Marine biological investigations in the Bahamas
23. Description of the littoral zonation at nine Bahamian rocky-shore localities

Hans Brattström

SARSIA

Brattström H. 1999. Description of the littoral zonation at nine Bahamian rocky-shore localities. *Sarsia* 84:319-365.

Nine typical, more or less vertical, rocky-shore localities were visited in April-May 1967, and one of these was revisited in March 1968. The topographies of the stations are described and illustrated, and the vertical zonation of their flora and fauna is documented.

On the whole the flora and fauna at the stations investigated was fairly poor. At least 37 species of algae and 85 animal species were recorded, but only 15 algae and 71 animals could be identified to species. Most of the algae were too undeveloped or grazed down to permit a reliable identification. Only half as many species were found at these nine stations as were found on three almost horizontal beach-rock stations described in an earlier article. Whereas many of the latter lived in a system of cavities below the rocks, all species found on the nine vertical stations were exposed to waves and the hot midday sun.

The common yellow, black, grey, and white zones typical of the Bahamas, were often well-developed. Some algae and many of the animals formed distinct belts within these zones, the higher up the more exposed the rocks were. Though tides and exposure presumably are responsible for the general zonation pattern, it is likely that in the cirripeds and vermetids the way of food-intake determines their upper limit. Other important factors as insolation and the nature of the substrate caused irregularities in the general pattern of zonation.

The algae occurred in a well-developed lower algal belt in the lower part of the yellow zone where they were often heavily sand-encrusted, and in a less developed upper belt in the black and the uppermost part of the yellow zone. In this upper belt a species of *Bostrychia* was characteristic.

Suggestions for future investigations in the littoral are presented.

Hans Brattström, Högbygatan 33, S-590 73 Ljungsbro, Sweden.

Keywords: Littoral rocks; algae; fauna; ecology; The Bahamas.

INTRODUCTION

This is the second and last article describing the zonation of some rocky shores in the Bahamas. The first article (Brattström 1992, below called "Part 1") described the littoral zonation on three slightly sloping beach-rock localities. In this Part the zonation of nine, more or less vertical, rocky shore stations are described in detail. This is the fourth and last article in a series of littoral zonation studies in various parts of the Caribbean region (see Brattström 1980, 1985, and 1992). More information on the background, the larger scope of the investigation, and earlier investigations, can be found in the Introduction to Part 1. The purpose of the investigation was to study the littoral organisms, their occurrence, and vertical distribution at different types of localities in the Bahama Islands and the factor or factors responsible for the zoning of algae and animals.

MATERIAL AND METHODS

Selection of stations

The general information in Part 1 is valid in principle in this part, too. The station numbers are those mentioned in the Expedition reports (Brattström 1968a, b). During the one-month cruises in 1967 and 1968 (Brattström 1968a, b) each participant had his own project, and the cruise program was set up so as to permit all to get as much research time as possible. Regarding my studies of the rocky littoral it thus wasn't always possible to decide in advance exactly where to work.

Because the coasts were unknown, the shores were studied from the sea in search for promising localities. At close quarters not all such places proved to be suitable, and the nine localities finally chosen were not all the most desirable ones, and some too cursorily investigated, especially those from 1968, have been left out in this Part.

The shore organisms often form belts on the rocks. The width of these belts and their height above zero are mainly the result of exposure. The search for good places for the investigations thus included evaluation of the exposure conditions at the projected stations. If wide areas of deep water were found all the way to the shore, this was supposed to be very exposed to waves, splash, and spray, keeping the rocks more or less constantly wet high up, thus permitting species to live at high levels. If the place was sheltered by islands or wide, shallow reef-flats, which reduce the force of the waves, the higher parts of the shore were supposed to be more or less dry at LW and the locality to be sheltered.

The expected degree of exposure influenced the choice of stations. It soon became evident, however, that the supposed degree of exposure sometimes was miscalculated. For example, since Stn 87-67 was facing the wide and deep Tongue of the Ocean (Fig. 1), it was thought to be very exposed, but in fact the species at this station had lower upper limits than at all other stations except 53-67 (Fig. 53, lower right corner). I cannot find any clear reason for this low degree of exposure, but currents, local reefs, and sand bars may prevent waves from reaching higher up on the shore.

The opposite situation was found at Stn 16-67. It was supposed to be sheltered because of the wide and shallow reef-flat outside (Figs 10, 12), but this apparently wasn't as sheltering as supposed, for the species at this station were found higher up than at any other station. The reason for this high degree of exposure may be that the station was situated in a funnel-like indentation in the shore, in which waves are pressed high up (Figs 9, 12). Sand accumulated in the inner part of the indentation and the ragged rocks strengthen this assumption.

It is regrettable that the degree of exposure was not well known at all stations before the investigations started. This of course has no influence on the results obtained, and the nine stations studied represent varying degrees of exposure. When differing degrees of exposure are mentioned it is relative to the other stations investigated.

If possible, a station ought to be studied during a whole tidal period, but because of the weather, tidal and local conditions, and time available not all stations could be investigated that thoroughly. The rocks might be too rugged, and waves or a high tide could prevent studies of the lowest part of the shore. Where the rocks were undercut and the sea level high, the underside of the overhangs and the bottom below these couldn't be investigated (e.g. Figs 7, 26, 30, 38, 39). As a result all stations couldn't be studied in the same way, and accordingly the description of the zones and belts varies from station to station.

In Part 1 (Brattström 1992) the vertical distribution at three beach-rock stations, 12-67, 65-67, and 19-68, was described. These were gently sloping and mainly because of that became dry and hot at low tide. The localities described in this paper differ from those treated in the previous one. The rocks were more or less perpendicular, often rugged with many holes and crevices, some of which were wet even when the sun was high. During the hottest part of the day they lay partly in shadow or were hit by the sun rays at an acute angle, thus being less heated.

In the following descriptions of the zones I have, deliberately, presented many details. The reason is the uncertainty connected to the zeros used at the different stations. The detailed descriptions, figures, maps, and photographs, especially those in colour, should make it possible to compare my measurements with those at other stations, or to find out possible changes over time. There, should be no difficulty in locating the stations and exactly those square metres in which the studies were carried out. It must be stressed, however, that storms may transform a station beyond recognition. The base of the rocks may have been buried in sand and debris, and sand that in other localities covered the base of the rock may have been washed away. Beach-rock may have been formed or broken down, and in rare cases overhangs may have collapsed, leaving bare virgin rock (cf. Fig. 8) not covered with Cyanophyta and other microscopic algae, which partly are responsible for creating the differently coloured zones (cf. Fig. 3). Because of lack of time these algae were not sampled.

The zero line

In studies of littoral ecology the use of a common zero is essential for all measurements, discussions, and comparisons with other stations. Because of that a tidal level is often used as zero. Unfortunately the tide gauge in Nassau was out of operation on the days the stations were studied and another zero had to be found. In the Bahamas a possible such zero is the limit between the two lowest coloured zones on the rocks, that between the yellow and black zones (cf. Fig. 3). However, this limit has some disadvantages. It is sometimes indistinct and it varies in height from station to station. Instead the upper limit of corals was chosen (Fig. 2), as in Part 1. It fairly well compares with the zeros of the charts and the Tide tables and the MLWS, a suitable tidal level also used as zero in other investigations. However, stray specimens of corals could occur above zero, for instance because of local splash, but such specimens cannot prevent the use of the zeros chosen. Where corals were absent, other criteria were used. At the coral stations the zero level was characterized by certain topographic and biological features, in addition to the corals. Since the same features were found at other stations, it was fairly easy to find out where to place the zero lines. Small measurement errors can be neglected, especially because the lower and upper levels of zones and of animals and plants can vary a little even within a station, and because the vertical order in which the organisms occur, their frequency, and vertical range is more important.

The species

All algae and animals identified to species are enumerated, with author names, in the Appendix. Because of that, author names have been left out in the text. Where numbers of species are mentioned in text and tables they always refer to the identified species and, in addition, pink encrusting lithothamnia, a red boring sponge, *Millepora* sp., and snapping shrimps, each counted as one species. These four taxa play a great role in the distribution pattern at many Bahamian localities.

Species only determined to genus or a higher taxon are treated as one species each. They are not enumerated in the Appendix, but if they are of interest in a special connection they are mentioned in the description of the respective stations. Of the species only identified to genus especially many were algae. These were often dwarfed or too young to permit a safe identification Though in many cases characterizing a certain level, these algae usually couldn't be used as character species in the description of the belts of species. Therefore one will sometimes get the impression that animals are the most important for creating the belts.

For the sake of brevity the following common and characteristic species, which are the only ones of their genus treated in this paper, will often be mentioned only by their generic name: *Dasycladus vermicularis*, *Anadyomene stellata*, *Digenia simplex*, *Homotrema rubrum*, *Lithothrya dorsalis*, *Chthamalus angustitergum*, *Tetraclita stalactifera*, *Clibanarius tricolor*, *Dynamenella perforata*, *Acanthopleura granulata*, *Fissurella barbadensis*, *Acmaea leucopleura*, *Cittarium pica*, *Puperita pupa*, *Echininus nodulosus*, *Cenchritis muricatus*, *Petaloconchus varians*, *Dendropoma corrodens*, and *Echinometra lucunter*. In the Appendix these species are marked with an asterisk. If other species are mentioned more than once in the description of a station or in a passage, these species, too, after the first mentioning, sometimes will be referred to by the generic name alone.

The following species have changed generic names since Part 1 was published (old names in brackets): *Dictyosphaeria* (*Valonia*) *ocellata*, *Lobophora* (*Pocockiella*) *variegata*, *Littoraria* (*Littorina*) *angulifera*, *Nodilittorina* (*Littorina*) *ziczac*, *Nodilittorina* (*Littorina*) *mespillum*, *Nodilittorina* (*Littorina*) *meleagris*, and *Cenchritis* (*Tectarius*) *muricatus*.

Later four more species have changed names (new names in brackets): *Acmaea* (*Lottia*) *leucopleura*, *Littorina lineolata* (*Nodilittorina mordax*), *Echinus noulosus* (*Tectarius antonii*), and *Morula* (*Trachyphyllia*) *nodulosa*. Contrary to the firstnamed seven species, the new names of the lastnamed four species have not been used in this part, since it would be confusing to use different names in the two parts.

The figures

All identified species are enumerated in the text or in the Appendix or in both places, but all have not been drawn in all figures. Bar graphs show the maximal vertical distribution of all identified species and some others. Black bars show the vertical distribution of the species, open ones the area, somewhere within which a species was found without the exact level being measured/noted.

The very motile hermit crabs and crabs normally keep to a certain level, but when disturbed stroll widely around, for next moment to be found far away from their normal whereabouts. Also these animals have got black bars which show the lower and upper limits of the specimens captured. These motile species play no rôle for creating the zoning pattern and therefore could have been left out, but from a faunistic point of view their occurrence is of interest. They may be new to the Bahamas or the island where they were found.

Because it wasn't always possible to count all specimens found at the different levels, all bars in the figures have been made equally broad, thus only showing occurrence and not abundance. However, in Fig. 22 short horizontal lines have been drawn across the bars at levels where the species were noted to be especially common. White bands across the ends of black bars in Fig. 15 indicate decreasing abundance. Breaks in the vertical distribution have not been marked in the bars. Such breaks only reflect local differences in the environment, for instance areas of sand on the rocks.

BAHAMIAN SHORES

Figs 3-8 show typical Bahamian shores, some from the stations investigated. Usually three coloured zones can be distinguished, even from a great distance (e.g. Fig. 3 of Smith's Bay), lowest down a yellow zone, above that a black, and upmost a grey (Figs 3, 4, 8, 34, and 45 show more or less distinct grey zones). If the rocks are high enough a white zone can sometimes be seen above the grey, but the limit between these two upper zones is mostly indistinct. The yellow zone can often be divided in two or even three sub-zones, based on the species present.

Most stations were only a few metres high. At Stn 48-67 the front wall was fairly smooth (Fig. 34), but usually it was very irregular with many depressions and holes, as seen in Figs 4 (Stn 54-68) and 18 (26-67). Figs 5 and 6 show examples of the terraces in the grey and white zones, Fig. 5 (Stn 16-67) of a station with smooth surface, below which there could be cavities, and Fig. 6 (Stn 41-67) of the opposite type, where the surface is extremely spiky.

Many shores were more or less undercut, e.g. Fernandez Cay (Fig. 7), a result of water erosion, sand scouring, and boring organisms, which weaken the rocks. Fig. 35 (Stn 48-67) shows an example of a rock totally pierced by the boring cirripede *Lithothrya*. Work below such overhangs was often difficult or impossible.

When an overhang collapses the original colour of the rock appears. Fig. 8 from Chub Rock shows that the colour of the rock is the same light yellow both in the yellow and the black zones. The differently coloured zones on the shore are the results of a combination of weathering processes and organisms.

At most stations there was a reef-flat outside, which often reached to the base of the rocks (e.g. Figs 4, 10).

THE STATIONS AND THEIR ZONATION

The general description of the stations refers to that part of the shore at which the stations were situated, whereas details describe the conditions of the smaller areas, which are the stations proper.

STN 16-67, GREAT EGG ISLAND

Western side of the island, south of the entrance to the lagoon, 25°29'40"N, 76°53'10"W, 17 and 18 April 1967 (Fig. 11).

Description of the station

The outer 10 m of the shore were jagged and rose gently to a height of about 230 cm (e.g. Fig. 13). From there inwards was a horizontal smooth terrace with cavi-

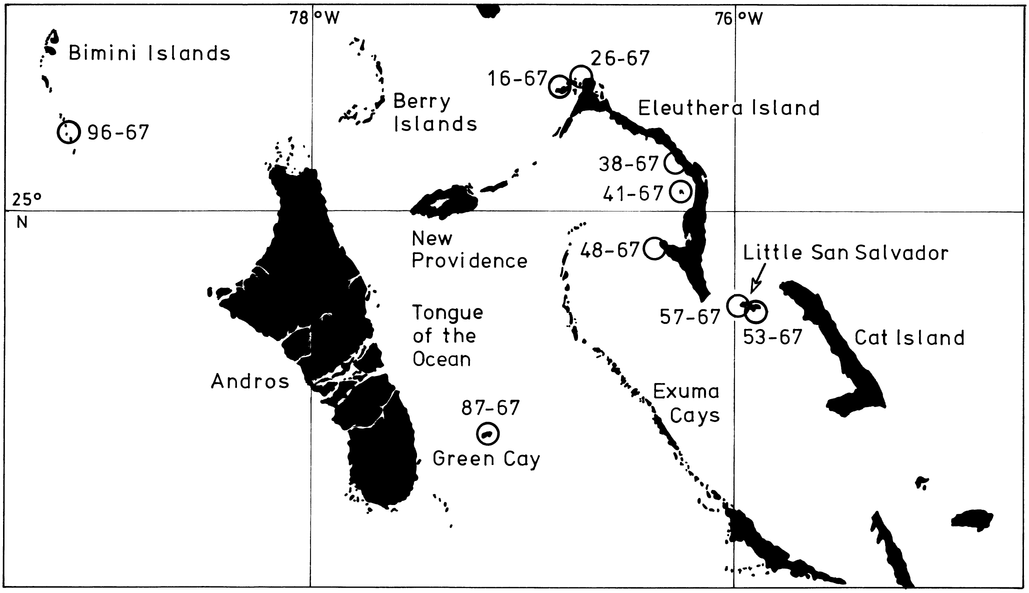


Fig. 1. Map of the central Bahama Islands showing the location of the nine stations.

Fig. 2. *Porites astreoides*, in the center, just above the zero line, West Bay, Little San Salvador, Stn 54-68 (= 57-67).

Fig. 3. The yellow, black, and grey zones at Smith's Bay.

Fig. 4. Typical rocky shore, West Bay, Little San Salvador, Stn 54-68 (= 57-67).

Fig. 5. Typical smooth terrace, Great Egg Island, Stn 16-67.

Fig. 6. Typical spiky terrace, Pineapple Cays, Stn 41-67. The limit between the black and grey zones runs from the upper right to the lower left corner.

Fig. 7. Undercut shore at Fernandez Cay.

Fig. 8. Chub Rock, natural colour of the rock.

Fig. 9. The indentation in the shore of Egg Island. The part in shadow is Stn 16-67.

Fig. 10. Egg Island, Stn 16-67, the wall investigated.

