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STUDIES ON THE FAUNA OF CURAÇAO AND OTHER CARIBBEAN ISLANDS: No. 202

THE ASCIDIAN FAUNA OF TWO CONTRASTING LAGOONS IN THE NETHERLANDS ANTILLES: PISCADERA BAAI, CURAÇAO, AND THE LAC OF BONAIRE

by

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This paper records the occurrence and distribution of ascidians in two contrasting salt water lagoons in the Netherlands Antilles, Piscadera Baai in Curaçao and Lac in Bonaire. The paper is based on material collected by Dr. P. WAGENAAR HUMMELINCK during several collecting trips to the West Indies, but particularly in 1963, 1967 and 1973.

The taxonomy of West Indian Ascidiacea is well known, largely due to the work of VAN NAME (1902, 1921, 1924, 1930, 1945), and previous discussion of ascidians in the Netherlands Antilles is to be found in VAN NAME (1924), MILLAR (1962) and VAN DER SLOOT (1969). More recently CLAUDE MONNIOT (1983a–c) and FRANÇOISE MONNIOT (1983a–c) have published papers describing the ascidian fauna of Guadeloupe. For this reason and since, apart from the Didemnidae, no taxonomic problems arise with the present collections, I have avoided taxonomic description of the animals; the reader is referred particularly to VAN NAME (1945) for

detailed descriptions. Unless otherwise indicated in the text the nomenclature used follows that of VAN NAME (1945).

All of the material collected by WAGENAAR HUMMELINCK was stored at Rijksuniversiteit Utrecht in the Laboratorium voor Zoölogische Oecologie en Taxonomie. C. J. VAN DER SLOOT (1969) had examined some of this material in the course of an earlier study arising from which he published a paper on the styelid ascidians. VAN DER SLOOT also left an unpublished manuscript on the ascidians of Piscadera Baai which primarily deals at length with taxonomic descriptions of the species concerned. With the exception of the styelids referred to in his published paper I have re-examined all material left by VAN DER SLOOT in Utrecht, as well as much other material found elsewhere in the museum collections. In presenting this account I have incorporated into the record all information about species in Piscadera Baai which is given in the papers of MILLAR (1962) and VAN DER SLOOT (1969). VAN DER SLOOT does not appear to have examined any material from Lac; I believe I have located and examined all ascidians in the collections from this locality. The specimens identified by me have been deposited in the Zoölogisch Museum, Universiteit van Amsterdam.

In February 1981, I made brief reconnaisance visits to both Piscadera Baai and Lac, spending two days at each locality. These visits were primarily to familiarise myself with the localities and make visual observations on the present occurrences of ascidians. No further collections were made at this time.

Dr. WAGENAAR HUMMELINCK was meticulous in recording information about the localities at which he collected specimens and this information is published in his paper on "Marine Localities" (1977). I have extracted information from this paper which relates to stations at which ascidians were collected and this is presented here as Appendices III and IV. In Figures 41 and 42 the location of station numbers is shown for Piscadera Baai and Lac of Bonaire respectively.

I am grateful to Dr. P. WAGENAAR HUMMELINCK for giving me the opportunity to examine these extensive collections and for his friendship and assistance during my visits to Utrecht. I also extend my thanks and appreciation to Mrs. C. H. E. WAGENAAR HUMMELINCK-BERKELBACH VAN DER SPRENKEL for her kind and courteous hospitality during my visits to Utrecht in 1976 and 1979.

I received generous help from the Director and Staff of the Caribbean Marine Biological Station (CARMABI) in Curaçao, from Dr. TOM VAN T'HOF in Bonaire, and RENÉ GORISSEN and GERT JAN MEIJER who helped me with field work in Lac in 1981. To all of these I extend my thanks. I also acknowledge with appreciation a grant from the Royal Society Browne Research Fund which assisted with my visit to Utrecht in 1979.

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THE LAGOONAL ENVIRONMENTS

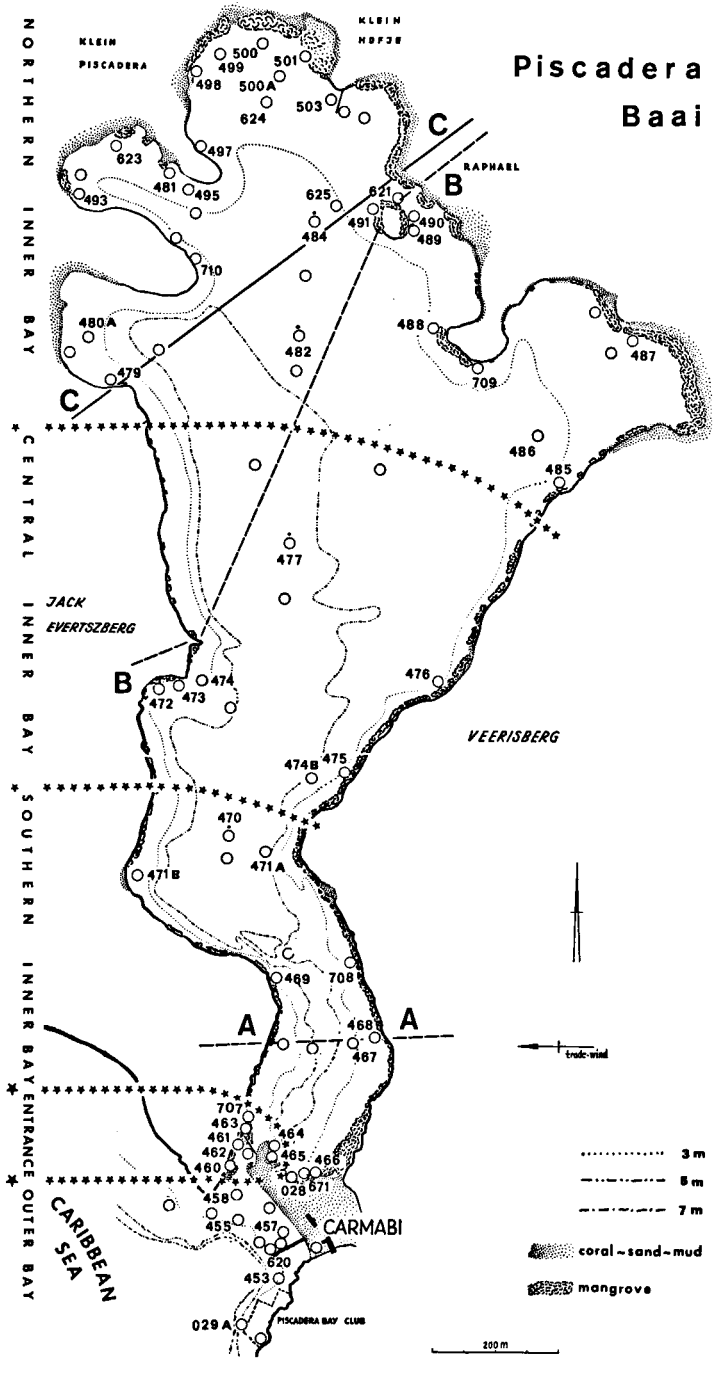
PISCADERA BAAI (Fig. 41)

Piscadera Baai is situated on the south coast of Curaçao about 4 km west of Willemstad. It is oriented north and south, lying between two low hills of about 100 metres in height. In its original condition the bay proper opened through a narrow shallow channel to an outer bay or Boca on the coastal platform of the island. The Boca has a depth of 6 metres or less and extends offshore for about 100 metres before the bottom slopes steeply downwards. Most of the entrance to the inner bay is blocked by a coral and debris bar on the western side of which is the narrow entrance. Until 1962 this entrance had a cross sectional profile of only 7 square metres, at which time it was widened to give a cross section of about 45 square metres. In 1972 the entrance was again widened and deepened so as to provide a channel about 60 metres from side to side.

The inner bay has an area of approximately 0.6 square kilometres, is steep sided and has an average depth of about 4 metres with a maximum of 7 metres. Because of the steep sides there is only narrow fringing mangrove, mostly *Rhizophora mangle*, and because of the depth and turbidity of the water there is insufficient illumination to support much growth of algae or seagrasses, such as *Thalassia*; in consequence the bottom is mostly composed of soft, muddy sediments.

The tidal range in Curaçao is only 30 cm (DE HAAN & ZANEVELD 1959, see also WAGENAAR HUMMELINCK 1953, fig. 1); because of this and because of the narrow entrance to the inner bay there is only a very limited water exchange between the Boca and the inner bay. The effects of this interchange are normally only immediately apparent in the most

Fig. 41. Map of PISCADERA BAAI, Curaçao showing the location of collecting stations. The initial digit (1) of every number is omitted. Thus 460 on the map indicates station number 1460; 028 on the map indicates station 1028 (From WAGENAAR HUMMELINCK, 1977). The dashed line A – – – A represents the approximate limits inside the bay of oceanic elements in the fauna, and B – – – B represents the inner limit of the intermediate fauna as indicated by Wagenaar Hummelinck's collections. The continuous line C —— C indicates the inner limits of ascidian distribution, except for *Diplosoma listerianum*, in 1981. For further detail see text.


Piscadera
Baai
KLEIN PISCADERA
KLEIN HOFJE
RAPHAEL
NORTHERN INNER BAY
CENTRAL INNER BAY
SOUTHERN INNER BAY
ENTRANCE OUTER BAY
CARIBBEAN SEA
JACK EVERTSZBERG
VEERISBERG
CARMABI
PISCADERA BAY CLUB
trade-wind
3 m
5 m
7 m
coral-sand-mud
mangrove
200 m

southern portions of the bay. Wind and density changes due to evaporation must provide the mixing process to maintain water quality throughout the northern portion of the bay. According to DE KOCK & DE WILDE (1964) salinity in the bay is constant throughout and remains within about 1 to 3% higher than that of seawater. Temperature varies from 26°C to 30°C which corresponds to normal sea water ranges for the Caribbean.

