Coral Reefs of the Cayman Islands

6

Alan Logan

Introduction

The British Overseas Territory of the Cayman Islands lies in the north-western part of the Caribbean Sea between 19°15′–19°45′N and 79°44′–81°27′W and consists of three islands, Grand Cayman, Cayman Brac and Little Cayman, the last two known as the Sister Islands. All are low-lying and are prominences on the submerged Cayman Ridge which is an extension of the east–west trending Sierra Maestra mountain range of south-eastern Cuba (Roberts 1977) (Fig. 6.1). The ridge is bordered to the south by the Cayman Trench where depths exceed 5,500 m and the Yucatan Basin to the north-west with depths around 4,500 m (Wells 1988; Spalding et al. 2001). Grand Cayman, lying approximately 250 km south of Cuba and 280 km north-northwest of Jamaica, is the largest of the three islands at almost 200 km^2, while Cayman Brac and Little Cayman are smaller and arranged *en echelon* at about 120 km east-north-east of the main island. The prevailing trade winds are generally from the north-west in winter and the south-east in summer and the tidal range is less than 1 m (Wells 1988).

This chapter discusses the submarine topography of the nearshore areas, coral reef geomorphology and zonation, biotic communities and substrate types of the reef complex as a whole. Then, the next chapter discusses a variety of related reef topics such as the ongoing programme of reef assessment as related to anthropogenic and other threats, coral bleaching and diseases, and iconic reef fish such as groupers and lionfish. This chapter concludes with a short overview of the regulatory structure and reef management methods designed to protect the reefs, mechanisms which assume special importance where their accessibility and pristine condition are the basis for a thriving diver-tourism industry.

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Submarine Topography

The geology of the Cayman Islands is now well known (Matley 1926; Brunt et al. 1973; Roberts 1977; Jones 1994). Jones (1994) has discussed the tectonic setting of the islands, in particular the active spreading centre of the Mid-Cayman Rise and its relation to transform fault movement in the region (Fig. 6.1). The nearshore submarine topography acts as a base for reef development, in that a narrow submerged fore-reef shelf about 0.5–2.0 km (average 500 m) in width surrounds all three islands and has two well-marked submarine terraces at 8–10 m and 20 m depth (Roberts 1977; Logan 1981) which are remarkably similar for all three islands. This suggests regional stability and contemporaneous reef and lagoonal development that allow the recognition of similar substrates and associated communities from all three islands (see substrate-community maps in Roberts 1988, 1994; Logan 1988, 1994). These terraces are described for Grand Cayman by Rigby and Roberts (1976) and Roberts (1977, 1994), and for Cayman Brac and Little Cayman by Logan (1994). The shallow (or upper) terrace slopes gradually from either the shoreline or fringing reef to a depth of between 8 and 10 m where there is a former sea cliff, now heavily colonized by reef growth, sloping down to about 15 m depth. The shallow terrace often shows spur-and-groove reef development. The deep (or lower) terrace has a depth of between 15 and 20 m and consists of a sand plain with scattered patch reefs and remnants of spur-and-groove. The seaward edge of the sand plain terminates at a slight ridge, beyond which is a steep drop-off down the fore-reef slope into deep water. Occasionally, as at Bloody Bay on Little Cayman, the deep terrace is absent and the drop-off occurs at the edge of the shallow terrace as an almost vertical wall. Typical profiles showing the submarine terraces and their reef zones are shown in Fig. 6.2a, b. The fore-reef slope beyond 40 m depth is virtually unexplored but fathometer profiles from Grand Cayman by Rigby and Roberts (1976) show a very steep wall to about 150 m, beyond which is a slight reduction in slope which probably represents a fan of proximal reef sediments stacked up against the base of the old reef wall.