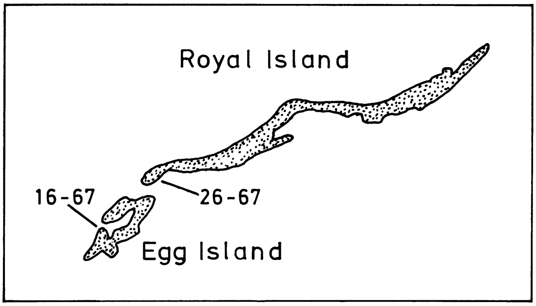


Fig. 11. Map showing the sites of Stns 16-67, Egg Island, and 26-67, Royal Island.

ties in the rock, which had a thin and very hard surface (Fig. 5). With a hammer-blow a metallic sound was heard indicating cavities underneath. Some of these had caved in, creating sand-filled depressions of varying size, in which bushes had gained foot-hold. From about 25-30 m inwards the terrace was covered by a dense shrub vegetation of the local xerophilous type.

The station was situated in a 6.5 m long and a few m broad east-west indentation in the straight shore-line (Figs 9, 12). The walls were more or less vertical, strongly pinnacled and honeycombed with sharp ridges and smoother parts in between (Fig. 10). A shallow almost horizontal reef-flat bordering the shore (Figs 10, 12) continued into the inlet but with slabs farthest out and, from 1.5 m in (square D 1, see below), covered by a layer of fine sand, increasing in thickness inwards, on the days of investigation burying the rock to a height of more than 50 cm farthest in.

Only the southern wall of the inlet was studied (Figs 10, 12). This was slightly undercut farthest out. The height increased inwards to about 225-250 cm in some places, but decreased farthest in to about 175. The rocks behind the front wall (not studied) were a little higher. Most of the wall lay in shadow from about 1000 o'clock. On the days of investigation the sea at LW reached the inner end of the reef flat, were the sand began (Figs 10, 12). This level was 25 cm above the zero of the charts, which was found on the reef flat a few m from the shore. Though the inlet was facing both the NW and NE Providence Channel, the wide area of shallow water (to where the boat in Fig. 10 is anchored), was supposed to make this station sheltered, but the sand accumulated in the inner part of the inlet indicated that waves at least occasionally are pressed into this. In fact this station seems to be the most exposed of the nine.

Methods

To facilitate the measurements and counting the specimens the southern wall was divided in 50 cm broad vertical strips, A to M, with A outermost. Each strip

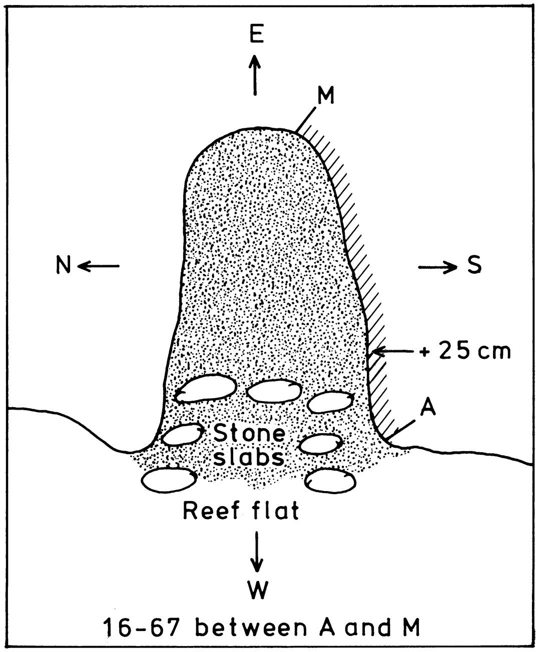


Fig. 12. Sketch of the indentation in the shore of Egg Island, in which Stn 16-67 was situated. Slanting lines mark the station, dots the sandy area.

was subdivided in squares of 1/4 m^2, the lowest numbered 1, the uppermost 4. The level where the reef flat met the sandy area, in strip D, was used as base for the lowest row of squares. Because both the height of the wall and thickness of the sand layer varied, many of the lowest and highest squares are incomplete or missing (cf. Figs 13, 14). Therefore some lower and upper limits are not natural.

In each square the lower and upper limits of all species were measured and their numbers counted. Other boring organisms than *Lithothrya* were not searched for, but a specimen of *Phascolosoma perlucens* was found (location not noted). By mistake *Nerita versicolor* and *N. tesselata*, respectively *Nodilittorina tuberculata* and *Echininus nodulosus* at this station were lumped together when sampled. This precludes giving exact numbers and limits of these species. When *Nerita* is mentioned below, the remarks thus may refer to one or both species. However, judging from their distribution at other stations there is reason to believe that the uppermost specimens are *versicolor*, the lowest *tesselata*. A similar assumption is excluded for the two littorinids, which coexist at other stations (See Fig. 53). The distribution and abundance of the species is shown in four figures, 13A-D.

Fig. 14 gives a more schematic picture of both the vertical and horizontal distribution of each species. It gives no information on abundance in different parts

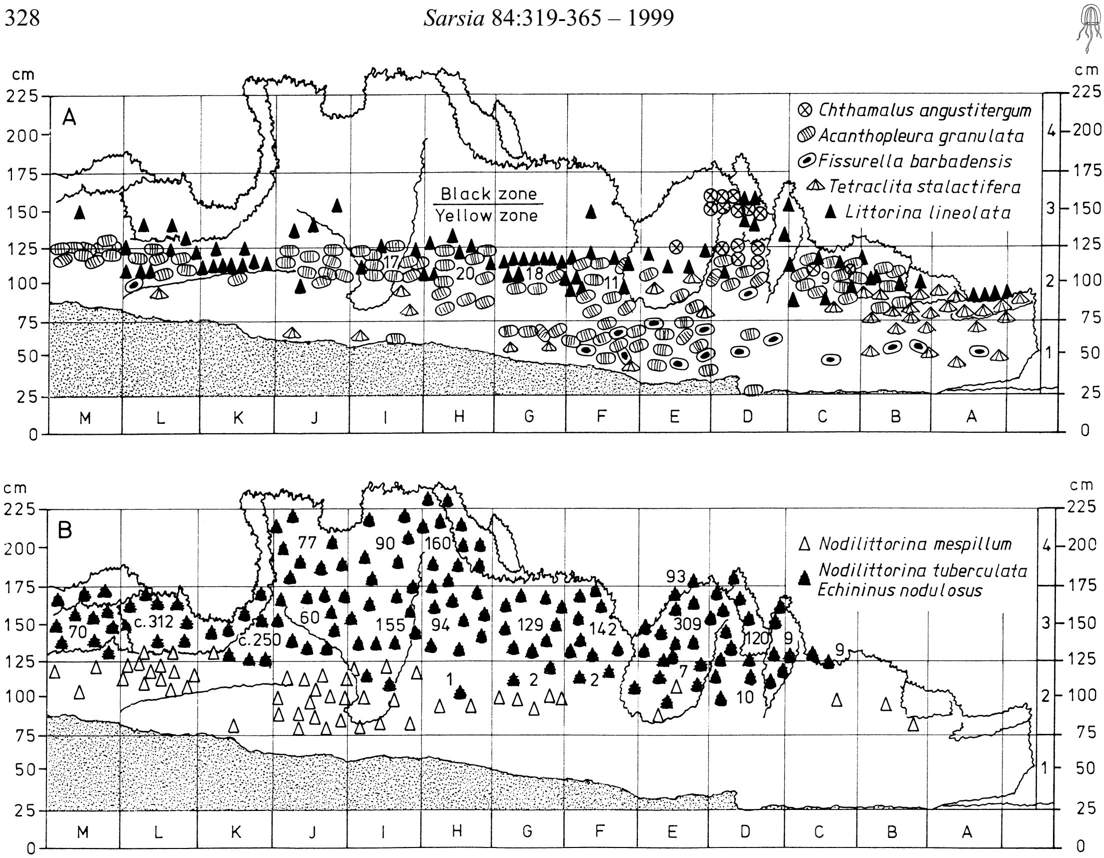


Fig. 13A-B. Egg Island, Stn 16-67, vertical and horizontal distribution of 8 species. The numbers in A refer to *Acanthopleura granulata*, in B to *Nodilittorina tuberculata* or *Echininus nodulosus* or both. Note the zonal limit.

and at different levels on the wall, but it is useful for comparison with other localities.

Several species have more or less coincident distribution, but it is not easy, from any of these figures, to find out which species occur at more or less the same level. For that reason Fig. 15 has been drawn, showing the lowest and highest levels at which the species were found. To get a good impression of the vertical and horizontal distribution of the species, all figures have to be compared.

Colour zones

Of the four colour zones usually distinguishable on Bahamian rocky shores only the yellow and lower part of the black were represented on the wall itself with the zone limit high up, at about 145/155 (Fig. 13). Some species in the yellow zone formed fairly distinct narrow belts, but from some distance one rather got the impression of a sliding transect of species within the zone. Because of the irregular rock surface the species limits varied between, as well as within the strips (Fig. 14). The number of specimens in the yellow zone was high and there was much overlapping, blurring possible sub-zone limits. Fig. 15 indicates such limits at about 45 and 115/125.

The wall investigated was so low that only the lower part of a black zone was developed there. The upper part of this zone was found on some high rocks behind the wall and on the jagged outer 10 m of the terrace inside the small bay. The inner smooth part of the terrace was blue-grey or pinkish and represents the grey zone (Fig. 5). Patches of a lighter colour on isolated higher parts may belong to the white zone.

Vertical distribution of the species (Figs 13-15)

In the lower yellow sub-zone, 25-45, some specimens of *Echinometra* were found, up to 35, accompanied by the lowest specimens of *Lithothrya*, *Acanthopleura* with *Dynamenella*, *Dendropoma*, and *Thais rustica*.

In the middle sub-zone, between about 45 and 115/125, *Lithothrya*, *Tetraclita*, *Acanthopleura*, *Fissurella*, *Acmaea*, the two *Nerita* species and *Dendropoma* formed a belt, with *Littorina lineolata* and *Nodilittorina mespillum* uppermost. Also in this sub-zone no algae were found. The lack of algae in the two lower sub-zones is no doubt because of sand-scouring.

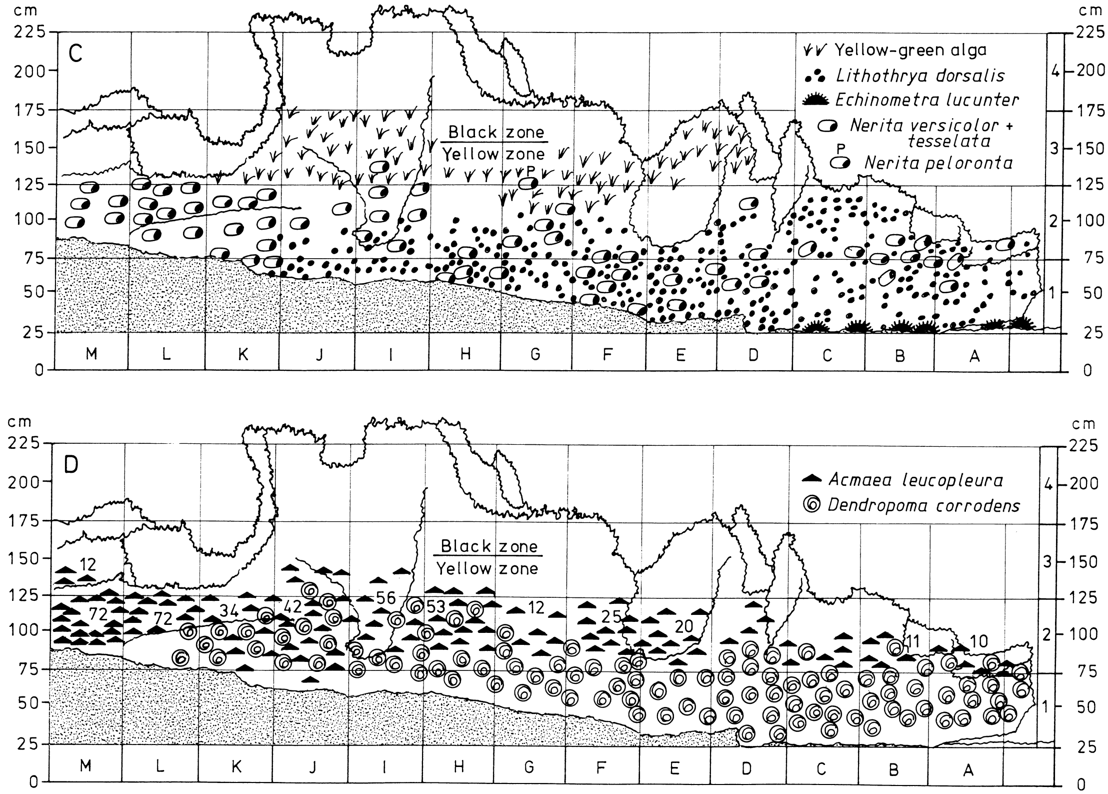


Fig. 13C-D. Egg Island, Stn 16-67, vertical and horizontal distribution of 8 species. The numbers in D refer to *Acmaea leucopleura*. Note the zonal limit.

In the upper sub-zone, 115/125 to 145/155, a yellow-green alga formed an upper algal belt, in which the uppermost specimens of some of the species from the middle sub-zone, especially *Littorina lineolata*, occurred together with the lowest occurring *Nodilittorina tuberculata* or *Echininus* (or both). A single *Nerita peloronta* was found at 130.

The black zone, from about 145/155 to the grey, was dominated by the two lastnamed littorinids and, lowest down, the yellow-green alga, to 175.

For some species the zoning pattern at 16-67 is not quite typical for the area. The lowest part of the wall was covered by sand, which precluded *Echinometra*, which was taken between 0 and 25 on the reef-flat, and *Lithothrya*, *Dendropoma*, perhaps also *Acanthopleura*, would have been found below 25. On the contrary, had the wall everywhere been higher than 225, the upper limit of *Echininus* would probably have been found higher up, for this species occurred at somewhat higher levels both on the rocks behind the wall and on the terrace, and *Cenchritis* would have found living conditions on the wall. Also outermost some upper limits are not natural but a result of the rock being too low.

Horizontal distribution of the species (Figs 13, 14, 16)
A circumstance, which makes 16-67 a little special, is its situation in a small narrow inlet, in which water in heavy weather will be pressed higher up than at the open shore. This can be the reason why many species occur so far in. A negative consequence is that sand, at least temporarily, becomes accumulated in the inner part of the inlet, covering the base of the rock and preventing some low-level species from living far in as well as low down.

Most of the important species were distributed along the whole or almost the whole length of the wall, though with great variation in abundance in different parts. *Tetraclita* was most common in the outer metre, *Chthamalus*, *Fissurella* (except for stray specimens far in), and *Echinometra* in the outer half of the rock, *Littorina lineolata* in the middle part, and *Acmaea* and *Nodilittorina mespillum* in the inner half. Some high-level animals were missing in the low outer part, whereas the high-level yellow-green alga and the low-level *Lithothrya* and *Dendropoma* were missing in the innermost metre, probably because the conditions there were too dry. For these two animals also sand-scouring and

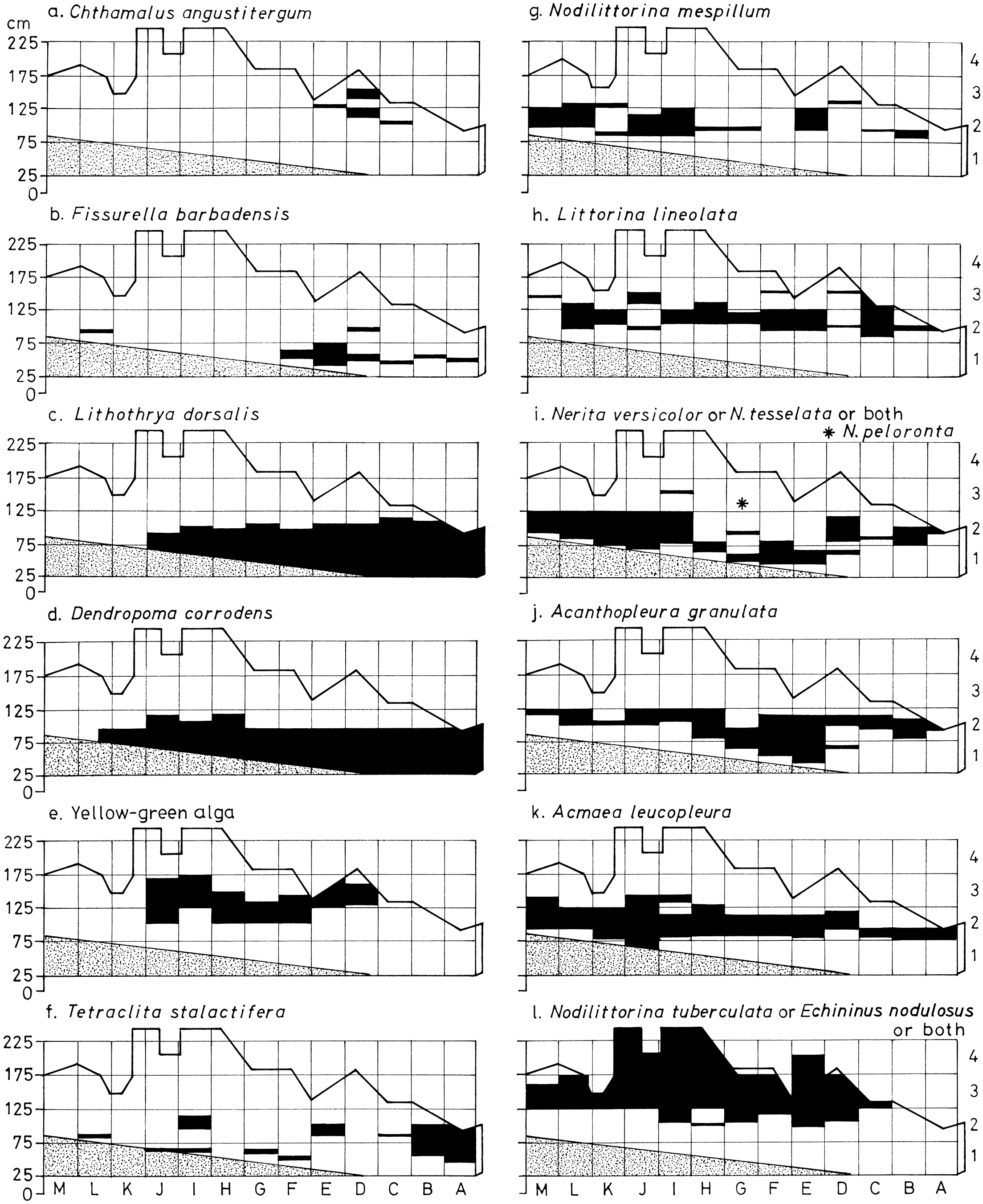


Fig. 14. Egg Island, Stn 16-67, schematic representation of the vertical and horizontal distribution of the species.

the risk of periodically becoming covered by sand must be considered. This also may be the reason why *Tetraclita* was rare innermost. *Cenchritis* wasn't found on the wall itself but occurred both on the higher rocks behind this, and on the terrace inside the inlet, from about 170 to 270 inwards to where the land vegetation began. It was more common in the grey than in the black zone.