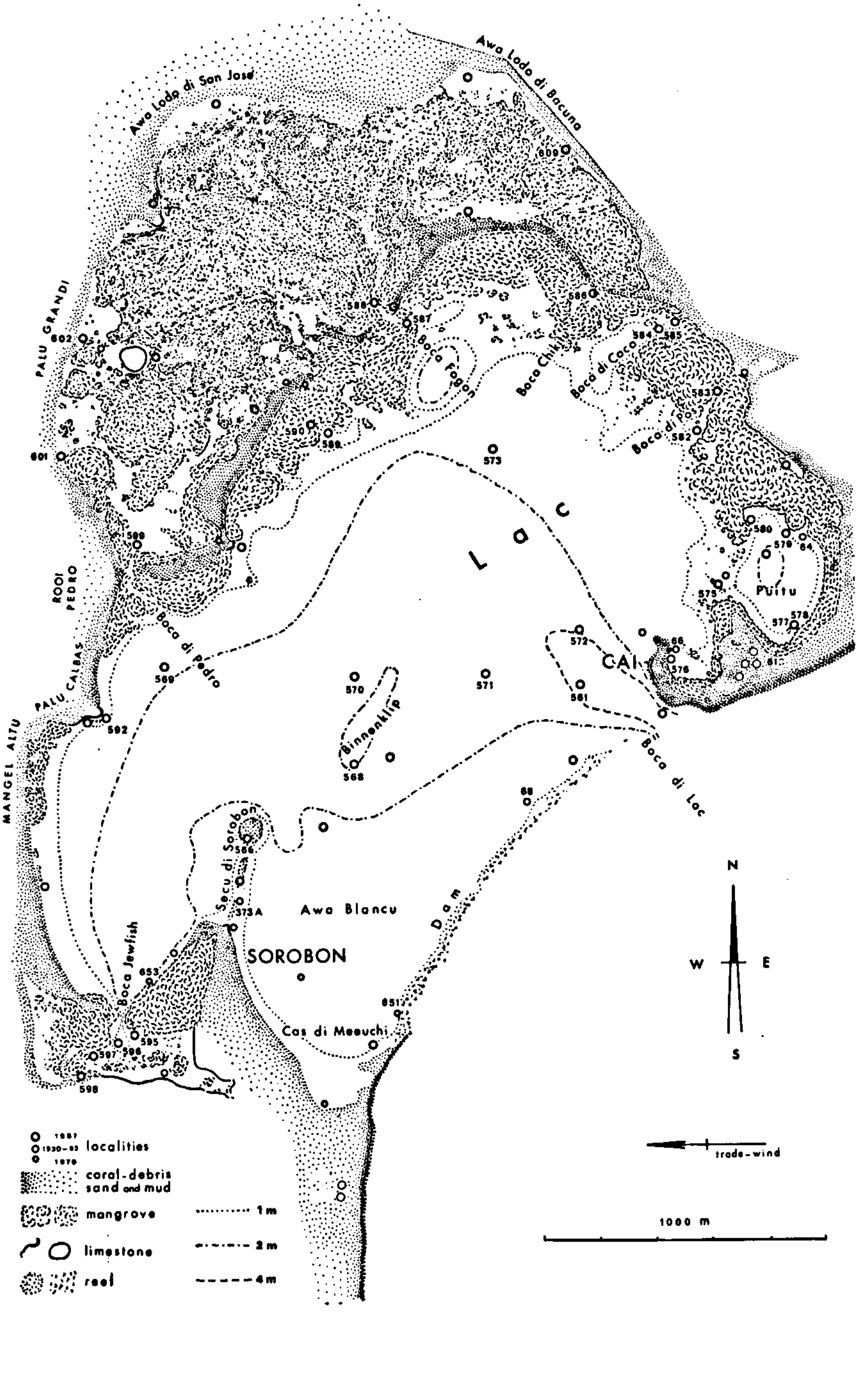
Piscadera Baai is subjected to pollutional stress due to the discharge of a small sewer pipe at the northern extremity. In its original condition this pipe deliverd no more than 1000 cubic metres of highly purified effluent per day. This effluent is probably responsible for the high phosphate content of the bay, 1.1 to 3.5 mg at. per litre (total phosphorus). The purity of the sewage effluent has probably deteriorated in recent years and has resulted in a change in the quality of the environment in the north, and particularly north-western part of the bay.

The clarity of the water is low, due to suspended matter and phytoplankton growth. A Secchi disc is reported to disappear at 35–50 cm in comparison to a depth in excess of 50 metres for open ocean waters. Piscadera Baai is essentially a eutrophic lagoon and this state is probably in part natural due to the impoundment and recycling of organic materials, but is also strongly influenced by the existence of the sewage effluent. For further detail on conditions in Piscadera Baai see HOFKER (1971).

THE LAC OF BONAIRE (Fig. 42)

Lac is situated on the south-eastern coast of Bonaire and comprises about 8 square kilometres of open water, mangrove swamp and salinas. The main lagoonal area is about 5 square kilometres in area and opens to the sea by a shallow entrance, about 1.5 kilometres wide and usually only about 0.5 metres in depth. Over much of its area Lac is only 1 to 1.5

Fig. 42. Map of LAC of Bonaire showing the location of collecting stations. The initial digit (1) of every number is omitted. Thus 585 on the map indicates station 1585; 064 on the map indicates station 1064 (From WAGENAAR HUMMELINCK, 1977).


Awa Lodo di San José
Awa Lodo di Bacuna
PALU GRANDI
ROOI PEDRO
PALU CALBAS
MANGEL ALTU
Boca di Pedro
Boca Fogon
Boca di Coco
Boca di Pos
Lac
Puitu
CAI
Boca di Loc
Binnenklip
Secu di Sorobon
Awa Blancu
SOROBON
Dam
Cas di Meeuchi
Boca Jewfish
N
W
E
S
trade-wind
1000 m
localities
coral-debris sand and mud
mangrove
limestone
reel
1 m
2 m
4 m

metres in depth but the central portion reaches depths of 3 to 3.5 metres, and at the north-eastern end of the entrance the bottom slopes rapidly down to 8 metres as it emerges to the open sea.

Because of the extent of the entrance and its orientation in relation to the prevailing trade winds there is a strong tidal and wind driven circulation of water through Lac and in consequence the waters are normally exceedingly clear in marked contrast to the turbid waters of Piscadera Baai.

Around the margin of the lagoon there is dense mangrove and in most places *Rhizophora* roots either hang freely in the water or root below the surface. In most places these hanging roots are conspicuously free of encrusting sessile organisms. Over much of the floor of the lagoon there is a carpet of *Thalassia* intermingled with *Halimeda* and sometimes *Syringodium*; in the northern sector at Boca di Coco there is a conspicuous area of the green alga *Avrainvillea.*

Throughout most of the lagoon normal sea water salinities prevail. For further detail on this and other features of the Lac see WAGENAAR HUMMELINCK & ROOS (1969).

The contrast between Piscadera Baai and Lac is well illustrated by WAGENAAR HUMMELINCK (1977, p. 5–6) who writes as follows:

"In Piscaderabaai (Piscadera inner-bay) the mangrove-roots are densely covered with oysters (*Crassostrea rhizophorae*) and barnacles (mainly *Chthamalus bisinuatus*) which in many places are thickly overgrown with ascidians (notably large patches of *Didemnum*). There are great masses of sponges and actinians (mainly *Aiptasia pallida*), beautiful colonies of hydroids (especially *Halecium halecinum* and *Laomedea bicuspidata*) and luxuriant patches of bryozoa (*Amathia, Zoobotryon* and *Bugula*), while in places *Schizoporella* may occur as the dominant organism. *Thalassia testudinum* occurs only in some shallow places, while *Halimeda* is almost absent. The bottom of the inner bay consists for the greater part of blackish mud, carrying in some shallow places large numbers of *Chione cancellata* and three *Corbula* species, while *Brachydontes exustus* is found nearly everywhere along the rocky shores.

In Lac, however, there are no mangrove-oysters and only very few barnacles (*Chthamalus angustitergum*), while ascidians, sponges, actinians and bryozoa are much less predominant than in Piscadera Bay. Hydroid colonies of *Dynamena crisoides* – common in the Piscadera outer-bay – are found in many places, and the athecate *Myrionema hargitti* is as strikingly present here as in many other Caribbean clear-water lagoons. The bottom of Lac is covered with a luxurious growth of *Thalassia*, in many places mixed with *Halimeda opuntia*. Locally *Codakia orbicularis* abounds, but *Chione* is absent. *Oreaster reticulatus* and several species of *Strombus* found in the basin of Lac are lacking in Piscadera's inner-bay. The author has been told that *Cassiopea* – common in Lac – used to occur in Piscaderabaai; in that case the bay must have been filled with clear water and would have had well-sheltered places; conditions which no longer exist."

THE DISTRIBUTION OF ASCIDIAN SPECIES

TABLE 1 shows the composition of ascidian species in the two lagoons as recorded from WAGENAAR HUMMELINCK's collections and my own observations. APPENDICES I and II show the distribution of each species by station number in each lagoon represented in a semi-quantitative manner. In these Appendices five different numerical categories are used based entirely on the number of specimens found in the collections. These are single individual or colony (*), two individuals (**), two to five individuals (***), six to ten individuals (****) and more than ten individuals or colonies (*****). (Information relating to *Didemnum* and *Symplegma* in Piscadera Baai, which is based on VAN DER SLOOT's manuscript notes supplemented by other material in the collections, is slightly different. For detail see the Appendices). In view of the precision and detail with which Dr. WAGENAAR HUMMELINCK undertook all his collecting activities it is reasonable to assume that this represents a fair description of the relative numerical abundance of species in the lagoons. In the following account these numerical data are supplemented where necessary by my own observations in 1981.

