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Short Communication

Dynamic patterns of zooplankton transport and migration in Catuama Inlet (Pernambuco, Brazil), with emphasis on the decapod crustacean larvae*

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ABSTRACT. The objective of this study was to quantify and to model zooplankton transport with emphasis on decapod crustacean larvae. Sampling was carried out at three depths with a plankton pump coupled to a 300-μm mesh. Current data were obtained with an ADCP. Our data showed the existence of vertically and horizontally heterogeneous current and transport fields. We identified 27 groups of Decapoda (larvae of Sergestidae, Porcellanidae, Upogebiidae, Caridea, Brachyura). Most of the species and larval phases showed characteristic vertical migration patterns, in phase with the diurnal tidal cycles, thus enhancing retention or export from the estuary.

Keywords: estuarine-coastal flows, ADCP, high resolution 3D transport model, zooplankton transport, vertical migration, decapod larvae.

Patrones dinámicos de transporte y migración de zooplancton en el estuario Catuama (Pernambuco, Brasil), con énfasis en las larvas de crustáceos decápodos

RESUMEN. Esta investigación tiene como objetivo cuantificar y modelar el transporte de zooplancton, con énfasis en las larvas de Crustacea Decapoda. El muestreo se realizó a tres profundidades con una bomba de plancton acoplada a una red con malla de 300 μm. Se obtuvieron los datos de corrientes con un ADCP. Los datos mostraron la existencia de campos de corrientes y de transporte vertical y horizontal heterogéneos. Se identificaron 27 grupos de Decapoda (larvas de Sergestidae, Porcellanidae, Upogebiidae, Caridea, Brachyura). La mayoría de las especies y fases larvales mostraron patrones de migración vertical característicos, en fase con los ciclos de la marea diurnos, favoreciendo la retención o exportación del estuario.

Palabras clave: flujos estuario-costa, ADCP, modelo de transporte 3D de alta resolución, transporte de zooplancton, migración vertical, larvas de Decapoda.

Tropical mangrove estuaries are widely known to provide a habitat for innumerous invertebrate species and that high adult biomasses may build up in these areas (Schwamborn & Saint-Paul, 1996). Whereas the outwelling of detritus and other particulates from tropical mangrove estuaries has been largely investigated (Dame *et al*., 1986; Dame & Lefeuvre, 1994; Lee, 1995; Schwamborn & Saint-Paul, 1996; Melo Júnior *et al*., 2007), the research of mechanisms involved in larval export from tropical estuaries has been limited to a few studies on the export of decapod shrimp and crab larvae (Dittel *et al*., 1991; Schwamborn & Bonecker, 1996; Fernandes *et al*., 2002), although larval

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production may be one of the main processes of benthopelagic coupling in mangrove areas (Schwamborn *et al*., 2002). The present study is the first attempt to quantify and model the dynamic transport of decapod crustacean larvae in a tropical estuarine inlet using high-resolution 3D current data and vertically and horizontally discrete plankton sampling.

Sampling was performed in Catuama Inlet (northeastern Brazil), which separates the northern margin of Itamaracá Island from the adjacent continent. Detailed descriptions of the Itamaracá area have been published elsewhere (Schwamborn, 1997; Medeiros *et al*., 2001). Samples were taken on board a small wooden vessel during spring tide (05-06 August 2001) and neap tide (11-12 August 2001) at 3-hour intervals over 12 hours for spring tide (n = 32 samples) and 22 hours for neap tide (n = 56 samples). Plankton samples were taken with a pump at three stations along a transect across the inlet. At the central station (Center or Convergence), three depth levels were sampled (50 cm below the surface, midwater, and 50 cm off the bottom); at the lateral stations, (Continent and Island), samples were taken only at subsurface and off the bottom. Thus, seven samples were taken for each sampling period. Sample water was pumped on board through a conical 300-μm plankton net for 3 to 5 minutes per sample at approximately 100 litres per minute. Immediately after sampling, all samples were fixed with formaline (final concentration: 4%; buffered with 5 $g \cdot L^{-1}$ sodium tetraborate). Before each sampling series, a complete 3-D current profile from one margin to the other was obtained with an ADCP (acoustic Doppler current profiler) probe that was attached to the side of the boat. Current velocity and direction were also measured continuously with the ADCP (RD Instruments) during all plankton samplings. In the laboratory, all samples were weighed (wet weight) and the zooplankton identified and counted *in toto*. Instantaneous transport rates ($ind \cdot s^{-1} \cdot m^{-2}$) of whole zooplankton and specific decapod crustacean taxa and stages were obtained by multiplying organism densities ($ind \cdot m^{-3}$) with the current velocity ($m \cdot s^{-1}$) for each sample. Total export or import rates ($ind \cdot s^{-1}$) were calculated by multiplying transport rates with the corresponding cross-sectional transect face area (m^2).

