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# Movements of juvenile and adult spider crab (*Maja squinado*) in the Ría da Coruña (N-W Spain)

C. Bernárdez*, E.González-Gurriarán, B. García-Calvo, A. Corgos, & J. Freire

*Dpto. Bioloxía Animal, B. Vexetal e Ecoloxía. Universidade da Coruña. Campus da Zapateira, s/n. E-15071 A Coruña (Spain). *Corresponding Author, e-mail: cbm@udc.es*

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**Abstract**

In July 2002, 12 juvenile and 12 adult (recently terminal moulted) spider crabs were tagged using ultrasonic pingers (Sonotronics, USA) in the Ría da Coruña (N-W Spain). Both adults and juveniles were released in the same sandy shallow bottoms (5-10 m) in which they were caught. This area, as known from previous studies, is a typical juvenile area where spider crabs carry out their terminal moult before the autumn migration to deep bottoms. The tracking was carried out daily for a period of two weeks, although not all the crabs were located every day. Juvenile crabs were found to move small distances, performing non-directional movements near the coast, in protected areas up to 10 m deep. Two of the adult crabs performed small-scale movements in the outer (more exposed) part of the estuary, at depths up to 20 m. The rest of the adult crabs remained in the juvenile area, performing the same non-directional movements as the juveniles. Four male adult crabs were recaptured by commercial fisheries in the following months, three of them at more than 40 m deep, in the central channel of the estuary, probably while performing their seasonal descent migration. A female carrying eggs was recaptured in December near the coast.

**Introduction**

The spider crab, *Maja squinado* (Decapoda, Majidae) (recently splitted into *Maja squinado* (Herbst, 1788), inhabiting Mediterranean coasts, and *Maja brachydactyla* Balss, 1922, in the Atlantic coasts of Europe (Neumann, 1996)), is a species that lives at depths ranging from subtidal level to more than 150 m (González-Gurriarán *et.al*., unpublished data). There is strong evidence that spatial segregation exists between juveniles and adults; these habitat differences are variable according to the season (Corgos *et al*., 2002). In the Ría da Coruña (N-W Spain), juveniles (carapace lenght < 120-140 mm) inhabit predominantly shallow waters characterized by mixed hard-and-soft bottoms. One or two months after the terminal moult that takes place in their second year, through which they attain maturity, females start their gonad maturation (González-Gurriarán *et al*., 1998). Some behavioural changes are also defined in this period, leading to migratory movements to deeper waters (Latrouite and Le Foll, 1989; González-Gurrirán and Freire, 1994; Hines *et al*., 1995). The adults inhabit deep areas where they are the target of a tanglenet fishery (González-Gurriarán *et al*., 1993; González-Gurriarán and Freire, 1994). Movements and habitat use of this species is highly important for the fishery, given that catches are directly related to the activity rhythms and migrations. Although many studies have been carried out analyzing migration movements using mark-recapture methods (Camus, 1983; Kergariou, 1976; Le Foll, 1993; González-Gurriarán *et al*., 2002), little information is available on the animal's activity in the coastal shallow areas in the months prior to migration (González-Gurriarán and Freire, 1994).

The objective of this study was to describe patterns of movement and habitat use in the summer period when shallow areas, determined by previous studies, are shared by juveniles and young adults (recently moulted to maturity). Local movements between habitats or areas within a habitat as well as aggregation patterns are aspects of interest as yet to be established.

The study used ultrasonic telemetry, previously shown to be an efficient tool to obtain accurate data on crab small-scale movements and migrations (Maynard and Webber, 1987; Wolcott and Wolcott, 2002). It has also been successfully used in the spider crab (Freire and González-Gurriarán, 1998; González-Gurriarán and Freire, 1994; González-Gurriarán *et al.*, 2002; Hines *et al.*, 1995).