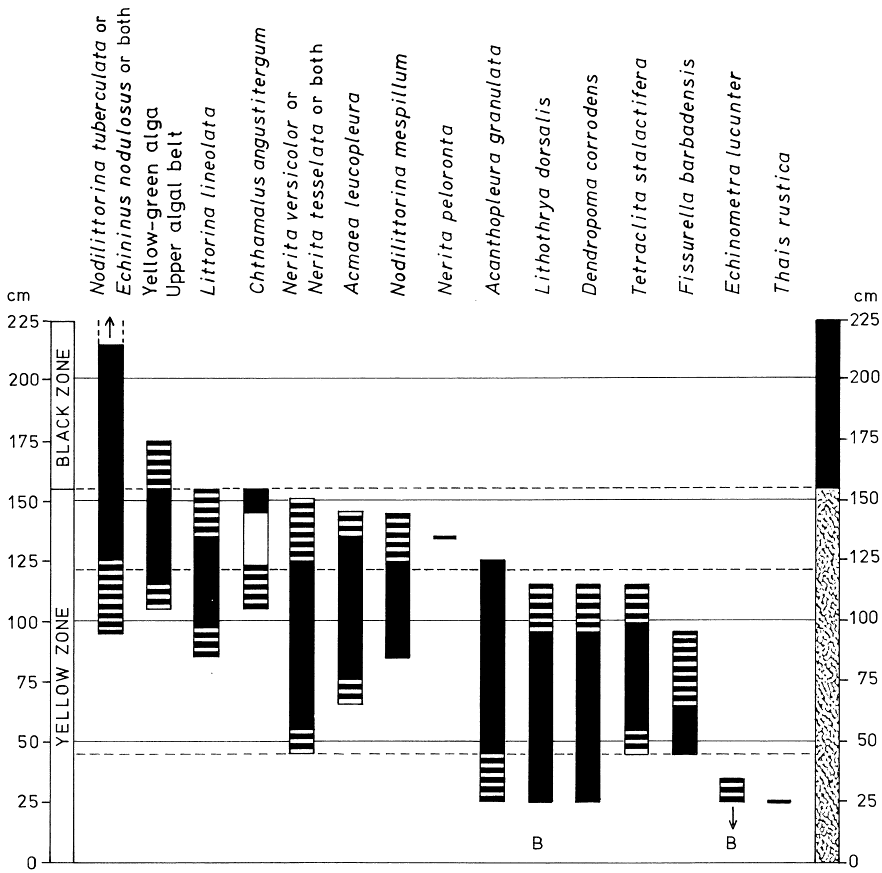


Fig. 15. Egg Island, Stn 16-67, vertical distribution of the species. B = boring species.

STN 26-67, ROYAL ISLAND

A small bay on the southern side of the western point of Royal Island, 25°30'18"N, 76°52'30"W, 19 April 1967 (Fig. 11).

Description of the station

Whereas Stn 16-67 was a small indentation in the shore, Stn 26-67 was a small protuberance on the straight and vertical rocky shoreline (Figs 17-19). The rock was lower than the highest parts of Stn 16-67, only 125-130 cm above the sand at its base, and 150-155 cm above zero. The base of the rock was dry at LW, which on 19 April was about 25 cm above the zero of the charts. A narrow sand-flat bordering the rock made the station a little less exposed than 16-67 (Fig. 17).

The rock surface was fairly similar to that of 16-67 but had more small and big holes, which offered hiding places for animals and considerably increased the surface, resulting in greater number of specimens per square area. The protuberance faced west, south, southeast, and east (Fig. 19). The southern side and the tip were partly undercut below the black zone, and part of the area below the overhang lay in shadow, when the sun was high (Fig. 17). Inside the small point was a narrow, horizontal terrace (not investigated) ending in dense brushwood.

Methods (Figs 19-21)

The rock wall was divided in four 1 m broad vertical strips, A and B on the southern side of the point, C at the southeastern tip, and D on the eastern side. Each strip was divided vertically in three rectangles, 1-3, with 1 lowest down and with the sand flat (+25) as base line (Fig. 19). The lowest two rows of rectangles were 50 cm high, thus each with an area of 0.5 m . Because the wall was low, the topmost rectangles were only 25-30 cm high, each covering about 0.25 m^2.

The lower and upper limits of the algal belts and of the animals were noted. Where possible all specimens within each rectangle were counted and their position measured. However, in most rectangles the number of species and specimens was so great that the zonation

Fig. 16. Egg Island, Stn 16-67, horizontal distribution of the species.

Fig. 17. Royal Island, Stn 26-67, from the south.

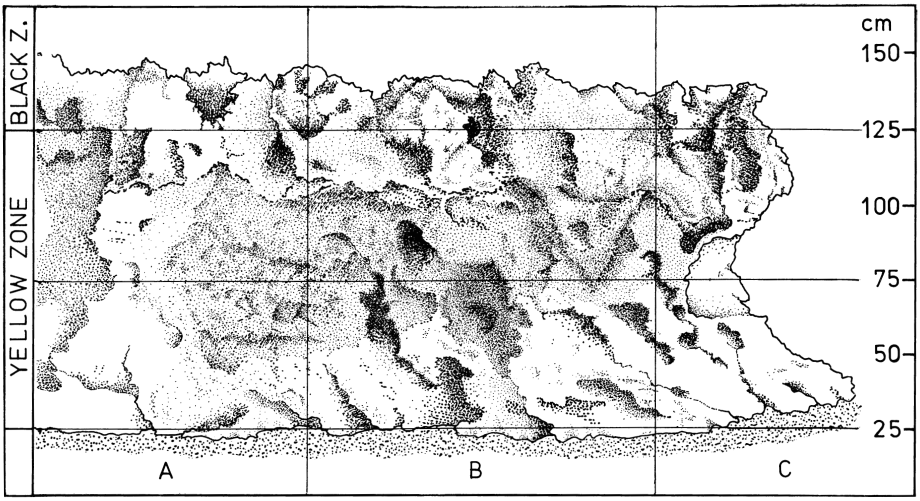


Fig. 18. Royal Island, Stn 26-67, sketch showing the net of squares.

pattern was obscured. The occurrence has been illustrated in Figs 20A-F, each showing the distribution of two to six species.

Since Fig. 20 is divided in six it is not so easy to find out which species occupy the same level and together form a belt. This is easier to see in Figs 21 and 22, in which the lowest and highest levels of occurrence, all strips combined, are shown for all species of importance for creating the zoning pattern. Especially Fig. 23 makes it easy to see which important species occur at the same level and to compare the zoning pattern with that at other stations and in other areas.

Colour zones

Owing to its inconsiderable height, 125-150 cm (Fig. 22), the whole rock wall was within the yellow and the lowest part of the black zone, with zone limit at a height of about 120 cm, varying a little both within and between the strips. This is about 30 cm lower than at Stn 16-67, indicating that 26-67 is less exposed than the former. The black zone continued a little landwards inside the crest of the wall, to where the grey zone began (Fig. 17, upper right corner).

Vertical distribution of the species

Because Fig. 22 only shows the lowest and highest levels, at which the species were found, it doesn't reveal that there is a variation in species levels within the strips. Figs 20 and 21 show that such differences can be considerable. Because the substrate was so irregular, light, waves, wash, and spray must vary, and the many holes and shadowy parts must be wetter for a longer time than the surrounding rock.

Figs 20 and 21 show that the lowest 10 cm of the rock, which were not covered by sand, were almost barren, most likely a result of sand-scouring. In contrast there was a very rich life above 35, to the crest of the rock. The species were fairly few, but the number of specimens high, resulting in a marked pattern of belts. This was not easy to see in the field, but the distribution pattern (Figs 22 and 23) shows that four fairly well defined belts can be discerned (limits see below), three in the yellow zone with sub-zone limits at 65 and 95/100, and one in the black.

1. The lowest yellow sub-zone, 25/35-65, is characterized by a lower algal belt, a mat of greenish and brownish algae, one probably being *Dasycladus*, the other (in A only) a species of *Valonia*. A violet sponge, *Phascolosoma antillarum*, *P. perlucens*, and a spotted holothurian were found lowest down, *Eriphia gonagra*, *Anurida maritima*, *Fissurella*, *Nerita tesselata*, and *Cerithium eburneum* in the upper part. Several character species in the middle yellow sub-zone had their lower limit more or less low down in the lower, being character species also there. Thus a red boring sponge, a boring? polychaet, and *Dendropoma* were taken from 35

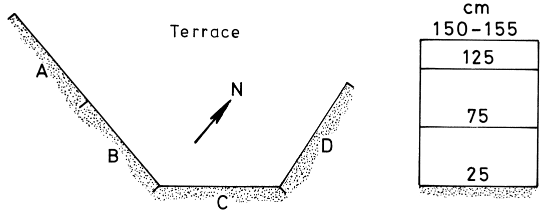


Fig. 19. Royal Island, Stn 26-67, sketch showing the position of the four strips investigated and the vertical division of the strips.

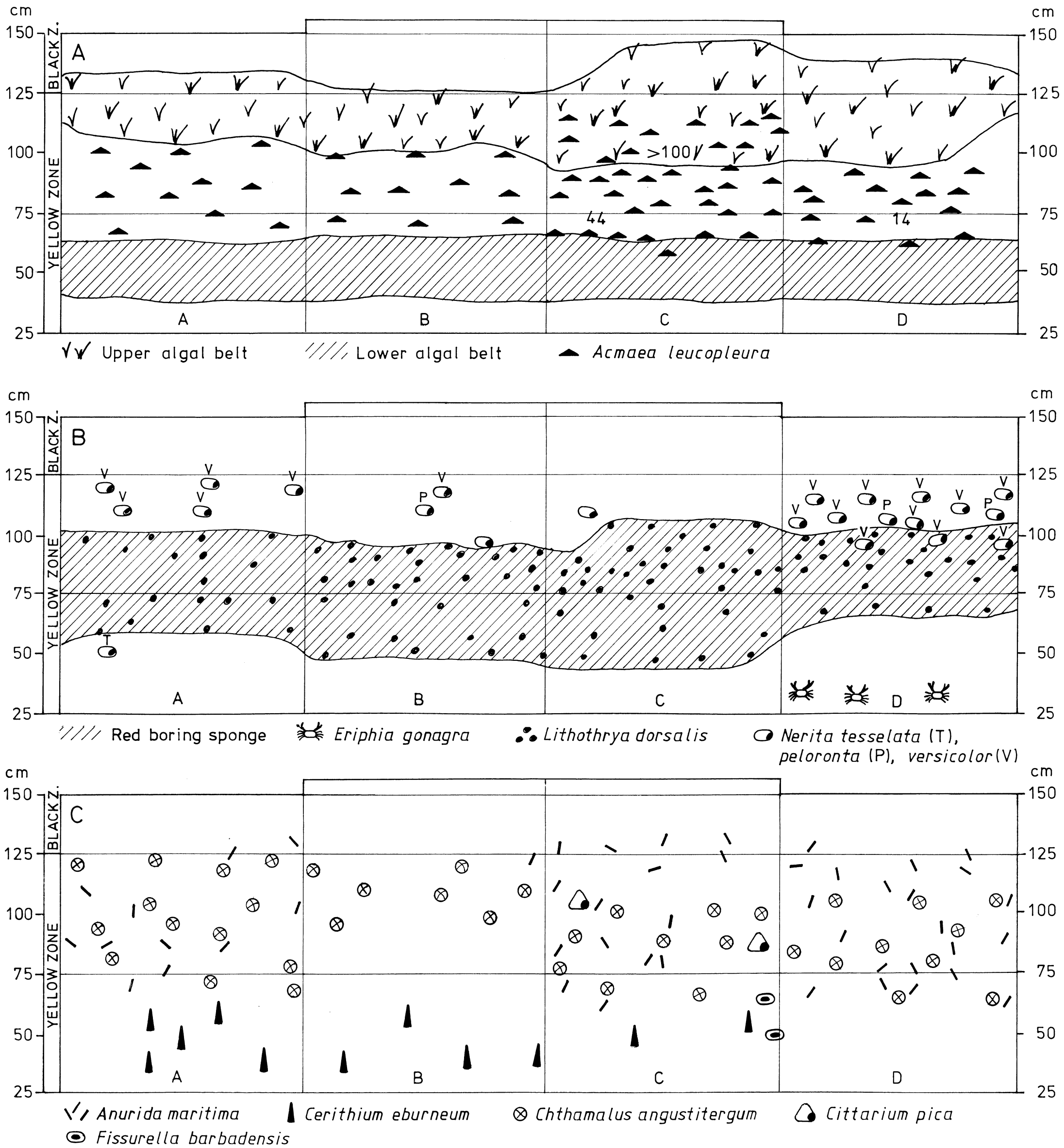


Fig. 20 A-C. Royal Island, Stn 26-67, vertical and horizontal distribution of the two algal belts and 12 animal species. The numbers in A refer to *Acmaea leucopleura*.

upwards, *Acanthopleura* common from 40, *Lithothrya* and *Brachidontes domingensis* from 50, and *Tetraclita* common from 55.

2. Beltforming in the middle yellow sub-zone, between 65 and about 95/100, were the red boring sponge, the boring? polychaet, *Lithothrya*, *Chthamalus*, *Tetraclita*, *Clibanarius*, *Acanthopleura*, *Acmaea*, *Nerita versicolor*, *Dendropoma*, and *Brachidontes domingensis*. All these species, except *Chthamalus*, *Acmaea*, and *Nerita* overlapped more or less with the species in the lower yellow sub-zone, and except for the two boring species, *Tetraclita*, and *Dendropoma* also with those of the upper yellow sub-zone.