The ADCP profiles showed the predominance of vertically and horizontally heterogeneous current fields. Accordingly, zooplankton transport was not homogenous, with higher organism and biomass transport rates in the surface layer. Most of the plankton export (biomass and organisms) from the estuary occurred during the low tide (Fig. 1). The total average instantaneous biomass export transport was 98.1 ± 75.9 $mg \cdot m^{-2} \cdot s^{-1}$ during spring tide and 31.46 ± 26.52 $mg \cdot m^{-2} \cdot s^{-1}$ during neap tide (Melo Júnior *et al*., 2007). The main biomass transport peaks were related to peak densities of decapod larvae (Fig. 2) and calanoid copepods. The total average instantaneous zooplankton export transport was 831.5 ± 1192.5 $ind \cdot m^{-2} \cdot s^{-1}$ (spring tide) and 342.3 ± 445.8 $ind \cdot m^{-2} \cdot s^{-1}$ (neap tide). We identified 27 decapod taxa (larvae of Sergestidae, Porcellanidae, Upogebiidae, Caridea, Brachyura). The dominant taxa were the first larval stages of *Lucifer faxoni*, *Acetes americanus*, *Petrolisthes armatus*, *Upogebia* spp., Alpheidae, *Pinnixa* spp., and *Uca* spp. Most species and stages showed characteristic vertical migration patterns in phase with tidal and diurnal cycles, enhancing estuarine retention or export.

The importance of tropical estuaries as sources of invertebrate larvae, and specifically decapod larvae, for marine ecosystems was partially confirmed in the present study. In addition to the massive export of mangrove-dwelling brachyuran and porcellanid crab larvae, this tropical estuary seems to be an important breeding area for sergestid shrimps (*Lucifer faxoni*, *Acetes americanus*). Especially for *L. faxoni*, our results indicate the occurrence of an important retention of virtually all larval stages in the Catuama Inlet area. This confirms the results of earlier studies in this area (Schwamborn, 1997; Schwamborn *et al*., 2001) that showed high densities of sergestid larvae in the Catuama area. Our study showed that the combination of high-resolution three-dimensional ACDP current profiles and vertically and horizontally discrete plankton sampling techniques can be an effective way to investigate dynamic transport patterns of invertebrates in estuarine areas.

