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TEN YEARS OF CHANGE ON THE GLOVER' S REEF CAYS

by

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List of Figures

1. Location and submarine topography of Glover's Reef. After Dillon and Vedder (1973).
2. Topography of Glover's Reef. From Stoddart (1962, fig. 37).
3. Legend to the detailed physical and vegetation maps of the cays.
4. Northeast Cay 1961 and 1971: topography.
5. Northeast Cay 1961 and 1971: vegetation.
6. Long Cay North 1961 and 1971: topography.
7. Long Cay North 1961 and 1971: vegetation.
8. Long Cay 1961 and 1971: topography.
9. Long Cay 1961 and 1971: vegetation.
10. Middle Cay 1961 and 1971: topography.
11. Middle Cay 1961 and 1971: vegetation.
12. Southwest Cay I 1961 and 1971: topography.
13. Southwest Cay I 1961 and 1971: vegetation.
14. Southwest Cay II 1961 and 1971: topography.
15. Southwest Cay II 1961 and 1971: vegetation.

List of Plates

1. Northeast Cay: aerial view from the east 1962
2. Northeast Cay: storm block and shore erosion on the east side 1961
3. Long Cay North: *Suriana* scrub on the north shore 1961
4. Long Cay North: the south shore in 1971
5. Long Cay from the southeast 1962
6. Southwest Cay II: aerial view from the southeast 1962
7. Long Cay: *Tournefortia* on the northeast spit 1961
8. Long Cay: upper surface of the windward shingle ridge 1961
9. Long Cay: sandy island surface with backslope of the windward shingle ridge 1971
10. Long Cay: mud hole and standing water at the east end, seen from the windward shingle ridge 1961
11. Middle Cay: windward shingle ridge with hedge of *Tournefortia* 1971
12. Middle Cay: low lagoon shore with *Conocarpus* 1971
13. Middle Cay: *Rhizophora* at the east end of the lagoon shore 1971
14. Southwest Cay I: seaward rubble shore 1971
15. Southwest Cay I: mangrove pool at the southern end of the island 1961
16. Southwest Cay II: exposed 'rootrock' on the retreating lagoon shore 1971
17. Southwest Cay I: open mangrove 1961
18. Southwest Cay II: beachrock with landward dip on the seaward shore 1961

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by D. R. Stoddart,¹ F. R. Fosberg² and M.-H. Sachet²

ABSTRACT

Scientific studies on the atoll of Glover's Reef, Belize, since an initial survey in 1961 are reviewed. Comparative maps are presented of each of the six islands on the atoll, showing morphology and vegetation, between the 1961 survey and a re-survey in 1971. Most of the islands show shoreline erosion and remodelling of windward shingle ridges as a result of hurricane activity. The recorded terrestrial plants are catalogued for each of the islands, and some extinctions are noted. Species-numbers on the cays are related to area, and are much higher than those for other Caribbean and Gulf of Mexico coral islands, presumably because of higher rainfall.

INTRODUCTION

Glover's Reef (16°45'N, 87°50'W) is one of three atolls off the mainland coast of Belize (British Honduras), central America. When visited in 1961 it was one of the least-known reefs in the Caribbean, in spite of its typical atoll features. It was delineated on charts (Admiralty Chart 1797 of 1929) in the most rudimentary manner, and published scientific literature about it was limited to brief reports on visits by the ornithologist Salvin in 1862, by the *Pawnee Expedition* in 1925, and by the Mandel Caribbean Expedition in 1940. The account of the atoll published by Stoddart (1962, pp. 17-30, 83-98) was thus necessarily of a preliminary nature.

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Since then, however, there has been a great deal of scientific investigation on Glover's Reef. The CITRE project (Comparative Investigations of Tropical Reef Ecosystems) included the atoll as one of its potential study sites, and reconnaissance visits were made to it in January and June 1971, followed in November 1971 by a planning workshop for 40 scientists held at Long Cay (Smith, in Sachet and Dahl (1974), lists participants). Descriptions of the reefs resulting from CITRE studies were given by Dahl *et al.* (1974, pp. 55-58), and marine algae and sea-grasses collected during the project were reported by Tsuda and Dawes (1974). In 1972 N. James, R. N. Ginsburg and associates carried out studies of the deep reefs using the deep-diving submersible *Nekton* (James and Ginsburg 1980). Finally, reef structures within the atoll lagoon have been studied by Hughes (1973), Schafersman (1972), Wallace (1974), and Wallace and Schafersman (1977). Apart from studies carried out during the CITRE workshop, terrestrial studies on the cays have been limited to plant collections made by Pippen in 1972 and by Linhart and students in 1973 (Linhart 1980; Fosberg *et al.* 1981).

This paper reports on the re-survey of the cays carried out during the CITRE workshop in 1971. Comparative maps of all the islands in 1961 and 1971 are presented, together with complete lists of terrestrial plants recorded from each cay (including those reported by Linhart (1980)). All of the islands were mapped by pace-and-compass methods. They were also photographed from the air in colour and black-and-white in 1961 and 1962, and more briefly in 1971. The maps of each of the islands are orientated conventionally (i.e. magnetic north at the top of the diagram).

HISTORY

The early history of the atoll is obscure, as indeed is that of most of the reefs in the western Caribbean. It can possibly be identified as the "Ilbob" or "Ylbob" of maps by Herrera dated 1601-1615 and of De Laet in 1625, and derivative charts (Vindel 1955). It appears as "Longorif" in the *Plano de la Costa de Honduras* of 1756; as "Arrecife de Guaneros" in a map by J. J. de Castillo, dated 1753 (reproduced by Craig 1966, p. 38); and as Glover's Reef by Speer (1771) and Arrecife Largo, Glover's Reef or Long Reef by Jefferys (1775). Speer's map marks three un-named cays; Jefferys's map has five un-named cays in the south and "The Two Spots" at the northern end. The first Admiralty survey by Richard Owen in 1830 adopts the name of Glover's Reef, which then became standard, and also for the first time names Northeast, Long, Middle, and Southwest Cays.

The only event of any significance in the recorded history of the atoll is the wreck of the schooner *Susan*, Captain Harry Maury, which sailed from Mobile on 4 December 1858 with emigrants and filibusters bound for Omoa, Republic of Honduras, wrecked 10-12 miles from the cays on 16 December (Doubleday 1886; Scroggs 1916). The vessel was found by a fishing boat which had taken fish, green turtle and coconuts to the Belize market, and the passengers and crew were taken to Middle Cay.

Table 1. Visitors to Glover's Reef

<u>Date</u>	<u>Visitor</u>	<u>Work</u>	<u>Publication</u>
1858 December	<i>Susan</i> , Capt. Maury		Maury 1859
1862 May	<i>Mary Ann</i> , O. Salvin	Ornithology	Salvin 1864; Coues 1864
1925 April 14-20	<i>Pawnee</i> , H. P. Bingham	Marine fauna	Boone 1927, 1928a-d, Breder 1927
1940 January 18	Mandel Caribbean Expedition	Marine mollusca Reptiles	Haas 1941; Schmidt 1941
1961	D. R. Stoddart S. P. Murray	Geomorphology Vegetation	Stoddart 1962
1969 March	D. M. Devaney	Echinoderms	Devaney 1974
1971 January 17-22	J. Weber A. Antonius	CITRE studies	Dahl <i>et al</i> 1974 Tsuda and Dawes 1974
June 20-27	A. Antonius, A. Dahl, K. Ruetzler		This paper
November 1-13	S. V. Smith and party of 40		
1972	N. P. James, R. N. Ginsburg, <i>Nekton</i>	Deep reef	James and Ginsburg 1980
1972	Pippen	Flora	
1973 July	Y. B. Linhart	Flora	Linhart 1980

This was said to be an island of 30 acres (12 ha), with a "continuous grove of cocoa palms ... [and] entire freedom from underbrush" (Doubleday 1886, p. 212). Here they lived on "conch and green-turtle soup, fish in great variety, cocoa-nuts, yams, plantains, and bread-fruit, all in great abundance", until rescued by H.M.S. *Basilisk*, sent from Belize, on Christmas Day 1858. There are brief accounts of this incident in *Harper's Weekly*, 8 January 1859, p. 22, and 15 January 1859, p. 39, and in the *Mobile Mercury* at the same time [not seen], but the most circumstantial account is contained in letters by Captain Maury published in *The Mobile Daily Register*, vol. 32 (no. 1329), p. 1 for 4 January 1859. We are grateful to Mr M. M. Weinstein, Library of Congress, for copies of these documents.

The present study began with a visit to Glover's Reef by Stoddart and S. P. Murray in 1961. This was a brief reconnaissance supported by the Office of Naval Research and the Coastal Studies Institute of Louisiana State University as part of a wider study of the British Honduras cays, and we are grateful to the late Professor Richard J. Russell and Miss Evelyn Pruitt for making it possible. The second visit took place as part of the CITRE workshop on 1-13 November 1971. The islands were re-mapped and plants collected by Stoddart, Fosberg and Sachet, and we are grateful to Dr Stephen V. Smith, Principal Investigator, for the opportunity to participate in the CITRE planning sessions. We also thank Mr M. Young and Mr R. Coe, of the Department of Geography at Cambridge University, for much cartographic and photographic work, and Mr M. M. Weinstein, Library of Congress, who obtained newspaper records relating to the wreck of the *Susan*.

STRUCTURE AND FORM

The structure of the east coast of the Yucatan Peninsula is controlled by a series of northeast-southwest trending fault blocks, arranged en echelon on the northwestern flank of the Cayman Trench. One of these lineaments underlies the Belize barrier reef south of Gladden Spit, Glover's Reef, and Lighthouse Reef; another the central barrier reef, Turneffe, and Banco Chinchorro; and a third the mainland coast north of Ambergris Cay. Of these, the first is best developed, and in places (as on the east side of Lighthouse Reef) has a seaward-facing scarp nearly 3000 m high. At Glover's Reef itself, the sea floor falls sharply to over 1000 m on the east side of the atoll, but only to shallow saddles of 300-400 m between the atoll and the barrier reef and the atoll and Lighthouse Reef. Wells drilled through the offshore reefs have reached metamorphic rocks probably equivalent in age to the mainland Santa Rosa Group (Carboniferous-Early Permian) at between 777 and 959 m on Glover's Reef, and extrusive volcanics of similar age at 1692 m on Turneffe.

The surface reefs, therefore, stand on fault-block structures, as originally inferred from topography and fully confirmed by seismic investigations (Dillon and Vedder 1972, 1973; Uchupi 1973). The deep well on Glover's Reef showed 260 m of calcareous siltstone of Late

Cretaceous age, overlain by 560 m of Tertiary reef facies; similarly, on Turneffe, 660 m of shale with limestone is overlain by 1030 m of reef facies (Dillon and Vedder 1973, p. 2721). These sequences indicate reef upgrowth on subsiding fault blocks at rates (1-2 cm/1000 yr) and over time periods (ca 60 million yr) comparable to those of upgrowth on open Pacific subsiding volcanoes such as Bikini and Enewetak.

Glover's Reef itself is an elongate rectangular atoll up to 32 km long and 12 km wide, with an area of 260 sq km. It is surrounded by a shallow reef flat, generally about 450-700 m wide but which reaches 1200 m on the eastern (windward) reefs. Living reef reaches the surface at the outer edge of the reef flat for about 150 m on the windward reefs. There is no algal ridge directly comparable to those of some Indo-Pacific atolls, but rather an algal pavement with rhodoliths of *Goniolithon boergesenii*, clearly the functional equivalent of the algal ridge. The leeward reefs are less well-defined and lack the algal-pavement zone (Stoddart 1962, pp. 23, 25-26). There are three gaps through the peripheral reefs; one in the northeast, 1300 m wide; one in the south, 1600 m in width and up to 12 m deep; and a smaller exposed channel at the southeast point.

The lagoon enclosed by the reefs has two components: a shallow shelf or platform 6-8 m deep and generally 1-2 km wide, and a central basin. The platform is similar to the "barrier platform" of the coastal shelf, and is probably a reef surface of last interglacial age on which the present surface reefs have grown. The central basin is probably about 20 m deep (no bathymetric survey has been undertaken), and contains some 700 patch reefs. Variation in patch reef ecology and sedimentology has been studied by Schafersman (1972), Hughes (1973), Wallace (1974), and Wallace and Schafersman (1977).

The coral fauna of Glover's Reef is known only in outline. York's (1971) list of the corals of the southern Belize barrier lists 18 genera. With the addition of *Mussa* and *Meandrina* this gives 20 genera recorded from the Belize reefs (Stoddart 1962, p. 19). 13 genera have been recorded from Glover's Reef (ibid), but unpublished CITRE records will undoubtedly increase this total. There are few other marine faunistic records from Glover's Reef. Devaney (1974) records 3 asteroids, 15 ophiuroids, one holothurian and 4 echinoids from collections made in 1969. Collections of crustaceans, molluscs, echinoderms, coelenterates and fishes made during the Pawnee Expedition are listed by Boone (1927, 1928a, 1928b, 1928c) and Breder (1927). Tsuda and Dawes (1974) list four sea-grasses and 100 species of marine algae from the CITRE investigations. Terrestrial records are limited to two reptiles (*Anolis sagrei*, *Ctenosaura similis*) collected by the Mandel Caribbean Expedition in 1940 (Schmidt 1941) and a hummingbird (*Ancathothorax prevosti*) listed by Todd (1942).