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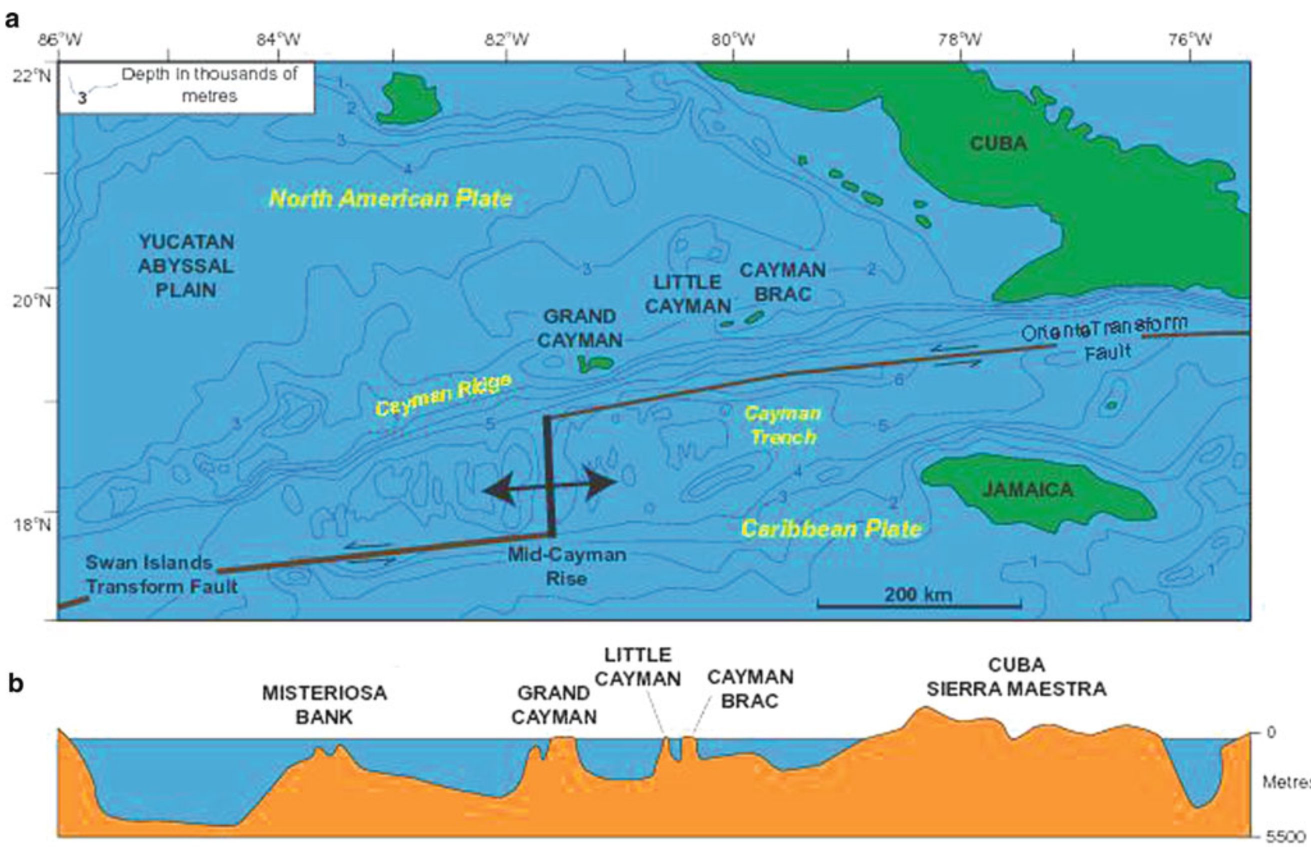

Fig. 6.1 Map and section of the central Caribbean to show the Cayman Islands as ridge pinnacles and the postulated relative movement of plates in the region (After Jones 1994)

The Reef Complex and Its Facies

The dominant influence on shallow marine substrates and their communities in the Cayman Island is the prolific growth of reef-building corals and coralline algae which help establish the biogenically-constructed limestone coral reefs. Initial reef growth on a shallow shelf under optimum conditions eventually leads to a complex of reef and reef-dependent environments termed the *reef complex* (Henson 1950). Here, over time, there is an interplay of constructional and destructional processes which results in reef growth on the one hand and the formation of reef-derived sediments on the other. The presence of a fringing reef near sea level and spur-and-groove structure on the deeper reefs reduces the effects of waves and provides quiet-water conditions in the lee of the reefs, where lagoon and shore communities can develop.