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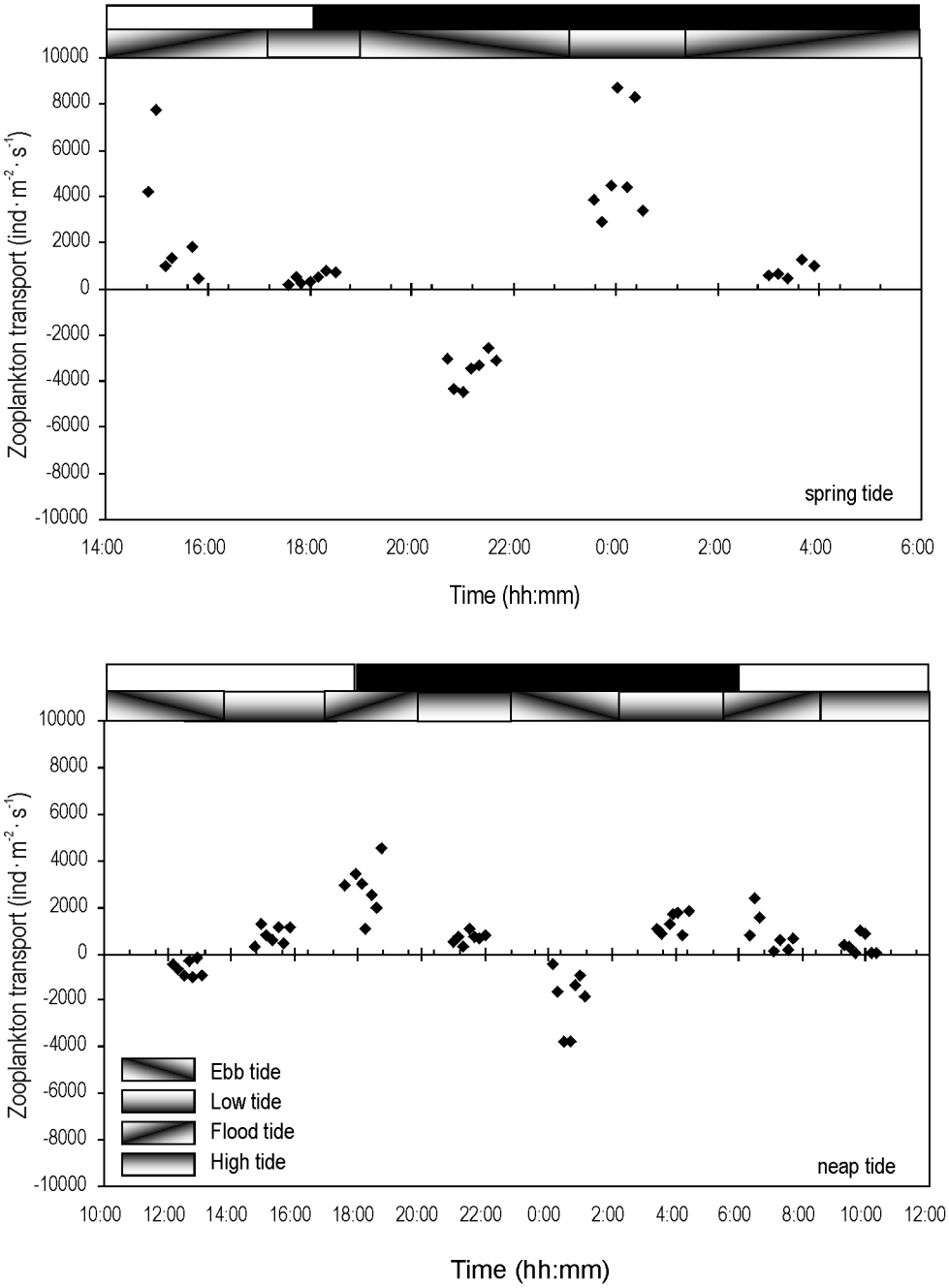

Figure 1. Zooplankton transport at Catuama Inlet (northeastern Brazil), during spring (5 to 6 August 2001) and neap tide (11 to 12 August 2001). Positive values mean zooplankton import from shelf area to Catuama Inlet and negative values mean zooplankton export from Catuama Inlet to shelf area. For each sampling period, 7 samples were taken. White bar: diurnal period and black bar: nocturnal period.

Figura 1. Transporte de zooplancton en la boca de Catuama (noreste de Brasil), en mareas de sicigias (5 al 6 Agosto 2001) y de cuadraturas (11 al 12 Agosto 2001). Los valores positivos indican la importación de zooplancton desde la plataforma continental hasta la boca de Catuama y los valores negativos indican la exportación para la plataforma continental. Siete muestras fueron obtenidas en cada situación. Las barras blancas y negras indican los periodos diurnos y nocturnos, respectivamente.