Family POLYCLINIDAE Verrill, 1871

Polyclinum constellatum Savigny

This is a cushion shaped, gelatinous colony often common in sessile communities in lagoons. In the collections it occurs only from Piscadera Baai as two fragments one from the entrance and one from station 1475 on the east side. In 1981 I found it on *Rhizophora* roots in small quantity all along the east side of the lagoon from Raphael Island (#1491) to the junction of the Central and Southern Inner Bay (#1475). Colonies were also found on mangrove on the west side at stations 1472 and 1473. *P. constellatum* is a rapidly growing species which breeds throughout the year in the West Indies and is associated with the early stages of sessile community growth. Hence its numbers tend to fluctuate from time to time and no particular significance can be attached to the difference between the collection and the more recent observations.

The species is not recorded from Lac.

Family DIDEMNIDAE Giard, 1872

Didemnum vanderhorsti Van Name

A flat encrusting colony usually coloured deep purple blue or brown and lacking the calcareous spicules normally found in didemnids. This species generally prefers an oceanic habitat or clear lagoonal water and in the collections occurs only in two stations in the entrance to the bay. However, in 1981 many colonies were observed along the mangroves on the eastern side of the Central Inner Bay where water conditions were relatively clear.

The species did not occur in collections from Lac.

Didemnum conchyliatum (Sluiter)
Didemnum psammathodes (Sluiter)
Didemnum duplicatum F. Monniot

Through most of the southern part of Piscadera Baai there are extensive colonies of didemnids, usually encrusting mangrove roots or the undersurface of marker buoys etc. These colonies may be pure white, brown, a mixture of white and brown or orange in colour and form flat sheets sometimes of considerable size. The whiteness is due to densely packed spicules in the test, the brown and orange colour is due to pigment cells or in some cases to faecal pellets accumulating in the test.

There are three distinct forms of these didemnids which are recognized by taxonomists as separate species, as indicated below.

1. Zooids have a single testis lobe; a large atrial aperture which exposes much of the branchial sac; the larval trunk does not normally exceed 600 μ in length. This is the form described as *Didemnum conchyliatum* (Sluiter, 1898).
2. Zooids have a bilobed testis; the atrial aperture is usually small and rounded; the larval trunk is usually more than 800 μ in length. This form has been described as *Didemnum duplicatum* by FRANÇOISE MONNIOT (1983a).
3. Zooids have a single testis lobe; the atrial aperture is large and exposes much of the branchial sac; the larval trunk is usually less than 500 μ in length; spicules are few or absent in the test but the test is usually packed

with faecal pellets. This is the form described as *Didemnum psammathodes* (Sluiter, 1895).

MILLAR (1962) recognised the first of these, *Didemnum conchyliatum*, and noted the presence of the second in collections from Curaçao without assigning a name to it. All three forms are recognised in VAN DER SLOOT's manuscript on the Ascidians of Piscadera Baai.

The present paper is not a place to discuss the taxonomy of the group and it is convenient to ascribe these three forms to the species indicated above. Nevertheless one may note that the morphological differences between them are small, they have a similar distribution and habitat requirement in the West Indies and no immediate ecological differences can be discerned. The group deserves further attention from a systematic point of view.

In the collections, colonies of these didemnids occurred from most parts of the bay but there is a definite preponderance of colonies from the southern sector as far north as 1473 and 1476. During my visit in 1981 colonies were common in parts of the southern sector and also along the eastern shore as far as station 1488.

These species were not recorded in the collections from Lac of Bonaire.

Diplosoma listerianum (Milne-Edwards, 1841)

D. listerianum is a fragile, gelatinous, encrusting colony and is a common component of the early stages of successional development in sessile communities. It may utilise primary space such as a *Rhizophora* root or secondary space such as oyster shell etc. for settlement and growth. It occurs commonly in mangrove lagoons and less commonly in reef associations. In 1981 I found it only in the heavily polluted waters of the northern Inner Bay and in rich ascidian communities along the east side of the Inner Bay (#1485 to 1476).

In the Lac it is also widely distributed in the collections from mangrove areas but I did not see any specimens in 1981. The species is obviously capable of tolerating a wide variety of ecological conditions.

Diplosoma listerianum from the West Indian region was described as *Diplosoma macdonaldi* by HERDMAN (1886) and this latter name has until recently been in general use in the literature on West Indian Ascidiacea. It

is now generally agreed that *D. macdonaldi* is synonymous with the widely distributed *D. listerianum* (Milne Edwards), 1841. For a discussion of the taxonomy see ROWE (1966).

Family POLYCITORIDAE

Eudistoma olivaceum (Van Name)

E. olivaceum forms clusters of grey-green "heads" each of which contains a number of zooids; it is a frequent inhabitant of mangrove lagoons where it grows on *Rhizophora* roots. In Piscadera Baai it has a restricted distribution in the southern inner bay on east and west sides, always growing on *Rhizophora.* In the collections it occurred only at three stations, 1469, 1473 and 1671 but in 1981 it was found to occur in small quantity along the whole eastern side of the southern inner bay.

In the Lac *E. olivaceum* is one of the commonest ascidians and colonies have been collected from most parts of the mangrove area. The species restriction to the southern inner bay in Piscadera and its widespread occurrence in Lac underline its apparent requirements for relatively clean conditions, a requirement which I have also noted in Jamaican lagoons.

Family PEROPHORIDAE Giard, 1872

Perophora bermudensis Berrill

Perophora forms colonies of tiny zooids connected by long stolons, the whole forming either a creeping mat or bush like structure depending on the prevailing water conditions; in quiet conditions bushes form, in fast currents mats. In the collections from Piscadera Baai single colonies were found at opposite ends of the lagoon at stations 1466 and 1488 but no colonies were found in 1981. In the Lac *P. bermudensis* occurs throughout the lagoon but never in large quantity and usually associated with the quieter areas of the mangroves. This may not necessarily reflect its true distribution because colonies are often small and easily overlooked unless associated with larger ascidians.

In the Lac *P. bermudensis* was found at four stations associated with colonies which have been attributed to the smaller, greener species *Perophora viridis*. The difference between these species is slight but distinct depending on the number of rows of stigmata in the branchial sac, five in *bermudensis* and four in *viridis*, and the arrangement of the mantle muscles. *Perophora bermudensis* was named by BERRILL (1932). CLAUDE MONNIOT (1983a) discusses its possible synonymy with *Perophora formosana* (Oka, 1931).

Ecteinascidia turbinata Herdman

Like Perophora the zooids of species of *Ecteinascidia* are connected by stolons, but they usually form closely packed bunches of soft zooids which in the case of *E. turbinata* are bright orange in colour and usually 3 to 4 cms in length. *E. turbinata* is characteristic of relatively quiet lagoonal waters, probably so restricted by the form of colony and relative delicacy of the zooids.

In the collections *E. turbinata* was restricted to the southern half of Piscadera Baai and was found in quantity at only three stations on the east side (1477, 1468 and 1475). This distribution accords well with what has been found in Jamaica where it also occurs only in quiet lagoons free of any pollutional effect or heavy eutrophication.

In 1981 *E. turbinata* was found only along a short stretch of mangrove on the eastern side of the Central Inner Bay between station 1475 and 1485. It is perhaps significant that this is the sheltered side of the bay thus underlining the habitat requirements of this species.

E. turbinata was not recorded from the Lac.

Ecteinascidia conklini Berrill

E. conklini has smaller zooids than *E. turbinata*, usually about one centimetre in length, and is green sometimes with orange tips to the siphons. Like *E. turbinata* it grows in tight bunches, often or usually attached to the roots of *Rhizophora*.

In Piscadera Baai the distribution of *E. conklini* contrasts strikingly

with that of *E. turbinata*: in the collections it was found only from stations in the Northern Inner Bay and in 1981 was observed only along the north-eastern sector of the bay from station 1476 to 1621 on Raphael Island. However in the Lac of Bonaire *E. conklini* was widespread but never common and had a very similar distribution to that of *Perophora bermudensis*. In 1981 I saw it only in Puitu and Boca Jewfish.

Ecteinascidia tortugensis Plough & Jones

Like other members of the family this species has zooids connected by stolons but in this case the colony forms a flat encrusting system with individual zooids attached to the substratum by the ventral side and the siphons directed dorsally. Colonies are normally greyish green in colour. The species is primarily an inhabitant of oceanic waters and occurs in the collections only from the Lac of Bonaire principally in the eastern half. Most colonies are small and attached to pieces of mangrove bark.

BERRILL (1932) described *Ecteinascidia conklini minuta* as a form of *E. conklini*. CLAUDE MONNIOT (1972) regards *E. tortugensis* as a synonym of this form and in a subsequent paper (1983a) refers to it as *Ecteinascidia minuta* (Berrill, 1932).

Family ASCIDIIDAE Adams, 1858

Ascidia nigra (Savigny)

This is a large solitary ascidian in which the test has a deep purple black colouration. It is a common inhabitant of inshore waters and lagoons throughout the West Indies but in general is absent from reefs or similar areas of clear water. *A. nigra* usually occurs on raised substrates where it is clear of bottom sediments and hence is common on *Rhizophora* roots. In the collections it occurs only from Piscadera Baai where it is widespread and locally common. In the 1981 survey it was absent from the west and north-west of the bay except in two areas of mangrove at 1469 and 1472/3. However on the east side of the bay it occurred commonly all along the fringing mangrove from Raphael Island (1490) to the southern end of the bay.

