POPULATION DYNAMICS AND FISHERY OF THE CHILEAN SQUAT LOBSTER *Cervimunida Johni* PORTER, (DECAPODA, GALATHEIDAE) OFF THE COAST OF COQUIMBO, NORTHERN CHILE

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ABSTRACT: Wolff, M. & T. Aroca. 1995. Population dynamics and fishery of the Chilean squat lobster *Cervimunida johni* Porter, (Decapoda, Galatheidae) off the coast of Coquimbo, northern Chile. Revista de Biología Marina, Valparaíso, 30(1):57-70

The population dynamics of the Chilean yellow shrimp *(Cervimunida johni)* and its level of exploitation in the fishing area of Coquimbo (29'59'S, 71'22'W) were studied during the period October 1988 to October 1989 on the basis of monthly samples from the fishing fleet. Males > 30 mm length of cephalotorax (Lc) are slightly heavier than females due to heavier and larger chelae. Female size at first maturity (Lm) is reached at 18.2 mm (C.I: 17.3- 19.1). First egg-carrying females appear in May and reach a maximum in August (99%). Egg eclosion starts in October and terminates in November. From December to early May, egg-carrying females are absent from the population. Lc of males and females ranges from 13 to 41 mm and 11 to 39 mm respectively. Large females (Lc >25 mm) are less represented in the catches than males. The overall sex proportion is 3 males: 1 female. Relative growth is well describes by the linear modell of Hiatt (1948) and does not seem to differ significantly between sexes. The size increment from one moult to the next is about 2.5 mm. From the first year of age onwards, both sexes seem to moult about 12 times during the remaing 6 years of life. Absolute growth is similar between sexes and seems to oscillate during the year as a function of temperatura and /or food availability. The von Bertalanffy growth parameters (k= 0.315; Loo = 46mm) indicate moderate growth which compares to other Galatheids. The standing stock as derived from a cohort analysis resulted to be consistently greater for males than females (2071-3417 t and 777-1280 t respectively). Total (Z) and natural mortality (M) is lower in males (0.87 and 0.66-0.77) than females (1.45 and 0.77-0.98). The total yield was 1319 t representing 28.1-46% of the average annual biomass. The density per area is estimated as 26-43g/m2. At the current fishing regime, the population does not seem endangered as indicated by the moderate exploitation rate (E) for the various size groups and by the fact that most specimens caught are far larger than the size at first maturity.

Key words: *Cervimunida johni*, population structure, growth, reproduction, exploitation, fisheries

RESUMEN: Wolff, M. & T. Aroca. 1995. Dinámica poblacional y pesquería del langostino amarillo *Cervimunida johni* Porter, (Decapoda, Galatheidae), frente a la costa de Coquimbo, norte de Chile . Revista de Biología Marina, Valparaíso, 30(1):57-70

Se estudió la dinámica poblacional del langostino amarillo chileno *(Cervimunida johni)* y su nivel de explotación en el área de pesca de Coquimbo (29'59'S, 71'22'W) durante el período octubre de 1988 a octubre de 1989 con base en muestras mensuales tomadas de la flota langostinera. Machos >30 mm longitud de cefalotarax (Lc) pesan levemente más que las hembras por tener quelas más grandes y pesadas. Las hembras alcanzan el tamaño de la primera madurez (Lm) a los 18.2 mm (I.C.: 17.3 -19.1). Las primeras hembras ovígeras aparecen a

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finales de mayo alcanzando un máximo en agosto (99%). La eclosión de los huevos comienza en octubre y termina en noviembre. Entre diciembre y principios de mayo no aparecen hembras con huevos. Los rangos de Lc para machos y hembras son 13 - 41 mm y 11- 39 mm respectivamente. Hembras grandes (Lc > 25 mm) están menos representadas en las capturas que los machos. La proporción de machos y hembras es 3: 1. El crecimiento relativo está bien descrito por el modelo de Hiatt (1948) y parece que no difiere entre los sexos. El incremento en el tamaño entre mudas es aproximadamente 2.5 mm. Desde el primer año en adelante, ambos sexos parecen mudar 12 veces durante los 6 años restantes de su vida. El crecimiento absoluto es similar entre los sexos y parece oscilar durante el año en función de la temperatura y/o disponibilidad de alimento. Los parámetros de la ecuación de von Bertalanffy (k = 0.315; Loo = 46mm) indican un crecimiento moderado y comparable con el de otros galateidos. El tamaño poblacional, calculado en base al análisis de cohortes, es consistentemente mayor en los machos que en las hembras (2071-3417 t y 777-1280 t respectivamente). Las tasas de la mortalidad total (Z) y natural (M) son menores en los machos (0.87 y 0.66 - 0.77) que en las hembras (1.45 y 0.77 - 0.98). El rendimiento total fue 1319 T, representando 28.1-46% de la biomasa promedio anual. La densidad por área se estima en 26-43g /m^2 . Bajo el régimen de pesca actual, la población no parece estar en peligro de una sobrepesca por la tasa de explotación (E) moderada de los diferentes grupos de edad y por que la mayoría de los especímenes capturados tienen una talla superior a la de primera madurez.