Lagoonal substrates are dominated by sediments varying in grain size from fine sands to coarse rubble. Sandy areas are often inhabited by sparse algae such as species of *Halimeda*, *Penicillus*, *Avrainvillia* and *Udotea*, while shells of the infaunal bivalve *Codakia orbicularis* are scattered over the surface of the sand. Where gravel or rubble occurs, attached green algae and *Sargassum* are present, as well as the brown algae *Padina* and *Turbinaria* and scattered coral heads of *Agaricia agaricites,* along with sea urchins belonging to *Echinometra* and *Diadema.* Marine grasses are patchy in distribution and dominated by *Thalassia testudinum*, with *Syringodium filiforme* and species of *Halodule* sometimes forming mixed stands (Logan 1994, Fig. 6.4). The sponge *Tedania ignis* is common in these grass beds, along with calcareous green algae and echinoids, while small coral colonies belonging to *Porites* occur between the blades. *Callianassa* and/or *Arenicola* sand mounds are present throughout the grass beds. Patch reefs dominated by species of *Montastrea* (Logan 1994, Fig. 6.6) are commonly seen in lagoonal areas, with single stands of *Acropora palmata* (Logan 1994, Fig. 6.5) in the lee of the fringing reef. Other corals encountered are *Porites astreoides*, *P. porites*, *Diploria strigosa*, *D. clivosa*, *Colpophyllia natans*, *Siderastrea siderea* and *Agaricia agaricites*, the latter often occurring as a prominent understorey species. The hydrozoan *Millepora complanata* in bladed growth form is also locally present (Logan 1994, Fig. 6.9).