The species is not recorded from the Lac of Bonaire a situation probably dictated by the relatively oligotrophic conditions in this lagoon.

Ascidia interrupta Heller

This species differs from *A. nigra* in being a greenish grey in colour and commonly living on the sea floor or close to it. In the collections it is shown to have a widespread distribution in Piscadera Baai reflecting the fact that it is less dependent on supporting structures (i.e. *Rhizophora* roots) than is *A. nigra.*

A. interrupta is more frequently found in reef areas than is *A. nigra* suggesting that it has a greater accommodation to waters poor in suspended matter. This is also reflected in the fact that there are two records from the Lac of Bonaire (# 1572 and 1589).

Ascidia curvata (Traustedt)

This small, sometimes glassy transparent, member of the genus is normally associated with relatively clear waters and reef areas. It is surprising therefore to have a single record from station 1473 in Piscadera Baai. There are two records from Lac, both near the entrance (# 1068 and 1572).

Family RHODOSOMATIDAE Hartmeyer, 1908

Rhodosoma turcicum (Savigny)

R. turcicum is a small solitary ascidian, greyish in colour, characterised by having a "lid" of test material which closes down as a protective flap over the siphons when they are withdrawn. It is seldom common and is normally an inhabitant of quiet lagoons. There is only a single record in the collections from station 1588A in the Lac which is a shallow creek in the mangroves.

Family STYELIDAE Sluiter, 1895

Botrylloides nigrum Herdman

B. nigrum forms flat encrusting colonies with the zooids arranged in regular systems around common atrial openings. In HERDMAN's (1886) original description he names the species *nigrum* because of the black colour of the colonies collected by the Challenger in Bermuda. This colour form does not appear to be common in the West Indies where many colonies are brick red in colour.

In the collections from Piscadera Baai *B. nigrum* is not recorded at all, which is surprising as it is normally common in coastal lagoons with fringing mangroves, often growing on the surface of other sessile organisms such as oysters, solitary ascidians etc. Absence from Piscadera Baai collections is made more incomprehensible by the fact that in the 1981 survey *B. nigrum* was found to be widespread throughout the bay including the heavily polluted area around stations 1494 and 1623. Dr. HUMMELINCK was too careful a collector to have overlooked this species during his several visits to the bay and we must conclude that by chance it never colonised until after the entrance was widened in 1972.

In the collections from the Lac of Bonaire the species is recorded in small numbers from the north-eastern sector of the lagoon, particularly in the area of Boca di Coco, Puitu and Cay. I found the species to have an almost identical distribution in the Lac during my visit in 1981. In the vicinity of Boca di Coco the species occurred commonly on the tips of fronds of the alga *Avrainvillea*, and all of these colonies were of the black form originally noted by HERDMAN. Elsewhere in the lagoon colonies were of the normal brick red colour.

B. nigrum is widespread throughout lagoons in the West Indies but seldom occurs on coral reefs where its place appears to be taken by species of *Botryllus*.

Symplegma viride Herdman

S. viride bears a superficial resemblance to *Botrylloides* forming flat encrusting colonies often growing on other sessile organisms in sheltered

lagoons. However, the zooids are not arranged in such ordered systems and each zooid has its own atrial opening.

The distribution of the species in Piscadera Baai has already been reported on by VAN DER SLOOT (1969) and additional specimens found by me in the collections confirm a widespread distribution but particularly along the more sheltered eastern side. This distribution was confirmed in 1981 when it was found to occur commonly on *Rhizophora* along the entire eastern side from station 1502 by the sewage pipe to the southern end at station 1468. In 1981 it was entirely absent from the stressed areas in the north-west sector of the lagoon.

In the Lac of Bonaire the species is not common and was recorded only from two stations in the central portion of the bay.

Styela partita (Stimpson) and **Styela plicata** (Lesueur)

S. partita is a small grey to pink solitary ascidian which often grows in dense clusters amongst sessile communities in mangrove areas. VAN DER SLOOT (1969) has already mapped its distribution in Piscadera Baai and additional specimens located in the collections confirm a widespread distribution throughout all parts of the bay. In 1981 I recorded it only from two places in the southern half of the bay, stations 1472/3 on the west and station 1468 on the east. This change in the population over the past decade may reflect only a temporary situation, or may be a permanent change due to increasing stress from the sewage outfall. The latter postion is supported by the discovery in 1981 of a single specimen of *Styela plicata* at station 1490 at Raphael Island. *S. plicata* is very tolerant of estuarine and stressed conditions and may now be replacing *S. partita* in the northern part of the bay.

S. partita is recorded from a single position in the Lac of Bonaire at station 1588, a shallow creek in the mangroves in the northern sector of the bay.

[KOTT & GOODBODY (1982) consider *Styela partita* Stimpson to be synonymous with *Styela canopus* Savigny.]

Polycarpa arnoldi Michaelsen

P. arnoldi is a small solitary species usually found in reef or rocky areas, often under stones. It is not normally an inhabitant of lagoonal areas. VAN DER SLOOT (1969) reports on two occurrences near the entrance to Piscadera Baai and there is a single record of an animal at station 1068A at the entrance to the Lac of Bonaire. This species was first reported from the West Indies by MILLAR (1962) who named it *Polycarpa crossogonima.* For a discussion of the taxonomy see VAN DER SLOOT (1981).

Polycarpa cartilaginea (Sluiter)

This species is also normally an inhabitant of reef or rocky areas occurring under stones. VAN DER SLOOT reports on five occurrences near the entrance to Piscadera Baai.

Polycarpa spongiabilis Traustedt

This solitary styelid is very variable in size, morphology and habitat. It appears to grow best as an inhabitant of soft bottoms where it is embedded in the sediments, particularly in quiet lagoonal areas, but it may also occur in *Thalassia* beds or attached to *Rhizophora* roots. VAN DER SLOOT (1969) has reported on its distribution throughout Piscadera Baai where its widespread distribution reflects its catholic tastes for habitat.

There are no records of the species in the Lac of Bonaire which is surprising as there are many suitable habitats particularly in Puitu and Boca Jewfish.

Polyandrocarpa tumida (Heller)

This species forms colonies of small tough tested individuals separated from one another and connected only by test material. They are usually deep red in colour. VAN DER SLOOT (1969) has reported on its occurrence

in Piscadera Baai where it is confined to the relatively clean waters of the southern part of the bay. The species is more normally an inhabitant of clearer oceanic waters.

Polyandrocarpa tincta (van Name)

P. tincta also forms colonies of individuals, reddish in colour. It is a characteristic inhabitant of shallow reef areas but occasionally forms larger colonies in the sheltered waters of clean mangrove lagoons. VAN DER SLOOT reported on its occurrence in Piscadera Baai and other specimens from the collection confirm that it is found in small quantity along the eastern side of the bay with one record from station 1473 on the west side. No colonies were seen in 1981, and the species is not recorded from the Lac of Bonaire.

Family PYURIDAE Hartmeyer, 1908

Pyura vittata (Stimpson)

P. vittata is a large solitary ascidian with a tough, often wrinkled test. It is commonly found on reefs and in the cleaner waters of inshore areas and lagoons. It tends to be replaced ecologically in lagoons by *Microcosmus exasperatus.*

P. vittata has been recorded in the collections from Piscadera Baai only in the extreme southern portion close to the entrance, except for a single record at station 1473 where there is a small mangrove patch overhanging the water. The distribution in Piscadera Baai is in conformity with what has been found also in Jamaican inshore areas. The species was not recorded in 1981.

There are only two records from Lac of Bonaire both (stations 1068a and 1651) being on the reef rubble dam across the entrance of the bay.

Microcosmus exasperatus Heller

Unlike *Pyura vittata*, *M. exasperatus* is seldom found in the clear waters of coral reefs and is more characteristic of inshore lagoons. As indicated above the two species appear to be ecological replacements for one another.

In the collections from Piscadera Baai *M. exasperatus* is recorded as of widespread occurrence normally attached to *Rhizophora* roots or to the undersurface of marker buoys. In 1981 the species distribution in Piscadera Baai was more restricted; it appeared to be confined to the eastern side of the bay from Raphael Island (station 1490) to the southern end at station 1467, and on the western side at stations 1472 and 1473. This change in the distribution of the species is probably a reaction to increased stress of pollution occurring in the past decade.

Microcosmus helleri Herdman

This is usually a smaller species than *M. exasperatus* and is an inhabitant of soft bottom communities, usually in clear oceanic water. It characteristically has tube like siphons enabling the body of the animal to lie buried in the substratum.

In the collections there are two records from the entrance to Piscadera Baai (stations 1460A and 1671), and no records from Lac.

Herdmania momus (Savigny)

H. momus is a large solitary ascidian with a soft pliable test, usually greyish in colour; the interior of the siphons often has a characteristic mixture of red and green colouration making it easily recognisable. The species is not recorded at all from the collections but in 1981 I found it in small numbers at stations 1476 and 1485. Like *Botrylloides nigrum* and *Styela plicata* this may be a new arrival to the lagoon since the basic collection was made in 1963. Elsewhere in the Caribbean *H. momus* is characteristically an inhabitant of intermediate waters between open ocean and enclosed mangrove lagoon, hence its presence in the southern portion of Piscadera Baai is not unexpected.

Molgula occidentalis Traustedt

M. occidentalis has similar habitat requirements to *M. helleri* the two species often being found in proximity. There is a single record of *M. occidentalis* from the Lac of Bonaire at station 1064b in the lagoon at Puitu. In view of the clarity of water in the Lac the species may in due course be found to have a wider distribution.

