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TERRESTRIAL AND MARINE ECOLOGY OF ETOILE, AMIRANTES, SEYCHELLES

BY

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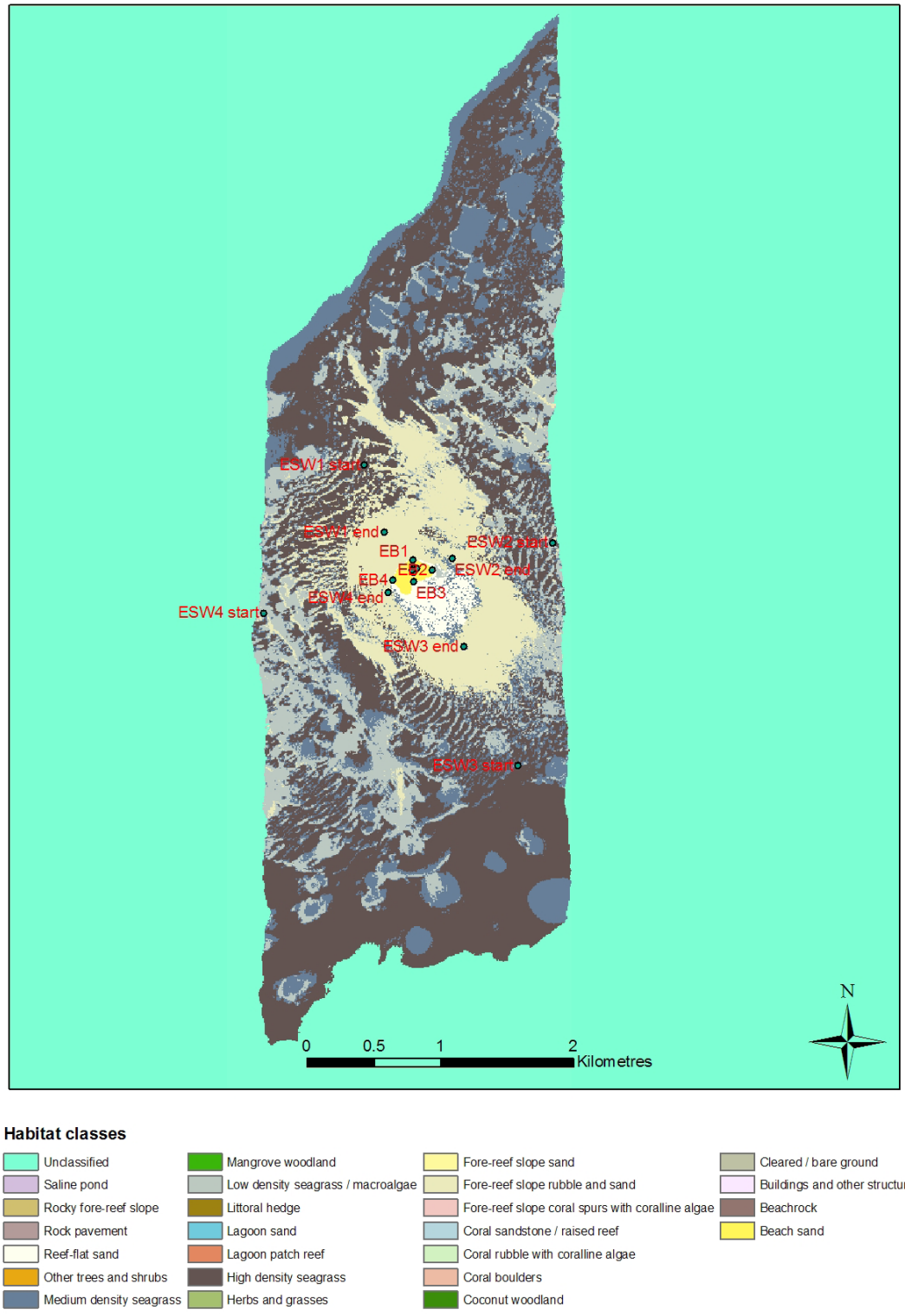

Figure 1. Location of beach profiles (EB1, EB2, EB3 and EB4) and shallow-water transects (ESW1, ESW2, ESW3 and ESW4) at Etoile, 25th January 2005. Habitat map from Spencer et al. (2009).

