Annual mass strandings of pelagic red crabs, *Pleuroncodes planipes* (Crustacea: Anomura: Galatheidae), in Bahia Magdalena, Baja California Sur, Mexico

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Pelagic red crabs (or langostilla in Spanish), *Pleuroncodes planipes*, are very abundant galatheid crustaceans off the west coast of Baja California. Some studies suggest that pelagic red crabs are the most abundant species in the micronekton, one of the most important consumers of phytoplankton, and the most common prey item for many marine vertebrates in the area (Boyd, 1962, 1967; Blackburn, 1969; Longhurst et al., 1967; Kato, 1974; Galván, 1988; Balart and Castro[1]).

Although widely used, the common name (pelagic red crab) describes only the planktonic period (about one year) in the life of the species. Larvae, juveniles, and young adults are planktonic. At about 17–20 mm standard carapace length (SCL), they become benthic, making occasional movements to the surface (mostly at night) in a circadian migration (Boyd, 1967). Once the animals reach 32–34 mm SCL, they are fully benthic as are other galatheid species (Boyd, 1967; Aurioles-Gamboa, 1992).

Pelagic red crabs breed from December through April; the peak of the reproductive season is in February (Boyd, 1962; Kato, 1974; Gómez, 1990). Females about 14–15 mm SCL, have been found carrying eggs, but most of the females start to breed when they are about 20 mm SCL (Boyd, 1962; Serrano, 1991).

The benthic population performs seasonal bathymetric movements, at least in the area from lat. 24° to 26° N, in which they disperse during winter and spring to occupy the benthos of the continental shelf (0–200 m depth). After the breeding season, the population moves to deeper waters (100–200 m), and probably invades the continental slope (Aurioles-Gamboa, 1992). Population withdrawal is associated with a rise in bottom temperature above 16°C, and pelagic red crabs remain from June through October in waters 100–200 m deep, where bottom temperature is in the range of 12–16°C (Aurioles-Gamboa, 1992).

One of the notable characteristics in pelagic red crab life history are mass strandings, which have been reported for Bahia Magdalena and the California Coast (Glynn, 1961; Boyd, 1962; Kato, 1974; Stewart et al., 1984). The main difference between strandings in California and Baja California is the frequency of ocurrence. Pelagic red crab beachings in California occur during El Niño events, which enable the population to move northward in warm water currents originating in the south. In contrast, pelagic red crab strandings in Bahia Magdalena are annual, and apparently recur on the same beaches and during the same season of year.

In Bahia Magdalena, pelagic red crabs were observed in the upper 50 cm of water of the surf zone before stranding. Onshore winds and receding tides hasten and intensify stranding (Boyd, 1962). Kato (1974) proposed that the presence of pelagic red crabs near shore is primarily due to winds, waves, and currents.

On 9 May 1991, one of us (D.A-G.) observed a mass stranding of pelagic red crabs on a beach of Magdalena Island close to the mouth of the Bahia Magdalena on the Pacific coast of Baja California (Fig. 1). About 1100 hours, a compact surface swarm of live crabs was seen 1–2 m from the beach. Small groups of crabs were thrown to the beach by waves, and were unable to return to the sea.

[1] Balart-Páez, E., and Castro-Aguirre, J. L. 1992. Habitos alimenticios de la merluza Bajacaliforniana *Merluccius angustimanus*, en la costa occidental de Baja California Sur, México. Paper pres. at the IX International Symposium of Marine Biology, 1–5 June 1992, La Paz Baja California Sur, México.