DISCUSSION

The information presented in the foregoing pages permits us to draw conclusions concerning the ascidian fauna of the two lagoons, Piscadera Baai a richly eutrophic enclosed situation and the Lac of Bonaire an open shallow almost oligotrophic bay.

The fauna of PISCADERA BAAI divides into three groupings, those ascidians which are typically oceanic, an intermediate group requiring shelter and a relatively rich food environment, and a widespread group which appears tolerant of a variety of conditions.

In the oceanic element two species of *Polycarpa*, *P. arnoldi* and *P. cartilaginea* were found only in the vicinity of the entrance to the bay. Two species of *Polyandrocarpa*, *P. tumida* and *P. tincta* also have distributions clustered around the entrance, but some colonies of *P. tincta* were found further into the bay on the sheltered eastern side. Finally in the oceanic element two specimens of *Microcosmus helleri* were found just inside the entrance of the bay, and a single specimen of *Ascidia curvata* at station 1473.

The second group in Piscadera Baai, the intermediate group, have a distribution clustered around the southern portion of the inner bay extending as far as station 1473 on the west and 1476 on the east. It is not clear what may be the ecological limitations defining this area which is nutritionally fairly rich; it may represent the limit to which the direct influence of tidal interchange is experienced. The region is characterised by the presence of *Polyclinum constellatum*, *Eudistoma olivaceum*, *Ecteinascidia turbinata*, *Pyura vittata* and *Herdmania momus*, all of which have been found to thrive in similar conditions in Jamaica, although *Pyura vittata* is also a common inhabitant of more open water conditions on reefs.

The group of more cosmopolitan ascidians for which there are records in the collection from most parts of Piscadera Baai includes *Diplosoma listerianum*, *Didemnum conchyliatum*, *D. psammathodes* and *D. duplicatum* (but not *D. vanderhorsti*), *Ascidia nigra* and *A. interrupta*, *Polycarpa spongiabilis*, *Styela partita*, *Symplegma viride* and *Microcosmus exasperatus*. All of these species must be fairly tolerant of the eutrophic conditions which have existed in the past in the northern portion of Piscadera Baai, as well as being tolerant of limited water exchange.

There remain two special cases to consider. *Didemnum vanderhorsti* is normally an inhabitant of well aerated reef flat situations but occasionally penetrates into clean lagoonal conditions. In the collections it occurs only from two stations (1463 and 1464) close to the entrance of the bay. However, in my observations in 1981 I recorded a number of colonies along the eastern side of the inner lagoon as far north as stations 1467 and 1709. The second special case is that of *Ecteinascidia conklini*, which, although by no means confined to lagoonal areas in its normal distribution often penetrates into more stressed conditions than does its congener *E. turbinata*. In Piscadera Baai the records of its occurrence are confined to stations in the northern, more stressed portion of the lagoon and the distribution of the two species of *Ecteinascidia* in the lagoon does not overlap.

The foregoing distributions of ascidians in Piscadera Baai represents the situation in 1963 when Dr. WAGENAAR HUMMELINCK's collecting was undertaken. Parallels between the distribution of ascidians reported here and the occurrence of Foraminifera are apparent by reference to the work of HOFKER (1971).

My visit to Piscadera Baai in 1981 was a reconnaissance visit and not a collecting trip, in which I relied on visual observation of distributions. In the intermediate group the distribution of *Ecteinascidia turbinata* and *Eudistoma olivaceum* remained unchanged but I saw no specimens of the other species in this group. In the cosmopolitan group there had been a widespread withdrawal of distribution away from the north-west sector of the bay, with the exception of *Diplosoma listerianum* which still maintained colonies in the highly stressed conditions then pertaining around stations 1493 and 1494. Although quantitative data are lacking in support it appears that this portion of the lagoon must have changed considerably since HUMMELINCK made his collections, probably due to changes or defects in the sewage discharge system. As reported earlier the appearance of *Styela plicata*, although only a single specimen was seen, may be an indicator of such change in the northern bay.

The most notable change in the bay since 1963 is the appearance in quantity of *Botrylloides nigrum*. *B. nigrum* is a characteristic inhabitant of lagoons such as Piscadera Baai and its absence from HUMMELINCK's collection remains unexplained.

The distribution of ascidians in Piscadera Baai may be considered to be

limited by four factors, available substrate, shelter, water quality and food. Food is unlikely to be a serious limitation except near the entrance to the bay where the decrease in suspended matter may affect such species as *Ecteinascidia turbinata*. Water quality appears to be a serious limiting factor for many species in the northern portion of the bay but not elsewhere. Throughout most of the bay, and in many other similar lagoons, substrate availability and shelter are apparently the two most important limiting factors. Since most of the floor of the bay is covered by mud and most species of ascidians are hard substratum limited only a few species such as *Polycarpa spongiabilis* can colonise the bottom of Piscadera Baai. The available surfaces for colonisation are restricted to hanging roots of the mangrove *Rhizophora* and the undersurfaces of floating buoys. Because the distribution of mangrove tends to be restricted by a need for shelter it is difficult to determine in the present case whether the distribution of ascidians is dependent on shelter or a need for substrate. In the collections and in the 1981 reconnaissance the greatest development of sessile animal growth in general and ascidians in particular occurred along the sheltered eastern shore from station 1488 to 1468 where there is a band of fringing mangrove with suitable hanging roots for substrate. Pockets of ascidian growth, and growth of other sessile organisms such as bryozoans, sponges and oysters occurred on the west side where suitable hanging roots occurred, such as at station 1469 and stations 1472 and 1473, which are relatively sheltered sites. On the exposed coastline in the neighbourhood of 1471 both mangrove development and sessile community growth were relatively poor. The shoreline between stations 1474 and 1479 is directly exposed to the trade wind and there is virtually no mangrove development with a consequent absence of sessile growth. The marker buoys at stations 1477, 1482 and 1484 which lie in the path of wave disturbance all had sessile communities on their undersurfaces but with the exception of some small colonies of *Diplosoma listerianum* the ascidian fauna was composed of large solitary forms, particularly, *Ascidia interrupta*, *Microcosmus exasperatus Polycarpa spongiabilis*, and *Styela partita*. In the more sheltered position of the buoy at 1470 *Didemnum* was also found. It seems likely therefore that most of the small colonial ascidians particularly the species of *Ecteinascidia* and *Eudistoma* are dependent on shelter.

WAGENAAR HUMMELINCK (1977) divided Piscadera Baai into five

regions, namely Outer Bay, Entrance, Southern Inner Bay, Central Inner Bay and Northern Inner Bay. The division of the inner Bay into three parts appears to have been undertaken on points of geography rather than ecology. It seems to me that on the basis of the ascidian distributions one might suggest the existence of faunal boundaries as follows (see Fig. 41):

(a) A line from station 1467 to 1468, south of which is found the oceanic element in the fauna.
(b) A line from station 1474–1491, south of which is found the intermediate group.
(c) A line from 1479 to 1491 and Raphael Island which now marks the northern limit of normal distributions. North of this line the lagoon may be too stressed for survival by most species.

The almost oligotrophic waters of the LAC of Bonaire provide a striking contrast to the eutrophic conditions prevailing in Piscadera Baai. The regime, and hence the fauna, in Lac appears to be governed by the wide entrance to the open sea and the prevailing winds creating extensive wave wash along the shallow mangrove fringed western sector of the bay. The heavy wave action and water with disturbed sediments are unsuitable conditions for most ascidian growth on the mangrove roots, and it is only in the sheltered areas of the northern part of Lac and in Boca Jewfish at the south that suitable conditions prevail. Much of the bottom of Lac is covered by *Thalassia* and *Halimeda*. *Thalassia* blades are seldom colonised by ascidians and *Halimeda* only occasionally by perophorids such as *Perophora bermudensis* and *Ecteinascidia tortugensis*.

The ascidian fauna of Lac is dominated by small colonial species, and there is a noticeable absence of large solitary forms such as *Microcosmus exasperatus*, *Ascidia nigra*, or *Polycarpa spongiabilis*. For several species there are so few records that no conclusions can be drawn about their distribution i.e. *Symplegma viride*, *Styela partita*, *Rhodosoma turcicum*, *Ascidia interrupta*, *Ascidia curvata*, *Polycarpa arnoldi*, *Pyura vittata* and *Molgula occidentalis*. In the case of *P. vittata* and *P. arnoldi* the single specimens occurred on the rock dam at the entrance which is a likely, relatively oceanic, habitat for such species.

Of the remaining species *Eudistoma olivaceum* is the most widespread and common in the collections, usually collected from mangrove roots.

The relative abundance of *E. olivaceum* in comparison to some other species may represent an unintentional bias in the collecting process as it is a very conspicuous object, particularly in comparison to the pale green transparent forms of the perophorids. Nevertheless it remains true that *E. olivaceum* is a conspicuous and common element of the fauna of Lac.

The three perophorids, *Perophora bermudensis*, *Ecteinascidia conklini* and *E. tortugensis* occur commonly in the northern sheltered part of the bay often growing on mangrove roots, pieces of bark or leaves on the floor, as well as on *Halimeda*. These species are probably more common in Lac than the records suggest; when growing on *Halimeda* in particular they are very difficult to see and can be overlooked in the collecting process.

Botrylloides nigrum, which is a conspicuous organism, appears to be confined to the sheltered northern sector of the lagoon. It is of note that while it seldom grows on leaves of *Thalassia* it appears to occur commonly on the tips of the green alga *Avrainvillea*. The distribution of *Diplosoma listerianum* in the Lac parallels that of *B. nigrum* in the northern part of the lagoon but there are also several records from the rocky areas of the Dam and Sorobon in the south. There are no records of other didemnids.