## Materials and methods

In July 2002, 24 spider crabs were tagged using ultrasonic pingers in the Ría da Coruña (NW Spain) (Fig. 1). The tagging took place in Bastiagueiro, a shallow sandy bottom area in the inner part of the Ría da Coruña (43º 21' N, 8º 22' W), between the 8th and the 10th July 2002. Twelve juvenile (with carapace length between 84 and 135.5 mm) and twelve adult (recently moulted to maturity; carapace length between 112 and 173 mm) spider crabs were tagged using Sonotronics IBT-96-2 and CHP-87-S pingers, respectively. The first has a weight of 2.5 g in water and dimensions of 28 by 9.5 mm. The battery lasts for 60 days, and the operating frequency is 69 or 76.8 kHz. Under ideal oceanographic conditions the pingers can be detected from distances up to 500 m (Sonotronics' technical specifications). The pingers used for the tagging of adult crabs weighted 8 g in water, and their dimensions were 67 by 18 mm. The battery lasts for 7 months and the transmission frequency is 75 kHz. They can be detected from distances up to 3000 m in ideal conditions.

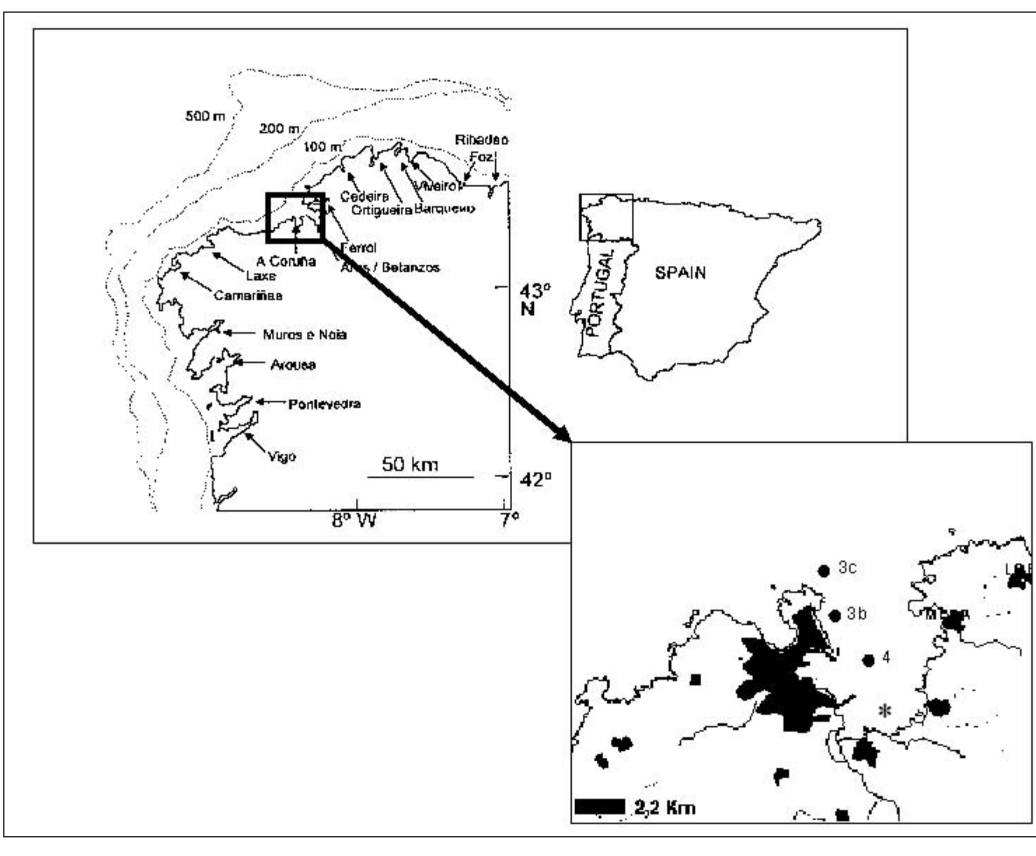


Fig. 1 – Ría da Coruña (NW Spain), showing tagging area (*) and oceanographic data collection stations (4, 3b and 3c).

The spider crabs were captured using pots. Algae and other epiphytes were cleaned off the dorsal part of the carapace by scrubbing them with a brush. Then the area was dried using alcohol and acetone in a cloth. Tags were then attached to the clean, dry carapace on the dorsal side, using quick epoxy. Adult crabs' tags, which are bigger, could be labelled by writing UDC´s (Universidade da Coruña) telephone number and the word "reward" on its surface. Smaller tags used for juveniles allowed no writing on their surface. Thus, the labelled part of a T-bar anchor tag was also attached to the carapace, using the same quick epoxy. The tagging process was as quick as possible (<20 minutes), in order to avoid long air exposure.