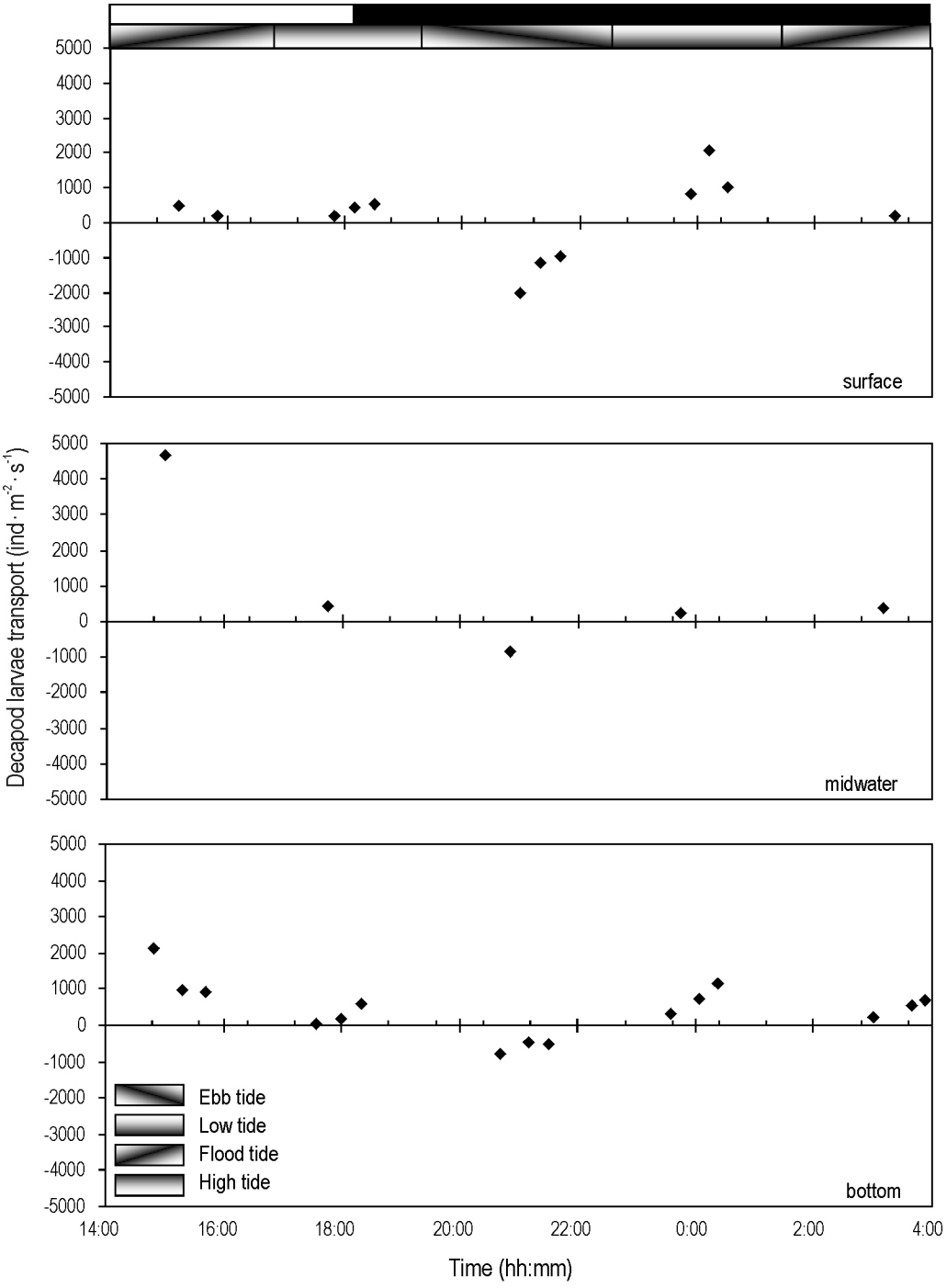

Figure 2. Transport of decapod larvae at Catuama Inlet (northeastern Brazil), during spring tide (5 to 6 August 2001), at three depth levels (surface, midwater and bottom). Positive values mean zooplankton import from shelf area to Catuama Inlet and negative values mean zooplankton export from Catuama Inlet to shelf area. White bar: diurnal period and black bar: nocturnal period.

Figura 2. Transporte de larvas de Decapoda en la boca de Catuama (noreste de Brasil), en mareas de sicigias (5 al 6 Agosto 2001) en tres niveles de profundidad (superficie, medio, fondo). Los valores positivos indican la importación de zooplancton desde la plataforma continental hasta la boca de Catuama y los valores negativos indican la exportación para la plataforma continental. Las barras blancas y negras indican los periodos diurnos y nocturnos, respectivamente.

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