It is likely that further collecting in Lac may reveal populations of benthic ascidians, particularly *Polycarpa spongiabilis*, *Microcosmus helleri* and *Molgula occidentalis*. All of these species are found on occasion in amongst *Thalassia*.

The contrast between these two lagoons, Piscadera Baai and Lac, in terms of their ascidian fauna is thus vivid; this is further demonstrated by the abundance of the mangrove oysters *Crassostrea rhizophorae* and *Isognomon alatus* in Piscadera Baai and their absence from the Lac of Bonaire. It is not easy to explain the contrast other than by reference to subjective measures of eutrophy and oligotrophy. While the high level of development of all sessile communities in Piscadera Baai must be due to corresponding levels of nutritional material in the form of suspended particulate organic matter, the paucity of sessile organisms in Lac is not necessarily a simple reflection of low levels of suspended material. Over much of Lac exposure to wave action may inhibit growth but it is not easy to see why there are not richer communities in the sheltered

mangrove enclosed lagoons at Puitu in the east and Boca Jewfish in the south. A contributory cause may be grazing by fish but we do not have information which would help to substantiate this. Another possibility is that there are seasonal levels of high salinity along the mangrove fringe

TABLE 1

SPECIES OF ASCIDIAN RECORDED FROM PISCADERA BAAI (CURAÇAO) AND LAC (BONAIRE).

The list includes all records. Species numbers according to Appendices I and II. Species marked* are not listed in the Appendices; see text for information

PISCADERA BAAI		LAC
1	*Polyclinum constellatum* Savigny, 1816	
19	*Didemnum conchyliatum* (Sluiter, 1898)	
20	*Didemnum duplicatum* F. Monniot, 1983	
21	*Didemnum psammathodes* (Sluiter, 1898)	
22	*Didemnum vanderhorsti* Van Name, 1924	
2	*Diplosoma listerianum* (Milne Edwards, 1841)	1
3	*Eudistoma olivaceum* (Van Name, 1902)	2
	Perophora viridis Verrill, 1871	3
4	*Perophora bermudensis* Berrill, 1932	4
5	*Ecteinascidia turbinata* Herdman, 1880	
6	*Ecteinascidia conklini* Berrill, 1932	5
	Ecteinascidia tortugensis Plough & Jones, 1939	6
7	*Ascidia nigra* (Savigny, 1816)	
8	*Ascidia interrupta* Heller, 1878	7
9	*Ascidia curvata* (Traustedt, 1882)	8
	Rhodosoma turcicum (Savigny, 1816)	9
*	*Botrylloides nigrum* Herdman, 1886	10
23	*Symplegma viride* Herdman, 1886	11
10	*Styela partita* (Stimpson, 1852)	12
*	*Styela plicata* (Lesueur, 1823)	
11	*Polycarpa arnoldi* Michaelsen, 1915	13
12	*Polycarpa cartilaginea* (Sluiter, 1898)	
13	*Polycarpa spongiabilis* Traustedt, 1883	
14	*Polyandrocarpa tumida* (Heller, 1878)	
15	*Polyandrocarpa tincta* (Van Name, 1902)	
16	*Pyura vittata* (Stimpson, 1852)	14
*	*Herdmania momus* (Savigny, 1816)	
17	*Microcosmus exasperatus* Heller, 1878	
18	*Microcosmus helleri* Herdman, 1881	
	Molgula occidentalis Traustedt, 1883	15

due to back-flooding from the salinas behind the mangrove. This would cause intermittent mortality and maintain sessile communities in an early stage of succession. There is insufficient information on salinity changes to pursue this suggestion.

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APPENDIX I A

DISTRIBUTION OF ASCIDIAN SPECIES, OTHER THAN *Didemnum* AND *Symplegma* (see Appendix I B), IN PISCADERA BAAI.

Data are based on numbers of individuals or colonies in the collections. Data for Styelidae are based in part on information given in VAN DER SLOOT (1969). +, Fragment only; *, Single zooid or colony; **, Two zooids or colonies; ***, 3–5; ****, 6–10; *****, More than 10 zooids or colonies. For detail relating to station numbers see Appendix III and Figure 41.

1. *Polyclinum constellatum*

1460	+
1475	+

2. *Diplosoma listerianum*

1028	+
1455A	+
1457	**
1458	+
1460	**
1460A	*
1461	*
1462	**
1463	+
1464	***
1465	+
1466	***
1468	+
1468A	+
1469	+
1470	**
1473	*
1476	+
1476a	+
1481a	+
1482	**
1484	***
1485	****
1487	**
1489	*
1493	++
1495	*
1500	*
1621	**

3. *Eudistoma olivaceum*

1466	++
1469	**
1473b	*

4. *Perophora bermudensis*

1466	*
1488a	*

5. *Ecteinascidia turbinata*

1466	**
1468	***
1469	+
1471A	+
1473	+
1474B	+
1475	***
1476A	+

6. *Ecteinascidia conklini*

1479	+
1481a	+
1484	+
1485	****
1487	***
1487a	*
1487b	*
1488	*
1488a	*
1489	**
1491	*
1621	+
1623	+

7. *Ascidia nigra*

1469a	*
1473b	****
1476b	***
1487a	****

1487b	****
1498a	*
1620	**
1621a	*
1671	***
1671A	*
1707	*
1708	****

8. *Ascidia interrupta*

1453a	*
1460	*
1460A	*
1461	*
1463	*
1464	****
1466	****
1468	****
1469	*****
1469a	**
1470	***
1472	*
1473	*****
1473a	*
1473b	***
1475	***
1476	*
1476b	****
1477	****
1479	****
1480A	*
1482	*
1485	*****
1487	****
1487b	*
1488	*
1489	**
1491a	*
1493	**
1498a	*
1671A	****
1621a	**
1708	****

9. *Ascidia curvata*

1473b	*

10. *Styela partita*

1460	****
1460a	***
1461	*****
1462	*****
1463	*****
1464	*****
1465	****
1466	*****
1467	***
1468	***
1468A	*
1469	*****
1469A	****
1470	*****
1472a	**
1473	*****
1473b	*****
1473A	*
1475	*****
1475A	****
1476	*****
1476a	****
1476b	****
1477	*****
1479	*****
1479a	***
1480A	***
1481a	*
1482	*****
1484	*****
1485	*****
1487	*****
1487a	**
1487b	**
1488	**
1489	***
1491	**
1491a	***
1493	*****
1493b	****
1495	***
1498	*
1498a	*****
1499	*
1500	*
1500a	*
1501	**
1503a	*****
1620	*
1623	*

1671	***
1707	****
1708	*****
1708A	*****

11. *Polycarpa arnoldi*

1457	*
1463	*

12. *Polycarpa cartilaginea*

1453	*
1460	*
1460a	*
1461	*
1463	*

13. *Polycarpa spongiabilis*

1463A	*
1464	***
1465	***
1466	*
1467	*
1469	****
1469B	*
1470	*
1471A	***
1471B	***
1473	****
1473b	****
1473A	*
1475	***
1476a	*
1476b	*
1477	*****
1480A	*
1482	***
1485	***
1486	**
1487	*****
1495	**
1498a	**
1510	*
1621	*
1623	**
1623A	*
1671	**
1708	*****
1709	*

14. *Polyandrocarpa tumida*

1460	**
1460A	*
1461	**
1463	*
1464	**
1465	***
1466	***
1469	*
1473	***
1671A	*

15. *Polyandrocarpa tincta*

1465	*
1466	*
1473b	*
1475	**
1485	**
1487b	*
1671	*

16. *Pyura vittata*

1029A	*
1457	**
1463	**
1464	**
1466	*
1469	*
1473	*
1620	*****
1707	***
1708	**
1708A	*

17. *Microcosmus exasperatus*

1028A	*
1458	**
1460A	**
1461	**
1462	*****
1463	***
1464	*****
1465	***
1466	*****
1468	*****
1469	****
1469a	**
1470	*****
1471B	*

1472	*
1472a	**
1473	*****
1473b	*****
1474	*
1474B	***
1475	*****
1475A	**
1476a	***
1476b	****
1477	*****
1479	*****
1481a	**
1482	*****
1484	*****
1485	*****
1486	*
1487	****
1487a	*
1487b	***
1488a	*
1489	***
1491a	**
1493b	****
1495	***
1498a	*****
1499	*
1620	*****
1621	*****
1621a	*
1623	*****
1623A	***
1671	**
1707	*
1708	**
1708A	*

18. *Microcosmus helleri*

1460A	*
1671A	*

APPENDIX I B

DISTRIBUTION OF SPECIES OF *Didemnum* AND *Symplegma* IN PISCADERA BAAI.

Data for *Didemnum* from unpublished manuscript (VAN DER SLOOT), MILLAR (1962) and the collections; data for *Symplegma* from VAN DER SLOOT (1969). –, Quantity not recorded; *, Single colony; **, A few colonies; ***, Rather common; ****, Numerous, very common; *****, Very numerous. For detail relating to station numbers see Appendix III and Figure 41.