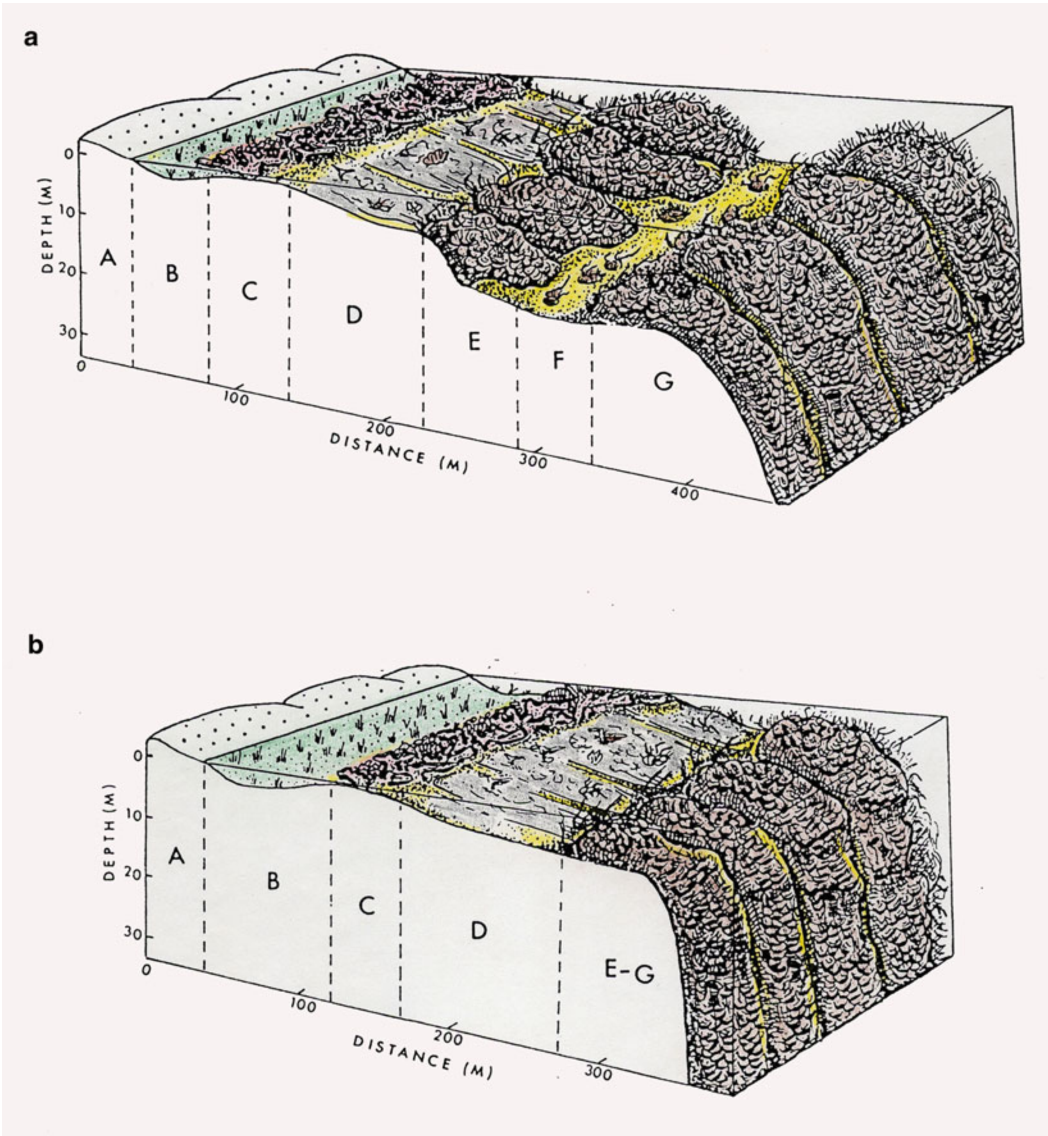

Fig. 6.2 (**a**) Idealised three-dimensional offshore profile typical of all three Cayman Islands where shallow and deep terraces are present. (**b**) Profile off Bloody Bay, Little Cayman with no deep terrace and sand plain. Key to substrates: *A* shoreline, *B* lagoon, *C* active fringing reef, with rubble zone behind, *D* barren rock pavement, *E* shallow terrace reefs with spur-and-groove, *F* sand plain, *G* deep terrace reefs (Modified after Logan 1994)

Coral Reef Zonation

Coral reefs, consisting mainly of a consortium of scleractinian corals and calcareous algae, are found at three depth levels in the Cayman Islands (Rigby and Roberts 1976; Roberts 1977, 1994; Logan 1994). The shallowest reefs (not including lagoonal patch reefs) form a linear wave-resistant crest at sea level responsible for lagoonal development in its lee around most of Grand Cayman and Little Cayman but only rarely on Cayman Brac. This reef is essentially a narrow fringing reef built on the apex of two oppositely-sloping surfaces and thrives in high energy wave conditions. The main reef-builders are massive wave-resistant corals, although even they may suffer extensive damage during hurricanes, resulting in the formation of a rubble flat zone on its landward side. A barren rock pavement separates the active fringing reef from a second reef development on the shallow terrace while a sand plain separates this reef from a third reef development at 15–20 m depth which extends down the fore-reef slope to the limit of coral growth at about 70 m. The zonation pattern of the reefs is remarkably similar for all three islands. Where submerged Pleistocene Ironshore Formation outcrops across bays, it usually acts as a locus for developing fringing reefs at or near sea level, although Blanchon and Jones (1997) have shown that storm-derived rubble may also control the location and architecture of some fringing reefs around Grand Cayman. Landwards of

Fig. 6.3 Waves breaking over nearshore fringing reef and associated rubble flat with storm deposits of boulder ramparts on the shore, near Brac Reef Hotel, Cayman Brac

these reefs are the lagoonal facies of grass beds, patch reefs and sand deposits, all comprising an integral part of the reef complex (Logan 1994).

Fringing Reef Rubble Flat

Shorewards of the active fringing reef is a zone of rubble derived from the mechanical breakdown of the reef by storms. This zone is extensively developed along the south coast of Little Cayman from The Flats to Sandy Point near the east end of the island (Logan 1994, Fig. 6.7) and is gradational with typical lagoonal substrates at depths close to sea level. Here wave energy is high and limestone blocks made up of dead fronds of *Acropora palmata* and zoned blades of *Millepora complanata* have been tossed shorewards into the rubble zone. There is a general dearth of living corals, only low-relief robust forms such as *Porites astreoides*, *P. porites*, *Diploria clivosa*, *Siderastrea siderea*, and *Agaricia agaricites* can survive here. Crustose coralline algae are common but calcareous green algae such as *Halimeda* are rare. Active bioerosion by parrot fish, sea urchins and the sponge *Cliona* contribute to the barren nature of this zone. Furthermore, much of the rubble flat is exposed at low tide (Logan 1994, Fig. 6.8) and bears the brunt of wave activity, thus providing a constant source of biologically and physically derived sediments for the lagoonal and shore areas and even forming boulder ramparts on the shore during the most violent of storms (Fig. 6.3).

