

## Observations on habitat utilization by the sea cucumber *Stichopus chloronotus*

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### Abstract

This paper adds to the list of observational studies of habitat utilization by juvenile and adult aspidochrotid holothurians. We used length data for *Stichopus chloronotus* collected in a nearshore, soft benthos area and its proximal reef flat, to assess the potential separation between adult and juvenile habitats. Individual sea cucumbers on back reefs in soft benthic areas were significantly smaller than those on adjacent hard benthic reef flats, indicating that juveniles and adults use separate habitats. We consider these results in relation to other similar observations and recruitment patterns of echinoderms to argue that the separate habitats used by juveniles and adults require specific attention in order to support decision-making with regard to ecosystem-based management.

### Introduction

Many marine organisms show linkages across multiple tropical habitats for growth, survival and movement (Parrish 1989). This feature of connectivity among seascape habitats is critically important to understanding and managing commercially important marine organisms. For example, the nursery function of seagrass beds for many marine organisms underlines the importance of understanding life-history characteristics for sound ecosystem-based management (Nagelkerken 2009). Spawning success and recruit input among echinoderms are highly stochastic (Uthicke et al. 2009), and larval input varies depending on substrate, location and time of year (Lamare and Barker 2001). This uncertainty restricts the ability to predict future population sizes and make informed fisheries management decisions. It is, therefore, important to improve the understanding of the patterns and processes involved in the recruitment of commercially important echinoderms.

Recruitment of commercially harvested sea cucumbers is poorly understood, including patterns and processes related to habitat use throughout the sea cucumbers' life history. Shiell (2004) compiled observations of juvenile and adult habitats for a range of sea cucumber species, and concluded that they are often separated. Specific knowledge gaps are attributed to the difficulty in finding juveniles in the wild. This is, for example, illustrated in the protected population of *Stichopus herrmanni* at One Tree Reef on the Great Barrier Reef in Australia. This population has been regularly monitored during the day and night over a period of nearly two years without having recorded any juveniles (<160 mm

(Eriksson et al. 2010). The lack of detailed ecological knowledge regarding habitat utilization in the early life-history stages of sea cucumbers restricts the ability to manage sea cucumber fisheries in an informed manner and with a wider ecosystem-based perspective, as prescribed by Purcell (2010).

In this study, we investigate how the size of *Stichopus chloronotus* differs between a back reef seagrass area and the proximal hard benthic reef flat at a site in Mayotte in the western Indian Ocean, and analyse habitat utilization in relation to size (as a proxy for age).