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INTRODUCTION

The Amirantes group, Seychelles, comprises 24 islands and islets lying between 5° and 6° south of the equator on the Amirantes Bank, western Indian Ocean. The islands were discovered by the Portuguese navigator Vasco de Gama on his second voyage to India in 1502, soon after acceding to the rank of Admiral, and the islands were subsequently named Ilhas do Almirante or Admiral's Islands (Lionnet, 1970). The group extends over a distance of 138 km, from African Banks in the north to Desnoeufs in the south. Etoile is one of the two sand cays which rises up from the Banc de la Boudeuse, approximately 30 km south-west of Poivre atoll. The other sand cay, Boudeuse, lies 30 km southwest of Etoile. Etoile is believed to have been named by Chevalier du Roslan in 1771, after one of the two ships of Bougainville's round the world voyage from 1766 to 1769. Due to its small size (and thus its probable lack of economically significant guano deposits), the fact that the sea is reportedly often rough around this shallow bank and the difficulty of getting ashore, the island has never been inhabited. It is designated as a bird reserve.

A collaborative expedition between Khaled bin Sultan Living Oceans Foundation, Cambridge Coastal Research Unit and Seychelles Centre for Marine Research and Technology – Marine Parks Authority to the southern Seychelles was conducted onboard M.Y. Golden Shadow, from 10th – 28th January 2005. The primary aim of the expedition was to use a CASI (Compact Airborne Spectrographic Imager) sensor onboard a seaplane to conduct large-scale mapping of the southern Amirantes, Alphonse/St. François (Spencer et al., 2009) and Providence Bank. All surveys at Etoile were conducted on 25th January 2005.

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REGIONAL BATHYMETRY, TOPOGRAPHY AND VEGETATION

Etoile is unusually situated near the western margin of the Amirantes Bank (most islands in the Amirantes sit on the eastern margin). Water depths immediately to the west of Etoile rapidly exceed 1,000 m but the western margin of the Amirantes Bank reaches to within 11 to 17 m of sea level, compared to depths in excess of 50 m in the centre of the Bank to the east. Etoile is positioned at a location where this marginal rim doubles in width; it is likely that the island occupies a small topographic high as local water depths are 9 m or less.

The sand cay is small (1 ha), broadly crescentic in form and flanked by an area of reef-flat sands, 600 m wide and bounded by a zone of breaking waves, to the southeast (Fig. 1, Plate 1). Both the cay and the reef-flat sands sit centrally within a larger, oval-shaped fore-reef sandsheet, *ca.* 1.5 km long and 1 km wide, orientated NW-SE. A tongue of bare sand also extends to the north, reaching 1.6 km from the sand cay. The centre of the cay supports a mat of herbaceous vegetation (Plate 2).

TERRESTRIAL SURVEY METHODS

Flora and Fauna Surveys

No quantitative vegetation surveys were undertaken at Etoile. However, general observations of the bird-life and plant-life present were recorded. If birds and plants could not be identified *in situ*, digital photographs were taken for subsequent identification by local experts on Mahé.

Beach Surveys

Four beach profiles were measured at Etoile on the north (EB1; 5°53.095′S, 53°01.624′E - 5°53.068′S, 53°01.628′E), east (EB2; 5°53.102′S, 53°01.642′E - 5°53.117′S, 53°01.693′E) south (EB3; 5°53.115′S, 53°01.630′E - 5°53.152′S, 53°01.639′E) and west (EB4; 5°53.107′S, 53°01.624′E - 5°53.144′S, 53°01.548′E) sides of the island (Fig. 1). Profiles were measured by Abney level and tape, in an offshore direction perpendicular to the beach, beginning at the terrestrial vegetation line and continuing to the offshore step (where the waves were breaking, typically marked by a downward step) or as far as safely possible into the water. Eight surface scrape sediment samples, of *ca.* 150 – 350 g by weight, were collected, typically at the start (upper beach) and end (lower beach) of each profile. Positions were recorded for the start and end of each beach profile and for the sites of the sediment samples using a hand-held GPS unit (horizontal resolution = ±10 m). Sediments were dried, disaggregated and sieved using standard techniques at 0.25 phi intervals.