Active Fringing Reef

The breaker zone around the Cayman Islands is narrow and usually defines the outer limit of bays and sounds (Fig. 6.4). This is the zone of the reef crest, dominated by an *Acropora-Millepora* thicket, and spans the *Palythoa-Millepora* and *Acropora palmata-Diploria strigosa* zones described for Caribbean fringing reefs by Geister (1977, 2011). According to this scheme *Acropora cervicornis* should occur shorewards of the fringing reef but this species is now rare almost everywhere in the Caymans, although it survives as isolated stands in the barren rock pavement zone seawards of the fringing reef and occasionally near the drop-off. *Acropora palmata* occurs as large arborecent colonies robust enough to withstand the constant surf, the upwardly-inclined fronds preferentially orientated towards the open ocean. Gaps between colonies are often filled by the hydrozoan *Millepora complanata* which forms a low hedge of vertically-inclined, upwardly-flaring blades, the flat faces facing the direction of wave advance (Logan 1994, Fig. 6.9). Understorey species include the zoanthid *Palythoa caribaeorum* and low relief colonies of species of the corals *Porites*, *Diploria*, *Agaricia* and *Montastrea*, with the foraminiferan *Homotrema rubrum* common in interstices. Fenner (1993) listed ten coral species from the reef crest in Cayman Brac. Although the reef crest acts as a protective barrier for the enclosed sounds and bays, channels do occur, allowing lagoonal water to periodically drain back to the open sea (see Fig. 6.4).

Fig. 6.4 Development of fringing reefs at Frank Sound and Gun Bay, east end of Grand Cayman resulting in lagoons with sands and grass beds (*dark patches*). Note banded reef zones on seaward side of fringing reefs. (Google Earth)

Barren Rock Pavement

Seawards of the fringing reef a shallow terrace forms the upper part of the shelf and comprises a barren rock pavement to a depth of about 8 m depth, merging seawards into the well-developed coral reefs of the shallow terrace. The barren rock pavement zone occurs around all three islands and comprises a rock surface gently dipping seawards from either the fringing reef or the shoreline (where a fringing reef is absent) to near the seaward edge of the shallow terrace. Subparallel grooves, named radial grooves by Rigby and Roberts (1976), extend seawards and may join up with sand-filled grooves of the spur-and-groove zone of the shallow terrace reefs. Typically the grooves are 3–4 m in width, about 1 m in depth relative to the adjacent rock surface, and have a U-shaped profile. Although they appear to be erosional the origin of these groves is unclear, and their possible influence on spur-and-groove development on the shallow terrace is not known. The rock pavement between the grooves is sparsely colonised by a variety of organisms capable of withstanding the relatively high wave energy environment of this zone. These include isolated heads of the corals *Acropora palmata*, *Porites astreoides*, *Diploria clivosa*, *D. strigosa* and species of *Montastrea*. Common algae include *Stypopodium*, *Padina*, *Galaxaura*, *Amphiroa*, *Dictyota*, *Turbinaria* and *Sargassum*. Stands of gorgonians are also common, particularly the sea fans *Gorgonia flabellum* and *G. ventalina* which may show alignment of the plane of the colony normal to the direction of wave advance for stability (Logan 1994, Fig. 6.11). Nevertheless, in the most violent of storms many sea fans are uprooted and end up on the nearby beaches.

