THE SABA BANK - A LARGE ATOLL IN THE NORTHEASTERN CARIBBEAN

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CONTENTS

Abstract

The Saba Bank is a rather large submerged island in the northeastern Caribbean. Its top is remarkably flat, the water depth being about 20 to 40 m over most of its surface. There are several peripheral reefs around the whole bank and because of this it may be called an atoll, even though on some of these reefs there is probably no modern coral growth. The presence and distribution of shallow water stony corals in the area is discussed in some detail. As an atoll the Saba Bank is remarkable for its very large surface area, the great height of most of its Holocene reefs and the exceptional width of its windward reef flats.

Resumen

El Banco de Saba es una isla sumergida, de extensión bastante grande, situada en el nordeste del Caribe. Su parte superior es notablemente llana y en la mayoría de su profundidad del agua es de 20 a 40 m. Alrededor del banco existen varios arrecifes perif6ricos, por lo que puede considerarse un atolón, aunque probablemente en algunos de esos arrecifes no se registran crecimientos modernos de coral. Se examina con cierto detalle la presencia y distribución de los corales pétreos de aguas poco profundas. Entre los atolones, el Banco de Saba destaca por la extensión de su superficie, la gran altura de la mayoría de sus arrecifes holocenos y la anchura excepcional de la plataforma de arrecife de barlovento.

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1. INTRODUCTION

Most Dutch institutes involved in the CICAR programme, including the Rijksmuseum van Natuurlijke Historie (National Museum of Natural History), concentrated their efforts on two areas, the Guyana region and an area near the Windward Islands of St. Martin, St. Eustatius and Saba, including the Saba Bank. The latter area was visited several times in 1972 by the hydrographic vessel H.NL.M.S. LUYMES, primarily to carry out bathymetric surveys. However, most of the cruises were partly, or even mainly, devoted to sedimentologic, geomorphologic and biological investigations. Unfortunately, physical and chemical oceanography could not be included in this part of our national programme.

Some results of our bathymetric, sedimentological and biological work on the Saba Bank are presented in this paper. A popular account of this work was given by Roessler (1974). The bathymetric survey was carried out by Commandant L.H. van Opstal, hydrographer of the Dutch Navy, and several of his officers. The results of their work, as well as the original echograms, were kindly put at my disposal by the Hydrographic Office in The Hague. The unusually accurate bathymetric survey of this area in the open sea was possible only because a Seafix navigation chain had been established on the three islands mentioned above. Part of the bathymetric work had been done already when we started our sedimentological and biological programme, but the morphology of some important areas was still unknown; consequently the station network did not cover some areas we would have liked to study.

Between 12 May and 17 June 1972 about 130 sedimentological and biological stations were made in the whole area; most are indicated on the map (Fig. 1). Because SCUBA diving proved to be the most important method for studying the structure and fauna of the Saba Bank, the diving stations have been specially indicated and numbered. The other stations include grab, dredge and trawl stations.

2. GENERAL SURVEY OP THE AREA

The Saba Bank proper is a roughly rectangular bank west of the islands of Saba and St. Eustatius. It is 60-65 km long, 30-40 km wide and has a surface area of 2 000 km^2. Water depth is 20-40 m over most of the bank. Its surface slopes very gradually from the shallower southeastern part to the deeper northwestern part. Due to the small differences in depth a bathymetrical chart cannot be made easily; moreover, on a small scale, it would not show the information we wish to present. I preferred, therefore, to compile a structural map (see Fig. 2) showing only geomorphologic details other than flat bottom and more or less gradual slopes, *viz*. reefs and escarpments. Reefs are defined here purely as morphological entities, i.e., as structures arising from the surface of the bank. In contrast to the rest of the bank, practically always they show a very irregular profile in the echograms. The reefs along the flanks of the bank always have a very steep, and mostly very high, seaward slope. The lagoonward limits of these reefs also are very often definite escarpments but, in some areas, they slope gradually, more or less, toward the lagoon floor. The escarpments indicated on the map are not associated with significant reef formations.

North of the Saba Bank there is a seamount which, for convenience, we called Luymes Bank. It has an extremely intricate structure, with several tops at depths between 73 and 80 m and is connected to the Saba Bank by a ridge having a minimum depth of about 90 m. It has been suggested that the Luymes Bank originated as a volcano belonging to the volcanic arc of Nevis, St. Kitts, St. Eustatius and Saba (Westermann and Kiel, 1961: p. 166-16?). This might well be the case, but nowadays the area is covered completely by carbonate rocks and sediments.

Fishermen on Saba told Boeke (1907: P. 45), one of the first authors to give a reasonably accurate description of the Saba Bank, there was a shallow area which they called Copper Bank, close to the Saba Bank, at 8-10 miles SSE of Saba. They did not fish on that bank as they believed fish from the area were always poisonous (apparently causing ciguatera). It is now evident that the Saba fishermen referred to the "peninsula" opposite St. Eustatius (see Fig. 1) and not to a separate bank.

