standard deviation were calculated by sex, month, fishing zone, and the following depths:

350 = 300 to 399 m;	650 = 600 to 699 m
450 = 400 to 499 m;	750 = 700 to 799 m
550 = 500 to 599 m;	850+ = 800 to 1000 m

The global sexual proportion of the samples taken was established in terms of the percentage of males present in the catches (% males).

Size-weight relation

A sub-sample was used to establish the size-weight relationship, measuring the total weight (± 1.0 g) and the carapace length (± 1.0 mm) of the specimens. We used the standard power function, in which W_{LC} is the total whole weight (g) of an individual of CL (mm), *a* is the condition, and *b* the allometry.

$$W_{LC} = a\ LC^b$$

The parameters were obtained by minimizing the sum of the difference of the least squares for the observed and predicted values: $E = \sum_{i=1}^{m} (W_i - a\ LC_i^{\ b})^2$.

Student's t test was used to establish the type of relative growth (allometric - isometric) presented by the golden crab (Dixon & Massey, 1957).

First sexual maturity

It tends to be difficult to estimate the size or age at which male crustaceans mature since they lack external characteristics that can be used for these purposes. Based on the assumption that, beginning with the puberty molt, the organisms register a noteworthy variation in relative growth of some structures (George & Morgan, 1979; Conan & Comeau, 1986), the morphometric relationships between the carapace

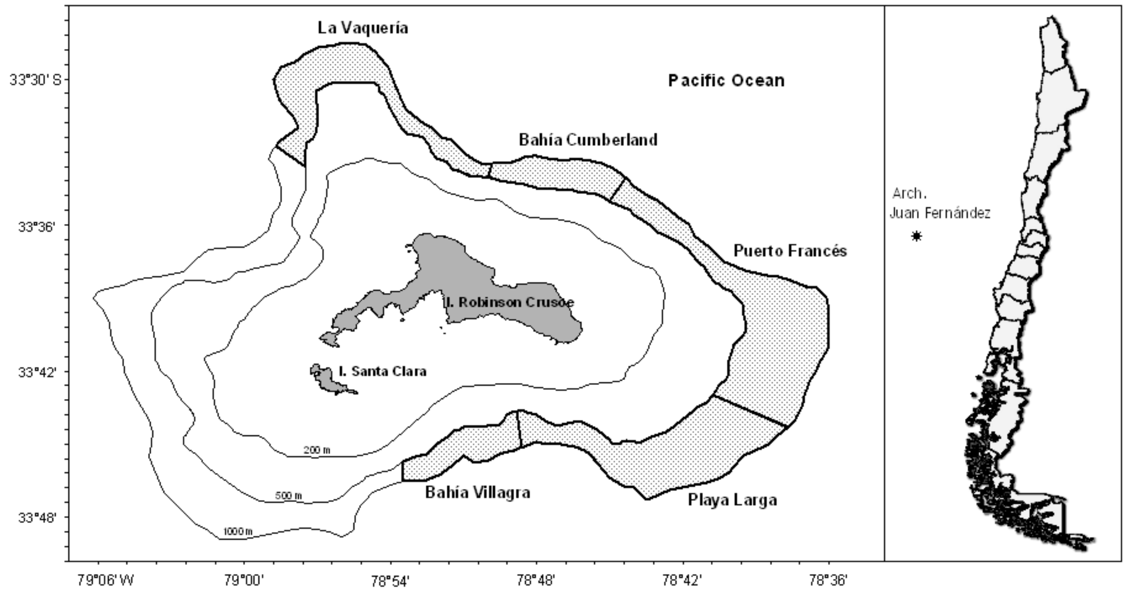


Figure 1. Golden crab fishing zones off Robinson Crusoe Island.
Figura 1. Zonas de pesca de cangrejo dorado alrededor de la isla Robinson Crusoe.

length and the chela length (both precise to ± 0.1 mm) were analyzed. This was done in order to establish the break in the relationship that could be attributed to the specimens' physical maturity (Fernández-Vergaz *et al.,*2000). Hence, the methodologies proposed by Somerton (1980) and Udupa (1986) were taken into account when determining male maturity, testing the equality of two linear regressions using the F test (α, n_1-2, n_2- 2) $\leq F^*$ (Neter & Wasserman, 1974).

RESULTS

During the development of this research, 13,027 individuals were measured, of which 12,754 were males and only 273 were females (Table 1). The sexual proportion in golden crabs was characterized by the recurrence of high levels of males throughout the analysis period, with a global average of 97.9% (Fig. 2).

Between July 2005 and May 2006, females sizes ranged from CL 68.7 to 150.0 mm, with an average of 94.3 mm, whereas the males had a greater range of sizes (CL: 46.0 to 189.7 mm) and a significantly higher average (118.9 mm) (Fig. 3). The average size of the specimens caught showed a marked difference between males and females, with males averaging between 114.4 mm (March) and 130.3 mm (September) and females, lesser in numbers and mean size, averaging from 91.1 mm (March) to 107.0 mm (September) (Table 1).