There are no environmental records from Glover's Reef. The atoll is under the influence of the Northeast Trades. There is a marked rainy season from June to September, and mean annual rainfall is probably about 2500 mm. Mean tidal range at springs is probably about 0.2 m.

The atoll is frequently affected by hurricanes, and reference to their effects will be made in the accounts of the cays.

There are six small islands on the southeastern reef of the atoll. Their combined area is about 32 ha, and it is with the changing morphology and vegetation of these cays that this paper is concerned.

THE CAYS OF GLOVER'S REEF

There are at present six cays on Glover's Reef, all on the southeast side. Five of these (Northeast, Long, Middle, Southwest I and Southwest II) are sizeable islands 360-600 m long; the sixth (Long Cay North or Small Cay) is an islet 160 m long northeast of Long Cay. In addition to the main islands, Jefferys in his 1775 chart marked "The Two Spots" at the north end of the atoll: these were presumably ephemeral sandbores and no longer exist. Admiralty Chart 1797 of 1929 also marks a further cay lying within the lagoon on the west side of the atoll, 7 km from the northwest corner; it is described as having trees 6 m tall (*West Indies Pilot*, 1956, pp. 459-460). This island did not exist in 1961, though an ephemeral sandbore near its location was known as "Bushy Spot" or "Bushy Cay". Owen in his 1830 chart (Admiralty MS chart H57) also shows no cay at this location. Owen in 1830 also noted two small sandbores between Middle Cay and Southwest Cays. Each of the existing islands was mapped in 1961 and 1971; they are described from north to south.

Northeast Cay (16°45'N, 87°45½'W)

Figures 4-5, Plates 1-2

Northeast Cay is situated at the south end of the unbroken eastern reef of Glover's Reef, on the north side of the entrance between it and Long Cay. It is semicircular in shape, with maximum dimensions of 360 x 200 m. Its southern and southwestern shores, facing the reef and the channel, are formed by a shingle ridge with a maximum height of about 2 m. In 1961 there was evidence of recent shore erosion on the east side of the cay, indicated by shore cliffing, surface sand stripping, and coral blocks on the cay surface; by 1971 the shingle ridge had extended northwards to cover much of this area. A small area of beachrock on the south shore in 1961 had also increased in length to about 90 m in 1971, and a further small exposure had appeared, indicating slight retreat of this shore. The northern shore is low and sandy, and was stable during 1961-1971. The interior of the island is also low and sandy, and there is a small mudhole. The area of the island was 4.73 ha in 1961 and 4.48 ha in 1971. The island is covered with coconut woodland, which is most dense and contains tall trees of *Bursera simaruba*, *Neea choriophylla* and *Thrinax radiata* near the south shore. There is a luxuriant undercarpet of *Wedelia*, *Euphorbia*, *Ambrosia* and grasses. The most extensive shrub on the seaward side of the island is *Tournefortia gnaphalodes* with scattered *Conocarpus*, *Coccoloba* and *Cordia*. There were extensive mats of *Sesuvium* along the lagoon shore. For further details of the island in 1961 see Stoddart (1962, pp. 87-88, figs. 38 and 39).

Forty species of plants have been recorded from the island (21 in 1961, 32 in 1971, and 32 by Linhart in 1973). Of the species collected in 1961 the orchid *Brassavola nodosa* was not found in 1971 or by Linhart in 1973, and the single shrub of *Suriana maritima* on the southwest shore had disappeared by 1971. In the following species list, C denotes a collection and S a sight record; the 1973 records are those listed by Linhart (1980, pp. 62-63). Species marked with an asterisk are not native to the Belize cay flora, but this does not necessarily imply that they have been deliberately introduced on all the islands on which they occur.

<i>Acrostichum aureum</i> 71C 73	* <i>Terminalia catappa</i> 71C 73
<i>Cenchrus incertus</i> 73	<i>Bumelia retusa</i> 71C 73
<i>Eragrostis prolifera</i> 61C 71C 73	<i>Pouteria campechiana</i> 71C 73
<i>Eustachys petraea</i> 71C 73	<i>Cordia sebestena</i> 61C 71C 73
<i>Paspalum distichum</i> 71C 73	<i>Tournefortia gnaphalodes</i> 61S 71C 73
<i>Paspalum laxum</i> 61C 73	<i>Stachytarpheta jamaicensis</i> 73
<i>Sporobolus virginicus</i> 71C	<i>Pithecellobium keyense</i> 73
<i>Sporobolus</i> sp. 61S	<i>Suriana maritima</i> 61S
<i>Cyperus ligularis</i> 73	<i>Bursera simaruba</i> 61S 71C 73
<i>Cyperus planifolius</i> 61C 71C 73	<i>Euphorbia blodgettii</i> 61C 71C
<i>Fimbristylis cymosa</i> 71C 73	<i>Euphorbia mesembrianthemifolia</i> 61C 71C 73
* <i>Cocos nucifera</i> 61S 71S 73	<i>Euphorbia</i> sp. 61S 73
<i>Thrinax radiata</i> 61C 71S 73	<i>Passiflora suberosa</i> 61C 71C 73
<i>Crinum amabile</i> 71C	<i>Conocarpus erectus</i> 61C 71C 73
<i>Hymenocallis littoralis</i> 71C	<i>Laguncularia racemosa</i> 73
<i>Brassavola nodosa</i> 61C	<i>Erithalis fruticosa</i> 61C 71C 73
<i>Ficus</i> sp. 61C 71C 73	<i>Ernodea littoralis</i> 71C
<i>Coccoloba uvifera</i> 61S 71C 73	<i>Ambrosia hispida</i> 61C 71C 73
<i>Neea choriophylla</i> 61C 71C 73	<i>Borrchia arborescens</i> 71C
<i>Sesuvium portulacastrum</i> 61C 71C 73	<i>Wedelia trilobata</i> 61C 71C 73
<i>Chrysobalanus icaco</i> 71C 73	
<i>Mucuna</i> sp. 71S	

Long Cay North (16°45'N, 87°46'W)

Figures 6-7, Plates 3-4

This is a small shingle cay on a detached reef patch in the main channel between Northeast Cay and Long Cay; it was so named by Stoddart (1962, pp. 88-89, fig. 40), though Dahl et al. (1974, p. 56) call it Little Cay and Fosberg et al. (1981) Small Cay. In 1961 it was mainly composed of sand with some shingle in the central part and along the east shore; it formed an island 145 m long and up to 48 m wide, with an area of 0.44 ha. It was probably not more than 1 m above sea-level. It was covered with a scrub of *Suriana maritima* 3 m tall with *Borrchia*, *Tournefortia* and *Conocarpus* and a ground cover of *Sesuvium*, *Euphorbia* and grasses. There were a few juvenile coconuts. By 1971 there had been some erosion on the south shore and considerable accretion on the north, and the greater part of the island was formed of shingle. The position of the group of coconuts on the south shore enables the relative locations to be plotted accurately. The

vegetation is still dominated by *Suriana* scrub, but *Conocarpus* and *Tournefortia* have greatly increased. There were several more juvenile coconuts. The length of the island remained at 145 m, but the maximum width had increased to 63 m and the area of 0.53 ha.

22 species of plants have been recorded from the island (9 in 1961, 16 in 1971 and 19 by Linhart in 1973). *Sophora tomentosa*, which existed as a single plant on the south shore in 1961, had disappeared by 1971. The species recorded are:

<i>Paspalum distichum</i> 71C 73	<i>Philoxerus vermicularis</i> 71C
<i>Sporobolus virginicus</i> 71C 73	<i>Sesuvium portulacastrum</i> 61S 71C 73
<i>Cyperus ligularis</i> 73	<i>Sophora tomentosa</i> 61S
<i>Cyperus planifolius</i> 71C 73	<i>Suriana maritima</i> 61S 71C 73
<i>Cyperus</i> sp. 61S	<i>Euphorbia blodgettii</i> 71C
* <i>Cocos nucifera</i> 61S 71S 73	<i>Euphorbia mesembrianthemifolia</i>
<i>Crinum amabile</i> 71C	71C 73
<i>Hippeastrum puniceum</i> 73	<i>Euphorbia</i> sp. 61S 73
<i>Hymenocallis littoralis</i> 73	<i>Conocarpus erectus</i> 61S 71C 73
* <i>Casuarina equisetifolia</i> 71S 73	<i>Ipomoea macrantha</i> 71C 73
<i>Coccoloba uvifera</i> 73	<i>Ipomoea pes-caprae</i> 71C 73
<i>Batis maritima</i> 73	<i>Tournefortia gnaphalodes</i> 61S 71C 73
	<i>Borrchia arborescens</i> 61S 71C 73

Long Cay (16°45'N, 87°46'W)

Figures 8-9, Plates 5, 7, 8, 9 and 10

Long Cay is situated at the northeastern extremity of the continuous southeast reef of the atoll. When first mapped in 1961 it was 620 m long and varied in width from 70 m in the centre to 150 m at each end; its eastern end was prolonged lagoonward by a low sandy peninsula. The area of the cay was 6.69 ha. The seaward side of the island was formed by a massive double shingle ridge. The outer ridge reached up to 2 m above sea level and the inner ridge 3 m; the shingle complex was 30-40 m along the whole seaward shore. The inner ridge was formed of older and coarser material, with blocks up to 0.6 m in diameter. There was an abrupt junction between the inner margin of the shingle and the low-lying sandy surface of the rest of the cay, especially at the eastern end where there was a depression with standing water. The north shore is low and sandy and faces a shallow bay carpeted with sea-grasses. The morphology of the cay had changed quite considerably by 1971. The seaward shingle ridge had been reworked, especially at its western end where it had been pushed back over the sand surface and had become a triple ridge. Retreat of a few metres had occurred along much of the seaward shore, increasing the length of a beachrock ridge exposed from 180 to 360 m. The greatest change, however, had taken place at the eastern end of the cay, where the shoreline had retreated from 15 to 25 m along its entire length. The northeastern peninsula had also narrowed and moved westwards. As a result the total length of the island had decreased to 600 m, and the width now varied from 65-130 m; the area in 1971 was 5.85 ha.

In 1961 Long Cay was covered with a coconut plantation. The island was inhabited, and the ground beneath the coconuts was kept cleared. Most of the seaward shingle ridges were bare, except for scattered *Tournefortia* and *Coccoloba*, and an extensive area at the eastern end of *Hymenocallis* with *Conocarpus*. The northeastern peninsula was covered with a low scrub of *Suriana*, *Conocarpus*, *Tournefortia* and *Laguncularia*, and indeed resembled Long Cay North. The general aspect of the cay was much the same in 1971. The extensive ridge-crest area of *Hymenocallis* remained, but all the *Coccoloba* and *Tournefortia* of the seaward coast had disappeared. The northeastern peninsula was covered with *Tournefortia*, *Laguncularia*, *Conocarpus* and *Sesuvium*.

In 1971 the mudhole area was found to be partly surrounded by a surface outcrop of phosphate rock, previously overlooked. This has a P_2O_5 content of 21.7% (Scoffin and Stoddart, in prep.). Long Cay is no longer a bird island. Salvin, who visited it on 12 May 1862, found a few terns and some pelicans (Salvin 1864, p. 384; Coues 1864). The date of formation of the phosphate rock is not known. The physiographic changes between 1961 and 1971 must be attributed to hurricanes. Possibly much of the coastal change resulted from Hurricane Hattie in 1961. Antonius (1972) was on Long Cay at the time of Hurricane Laura on 20 November 1971. This had winds of 35 m/sec, for a time reaching more than 50 m/sec, but although some coconut palms were felled the effects were negligible. Long Cay was occupied by a local family in 1961 to look after the plantation. By 1971 an American-owned tourist resort had opened on the cay, with a series of holiday chalets at the east end. These were damaged in Hurricane Laura.

28 plant species have been recorded from the cay (10 in 1961, 21 in 1971, and 22 by Linhart in 1973); in addition there are some collections made by Pippen in 1972. One species found in 1961 (*Sophora tomentosa*) has not been seen since. In addition to the species listed below, the sea-grasses *Thalassia testudinum* and *Syringodium filiforme* occur in shallow water on the lagoonward side of the cay. In the following list species marked 72 were collected by Pippen in that year. For further notes on this island, see Stoddart (1962, pp. 89-91, figs. 41, 42 and 44).

