Movements of juvenile and adult spider crab (*Maja squinado*) in the Ría da Coruña (NW Spain)

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ABSTRACT

In August 2002, 12 juvenile and 12 adult (recently terminal moulted) spider crabs were tagged using ultrasonic pingers (Sonotronics, USA) in the Ría da Coruña (NW 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 juvenile 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 of 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, probably after carrying out both a descent and ascent migration.

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1996)), is a species that lives at depths ranging from subtidal level to more than 150 m (González-Gurriarán *et.al*., unpublished data).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.*, 2001). In the Ría da Coruña (NW Spain), juveniles (carapace lenght of < 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 (González-Gurrirán & Freire, 1994; Hines et al., 1995, Latrouite & LeFoll, 1989). The adults inhabit deep areas where they are the target of a tanglenet fishery (González-Gurriarán *et. al*., 1993, 1994). Movements and habitat use of this species is highly important for the fishery, given that catches are directly related to the activity rythms 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 previous to migration (González-Gurriarán & Freire, 1994). The objective of this study was to describe movement and habitat use patterns in the summer period when shallow areas, determined by previous studies, are shared by juveniles and young adults. Local movements between habitats or areas within a habitat as well as aggregation patterns are aspects of interest as yet to be established.

Ultrasonic telemetry has been efficiently used as a tool to obtain accurate data on crab small-scale movements and migrations (Freire & González-Gurriarán, 1998, González-Gurriarán *et. al*., 2002, Hines *et al*., 1995, Maynard & Webber, 1987, Wolcott & Wolcott, 2002).

METHODOLOGY

In August 2002, 24 spider crabs were tagged using ultrasonic pingers in the Ría da Coruña (NW Spain) (figure 1). This was the first tagging experiment of a planned experimental design consisting on two telemetry experiments (a summer experiment and a spring experiment). The second one, planned for spring 2003, could not take place due to the "Prestige" oillspill and its effects on the spider crab populations.

The summer 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 lenght between 112 and 173 mm) spider crabs were tagged using Sonotronics IBT-96-2 and CHP-87-S pingers, respectively. The first have a weight of 2.5 g in water and dimensions of 28 by 9.5 mm. The battery lasts for 60 days, and the beep code is produced at a frequency of 69 or 76.8 kHz. Under ideal oceanographic conditions they can be detected from distances of up to 500 m. 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 their emision frequency is 75 kHz. They can be detected from distances of up to 3000 m in ideal conditions.

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 epoxi. Adult crabs' tags, which are bigger, could be labeled by writting UDC´s (Universidade da Coruña) telephone number and the word "reward" on its surface. Smaller tags used for juveniles allowed no writting on their surface. Thus, the labelled part of a T-bar anchor tag was also attached to the carapace, using the same quick epoxi. The tagging process was as quick as possible (< 20 minutes), in order to avoid long air exposure.

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

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 - from I to IV and from A to C, respectively -, spermathecae fullness - from 0 to 4 -, and number of sperm masses (González-Gurriarán *et al*., 1998).

Oceanographic data 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.

Distance between consecutive locations and movement direction in relation to the north was estimated from GPS location data obtained in the telemetry experience. The distance between locations was assumed to be the minimum distance travelled by the animal between observations. Speed (m/day) 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 lenght 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. Test of Rayleigh 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).

RESULTS

From a total of 24 tagged crabs, 4 of them were never tracked (lost after release) and one more was located just once. These five crabs were all adults. Mean number of locations 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. 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 m/day for juveniles and 159 m/day 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. For both juveniles and adults, 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 m/day), the average distance between crabs during tracking (80 m; range 17-106 m) would point to an aggregative pattern as suggested in previous studies (Corgos et al., 2002).

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 (table 1; tests of Rayleigh, p>0.05; figures 2 and 4). r statistic ranged between 0.08 and 0.4.

In late August, one month after the end of the tracking, three adult males were recaptured by commercial fisheries. One of them was recaptured still 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., suggesting the beggining of migratory movements to deeper areas. 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, probably after performing both a descent and ascent migration.

Oceanographic data (figure 5) show a stable pattern of both temperature and salinity during tthe 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.

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.*, 2001). Between June and November the aggregative pattern is broken by the presence of recently moulted adults, and both juveniles and adults are dispersed along the area. 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 & Freire, 1994, describe a two-phase movement pattern for these young adults. The first stage is characterised by movements that follow the same pattern as those of the juveniles. During this stationary stage, while they perform small scale movements in shallow waters, adult males gradually increase their gonad, muscle and hepatopanchreas condition. Gonad development starts later in females.