The size of the specimens was also analyzed by fishing zone. The lowest average value (112.2 mm) was found at La Vaquería, in the north sector of the island. In the remaining areas, the average carapace length of the golden crab was higher and similar: 117.1 mm in Bahía Villagra, 118.3 mm in Bahía Cumberland, and 119.5 mm in Puerto Francés and Playa Larga (Fig. 4, Table 2). The bathymetry revealed an increasing tendency between average size and depth; the specimens caught as of 750 m depth were larger than CL 123 mm, whereas those caught in the shallower strata averaged from 113.1 to 118.9 mm (Fig. 5, Table 3).

The size frequency distribution for males was bimodal, with one mode around 100 mm and another, the most important, around 130 mm. On the other hand, the females showed a relatively uniform structure with only one modal size at 93 mm (Fig. 6).

In monthly terms, the size range dropped from July 2005 to May 2006 and fewer large specimens were observed (Fig. 7). Regardless, throughout the analyzed period, the size structures of the males maintained two modes. In an analysis of size frequency distribution by fishing zone, the area corresponding to Bahía Cumberland stands out, having an ample size range and greater relative importance of specimens over CL 130 mm (Fig. 8). In bathymetric terms, the deeper strata are lacking smaller specimens; at over 800 m depth, only specimens over CL 100 mm (Fig. 9) are found.

Table 1. Main statistics of the carapace length in golden crabs between July 2005 and May 2006.

Tabla 1. Principales estadígrafos de la longitud cefalotorácica en cangrejo dorado, entre julio 2005 y mayo 2006.

		Month											Total
		July	August	September	October	November	December	January	February	March	April	May	
Number of sampled specimens (N)	Males	880	1,198	544	669	1,575	562	678	725	2,269	1,819	1,801	12,720
	Females	5	23	5	7	16	17	24	4	108	36	24	269
	Total	885	1,221	549	676	2	579	702	729	2	2	2	1
Range (mm)	Males	46 - 177.4	74.3 - 165	79 -162.1	76.6 - 165.6	69.8 - 148.7	63.1 - 153.7	77.8 - 153.7	80.4 - 153.7	74.1 - 147.1	78,4 - 189.7	75.1 - 170.4	46 - 189.7
	Females	86.2 - 114	80.1 - 117.2	97.2 - 111.2	80 - 150	76.1 - 101,1	85.4 - 98	84.1 - 103.6	91 - 100.9	73.2 - 112.9	68.7 - 105.7	87 - 109.4	68.7 - 150
	Total	46 - 177.4	74.3 - 165	79 - 162.1	76.6 - 165.6	69.8 - 148.7	63.1 - 153.7	77.8 - 153.7	80.4 -153.7	73.2 - 147.1	68.7 - 189.7	75.1 - 170.4	46 - 189.7
Mean (mm)	Males	124.6	123.9	129.8	118.2	119.3	119.4	117.7	119.3	114.0	117.1	114.3	118.5
	Females	95.2	104.9	106.6	98.0	90.7	92.2	94.5	96.3	90.6	94.4	95.3	93.9
	Total	124.5	123.6	129.6	118.0	119.0	118.6	116.9	119.1	112.9	116.6	114.1	118.0
Median (mm)	Males	130.0	127.3	132.8	121.3	121.7	122.6	120.7	122.2	116.4	119.4	115.1	120.6
	Females	92.0	110.6	107.0	91.5	90.8	93.0	95.2	96.6	91.2	93.2	95.6	93.2
	Total	129.5	126.3	132.6	121.0	121.5	122.2	120.2	122.1	115.2	119.1	114.9	120.1
Standard deviation (mm)	Males	20.0	19.2	17.4	17.1	15.2	13.5	15.0	13.8	14.4	13.5	14.1	16.1
	Females	11.0	12.6	5.7	24.1	6.2	3.3	5.7	4.1	6.9	7.4	5.9	9.0
	Total	20.1	19.3	17.5	17.3	15.4	14.1	15.3	13.9	15.0	13.7	14.2	16.3

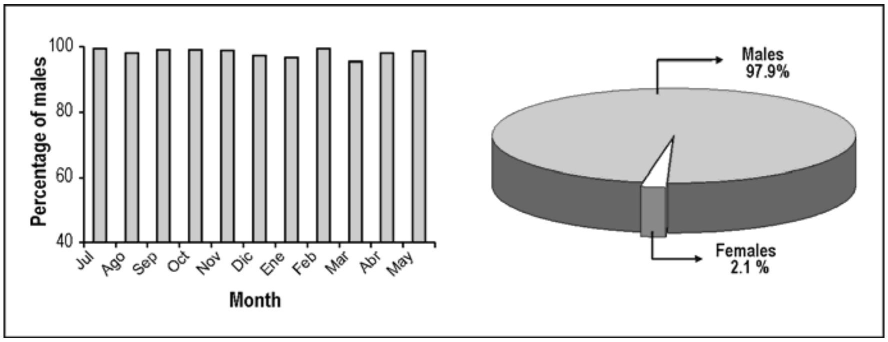


Figure 2. Global sexual proportion (% males) of golden crabs recorded between July 2005 and May 2006.

