Coral Reefs and Their Zonation in Netherlands Antilles[1]

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Abstract Although coral reefs are well developed in the Leeward islands of the Netherlands Antilles, they are poorly developed in the Windward group. Coral communities are common in the Dutch Windward islands, but no structural reefs have been observed. Flat, sandy bottoms there seem to prevent reef development, as is also the case on large parts of the southwest coast of Aruba.

The zonation of corals on the reefs, with respect to depth, distance from shore, and conformation to the bottom, resembles that of other Caribbean reefs. Density of living-coral cover ranges in the several zones from nearly zero to almost 100%. Below 20 to 25 m on the forereef slope the corals are areally less abundant than crustose coralline algae. Generic diversity of hermatypic corals is comparable in the Leeward and Windward groups of the Dutch islands, with 24 and 23 genera present, respectively. These numbers are comparable to those of other highly diverse reefs in the Caribbean. The number of species in the Windward group, however, is relatively low. The differences in abundance of coral genera (and species) throughout the Caribbean needs more thorough investigation.

INTRODUCTION

The reefs of the Netherlands Antilles are relatively well studied. Most of the resulting extensive information is available through the journal, *Studies Fauna Curaçao,* and the *Collected Papers Carmabi.* The first note on the stony corals (Scleractinia) was by van der Horst (1927). Roos (1964, 1967, 1971) studied the composition and ecology of the coral fauna of Curaçao and also the coral species of the shallow (<10 m) reefs of the five other islands of the Netherlands Antilles. Scatterday (1974) discussed the leeward reefs of Bonaire. Van den Hoek et al (1975) described the algal and coral composition of a transect running from the shore to a depth of 20 m on the southwest coast of Curaçao. A general description of shallow and deep reefs of all six islands (to a depth of 90 m in Curaçao), together with aspects of their ecology and distribution of coral species, is given by Bak (1975).

The data presented here are the first quantitative data on the composition of the coral community to a depth of 40 m.

REGIONAL SETTING[3]

The Netherlands Antilles comprises six main islands (Fig. 1). The Leeward group is formed by the islands Aruba (1) Curaçao (2), and Bonaire (3). The Windward group, 900 km from the Leeward group, consists of St. Maarten (4; the southern half of St. Martin), St. Eustatius (5), and Saba (6). The Windward islands are part of the arc of the Lesser Antilles. Their location is between lats. 17°27′N and 18°08′N and longs. 62°56′W and 63°16′W. No extensive reefs are known from the Windward group, but the most exposed coasts of the Windward islands are virtually unexplored. The Saba

[3] *Editors' note:* In referring to the Leeward and Windward islands or groups of the Netherlands Antilles, we have used lower case to differentiate these from the Leeward and Windward Islands of the Lesser Antilles. The islands of Aruba, Curaçao, and Bonaire are referred to as the "Leeward" group in the Netherlands Antilles, whereas they lie geographically within the Windward Islands of the Lesser Antilles. Likewise, St. Martin, St. Eustatius, and Saba are referred to by the Dutch as the "Windward" group, although they lie geographically within the Leeward Islands of the Lesser Antilles.

Bank, an extensive area of approximately 2,000 km², ranging in depth from 7 to 50 m, has extensive coral reefs on the southern and eastern margins (van der Land, personal commun.).

The Leeward group of islands is situated off the coast of Venezuela, between lats. 12°00'N and 12°40'N and longs. 68°12'W and 70°04'W. These islands all have flourishing coral reefs. Curaçao, the island on which most reef studies have concentrated, lies at a distance of approximately 70 km from the coast of the mainland. The greatest depth of the sea between the island and mainland is about 1,350 m. The maximum depth between Curaçao and Bonaire is 1,700 m, and between Curaçao and Aruba, 1,400 m. Although Curaçao and Bonaire are oceanic islands, Aruba is situated on the continental shelf. Around Curaçao and Bonaire the 200-m isobath lies about 1 km off the coast. The same is true only for the northeast coast of Aruba. Coral growth on the southwest coast of Aruba is limited to shallower depths than on the other two islands, because a sandy bottom at maximum depths of 20 to 30 m obstructs the formation of coral reefs (Bak, 1975). The longitudinal axes of these islands run roughly from southeast to northwest. The eastern trade wind has a normal velocity of 7.2 m/sec and a very high persistency of more than 96%. This causes large differences between the exposed northeast coasts and the sheltered southwest coasts. Occasionally strong gales, commonly the accompaniment of hurricanes passing north of the Leeward group, cause heavy damage in the shallow parts of the reefs of the southwest coasts (de Buisonjé, 1974; Bak, 1975). The mean tidal range is about 30 cm (maximum 55 cm). Superimposed is a yearly oscillation of about 15 cm of the mean tide level (de Haan and Zaneveld, 1959). There is usually a northwest current along the southwest coast of Curaçao with a velocity rarely exceeding 1 knot. Although the direction of the main current is highly predictable, the formation of eddies along the coast distorts this general pattern. The current on the northeast coast, as well as the currents around the tips of the island, can be much stronger than the current on the southwest coast. The salinity of the coastal zone varies between 34.4 and 36.0 °/oo S (de Kock and de Wilde, 1964).

DESCRIPTION OF REEFS

Development of coral reefs around the islands of the Windward group is poor. These islands are almost surrounded by shallow, flat sandy bottoms that slope gently to great depth. In more exposed areas *Acropora palmata* can form shallow reefs, but other than this, the corals occur scattered on the bottoms and on large boulders that are present locally. Wherever steep slopes occur, the corals are more densely packed, but they never attain the status of a coral-reef community in the sense of Wainwright (1965). The gentle sandy bottoms and the paucity of slope breaks doubtless account for the absence of true reefs, for Goreau and Wells (1967) and Porter (1972b) have both called attention to the stimulating effect upon reefs of slope breaks and terrace edges.

