Diversity and distribution of the shallow water (23-50 m) benthic habitats on the Saya de Malha Bank, Mascarene Plateau

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Abstract

The Saya de Malha Bank (SMB) is one of the largest and least studied marine banks on the Mascarene Plateau. This study aimed to examine the diversity and distribution of the main benthic habitats in the shallow waters of the SMB (23 to 50 m). The survey was carried out in May 2018 during the EAF-Nansen Indian Ocean Research Expedition using a Remotely Operated Vehicle (ROV) deployed at 15 stations. Four main benthic habitats were investigated and their relative abundance determined during the survey. The 143,110 m^2 surveyed area revealed proportional benthic habitat cover of 43.6 ± 22.4, 24.5 ± 21.9, 21.2 ± 27.8, and 10.5 ± 12.6 % for seaweed, abiotic substrate, seagrasses and corals, respectively. The seaweed habitat (43.6 %) was mainly composed of *Halimeda* spp. It represented up to 77 % of the habitats observed at SS34 (4553 m^2). Even though seaweeds are considered seasonal, their dominance at all stations creates an important habitat structure for many organisms. The seagrass habitat (21.2 %) was dominated by *Thalassodendron ciliatum.* This habitat covered up to 93 % of the area investigated at SS38 (5950 m^2) and was found mainly on the eastern side of the bank. The live hard coral habitat (10.5 %) was the highest at SS36-2 (35% of 9819 m^2) and was more homogenously spread within the shallow areas. The unstable and the stable bare bottom substrate habitat (24.7 %) characterized as abiotic habitat was mainly composed of bedrock, sand, and rubble. It dominated at SS42 where it constituted 72.5 % of the 5114 m^2 investigated and was recorded at all stations. Further research is warranted to better understand the diversity and the distribution of benthic habitats within the shallow waters of the SMB, along with collection of targeted benthic organisms for identification at higher taxonomic levels, to better formulate conservation and management measures and strategies.

Keywords: Saya de Malha Bank, shallow water, benthic habitat, distribution, diversity, ROV

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Introduction

The Saya de Malha Bank (SMB) forms part of the Mascarene Plateau, an aseismic ridge that extends from Mauritius to the Seychelles and is comprised of the SMB, the Nazareth Bank, and the Cargados Carajos Bank. It is one of the largest submerged ocean banks in the world, with the closest land approximately 300 km to the west known as Agalega (Bhagooli and Kaullysing, 2019). The bank covers an area of approximately 40,808 km^2 and is subsequently divided into two regions: the north, also known as the Ritchie Bank; and the south which is known to be the largest area of the SMB (Vierros, 2009). The bank consists of a series of narrow shoals, with depths ranging from 17 to 29 m on the rim, and slopes on all sides of the bank. Some areas of the bank are shallow, with the shallowest point (8 m) known as the Poydenot Rock (New *et al.,* 2013). The shallow areas of the SMB are covered with seagrass and sparsely distributed small coral reefs (Obura *et al.,* 2012). Due to its remote location, limited studies on its benthic habitats have been carried out. Most of the studies conducted were between the 1960's and 1990's, mostly by the Russian expedition, principally targeting physical oceanography and fishery research (Vortsepneva, 2008) or seabed mineral resources and bathymetry studies (Shor and Pollard, 1963; Meyerhoff and Kamen-Kaye, 1981; Gershanovich and Dubinets, 1991; Badal, 2003; Rogers, 2012; Seamounts Project, 2013; Lindhorst *et al.,* 2019).

Since 2012, the SMB has been jointly managed by the Republic of Mauritius and the Republic of Seychelles through the Mauritius-Seychelles Joint Management Area (JMA) Commission (CLCS, 2011), where the Commission has exclusive rights to explore, exploit, conserve and manage natural resources such as minerals, petroleum, and benthic resources found on the seabed and subsoil. Benthic habitats are diverse as are the biological communities inhabiting and shaping them (Henseler *et al.,* 2019). However, only a few comprehensive major benthic habitat (corals, seagrass, seaweed, and bare substrate) studies are available to date (Rosen, 1971; Fredericq *et al.,* 1999; Hagan and Robinson, 2001; Hilbertz and Goreau, 2002; and Milchakova *et al.,* 2005). In February 2021, the SMB was the target of an expedition led by Greenpeace with the Arctic Sunrise vessel (Drozdovskiy, 2021). It aimed at documenting the biodiversity and threats to the bank. However, no data has been made available on the area to date following that expedition. Consequently, an assessment of the benthic habitat making up the SMB is urgently needed to better understand the potential marine resources it hosts and the sensitivity of the area.

The bank has been used as an illustration of a likely Ecologically or Biologically Significant Area (EBSA), satisfying four out of the seven criteria: it's uniqueness or rarity; special importance for life history stages of species; importance for threatened, endangered or declining species and/or habitats; and for its biological productivity (Obura *et al.,* 2012). Another analysis by the World Wildlife Fund (WWF) further emphasized the significance of Saya de Malha through satisfying three other EBSA criteria such as: vulnerability, fragility, sensitivity, or slow recovery; biological diversity; and naturalness, and the bank was selected as a priority seascape of global significance for its ecoregional conservation strategy (Christiansen, 2010). Due to the importance of some areas in the SMB, Hilbertz and Goreau made two expeditions to the bank in 1997 and 2002 with the aim of creating an artificial island using electricity to accrete the minerals in sea water onto a metal structure (Hilbertz and Goreau, 2002) on the Ritchie Bank (northern region).