Figura 2. Proporción sexual global (% machos) en cangrejo dorado, registrado entre julio 2005 y mayo 2006.

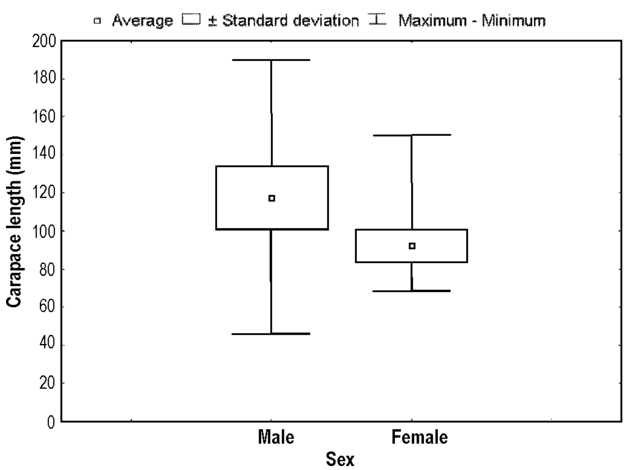


Figure 3. Average, standard deviation, and maximum and minimum carapace length of the golden crabs by sex.

Figura 3. Promedio, desviación estándar y valores máximos y mínimos de la longitud cefalotorácica en cangrejo dorado, por sexo.

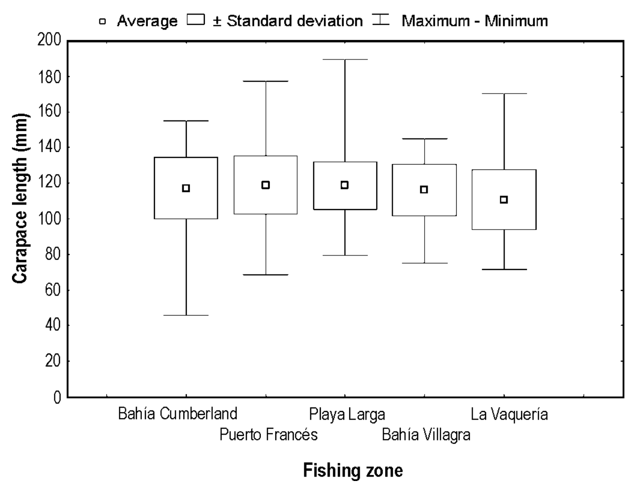


Figure 4. Average, standard deviation, and maximum and minimum carapace length of male golden crabs by fishing zone.

Figura 4. Promedio, desviación estándar y valores máximos y mínimos de la longitud cefalotorácica en machos de cangrejo dorado, por zona de pesca.

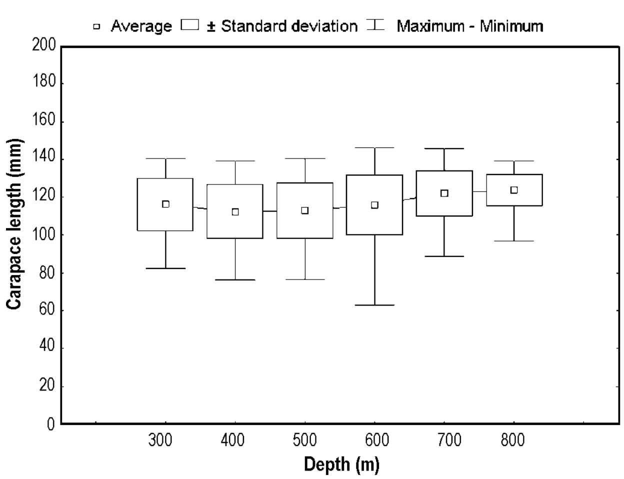


Figure 5. Average, standard deviation, and maximum and minimum carapace length of male golden crabs by depth.

Figura 5. Promedio, desviación estándar y valores máximos y mínimos de la longitud cefalotorácica en machos de cangrejo dorado, por estrato de profundidad.

Table 2. Main statistics of the carapace length in male golden crabs by fishing zone.
Tabla 2. Principales estadígrafos de la longitud cefalotorácica en machos de cangrejo dorado, por zona de pesca.

Fishing zone	Number of specimens	Mean (mm)	Standard deviation (mm)
Bahía Cumberland	2 196	118.3	7.2
Puerto Francés	5 929	119.5	3.9
Playa Larga	1 104	119.5	5.1
Bahia Villagra	695	117.1	6.7
La Vaquería	1 515	112.2	5.5

Due to the limited catches of females, the size-weight relationship was defined by analyzing a sample of 264 males. The estimated growth factor (b) was 3.0694, whereas the condition factor (a) was 0.0004. According to the isometry test, this shows an isometric growth factor (Table 4).