3. The upper yellow sub-zone, between 95/100 and 125, was poor in species. It was characterized by an upper algal belt one of its species probably being a *Bostrychia* sp. Of animals in the algal belt *Cenchritis* and *Echininus* continued up in the black zone. *Chthamalus*, *Acanthopleura*, *Acmaea*, *Nerita versicolor*, and *Brachidontes* from the middle yellow sub-zone were also

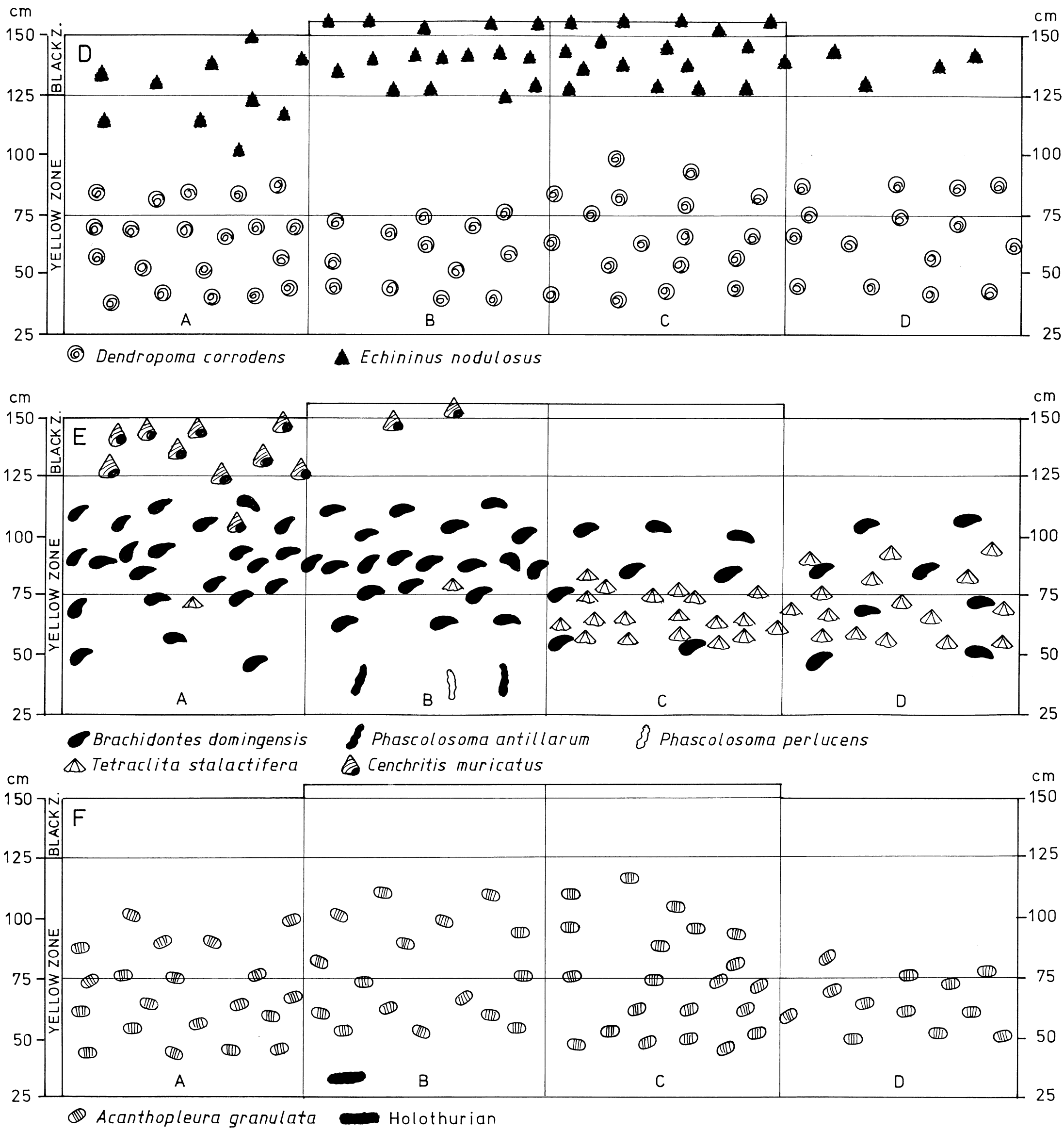


Fig. 20 D-F. Royal Island, Stn 26-67, vertical and horizontal distribution of 9 animal species.

characteristic of the upper. *Cittarium* occurred on both sides of the limit between the two highest sub-zones, and a few *Pachygrapsus transversus* and *Nerita peloronta* were restricted to the sub-zone.

4. In the black zone, above 125, the upper algal belt continued to 140, and *Cenchritis* and *Echininus* to 155, the top of the rock. The former was common and was also found on the terrace inside the crest (not drawn), where it was found in great numbers, as also on the outermost trees. The black zone continued a little landwards, inside the crest of the wall, but the remainder of the terrace belonged to the grey zone.

In most cases the species in the middle and upper parts of the shore had a greater vertical distribution than those living low down, as was also the case at 16-67.

Horizontal distribution of the species

Fig. 24 (cf. also Fig. 20) shows that two algal belts, the red boring sponge, and nine of the 21 identified animal species of importance for creating a zoning pattern, were

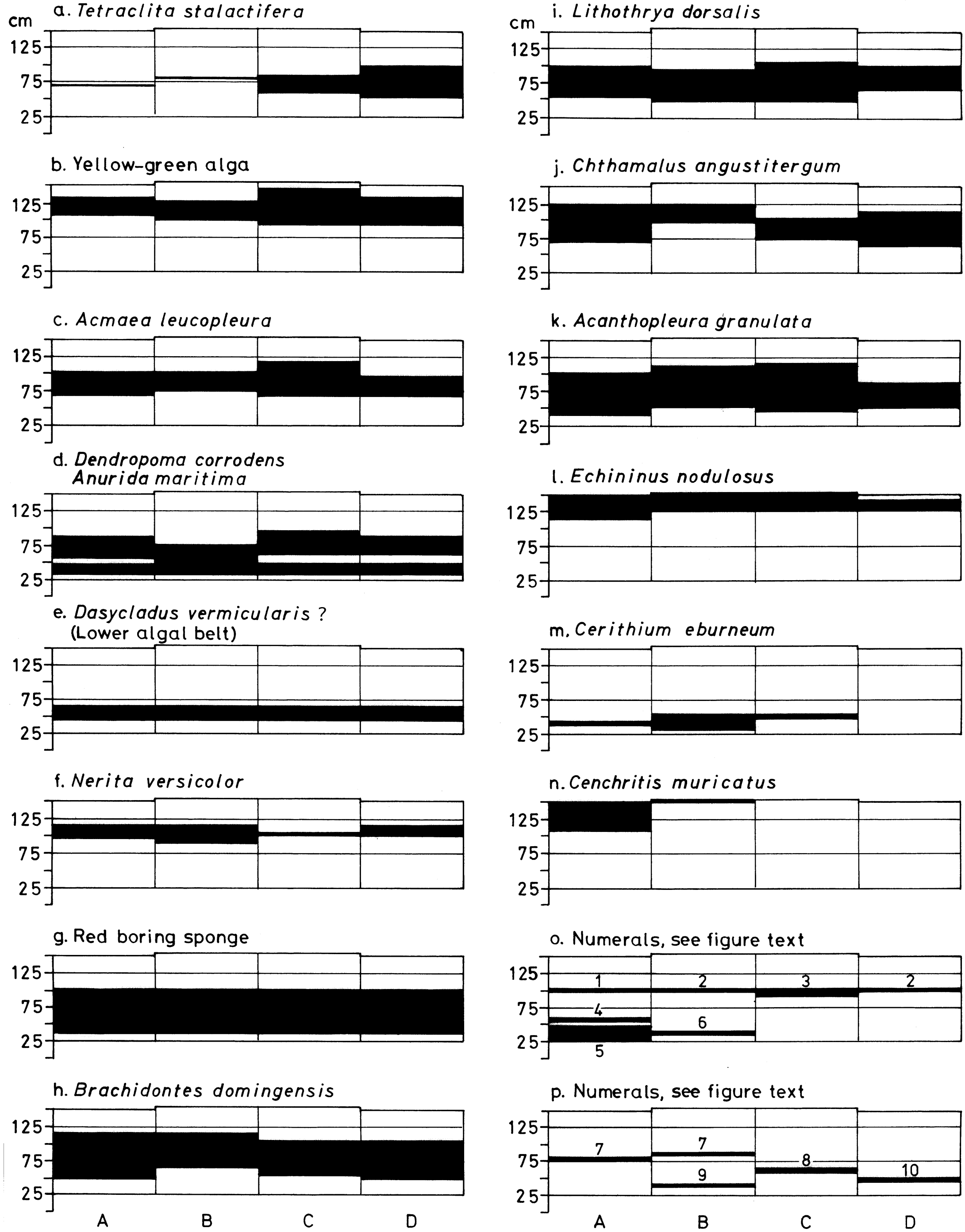


Fig. 21. Royal Island, Stn 26-67, schematical picture of the distribution of the species. The numbers in o and p refer to: 1 *Pachygrapsus transversus*, 2 *Nerita peloronta*, 3 *Cittarium pica*, 4 *Nerita tesselata*, 5 *Valonia* sp., 6 *Phascolosoma antillarum* and *P. perlucens*, 7 *Clibanarius tricolor*, 8 *Fissurella barbadensis*, 9 spotted holothurian, and 10 *Eriphia goniagra*.

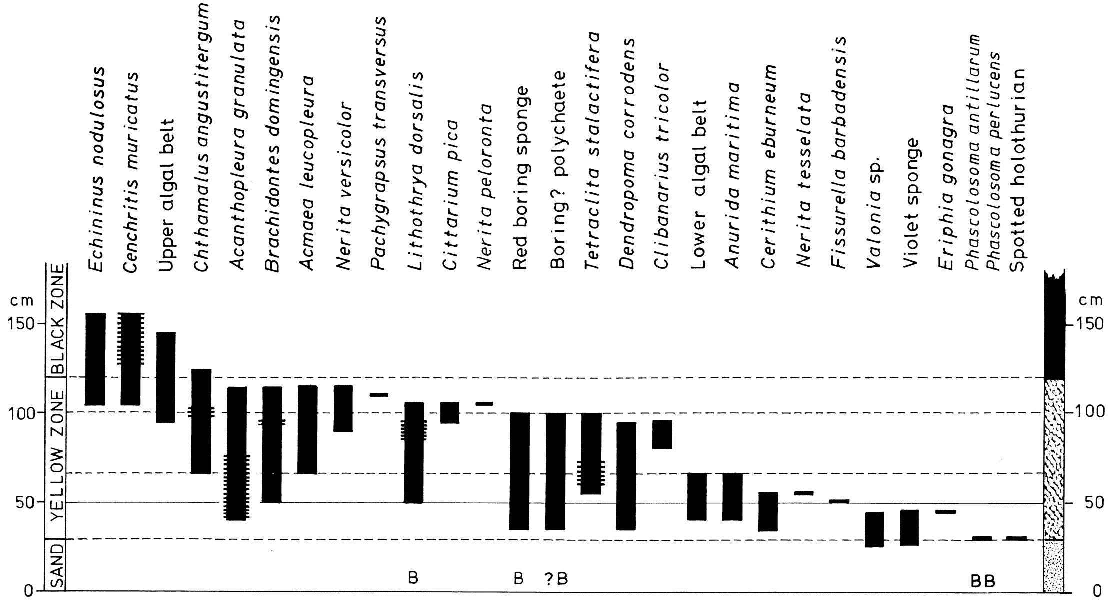


Fig. 22. Royal Island, Stn 26-67, vertical distribution of the species.

distributed on all sides of the protruding rock, but with a majority at the two southern strips. The easily overlooked *Anurida maritima* and *Cerithium eburneum* were found in strips A and C.

Of the remaining 10 animal species *Pachygrapsus transversus* and *Nerita tesselata* were only taken in strip A, *Phascolosoma antillarum*, *P. perlucens*, and the spotted holothurian in B, *Clibanarius* and *Cenchritis* in A and B, *Fissurella* and *Cittarium* in C, *Eriphia gonagra* in D, and *Nerita peloronta* in B and D. Most species which because of number, colour, size etc. created a zonation pattern, were more or less equally common throughout the station, except for the yellow-green alga and *Tetraclita*, which were concentrated to the most exposed strips C and D, the former high up, the latter low down as in 16-67, and *Cenchritis*, which in both stations occurred high up in the most sheltered part of the station. The two motile decapods are moving around and at another time perhaps would have been found in other strips.

STN 38-67, PELICAN CAY

The shore rocks on the eastern side of Pelican Cay, off James Cistern, 25°16'45"N, 76°20'20"W, 22 April 1967 (Fig. 25).

Description of the station

The locality was situated in a small, very sheltered bay, facing Eleuthera. It consisted of low, heavily broken-up, jagged rocks with many small and larger holes and depressions, some with miniature rock pools. Parts of the rocks were deeply undercut (Figs 26 and 27, right), and the outermost part was eroded down to a low platform ending in sand. The platform and part of the rock-wall inside were exposed to the sun, whereas some holes and parts below the overhang were in shadow.

Notes on sea levels are lacking, but information from the Tide Tables and observations from other stations suggest that the outer base of the rock platform corresponds to the zero of the charts. Based on this the height of the shore was only about 100 cm.

Methods

The platform and the rocks inside were investigated. Because of the very irregular substrate and the difficulties in making measurements and counts, the station could be only cursorily studied. However, the measurements of the upper and lower levels of the species are probably fairly accurate (Fig. 28). The fauna was poor but not quite as poor as the figure indicates, because species, for which notes on levels are missing, have been left out.

Colour zones

Since the rocks were low, only about 100 cm high (Figs 26, 28) most of the shore belonged to the yellow zone. Only the topmost 20-30 cm and the terrace landwards of the rocks belonged to the black, which continued to the outer limit of the land vegetation of shrubs. No grey or white zones were observed. Because of the very ir-

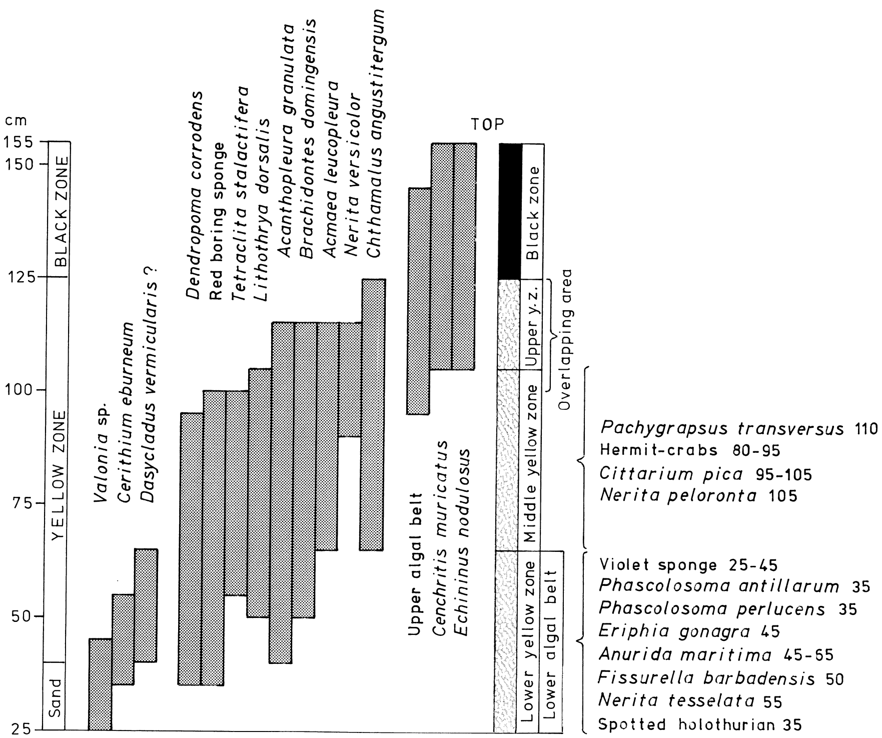


Fig. 23. Royal Island, Stn 26-67, vertical distribution of the species most important for creating the zoning pattern.

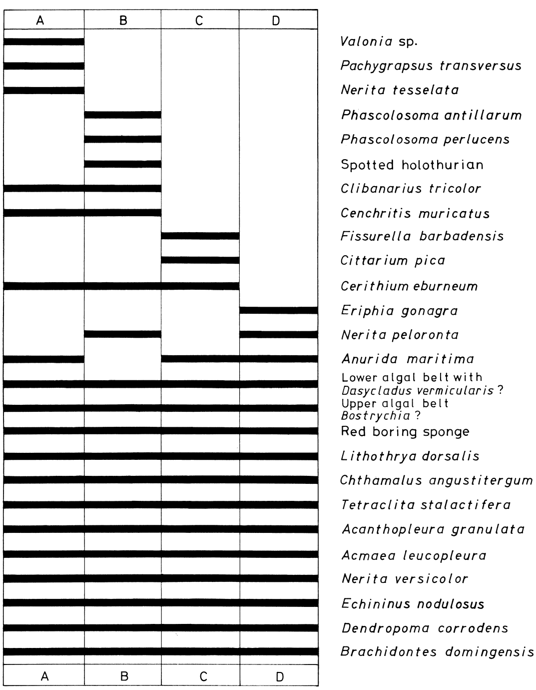


Fig. 24. Royal Island, Stn 26-67, horizontal distribution of the species.

regular rock surface the limit between the yellow and black zones wasn't a straight line but wavy, with a mean height of about 70 cm.

