VERHANDELINGEN DER KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN, AFD. NATUURKUNDE

TWEEDE REEKS, DEEL 61. No. 2

ALGAL VEGETATION-TYPES ALONG THE SHORES OF INNER BAYS AND LAGOONS OF CURAÇAO, AND OF THE LAGOON LAC (BONAIRE), NETHERLANDS ANTILLES

C. VAN DEN HOEK, F. COLIJN, A. M. CORTEL-BREEMAN
and J. B. W. WANDERS

NORTH-HOLLAND PUBLISHING COMPANY - AMSTERDAM, LONDON - 1972

ISBN 72048235 6

LIBRARY OF CONGRESS
CATALOGUE CARD NUMBER: 72–83527

AANGEBODEN: DECEMBER 1971

AANVAARD: MAART 1972

GEPUBLICEERD: SEPTEMBER 1972

1. INTRODUCTION

In an earlier paper (VAN DEN HOEK, 1969) algal vegetation-types distinguished along the open coasts of Curaçao were described, and only a limited number of observations on the vegetation of inner bays and lagoons was given.

In the period from 13.VIII.1969 to 20.IX.1969 we visited Curaçao for field work on the vegetation of inner bays and lagoons; we made one trip to Bonaire to investigate the algal vegetation of the Lagoon Lac.

Both papers on algal vegetation-types along the shores of Curaçao are intended to provide background information on the distribution of *Cladophora* species as the senior author is currently revising this genus.

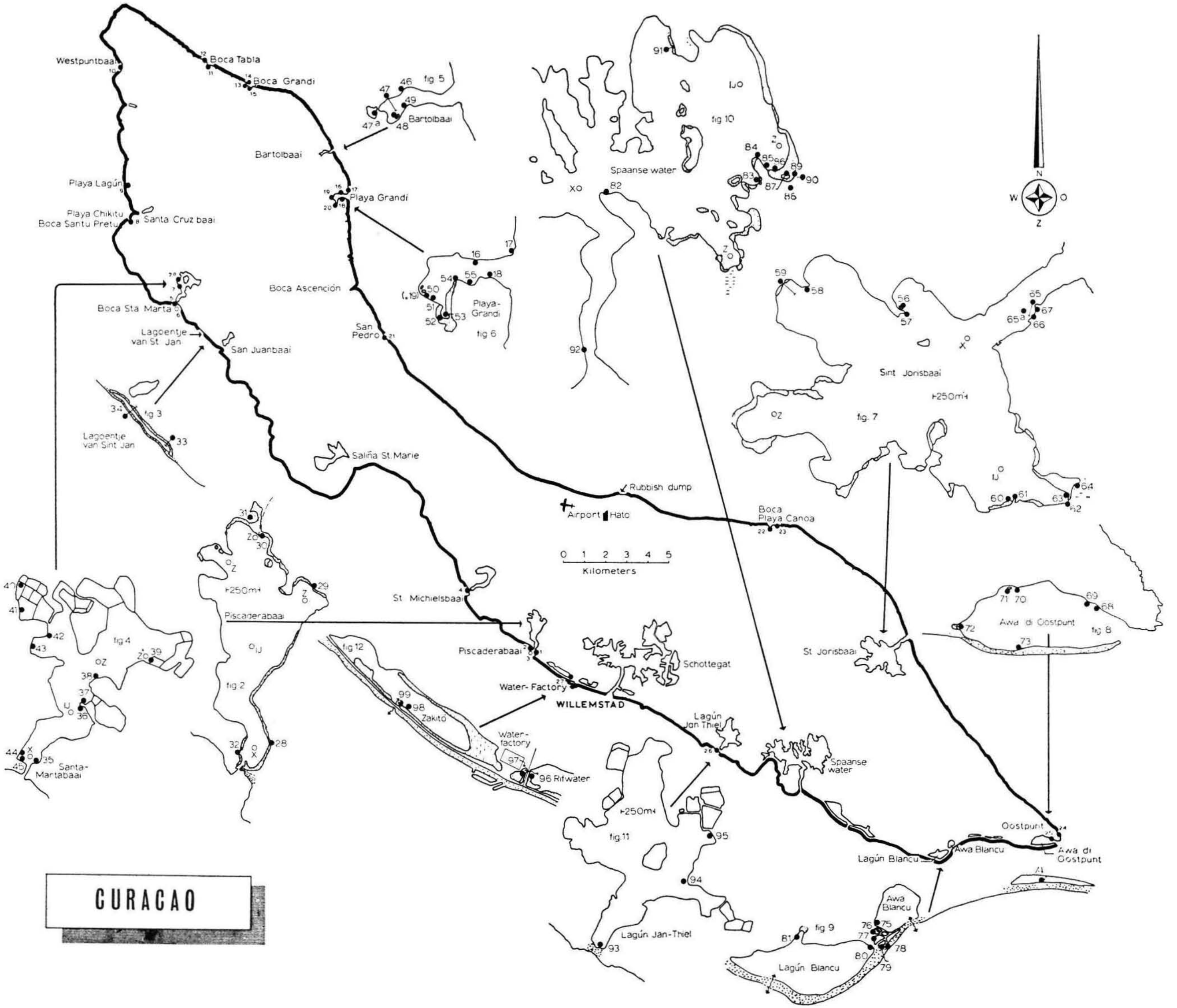
2. THE REGION

Long stretches of the coast of Curaçao are bordered by plateaus of pleistocene coral limestone that terminate in steep cliffs on the seaward edge. At a depth of about three to five meters these cliffs merge into a submarine rocky and partly sand-covered plateau which shelves to about 10 m depth at a distance of ca 100 m from the coast, where a steep slope dives to a still deeper plateau (see VAN DEN HOEK, 1969; DE BUISONJÉ, 1964). These cliff-coasts are interrupted by narrow inlets, wide bays with sandy beaches or beaches of coral debris, and also by the narrow entrances to the inner bays (fig. 1). For general data and a more detailed description of the structure of the open coast, see VAN DEN HOEK (1969; with further references).

The wide and intricately ramified inner bays are considered to be inundated pleistocene valley-systems (DE BUISONJÉ, 1964; HOETINK, 1969, pp. 212–213). No rivers flow in the non-inundated stretches of these valleys, but during and for some time after the short and heavy showers the rainwater runs off towards the bays through otherwise dry beds ("rooien") and transports much sediment into the bays. The shores of the bays consist for the greater part, of gently sloping alluvial beaches merging into marginal shallows which are covered by extensive seagrass- (mainly *Thalassia*-) beds and which are bordered by mostly narrow fringes of mangroves (predominantly *Rhizophora mangle*) (figs. 2, 6, 7, 10). The entrances of the bays are bordered by extensions of the perpendicular cliffs of pleistocene coral limestone that line the open coast (see figs. 16, 18, 27). Generally, at a depth of about 0–1 m, these cliffs dive into mostly gently sloping sands.

A number of bays are closed by barriers of coral debris and are hypersaline (Lagún Jan Thiel, Saliña St. Michiel, Saliña Sta. Marie, San Juan Baai, Santa Cruz Baai, see fig. 1).

Several shallow lagoons are, completely or incompletely, separated from the sea by barriers of coral debris (figs. 3, 9, 12). The two largest lagoons


CURACAO
Westpuntbaai
Boca Tabla
Boca Grandi
Bartolbaai
Playa Lagún
Playa Chikitu
Boca Santu Pretu
Santa Cruz baai
Playa Grandi
Boca Ascención
Boca Sta Marta
Lagoentje van St. Jan
San Juanbaai
San Pedro
Saliña St. Marie
Rubbish dump
Airport
Hato
St. Michielsbaai
Piscaderabaai
Water-Factory
WILLEMSTAD
Schottegat
Lagún Jan Thiel
Spaanse water
Boca Playa Canoa
St Jorisbaai
Sint Jorisbaai
Lagún Blancu
Awa Blancu
Oostpunt
Awa di Oostpunt
Spaanse water
Lagoentje van Sint Jan
Santa-Martabaai
Zakito
Water-factory
96 Rifwater
Lagún Jan-Thiel
Lagún Blancu
Awa Blancu
fig 2
fig 3
fig 4
fig 5
fig 6
fig 7
fig 8
fig 9
fig 10
fig 11
fig 12
250m
0 1 2 3 4 5
Kilometers
N
W
O
Z

Figs. 1–12

investigated, Awa di Oostpunt on Curaçao (fig. 8) and Lac on Bonaire (fig. 13), which are in open connection with the sea, contain clear regularly replenished oceanic water and show resemblances with the vast oceanic lagoonal areas of the Florida Keys. These two lagoons are situated in places where the coastal plateau of coral limestone arises only a few dm above or dips below the sea-level. The barriers of coral debris between the sea and the lagoon have been deposited on top of the plateau.

3. SUBDIVISION OF THE ASSEMBLAGE OF BAYS AND LAGOONS

3.1. *Bays with relatively wide and bays with relatively narrow entrances (see table 1)*

The entrances of Bartolbaai (fig. 5), Playa Grandi (fig. 6), Sint Jorisbaai (fig. 7), and Spaanse Water (fig. 10) have widths that amount to about 70 m, 130 m, 200 m, and 70 m respectively, whereas the entrances of Piscaderabaai (fig. 2) and Sta. Martabaai (fig. 4) are only 7 m and 30 m wide respectively. For most entrances no exact data are available about their depths. Some approximate values are given in table 1.

TABLE 1

Widths and approximate depths of the entrances of bays and the lagoons Awa di Oostpunt and Lac.

	width	depth	fig.
Bartolbaai	70	5	5
Playa Grandi	130	3–5	6
St. Jorisbaai	200		7
Spaanse Water	70	12	10
Piscaderabaai	7	1	1
Santa Martabaai	30	3	4
Awa di Oostpunt	120	ca 10	8
Lac	100	8	13

The entrance-channel of the Spaanse Water (fig. 10), in its deepest parts, varies from about 5 to 19 m (DE KOCK & DE WILDE, 1964). According to ROOS (1964) at it's southernmost end the entrance-channel has a sill, the top of which lies at a depth of about 12 m. Behind the sill the water is relatively warm and turbid; this brown turbid water runs off through a gully approximately 1 m wide and 0.3 m deep. Above it the water is clear and relatively cool.

The comparatively wide entrances ensure a relatively great exchange of seawater with baywater, and one would expect that temperature, salinity, and turbidity would show much less pronounced fluctuations and deviations from those of the open sea than in the two bays with comparatively narrow and shallow entrances. Our visit to Curaçao was too short to collect data about these environmental factors, but some relevant data are given by DE KOCK & DE WILDE (1964). It is interesting that neither as to salinity, nor as to temperature did the bays with wide entrances show significant differences from the two bays with narrow entrances. In both types of bay salinities amounted to about 36 $^{0}/_{00}$–39 $^{0}/_{00}$, the highest values of which were reached, as would be expected, in the more peripheral and sheltered parts (the open sea value amounted to 36 $^{0}/_{00}$). The temperatures amounted to about 26° C–29° C (in the course of the period January–June) (the values given for the open sea amounted to 27.3–27.6° C). At high tide particularly the water in the bay-entrances of the bays on the South coast shows a distinct temperature-stratification; the upper layer, which varies between 0.5–1 m deep, is distinctly colder than the water below it. The colder water is inflowing seawater with relatively low salinity, the warmer water is outflowing baywater with relatively high salinity caused by evaporation. The oxygen-content is always near saturation point both day and night, as a result of the small productivity and the constantly blowing trade wind.

However, the transparency of both bays with narrow entrances was significantly lower, particularly in stations remote from the bay-entrances, than that of the bays with wide entrances (tables 2, 3). As could be expected the transparency of the baywater in general is much lower than that of the sea, and this probably explains why the lower limit of algal growth is reached at a depth of about 4 to 2 meters in the inner bays. The feeble transparency of the baywater is mainly caused by inorganic silt and not by organic matter, as De Kock and De Wilde obtained low B.O.D.-values.

All bays are quite shallow: their depths vary between 4 and 6 m, and in the marginal areas they amount to about 2 to 3 m. Only the Spaanse Water is deeper near the entrance-channel (station x: 9–13 m).

Both bays with narrow entrances appeared to harbour vegetation-types that differed considerably from those of the "wide-mouthed" bays and one would be tempted to correlate these differences in vegetation with the differences in transparency.

However, both Sta. Martabaai and Piscaderabaai have been considerably influenced by human interference which undoubtedly profoundly changed the vegetation-types originally inhabiting these two bays.

TABLE 2

Transparency of baywater expressed as the depth in m at which a secchi-disc is still visible. Value for open sea near Piscaderabaai: > 24 m. In Lac no secchi-disc was used, but the bottom was visible everywhere from the surface. The secchi-data after De Kock and De Wilde (1964).

	station near entrance (x)	station in middle of bay (y)	station remote from sea (z)	inshore station remote from sea (z^1)
St. Jorisbaai	1.9–2.3	1.9–2.3	1.7–2.0	
Spaanse Water	4	2.8–2.1	2.3–2.4	
Piscaderabaai	1.3–1.8	2.6	1.1–1.3	0.5
Santa Martabaai	3.0	1.3–1.4	0.7	0.1
Lac	> 5	> 3.5	> 1	

TABLE 3

Ranges of phosphate-concentrations and pigment-concentrations measured in different bays and the open sea near Piscaderabaai (after De Kock and De Wilde, 1964).

	PO_4'''-P mg/m^3	pigments mg/m^3
St. Jorisbaai	0–19.5	0–0.5
Spaanse Water	0–10.8	0.1–0.6
Piscaderabaai	30.4–80.6	0.6–3.9
Santa Martabaai	0.6–1.6	0.3–0.6
Open Sea	0–1.6	0.2–0.3

Until 1962 the Sta. Martabaai was only intermittently connected with the sea through a very narrow and shallow channel which was often plugged by coral debris. At that time the vegetation of this undoubtedly hypersaline bay was probably very poor and consisted mainly of *Cyanophyceae*. Koster (1963) described a sample of *Cyanophyceae* collected in the former salt-pan of San Nicolas on 5.XII.1960 (near our stations 40 and 41), when salinity amounted to ca 66 $^0/_{00}$ after heavy rains whereas it amounted to 86 $^0/_{00}$ before the rains. Only two months earlier the channel to the sea had been reopened. Since 1962, when a broader and deeper channel was dug through the barrier of coral debris (table 1), Sta. Martabaai has been recolonized by algae with a narrower salinity tolerance.

Piscaderabaai is continuously polluted by the inflow, at its northernmost end (station 30) of domestic effluent. Certainly this pollution is responsible for the relatively high phosphate-concentrations and pigment-concentrations measured by De Kock and De Wilde (1964) (see table 3).

The Schottegat, which forms the port of Willemstad, is heavily polluted by the Shell oil-refineries, and by domestic sewage. It has not been investigated, but apparently it is devoid of any striking algal growth.

3.2. *Bays completely separated from the sea by barriers of coral debris*

These bays – Lagún Jan Thiel, Saliña St. Michiel, Saliña Sta. Marie, San Juan Baai and Santa Cruz Baai – are hypersaline and have formerly been exploited as salt-pans. Only in Lagún Jan Thiel are (fig. 11) the salt-pans still operated. Observations were made on the algal vegetation of Lagún Jan Thiel (fig. 11). The bottom of this bay, like that of other hypersaline bays, is covered by a crust of salt-crystals about 1 cm thick. Below this crust the muddy bottom shows signs of anaerobic conditions (blackish colour; H_2S odour). It is to be expected that the salinity will be very high and reach saturation-values (as e.g. 200 to 275 $^0/_{00}$ in the salt-pans of Cas Abau, see Koster, 1963). After heavy rains in particular the waters of hypersaline bays have a pronounced salinity- and temperature-stratification.

3.3. *Relatively large lagoons in open communication with the sea and with clear, oceanic water (Awa di Oostpunt and Lac) (tables 1, 2; figs. 8, 13)*

These two lagoons differ from the inner bays by their clear oceanic water, which enters through the wide and rather deep entrances. The difference between their clear waters and the murky water of, e.g., Piscaderabaai and Sta. Martabaai, is very obvious. The inflow of silt-loaded rainwater during and after heavy rains is certainly much smaller than that into the bays into which numerous gullies discharge their sediments during and after rains. Conditions in the shallower parts of these lagoons much resemble those of the oceanic lagoons on the southern side of the Florida Keys. In Awa di Oostpunt a broad, shallow plateau (50 m broad, 0–1 m deep) along the northern shore which is lined, on the shore side, by a shallow surf-niche offers conditions for the development of a rich lagoonal vegetation (see figs. 19, 20). The open part of Lac is 5–1 m deep over most of its surface, and hence the lagoonal vegetation covers most of the bottom (WAGENAAR HUMMELINCK and ROOS, 1969).

The lagoons Awa Blancu and Lagún Blancu (fig. 9) communicate with the sea over shallow places in the barriers of coral debris that separate these lagoons from the sea (fig. 9, arrows). The water of Lagún Blancu is not very transparant. A "rooi" (gully) runs into it near station 81.

3.4. *Relatively small and shallow clear-water lagoons with limited communication with the sea*

The following lagoons can be ranged under this type: the "Lagoentje van Sint Jan" (fig. 3); several small lagoons between Awa Blancu and Lagún Blancu which were formed by sand digging; a narrow lagoon N.W. of Awa Blancu (fig. 9); and a small sublagoon of Lac (fig. 13, stations 102 and 103). Most of these small lagoons are completely separated from the sea by barriers of coral debris and only receive seawater as seepage through these barriers. The sublagoon of Lac is in communication with the large lagoon. Depending on the measure of water-exchange and the depth (varying from 0.1–1.0 m) the small lagoons show varying degrees of hypersalinity and the temperature that they reach during the day, and show corresponding differences in vegetation.

3.5. *Polluted lagoons*

The lagoons Rifwater and Zakitó (fig. 12) are seriously polluted by surrounding settlements, the dumping of refuse on the shores, and the discharge of ferric chloride by the water-factory (which causes all submerged objects to be covered by a flocculent red deposit). Both lagoons are each connected with the sea by a narrow gully dug through the barrier of coral debris.

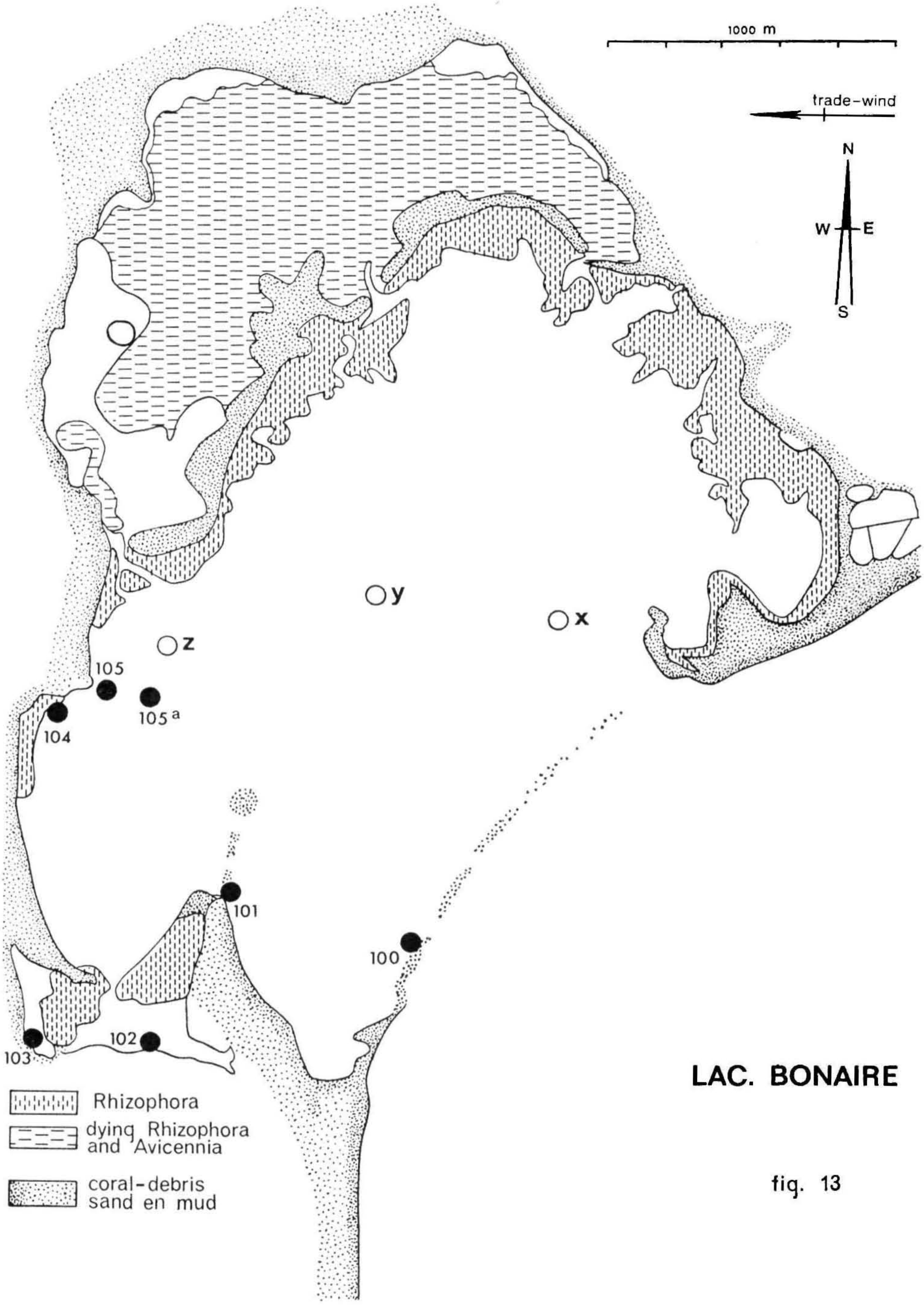

1000 m
trade-wind
N
W
E
S
y
x
z
105
105 a
104
101
100
102
103
Rhizophora
dying Rhizophora and Avicennia
coral-debris sand en mud
LAC. BONAIRE
fig. 13

Fig. 13.

4. MATERIAL AND METHODS

The algal vegetation was investigated at the stations indicated on figs. 2–13 (stations 28–105a; the numbers 1–27 were used to designate the stations in the study on the vegetation-types of the open coasts (VAN DEN HOEK, 1969)). Relevant details of the stations will be treated in conjunction with other discussions of the vegetation-types. For the analysis of the vegetation the phytosociological methods of BRAUN-BLANQUET were used. For a more detailed treatment, see VAN DEN HOEK (1969).

Apart from the systematic works mentioned in VAN DEN HOEK, 1969, the following literature was used in addition: BLIDING, 1963; CHAPMAN, 1961; DENIZOT, 1968; DROUET, 1968; FRÉMY, 1934; HALOS, 1964, 1965; DEN HARTOG, 1970; HAUCK, 1885; KOSTER, 1955; SMITH, 1948; ZANARDINI, 1871. PARKE & DIXON (1968) was consulted on questions of nomenclature.

The sample-plots in extensive and monotonous *Thalassia*-beds were often quite large and could vary from about 2 m × 5 m (in relatively narrow and relatively steeply sloping zones) to 10 m × 50 m (in broad and very gradually sloping zones).

In the tables 4 to 14, which are intended to give comprehensive pictures of vegetation-types distinguished, the figures expressing presence are given in combination with figures expressing abundance. For instance IV^{3-5} means that the considered species was present in 3/5–4/5 of the sample-plots with an abundance of 3–5.

Table 15 has been composed in a similar way to table 6 in VAN DEN HOEK (1969). All species encountered are alphabetically listed within each separate class in the following sequence: *Cyanophyceae*, *Chlorophyceae*, *Phaeophyceae*, *Rhodophyceae*, *Chrysophyceae*, *Xanthophyceae*, *Phanerogamae*.

In the first column of table 15 (A–I) the distribution is given in relation to exposure to wave action and to "oceanity". A encompasses all very exposed stations, and I the most sheltered, shallow (ca 0.05 m) pools in back-mangroves. The series A to I is meant to represent an "exposure-oceanity" gradient:

A includes the stations on the open N.E. coast (stations 12, 14, 17, 21, 23, 24, in VAN DEN HOEK, 1969);
B the stations in inlets on the N.E. coast (11, 13, 15, 16, 18, 22);
C the S. exposed stations on the S.W. coast (which are relatively more exposed to wave action than the W. exposed stations (1, 2, 5, 26);
D the W. exposed stations on the S.W. coast (4, 8, 9, 10);
E the stations in the entrances of the bays on the N.E. coast (46, 49, 54, 55, 65, 65a, 66, 67) and the relatively exposed stations in the oceanic lagoons Awa di Oostpunt and Lac (68, 69, 70, 71, 73, 100, 101, 104, 105, 105a);
F the relatively exposed stations in the inner bays with wide entrances (50, 51, 56, 57, 58, 59, 60, 61, 81, 82, 84, 85, 86, 91) and the relatively exposed stations near the entrances of bays on the S. coast (32, 35, 44, 45, 92);

G the most sheltered stations in the inner bays with large entrances (47, 48, 52, 53, 62, 63, 83) and the greater parts of the inner bays with narrow entrances (28, 29, 30, 36, 37, 38, 40, 41, 42, 43);
H shallow, but permanent pools in back-mangroves (87, 103);
I very shallow and mostly temporary pools in back-mangroves (31, 39, 64, 88, 89) and emersed cyanophycean felts on silt-bottoms (64, 88, 90, 103).

Data regarding the distribution with relation to the "exposure stages" A → G are borrowed from Van den Hoek (1969).

Presumably the transparency, salinity and temperature of seawater at the stations ranged under A to D are similar and only factors directly or indirectly correlated with water motion influence the distribution of algal species growing in these stations. For the stations ranged under E to I not only does the degree of exposure to water motion diminish, but the degree of turbidity increases and, particularly for the stations ranged under H and I, the salinity and temperature (and the variations of these factors). In stations ranged under I – very shallow pools in back-mangroves – the water can be rather turbulent when it is exposed to the trade wind; in such cases the bottom mud is continuously stirred up so that development of any algal vegetation is impossible.

In the second column of table 15 (G^1–I^1) the distribution is given in small lagoons with clear water but with increasing salinities and temperature (or: with increasing isolation from the sea and/or decreasing depth).

G^1 includes the small lagoons in which salinity does not increase much above that of seawater (stations 34, 76, 102), and where the algal vegetation is rather diversified;

H^1 includes small clear-water lagoons with relatively high salinities, in which *Batophora* is still capable of massive development (stations 33, 78);

I^1 includes small and often shallow clear-water lagoons in which salinity increases to such values that only *Cyanophyceae* are capable of massive development (stations 74, 79).

The salinities of the lagoons ranged under G^1–I^1 were not measured. However Wagenaar Hummelinck and Roos (1969) give the salinity of the sublagoon of Lac at station 102 (ranged under G^1) (ca 36–40 $^0/_{00}$); and of a number of *Batophora* pools in back-mangroves (ca 42 $^0/_{00}$ at station 103, and up to ca 280 $^0/_{00}$ in other *Batophora* pools which is high even for *Batophora*).

In the third column of table 15 (G^2) the occurrence is indicated in the heavily polluted lagoons Zakitó and Rifwater and in their sublagoons (excluding the entrance-channel to Zakitó) (stations 96, 97 and 98).

In the columns A–I, G^1–I^1, and G^2 the abundance is indicated with which each species occurs in at least one of the stations with a given exposure or "oceanity".

█: the species occurs in at least one of the stations and in at least one of its vegetation-types with an abundance of 2 or >2.

▬ : the species occurs in at least one of the stations and in at least one of its vegetation-types with an abundance of 1.
— : the species occurs in at least one of the stations and in at least one of its vegetation-types with an abundance of + or ×.

In the fourth column (a–w^2) the distribution over the distinguished vegetation-types is given.

— presence I
= presence II
≡ presence III
≣ presence IV
▤ presence V

The vegetation-types are designated by the letters a to w (see figs. 14 and 15). In the publication on the vegetation-types of the open coasts vegetation-types designated with the letters a–j were described, and the letters used in this paper are in continuation with the series a–j. Some letters, and hence vegetation-types, of the former paper are also treated in the present one.