A Sonotronics USR-5W receiver with a Sonotronics DH-2 directional hydrophone was used to locate the tagged crabs on a daily basis (although some of the crabs were not located every day due to unfavourable weather and oceanographic conditions, crab loss, lack of time, etc…), using a small boat equipped with echo-sounder and GPS. The telemetry experiment started the 8$^{th}$ July 2002 and ended the 24$^{th}$ July 2002.

Distance between consecutive locations and movement direction in relation to the north was estimated from GPS positions of located crabs. The distance between locations was assumed to be the minimum distance travelled by the animal between observations. Speed (mday$^{-1}$) was calculated as distance between locations in consecutive days. Distance between locations, speed and mean depth was calculated omitting the release observation. The statistic $r$ was computed, which is equal to the mean vector length and represents a measurement of concentration of the different movement angles. The length will range from 0 to 1; larger number indicates that the observations are clustered more closely around the mean than lower numbers. The Rayleigh test was performed to determine if the movement of each animal presented a significant directional orientation. The test calculates the probability of the null hypothesis that the data are distributed in a uniform manner (Batschelet, 1981).

Some recaptures were obtained from commercial fisheries in the following months. Data such as fishing date, position and depth were taken. In the only case of a recaptured female, dissection was performed to determine gonad and egg maturation stage and number of sperm masses (González-Gurriarán *et al.*, 1998).

Oceanographic data, recorded monthly, were provided by the Instituto Español de Oceanografía (Centro Costero de A Coruña). These included temperature and salinity in three sampling stations in the tagging area and outer part of the estuary, from 20 to 40 m depth. Two data loggers, that recorded temperature data every two hours, were placed in the tagging area, at fixed depths of 5 and 10 m.

## Results

From a total of 24 tagged crabs, four were never located (lost after release) and one crab was located only once. These five crabs were all adults. Mean number of position fixes per crab was 10 (range: 4-12). During the tracking period, both juvenile and adult spider crabs performed small-scale movements within the inner part of the estuary (Fig. 2). The mean distance between locations was 187 m for juveniles and 179 m for adults (range: 94-517 and 114-250, respectively) and the mean speed 154 mday$^{-1}$ for juveniles and 159 mday$^{-1}$ for adults (range: 58-272 and 100-250, respectively). These movements were carried out in shallow sandy bottoms. Mean depth was 6.5 m for juveniles and 9.5 m for adults.

Figure 3 shows the distance between crabs during the experiment. Crabs moved up to 187 mday$^{-1}$, and average distance between crabs was 80 m (range: 17-106 m).

One juvenile crab showed significant directionality (SW) in its movements ($r$=0.57, p=0.03). Two crabs that were lost for more than one week during the tracking were excluded from the directionality analysis. The rest of the crabs did not show significant directionality in their movements (tests of Rayleigh, p>0.05; Figs. 2 and 4); $r$ statistic ranged between 0.08 and 0.4.

