The red-crab bloom off the west coast of Baja California, México

Carlos J.Robinson and Jaime Gómez-Gutiérrez
Laboratorio de Ecología de Pesquerías, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Apartado Postal 70-305, CP 04510, México, D.F. and Departamento de Plancton y Ecología Marina, Centro Interdisciplinario de Ciencias Marinas, Apartado Postal 592, CP 23000, La Paz, Baja California Sur, México

Abstract. Hydroacoustic data indicate that the benthic red crab Pleuroncodes planipes (Stimpson, 1860) rises from the bottom towards the surface at dusk from very compacted patches settled on the continental shelf. The behaviour is fast and abrupt, lasting <60 min.

The red crab Pleuroncodes planipes (Stimpson, 1860) (Figure 1) is an important component of the pelagic and benthic ecosystem along the west coast of Baja California, México. This crustacean of the Galatheidae family, langostilla as it is known commonly in México, is a very abundant grazing organism in the coastal upwelling at the southern part of the California Current System (Longhurst et al., 1967; Blackburn and Thorne, 1974), and a common prey for some marine vertebrates and invertebrates (Walsh et al., 1974; Galván, 1988). In its benthic phase, this crab is detritophagous in low-oxygen-concentration environments (Rowe et al., 1985). Juvenile and young adults may be found at the bottom as well as in the water column. However, when they reach their second year, >32 mm in standard carapace length, they become strictly benthic (Boyd, 1967). The seasonal inshore–offshore movements of benthic P.planipes are well studied (Aurioles-Gamboa, 1992), as well as the inshore–offshore larval drift (Gómez-Gutiérrez and Sánchez-Ortiz, 1997). However, the diel movements of this red crab are not well understood. Although migration from the bottom to mid-water during the night is a common behaviour (Boyd, 1967; Kato, 1974), P.planipes may also be found on the surface during the day (Alvarino, 1976; Blackburn, 1977). We have observed surface swarms arranged in bands at Magdalena Bay (24°N) during summer, like those observed with Munida gregaria (New Zealand) by Jillet and Zeldis (1985) aggregated by internal waves and surface Langmuir circulation. Boyd (1967) reported that the red crabs do migrate towards the sea surface during the night; however, Aurioles-Gamboa (1992) observed that only a fraction of the benthic red crabs migrate towards the surface. Pelagic and benthic phases can be found simultaneously only inshore and during the seasonal reproductive months (spring, February–March), the benthic phase may migrate into the pelagic zone for reproduction (Gómez-Gutiérrez and Sánchez-Ortiz, 1997). Our personal observations using hydroacoustic records indicate horizontal movements and dispersion during the night in the water column. During the day, however, the pattern is less regular; the red crabs may be found compacted and very close to...
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the bottom, compacted and in continuous layers in deep water, in dense groups in mid-water or near to the surface. One of the problems when assessing pelagic stocks and behaviour of anchovies and sardines in the west coast of Baja California is the sudden, huge appearance of red crabs in middle water during dusk in areas where they were absent during the day. Although hydroacoustically it is possible to discriminate between the anchovy’s target strength and the red crab’s (MacLennan and Simmonds, 1992; Robinson et al., 1995), the problem remains when it is necessary to obtain mid-water net samples to validate the observations. A few minutes of trawl are more than enough for a net to be lost or damaged due to the presence of these crabs. Their sudden appearance may be an expansion of the red crabs observed in the middle water layer, they are very active swimmers during the night, or perhaps they rise from the bottom. The aim of this study is to find out from where, and how, the red-crab swarms appear suddenly in the middle water.

In March 1995, considered as the peak of reproduction of the red crab, three transects each 18 km long, perpendicular to the coast and separated 36 km from each other, were defined from the RV ‘El Puma’ off the west coast of Baja California near Punta Eugenia, between 27°30’N, 115°00’W and 26°00’N, 114°00’W (Figure 2). Continuous hydroacoustic survey of the water column was obtained on each transect, starting from the neritic zone, heading to the oceanic zone and returning to the neritic zone ~4 h later. Observations started on 18 March in transect one at 10:35 h and finished the next day at 09:00 h. Transect two started on 19 March at 12:00 h and finished the next day at 08:00 h. Transect three started on 20 March at 11:30 h and finished the next day at 07:00 h (standard Pacific time).

A Simrad EY-200, single-beam echosounder with a working frequency of

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**Fig. 1.** Adult of the red crab *Pleuroncodes planipes* (Stimpson, 1860).
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Fig. 2. Map of the study area showing the location of the three transects.