The following vegetation-types are tabulated in the fourth column of table 15.

a) The eulittoral *Entophysalis deusta* subzone (5.1.1.1; 5.2.1; 5.3.1).
b) The eulittoral chlorophycean subzone (5.1.1.2).
b^1) The type of *Enteromorpha clathrata* and *Cladophora dalmatica* (5.1.1.2).
b^2) The type of *Cladophoropsis membranacea* and *Cladophora laetevirens* (5.1.1.2; 5.2.1).
b^4) The type of *Cladophora "conferta Crouan"* (5.1.1.2).
b^5) The chlorophycean zone of *Enteromorpha flexuosa* (in the hypersaline Lagún Jan Thiel) (5.6).
c) Upper sublittoral rhodophycean turfs of *Laurencia papillosa* (5.1.2.1).
c^2) The type of *Laurencia papillosa* and *Gelidiella acerosa* (5.1.2.1).
c^4) The type of *Laurencia papillosa* and *Goniolithon strictum* (5.1.2.1).
e^1) The sublittoral *Porolithon pachydermum* coral formations (5.1.2.2; 5.2.2.1).
i) The eulittoral *Bostrychia* subzone (5.1.1.3).
l) Emerged *Microcoleus* felts on compact silty flats in back-mangroves (5.1.1.4).
m) The upper sublittoral *Murrayella* zone on aerial roots of *Rhizophora mangle* (5.1.2.3).
n) *Periphyton* on submerged *Rhizophora* roots in the most sheltered parts of the bays.
n^1) The type of *Isognomon alatum* (5.1.2.4).
n^2) The type of *Crassostrea rhizophorae* and *Isognomon alatum* (Piscadera-baai) (5.3.2.1).
o) Sublittoral *Caulerpa verticillata* types.

o^1) The type of *Caulerpa verticillata* on very sheltered muddy bottoms under *Rhizophora* thickets in bays and lagoons with wide entrances (5.1.2.5).

o^2) The type of *Caulerpa verticillata* and *C. sertularioides* characteristic of most of the sublittoral of Piscaderabaai (5.3.2.2).

p) Submerged cyanophycean types in more or less extreme habitats.

p^1, p^2) *Lyngbya* films covering muddy bottoms under or among *Rhizophora* thickets (5.1.2.5).

p^3) Cyanophycean *periphyton* on *Avicennia* pneumatophores (5.1.2.6).

p^4) Submerged *Microcoleus* felts on shallow muddy bottoms (5.1.2.8).

p^5) Cyanophycean felt on *Brachydontes* and barnacles in Santa Martabaai (5.2.2.5).

p^6) Submerged Cyanophycean films in back-mangroves of Piscaderabaai (5.3.2.3).

p^7) The bottom vegetation of the polluted lagoon Zakitó: a film of *Lyngbya majuscula* (5.4.1).

p^8) The vegetation on submerged *Rhizophora* roots in the polluted lagoon Zakitó: *Cyanophyceae* and *Rhizoclonium implexum* (5.4.2).

p^9) Small clear-water lagoons with a vegetation of *Cyanophyceae* (5.5.3).

p^{10}) *Microcoleus* zone just below water-level in the hypersaline Lagún Jan Thiel (5.6.3).

p^{11}) A zone of flocculent, gelatinous, gloeocapsoid *Entophysalis deusta* in the hypersaline Lagún Jan Thiel (5.6.4).

q) The sublittoral *Thalassia* meadows.

q^1) The type of *Thalassia testudinum, Halimeda opuntia,* and *Penicillus* (5.1.2.9).

q^2) The type of *Thalassia testudinum, Halimeda opuntia,* and *Goniolithon strictum* (5.1.2.9).

q^3) The type of *Thalassia testudinum* and *Halimeda opuntia* (5.1.2.9).

q^4) The poor *Thalassia testudinum* type (5.1.2.9).

r) The sublittoral *Syringodium* meadow (5.1.2.10).

s) Sublittoral sand- and muddy sand-binding vegetations of small *Rhodophyceae* below *Thalassia* meadows.

s^1) Sublittoral sand-binding vegetation of small *Rhodophyceae* in the entrance of a bay on the N.E. coast (5.1.2.11).

s^2) Sublittoral sand-binding vegetation of small *Rhodophyceae* in the lagoons Lac and Awa di Oostpunt: the type of *Centroceras clavulatum, Polysiphonia subtilissima,* and *Penicillus capitatus* (5.1.2.11).

s^3) Sublittoral sand-binding vegetation of small *Rhodophyceae* in the entrance of Spaanse Water (5.1.2.11).

s^4) Sublittoral sand-binding vegetation of small *Rhodophyceae* in bays with wide entrances and the outer basins (W. shores) of Piscaderabaai and Santa Martabaai: the type of *Centroceras clavulatum, Polysiphonia subtilissima,* and *Griffithsia tenuis* (5.1.2.11).

t) Poor sublittoral shingle-bound vegetations without *Thalassia* in Santa Martabaai and the entrance of the lagoon Zakitó.

t¹) Mixed vegetation of *Dictyota* and *Rhodophyceae* near entrance of Santa Martabaai (5.2.2.2).

t²) Sublittoral algal vegetation in the inner basin of Santa Martabaai; the type of *Caulerpa sertularioides* and *Acanthophora spicifera* (5.2.2.3).

t³) Bottom vegetation close to the entrance-channel of the polluted lagoon Zakitó (5.4.3).

u¹) *Vaucheria* felt on the bottom of a part of Santa Martabaai (5.2.2.4).

v) Submerged *Batophora* vegetations in small, more or less hypersaline water-bodies.

v¹) Submerged *Batophora* vegetations in pools of back-mangroves (5.1.2.7).

v²) Small clear-water lagoons with *Batophora* (5.5.2).

w¹) Small clear-water lagoons with *Thalassia testudinum* and a varied algal vegetation (5.5.1).

w²) The vegetation of a small polluted lagoon in connection with Rif-water (5.4.4).

In the fifth column the stations are given where the species were collected.

The abbreviation ep., when added to a species in the table, means that this species is an epiphyte.

A column for the vertical distribution in relation to the waterlevel (as given in table 6 in VAN DEN HOEK, 1969) has been omitted, because the variable transparency in baywaters makes comparison virtually impossible.

5. THE VEGETATION (cf figs. 14–33)

5.1. *The vegetation of the bays with relatively wide entrances (Bartolbaai, Playa Grandi, Sint Jorisbaai, Spaanse Water) and that of oceanic lagoons (Awa di Oostpunt and Lac) (with remarks on the vegetation near the entrances of Piscaderabaai and Santa Martabaai)*

5.1.1. *The eulittoral zone*

The eulittoral zone is defined as the zone between the upper limit of *Entophysalis deusta* and the upper limit of *Thalassia testudinum.* The low water line is roughly situated on the upper limit of *Thalassia testudinum.*

The vertical extent of the eulittoral zone is largest in the entrances of the bays on the N.E. coast (fig. 14, column I) and is up to about one meter (for comparison: up to 5 m on the open N.E. coast, see VAN DEN HOEK, 1969).

5.1.1.1. *a) The eulittoral Entophysalis deusta subzone (the high-littoral splash zone) (a in figs. 14, 15, 16, 18, 19, 20, 22, 27, 31, 32)*

The upper limit of *Entophysalis deusta* can only be observed clearly on the extension, into the bays, of the cliff-coasts, upon which the lime-

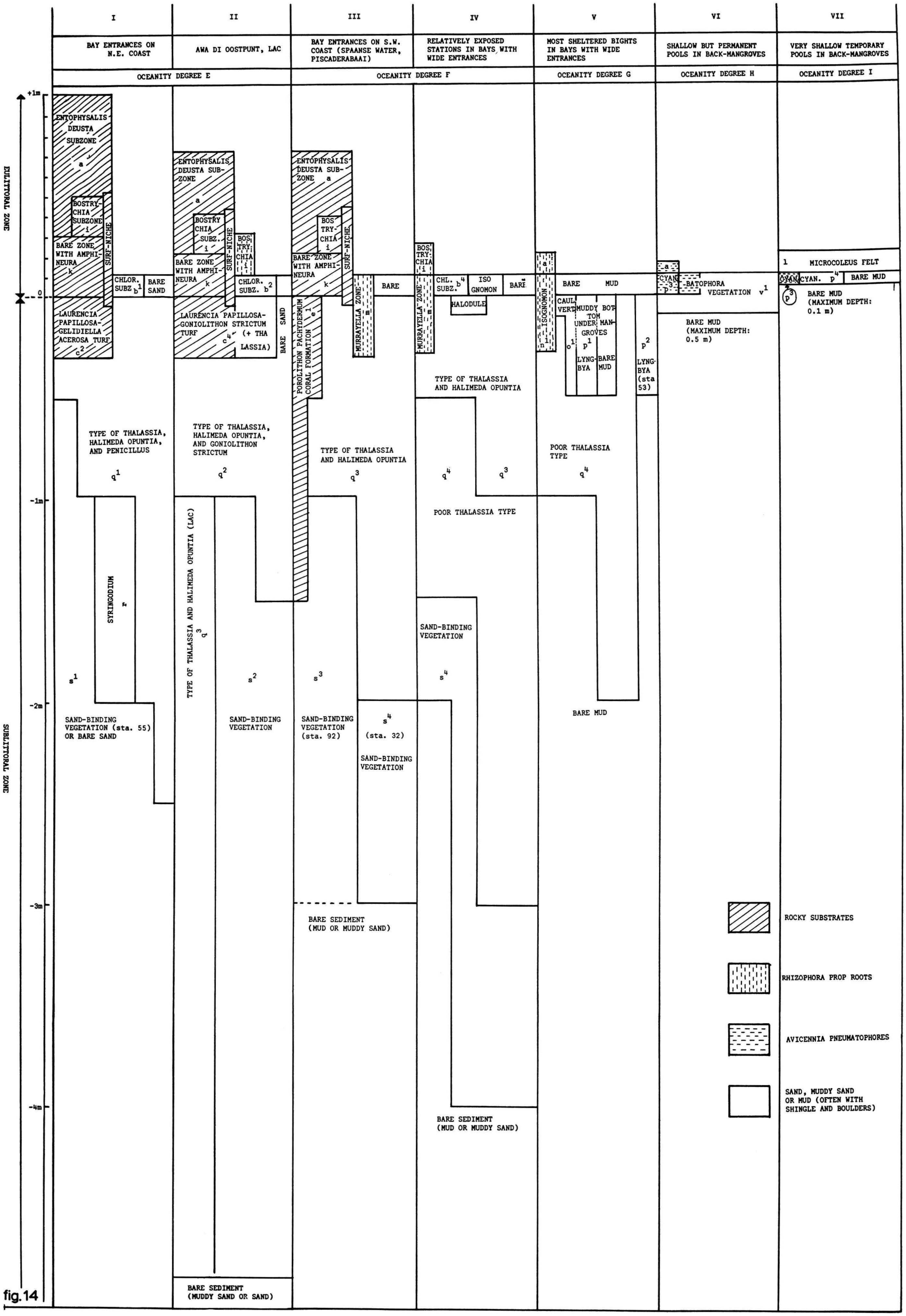


fig.14

Diagram giving the distribution of the vegetation-types in relation to water-level and oceanity.

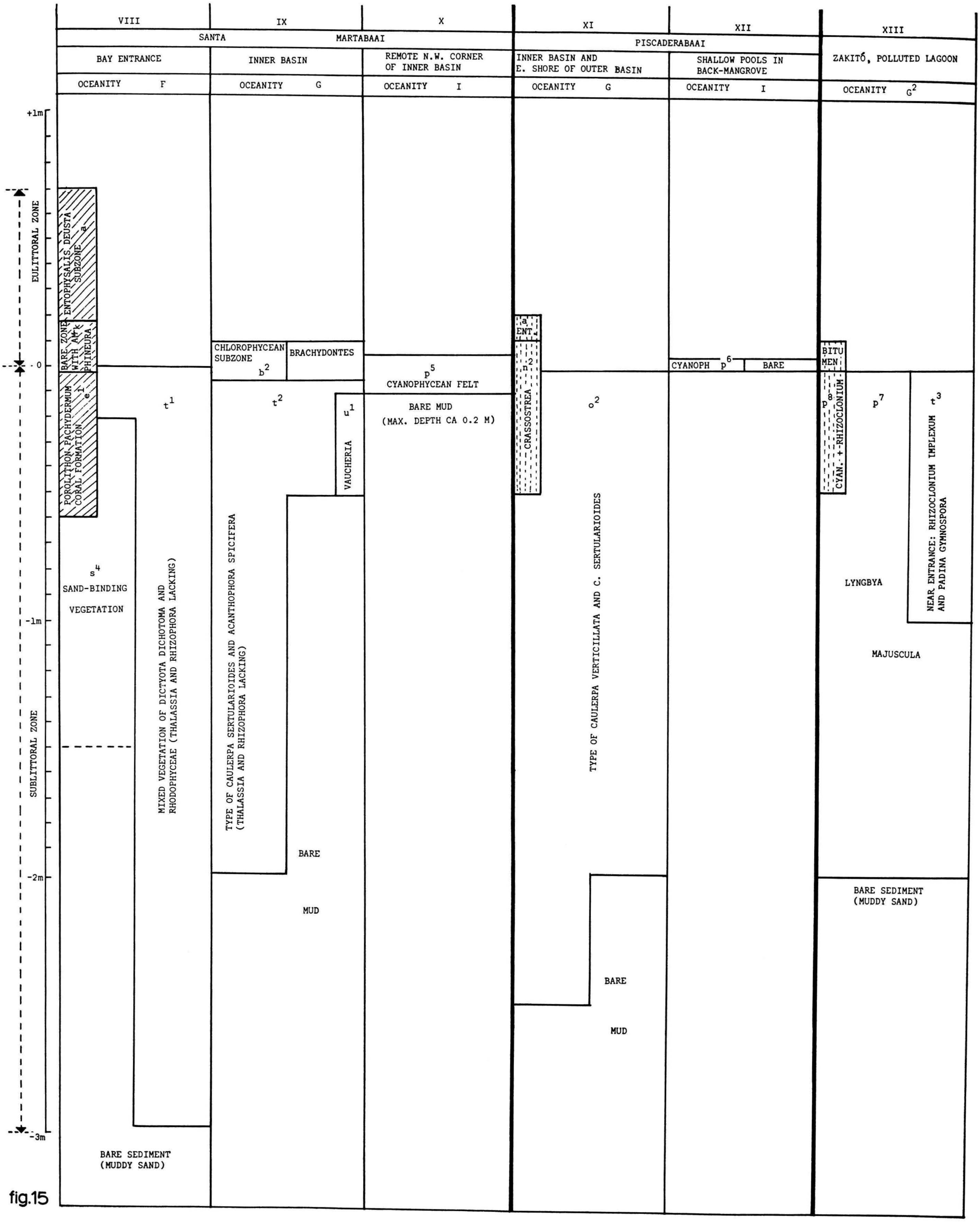


fig.15

Diagram giving the distribution of the vegetation-types in relation to water-level and oceanity.

stone perforating *Hyella* phase of *Entophysalis deusta* imprints its characteristic bluish colour. In the remote most sheltered parts of the bays the vertical extent of this subzone amounts to about 5–20 cm. It is however rather difficult to determine the upper limit, as *Entophysalis* does not occur on muddy beaches, but only on the aerial roots and stems of *Rhizophora,* where it never forms a distinct zone (fig. 14, column V), but grows as mostly scattered gloeocapsoid colonies. This *Entophysalis* zone has not been systematically investigated, but in a few places its composition has been determined. For instance, on aerial roots of isolated *Rhizophora* thickets growing at station 50 the zone was 5 to 10 cm high, and contained the following species: *Entophysalis deusta* (gloeocapsoid), *Schizothrix calcicola, Calothrix crustacea, Lyngbya meneghiniana,* and "*Arnoldiella*" (a chlorophycean species growing in the outer layers of the bark of *Rhizophora*).

The density of this algal growth was obviously greater on the outermost aerial roots than on the most sheltered roots in the centre of the *Rhizophora* thicket.

The *Entophysalis* zone was also characterized by the presence, in quite large numbers, of barnacles (*Chthamalus*). Barnacles were never encountered in the eulittoral zone of the open coast, where productivity is probably too low for this filter-feeder. It was also lacking in the entrances of the bays. The occurrence of mostly scattered colonies of *Entophysalis deusta* and *Schizothrix calcicola* directly above water-level on *Rhizophora* roots was confirmed several times.

In the parts of the lagoons Lac and Awa di Oostpunt where the shore profiles terminate in low limestone cliffs on the landward side, the usual perforating *Entophysalis* subzone discoloured the rocks up to about 70 cm above low water level (figs. 14, 19, 33). In both stations *Calothrix crustacea* participated in the *Entophysalis* subzone.

In Sint Jorisbaai and Spaanse Water the lamellibranchiate *Isognomon alatum* penetrated up to about 10 cm above low water level into the eulittoral zone on *Rhizophora* roots (fig. 14, column V).

5.1.1.2. *b*) *The eulittoral chlorophycean subzone* (*fig. 14*)

On the open coasts, this is the highest conspicuous algal zone (mostly with a vividly green or yellowish colour). However, in the bay-entrances on the N.E. coast, on steep rocky surfaces (mostly in surf-niches), and on *Rhizophora* roots in the relatively exposed stations of the inner bays (fig. 14, columns I–IV) the eulittoral *Bostrychia* subzone (i) is situated higher than the eulittoral chlorophycean subzone. Where rocky profiles or aerial roots of *Rhizophora* dive into the baywater the substrate for chlorophycean subzones is generally lacking, and only rarely are the two subzones adjacent (fig. 14).

b^1) The type of Enteromorpha clathrata [1] *and Cladophora dalmatica (figs. 14, 21, 33; table 15)*

This type is characteristic of rocky surfaces and boulders lying in close contact with sand with which they are regularly covered and uncovered. The dominant species have, apart from a certain resistance to emersion, the capacity to reproduce continuously and richly and to grow rapidly. This vegetation-type is characteristic for sandy places on the open coasts (VAN DEN HOEK, 1969, p. 546). It was observed in the entrance of Sint Jorisbaai where it grew on sand-covered boulders (station 66) and in the lagoon Lac (station 101) where it grew on sand-covered shells and boulders.

b^2) The type of Cladophoropsis membranacea and Cladophora laetevirens (figs. 14, 19; table 15)

This type is characteristic for gently sloping rocky surfaces along the open coasts which are not in close contact with sand (VAN DEN HOEK, 1969, p. 547). Chlorophycean zones much resembling this type were observed in the lagoon Awa di Oostpunt where they grew along the landward edge of the shallow rocky plateau (station 68) and on the barrier of coral debris (station 73). *Cladophora laetevirens* was lacking in both stations, but *Boodlea composita* occurred (with an abundance of 1) in station 73.

b^4) The type of Cladophora "conferta Crouan" [2] *(table 4; figs. 14, 24, 33)*

Relatively exposed beaches of muddy sand with shingle (oceanity-stage F, see table 4, and fig. 14, column IV) in the inner bays are often covered by a ca 5–10 cm high and 2–3 m broad lower eulittoral chlorophycean zone. This zone is characterized by the presence, often in considerable abundance, of *Cladophora "conferta* Crouan",[2] which species seems to be limited to this habitat. The general occurrence of the mollusc *Isognomon alatum*, growing attached to the shingle, is also characteristic for this habitat, but it reaches a greater abundance when growing attached to aerial roots of *Rhizophora*.

All other algal species participating in this vegetation-type with a degree of presence $\geqslant$ III have wide ecological amplitudes and occur in almost all vegetation-types distinguished (see table 15).

The algae participating in the *Cladophora "conferta* Crouan" vegetation-type grow attached to shingle, and therefore their abundance depends on the density of the shingle. This vegetation-type only occurs in relatively exposed inner bay stations probably because a certain amount of wave action is required to bank the shingle in sufficient quantity to support any striking algal growth. On the other hand the shingle must be sufficiently

---

[1] This species was identified as *Enteromorpha compressa* in VAN DEN HOEK, 1969. See taxonomic and floristic notes (7).

[2] See taxonomic and floristic notes.

TABLE 4

The eulittoral chlorophycean subzone. The type of *Cladophora* "*conferta*" (b^4). 6 survey-plots from stations 47, 51, 61, 85 (2 ×), 91.

vegetation-type	b^4
Cladophora "conferta"	V^{+-2}
Spyridia filamentosa	V^{+-2}
Enteromorpha clathrata	V^{+}
Centroceras clavulatum	V^{+}
Lyngbya aestuarii	IV^{+-2}
Lyngbya majuscula	IV^{+-1}
Sphacelaria tribuloides	IV^{+-2}
Cladophoropsis membranacea	IV^{+-1}
Isognomon alatum	IV^{+-1}
Chaetomorpha gracilis	III^{+}
Dictyota dichotoma (juv.)	III^{+}
Jania adhaerens	III^{+}
Acanthophora spicifera	III^{+}
Chthamalus	III^{+}
Chaetomorpha linum	III^{+}

stable to permit the development of algal growth (shingle beaches on the open coast are generally completely devoid of an algal growth!). Shingle beaches are lacking in the most remote and sheltered bights of the inner bays, and hence the *Cladophora* "*conferta* Crouan"-type is lacking there (e.g. stations 52, 62, 83). In some stations on the inner bay shores shingle beaches occur without any striking algal growth. There are probably two reasons for this absence of algae: some shingle beaches are too exposed which causes the substrate to be unstable (e.g. station 58; barnacles (*Chthamalus*), however, grow attached to the shingle); other shingle beaches, which are exposed to the easterly trade winds, are constantly covered by dense masses of washed up seagrasses and algae and are therefore unfit for algal growth (e.g. station 59 where enormous masses of mainly *Sargassum platycarpum* torn from the submarine plateau in front of the N.E. coast is washed in and piled up, mixed with *Thalassia* torn from the bay-bottom; station 84 where much *Thalassia* is washed up, but here the shingle still supports a population of *Isognomon alatum*).

5.1.1.3. *i*) *The eulittoral Bostrychia subzone* (*figs. 14, 16, 19, 20, 22, 33; tables 5, 15*)

The eulittoral *Bostrychia* subzone is perhaps the only true eulittoral vegetation-type besides the *Entophysalis deusta* subzone. The species of the chlorophycean subzone (b) are mainly sublittoral species capable of surviving the adverse conditions of short emersion, whereas, on the other hand, the dominant species *Bostrychia binderi*, *Bostrychia tenella*, *Boodleopsis pusilla*, and *Polysiphonia howei* of the *Bostrychia* subzone clearly have their optimum in the lower eulittoral zone, and hardly penetrate

TABLE 5

The eulittoral *Bostrychia* subzone (i). 19 survey-plots from stations 46 (2 ×), 54, 56, (2 ×), 59 (2 ×), 60, 66, 69, 70, 71, 82, 83, 86 (2 ×), 102, 104, 105.

vegetation-type	i
Bostrychia binderi	$\mathrm{V}^{(+-)\,2-5}$
Bostrychia tenella	$\mathrm{IV}^{(+-)\,2-5}$
Boodleopsis pusilla	III^{2-5}
Polysiphonia howei	III^{+-5}
Lyngbya aestuarii	III^{+-2}
Lyngbya majuscula	III^{+-2}

at all into the sublittoral zone. The two frequent and abundant *Lyngbya* species participating in the subzone, however, occur in almost all bay vegetation-types and are often equally abundant.

The *Bostrychia* subzone is characteristic for steep or overhanging rocky surfaces (particularly surf-niches in the bay-entrances on the N.E. coast and in the lagoons Awa di Oostpunt and Lac, stations 46, 49, 54, 56, 59, 66, 69, 70, 82, 102, 105), and for aerial roots of *Rhizophora mangle* (stations 56, 59, 60, 71, 82, 83, 86, 104).

Although shady surfaces seem to be preferred by this vegetation-type it occurs quite often on places that are, at least during some time of the day, exposed to full sunshine.

The upper limit of the *Bostrychia* subzone clearly depends on the degree of exposure to wave action: in the entrances of bays on the N.E. coast it is situated at ca 0.5 m; in the clear-water lagoons at ca 0.4 m, and in the relatively exposed inner bay stations at ca 0.25 m above low water level (see fig. 14). The lower limits of the *Bostrychia* subzone in the surf-niches in the bay-entrances on the N.E. coast and in the lagoons Awa di Oostpunt and Lac are very irregular and clearly set by the browsing activities of *Amphineura* ("Chiton": mainly *Acanthopleura granulata*) which inhabit a characteristic, narrow zone a little above low water level on all rocky coastal profiles (figs. 14, 15 e, k, 16, 20, 22, 33).

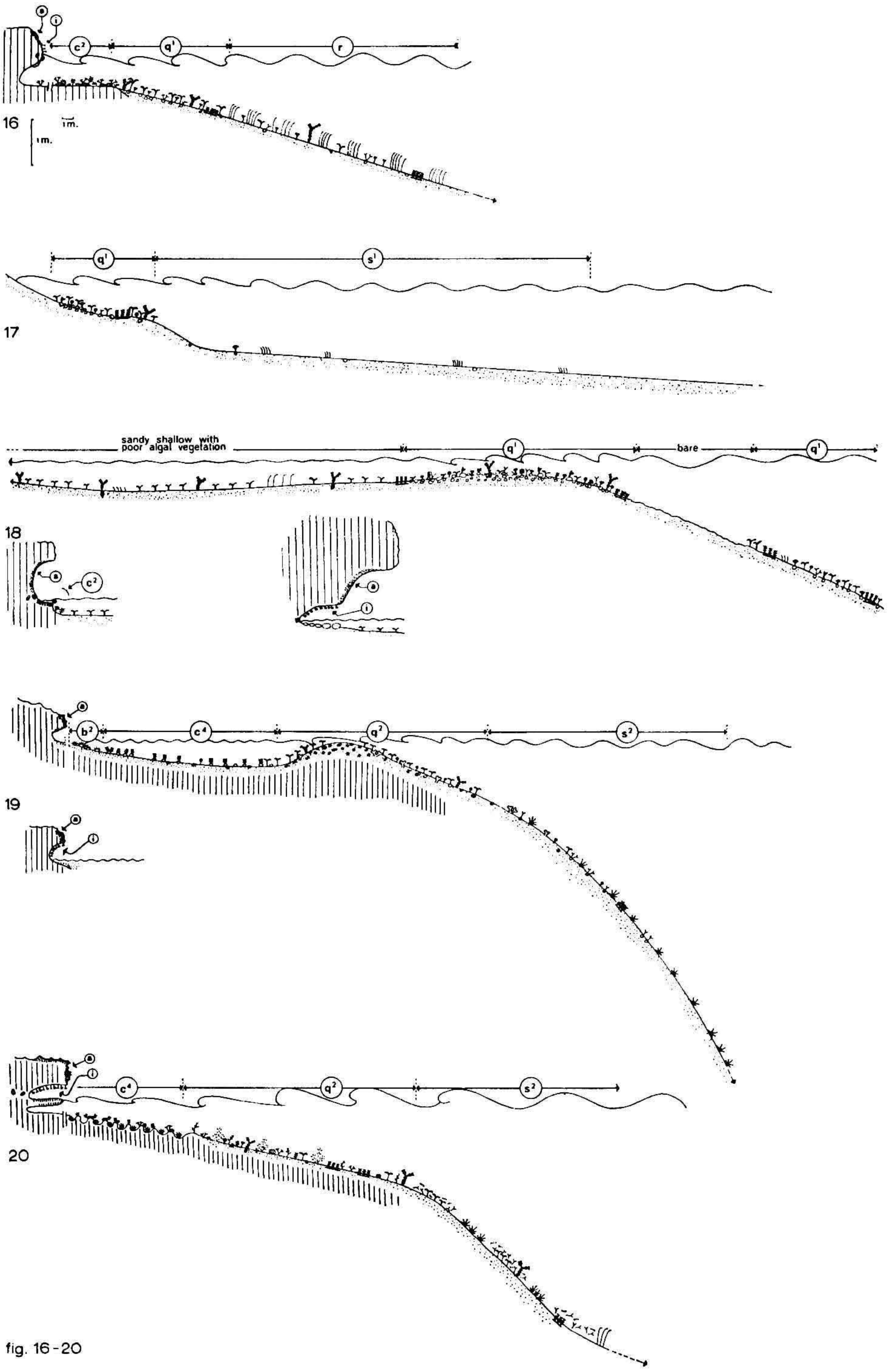
The lower limit of the *Bostrychia* subzone on *Rhizophora* roots lies at about low water-level; *Amphineura* are lacking here.

The composition as to frequent and abundant species, on rocky substrates and on *Rhizophora* roots is identical. However, the chlorophycean "*Arnoldiella sp.*" [1] was twice encountered growing in the outer dead bark of the *Rhizophora* roots (stations 56, 59).

This vegetation-type does not seem to occur on the open coast profiles; at least we never observed it there. Its absence there could have a direct correlation with the heavy wave action (which could prevent spores from settling) or an indirect correlation (the heavy wave action permitting the

---

[1] See floristic and taxonomic notes.



Figs. 16–20. Diagrammatical sections of the coastal profiles and the dominant algae and seagrasses growing on them; stations 49, 55, 65, 68, and 70, respectively. For explanation of symbols, see fig. 33.

development of much denser populations of grazing gastropods – *Amphineura, Nerita spp., Nodolittorina, Littorina, Tectarius*). The *Bostrychia* subzone was also lacking in the most sheltered stations of the bays (exposure-stages G–I, see fig. 14). A minimum amount of wave action which is still present in the relatively exposed inner bay stations (exposure-stage F) seems to be required for the development of this vegetation-type.

Bostrychia spp. and their characteristic companions apparently do not rapidly colonize available substrates. In *Rhizophora* thickets containing *Bostrychia* vegetations only the older roots are covered by it, whereas the younger roots look devoid of any striking algal growth and only bear a sparse *Entophysalis deusta* vegetation (with *Schizothrix calcicola*).