The sexual maturity of the males was determined using the carapace length (CL) and chela length (QL) from a sample of 1,067 specimens whose sizes varied between CL 71 and 141 mm. Before establishing the CL QL^{-1} relationship, the values were grouped by determining the average QL in each range of CL 1 mm. These values, when graphed, revealed a break in the relationship between these two variables at CL 100 mm, establishing the following statistically different linear functions (Fig. 10), which show that physical maturity occurs at CL 100 mm in males:

$$QL_1 = 0.85697\,CL - 7.47098$$

in the range between CL 71 and 100 mm; and

$$QL_2 = 0.99243\,CL - 17.85592$$

in the range between CL 100 and 141 mm

Given the two important modes found for male golden crabs, a bimodal distribution made up of mature and immature individuals was determined for the captured specimens. Thus, the maturing process occurs within the size range of the first modal group and, supposing a normal distribution within this, its ave age would be the established physical maturity size (CL: 100 mm). Using numerical approximation, it was possible to establish the fraction of mature specimens in each size range. Finally, through a non-linear fit of the data to the sigmoid curve, the curve's parameters were set, thereby determining the first sexual maturity in male golden crab ($SSM_{50\%}$) at CL 109 mm (CW: 125 mm) (Fig. 11).

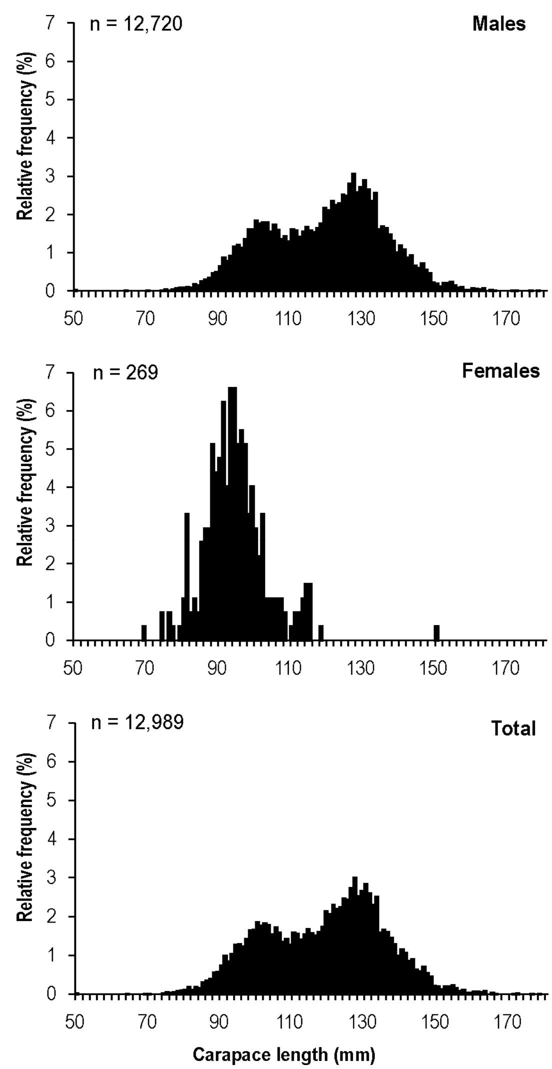


Figure 6. Distribution of size frequencies in golden crabs by sex.

Figura 6. Distribución de frecuencias de tallas en cangrejo dorado, por sexo.