Vertical distribution of the species

Because of the extremely varying environment a variety of mini-biotopes was found. No distinct animal belts were discernible, but rather a gradual transition of species.

The lower yellow sub-zone was characterized by a lower algal belt, consisting of a fine felt of small, sand-encrusted algae, namely filiform Cyanophyta, *Cladophora* sp., *Anadyomene*, *Catenella* sp., *Centroceras clavulatum*, *Taenioma* sp., *Polysiphonia* sp., *Bostrychia* sp., *Lophosiphonia* sp., and *Laurencia* sp. Some white foraminiferarns, polychaetes, a sipunculan of the family Golfingiidae, many hermit-crabs, *Sesarma* cf. *miersii* (0-50), amphipods and isopods were also found in this belt. The area below 10-20 cm was devoid of animals, probably a result of sand-scouring and the risk of being buried in sand. The only exception was a *Paguristes tortugae*, which occurred in great numbers under stones at about –15 and –10, just outside the station.

The lowest specimens of *Chthamalus*, *Acanthopleura*, and *Brachidontes domingensis* of the upper sub-zone had their lower limit uppermost in the lower, the latter

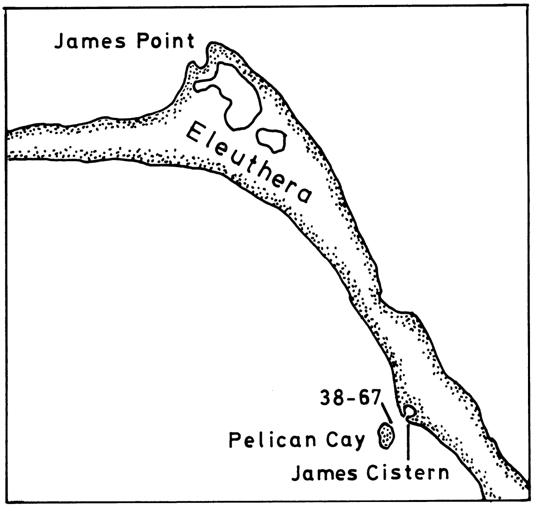


Fig. 25. Pelican Cay, map showing the site of Stn 38-67.

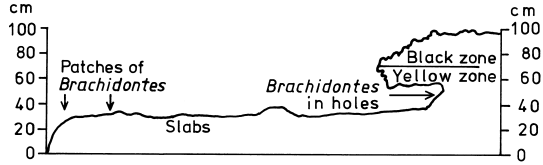


Fig. 26. Pelican Cay, Stn 38-67, sketch of the station.

in great numbers in depressions on the terrace as well as in holes higher up on the rock. A flat patelloid or siphonarian was taken somewhere near the zone limit.

The upper yellow sub-zone was characterized by an indistinct upper algal belt, 40-60, consisting of scattered unidentified species between the animals at this level. The characteristic animals were *Chthamalus* (low down only), *Acanthopleura*, *Acmaea*, *Littorina lineolata*, and *Brachidontes domingensis*. A *Cittarium* was taken in a small rock pool at 60 and a *Cerithium* sp. was common in rock pools with surface at 70. *Microphrys bicornutus* and *Petaloconchus* occurred too, but no levels were noted.

The only species in the black zone was *Cenchritis* from 100 on the crest and 5-7 m inwards on the terrace.

STN 41-67, PINEAPPLE CAYS

A minute, northeast-facing inlet on the north side of the northernmost Pineapple Cay, 25°08'25"N, 76°11'50"W, 23 April 1967 (Fig. 29).

Description of the station

The station was located at the western side of the inlet (Fig. 30, insert). It differed from the other localities investigated in the area (Brattström 1992 and this paper) by the absence of a reef flat outside. Exposed to swell at north and northwest winds it was more exposed than 38-67.

The rock was vertical but undercut (Fig. 30). The overhang protruded one metre and its almost horizontal underside was about one metre above zero of the charts. The outer and upper side of the overhang and

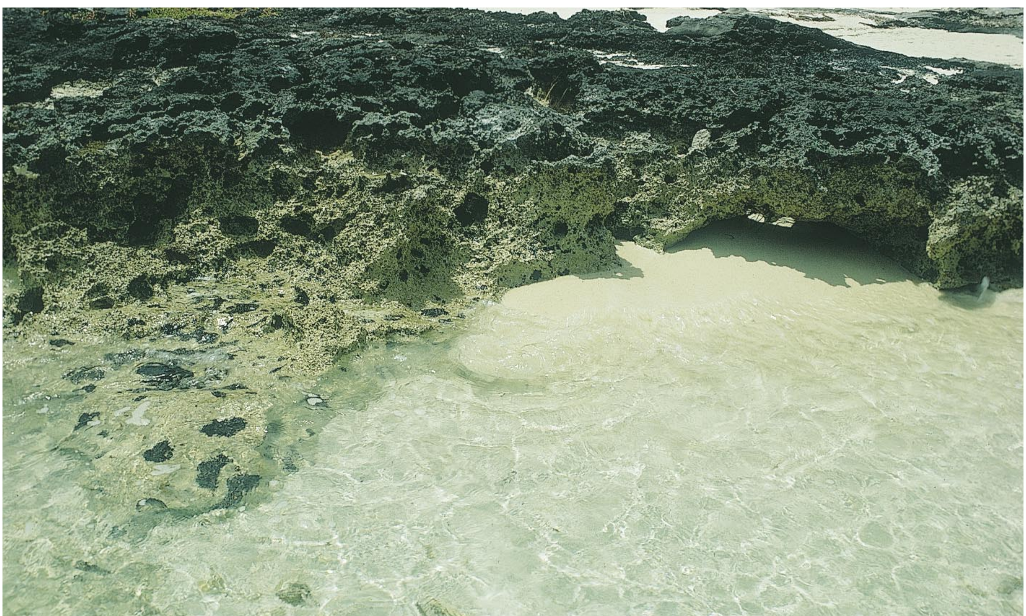


Fig. 27. Pelican Cay, Stn 38-67. In the foreground patches of *Brachidontes domingensis*.

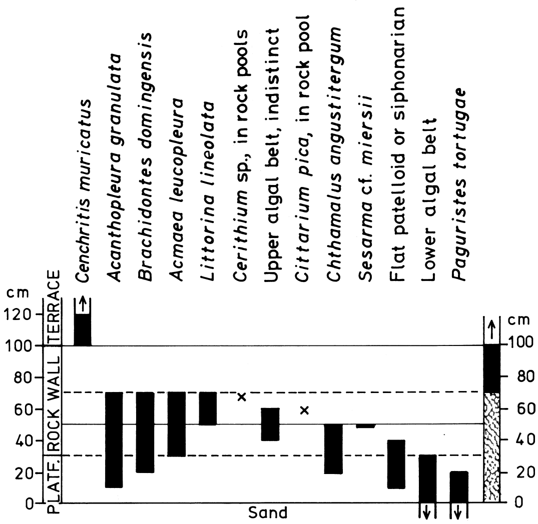


Fig. 28. Pelican Cay, Stn 38-67, vertical distribution of the species. PLATF = platform. ×: Rock-pool records.

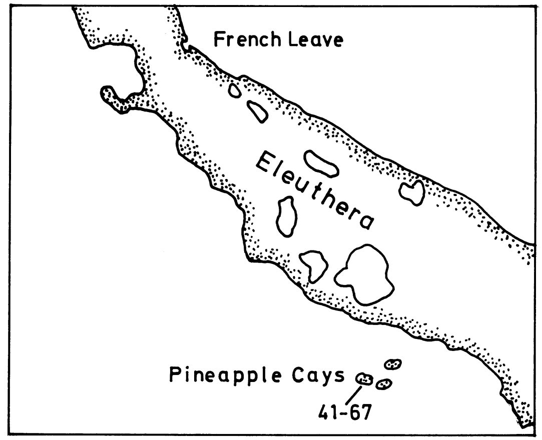


Fig. 29. Pineapple Cays, map showing the site of Stn 41-67.

the outer part of the rock terrace inside were extremely spiky (Fig. 6), whereas the whole underside was fairly smooth due to wave erosion.

The bottom under the overhang was almost horizontal, whereas the next metre outside sloped gently and irregularly to a depth of 40 cm, from where the angle of the slope increased to almost 45 degrees. At a depth of about 120 cm the bottom dropped vertically to about 340 cm, where it flattened out and became horizontal and was covered with sand, stones, and corals.

Based on comparison with other stations and the upper limit of corals, the flat bottom below the overhang probably corresponds to the zero of the charts. If this is correct the rock was 180 cm high.

Methods

At the time of investigation the sea level was about 60 cm above zero, and only the uppermost 20 cm of the rock below the overhang were above the sea surface (Fig. 30). Because of waves up to 60, sampling and making observations below the overhang was impossible. Notes on flora and fauna between 10 and 80 are accordingly missing.

Underwater sampling down to –40 was possible, but some species and specimens here may have been overlooked. In the deeper parts outside the station only samples of the most common and conspicuous species were secured, and notes on levels only tell within which depth region the species were found. Fig. 30, a free-hand sketch of a vertical section through the station and the bottom outside, gives information about the life at these depths.

Colour zones

The yellow and black zones were distinct with zonal limit at 120. The part below the overhang, from a little below zero to 120, belonged to the yellow zone, the spiky overhang from about 120 upwards and the outer part of the rock to the black zone. The grey zone was also spiky with a less distinct limit to the black (Fig. 6).

Vertical distribution of the species. (Figs 30, 31)

Between –40 and +10 in the yellow zone was a lower algal belt with sponges and corals. The lowest part, –40 to +20, was characterized mainly by a branched brown alga and low, almost crust-shaped *Millepora* sp. with single erect specimens at about –40. An *Oreaster* sp. was taken at –30. From –30 to +10 a brown coarse-branched alga dominated together with *Dictyosphaeria cavernosa*, *Lobophora variegata*, *Galaxaura* sp., *Laurencia* sp., a grey lump-shaped and a blackish sponge, *Millepora* sp., *Siderastrea radians*, *Porites astreoides*, *Favia fragum*, and *Barbatia cancellaria*.

No investigations were made between 10 and 80, the part under the overhang. From there to 110 was an upper algal belt with a crustlike brown alga. In this part of the upper sub-zone up to the black zone at 120 were also found *Acanthopleura*, *Emarginula pumila*, *Acmaea*, and *Brachidontes exustus* (scattered or in small patches). From 90 *Chthamalus* and *Tetraclita* formed a belt up to 140 in the black zone. The only other species found in that zone was *Littorina lineolata*, mainly in small holes from 120 to about 180 (limit not noted). One specimen of *Cenchritis* was found somewhere between 80 and 140 (not drawn in Fig. 31).

Species outside the station (Fig. 30)

In the upper sublittoral, the steeply sloping area between –40 and –120, a mixture of algae and *Millepora* sp.,

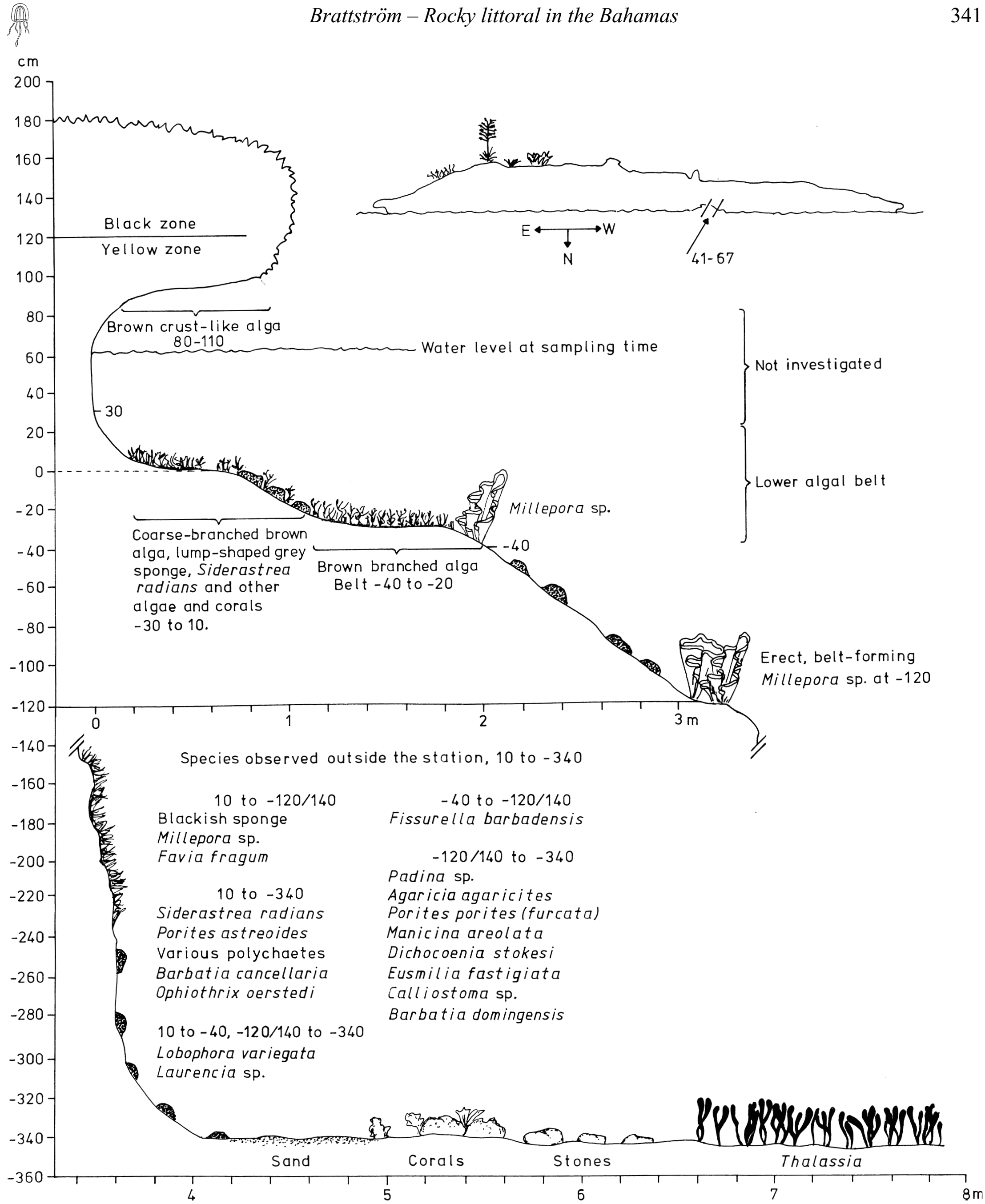


Fig. 30. Pineapple Cays, cross-section of Stn 41-67. Insert showing the site of the station.

Siderastrea radians, *Porites astreoides*, *Favia fragum*, *Barbatia cancellaria*, and *Ophiothrix oerstedi* was found. Large *Millepora* sp. formed a distinct belt along the lower end of the slope, at about –120.