200 kHz and a pulse length of 0.3 ms was used, together with a Hydro Acoustic Data Acquisition System (HADAS) (Lindem and Houari, 1988). This latter is an echo-counting program which transforms the received echo distribution into area densities and abundance estimates. The system is based on a combination of hardware and computer software which together allow the digitizing and storing of hydroacoustic transects. This program uses a modification of the Craig and Forbes (1969) algorithm to remove the beam pattern effect. Since a time-varied gain of 40 LogR was used, analyses of echo count for individuals were performed. Before the cruise, the unit was calibrated with a 13.7-mm-diameter copper sphere (-45 dB). Calibrations were performed before the observations in order to obtain the approximate target strength (TS) of the red crab and then use it to discriminate the swarms of this crustacean from other organisms. These consisted of analysing echograms, using HADAS, at depths and positions where Isaacs-Kidd net midwater samples have shown >95% in weight of red crabs. Results demonstrated that -52 to -54 dB is the range of TS for *P. planipes*, using this hydroacoustic system and set-up. Red crabs were found in all transects. In transect one, they were found above the continental platform and near the shelf break. They were observed in several ways: a few scattered on the surface during the day, forming continuous swarms at several depths also during the day and dispersed during the night. In transects two and three, a sudden presence of the crustaceans was observed.
Therefore, we will describe the results only in these two areas. The 11:00 h survey in transect two, which started in the oceanic zone, is presented in Figure 3. There was no evidence of red crabs. Most of the echoes were below -56 dB.

The 17:00 h survey, which also started from the oceanic zone, is presented in Figure 3B. Here, in the oceanic side of the transect, at -100 m depth, a deep scattering layer composed by the euphausid *Nyctiphanes simplex* was found. In this same figure, a dense biomass rising from the continental shelf is observed. A zoomed view of this bloom is shown in Figure 3C. On its base, the patch lasted 110 pings. With a ping rate of 1.8 s\(^{-1}\) and a ship speed of 11.5 knots h\(^{-1}\), the swarm was calculated to measure ~366 m in length. The time when the boat passes over the shoal was about 18:45 h, just after sunset, which occurs around 18:00 h. A TS analysis using HADAS was performed on this echogram. Target strength distribution was similar to the range associated with *P.planipes*. The following survey, from the neritic towards the oceanic zone, started at 19:30 h, and the echogram around the area where the dense swarm was previously found is presented in Figure 3D. In this survey, a mid-water trawl was performed. The trawl lasted for 20 min at 15 m depth. The catch weighed 18 kg and 95.1% in weight of all the sample were red crabs (Table I).

The 14:30 h survey in transect three, beginning in the oceanic zone, is presented in Figure 4A. Here, again, the echo analysis shows a few scatters below -56 dB. The 16:45 h survey starting in the oceanic zone is presented in Figure 4B. Notice a smaller but distinctive biomass rising over the continental shelf. A zoomed view of this shoal is presented in Figure 4C. This swarm on its base lasted 25 pings, i.e. ~83 m long. The oceanographic ship passed over this shoal at about 18:15 h. A TS analysis was performed and results show a similar range of TS as the range associated with *P.planipes*. The following survey, from the neritic towards the oceanic zone, started at 19:00 h. The echogram around the area where the rising biomass was previously found is presented in Figure 4D. During this survey, a mid-water trawl was performed. The trawl lasted 22 min at 20 m depth. The total catch weighed 3 kg and 78.1% in weight of all the sample were red crabs (Table I).

Results show that benthic *P.planipes* rises from the bottom towards the surface.

<table>
<thead>
<tr>
<th>Species</th>
<th>Transect two</th>
<th>Transect three</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean length</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pleuroncodes planipes</em></td>
<td>24.2 (2.3)</td>
<td>21.2 (1.5)</td>
</tr>
<tr>
<td><em>Nyctiphanes simplex</em></td>
<td>7.4 (7.2)</td>
<td>8.2 (6.9)</td>
</tr>
<tr>
<td>Phasiphaideae</td>
<td>34.2 (4.7)</td>
<td>33.9 (4.2)</td>
</tr>
<tr>
<td><em>Engraulis mordax</em></td>
<td></td>
<td>11.5 (1.5)</td>
</tr>
<tr>
<td>Relative abundance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pleuroncodes planipes</em></td>
<td>95.1</td>
<td>78.1</td>
</tr>
<tr>
<td><em>Nyctiphanes simplex</em></td>
<td>1.2</td>
<td>1.1</td>
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<tr>
<td>Phasiphaideae</td>
<td>3.7</td>
<td>6.3</td>
</tr>
<tr>
<td><em>Engraulis mordax</em></td>
<td></td>
<td>14.5</td>
</tr>
</tbody>
</table>