<i>Psilotum nudum</i> 72	<i>Ficus</i> sp. 73
<i>Acrostichum aureum</i> 73	<i>Coccoloba uvifera</i> 61S 71C 73
<i>Spartina patens</i> 71C	<i>Sesuvium portulacastrum</i> 71C 73
<i>Sporobolus virginicus</i> 71C 72	<i>Mucuna</i> sp. 71C
73	<i>Sophora tomentosa</i> 61S
<i>Cyperus ligularis</i> 73	<i>Suriana maritima</i> 61S 71C 73
<i>Cyperus planifolius</i> 71C 72	<i>Euphorbia blodgettii</i> 73
<i>Cyperus</i> sp. 61S	<i>Euphorbia mesembrianthemifolia</i>
<i>Fimbristylis cymosa</i> 71C 72 73	71C 73
* <i>Cocos nucifera</i> 61S 71S 73	<i>Euphorbia</i> sp. 61S 73
<i>Thrinax radiata</i> 71C 73	<i>Rhizophora mangle</i> 73
<i>Hymenocallis littoralis</i> 61S	<i>Conocarpus erectus</i> 61S 71C 72 73
71C 73	<i>Bumelia retusa</i> 71C 72 73

Cordia sebestena 71C 73
Tournefortia gnaphalodes 61S
 71C 73
Erithalis fruticosa 71C 73

Ageratum littorale 61C 71C 73
Ageratum (abnormal) *littorale*
 71C
Borrchia arborescens 71C 72 73
Melanthera nivea 71C

Middle Cay (16°44'N, 87°48'W)

Figures 10-11, Plates 11-13

Middle Cay is located near the centre of the unbroken southeast reef of Glover's Reef. It is aligned northeast-southwest, parallel to the trend of the reef. When mapped in 1961 it was about 415 m long and up to 175 m wide, with an area of 6.03 ha. In 1971 erosion at the southwest point had been counterbalanced by aggradation at the northeast spit, and the overall dimensions and area (5.97 ha) remained the same. The seaward shore is formed by a shingle ridge up to 35 m wide and 2 m high; beachrock outcrops at the foot of this ridge, more extensively in 1961 than in 1971. Most of the rest of the cay is low-lying and sandy, with a low leeward sand beach, but at the southwestern end there is an extensive swamp area with standing water about 170 m long and 45 m wide. In 1961 this was separated from the sea by a belt of tall *Rhizophora*, but by 1971 this had been greatly reduced and the shore showed signs of erosion. The sand spit at the northeast end of the cay had expanded lagoonward during this interval and increased in size.

Most of the island is covered with coconut woodland. In 1961 the seaward shingle was largely bare, except for extensive *Hymenocallis* and *Tournefortia* at the eastern end. This had almost completely disappeared by 1971, but *Tournefortia* had colonised afresh along most of the seaward shore. There had also been much growth of *Laguncularia*, *Conocarpus*, *Rhizophora* and *Borrchia* along the lagoon shore and on the northeast spit. There is a luxuriant ground cover beneath the coconuts. These were the dominant vegetation as early as 1858 when Maury found a "continuous grove of cocoa palms" and "entire freedom from underbush" (Doubleday 1886, p. 212). That the swampy area was also then in existence is shown by Salvin's record of *Acrostichum aureum* in May 1862 (Salvin 1864).

42 plant species have been recorded from the cay (11 in 1961, 40 in 1971, and 32 by Linhart in 1973). *Hibiscus tiliaceus*, collected in 1961, has not been seen since. Plants recorded are:

Acrostichum aureum 1862S
 71C 73
Andropogon glomeratus 71C 73
Cenchrus incertus 71C
Eragrostis prolifera 71C 73
Eustachys petraea 71C 73
Paspalum distichum 71C 73
Paspalum laxum 71C
Sporobolus virginicus 71C
Cyperus ligularis 71C 73
Cyperus planifolius 71C 73
Fimbristylis cymosa 61C 71C 73

**Cocos nucifera* 61S 71S 73
Thrinax radiata 71C
Hymenocallis littoralis 61S
 71C 73
Ficus sp. 71C 73
Coccoloba uvifera 71C 73
Neea choriophylla 71C
Sesuvium portulacastrum 71C
Pithecellobium keyense 71C 73
Sophora tomentosa 71C 73
Suriana maritima 71C 73
Euphorbia blodgettii 71C

<i>Euphorbia mesembrianthemifolia</i> 71C 73	<i>Tournefortia gnaphalodes</i> 61S 71C 73
<i>Euphorbia</i> sp. 61S 73	<i>Stachytarpheta jamaicensis</i> 61S 71C 73
<i>Hibiscus tiliaceus</i> 61C	<i>Diodia serrulata</i> 71C
<i>Passiflora suberosa</i> 71C 73	<i>Erithalis fruticosa</i> 71C 73
<i>Rhizophora mangle</i> 61S 71C 73	<i>Ernodea littoralis</i> 71C 73
<i>Conocarpus erectus</i> 61S 71C 73	<i>Ageratum littorale</i> 71C
<i>Laguncularia racemosa</i> 71C 73	<i>Ageratum maritimum</i> 73
* <i>Terminalia catappa</i> 71C	<i>Ambrosia hispida</i> 61S 71C 73
<i>Bumelia retusa</i> 71C 73	<i>Borrchia arborescens</i> 61S 71C 73
<i>Pouteria campechiana</i> 71C 73	<i>Wedelia trilobata</i> 71C 73
<i>Cordia sebestena</i> 71C 73	

There is in addition the casual record in 1858, already mentioned, of *Dioscorea* sp., *Musa* sp., and *Artocarpus altilis* (Doubleday 1886, p. 212).

For further details of Middle Cay, see Stoddart (1962, pp. 92-93; figs. 43-45).

Southwest Cay I (16°42'N, 87°49½'W) Figures 12-13, Plates 14, 15 and 17

Southwest Cays are located at the southwest extremity of the southeast reef of the atoll, immediately east of the broad southern entrance to the lagoon. Southwest Cay I is the easterly of the two. It is a trapezoidal island with maximum dimensions in 1961 of 360 x 270 m. The seaward shore is formed by a low carpet of rubble and shingle rather than by a distinct shingle ridge, as on the other cays, though there was a sector of shingle ridge up to 2 m high at the southern point of the cay. This seaward rubble zone is backed by a zone of swamp and standing water measuring some 230 x 130 m at the eastern end of the island, with a second smaller zone at the western end. Only in the lee of the shingle ridge is the land surface continuous to the lee shore. The lagoon shore is low, sandy, and in 1961 was undercut, with a number of fallen coconuts. By 1971 there were only minor physiographic changes. There was some rearrangement of rubble on the seaward side, and the seaward shingle ridge was much smaller and eroded. The gross dimensions of the island remained the same, and the area was only slightly smaller (8.70 ha compared with 9.02 ha).

The vegetation of the island consists of coconut woodland and mangroves. The western shore has a stand of tall *Rhizophora* closing the entrance to the western marsh. *Rhizophora* was also found at the eastern marsh entrance, together with *Avicennia*, and there was a large clump of *Avicennia* on the seaward shore. The larger marsh was fringed with *Conocarpus* and other shrubs, and many coconuts had recently been planted in it. Changes by 1971 were relatively minor. Much of the mangrove at the entrance to the larger marsh had disappeared, as had most of the *Avicennia* on the seaward shore. There had, however, been extensive colonisation of the shingle ridge by *Cordia* at the south point.

40 species of plants are recorded from the cay, and this total doubtless reflects the diversity of habitat on the island. 16 were recorded in 1961, 24 in 1971 and 34 by Linhart in 1973. Of the species recorded in 1961 only *Euphorbia trichotoma* has not been seen since, but this suggests oversight rather than extinction. In particular the island was less thoroughly collected, except for the west end, than the other Glover's Reef cays. Species in the following list marked 72 were collected by Pippen in 1972. In the following list *Ageratum maritimum* must be considered a dubious record, probably a misidentification of *A. littorale*.

<i>Andropogon glomeratus</i> 73	<i>Euphorbia blodgettii</i> 72
<i>Cenchrus incertus</i> 71C 73	<i>Euphorbia mesembrianthemifolia</i>
<i>Eragrostis prolifera</i> 71C 73	73
<i>Eustachys petraea</i> 71C 73	<i>Euphorbia trichotoma</i> 61C
<i>Paspalum distichum</i> 71C 73	<i>Euphorbia</i> sp. 61S 73
<i>Paspalum laxum</i> 73	<i>Passiflora suberosa</i> 71C 73
<i>Spartina patens</i> 71C	<i>Rhizophora mangle</i> 61S 71S 73
<i>Sporobolus</i> sp. 61S	<i>Conocarpus erectus</i> 61S 71S 73
<i>Cyperus ligularis</i> 73	<i>Laguncularia racemosa</i> 71C
<i>Cyperus planifolius</i> 73	<i>Rhabdadenia biflora</i> 73
<i>Cyperus</i> sp. 61S	<i>Ipomoea pes-caprae</i> 61S 73
<i>Fimbristylis cymosa</i> 73	<i>Cordia sebestena</i> 61S 71C 73
<i>Fimbristylis</i> sp. 61S	<i>Tournefortia gnaphalodes</i> 61S
* <i>Cocos nucifera</i> 61S 71S 73	71C 73
<i>Hymenocallis littoralis</i> 71S 73	<i>Avicennia germinans</i> 61S 71C 73
<i>Myrica cerifera</i> 73	<i>Stachytarpheta jamaicensis</i>
<i>Coccoloba uvifera</i> 61S 71S 73	71C 73
<i>Batis maritima</i> 71C 73	<i>Capraria biflora</i> 71C 73
<i>Iresine diffusa</i> 61C 72 73	<i>Erithalis fruticosa</i> 71C 73
<i>Philoxerus vermicularis</i> 73	<i>Ageratum littorale</i> 71C
<i>Portulaca oleracea</i> 71S	<i>Ageratum maritimum</i> 73
<i>Sesuvium portulacastrum</i> 61S 73	<i>Borrchia arborescens</i> 71C 73
<i>Suriana maritima</i> 61S 71S 73	<i>Eclipta alba</i> 73
	<i>Wedelia trilobata</i> 71S 73

For further notes on this island, see Stoddart (1962, pp. 93-95, figs. 46-47).

Southwest Cay II (16°41½'N, 87°50'W)

Figures 14-15, Plates 6,
16 and 18

Southwest Cay II is the most southerly island on Glover's Reef. Although immediately adjacent to Southwest Cay I it is of very different character. It is aligned at an angle of 45° to the reef edge, and shingle is only found along the southern shore close to the reef. The rest of the island is sandy, and there is no interior depression or mangrove swamp. When mapped in 1961 the island was 560 m long and had a maximum width of 235 m; its area was 6.66 ha. The narrow southern shingle ridge reached about 1.5 m above sea level. Much of the eastern shore was low and sandy, with many *Rhizophora* seedlings, in spite of being on the seaward side of the island; it faced a broad

shallow reef flat connecting with Southwest Cay I. The western shore is also sandy, but narrow and undercut: in its northern part it was lined with coconut boles and fallen trunks. There were several exposures of relict beachrock on this western shore, indicating both beach retreat and re-alignment as the shoreline moved in a clockwise direction. There was further evidence of shore erosion at the southwest point, though masked in 1961 by a fresh sandspit. Beach retreat was likewise evident on the east shore, as shown by undercut coconuts and small patches of beachrock which unusually showed landward dip. Physiographic changes had been minor by 1971. There had been erosion round the southern part of the cay, and the southern shingle ridge was more extensive; there had also been erosion at the northern end. As a result the overall length of the cay had decreased to 540 m and the area to 6.23 ha. The previous beachrock outcrops were still visible, together with another on the south shore.

The island is entirely covered with coconut woodland. Except in the southern part this has an undergrowth of herbs and grasses. Apart from occasional *Conocarpus* and *Suriana* bushes the only coastal vegetation is a narrow belt of *Rhizophora* on part of the east shore. 40 species of plants are recorded from the island (12 in 1961, 37 in 1971, and 31 by Linhart in 1973), a reflection of the diversity of the ground cover under the coconut woodland. They are:

<i>Andropogon glomeratus</i> 61S 71C	<i>Canavalia rosea</i> 71C 73
<i>Cenchrus incertus</i> 71C 73	<i>Suriana maritima</i> 71C 73
<i>Eragrostis prolifera</i> 71C	<i>Euphorbia blodgettii</i> 61C 71C
<i>Eustachys petraea</i> 71C 73	<i>Euphorbia mesembrianthemifolia</i>
<i>Paspalum distichum</i> 71C	71C 73
<i>Paspalum laxum</i> 71C	<i>Euphorbia</i> sp. 61S 73
<i>Spartina patens</i> 71C	<i>Passiflora suberosa</i> 71C 73
<i>Spartina spartinae</i> 73	<i>Rhizophora mangle</i> 61S 71C 73
<i>Sporobolus virginicus</i> 71C 73	<i>Conocarpus erectus</i> 61S 71C 73
<i>Sporobolus</i> sp. 61S	<i>Terminalia catappa</i> 71C
<i>Cyperus ligularis</i> 73	<i>Ipomoea macrantha</i> 71C 73
<i>Cyperus planifolius</i> 71C 73	<i>Ipomoea pes-caprae</i> 71C 73
<i>Fimbristylis cymosa</i> 71C 73	<i>Ipomoea stolonifera</i> 71C 73
* <i>Cocos nucifera</i> 61S 71S 73	<i>Ipomoea</i> sp. 61S
<i>Hymenocallis littoralis</i> 61S 71C 73	<i>Tournefortia gnaphalodes</i> 71C 73
<i>Coccoloba uvifera</i> 71C	<i>Stachytarpheta jamaicensis</i>
<i>Batis maritima</i> 73	61C 71C 73
<i>Iresine diffusa</i> 71C 73	<i>Capraria biflora</i> 71C 73
<i>Rivina humilis</i> 71C 73	<i>Erithalis fruticosa</i> 71C 73
<i>Portulaca oleracea</i> 71C 73	<i>Ernodea littoralis</i> 71C 73
<i>Sesuvium portulacastrum</i>	<i>Morinda citrifolia</i> 71C
61S 71C 73	<i>Ageratum littorale</i> 71C 73
<i>Cakile lanceolata</i> 61S 71C	<i>Wedelia trilobata</i> 71C 73

Salvin visited this island on 12 May 1862. He found "noddies everywhere ... many thousands in all", and speculated "what must the numbers have been when the Sooty Terns flocked to the same island" (Salvin 1864, p. 383). Coues (1864) listed *Anous stolidus* (on coconuts)

and *Anous tenuirostris* (on mangroves). The brown noddies still inhabit the cay but in small numbers; there are no records of Sooty Terns breeding there. For further details, see Stoddart (1962, pp. 95-98, fig. 48).