In quite a considerable number of stations *Rhizophora* roots were not covered by the eulittoral *Bostrychia* subzone, although it could be expected there because these stations can be ranged under the oceanity-stage F (see 4; fig. 14) (e.g. stations 32, 48, 50, 81, 92).

In Playa Grandi and Bartolbaai (stations 48, 50) there seems to be an obvious reason for the absence of the eulittoral *Bostrychia* subzone on *Rhizophora* roots. Surf-niches in these bays do contain the *Bostrychia* subzone. Directly East of the airport at Hato (on the N.E. coast) lies the municipal rubbish dump of Willemstad, where the refuse is dumped from the cliff into the sea. The strong N.W. current along the N.E. coast transports much of the rubbish along the coast, particularly floating material like plastic bottles and light material like plastic sheets and wood. Much of this light material is washed into the bays Boca Ascencion, Playa Grandi, and Bartolbaai (fig. 1), where it piles up to form an ill-smelling fringe along the Western shores; plastic bottles and rags are blown by the trade wind far into lands bordering the bays. Much plastic material, and particularly plastic bags and sheets, become entangled in the roots of the mangroves, and smother any vegetation that might possibly grow on them.

This serious form of pollution not only endangers the biota of these bays, but also makes them completely unfit for any form of recreation and hence considerably diminishes the value of the properties in which these bays are situated.

It is more difficult to find a reason for the absence of the *Bostrychia* subzone near the entrance of Piscaderabaai (station 32; on *Rhizophora* roots as well as in the surf-niche), in Lagún Blancu (*Rhizophora* roots near station 81) and in the entrance of Spaanse Water (station 92; *Rhizophora* roots and surf-niche).

Catenella repens, a cosmopolitan species characteristic of more or less shady and often slightly brackish eulittoral localities both in temperate and tropical regions, was once found in the *Bostrychia* subzone (sublagoon of Lac, Bonaire, in a surf-niche, station 102).

Cladophora coelothrix, with about the same ecological amplitude as *Catenella repens* on European and American Atlantic coasts, was also observed once in the *Bostrychia* subzone (Spaanse Water, on *Rhizophora* roots, station 86) (cf. VAN DEN HOEK, 1963).

Caloglossa leprieurii, a species that is often mentioned as a characteristic constituent of the *Bostrychia* subzone, was never encountered in this subzone of Curaçao although it has been found growing in the *Dictyopteris delicatula* zone (f) in the surf-niche of the S.W. coast of Curaçao (station 8) and collected from deep stations (60 m at station 3 b; 25–30 m at station 6 b).

ALMODOVAR and BIEBL (1962) demonstrated that species of the *Bostrychia* subzone (namely *Bostrychia tenella*, *Catenella repens*, and *Caloglossa leprieurii*) had a significantly higher "osmotic resistance" (defined as the ability to survive a 24 hours exposure to more or less diluted or concentrated seawater) than species that occur only submerged or in the surf-zone. For instance *Bostrychia tenella*, *Catenella repens*, and *Caloglossa leprieurii* could survive exposure to 0.0–4.0 times concentrated seawater, whereas *Centroceras clavulatum*, *Acanthophora spicifera*, *Spyridia filamentosa*, *Hypnea musciformis*, *Falkenbergia hillebrandii*, and *Dictyota dichotoma* could only survive exposure to 0.2–2.6, 0.4–2.4, 0.4–2.0, 0.4–1.6, 0.5–1–4, and 0.6–1.7 times concentrated seawater, respectively.

They also found that *Murrayella periclados*, *Enteromorpha flexuosa*, and *Rhizoclonium hookeri* (= *R. implexum* sensu Koster) had the same "osmotic resistance" as the species of the *Bostrychia* subzone, namely 0.0–4.0. *Murrayella periclados* forms a characteristic sublittoral zone on mangrove roots immediately below the *Bostrychia* subzone (see fig. 14, m) but is capable of penetrating into the lower parts of the *Bostrychia* subzone (station 56, 59); *Enteromorpha flexuosa* is the only conspicuous algal species of hypersaline lagoons apart from a number of *Cyanophyceae* (see b^5, 5.6.2), and *Rhizoclonium implexum* is also capable of penetrating into the *Bostrychia* subzone (observed in stations 56, 69, 71, 82, 86) and into more or less shady places of the lower eulittoral zone in general, although it reaches a massive sublittoral development in the polluted lagoons Zakitó and Rifwater (p^8; see also table 15).

Apparently the most conspicuous species of the eulittoral *Bostrychia* subzone (*Bostrychia binderi*, *B. tenella*, *Catenella repens*, probably also *Polysiphonia howei*) have quite precise ecological requirements that are only realized in the littoral surf-niches or on the *Rhizophora* roots in bay-entrances and relatively exposed stations in the inner bays. One can only speculate about these requirements, for Almodovar and Biebl investigated only the resistance versus one of the adverse factors in the lower eulittoral zone. It would be interesting to investigate, by culture experiments, if all stages in the life-histories of e.g., *Bostrychia* spp., *Polysiphonia howei*, and *Catenella repens* are capable of growing continuously submerged, or whether intermittent emersion in some or all stages of the life-history is required.

The other investigated species with equally high osmotic resistances are species with wide ecological amplitudes and which are capable of penetrating into the lower eulittoral zone (*Rhizoclonium implexum* and *Enteromorpha flexuosa; Murrayella periclados* seems to be limited to submerged parts of the aerial roots of *Rhizophora*).

5.1.1.4. *l) Emerged Microcoleus felts on compact silty flats in back-mangroves (fig. 14, column VII; table 15)*

The mangrove thickets fringing the bays are often bordered, on the landward side, by bare strips or sometimes plains of compact, saline, silty soils. These strips or plains, which to landward often bear a vegetation of *Batis maritima* and/or *Sesuvium portulacastrum*, are mostly devoid of any visible algal growth, but parts of it are covered by *Microcoleus* felts, which generally show polygonal patterns as a result of shrinkage of the soil during dry periods. The polygonal sheets of *Microcoleus* felt may peel off and be blown away by the trade wind.

The *Microcoleus* felts can hardly be ranged under the eulittoral zone, as they are seldom, if ever, inundated by baywater during high tide (perhaps rarely during exceptionally high waters). However, evaporation causes salts to be concentrated in the upper soil layers, so that the soil bearing this vegetation-type is covered by small glittering salt crystals. Showers, rather than inundation by baywater, intermittently moisten the *Microcoleus* felts which are therefore able to tolerate very large salinity- and moisture-fluctuations (this is quite a common feature of *Microcoleus* felts all around the world).

The *Microcoleus* felts of 4 stations (64, 88, 90, 103) were investigated. The dominant species were *Microcoleus chthonoplastes* (64, 88, 90, 103), *Microcoleus tenerrimus* (64, 88, 103) and *Lyngbya aestuarii* (88, 90, 103). *Lyngbya aestuarii* in all three stations largely consisted of empty sheaths. This species probably develops during wet periods and gradually dies off during dry periods. Apparently *Lyngbya aestuarii*, which species is quite common in all submerged vegetation-types in the bays (see table 15) is less well adapted to temporary desiccation. This is in accordance with observations on the distribution of *Lyngbya aestuarii* in the salt-marshes ("sansouires") bordering the Mediterranean lagoons in the South of France (VAN DEN HOEK, 1960). In one station (90), with a relatively high soil bearing a growth of *Sesuvium portulacastrum*, *Gloeothece fuscolutea* was codominant (for taxonomic remarks on the above-mentioned *Cyanophyceae* see 7).

5.1.2. *The sublittoral zone (fig. 14)*

The sublittoral zone is defined as the region from the upper limit of *Thalassia*, which roughly coincides with low water level, downwards to the lower limit of vegetation. The lower limit depends on the transparency of the water and hence reaches its deepest levels in the entrances of the bays and in the clear-water lagoons Awa di Oostpunt and Lac, where it is situated at a depth of about four or more meters (fig. 14, columns I and II). In the less transparent inner bays (fig. 14, columns III–V) the lower limit of vegetation reaches a depth of about 2–4 m. In some places, particularly in the bay entrances, the lower limit of vegetation is determined by the instability of the substratum. This instability increases rapidly towards the middle of each bay entrance where the bottom consists of continuously moving sands. In such places the lower limit of vegetation lies at very variable depths.

In the extremely murky water of permanent and temporary pools of back-mangroves (fig. 14, columns VI and VII) the lower limit of vegetation lies at about 5 to 10 cm below water-level.

5.1.2.1. c) *The upper sublittoral rhodophycean turfs of Laurencia papillosa (fig. 14, columns I and II)*

On the open coasts the *Laurencia papillosa* turfs are situated in the lowest part of the eulittoral zone, in the surf-zone (VAN DEN HOEK, 1969) where their lower limit is mostly set by the upper sublittoral *Sargassum polyceratium* types.

Extensions of the open coast *Laurencia papillosa* turfs occur in the bay entrances on the N.E. coast and in the lagoons Awa di Oostpunt and Lac, where cliffs (in the bay entrances) and plateaus (in the lagoons) of coral limestone provide rocky substrates for the attachment of these rhodophycean turfs (fig. 14, column I and II). The *Laurencia* turfs, however, are here sublittoral rather than eulittoral, and their lower limit is not set by the upper limit of *Sargassum polyceratium*, but by the line where the rocky substrate dives into the sandy submarine slopes (about 0.2–0.4 m below low water line).

Laurencia papillosa is clearly a species of the open coasts but which is also capable of penetrating and developing luxuriantly in the bay-entrances on the N.E. coast and the oceanic lagoons (this in contrast to the opinion expressed in VAN DEN HOEK, 1969, p. 549, which was based on too few observations).

c^2) *The type of Laurencia papillosa and Gelidiella acerosa (tables 6, 15, c^2; figs. 14, 16, 18, 33)*

This type is characteristic for flat, gently sloping rocks in inlets on the extremely exposed N.E. coast (VAN DEN HOEK, 1969). The upper sublittoral rhodophycean turfs in the bay-entrances of the N.E. coast much resemble this type and are considered to be its extension into the bay-entrances.

Chaetomorpha media, a species of wave-battered rocks and characteristic for this vegetation-type on open coasts, was not observed in the bay-entrances. The extension into the bay-entrances is very rich in species: a total number of 97 of which 27 have a degree of presence $\geqslant$ III (for the open coast variant the total number of species observed amounts to

TABLE 6

The extension of the *Laurencia papillosa* turf into the entrances of the larger bays of the N. coast (c^2) and into the lagoons Awa di Oostpunt and Lac (Bonaire) (c^4).

c^2. The type of *Laurencia papillosa* and *Gelidiella acerosa*. 9 survey-plots from stations 45, 49 (2 ×), 54, 57, 66, 73, 100 (2 ×).

c^4. The type of *Laurencia papillosa* and *Goniolithon strictum*. 5 survey-plots from stations 68 (2 ×), 70, 101 (2 ×).

vegetation-types	c^2	c^4
Laurencia papillosa	V$^{1-4}$	V$^{1-4}$
Jania capillacea (also ep.)	V$^{+(-2)}$	IV^{+}
Ceramium gracillimum (ep.)	V^{+-1}	IV^{+}
Cladophoropsis membranacea	IV^{+-2}	V^{+}
Acanthophora spicifera	IV^{+-3}	IV^{+-2}
Jania adhaerens	IV^{+-1}	III^{+}
Valonia ocellata	III^{+}	IV^{+}
Cladophora dalmatica	III^{+}	IV^{+}
Caulerpa sertularioides	III^{+}	IV^{+}
Herposiphonia tenella (also ep.)	III^{+-2}	IV^{+-1}
Centroceras clavulatum	III^{+-2}	III^{+-1}
Halimeda opuntia	III^{+-3}	III^{+-1}
Dictyota dichotoma	III^{+-2}	III^{+}
Lyngbya majuscula	III^{+-1}	III^{+}
Lyngbya sordida	III^{+}	III^{+}
Gelidium pusillum/crinale	III^{+-1}	III^{+}
Caulerpa racemosa	II^{+-2}	III^{+}
Chaetomorpha linum	II^{+}	III^{+}
Gelidiella acerosa	III$^{(+-)2-3}$	I^{1}
Ceramium tenerrimum	III^{+-2}	I^{+}
Spyridia filamentosa	III^{+-2}	I^{1}
Cladophora socialis	III^{+-2}	I^{+}
Porites porites	I^{1}	III^{+-1}
Goniolithon spectabile	I^{+}	III^{+-2}
Hypnea spinella	IV^{+-3}	I^{+}
Thalassia testudinum	I^{+}	IV^{+-3}
Hypnea cervicornis	I^{+}	IV^{+-2}
Caulerpa cupressoides	I^{+}	IV^{+}
Dictyosphaeria cavernosa	II^{+}	V^{+-1}
Phormidium crosbyanum	I^{+}	V^{+-2}
Dictyopteris delicatula	IV^{+-1}	
Enteromorpha clathrata	IV^{+}	
Sphacelaria tribuloides	III^{+-2}	
Bryopsis pennata	III^{+}	
Valonia ventricosa	III^{+}	
Herposiphonia secunda	III^{+}	
Polysiphonia subtilissima	III^{+}	
Dichothrix sp.		IV^{+-2}
Goniolithon strictum		V$^{1-2}$
Cruoriopsis cruciata		IV^{+}

53, of which 20 have a degree of presence $\geqslant$ III). The large majority of frequent ($\geqslant$ III) species have wide ecological amplitudes with regard to exposure and oceanity. Frequent species that have their main distribution on the open coasts are *Laurencia papillosa*, *Gelidiella acerosa*, and *Dictyopteris delicatula* (see table 6 and table 15, c^2); the only frequent species with their main distribution in bays and lagoons are *Valonia ventricosa* and *Polysiphonia subtilissima*. However, the large group of species with a degree of presence $<$ III contains many typical open coast species (*Pocockiella variegata*, *Wrangelia bicuspidata*, *Hydroclathrus clathratus* (rel. sheltered open coasts), *Turbinaria turbinata*, *Porolithon pachydermum*, *Lithophyllum daedaleum*, *Pterocladia americana*, *Gracilaria mammillaris*, *Dictyota ciliolata*, *Laurencia microcladia*, *Hypnea musciformis*, *Dictyota dentata*) as well as a considerable number of typical bay and lagoon species (*Acicularia schenckii*, *Cladophora delicatula*, *Thalassia testudinum*, *Cladophora jongiorum*, *Penicillus capitatus*, *Phormidium crosbyanum*, *Chaetomorpha linum*, *Ernodesmis verticillata* (in small abundance also on open coasts).

The bay-entrances, as a – rather narrow – contact environment between the bays and the open coast, harbour the richest algal vegetation observed. In the Bartolbaai the *Sargassum polyceratium* vegetation (typical for all open coasts) appears at about 50 m seawards from station 49, and at about 100 m seawards the *Sargassum rigidulum* vegetation – characteristic for the heavily battered surf-platform of the N.E. coast – appears (cf. VAN DEN HOEK, 1969). So typical open coast habitats are quite near to station 49. This is true for all comparable stations in the other bay-entrances on the N.E. coast.

c^4) *The type of Laurencia papillosa and Goniolithon strictum (tables 6, 15, c^4; figs. 14, 19–21, 33)*

This type is characteristic for the clear-water lagoons Awa di Oostpunt and Lac. The following frequent (degree of presence $\geqslant$ III) and often also abundant ($\geqslant$ 1) species differentiate the *Laurencia papillosa* – *Goniolithon strictum* type from other *Laurencia papillosa* turfs: *Goniolithon strictum*, *Goniolithon spectabile*, *Cruoriopsis cruciata* (growing attached to the undersides of *Goniolithon* and the coral *Porites porites*), and, to a lesser degree, *Thalassia testudinum*, *Hypnea cervicornis*, *Caulerpa cupressoides*, *Dictyosphaeria cavernosa*, and *Phormidium crosbyanum*.

Both *Goniolithon* species are characteristic for all sublittoral vegetation-types of oceanic lagoons. This is probably a consequence on the one hand of the fact that the brittle plants of these species are loose-lying or only feebly attached to the substrate, so that they require a relatively sheltered habitat in order to remain in place and not to be broken up, on the other hand of their requirement for clean oceanic water. Such conditions – clean, regulary replenished, and at the same time quiet water – are only realized in the clear-water lagoons Lac and Awa di Oostpunt.

The frequent and abundant occurrence of *Thalassia* and *Caulerpa cupressoides* reflects the fact that this vegetation-type grows on a partly sand-covered plateau.

The majority of frequent (degree of presence $\geqslant$ III) species have wide ecological amplitudes with regard to exposure and oceanity. The total number of plant-species encountered in the *Laurencia papillosa – Goniolithon* type amounts to 47.

The occurrence of living corals, though small and infrequent (apart from the frequent and abundant *Porites porites*), are also an indication of the relatively high degree of oceanity of such lagoons (*Porites astreoides*, *Favia fragum*, *Millepora alcicornis*).

In one lagoonal station (70), situated opposite the entrance of Awa di Oostpunt and exposed to relatively strong wave action, the *Laurencia papillosa* turf contained numerous pits in which individuals of the sea-urchin *Echinometra lacunter* were living. This is usual for *Laurencia papillosa* turfs on the open coasts. Another indication of a relatively strong wave action in that station was the occurrence of *Gelidiella acerosa* (table 6).

5.1.2.2. e^1) *The sublittoral Porolithon pachydermum coral formation (tables 7, 15, e^1; figs. 14, 27, 33)*

The sublittoral part of the S.W. cliff-coast and the submarine plateau in front of it are covered by rich formations of corals and the coralline *Porolithon pachydermum*. Large populations of the long-spined sea-urchin *Diadema antillarum* inhabit the *Porolithon*-covered surfaces. A very sparse and inconspicuous growth of browsed algae occurs in this formation which is, however, rich in species (VAN DEN HOEK, 1969).

Impoverished extensions of the *Porolithon pachydermum* coral formation occur on W. shores of the entrances of Piscaderabaai (station 32), Santa Martabaai (station 44) and Spaanse Water (station 92), and at the northernmost end of the entrance-channel of Spaanse Water (station 82). These extensions grow on cliffs of coral limestone (fig. 27) down to where the cliffs dive into submarine sandy slopes (at a depth of about 0.5–1.5 m).

Here, as on the open coast, a poorly developed vegetation of small algae usually grew attached to *Porolithon* and dead coral (a total number of 55 algal species was observed). The only frequent (degree of presence III) species characteristic for bays and lagoons was *Valonia ventricosa* (table 7).

In the Santa Martabaai and Piscaderabaai (stations 44, 32) this formation occurs only in a very limited area directly adjacent to the bay-entrances, and only on the W. shores which are directly washed by the seawater flowing into the bays during high tide. The number of coral species and their development in both bays is obviously much smaller than in the extensions of the *Porolithon pachydermum* coral formation in the entrance of Spaanse Water. Thus, in Santa Martabaai only few and small colonies of *Millepora alcicornis* and *Agaricia agaricites* were

TABLE 7

Extension of the *Porolithon pachydermum* coral formation (e^1) into the entrances of bays on the S. coast. 5 survey-plots from stations 32, 44, 82 (2 ×), 92.

vegetation-type	e^1
Porolithon pachydermum	V$^{2-5}$
Diadema antillarum	V^{+-2}
Agaricia agaricites	V^{+-1}
Favia fragum	V^{+}
Siderastrea radians	IV$^{1-2}$
Porites astreoides	IV^{+-2}
Hypnea spinella	IV^{+-2}
Millepora alcicornis	IV^{+-2}
Ectocarpus duchassaignianus	IV^{+-2}
Polysiphonia ferulacea	IV^{+-1}
Laurencia microcladia	IV^{+}
Ceramium tenerrimum	IV^{+}
Antithamnion antillanum	IV^{+}
Bryopsis pennata	IV^{+}
Diploria labyrinthiformis	III^{+-2}
Porites porites	III$^{1-2}$
Echinometra lacunter	III^{+-1}
Sphacelaria furcigera	III^{+-1}
Lyngbya aestuarii	III^{+-1}
Jania adhaerens	III^{+}
Jania capillacea	III^{+}
Gelidiopsis gracilis	III^{+}
Acanthophora spicifera	III^{+}
Lyngbya sordida	III^{+}
Caulerpa vickersiae	III^{+}
Ceramium gracillimum	III^{+}
Cladophora dalmatica	III^{+}
Enteromorpha clathrata	III^{+}
Valonia ventricosa	III^{+}

found growing, and in Piscaderabaai only few and small colonies of *Favia fragum*, *Siderastrea radians*, and *Agaricia agaricites*. ROOS (1964) also mentions *Porites astreoides* for this locality, and he found *Siderastrea radians* in the innermost part and along the entire E. shore. The poor growth of corals in the direct vicinity of the entrances of both bays reflects the low "degree of oceanity" of Santa Martabaai and Piscaderabaai in general.

The occurrence of quite a considerable number of coral species near the innermost end of the entrance-channel of Spaanse Water (station 82) reflects the relatively high degree of oceanity of this bay as compared with that of Santa Martabaai and Piscaderabaai (see table 7 and 15 e^1); at this station *Acropora cervicornis* occurred, and *Siderastrea radians* colonies reaching sizes of more than one meter in diameter. For a more complete picture of the distribution of corals in Spaanse Water, see ROOS (1964).

In the bays on the N.E. coast (Bartolbaai, Playa Grandi, and St. Jorisbaai) conspicuous coral formations are lacking, probably because: 1. the distance from the well-developed reefs on the S.W. coast is too great (the extremely strong wave action on the N.E. coast does not permit the development of coral reefs; only on the edge of the submarine plateau, about 100 m from the coast, were conspicuous coral colonies observed), 2. the zone in the entrances of the bays which is suitable for the development of corals is relatively narrow.

5.1.2.3. *m) The upper sublittoral Murrayella zone on aerial roots of Rhizophora mangle (fig. 14; table 15, m)*

This upper sublittoral zone on *Rhizophora* roots usually succeeds the lower eulittoral *Bostrychia* zone. However, in a few places (stations 92, 50) a *Murrayella* zone only was present and the *Bostrychia* zone was absent. The *Murrayella* zone rises to about 10 cm above low water line, and has its lower limit at a depth of 20 to 40 cm, where the *Rhizophora* roots meet the bottom.

Only two species out of a total of 43 had a degree of presence $\geqslant$ III, namely *Murrayella periclados* (V^{1-4}) and *Lyngbya majuscula* (IV^{+-2}) (8 survey-plots from stations 50 (2 ×), 56, 59, 60, 86, 92, 102).

The *Murrayella* zone occurs in relatively exposed stations of the inner bays, and also in the entrance of Spaanse Water (fig. 14, columns III and IV, "oceanity" degree F).

The large majority of other species found in the *Murrayella* zone have wide ecological amplitudes and most of them also occur in the surrounding *Thalassia* meadows (q^3). In two stations (59, 60) a dense colony of the lamellibranchiate *Isognomon alatum* grew, mainly in the upper part of the zone. In one station (59) *Spermothamnion speluncarum* was the dominant species (abundance 4), while *Murrayella* was less abundant (abundance 1).

5.1.2.4. n^1) *Periphyton on submerged Rhizophora roots in the most sheltered parts of the inner bays. The type of Isognomon alatum (tables 8, 15,* n^1*; fig. 14)*

In the most sheltered bights of the large inner bays (fig. 14, column V; "oceanity" degree G) the lamellibranchiate *Isognomon alatum* replaces the algae in determining the aspect of the periphyton on *Rhizophora* roots. The density of *Isognomon* growth increases towards low water level. The algal vegetation is inconspicuous, the total number of species amounts to 25, of which 8 are frequent (degree of presence $\geqslant$ III), and they all have a small degree of abundance. "*Arnoldiella*", a chlorophycean species growing in the outer bark of the *Rhizophora* roots, is quite characteristic (see taxonomic and floristic notes).

5.1.2.5. o^1), p^1), p^2) *The Caulerpa verticillata type* (o^1*, tables 9, 15; fig. 14) and Lyngbya types* (p^1, p^2*, table 15; fig. 14) on very sheltered muddy bottoms*

The first two vegetation-types occur on soft muddy bottoms (depth ca 0.5–0.7 m) of *Rhizophora* thickets in the most sheltered parts of the

TABLE 8

Periphyton on submerged *Rhizophora* roots in the most sheltered parts of the bays (n). Dominance of filter-feeders. Poor development of algae.

n^1. The type of *Isognomon alatum* in the larger bays. 4 survey-plots from stations 48, 63 (2 ×), 86.

n^2. The type of *Crassostrea rhizophorae* and *Isognomon alatum* in Piscaderabaai. The growth of filter-feeders in the eutrophied bay is obviously more vigorous than in the larger bays. 4 survey-plots from station 28, 29, 30, 32.

vegetation-types	n^1	n^2
Isognomon alatum	IV^{2}	IV^{+-1}
Lyngbya meneghiniana	III^{1}	V^{+-1}
Rhizoclonium implexum	III^{+}	IV^{+}
Entophysalis deusta (gloeocapsoid)	III$^{1-2}$	III^{+}
cf. "Arnoldiella sp."	III^{+-1}	III^{+}
Acanthophora spicifera	III^{+}	III^{+}
hydroids	IV$^{2-3}$	I^{2}
sponge	I$^{\times}$	III^{2}
Caulerpa verticillata	I^{2}	III^{+}
Cladophora socialis	III^{+}	
Calothrix aeruginea	III^{+}	
Enteromorpha clathrata	III^{+}	
Crassostrea rhirophorae		V$^{1-3}$
Balanus sp. (large barnacle)		V$^{1-2}$
Brachydontes sp.		IV$^{1-2}$
Black tunicate		IV^{+-1}
Bryozon		III^{2}
Lyngbya sordida		III^{+}
Spermothamnion speluncarum		III^{+}
Chaetomorpha gracilis		III^{+}

bays with wide entrances (fig. 14, degree of "oceanity" G). Both types contain but few species: the *Caulerpa verticillata* type contains 16 species of which only *Caulerpa verticillata* is frequent and mostly also abundant (V^{+-5}), and in the two stations (34 and 63) where a *Lyngbya* film covered the soft muddy bottom under mangroves 7 species in total were observed, two of which were abundant (*Lyngbya aestuarii* at station 34, and *Lyngbya majuscula* at station 63).

In general, however, soft muddy bottoms in comparable localities are bare and apparently devoid of any algal growth (apart from some diatoms, which were not investigated). The southernmost part of Playa Grandi consists of a shallow pool surrounded by a fringe of *Rhizophora* thickets (station 53). The bottom (about 0.5–0.6 m deep) is covered by a film of *Lyngbya majuscula* (p^2). Other species: *Microcoleus chthonoplastes*, *Acanthophora spicifera*, *Chaetomorpha linum*, *Chaetomorpha gracilis*, *Cladophora delicatula* (6 species in total). Most species participating in the vegetation-types o^1, p^1 and p^2 have wide ecological amplitudes and also occur in most other bay-habitats.

TABLE 9

The sublittoral *Caulerpa verticillata* types (o).

o^1. The type of *Caulerpa verticillata* on very sheltered muddy bottoms under *Rhizophora* thickets in bays and lagoons with wide entrances. 5 survey-plots from stations 52 (2 ×), 83, 102, 104.

o^2. The type of *Caulerpa verticillata* and *Caulerpa sertularioides* characteristic of most of the sublittoral of Piscaderabaai. This type replaces the *Thalassia-Halimeda opuntia* type of the larger bays. 10 survey-plots from stations 28 (3 ×), 29 (3 ×), 30 (4 ×).

vegetation-types	o^1	o^2
Caulerpa verticillata	V^{+-5}	V^{1-4}
Caulerpa sertularioides		V^{+-3}
Lyngbya majuscula	II^{+-5}	III^{+-2}
Lyngbya aestuarii	I^{+}	II^{2}
Rhizoclonium implexum	I^{+}	III^{+-1}
Enteromorpha clathrata		III^{+}
Bryopsis pennata		III^{+}
Ceramium codii		III^{+}

Only *Caulerpa verticillata* seems to find here its optimum conditions for growth.

In the westernmost extension of Awa di Oostpunt (station 72) a muddy shallow (10 cm deep) with *Avicennia* pneumatophores was partly covered by a film of *Lyngbya aestuarii* and *Lyngbya majuscula* (of which species also flocculent masses grew attached to the pneumatophores). This *Lyngbya* vegetation is comparable to the p^1 type. Other (all inabundant) species: *Enteromorpha clathrata, Rhizoclonium riparium, Chaetomorpha linum, Cladophora socialis, Cladophoropsis membranacea.*

5.1.2.6. *p^3) Cyanophycean periphyton on Avicennia pneumatophores (fig. 14, column VI, VII; tables 10, 15, p^3)*

Pneumatophores of *Avicennia nitida* sticking out of the muddy bottom of permanent ("oceanity" H) and semi-permanent to temporary pools ("oceanity" I) are covered by a cyanophycean felt, the most characteristic "species" of which seemed to be *Lyngbya meneghiniana* (for taxonomic remarks, see 7). "*Arnoldiella sp.*", a Chlorophycean growing in the outer bark of the *Avicennia* pneumatophores (and also encountered on aerial roots of *Rhizophora*) seemed to be a characteristic non-cyanophycean species.