MARINE SURVEY METHODS

Shallow-water Boat Transects

Shallow-water transects were undertaken using a rigid inflatable boat at four sites around Etoile. Transects started at a water depth of approximately 20 m (the limit at which the bottom substrate could be accurately determined from the surface) and ran in towards a pre-decided point on the cay surface. Transects ran from N-S (ESW1; 5°52.646′S, 53°01.379′E - 5°52.894′S, 53°02.231′E), E-W (ESW2; 5°52.891′S, 53°02.231′E - 5°53.024′S, 53°01.730′E), S-N (ESW3; 5°53.937′S, 53°02.015′E - 5°53.441′S, 53°01.808′E) and W-E (ESW4; 5°53.182′S, 53°00.945′E - 5°53.218′S, 53°01.530′E) (Fig. 1). Each time the boat was stopped a GPS position was taken and the water depth and bottom substrate (viewed through a glass-bottomed bucket) recorded. Nine substrate observations were recorded on the N-S transect, 13 substrate observations were recorded on the W-E transect, 14 substrate observations were recorded on the S-N transect and 15 substrate observations were recorded on the E-W transect. No SCUBA diving surveys were undertaken at Etoile due to time constraints.

RESULTS OF TERRESTRIAL SURVEYS

Flora and Fauna Surveys

The herbaceous vegetation mat consists of a mixture of *Portulaca oleracea* and *Boerhavia* spp. (including *Boerhavia repens*). Numerous nesting seabirds were associated with the vegetated area in January 2005 (Plate 3). On the southern side of the vegetation patch, there were two separate colonies (n = 120 and n = 140) of *Anous stolidus* (Brown or Common Noddy) and on the northern side, there was one colony (n = 60) of *Sterna fuscata* (Sooty Tern) and a mixed colony of *Anous stolidus* (Brown or Common Noddy) (n = 80) and *Sterna fuscata* (Sooty Tern) (n = 50). Numerous eggs and chicks were observed in these colonies.

Beach Surveys

Beach sediments at the cay on Etoile are all coarse sands, generally well sorted but ranging from moderately well sorted to very well sorted in character (Table 1, Fig. 2). All beach profiles fall within the textural group of slightly gravelly sand, except for the base of profile EB2 (i.e. sample EB2.2) which is classified as sand.

Table 1. Folk and Ward (1957) particle size distribution statistics for sediment samples from beach profiles. Units are given on the phi (ø) scale.

Sample	Environment	D_{50}	M_z	σ_1	SK_1	K_G	Description
EB1.1	Upper beach	0.514	0.517	0.447	-0.013	0.998	Coarse Sand, Well Sorted, Symmetrical, Mesokurtic
EB1.2	Lower beach	0.644	0.626	0.429	-0.128	1.018	Coarse Sand, Well Sorted, Coarse Skewed, Mesokurtic
EB2.1	Upper beach	0.524	0.520	0.384	-0.031	1.073	Coarse Sand, Well Sorted, Symmetrical, Mesokurtic
EB2.2	Lower beach	0.774	0.786	0.329	0.032	0.962	Coarse Sand, Very Well Sorted, Symmetrical, Mesokurtic
EB3.1	Upper beach	0.442	0.421	0.366	-0.016	1.072	Coarse Sand, Well Sorted, Coarse Skewed, Mesokurtic
EB3.2	Lower beach	0.436	0.427	0.319	-0.002	1.038	Coarse Sand, Very Well Sorted, Symmetrical, Mesokurtic
EB4.1	Upper beach	0.317	0.288	0.560	-0.107	1.026	Coarse Sand, Moderately Well Sorted, Coarse Skewed, Mesokurtic
EB4.2	Lower beach	0.668	0.689	0.382	0.018	0.952	Coarse Sand, Well Sorted, Symmetrical, Mesokurtic

