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Effects of the sandbar breaching on hydrobiological parameters and zooplankton communities in the Senegal River Estuary (West Africa)

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ABSTRACT

This study describes the changes in hydrology, zooplankton communities and abundance in the Senegal River Estuary (SRE) before and after the breaching of the sandbar in October 2003. Samples were taken in 2003 at 3 stations located upstream (DI), in mid estuary (HY) and downstream (RM), and in 2005 at the same stations (RM becoming Old River Mouth: ORM), plus the new river mouth (NRM) resulting from the morphological evolution of the SRE.

The study showed marked seasonal variations that affected the structure and distribution of zooplankton as well as major changes caused by the sandbar opening:

- increased marine influence throughout the whole SRE,
- changes in the horizontal gradients,
- arrival of euryhaline species and increase in meroplankton, in particular decapod larvae,
- transformation of the ORM area into a slackwater area with limited exchanges and the highest zooplankton numbers during high waters.

1. Introduction

The Senegal River Estuary (SRE) is located in the coastal Sahelian zone with only one rainy season a year. It has undergone major anthropogenic developments since the 1980s. Up to 1985, it was a long stretch of water, orientated north–south and separated from the Atlantic coast by a sandbar (Langue de Barbarie) (Fig. 1A). To prevent the seasonal intrusion of the sea up to 200 km upstream, a salt-wedge dam was opened at Diama in 1985, 50 km from the river mouth. Thereafter, from 1985 to 2003, the river flow was controlled regularly. During the low water period (LW, from November or December to June) corresponding to the dry season, the dam was permanently closed and the estuary was mainly under tidal influence. During the high water period (HW, between July to October or November) corresponding to the rainy season, the dam was opened occasionally, allowing massive and irregular freshwater inflows with the resultant continental influence.

In October 2003, to minimize the effects of severe flooding in Saint Louis city, a 5 m wide channel was dug across the sandbar 4–5 km downstream of the city, half way down the total estuary and about 25 km from the Diama dam. This temporary solution turned out to be irreversible since the channel became rapidly deeper and wider (>1 km wide in 2004, >2 km in 2009) and is now the sole river mouth (Fig. 1B) while the shallow natural river mouth progressively filled up with sediment and closed permanently in late 2004 (Fig. 1C). Due to these morphological changes, the shortened estuary is now about 30 km long, about 2 km wide and deeper upstream (~10 m) than downstream (~5 m).

Zooplankton is an important component in the estuarine food web, acting as a trophic link between small particles and planktivorous fish (Correll, 1978; Giske et al., 1990; Buskey, 1993; Banse, 1995; Morgan et al., 1997; Froneman, 2000; Froneman, 2003). Owing to their strong dependence on fluctuations of environmental factors (temperature and salinity in particular), zooplankton communities are good indicators of the evolution of estuarine tropical ecosystems, which vary considerably in both time and space (Downing et al., 1987; Schlacher and Wooldridge, 1995; Kibirige and Perissinotto, 2003).

Initial studies were undertaken on the hydrodynamics in the estuary and the lower delta of the Senegal River (Rochette, 1974; Gac et al., 1986a,b). Studies of the ecology of bacterioplankton, (Troussellier et al., 2004, 2005; Bouvy et al., 2006), zooplankton and macro-zooplankton (Pagano et al., 2006; Champalbert et al., 2007) covered the period before 2003. Isupova and Mikhailov