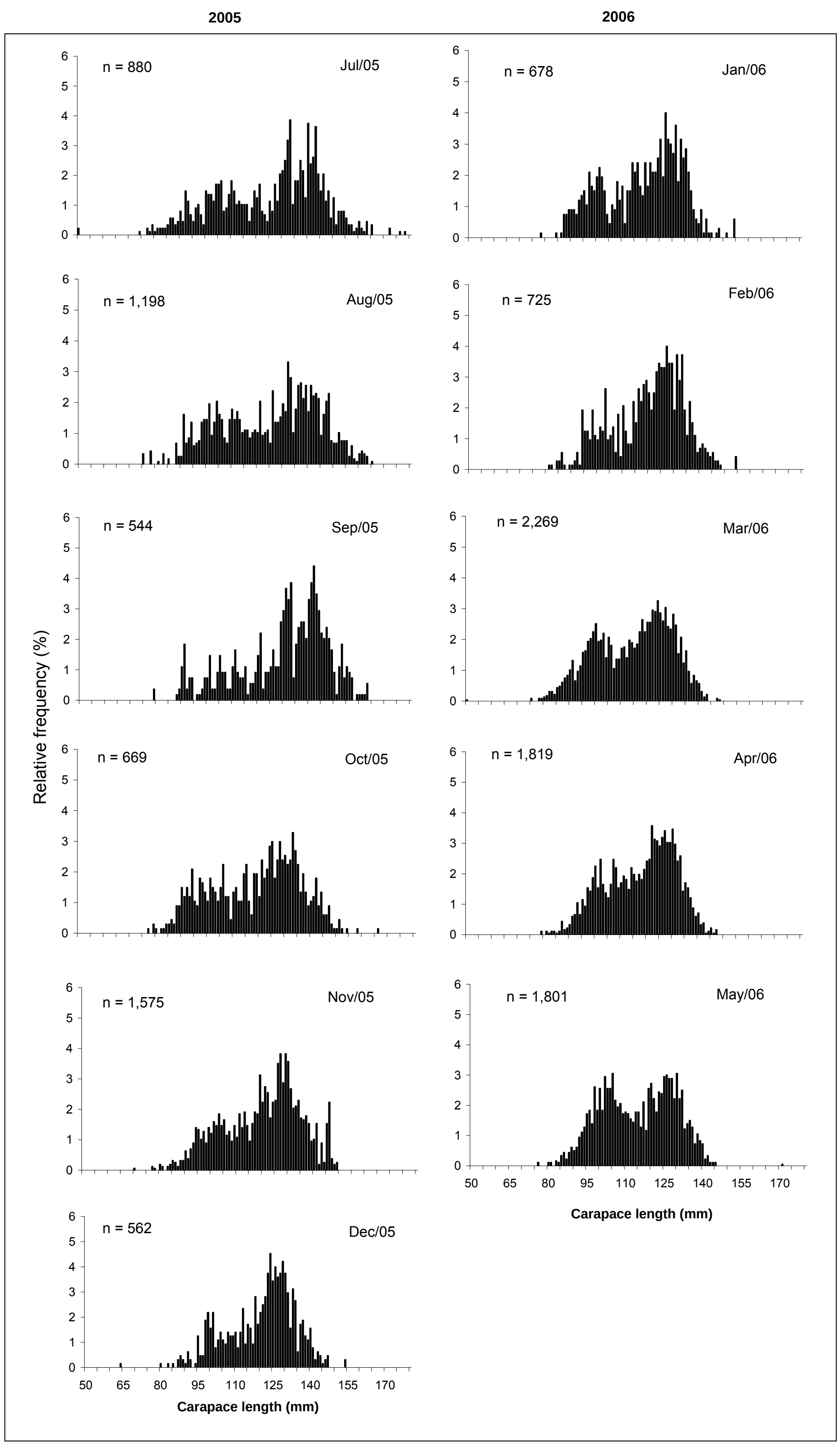


Figure 7. Monthly distribution of size frequencies in male golden crabs from July 2005 to May 2006.

Figura 7. Distribución mensual de frecuencias de tallas en machos de cangrejo dorado, julio 2005 a mayo 2006.