SUMMARY AND CONCLUSIONS

These surveys have established the variability of reef islands even over so short a period as a decade. All of the larger islands have decreased in area (Table 2), with the possible exception of Middle Cay, and these changes have been mainly effected by erosion and remodelling of windward coasts during major storms. Change has been most severe at the eastern end of Long Cay, but can be traced on all the islands in changed shore morphology, distribution of windward shingle ridges, and exposure of beachrock. Leeward or lagoon shores, on the other hand, have been more stable, and in some cases leeward sand spits have increased in area (Long Cay, Middle Cay). The islet of Long Cay North is the only one to have increased markedly in size, but it is so small that the change could readily be reversed.

Our data do not allow inferences about colonisation of the cays by new plant species between the surveys, nor do we wish to discuss the floristic biogeography of the islands in this paper. We can, however, record the following local extinctions: *Brassavola nodosa* and *Suriana maritima* on Northeast Cay; *Hibiscus tiliaceus* on Middle Cay; and *Sophora tomentosa* on Long Cay and Long Cay North. All were represented in 1961 by single specimens. *Brassavola* is an uncommon epiphyte; the *Hibiscus* was a single lagoon-shore tree; *Sophora* is a beach legume liable to substrate disturbance. This last effect is also seen in the widespread disappearance of *Tournefortia* and *Coccoloba* on the windward shingle ridges of Long Cay between 1961 and 1971, as a result of topographic change; they did not become locally extinct only because they existed in other habitats on the cay.

The total recorded terrestrial flora of Glover's Reef now stands at 70 species. Of these, 30 per cent (21 species) occur on only one island. Taking the species recorded from all the Belizean atolls (Lighthouse Reef, Turneffe, Glover's Reef), 28 species or 40 per cent of the Glover's Reef flora are recorded only from that atoll: this undoubtedly reflects the state of collecting on the other atolls rather than any local peculiarity on Glover's Reef. There is a simple relationship between number of plant species and area of the cays, though the anomalously low figure of species for Long Cay indicates the effect of coconut planting and clearing on that island. The species diversity figures for the Glover's Reef cays are markedly higher (by a factor of two) than those of other Caribbean and Gulf of Mexico reef island groups, such as the Dry Tortugas, Alacran, the Pedro Cays, and the Morant Cays. This probably results from the much wetter environment of Glover's Reef rather than from differing proximity of islands to source areas. The floristic biogeography of western Atlantic reef islands will form a separate paper; that of the Belize cays in general has been examined by Stoddart and Fosberg (in press).

Table 2. Change on the cays 1961-1971

Island	Area in hectares 1961	Area in hectares 1971	Percentage change	Species of land plants according to Linhart (1980)	Total number of species of land plants recorded
Northeast	4.73	4.48	-5.2	32	40
Long North	0.44	0.53	+20.8	19	22
Long	6.69	5.85	-12.6	21	28
Middle	6.03	5.97	-1.0	32	42
Southwest I	9.02	8.70	-3.5	35	40
Southwest II	6.66	6.23	-7.1	31	40
Total	33.57	31.76	-5.39	59	70

REFERENCES

- Antonius, A. 1972. Hurricane Laura, witnessed in British Honduras. *Atoll Res. Bull.* 162: 11-12.
- Boone, L. 1927. Scientific results of the First Oceanographic Expedition of the "Pawnee" 1925. Crustacea from tropical east American seas. *Bull. Bingham oceanogr. Coll.* 1(2): 1-147.
- Boone, L. 1928a. Scientific results of the First Oceanographic Expedition of the "Pawnee" 1925. Mollusca from tropical east American seas. *Bull. Bingham oceanogr. Coll.* 1(3): 1-20.
- Boone, L. 1928b. Scientific results of the First Oceanographic Expedition of the "Pawnee" 1925. Echinodermata from tropical east American seas. *Bull. Bingham oceanogr. Coll.* 1(4): 1-22.
- Boone, L. 1928c. Scientific results of the First Oceanographic Expedition of the "Pawnee" 1925. Coelenterata from tropical east American seas. *Bull. Bingham oceanogr. Coll.* 1(5): 1-8.
- Breder, C. M. Jr. 1927. Scientific results of the First Oceanographic Expedition of the "Pawnee" 1925. Fishes. *Bull. Bingham oceanogr. Coll.* 1(1): 1-90.
- Coues, E. 1864. Notes on certain Central-American Laridae collected by Mr Osbert Salvin and Mr F. Godman. *Ibis*, (1) 6: 387-393.
- Craig, A. K. 1966. Geography of fishing in British Honduras and adjacent coastal areas. *Louisiana State University, Coastal Studies Institute, Technical Report* 28, i-xv, 1-143.

- Dahl, A. L., Macintyre, I. G. and Antonius, A. 1974. A comparative study of coral reef research sites. *Atoll Res. Bull.* 172: 37-120.
- Devaney, D. M. 1974. Shallow-water echinoderms from British Honduras, with a description of a new species of *Ophiocoma* (Ophiuroidea). *Bull. mar. Sci.* 24: 122-164.
- Dillon, W. P. and Vedder, J. G. 1972. Structure and development of the British Honduras continental margin. *Earth plan. Sci. Lett.* 17: 175-180.
- Dillon, W. P. and Vedder, J. G. 1973. Structure and development of the continental margin of British Honduras. *Geol. Soc. Am. Bull.* 84: 2713-2732.
- Doubleday, C. W. 1886. *Reminiscences of the "Filibuster" War in Nicaragua*. New York and London: G. P. Putnam's Sons. ix, 225 pp.
- Fosberg, F. R., Stoddart, D. R., Sachet, M.-H., and Spellman, D. L. 1981. Plants of the Belize cays. *Atoll Res. Bull.* 258.
- Haas, F. 1941. Marine shells from the Mandel Caribbean Expedition. *Publs Field Mus. nat. Hist., Zool. Ser.* 24: 173-174.
- Hughes, S. M. 1973. *Foraminifera and sediments of patch reefs, Glover's Reef, British Honduras*. University of Montana, senior thesis. 36 pp. [not seen].
- Jefferys, T. 1775. The Bay of Honduras. In: *The West India Atlas or a general description of the West Indies*. London.
- Linhart, Y. B. 1980. Local biogeography of plants on a Caribbean atoll. *J. Biogeogr.* 7: 159-171.
- Maury, H. 1859. Loss of the Susan. *The Mobile Daily Register*, 32 (1329), 1.
- Sachet, M.-H. and Dahl, A. L., eds. 1974. Comparative investigations of Tropical Reef Ecosystems: background for an integrated coral reef program. *Atoll Res. Bull.* 172: 1-169.
- Salvin, O. 1864. A fortnight amongst the sea-birds of British Honduras. *Ibis*, (1) 6: 372-387.
- Schafersman, S D. 1972. *Carbonate sediments and Foraminifera of patch reefs, Glover's Reef, British Honduras*. Northern Illinois University, Master's thesis. 99 pp. [not seen].
- Schmidt, K. P. 1941. The amphibians and reptiles of British Honduras. *Field Mus. nat. Hist., Zool. Ser.* 22(8): 475-510.
- Scroggs, W. O. 1916. *Filibusters and financiers: the story of William Walker and his associates*. New York: Macmillan. xii, 408 pp. Reprinted (1969) by Russell and Russell.

- Speer, J. S. 1771. *The West-India Pilot. Containing piloting directions ... from Jamaica to Black River on the Mosquito Shore, and from thence to every Bay, Harbour, River, &c. in the Bay of Honduras. ... By an Officer who has served upwards of Twenty Years in the West Indies.* Second Edition. London.
- Stoddart, D. R. 1962. Three Caribbean atolls: Turneffe Islands, Lighthouse Reef, and Glover's Reef, British Honduras. *Atoll Res. Bull.* 87: 1-151.
- Stoddart, D. R. and Fosberg, F. R. In press. Species-area relationships on small islands: floristic data from Belize sand cays, western Caribbean. *Smithson. Contr. mar. Sci.* 12? 1982.
- Todd, W. E. C. 1942. List of the hummingbirds in the collection of the Carnegie Museum. *Annls Carnegie Mus.* 29: 271-370.
- Tsuda, R. T. and Dawes, C. J. 1974. Preliminary checklist of the marine benthic plants from Glover's Reef, British Honduras. *Atoll Res. Bull.* 173: 1-13.
- Uchupi, E. 1973. Eastern Yucatan continental margin and western Caribbean tectonics. *Am. Ass. petrol. Geol. Bull.* 57: 1075-1085.
- Vindel, F. 1955. *Mapas de America en los libros Espanoles de los siglos XVI al XVIII (1503-1798).* Madrid.
- Wallace, R. J. 1974. *A reconnaissance of the sedimentology and ecology of Glover's Reef atoll, Belize (British Honduras).* Princeton University, Ph.D. thesis. 140 pp. [not seen].
- Wallace, R. J. and Schafersman, S. D. 1977. Patch-reef ecology and sedimentology of Glover's Reef Atoll, Belize. *Am. Assoc. petrol. Geol. Stud. Geol.* 4: 37-52.
- York, M. E. 1971. Patch reef coral communities of southern British Honduras and illustrated catalogue of common British Honduras corals. In K. F. Wantland and W. C. Pusey III, eds.: *A guidebook for the field trip to the southern shelf of British Honduras, October 10-13, 1971* (New Orleans: New Orleans Geological Society), Appendix 1.

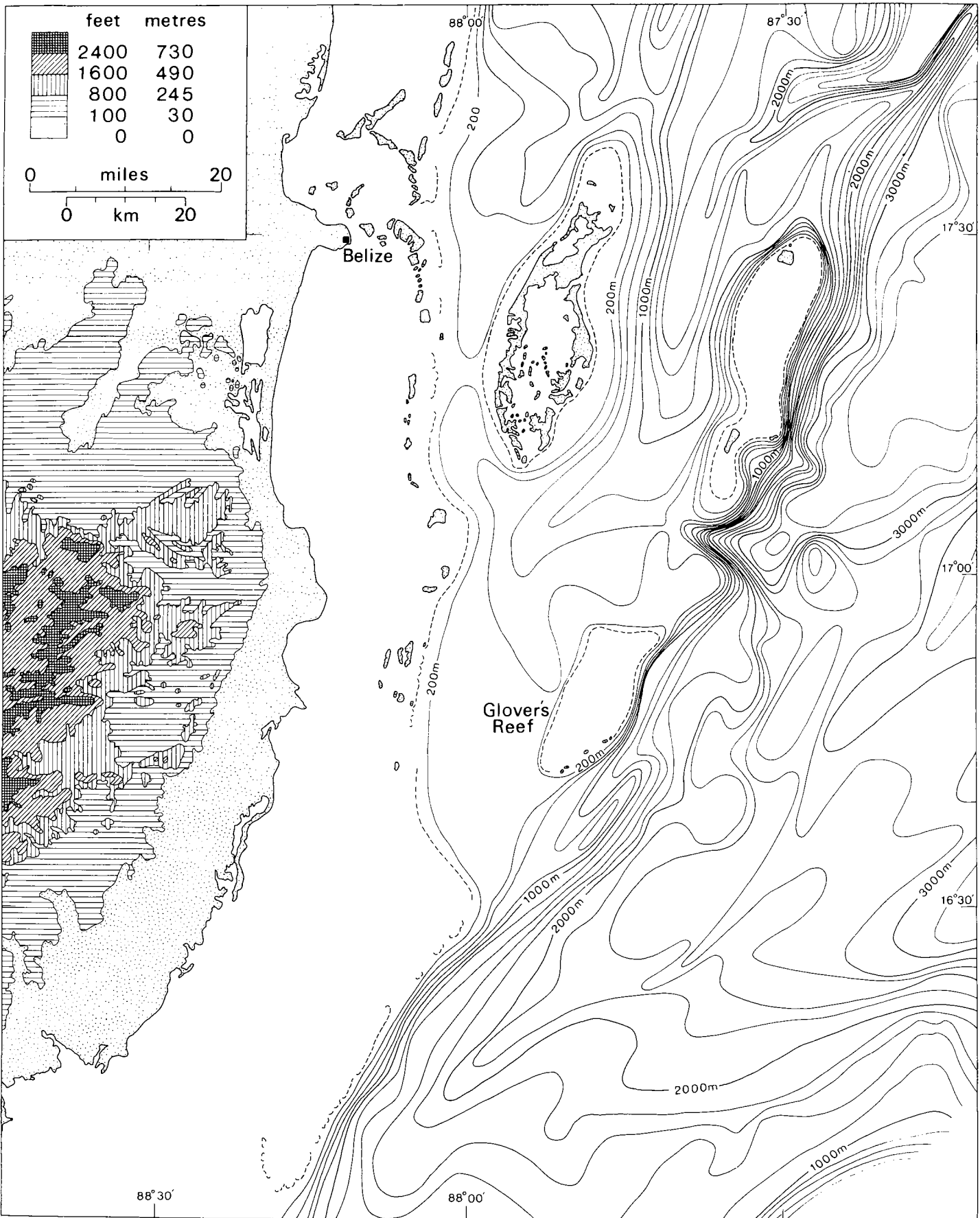


Figure 1. Location and submarine topography of Glover's Reef. After Dillon and Vedder (1973)