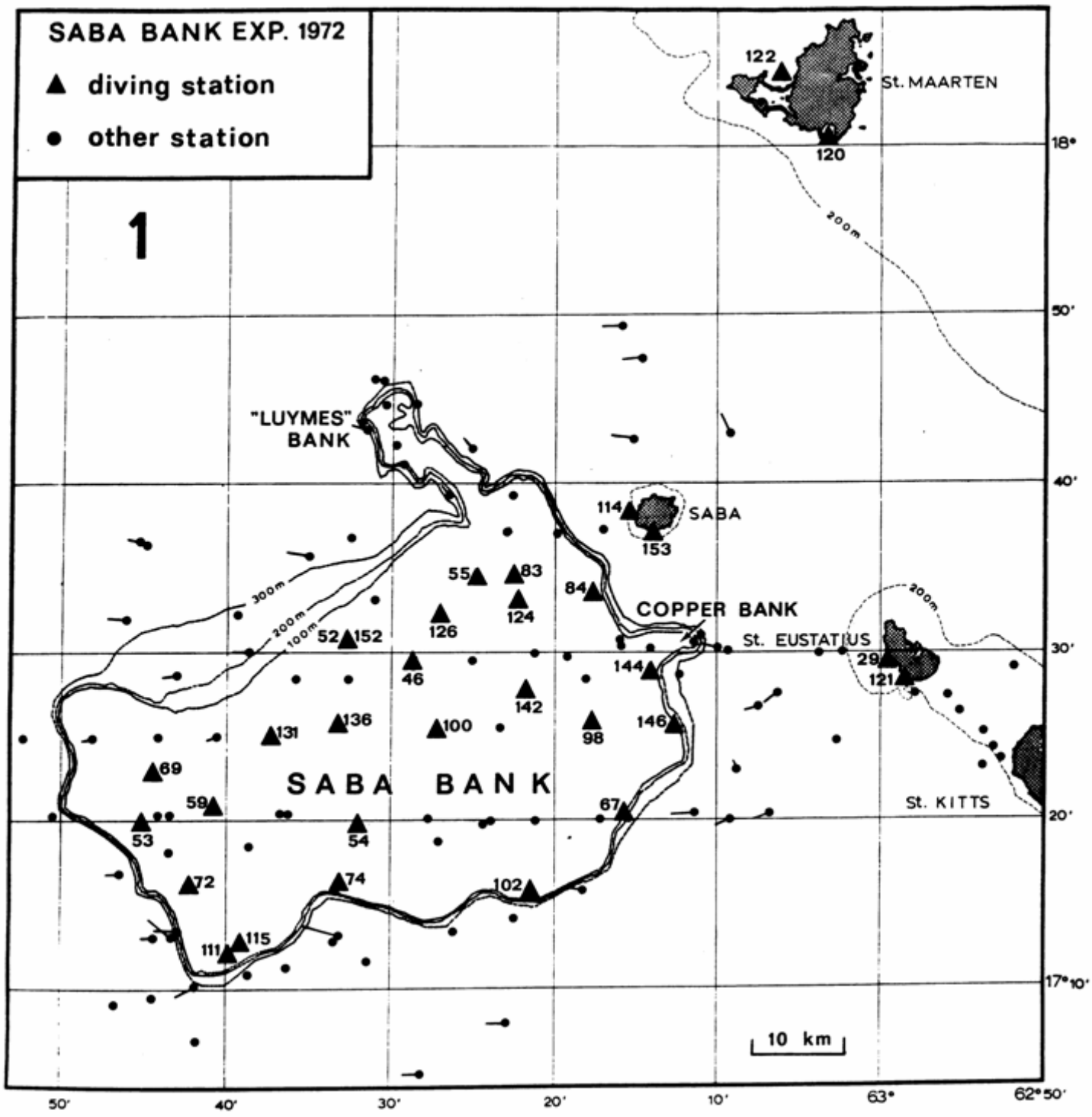

Fig. 1 Map with stations of the Luymes Saba Bank Expedition of May to June 1972. The numbers refer to the diving stations only.