Among the reefs of the Leeward group, those of the southwest coasts of Curaçao and Bonaire generally have a common profile (Fig. 3). The main features are: (1) a submarine terrace stretching across a distance of 50 to 100 m from the coast to where there is an 8 to 12 m drop-off, and (2) a steep slope from the drop-off to a depth of 50 to 60 m. Over this terrace and slope the most prolific coral growth is found (Figs. 4-6). Individual colonies do penetrate deeper and are found on a second drop-off at 80 m (Bak, 1975). This second drop-off is separated from the steep slope by a sediment-covered terrace. Variations of this general model occur according to differences in the geomorphology of the nearby shore (beach, bedrock, or cliff), the width of the terrace, and the steepness of the submarine slope. No such drop-off occurs on the southwest coast of Aruba, where a sandy, sloping bottom impedes reef growth.

The northeast coasts of these islands have steep shore cliffs and very rough seas that make access to them difficult, but the general submarine morphology described for the sheltered coasts also seems applicable to the windward coasts. Nevertheless, the impact of the heavy surge and strong currents have important consequences for the

presence and growth form of reef organisms. Large parts of the reef terrace on the exposed coast are densely covered with the brown alga *Sargassum platycarpum.* Generally, the area on and below the drop-off has abundant coral growth. In places the algal fields stretch over the drop-off down to the sediment plain at 40 m. Elsewhere on the same coast, hermatypic corals and *Millepora* species cover the terrace as well as the slope. The growth form of the corals is adjusted to the high wave energy and the currents.

ZONATION OF CORALS

Previous Work

Despite the abundant literature on Caribbean coral reefs, few quantitative data are available concerning the distribution of hermatypic corals. A large part of the descriptions of the coral reefs is restricted to depths less than 15 m (Goreau, 1959; Scheer, 1960; Kornicker and Boyd, 1962; Storr, 1964; Kissling, 1965; Adams, 1968; Macintyre, 1968; Pressick, 1970; Kühlman, 1971, 1974a, b; Roos, 1971; Roberts, 1972). Studies of the deeper parts of the reefs include those by Lewis (1960), Roos (1964), Lang (1970), Porter (1972a), Goreau and Wells (1967), Scatterday (1974), Bak (1975), and Ott (1975). Goreau and Goreau (1973) explored as deep as 100 m. Recently, by using submersibles, the deep base of the reefs and the lower limit of coral growth have been studied more extensively (Ginsburg and James, 1973; Hartman, 1973; Porter, 1973; Lang, 1974).

Students of coral distribution and reef zonation typically report their observations or count the species within successive quadrats. Quantitative coral-reef studies use methods that are phytosociological in origin. The rating system of Braun-Blanquet has been used extensively in reef surveys (e.g., Scheer, 1967, 1971, 1974; Barnes et al, 1971; Nagelkerken, 1974; Vasseur, 1974; van den Hoek et al, 1975). Loya (1972) and Loya and Slobodkin (1971) used line-transect techniques to describe coral zonation in the Red Sea. This method has not been used to quantify coral distribution in the Caribbean. Porter (1972b), while employing line transects in the San Blas Islands, concentrated on diversity patterns rather than coral zonation.

Counting and Survey Methods

This study is part of a more extensive investigation in the zonation of reef organisms. The Braun-Blanquet method was chosen by van den Hoek et al (1975) for use
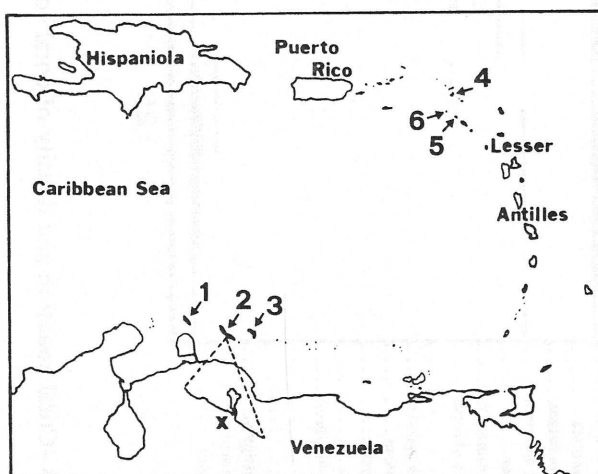

FIG. 1—Index map of islands of Netherlands Antilles. Leeward group consists of Aruba (1), Curaçao (2), and Bonaire (3). Windward group includes St. Martin (4), St. Eustatius (5), and Saba (6). Piscadera Bay, on southwest coast of Curaçao, near site of transects 1 and 2, is indicated by "x."
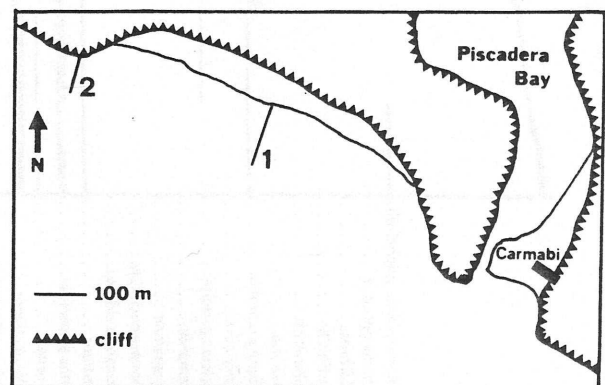