Palabras claves: *Cervimunida johni*, estructura poblacional, crecimiento, reproducción, explotación, pesqueria

INTRODUCTION

The decapod "langostino amarillo" (*Cervimunida johni*) is distributed on the Chilean shelf from Taltal (29'19'S) to Isla Mocha (38'20'S) in a depth from 50-500 m. Together with two other decapod species ("langostino colorado", *Pleuroncodes monodon*, and "camaron nylon", *Heterocarpus reedi*), *C. johni* occupies a central role within the bentho-demersal ecosystem: as a detritus feeder it uses a great part of the production of the euphotic zone that falls out into deeper waters and as a prey of many fish species: "congrios" (*Genypterus spp.*), flatfish (*Hippoglossina macrops*) and hake (*Merluccius gayi*), (Arancibia & Melendez 1987, Henríquez 1979, Miranda 1959). It transpasses great amounts of biomass to the upper levels of the food chain. As Rowe (1985) stated for the langostino of Baja California, *Pleuroncodes planipes*, *C. johni* can be considered as the only dominant species in its fishing area in terms of biomass, production and respiration.

About 30 years ago, *C. johni* represented an important fishery resource in Northern Chile with annual catches of about 1800 ton. After catches peaked in 1973 (3300 ton.), the population virtually disappeared, however, and the fishery collapsed.

But in the 80 ties, the population reappeared again, and since 1988, 12 fishing vessels are operating regularly 24-25 days/month. The reasons for the population collapse and its reappearance have as yet never been explained. Present catches are of the same magnitude as in the late sixties (above 1500 ton/year, SERNAP, 1988; 1989a,b).

Published reports on *C.johni* deal with its taxonomy, reproduction, population structure, exploitation and ecology (Alegría et al. 1963, Andrade & Baez 1980, Arana & Pizarro 1970, Arancibia & Melendez 1987, Bahamonde 1965, De Buen 1957, Henríquez & Avilés 1977, Martínez & Carrasco 1986).

Despite of these studies, only little is known on its population dynamics and present rate of exploitation. We therefore decided to aim our study on those aspects, especifically on: (1) reproductive cycle of the population; (2) size structure, sex proportion and number of moult stages within the population; (3) von Bertalanffy growth parameters and the instantaneous rates of natural (M) and fishing mortality (F); (4) population size and exploitation rate in the fishing area of Coquimbo.

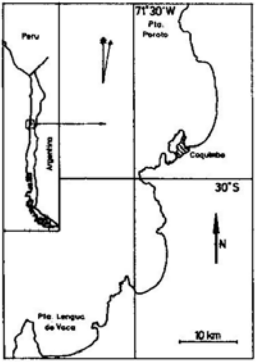

Fig. 1.- *Cervimunida johni*. Fishing area off Coquimbo.

MATERIAL AND METHODS

DATA COLLECTION AND BIOMETRIC RELATIONSHIPS:

The sampling was conducted during the study program of SERNAP entitled "Diagnostics of the crustacean catches in the fourth region" in the period October 1988 to October 1989. The specimens sampled were caught within the fishing area of Coquimbo between Punta Poroto (29'45'S) and Punta Lengua de Vaca (29'15' S) (Fig. l) about 4 nautical miles offshore in a depth of 200-400 m (SERNAP 1989a). Of the commercial catches, 1-3 samples were taken during the second half of each month (average: 330 specimens/month) with a total of 4008 individuals. Each specimen was analysed as follows:

l. Sex detemination by the external characters following Alegría et al. (1963) and classification of females into egg carrying females and those without eggs. 2. Classification of egg carrying females according to colour and structure of the egg following Bustos & Retamal (1985) and González (1985): Stage I- vitellum homogeneous, egg colour yellow; Stage II- vitellum heterogeneous, colour dark orange to cafe; Stage III - larval structures, colour dark cafe. 3. Determination of length (Lc) and width (Ac) of cephalotorax to the nearest 0.1 mm and wet weight (Wt) to the nearest 0.0lg. Specimens with damaged or broken appendices were excluded from weight measurements.