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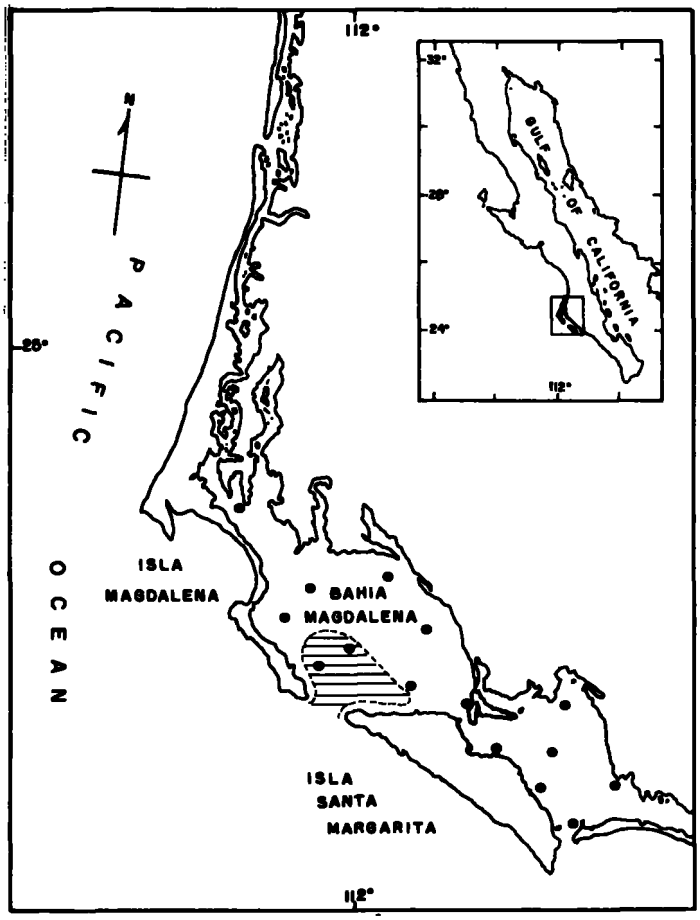

Figure 1

Study area on the west coast of Baja California Sur, México. Dots inside Bahia Magdalena indicate the location of stations sampled. The shaded area is the region where pelagic red crabs, *Pleuroncodes planipes*, were found as indicated by positive stations and visual observations (from Solís, 1991).

The general appearance of these pelagic red crabs (color and mobility) suggested that the crustaceans were healthy and that the stranding could be considered accidental (Boyd, 1962). We questioned local fishermen about crab strandings and determined that mass strandings 1) occur annually, usually in spring, from April through June, and 2) are common on Santa Margarita and Magdalena Islands but rarely seen on the peninsular coast.

Since strandings coincide with the end of the breeding season, we addressed the null hypothesis that stranded pelagic red crabs, particularly females, were in a weakened state because of energy expended in reproduction, as reported for many crustaceans (Hartnoll, 1985). It is known that pelagic red crabs are able to breed twice in a single breeding season and may produce, depending on body size, from 500 to 5000 eggs in each brood (Serrano, 1991). Based on this fact, debilitation caused by reproductive investment should be more evident in females. For that reason, the chemical composition of pelagic red crabs in Bahia Magdalena was determined for both sexes. We were aware that males were overrepresented in samples collected on the continental shelf (Boyd, 1962; Serrano, 1991); thus we also wished to determine if stranded animals were female-biased, as an explanation for the unbalanced sex ratio recorded on the continental shelf.

Materials and methods

To test whether the strandings were due to weakness caused by starvation or malnutrition, about 20 kg of live-stranded pelagic red crabs were collected as soon they were stranded. From this sample, a total of 1,150 individuals were sexed and measured for SCL to the nearest 1.0 mm. Sex was determined by the presence or absence of modified pleopods, which males use to fertilize the eggs (Boyd, 1962). Standard carapace length was measured from the antorbital notches of the rostrum to the midpoint of the posterior border of the carapace (Kato, 1974). This measurement is usually preferred over total length because it does not vary with shrinkage of the abdomen.

Stomach contents were analyzed in order to determine if 1) the animals had been feeding before stranding, and 2) the number of items and composition was similar to stomach contents of pelagic red crabs collected on the continental shelf (Pérez and Aurioles-Gamboa[2]). We examined the stomach contents from a subsample of nine individuals after fixing in formalin (4%), removing the cardiac-pyloric stomach from the animal, dissolving its contents in two drops of water and placing them on a smear slide. Pérez and Aurioles-Gamboa[2] determined that the average stomach composition in a swarm of crabs does not vary significantly after a sample of six crabs.