The vertical wall, –120 to –340, was characterized by algae and corals. The following were sampled: *Padina* sp., *Lobophora variegata*, *Laurencia* sp., *Agaricia agaricites*, *Siderastrea radians*, *Porites astreoides*, *Porites porites*, *Manicina areolata*, *Dichocoenia stokesi*, *Eusmilia fastigiata*, *Calliostoma*? sp., *Barbatia cancellaria*, *B. domingensis*, and *Ophiothrix oerstedi*. Some polychaetes were also ob-

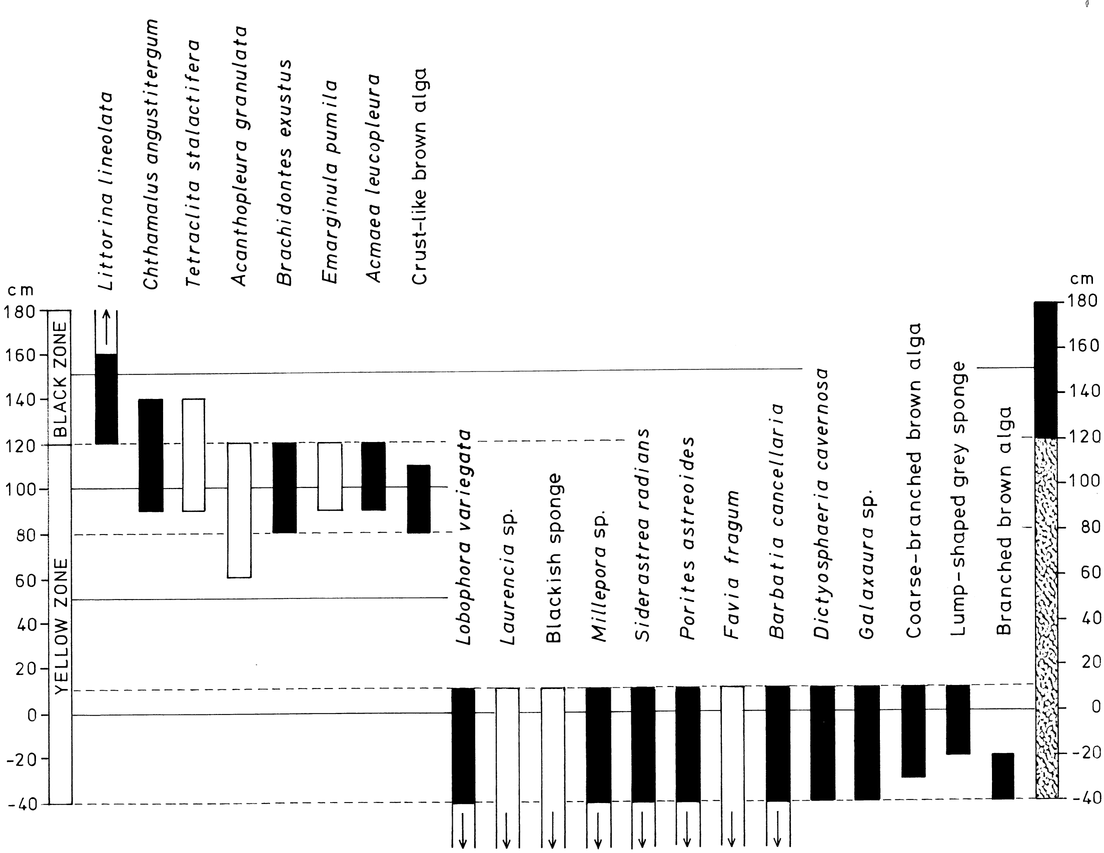


Fig. 31. Pineapple Cays, Stn 41-67, vertical distribution of the species. The area between –10 and +80 couldn't be investigated.

served in the corals. On the sand bottom below the vertical wall, grey clump-shaped sponges and single corals were found. At about 3 m from the slope a *Thalassia* meadow had its inner limit.

STN 48-67, ELEUTHERA, CHUB ROCK

Western side of southern Eleuthera., south of Powel Point, 24°49'42"N, 76°20'45"W, 25 April 1967 and 28 March 1968 (Fig. 32).

Description of the station

Topographically the station in many respects differed from those described earlier in this paper. It was not situated in an indentation in the shore, nor on a part protruding from this, but was part of the straight up to about 2 m high, almost vertical rocky shore, which at the station was not undercut (Fig. 34). Very shallow minute rock pools were common at different levels, especially in the black zone.

There was no sheltering reef flat outside, but at about zero the rocks flattened out to an outwards slightly sloping and only a few metres broad and about 1 m deep ledge, covered with scarce algal growth and single gorgonians. In the ledge was a series of closely-set short and narrow, a few metres deep ravines, perpendicular to the shore (Fig. 33) with a luxuriant coral community. Outside the ledge the bottom dropped to great depths. Because of these conditions the locality was fairly exposed but less than could be expected, as a coral reef some distance out gave a little shelter.

Inside the crest the shore leveled out into an inwards slightly sloping, fairly smooth shore terrace with slabs and, farther in, big stones and boulders on the surface (Fig. 34). Here and there very split-up and spiky parts of the rock rose above the terrace. At about 10 m from the crest scattered bushes grew in holes and depressions, and 17 m from the shore line there was a dense vegetation of herbs, bushes, palms, and other trees (Fig. 34, uppermost).

Methods

At LW the tops of the corals on the reef outside the station were seen above the surface and some *Montastraea cavernosa* occurred at the base of the rocks. The zero was placed at this level and is thus comparable with those at the other stations. Since there was

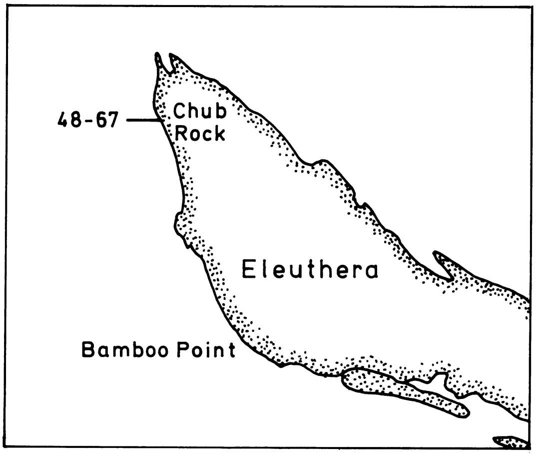


Fig. 32. Chub Rock, map showing the site of Stn 48-67.

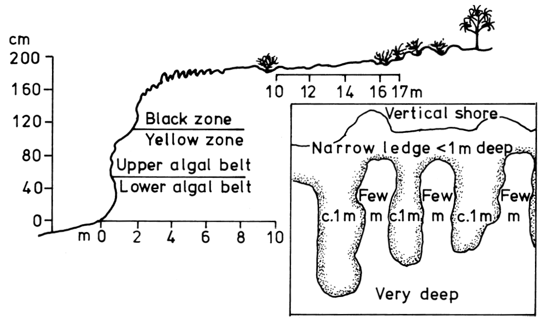


Fig. 33. Chub Rock, cross section of Stn 48/67. Insert = the ledge seen from above.

no reef flat outside the vertical rock wall on which to stand when measuring and collecting samples, all work had to be made from a tossing dinghy, and measurement errors of 10-20 cm are likely to occur. No attempt was made to study the conditions below zero, and in the lowest, partly drenched base of the rock only larger and conspicuous algae and animals could be sampled. Boring species and such living in holes could not be searched for.

Colour zones

Because the rock surface wasn't smooth, the limit between the yellow and black zones was not a straight line but varied in different parts of the rock with a mean level of 110/120, where there often was a weak indentation in the vertical front wall (Fig. 33). The black zone continued on the terrace inside the crest, where also a grey zone could be distinguished (Fig. 34, uppermost). The two zones graded into each other, making the limit between them indistinct.

Vertical distribution of the species

The yellow zone can be divided in two distinct subzones. Lowest down, up to 50 or 60, was a well developed, brownish lower algal belt, strongly contrasting to the yellow rock above (Fig. 34). The belt was characterized by a dense growth of *Lobophora variegata*, *Turbinaria tricostata*, *Gelidiella acerosa*, *Digenia*, and at least a dozen unidentified species of the genera *Cladophora*, *Halimeda*, *Dictyota*, *Padina*, *Sargassum*, *Jania*, *Hypnaea*, *Lophosiphonia*, and *Laurencia*. Cyanophyta and pink encrusting lithothamnia also occurred (not drawn in Fig. 31). An *Avrainvillea* sp. and a *Cystoseira* sp. were also taken without notes on levels.

The animals were few. Except for single specimens in rock pools *Homotrema*, *Millepora* sp., *Gorgonia ventalina*, *Montastraea cavernosa*, *Cittarium*, *Thais deltoidea*, and *Echinometra* were restricted to the lower yellow sub-zone.

In the upper yellow sub-zone, between 50/60 and 110/130, the rocks were fairly naked (Fig. 34) with an ill-defined light-green upper algal belt. *Lobophora* sp. continued up to 80. The only other identified algae were *Boodleopsis pusilla* (limits not noted) and *Laurencia nana* at about 95. Characteristic animals in this subzone were the very common *Lithothrya* (Fig. 35), *Acanthopleura* with the isopod *Dynamenella*, *Nerita versicolor*, *Nodilittorina mespillum*, *Petaloconchus* and *Dendropoma*. *Acmaea* was found at the limit between the yellow and black zones.

Apart from *Acanthopleura* and *Nerita versicolor*, which occurred lowest down in the black zone, this was one of littorinids. *Littorina lineolata*, *Nodilittorina ziczac*, and *N. mespillum* were found lowest down, to 130 or 150, and *N. tuberculata* and *Echininus* from 130 to 310, thus also on the outer part of the terrace. *Cenchritis* was only found on the terrace, from 210 to 400, 17 m from the crest, with the innermost specimens found in bushes and trees.

Several species were also taken in a small rock pool at 150 uppermost in the yellow zone (Fig. 36). *Clibanarius* (in shells of *Nodilittorina ziczac* and *N. tuberculata*), *Eriphia gonagra*, *Nerita peloronta*, *Puperita pupa* (mass occurrence), and *Brachidontes domingensis*, were only taken in this pool. When comparing the species limits at different localities specimens from rock pools will not be considered.

STN 53-67, LITTLE SAN SALVADOR, THE LAGOON

Southwestern point of a small, low island in the lagoon, 24°34'29"N, 75°55'55"W, 26 April 1967 (Fig. 37).

Description of the station

The lagoon was connected with the sea by a very narrow, only about one metre deep entrance, but the con-

Fig. 34. Chub Rock, Stn 48-67 seen from the sea. Lowest down a well-developed yellow zone on the vertical rock, above the terrace with distinct black and grey zones. Lowest down a very distinct algal belt, above which is a zone with holes of the boring *Lithothrya dorsalis* (cf. Fig. 35).

Fig. 35. Chub Rock, Stn 48-67, close-up picture of the *Lithothrya* belt. In the left part of the rock is a specimen of *Acanthopleura granulata*.

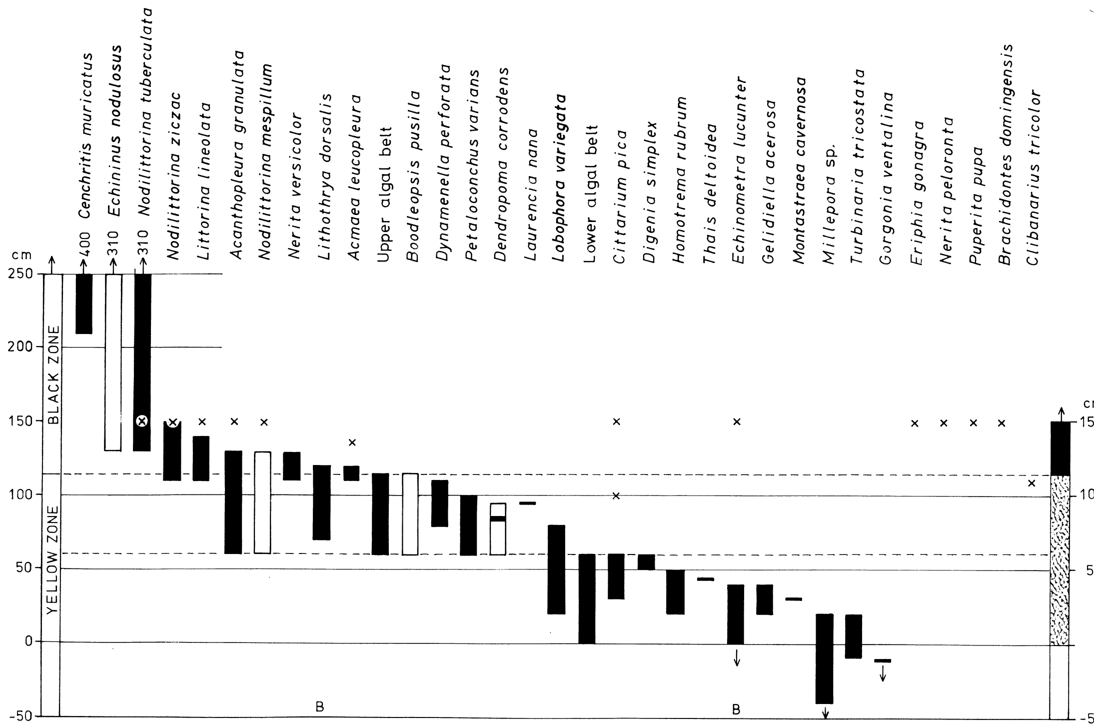


Fig. 36. Chub Rock, Stn 48-67, vertical distribution of the species. B = boring species, x = rock-pool records.

ditions in the lagoon were nevertheless quite marine with the same corals and other species as normally found on open shores.

The island was only about 75 cm high, 60 cm above the HW-line on 26 April. It was separated from another small island (Fig. 38, insert) by a 50 to 100 cm deep sound, which probably, at least partly, becomes dry at extreme LW. The shallow and sandy bottom of this sound was characterized by scattered algae, *Thalassia*, sponges, and corals. The rock was heavily undercut, the overhang being more than one metre wide (Figs 38, 39). Its upper surface was very jagged, the underside smooth and horizontal and only about 10 cm above the sea at HW. A vegetation of bushes and small trees was found only a few metres from the shore line. The other side of the island was different with marl and mangrove.

Methods

At the time the lagoon could be visited the sea level unfortunately was too high for detailed measurements. Therefore collections and notes were made within four levels, –35/45 to –15, –15 to –5, –5 to 5, and 10-75. The measurements thus don't show the exact lower and upper limits of the species, only tell within which of the four collecting levels they were observed. Because of that the bars in Fig. 40 are open. Though the water was extremely clear, the measurements were somewhat hampered because high water at the time of investigation excluded studying the underside of the overhang. Its height above water was only about 10 cm (Fig. 38).

Colour zones

The position in a shallow lagoon makes this station the most sheltered of the nine stations. The limit between the yellow and black zones was found as low as 25-30 cm, at the very edge of the overhang (Fig. 40).

Vertical distribution of the species (Fig. 40)

The number of species and specimens was so low that no belts of species could be distinguished in the yellow zone. Less than 20 identifiable species were observed, four being algae. A somewhat greater number, mainly algae, sponges, and small snails could not or have not been determined. One reason for the scarcity probably is that the station was small and because there will be very little wave action, the shore will be exposed to the sun for a considerable time of the day.

There was a change in flora and fauna at about 5 and 15 in the yellow zone. Algae, sponges, and corals were restricted to the area below 5, whereas mollusks domi-

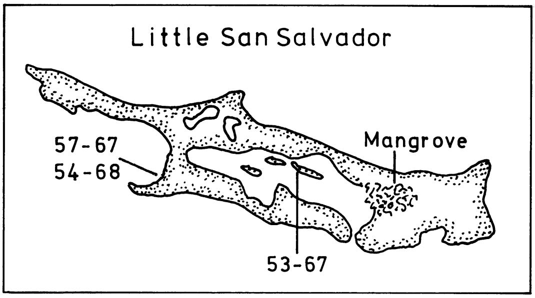


Fig. 37. Little San Salvador, map showing the sites of Stns 53-67 and 57-67.

nated in the upper part of the zone. *Dictyosphaeria cavernosa*, *Dasycladus*, *Anadyomene*, *Porites porites*, *Manicina areolata*, and *Isognomon radiatus* were found between –5 and 5, *Acanthopleura* with *Dynamenella* at 15, a red boring sponge, *Lithothrya*, and *Brachidontes exustus* between 10 and 25, *Nerita versicolor* and *Nodilittorina ziczac* at 25. Large quantities of *Clibanarius* were taken between –50 and 25.

The only species in the black zone were a *Bostrychia* sp. lowest down, 25-30, and *Cenchritis* between 55 and 75, as at other stations to, and in, the outermost bushes.

STN 57-67 = 54-68, LITTLE SAN SALVADOR, WEST BAY
Southern side of West Bay, 24°34'26"N, 75°57'15"W, 26 April 1967 and 27 March 1968 (Fig. 37).

Description of the station

The station was situated in the southeastern corner of the bay, where the rocky coast ended in a beach. There the rocks were about 2 m high and of the same type as most shores in the area, more or less vertical, jagged, and with many holes and depressions, some with minute rock pools, especially about 90.

At a height of about 40/50 cm the rocks flattened out, forming an about 2 m broad, outwardly gently sloping ledge with some shallow depressions. It ended in a low vertical wall, of which only the upper 10 cm were seen above the sand innermost, against 40 outmost, where the depth was a little greater.

On such a shore sand-scouring and sand accumulation must have a great influence on low-level species. This was clearly demonstrated when the station was revisited in 1968. Then part of the ledge studied in 1967 was totally buried in sand, whereas the conditions above 40 were as in 1967 with the same species at the same levels.

Methods

The zero was placed where in 1967 the low ledge met the sand bottom (Fig. 2). Horizontal belts, 10 cm broad, were investigated with rising tide and the lower and upper limits of the species could be easily stated. Being irregular in shape the rocks didn't form a uniform biotope. Light and humidity varied, as did the species levels.

The identified species are presented in Fig. 42, the many unidentified ones separately in Fig. 43, because otherwise the figure would have been difficult to read.

