First field observations of *Halimeda* beds at depths of 37-62 m at Saya de Malha and Nazareth banks, Mascarene Plateau

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Halimeda spp. are cosmopolitan benthic marine green calcifying macroalgae occurring in shallow and deep waters. Their leaf-like segments are produced in a branched and segmented manner. Reproduction occurs by the edges of the segments turning into whitish reproductive cells that release the protoplasmic contents of spores, a process known as holocarpy, followed by the death and disintegration of the *Halimeda* segments (Drew and Abel, 1988). The segments grow continuously with a maximum of one segment per branch per day (Vroom et al., 2003). This rapid segmental growth may have a full turnover of about 30 days or less (van Tussenbroek and van Dijk, 2007). Walters et al. (2002) documented the vegetative reproduction of fragments of *Halimeda* on Conch Reef, Key Largo, Florida, which generated 4.7 – 9.4 fragments m⁻² day⁻¹. *Halimeda* beds, or bioherms, are important in fixing and storing atmospheric carbon in the long-term in the tropics (Kinsey and Hopley, 1991) and result in the production of extensive sediment deposits due to the large biomass resulting from the thick mats. Therefore, sediments from *Halimeda* may be considered as carbon sinks and carbonate buffers (Rees et al., 2007). In the tropics *Halimeda*’s calcareous segments provide a major carbonate sediment (Freile et al., 1995), contributing to a reef development framework and a build-up of carbonate platforms (Pomar and Kendall, 2007). This allows *Halimeda* spp. to significantly contribute to the carbon budget estimated to be similar to or exceeding that of corals within the reef (Rees et al., 2007).

The occurrence and increase of *Halimeda opuntia* cover from 1997 to 2002 in the shallow areas (<20 m) of the Ritchie Bank in the north of Saya de Malha has been reported by Hilbertz and Goreau (2002). They suggested these changes may be attributed to the coral bleaching/mortality of 1998, when some 77% on the windward and 87% on the leeward coasts bleached or died around St. Pierre, Republic of Seychelles (Spencer et al., 2000). A review by Vortsepneva (2008) indicated that Karpitenko and Bidenko (1980) reported that *Halimeda* algae were more frequently found on the low terrace, with study stations not clearly defined by depths, but related to the landscape of the submerged circular reef areas between the upper terrace and the slopes and foot of the reef. However, these studies in the 1980s, late 1990s and early 2000s did not thoroughly document the green coralline algae, *Halimeda*, in the dynamic southern bank of Saya de Malha, a region which is well known to be data deficient.

The May 2018 EAF-Nansen Programme research cruise provided a unique opportunity to visually document the green coralline algae-dominated beds at the studied locations (Fig. 1A) 36, 37, 39 and 40 at
Saya de Malha (Fig. 1B), and 44, 47 and 52 at Nazareth (Fig. 1C) Banks using the Video-Assisted Multi-Sampler (VAMS) for standard inspection of the seabed by video. The Van Veen grabs attached to the VAMS also collected some samples at the study locations. In this paper, the presence of quite large Halimeda beds is reported at depths ranging from about 37 to 43 m at locations 36 (Fig. 2 A, B, D, F), 37 (Fig. 2C), 39 (Fig. 2E) and 40 (Fig. 2G) at Saya de Malha, and locations 44 (Fig. 2H), 47 (Fig. 2I) and 52 (Fig. 2J, K) at Nazareth Bank, where such environments are considered as oligotrophic and receiving low irradiance. Ramah et al. (in prep for submission in this Special Issue) indicated that at locations 36, 37, 39, and 40, the general macroalgal cover was estimated at 23-72%, 52-71%, 21-71% and 48%, respectively. Based on the morpho-anatomy description in Oliveira et al. (2005), three species of Halimeda were observed, namely H. opuntia, H. discoidea and H. tuna, the latter being most dominant. Halimeda beds not only provide an important substrate but also a diverse habitat for marine organisms (Multer and Clavijo, 2004). For instance, the ophistobranchian Bosellia mimetica feeds on the chloroplast and camouflages itself in a green colour similar to H. tuna (J Ellis and Solander) JV Lamouroux 1816, segments. The Halimeda beds of the southern Saya de Malha bank harboured fishes like the regionally endemic Amphiprion sp. (Fig. 2B), commercially important red emperor, Lutjanus sebae (Fig. 2D) and the emperor, Lethrinus sp. (Fig. 2F). The Halimeda fields of the Nazareth bank were inhabited by Helipora coerula and Porites sp. (Fig. 2G), Seriatopora sp. (Fig. 2H), and the elephant trunk sea cucumber, Holothuria fuscopunctata (Fig. 2K); the first record of this species at a depth as great as 61.64 m. McGrouther (2018) mentioned the accidental discovery of a Halimeda bed or meadow at 30-40 m depth near Lizard Island on the Great Barrier Reef in 1982. Out of the 14 fish species they recorded, a new goby species, Minysicya caudimaculata, was described by Larson in 2002 (McGrouther, 2018). In 2001, Leis and colleagues collected fish samples at depths of 23-27 m at the same Halimeda bed and found 378 fishes (35 species in 18 families), at least 4 gobies of the genus Hetereleotris, and 1 cardinal fish of the genus Fowleria. 