FIG. 2—Location of study area in vicinity of Piscadera Bay, Curaçao. Positions of transects 1 and 2, respectively, in front of a shingle beach and a limestone cliff, are shown.
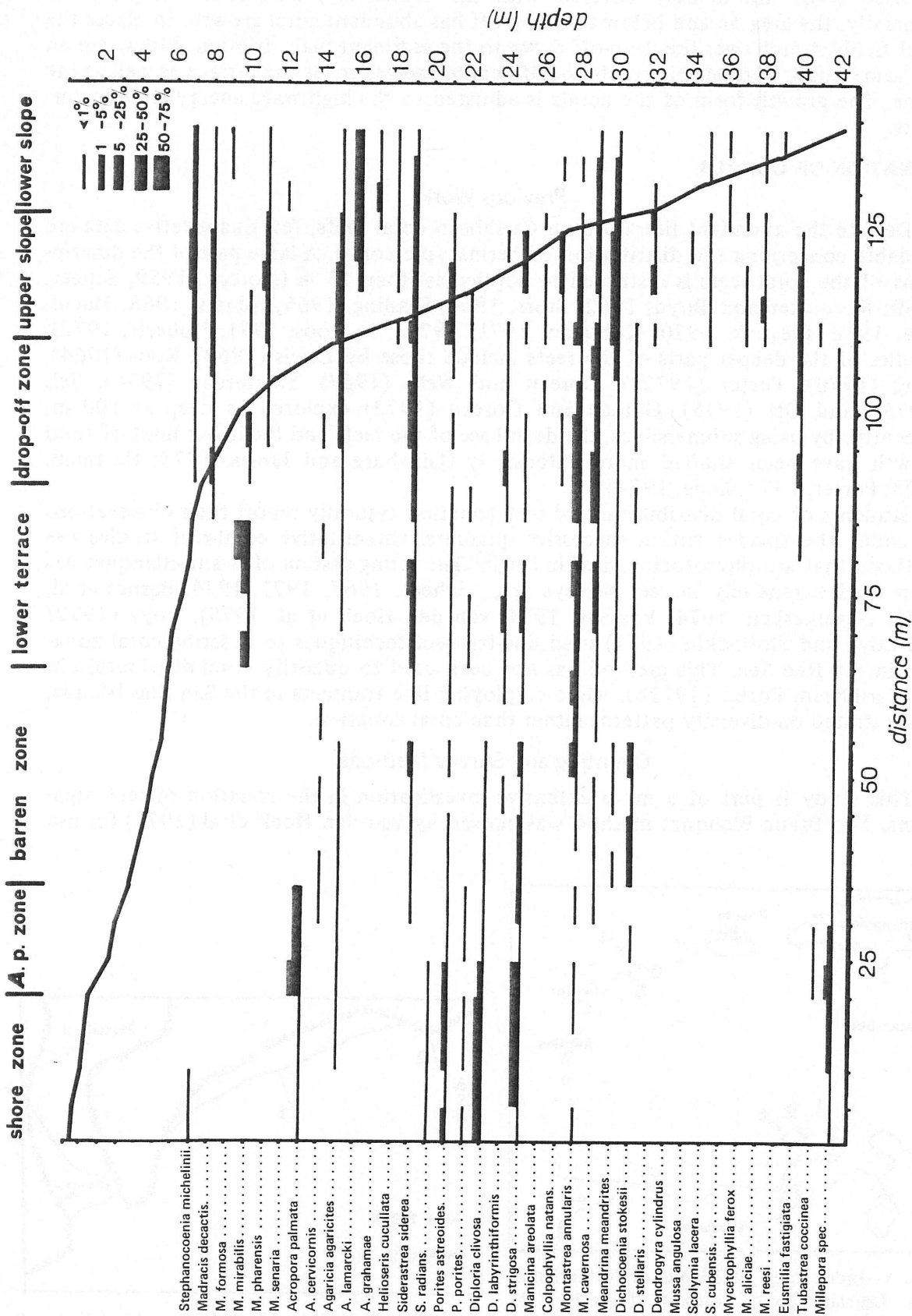
FIG. 3 —Coral zonation and density of coral cover along transect 1, normal to shore at a point 600 m northwest of Piscadera Bay (see Fig. 2).
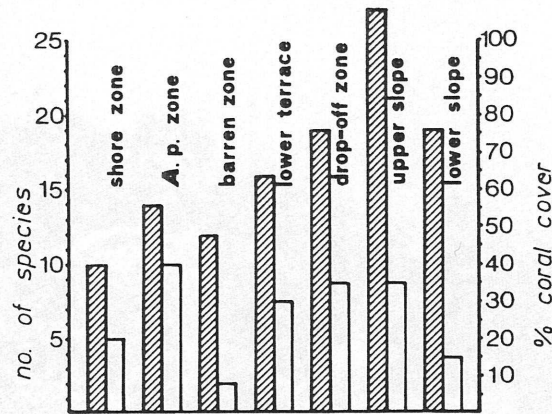
FIG. 4—Percentage of coral cover per unit area (empty bars) and number of species of coral per reef zone (shaded bars) on transect 1.

with reef algae because of their patchy distribution and small size. It was well suited to the present task also. The scale of abundance (density of cover) was modified slightly, as follows: +, present, but covering less than 1% of quadrat surface; 1, quadrat cover is 1 to 5%; 2, quadrat cover is 5 to 25%; 3, quadrat cover is 25 to 50%; 4, quadrat cover is 50 to 75%; 5, quadrat cover is 75 to 100%. The difficulties encountered when trying to identify separate corals from single coral colonies excluded the use of a sociability classification. Only hermatypic corals were included in the data, with the exception of the ahermatypic *Tubastrea coccinea* which is very conspicuous in the field. The *Millepora* were not distinguished at the species level owing to the difficulties in identifying the encrusting colonies in the deeper reef.

On the southwest coast of Curaçao, two lines with 5-m markings were run from the shore to a depth of 40 m (Fig. 2). Along each line, continuous 5-by-5 m quadrats were studied. Transect 1 (Figs. 2, 3) is 600 m northwest of the mouth of Piscadera Bay. It was run from a shingle beach, across a terrace 100 m wide, to the drop-off. In the middle of the terrace, the scattered coral colonies are surrounded by loose rippled sand. The slope over the drop-off makes an angle of about 45° with the horizontal. Down the sloping face the sand cover increases, although the grain size decreases with depth. The slope ends in another inclined terrace covered with fine sediment and some outcrops at a depth of 60 m.

The second transect (Figs. 2, 9), 1 km northwest of the mouth of Piscadera Bay, is in front of a small cape. This is a more exposed location than transect 1. The shore is a limestone cliff that drops to the submarine terrace at a depth of 1.5 m. This terrace has a width of 45 m. Owing to its exposure to waves and currents, little loose sand is present. In the low algal turf, a thin layer of sediment is trapped. From the drop-off at 9 m, there is a vertical dip to 20 m. From 20 to 40 m depth, the angle of the slope varies between 40 and 60° with the horizontal. Below 45 m the slope lessens to about 25° and continues to deeper water (> 75 m). This transect runs over a coral promontory separated from similar structures on each side by chutes containing rivers of sediment that fan out at greater depth, so that at 50 m most of the hard subtrate is covered with sediment. On the promontory itself very little loose sediment is present.