Scientific research on the underlying seafloor of the SMB has become critical to help both the Republic of Mauritius and the Republic of Seychelles in the future management and development of effective conservation strategies within the JMA using science-based evidence. As such, in May 2018, an Indian Ocean Research Expedition was carried out on the SMB on board the RV Dr Fridtjof Nansen under the EAF-Nansen Programme Science Plan Theme 7 'Habitat mapping' - facilitating collection of baseline data on a range of benthic habitats. The expedition surveyed the shallow plateau of the SMB as well as the rim and upper slopes. For this study, particular attention has been given to the most important shallow water benthic habitats found on SMB at depths between 23 – 50 m, while areas of the plateau deeper than 50 m were considered by Bergstad *et al.* (2021, *in press*). The aim of this study was to supplement earlier studies and characterise the major marine benthic habitats (biotic and abiotic) found within the shallow waters of SMB. The present survey used a non-destructive methodology; that is, visual observations by using high-definition videos taken from a remotely operated vehicle (ROV), as compared to the use of benthic samplers and trawls used in previous surveys (Hilbertz and Goreau, 2002; Vortsepneva, 2008). The objective was to develop the first map of the SMB characterising the diversity and the distribution of its major benthic biotic and abiotic habitats found within its shallow water areas.

Materials and methods

Study sites

The Saya de Malha Bank (SMB) is located between 8°30' – 12°00'S and 59°30' – 62°30'E and is the largest bank of the Mascarene Plateau with an area of approximately 40,000 km^2. The shallow waters of the SMB were investigated during the EAF-Nansen Indian Ocean Research Expedition on board the RV Dr Fridtjof Nansen, within the 23 to 50 m depth range. Two high-resolution Multi Beam Echo Sounders (MBES), Kongsberg EM 710 and EM 302 (operation depth 3 to 2000 m and 10 to 7000 m, respectively) helped with mapping the seafloor to adequately select the studied stations. Fifteen stations (SS4, SS9, SS13, SS34, SS36-1, SS36-2, SS37-1, SS37-2, SS38, SS39-1, SS39-2, SS39-3, SS39-4, SS40 and SS42) were within the targeted depth range and were therefore selected for the survey (Fig. 1). SS36, SS37 and SS39 were split into different stations but were found within the same area.

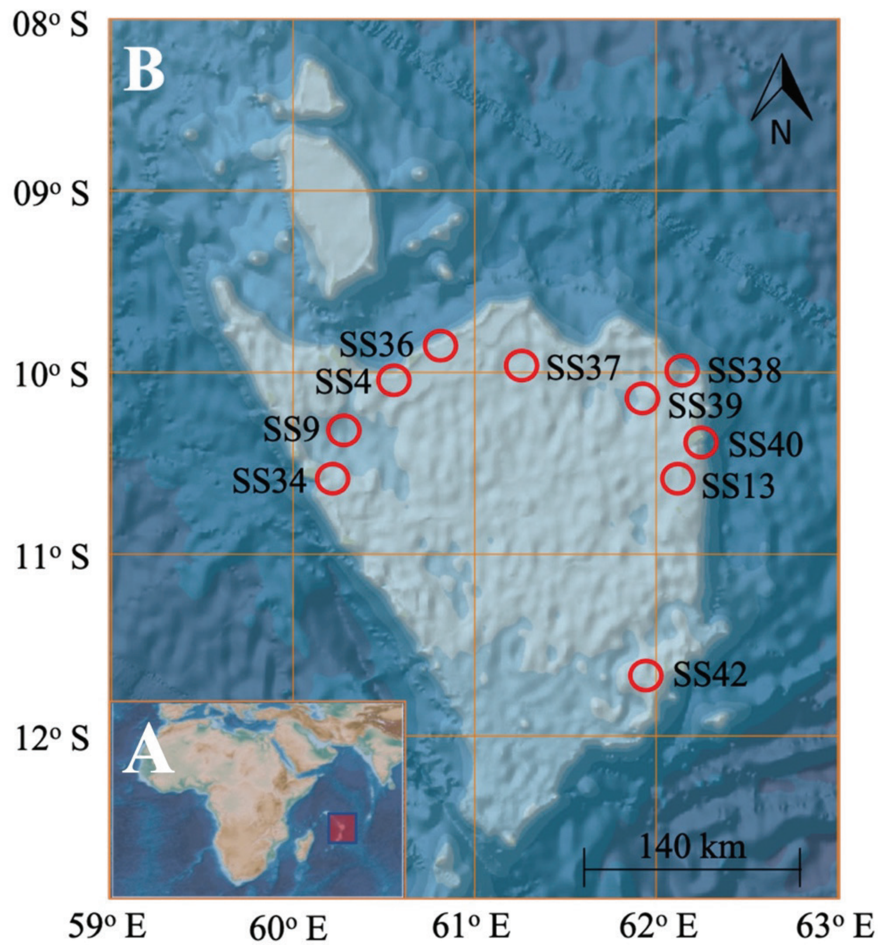

Figure 1. Map of the Saya de Malha Bank indicating the surveyed stations. A: Western Indian Ocean region map showing the location of Saya de Malha Bank in the red box. B: Map showing the 15 shallow surveyed stations (SS) in red circles. SS36 represents both stations SS36-1 and SS36-2l, SS37 represents both stations SS37-1 and SS37-2 and SS39 represents stations SS39-1, SS39-2, SS39-3 and SS39-4. The maps were prepared using the General Bathymetric Chart of the Ocean (EBCO) Bathymetry Grid layer data 2020.

Video transect data collection

In-situ visual data collection was carried out using the HD camera of a tethered ROV, able to operate at depth between 20 – 1000 m, attached to a Video-assisted Multi-sampler (VAMS), a tubular cage hosting the ROV (Serigstad *et al.*, 2015). The ROV attached to the VAMS was used to carry out the video transect survey in two modes: 1) as a point sampler where the VAMS was deployed on the seabed allowing the ROV to explore the immediate 15 m vicinity in four directions (north, east, south and west); and 2) in a towed

Table 1. Percentage cover of the biotic (seagrass, seaweed and live hard coral) and the abiotic (sand, rubble and bedrock) habitats, depth range of each station, GPS locations and total area surveyed at each station.