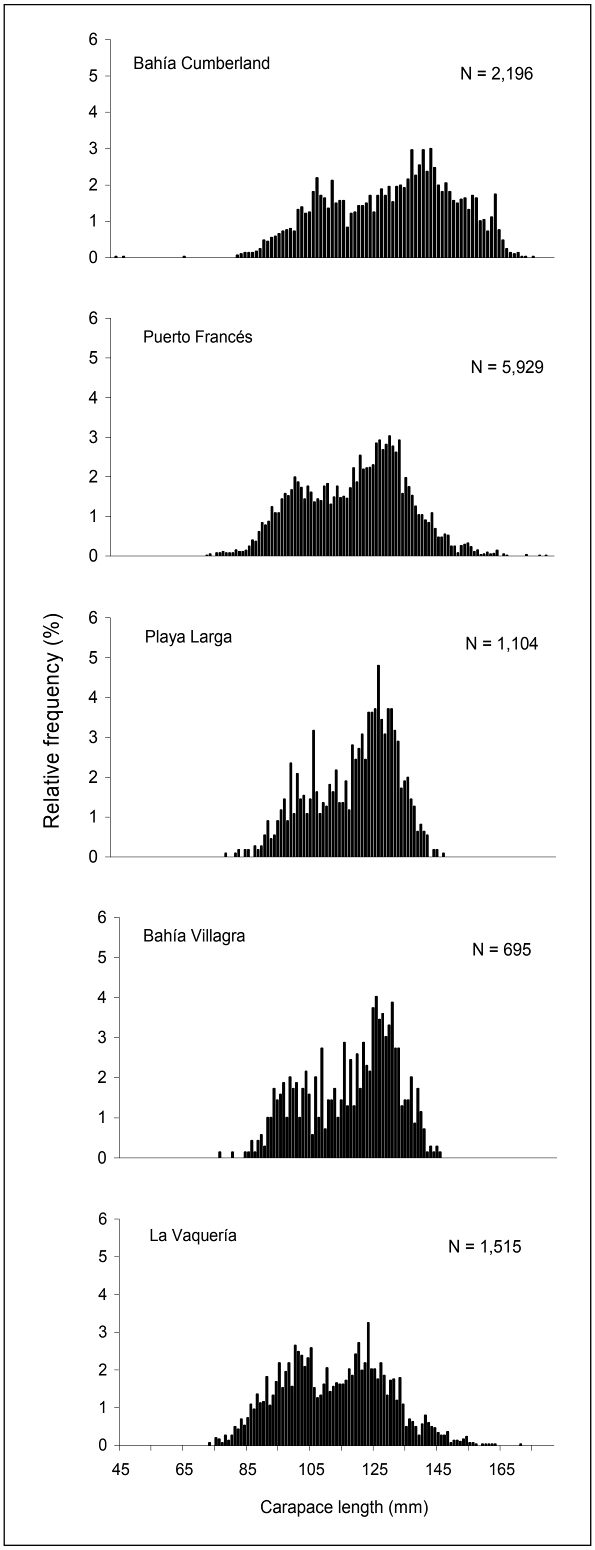


Figure 8. Distribution of size frequencies in male golden crabs by fishing zone.

Figura 8. Distribución de frecuencias de talla en machos de cangrejo dorado, por zona de pesca.

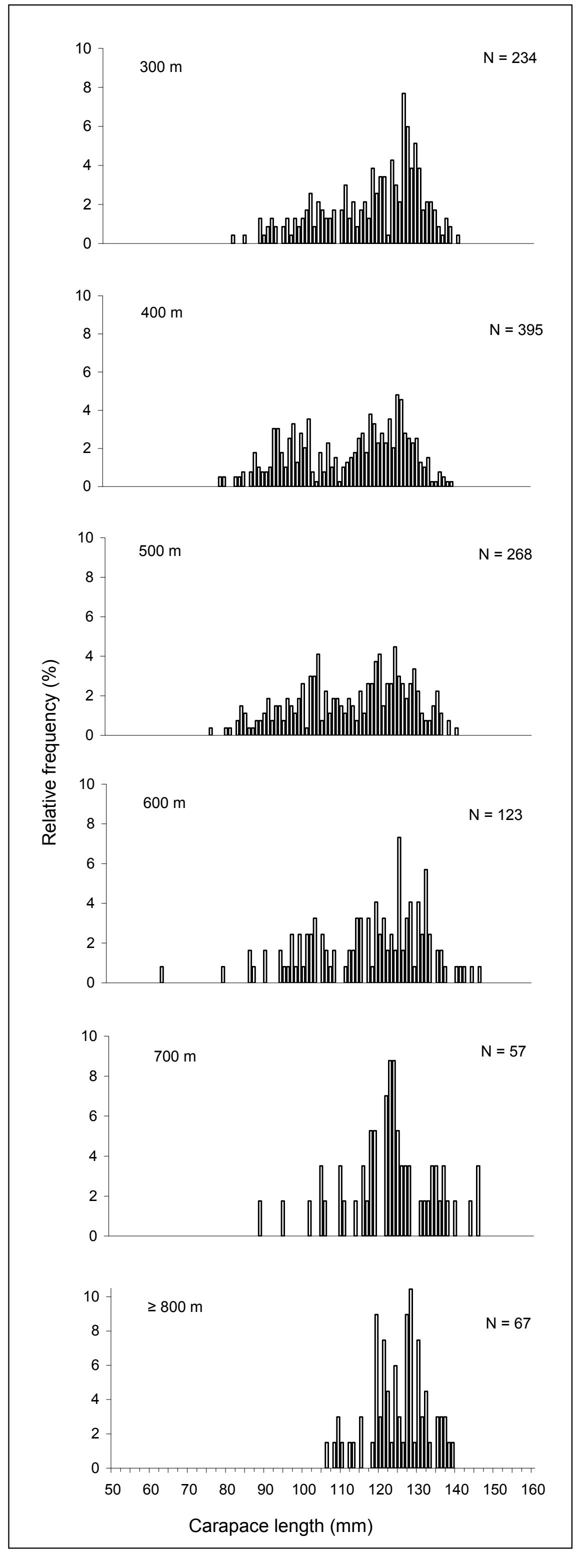
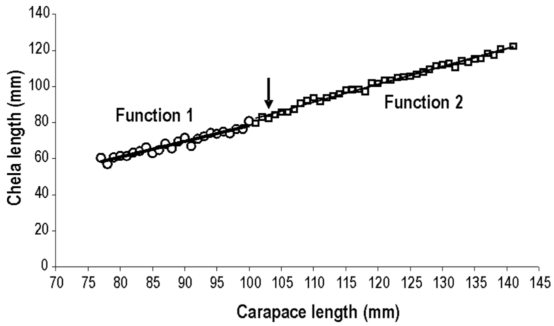


Figure 9. Distribution of size frequencies in male golden crabs by depth.

Figura 9. Distribución de frecuencias de talla en cangrejos dorados machos, por estrato de profundidad.



	Function 1	Function 2	Both
Intercept	-7.47098	-17.85592	-21.50162
Slope	0.85697	0.902243	1.02049
Coefficient of determination (R^2)	0.93719	0.98823	0.992963
SSE	56.60476	62.61405	161.65091
N	24	40	64
F*		10.677534	
p		< 0.05	

Figure 10. Relationship between carapace length and chela length in male golden crabs.
Figura 10. Relación entre la longitud cefalotorácica y la longitud de la quela en machos de cangrejo dorado.