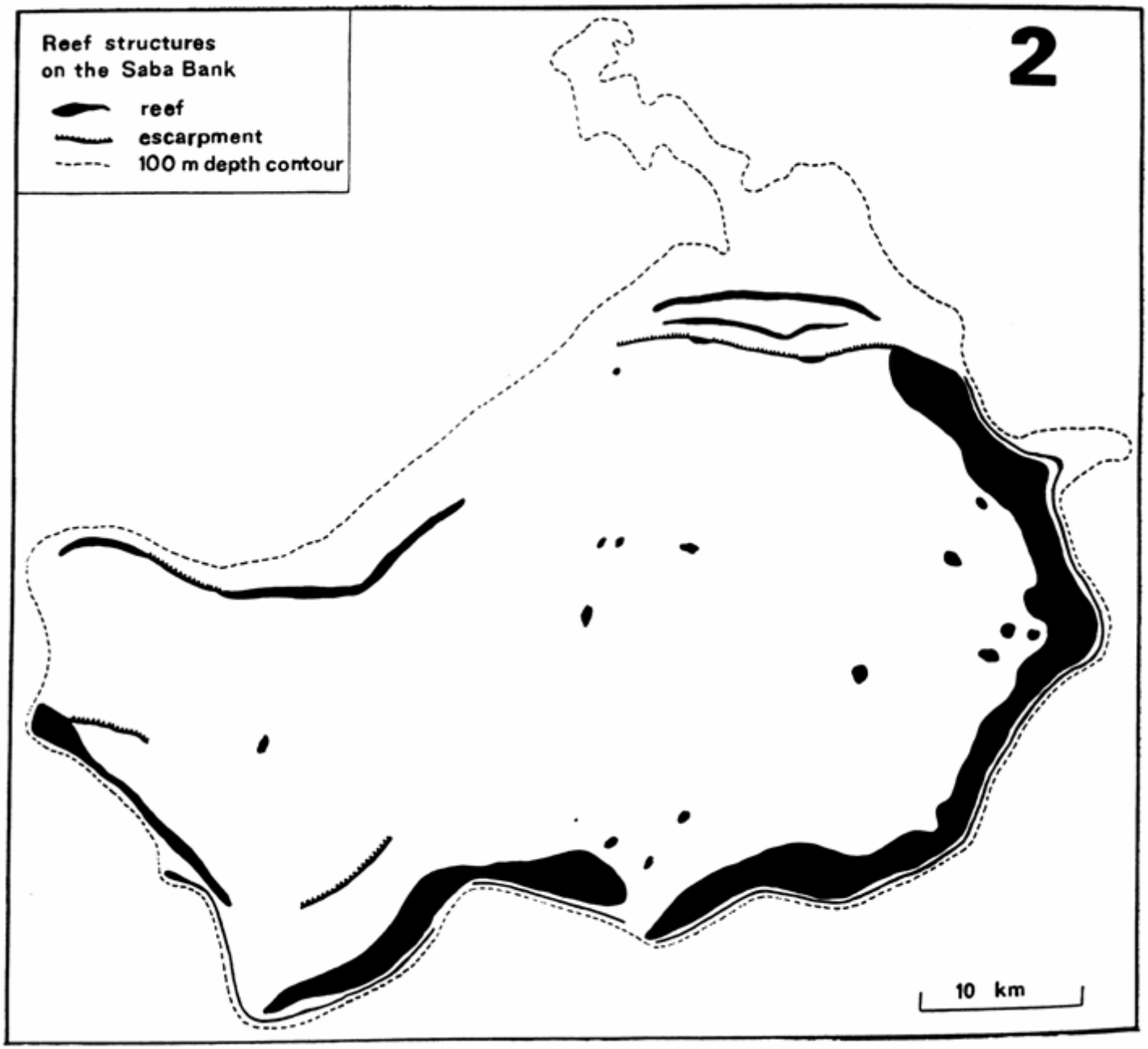

Fig. 2 Map of the Saba Bank indicating reef structures found during bathymetric surveys by H.NL.M.S. LUYMES in 1972

So far as I know, the currents in the area run in a WNW direction constantly throughout the year and, usually, the wind direction varies only between E and ESS. In general the current is not very strong, but we observed a relatively strong current over the shallow windward reefs, which is quite understandable.

3. DESCRIPTION OF THE REEF STRUCTURES

A rough description of all reef structures as defined before, and based exclusively on the echo soundings, is given below.

3.1 The Southeastern Reef

This semicircular reef, running along the eastern and part of the southern edge is, by far, the largest reef on the Saba Bank. Its total length is about 55 km and its width varies from 1 to 3 km (in some places it widens to 3.5-4 km). Over the whole length of the reef the minimum water depth varies from 12.5 to 16 m. This means the reef rises to a maximum height of 6-9 m above the lagoon floor, which floor lies at a depth of 19.5-23 m on this part of the bank. Hong the greater part of its length there is a distinct, 2-4 m high, escarpment on the lagoonward side of the reef, but in some areas the reef slopes gradually down to the lagoon floor. In most areas the reef has a very irregular surface morphology, as shown by numerous sharp peaks on the echograms but, in places, its surface is rather flat. In general the highest parts of the reef lie close to the seaward slope. Often one can distinguish an outer reef flat and an inner reef flat, the latter being a few meters lower. The reef front is invariably very steep, sloping down to a terrace which lies usually at a depth of 21-30 m, sometimes at a depth of about 40 m. This means the slope is mostly 7-15 m, sometimes up to 25 m high.

3.2 The Southern Reef

This second largest reef has a length of about 25 km and varies in width from 1.5 to 3 km. It looks very much like the SB reef but, in general, lies at a slightly lower level. On this part of the bank the lagoon floor is at a depth of 27-30 m, while the highest points of the reef reach up to depths varying from 15 to 24 m. This means this reef has a maximum height of 3-12 m above the lagoon floor and is consequently, on average, somewhat higher than the SB reef.