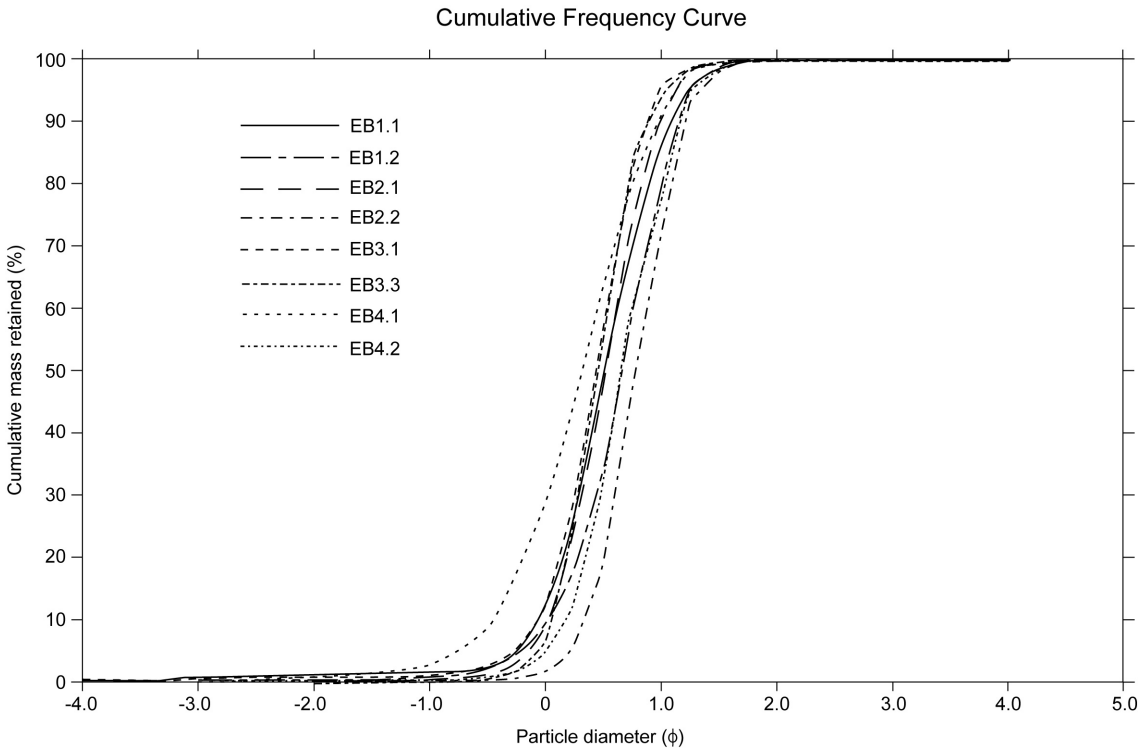

Figure 2. Cumulative frequency curves for sediment samples from upper and lower beaches.

Beaches vary in width from *ca.* 45 m, on the north side of the cay (Fig. 3a), to 70 m on the southern aspect (Fig. 3c), where the beach lies behind the 600 m wide reef flat. Widths are *ca.* 60 m on east and west-facing beaches (Figs. 3b, 3d). The elevation of the top of the beach generally falls within the range of + 2.5 to + 2.9 m above mean sea level but reaches + 3.7 m on the windward eastern side of the sand cay. Beach angles are typically 4 – 6^{o} on the lower beach and 1 – 3^{o} at the upper margin where field observations suggested that profiles are flattened by wave washover processes (Plate 4). In the absence of washover, the steepest beaches lie on the northern side of the cay, the area most protected from waves from the south-east, being 6 – 9^{o} on the lower beach and reaching 14^{o} at the landward beach margin (Fig. 3a).