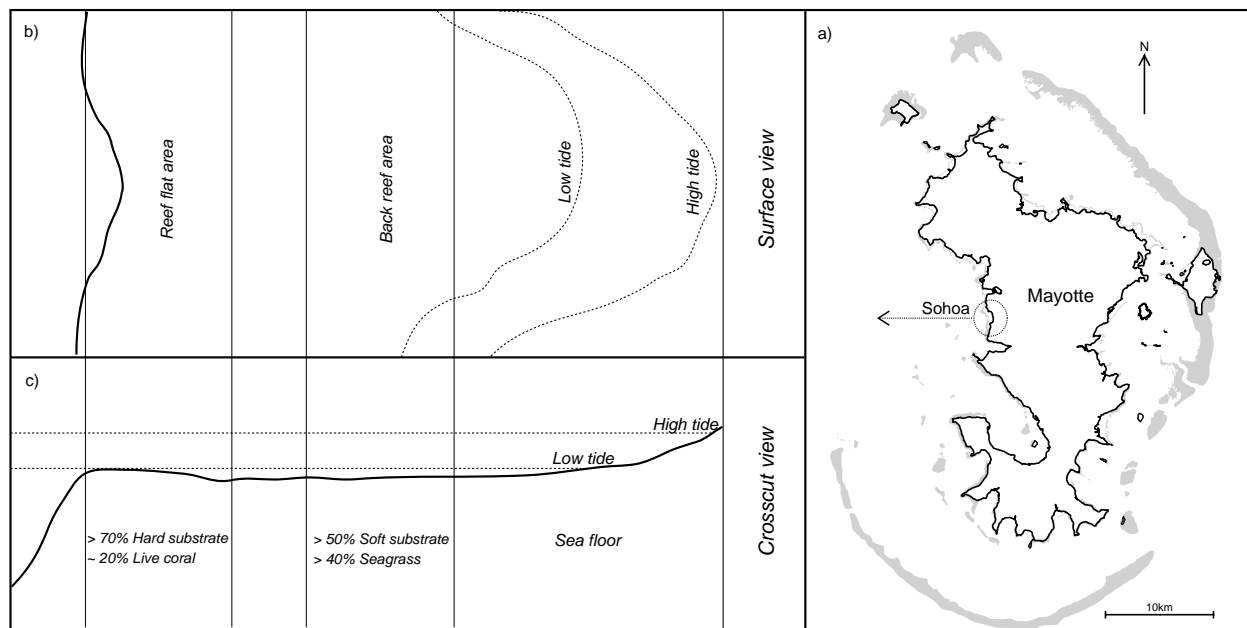
### Methods

We sampled the back reef seagrass area and adjacent hard benthic reef flat near the village of Sohoa in Mayotte, western Indian Ocean at low tide on 10 June 2010 (Fig. 1). We used 40 m x 1 m transect lines to sample the density of the commercial sea cucumber *S. chloronotus*. Transect lines (n = 18) were laid out perpendicular to the shoreline in both nearshore seagrass areas and on reef flats. The distance between the two sampled habitats varied between 100 m and 200 m. *S. chloronotus* individuals were measured along their centerline to the nearest 10 mm. Variance in length of *S. chloronotus* between the two habitats was tested with a one-way analysis of variance (ANOVA), with habitat as a fixed factor using the program R.2.9.2.

### Results

In the back reef seagrass area, 17 individuals of *S. chloronotus* were encountered in depths of 20–30 cm and 26 individuals were recorded on the reef flat. The mean length ( $\pm$ SE) of individuals

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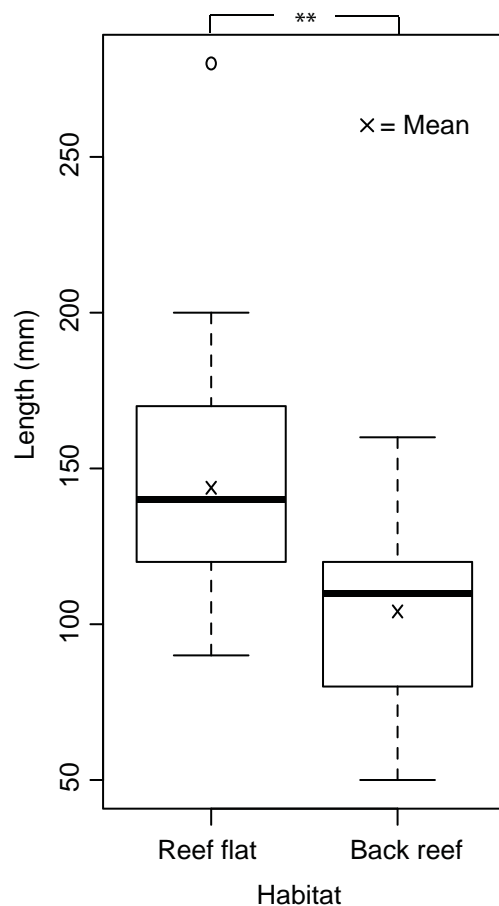


**Figure 1.** Substrate composition in the back reef seagrass area and adjacent hard benthic reef flat in front of the village of Sohoa in Mayotte.

of *S. chloronotus* recorded in the back reef area was  $104.1 \pm 8.7$  mm and differed significantly ( $F_{1,41} = 10.8$ ,  $p = 0.002$ ) from the mean length ( $143.8 \pm 7.9$  mm) of individuals recorded on the reef flat (Fig. 2). The smallest animal (50 mm) was recorded in the seagrass area while the largest (280 mm) was recorded on the reef flat. In addition, aggregations of small juveniles were observed in the nearshore shallow waters outside the sampled transects of 5–10 animals (~ 30–40 mm) on football-sized boulders that were partially submerged during low tide.