With the length and weight data ln(Lc)-ln(Wt) and Lc-Ac regressions were calculated for both sexes.

SIZE AT FIRST MATURITY, SPAWNING TIME AND EGG ECLOSION

The size at which 50% of the females carried eggs (Lm) was estimated by a method published by Udupa (1986), which allows for the calculation of confidence limits around Lm. For the calculation only those samples were used which had a high percentage of egg carrying females, thus representing the reproductive period of the population (Heydorn 1965). The calculation procedure is given in the result section (Table l).

Tabla 1.-*Cervimunida johni*. Calculation of the female size at first maturity (Lm) (procedure: ln (Lm) = Xk+ X/2 -Σ Pi, where Xk= ln size at which 100% of specimens are mature; X= average size increment. 95% confidence intervals (C.I.)= antilog { ln (Lm) ± 1.96 $\sqrt{X^2 \Sigma Pi (1-Pi)/(Ni-1)}$ }; Result: Lm= 18.2mm (C.I. 17.3mm - 19.1mm).

ML (cm)	log ML (Xi)	N tot. sample (ni)	N (gravid females) (ri)	(Pi) ri/ni	X=(Xi+1)-Xi	Qi=1-Pi	P*Q/ni-1
1,65	0,2175	1	0	0,00	0,0255	1,00	0,0000
1,75	0,2430	2	1	0,50	0,0242	0,50	0,2500
1,85	0,2672	4	3	0,75	0,0228	0,25	0,0625
1,95	0,2900	10	9	0,90	0,0218	0,10	0,0100
2,05	0,3118	21	20	0,95	0,0206	0,05	0,0024
2,15	0,3324	16	16	1,00	0,0198	0,00	0,0000
2,25	0,3522	35	31	0,89	0,0189	0,11	0,0029
2,35	0,3711	45	42	0,93	0,0181	0,07	0,0015
2,45	0,3892	29	28	0,97	0,0173	0,03	0,0010
2,55	0,4065	38	33	0,87	0,0167	0,13	0,0031
2,65	0,4232	35	32	0,91	0,0161	0,09	0,0024
2,75	0,4393	22	19	0,86	0,0155	0,14	0,0057
2,85	0,4548	26	19	0,73	0,0150	0,27	0,0079
2,95	0,4698	21	21	1,00	0,0145	0,00	0,0000
3,05	0,4843	20	20	1,00	0,0140	0,00	0,0000
3,15	0,4983	18	17	0,94	0,0136	0,06	0,0033
3,25	0,5119	13	13	1,00	-	0,00	0,0000
totals				14,20	0,0184		0,3527

Spawning time was determined by the proportion of egg carrying females:females without eggs in consecutive samples over the study period. Eclosion time was estimated by the proportion of the different egg- stages within the egg masses.

DETERMINATION OF MOULT STAGES AND RELATIVE GROWTH

For each sex, the size histograms of the pooled catches (size interval:0.5mm) were separated into modal groups using the method of Bhattacharya (1967) as executed by the COMPLETE ELEFAN computer package (Pauly 1985). With the so obtained model groups (Lc's) a plot of a moult stage (Lct) against the following stage (Lct+l) was established. As the points conforme to a straight line, a linear regression was calculated and the parameters of Hiatts growth model (Hiatt 1948) were determined.

ABSOLUTE GROWTH, VON BERTALANFFY GROWTH PARAMETERS

Using the COMPLETE ELEFAN package, the monthly length frequencies of both sexes (interval width 2mm) were analysed and the growth parameters of the following modified version of the von Bertalanffy growth equation (Pauly & Gaschuetz, 1979) estimated:

(1) $Lt = Loo\,(1 - e^{-k(t-to) + C/2\pi \sin 2\pi (t-ts))})$, where

Lt,Loo,to and k are the von Bertalanffy growth parameters; C is a constant that represents the amplitud of the growth oscillation and ts marks the onset of the oscillation when to = 0

MORTALITY

Total mortality (Z) for each sex was estimated from a catch curve of the pooled samples using the above-mentioned ELEFAN package. Natural mortality (M) was estimated from two empirical equations:

(2) M (1%)= -ln (0.01)/ Tm (Alagaraja, 1984)

(3) M = 1.5211 ($Tm50^{0.720}$) - 0.155 (Rikhter & Efanov 1976), where

M(1%) corresponds to the natural mortality at which 1% of the initial population is still alive; Tm is the corresponding age; Tm 50 represents the age at which 50% of the females are mature (corresponding to Lm).