Table 1. Mean caparace length of red crab (mm), mean total length (mm) of crustaceans, total length (cm) of anchovies and relative abundance in weight expressed as a percentage from samples caught in transect two and three with an Isaacs-Kidd net. The SD is in parentheses.
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Fig. 3. Echograms on transect two. The white continuous layer is the bottom. Colours represent echo intensity. Yellow and red represent 1480 mV, green and yellow 920 mV, blue and green 560 mV. The 920 mV interval represents approximately the target strength used to describe the behaviour of the red crab. A white colour means a high degree of compactness of echoes. (A) At 11:00 h starting in the oceanic zone. (B) At 17:00 h starting in the oceanic zone. Notice a tower-like patch rising from the bottom on the continental shelf. (C) A zoomed view of the previous echogram showing the red crab bloom. (D) Same area as in (C), but at 19:30 h and coming from the neritic zone.

Fig. 4. Echograms on transect three. (A) At 12:30 h starting in the oceanic zone. (B) At 16:45 h starting in the oceanic zone. Here as well there is a small, but distinctive patch observed on the continental shelf. (C) A zoomed view of the previous echogram showing the red crab bloom (D). Same area as in (C), but at 19:00 h starting from the neritic zone.
at dusk from very compacted patches settled on the continental shelf. The behaviour is fast and abrupt. With these data, it is difficult to calculate the precise length of the behaviour; however, using the time when the swarm was first recorded (about 18:45 h in transect two and 18:15 h in transect three) and the time when the ship passes over the same area again (19:45 and 19:15 h), it is estimated that the behaviour lasted <60 min in both cases. The sudden appearance is similar to that observed with the anchovy (*Engraulis mordax*) in the same area; however, anchovies appear from deeper waters (Robinson et al., 1995).

The way that red crabs rise from the bottom indicates that the spatial distribution in the benthic habit of this crustacean is in the form of dense patches, rather than homogeneous. A similar conclusion was reached by Aurioles-Gamboa (1992) using a stern-trawling equipment and twin-bottom trawls. Studies on the vertical migration of zooplankton suggest that the behaviour occurs mainly in response to external stimuli, of which light intensity is seen as the most important (Cushing, 1951; Longhurst, 1976; Raymont, 1983). In the present work, the sudden rising just after sunset also suggests light intensity as the trigger. However, vertical migration is a highly variable behaviour which cannot be explained by a single factor (Dini and Carpenter, 1992). The behaviour may be modified by conditions in the local environment such as temperature (Neilson and Perry, 1990), food availability (Verheye and Field, 1992), presence of predators (Iwasa, 1982) or chemical cues (Bollens et al., 1994), and ultimately seems to depend on the individual behavioural plasticity (Bollens and Frost, 1991). This may explain the observation in transect one, where there was not an evident vertical migration. Moreover, the observation in that transect coincided with other results reporting red crabs near the surface during the day (e.g. Alvarino, 1976; Blackburn, 1977) and also with Aurioles-Gamboa (1992) who observed that only a fraction of the benthic langostilla migrate towards the surface.

According to Gallardo et al. (1994), recruitment of *P. monodon* on the continental shelf off Chile appears to be associated with late summer development of the giant sulphur bacteria *Thioploca* spp., when the oceanographic regime in the area shifts to a relaxation of the upwelling regime. Geographical differences in bottom detritus composition can affect dense red crab swarms, which remain at mid-water column feeding on phytoplankton blooms (Smayda, 1975) or zooplankton aggregations instead of feeding on detritus in the sea bottom.

**Acknowledgements**

Thanks to all the people from the Laboratory of Ecología de Pesquerías UNAM and to the RV 'El Puma' crew for assistance and comradeship at sea. This research was supported by funds provided by the Consejo Nacional de Ciencia y Tecnología (CONACyT 940511, N511-N9108), México. The authors are supported by Sistema Nacional de Investigadores (SNI) and the second author is also supported by Comisión de Operación y Fomento Actividades Académicas del Instituto Politécnico Nacional (COFAA-IPN) fellowships.

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*Received on November 11, 1997; accepted on May 28, 1998*