3.3 The Southwestern Reef

This reef is about 17 km long, about 1.5 km at its widest, but only 300-500 m wide over most of its length. This reef, again, lies at a lower level than the preceding one. The lagoon floor lies at a depth of 40-44 m, while the minimum depth over the reef varies between 30 and 40 m. The reef height above the lagoon floor varies from a few meters to 10 m. There is a seaward terrace at a level of about 40 m.

3.4 The Northwestern Reef

This structure, overall, is about 25 km long, but no significant reef formations are present over 4.5 km of this length. Its width could not be measured accurately, but is in the order of 200 m. In this area the lagoon floor slopes in a westerly direction from 41 m to a depth of 53 m, at the same time the minimum water depth over the reef decreasing from 34 to 43 m. Maximum height of the reef relative to the lagoon floor varies between 4 and 10 m. Between the two parts the line of the reef can only be followed as an escarpment with a height of about 3 m. There is a steep seaward slope 10-20 m high passing into a more gradual slope; a distinct terrace is lacking here.

3.5 The Northern Reefs

The northern part of the Saba Bank, facing the Luymes Bank, is exceptional in that, here, a series of three reefs on different levels can be recognized. The first, lagoonward reef, which could well be considered a continuation of the SE reef, is not much more than an escarpment with a few reef patches (probably rather

more than the two indicated on the map). It is about 16 km long. The top of the escarpment slopes from 21 m deep in the east to 39 m deep at its western end, while the terrace at its bottom lies at a depth of 30-41 m. It is between 3 and 9 m high, depending partly on the presence or absence of a reef.

The second reef is considerably shorter but appears to be continuous. It is situated on the edge of a terrace sloping in a westerly direction from 41 to 52 m water depth. The highest tops of the reef are about 30 m deep at the eastern to 45 m deep at the western end. Maximum height relative to the level of the terrace varies from 7 to 12 m.

The third, seaward reef is on a sloping terrace 42-58 m deep; its highest tops are at depths of 33-47 m while its maximum height varies from 7 to 11 m.

3.6 The Patch Reefs

As indicated on the map, at least 15 patch reefs were found in the lagoon but we can be sure their real number is considerably higher. Doe to their small size, most of them must have been missed during the soundings. On the echograms they stand out as conspicuous structures on the flat lagoon floor. Their height varies from 2 to 6 m but most are about 4 m high. Host patch reefs were encountered on the eastern half of the bank, where the lagoon floor is 20-29 m deep. On the western half of the bank only one patch reef was found at a depth of 36 m.

3.7 The Front Reefs

One of the most remarkable features of the Saba Bank is the presence of a narrow ridge in front of some reefs mentioned before, along practically the whole length of the eastern and southern "coasts". Usually the base of the front reef occupies most of the narrow terrace which is present everywhere in this area and which is 100-500 m wide (only in some places it is up to 1 000 m wide). The reef top in front of the SB reef lies 21-28 m below sea level in its northern half and 14-20 m below sea level in its southern half. As mentioned above, the terrace in this area is 21-30 m deep, sometimes even 40 m deep. In some places the front reef is so low as to be barely visible on the echograms. Mostly it has a considerable height, up to 15 m, in some places even up to 20 m, which means that it is higher than any of the other reefs on the Saba Bank.

The rim in front of the south reef is somewhat smaller and even lacking in the central part but along most of its length it is still 4-9 m high (the rim lies on a terrace at a depth of 24-33 m while its top lies 19-26 m below sea level).

In the area where the western parts of the front reef are situated the number and the quality of the bathymetric observations do not allow us to give an exact description. Between the south reef and the southwestern reef the rim is certainly not very high and probably not continuous. As indicated on the map, the western extremity is situated on the edge of a terrace more than 1 km wide and about 42 m deep. Here the massive front reef rises to 14 m above the terrace level.

It should be noted that the terrace on which the front reefs are situated lies at the same depth as the lagoon floor in the same area in most places, or only a little lower.

4. THE SHALLOW-WATER STONY CORALS

Numerous zoological specimens and samples were collected in the area. All material has been sorted in the museum sorting centre and several groups have been either worked up or are being studied. In this paper I have confined myself to the presentation of results obtained by a study of the shallow-water stony corals (Milleporina and Scleractinia) as these animals are most important for an understanding of the morphology of the area.

The qualitative results are summarized in Table I. Since I do not wish to enter into taxonomic and nomenclatorial discussions in this paper, and in order to avoid confusion, I adhered strictly to Roos' (1971) views on the taxonomy and nomenclature of these animals. This author undertook an extensive survey of the shallow-water stony corals of the Netherlands Antilles and the results of his work on St. Martin, Saba and St. Eustatius are particularly relevant to the present study. Bak (1975) contributed some valuable additional observations on the coral fauna of these islands. We only worked incidentally in coastal waters, the results being summarized in the last columns of Table I. We collected very few corals near St. Martin since we dived in only two of the sheltered bays.