An increase in movement scale and directionality is found in the second phase, which is described as a transitional period prior to migration (González-Gurriarán & Freire, 1994). Right before the descent autumn migration (high speed high directional movement towards deep areas), adults move progressively to the outer part of the shallow area, leaving it coordinately in September (males) and October (females) (Corgos *et.al.*, 2001). Different strategies of movement between sexes at particular life stages have been also investigated in other crab species (Maynard & Webber, 1987).

Seasonal migrations occur in decapods such as blue crab (Skajaa *et. al*., 1997; Wolcott & Wolcott, 2002), king crab (Fotheringham, 1975) and swimming crabs (Venema & Creutzberg, 1973). Most of these seasonal migration movements tend to occur in late summer or autumn.

The beggining of the descent migration has been found to be strongly related to oceanographic parameters together with ontogenetic aspects. A decrease in salinity, which takes place at the start of the autumn as a consequence of the frequent rain, has been described as the main environmental signal for the onset of migration to deep bottoms in *Maja squinado* (González-Gurriarán *et. al*., 2002). Latrouite *et. al.* (1989) proposed that currents, temperature and bathymetry gradient are the orientation mechanisms employed in migratory movements. In estuarine lobsters, these seasonal migrations are supposed to enhance their growth and survival by enabling them to avoid low salinity events in the spring and fall, and to accelerate their growth in warmer estuarine waters during the summer (Watson *et.al.*, 1999). Female blue crabs leave low-salinity areas of estuaries and migrate seaward in late summer or autumn (Tankersley *et. al*., 1998, Wolcott & Wolcott, 2002). Similar migratory fall movements were studied for swimming crabs, and were found to be determined by salinity decrease (Venema, & Creutzberg, 1973). The stability in the recorded oceanographic parameters during our study supports the hypothesis of environmental changes as signals leading to migration movements. The period in which our tracking was performed corresponds to the first stability phase described by González-Gurriarán & Freire (1994). The lack of directionality and depth stability in both juveniles and adults and the small scale movements they perform, describe a period in which stability in both internal (gonad development, body condition) and external (oceanographic parameters) factors determine behaviour. It is probably the combination of changes in those factors (decrease in salinity, gonad development) that take place a couple of months later, in early autumn, that leads to behavioural changes ending in the migration episodes to deep areas. These deep bottoms, where oceanographic conditions would remain more stable, could be also providing mating grounds. The exact moment of mating, that might take place in deep areas (González-Gurriarán *et al*., 1998), has not yet been defined, although a lek mating system has been suggested by Corgos *et. a*l., 2001.

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

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LITERATURE

Batschelet, 1981. Circular statistics in Biology. Academic Press, New York, 371 pp.

Camus, 1983. Résultats d'une opération de marquage d'araignée de mer (Maja squinado, Herbst) adult en baie d'Audierne (Bretagne Sud). ICES, Shellfish Committee, C.M. 1983/K:29, 11 pp.

Carr, S. D., R. A: Tankersley, J. L. Hench, R. B. Jr. Forward & R. A. Jr. Luettich, 2002. Field observations of ebb-transport of the blue crab Callinectes sapidus near a barrier island inlet using ultrasonic telemetry. Open Sciences 2002, Honolulu, Hawaii.

Corgos A., C. Bernárdez, P. Verísimo & J. Freire, 2002. Population dynamics of Maja squinado in the Ría de A Coruña (Galicia, NW Spain), using mark-recapture experiments. 8th Colloquium Crustacea Decapoda Mediterranea, 2-6 September 2002, Corfu, Greece.

Fotheringham, N., 1975. Structure of seasonal migrations of the littoral hermit crab *Clibanarius vittatus*. J. Exp. Mar. Biol.. Ecol. 18(1), 47-53.

Freire, J. & González-Gurriarán, E. 1998. New approaches to the behaviour ecology of decapod crustaceans using telemetry and electronic tags. Hydrobiology 371/372:123-132.

Fujita, H., K. Takeshita & S. Kawasaki, 1973. Seasonal movement of adult male king crab in the eastern Bering Sea revealed by tagging experiment. Bull. Far. Seas. Fish. Res. Lab. 9, 89-107.