A total number of 15 species, of which 8 had a presence $\geqslant$ III, were discovered in this vegetation-type. Apart from "*Arnoldiella*" three other *Chlorophyceae* were part of this vegetation-type, namely juvenile *Batophora oerstedii* (III^{+-2}) (apparently where a nearby well-developed *Batophora* vegetation could provide a constant supply of diaspores, e.g. station 87), *Rhizoclonium riparium* (I^{+}, station 87), *Rhizoclonium implexum* (II^{+}, station 64), and *Enteromorpha clathrata* (I^{+}, station 64).

TABLE 10

Cyanophycean periphyton on submerged *Avicennia* pneumatophores in very shallow pools in back-mangroves. 7 survey-plots from stations 64 (2 ×), 87 (4 ×), 89.

vegetation-type	p^3
Schizothrix calcicola (Plectonema nostocorum)	V^{1-5}
Entophysalis deusta (gloeocapsoid)	V^{+-2}
Lyngbya meneghiniana	IV^{2-5}
cf. "Arnoldiella sp."	IV^{+-2}
Calothrix aeruginea	IV^{+}
Aphanothece pallida	III^{+-5}
Aphanocapsa littoralis	III^{+-1}
Batophora oerstedii (juv.)	III^{1-2}

The last three species have very wide ecological amplitudes and occur in the large majority of bay habitats (see table 15).

The vegetation is encrusted with a thin, brittle layer of lime which forms about ten (column H) to five (column I) cm high delicate bands around the *Avicennia* pneumatophores. One would be tempted to ascribe the deposition of lime to *Schizothrix calcicola*, which species is known to form lime incrustations, particularly in fresh water (see DROUET, 1968).

The lower limit of this vegetation-type lies at about 10 cm depth in the extremely murky water where it occurs. The bottom or other substrates below it are devoid of any algal growth.

5.1.2.7. v^1) *Submerged Batophora vegetations in pools of back-mangroves (fig. 14; table 15,* v^1)

Shallow, but permanent pools in back-mangroves may contain vegetations of *Batophora oerstedii* with several *Cyanophyceae*. In two stations (87 and 103) well-developed *Batophora* vegetations were observed. According to WAGENAAR HUMMELINCK and ROOS (1969) a series of *Batophora* pools fringes the back-mangroves of Lac (Bonaire).

Batophora needs solid substrates for attachment. At station 87 this substrate is provided by a zone of *Avicennia* pneumatophores fringing a pool ca 30 m × 50 m large and ca 20 cm deep), the deepest part of which (0–10 cm deep and about 1 m broad) is covered by a dense growth (abund. 3) of *Batophora*. At station 103 the solid substrate consists of a part of the limestone plateau which here emerges through the sediments; further *Batophora* grows attached to mollusc-shells. At the latter station *Batophora* was accompanied by a few *Acetabularia crenulata* plants.

Batophora oerstedii is known as a very euryhaline species occurring from brackish water with low salinity to hypersaline waters (WAGENAAR HUMMELINCK and ROOS, 1969, mention salinities of *Batophora* pools ranging from 20–23 to 120–160 $^0/_{00}$).

At station 87 *Batophora* was partly overgrown by *Phormidium fragile, Agmenellum quadruplicatum, Johannesbaptistia pellucida, Spirulina subsalsa*, and diatoms.

5.1.2.8. p^4) *Submerged Microcoleus felts on shallow muddy bottoms (table 15, p^4; stations 87 and 89)*

Two places were investigated where shallow (ca 5 cm) muddy bottoms in back-mangroves (*Avicennia* thickets and adjacent pools) had a covering of *Microcoleus chthonoplastes* (abundance 5). *Microcoleus chthonoplastes* and *Microcoleus tenerrimus* (abund. 2) indicate the probably rather regular emersion (through evaporation) of these two stations. The abundant occurrence of the *Cyanophyceae Johannesbaptistia pellucida, Aphanocapsa littoralis,* and *Agmenellum quadruplicatum* is probably correlated with the submergence at the time of our visit. Total number of species (all *Cyanophyceae*): 8. This type contains many diatoms, which were not investigated. Most comparable stations in back-mangroves were devoid of any obvious algal vegetation, e.g. at station 64, where a shallow (ca 5–10 cm) pool was continuously whirled up by the N.E. trade wind. Here, however, *Avicennia* pneumatophores appeared to bear, at the water-air interface, a muddy, ca 3 cm high collar containing much *Microcoleus chthonoplastes, Microcoleus tenerrimus,* and *Lyngbya aestuarii.* This muddy, ca 1 cm thick collar appeared to have a layered structure; apparently these three *Cyanophyceae* were capable of catching mud-particles and of building these into layered mud-collars around the tips of the *Avicennia* pneumatophores.

5.1.2.9. q) *The sublittoral Thalassia meadows (figs. 14, 16–27, 33; tables 11, 15, q^1–q^4)*

Sublittoral *Thalassia* meadows cover vast shallows in the inner bays with large entrances, the bottoms of these entrances, and the bottoms of the clear-water lagoons Awa di Oostpunt and Lac. The upper limit of *Thalassia testudinum* roughly coincides with low water level. The lower limit in the inner bays is mostly set by the transparency of the water and lies at about 1–2 m in more peripheral regions of the bays and down to 1.5–3 m in the more central parts. In the lagoon Lac the lower limit of *Thalassia* is reached at about 4–5 m (see also WAGENAAR HUMMELINCK and ROOS, 1969).

In the bay-entrances the lower limit of *Thalassia* is set rather by the instability of the substrate which roughly increases towards the centre of the entrances where constantly shifting sands are unfit for the settlement of *Thalassia.* Hence the depth of the lower limit in the entrances of the bays is very variable.

As would be expected, the accompanying algal flora differs much depending on the degree of "oceanity". Four types of *Thalassia* meadows could be distinguished.

q^1) *The type of Thalassia testudinum, Halimeda opuntia, and Penicillus (tables 11, 15, q^1; figs. 14, 16–18, 33)*

This type is characteristic for the bay-entrances on the N.E. coast. It is very rich in species: 113 species in total, of which 27 have a degree

TABLE 11

The sublittoral *Thalassia* meadows.

q^1. The type of *Thalassia, Halimeda opuntia,* and *Penicillus.* 8 survey-plots from stations 49, 54, 55 (2 ×), 65 (2 ×), 65a.

q^2. The type of *Thalassia, Halimeda opuntia,* and *Goniolithon strictum.* 8 survey-plots from stations 68 (4 ×), 70, 101, 105 (2 ×).

q^3. The type of *Thalassia* and *Halimeda opuntia.* 15 survey-plots from stations 32, 50, 51, 57, 58, 59, 61, 80, 81, 84, 85 (2 ×), 91, 92, 105a.

q^4. The poor *Thalassia*-type. 9 survey-plots from stations 47, 59, 61, 62, 83 (2 ×), 84, 85, 91.

vegetation-types	q^1	q^2	q^3	q^4
Thalassia testudinum	V$^{(+-)1-3}$	V^{+-4}	V^{+-4}	V$^{2-3}$
Halimeda opuntia	IV^{+-2}	V^{+-3}	V^{+-3}	II^{+}
Dictyota dichotoma	V^{+-3}	V^{+-4}	IV^{+-2}	III^{+-1}
Ceramium gracillimum (ep.)	V^{+-1}	IV^{+-2}	V^{+-2}	III^{+}
Jania capillacea	V^{+-1}	IV^{+-1}	V^{+-1}	I^{+}
Centroceras clavulatum (also ep.)	III^{+-1}	III^{+-2}	V^{+-1}	IV^{+}
Spyridia filamentosa	V^{+-1}	II$^{1-3}$	V^{+-2}	I^{+}
Acanthophora spicifera	IV^{+}	II^{+}	IV^{+-2}	II^{+}
Polysiphonia subtilissima	IV^{+-1}	II^{+}	III^{+}	III^{+}
Ceramium tenerrimum (also ep.)	IV^{+-2}	III^{+}	III^{+-1}	I^{+}
Lyngbya sordida	II^{+}	II^{+-1}	IV^{+-2}	II^{+-2}
Lyngbya majuscula	IV^{+}	III^{+-2}	III^{+-2}	I^{+}
Lyngbya aestuarii	I^{+}	III^{1}	II^{+-1}	II^{+-2}
Enteromorpha clathrata	IV^{+}	II^{+}	III^{+}	I^{+}
Rhizoclonium implexum	IV^{+}	I^{+}	III^{+-2}	I^{+}
Cladophora dalmatica	IV^{+}	II^{+}	II^{+}	II^{+}
Cladophora socialis	II^{+-1}	III^{+-1}	II^{+}	II^{+}
Calothrix confervicola (ep.)	III^{+}	II^{+}	III^{+}	II^{+}
Polysiphonia cf. macrocarpa	II^{+}	III^{+}	II^{+-2}	II^{+}
Sphacelaria tribuloides	II^{+}	II^{+-1}	III^{+-1}	II^{+}
Polysiphonia ferulacea	II^{+}	II^{+}	II^{+}	III^{+}
Padina gymnospora	III^{+-1}	II^{+-2}	II^{+-1}	I^{+}
Hypnea cervicornis	II^{+}	II$^{1-2}$	III^{+-1}	I^{+}
Acicularia schenckii	I^{+}	I^{+}	III^{+-1}	II^{+}
Penicillus spp. (pyr. + cap.)	V^{+-2}	IV^{+-2}	II^{+-1}	
Penicillus capitatus	IV^{+-1}	III^{+-2}	II^{+-1}	
Penicillus pyriformis	I^{2}	I^{+}	I^{+-1}	
Jania adhaerens	III^{+-2}	II^{+-2}	IV^{+-2}	
Hypnea spinella	III^{+-2}	I^{+}	IV^{+-1}	
Caulerpa sertularioides	IV^{+-2}	III^{+-1}	II^{+}	
Caulerpa cupressoides	IV^{+}	II^{+-1}	II^{+}	
Herposiphonia tenella (ep.)	II^{+-1}	II^{+}	III^{+-2}	
Porites porites	I^{+}	III^{+-3}	III^{+-2}	
Cladophoropsis membranacea	II^{+}	II^{+}	IV^{+}	
Dictyosphaeria cavernosa	I^{+}	IV^{+-1}	II^{+-1}	
Siderastrea radians	I^{+}	II^{+}	III^{+-1}	
Chondria curvilineata	II^{+}		III^{+-1}	II^{+}
Halodule beaudettii	III^{+-1}		I^{+-2}	I^{2}
Ceramium codii	II^{+-2}		IV^{+}	II^{+}
Porolithon "aegagropiloid form"	I^{+}	IV^{+-2}		
Caulerpa mexicana	IV^{+-1}		II^{+}	
Aglaothamnion cf. furcellariae	III^{+-1}		I^{+-1}	
Goniolithon strictum		V^{+-3}	I^{+}	
Valonia ventricosa		I^{1}	IV^{+-1}	
Goniolithon spectabile		IV^{+-5}		

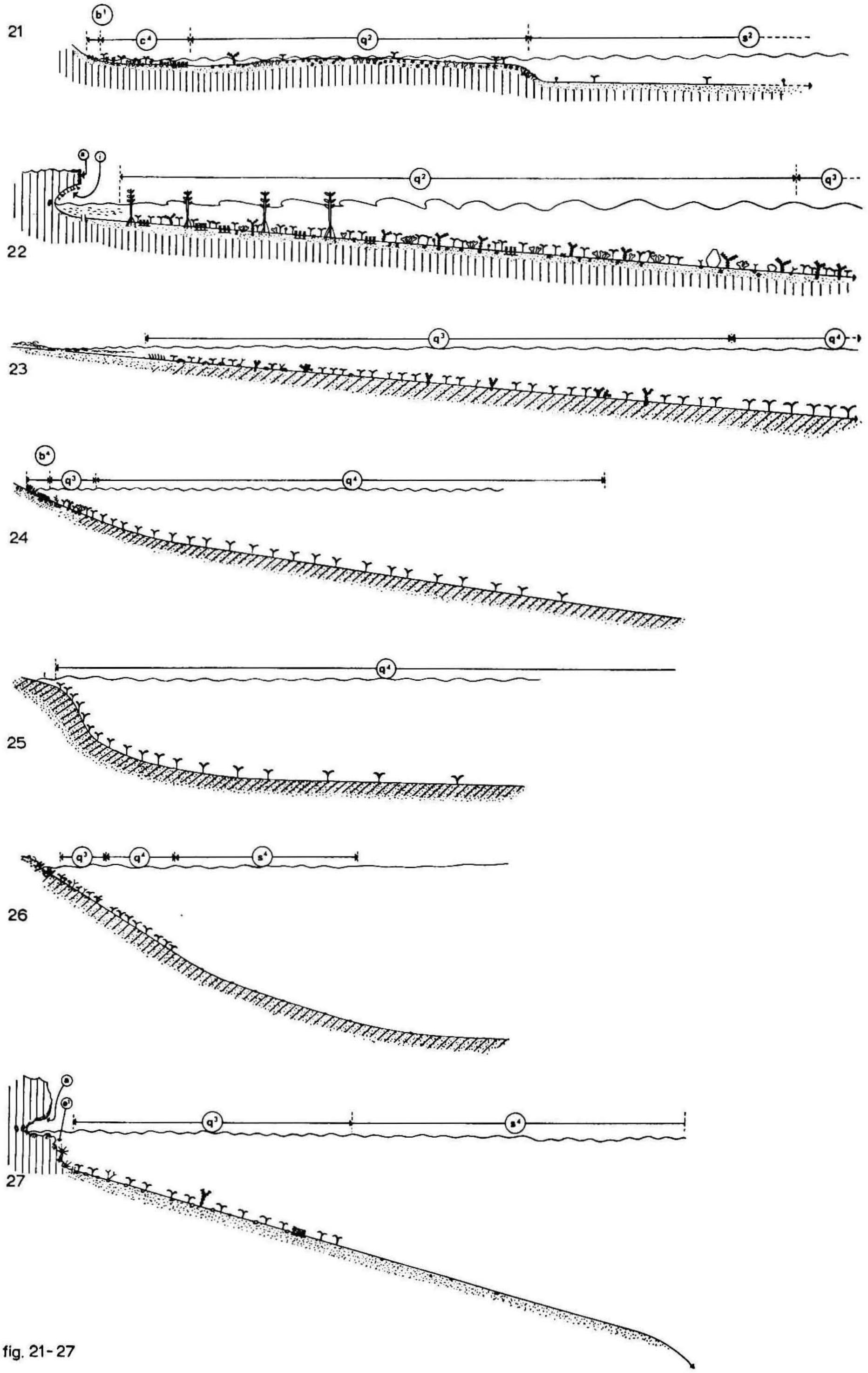


fig. 21-27

Figs. 21–27. Diagrammatical sections of the coastal profiles and the dominant algae and seagrasses growing on them; stations 101, 104, 59, 61, 62, 84, and 32, respectively. For explanation of symbols, see fig. 33.

of presence $\geqslant$ III. This high floristic diversity reflects the fact that this vegetation-type inhabits the rather narrow contact zone between the open coast vegetation of the N.E. coast and the bay vegetations. In this respect it is comparable to the extension of the type of *Laurencia papillosa* and *Gelidiella acerosa* into the bay-entrances on the N.E. coast (5.1.2.1. c^2).

The substrate of this vegetation-type is sand with shingle and small boulders; the shingle is often more or less consolidated by the *Thalassia* rhizomes. Shingle and boulders serve as solid substrates for the majority of algae participating in this vegetation-type; but it also contains species with rhizomes creeping in the surface of the sand (*Caulerpa spp.*) or attached in the sand by bulbous feet. (*Penicillus spp.*, *Avrainvillea*, *Udotea*, *Halimeda simulans*). The density of the vegetation is therefore correlated with the density of the available solid substrate. Where wave action causes the shingle to form banks, the algal vegetation – near the water surface – is very rich, for instance in the entrances of St. Jorisbaai (station 65; fig. 18). Here wave action has caused a shallow (0.2–0.4 m) shingle bank covered with a rich algal vegetation. The coral *Siderastrea radians* occurs here as a kind of "living shingle" (+). Behind the shingle bank in relatively quiet water the bottom is completely sandy and is covered by a comparatively poor algal vegetation which is dominated by the seagrass *Thalassia testudinum*. From the shingle bank 55 species were collected, from the sandy shallow behind it only 12 species [viz. *Thalassia testudinum* (3), cf. *Vaucheria* (2), *Melobesia sp.* (epiphytically on *Thalassia*) (1), *Halimeda incrassata* (+), *Ceramium gracillimum* (ep.) (+), *Centroceras clavulatum* (ep.) (+), *Rhizoclonium implexum* (+), *Ceramium tenerrimum* (+), *Chaetomorpha sp.* (+), *Halodule beaudettii* (+), *Syringodium filiforme* (+) (5×5 m^2)] (this survey-plot was not used for the composition of table 11, q^1). This is the only station where fructifications and germinating seeds of *Thalassia* were observed.

The majority of frequent (degree of presence $\geqslant$ III) species have wide ecological amplitudes, a smaller number are more or less characteristic bay-species, namely *Polysiphonia subtilissima*, *Caulerpa sertularioides* (also in some bights of the S.W. open coast), *Caulerpa cupressoides* (also in some bights of the S.W. open coast), *Halodule beaudettii* (known from one bight on the S.W. coast), and *Aglaothamnion furcellariae*.

Penicillus capitatus, probably also *Penicillus pyriformis*, and *Caulerpa mexicana* are frequent species that have their main strongholds in the bay-entrances on the N.E. coast, the *Penicillus* species also occur in the lagoons Lac and Awa di Oostpunt. It is in these most oceanic of all bay habitats that one encounters dense fields of *Penicillus* "shaving-brushes", amidst *Thalassia* meadows; specimens also occur in relatively exposed stations of the inner bays (degree of "oceanity" F) but here they are usually scattered. None of the frequent species are typical open coast species, but the category of infrequent (presence $\leqslant$ II) species contains many open coast species, namely: *Laurencia papillosa*, *Gelidiella acerosa*, *Laurencia microcladia*, *Hypnea musciformis*, *Hydroclathrus clathratus*, *Dilophus guineensis*, *Liagora farinosa*, *Liagora valida*, *Neomeris annulata* (often in open coast rock pools), *Dictyota ciliolata*, *Trichogloeopsis pedicellata*, *Dictyota dentata*, *Amphiroa hancockii*, *Gracillaria mammillaris*, *Cladophora laetevirens*, *Falkenbergia hillebrandii*, *Wrangelia argus*, *Dictyopteris delicatula*, and *Jania pumila*. *Acetabularia calyculus* was only collected in bay-entrances of the N.E. coast (stations 49, 55, 65).

Infrequent typical bay species were: *Halimeda simulans*, *Udotea flabellum*, *Acicularia schenckii*, *Caulerpa verticillata* and *Avrainvillea nigricans*.

Only infrequent, small colonies of the following corals were observed in the *Thalassia-Halimeda opuntia-Penicillus* type: *Siderastrea radians* and *Porites porites*. For a discussion on the distribution of corals, see 5.1.2.2.

q^2) *The type of Thalassia testudinum, Halimeda opuntia, and Goniolithon strictum (tables 11, 15,* q^2*; figs. 14, 19–22, 33)*

This is the type characteristic for the clear-water lagoons Awa di Oostpunt and Lac. It is distinguished by the frequent and abundant occurrence of the corallines *Goniolithon strictum*, *Goniolithum spectabile*, and *Porolithon sp.* ("aegagropiloid form")[1]. *Goniolithon strictum* and *G. spectabile* also occur in the type of *Laurencia papillosa* and *Goniolithon strictum* (the *Laurencia papillosa* turf typical for clear-water lagoons, c^4). It has been argued under c^4 (5.1.2.1) that both *Goniolithon* species – brittle and mostly loose-lying – probably need clear regularly replenished oceanic water and sheltered conditions that are realized only in the clear-water lagoons. *Porolithon sp.* ("aegogropiloid form") is a mostly loose-lying, bulbous form.

Wave action probably causes the establishment of the banks of *Goniolithon strictum*, *Goniolithon spectabile*, and *Porolithon* ("aegagropiloid form") observed at the stations 68 and 101 (figs. 19, 21, 33) (the coral *Porites porites* also takes part in the formation of such banks). During extreme low waters the tops of such banks may partly emerge and there the component corallines and corals die off. The substrate is a shallow submarine plateau of coral limestone covered by a thin layer of sand with scattered shingle and boulders. Algae can grow attached to the rocks (where these protrude through the sand); to the shingle and boulders; and to the dead remains of corallines and corals.

The large majority of frequent and abundant species (table 11) have wide ecological amplitudes. However, *Penicillus spp.* and *Dictyosphaeria cavernosa* seem to have a stronghold in the clear-water lagoons. *Dictyosphaeria* also occurs on open coasts and in the relatively exposed stations of inner bays (see table 15). *Penicillus spp.* are also relatively abundant and frequent in the entrances of bays on the N.E. coast (q^1). *Caulerpa sertularioides* is a more or less characteristic bay species.

The flora of this type of *Thalassia* meadow is less diversified than that

---

[1] See taxonomic and floristic notes.

in the entrances of the bays of the N.E. coast, and consists of a total of 74 species (113 species in the bay-entrances of the N.E. coast!), 18 of which were frequent (with a degree of presence ⩾ III). None of the frequent species are characteristic for open coast habitats, but the category of infrequent (degree of presence ⩽ II) species contain four species characteristic for open coasts, namely *Dilophus guineensis*, *Laurencia microcladia*, *Gelidiella acerosa*, and *Laurencia papillosa* (19 typical open coast species occurred in q^1, the *Thalassia* meadows in entrances of bays on the N.E. coast!). Infrequent typical bay species were *Avrainvillea rawsonii*, *Avrainvillea nigricans*, *Caulerpa cupressoides*, *Chrysonephos lewisii*, *Polysiphonia subtilissima*, *Acicularia schenckii*, *Udotea flabellum*, *Halimeda incrassata*, *Halimeda simulans*, and *Valonia ventricosa*.

Apparently the clear-water lagoons are unsuitable for the majority of open coast species. Station 68 in Awa di Oostpunt contained few open coast species despite being situated in the near vicinity of the open coast.

Apart from *Porites porites*, the corals *Siderastrea radians* (mostly loose colonies; "living shingle") and *Porites astreoides* were observed.

In one station (70) along the shore of Awa di Oostpunt *Corallina cubensis* was one of the dominant species (abundance 3), whereas it was not observed in any of the other lagoonal stations (figs. 20, 33).

q^3) *The type of Thalassia testudinum and Halimeda opuntia (tables 11, 15, q^3; figs. 14, 23, 24, 26, 27, 33)*

A shallow zone – 0 to 0.5–1.0 m below low water level – along relatively exposed shores of the inner bays is occupied by this vegetation-type. Its width depends on the inclination of the substrate and varies from about 4 to 50 m. In the entrances of two bays on the S.W. coast (Spaanse Water and Piscaderabaai, stations 92 and 32 respectively) the lower limits are deeper, namely from about 1 to 2 m.

On the W. shore of Lac the *Thalassia-Halimeda opuntia-Goniolithon strictum* type (q^2) merges downwards, at a depth of somewhat more than one meter, into a vast *Thalassia* meadow which has been ranged under the type of *Thalassia* and *Halimeda opuntia* (q^3) (figs. 14, 22).

This type of *Thalassia* meadow merges, in the relatively exposed stations of the inner bays, into the "poor *Thalassia* type" (q^4), from which it differs by the occurrence of a quantitatively and qualitatively rich algal vegetation. The substrate consists of sand or muddy sand with shingle, sometimes also small boulders. Wave action probably has sorted out the sediments and shingle in such a way, that near to the water surface a zone of concentrated shingle and sand occurs whereas deeper down the bottom is mainly muddy. The presence of a solid substrate, like shingle, is required for the development of a rich algal vegetation, and this is certainly one of the reasons why a rich algal vegetation in the inner bays is concentrated in the upper 0.5 to 1.0 m below low water level. At the same time, however, the low transparency of the inner baywaters (see table 2) certainly plays a rôle in determining the lower limit of many species at a relatively shallow depth; for instance *Padina gymnospora* and *Padina sanctae-crucis* are always concentrated in the upper part of this type of *Thalassia* meadow. However, we have the strong impression that the availability of solid substrate in this vegetation-type is the main reason for the development of a comparatively rich algal vegetation, since, in the inner bays, the lowest limit of any algal growth lies at about 2 to 4 m (in the s^4 vegetation-type, see 5.1.2.11).

The large majority of frequent and abundant species (table 11) have wide ecological amplitudes; of this category only *Acicularia schenckii* and *Valonia ventricosa* have strongholds in the inner bays. *Valonia ventricosa* also reaches a great abundance in small clear-water lagoons (see 5.5.1).

The flora of this vegetation-type is comparatively rich: a total number of 91 species were collected from it, of which 25 were frequent (degree of presence $\geqslant$ III) and mostly also abundant (abundance $\geqslant 1$).

None of the frequent species are characteristic for open coasts, but the group of infrequent (degree of presence $\leqslant$ II) species contains five species hacracteristic for open coasts, namely *Laurencia papillosa*, *Laurencia cmirocladia*, *Gracilaria ferox*, *Hypnea musciformis*, and *Gelidiella acerosa*.

Infrequent typical bay species are *Halimeda simulans*, *Halimeda incrassata*, *Udotea flabellum*, *Caulerpa mexicana* (mainly in bay-entrances of the N.E. coast, q^1), *Caulerpa sertularioides*, *Caulerpa cupressoides*, *Caulerpa verticillata*, *Penicillus pyriformis*, *Penicillus capitatus* (both *Penicillus spp.* mainly in bay-entrances on the N.E. coast, q^1, and in clear-water lagoons, q^2), *Avrainvillea rawsonii*, *Aglaothamnion furcellariae*, and *Gracilaria confervoides*.

In two stations the seagrass *Halodule beaudettii* participated in the *Thalassia-Halimeda opuntia* type, namely at station 50 (abundance +) and station 85 (abundance 2). At the latter station it formed a narrow (1–2 m wide) interrupted zone in the upper part of the *Thalassia-Halimeda opuntia* zone. Only in the inner shallow part of Bartolbaai (near station 48) was *Halodule* observed to form a rather extensive zone near low water-level. This species is known to be able to tolerate short emersion during low water (see DEN HARTOG, 1970). On the other hand scattered *Halodule beaudettii* fields were observed below the lower limit of *Thalassia* meadows in the bay-entrances on the N.E. coast (compare figure 23 with figs. 17, 18) where it gave the impression of being better able to colonize the more or less unstable shifting sands than *Thalassia*.

The corals *Porites porites* (forming small banks) and *Siderastrea radians* (as "living shingle") were quite frequent and also often abundant in the *Thalassia-Halimeda opuntia* type (see table 11). These two coral species are the ones that penetrate farthest into the inner bays (see also ROOS, 1964). The corals *Porites porites*, *Dichocoenia stokesii*, *Favia fragum*, *Agaricia agaricites*, and *Millepora alcicornis* were only infrequently and inabundantly encountered as participants in the *Thalassia-Halimeda opuntia* type (see table 15).

q^4) The poor Thalassia testudinum type (tables 11, 15, q^4; figs. 14, 23–26, 33)

This type of *Thalassia* meadow is characterized by the obvious absence of any striking algal growth. Only *Thalassia,* and to a much lesser degree also *Dictyota dichotoma* (partly as loose-lying plants), are frequent and abundant. *Lyngbya sordida* and *Lyngbya aestuarii* in one station (47) were also abundant as gelatinous fluffs. The poor *Thalassia* type covers extensive shallows in the inner bays, where it is certainly the most dominant vegetation-type. In relatively exposed inner bay stations (fig. 14, column IV; stations 59, 61, 84, 85, 91) the *Thalassia-Halimeda opuntia* type merges downwards into the poor *Thalassia* type, of which the upper limit is situated at a depth of about 0.5–1.0 m, and the lower limit at a depth of about 1.5–3.0 m (figs. 23, 24, 26). Below its lower limit the muddy bottom is often bare, but often also covered by a mud- or sand-binding vegetation (see 5.1.2.4. s^4).

In the most sheltered bights of the inner bays (stations 47, 62, 83), the poor *Thalassia* type extends from about low water level down to a depth of about 1 to 2 m (fig. 14, column V; fig. 25). In such sheltered bights shingle as a solid substrate for algae is lacking and the bottom consists of soft mud from low water line downwards; furthermore the water is here very murky. In such extremely sheltered bights the lower limit of *Thalassia* coincided with the lower limit of any obvious plant growth.