POPULATION STRUCTURE, - SIZE AND EXPLOITATION RATE (E)

For each month, the size distribution and sex proportion was registered and size histograms were established using an interval of 2mm. To see if the sex proportion in the samples was significantly different from 1:1, X^2 tests ($p<0.05$) were conducted with the monthly samples with all length groups combined and for each size interval.

Population size in numbers and biomass as well as the exploitation rate for the different size intervals were estimated by a size -based cohort analysis, using the program LENVPA written by Sparre (1987). The input data were the numbers captured per size interval, the von Bertalanffy growth parameters k and Loo, the proportion M/Z and the exploitation rate (E=F/Z)for the oldest length group.

RESULTS

BIOMETRIC RELATIONSHIPS

Fig.2 shows a higher weight of males than females at Lc > 30 mm. The exponent of the weight:length relationship is around 3 (3.06 for males, 2.88 for females) indicating isometric growth. The length: width relationship of both sexes (data not included here) is almost identical.

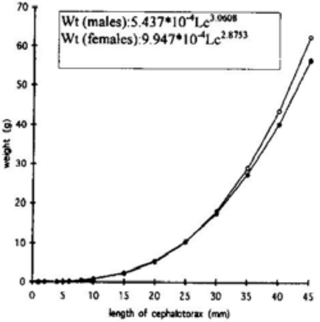

Fig.2. *Cervimunida johni.* Length-weight relationship of females and males.

SIZE AT FIRST MATURITY (LM), REPRODUCTIVE CYCLE

The smallest females found with mature eggs, were within the size interval 16-18mm Lc. Lm was estimated as 18.2mm (c.i. 17.3mm-19.1mm) (Table I). The onset of the reproductive cycle began in May (3% egg carrying females), it peaked in August (99%) and egg carrying females were totally absent from December to May (Fig.3).

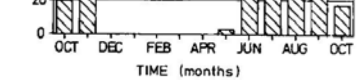

Fig. 3.-*Cervimunida johni.* Egg-carryng females over the year cycle as percentage of all females.

In May, 100% of females carried stage I-eggs; during June and July some females (<10%) already had stage II-eggs and in August most females carried stage II-eggs, some stage III-eggs. Stage III-eggs predominate until November, thereafter they rapidly disappeared (Fig.4). According to figs.3 and 4, egg eclosion started in October, resulting in a varying proportion of the different egg stages thereafter.

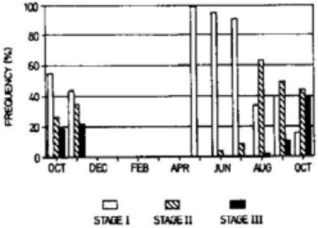

Fig. 4.-*Cervimunida johni*. Development stages of eggs over the annual cycles

MOULT STAGES AND RELATIVE GROWTH

Within the size range sampled, 12 moult stages could be separated for both sexes (Table 2) which could be used for calculating the "Hiatt- regression line" for both sexes (Fig.5). The lines for both sexes are very similar and the size increment from one moult stage to the next remain constant and is about 2.5 mm for both sexes.

ABSOLUTE GROWTH

When the growth parameters were estimated for both sexes separately, no significant differences between sexes were found. Therefore, the data for both sexes were pooled for the subsequent analysis. Fig.6 shows the growth curve calculated by the ELEFAN program and the corresponding growth parameters. The goodness of fit criteria of the ELEFAN- program (ESP/ASP = 0.432) reveals a good fit of the growth curve. Fig. 7 shows the growth curve with the superimposed moult stages.

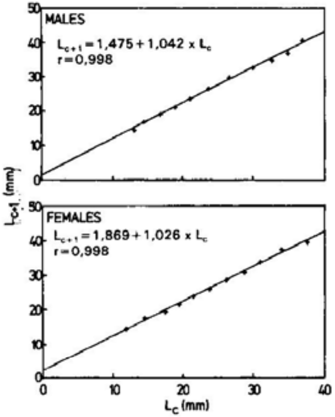

Fig. 5.-*Cervimunida johni*. Hiatt diagram for males and females.

TOTAL AND NATURAL MORTALITY (Z,M)

According to the catch curves calculated for both sexes (Fig.8), total mortality is almost twice as high in females (1.45 compared to 0.87).