Food items were identified and counted under the microscope and relative abundance of major groups

[2] Pérez, F. R., and D. Aurioles-Gamboa. 1992. Cambios en la alimentación invierno-verano de la langostilla *Pleuroncodes planipes*, en la costa oeste de Baja California. Paper pres. at the IX International Symposium of Marine Biology, 1–5 June 1992. La Paz B. C. S. México.

of food items was determined. Following Pérez and Aurioles-Gamboa[2], we recorded some of the phyto and zooplankton components in four major groups: 1) phytoplankton, 2) zooplankton, 3) particulate organic matter (POM), and 4) inorganic matter (small grains of sand, clay or mud). The number of diatoms, crustacean parts, foraminifers, and other components, such as small agglomerations of POM, were counted and their numbers converted to relative frequency.

Proximate analyses was based on 200 g ♂ and 200 g ♀ of sun dried and milled pelagic red crabs (about 4 kgs of fresh crabs). The techniques used were those of the Association of Official Analytical Chemists (A.O.A.C., 1984): moisture (7.007), ash (7.009), crude fiber (7.006), crude protein (2.057), ether extract (7.060), carbohydrates (by difference from all other determinations at 100%). This methodology had been used previously to analyze pelagic red crabs sampled from the benthos of the continental shelf (Castro, 1993). Two-sample *t*-tests (Zar, 1984) were conducted to identify differences in food composition, proximate composition, and mean SCL between stranded pelagic red crabs in Bahia Magdalena and breeding pelagic red crabs collected on the continental shelf in March 1990. A chi-square test for determining a possible deviation of sex ratio was applied for the stranded pelagic red crabs (Zar, 1984).

Results

The stranded crabs formed a long brilliant red line of several kilometers on the interior coast of the northern part of Bahia Magdalena (Fig. 1). In addition, there were two lines of dried crabs separated by a few meters, higher on the beach and stranded during the previous days.

Behavior of pelagic red crabs during stranding

Two hours of observations on a surface swarm about 12 m long and 1 m wide were conducted after 1100 hours (11 May 1991) during the receding tide. The swarm was propelled to and from the beach by the waves and was unable to move offshore. When the swarm was pushed toward the beach by the wave action, some animals were thrown onto the sand and exposed as the water receded.

During sampling on the beach, the pelagic red crabs moved their legs and actively used their chelae as pincers. This behavior was typical of pelagic red crabs caught in trawls from the continental shelf. Pelagic red crabs had been caught from the shelf in all seasons, but only during mid-summer (when the bottom-surface temperature difference is as great as 17°C) did the crabs show signs of damage as they moved slowly and died rapidly on the deck (Aurioles-Gamboa, unpubl. data). In contrast, crabs were very active in the first minutes after stranding, and moved less frequently later. The crabs were brilliant red, which differentiated them from the lighter color of crabs collected on the continental shelf. Based on their vigorous activity, the pelagic red crabs stranded on Magdalena Island (Fig. 1) appeared to be in good health.

Stomach contents of stranded pelagic red crabs

The total number of items and relative frequency of the four major groups found in the stomachs is shown in Figure 2A. For comparison, the results of a typical sample taken on the continental shelf is provided in Figure 2B (Pérez, 1992). The minimum number of items counted was 457 and the maximum about 2,266. This range was greater than that found in crabs from the continental shelf (841–1,495 items). However, there was no significant difference in the mean number of items ($\bar{x}$=1,027 versus 1,100) between stomachs from the stranded crabs and those from the shelf (two sample *t*-test, $P>0.05$, df=9; $t=-0.3082$).