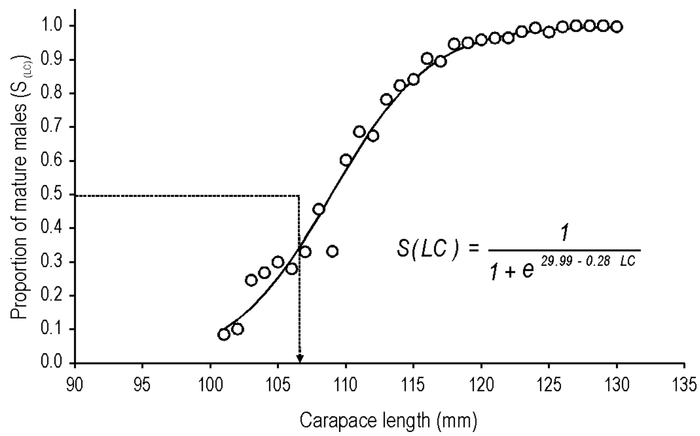


Figure 11. Ojive of maturity determined for male golden crabs.
Figura 11. Ojiva de madurez determinada en machos de cangrejo dorado.

Table 3. Main statistics of the carapace length in male golden crabs by depth.
Tabla 3. Principales estadígrafos de la longitud cefalotorácica en machos de cangrejo dorado, por estrato de profundidad.

Depth (m)	Number of specimens	Mean length (mm)	Standard deviation (mm)
350 (300 - 399)	234	118.9	9.2
450 (400 - 499)	395	113.1	7.0
550 (500 - 599)	268	113.7	9.5
650 (600 - 699)	123	118.0	22.6
750 (700 - 799)	57	123.3	18.0
850+ ($\geq$ 800)	67	124.7	7.2

Table 4. Regression parameters by region and sex of the carapace length-total weight relationship in golden crab.

Tabla 4. Parámetros de regresión, por región y sexo, de la relación longitud-peso de cangrejo dorado.

	Males	
	a	b
Estimate	0.0004	3.069
Standard error	0.000067	0.032472
t-Student	6.394724	94.52792
p value	0.000000	0.000000
Bottom limit	0.000297	3.005613
Top limit	0.000560	.133300
Correlation coefficient (R)	0.9958	
Sample (n)	264	

DISCUSSION

One characteristic of the golden crab fishery is the fact that it is carried out almost exclusively on male specimens. In fact, the percentage of males caught was 97.9%, similar to the value determined by Arana (2000a) prior to the development of commercial fishing; this author estimated a value of 98.1%, whereas Arana (2000b) and Arana & Vega (2000) estimated a value of 97.8%. Low proportions of females were also found by McElman & Elner (1982) for *Geryon quinquedens* over the Scottish platform; by Wenner *et al*. (1987) for *Geryon fenneri* off the coasts of South Carolina and Georgia; and by Kendall (1990) for the golden crab fishery of Georgia. Likewise, Pinho *et al.* (2001) determined a male predominance of 1.7:1 (63%) for *Chaceon affinis* off the Azore Islands, whereas López-Abellán *et al.* (2002) determined a male proportion of 57% (1:0.74) for this same species off the Canary Islands.

According to Barea & Defeo (1986), this could be explained i) by the trap soak time, which would allow smaller specimens to escape (and females are, in general, smaller), and ii) by the low mobility of the females, which would not enter the traps. Another explanation could be a stratification of the sexes by depth or a different spatial distribution; however, such a situation has not yet been found in these islands.

The results for the size of the specimens caught in this investigation differ from those obtained in the exploratory and experimental fishing campaigns carried out in 1996-1997. First, the size range in the present study is wider, including specimens from CL 46 to 189.7 mm. These sizes exceed the results of Arana (2000a), who recorded specimens between CL 86 and 140 mm, and those of Arana & Vega (2000), who reported individuals from 84 to 147-mm.

In spite of the larger size rage found herein, the average size of the males (118.9 mm) was lower than in 1997 (123.0 mm). This is due to the increased representation of smaller specimens, evident when observing the size frequency distributions of the two relevant modal groups (CL: 130 and 100 mm). It should be noted that the first mode was not apparent in the size structures found by Arana (2000b) during the experimental fishing done in 1996-1997.

The differences detected in both the size structure and the average size of the specimens caught is mainly due to the fact that the previous results correspond to the development of experimental fishing operations intended to evaluate catches using different kinds of traps and diverse depth ranges. Such variables are absent in commercial fishing, as the fishers have adopted one kind of fishing gear and determined the best places to fish for golden crab.

Nonetheless, the difference in the size frequency distributions between both sexes coincides with reports by other authors for *C. affinis* (Pinho *et al*., 2001; López-Abellán *et al.,* 2002) and shows a general pattern for geryonids. Similarly, Melville-Smith (1989) attributes this difference in *C. maritae* to the different molting process of males and females, stating that the unimodal structure of the latter could be the result of short intermolt periods in immature specimens and long periods after maturity.