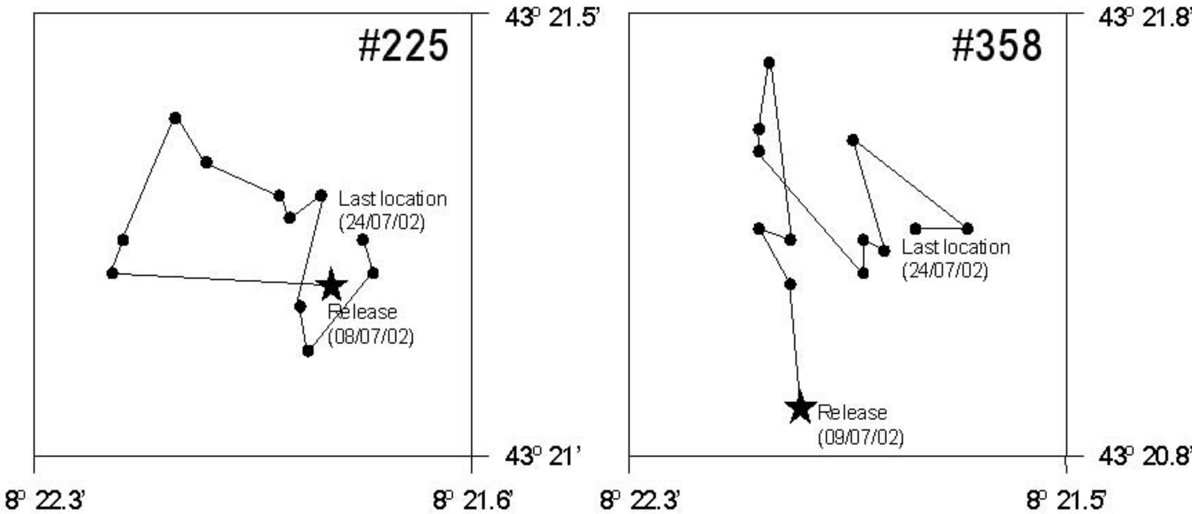


Fig. 2 – Examples of movements of two juvenile crabs (#225 and #358).

In late August, one month after the end of the tracking, three adult males were recaptured by commercial fisheries. One of them was recaptured in the inner part of the estuary, at a depth of 17 m. The other two were recaptured in the central channel, outside the estuary, at a depth of 50 m. Another male was recaptured outside the estuary in May 2003, at a depth of 45 m. A female carrying eggs was recaptured in late December 2002 in coastal shallow waters.

Oceanographic data (Fig. 5, a and b) show a stable pattern of both temperature and salinity during the late spring-summer period (May to September). Mean temperatures show an oscillation of 2 ºC and salinity initiates a slow decrease in September, related to the first autumn rains.

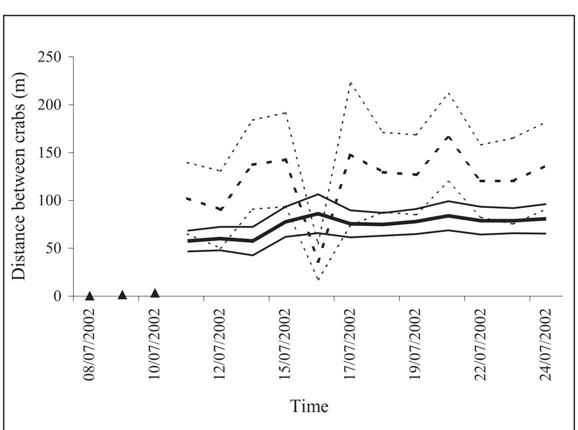


Fig. 3 – Average distance (m) between crabs (both juvenile (solid line) and adult (dotted line) from release to the end of the experiment. Thinner lines show the confidence interval. Triangles represent release dates.

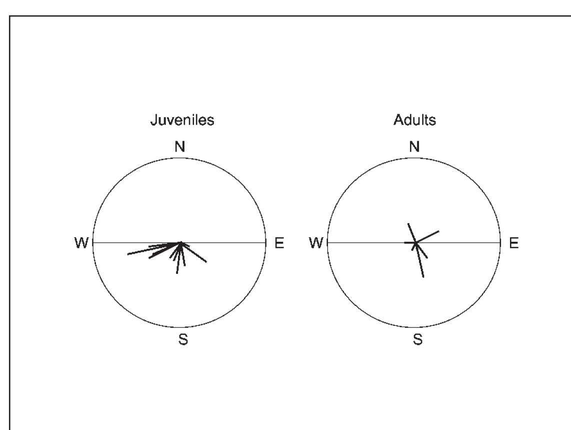


Fig. 4 – Average angles of movements in juveniles and adults. Vector length is proportional to directionality of movement (statistic *r*; radius of the circumference=1).