ROV Operation Modes	Station N°	Latitude (S)	Longitude (E)	Total Surface Explored by ROV per dive (m²)	Depth Range (m)	Biotic Category			Abiotic Category
						Seagrass (%)	Seaweed (%)	Live Hard Coral (%)	Bottom Substrate (Unstable & Stable) (%)
Mode 1	SS4	-10.113192	60.575226	703	29 - 32	20	51.8	5.2	23
	SS9	-10.427421	60.140288	703	45 - 50	0	30	0	70
	SS13	-10.732368	62.130394	703	28 - 31	52	47	0	1
Mode 2	SS34	-10.625219	60.199550	4553	44 - 46	1	77	0	22
	SS36-1	-9.831724	60.762377	12228	46 - 50	0	72.4	23.3	4.3
	SS36-2	-9.859240	60.791336	9819	23 - 30	13.9	23.1	35	28
	SS37-1	-10.094556	61.221217	11674	37 - 42	11.1	71.2	4.3	13.4
	SS37-2	-10.092485	61.242757	13330	32 - 35	19.6	52.5	4.2	23.7
	SS38	-10.062541	62.183355	5950	26 - 30	93	5	1	1
	SS39-1	-10.382314	62.078151	13070	39 - 43	1.2	71.3	13.8	13.7
	SS39-2	-10.381302	62.093671	10211	31 - 33	0	33.3	33.3	33.4
	SS39-3	-10.379792	62.123875	4143	24 - 26	65	21	9	5
	SS39-4	-10.377526	62.204940	14600	33 - 43	22.6	26.2	25	26.2
	SS40	-10.736205	61.945050	36309	38 - 50	18.8	48	0.2	33
	SS42	-11.676877	61.948717	5114	47 - 50	0	25	2.5	72.5

mode whereby the vessel towed the VAMS at 5 m above the seabed along pre-determined transects perpendicular to isobaths at 0.1-0.4 knots while the ROV, attached to the VAMS, explored the underlying seabed. The distance between the ROV camera and the seabed was kept at 2 m, with a lens' swarth width of 15 m during steady passage, depending on the environment and sea condition. As a first exploratory survey, several stops were made along the transects in order to capture close-up videos for record and identification of certain benthic organisms. The video records were logged with data on GPS position to calculate the distance covered by the ROV along the transect, dive time and depth using the CAMPOD Logger software, a camera-based data collection software designed by the Institute of Marine Science of Norway (IMR) that is used with the ROV. The CAMPOD Logger uses the same principle as the Coral Point Count with Excel extension (CPCe) Software (Kohler and Gill, 2006). The data was further analysed after the cruise.

Video data analyses

The video records were further analysed during a workshop organised in August 2019 in Mauritius that brought together various experts. From the footage obtained at the different stations, focus was placed on the four main benthic habitats: live hard corals; seagrass; seaweed; and bare substrate (stable and unstable). The abiotic bottom substrate cover was calculated when no other biotic benthic habitat was present, and it was further sub-categorised into sand and rubble, which represented the unstable substrate, and bedrock, which represented the stable substrate. The sub-category 'sand' was used for fine and coarse substrates, where typically ripple marks were present comprising of small fossil gastropod and bivalve shells and dead calcareous seaweed leaves (e.g., *Halimeda* spp.). The 'rubble' sub-category was used for broken corals, small pebbles, broken gravel, and stones while the 'bedrock' sub-category was used to describe substrates involving basalt, limestone, cemented sand, and/or boulders, including when covered by a thin superficial layer of soft sediment. The percentage habitat cover was determined by dividing the area covered by each habitat category recorded along the transect by the total area of the transect at each station and multiplied by 100. The area of one habitat category was calculated using the distance moved by the ROV over the transect, calculated using the GPS coordinates at the point where a specific habitat category started and ended, multiplied by the ROV lens' swarth of 15 m.