The substrate of this vegetation-type consists of soft mud. Solid substrates for the attachment of algae are lacking or rare. Furthermore the *Thalassia* plants capture mud which forms a thin film over all possible solid substrates among the *Thalassia* plants and also partly covers the *Thalassia* leaves which would otherwise be available for the development of an epiphytic algal flora. This epiphytic flora is also, therefore, qualitatively and quantitatively sparse. Apart from the absence of a solid substrate, the low transparency of the water is also probably a limiting factor. Since the gradient in the composition of the substrate (muddy sand and shingle in the upper sublittoral zone → soft mud in the lower sublittoral zone) is indirectly correlated with the degree of transparency it is difficult at present to disentangle the influence of the two factors on the composition of the algal vegetation-types.

The flora of this vegetation-type is comparatively poor: 42 species have been collected from it, of which only 6 were frequent (degree of presence $\geqslant$ III, see table 11). Of the frequent species *Thalassia testudinum* and *Polysiphonia subtilissima* are typical bay species; the remaining four frequent species (*Dictyota dichotoma, Ceramium gracillimum, Centroceras clavulatum,* and *Polysiphonia ferulacea*) have wide ecological amplitudes (see table 15).

None of the infrequent (degree of presence $\leqslant$ II) species was characteristic for open coast habitats. The following infrequent typical bay species were observed: *Halimeda incrassata, Halimeda simulans, Acicularia schenckii, Caulerpa verticillata, Cladophora delicatula.* The large majority of infrequent species, however, have wide ecological amplitudes.

Living corals were never observed in this vegetation-type.

In station 47 (Bartolbaai) *Halodule beaudettii* was an abundant (2) component of the poor *Thalassia* type; landwards it formed an almost pure zone.

Along the N. shore of Awa di Oostpunt, in relatively sheltered bights (e.g. between station 69 and 70), poor *Thalassia* meadows growing on a soft bottom of whitish lime-mud were growing in very shallow (ca 10 cm) water. Apparently the absence of solid substrates was here responsible for the absence of a striking algal growth, as light could hardly be considered to be a limiting factor. Unfortunately no analysis was made of the algal flora growing in this poor *Thalassia* meadow.

In only one station (47: Bartolbaai) was the poor *Thalassia* type observed to form a zone directly below the lower eulittoral chlorophycean subzone (the "type of *Cladophora conferta*", 5.1.1.2. b^4). Here the poor *Thalassia* type covers most of the shallow bottom of the inner basin of Bartolbaai.

5.1.2.10. *r) Sublittoral Syringodium meadow (fig. 14, column I, figs. 16, 33)*

An extensive *Syringodium* meadow was encountered in only one station, namely the entrance of Bartolbaai (station 49), where it formed a ca 20 m broad zone at depths of ca 1 to 2 m below the *Thalassia* meadow of the type q^1.

Only the following species had an abundance $\geqslant$ 1: *Syringodium filiforme* (2), *Penicillus pyriformis* (1), *Melobesia sp.* (2) (ep.), *Ceramium codii* (1) (ep.), and *Lyngbya majuscula* (1) (survey-plot: 10×10 m^2). For the remaining 15 non-abundant species: see table 15 r. The bottom was sandy.

Extensive *Syringodium* meadows probably cover some deeper parts of Awa di Oostpunt, since much material of this species was found washed up on the W. shore of this lagoon. We found scattered stands of this seagrass in the deeper parts (about 4 m) of Awa di Oostpunt at station 70 (s^2). *Syringodium* is reported from the *Thalassia* beds in Lac (Bonaire) by WAGENAAR HUMMELINCK and ROOS (1969), but this species was not encountered in our survey-plots made in this lagoon.

Syringodium is reported from other areas (PHILLIPS, 1960) to develop massively on permanently submerged substrates. Often the seagrasses *Halodule*, *Thalassia*, and *Syringodium* form successive zones, in this order, from water-level downwards. Such a zonation was observed in Bartolbaai, where the innermost W. shallows were covered by *Halodule*, followed by *Thalassia* and *Syringodium* in a roughly seaward direction. However, *Halodule* was also observed, in several places, to grow below and amidst *Thalassia*, and *Syringodium* amidst a shallow *Thalassia* meadow (0.4 m, station 65).

5.1.2.11. *s) Sublittoral sand- and muddy sand-binding vegetations of small Rhodophyceae below Thalassia meadows (tables 12, 15, s^1–s^4; figs. 14, 15)*

In several profiles the lower limit of *Thalassia* roughly coincides with the lower limit of any algal vegetation. However, the *Thalassia* meadow

TABLE 12

Sublittoral sand- and muddy sand-binding vegetations of small *Rhodophyceae* below *Thalassia* meadows.

s^{2}. The type of *Centroceras clavulatum*, *Polysiphonia subtilissima*, and *Penicillus capitatus* characteristic of the lagoons Lac (Bonaire) and Awa di Oostpunt. 4 survey-plots from stations 68, 70, 73, 101.

s^{4}. The type of *Centroceras clavulatum*, *Polysiphonia subtilissima*, and *Griffithsia tenuis* characteristic for bays with wide entrances and the outer basins (W. shores) of Piscaderabaai and Santa Martabaai. 5 survey-plots from stations 32, 44, 51, 57, 84.

vegetation-types	s^{2}	s^{4}
Spyridia filamentosa	V^{+-1}	IV^{+}
Dictyota dichotoma	IV$^{1-2}$	V^{+}
Centroceras clavulatum	IV^{+}	V^{+-1}
Polysiphonia subtilissima	IV^{+-1}	V^{+}
Jania capillacea	IV^{+-1}	III^{+}
Chondria curvilineata	III^{+-1}	IV^{+}
Enteromorpha clathrata	III^{+}	IV^{+-1}
Ceramium tenerrimum	III^{+-1}	III^{+}
Chaetomorpha linum	III^{+}	III^{+-1}
Lyngbya sordida	I^{+}	III^{+-1}
Lyngbya majuscula	I^{+}	IV^{+-2}
Lyngbya aestuarii		III^{+}
Chaetomorpha gracilis	I^{+}	III^{+}
Griffithsia cf. globulifera	I^{+}	III^{+-1}
Acanthophora spicifera	I^{+}	III^{+}
Ceramium gracillimum	IV^{+-1}	I^{1}
Jania adhaerens	IV^{+}	I^{+}
Halimeda opuntia	IV^{+}	I^{+}
Caulerpa sertularioides	III^{+}	
Dictyosphaeria cavernosa	III^{+}	
Hypnea cervicornis	IV^{+}	
Penicillus capitatus	IV^{+}	
Amphiroa fragilissima	IV^{+-1}	
Cladophora socialis	IV^{+-2}	
Polysiphonia macrocarpa (ep.)	V^{+}	
Griffithsia tenuis		V^{+}
Ceramium codii (ep.)		IV^{+-1}
Acicularia schenckii		III^{+-1}
Hypnea spinella		III^{+}
Cladophora dalmatica		III^{+}
Padina gymnospora (juv.)		III^{+}

often merges downwards into a sand- or muddy sand-binding vegetation of mainly small *Rhodophyceae*. Apparently a number of lithophytic algae are capable of growing attached to sand-grains, when this substrate is sufficiently stable. These species attach to and connect sand-grains by rhizoids and systems of creeping stolons. Examples are: *Centroceras clavulatum*, *Polysiphonia subtilissima*, *Chondria curvilineata*, *Ceramium tenerrimum*, and *Ceramium gracillimum*. *Lyngbya majuscula* and *Lyngbya aestuarii* are also capable of binding sand or muddy sand with their gelatinous sheaths. It is generally assumed that sand- and muddy sand-bottoms can only be inhabited by algae adapted to this environment by having rhizomes creeping through the surface layer of the sediment (*Caulerpa spp.*) and bulbous feet anchoring the plants in the sediment (e.g. *Udotea spp.*, *Halimeda spp.*, *Penicillus spp.*). However, where such substrates are relatively stable (i.e. stable during sufficiently long periods for fastgrowing algae to establish), spores of the above mentioned species of *Centroceras*, *Polysiphonia*, *Chondria*, *Ceramium*, can attach to sand-grains and more or less stabilize the sediment by creeping stolons. *Spyridia filamentosa* and *Dictyota dichotoma* frequently occur in these vegetation types, predominantly as loose-lying forms, partly attached to sparse shingle or stones. Therefore the vegetation types of small sand-binding *Rhodophyceae* much resemble the "type of *Dictyota dichotoma* and *Spyridia filamentosa*" which occurs on the bottom of inlets and open bays on the S.W. coast (type e^2; VAN DEN HOEK, 1969). The following species also occurred predominantly as loose-lying forms: *Jania capillacea*, *Chaetomorpha linum*, *Chaetomorpha gracilis*, *Jania adhaerens*, *Amphiroa fragilissima*, and *Cladophora socialis*.

s^1) Sublittoral sand-binding vegetation of small Rhodophyceae in the entrance of a bay on the N.E. coast (table 15, s^1; figs. 14, 17, 33)

This vegetation-type only occurred in the entrance of Playa Grandi (station 55), at a depth of 0.5–1.5 m and forming a zone ca 35 m broad. In general the sandy bottom below the lower limit of seagrass vegetations in the bay-entrances is too unstable for the establishment of any vegetation at all. Here *Halodule beaudettii* (ab. 1) and *Caulerpa mexicana* (ab. 1) were the most conspicuous elements. Other species with an abundance of 1 (*Hypnea musciformis*, *Spyridia clavata*, and *Polysiphonia ferulacea*) were growing attached to *Halodule* rhizomes. All other 25 species were non-abundant (+). The partly sand-binding species *Polysiphonia subtilissima*, *Vaucheria sp.*, *Ceramium gracillimum*, *Ceramium tenerrimum*, and *Acetabularia calyculus* growing attached to small pebbles, were also encountered here. For the remaining species, see table 15, s^1.

s^2) Sublittoral sand-binding vegetation of small Rhodophyceae in the lagoons Lac and Awa di Oostpunt: the type of Centroceras clavulatum, Polysiphonia subtilissima, and Penicillus capitatus (tables 12, 15, s^2; fig. 14, 19–21, 33)

In Lac sandy shallows, down to ca 0.5–0.7 m north of station 101 (figs. 13, 21) were covered by this vegetation-type. In Awa di Oostpunt the shallow plateau along the N. shore (figs. 8, 19, 20) merges at about 30 to 40 m from the coast, at a depth of ca 1 m, into a relatively steep sandy slope. This sandy slope is covered, down to a depth of 5 m, with a sparse vegetation of small sand-binding *Rhodophyceae*. The most conspicuous elements are masses of loose-lying algae: *Dictyota dichotoma*, *Spyridia filamentosa*, *Jania capillacea*, *Amphiroa fragilissima*, *Cladophora* *socialis.* In station 70 enormous masses of loose-lying *Cladophora jongiorum* VAN DEN HOEK (1969) covered the bottom (see 7, floristic and taxonomic notes).

In Lac the sea-urchin *Lytechinus esculentus* was quite common, in Awa di Oostpunt *Diadema antillarum.*

A total number of 52 species were collected from this vegetation-type, of which 19 were frequent (degree of presence $\geqslant$ III). Of the frequent species *Penicillus capitatus* is considered to be more or less characteristic for the relatively high degree of "oceanity" in the lagoons, to a lesser degree also *Dictyosphaeria cavernosa.* The majority of frequent species, including the sand-binding *Rhodophyceae,* have wide ecological amplitudes. More of less typical bay species are the frequent *Polysiphonia subtillissima* and *Caulerpa sertularioides.*

Infrequent (degree of presence $\leqslant$ II) species characteristic for open coasts were *Laurencia papillosa* and *Gelidiella acerosa.* Infrequent bay species were the seagrasses *Halophila sp.* and *Syringodium filiforme,* and the algae *Caulerpa mexicana* and *Goniolithon spectabile* (the latter characteristic for clear-water lagoons).

In one station (68) the coral *Porites porites* was found growing in this vegetation-type.

s^3) Sublittoral sand-binding vegetation of small Rhodophyceae in the entrance of Spaanse Water (fig. 14; table 15, s^3)

The vegetation covering the sandy slope below the *Thalassia* meadow in the entrance of Spaanse Water (station 92) was ranged under this vegetation-type. The slope, however, consisted also of coral debris, to which algae and corals grew attached. The depth was about one to three meters (see fig. 14). The aspect of this vegetation was predominantly determined by *Dictyota dichotoma* (ab. 2) growing attached to coral debris. *Spyridia filamentosa* (+), growing attached to coral debris, also participated in this vegetation-type which therefore showed much resemblance to the "type of *Dictyota dichotoma* and *Spyridia filamentosa*" which occurs on bottoms of inlets and open bays of the S.W. coast (e^2; VAN DEN HOEK, 1969). Other conspicuous algae: *Cladophora socialis* (1), *Lyngbya aestuarii* (1), *Gelidiopsis gracilis* (1), "*Lithothamnion*" (1). Quite characteristic was the occurrence of a considerable number of coral species indicating a high degree of "oceanity": *Diploria strigosa* (+), *Diploria labyrinthiformis* (+), *Porites astreoides* (+), *Dichocoenia stokesii* (+), *Eusmilia fastigiata* (+), *Porites porites* (+), *Siderastrea radians* (1), *Agaricia agaricites* (+).

Penicillus capitatus (+), *Valonia ventricosa* (+), *Caulerpa sertularioides* (+) and *Polysiphonia subtilissima* (+) were more or less typical bay species; *Galaxaura marginata* (+) and *Laurencia microcladia* (+) open coast species.

s[4]) *Sublittoral sand-binding vegetation of small Rhodophyceae in bays with wide entrances, and the outer basins (W. shores) of Piscaderabaai and Santa Martabaai: the type of Centroceras clavulatum, Polysiphonia subtilissima, and Griffithsia tenuis (tables 12, 15; figs. 14, 26, 27, 33)*

In relatively exposed stations of the inner bays this type may occur on slopes of muddy sand below the lower limit of *Thalassia testudinum*, down to depths of ca 2 to 4 m. In the most sheltered bights this vegetation-type is lacking, probably because sand-grains or small fragments of shells are lacking which are required for the attachment of spores of the sand-binding *Rhodophyceae*. Also the low transparency of the water in such places is probably a limiting factor.

In contradistinction to s^2, *Dictyota dichotoma* and *Spyridia filamentosa*, though frequent species, do no determine the aspect of the vegetation. Of the total number of 52 species collected from this vegetation-type 21 species were frequent (degree of presence $\geqslant$ III). Most frequent species have wide ecological amplitudes. *Polysiphonia subtilissima* and *Acicularia schenckii* (growing attached to shells or fragments of shells) are frequent bay species. Of the infrequent species (degree of abundance $\leqslant$ II) *Avrainvillea nigricans, Caulerpa verticillata, Caulerpa cupressoides, Aglaothamnion cf. furcellariae, Cladophora delicatula, Thalassia testudinum, Halodule beaudettii* and *Halophila sp.* (station 32) are bay species. No typical open coast species were encountered in this vegetation-type.

The sea-urchins *Lytechinus* and *Diadema antillarum* were rather common.

5.2. *The vegetation of Santa Martabaai (figs. 4, 15)*

Santa Martabaai differs from Bartolbaai, Playa Grandi, St. Jorisbaai, and Spaanse Water by its narrow entrance and a relatively high turbidity of its waters. In 1962 the channel which now penetrates the barrier of coral debris was dug and since that time algae with a relatively narrow tolerance for high salinities have been able to recolonize Santa Martabaai (see 3.1; tables 1–3).

The shores of Santa Martabaai are characterized by the absence of mangroves and seagrasses (apart from *Ruppia*), which have not yet had opportunity to recolonize these shores. The algal vegetation is qualitatively poor and together with the absence of the seagrass *Thalassia*, causes the aspect of the sublittoral vegetation-types to differ markedly from those in the bays with wide entrances. Nowhere in this bay was a quantitatively rich development of few algal species observed.

5.2.1. *The eulittoral zone*

Where profiles of coral limestone form the coast the *Entophysalis deusta* subzone can be distinguished (figs. 15a, 29). Near the entrance of Santa Martabaai (W. shore, station 44) this subzone terminates, near water-level, in a bare zone with *Amphineura* (fig. 15, column VIII, k). A chlorophycean subzone with *Cladophoropsis membranacea* as a dominant species and ranged under type b^2 occurred along the W. shore of the inner basin (stations 42, 43), growing on a beach of muddy sand with shingle (see table 15, b^2; fig. 30, b^2).

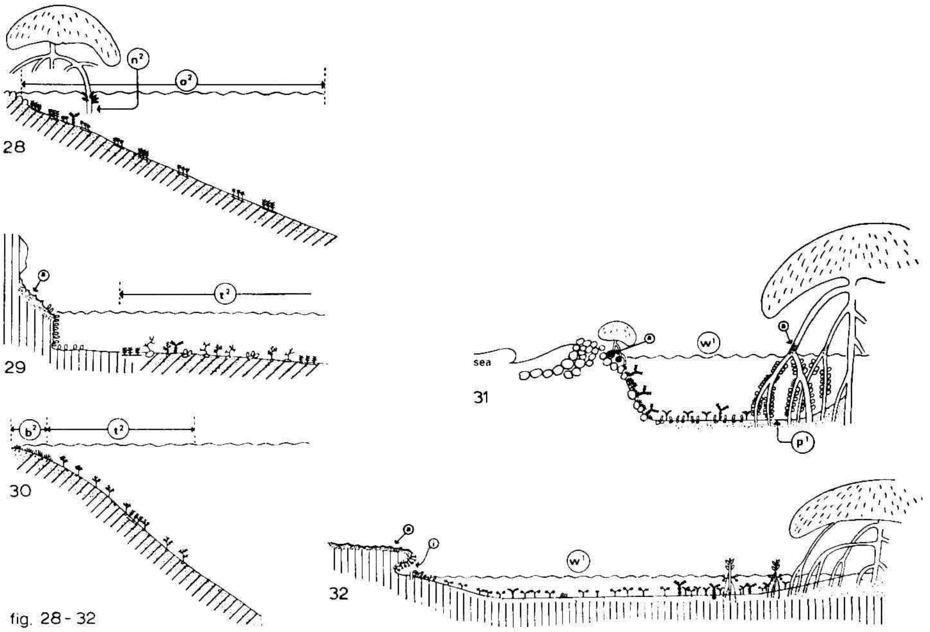
5.2.2. *The sublittoral zone*

5.2.2.1. e^1) *The extension of the Porolithon pachydermum coral formation into the entrance (W. shore) of the bay*

The steep cliffs of coral limestone on the W. shore near the entrance (station 44) were covered from low water-level down to a depth of 0.6 m, with a very impoverished growth ranged under the *Porolithon pachydermum* coral formation (see 5.1.2.2).

5.2.2.2. t^1) *Mixed vegetation of Dictyota dichotoma and Rhodophyceae (fig. 15, column VIII, t^1; table 15, t^1)*

Near the bay-entrance (stations 35, 44, 45) shallows and slopes of muddy sand with boulders and shingle (from water-level down to ca 3.0 m) were covered with a vegetation in which *Dictyota dichotoma* (+ – 2) was the most conspicuous element. The following species were collected from all three survey-plots investigated: *Lyngbya aestuarii* (+ – 2), *Centroceras clavulatum* (+ – 2), *Ceramium gracillimum* (+ – 1) (ep.), *Padina gymnospora* (+), *Hypnea spinella* (+ – 2), *Griffithsia cf. globulifera* (+), *Sphacelaria tribuloides* (+), *Bryopsis pennata* (+ – 1), *Polysiphonia subtilissima* (+ – 1), *Cladophora dalmatica* (+ – 1), *Acicularia schenckii* (+). In stations



Figs. 28–32. Diagrammatical sections of the coastal profiles and the dominant algae and seagrasses growing on them; stations 28, 38, 43, 34, and 102, respectively. For explanation of symbols, see fig. 33.

35 and 44 *Vaucheria dichotoma* (fr!) occurred with an abundance of 2, covering parts of the muddy sand. The total number of species encountered amounted to 41.

The sea-urchin *Diadema antillarum* was quite common.

TABLE 13

Sublittoral algal vegetation in the inner basin of Santa Martabaai. The type of *Caulerpa sertularioides* and *Acanthophora spicifera* (t^2). This type replaces the *Thalassia-Halimeda opuntia* type of the larger bays. 7 survey-plots from stations 36, 37, 38, 40, 41, 42, 43.

vegetation-type	t^2
Caulerpa sertularioides	V^{+-2}
Acanthophora spicifera	IV^{1-2}
Spyridia filamentosa	IV^{+-2}
Brachydontes sp.	IV^{+-2}
Hypnea spinella	III^{1-2}
Aglaothamnion cf. furcellariae	III^{+-1}
Ernodesmis verticillata	III^{+-3}
Acicularia schenckii	III^{+-2}
Cladophoropsis membranacea	III^{+-1}
Dictyota dichotoma	III^{+-1}
Cladophora vagabunda	III^{+-1}
Polysiphonia subtilissima	III^{+}

5.2.2.3. t^2) *Sublittoral algal vegetation in the inner basin of Santa Martabaai: the type of Caulerpa sertularioides and Acanthophora spicifera (tables 13, 15; fig. 15, column IX,* t^2*, figs. 29, 30, 33)*

The shores of the inner basin are covered, down to a depth of 0.5 m (in the most sheltered parts) to 2.0 m, by a qualitatively poor vegetation in which *Caulerpa sertularioides* and *Acanthophora spicifera* are the most conspicuous species.

The bottom consists of muddy sands with shingle and some boulders. The total number of species amounts to only 25, of which 11 were frequent (degree of presence $\geqslant$ III). For a comparison: the total number of species collected from the type of *Thalassia testudinum* and *Halimeda opuntia* (q^3) amounts to 91 of which 25 were frequent. Of the frequent species *Caulerpa sertularioides*, *Aglaothamnion* cf. *furcellariae*, and *Acicularia schenckii* are bay species, the other frequent species have wide ecological amplitudes. Of the infrequent species only *Ruppia maritima* is characteristic for bay habitats (probably this seagrass, which is able to tolerate wide variations in salinity, was already present before 1962). All remaining infrequent species have wide ecological amplitudes.

The sea-urchin *Diadema antillarum* was quite common.

The lamellibranchiate *Brachydontes sp.* (see table 13) occurred, it was concentrated towards low water-level and penetrated up to 0.1 m into the eulittoral zone (figs. 15, 29).

5.2.2.4. u^1) *Vaucheria dichotoma felt on muddy bottom (table 15; fig. 15)*

The soft muddy bottom (depth ca 0.5 m) of one of the basins of the former salines (station 40) was covered by a felt of *Vaucheria dichotoma* (ab. 5). Further *Ruppia* (+) was growing attached in the mud, and *Cladophora delicatula* (+) was collected from the *Vaucheria* felt.

In other places the soft muddy bottom was devoid of any vegetation.

5.2.2.5. p^5) *Cyanophycean felt on Brachydontes and barnacles (table 15; fig. 15, column X)*

At station 39, in the remote N.W. corner, the bay is very shallow, reaching only about 0.2 m. The bottom consists of soft mud that is constantly whirled up by the N.E. trade wind. This causes the transparency to be very low (see table 2).

The muddy bottom is devoid of any algal growth, but barnacles and *Brachydontes sp.* grow attached to the stones of the old enclosures of the former salines. Only three algal species (apart from diatoms which were not investigated) were growing attached to *Brachydontes* and barnacles, namely *Lyngbya meneghiniana* (ab. 2), *Rhizoclonium implexum* (+), and *Enteromorpha flexuosa* (+). The lower limit of this algal growth lies at a depth of about 0.1 m. Hydroids were also very common. Although the fertility (see table 3) of Santa Martabaai seems to be low, a number of filter feeders (*Brachyodontes sp.*, barnacles, hydroids, a.o.) develop quite luxuriantly, although clearly less so than in Piscaderabaai.

5.3. *The vegetation of Piscaderabaai (figs. 2, 15) (the E. shore of the outer basin and the shores of the inner basin)*

Picaderabaai differs from Bartolbaai, Playa Grandi, St. Jorisbaai, and Spaanse Water by its narrow entrance, by the relatively high turbidity of its waters, and by its relatively high phosphate-concentration that is caused by the inflow, at its northernmost end, of domestic effluent (see 3.1, tables 1–3).

The shores are, for the greater part, lined by narrow fringes of mangroves (mainly *Rhizophora mangle*; in a few places back-mangroves of *Avicennia nitida*, see fig. 2).

On the W. shore of the outer basin (station 32) a *Thalassia* meadow covered the bottom of muddy sand with shingle. The steep rocky coral cliffs were covered, below water-level, by an impoverished extension of the *Porolithon pachydermum* coral formation. These vegetation types have been treated under 5.1.1.2 and 5.1.2.9, q^3.

At the other stations investigated (28, 29, and 30) *Thalassia* was lacking where it could be expected to grow, and in its place the qualitatively poor vegetation-type of *Caulerpa verticillata* and *Caulerpa sertularioides* (see table 9, o^2) covered the bottom. The absence of *Thalassia* is probably caused by the pollution of Piscaderabaai. In the heavily polluted lagoons Zakitó and Rifwater (5.4) *Thalassia* is also lacking.

The massive development of filter feeders (mainly *Crassostrea rhizophorae*, *Isognomon alatum*, *Balanus sp.*, holothurians, hydroids, tunicates) mainly growing attached to *Rhizophora* roots is most probably correlated with the relatively high fertility of the water caused by the discharge of domestic effluent (see table 3; high phosphate and pigment concentrations).

Nowhere was a massive development of benthic algae observed such as occurs in eutrophic Mediterranean lagoons (VAN DEN HOEK, 1960). However, DIAZ-PIFERRER (1964) observed a massive development of *Ulva rigida* near the outflow of the effluent (station 30). As such a development did not occur during our visit it would seem to be a transient feature.

The pollution most probably caused the very much impoverished algal vegetation of Piscaderabaai (no data from before the pollution started are available, but comparison with other bays makes this statement quite reasonable). It makes this bay unfit for any recreational purposes and hence diminishes the value of the properties in which it is situated.

5.3.1. *a) The eulittoral zone: the type of Entophysalis deusta*

In stations 28 and 23 an inconspicuous zone of scattered gloeocapsoid colonies of *Entophysalis* (+, 2) covered *Rhizophora* roots from low water-level up to about 0.1 m above it. Large barnacles also extended from the sublittoral periphyton into the eulittoral zone; *Crassostrea rhizophorae* and *Isognomon alatum* penetrated only slightly into the eulittoral zone. Few other algae were observed: *Schizothrix calcicola* (+), *Lyngbya meneghiniana* (+, 1), *Rhizoclonium implexum* (+), *Calothrix crustacea* (28: +), and *Bulbocoleon piliferum* (28: 1).

5.3.2. *The sublittoral zone*

5.3.2.1. *n²) Periphyton on submerged Rhizophora roots: the type of Crassostrea rhizophorae and Isognomon alatum (tables 8, 15; fig. 15, column XI, fig. 28)*

As in the most sheltered bights of the large inner bays (see 5.1.2.4. n¹) filter feeders and not algae determine the aspect of the periphyton on *Rhizophora* roots. However, qualitatively as well as quantitatively the periphyton of filter feeders is obviously more strongly developed in Piscaderabaai than in the sheltered bights of the large inner bays (see table 8).

The density of *Isognomon*, *Crassostrea* and *Balanus* increases towards low water-level.

The periphyton covers the *Rhizophora* roots from low water-level down to 0.3–0.5 m, where the roots meet the sediment.

Of the total number of algal species (19) participating in this periphyton nine are frequent (degree of presence ⩾ III) (see table 8), and in almost all cases they have a very low abundance (+), so that the algal growth is quite inconspicuous. Of the frequent species only *Caulerpa verticillata* is characteristic for (very quiet) bay habitats, of the infrequent species

Aglaothamnion cf. furcellariae is characteristic for bay habitats. All other species have wide ecological amplitudes and occur in open coast habitats as well as bay and lagoon habitats.

5.3.2.2. o^2) *The sublittoral vegetation type of Caulerpa verticillata and Caulerpa sertularioides (tables 9, 15; fig. 15, column XI, figs. 28, 33)*

The bottom of muddy sand with shingle lining the coast of Piscaderabaai (E. shore of outer basin and inner basin) is covered with this vegetation type down to a depth of ca 2.0 to 2.5 m from low water-line. It forms a zone 2 to 50 m broad depending on the inclination of the substrate. Towards its lower limit the vegetation becomes more sparse; *Caulerpa sertularioides* does not occur as deep as *C. verticillata.* This vegetation replaces the *Thalassia-Halimeda opuntia* type (q^3) of bays with wide entrances. It is poor in species: of the total number of 33 species 8 were frequent (abundance $\geqslant$ III) (for a comparison: the total number of species collected from the *Thalassia-Halimeda opuntia* type (q^3) amounts to 91 of which 25 were frequent). Of the frequent species *Caulerpa verticillata* is a characteristic (sheltered) bay species, of the infrequent species *Acicularia schenckii, Aglaothamnion cf. furcellariae, Vaucheria sp.*, and *Halophila sp.* are typical bay species. All other species have wide ecological amplitudes in relation to the "oceanity" stages and occur in open coast as well as in bay habitats.