Observations and Coral Zonation

The profile of transect 1 and its cover of hermatypic corals are shown in Figure 3. The number of species and the density of living-coral cover of each zone are shown in Figure 4. Transect 1 approximates the most general picture of the southwest coastal reefs. It is divisible into seven zones (Fig. 3).

The *shore zone* is in shallow water and is characterized by the abundance of colonies of *Diploria. D. clivosa*, an encrusting species adapted to vigorous motion of the water, is almost confined to this zone.
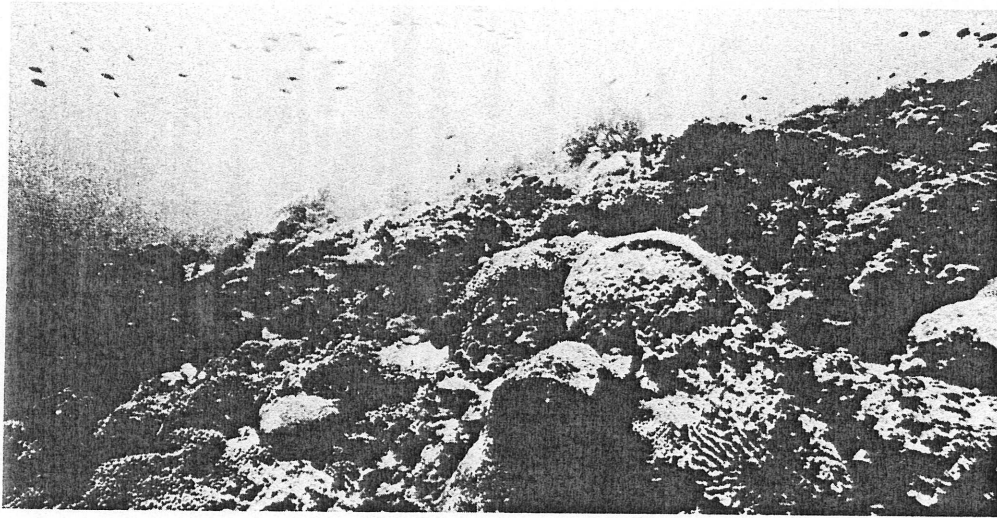
FIG. 5—Coral growth is prolific on bottom in lower-terrace zone where it slopes toward drop-off zone. Scuba diver left of center gives scale.

Next seaward is the *Acropora palmata zone*, which is dominated by dense stands of this heavy, branching coral. This coral is an extraordinarily fast calcifier that can produce up to about 10^5 g $CaCO_3/m^2$/year (Bak, 1976). This fast growth is an important adaptive value in an area where destruction of colonies and break-off due to storms are common. *Acropora palmata* is usually confined to this zone on coral reefs. It is likely that one of the factors which prevents a wider distribution of *Acropora palmata* into deeper water is that this species is unable to clean itself of sediment (Bak and Elgershuizen, in press) and depends on water movement to be cleaned. Species characteristic of shallow, rough-water conditions, such as *Siderastrea radians* and *Diploria clivosa*, hardly penetrate past the *Acropora palmata* zone to the deeper reef. In this zone, *Millepora* species and crustose coralline algae, especially *Porolithon pachydermum*, are important calcifying organisms. Apart from the harsh physical conditions that influence settlement and subsequent survival of sessile organisms on the shallow reef, the impact of biologic factors, such as grazing and predation by the sea urchin *Diadema antillarum*, is very important (Bak and van Eys, 1975).

Seaward of the *Acropora palmata* zone the seafloor consists in large part of unconsolidated coral and algal fragments. As in the shallower reef, crustose coralline algae are important as cementers of loose, hard material. This *barren zone*—so-called because of the patchy, dispersed animal cover—nevertheless has a fair number of coral species. Gorgonians (e.g., *Pseudopterogorgia acerosa* and *P. americana*) are common.

The topography and biotic communities of the barren zone grade to the *lower-terrace zone*, wherein the number of species and the density of the coral cover both increase (Figs. 3, 4). *Madracis mirabilis* is very abundant in places and grows in almost monospecific fields. Due to its relatively rapid calcifying (Bak, 1976) and because the skeletons are buried in situ, these fields form large mounds rising above the general profile of the zone.

Coral cover is very high in the area of the *drop-off zone* (Figs. 3, 5). Down to this depth (8 to 12 m) the light intensity decreases abruptly and it is only 25 to 30% of surface illumination in the drop-off area (G. van Buurt, personal commun.). Some species of the deeper reef penetrate this zone, thus increasing the coral diversity compared with other parts of the terrace (Fig. 4). *Montastrea annularis, M. cavernosa,* and *Siderastrea siderea* cover significant parts of the bottom. *Agaricia agaricites*, although present in shallower water, becomes abundant here.

Below the drop-off zone is the *upper-slope zone*. As light intensity decreases, another agaricid besides *Agaricia agaricites—A. lamarcki*—becomes suddenly prominent in the coral community. This zone extends from about the 15 to 30 m depth, and is the lower limit of occurrence of many coral species. In addition, many species (e.g.,
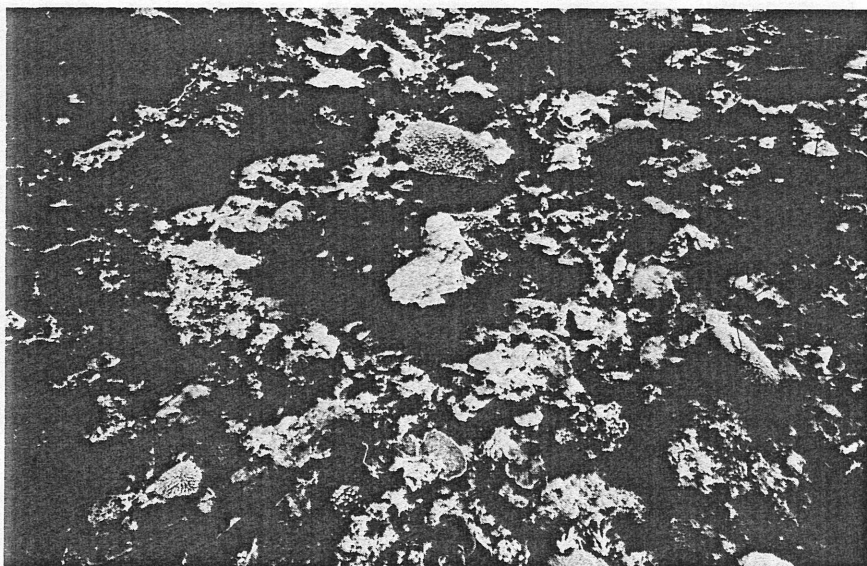
FIG. 6--At 20-m depth in upper-slope zone on transect 1, coral species typical of both shallower and deep parts of reef occur together. Mixture produces most diverse coral community of reef, as well as abundant coral cover. This picture and Figures 7 and 8 were taken near transect 1, with a 15-mm U-W Nikkon lens.