In general, sexual maturity studies have been based on functional characteristics that show mating capacity (Goshima *et al.*, 2000; Gardner & Williams, 2002), physiological characteristics (the presence of spermatophores) (Warner, 1977; Melville-Smith, 1987; Comeau & Conan, 1992), and/or morphometric features such as the use of some physical trait to distinguish between mature and immature individuals (Somerton, 1980; Conan & Comeau, 1986; Comeau & Conan, 1992; Gardner & Williams, 2002). In this last case, the morphometric (or physical) maturity of the males has been determined by analyzing the relationships between body size and the dimension of some body parts (Hall *et al*., 2006).

Due to the scarce female specimens caught for this study, it was not possible to establish the sexual maturity (SSM) of the female golden crabs. However, since females are smaller than males and the smallest female caught with eggs under the abdomen measured CL 81 mm, we can estimate an SSM for females to be around this carapace length (CW 95 mm, according to the CL/CW relationship determined by Arana, 2000b).

Table 5. Estimates of size at sexual maturity for the genus *Chaceon* carried out by diverse authors. CW: carapace with, LC: carapace lengh.

Tabla 5. Estimaciones de talla de madurez sexual en el género *Chaceon* efectuadas por diversos autores. CW: ancho cefalotorácico, LC: longitud cefalotorácica.

Species	Location	Methodology	Size at sexual maturity (mm)		Type of measurement	Author
			Males	Females		
Chaceon affinis	Canary Islands	Morphometric relations Gonad maturity	129 -	99.3 109	CW CW	Fernández-Vergaz *et al*. (2000)
Chaceon affinis	Azore Islands	Macroscopic observation	-	83	CL	Pinho *et al*. (2001)
Chaceon quinquedens	Chesapeake Bay	Morphometric relations Gonad maturity	-	80-91	CW	Haefner (1977)
Chaceon quinquedens	Canada	Gonad maturity	>115	-	CW	Lawton & Duggan (1998)
Chaceon maritae	Côte d'Ivoire	Gonad development	105-115	80-90	CW	Le Loueuff *et al*. (1978)
Chaceon maritae	Senegal	Morphometric relations	100	83	CW	Gaetner & Laloé (1986)
Chaceon maritae	Namibia	Histological analysis	>80	100	CW	Melville-Smith (1987)
Chaceon notialis	Brasil	Morphometric relations Vulva condition and eggs	69	97 84	CW	Sant'Ana & Pezzuto (2009)
Chaceon notialis	Uruguay	Gonad maturity	-	70.2-71.7	CW	Delgado & Defeo (2004)
Chaceon chilensis	Juan Fernández Archipelago	Morphometric relations	109	-	CW	Present study

In males, a change occurred in the relationship between carapace and chela length at CL 100 mm (that is, CW 115 mm). According to the growth estimate done for this resource, the size of the first physical (or morphometric) maturity corresponds to the change in the molting state, possibly between the modal classes of CL 100 and 109 mm. It should be noted that this length is comparable to estimates made by diverse authors for other *Chaceon* species (Table 5).

The methodological focus used was based on the affirmation of Hartnoll (1974), who indicated that some species might present ontogenic variations in the relative growth pattern of some body parts that can be translated into differences in the development between sexes and/or between immature and mature specimens. In morphometric relationships, these changes contribute to the reproductive behavior and are required for successful reproduction. In some brachyurans, the size of the chela in males is particularly important in the reproductive process, whether for fighting over females, courting, copulating, or protecting the females after mating.

It is important to note that males can be functionally and physiologically mature before being able to reproduce, and that the reproduction capacity is achieved upon reaching morphometric or physical maturity (Hall *et al*., 2006). From this point of view, the size at first sexual maturity ($SSM_{50\%}$) as such would occur at sizes greater than those of morphometric or physical maturity, as determined herein.

Our results ratify that the golden crab fishery is sustained mainly by males, an important aspect for future fishery management and one that will require constant monitoring since a reduction in the number of males could influence the sustainability of the stock. Thus, it is also important to determine the size at which males reach sexual maturity (Conan & Comeau, 1986; Ennis *et al*., 1988; Wenner, 1990; Gardner & Williams, 2002), as this is an important reference parameter for management. The results obtained in this study are favorable since the average size of the males caught (CL: 118.9 mm) exceeded the $SSM_{50\%}$ (CL: 109 mm).

Finally, we would like to point out that, in the particular case of the Juan Fernández golden crab fishery, the fishers themselves have established a minimum saleable size of CW 130 mm (Arana *et al*., 2006), equivalent to CL 113 mm. This value is also higher than the $SSM_{50\%}$, and so we can conclude that the *C. chilensis* stock is, at least from this point of view, protected from overexploitation by recruitment, although the vulnerability presented due to the mainly male catches must also be taken into account.

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