19. *Didemnum conchyliatum*

1460	****
1460A	**
1461	**
1462	*****
1463	*****
1463A	*
1464	****
1465	–
1469	*****
1472a	****
1476b	*
1479	*
1671	*
1708A	**

20. *Didemnum duplicatum*

1028A	**
1457	*
1460A	*
1461	*
1462	*****
1463	*****
1464	*****
1468	***
1469	*****
1470	*****
1472	***
1472a	****
1473	****
1475	****
1476	****
1476a	***
1479	***

21. *Didemnum psammathodes*

1028A	*
1460	*****
1461	***
1462	****
1463	*
1463A	–
1464	****
1464A	*
1465	**
1466	*
1466A	*
1468	*****
1469	**
1469A	*
1473	**
1475	*
1482	**
1485	***
1487	*
1708A	**

22. *Didemnum vanderhorsti*

1463	**
1464	*

23. *Symplegma viride*

1466	***
1474B	*
1475	**
1476a	***
1482	*****
1485	****
1487	*****
1487b	*
1621	**
1623	***
1671	**
1708A	**

APPENDIX II

Distribution of ascidian species in the Lac of Bonaire.

Data are based on the number of individuals or colonies in the collections and include information already published by Millar (1962) for earlier records. Because colonies fragment during collection and in storage, data for *Eudistoma olivaceum* may be subject to error. +, Fragment only; *, Single zooid or colony; **, Two zooids or colonies; ***, 3–5; ****, 6–10; *****, More than 10 zooids or colonies. For detail relating to station numbers see Appendix IV and Figure 42.

1. *Diplosoma listerianum*	
1066	+
1068	+
1373A	*
1566	+
1568A	+
1575A	**
1576A	*
1585A	*
1586	+
1586A	*
1587	*
1587A	*
1588	+
1590	*

2. *Eudistoma olivaceum*	
1064a	**
1064b	***
1064c	*
1576	**
1576A	*
1577	***
1577a	***
1579	***
1582	*
1583	***
1584A	***
1585	*
1586	***
1586A	*
1587	**
1588	*
1589	*
1590	***
1595	+
1596A	*
1597	*
1599	+
1601	*
1602	***
1602A	*
1653	***

3. *Perophora viridis*	
1064c	*
1576A	*
1590	*
1595	*

4. *Perophora bermudensis*	
1064	*
1064a	+
1064c	**
1064A	*
1066	*
1066b	**
1566	*
1573	*
1576	**
1576A	**
1577	*
1587	*
1590	**
1592A	+
1595	*
1597	+
1601	*

5. *Ecteinascidia conklini*	
1064	*
1064a	+
1064b	*
1064c	*

1066b	**
1571	*
1573	*
1576	**
1576A	*
1577	*
1577a	*
1578	*
1579	**
1584A	*
1586	*
1587	**
1590	*
1592	*
1592A	+
1597A	+
1599	*
1601	*

6. *Ecteinascidia tortugensis*

1064	*
1064b	*
1064c	*
1569	+
1573	+
1575A	*
1576	*
1576A	***
1577	**
1578	***
1582	*
1582A	+
1586A	*

7. *Ascidia interrupta*

1572	*
1589	*

8. *Ascidia curvata*

1068a	*
1572	*

9. *Rhodosoma turcicum*

1588A	*

10. *Botrylloides nigrum*

1064	**
1064b	*
1064c	*
1064A	**
1064Ab	*
1066	+
1576	*
1576A	**
1580	**
1584A	**
1585	**
1585A	*
1587A	*

11. *Symplegma viride*

1561	*
1570	*

12. *Styela partita*

1587	**
1588	*****
1588A	***
1598A	*

13. *Polycarpa arnoldi*

1068a	*

14. *Pyura vittata*

1068a	*
1651	**

15. *Molgula occidentalis*

1064b	*

APPENDIX III

STATIONS IN PISCADERA BAAI FROM WHICH ASCIDIANS WERE COLLECTED.

(From WAGENAAR HUMMELINCK, 1977; Fig. 41)

STATION NUMBER	DATE	LOCALITY	SUBSTRATE CHARACTERISTICS
1028A	2.II.49	Southern Inner Bay	*Rhizophora* with oysters and ascidians; 0–1 m.
1029A	29.I.49	Outer Bay	Fence posts of swimming pool; 0–1 m.
1453	3.I.64	Outer Bay	Sand with limestone boulders; 3.5 m.
1453a	29.XI.63	Outer Bay	Sand; 3.5. m.
1455A	2.I.64	Outer Bay	Muddy Sand; 3.5 m.
1457	5.I.64	N.E. part Carmabi	Sandy pebbles with some coral; 1–2 m.
1458	5.I.64	Outer Bay	Muddy sand with rock debris; 1–1.5 m.
1460	14.XII.63	Entrance	Sandy inlet with *Rhizophora*; 0–0.5 m.
1460a	14.XII.63	Entrance	Stones and debris with algae; 0.5 m.
1460A	14.XII.63	Entrance	Sand, leaf decay, *Halimeda*, *Thalassia*; 0.5 m.
1461	14.XII.63	Entrance	Sandy, with *Rhizophora*; tidal flow; 0–1 m.
1462	2.I.64	Entrance	Iron supports; tidal flow; dense ascidians; 0–1 m.
1463	14.XII.63	Entrance	Beachrock with muddy sand; *Rhizophora*; 0–1 m.
1463A	14.XII.63	Entrance	Sandy with *Halimeda*; scanty *Thalassia*; 1 m.
1464	28.XI.63	Entrance	Muddy bottom; *Rhizophora*; 0–0.5 m.
1464A	11.XII.63	Entrance	Sandy mud with *Halimeda*; 1 m.
1465	11.XII.63	Entrance	Sandy mud with *Rhizophora*; 0–0.5 m.
1466	17.XII.63	Southern Inner Bay	*Rhizophora* with *Crassostrea*; 0–1 m.
1466A	17.XII.63	Southern Inner Bay	Soft mud amongst *Rhizophora*; 1–1.5 m.
1467	29.XI.63	Southern Inner Bay	Muddy sand; 1.5 m.
1468	18.XII.63	Southern Inner Bay	Diabase debris with mud; *Rhizophora*; 0–1 m.
1468A	18.XII.63	Southern Inner Bay	Rock bottom with some mud; 1.5 m.

1469	18.XII.63	Southern Inner Bay	Scanty *Rhizophora* on rock shore; 0–1 m.
1469a	27.VII.73	Southern Inner Bay	*Rhizophora* in muddy rock debris; 0–1 m.
1469A	18.XII.63	Southern Inner Bay	Rocky or sandy bottom with some mud; 1–1.5 m.
1469B	18.XII.63	Southern Inner Bay	Limestone cliff & rock debris; 0–0.5 m.
1470	31.X.63	Southern Inner Bay	Buoy overgrown by oysters, ascidians; 0–0.75 m.
1471A	29.XI.63	Southern Inner Bay	Sandy mud with shell debris; 2 m.
1471B	29.XI.63	Southern Inner Bay	Muddy sand with shell debris; 2 m.
1472	25.VII.62	Central Inner Bay	*Rhizophora*; 0–0.5 m.
1472a	26.IX.62	Central Inner Bay	*Rhizophora*; 0–0.5 m.
1473	13.XII.63	Central Inner Bay	*Rhizophora* on rock shore; 0–1 m.
1473a	27.IX.67	Central Inner Bay	*Rhizophora*; 0–0.5 m.
1473A	13.XII.63	Central Inner Bay	Sandy gravel with very little mud; 0–1 m.
1473b	26.VII.73	Central Inner Bay	*Rhizophora*; 0–1 m.
1474	29.XI.63	Central Inner Bay	Sandy mud with shell debris; 2 m.
1474B	29.XI.63	Central Inner Bay	Mud with shell debris; 2 m.
1475	13.XII.63	Central Inner Bay	*Rhizophora*, *Crassostrea*; 0–1 m.
1475A	13.XII.63	Central Inner Bay	Sandy debris with some mud; 0–1 m.
1476	25.VII.62	Central Inner Bay	*Rhizophora*; 0–0.5 m.
1476a	26.IX.62	Central Inner Bay	*Rhizophora*; 0–0.5 m.
1476A	25.VII.62	Central Inner Bay	Mud; 1 m.
1476b	25.VII.73	Central Inner Bay	*Rhizophora*; 0–1 m.
1477	31.X.63	Central Inner Bay	Buoy crowded with ascidians; 0–0.75 m.
1479	11.XII.63	Northern Inner Bay	Muddy sand, scanty *Rhizophora*; *Crassostrea*, *Chthamalus*, *Brachidontes*; 0–0.5 m.
1479a	26.VII.73	Northern Inner Bay	*Rhizophora*; 0–1 m.
1480A	30.X.63	Northern Inner Bay	Muddy sand; *Brachidontes*; 2 m.
1481a	26.IX.62	Northern Inner Bay	*Rhizophora*; 0–0.5 m.
1482	31.X.63	Northern Inner Bay	Buoy with ascidians, barnacles and mussels; 0–0.75 m.
1484	2.XI.63	Northern Inner Bay	Buoy with ascidians, oysters, algae; 0–0.75 m.
1485	11.XII.63	Northern Inner Bay	*Rhizophora* on rocky shore; oysters; 0–1 m.
1486	30.X.63	Northern Inner Bay	Sandy mud; 3.5 m.
1487	25.XI.63	Northern Inner Bay	Poor *Rhizophora* on muddy diabase debris; oysters; 0–1 m.
1487a	27.IX.67	Northern Inner Bay	*Rhizophora* in muddy sand; 0–0.5 m.
1487b	25.VIII.73	Northern Inner Bay	*Rhizophora*; 0–1 m.