Colour zones

A yellow, a black, and a grey zone were well-developed and could be distinguished even from a distance (Fig. 4). Zonal limits were found at about 90 and 190.

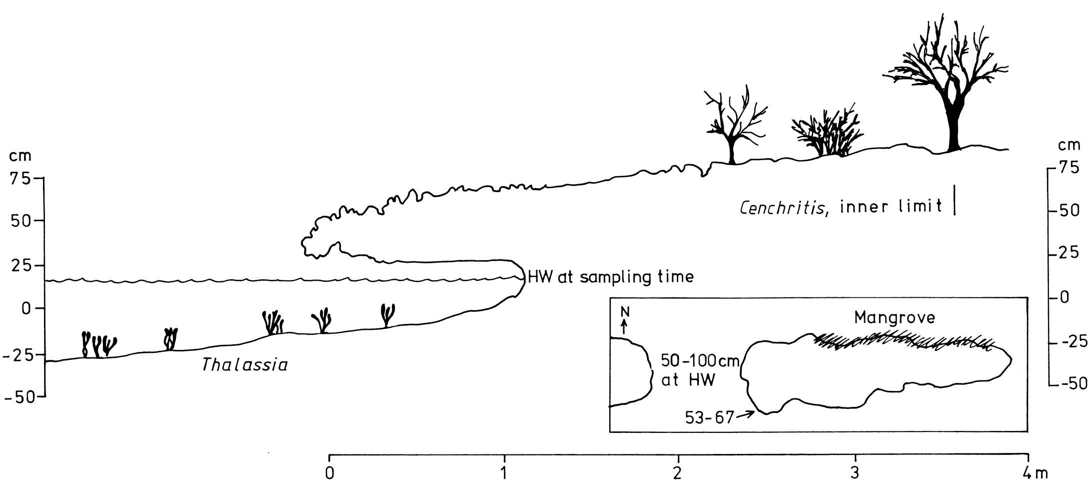


Fig. 38. Little San Salvador, cross-section of Stn 53-67. Insert, map showing the site of Stn 53-67.

Fig. 39. Little San Salvador, the lagoon, Stn 53-67.

Vertical distribution of the species

Two sub-zones could be distinguished in the yellow zone (Figs 42, 43, note different height scales). In the lower, 0-40/50, the lowest 10 cm of the rocks were covered by pink encrusting lithothamnia and a great number of small, heavily sand-encrusted algae, creating a well-developed yellow-brown lower algal belt (Fig. 4), mainly in the lowermost 30 cm. In some areas larger algae covered the smaller ones. Most algae were too small or under-developed to permit identification to

Fig. 40. Little San Salvador, Stn 53-67, vertical distribution of the species. B = boring species.

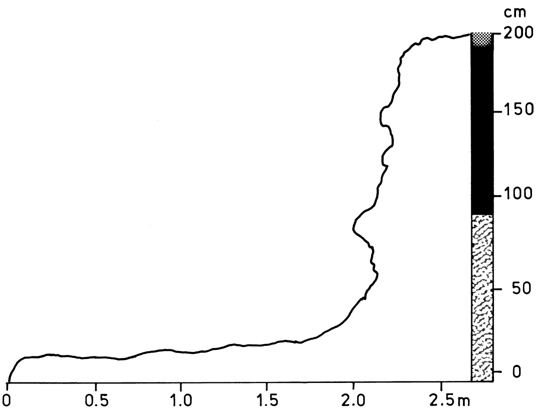


Fig. 41. Little San Salvador, West Bay, cross-section of Stn 57-67.

species, and 11 had a vertical distribution of only 10 cm. The following list shows the distribution of the algae in the lower yellow sub-zone:

Cladophora sp. 0-40*
Dasycladus vermicularis 0-10*
Dictyosphaeria ocellata 40-50*
Anadyomene stellata 30-60
Caulerpa sp. 10-20*
Penicillus sp. 10-20*
Halimeda , sp. 10-15*
Lobophora variegata 0-10*
Padina sp. 0-10*
Gelidiella acerosa 20-40*
Corallina cubensis 0-10*
Corallina sp. 10-30*
Jania sp. 0-10*
Pink encrusting lithothamnia 0-10*
Digenia simplex 0-50, 80-90
Lophosiphonia sp. 0-10, 40-80
Laurencia sp. 10-40*

A thick mat of sand-encrusted algae is not a suitable biotope for many animals. Nevertheless four boring, eight sessile, and at least eleven motile species were found. No borer was found below 10, and nine species had a very restricted distribution of only 10 cm. The following list shows the vertical distribution of the animals in the lower yellow sub-zone:

Homotrema rubrum 0-40*
White foraminiferans 10-70
Millepora sp. 10-40*
Siderastrea radians 0-40*
Porites astreoides 10-20*
Polychaetes 10-90
Lithacrosiphon alticonus 10-20*
Paraspidosiphon steenstrupi 30-60
Lithothrya dorsalis 40-130
Snapping shrimp 20-30*
Hermit-crabs 90-120
Microphrys bicornutus 30-40*
Mithrax coryphae 30-40*
Pilumnus holocericus 30-40*
Pilumnus nudimanus 20-30*
Calcinus tibicen 20*
Amphipods 20-70
Tanaidaceans 40-60
Dendropoma corrodens 10-70
Thais rustica 40-50*
Brachidontes domingensis 40-70
Lithophaga bisulcata 10-40*

Most of the algae and more than half of the animals (in the lists above marked *) in the lower yellow sub-zone were restricted to that zone, but some continued up into the upper: *Anadyomene*, *Paraspidosiphon steenstrupi*, and tanaidaceans to 60, white foraminiferans, amphipods, *Dendropoma*, and *Brachidontes domingensis* to 70, *Lophosiphonia* sp. to 80, *Digenia* and polychaetes to 90. *Lithothrya* from 40 in the lower yellow sub-zone continued to 130 in the black zone.

Restricted to the upper yellow sub-zone were *Ceramium* sp. 50-60, *Fissurella barbadensis* 60-80, *Cittarium pica*, and *Brachidontes exustus* at 80. *Polysiphonia* sp. and *Lophosiphonia* sp. dominated this sub-zone together with *Digenia simplex*, *Anadyomene*,

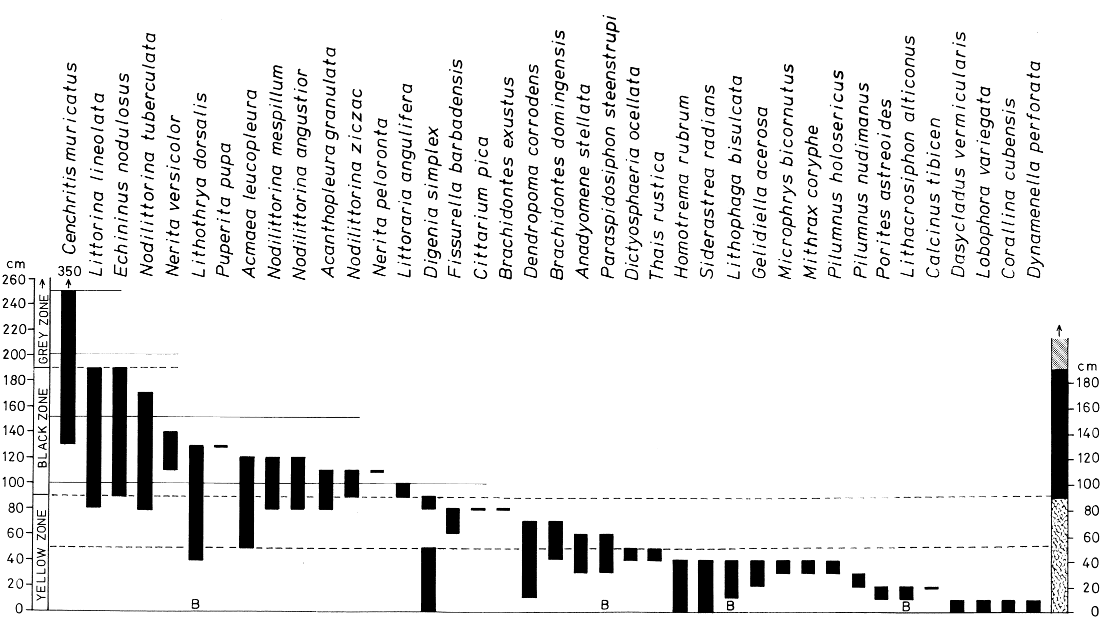


Fig. 42. Little San Salvador, West Bay, Stn 57-67, vertical distribution of the identified species. B = boring species.

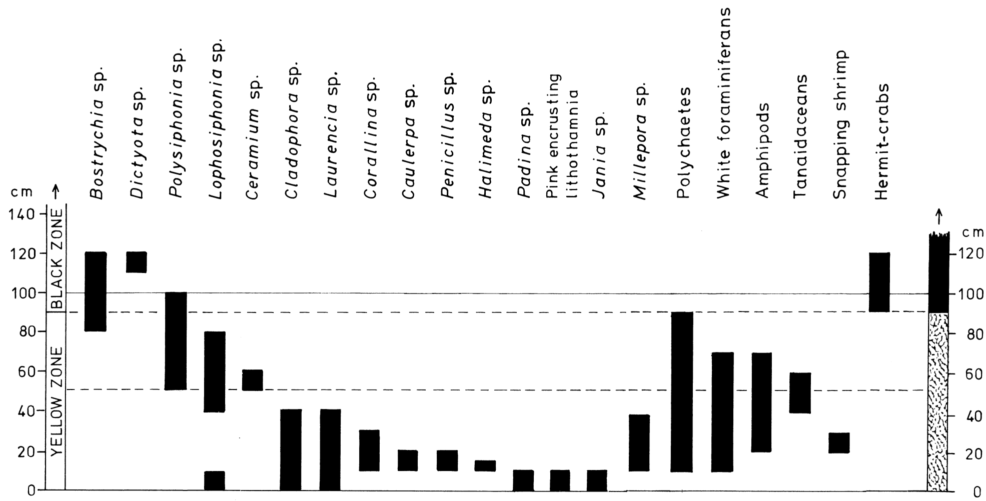


Fig. 43. Little San Salvador, West Bay, Stn 57-67, vertical distribution of not identified species.

Ceramium sp., and *Bostrychia* sp. and formed a yellow-brown fluff up to 80.

Of species with lower limit in the upper yellow subzone the following were found also in the black zone, *Polysiphonia* sp. 50-100, *Acanthopleura* with *Dynamenella* 80-110, *Bostrychia* sp. 80-120, *Acmaea* 50-120, *Nodilittorina mespillum* and *N. angustior* 80-120, *N. tuberculata* 80-170, and *Littorina lineolata* 80-90.

Restricted to the black zone were *Littoraria angulifera* 90-100, hermit-crabs 90-120, *Dictyota* sp. 110-120, *Nerita peloronta* 110, *Nodilittorina ziczac* 90-110, *Puperita pupa* 130, *Nerita versicolor* 110-140, and *Echininus* 90-190.

Cyanophyta, *Dictyota* sp. and, lowest down, *Polysiphonia* sp. formed an upper algal belt in the black zone, up to 120. Otherwise this zone was one of littorinids, in which no less than eight species were found, namely *Littorina lineolata*, *Littoraria angulifera*, *Nodilittorina ziczac*, *N. mespillum*, *N. angustior*, *N. tuberculata*, *Echininus*, and *Cenchritis*. A ninth species, *Nodilittorina meleagris*, was found in a rock pool at about 90 (not drawn). There also a young *Echinometra* was found, high above its normal level of occurrence. Only four of the littorinids occurred above 140, *Cenchritis* from 130-350, where it lived in bushes and trees, being the only species in the grey zone.

Horizontal distribution

Some species, especially those living lowest down, were found only in the outer part of the station, where the ledge was higher than farthest in and thus being less exposed to sand-scouring.

STN 87-67, GREEN CAY (ANDROS)

Rocks bordering a small, sandy bay in the southwestern corner of the Cay, 24°02'30"N, 77°10'55"W, 3 May 1967 (Fig. 44, insert).

Description of the station

The station faced the wide and deep Tongue of the Ocean but was nevertheless fairly well sheltered thanks to a bordering shallow reef flat.

In many respects this station wasn't like any other described in this and the previous paper (Brattström 1992). The rocks above 60 consisted of, thick, horizontal and fairly smooth layers, whereas the lower rocks, bordering the sea probably were beach-rock, partly covered by sand. The uncovered parts lay as islands in a sea of sand. Farthest out the sand had been washed away and the naked rock appeared as a dark band next to the sea (Fig. 46).

The highest point, about 360 cm, was found on the terrace, 3-4 m inland as measured from the front of the steep rock (Fig. 44). Inside the top the height of the cay decreased to about 300 cm, from where it became almost horizontal, here and there covered with sand and stones and with bushes (Fig. 45).

Methods

There were no corals at this station, and as zero was used the level where the outer slabs (Fig. 46) met the sea. The irregular shape of the rocks and the low number of species and specimens did not permit sampling in the usual detailed way. Collecting was instead made within five broad belts, –30 to 0, 0-30, 30-60, 60-150, and the area above. Since the locality could be only cursorily stud-

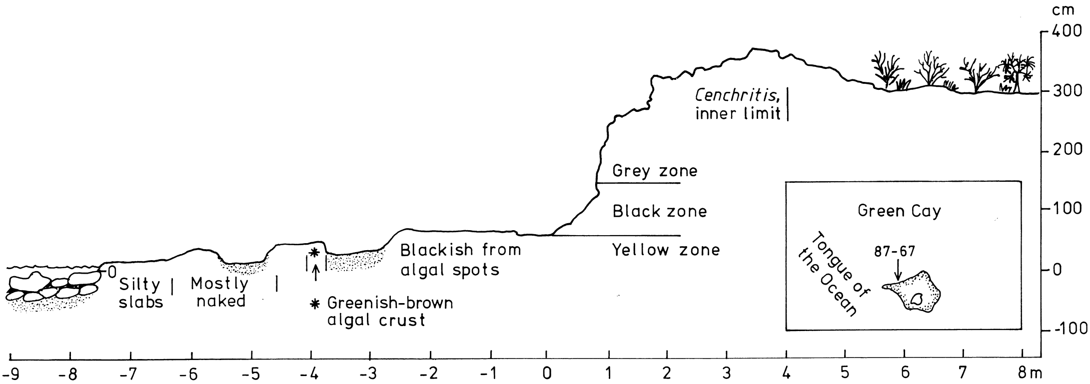


Fig. 44. Green Cay (Andros), cross-section of Stn 87-67. Insert map of Green Cay showing the site of the station.

ied, all that can be said with certainty is that the vertical order in which the species occurred is correct, and that errors in levels are not greater than 30 cm. Because of this uncertainty the bars in Fig. 47 are open.

Colour zones

Most of the lower parts of the rocks were covered by dark algae and the rocks themselves were dark, which made the limit between the yellow and black zones indistinct, except for some areas where the rock below about 60 had a little lighter colour than the area above. The zone limit probably is found at this level, which is supported by a fairly distinct species limit there (Fig. 47). At about 150 the black zone yielded to the grey.

Vertical distribution of the species (Fig. 47)

The fauna was very poor and most algae were dwarfed and sand-encrusted. The environment below the slabs was not sampled. The animal species were represented by one or a few specimens only, except for hermit crabs, which were numerous. The rocks in most parts of the wall and the terrace looked lifeless. The scarcity lowest down is probably due to sand scouring, whereas it is possible that the dark rocks, which will be above the sea for many hours a day, will be too hot for many algae and animals.

Because the species and specimens were so few, no distinct belts of algae and animals could be seen, but one could speak of an algal area in the yellow zone below about 60 and one of animals in the black zone. In one place some boulders far out were covered with a sand-encrusted mat of *Batophora oerstedi*, *Dictyosphaeria cavernosa*, *Digenia*, *Laurencia* sp., and also some *Dasycladus*, which here were reddish. Animals in the yellow zone were *Homotrema* on the boulders and some *Lithophaga* sp. The only common species were hermit-crabs, *Clibanarius*, in *Cerithium* shells, clumped together in hundreds on the tops of some boulders (Fig. 48).

In the black zone, between 60 and 150, the only algae found were some *Polysiphonia* sp., *Lophosiphonia* sp., and *Bostrychia* sp., and of animals *Chthamalus*, *Nerita versicolor*, *Nodilittorina tuberculata*, *Echininus*, and *Brachidontes domingensis*. A *Nerita tesselata* was taken near the yellow/black zone limit.

The only marine species recorded from the grey zone were *Cenchritis* between 220 and 300 and *Coenobita clypeatus* between 160 and 280 cm, some in shells of land snails. Shrubs and single palms and other land vegetation began to appear at a height of 300 cm, 4 m from the crest of the vertical rock.