The instantaneous rate of the natural mortality estimated for both sexes by the two formulas of Alagaraja (1984) and Rikhter & Efanov (1976) is as follows:

Method	m	Tm
Alagaraja (1984)		
	females 0.92-0.77	
	males 0.77-0.66	
Rikther & Efanov(1976)		
	females 0.88-0.98	**1.5-1.7**

Table 2.- *Cervimunida johni*. Moult stages of females and males as derived from the Bhattacharya (1967) analysis and t-test for the diference of the size -at - moult between sexes.

malt stage	females X Lc mm	f SD	N	males X Lc mm	SD	N	t	significance
1	11,75	0,658	10	13,07	1,279	32	3,061	S.
2	14,41	0,607	14	14,42	0,755	49	0,045	N.S.
3	17,36	1,148	94	16,83	0,804	136	4,1	S.
4	19,29	0,878	135	18,86	0,797	184	4,545	S.
5	21,25	0,773	291	21,01	0,79	251	3,56	S.
6	23,71	0,894	400	23,65	1,163	523	0,855	N.S.
7	26,06	0,895	289	26,59	0,845	388	7,858	S.
8	28,52	0,882	138	29,94	0,798	239	15,965	S.
9	30,77	0,809	81	32,67	0,936	205	16,755	S.
10	33,82	0,838	62	34,77	0,775	138	7,776	S.
11	37,5	0,926	26	36,82	1,005	119	3,169	S.
12	39,45	0,508	7	40,55	0,78	15	3,25	S.

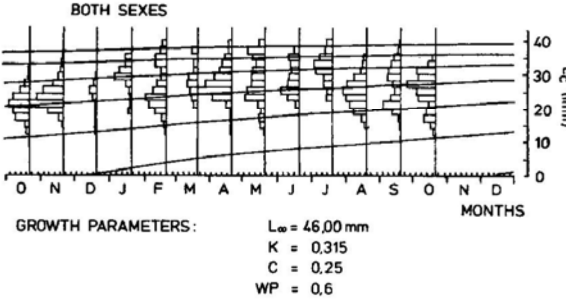

Fig.6. *Cervimunida johni*. Absolute growth for both sexes combined as derived from the ELEFAN analysis: L∞, k:von Bertalanffy growth parameters; C: constant of growth oscillation; Wp: time of the year when growth is lowest.

The range for the M-estimates of females lies above that for males (0.77-0.98 compared to 0.66-0.77).

POPULATION STRUCTURE, -SIZE AND EXPLOITATION RATE

As seen in figs. 6 and 9, most collected specimens are within the size range of 21 - 27 mm, the smallest and largest individuals of males and females are 13 and 4lmm and 11 and 39 mm respectively. Fig.10 shows that the proportion of the sexes in the catches changes with size: in the small and large length groups males clearly dominate, while in the middle groups (21-25mm) both sexes comprise about 50% of the catches. The sex proportion of the pooled sample is approx. 3 males: 1 female (X2 test; $p<0.05$).

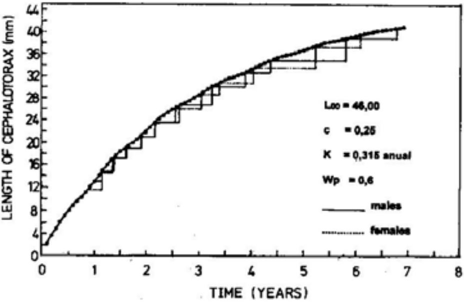

Fig.7 *Cervimunida johni.* Growth curve with súperimposed moult stages.

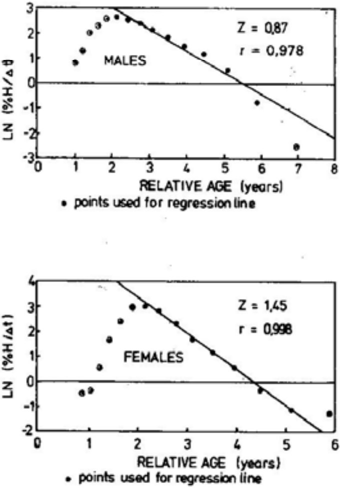

Fig.8. *Cervimunida johni.* Catch curves for males and females with estimates of instantaneous rates of total mortality (Z).

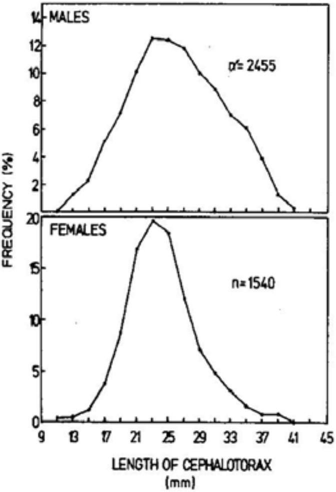

Fig.9. *Cervimunida johni.* Size frequencies of the pooled catches for males and females.