The qualitative poverty is probably the result of the pollution of this bay. It is interesting that *Halimeda opuntia* was observed in only one station (28), where it had an abundance of +. In the heavily polluted lagoon Zakitó *Halimeda opuntia* is lacking, but the numerous dead segments indicate that formerly this species was very important here. These observations suggest that *Halimeda opuntia* is as sensitive to pollution as *Thalassia* seems to be.

5.3.2.3. p^6) *Submerged cyanophycean film in back-mangrove (fig. 15, column XII; table 15 p^6)*

Shallow (up to 0.05 m) pools in and behind an *Avicennia* back-mangrove at station 31 had soft muddy bottoms covered by a film of *Phormidium fragile* (5), with *Agmenellum quadruplicatum* (+) and *Aphanocapsa littoralis* (+), plus many diatoms. Elsewhere (e.g. station 29) the bottom of comparable pools was only covered by a thin film of diatoms plus a little *Phormidium fragile* (+).

5.4. *The vegetation in the polluted lagoons Zakitó and Rifwater (figs. 12 and 15, column XIII)*

Both lagoons are surrounded by mangrove thickets which, on the lagoonside, consist of *Rhizophora mangle. Laguncularia* is mentioned for the back-mangroves by STOFFERS (1956). Apparently *Rhizophora* does not suffer from the pollution in these lagoons, for many young plants were found amidst and near the thickets.

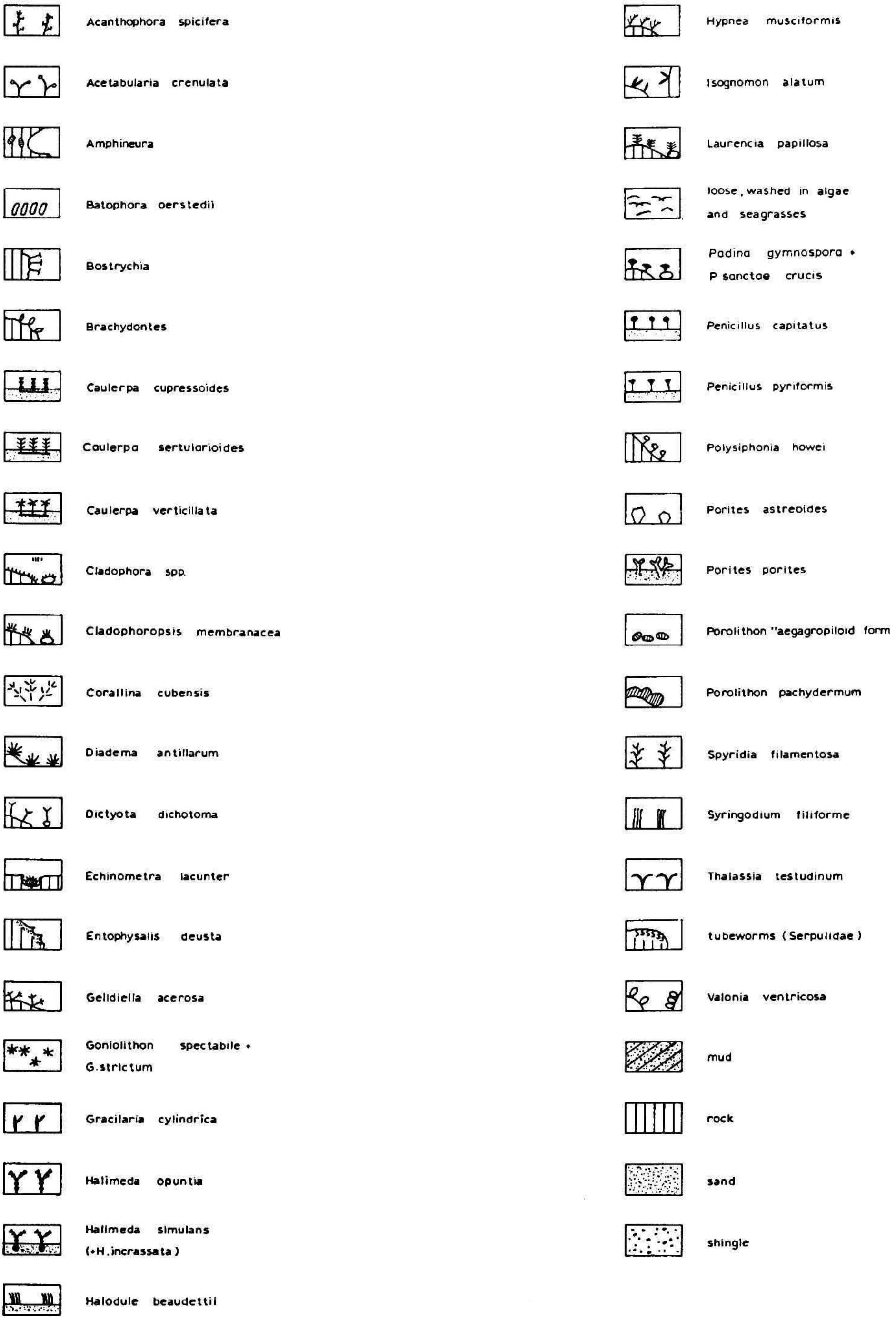

Acanthophora spicifera
Acetabularia crenulata
Amphineura
Batophora oerstedii
Bostrychia
Brachydontes
Caulerpa cupressoides
Caulerpa sertularioides
Caulerpa verticillata
Cladophora spp.
Cladophoropsis membranacea
Corallina cubensis
Diadema antillarum
Dictyota dichotoma
Echinometra lacunter
Entophysalis deusta
Gelidiella acerosa
Goniolithon spectabile +
G.strictum
Gracilaria cylindrica
Halimeda opuntia
Halimeda simulans
(+H.incrassata)
Halodule beaudettii
Hypnea musciformis
Isognomon alatum
Laurencia papillosa
loose, washed in algae
and seagrasses
Padina gymnospora +
P sanctae crucis
Penicillus capitatus
Penicillus pyriformis
Polysiphonia howei
Porites astreoides
Porites porites
Porolithon "aegagropiloid form
Porolithon pachydermum
Spyridia filamentosa
Syringodium filiforme
Thalassia testudinum
tubeworms (Serpulidae)
Valonia ventricosa
mud
rock
sand
shingle

Fig. 33.

On the other hand, the submerged vegetation is extremely poor. *Thalassia* (and other seagrasses) are completely lacking, as is *Halimeda opuntia*. The bottom consists of muddy lime sand containing numerous dead segments of *Halimeda opuntia*, an indication that formerly extensive banks of *Halimeda opuntia* covered the bottom as is presently the case in the Lagoentje van Sint Jan (station 34).

All submerged surfaces and objects are covered by a flocculent red deposit, the result of the discharge of ferric chloride into the lagoons by the water factory. The water is very murky.

5.4.1. p^7) *The bottom vegetation of Zakitó: a film of Lyngbya majuscula (fig. 15, column XIII; table 15* p^7)

At station 98 the gently sloping bottom of muddy sand was covered, at a depth of 1–2 m, by fluffy patches of *Lyngbya aestuarii* (ab. 3). Other species (apart from numerous diatoms): *Schizothrix calcicola* (*Plectonema nostocorum*) (+), *Lyngbya semiplena* (+), *Phormidium sp.* (+), and *Rhizoclonium implexum* (+) (survey-plot: 5 m × 5 m).

5.4.2. p^8) *The vegetation on submerged Rhizophora roots: Cyanophyceae and Rhizoclonium implexum (fig. 15, column XIII; table 15* p^8)

At station 98 the *Rhizophora* roots (down to a depth of 1 m, where they meet the bottom) were covered by *Lyngbya meneghiniana* (ab. 2), *Plectonema sp.* (2), *Lyngbya majuscula* (1), *Schizothrix calcicola* (*Plectonema nostocorum*) (+), *Rhizoclonium implexum* (2), *Vaucheria sp.* (1), and many diatoms.

It was interesting that an animal periphyton of filter feeders, such a characteristic feature of Piscaderabaai, was completely lacking. This can probably be ascribed to the rather serious pollution with crude oil: above low water-line the *Rhizophora* roots were all covered by a band, about 10 cm broad, of black, oily deposit (fig. 15, column XIII).

5.4.3. t^3) *The bottom vegetation close to the entrance channel (fig. 12, station 99; fig. 15, column XIII): Rhizoclonium implexum and Padina gymnospora*

Only close to the entrance channel were more algal species encountered, although even here *Thalassia* and *Halimeda opuntia* were completely absent. On a slope of sand (mixed with bitumen) down to a depth of 1 m and in a zone ca 5 m broad the following species were observed: *Rhizoclonium implexum* (3), *Lyngbya majuscula* (2), *Padina gymnospora* (2: in upper part), *Acrochaetium sp.* (ep.) (2), *Feldmannia sp.* (ep. on *Padina*) (2), *Acetabularia crenulata* (+), *Enteromorpha chaetomorphoides* (+), *Cladophora delicatula* (+), *Enteromorpha clathrata* (+), *Lyngbya aestuarii* (+), *Udotea flabellum* (+) (survey-plot: 3 m × 3 m).

Near to station 99 a small (3 m diam.; 1 m deep) pool in open connection with the lagoon contained *Caulerpa sertularioides* (2), *Caulerpa verticillata* (+), *Acetabularia crenulata* (2), *Lyngbya majuscula* (+), *Cladophoropsis* *membranacea* (+), *Cladophora delicatula* (+), and *Spirulina sp.* (+). The algae were growing attached to lumps of bitumen and dead *Rhizophora* branches.

5.4.4. w^2) *The vegetation of a pool in connection with Rifwater (fig. 12; station 97)*

The vegetation of this pool (which was about 1 m deep) was characterized by the massive development of *Rhizoclonium implexum* which had developed to such an extent that dense masses of it were kept floating at the pool surface by means of the oxygen it was producing being entrapped among the filaments. Parts of these floating masses of *Rhizoclonium* had sunk to the bottom, died off, and become covered by *Cyanophyceae;* this caused the production of hydrogen sulphide at the bottom of the pool. The massive growth of *Chlorophyceae* floating at the surface of lagoons and lagoonal pools has not been observed in any of the other localities investigated on Curaçao or Bonaire. It is quite common in eutrophic Mediterranean lagoons (VAN DEN HOEK, 1960), where, however, other species (e.g. *Monostroma oxyspermum, Ulva sp., Cladophora vagabunda, Cl. albida*) form floating masses. At station 97 *Rhizoclonium* probably starts its development from plants attached to *Rhizophora* roots.

Cladophoropsis membranacea and *Cladophora socialis* are also capable of massive development in this pool.

The flora comprised the following species: *Rhizoclonium implexum* (5), *Acetabularia crenulata* (2) (attached to pebbles, etc.), *Enteromorpha clathrata* (1–2), *Cladophoropsis membranacea* (1–2), *Cladophora socialis* (1–2), *Schizothrix calcicola* (*Plectonema sp.*) (3) (on dying *Rhizoclonium*), *Entophysalis deusta* (+); there was also a rich development of diatoms.

The shallow bottom (ca 0.3 m) near the W. shore of Rifwater (station 97) was also covered by a mainly cyanophycean vegetation. The trade wind had driven much rubbish – wood, tyres, etc. – into this corner. Large hairy masses of *Chaetomorpha linum*, also driven by the wind into this corner, were floating at the surface of the water. Although *Chaetomorpha linum* is a very common species on Curaçao with a wide ecological amplitude (see table 15), nowhere else did it reach such a quantitative development, which is a common feature of this species in eutrophic brackish water of temperate regions and in Mediterranean lagoons.

The vegetation comprised the following species: *Chaetomorpha linum* (5) (floating), *Lyngbya majuscula* (2), *L. sordida* (2), *L. meneghiniana* (2) (ep. on *Chaetomorpha*), *Xenococcus schoesboei* (2) (ep. on *Chaetomorpha*), *Calothrix confervicola* (2) (ep. on *Chaetomorpha*), *Schizothrix calcicola* (*Plectonema nostocorum* (2) (ep. on *Chaetomorpha*), *Cladophora delicatula* (1), *Enteromorpha flexuosa* (1), *Caulerpa sertularioides* (+) (survey-plot: 3 m × 3 m).

In table 15 the species tolerant to rather serious pollution are ranged under column G^2.

5.5. *The vegetation of small clear-water lagoons with a limited communication with the sea (Lagoentje van St. Jan, fig. 3; several small lagoons between Awa Blancu and Lagoen Blancu, and a narrow lagoon N.W. of Awa Blancu, fig. 9; a small sublagoon of Lac, fig. 13, stations 102 and 103)*

5.5.1. *w^1) The vegetation of small lagoons with Thalassia testudinum and a varied algal vegetation (tables 14, 15 w^1; figs. 31, 32)*

Such lagoons receive fresh seawater as seepage through barriers of coral debris (stations 34, 76) (and during storms, by waves swept over the barriers) or via an open communication (station 102). The depth varies from 0.3 (station 102) to 1.0 (stations 34, 76) m, and the bottom consists of coral limestone, more or less covered with a layer of lime mud (station 102), or of lime sand with boulders and shingle (stations 34, 76). Probably salinity and temperature do not rise very much above those of the sea; no measurements of our own are available, but WAGENAAR HUMMELINCK and ROOS (1969) give values between 20 $^0/_{00}$ and 23 $^0/_{00}$ Cl^1 for station 102.

TABLE 14

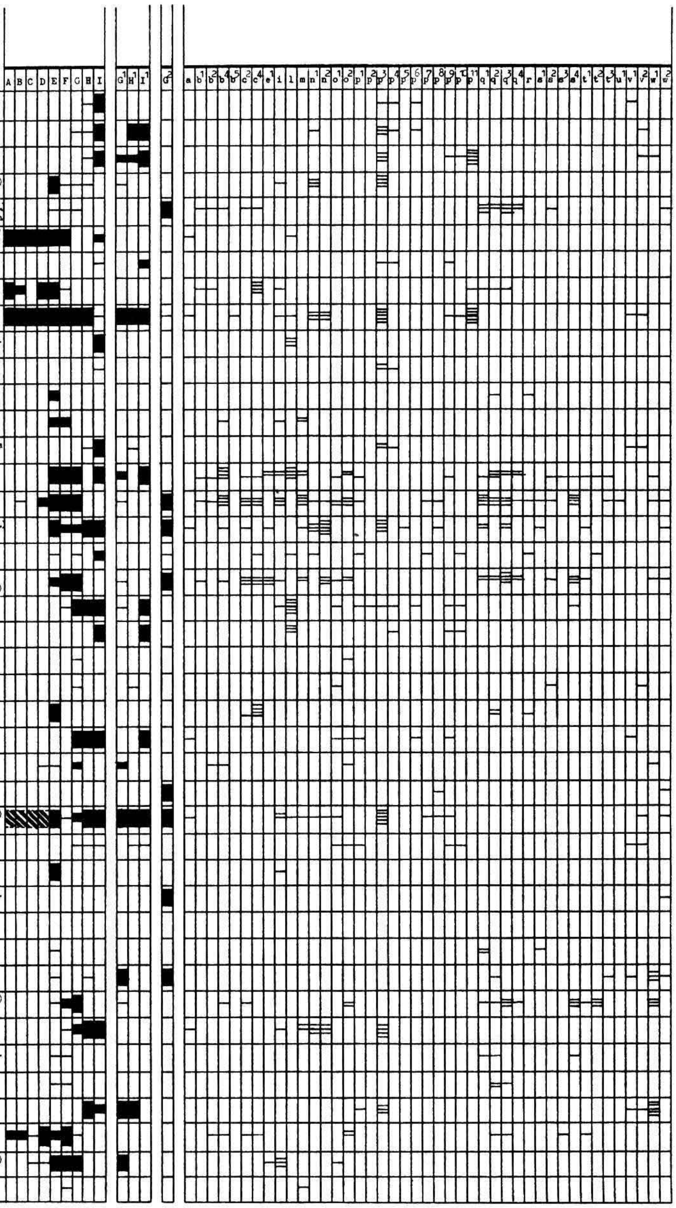
The vegetation of small clear-water lagoons (w^1). 6 survey-plots from stations 34 (2 ×), 76, and 102 (3 ×).

vegetation-type	w^1
Thalassia testudinum	V^{+-3}
Cladophoropsis membranacea	V^{+-5}
Batophora oerstedii	V^{+-2}
Halimeda opuntia	IV^{+-2}
Cassiopeia (Scyophozoa)	IV^{+-2}
Acanthophora spicifera	IV^{+}
Acetabularia crenulata	III^{1-5}
Herposiphonia tenella	III^{+-3}
Valonia ocellata	III^{+-2}
Caulerpa sertularioides	III^{+-1}
Valonia ventricosa	III^{+-1}
Udotea flabellum	III^{+}
Melobesia sp. (ep.)	III^{+}
Acicularia schenckii	III^{+}
Ernodesmis verticillata	$\mathrm{III}^{+(-2)}$

Of the total number of 39 species 14 were frequent (degree of presence ⩾ III). Of the frequent species *Batophora oerstedii*, *Acetabularia crenulata*, *Caulerpa sertularioides*, *Valonia ventricosa*, *Udotea flabellum*, and *Acicularia schenckii* are characteristic bay species, of the infrequent species *Caulerpa verticillata*, *Halimeda simulans*, *Penicillus pyriformis*, *Halodule beaudettii*, and *Caulerpa cupressoides* are also bay species. All other species have wide ecological amplitudes.

There are no species characteristically limited to this type of habitat. However, the often massive development locally of one or a few species can be considered a characteristic feature of this type of habitat. Thus,

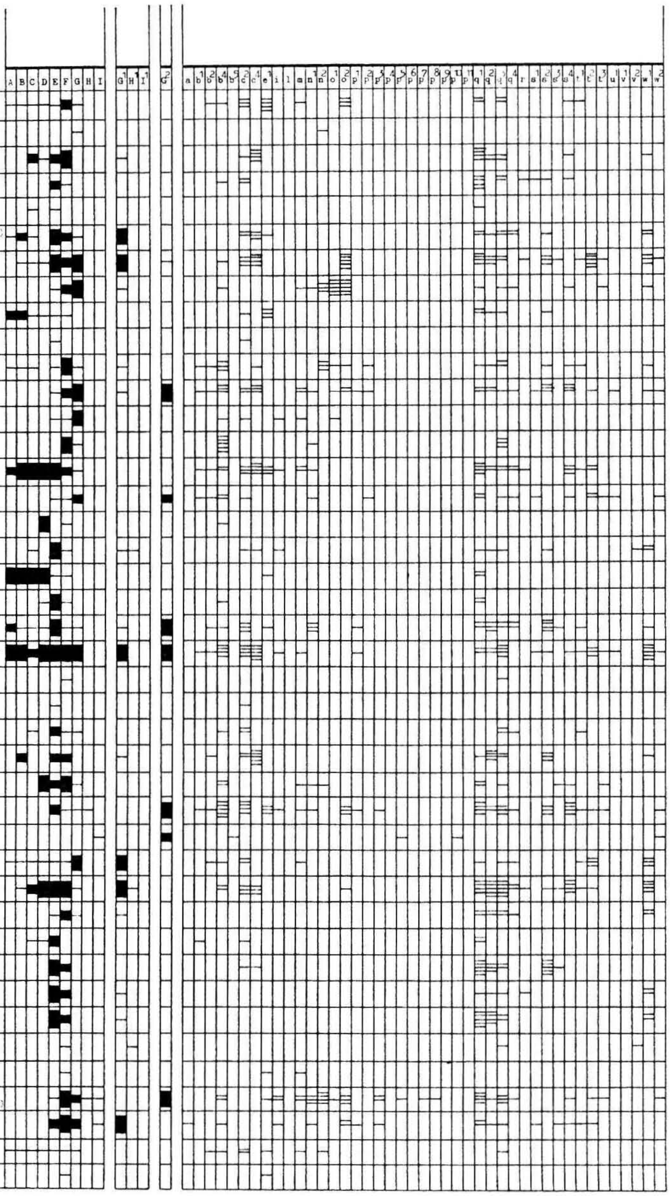
TABLE 15.1.



CYANOPHYCEAE	
Agmenellum quadruplicatum (Menegh.) Bréb.	31,87
Aphanocapsa litoralis Hansg.	31,63,77,79,87,89
Aphanothece pallida (Kütz.) Rabenh.	33,34,74,78,87,89,93,94,95
Calothrix aeruginea [(Kütz.) Thur.] Born. et Flah.	54,56,63,64,86,87,89,102
Calothrix confervicola (ep.) [(Roth.) C. Ag.] Born. et Flah.	49,50,51,55,57,59,61,65,66,68,70, 73,75,81,91,96,105a
Calothrix crustacea [Thur.] Born. et Flah.	50,90
Chroococcus turgidus (Kütz.) Näg.	74,87,89
Dichotrix sp. (also ep.)	65,66,68,70,71,80,81,93,101
Entophysalis deusta (Menegh.) Dr. et D.	28,32,33,34,49,50,54,63,64,74,75, 77,78,86,87,89,93,94,95,103,59,97
Gloeothece fusco-lutea Näg. (?)	90,103
Gomphosphaeria aponina Kütz.	87,89
Hormothamnion enteromorphoides Grunow	49,101
Hydrocoleum lyngbyaceum Kütz.	56,60,91,92
Johannesbaptistia pellucida (Dick.) W.R. Taylor & Dr.	78,87,89
Lyngbya aestuarii (Mert.) Lyngb.	28,30,32,34,35,38,43 – 45,47,54,56, 59 – 62,66,68 – 73,75,79,82,84,85, 88,90 – 92,99,101,102,103,105
Lyngbya majuscula (Dillw.) Harv.	28,29,30,34,41,46,47,49 – 60,63,65a 66,68,70 – 73,75,80,83 – 86,96,98, 99,102,105,105a
Lyngbya meneghiniana (Kütz.) Hansg. (ep.)	32,35,39,47,49,50,54,55,63,64,75, 80,81,87,96,98
Lyngbya semiplena (Ag.) J.Ag.	38,49,64,72,86,93,98,101
Lyngbya sordida (Zanard.) Gom. (mostly ep.)	28,32,35,44,45,47,49,51,54,56 – 59,66,68,70,75,80 – 82,84,85,91, 96,100,101,102,105a
Microcoleus chthonoplastes (Mert.) Zanard.	41,52,53,63,64,71,79,88,87,89, 90,93,102,103
Microcoleus tenerrimus Gom.	64,74,87,88,89,93,103
Nodularia sp.	30
Oscillatoria nigro-viridis Thwaites	52,75,78,101
Phormidium crosbyanum Tild.	49,68,70,75,100,101
Phormidium fragile (Menegh.) Gom.	28,31,50,52,63,79,87
Polythrix corymbosa (Harv.) Grun.	8,28,91,102
Plectonema sp.	96,98
Schizothrix calcicola (Ag.) Gom. sensu Dr.	32,33,34,49,50,52,54,56,59,63,64, 66,74,77,78,87,89,90,96,97,98
Spirulina spp.	28,33,52,74,77,78,87,93
Symploca hydnoides (Harv.) Kütz.	34
Xenococcus schoesboei Thur. (ep.)	36
CHLOROPHYCEAE	
Acetabularia calyculus Quoy & Gaim.	49,55,65
Acetabularia crenulata Lamour.	68,97,99,102,103
Acicularia schenckii (Möb.) Solms - Laub.	28,32,34,35,36,42,43,44,45,61,65, 68,76,84,85,91
cf. "Arnoldiella"	8,32,50,56,59,60,63,64,87,89
Avrainvillea nigricans Dec.	65,84,105
Avrainvillea rawsonii (Dicki) Howe	70,80,81,105
Batophora oerstedii J. Ag.	3,34,76,77,78,87,102,103
Boodlea composita (Harv. & Hook.) Brand	3,32,44,61,68,70,73,91,92
Boodleopsis pusilla (Coll.) Taylor, Joly & Bernatowicz	46,49,54,59,69,70,82,86,102,183
cf. Bryobesia cylindrocarpa Howe	50

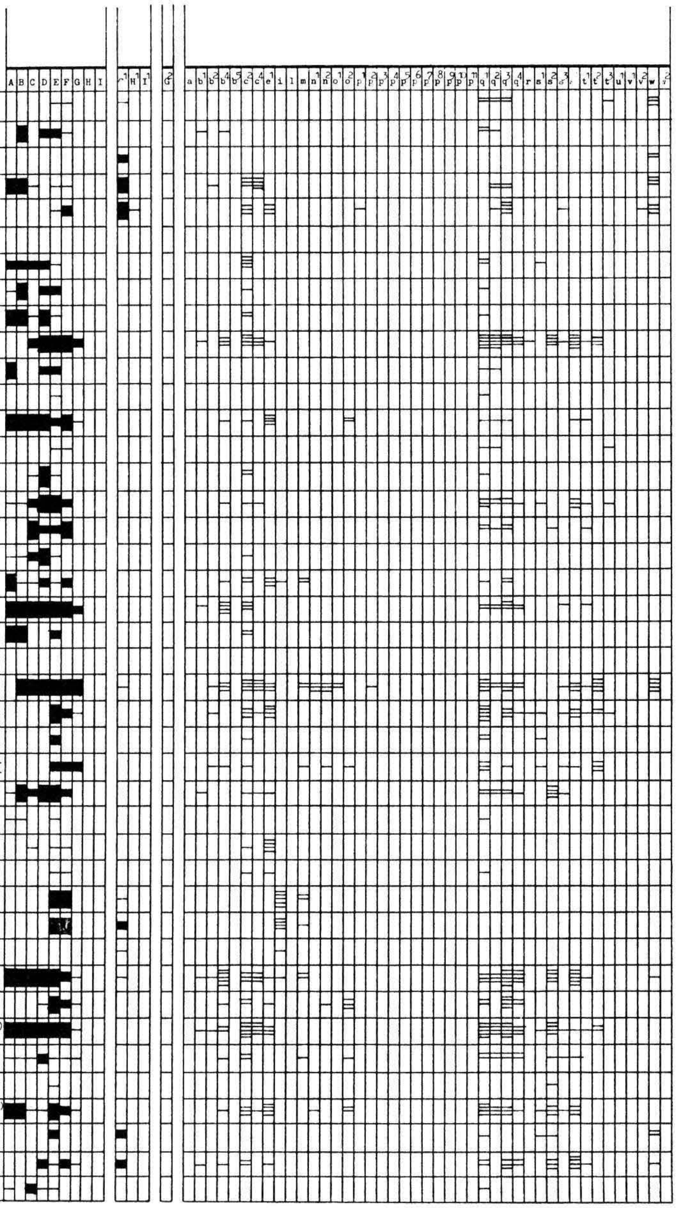
TABLE 15. A list of the species encountered (cf. sections 4 and 6).

TABLE 15.2.