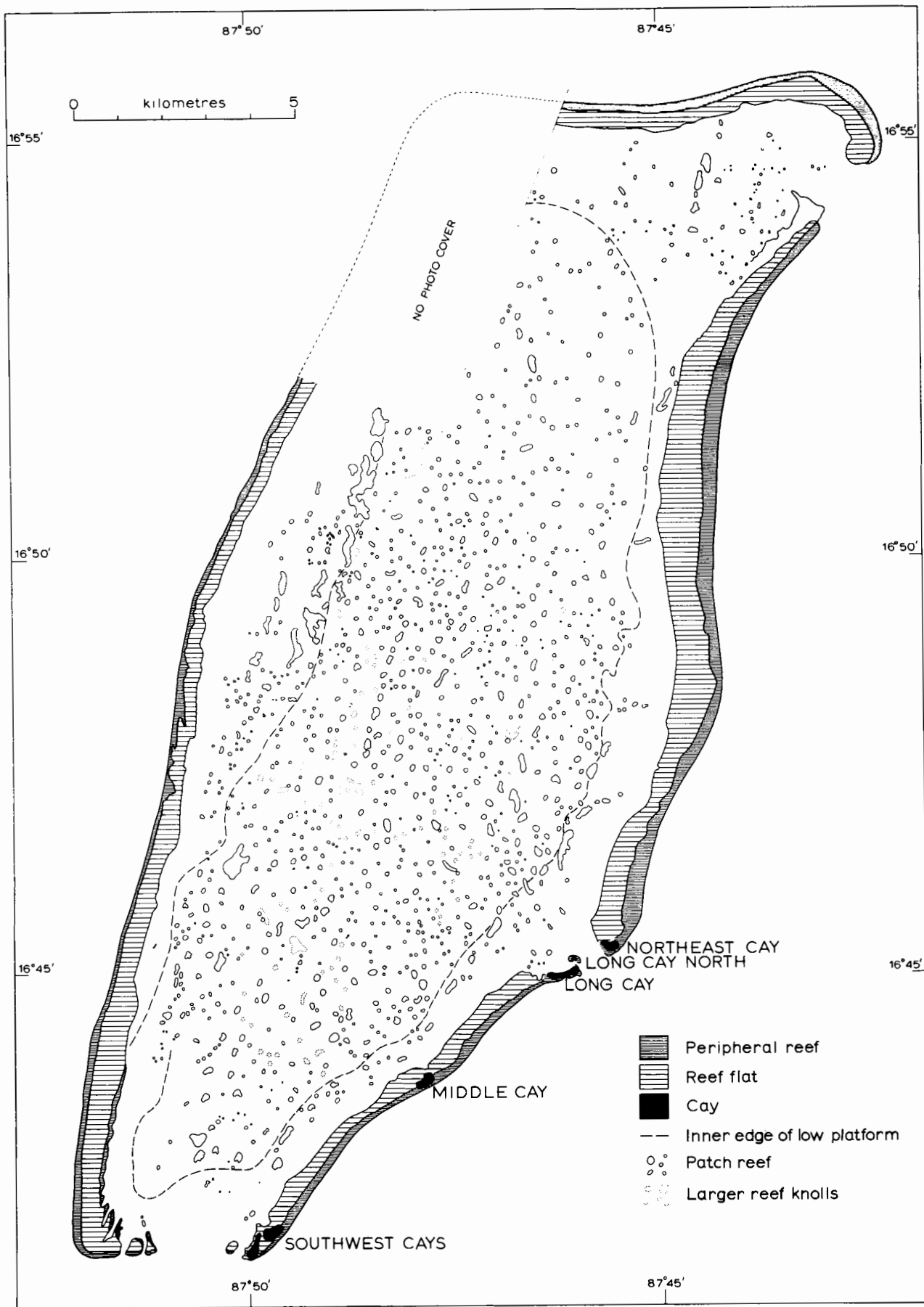
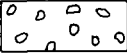
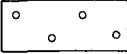
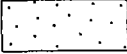
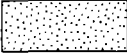




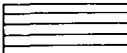
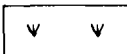


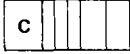


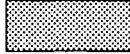






Figure 2. Topography of Glover's Reef. From Stoddart (1962, fig. 37)

PHYSICAL







	Rubble
	Shingle
	Sand
	Fresh sandspit
	Undercut shoreline
	Beach ridge - crest
	Beachrock
	Phosphate rock
	Peat
	Marsh

VEGETATION

Trees

	Coconut; Coconut woodland (dense, open)
	Rhizophora
	Avicennia
	Laguncularia
	Coccoloba
	Cordia
	Morinda
	Ficus
	Terminalia
	Bursera

Shrubs

	Tournefortia
	Conocarpus
	Suriana
	Borrnichia
	Sophora
	Indeterminate

Herbs



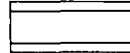
	Hymenocallis
	Sesuvium
	Herbs and grasses

