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The response of sandy beach meiofauna to nutrients from sea turtle eggs

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ABSTRACT

Organic matter transfer across ecosystem boundaries strongly influences consumer populations and food web dynamics. Consequently, it is hypothesized that sandy beaches, which are organic matter-limited ecosystems and almost exclusively subsidized by allochthonous inputs, should respond to pulses of organic matter. Large quantities of organic matter in the form of eggs are deposited on the high shore of tropical and subtropical beaches during the turtle nesting season. This study quantifies the response of meiofauna to the decomposition of turtle eggs over time. Meiofaunal densities were first measured in predated nests. Second, the response of meiofauna to organic matter inputs over time were quantified experimentally, in situ, by comparing meiofauna communities from five artificially predated pseudo-nests with those from five control pseudo-nests, sampled daily at three depths for 3 weeks. There was a strong temporal response of the meiofauna in the experimental treatment compared to that in the controls. After 5 days, the meiofaunal communities in the experimental treatment were significantly different to those in the control treatment, with abundance of all taxa higher in the experimental treatments, particularly nematodes. The peak of the response (maximum nematode abundance: 2.5×10^5 ind·cm^3) was observed after 7 days. Thereafter, their abundance declined until it returned to the background density (<100 ind·cm^3) after 20 days. Given the large quantity of turtle eggs deposited above the high tide mark, these seasonal inputs represent a pulsed resource with a significant contribution to the energy budget of sandy beach/dune ecosystems. Turtle nesting may thus play a key ecological role in structuring meiofaunal communities of sandy beach ecosystems.

1. Introduction

Nutrient fluxes across habitats can strongly influence populations and community dynamics in many ecosystems (Polis and Hurd, 1996; Polis et al., 1997; Cross et al., 2006). The most dramatic effects are produced in response to resource pulses, which are ephemeral events of increased resource availability that combine low frequency, large magnitude and short duration (Yang, 2004; Yang et al., 2008; Holt, 2008). In such events, resources are gradually accumulated over time and then released to consumers in a pulse, e.g., the salmon migration (Fennessy et al., 2010), sardine run (Hutchings et al., 2010), and insect outbreaks (Yang, 2004). The associated population responses include increased primary (plant) and secondary (animal) productivity (unless it results in a bloom event and unfavourable conditions are produced), followed by an increased abundance of consumers (Polis et al., 1997; Cross et al., 2006). When resource pulses are spatially localized, consumers should generally aggregate, build up in numbers, and then disperse to adjacent patches when those resources are depleted (Holt, 2008). In this way, resource pulses play important ecological roles, influencing nutrient flows which in turn affect the productivity, food webs, and community structure and dynamics of ecosystems (Polis et al., 1997; Loreau and Holt, 2004). The question however remains how communities respond in nutrient-poor systems where resources are inherently scarce, such as in sub-/tropical sandy beach ecosystems?

Sandy beaches are at the interface between marine and terrestrial ecosystems and are generally characterized by low primary productivity due to the absence of macrophytes/plants in the surf and intertidal zones (McLachlan and Brown, 2006; Botton and Loveland, 2011). Food availability is highly erratic and beach food webs are almost entirely supported by allochthonous subsidies, e.g., macrophyte wrack, which is particularly abundant adjacent to cold, kelp-dominated systems; stranded algae and seagrass; and carrion (McLachlan and Brown, 2006). Under particular conditions (off long, high-energy beaches with dissolved organic matter inflows) phytoplankton stocks can be extremely high due to surf diatom accumulations (Campbell, 1996; Netto and Meneghel, 2014). Studies on sandy beach subsidies thus have largely concentrated on the effect of macrophyte wrack inputs on macrofauna, frequently in temperate systems (Stenton-Dozey and Griffiths, 1983; Colombini et al., 2000; Jedrzejczak, 2002; Dugan et al., 2003, 2011; Olabarria et al., 2007; Lastra et al., 2008). In contrast, the effects on meiofauna have received substantially less attention, despite the high diversity and density of these animals in the sediment (which can be orders of magnitude more abundant than macrofauna, reaching

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1×10^6 individuals per square meter; Gheskiere et al., 2004; McLachlan and Brown, 2006; Giere, 2009). Similarly, the effects of sea turtle eggs as a pulsed resource has also been largely overlooked, even though it likely represents an important resource subsidy given the quantity of eggs deposited (ranging from >525.000–95,000,000 eggs per season; Nel et al., 2013; Valverde et al., 2012) and high quality of the organic matter. Further, turtle nesting is restricted to tropical and subtropical shores which are adjacent to oligotrophic oceans (Raymont, 1980; Schlosser et al., 2014), enhancing the relative importance of this resource to beach/dune ecosystems.