It appeared that a rich coral fauna was present, only on the two large windward reefs on the Saba bank, the southeast and the south. In this area we made eight diving stations, finding 22 coral species. Collecting methods were far from intensive so the number of species actually occurring is, no doubt, considerably higher. The main reason we can call this a rich coral reef is that the number of colonies per station is very high and large colonies are common. Moreover, the patches of sand and bare rook are usually small. It is evident that both reefs form an area with constructional coral growth. This is not the case with fore-reef stations numbers 111 and 146, where only small, scattered colonies were found. Sand patches and sediment rivers are common there.

Corals are common also on the first of the northern reefs (station 55) but the colonies are small and scattered, at least on the single station in this area. On the second reef a few corals only were found (station 83, 41 m) but the diving station was on one of the lowest parts of the reef.

On the lagoon diving stations, seven were made in the southeastern half of the lagoon (east of a line between the western ends of the series of north reefs and the south reef) at depths from 21 to 36 m. At two of these stations (numbers 54 and 98) there were no stony corals at all. At the other stations (see Table I, numbers 46 to 126) a total of 17 species was collected but in all cases there were small and scattered colonies with only an occasional coral head. Eight diving stations were made in the northwestern half of the lagoon at depths from 34 to 44 m. Only two small coral colonies of two species were found at two stations (see Table I. numbers 59 and 69).

The following general observations must be added here:

(a) Many reef areas in the Caribbean are dominated by one or a few species which form dense stands or huge colonies, sometimes to such an extent that definite reef communities can be distinguished, e.g., Montastrea annularis reef, Porites reef or Acropora cervicornis reef. On the Saba Bank this is nowhere the case. At none of the diving stations was the scene dominated by certain species and really large colonies were never found.

(b) Most coral species do not show a definite distribution pattern on the Saba Bank; the only exception is Acropora cervicornis, which was found only on the windward reefs, i.e., the southeast and the south reefs,at six stations (including three diving stations) and only in shallow water, from 15 to 24 m depth. The Acropora colonies were invariably very low and often streamlined.

(c) Only three species of scleractinians were found in the coastal waters but not on the Saba Bank, viz. Acropora palmata, Astrangia solitaria and Tubastraea tenuilamellosa. So far as I know all three are typically shallow water species which can hardly be expected to occur on the Saba Bank.

(d) Madracis asperula is the only species found in several localities on the Saba Bank but not in the coastal waters. Roos (1971) did not find this species in any of the many localities he visited along the coasts of the island of Saba, St. Eustatius and St. Martin. He has already stated, "this species is restricted to shallower parts of the open sea".

TABLE I

Stony corals (Milleporina and Scleractinia) collected at the diving stations

	Windward reefs								N reefs		Lagoon stations							Coastal waters		
Diving stations:	102	144	84	67	74	115	111	146	55	83	46	142	100	124	126	59	69	S	E	M ☆
Depth in meters:	16	16	17	20	23	26	28	30	39	41	21	22	24	24	36	37	44	-20	-15	-15
Millepora squarrosa	·	★	★	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	·
Millepora alcicornis	★	★	★	★	★	★	★	★	·	·	·	·	·	★	·	·	·	★	·	·
Millepora complanata	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	·	·
Stephanocoenia intersepta	·	·	★	·	★	·	★	★	★	★	·	·	★	·	·	·	·	★	·	·
Madracis asperula	·	★	·	★	★	·	★	·	★	·	·	·	·	·	·	·	·	·	·	·
Acropora cervicornis	·	★	★	★	·	·	·	·	·	·	·	·	·	·	·	·	·	★	★	·
Acropora palmata	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	★	★
Agaricia agaricites	★	★	★	·	★	·	★	★	★	·	★	·	·	★	·	·	·	★	★	·
Porites porites	★	★	★	★	·	★	·	★	·	·	·	·	·	·	·	·	·	★	·	★
Porites astreoides	★	★	★	★	·	★	·	★	·	·	·	·	·	★	·	·	·	★	·	·
Siderastrea radians	★	★	★	★	★	★	★	·	★	·	★	★	★	★	·	·	★	·	★	·
Montastrea annularis	·	·	·	★	★	·	★	·	★	·	·	·	·	·	·	·	·	★	★	·
Montastrea cavernosa	★	★	★	★	★	★	·	·	★	·	★	★	★	★	·	·	·	★	★	·
Solenastrea bournoni	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	·	·	·	·
Diploria clivosa	·	·	·	·	·	·	·	·	·	·	·	★	·	·	·	·	·	★	·	·
Diploria strigosa	·	·	★	★	★	·	·	·	·	·	·	·	★	★	·	·	·	★	★	·
Diploria labyrinthiformis	★	★	★	·	★	★	·	·	·	·	★		★	·	·	·	·	★	·	·
Manicina areolata	★	★	·	·	★	★	★	★	★	★	★	★	·	★	★	·	·	★	★	★
Colpophyllia natans	★	·	★	·	★	★	★	★	★	·	·	★	·	·	·	·	·	★	★	·
Astrangia solitaria	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	·	·
Dendrogyra cylindricus	·	★	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	·	·
Dichocoenia stokesii	★	★	★	·	★	★	★	★	·	·	★	·	★	·	·	·	·	★	★	★
Scolymia lacera	·	·	·	·	·	·	·	·	·	·	·	★	·	·	·	·	·	·	·	·
Mussa angulosa	·	★	·	★	★	·	·	·	★	·	·	·	★	★	·	·	·	·	★	·
Isophyllastrea rigida	·	·	·	·	·	·	★	·	·	·	★	★	·	·	·	·	·	★	★	·
Isophyllia sinuosa	·	★	★	·	★	★	★	·	·	·	·	·	·	★	·	·	·	★	★	★
Mycetophyllia lamarckana	·	★	·	·	★	·	·	★	★	·	·	·	·	·	·	·	·	★	★	·
Eusmilia fastigiata	★	★	·	·	★	·	·	★	·	★	·	·	·	★	·	·	·	·	★	·
Tubastraea tenuilamellosa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	★	·	·
Number of species:	11	17	14	10	16	10	11	10	10	3	7	7	7	10	1	1	1	12	16	5
Total number of species:	22								11		18							26		