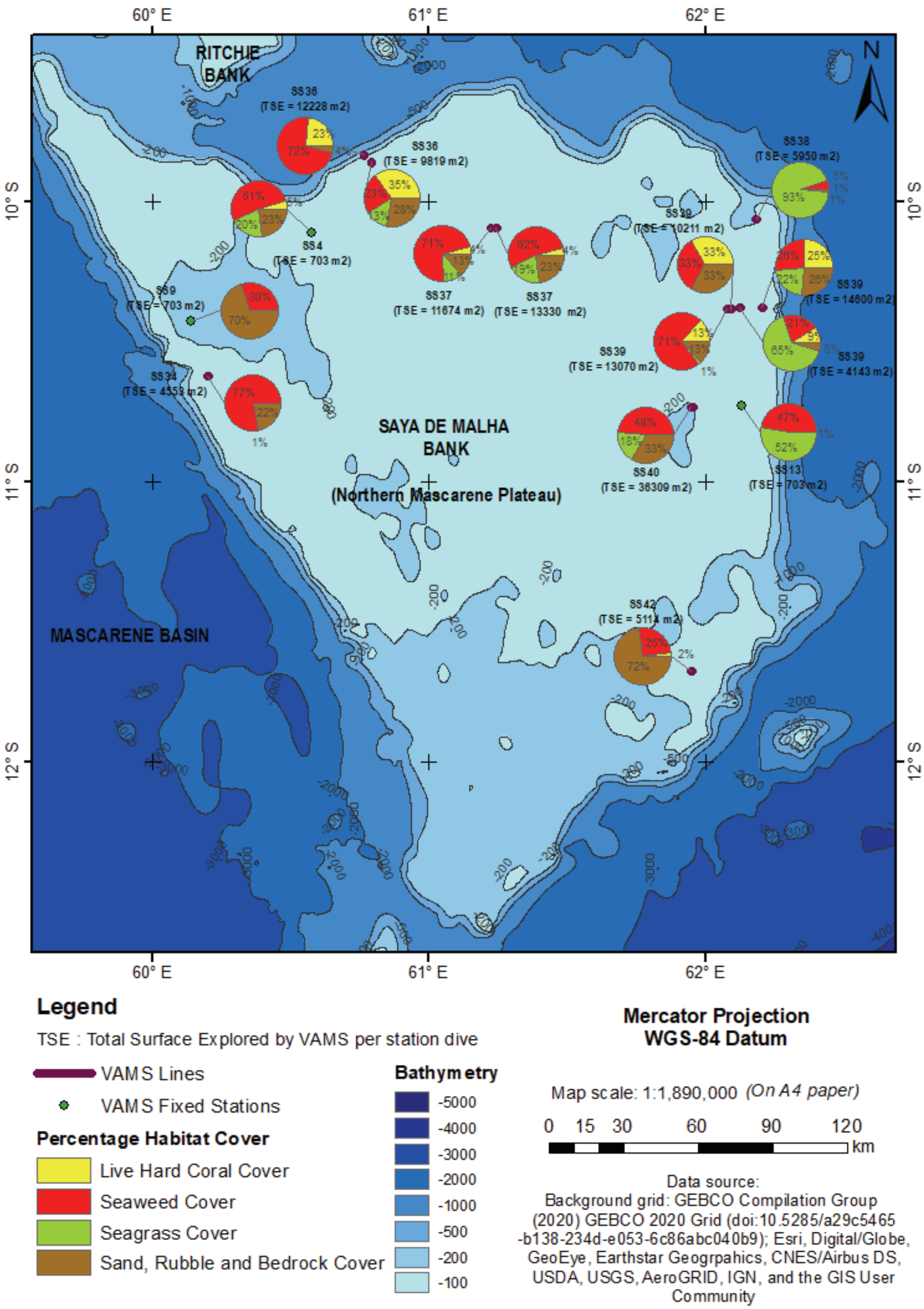

Figure 2. Percentage habitat cover for the total shallow-water seafloor area explored by the ROV (VAMS) in the shallow water of Saya de Malha Bank. Total habitat cover represented by live hard coral cover (yellow), seaweed cover (red), seagrass cover (green) and bottom substrate (sand, rubble and bedrock) cover (brown). Total number of stations = 15. Map Data Source: Background grid – GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234d-e053-6c86abc040b9); Esri,Digital/Globe, GeoEYe, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGrid, IGN, and the GIS User Community. Mercator Projection WGS-84 Datum.

Results

Live hard coral cover and diversity

The highest percentage of live hard corals was recorded at station SS36-2 (35 % in 9819 m²), at depths ranging from 44.5 - 46.8 m. The lowest percentage of live hard coral cover was recorded at station SS40 with 0.2 % in an area of 36309 m². No live hard corals were recorded during the survey at stations SS4, SS9 and SS13 (Table 1 and Fig. 2). Shallow waters harboured a range of hard live coral colonies such as branching and massive *Porites, Acropora* spp., *Heliopora* sp., *Turbinaria* spp., *Danafungia* spp., *Herpolitha* spp., *Favites* spp., *Dipsastraea* spp., *Goniastrea* spp., *Lobophyllia* spp., *Seriatopora* spp., and *Goniopora* spp. (Fig. 3 and Table 2).

Seagrass cover and diversity

The highest seagrass cover was recorded at station SS38 with 93 % per 5959 m². This station had an abiotic substrate cover (1 %) comprised of rubble and sand. These are suitable substrates for *Thalassodendron ciliatum* which was abundant at those stations. The lowest seagrass percentage cover was observed at station SS34 with 1 % per 4553 m², while no seagrass was observed at stations SS9, SS36-1, SS39-2 and SS42 (Table 1 and Fig. 2). Another species of seagrass observed during the survey was *Halophila decipiens* (Table 2 and Fig. 4) observed to occur as deep as 50 m, but in small, isolated patches. These mainly occurred at stations SS34, SS37 and SS40 where sand was abundant. Seagrass, consisting primarily of *T. ciliatum,* occurred from 38 m in depth and formed large meadows as depth became shallower.

Seaweed cover and diversity

The highest percentage cover for seaweed was found at SS34 (77 % in 4553 m²) while the lowest percentage cover was observed at SS38 (5 % in 5950 m²) (Table 1