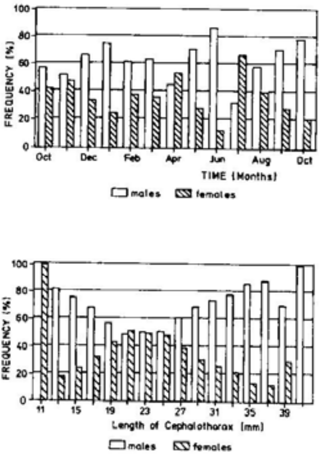

Fig.10. *Cervimunida johni.* Proportion of males and females in the monthly samples (above) and in the various to size groups (below).

Table 3 shows the catch in numbers for each size group as well as the other input and output data for and from the length cohort analysis. For the calculations, the values of the growth parameters (K= 0.32; Loo = 46), the proportion M/K and the exploitation rate E (F/Z) for the largest length group was used. Calculations were done with an envelope of M-values corresponding to the range of M estimated for both sexes.

In both sexes, the highest exploitation rate (E) was found for the larger (except for the largest) size groups (Fig. 11). The E-values (below or near 0.5, depending on the M-values considered) do not indicate overfishing.

The total yield of males (891.95 ton) was about twice as high as in females (427.05 ton) and representad a lower fraction of the average biomass (26-43% compared to 33-55% in females).

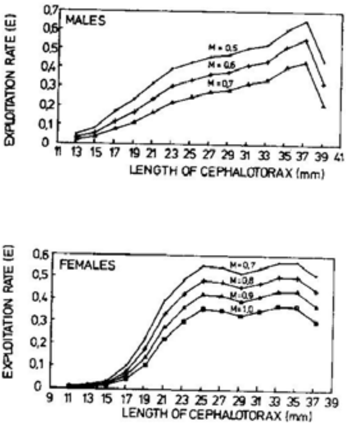

Fig. 11. *Cervimunida johni.* Exploitation rates (E) for both sexes according to size interval as computed from the cohort analysis (see Table 3)

DISCUSSION

BIOMETRIC RELATIONSHIPS, MATURITY AND REPRODUCTIVE CYCLE

Males are heavier than females above 30mm carapax length, due to their stronger. developed chelae. This coincides with the findings of Arana and Pizarro (1970).

The age at first maturity,(Tm = 1.5-1.7 yrs) found for the females in this study is much lower than that reported by Alegría et. al. (1963) (about 3.1 yrs.) This could be due to a compensatory response of the population to the fishing pressure during the past decades that had lead to a juvenilization of the population.

FEMALES

group (i)	midlengt hmm	catch (n)	weight (g)	Dt	relative age	fishing mortality (F) M=0,7	M=0,8	M=0,9	M=1,0	total mortality (Z) M=0,7	M=0,8	M=0,9	M=1,0	exploitation rate (E) M=0,7	M=0,8	M=0,9	M=1,0	average biomass (t) M=0,7	M=0,8	M=0,9	M=1,0	yield (t)
1	11	157364	0,982	0,179	0,179	0,006	0,005	0,004	0,003	0,706	0,809	0,904	1,003	0,009	0,006	0,004	0,003	24,718	30,877	39,325	51,454	0,154
2	13	183973	1,587	0,189	0,368	0,008	0,006	0,005	0,004	0,708	0,806	0,905	1,004	0,011	0,008	0,006	0,004	37,214	45,652	57,096	73,380	0,291
3	15	472050	2,395	0,202	0,570	0,022	0,181	0,015	0,012	0,722	0,818	0,915	1,012	0,030	0,022	0,016	0,012	51,987	62,574	76,782	96,785	0,131
4	17	1547301	3,432	0,216	0,784	0,078	0,066	0,055	0,044	0,778	0,866	0,959	1,044	0,100	0,076	0,057	0,042	68,119	80,433	96,810	119,688	5,311
5	19	3514192	4,726	0,232	1,017	0,199	0,171	0,145	0,119	0,899	0,971	1,045	1,119	0,221	0,176	0,139	0,107	83,555	96,888	114,557	139,028	16,606
6	21	6644781	6,302	0,250	1,267	0,458	0,401	0,344	0,287	1,158	1,201	1,244	1,287	0,396	0,334	0,276	0,223	93,946	107,475	125,278	149,947	43,135
7	23	7920000	8,186	0,272	0,539	0,678	0,597	0,517	0,436	1,378	1,397	1,417	1,436	0,492	0,428	0,365	0,303	97,333	108,190	125,095	148,531	64,833
8	25	7421750	10,404	0,298	1,837	0,881	0,779	0,675	0,570	1,581	1,579	1,579	1,570	0,557	0,492	0,429	0,363	87,119	98,636	113,799	134,677	77,214
9	27	4877891	12,981	0,329	2,166	0,857	0,757	0,656	0,553	1,557	1,557	1,557	1,553	0,550	0,486	0,422	0,356	73,327	83,096	95,968	113,972	63,318
10	29	2858555	15,941	0,368	2,534	0,763	0,675	0,585	0,494	1,463	1,475	1,485	1,494	0,522	0,458	0,394	0,330	59,292	67,108	77,453	91,951	45,569
11	31	1993124	19,311	0,417	2,951	0,845	0,750	0,652	0,550	1,545	1,550	1,552	1,550	0,547	0,484	0,420	0,355	49,063	50,876	58,616	69,543	38,487
12	33	1258821	23,114	0,482	3,433	0,944	0,837	0,726	0,610	1,644	1,637	1,626	1,610	0,574	0,511	0,446	0,379	30,326	34,303	39,852	47,262	29,096
13	35	629399	27,375	0,570	4,003	0,953	0,838	0,720	0,598	1,653	1,638	1,620	1,598	0,577	0,512	0,445	0,374	17,688	20,186	23,580	28,471	17,230
14	37	340926	32,118	0,697	4,700	0,749	0,649	0,549	0,449	1,449	1,449	1,449	1,449	0,517	0,446	0,379	0,310	9,294	10,726	12,679	15,501	10,950
15	39	367162	37,366	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,719
																	totales	776,960	897,018	1056,679	1260,388	427,048