mussids) that are typical of the deep reef appear here. This results in the most diverse coral community of the reef (Figs. 4, 6).

In the deeper water of the *lower-slope zone* (Figs. 4, 7), both the number of species and amount of coral cover decline. *A. agaricites* is almost completely replaced by *A. lamarcki* and *A. grahamae*. Corals characteristic of deep reefs, such as *Madracis formosa* and *Mycetophyllia reesi*, occur. The corals at these depths are mostly flattened and encrusting. Though most colonies are small, some species grow to large size; *A. lamarcki*, especially, forms very large encrusting sheets.

Over the whole of the slope, coral cover decreases and the amount of sediment increases (Figs. 6 - 8). The composition of the sediment is diverse, the main component
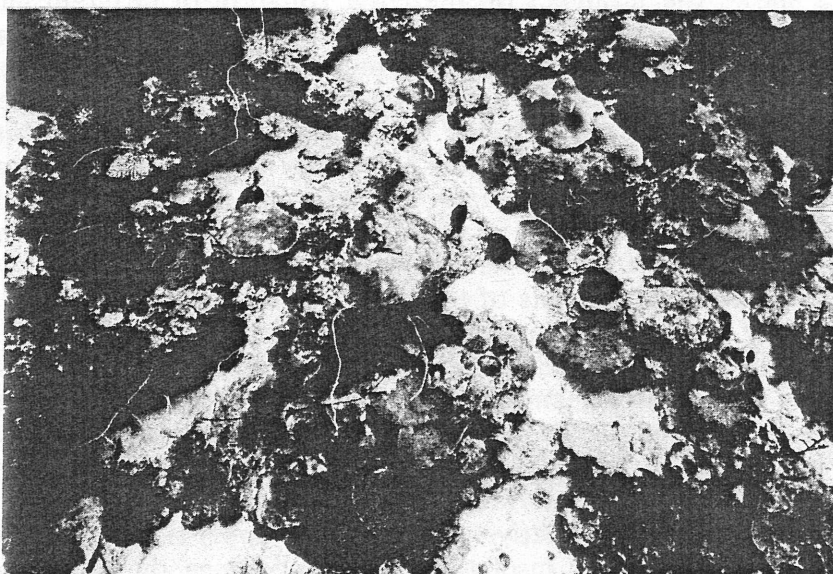

FIG. 7—At 30-m depth, near boundary of upper-slope and lower-slope zones, coral cover thins and amount of loose sediment increases. *Meandrina meandrites*, *Stephanocoenia michelinii*, and *Agaricia lamarcki* are abundant. The latter replaces *A. agaricites* as most important agaricid in the deep-reef habitat. Thin wiry filaments are Antipatharia.
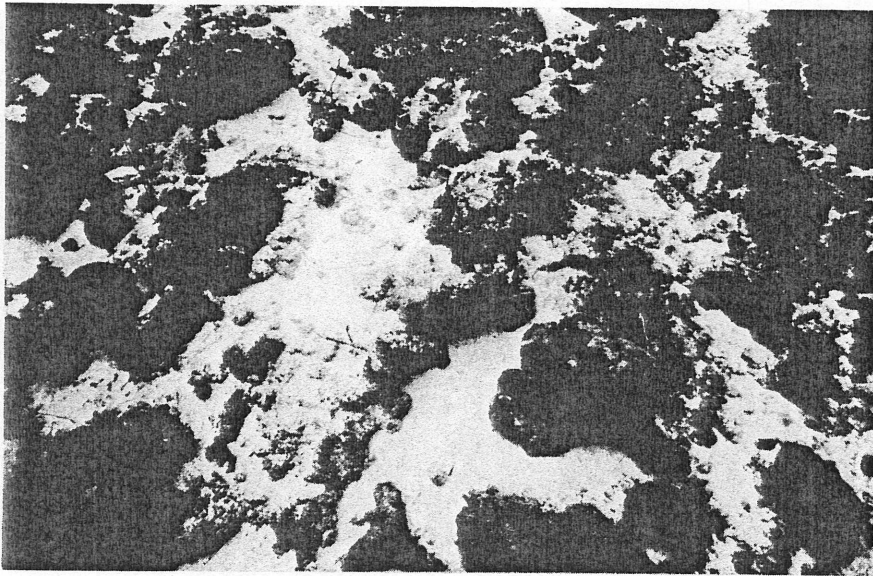
FIG. 8—At 40 m, in lower-slope zone of transect 1, coral cover is much reduced and major parts of slope become covered with sediment. In other parts of reef, where less sediment is present, coral cover may be twice as dense. All rocky outcrops without coral growth are coated with crustose coralline algae. Note abundance of sponges.

being coral debris. The second terrace (at 60 m) is covered with fine sediment which limits the growth of corals to a few rocky outcrops. Where hard substrates are available, hermatypic corals continue to grow to depths of at least 80 m (Bak, 1975).

Apart from corals, crustose coralline algae (Corallinaceae) are important as calcifying organisms on the reef. In shallow water, *Porolithon pachydermum*, together with *Acropora palmata* and *Millepora* species, builds structures up to 2 m high. The cover of crustose coralline algae is very short on the shallow terrace, but becomes significant again in the slope zones of the reef. The most important species there are *Hydrolithon boergesenii* and *Archeolithothamnion dimotum*. On the lower slope, the Corallinaceae cover 40 to 50% of the bottom compared with a coral cover of 10 to 20%. The deep second drop-off at 70 to 90 m is also heavily coated with these algae.

