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Species composition, distribution patterns and population structure of penaeid shrimps in Malindi-Ungwana Bay, Kenya, based on experimental bottom trawl surveys

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ABSTRACT

The species composition, distribution patterns and abundance of penaeid shrimps in Malindi-Ungwana Bay, Kenya, were investigated after six years of no bottom trawling in the area. Two surveys undertaken during the dry Northeast Monsoon (NEM) and wet Southeast Monsoon (SEM) seasons in 2011 identified areas with abundant shrimps near the outflows of the Sabaki and Tana rivers. Distinct species composition and abundance patterns were found at the two areas, attributed mainly to depth, turbidity and season. *Penaeus semisulcatus* was more abundant at the Sabaki area, where it was deeper with a muddy bottom and less turbid waters. *Fenneropenaeus indicus* was more abundant in the Tana area, a shallower, more turbid area with sandy-mud sediments. *Penaeus monodon*, *Penaeus japonicus* and *Metapenaeus monoceros* were found in both areas, suggesting wider tolerance to environmental conditions. Shrimp total biomass and catch rates were significantly greater during the SEM survey, and decreased as depth increased beyond 10 m. Small-sized *M. monoceros* and *P. monodon* individuals were abundant during the SEM survey, whereas large ones with ripe and spent gonads were more common during the NEM survey, suggesting that spawning took place between the two surveys. Seasonal patterns in gonad maturity were less clear for *F. indicus* and *P. semisulcatus*. The length at first maturity (L_{50}) varied among species, suggesting that different species in the bay start spawning at different sizes, an important biological reference for sustainable resource exploitation. This study confirms the importance of the Sabaki and Tana areas as important habitats for penaeid shrimps in Malindi-Ungwana Bay.

1. Introduction

The penaeid shrimps (or prawns) have a worldwide distribution in the tropical and subtropical seas, where they constitute an important exploitable resource in estuarine and coastal habitats (Garcia and le Reste, 1981). At least 19 species from 7 genera have been reported from the Western Indian Ocean (WIO) region (Holthuis, 1980; de Freitas, 2011), where they support artisanal and industrial shrimp trawl fisheries along the eastern coast of Africa and in Madagascar (Teikwa and Mgaya, 2003; Gillet, 2008; Le Monach et al., 2011).

Most shrimp fishing in Kenya takes place in Malindi-Ungwana Bay (Fig. 1), where two fishing sectors are active: an artisanal fishery comprising about 3500 fishers and a fleet of roughly 600 traditional fishing crafts used to catch finfish and shellfish (Fulanda et al., 2011); and a commercial bottom trawl fishery. Annual fish and shrimp landings from the artisanal fishery in this area ranged between 1013 and 1653 t between 2001 and 2008, with shrimps representing between 71.5 and 187.1 t of the landings (Munga et al., 2012). The commercial bottom trawl fishery in the bay was initiated after a series of successful surveys undertaken by the Kenya Government, UNDP and FAO since early 1960 (Iversen, 1984; Venema, 1984; Saetersdal et al., 1993). Bottom trawling with a fleet of three or more trawlers continued for several decades, landing an average of 400 t of shrimps per year in the 1970s, 80s and 90s (Mwatha, 2005). The trawl fishery was, however, banned by the Kenyan Government in 2006, as a result of user conflicts between trawl and artisanal fishers, and declining catches (Fulanda et al., 2009, 2011; Munga et al., 2012).