Food composition (particulate organic matter, zooplankton, and phytoplankton) was not different between crabs from the two regions. Inorganic matter (grains of sand, clay, etc.) was more abundant in the stomachs of the pelagic red crabs collected from the shelf ($\bar{x}$=365 versus 60; two sample *t*-test, $P<0.05$, df=9; $t=-0.0046$). This difference, however, does not account for a significant change in the feeding habits of crabs from the two samples.

Proximate composition of stranded red crabs

In stranded pelagic red crabs, the sexes were not different in protein and crude fiber (Table 1), however they differed significantly in lipids and ash contents (two sample *t*-test, $P<0.05$, df=9; $t=1.870$ and 10.012 respectively). Females had higher lipid and lower ash content than males, both by about 1.5%.

There were significant differences when the chemical composition of stranded crabs (sexes combined), were compared to crabs from the continental shelf (Table 1). Crabs from both areas were similar in their protein content, but differed in lipids and ash. The lipid content in Bahia Magdalena crabs was almost nine times higher than that in shelf crabs (*t*-test, $P<0.05$, df=16, $t=35.664$). Crabs from the continental shelf were higher in fiber and ash but lower in carbohydrate content.

It was also noted that during handling of stranded crabs an oily, orange film was left in the containers, a phenomenon not previously observed in crabs collected in more than 200 bottom trawls on the continental shelf (Aurioles-Gamboa, 1992). The substance probably contained carotenoids, which in this species have been identified as astaxanthins (Wilkie, 1972).

Size and sex of stranded pelagic red crabs

Pelagic red crabs collected in Bahia Magdalena were 12–28 mm SCL. Size distribution was similar for males and females (Fig. 3); mode and mean were 15.82 and 17.02 mm for females and 17.36 and 17.26 mm for males, respectively. Differences in mean size of males and females were statistically significant (two-sample t-test=2.057, $P<0.05$, df=1,147). In older organisms, slight sexual dimorphism is evident in males which are slightly larger and heavier with longer and wider chelae (Serrano and Aurioles-Gamboa, 1991).

Pelagic red crabs are about 14 mm SCL at the end of the first year of life (about February–March) and grow approximately 1 mm per month (Boyd, 1962). Because the crabs were about 17 mm SCL (mode), they should have been about 14–15 months old. Some individuals were about 24–28 mm SCL (Fig. 3), which according to Boyd (1962) were about 26–27 months old.

The number of females (605) in relation to the number of males (544), deviates significantly from the expected 1:1 proportion (chi-square $P<0.001$). In contrast, the sex ratio of crabs from the continental shelf is slightly male biased throughout the year (Serrano, 1991).