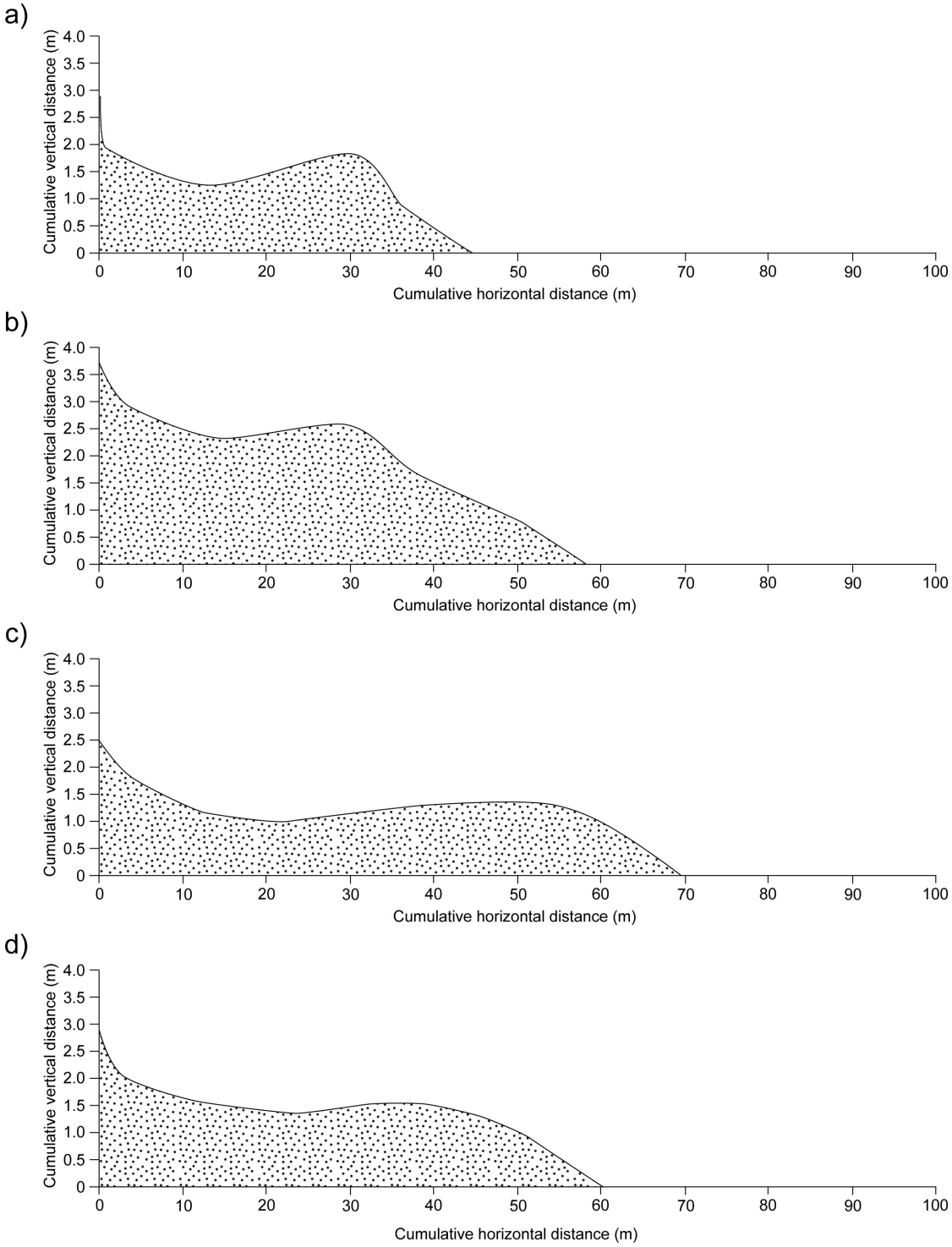

Figure 3. Beach profile a) on the north side of the island at 05°53.095′S, 53°01.624′E - 5°53.068′S, 53°01.628′E; b) on the east side of the island at 5°53.102′S, 53°01.642′E - 5°53.117′S, 53°01.693′E; c) on the south side of the island at 5°53.115′S, 53°01.630′E - 5°53.152′S, 53°01.639′E; d) on the west side of the island at 5°53.107′S, 53°01.624′E - 5°53.144′S, 53°01.548′E.