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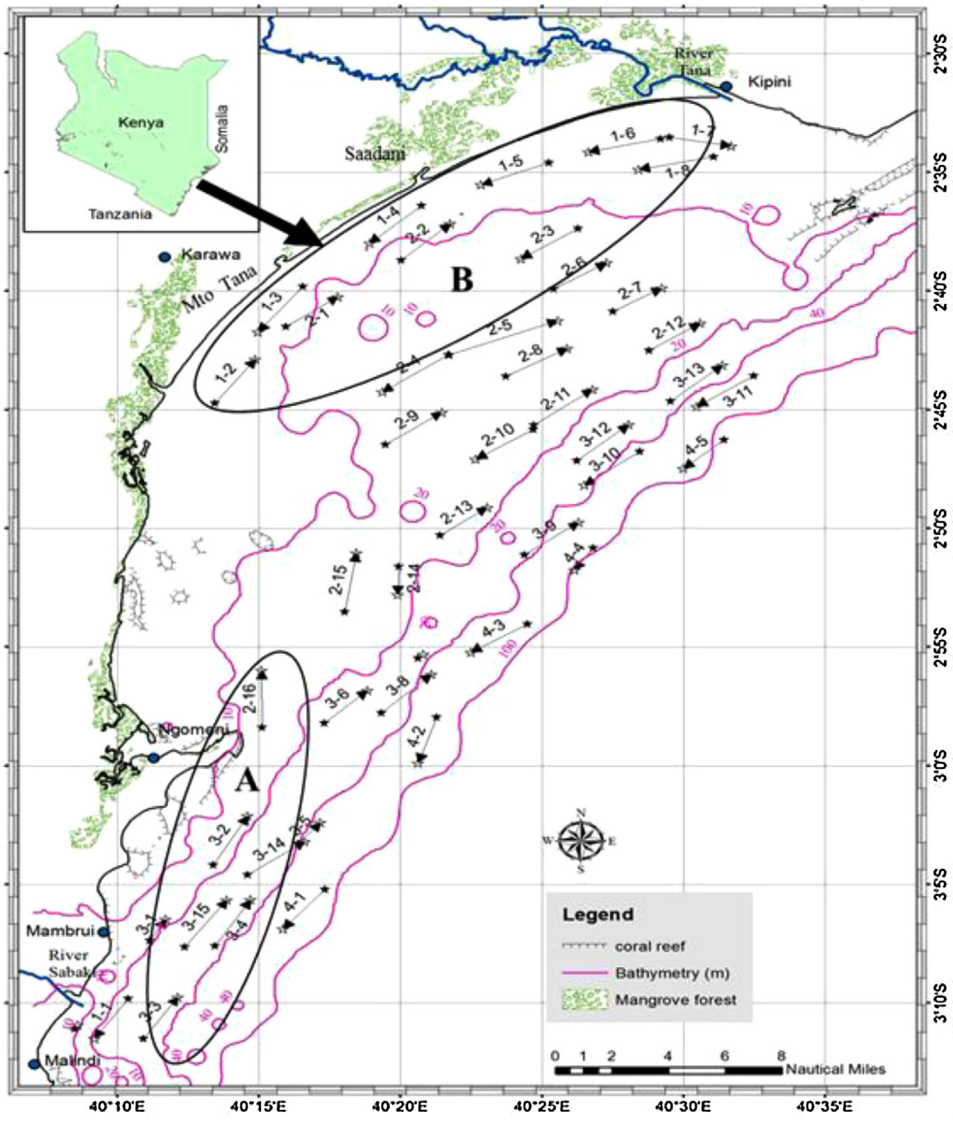

Fig. 1. A map of Malindi-Ungwana Bay, Kenya, showing the groupings of trawl transects at the Sabaki (area A) and Tana (area B) areas. Figures on the map indicate transect number and depth stratum respectively. Transect 1–2 means transect No. 1 in depth stratum 2. Transect 1–1 was incomplete and hence excluded from the survey data.

Shrimp catches in the bay comprise mainly five species: *Fenneropenaeus indicus* (formerly known as *Penaeus indicus*), *Penaeus monodon*, *P. semisulcatus*, *P. japonicus* and *Metapenaeus monoceros* (Iversen, 1984; Mwatha, 2005; Munga et al., 2012). The post-larvae of these species prefer estuaries or estuarine-like environments, and juveniles migrate from the estuaries to shallow offshore mud banks where they grow to maturity and spawn (Garcia and le Reste, 1981; Dall et al., 1990). Post-larvae move back into the estuarine nursery grounds from the adult breeding grounds to complete their life cycle. The life span of most penaeids is between 1 and 2 years and their abundance and mean size on offshore banks may vary greatly by depth and between seasons, reflecting spawning, recruitment, population age structure and catchability (Garcia and le Reste, 1981; Dall et al., 1990; Bishop and Khan, 1991).

A major difference between closely related shrimp species is that they prefer different habitats along gradients of substrate type, depth, turbidity, temperature and salinity (Garcia and le Reste, 1981; Dall et al., 1990). Substrate preference by juveniles tends to be maintained in the adult phase. Furthermore, movement and dispersal of post-larvae in estuarine environments involve specific sets of behavioural cues and responses, which are associated with a particular developmental period, and can be species-specific (Forbes and Benfield, 1986a, 1986b; Benfield et al., 1989; Dall et al., 1990). These differences in environmental variables may lead to differences in species composition of penaeid shrimps (Demetriades and Forbes, 1993).

Two major rivers, Tana (850 km long) and Sabaki or Athi/Galana (650 km) drain into Malindi-Ungwana Bay from the Kenyan highlands. The estuaries and nearshore mud banks with terrigenous sediments support the bulk of the shrimp fishery in the bay (Abuodha, 2003; Kitheka et al., 2005). The productivity of the bay is influenced by the river and nutrient discharge, as well as patterns of monsoon winds, tides and the offshore Somali and East African Coastal currents (McClanahan, 1988; Kitheka et al., 2005; Bouillon and Dehairs, 2007). The river discharge is highest during the wet Southeast Monsoon (SEM) season between April and October. The Northeast Monsoon (NEM) season, between November and March, receives less rain, and hence river discharge is reduced during these months. However, the influence of the sediments and the freshwater discharge by the Tana and Sabaki river systems on the bay remain poorly understood (Kitheka et al., 2005; Bouillon and Dehairs, 2007; Bouillon et al., 2009).

The aims of this study were to investigate the spatial and temporal patterns in the composition of the shrimp communities