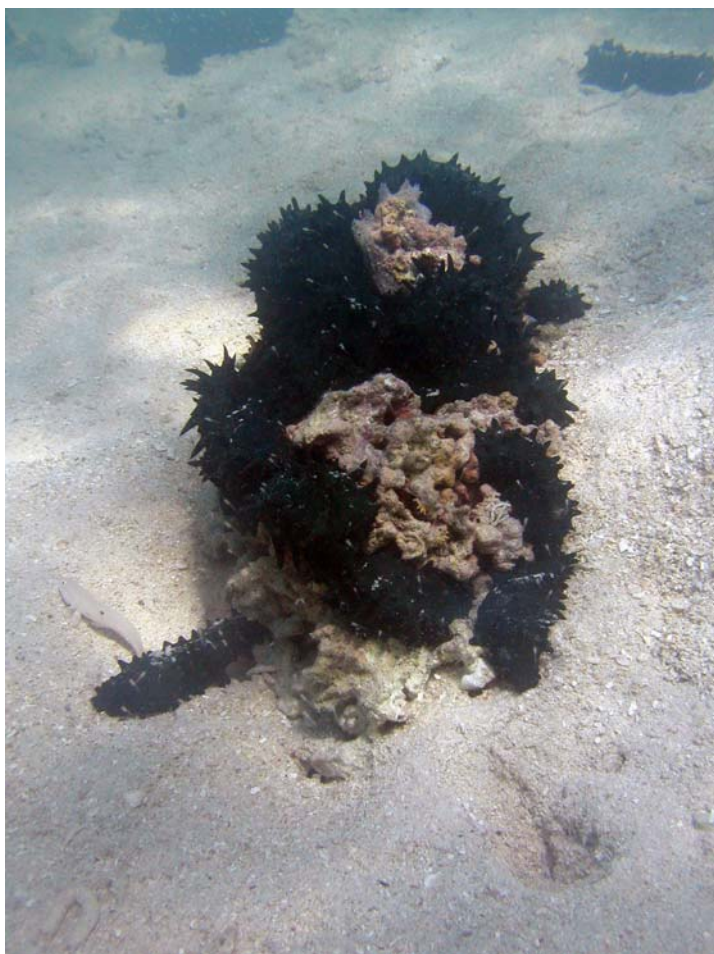
**Discussion**

As with other organisms (e.g. Nagelkerken 2009) and specific observations reported by Shiell (2004), our findings suggest that *S. chloronotus* utilizes different habitats throughout its life history. Similar to *H. scabra* (Hamel et al. 2001), seagrass beds are likely to be important settlement substrates for this species within the back reef habitat. We postulate that when individuals grow larger they migrate to the harder substrate on the proximal reef flat, about 200 m away. Similar observations of aggregated juvenile *S. chloronotus* have also been noted elsewhere (e.g. Samoa) (see Friedman et al. 2011) (Fig. 3). In addition, during the survey in Mayotte, we observed subadult (10–15 cm) white teatfish *H. fuscogilva* on nearshore shallow seagrass areas within a larger group of adults in deeper water (15–20 m) outside the sandy reef front area; these individuals exhibited a similar pattern to that of *S. chloronotus* reported on in this study. Identical observations have also been made by Reichenbach (1999) who concludes that recruitment of *H.*



**Figure 2.** Mean length ( $\pm$ SE) of individuals of *Stichopus chloronotus* recorded in the back reef area and on the reef flat near the village of Sohoa in Mayotte.

*fuscogilva* occurs in shallow seagrass areas. In addition, subadults (10–15 cm) of black teatfish *H. nobilis* have been observed in intertidal seagrass areas in Zanzibar (pers. observ. by one of the authors of this paper H. Eriksson), inside its preferred adult general habitat on the reef flat. Similar observations have also been recorded for the species *H. whitmaei* in the Pacific (Byrne et al. 2004). Conand (1993) has also noted similar patterns for *S. herrmanni* recruiting into shallow waters (shallow reef flats, or seagrass beds). These observations show that many sea cucumber species harvested for the beche-de-mer trade depend on various habitats within the coastal seascape, and underline the fact that an ecosystem-based perspective is indeed important for managing sea cucumber stocks. *S. chloronotus* exhibit both sexual and asexual reproduction (Franklin 1980; Conand et al. 2002), and fission seemingly occurs during colder winter months when sexual reproduction is inactive (Uthicke 1994; Conand et al. 1998). The animals observed in this study showed no signs of being fission products, despite sampling being performed during the winter.



**Figure 3.** Aggregated juveniles of *Stichopus chloronotus*.

In conjunction with our sea cucumber study in Mayotte, an interview-based study on the importance of seagrass beds to local communities found that over the last 10–20 years there has been extensive losses of seagrass cover due to anthropogenic development (e.g. land reclamation, road and construction work) and cyclones. In addition, previously lush extensive seagrass meadows of *Thalassodendron ciliatum* in barrier reef areas in Mayotte have disappeared (pers. observ. by one of the authors of this paper, J. Wickel). Contextualising this loss of substrate for sea cucumber recruitment, Mercier et al. (2000) found that in the absence of suitable substrate (i.e. the seagrass *Thalassia hemprichii*) the sandfish *H. scabra* delays settlement for about four days, and that survival then is <0.5%, illustrating the potential bottleneck in recruitment and stock recovery from overfishing if this habitat is lost. Our conclusion is that even if overfishing is acknowledged to be the most apparent reason for depleted stocks (e.g. Friedman et al. 2011), the issue is potentially worsened by the loss of settlement areas that are important during the early life-history stages of sea cucumbers. Therefore, fisheries managers need to monitor stocks and identify areas of settlement and recruitment because these areas vary (Lamare and Barker 2001), and apply ecosystem-based management accordingly (Purcell 2010).

This study was constrained by 1) a methodology that did not aim to collect the maximum number of lengths, and 2) a sample unit that was too coarse to capture the highly aggregated behaviour of juveniles on boulders in nearshore areas. Our findings warrant further studies on habitat selectivity that can provide insight into juvenile and adult utilization of habitats. For example, because *S. chloronotus* is selective with regard to feeding sediment (Uthicke 1999), investigating sediment granulometry or feeding substrate in relation to body size can prove useful. We propose that more research is needed on the issue of habitat connectivity and cross-habitat movement for commercial sea cucumbers. We also stress the need to develop a better understanding of habitat utilization by moving away from general geomorphologic descriptions of distribution, and to further explore and quantify habitat utilization at a scale that incorporates habitat substrates as well as the coverage of seagrass or coralline algae, both of which are settlement substrates for echinoderms (Mercier et al. 2000; Hugget et al. 2006).

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