Figure 3. Legend to the detailed physical and vegetation maps of the cays

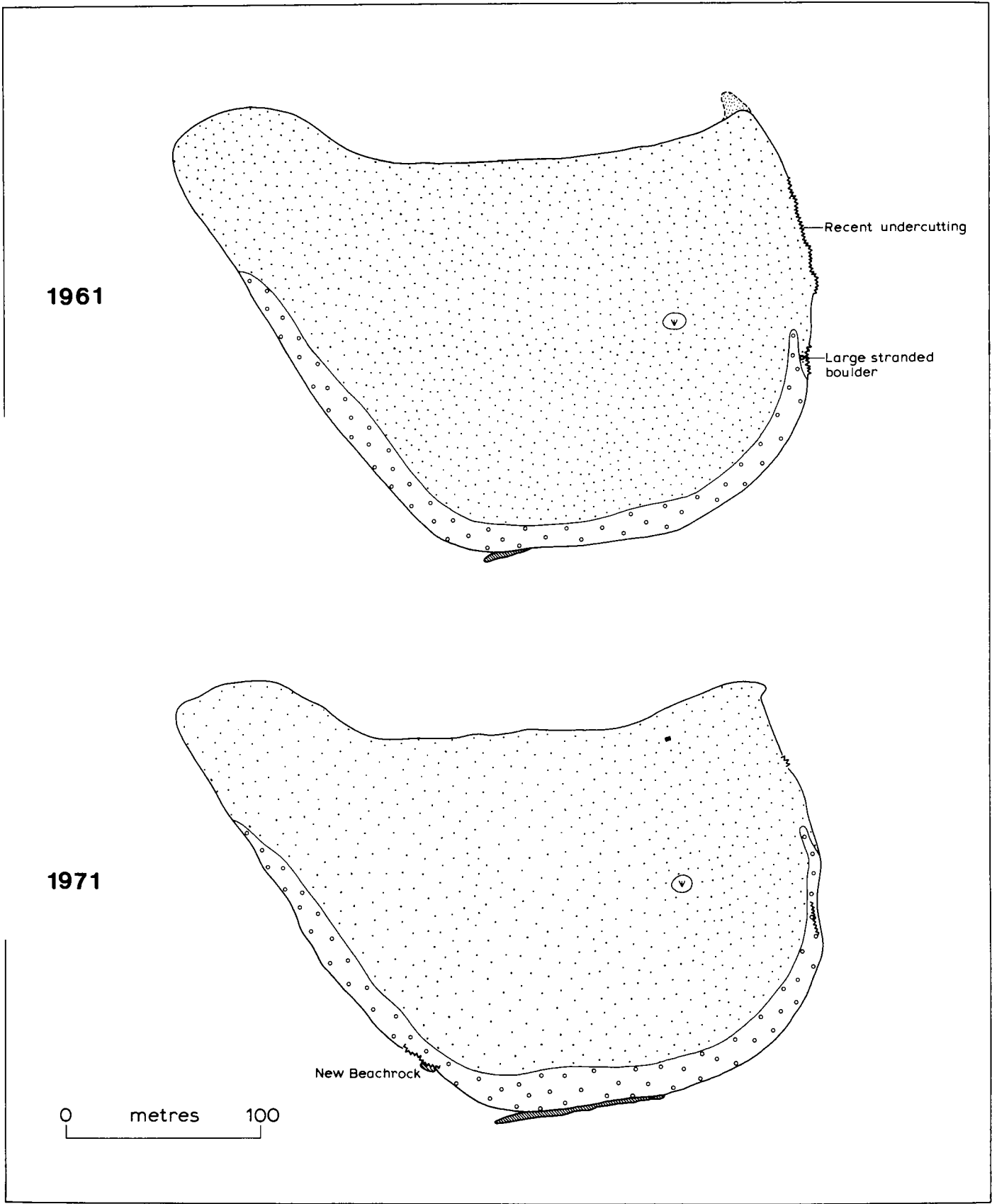


Figure 4. Northeast Cay 1961 and 1971: topography

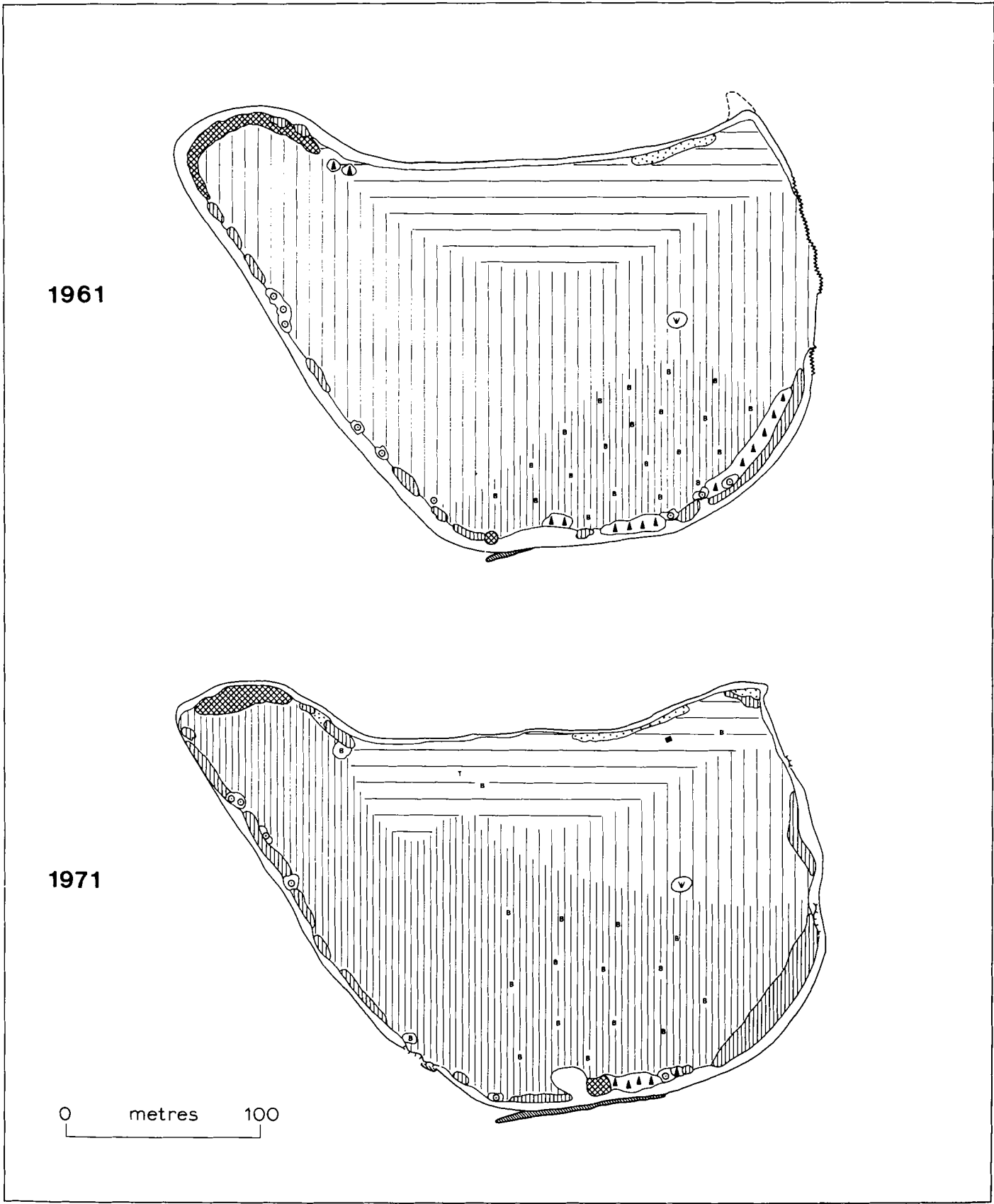


Figure 5. Northeast Cay 1961 and 1971: vegetation

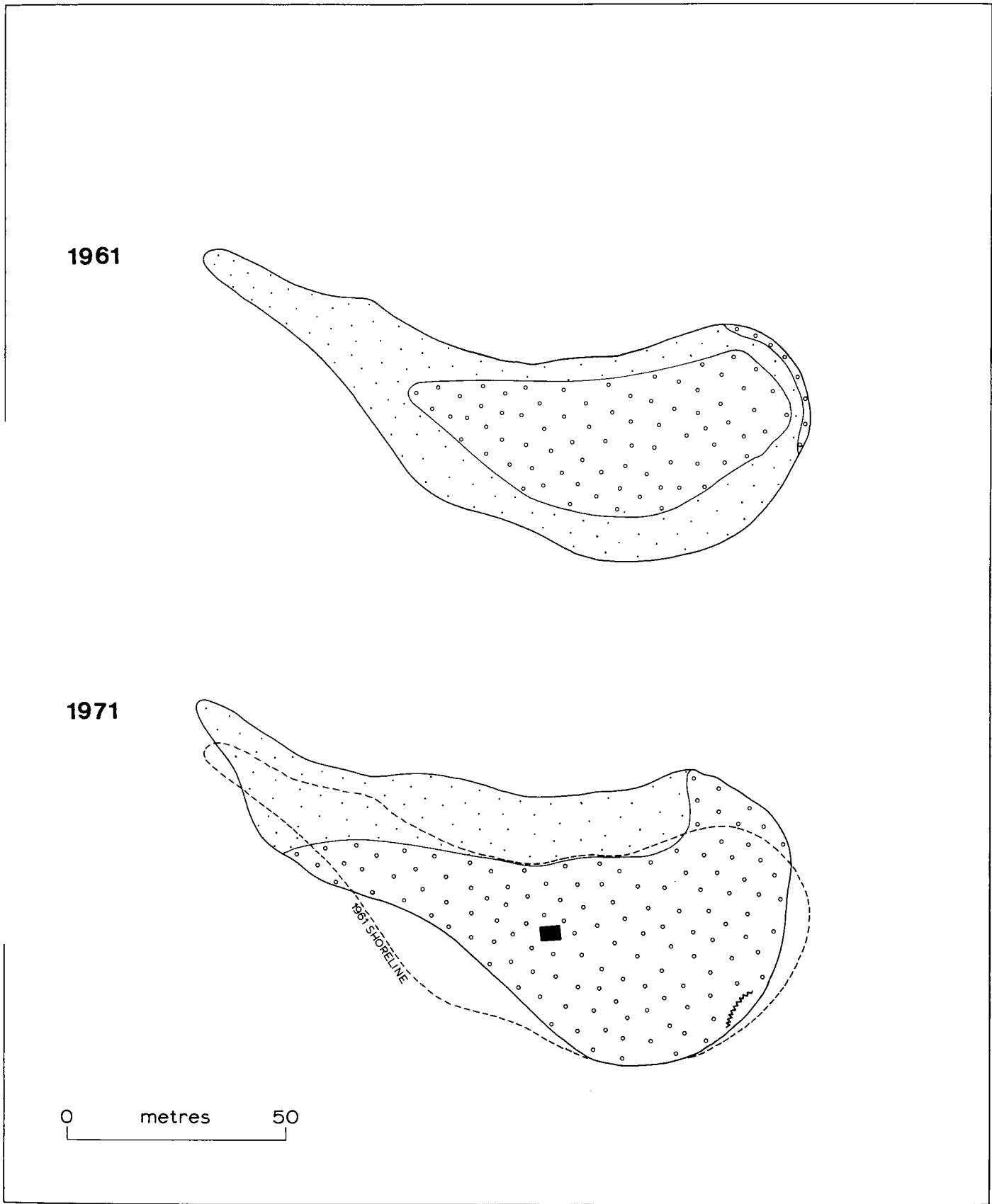
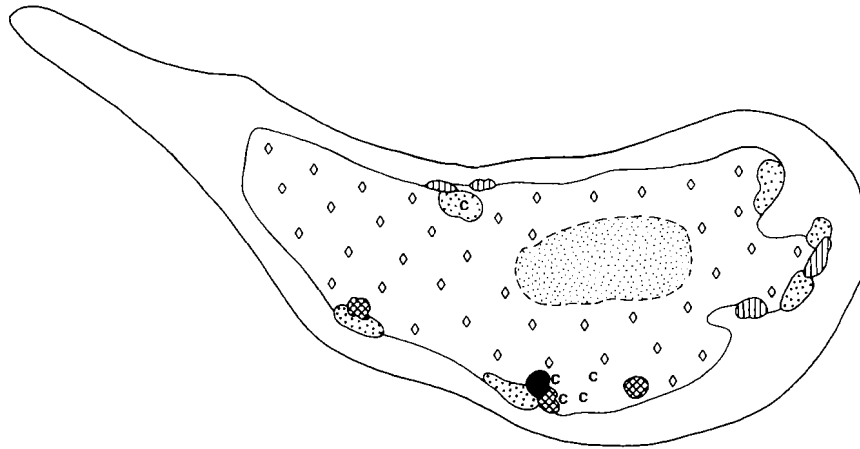
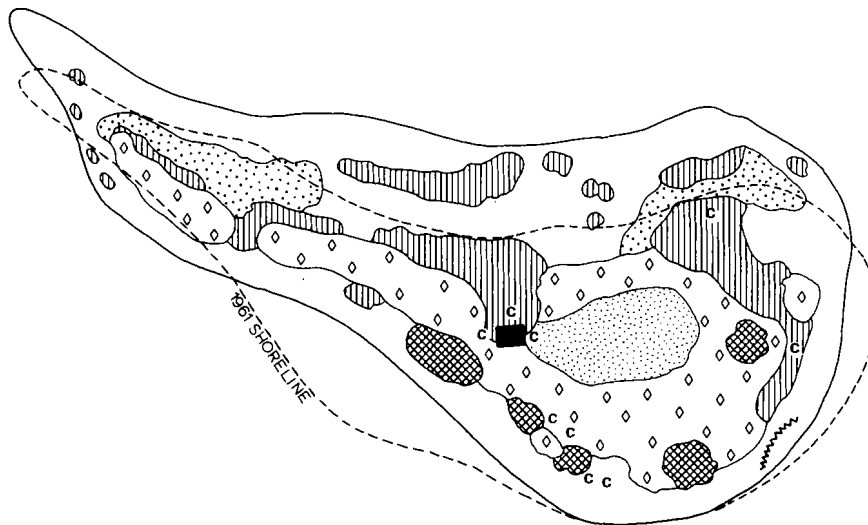