Transect 2 shows the influence on the coral zonation of different environmental factors. On the very short and exposed terrace, the four zones are compressed and partly overlap. For this reason no zonation is indicated in Figure 9 and species number and coral cover along this transect are shown per quadrat (Fig. 10). The shore zone and the *Acropora palmata* zone overlap completely. The *Acropora* colonies directly below the sea cliffs are partly encrusting and partly plate shaped in response to the force of the water. The encrusting *Diploria clivosa* and the hemispherical *D. strigosa* are firmly cemented to the bottom, as are *Siderastrea radians* and *S. siderea*. The small number of species present in these shallow waters contrasts with nearly twice as many observed in the shallowest quadrats of transect 1, where the quieter water permitted a greater diversity of occupants (cf Figs. 4, 10). Coral cover per unit area, however, is much higher in the more turbulent conditions of transect 2 (Fig. 10). Because of the absence of loose sand in any quantity at shallow and intermediate depths on the terrace, the coral cover does not drop dramatically and the barren zone is not clearly developed (Fig. 10). As in transect 1, both the coral cover and the number of species increase with depth on the lower terrace. The drop-off zone is very narrow because the drop-off is abrupt and, at 8 m, relatively shallow. The upper-slope zone in transect 2 is partly vertical; this so reduces insolation as to encourage the growth of *Madracis formosa* and *Agaricia lamarcki*. In the lower part of this zone and in the lower-slope zone, the profile of this transect resembles that of transect 1. However, because transect 2 is over a coral promontory, with sediment chutes on each side, much less loose sediment is present and this appears to favor the growth of sessile calcifiers.
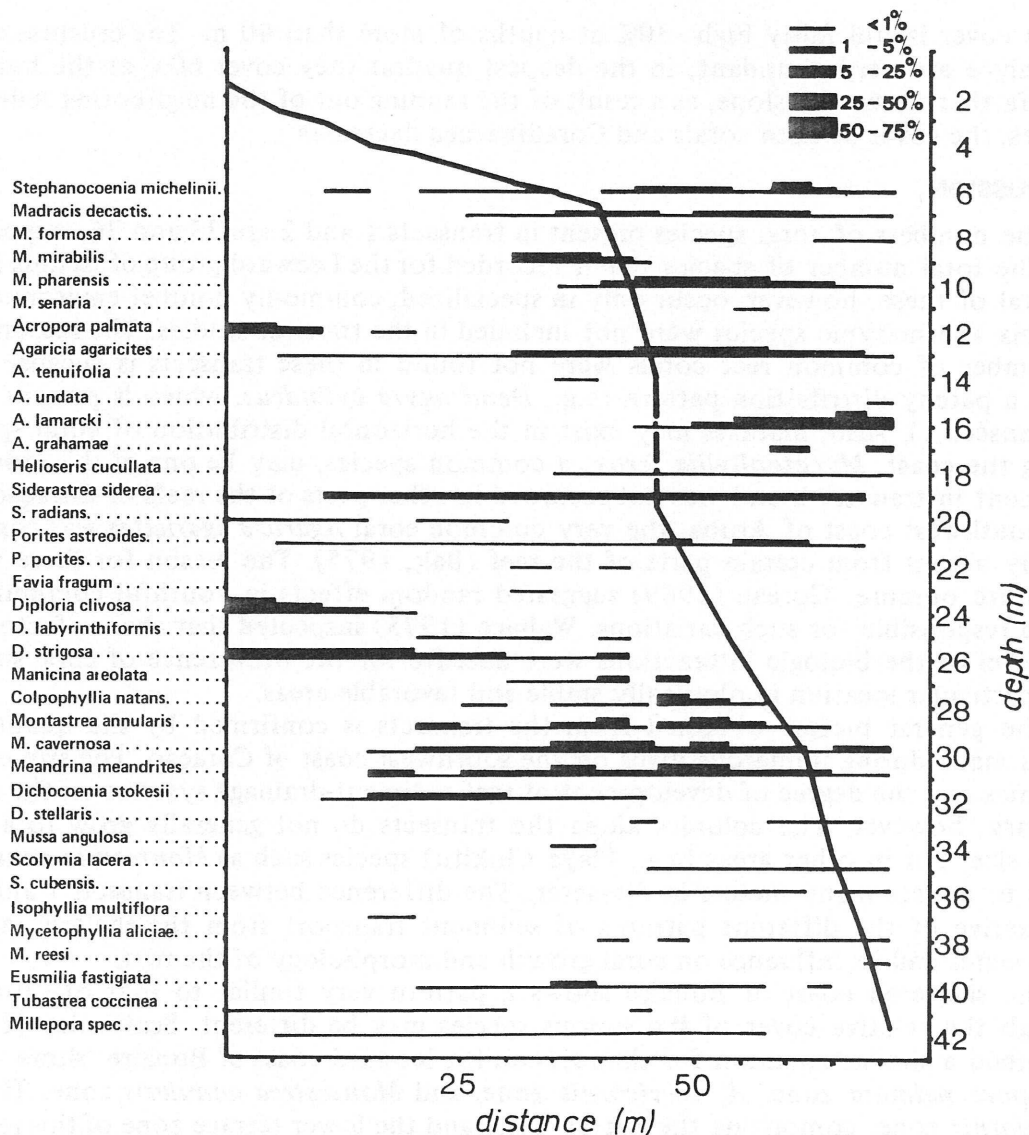
FIG. 9—Coral cover along transect 2, normal to shore, 1 km northwest of mouth of Piscadera Bay (cf Fig. 2). Presence or absence of species on vertical wall is indicated, respectively, by uninterrupted and interrupted lines. *Madracis formosa* is represented by a dot. Compare with Figure 3, and note how steeper, more rugged profile compresses coral zones laterally.
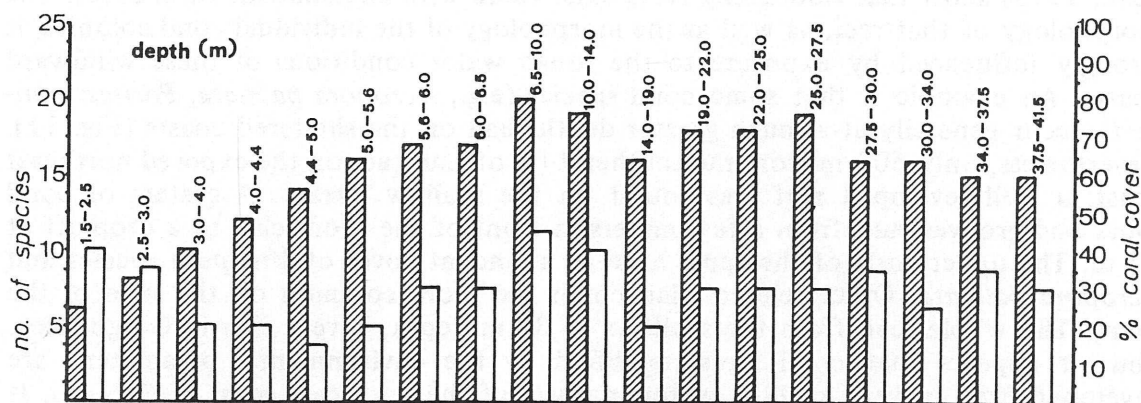