Shallow Terrace Reefs

The barren rock pavement zone grades seawards at depths of 6–8 m into a fully-fledged, highly-diverse coral reef colonising the seaward edge of the shallow terrace and, in places, draped over remnants of the old sea cliff (Fig. 6.2a). This is the zone of spur-and-groove, a feature seen in reefs worldwide (Shinn 2011) where coral spurs and intervening grooves are developed in response to wave energy conditions. This zone is present around almost all of Grand Cayman and Little Cayman, but less so around Cayman Brac (see substrate maps in Roberts 1988, 1994 for Grand Cayman and Logan 1988, 1994 for Cayman Brac and Little Cayman). Relief between spur tops and adjacent grooves averages 3–4 m. Spur tops are colonised mainly by branching or domal coral growth forms but the flanks are dominated by platy growth forms that form overlapping shingle-like structures. Coalescence of the sides of adjacent spurs often result in roofing over to form caves and tunnels (Logan 1981) which support shade-loving communities (coelobites), with a coralline algae community at the tunnel entrance, grading into a demosponge-bryozoan community further into the tunnel and a sclerosponge-brachiopod community in dimly-lit areas with less than 1%

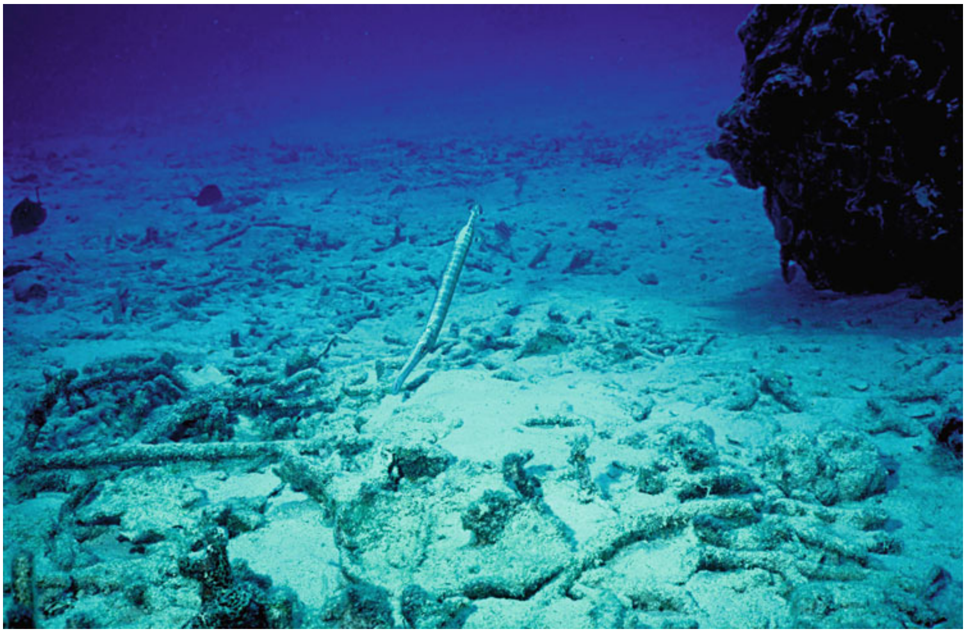

Fig. 6.5 Beginning of sand plain at junction with shallow terrace reef off Seaview Hotel, Grand Cayman. Note sticks from dead branching corals on sand. Pipe fish is about 0.5 m long

surface illumination, where biotic coverage is much reduced (Logan 1981, Fig. 4; Logan 1994, Figs. 6.13–6.14). The dominant coral on the spurs is *Montastrea annularis* and its sibling species which adopt a variety of growth forms from columnar-lobate to massive on the open reef to platy on the flanks. Species of *Diploria* and *Porites* are common, representing the *Diploria-Montastrea-Porites* coral community found throughout the Caribbean and in Bermuda. Bifacial *Agaricia agaricites* and *A. tenuifola* are also common, both box-like in growth form in open areas, but platy on the reef flanks. *Acropora cervicornis* was formerly common on the spur tops but is now rare. Other corals include *Colpophyllia natans*, *Siderastrea siderea*, *Montastrea cavernosa, Porites astreoides, Eusmilia fastigiata, Dichocoenia stokesi, Manicina areolata, Mussa angulosa, Meandrina meandrites* and species of *Diploria*, *Scolymia* and *Mycetophyllia*. Other groups represented include gorgonians, green algae and demosponges, plus the shade-loving sclerosponges *Goreauiella auriculata* and *Ceratopora nicholsoni*.