MALES

group (i)	midlengt hmm	catch (n)	weight (g)	Dt	relative age	fishing mortality (F) M=0,5	M=0,6	M=0,7	total mortality (Z) M=0,5	M=0,6	M=0,7	exploitation rate (E) M=0,5	M=0,6	M=0,7	average biomass (t) M=0,5	M=0,6	M=0,7	yield (t)
1	11	839189	1,196	0,189	0,189	0,024	0,018	0,012	0,524	0,618	0,712	0,045	0,029	0,017	49,447	66,195	94,840	1,172
2	13	1468800	2,163	0,202	0,391	0,043	0,033	0,023	0,543	0,633	0,723	0,080	0,052	0,032	73,492	96,634	135,974	3,177
3	15	3278181	3,173	0,216	0,607	0,102	0,079	0,057	0,602	0,679	0,757	0,169	0,116	0,075	102,265	132,158	182,724	10,403
4	17	4589430	4,460	0,232	0,838	0,152	0,120	0,082	0,652	0,720	0,788	0,234	0,167	0,112	134,201	170,681	232,140	20,470
5	19	6477628	6,059	0,250	1,088	0,235	0,188	0,140	0,735	0,788	0,840	0,320	0,238	0,167	166,599	208,842	280,001	39,249
6	21	8024900	8,005	0,272	1,360	0,329	0,265	0,200	0,829	0,865	0,900	0,392	0,307	0,222	195,085	241,748	320,482	64,236
7	23	7972480	10,332	0,298	1,658	0,380	0,310	0,236	0,880	0,910	0,936	0,432	0,341	0,252	216,250	265,488	348,954	82,370
8	25	7605314	13,076	0,329	1,987	0,436	0,358	0,274	0,916	0,958	0,974	0,466	0,374	0,282	227,626	277,236	362,040	99,448
9	27	6425192	16,273	0,368	2,356	0,458	0,379	0,292	0,958	0,979	0,992	0,478	0,387	0,294	227,675	275,270	357,728	104,557
10	29	5590695	19,958	0,417	2,773	0,527	0,439	0,339	1,027	1,039	1,039	0,513	0,423	0,326	214,465	257,897	334,151	113,579
11	31	4484549	24,167	0,462	3,255	0,576	0,462	0,371	1,076	1,082	1,071	0,535	0,445	0,346	188,916	223,862	291,084	108,379
12	33	3933741	28,936	0,570	3,844	0,787	0,654	0,496	1,287	1,254	1,194	0,611	0,522	0,415	142,485	171,921	227,809	113,828
13	35	2517610	34,301	0,698	4,522	0,974	0,760	0,580	1,474	1,380	1,280	0,661	0,565	0,444	88,081	108,326	152,255	88,357
14	37	865453	40,299	0,899	5,421	0,399	0,300	0,200	0,899	0,900	0,900	0,444	0,333	0,222	48,431	64,568	96,844	34,877
15	39	209854	46,964	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9,656
														totales	2071,018	2560,566	3417,025	891,957

Table 3 *Cervimunida johni*. Cohort analysis for males and females. The calculations were made with envelope values of M for both sexes (see text).