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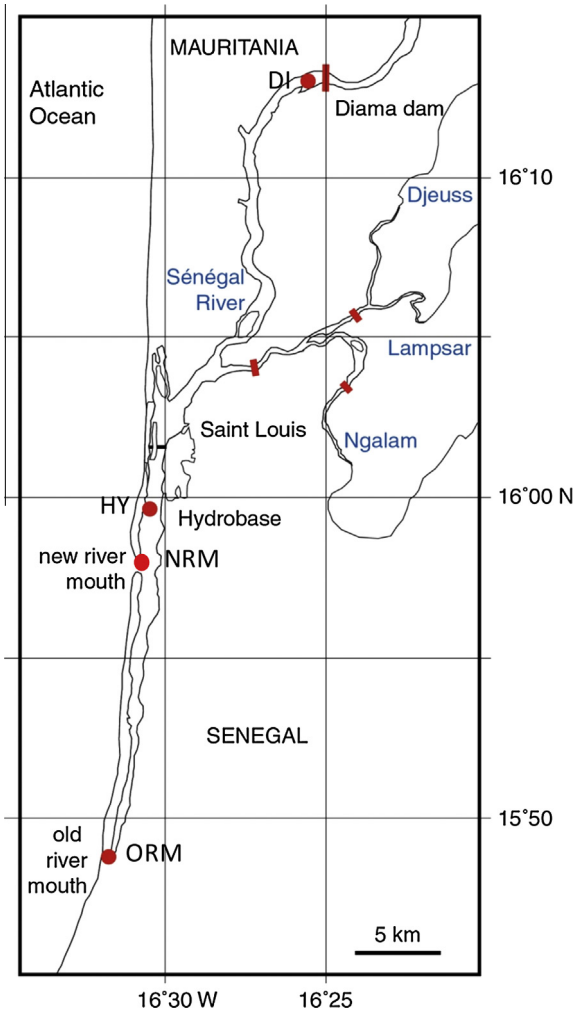

Fig. 1a. Map of the Senegal River Estuary (SRE), with position of the sampling stations.

(2008) carried out a literature study to summarize the hydrological and morphological processes that occurred in the SRE after the sandbar was breached in 2003. Modeling studies examined the possible effect of these changes on salinity variations (Chevalier et al., in preparation) and on plankton dynamics under osmotic stress (Baklouti et al., 2011). However, the impact of these recent human-driven changes on the zooplankton and the pelagic ecosystem has never been studied.

To assess the effect of breaching the channel on the estuarine pelagic ecosystem – in particular hydrology and zooplankton – a time series study was carried out in 2005 which allowed a comparison with a previous study performed in 2003 just before the sandbar was breached (Champalbert et al., 2007).

2. Materials and methods

2.1. Sampling and measurements

This study compared hydrological and biological samples collected in 2003 and 2005. Measurements and sampling were carried out in the same way for both periods (see Champalbert et al., 2007).

In 2003 (Champalbert et al., 2007), samples were collected during 9 surveys between January and December (January 14–16, February 25–27, March 25–27, April 28–30, June 10–12, July 21–23, September 15–17, October 27–29 and December 15–17) at 3 sampling stations:

"Diama" (DI, 16°13N, 16°25W), 500 m downstream from the dam at a depth of about 9 m, "Hydrobase" (HY, 15°59N, 16°30W), 4 km downstream from Saint Louis, at a depth of about 7 m,
"River Mouth" (RM, 15°45N, 16°32W) a few meters from the sea, at a depth of about 4.5 m (Fig. 1A).

In 2005, samples were collected during 11 surveys between January and December (January 4–5, February 1–2, March 8–9, April 28–30, May 24–25, June 21–22, July 25–26, September 27–28, October 26–27, November 22–23 and December 27–28) at the 3 sampling stations selected in 2003, DI, HY and the "Old River Mouth" (ORM, same coordinates as RM in 2003), and at the "New River Mouth" (NRM, 15°57N, 16°30W), a few meters from the sea at a depth of 5–6 m about 4 km south of HY.

Temperature, salinity, dissolved oxygen and *in vivo* fluorescence were measured on vertical profiles using a Sea Bird Electronics recorder (SBE 19). Surface water was collected in a bucket for analysis. Nitrates and nitrites were measured with a Bran Luebbe Auto-Analyzer 3 (Strickland and Parsons, 1972) and phosphates

Fig. 1b. View of the New River Mouth.