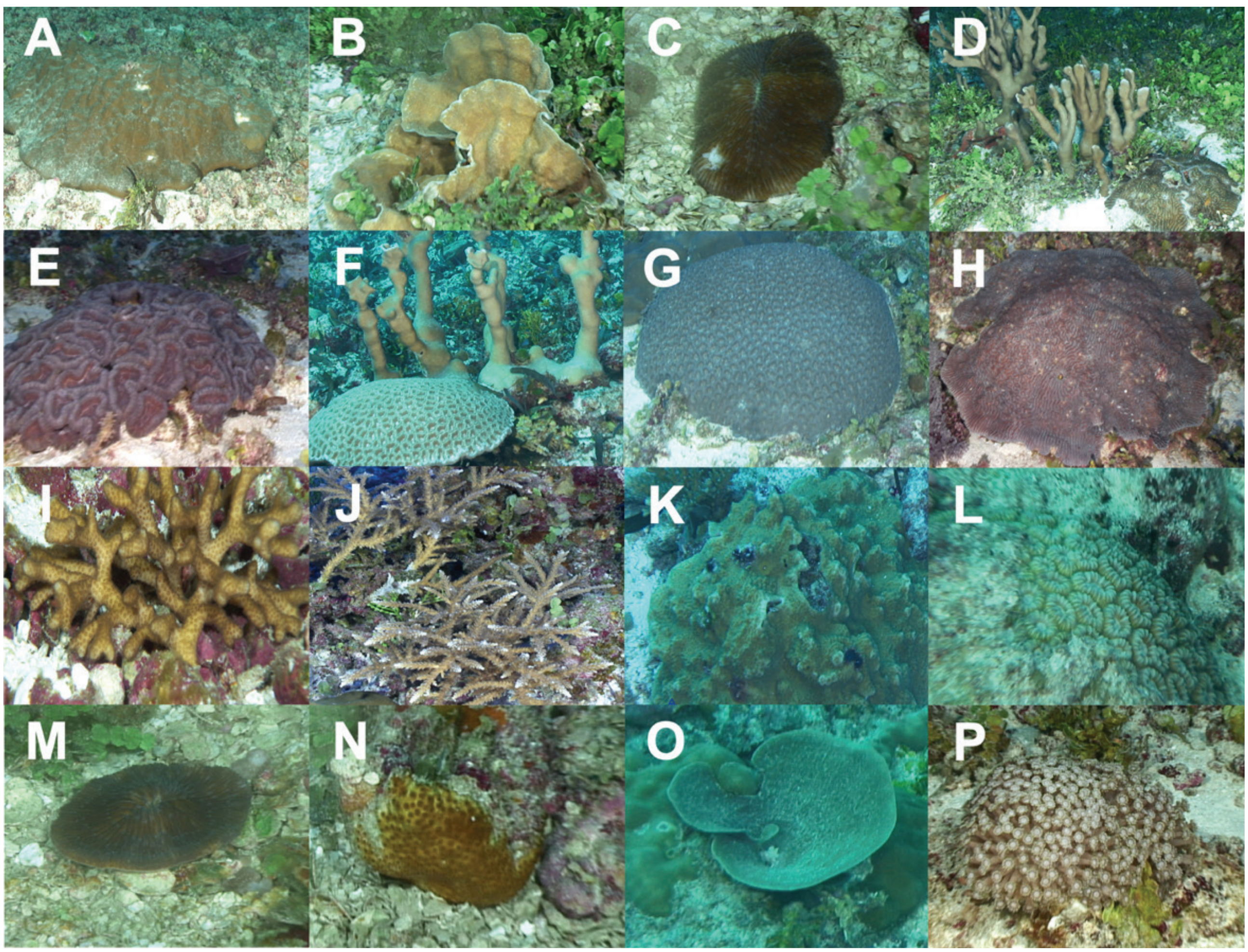

Figure 3. Common coral genera found in the shallow waters of Saya de Malha Bank. A: *Porites* sp. at SS4 (32 m); B: *Turbinaria* sp. at SS36 (38 m); C: *Herpolitha* sp. at SS36 (38 m); D: *Heliopora* sp. and *Platygyra* sp. at SS36 (38 m); E: *Lobophyllia* sp. at SS39 (39 m); F: *Porites* sp. and *Goniastrea* sp. at SS39 (33 m); G: *Favites* sp. at SS39 (37 m); H: *Leptoria* sp. at SS39 (43 m); I: *Seriatopora* sp. at SS42 (49 m); J: *Acropora* sp. at SS39 (35 m); K: *Echinopora* sp. at SS36 (25 m); L: *Dipsastraea* sp. at SS36 (25 m); M: *Danafungia* sp. at SS36 (42 m); N: *Cyphastrea* sp. at SS36 (38 m); O: *Pachyseris* sp. at SS36 (25 m); and P: *Goniopora* sp. at SS37 (39 m).

Table 2. List of recorded biotic habitat genera at each station (SS) and depth range (m).

Station N°	Depth Range (m)	Biotic habitat category		
		Seagrass genera	Seaweed genera	Live Hard Coral genera
SS4	29 - 32	*Thalassodendron ciliatum*	*Halimeda* spp., *Lithothamnion* spp.	*Heliopora* sp., *Porites* spp., *Favites* spp.
SS9	45 - 50	Nil	*Lithothamnion* spp.	Nil
SS13	28 - 31	*T. ciliatum*	*Lithothamnion* spp., *Caulerpa cuppresoides,* *Udotea* spp.,	Nil
SS34	44 - 46	*Halophila decipiens*	*Lithothamnion* spp., *Halimeda* spp., *Udotea* sp.	Nil
SS36-1	46 - 50	Nil	*Lithothamnion* spp., *Halimeda* spp.	Unk. Encrusting coral, *Galaxea* sp., *Danafungia* sp., *Acropora* spp., *Porites* spp., *Turbinaria* sp., *Herpolitha* sp., *Dipsastraea* sp., *Heliopora* sp., *Astreopora* sp., *Pocillopora* sp., *Platygyra* sp., *Cyphastrea* sp.
SS36-2	23 - 30	*T. ciliatum*	*Lithothamnion* spp., *Halimeda* spp.	*Acropora* spp., *Porites* spp., *Turbinaria* sp., *Herpolitha* sp., *Dipsastraea* sp., *Heliopora* sp, *Pocillopora* sp., *Millepora* sp., *Echinopora* sp., *Pachyseris* sp.
SS37-1	37 - 42	*T. ciliatum*	*Lithothamnion* spp., *Halimeda* spp., *Udotea* spp.	*Heliopora* sp., *Porites* spp., *Favites* spp., *Turbinaria* sp., *Herpolitha* sp., *Dipsastraea* spp., *Acropora* spp., *Goniopora* sp.
SS37-2	32 - 35	*T. ciliatum*	*Lithothamnion* spp., *Caulerpa cuppresoides,* *Udotea* spp.,	*Porites* spp., *Goniopora* sp., *Dipsastraea* spp., *Turbinaria* spp., *Acropora* spp., *Acanthastrea* spp.
SS38	26 - 30	*T. ciliatum*	*Lithothamnion* spp., *Caulerpa cuppresoides,* *Halimeda* spp.	*Acropora* spp.
SS39-1	39 - 43	*T. ciliatum, H. decipiens*	*Lithothamnion* spp., *Halimeda* spp., *Caulerpa cuppresoides*, *Udotea* spp.,	*Turbinaria* sp., *Porites* spp., *Acropora* spp., *Dipsastraea* spp., *Heliopora* sp., *Lobophyllia* sp., *Favites* spp.
SS39-2	31 - 33	Nil	*Lithothamnion* spp., *Halimeda* spp., *Caulerpa taxifolia*	*Heliopora* sp., *Porites* spp., *Dipsastraea* spp., *Goniastrea* sp.
SS39-3	24 - 26	*T. ciliatum*	*Lithothamnion* spp., *Udotea* spp., *Caulerpa cuppresoides,* *Halimeda* spp.	*Porites* spp., *Heliopora* sp.,
SS39-4	33 - 43	*T. ciliatum*	*Lithothamnion* spp., *Halimeda* spp., *Udotea* spp., *Caulerpa taxifolia*.,	*Porites* spp., *Acropora* spp., *Platygyra* spp., *Heliopora* sp., *Goniopora* spp., *Dipsastraea* spp., *Turbinaria* spp., *Danafungia* spp., *Pavona* spp., *Seriatopora* spp., *Stylophora* sp., *Lobophyllia* sp., *Goniastrea* sp., *Leptoria* sp.
SS40	38 - 50	*H. decipiens*	*Lithothamnion* spp., *Caulerpa cuppresoides,* *Caulerpa taxifolia*., *Udotea* spp., *Halimeda* spp.,	*Heliopora* sp., *Stylophora* sp.
SS42	47 - 50	Nil	*Lithothamnion* spp.	*Acropora* spp., *Seriatopora* spp.