FIG. 10—Percentage of coral cover per unit area (empty bars) and number of species of coral per quadrat (shaded bars) on transect 2. Depth of quadrats is shown. Coral cover nowhere falls below 15% and is still abundant in deepest quadrat. Note effect of vertical dip on both number of species and cover. In this quadrat coralline algae are abundant.

Coral cover is still fairly high—30% at depths of more than 40 m. The crustose coral-line algae are very abundant; in the deepest quadrat they cover 60% of the bottom. Still farther down the slope, as a result of the fanning out of the neighboring sediment chutes, the cover of both corals and Corallinacaea decreases.

DISCUSSION

The numbers of coral species present in transects 1 and 2 are 35 and 36, respectively. The total number of species that I recorded for the Leeward group of islands is 57. Several of these, however, occur only in specialized, commonly nonreef environments, and six ahermatypic species were not included in the transect studies. The reason that a number of common reef corals were not found in these transects is because they have a patchy distribution pattern (e.g., *Dendrogyra cylindrus*, which is present only in transect 1). Also, hiatuses may exist in the horizontal distribution of coral species along the coast. *Mycetophyllia ferox*, a common species, may be one of this group; it is absent in transect 2 and was not recorded in other parts of the reefs of Curaçao. On the southwest coast of Aruba, the very common coral *Agaricia agaricites* was conspicuously absent from certain parts of the reef (Bak, 1975). The reason for these variations are obscure. Goreau (1969) suggested random effects in youthful communities to be responsible for such variations. Wallace (1975) suspected that chance factors on the level of the biologic interactions were decisive for the occurrence of coral species in a particular location in physically stable and favorable areas.

The general picture obtained from the transects is confirmed by the qualitative notes made during numerous dives on the southwest coast of Curaçao. The size of the colonies and the degree of development of reef sediment-drainage systems on the slope do vary, however. The colonies along the transects do not generally grow to a very large size, but in other areas (e.g., Playa Chikitu) species such as *Montastrea annularis* grow to masses many meters in diameter. The difference between transects 1 and 2 is illustrative of the different patterns of sediment transport from the shallow reef to deep water and its influence on coral growth and morphology of the reef.

The sheltered coast of Bonaire shows a pattern very similar to that of Curaçao, though the relative cover of the various species may be different. Scatterday (1974) described a similar zonation for the reefs on the leeward coast of Bonaire: shore zone, *Acropora palmata* zone, *A. cervicornis* zone, and *Montastrea annularis* zone. The *A. cervicornis* zone, comprising the barren zone and the lower terrace zone of this report, is also found on parts of the leeward coast of Curaçao (Roos, 1971). As mentioned, the sea bottom and slope of the sheltered coast of Aruba are different and coral reefs are either absent or different in morphology and species composition (Roos, 1971; Bak, 1975).

The northeast coasts of both the Leeward and the Windward islands have hardly been studied, because of their inaccessibility. The data available so far for Curaçao (Bak, 1975) show that flourishing reefs exist there with an abundant coral cover. The morphology of that reef, as well as the morphology of the individual coral colonies, is strongly influenced by exposure to the rough water conditions of these windward coasts. An example is that some coral species (e.g., *Acropora palmata, Porites branneri*) occur generally at a much greater depth than on the sheltered coasts (Fig. 11). Nevertheless, only 500 m from the southeast tip of Curaçao, on the exposed northeast coast, a well-developed reef was found on the shallow terrace. A system of coral spurs and grooves runs from a few meters in front of the shore cliff to a drop-off at 10 m. The upper parts of the spurs have an abundant cover of *Millepora* species and *Acropora palmata*. Other scleractinian corals are more common on the sides of the spurs. The whole reef, from the shallows to 30 m depth, is very rich in Gorgonacea. Thus it appears that coral reefs, modified by the environmental parameters, are developed even in very shallow water in parts of the northeast coast of Curaçao. It is reasonable to assume that coral reefs occur similarly along the exposed coasts of Aruba and Bonaire.
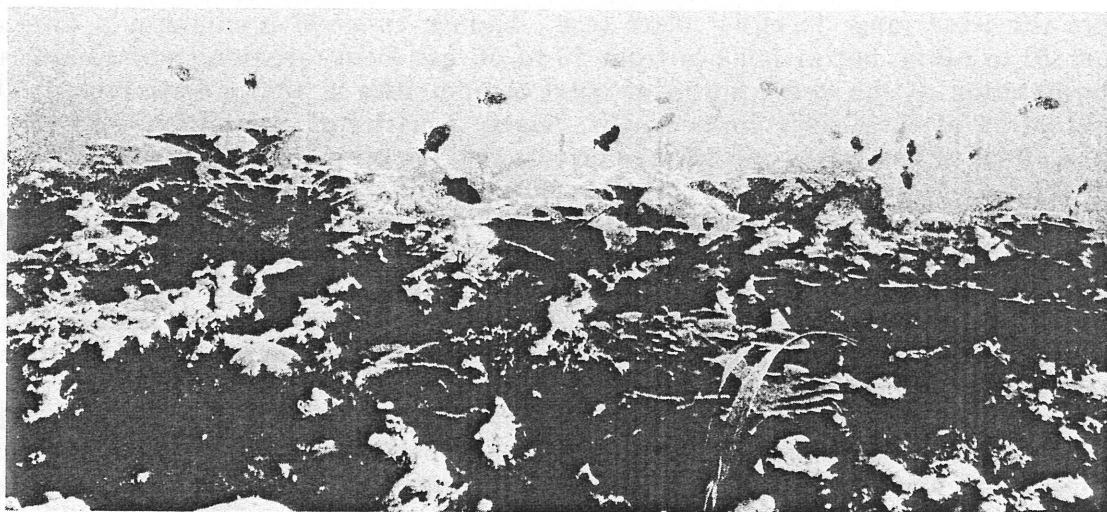
FIG. 11—At exposed northwest coast of Curaçao, most-abundant growth of *Acropora palmata* is at much greater depth than at leeward coast. At drop-off (depth, 12 m), *A. palmata* intermingles with gorgonians, crustose coralline algae, and patches of the large brown alga *Sargassum platycarpum. A. palmata* colonies in center are about 2 m across.