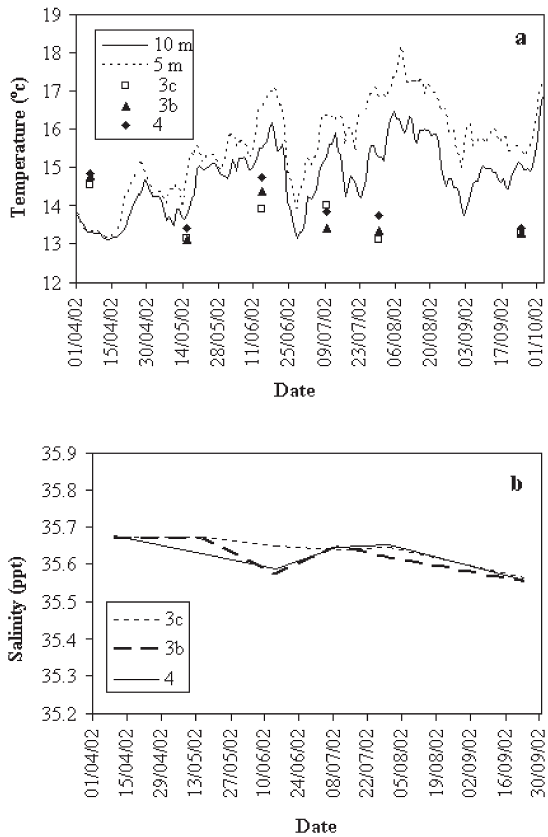


Fig. 5 – **a**, Bottom temperature at stations 4, 3b and 3c (20, 35 and 40 m depth, respectively), and temperature at 5 and 10 m in the tagging area. **b**, Bottom salinity at stations 4, 3b and 3c.

## Discussion

In the Ría da Coruña, juvenile spider crabs show a clear aggregative pattern in shallow areas, probably to avoid predation risk (Corgos *et al*., 2002). During late summer, both juveniles and recently moulted to maturity adults carry out small-scale, non-directional movements. This kind of short, random movement in shallow areas has also been observed in other crabs, such as *Cancer pagurus* (Skajaa *et al*., 1998), and in *Homarus americanus* (Watson *et al*., 1999).

González-Gurriarán and Freire (1994), describe a two-phase movement pattern for these young adults, while gradually increasing their gonad, muscle and hepato-pancreas condition. The first stage is characterized by movements that follow the same pattern as those of juveniles. We found, for both juveniles and adults, that the average distance between animals was smaller than the average distance between consecutive locations. Taking into account the potential movement of the crabs (up to 187 mday$^{-1}$), the average distance between crabs during tracking (80 m) would point to an aggregative pattern as suggested in previous studies (Corgos *et al*., 2002).

An increase in movement scale and directionality was found in the second phase, prior to migration (González-Gurriarán and Freire, 1994). Right before the descent autumn migration, adults move progressively to the outer part of the shallow area, leaving it coordinately in September (males) and October (females) (Corgos *et al*., 2002). Our results show recaptures in the central channel outside the estuary, at a depth of 50 m, suggesting the beginning of movements to deeper areas. Seasonal migrations have been described in decapods such as blue crab (Skajaa *et al*., 1998; Wolcott and Wolcott, 2002), snow crab (Maynard and Webber, 1987), king crab (Fotheringham, 1975) and swimming crabs (Venema and Creutzberg, 1973).

The beginning of the descent migration, which tends to occur in late summer or autumn, has been found to be strongly related to oceanographic parameters together with ontogenetic aspects (Venema and Creutzberg, 1973; Latrouite and Le Foll, 1989; González-Gurriarán and Freire, 1994; Tankersley *et al*., 1998; Watson *et al*., 1999; González-Gurriarán *et al*., 2002; Wolcott and Wolcott, 2002). The period in which our tracking was performed corresponds to the first stationary phase described by González-Gurriarán and Freire (1994). Mating might take place in deep areas (González-Gurriarán *et al*., 1998) where a lek mating system has been suggested by Corgos *et al*. (2002).

The possibility of fertilizing eggs with sperm from previous matings would give the females the opportunity to spawn two o three times without remating (González-Gurriarán *et al*., 1998). The hypothesis of a late winter-early spring ascent migration towards shallow coastal areas, where higher temperatures would favour egg development, was suggested by González-Gurriarán *et al.* (2002). Spawning migrations have also been described for *Callinectes sapidus* (Carr *et al.*, 2002; Tankersley *et al.*, 1998; Wolcott and Wolcott, 2002). Male spider crab recaptures still occur in spring in deep areas, thus supporting the hypothesis of a just-female ascent migration. Breeding female recaptures in shallow waters occur from December on, as it is the case in our study, supposedly after performing both migrations.

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