Sands

The grooves between the spurs are floored by sediments ranging in texture from coarse coral rubble to fine sands. The coarse sediments comprise fragments of the branching corals *Acropora cervicornis* and *Porites porites*, the fine sands *Halimeda* segments and the red foraminiferan *Homotrema rubrum*. These sands continue onto a sand plain of upto 350 m (Fig. 6.5) separating the spur-and-groove zone of the shallow terrace from the reefs of the deep terrace at the edge of the drop-off and down the fore-reef slope. The sand plain is a barren zone, with only a few isolated lens-shaped patch reefs, but forms a consistent and easily mappable feature on aerial photographs (Roberts 1988; Logan 1988). However, in Bloody Bay, Little Cayman, for a distance of about 2 km, the deep terrace and its associated sand plain are inexplicably absent, the shallow and deep terrace reefs merging in water as shallow as 7 m to produce a very shallow drop-off known as the Little Cayman Wall, popular with divers. This spectacular area is part of the Bloody Bay to Jackson's Point Marine Park (Wells 1988) and is illustrated in Logan (1994, Figs. 6.15–6.19) and in Fig. 6.6.

Deep terrace and Fore-Reef Slope Reefs

Sand plain sediments at their seaward edge are banked up against a prominent lip of coral reef at about 15 m depth, the reef edge forming a dam with occasional gaps that allow sediments to be funnelled down the steep fore-reef slope into deep water (Roberts 1983) (Fig. 6.2a, b). Initially the seaward slope of the reef is gradual but increases rapidly below about 20 m. Remnants of spur-and-groove are represented by massive buttresses which overhang the steep slope and harbour cryptic habitats not yet studied. These reefs show high coral coverage and diversity (Fenner 1993). Many coral colonies show platy growth form in response to diminished

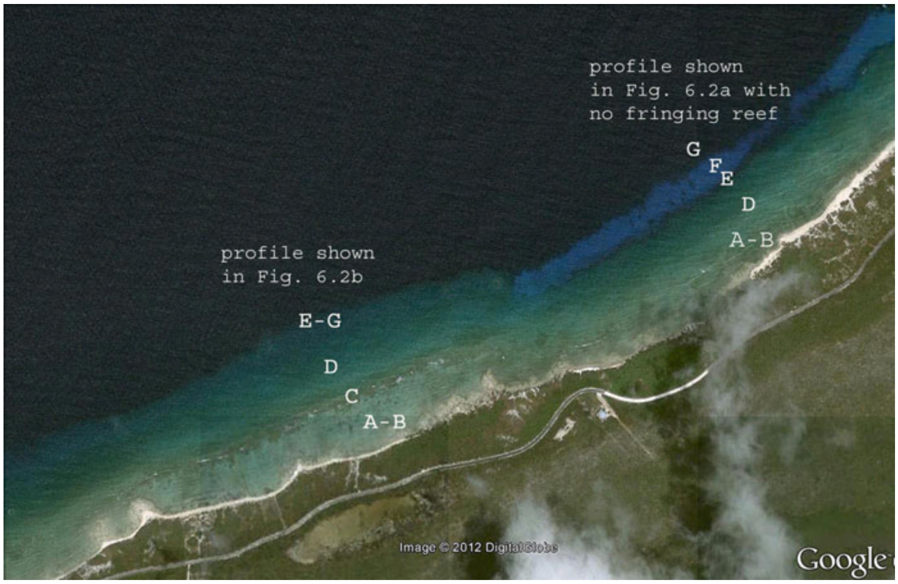

Fig. 6.6 Zonation of reefs in Bloody Bay, Little Cayman. Upper profile as shown in Fig. 6.2a, lower profile as in 6.2b

Fig. 6.7 Deep terrace reef, Little Cayman Wall, off Jackson's Point, 30 m depth, showing *Montastrea cavernosa* (*left*), red sponge *Haliclona rubescens* and alcyonarians

light. Enormous plates of *Agaricia* are attached precariously to the steep slope by their narrow bases and become unstable at the slightest disturbance. Massive hemispherical mounds of *Montastrea cavernosa* (Fig. 6.7) and large sheets of *Mycetophyllia ferox* occur. Multi-coloured sponges exhibit a wide variety of growth forms, from encrusting to whip-like to tubular to vasiform, with large barrel sponges belonging to *Xestospongia* in evidence. Gorgonians are abundant, as well as a host of other invertebrates such as crinoids, bryozoans, molluscs and ascidians.

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