Coral reefs of the Netherlands Antilles may be compared with those reported from other localities in the Caribbean Sea. The morphology of reefs is varied, and the form does affect the details of zonation. Nevertheless, all have many features in common. Most reefs have a shallow *Acropora palmata* zone and a deeper-water zone of mixed coral growth in which *Montastrea annularis* commonly is the dominant species. The establishment of other zones between these two coral communities depends on the depth and slope of the bottom, the presence of sediment, and the degree of exposure to waves and currents. The zonation deeper than the mixed *M. annularis* - dominated zone depends strongly on the morphology of the seafloor: steep slopes favor the development of coral reefs; sandy bottoms obstruct reef formation.

Quantitative data on the distribution of other coral reefs to greater depths, including recently described coral species (Wells, 1973a, b), are scarce. Goreau and Goreau (1973) presented an extensive description of the north-coast reefs of Jamaica which, although probably also based on "observations," represents a vast knowledge of a thoroughly studied reef system. It appears that the zonation of the reefs on the southwest coast of Curaçao and the north coast of Jamaica is roughly comparable. An *Acropora palmata* zone and a barren zone are present in both localities; the mixed and buttress zones of Jamaica are represented in Curaçao by the lower-terrace and upper drop-off zones. The buttress zone appears not to be invariably present in the Jamaican reefs. In Curaçao, buttresses are present in only a few parts of the explored coast (e.g., at Kaap Malmeeuw, northeast Oostpunt) in relatively exposed spots. In Curaçao there is no equivalent of the Jamaican sediment terrace, which separates the deeper from the shallower reef. The Jamaican deeper reef—the forereef—is represented in Curacao by the steep slope seaward of the drop-off (the upper-slope and lower-slope zones of this report; Figs. 3, 6, 7, 8). This slope in Curaçao has a more extensive depth range from 10 to 60 m.

Though the general distribution of corals, with regard to habitat and depth range, shows very similar patterns in Jamaica and Curaçao, there are important differences. These mainly concern the depth range and the abundance at a particular depth. It appears that a number of species (1) reach their greatest abundance considerably deeper on Jamaican reefs (e.g., *Madracis mirabilis, Acropora cervicornis, Agaricia agaricites, Eusmilia fastigiata*); (2) extend to greater depths in Jamaica (e.g., *Siderastrea radians, Diploria labyrinthiformes, Dichocoenia stokesii, Mycetophyllia ferox*); (3) extend into shallower depth at Curaçao (e.g., *Mycetophyllia aliciae*); or (4) have a

more restricted range in either place (e.g., *Agaricia lamarcki* is common in Curaçao from 20 to 60 m, but in Jamaica from 50 to 60 m). Such variations may complicate interpretation of the composition of coral communities in the geologic record. The explanation of these differences remains largely a matter of speculation. Probably it is the effect of the waves and strong currents that are prominent to greater depths on the exposed Jamaican coasts. The difference in depth range of some coral species between the exposed and sheltered coasts in Curaçao supports this hypothesis. The factor that presumably enables the Jamaican corals to reach greater depth is the availability of hard substrates in very deep water. A possible important variable is water clarity; however, as corals (e.g., *Stephanocoenia michelinii*, *Agaricia undata*, *Montastrea cavernosa*) grow at the second drop-off in Curaçao up to a depth of 90 m, this factor may not be limiting.

The number of coral species and genera that is present in the Leeward group of the Netherlands Antilles indicates that these islands belong to the Caribbean diversity center (Stehli and Wells, 1971). Species lists of hermatypic corals (classification based on concepts of Wells and Lang, 1973) give 48 species (Goreau and Goreau, 1973) and 50 species (Wells and Lang, 1973) for Jamaica; 49 species for the Caribbean coast of Panama (Porter, 1972a); 42 species for Bonaire (Scatterday, 1974); and 50 species for Curaçao (Bak, 1975). The similarity between communities at these locations is even more evident when generic lists are compared: Jamaica, 24; Panama, 23; Bonaire, 22; and Curaçao, 24. When the corals of the Leeward group are compared with those of the Windward group, it appears that the number of genera is about the same—23 genera being present in the Windward islands. The number of species in the Windward group is much smaller, however: 33 hermatypic coral species versus 50 in the Leeward group. This is presumably largely the effect of adverse bottom conditions. All species characteristic of the deep reef are absent in the Windward group.

There is, however, another striking feature about the composition of the coral community in the Windward group. This is the abundance of specimens of the genera *Isophyllia* and *Isophyllastrea*. These corals, rare in Curaçao and the other Leeward islands, are among the most common species in the Windward group. Though there is no doubt that the corals of the Caribbean are part of a widespread fauna, the distribution of which depends on a complex set of environmental factors, the possible trends in species abundance should receive more attention than has been done so far.

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