González-Gurrirán, E. & J. Freire, 1994. Habitat, movements and migration of the spider crab *Maja squinado* in the Ria de Arousa (NW Spain). Preliminary data using ultrasonic telemetry. ICES, Shellfish Committee, C.M. 1994/K:30, 11 pp.

González-Gurriarán, E., L. Fernández, J. Freire, R. Muiño & J. Parapar, 1993. Reproduction of the spider crab *Maja squinado* (Brachyura: Majidae) in the southern Galician coast (NW Spain). ICES, Shellfish Committee, C.M. 1993/K:19, 15 pp.

González-Gurriarán, E., L. Fernández, J. Freire & R. Muiño, 1998. Mating and role of seminal receptacles in the reproductive biology of the spider crab *Maja squinado* (Decapoda, Majidae). Journal of Experimental Marine Biology and Ecology, 220:269-285.

González-Gurriarán, E., J. Freire & C. Bernárdez, 2002. Migratory patterns in the spider crab Maja squinado using electronic tags and telemetry. Journal of Crustacean Biology 22 (1):91-97.

Hines, A.H., T.G. Wolcott, E. González-Gurriarán, J.L. González-Escalante & J. Freire, 1995. Movement patterns and migrations in crabs: telemetruy of juvenile and adult behaviour in *Callinectes sapidus* and *Maja squinado.* Journal of the marine biological Association of the United Kingdom, 75: 27-42.

Kergariou, G., 1976. Premiers résultats obtenus par marquage de l'araignée de mer, *Maia squinado*, déplacements, mortalit par pêche. ICES, Shellfish and Benthos Committee, C.M. 1976/K:14, 6 pp.

Latrouite, D. & D. le Foll 1989. Donnees sur les migrations des crabes torteau

Cancer pagurus et les arignees de mer *Maja squinado*. *Océanis* 15 (2): 133 – 142.

Le Foll, D., 1993. Biologie et exploitation de l'araignée de mer *Maja squinado* Herbst en Manche Ouest. Université de Bretagne Occidentale. IFREMER, RI DRV 93-030. Thése de Doctorat, 524 pp.

Maynard, D.R. & D.M. Webber, 1987. Monitoring the movements of snow crab (*Chionoecetes opilio*) with ultrasonic telemetry. Proceedings of Oceans 87, vol 3, 962-966

Neumann, 1996. Comparative investigations of the systematics and taxonomy of European *Maja* species (Decapoda, Brachyura, Majidae). Crustaceana, 69:821-852.

Pawson,M.G., 1995. Biogeographical identification of English Channel fish and shellfish stocks. Fisheries technical report number 99. Ministry of agriculture, fisheries and food directorate of fisheries research.

Skajaa, K.., A. Fernoe, S. Loekkeborg & E. K. Haugland, 1997. Basic movement pattern and chemo-oriented search towards baited pots in edible crab (*Cancer pagurus* L.). Hidrobiología, 371-372, no. 1-3, 143-153.

Tankersley, R. A., M. G. Wieber, M. A. Sigala & K. A. Kachurak, 1998. Migratory behavior of ovigerous blue crabs *Callinectes sapidus*: Evidence for selective tidal-stream transport. Biological Bulletin, 195(2): 168-173.

Vannini, M. & S. Cannicci, 1995. Homing behaviour and possible cognitive maps in crustacean decapods. J. Exp. Mar. Biol.. Ecol. 193(1), 67-91

Venema, S.C & F. Creutzberg,, 1973.Seasonal migration of the swimming crab *Macropipus holsatus* in an estuarine area controlled by tidal streams. Neth. J. Sea. Res. 7, 94-102.

Watson, W.H.,III; A. Vetrovs & W.H. Howell, 1999. Lobster movements in an estuary. Mar. Biol. 134(1), 65-75.

Wolcott, T. G. & D. L. Wolcott, 2002. Migration of adult female blue crabs to spawning grounds: mechanisms and routes. CBSAC 2002 Project Presentation Workshop.
Available at: http://noaa.chesapeakebay.net/fisheries/WolcottAb2002.pdf

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

Figure 2. Examples of movements of two juvenile crabs.

Figure 3. Average distance (m) between crabs (both juvenile and adult) from release to the end of the experiment. Dotted lines show the confidence interval. Triangles represent release dates.

Figure 4. Average angles of movements in juveniles and adults. Vector length is proporcinate to directionality of movement (statistic r; radius of the circunference = 1).

Figure 5. Bottom temperature and salinity in stations 4, 3b and 3c (20, 35 and 40 m depth, respectively)