S = Saba (stations 114, 153), E = St. Eustatius (station 121), M = St. Martin (stations 120, 122)

5. MISCELLANEOUS OBSERVATIONS

The fauna of the two large windward reefs is dominated by stony corals, but practically everywhere gorgonians are also very common. In some places they form dense stands of different species with but few stony corals in between. As in Acropora cervicornis, the branching colonies always remain relatively low and really large colonies, such as those commonly found in coastal waters, were never encountered.

In the eastern part of the lagoon, stony corals as well as gorgonians are usually present but they are nowhere dominant. In general the fauna is rather rich. In some places algae or sponges can be considered the dominant bottom organisms. In this area the bottom is usually rocky with stones and scattered (mostly dead) coral heads. Sand patches are quite common but the layer of sand is always very thin.

In the western part of the lagoon not only corals, including gorgonians, are virtually absent, but the rest of the fauna is also extremely poor. Most of this area is covered with sand and, in several places, sandwaves, possibly caused by hurricanes, could be recognized, nevertheless, the layer of sediment is rather thin and probably never more than 10-20 cm thick. At most stations the area gave the impression of a desert to the divers and not many animals were encountered. At a few stations there was an algal vegetation of some significance. Although In general the bottom is sandy, trawling proved to be practically impossible because of the still rather numerous outcrops and boulders, as was also experienced by Boeke (1907: p. 145).

Probably much of the sandy sediment in the lagoon is produced by calcareous algae and, in several places, this is particularly evident because the sand particles can still be recognized as segments of Halimeda.

6. GENERAL CONCLUSIONS

It is to be regretted that several of the reef structures on the Saba Bank could not be studied, mainly because we were not aware of their existence when we started our expedition, partly because of technical difficulties and lack of time. However, we do know now that the two large windward reefs over most, or even all, their length carry such a rich reef fauna that reef building processes must be quite active there. We can be sure that structural coral growth occurs also to a greater or lesser extent on the first north reef, the front reefs and at least part of the patch reefs. We do not know anything about the fauna of the southwest, the northwest and the deeper north reefs, but we doubt very much that reef-building of any significance occurs there at the present time. Not only do they have a less favourable leeward position but they are also situated at a considerably greater depth than the other reefs. Moreover, the desert-like environment of the rest of the northwest half of the Saba Bank is not very promising.

7. THE ORIGIN OF THE SABA BANK

The Saba Bank undoubtedly has a volcanic base but, as yet, we have no information on this. We can only say that we did not find rooks of volcanic origin, but did find some black sand, presumably of volcanic origin, on the southwestern part of the Bank. At present its surface seems to consist almost completely of carbonate rook and carbonaceous sediments. Geologists believe that a composite volcanic island is buried under these more recent formations (Westermann and Kiel, 1961: p. 166).

One of the most puzzling aspects of the bank is that it has a remarkably flat top. Vaughan (19191 p. 320) has already written: "What the processes were that caused the leveling of the summits of Saba, Pedro and Rosalind Banks is a matter of pure speculation, but it seems probable that they were subaerial erosion and submarine planation". Davis (1926, p. 137-138) explained the flat top of the Saba Bank by considering it "an atoll-lagoon floor, deprived of its original reef and probably somewhat planed down by low-level abrasion in the last glacial epoch".