Figure 6. Long Cay North 1961 and 1971: topography

1961



1971



0 metres 50

Figure 7. Long Cay North 1961 and 1971: vegetation

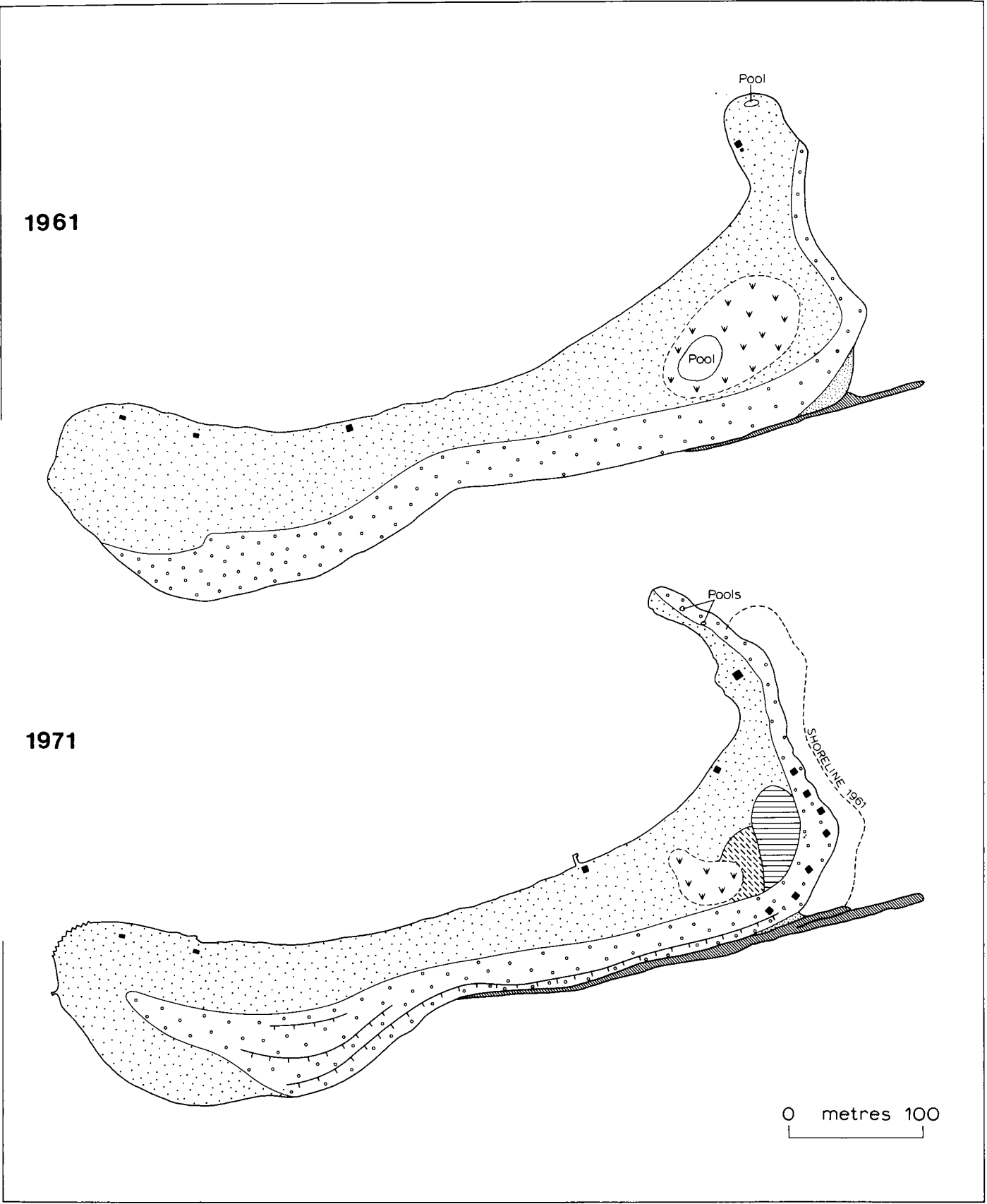


Figure 8. Long Cay 1961 and 1971: topography

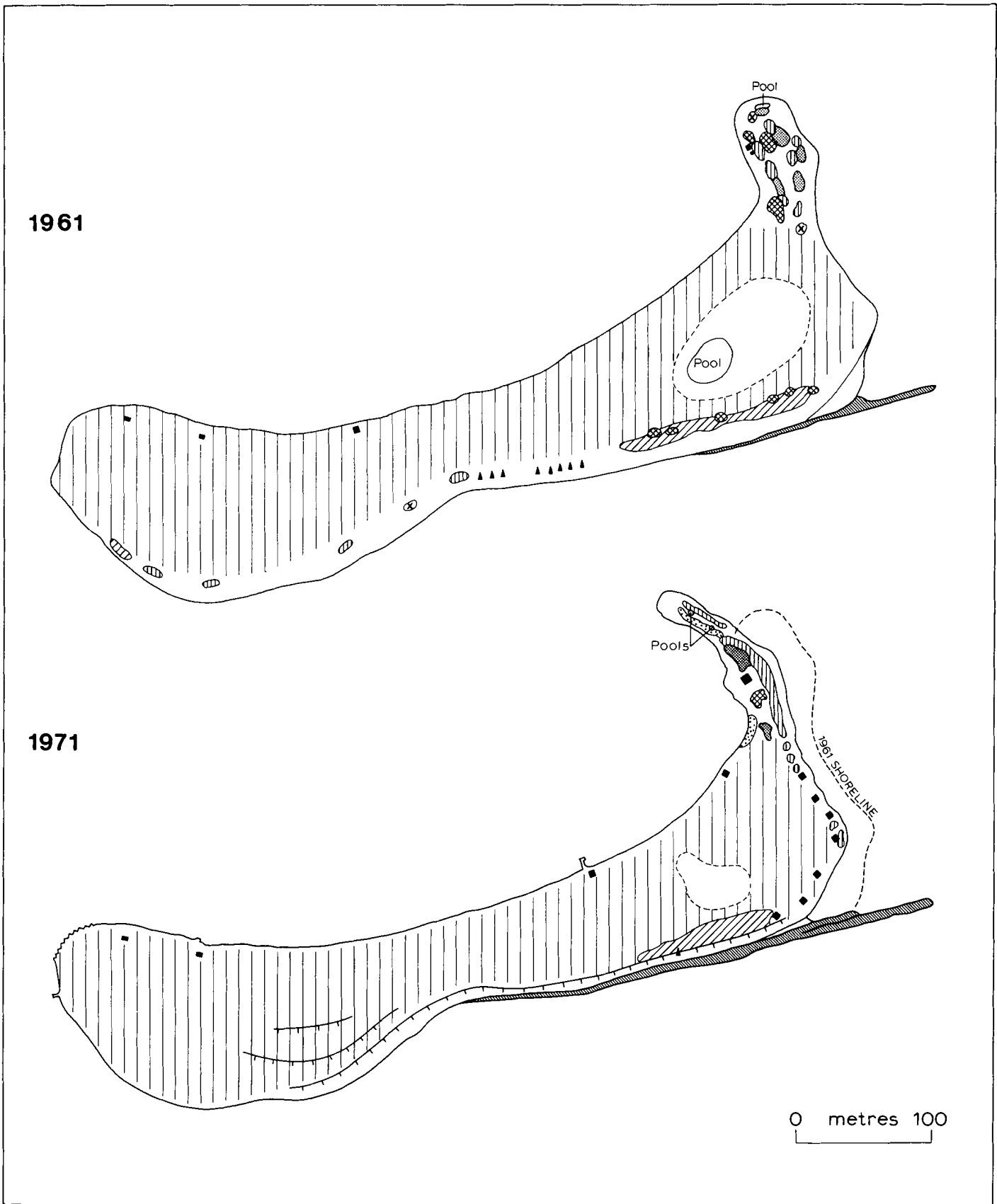


Figure 9. Long Cay 1961 and 1971: vegetation

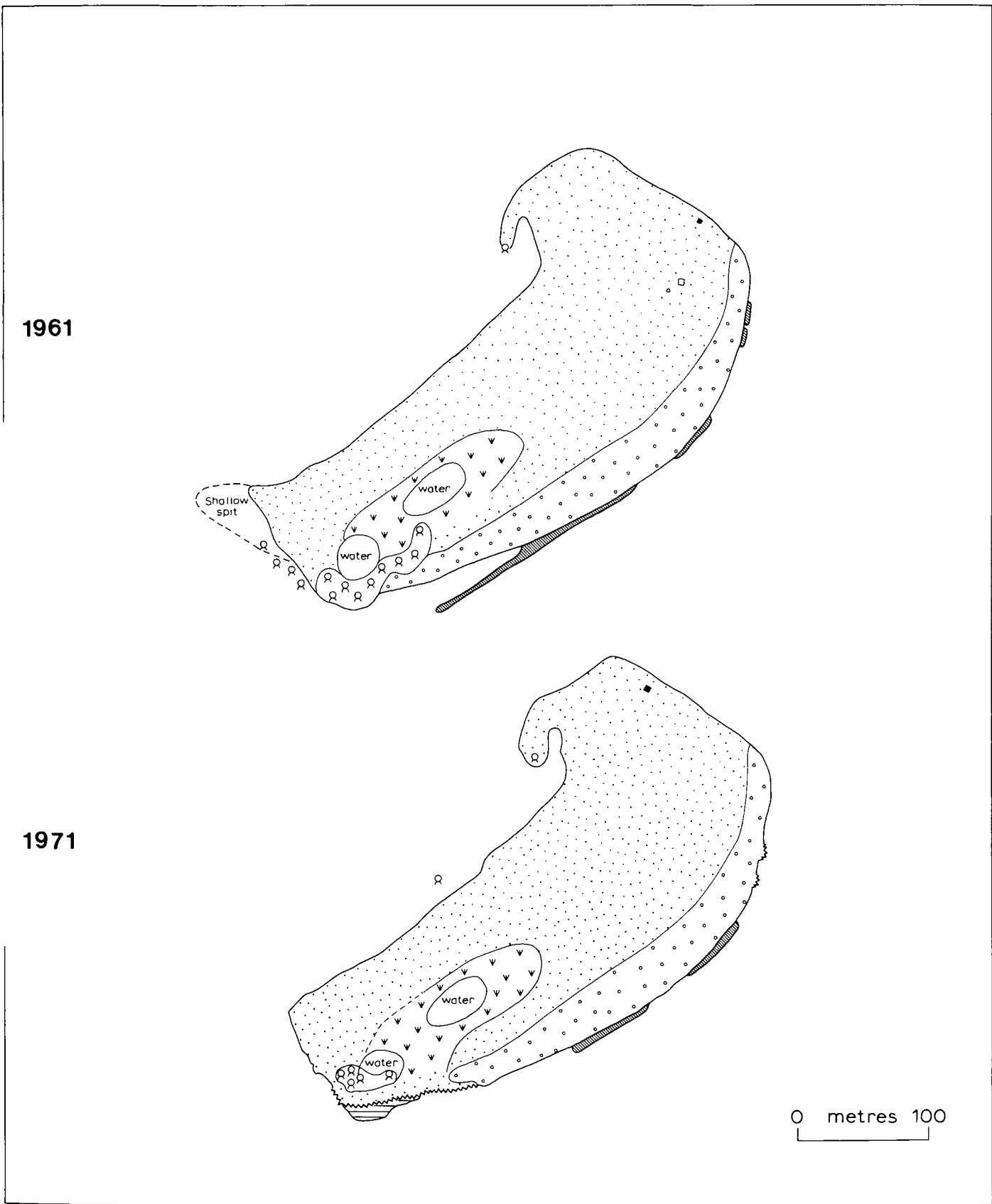
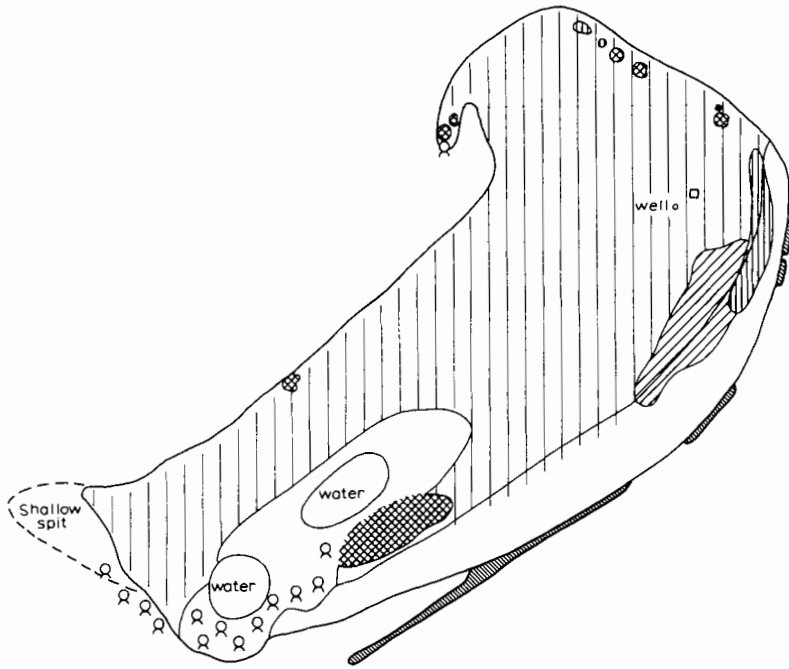
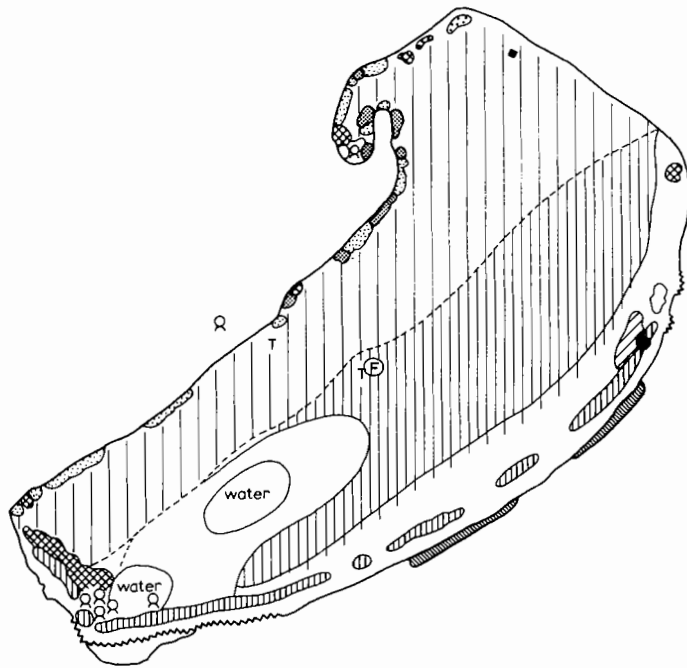