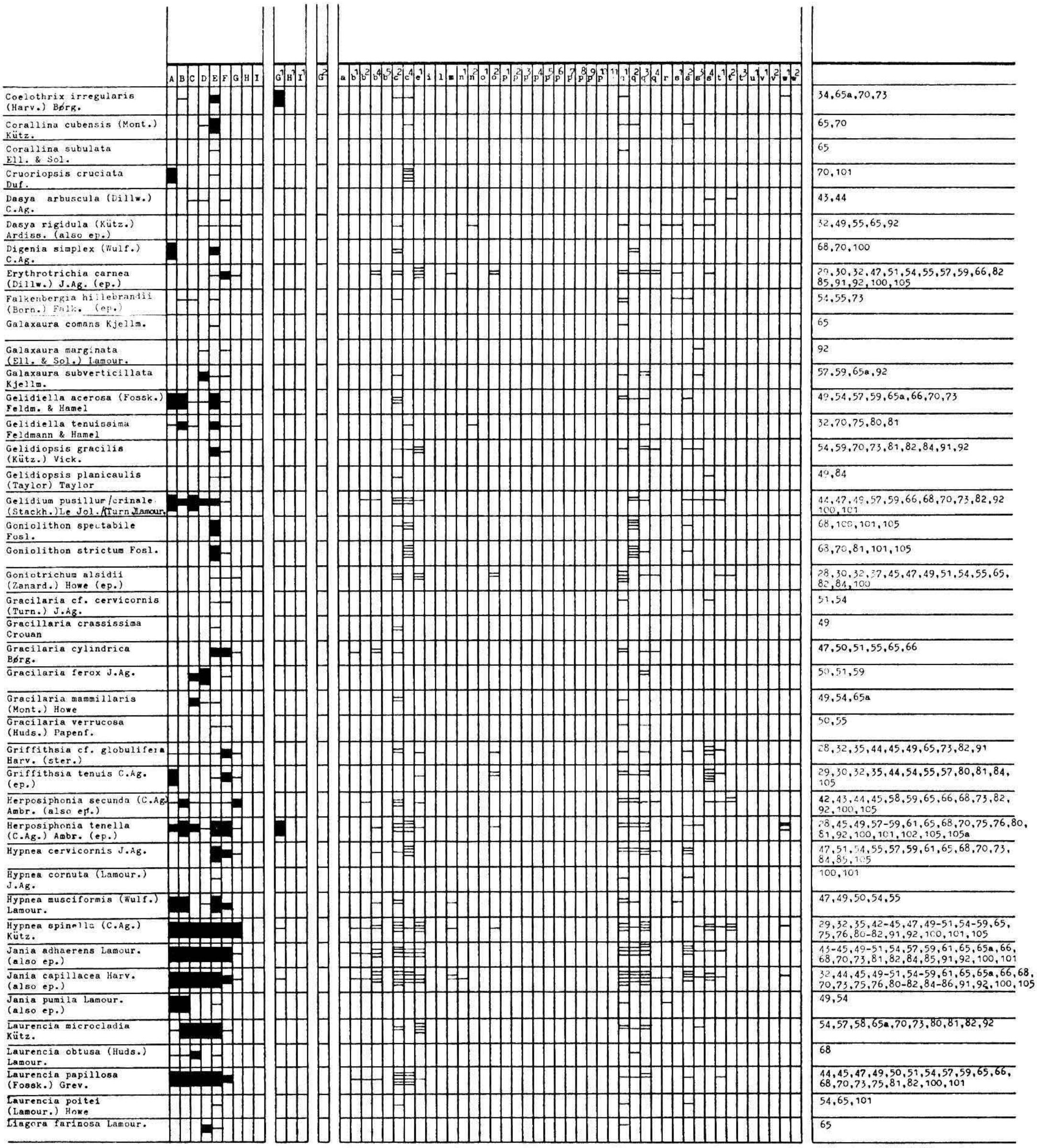
Bryopsis pennata Lamour	28,29,30,32,35,44,45,49,50,54,57,65,73,82,85,91,100
Bolbocoleon piliferum N. Pringsh.	28
Caulerpa cupressoides (West) C.Ag.	50,51,54,55,59,65,68,70,76,101,105
Caulerpa mexicana (Sond.) J.Ag.	49,51,54,55,61,65,70,91,
Caulerpa microphysa (W.-v.B.) Feldm.	65
Caulerpa racemosa (Forssk.) J.Ag.	34,49,51,54,55,59,61,68,73,75,76 82,83,84,85,101
Caulerpa sertularioides (Gmel.) Howe	28-30,32,34-38,41-43,45,47,49-51,54,61,65,68,70,91,92,96,99-102,105
Caulerpa verticillata J.Ag.	28,29,30,52,55,83,84,85,86,91,99,102,104
Caulerpa vickersiae Børg.	65,70,73,82,91
Caulerpa vickersiae var. furcifolia Taylor	73
Chaetomorpha gracilis Kütz.	28,29,30,32,34,35,53,57,65,66,68,73,83,84,85,91,101
Chaetomorpha linum (Müll.) Kütz.	28,30,32,34,42,43,47-53,55,56,61,65,65a,66,68,70,72,73,96,100,101
Cladophora coelothrix Kütz.	47, 49,65,86
Cladophora "conferta Crouan"	47,51,58,61,84,85,86,91
Cladophora dalmatica Kütz.	32,35-37,42,44,45,49,51,54,56,59,61,65,65a,66,68,70,73,81-84,86,100,101
Cladophora delicatula Mont.	40,41,42,43,45,47,48,51,53,55,61,65,66,91,96,99
Cladophora globulina (Kütz.) Kütz.	91
Cladophora jongiorum van den Hoek	56,70,76,77,80,81,100,102,105
Cladophora laetevirens (Dillw.) Kütz.	32,55,65a
Cladophora liniformis Kütz.	65,65a,91
Cladophora socialis Kütz. (also ep.)	44,45,58,63,65,68,70,72,73,83,85,91,92,100,102,105
Cladophoropsis membranacea (C.Ag.) Børg.	32,34,40-45,47,49,51,55-59,61,66,68,70 72,73,75,76,81,84,85,91,97,99,100-102
Codium isthmocladum Vick. ssp. isthmocladum	51
Codium taylorii Silva	100
cf. Derbesia (ster.)	45,47,51,54,61,91
Dictyosphaeria cavernosa (Forssk.) Børg.	49,58,65,68,70,75,76(†),80,81,84,100,101,105
Enteromorpha chaetomorphoides Børg.	32,49,65,65a,84,85,86,91,92,99
Enteromorpha clathrata (Roth) Grev.	28-30,32,36,44-45,47,50,51,54-57,59,61,63,65,65a,66,68,70,72,73,82,85,86,91,92,97,99-101
Enteromorpha flexuosa (Wulf. ex Roth) J.Ag.	32,93,96
Ernodesmis verticillata (Kütz.) Børg.	34,37,40,41,42,43,44,45,47,49,50,51,76,91
Halimeda opuntia (L.) Lamour.	28,32-34,38,45,47,49-51,54,55,57-59,61,65,68,70,72,73,76,80,81,84,85,91,92,101,102,105,105a
Halimeda simulans Howe	58,59,65,70,85,91,92,102,105,105a
Neomeris annulata Dickie	65,66,100
Penicillus capitatus Lamarck	51,55,59,65,68,80,91,92,100,101,105
Penicillus pyriformis A. & E.S. Gepp.	49,58,70,80,102
Penicillus spp.	49,54,55,58,59,65,68,70,80,91,100,102,105
Phaeophila dendroides (Crouan frat.) Batt.	61,77
Pilinia cf. rimosa Kütz.	53,82
Rhizoclonium implexum (Dillw.) Kütz. (sensu Koster)	28-30,32,36,39,49,50-52,54-56,58,60-65,65a,69-71,80,82,84-86,97-99
Rhizoclonium riparium (Roth) Harv.	25,30,32,37,38,40,47,49,55,58,65,70,72,86,87,92,102
Struvea anastomosans (Harv.) Picc.	32,43,47,49,50,51,61,66,84,92
Struvea ramosa Dickie	92

TABLE 15.3.



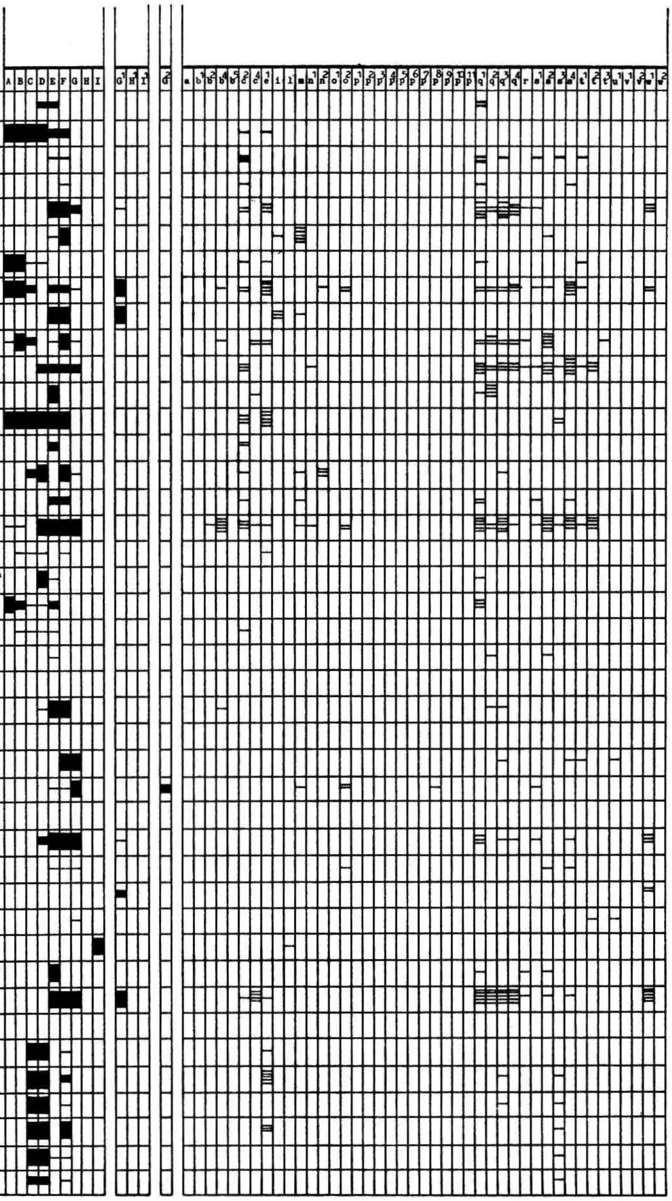
Udotea flabellum (Ell. & Sol.) Lamour.	1,65,76,80,92,99,102,105,105a
Ulva "lactuca" L.	65,66,68,91,100
Valonia aegagropila C.Ag.	76,102
Valonia ocellata Howe	34,49,58,66,68,70,73,75,80,81,100,101,102
Valonia ventricosa J.Ag.	32,33,34,49,57,58,59,61,73,75,76,80,81,82,84,92,105,105a
PHAEOPHYCEAE	
Dictyopteris delicatula Lamour.	49,54,55,66,73
Dictyota ciliolata Kütz.	54,65
Dictyota dentata Lamour.	49,65,66
Dictyota dichotoma (Huds.) Lamour.	32,35,36,42-45,49,51,54,55,57-59,61,65,65a,66,68,70,73,80-84,85,91,92,100,105
Dilophus guineensis (Kütz.) J.Ag.	65,68
Eudesme zosterae (J.Ag.) Kyl. (ep.) (cf.)	65
Giffordia duchassaingiana (Grun.) Taylor (also ep.)	29,30,32,35,44,45,49,55,59,68,82,91,100
Feldmannia irregularis (Kütz.) Hamel (ep.)	51,55,99
Hydroclathrus clathratus (Bory) Howe	65,100
Padina gymnospora (Kütz.) Vick.	44,45,51,55,58,65,68,84,85,99
Padina sanctae-crucis Børg.	35,65,70,80,81,91
Pocockiella variegata (Lamour.) Papenf.	49
Sphacelaria furcigera Kütz. (also ep.)	32,45,50,56,57,59,65a,66,81,82,91,92,100
Sphacelaria tribuloides Menegh. (also ep.)	35,44,45,47,49,51,57,58,61,65,66,68,70,81,83,84,85,91,92,100
Turbinaria turbinata (L.) Kuntze	100
RHODOPHYCEAE	
Acanthophora spicifera (Vahl) Børg.	28,32,34,36-38,42-45,47-54,57,59-61,63,65,65a,68,70,73,80-83,85,91,92,100,101,102
Acrochaetium sp. (ep.)	32,42-45,49-51,54,55,57,59,61,65,65a,66,70,82,84,91,92,99,100
Agardhiella tenera (J.Ag.) Schm.	54,55
Aglaothamnion cf. furcellariae (J.Ag.) Feldm.-Mazoyer	28,32,42,43,44,47,49,50,51,54,55,92
Amphiroa fragilissima (L.) Lamour.	51,65,65a,66,68,70,73,84,85,92,100,101,105, 61
Amphiroa hancockii Taylor	65a
Antithamnion antillanum Børg.	54,82,92
Antithamnion tristicum Joly et Yamaguishi	49,54,82
Bostrychia binderi Harv.	46,49,54,56,59,60,69,70,71,83,86,102,104,105
Bostrychia tenella (Vahl) J.Ag.	46,49,56,60,69,70,71,82,83,86,102,104,105
Catenella repens (Lightfoot) Batt.	102
Centroceras clavulatum (C.Ag.) Mont. (also ep.)	32,35,44,47,49-51,55-62,65,66,68,70,73,80,82-85,91,92,100-102
Ceramium codii (Rich.) Feldm.-Mazoyer (ep.)	28,29,30,32,49,51,54,57-59,61,62,65a,66,80,82,84,85,91,105a
Ceramium gracillimum (Kütz.) Griff. et Harv. (ep.)	32,35,38,42,44,45,47,49-51,54,55,57-59,61,65,65a,66,68,70,73,75,80-85,91,92,100,101,105
Ceramium leutzelburgii Schm. (also ep.)	30,32,44,49,50,54,57,59,61,65a,68,70,85,92,100,105
Ceramium nitens (C.Ag.) J.Ag.	101
Ceramium tenerrimum (Martens) Okamurai (also ep.)	30,32,44,47-51,54,55,57,59,61,65,65a,66,68,70,73,82,84,91,92,100,101
Champia parvula (C.Ag.) Harv. (ep.)	55,76,101,102
Chondria curvilineata Coll. & Herv.	32,44,50,51,55,58,61,65,66,73,80,82,84,91,100,101,102
Chondria polyrhiza Coll. & Herv.	68

TABLE 15.4.



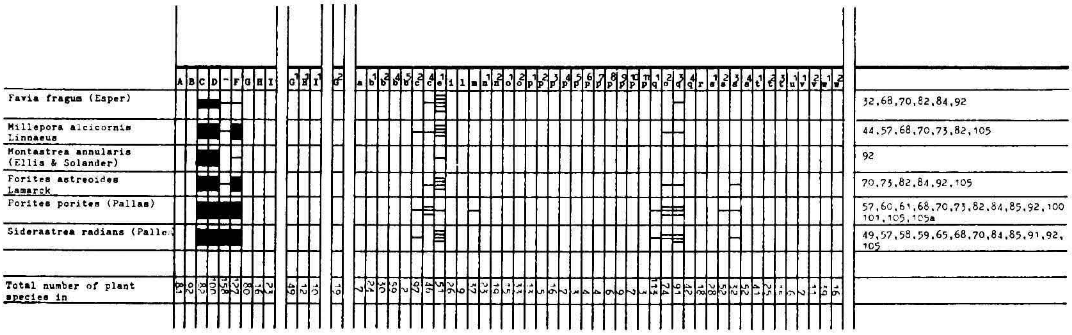
Coelothrix irregularis (Harv.) Børg.	34,65a,70,73
Corallina cubensis (Mont.) Kütz.	65,70
Corallina subulata Ell. & Sol.	65
Cruoriopsis cruciata Duf.	70,101
Dasya arbuscula (Dillw.) C.Ag.	43,44
Dasya rigidula (Kütz.) Ardiss. (also ep.)	32,49,55,65,92
Digenia simplex (Wulf.) C.Ag.	68,70,100
Erythrotrichia carnea (Dillw.) J.Ag. (ep.)	29,30,32,47,51,54,55,57,59,66,82 85,91,92,100,105
Falkenbergia hillebrandii (Born.) Falk. (ep.)	54,55,73
Galaxaura comans Kjellm.	65
Galaxaura marginata (Ell. & Sol.) Lamour.	92
Galaxaura subverticillata Kjellm.	57,59,65a,92
Gelidiella acerosa (Fossk.) Feldm. & Hamel	49,54,57,59,65a,66,70,73
Gelidiella tenuissima Feldmann & Hamel	32,70,75,80,81
Gelidiopsis gracilis (Kütz.) Vick.	54,59,70,73,81,82,84,91,92
Gelidiopsis planicaulis (Taylor) Taylor	49,84
Gelidium pusillum/crinale (Stackh.)Le Jol./(Turn.)Lamour.	44,47,49,57,59,66,68,70,73,82,92 100,101
Goniolithon spectabile Fosl.	68,100,101,105
Goniolithon strictum Fosl.	68,70,81,101,105
Goniotrichum alsidii (Zanard.) Howe (ep.)	28,30,32,37,45,47,49,51,54,55,65, 82,84,100
Gracilaria cf. cervicornis (Turn.) J.Ag.	51,54
Gracillaria crassissima Crouan	49
Gracilaria cylindrica Børg.	47,50,51,55,65,66
Gracilaria ferox J.Ag.	50,51,59
Gracilaria mammillaris (Mont.) Howe	49,54,65a
Gracilaria verrucosa (Huds.) Papenf.	50,55
Griffithsia cf. globulifera Harv. (ster.)	28,32,35,44,45,49,65,73,82,91
Griffithsia tenuis C.Ag. (ep.)	29,30,32,35,44,54,55,57,80,81,84, 105
Herposiphonia secunda (C.Ag.) Ambr. (also ep.)	42,43,44,45,58,59,65,66,68,73,82, 92,100,105
Herposiphonia tenella (C.Ag.) Ambr. (ep.)	28,45,49,57-59,61,65,68,70,75,76,80, 81,92,100,101,102,105,105a
Hypnea cervicornis J.Ag.	47,51,54,55,57,59,61,65,68,70,73, 84,85,105
Hypnea cornuta (Lamour.) J.Ag.	100,101
Hypnea musciformis (Wulf.) Lamour.	47,49,50,54,55
Hypnea spinella (C.Ag.) Kütz.	29,32,35,42-45,47,49-51,54-59,65, 75,76,80-82,91,92,100,101,105
Jania adhaerens Lamour. (also ep.)	43-45,49-51,54,57,59,61,65,65a,66, 68,70,73,81,82,84,85,91,92,100,101
Jania capillacea Harv. (also ep.)	32,44,45,49-51,54-59,61,65,65a,66,68, 70,73,75,76,80-82,84-86,91,92,100,105
Jania pumila Lamour. (also ep.)	49,54
Laurencia microcladia Kütz.	54,57,58,65a,70,73,80,81,82,92
Laurencia obtusa (Huds.) Lamour.	68
Laurencia papillosa (Fossk.) Grev.	44,45,47,49,50,51,54,57,59,65,66, 68,70,73,75,81,82,100,101
Laurencia poitei (Lamour.) Howe	54,65,101
Liagora farinosa Lamour.	65

TABLE 15.5.



Liagora valida Harv.	65
Lithophyllum daedaleum Fosl. & Howe	49,92
"Lithothamnion"	44,54,55,65,84,92,100
Lophocladia trichoclados (Mert.) Schm.	51,54
Melobesia sp. (ep.)	32,47,49-51,54,55,57,59,61,62,65,68, 75,76,80-85,91,92,100,102,105,105a
Murrayella periclados (C.Ag.) Schm.	50,56,59,60,70,86,92,102
Peyssonellia rubra (Grev.) J.Ag.	32,44,45,57,65a
Polysiphonia ferulacea Suhr (also ep.)	29,30,32,35,44,45,54,55,57,61,62, 65,68,73,82-85,91,100-102
Polysiphonia howei Hollenb.	46,49,66,69,70,71,86,102,105
Polysiphonia macrocarpa Harv. (also ep.)	49,55,68,70,73,80,81,85,91,92,99, 100,101,105,105a
Polysiphonia subtilissima Mont. (also ep.)	32,35,37,38,42,44,45,49-51,54,55,5 59,61-63,68,70,73,83-85,91,92,100, 101,105
Porolithon "aegagropiloid form"	49,68,70,73
Porolithon pachydermum (Fosl.) Fosl.	32,44,45,49,57,82,92
Pterocladia americana Taylor	49,54
Spermothamnion speluncarum (Coll. & Herv.) Howe	28,32,54,59,80
Spyridia clavata Kütz.	50,51,54,55
Spyridia filamentosa (Wulf.) Harv.	29,30,32,35,43-45,47,50,51,54,55,57- 61,65,68,70,73,81,84-86,91,92,100,101
Taenioma nanum Kütz. (also ep.)	82
Trichogloeopsis pedicellata (Howe) Abbott & Doty	65
Wrangelia argus Mont. (also ep.)	54,55,100
Wrangelia bicuspidata Børg. (also ep.)	49
Wurdemannia miniata (Drap.) Feldm. & Hamel	70,73
CHRYSOPHYCEAE	
Chrysonephos lewisii (Taylor) Taylor	68,85
XANTHOPHYCEAE	
Vaucheria dichotoma (L.) Martius	32,35,40,44
Vaucheria sp. (ster.)	30,55,59,98
PHANEROGAMAE	
Halodule beaudettii (Den Hartog) Den Hartog	47,50,51,55,65,65a,76,85,102
Halophila spp.	30,32,70
Rhizophora mangle L. (juv.)	34,102
Ruppia maritima L.	40,43,47a (fert.)
Sesuvium portulacastrum L.	90
Syringodium filiforme Kütz.	49,65,70
Thalassia testudinum Banks ex König	32,34,47,49-51,54,55,57-59,61,62,65, 65a,65(fr.!) 68,70,75 (partly†),76, 80-85,91,92,101,102,105,105a
CORALS	
Acropora cervicornis (Lamarck)	82
Agaricia agaricites (Linnaeus)	32,44,57,82,84,92
Dichocoenia stokesii Edwards & Haime	84,92
Diploria labyrinthiformis (Linnaeus)	82,92
Diploria strigosa (Dana)	68,92
Eusmilia fastigiata (Pallas)	92

TABLE 15.6.



Favia fragum (Esper)	32,68,70,82,84,92
Millepora alcicornis Linnaeus	44,57,68,70,73,82,105
Montastrea annularis (Ellis & Solander)	92
Porites astreoides Lamarck	70,73,82,84,92,105
Porites porites (Pallas)	57,60,61,68,70,73,82,84,85,92,100 101,105,105a
Siderastrea radians (Palla	49,57,58,59,65,68,70,84,85,91,92, 105

	A	B	C	D	E	F	G	H	I	G^1	H^1	I^1	G^2
Total number of plant species in	81	92	82	100	158	127	80	16	21	49	12	10	19

	a	b^1	b^2	b^4	b^5	c^2	c^4	e^1	i	l	m	n^1	n^2	o^1	o^2	p^1	p^2	p^3	p^4	p^5	p^6
Total number of plant species in	7	24	30	59	2	97	46	51	26	9	37	23	19	15	33	13	5	16	2	3	4

	p^7	p^8	p^9	p^{10}	p^{11}	q^1	q^2	q^3	q^4	r	s^1	s^2	s^3	s^4	t^1	t^2	t^3	u^1	v^1	v^2	w^1	w^2
Total number of plant species in	4	6	9	2	3	113	74	91	42	18	28	52	32	52	41	25	15	6	2	11	19	16

in station 34, the massive development of *Cladophoropsis membranacea* (ab. 2), *Batophora oerstedii* (2), *Caulerpa racemosa* (4), *Valonia ventricosa* (2), *Ernodesmis verticillata* (2), and *Coelothrix irregularis* (2) was noticed; in station 76 of *Cladophoropsis membranacea* (5), and *Herposiphonia tenella* (3); in station 102 of *Acetabularia crenulata* (5) and *Batophora oerstedii* (2). The upside down jellyfish *Cassiopeia*, which in station 34 reached an abundance of 2, seems to be rather characteristic for this type of habitat.

Thalassia occurs mainly where a sandy substrate is available.

Young *Rhizophora* plants growing at station 102 (fig. 32) bore collars of *Acetabularia crenulata* mainly concentrated directly below low water-level; and 5–10 cm directly above low water-level up to 1 cm thick silt containing collars of *Polythrix corymbosa.*

The Lagoentje van Sint Jan (station 34) is lined, on its landward side, by a fringe of *Rhizophora mangle* (figs. 3, 31). The roots of *Rhizophora,* which lie in the shade of the foliage, were covered from water-level down to the bottom (ca. 0.75 m deep) by a dense growth of algae dominated by *Valonia ventricosa* (ab. 3). Other algae growing on the roots were: *Ernodesmis verticillata* (1), *Cladophoropsis membranacea* (1), *Caulerpa racemosa* (1), *Valonia ocellata* (+), "*Arnoldiella*" (in the bark), and *Entophysalis deusta* (gloeocapsoid form) (+).

Up to 0.10 m above water-level the roots were covered by a eulittoral zone (a) of *Entophysalis deusta* (gloeocapsoid form) (2), *Schizothrix calcicola* (5), and *Rhizoclonium riparium* (2).

On the seaward side the barrier of coral debris was covered, up to 0.10 m above water-level, by a eulittoral zone of *Entophysalis deusta* (a) (mainly perforating) and *Schizothrix calcicola,* forming a zone ca 1.5 m broad.

The eulittoral *Bostrychia*-subzone occurring in the surf niche along the sublagoon of Lac (station 102) was treated under 5.1.1.3 (see also fig. 32).

For station 76 the algal growth of the slopes, consisting of coral debris lying on sand, is given in table 14. The sandy bottom, with shingle (depth

1.0–1.5 m) was mainly covered by *Batophora oerstedii* (3), *Entophysalis deusta* (3), *Cladophoropsis membranacea* (+), *Acicularia schenckii* (+), *Herposiphonia tenella* (+) and *Cladophora jongiorum* (+).

In general, in the small lagoons, the availability of solid substrates determines the density of algal growth which correspondingly is greatest on the slopes of coral debris.

5.5.2. v^2) *Small Batophora lagoons*

Some shallow parts (about 0.5 m) of the Lagoentje van Sint Jan (station 33, fig. 3) and two small lagoons between Awa Blancu and Lagún Blancu (stations 77, 78; fig. 9), 1.0 and 0.3 m deep, respectively, contained almost pure vegetations of *Batophora oerstedii* with several abundant *Cyanophyceae* (stations 77, 78), namely *Entophysalis deusta, Aphanocapsa littoralis, Schizothrix calcicola,* and *Aphanothece pallida.*

Batophora is capable of tolerating brackish to hypersaline conditions. WAGENAAR HUMMELINCK and ROOS (1969) mention *Batophora* for pools in back-mangroves of Lac (Bonaire) with salinities between 20–23 to 120–160 $^0/_{00}$ Cl^- (compare also 5.1.2.7. v^1). Probably the small clear-water lagoons with almost pure *Batophora* stands reach salinities which are too high for other algae.

5.5.3. p^9) *Small clear-water lagoons with a vegetation of Cyanophyceae*

Shallow (up to 0.10 m) clear-water lagoons, in which the salinity rises very high, or which sometimes dry up, are covered by dense vegetations of *Cyanophyceae* (stations 74, 79; vicinity of Awa Blancu, see fig. 9). Polygonal patterns (ca 10 to 30 cm in diameter) in the cyanophycean felts indicate intermittent drying up of these shallow lagoons. In station 74 up to 5 cm thick layered gelatinous "pancakes" of *Cyanophyceae* covered the bottom. Down to at least 1 cm below the surface the pancakes still contained living *Cyanophyceae*, but still lower only dead ones. The high salinities possibly preserve the gelatinous sheaths. Such "pancakes" are very reminiscent of living *stromatolithes.*

In station 74 the following species were observed: *Aphanothece pallida* (5), *Entophysalis deusta* (gloeocapsoid) (2), *Microcoleus chthonoplastes* (2), *Microcoleus tenerrimus* (2), *Schizothrix calcicola* (*Plectonema nostocorum*) (2), *Chroococcus turgidus* (1), and *Spirulina subsalsa* (+).

In station 79: *Aphanocapsa littoralis* (5), *Microcoleus chthonoplastes* (2), *Lyngbya aestuarii* (2), *Phormidium fragile* (2), *Spirulina subsalsa* (+), *Spirulina sp.* (+).

5.6. *The vegetation of a hypersaline bay: Lagún Jan Thiel (fig. 11)*

A number of bays are closed by barriers of coral debris and are hypersaline. The vegetation of one of these bays, Lagún Jan Thiel, has been investigated. In the N.E. part salines are still operated (just N. of station 95).

On the barrier of coral debris a zonation of algal vegetation types could be distinguished. This zonation is probably the consequence of seepage of seawater through the barrier. Water of relatively low salinity floats on deeper layers with higher salinities; the lowest layers are undoubtedly saturated, as a saltcrust is formed on the bottom. The upper water layer is distinctly cooler than the lower water layers.

5.6.1. *a) The eulittoral type of Entophysalis deusta, from water-level up to 10 cm above it and ca 1 m broad*

This *Entophysalis* zone, giving the blocks of coral debris a dark bluish colour, is identical to all other eulittoral *Entophysalis* zones. It contained the perforating *Hyella* phase and the epilithic phase; *Schizothrix calcicola* was also present.

5.6.2. *b^5) A chlorophycean zone of Enteromorpha flexuosa (from water-level down to a depth of 0.05 m, and ca 0.4 m broad)*

The dominant species was *Enteromorpha flexuosa* (ab. 5). This is the sole non-cyanophycean plant species observed in the Lagún Jan Thiel. It was only observed growing on the barrier of coral debris. Probably seawater enters the lagoon here as seepage through the barriers. In the salt-pans of Bonaire *Enteromorpha* fringes circular patches where seawater seeps into these salt-pans.

Other participants of this zone: *Lyngbya semiplena* (2), *Entophysalis deusta* (perforating and epilithic) (2).

5.6.3. *p^{10}) A Microcoleus zone (0.05–0.15 m deep; 1.0–1.5 m broad)*

The dominant species were *Microcoleus chthonoplastes* (2) and *Microcoleus tenerrimus* (2). Other species: *Entophysalis deusta* (2), *Lyngbya semiplena* (2), *Enteromorpha flexuosa* (+), *Aphanothece pallida* (+), *Spirulina subsalsa* (+).

This zone covers blocks of coral debris and the saltcrust covering the sediment.

5.6.4. *p^{11}) A zone of flocculent, gelatinous, gloeocapsoid Entophysalis deusta*

From 0.15 m down to more than 4 m, the bottom – which consists of a thick crust of salt crystals – is covered by dense flocculent brown masses of gloeocapsoid *Entophysalis deusta* (5). Other species were: *Aphanothece pallida* (+), and *Dichothrix sp.* (+). Large numbers of chrysalids of the saltfly *Ephydra* are quite characteristic.