Several studies have shown that turtle-derived organic matter can be incorporated into dune food webs in a variety of ways. These include: terrestrial vertebrates, like raccoons and birds (Bouchard and Bjorndal, 2000); coastal insects, including fly larvae, mites, beetles, crickets and ants (Maros et al., 2006; Madden et al., 2008); and dune plants (Plog et al., 2003; Hannan et al., 2007; Vander Zanden et al., 2012). To date,

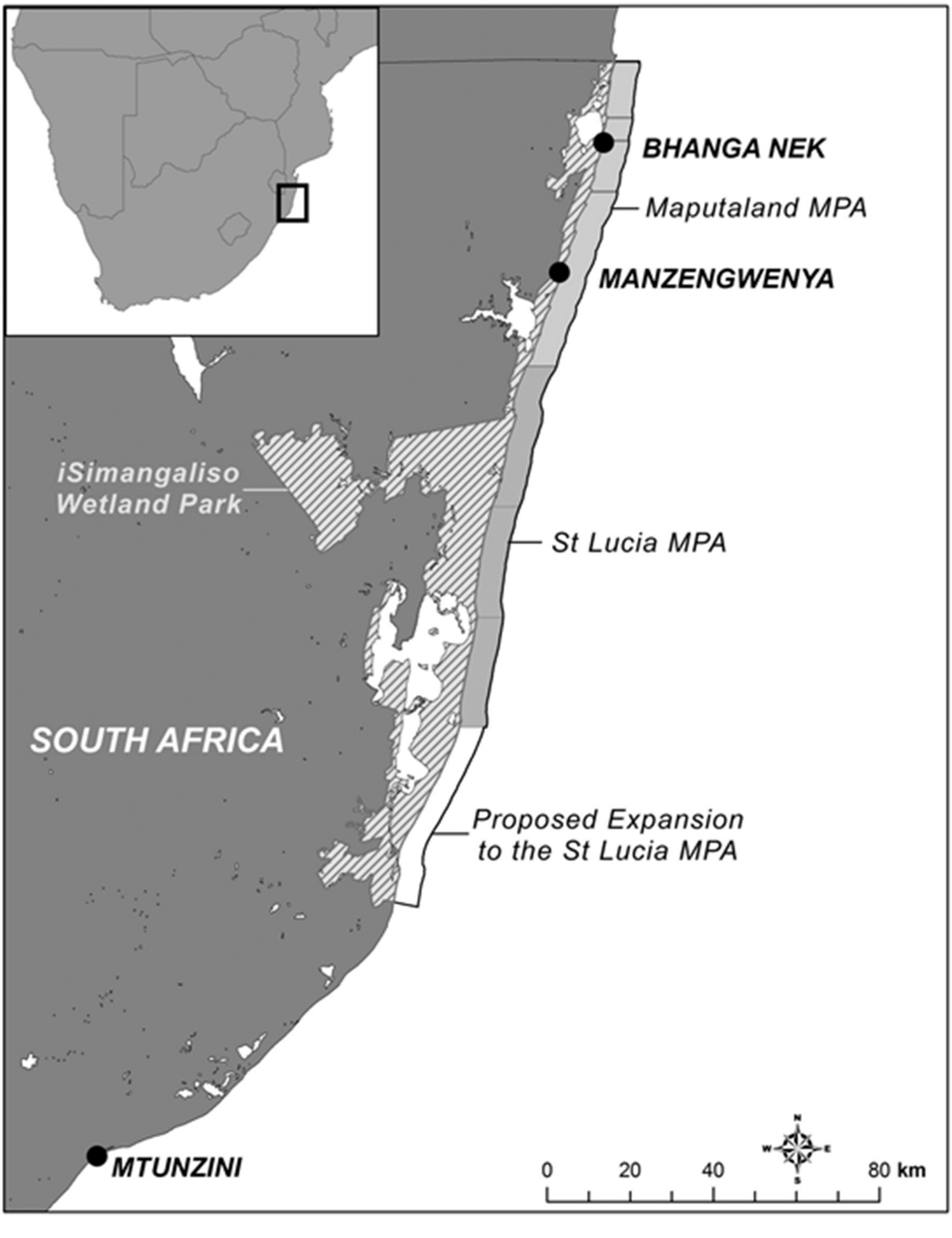

Fig. 1. iSimangaliso Wetland Park in north-eastern South Africa comprises contiguous terrestrial reserves (hatched grey) and two marine reserves: Maputaland and St Lucia MPAs. Turtle nesting is predominantly along the Maputaland coast; nest density is high at Bhanga Nek, and decays to the south, with low nest density at Manzengwenya and southwards. Major lakes are shown in white.