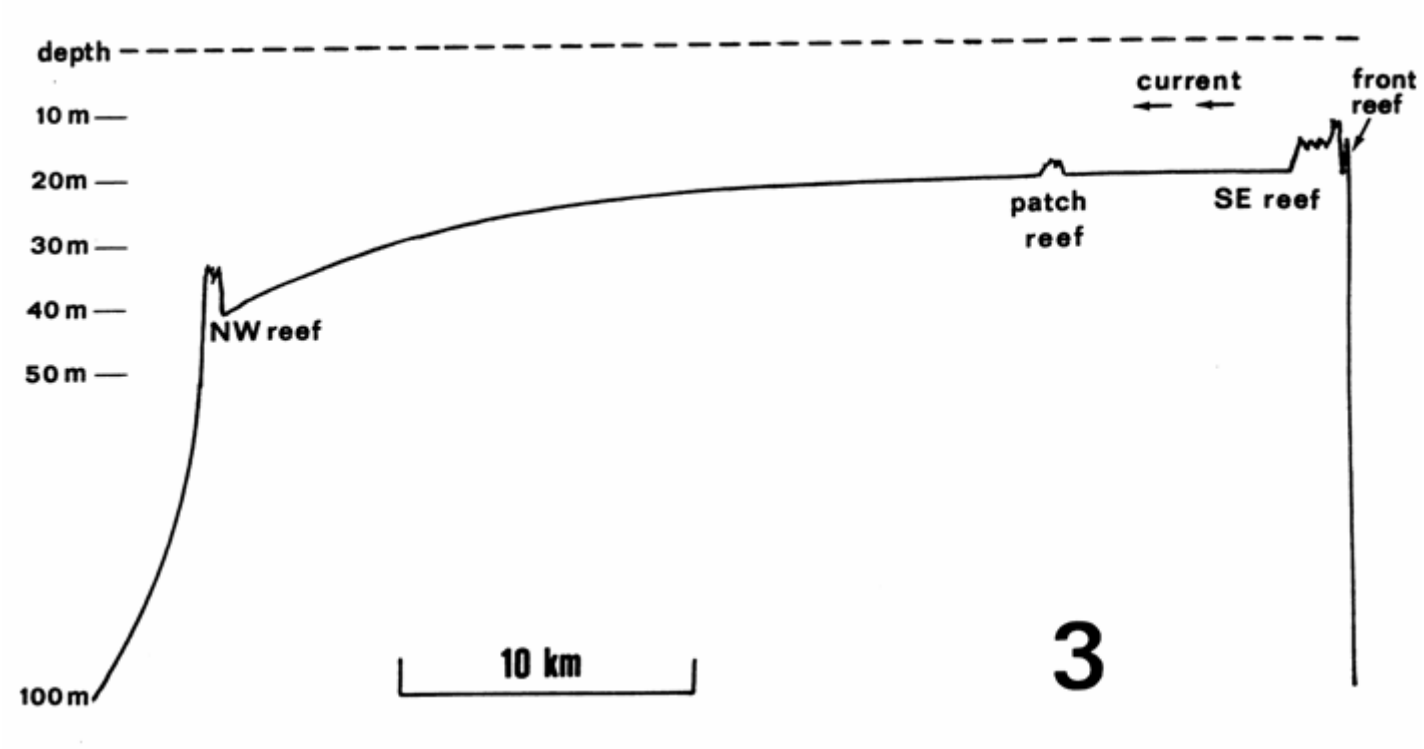

Fig. 3 Diagrammatic cross-section of the Saba Bank in a direction WNW to ESE

Indeed, we can be sure that the Saba Bank was an island during the last glacial period until at least about 5 000 years ago, but it is remarkable that effects of subaerial erosion could not be found. On a former island if this size one expects to find at least some traces of rivers or gullies. It should parenthetically be remarked that all channels between the reefs lie at the sane level as the adjoining lagoon floor. Consequently they cannot be considered drowned rivers or ravines. Perhaps the area was extremely dry during the last glacial epoch.

8. HOLOCENE DEVELOPMENTS

It is evident that all ridges described before must be considered reefs. Their quite irregular surface, their very steep slopes and their sharp summits indicate that they do not date back to the time when the Saba Bank was an island but that they were formed afterwards
(Fig. 3).

So far as we know, luxuriant coral growth is restricted mainly to the two large windward reefs. It waa not unexpected that only a meager growth of reef corals was found on the rest of the bank since most of the food supply must be filtered away by the large windward reefs. The filtering efficiency of a reef can be remarkably high, as was shown by Glynn (1973; 1973a). Over a Porites reef flat he found an efficiency of 91 percent for diatoms and of 60 percent for zooplankton. The filtering effect of the unusually wide reef flats involved here must be considerable. Moreover, a rather large part of the Saba Bank lies too deep. Indeed, constructional coral growth may occur even down to depths of 40 m (Glynn, 1973a: p. 281) but Adey and Burke (1976: p. 108) observed that, in the eastern Caribbean, major bank-barrier systems did not develop on shelves more than 20-25 m deep.

In the lagoon there are large areas of calcareous bedrock, so sedimentation is not a limiting factor for the settlement of corals. In fact many corals have settled there and the number of species is not

significantly lower than on the reef. The colonies just remain small in size and number. As in most other atoll lagoons, constructional coral growth is restricted to small patch reefs.