Figure 1A. Map indicating the Saya de Malha and Nazareth banks studied during the EAF-Nansen 2018 research cruise on the Mascarene Plateau. B. Study locations 36, 37, 39 and 40 on the Southern Saya de Malha. C. Study locations 44, 47 and 52 on the Nazareth Bank.
Figure 2. Fields of *Halimeda* at Saya de Malha Bank: A. Location 36 at a depth of 38.63 m – Sponges in the *Halimeda* bed; B. Location 36 at a depth of 37.86 m – Regionally endemic clownfish *Amphirion* sp.; C. Location 37 at a depth of 37.48 m – Corals in the *Halimeda* bed; D. Location 37 at a depth of 38.57 m – The emperor red snapper, *Lutjanus sebae*, native to the Indian Ocean and the Western Pacific region; E. Location 39 at a depth of 43.29 m – Plate corals in the *Halimeda* bed; F. Location 36 at a depth of 38.01 m – Commercially fished *Lethrinus* sp.; G. Location 40 at a depth of 43.05 m – *Halimeda* whitening. Fields of *Halimeda* at Nazareth Bank: H. Location 44 at depth 40.98 m – *Helipora* coralloides and *Porites* sp.; I. Location 47 at depth 39.64 m – *Seriastopora* sp.; J. Location 52 at depth 61.57 m – *Porites* sp.; K. Location 52 at depth 61.64 m – *Holothuria fuscopunctata* (elephant trunk sea cucumber, maximum depth previously reported is 30 m). Photos taken using the Argus Remote Operated Video (ROV). RV Dr Fridtjof Nansen, 2018.
(McGrouther, 2018). With only 3 collections, 8 fish species were recognised as new to Australia along with at least 5 undescribed ones, indicating that *Halimeda* beds are potential hotspots of biodiversity.

From a biotechnological perspective, in addition to antioxidant (De Oliveira e Silva et al. 2012), antimicrobial properties (Escherichia coli, Klebsiella oxytoca, K. pneumonia, Lactobacillus vulgaris, Proteus mirabilis, Pseudomonas sp., Salmonella paratyphi, T. typhimurium, Staphylococcus aureus and Vibrio cholerae), and antifungal (Aspergillus flavus, A. niger, Alternaria alternaria, Candida albicans, Epidermophyton floccosum, Pseudomonas sp., Rhizopus sp., Trichophyton mentagrophytes and T. rubrum) (Indira et al., 2013) properties, activity against the marine coronavirus A59 by Halitunal, an uncommon diterpene aldehyde isolated from *H. tuna*, has been documented (Koehn et al., 1991).

This first observation of quite large *Halimeda* beds at 37-62 m depths at the Saya de Malha and Nazareth Banks suggests the possibility of such a habitat acting as an important carbon sink, requiring conservation and preservation of the regionally endemic and commercially important biodiversity, and warranting further exploration and sustainable use of the potential associated biotechnological resources of the Mascarene Plateau. Further in-depth ecological and biotechnological investigations are imperative to thoroughly understand the potential of such a biodiversity hotspot and its related marine resources, especially within the framework of Sustainable Development Goal 14, life under the sea.

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