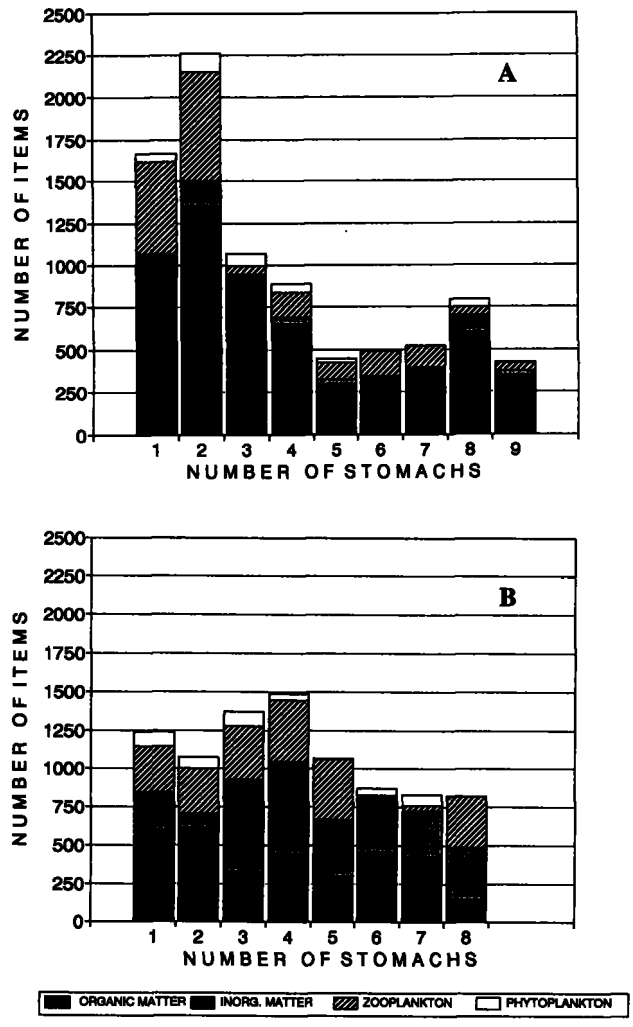

Figure 2

Total number of items and gross stomach composition from pelagic red crabs, *Pleuroncodes planipes*, collected in Bahía Magdalena (**A**), and organisms typically found on the benthos of the continental shelf off Baja California (**B**). POM = Particulate Organic Matter, IM = Inorganic Matter. Numbers below the x-axis indicate number of stomachs.

Discussion

Debilitated pelagic red crabs as explanation of strandings

We rejected the null hypothesis that stranded pelagic red crabs represent a debilitated fraction of the population because 1) the stranded crabs moved vigorously during and just after stranding, 2) the stomachs of crabs were full and the contents were similar to those collected on the continental shelf, which indicated they were feeding normally, 3) the chemical composition was generally similar to those collected on the continental shelf, and when different, did not suggest malnutrition, and 4) timing and area of strandings are better explained by physical phenomena (i.e. by accidental stranding due to funneling effect, wave action, and receding tide). Our observations support the observations made by Boyd (1962), that waves and receding tide play a major role after the animals enter the surf zone. Two available stranding reports (Boyd, 1962; Jorge Llinas[3]), indicated that beachings occurred during falling tides. According to local fishermen, the two higher lines of stranded crabs we found on the beach of Isla Magdalena on 9 May 1991, were stranded two mornings before our visit, also during receding tides.

[3] Llinas, J. Centro de Investigaciones Biologicas de Baja California Sur. Apdo. Postal 128. La Pax Baja California Sur, Mexico, personal commun. 1993.

Differences in pelagic red crab chemical composition

The lipid content of the younger stranded pelagic red crabs was different from that recorded in older specimens caught on the benthos of the continental shelf (Table 1). Differences in the proportion of chemical components between young and old individuals have been reported for many decapod species (Herring, 1973; Morris, 1973). The observed differences in lipid concentration and apparent pigmentation between young-adult and older-benthic pelagic red crabs cannot be considered abnormal or attributable to unhealthy specimens. There was no evidence to support the hypothesis of a debilitated fraction of pelagic red crabs, and strandings can be explained by mere accident.

The differences in lipid and ash content between male and female stranded crabs would be attributable to metabolic differences in which females require more lipid to invest in egg production (Hartnoll, 1985). Some females still had eggs attached on the pleopods as evidence of their reproductive condition; however, the low numbers of ovigerous females in the sample, suggested that we collected them at the end of the breeding season.

Table 1

Mean values for proximate chemical analyses of *Pleuroncodes planipes* samples from Bahia Magdalena and the Continental Shelf of Baja California.

	Bahia Magdalena				
	Males % $n = 5$		Females % $n = 6$		Significant difference 95% conf. *
Moisture	4.7	(0.28)	4.73	(0.23)	
Ash	29.79	(0.36)	28.21	(0.66)	+
Ether extract	12.79	(0.72)	15.46	(1.39)	+
Crude fiber	7.91	(0.99)	8.70	(0.65)	–
Crude protein	41.75	(0.14)	40.64	(0.07)	–
Carbohydrates	3.06		2.26		–
	Bahia Magdalena Both sexes % n = 11		Continental Shelf Both sexes % n = 12		
Moisture	4.71	(0.20)	4.12	(0.32)	
Ash	29.04	(0.24)	40.30	(0.03)	+
Ether extract	14.12	(1.98)	2.75	(0.007)	+
Crude fiber	8.30	(0.62)	12.83	(0.03)	+
Crude protein	41.19	(0.22)	38.61	(0.29)	–
Carbohydrates	2.64		1.39		–

* Two-sample *t*-test for means; + significant difference, – no difference (Alpha=0.05).