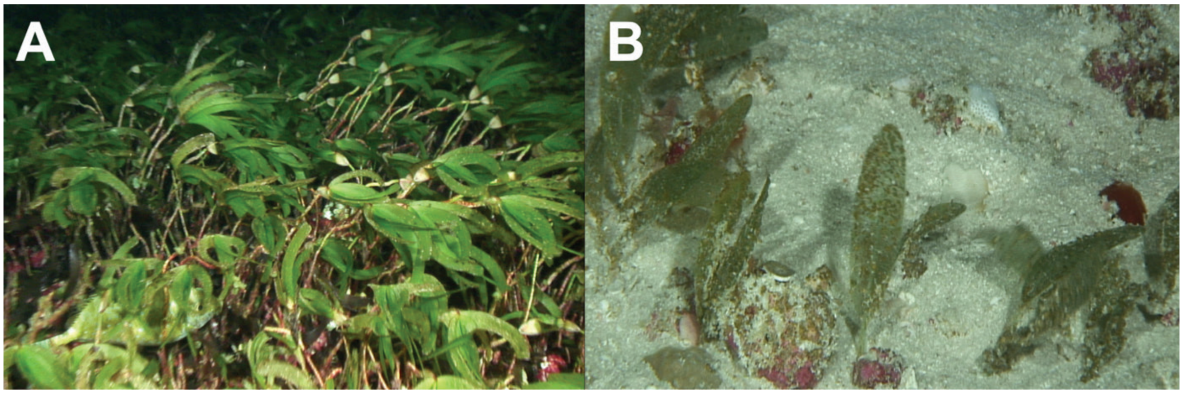

Figure 4. Seagrass species found in the shallow waters of the Saya de Malha Bank. A: *Thalassodendron ciliatum* at SS38 (28.8 m); and B: *Halophila decipiens* at SS40 (45.5 m).

and Fig. 2). Five main seaweeds were observed in the shallow water of SMB, namely *Halimeda* spp., *Lithothamnion* spp., *Caulerpa cupressoides, C. taxifolia* and *Udotea* spp. (Table 2 and Fig. 5), with *Halimeda* spp. being the most dominant at all stations except for SS42 where only *Lithothamnion* spp. occurred (25 % in an area of 5114 m^2). At all the stations where *Halimeda* spp. cover was found to be high, the upper layer of the sediment seemed to consist of the dead calcareous leaves of this species. The seaweed *Caulerpa cupressoides* was observed forming clusters within *T. ciliatum* seagrass meadows, while the seaweed *Udotea* spp. and *Caulerpa taxifolia* were also observed to occur in small isolated patches.

Bottom substrate cover and characteristics

The highest bottom substrate percentage cover (consisting of either one of sand, rubble and bedrock or a mixture of the three) was observed at station SS42 with 72.5 % over an area of 5114 m^2. The lowest percentage substrate cover was at SS13 and SS38 with 1 % over an area of 703 m^2 and 5950 m^2, respectively. Most of the cover at the stations varied between sand and rubble while the presence of bedrock was recorded at stations SS36, SS37 and SS39 only. Station SS39 had the highest percentage of bedrock cover recorded while at stations SS34, SS38, SS40 and SS42 the bottom substrate was composed of sand and/or rubble.