Figure 10. Middle Cay 1961 and 1971: topography

1961



1971



0 metres 100

Figure 11. Middle Cay 1961 and 1971: vegetation

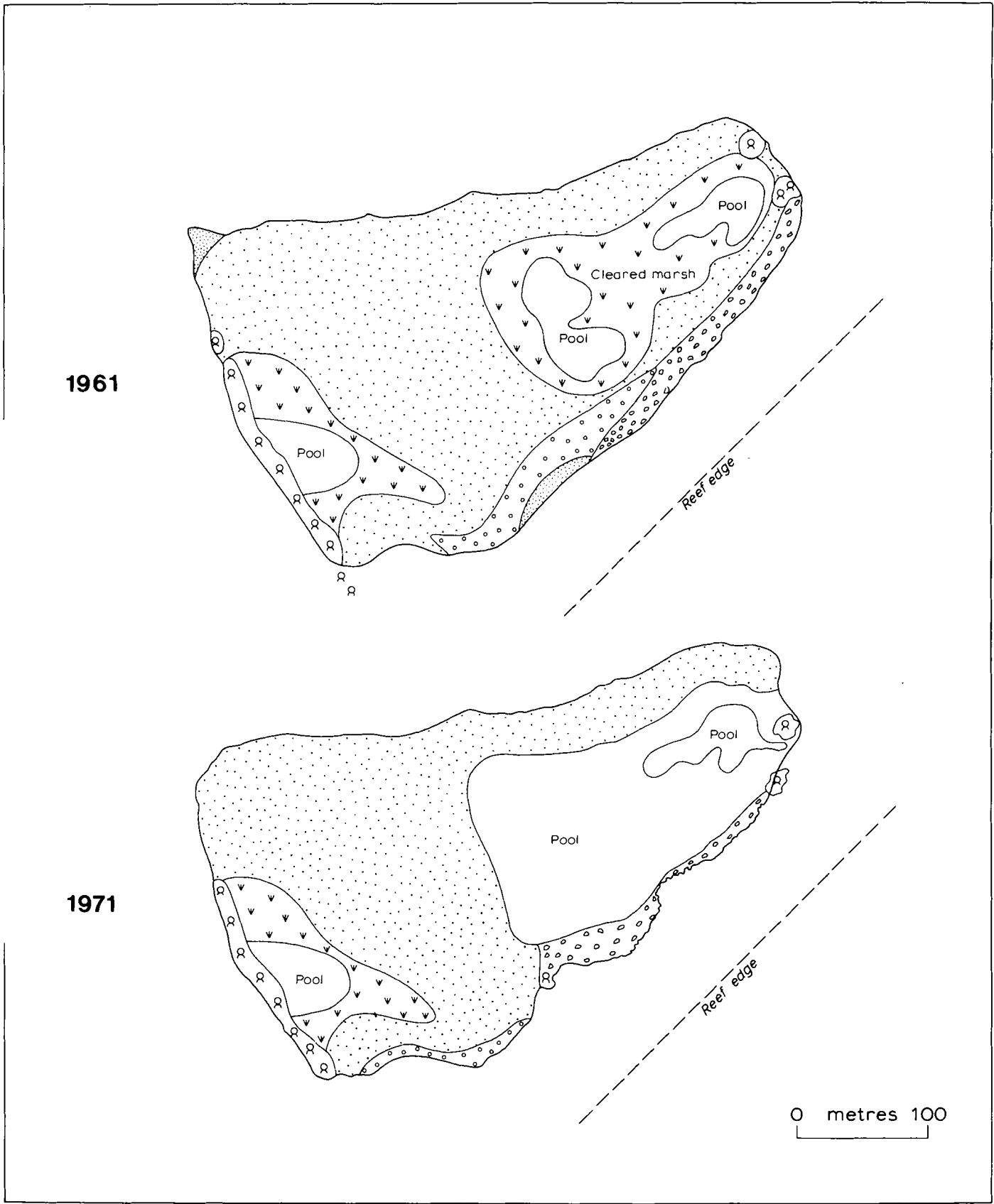


Figure 12. Southwest Cay I 1961 and 1971: topography

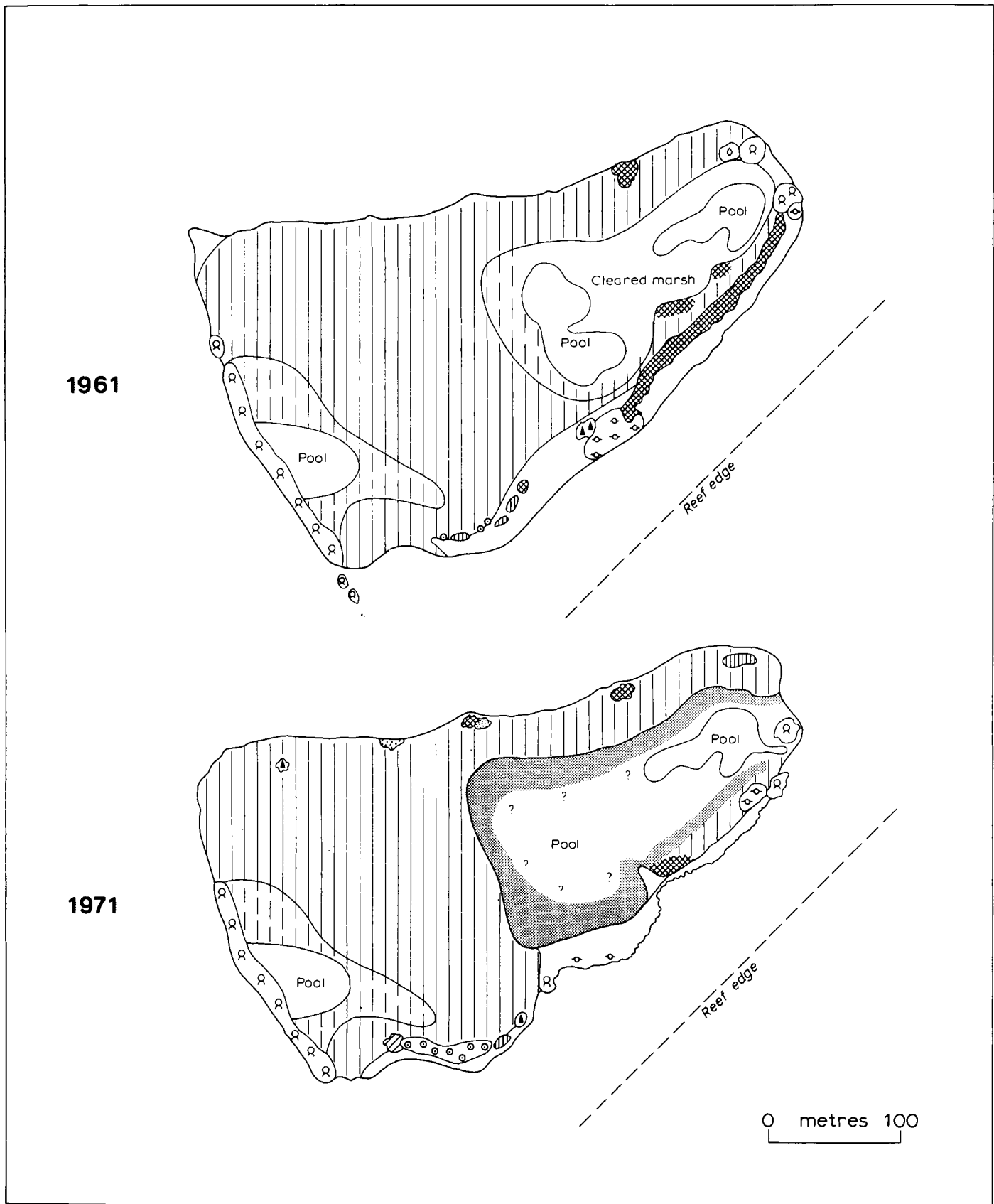


Figure 13. Southwest Cay I 1961 and 1971: vegetation

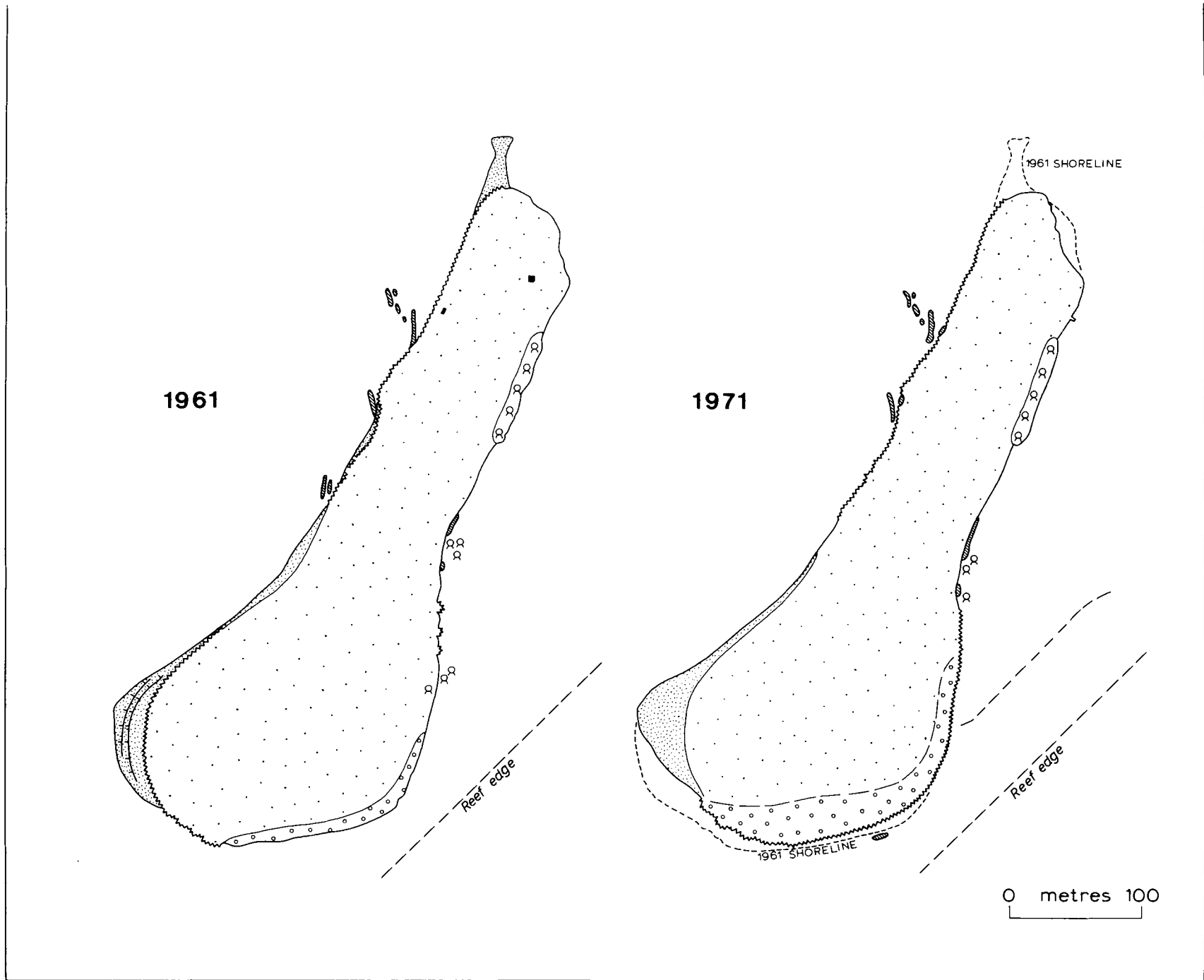


Figure 14. Southwest Cay II 1961 and 1971: topography

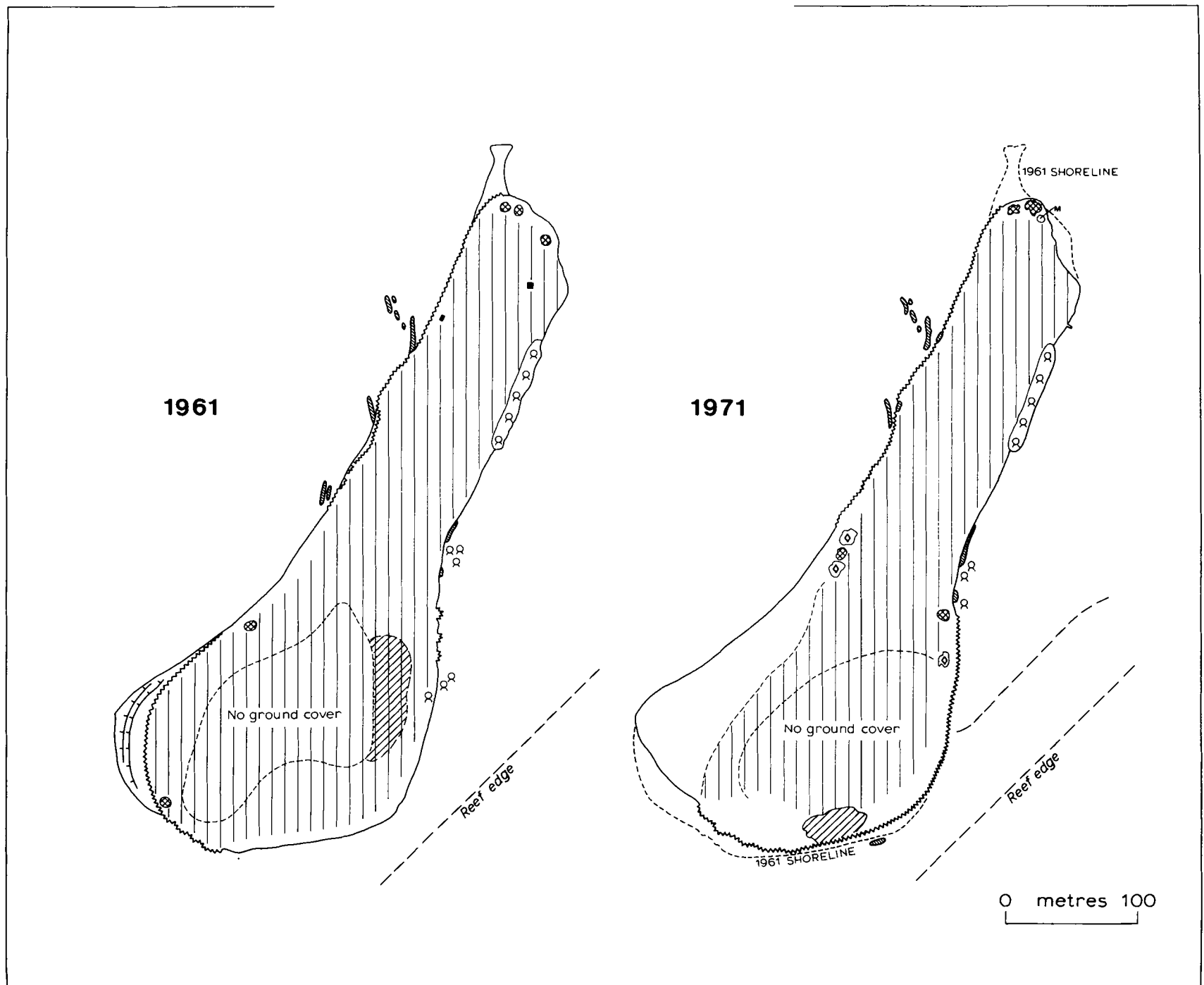


Figure 15. Southwest Cay II 1961 and 1971: vegetation



Plate 1. Northeast Cay: aerial view from the east 1961



Plate 2. Northeast Cay: storm block and shore erosion on the east side 1961



Plate 3. Long Cay North: *Suriana* scrub on the north shore 1961



Plate 4. Long Cay North: the south shore in 1971



Plate 5. Long Cay: aerial view from the southeast 1962

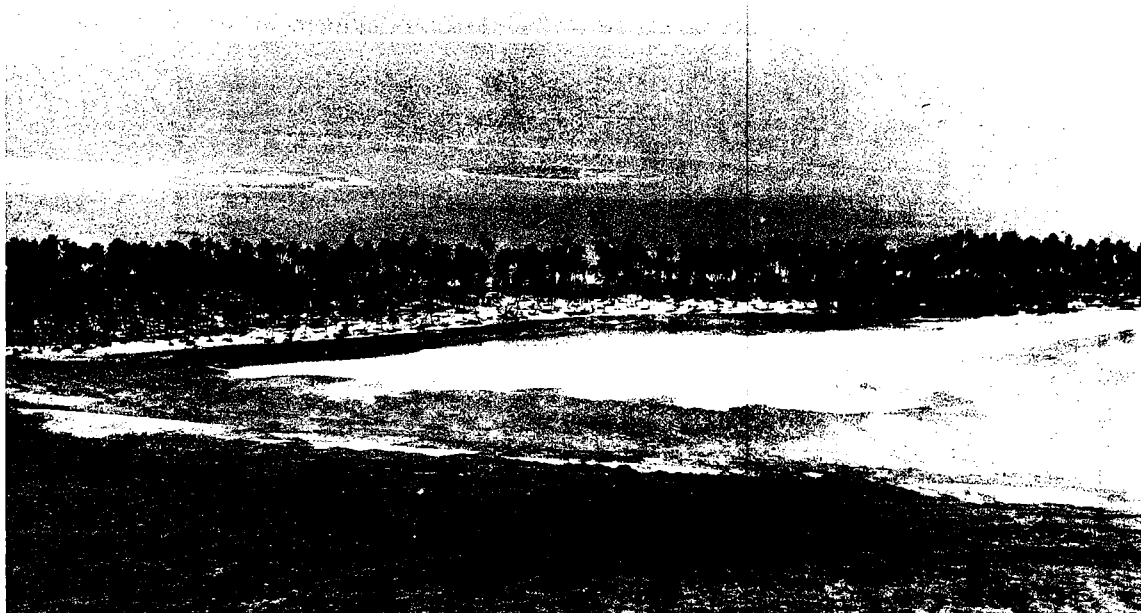


Plate 6. Southwest Cay II: aerial view from the southeast 1962



Plate 7. Long Cay: *Tournefortia* on the northeast spit 1961



Plate 8. Long Cay: upper surface of the windward shingle ridge 1961



Plate 9. Long Cay: sandy island surface with backslope of the windward shingle ridge 1971



Plate 10. Long Cay: mud hole and standing water at the east end, seen from the windward shingle ridge 1961



Plate 11. Middle Cay: windward shingle ridge with hedge of *Tournefortia* 1971



Plate 12. Middle Cay: low lagoon shore with *Conocarpus* 1971



Plate 13. Middle Cay: *Rhizophora* at the east end of the lagoon shore 1971



Plate 14. Southwest Cay I: seaward rubble shore 1971



Plate 15. Southwest Cay I: mangrove pool at the southern end of the island 1961



Plate 16. Southwest Cay II: exposed 'rootrock' on the retreating lagoon shore 1971



Plate 17. Southwest Cay I: open mangrove 1961



Plate 18. Southwest Cay II: beachrock with landward dip on the seaward shore 1961