1488	25.VII.62	Northern Inner Bay	*Rhizophora* with *Crassostrea*; 0–0.5 m.
1488a	26.IX.62	Northern Inner Bay	*Rhizophora*; 0–0.5 m.
1489	25.XI.63	Northern Inner Bay	*Rhizophora* with oysters, sponges, *Caulerpa*; 0–1 m.
1491	25.VII.62	Northern Inner Bay	*Rhizophora*; 0–0.5 m.
1491a	26.IX.62	Northern Inner Bay	*Rhizophora*; 0–0.5 m.
1493	25.XI.63	Northern Inner Bay	Coarse muddy sand with *Rhizophora*; many oysters; 0–1 m.
1493b	26.VII.73	Northern Inner Bay	*Rhizophora*; 0–0.5 m.
1495	29.X.63	Northern Inner Bay	Muddy sand with *Ulva*, *Thalassia*, *Halodule*; *Chione*; 1–2 m.
1498	25.XI.63	Northern Inner Bay	*Rhizophora* in mud smelling of oil; *Isognomon* & *Crassostrea*; 0–1 m.
1498a	26.VII.73	Northern Inner Bay	*Rhizophora*; 0–1 m.
1499	26.X.63	Northern Inner Bay	Sandy Mud; *Ulva* & *Caulerpa*; 1.5–2 m.
1500	25.X.63	Northern Inner Bay	Sandy mud with algae near *Rhizophora*; 1.5 m.
1500A	25.X.63	Northern Inner Bay	*Caulerpa* and shells in mud; 1.5–3 m.
1501	25.XI.63	Northern Inner Bay	Dead *Rhizophora*; diabase debris with mud *Caulerpa* and *Enteromorpha*; 0–0.5 m.
1503a	21.X.68	Northern Inner Bay	Iron supports of sewer pipe; 0–0.5 m.
1510	5.VI.62	Southern Inner Bay	N.W. side; 6 metres (not on map).
1620	14.X.67	Carmabi Pier	Iron & Wooden poles; 0–1 m.
1621	26.IX.67	Northern Inner Bay	*Rhizophora*; balanids & oysters; 0–1 m.
1621a	25.VIII.73	Northern Inner Bay	*Rhizophora*; 0–1 m.
1623	26.IX.67	Northern Inner Bay	*Rhizophora* in muddy sand; sponges; 0–1 m.
1623A	26.IX.67	Northern Inner Bay	Muddy sand crowded with *Chione*; 0.5–1 m.
1671	30.III.70	Southern Inner Bay	*Rhizophora* in mud and sand; 0–0.5 m.
1671A	30.III.70	Southern Inner Bay	Sandy mud with rock debris; 1–1.5 m.
1707	27.VII.73	Entrance	*Rhizophora*; limestone and mud; 0–1 m.
1708	27.VII.73	Southern Inner Bay	*Rhizophora* on rock shore, some mud; 0–1 m (not on map).
1708A	27.VII.73	Southern Inner Bay	Rocky bottom with mud; 1–1.5 m.
1709	3.VIII.73	Northern Inner Bay	*Rhizophora* in sand and debris; 0–0.5 m.

APPENDIX IV

STATIONS IN THE LAC OF BONAIRE FROM WHICH ASCIDIANS WERE COLLECTED.

(From WAGENAAR HUMMELINCK, 1977; Fig. 42)

STATION NUMBER	DATE	LOCALITY	SUBSTRATE CHARACTERISTICS
1064	19.X.30	NE Basin, Puitu	*Rhizophora* in soft mud; 0–1.5 m.
1064a	18.XI.30	NE Basin, Puitu	*Rhizophora* in soft mud; 0–1 m.
1064b	17.IX.48	NE Basin, Puitu	*Rhizophora* in mud; 0–1 m.
1064c	17.IV.55	NE Basin, Puitu	*Rhizophora* in mud; 0–1 m.
1064A	12.X.30	NE Basin, Puitu	Muddy; *Thalassia*; 1–1.5 m.
1064Ab	17.IX.48	NE Basin, Puitu	Mud with *Thalassia*; 1–1.5 m.
1066	1.IX.48	NE shore of Cai	Shallow part of muddy lagoon with *Thalassia* and *Avicennia*; 0.25–1 m.
1066b	19.III.36	NE Basin, Puitu	Mud with *Rhizophora* and *Avicennia*; 0–0.5 m.
1068	26.X.30	Centre of entrance	Sandy reef with debris; 1–2 m.
1068a	1.X.48	Entrance, near Cai	Sandy reef; *Acropora*; 1–2 m.
1373A	17.IV.55	N. of Sorobon Point	*Porites* with *Thalassia* and *Lithothamnion;* 0.25–0.5 m.
1561	11.VIII.67	Entrance, W of Cai	Sand with *Thalassia*, *Syringodium*; 6 m.
1566	21.VIII.67	N. of Sorobon Point	*Porites*, *Thalassia*, *Lithothamnion*; 0.1–0.5 m.
1568A	10.III.70	Central Basin	Sand on limestone; 2.5 m.
1569	11.VIII.67	E. of Palu Calbas	Thin sand on limestone; *Porites* and *Siderastrea*; 2 m.
1570	11.VIII.67	Centre of Basin	Sand; *Thalassia*; 3 m.
1571	11.VIII.67	Centre of Basin	Sand; *Thalassia*; 3.5 m.
1572	11.VIII.67	East Centre of Basin	Muddy sand; *Thalassia*; *Halimeda*; 2 m.
1573	25.VIII.67	Centre of Basin	Muddy sand; *Thalassia*, *Halimeda*; 1.5 m.
1575A	11.VIII.67	Entrance of Puitu	Mud; *Thalassia*, *Halimeda*; 0.1–0.5 m.
1576	16.IX.67	NE of Cai	Mud; *Rhizophora*, *Thalassia*; 0–0.5 m.
1576A	16.IX.67	NE of Cai	Muddy; *Thalassia*, *Halimeda*; 0.25–1 m.

1577	10.VIII.67	Puitu	Sandy mud; *Rhizophora*, *Thalassia*, *Caulerpa*; 0–0.5 m.
1577a	11.III.70	Puitu	*Rhizophora* in mud; 0–0.5 m.
1578	10.VIII.67	Puitu	*Thalassia* on sandy mud with *Codakia*, *Rhizophora* with *Chthamalus*; 0–0.5 m.
1579	10.VIII.67	Puitu	Mud with *Rhizophora*; *Codakia*; 0–0.5 m.
1580	10.VIII.67	Puitu	Mud; *Rhizophora* with *Chthamalus*; *Thalassia* with *Codakia*; 0–0.5 m.
1582	14.VIII.67	NE part of Basin	*Rhizophora* in mud; 0–0.5 m.
1582A	14.VIII.67	Boca di Pos	Sandy mud; *Thalassia*; *Halimeda*; 0.5–1 m.
1583	14.VIII.67	Boca di Pos	Sand & mud; *Rhizophora*; 0–1 m.
1584A	15.VIII.67	Boca di Coco	Muddy sand; *Avrainvillea*, *Halimeda*, *Thalassia*; 0.5–1 m.
1585	15.VIII.67	Boca di Coco	Mud and sand; *Rhizophora*; 0–0.5 m.
1585A	15.VIII.67	Boca di Coco	Mud on sand; *Avrainvillea*; *Thalassia*; 0.5–1 m.
1586	15.VIII.67	Boca Chikitu	Mud on sand; *Rhizophora*; *Acetabularia*; 0–0.25 m.
1586A	15.VIII.67	Boca Chikitu	Mud with dense *Avrainvillea*; 0.25–1 m.
1587	24.VIII.67	Boca Fogon	Sandy mud; *Acetabularia*; *Rhizophora*; 0–0.5 m.
1587A	24.VIII.67	Boca Fogon	Sandy mud; *Avrainvillea*; *Halimeda*; 0.5–1 m.
1588	24.VIII.67	Boca Fogon	Muddy sand; *Rhizophora*; *Acetabularia*; 0–0.5 m.
1588A	24.VIII.67	Boca Fogon	Mud and sand; 1.5 m.
1589	14.VIII.67	North West edge	Sandy mud; *Rhizophora*; *Chthamalus*; 0–0.5 m.
1590	14.VIII.67	North West edge	Sandy mud, *Rhizophora*, *Thalassia*, *Batophora*; 0–0.5 m.
1592	5.IX.67	West edge of Basin	Muddy sand; *Rhizophora*; *Halimeda*; *Thalassia*; 0–0.5 m.
1592A	5.IX.67	West edge of Basin	Muddy sand; *Thalassia*; *Avrainvillea*; 0.25–0.75 m.
1595	24.VIII.67	Boca Jewfish	*Rhizophora*; *Caulerpa*; 0.25–1.5 m.
1596A	24.VIII.67	Boca Jewfish	Sandy mud with decay; 2 m.
1597	22.VIII.67	Boca Jewfish	Sandy mud; *Rhizophora*; *Acetabularia*; 0–0.25 m.
1597A	22.VIII.67	Boca Jewfish	Sandy mud; *Rhizophora*; *Acetabularia*; 0–0.25 m.
1598A	22.VIII.67	Boca Jewfish	Sandy mud on limestone; sparse *Thalassia*; 0.25–0.5 m.
1599	4.IX.67	NW Salina	Sandy creek; *Rhizophora*; 0–0.5 m.
1601	31.VIII.67	NW Salina	Muddy; *Rhizophora*; *Acetabularia*; 0–0.5 m.
1602	30.VIII.67	NW Salina	Muddy sand; *Rhizophora*; *Acetabularia*; 0–0.5 m.
1602A	30.VIII.67	NW Salina	Muddy sand; *Batophora*; *Acetabularia*; 0.25–0.5 m.
1651	9.III.70	Entrance-South end	Coarse beach-rock, pools; 0–0.5 m.
1653	10.III.70	Boca Jewfish, entrance	Muddy sand, *Thalassia*, *Halimeda*; 0–0.5 m.