The reproductive cycle of the population as revealed by the present study (appearance of the first gravid females in May-egg eclosion until November, thereafter disappearance of gravid females) differs somewhat from the findings of Alegría et. al. (1963) and Henríquez (1979) who found the egg eclosion not to start before November and to last until December. An explication could be that these authors concentrated their studies on populations in the area of Valparaíso (about 500 km further south) where due to the colder temperatures spawning could be delayed. This has been reported by Mistakidis & Henríquez (1966) for the "nylon shrimp" *(Heterocarpus reedi)*.

RELATIVE GROWTH

The fit of the linear model of Hiatt (1 948) to the data of the present study was good and there is no indication of differential growth (a set of two or more lines) over the size range sampled, as has been found for many other crustacea (Somerton 1980 a,b; Wolff & Soto 1992). However, larval and juvenile growth (not studied here) might well differ. The smallest individuos found in the study (11-13 mm, approx. age of one year) seem to moult during their subsequent 6 years of life as an average 5,2,2,1,1,1 times/year. As a high number of soft, recently moulted specimens of both sexes were found during December to April (when no reproductive activity was registered), this time could be the main moulting period of the population.

ABSOLUTE GROWTH

According to our results, both sexes of *C. johni* do not significantly differ in their growth performance. Growth seems to oscillate during the year probably as a function of the temperatura cycle and/or the food availability which has been reported for many crustacea (González 1985, Kurata 1962, Rodríguez 1977, Siegel 1987, Wolff & Cerda 1992, Wolff & Soto 1992 among others). The smallest specimens found in the fishing nets (Lc: ll-l3mm) have an age of about l year. This size at age coincides with reports of Bahamonde et. al. (1986) and Bustos et. al (1982), for the "squat lobster" *(Pleuroncodes monodon)* who found a size of about 11 mm corresponding to an age of 1 year. The authors found 6 year classes of both sexes distributed over the range of Lc= 11-39 mm which coincides roughly with the findings for *C. johni* of this study.

POPULATION STRUCTURE, - SIZE, MORTALITY AND EXPLOITATION RATE

The similar size distribution of both sexes found in the present study (by a higher proportion of males in the larger size groups) differs from that reported by Bahamonde (1965), Arana & Pizarro (1970) and Henríquez (1979) who, during the entire year found larger males than females which led the authors to postulate differential growth for both sexes.

The smaller fraction of females found in the large length groups during this study (and the higher Z-value of 1.45 compared to 0.87 in males) suggest a higher vulnerability of large gravid females to the fishing gear. The maximum percentage of females found in July during this study is coincident with findings of Bahamonde (1965) and suggests that females migrate for spawning to areas where they are more accessible to the fishing gear and, as seen by the higher natural mortality rate also to their natural predators. In this context it is interesting to quote Miranda (1959) who found the highest incidence of *C. johni* in flatfish stomachs during May the time when females began to spawn. Rodríguez & Bahamonde (1986 a and b) also found a higher mortality rate of females of the "channel shrimp", *Munida subrugosa* conforming our findings for *C. johni*. The much higher Z-value of females indicates a general higher turnover compared to males and could be an expression of a life strategy towards the maximization of the reproductive potential at the expense of a lower survival (Fenwick 1984). The average population turnover (males and females combined) is around 1, which means that the total annual biomass (2848-4697 ton) is about replaced once a year.

At the current fishing regime, 28.1-46 % of this biomass goes into the flshery (1319 ton), and a similar amount to the natural predators. The population does not seem endangered under this fishing regime, as indicated by the moderate values of the exploitation rate (E) for the various size groups, which rarely exceed the optimum value of 0.5.

The female size groups between 25 and 35 mm are the most vulnerable to the fishery and if the size at first maturity of Lm = 31 mm reported by Alegria et al. (1963) was correct, the population should have collapsed already due to recruitment overfishing, as most female specimens would have died before their first reproduction. Our estimate of Lm = 18.2 $\pm$ 0.9 mm seems therefore more reasonable. If the relatively small coastal strip (about 55 km length and 2 km width) on which the fishery is operating, is taken as the area over which the here estimated biomass is distributed, one arrives at an estimate of about 26-43 g /m^2. This is of the same order of magnitude as estimates for the squat lobster *Pleuroncodes planipes* off the Pacific Coast of Baja California reported by Aurioles-Gamboa (1992) (7- 50 g/m2). It is evident from this biomass figures that these species must occupy a central role within the bentho-demersal ecosystem as a key prey for many demersal fish.

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