Size and sex of pelagic stranded red crabs

The stranded individuals we sampled were predominantly 13 to 20 mm SCL, although some larger crabs were also found (Fig. 3). Kato (1974) also reported individuals of these two size distributions in a mass stranding in Bahia Magdalena. Photos were available of a mass stranding in May of 1979, in which pelagic red crabs larger than 25 mm SCL (second year of life, Boyd 1962) were very abundant. Therefore, the over-representation of young adults in the 1991 stranding we sampled is not the rule, as both size and age groups were found.

The sex ratio (1:1.11) of our sample was significantly female biased ($P<0.05, \chi^2=22.97$, df=1,147). Benthic samples of crabs in Bahía Magdalena during 1990 (Solís, 1991), also

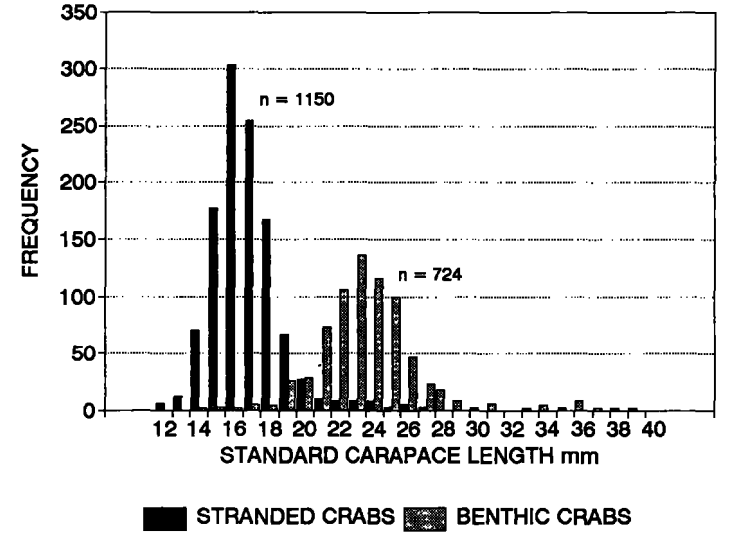

Figure 3

Size distribution of pelagic red crabs, *Pleuroncodes planipes*, stranded in Bahía Magdalena and the typical distribution of benthic crabs on the continental shelf off Baja California.

had an overrepresentation of females (1:1.23), suggesting that a higher abundance of females in stranded crabs would be a reflection of the sex ratio in the bay. Additional evidence for a female biased sex ratio in coastal waters comes from Serrano (1991), who reported higher frequency of females inshore during the breeding season. Similar findings were obtained by Escoto and Orellana (1981) for pelagic red crabs off the Nicaragua coast, and for a closely related species, *P. monodon*, from Chile (Arana and Culquichicón[4]). However, several authors have reported that the total sex ratio on the continental shelf is male biased (Boyd, 1962; Boyd and Johnson, 1963; Serrano, 1991). Boyd (1962), suggested that the sex-ratio differences on the continental shelf could be due to one or a combination of the following causes: 1) a deviation in primary sex ratio, 2) lower survival rate of females, or 3) the fact that plankton nets may not sample males and females with equal effectiveness.

The hypothesis that females die at a higher rate than males is supported by the present data, since females were more abundant where there was a natural cause of mass mortality. It has been mentioned that the breeding season of the species is synchronized to the time (winter-spring) when coastal upwelling is more intense. Pelagic red crabs may be more abundant in places where phytoplankton is more plentiful (Blackburn, 1969). Thus, it can be advantageous for pelagic red crab females to move to shore and release larvae in upwelled water. However, by doing so, females are more likely to enter Bahia Magdalena or other coastal lagoons and die in accidental strandings.

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