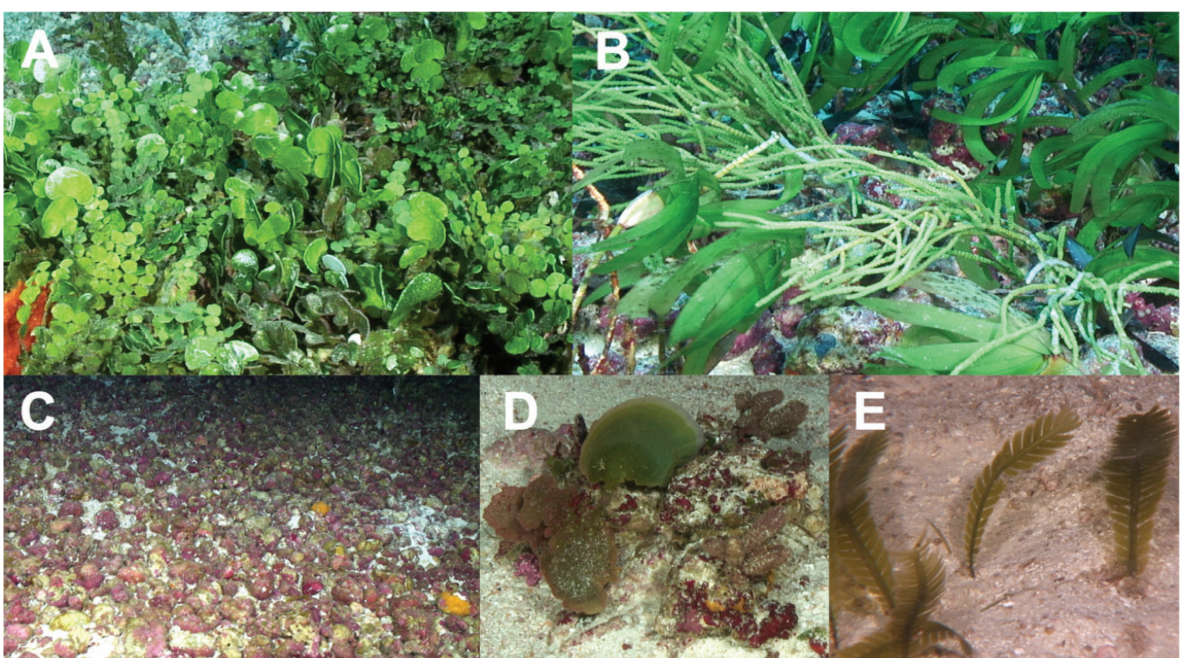

Figure 5. Seaweed in the shallow waters of the Saya de Malha Bank. A: *Halimeda* spp. at SS36 (38 m); B: *Caulerpa cupressoides* at SS13 (31 m); C: *Lithothamnion* spp. at SS42 (49 m); D: *Udotea* spp. at SS37 (34 m); and E: *Caulerpa taxifolia* at SS40 (50 m).

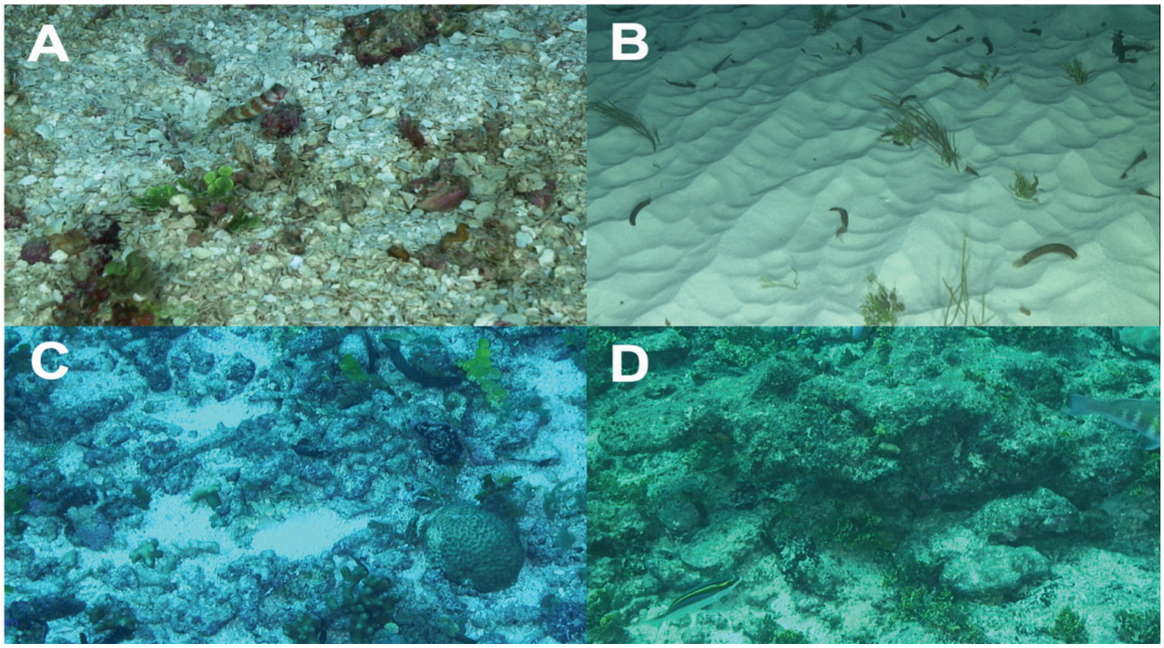

Figure 6. The four main bottom substrate habitats present within the Saya de Malha Bank. A: Sand made from calcified *Halimeda* spp. at SS38 (36 m); B: Fine sand at SS37 (32 m); C: Rubble at SS36 (24 m); and D: Bedrock at SS39 (26 m).

Discussion

The present study from the 2018 Nansen research expedition covered 3.6 x 10^{-4} % (1.4 x 10^{-1} out of about 40,000 km^2) of the SMB area which was calculated along a transect assuming the swath width of the camera lens to be 15 m. The 143,110 m^2 surveyed area revealed the benthic habitat cover of 43.64 ± 22.36, 24.48 ± 21.85, 21.21 ± 27.77, and 10.46 ± 12.55 % for seaweed, abiotic substrate, seagrasses and corals, respectively. These findings indicate the presence of significant biotic benthic habitats in the shallow areas between 23-50 m on the SMB. One of the most striking observations made on the bank was the dominance of seaweed at almost all the stations (notably *Halimeda* spp.) even though other species of seaweed were also recorded in lower abundance. However, this abundance is highly relative to season and the dominance of this species may alter over time (Spalding *et al.,* 2019). Vortsepneva (2008) reported that red calcareous coralline algae and *Halimeda* were more frequent than corals in the shallow waters with beds (mainly rhodolith) that extended over 80-90 % of the fringing reef area. In the present study green calcareous algae (*Halimeda* spp.) were the most abundant among the seaweeds and probably constitutes the main source of unstable substrate (sand) dominating the stations surveyed. *Halimeda* spp. are known to be important and rapidly growing primary producers which are known to sometimes be associated with coral reefs (Vogel *et al.,* 2015). They act as suitable habitat for many important invertebrates (Fukunaga, 2008) such as communities of the sea cucumber *Thelenota ananas* that were observed in this study. Moreover, they also contribute considerably to carbonate production and sediment formation due to their calcium carbonate skeleton and are considered important for establishing the substrate needed for other species to develop (e.g. seagrasses), in addition to their role in carbon sequestration (Rees *et al.,* 2007).