At the other two stations (94 and 95) no zonation was observed, and the vegetation was there identical to the lowest zone at station 93. The gently sloping bottom was covered by a saltcrust which was overgrown (down to at least 0.5 m) by dense, brown, flocculent masses of gloeocapsoid *Entophysalis deusta* (5). *Aphanothece pallida* was also abundant (1, 2), and so were the saltfly-chrysalids.

Apparantly in a number of other hypersaline bays on Bonaire and Curaçao *Entophysalis deusta* is the most important constituent of the otherwise extremely poor algal vegetation (KOSTER, 1963).

Data regarding the ecology, in hypersaline bays, of the fishes *Cyprinodon dearborni* and *Mollienesia sphenops vandepollii*, and of the brine shrimp *Artemia salina* are given by KRISTENSEN (1962).

6. A LIST OF THE SPECIES ENCOUNTERED (table 15)

The species list has been composed according to the procedures described under 4 (cf. 4 for the explanation of the symbols used).

The exposure-oceanity gradient A → I has been composed on the basis of the geographic configuration of the coast (cf. 4). If we use the simple coefficient of similarity $S = (c/a + b - c)\ 100$, in which a = the total number of species in one habitat (e.g. A), b = the total number of species in another habitat (e.g. B), and c = the number of species shared by both habitats (e.g. A and B), it appears that, starting with A, one can compose a gradient of similarity from A to I ($S_{AB} = 65$ %, $S_{AC} = 40$ %, $S_{AD} = 32$ %, $S_{AE} = 31$ %, $S_{AF} = 26$ %, $S_{AG} = 23$ %, $S_{AH} = 2$ %, $S_{AI} = 3$ %).[1] Since both gradients follow roughly the same sequence, they mutually confirm each other.

For a further treatment of the environmental factors involved in the gradient A → I, see sections 3 and 4.

It should be pointed out again that almost nothing is known about the ecology of the individual species; some experiments have been carried out on the ecology of the species participating in the eulittoral *Bostrychia* subzone (cf. 5.1.1.3).

Along the relatively sheltered open S.W. coast conspicuous coral reefs occur and there intensive grazing by herbivorous animals, especially fishes, is considered to reduce the algal vegetation to an unobtrusive stubble (VAN DEN HOEK, 1969). (Apart from the dominant coralline *Porolithon pachydermum*).

Grazing does not seem to play an important rôle in determining the aspect of vegetation-types in bays and lagoons, except in the extensions of the *Porolithon pachydermum* coral formations in the bay-entrances on the S.W. coast (cf. 5.1.2.2. e^1).

The number of species of *Rhodophyceae* is much higher than that of *Phaeophyceae* and *Chlorophyceae*.

The R/P quotient (= the number of rhodophycean species/the number of phaeophycean species) of amounts to 3.7 (in VAN DEN HOEK, 1969 an R/P quotient of 3.2 is given; this lower value reflects the fact that only

---

[1] The values of S_{AE}, S_{AF}, and S_{AG} given in VAN DEN HOEK (1969) are here corrected; for this publication only incidental observations on the algal vegetations in bays and lagoons were available. However, the direction of the gradient remains the same.

incidental observations on the algae of bays and lagoons were included).

However, it appears from table 16 (in which the total numbers and relative proportions of *Chlorophyceae*, *Rhodophyceae*, and *Phaeophyceae* are given) that on open coasts the R/P quotient shows a shift in favour of the *Phaeophyceae* and amounts to 3.0, whereas in bays and lagoons the R/P amounts to 5.3.

When we take only species which are more important constituents of the algal vegetation, e.g. species with a presence $\geqslant$ III and an abundance $\geqslant$ I in at least one vegetation-type, then the difference between the R/P quotient of open coasts (1.6) and that of bays and lagoons (7.4) is still more evident. If we take the numbers of species of the above category which are ca 10 cm or $>$10 cm high, the R/P quotient on open coasts amounts to 0.7, and that in bays and lagoons to 7.0. As to the numbers of chlorophycean species, it appears that, like rhodophycean species, these are relatively more abundant in bays and lagoons than on open coasts; this relative abundance is accentuated for frequent ($\geqslant$ III) and simultaneously abundant ($\geqslant$ I) species, and still more so for frequent, abundant, and large ($\geqslant$ 10 cm) species.

6.1. *Species determining the aspects of vegetation on open coasts (presence $\geqslant$ III and abundance $\geqslant$ I in at least one vegetation-type, height $\geqslant$ 10 cm)*

Apparently the aspects of most algal vegetations *on open coasts* are predominantly determined by relatively *large Phaeophyceae* ($\geqslant$ 10 cm). These are the following species: *Sargassum rigidulum*, *S. platycarpum*, *S. polyceratium*, *Turbinaria turbinata*, *Stypopodium zonale*, *Dictyopteris justii*, *Dictyota dentata*, *D. ciliolata*, and *Dictyota dichotoma*. Conspicuous *Rhodophyceae* have secondary importance: *Porolithon pachydermum*, *Lithophyllum daedaleum* (these two species determining the aspect of the *Porolithon pachydermum* coral formation (e^1) and the *Sargassum rigidulum–Porolithon pachydermum* type (d^3), cf. VAN DEN HOEK, 1969), *Lithophyllum "Oostpunt"*, *Hypnea musciformis*, *Acanthophora spicifera* and *Spyridia filamentosa.*

Only two chlorophycean species belong to this category, namely *Cladophora vagabunda* and *Halimeda opuntia;* the latter species apparently has its main distribution in bays and lagoons.

6.2. *Species determining the aspects of vegetation in bays and lagoons (presence $\geqslant$ III and abundance $\geqslant$ I in at least one vegetation-type; height $\geqslant$ 10 cm)*

The aspects of vegetation in bays and lagoons are largely determined by the seagrass *Thalassia testudinum*. As to the algal species *Chlorophyceae* and *Rhodophyceae* play an equally important rôle. Of the *Chlorophyceae* a number of tropical sand-dwelling species determine the aspects of vegetation: *Caulerpa cupressoides*, *C. mexicana*, *C. sertularioides*, *C. racemosa*, *C. verticillata*, *Halimeda opuntia* and *Penicillus capitatus.*

TABLE 16

	Chlorophyceae			Phaeophyceae			Rhodophyceae			C:R:P	C:R:P	C:R:P
	open coasts	bays & lagoons	both	open coasts	bays & lagoons	both	open coasts	bays & lagoons	both	open coasts	bays & lagoons	both
Total number of species	42	56	68	30	16	32	91	84	118	1.4 : 3.0 : 1	3.6 : 5.3 : 1	2.2 : 3.7 : 1
Number of spp. with frequency P $\geqslant$ III and abundance $\geqslant$ I in at least one vegetation-type	12	26	32	17	5	13	27	37	47	0.7 : 1.6 : 1	5.3 : 7.4 : 1	2.5 : 3.6 : 1
The number of species of the above category which are ca 10 cm or $>$ 10 cm high	2	7	8	9	1	9	6	7	10	0.2 : 0.7 : 1	7 : 7 : 1	0.9 : 1 : 1

The following *Rhodophyceae* belong to this category: *Acanthophora spicifera, Spyridia filamentosa, Laurencia papillosa, Porolithon pachydermum* (only in the extension of the *Porolithon pachydermum* coral formations (e) in bay entrances on the S.W. coast), and the lagoonal species *Goniolithon spectabile, G. strictum* and *Hypnea cervicornis.*

Only one *Phaeophycea* belongs here: *Dictyota dichotoma.*

The above considerations make it clear that, as to biomass, purely oceanic habitats along the coasts of Curaçao are either dominated by large *Phaeophyceae* (along the most severely battered N.E. coast), or by crustaceous corallines (in less battered stations along the S.W. coast where coral reefs can develop).

On the other hand, as to biomass, lagoonal and bay habitats are dominated by the seagrass *Thalassia testudinum* and secondarily by a number of tropical, sand-dwelling *Chlorophyceae* (*Halimeda opuntia* and several *Caulerpa ssp.*) and *Rhodophyceae.*

These vegetational differences between open coast and lagoonal plus bay habitats are rather clear cut (see table 16).

Presumably the shift of the R/P quotient in favour of the *Rhodophyceae* from temperate towards tropical regions is determined to a considerable extent but not entirely by the availability of more or less extensive lagoonal habitats, which are apparently unfit for the growth of many *Phaeophyceae,* and by the relative lack of oceanic sublittoral rocky substrates other than coral reefs, where large *Phaeophyceae* can develop massively.

The relatively easy accessibility of lagoonal areas for investigation as compared with the inaccessibility of sublittoral regions where lush development of *Phaeophyceae* could be expected possibly also contributes to the high R/P values given for tropical regions.

7. TAXONOMIC AND FLORISTIC NOTES (see also VAN DEN HOEK, 1969)

Cyanophyceae

Critical identification of blue-green algae is difficult. Recent revisions of coccoid *Cyanophyceae* and the *Oscillatoriaceae* by DROUET and DAILY (1956) and DROUET (1968) considerably reduced the number of species traditionally contained in both groups. It is our opinion that part of these reductions to synonymy by Drouet are justified; we are, however, not convinced that all such reductions are justified. For this reason we generally adopted the taxonomic concepts of more traditional taxonomic literature on *Cyanophyceae* (TILDEN, 1910; CHAPMAN, 1961; FRÉMY, 1934; GEITLER, 1932), although we fully realize the deficiencies of this traditional literature. For a few species we adopted Drouet's specific concepts and nomenclature, although with some hesitation.

Matters are furthermore complicated, because taxonomic and nomenclatural difficulties are seriously entangled. The above mentioned "traditional" authors only rarely investigated type specimens of the names they used; therefore their concepts of certain species do not necessarily correspond with the concepts of the authors who described these species (see, e.g., *Symploca hydnoides*).

Agmenellum quadruplicatum (Menegh.) Bréb. sensu Drouet and Daily. This entity covers a considerable number of species ranged under *Merismopedia* in the traditional literature.

Aphanocapsa littoralis Hansgirg. According to Drouet and Daily this is a synonym of *Entophysalis deusta* (Menegh.) Dr. et D. However, our material identified as *A. littoralis* agreed with the descriptions and figures of the latter species in Frémy and Geitler, and differed from any of the forms known to us belonging to the highly plastic *Entophysalis deusta.*

Aphanothece pallida (Kütz.) Rabenh. and *Gloeothece fusco-lutea* Näg. are considered synonyms of *Coccochloris stagnina* Sprengel by Drouet and Daily.

Chroococcus turgidus (Kütz.) Näg. is considered a synonym of *Anacystis dimidiata* Drouet and Daily by the latter two authors.

Hydrocoleum lyngbyaceum Kütz. ex Gom., *Lyngbya majuscula* (Dillw.) Harv., *Lyngbya aestuarii* (Mert.) Lyngb., *Lyngbya semiplena* (Ag.) J. Ag. and *Lyngbya meneghianiana* (Kütz.) Hansg. are all considered by Drouet to be synonyms of *Microcoleus lyngbyaceus* (Kütz.) Crouan, a species of which the diameter of the trichomes varies between 3.5–80 μ, and which may consist of single naked or sheathed trichomes or of few to many trichomes in a common cylindrical sheath.

Lyngbya sordida (Zanard.) Gom. is a synonym of *Schizothrix mexicana* Gom., according to Drouet.

Microcoleus chthonoplastes (Mert.) Zanard. is considered a synonym of *Schizothrix arenaria* (Berk.) Gom. by Drouet.

Microcoleus tenerrimus Gom. should be referred to as *Schizothrix tenerrima* (Gom.) Drouet according to the latter author.

Oscillatoria nigro-viridis Thwaites is ranged under *Porphyrosiphon notarisii* (Menegh.) Kütz. by Drouet.

Phormidium crosbyanum Tilden and *P. fragile* (Menegh.) Gom. are both considered synonyms of *Schizothrix calcicola* (Ag.) Gom. by Drouet. However, *Phormidium crosbyanum* is an easily recognizable entity in the field (see also VAN DEN HOEK, 1969).

Symploca hydnoides (Harv.) Kütz. The nomenclatural type of this species belongs to the genus *Calothrix*, according to Drouet. Our material agreed with descriptions and figures of *Symploca hydnoides* in Frémy and Geitler.

Xenococcus schoesboei Thur. A synonym of *Entophysalis conferta* Drouet and Daily, according to these two authors.

Chlorophyceae

Cf. "*Arnoldiella*". This unidentifiable species was found growing quite frequently on and in the outer dead layers of the bark of *Rhizophora* roots.

It shows some resemblance to the *Cladophoracea Arnoldiella conchophila* Miller, a species described from fresh water in Russia (cf. FRITSCH, 1935, pp. 245–246) or *Wittrockiella paradoxa* Wille (cf. FRITSCH, 1935, pp. 243–244), a species described from saltmarshes in Norway. It is referred to in the text as cf. "*Arnoldiella*".

Chaetomorpha gracilis Kütz. This species was referred to as *Chaetomorpha capillaris* (Kütz.) Börg. in VAN DEN HOEK, 1969.

"*Cladophora conferta* Crouan". This is a nomen nudum listed in SCHRAMM and MAZÉ (1865). Material edited in the exsiccata-series "Algae guadeloupenses" (H. Mazé, nrs. 676, 679, and 1047; in the herbarium of Kew Gardens) was investigated. It appeared to be an undescribed species of *Cladophora*, which will be published elsewhere. On the shores of the bays with wide entrances "*Cl. conferta* Crouan" appeared to be a characteristic constituent of the eulittoral chlorophycean zone.

Cladophora delicatula Montagne. In VAN DEN HOEK (1969) *Cl. albida* (Huds.) Kütz. was distinguished from *Cl. delicatula. Cl. albida* (a species with a subtropical and temperate distribution) very much resembles *Cl. delicatula* (a probably subtropical to tropical species). The plants identified as *Cl. albida* in VAN DEN HOEK (1969) are now considered to belong to *Cl. delicatula.*

Cladophora jongiorum Van den Hoek (1969^b). This recently described species was first discovered growing attached to coral debris at a depth of 10 m in Boca Santa Marta, on the South coast of Curaçao. We have subsequently collected it quite frequently in bay and lagoon habitats (cf. table 15). In Awa di Oostpunt (station 70) extensive masses of loose entangled *Cl. jongiorum* plants covered the bottom (see 5.1.2.11 s^2).

Enteromorpha clathrata (Roth) Grev. When using BLIDING's (1963) work on European *Enteromorphas* most of our *Enteromorpha* material could be ranged under *E. clathrata* (including the *Enteromorpha* material identified as *E. compressa* in VAN DEN HOEK, 1969^a) and which showed the characteristic growth-habit of *E. compressa*). However, we realize that identification of Caribbean *Enteromorphas* can hardly be critical at this moment.

Rhodophyceae

Acrochaetium sp. In VAN DEN HOEK (1969) no attention was paid to the occurrence of *Acrochaetium*. Therefore, the data on its distribution given in table 15 are incomplete with regard to the columns A, B, C, D.

Aglaothamnion cf. furcellariae (J. Ag.) Feldm.-Mazoyer. Gonimocarps are needed to differentiate between *A. furcellariae* and *A. pseudobyssoides* (Crouan) Halos. All our material was sterile and so we could not assign it to *A. furcellariae* with certainty (see HALOS, 1964, 1965).

Cruoriopsis cruciata Duf. This species was identified as *Cruoria sp.* in VAN DEN HOEK (1969). It contained often cruciate tetrasporangia, and agrees with descriptions and figures of *Cruoriopsis cruciata* in ZANARDINI (1871, p. 25, t. 86), HAUCK (1885), FELDMANN (1942). According to HAUCK

(1885) and DENIZOT (1968) *Cruoriopsis cruciata* is a synonym of *Cruoriella armorica* Crouan 1859.

As far as we know, this is the first record of a *Cruoriopsis* (or *Cruoriella*) for the Caribbean.

Erythrotrichia carnea (Dillw.) J. Ag. The same remark is valid as for *Acrochaetium sp.*

Goniolithon spectabile Fosl. and *G. strictum* Fosl. These two corallines cannot be maintained in the genus *Goniolithon*, as the type species of *Goniolithon* does not have heterocysts (megacells). They belong to the genus *Neogoniolithon* Setchell et Mason (1943), and should therefore be referred to as *Neogoniolithon spectabile* (Foslie) Setchell et Mason and *Neogoniolithon strictum* (Foslie) Setchell et Mason. See also ADEY 1970. The differences between *Lithophyllum*, *Dermatolithon*, *Goniolithon*, *Neogoniolithon* and *Porolithon* have been recently treated by CABIOCH (1968; 1970 a, b).

Goniotrichum alsidii (Zanard.) Howe. The same remark is valid as for *Acrochaetium sp.*

Melobesia sp. The same remark is valid as for *Acrochaetium sp.*

ACKNOWLEDGEMENTS

We would like to thank the Director of the Carmabi (Caribbean Marine Biological Station, Curaçao; at the time of our investigations Dr. F. Creutzberg), and his staff, for their hospitality and help with field work.

We record our indebtedness to the proprietors of the estates Klein Sint Joris, Wacawa, and Koraal Tabak, and to the directors of the Coral Cliff Hotel and the Shell Cy., for permission to carry out investigations from the shores of the bays in their grounds.

Our acknowledgements are due to Mrs. Y. M. Butler for correcting the English text, to Miss C. J. Hoeksema and Miss G. Brinkman for preparing the manuscript, and to Mr. E. Leeuwinga for preparing the figures for publication.

The field work has been supported by a grant from the Netherlands Foundation for Advancement of Tropical Research (WOTRO).

SUMMARY

The algal vegetations along bay- and lagoon shores of Curaçao have been investigated using the phytosociological methods of Braun-Blanquet.

Bays with wide (70–200 *m*) *and deep* (3–12 *m*) *entrances.*

The shores mostly consist of gently sloping beaches strewn with shingle and pebbles and merging into marginal shallows covered by *Thalassia* meadows. Here the following vegetation-types were distinguished from the upper limit of algal vegetation down to the lower limit (at a depth of 2–4 m):

- the eulittoral *Entophysalis deusta* subzone (a) (on extensions of limestone cliffs into the bays, and on *Rhizophora* roots, lacking on beaches);
- the eulittoral chlorophycean subzone (mainly the type of *Cladophora "conferta Crouan"*) (b^4);

- the eulittoral *Bostrychia* subzone (i) (on *Rhizophora* roots or in surf-niches in the bay-entrances). This subzone was lacking in the most sheltered parts;
- the upper sublittoral rhodophycean turf of *Laurencia papillosa* and *Gelidiella acerosa* (c^2) (on rocky substrates in bay-entrances on the N. coast);
- extensions of the sublittoral *Porolithon pachydermum* coral formation (e^1) into the entrances of bays on the S. coast;
- the upper sublittoral *Murrayella* zone on aerial roots of *Rhizophora* (m) (lacking in the most sheltered parts of the bays);
- the rich sublittoral type of *Thalassia testudinum*, *Halimeda opuntia*, and *Penicillus* (q^1) (in bay-entrances on the N. coast);
- the sublittoral type of *Thalassia testudinum* and *Halimeda opuntia* (q^3) (along relatively exposed bay shores);
- the sublittoral "poor" *Thalassia*-type (q^4) (below q^3 and directly below low water-level in the most sheltered parts of the bays; no obvious algal growth);
- sublittoral sand- and muddy sand-binding vegetations of small *Rhodophyceae* (e.g. *Centroceras clavulatum* and *Polysiphonia subtilissima*) below *Thalassia* meadows (s-types).

Oceanic lagoons (Awa di Oostpunt and Lac on Bonaire).

In these regularly replenished lagoons with relatively clear water the vegetation resembled that of the oceanic lagoons along the Florida-Keys. A zonation occurred which resembled that along the shores of the entrances of bays on the N. coast of Curaçao, the most obvious difference being the rich occurrence of the loose corallines *Goniolithon strictum*, *G. spectabile*, and of *Porolithon* ("aegropiloid form") in the lagoons. Furthermore, the vegetation-types in the bay-entrances were obviously much richer, because they contained numerous open coast species.

Santa Martabaai has had a narrow (30 m) and shallow (3 m) entrance since 1962 (before that time it was separated from the sea most of the time by a barrier of coral debris). The algal vegetation in the turbid water was poor, and was dominated by *Caulerpa sertularioides*, *Acanthophora spicifera*, and *Spyridia filamentosa*. *Thalassia* and *Rhizophora* were lacking (they probably had not yet migrated into this formerly hypersaline habitat).

Piscaderabaai has a narrow (7 m) and shallow (1 m) entrance. It is polluted and eutrophied by the inflow of domestic sewage. The algal vegetation was poor and consisted mainly of *Caulerpa verticillata* and *C. sertularioides* (type o^2). The massive development of filter-feeders (e.g. *Crassostrea*, *Isognomon*, barnacles, holothurians, hydroids, tunicates), mainly growing attached to *Rhizophora* roots, was most probably correlated with the relatively high fertility. *Thalassia* occurred only in the vicinity of the entrance-channel.

Small, more or less hypersaline lagoons and pools in back-mangroves.

Contained vegetations of *Batophora oerstedii* and/or *Cyanophyceae.*

Flats of compact silty soils fringing back-mangroves on the land side, and which are intermittently wetted by either high water or showers, were bare or covered by cyanophycean felts (predominantly *Microcoleus chthonoplastes* and *M. tenerrimus*).

The heavily polluted lagoons Zakitó and Rifwater were surrounded by *Rhizophora* thickets. The submerged vegetation was extremely poor, and consisted mainly of *Lyngbya spp.* and *Rhizoclonium implexum*, in one station of loose *Chaetomorpha linum*. *Thalassia* and living *Halimeda opuntia* (of which dead remains were abundant) were lacking.

Small, and slightly hypersaline clear-water lagoons.

The number of species was small, but they often occurred massively, e.g. *Thalassia, Cladophoropsis membranacea, Batophora oerstedii, Halimeda opuntia, Acetabularia crenulata, Valonia ventricosa.*

A hypersaline bay: Lagún Jan Thiel.

In the N.E. part salines were still operated. The bottom was covered by a thick saltcrust overgrown by dense, brown, flocculent masses of *Entophysalis deusta* and *Aphanothece pallida.*

REFERENCES

ADEY, W. H., A revision of the Foslie crustose coralline herbarium. Det. Kong. Norsk. Vidensk. Selsk. Skr. no. 1 (1970); 1–46.

ALMODOVAR, L. R. and R. BIEBL, Osmotic resistance of mangrove algae around la Parguera, Puerto Rico. Rev. Algol. N.S. 203–208 (1962).

BLIDING, C., A critical survey of European taxa in *Ulvales*, part I. Opera Botanica 8 (3), 1–160 (1963).

BUISONJÉ, P. H. DE, Marine terraces and subaeric sediments on the Netherlands Leeward Islands, Curaçao, Aruba and Bonaire, as indications of quaternary changes in sea level and climate. Proc. Kon. Ned. Akad. Wetensch. **B 67**, 60–79 (1964).

CABIOCH, J., Sur le mode de formation des trichocytes chez le *Neogoniolithon notarisii* (Dufour) Setchell et Mason. C.R. Acad. Sci., Paris **266**, 333–336 (1968).

———, L'origine des mégacytes chez les *Porolithon* (*Corallinacées, Rhodophycées*). C. R. Acad, Sci. Paris **270**, 474–476 (1970a).

———, Application des caractères morphogénétiques à la systématique des *Corallinacées*: le genre *Goniolithon*. C.R. Acad. Sci., Paris **270**, 1447–1450 (1970b).

CHAPMAN, V. J., The marine algae of Jamaica, part I. *Myxophyceae* and *Chlorophyceae*. The Institute of Jamaica (1961).

DENIZOT, M., Les algues floridées encroutantes (à l'exclusion des *Corallinacées*). Paris, Lab. Cryptogamie Mus. Nat. Hist. Nat. (1968).

DIAZ-PIFERRER, M., Adiciones a la Flora Marina de las Antillas Holandesas Curazao y Bonaire. Carib. J. Sci. **4**, 513–543 (1964).

DROUET, F., Ecophenes of *Schizothrix calcicola* (*Oscillatoriaceae*). Proc. Acad. Nat. Sci. Philadelphia **115**, 261–281 (1963).

———, Revision of the classification of the *Oscillatoriaceae*. Monograph 15. The Academy of Natural Sciences of Philadelphia (1968).

——— and DAILY, W. A., Revision of the coccoid *Myxophyceae*. Butler Univ. Bot. Stud. 12 (1956).

FELDMANN, J., Les algues marines de la Côte des Albères IV. *Rhodophycées*. Paris (1942).

FRÉMY, P., Les *Cyanophycées* des côtes d'Europe. Mém. Soc. Nat. Scienc. Nat. Math. Cherbourg **41**, 235 pp (1934).

FRITSCH, F. E., The structure and reproduction of the algae I. Cambridge Univ. Press (1935).

GEITLER, L., *Cyanophyceae* in L. Rabenhorst, Kryptogamenflora 14. Leipzig (1932).

HALOS, M.-TH., Etude morphologique et systématique de quelques *Céramiacées* de la Manche. Thèse, Paris (1964).

———, Sur trois *Callithamniées* des environs de Roscoff. Cah. Biol. Mar. **6**, 117–134 (1965).

HARTOG, C. DEN, The sea-grasses of the world. Verhand. Kon. Ned. Akad. Wetensch., Afd. Natuurkunde, 2^e^ reeks **59** (1), 1–275 (1970).

HAUCK, F., Die Meeresalgen Deutschlands und Oesterreichs. In: Rabenhorst, Kryptogamen-Flora 2^e^ Aufl., vol. 2, Leipzig (1885).

HOEK, C. VAN DEN, Groupements d'algues des étangs saumâtres méditerranéens de la côte française. Vie et Milieu **11**, 390–412 (1960).

———, Revision of the European species of *Cladophora*, Leiden (1963).

———, Algal vegatation-types along the open coasts of Curaçao, Netherlands Antilles. Proc. Kon. Ned. Akad. Wetensch. ser. **C 72**, 537–577 (1969a).

HOEK, C. VAN DEN, Notes on *Cladophora* (*Chlorophyceae*). I. Two new Caribbean species: *Cladophora jongiorum* nov. sp. and *Cladophora longicellulata* nov. spec. Journ. Phycol. **5**, 128–134 (1969b).

HOETINK, H., Encyclopedie van de Nederlandse Antillen, Amsterdam, Brussel (Elsevier) (1969).

KOCK, W. C. DE, and W. J. J. O. DE WILDE, Verslag over het onderzoek naar de fertiliteit van enige Curaçaose binnenbaaien. Uitgave Caraïbisch Marien-Biologisch Instituut. Collected Papers 3 (51) (1964).

KOSTER, J. TH., The genus *Rhizoclonium* in the Netherlands. Pubbl. Staz. Zool. Napoli **27**, 335–357 (1955).

————, Antillanean *Cyanophyceae* from salt-pans and marine localities. Blumea **12**, 45–56 (1963).

KRISTENSEN, I., Ecology of salines. Ass. Island Marine Laboratories, 4th meeting (1962) 20–22 (abstr.) (Car. Mar. Biol. Inst. Curaçao, coll. papers 2 (32)).

————, Hypersaline bays as an environment of young fish. Proc. Gulf and Caribbean fisheries institute, 6th Annual Session, 139–142 (1963).

PARKE, M. and P. S. DIXON, Check-list of British marine algae-second revision. J. Mar. Biol. Ass. U.K. **48**, 783–832 (1968).

PHILLIPS, R. C., Observations on the ecology and distribution of the Florida Seagrasses. Florida State Board of Conservation Marine Laboratory, St. Petersburg, professional paper no. 2, 72 pp.

ROOS, P. J., The distribution of reef corals in Curaçao. Studies on the fauna of Curaçao and other Caribbean Islands **81**, 1–51 (1964).

SCHRAMM, A. and H. MAZÉ, Essai de classification des algues de la Guadeloupe (1st Print). Basse-Terre, Guadeloupe (1865).

SMITH, F. G. WALTON, Atlantic reef corals. University of Miami Press (1948).

STOFFERS, A. L., The vegetation of the Netherlands Antilles. Mededelingen van het Botanisch Museum en Herbarium van de Rijksuniversiteit te Utrecht **135**, 1–142 (1956).

TILDEN, J., The *Myxophyceae* of North America and adjacent regions including Central America, Greenland, Bermuda, the West Indies and Hawaiï. In: Minnesota Algae I. Minneapolis (1910).

WAGENAAR HUMMELINCK, P., Description of new localities. Studies on the fauna of Curaçao and other Caribbean Islands. Vol. **IV**, 1–108 (1953).

————, and P. J. ROOS, Een natuurwetenschappelijk onderzoek gericht op het behoud van het Lac op Bonaire. West Ind. Gids, 25 pp (1969).

ZANARDINI, G., Iconographia phycologica mediterraneo-adriatica, vol. 3. Venezia (1871).