If the windward reefs have developed during the last 5 000 years (Goreau, 1969: p. 324), as all modern reefs have, the amount of reef accumulation has been considerable in this area. The maximum height of these reefs is 6-12 m above the level of the lagoon, while Milliman (1973: p. 41) reports a reef accumulation of less than 1 m in Florida and less than 7 m in Jamaica. Of course, it must not be excluded that the reefs grew on pre-existing rims, although the presence of such rims cannot easily be explained.

The presence of the front reefs is very difficult to explain. Of course, the presence of a reef along the edge of a terrace is quite normal, but in this case the greater part of the terrace lies at the same depth as the lagoon floor, which means that in most areas the front reef and the large reef must have developed simultaneously. In some areas the base of the front reef lies at a considerably lower level than the base of the large reef and, here, reef formation could start earlier, i.e., before the surface of the island was flooded. Even if parts of these reefs had more than 5 000 years available, their great height (even up to 20 m) is quite remarkable.

The innermost of the north reefs lies at the same level as the windward reefs. The relatively meager coral growth in this area is undoubtedly due to its unfavourable leeward position.

All other reefs lie at a lower level. Their bases lie at a depth of more than 40 m and their tops never reach to a water depth of less than 30 ». In my opinion these reefs started growing when the greater part of the Saba Bank was still an island, i.e., when the seawater was still 20-30 m below the present level. Consequently they originated as leeward fringing reefs. In this situation a considerable reef accumulation in the area can easily be imagined, in the first place because of the shallow water and in the second place because a leeward position off an island often facilitates rather than retards coral growth. The only problem is it is generally accepted that the level of the seawater rose rather rapidly towards the end of the last glacial period and, if this is true, only a cooperatively short time has been available for the development of these reefs.

I find it difficult to relate the terrace and reef base levels with those of platforms in other parts of the Caribbean. According to Goreau (1969: p. 324) drowned reef platforms are often found at -60, -40 and -25 m levels, while Milliman (1973: p. 41) states that 18 and 35 a terraces are present on many islands. Terrace levels on the Saba Bank are too variable to allow sensible comparisons. Moreover some terraces slope gradually over considerable distances.

9. THE ATOLL QUESTION

Vaughan (1919: p. 304) has already suggested that the Saba Bank (and the Rosalind and Pedro Banks) could be compared with atolls by stating "these banks are scientifically of great importance, for, except that the coral growth is not so luxuriant, they essentially duplicate the great atolls in the Pacific". Nevertheless, Bryan (1953) did not mention the Saba Bank in his list of 27 possible Caribbean atolls. Milliman (1973: p. 20) estimated that there are only about ten atolls in the Caribbean and did not include the Saba Bank in his list either. Indeed, until now, the Saba Bank could hardly be called an atoll with certainty because of lack of information. We can now put forward on a firmer basis the question as to whether or not the Saba Bank must be considered an atoll.

On the map presented here (Fig. 2) the Saba Bank shows all the characteristics of a typical atoll; but we have to admit that this map is somewhat misleading because the depth factor is not included. It is still necessary, therefore, to discuss the atoll question in some detail.

Atolls do not have a particular shape and, in fact, the classical circular atoll is comparatively rare (Wiens, 1962). In many atolls the peripheral reefs carry one or more islands, but this is certainly not always the case. In some oases there is a single peripheral reef completely encircling the lagoon, but in most atolls there are one or more channels connecting the lagoon with the open sea. In most Caribbean atolls the lack of leeward peripheral reefs even results in relatively open lagoons (Milliman, 1973: P* 24). Although volcanic activities nearly always have played an important role in the geologic history of atolls, one of the most important characteristics of atolls is the almost complete absence of outside terrigenous influences.

With the preceding rules in mind and comparing the Saba Bank with other Caribbean atolls (described most excellently by Stoddart, 1962, 1971, 1973) we may conclude that it must be considered an atoll. However, we have reason to believe that the leeward reefs, including the southwest reef and the northwest reef, are not now growing significantly and that they should be considered drowned reefs. Consequently they do not belong to the present atoll system. For the same reason, submerged atolls, on which modern coral growth appears to be insignificant, must be considered fossil atolls. Such drowned atolls are particularly common in the Indian Ocean (Stoddart, 1973).

It must be concluded, therefore, that only the eastern and largest part of the Saba Bank can be called a living atoll with an open lagoon, while the western part is a bank with drowned fringing reefs.

Whether the western part is included or not, the Saba Bank ranks among the largest atolls in the world, its surface area being of the same order as those of the Suvadiva Atoll in the Maldives (2 240 km^2; see Stoddart, 1971: p. 7) and Kwajelein in the Marshalls (1,683 km^2; see Wiens, 1962: p. 28). The size of its living reefs is also remarkable. According to Wiens, (1962: p. 113) the width of atoll reefs is usually not more than 500 m, although in the Moluccas, reef widths of 2-2.5 km do occur.

A better knowledge of the Saba Bank would be important, not only for comparative atoll studies of the Caribbean region, but undoubtedly also for a better understanding of the Caribbean reefs in general. Therefore, I hope that our preliminary observations, which, raised rather than answered questions, will be considered a challenge for future, more detailed, research in the area.

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