RESULTS OF MARINE SURVEYS

Shallow-water transects

Benthic observations from a depth of 13.5 m to 3.5 m were made on the north side of the island over a distance of approximately 0.5 km. In depths greater than 10 m, dense seagrass beds were observed, interspersed with coral rubble. Habitat mapping has shown large patches (long axes of > 200 m) of medium density seagrass within these dense seagrass beds (Spencer et al., 2009). At shallower depths, the substrate was dominated by a mixture of sand, coral rock and rubble. Minimal live coral (< 5% cover) was observed here. On the eastern side of the island, the shallow water transect was conducted between depths of 18 m and 2.6 m over a distance of approximately 0.75 km. At depths greater than 16 m, and between 10 m and 4 m depths, *Thalassodendron ciliatum* seagrass was interspersed with sand and rubble. Habitat mapping shows seagrass beds here organised into linear structures, separated by sand channels at typical wavelengths of *ca.* 60 m (Spencer et al., 2009). Between 10 m and 16 m depths, the substrate was comprised of coral rubble on sand and at 2.6 m, bare rock pavement was observed. No live coral was observed on this transect. The benthic habitat on the south side of the island was again dominated by *Thalassodendron ciliatum* seagrass beds at depths greater than 11 m, with circular areas (typical diameter of 100 – 180 m, but up to d = 320 m) of medium density seagrass; shallower than 10 m the benthos was rock pavement, covered in filamentous algae. On the western side of the island, *Thalassodendron ciliatum* seagrass was observed from *ca.* 20 m up to 5 m water depth; linear structures interspersed with sand were often observed, with wavelengths, as on the eastern side of the island, at 60 m. Bare rock pavement was seen at shallower depths.

DISCUSSION

The sand cay at Etoile is an unstable system. In 1976 the island was reported to have been 'largely eroded away, leaving a large sea-swept sand bank with a small, *ca.* 0.3 ha vegetated area' (Feare et al., 2007: 428) and the comparison of aerial photographs from 1999 and airborne remote sensing from 2005 shows considerable change in size, orientation and position (Spencer et al., 2009). This dynamism has not allowed the development of an extensive vegetative cover and has implications for seabird populations. The breeding colony of *Sula dactylatra* (Masked Booby) reported from Etoile in September – October 1941 (Vesey Fitzgerald, 1941) was not present in November 1976; it has been suggested that the extinction of this colony was due to significant island erosion (Feare, 1978). Additionally, the greatest threat to the breeding colony of *Sterna fuscata* has also been identified as island erosion (Feare et al., 2007).

The shallow-water surveys around the Etoile sand cay indicate that there is no true coral reef present. The benthos is dominated by dense *Thalassodendron ciliatum* seagrass beds, which reaches as shallow as 5 m water depth. On the east, south and west sides of the island, no coral was observed, only bare rock pavement, with an occasional covering

of filamentous algae. Live coral cover was observed at only one sampling location, on the northern side of the island, and here was estimated to represent less than 5% of the benthos. The coral bleaching event of 1997-98 that severely impacted the reefs of the granitic Seychelles (Lindén and Sporrong, 1999; Spencer et al., 2000) is unlikely to have caused any damage at Etoile. It appears that there is little coral present at Etoile and what is present can be best described as a patchy cover of coral communities rather than a true reef structure.

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PLATES

Plate 1. Aerial view of Etoile showing sand cay, vegetated area and surrounding marine habitats (source: Maps Geosystems; reproduced with kind permission of the Government of the Seychelles). (Note: Photograph taken in 1999; shape of cay different from that shown on the 2005 habitat map).

Plate 2. Vegetated area of the sand cay at Etoile (photograph: Jen Ashworth, January 2005).

Plate 3. *Sterna fuscata* (Sooty Tern) nesting on herbaceous vegetation mat at Etoile (photograph: Jen Ashworth, January 2005).

Plate 4. Unvegetated area of the sand cay at Etoile, showing a wide berm at the landward margin of the beach and sand washover deposits (photograph: Jen Ashworth, January 2005).