Current knowledge suggests that the SMB supports the largest contiguous seagrass beds in the world (Obura *et al.,* 2012) with 80–90 % of shallow surfaces being covered by seagrasses and dominated almost exclusively by *T. ciliatum* up to depths of 30–40 m, with additional records of *H. decipiens* and *Enhalus acoroides*. (Obura *et al.,* 2012; Klaus, 2014). This expedition confirmed the presence of two species of seagrass, where *T. ciliatum* was dominant and formed large meadows principally at SS38. No *E. acoroides* was observed during the expedition. However, *E. acoroides* may be present in the shallower areas of Saya de Malha as this expedition did not investigate stations shallower than 23 m deep (Hilbertz and Goreau, 2002; Vortsepneva, 2008). Seagrass beds are among the most productive aquatic ecosystems. They are important as nursery grounds, foraging areas, and predation refuges for numerous vertebrates and invertebrates (Hilbertz and Goreau, 2002; Klaus, 2014). The large seagrass beds found within the SMB are also considered to provide great benefits for commercial, subsistence and recreational fisheries. The clear water observed during the survey may be attributed to the complex architecture of the leaf canopy in combination with the dense network of roots and rhizomes, allowing seagrass beds to stabilize bottom sediments and serve as effective hydrodynamic barriers reducing wave energy and current velocity, thereby reducing turbidity (Burnett *et al.,* 2001; Hagan and Robinson, 2001; Gullstrom *et al*., 2002; Milchakova *et al*., 2005; GOBI, 2009). Further, seagrass beds trap large amounts of nutrients and organic matter in the bottom sediment through microbial decomposition, and seagrass biomass may enter the marine food web as detritus and support productivity through recycling of nutrients and carbon (Lindhorst *et al.,* 2019). This makes SMB a hot spot for blue carbon sequestration within the region and worldwide. Due to their high productivity, they are often a food source for animals resident in adjacent ecosystems such as coral reefs and may increase the biodiversity in these systems (Sala *et al.,* 2016).

The shallow water of the SMB also supported several coral. New *et al.* (2013) reported coral reefs on the SMB to occur on rocky patches and outcrops, while Gershanovich and Dubinets (1991) found the corals to be on the edges of the bank forming an atoll ring with a lagoon and intra-lagoon reefs. Thirteen genera of corals have previously been recorded from the shallow areas of the SMB (Rosen, 1971). At the north bank, however, an entirely different coral ecosystem was found, dominated by large stands of a single species of branching *Acropora* corals (Hagan and Robinson, 2001). *Acropora, Pocillopora, Montipora*, *Porites* and *Heliopora* sp. were the most common genera (Sirenko, 1993 in Vortsepneva, 2008) which is in concurrence with records from the present study, with several other common genera recorded such as *Danafungia*, *Favites*, *Dipsastraea*, *Seriatopora* and possibly *Stylophora* amongst others. In this study the highest live coral cover was observed at station 36-2 with 35 % over an area of 9819 m^2 in a depth range 23 – 30 m on the south bank. All the studies previously carried out on the corals of the SMB have targeted the north bank mainly due to its shallowness, with no focus on the south bank (Rosen, 1971; Hilbertz and Goreau, 2002; Vortsepneva, 2008). The current study fills some of these gaps and provides a stronger basis for future studies on corals in this region. In addition, Vortsepneva (2008) estimated a 5 % rate of endemism in the area which corroborates with this study where coral genera such as *Seriatopora* and *Stylophora* were observed.

Although the present study gave a good indication of the diversity and distribution of the benthic habitats in the shallow waters (23-50 m) of the SMB, several limitations such as the inaccuracy of the existing bathymetry maps prevented the survey from being carried out in shallower waters. All dives were carried out during daytime and the technical crew was only available for 8-12 hours per day, hence limiting operation time. Another major setback that made the identification process difficult was the inability to carry out targeted collection of samples to confirm identification from videos. Accordingly, most of the marine organisms were identified to family and/or genus levels as compared to previous studies where SCUBA diving (Hilbertz and Goreau, 2002) and bottom trawling (Vortsepneva, 2008) allowed sample collection. This limitation may be considered in future explorations in order to more extensively uncover the relative importance of the habitats documented to the diversity and productivity of the area, especially with regards to their blue carbon capacity.

Conclusions

This study presents a first documentation of the diversity and distribution of the main biotic and abiotic habitats present in the shallow waters (23 – 50 m) of the SMB. Though the SMB is renowned for being one of the largest banks in the world with extensive seagrass beds, the present study indicates that seaweeds, in particular the coralline green algae (*Halimeda* spp.), were more dominant than the seagrasses and corals at the surveyed shallow-water (23-50 m) stations during the survey period. This study therefore brings forth new data and further adds to the limited information present on the diversity and distribution of benthic habitats in the shallow water areas of the SMB which may be used to contribute to the better management of the bank. It is however worth carrying out further in-depth research in the shallower waters (less than 23 m) of the SMB to obtain a better understanding of the diversity and distribution of its benthic habitats.

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