STN 96-67, BEAK CAY

Rocks on the inner (east side) of the cay, 25°22'30"N, 79°11'30"W, 7 May 1967 (Fig. 49).

Description of the station

The southern part of the cay, where the station was located, was only 2-3 m high and about 50-100 m broad, with the narrowest part farthest south. The upper surface consisted of smooth, horizontal slabs in sand. The outer (west) side, facing the Florida Current, was heavily exposed, eroded, jagged and with many rock pools. Breaking waves prevented investigations on that side.

The inner side, facing the Great Bahama Bank, was less exposed but nevertheless the second most exposed of the nine stations. The shore rocks were steep with undercut areas alternating with more vertical ones (Fig. 51, insert B). At the foot the rocks were fairly smooth, whereas the higher parts were jagged. Outside the rock wall was a narrow area with polished, rounded stones and *Strombus* shells, and farther out sand with a *Thalassia* meadow.

Methods

An only slightly undercut part of the rock wall was chosen for investigation. No corals were found, but based

Fig. 45. Green Cay (Andros), Stn 87-67, seen from the sea. The area investigated was to the left of the small sandy bay.

Fig. 46. Green Cay (Andros), Stn 87-67, the lower part of the station with slabs in sand. Note the wide reef flat.

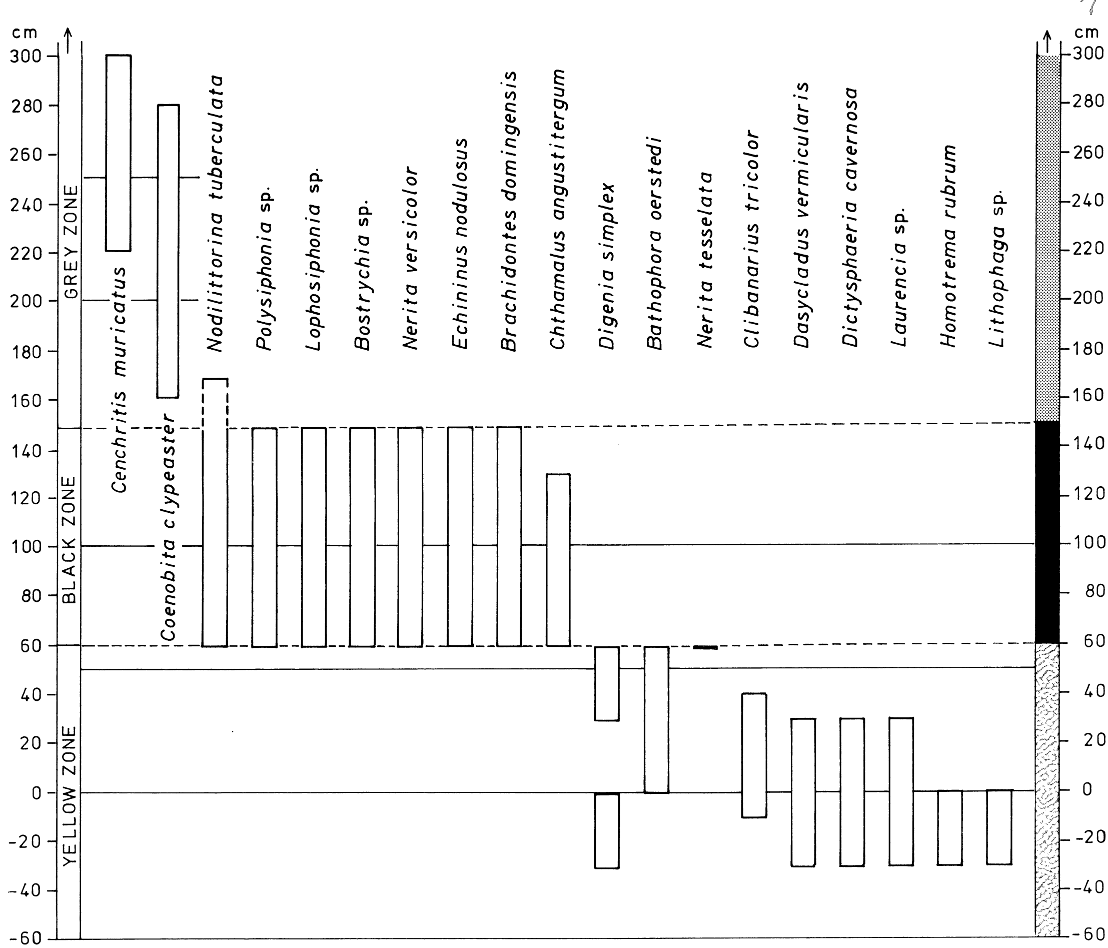


Fig. 47. Green Cay (Andros), Stn 87-67, vertical distribution of the species.

on the Tide Tables, the observed LW level 7 May, and the general impression of the shore, the zero was placed at the transition between the stones and the sand-bottom outside (Fig. 51).

Colour zones

A yellow, black and grey zone were well-developed, with zonal limits at about 125/130 and 230 (Figs 51, 52). The yellow zone went higher up in the undercut areas, because the waves there were pressed high up and became reflected seawards by the smooth underside of the overhangs (Fig. 51, insert C).

In the narrow southern part of the cay the waves from the exposed outer side broke heavily and sent wash and spray all over the cay (Fig. 50). As a result the black zone here covered the area across the cay. At the station the upper limit of the black zone was at about 230. Farther north the cay became higher and broader and a grey or rust-brown zone separated the black zones from both sides, that from the outside reaching farther in than that from the inner side (Fig. 51, insert A).

Vertical distribution of the species (Fig. 52)

The yellow zone can be divided in three sub-zones with limits at 60 and 90. The lower sub-zone was yellow-green or yellow-grey and polished smooth by the sea. Shells of *Dendropoma* made the surface of the middle sub-zone rugged and a little darker than the lower one. The upper sub-zone was smoother than the middle one and was less conspicuous than the two lower ones.

The lower yellow sub-zone was poor in species. It consists of a lower algal belt of short, slimy algal tufts, boring? polychaetes, *Phascolosoma antillarum* and, at the upper limit, sea anemones and a specimen of *Isognomon bicolor*.

The middle yellow sub-zone, 60-90, was especially rich in animals, some in great numbers. *Phascolosoma antillarum* occurred lowest down. Restricted to the sub-

Fig. 48. Green Cay (Andros), Stn 87-67, *Clibanarius tricolor* in shells of *Cerithium*.

zone were a red boring sponge, *Lithothrya*, *Chthamalus*, *Tetraclita*, *Nerita tesselata*, *Petaloconchus*, and *Dendropoma*, the sponge and *Tetraclita* being common. Other species in this sub-zone, also found in the upper, were sponges, *Acanthopleura* with *Dynamenella*, and *Acmaea*, all common, together with a specimen of *Siphonaria pectinata*, the only pulmonate found at the nine stations and the three beach-rock stations. *Geograpsus lividus* occurred in the whole yellow zone.

The upper yellow sub-zone, 90-130, was characterized in its lower half by *Acmaea* and *Acanthopleura* from the middle sub-zone. The latter species formed a belt between 90 and 110, where an upper algal belt had its lower limit, the upper being found at 150 in the black zone. At about 130 a *Nerita peloronta* occurred.

In the black zone the upper algal belt continued up to 150. It was formed by different kinds of unidentified algae, among them a *Bostrychia* sp.. The algae were larger and more common in crevices and under the overhangs. In addition the zone was totally dominated by littorinids, namely *Littorina lineolata*, *Nodilittorina ziczac*, *N. angustior*, *N. tuberculata*, *Echininus*, and *Cenchritis*. The latter occurred from 150 in the black to more than 250 in the grey, being the only species in the grey zone, about 10 m inland. It was especially common 5-6 m in. Land vegetation began about 6 m in and consisted of small succulent herbs, low bushes, and some *Opuntia*? sp. A great many *Gecarcinus lateralis* were found. The entrances to their burrows were found under bushes and lead into galleries, some dm long and 10 cm deep. The crabs were found in the inner end, where it was moist, whereas the surface of the sand was dry and burning hot.

The sand bottom outside the station

Among the algae were *Ventricaria ventricosa*, *Udothea* sp., *Penicillus* sp., and *Halimeda* sp., and among animals a snapping shrimp, *Calcinus tibicen*, *Percnon gibbesi*, *Ocypode quadrata*, *Calappa gallus*, *Morula nodulosa*, black brittle stars, *Eucidaris*, a brown-spotted *Holothuria* (*floridana*?), and a 50 cm long synaptid.

The outside (west) of the cay

All belts were here wider and occurred higher up than on the inner side. The chitons were bigger and the snails occurred in great quantities. *Nodilittorina tuberculata* was very common in rock pools. *Cenchritis* went farther inland, to over the midline of the cay (Fig. 51, insert A).

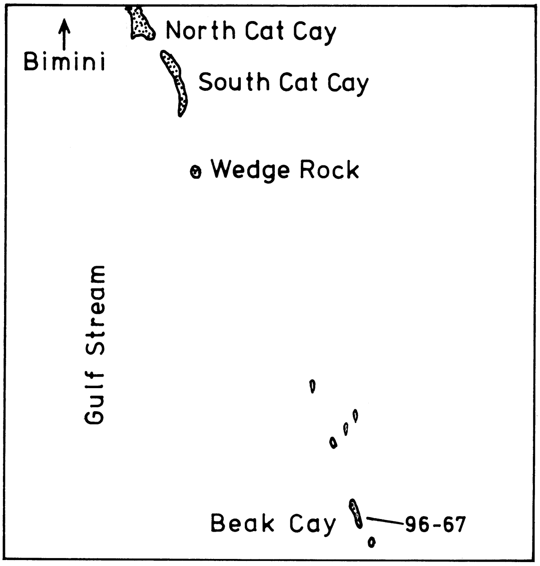


Fig. 49. Beak Cay, map showing the site of Stn 96-67.

SUMMARY, DISCUSSION, AND SUGGESTIONS

Number of species

The Appendix shows that 86 identifiable species were found, 15 algae and 71 animals. Table 1 shows the number of species found at the respective stations. Stn 57-67, Little San Salvador, West Bay, had the most varied flora and fauna, 44 species, followed by 96-67 and 48-67 with 32 and 29 species respectively. The high number of species at 57-67 is partly due to the fact that this station was studied both in 1967 and 1968. The stations with few species, 38-67, 41-67, and 53-67, were more or less undercut and couldn't be thoroughly investigated below the overhang, and 16-67 and 87-67 were partly covered by sand lowest down or, at least occasionally, exposed to sand scouring.

Not identified species

The number of algae mentioned above is but a fraction of those really present. In addition at least 22 species only identified to genus were found, all too small or underdeveloped to be determined to species. In addition were sampled some algae of a yellow-green colour and some others, which could not be determined even to genus. There were also many animals which could not be collected or determined. Notes on these are incomplete, but they are sometimes mentioned in the text or included in the figures. The numbers in the below list are station numbers in which the year 67 has been left out, thus 38 = Stn 38-67, etc.

Algae	Animals
Cladophora 38, 48, 57	White foraminiferans 38, 53, 57
Valonia 26	Various sponges 26, 41, 53, 96
Caulerpa 57	Sea anemones 26, 96
Avrainvillea 48	Polychaetes 26, 38, 46, 57, 96
Udothea, 96	Sipunculid of the family Golfingiidae 38
Penicillus 57, 96	Hermit-crabs 38, 57
Halimeda 48, 57, 96	Snapping shrimps 57, 96
Dictyota 48, 57	Isopods 38
Padina 41, 48, 57	
Cystoseira 48	
Sargassum 48	
Galaxaura 41	

Fig. 50. Beak Cay, southern tip, showing breakers from the outer side and a black zone from shore to shore. The station was situated a little to the right of the middle part of the figure.

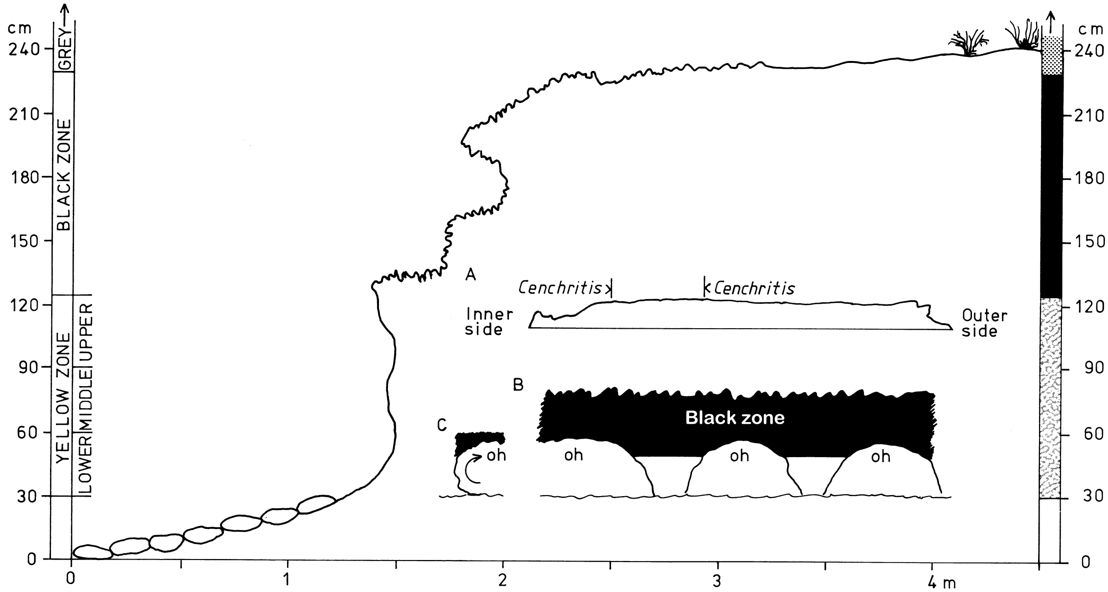


Fig. 51. Beak Cay, Stn 96-67, cross-section. Insert A shows that *Cenchritis muricatus* from the outer side crosses the middle part of the cay, whereas it on the inner sheltered side only goes a little inland. Insert B shows the undercut part where the station is located, and insert C how waves are pressed upwards undermining the shore. oh = overhang.

Corallina 57
Jania 48, 57
Catenella 38
Hypnaea 48
Ceramium 57
Taenioma 38
Polysiphonia 38, 57, 87
Bostrychia 26, 38, 41, 48, 53, 57, 87, 96
Lophosiphonia 38, 41, 48, 57, 87
Laurencia 38, 41, 48, 57, 87
Amphipods 57
Tanaidaceans 57
A grey vermetid
A flat patelloid or siphonarian 38
Lithophaga sp. 87
Oreaster sp. 41
Black ophiuroid 96
Spotted holothurian 26, 96
Great synaptid 96

Differences in species numbers at the beach-rock and vertical stations

Table 2 shows that a total of 16 identified algae and 145 animal species was found at the two groups of stations. The three beach-rock stations had 11 algal and 124 animal species, the nine vertical stations 15 algae and only 71 animals. Fig. 13 in Part 1 shows that 68 of the 124 animals at the beach-rock stations, thus about half the species, were taken at one station only. At the vertical stations the corresponding numbers were 71 and 34.

There were thus no great differences in numbers of algae, 11 and 15 respectively, between the two groups of stations, whereas animal numbers differed much, the three beach-rock stations having about twice as many species, 124, as the nine vertical stations with only 71.

The reason for this difference in numbers is mainly a question of station size. The beach-rock stations were much larger than the vertical ones. They were gently sloping and a height of for instance 100 cm wasn't found until 10, 21, and 24 m inland from the zero line. Since the strips investigated were 4, 4, and 9 m broad respectively, the total areas between zero and 100 cm were 40, 84, and 216 m^2 respectively.

In contrast the 100 cm level at the nine vertical stations was found more or less vertically above the zero line. Because of that the surface of each of the stations was only a few m^2, at most 10 m^2 at 16-67 and 15 m^2 at 48-67. Under such conditions it is only natural that the number of species at the vertical stations is relatively low as compared to the relatively flat beach-rock stations with their large areas. These were also much easier to investigate than the vertical ones, where it often could be difficult to get a secure foothold when working and therefore easy to overlook some species.

The difference in numbers between the two types of stations is thus deceptive and would have been smaller, had the vertical stations had a surface area corresponding to that of the beach-rock stations. However, even considering the different size of the stations, there no doubt is a real difference in numbers between the two groups of stations. This is a result of differences in the biotopes, such as topography, subterranean cavities, and exposure to the sea and the sun.

Differences in systematic composition of algae and animals at the two groups of stations

Table 3 shows the systematic composition of the fauna at the two types of stations. Some are of special inter-

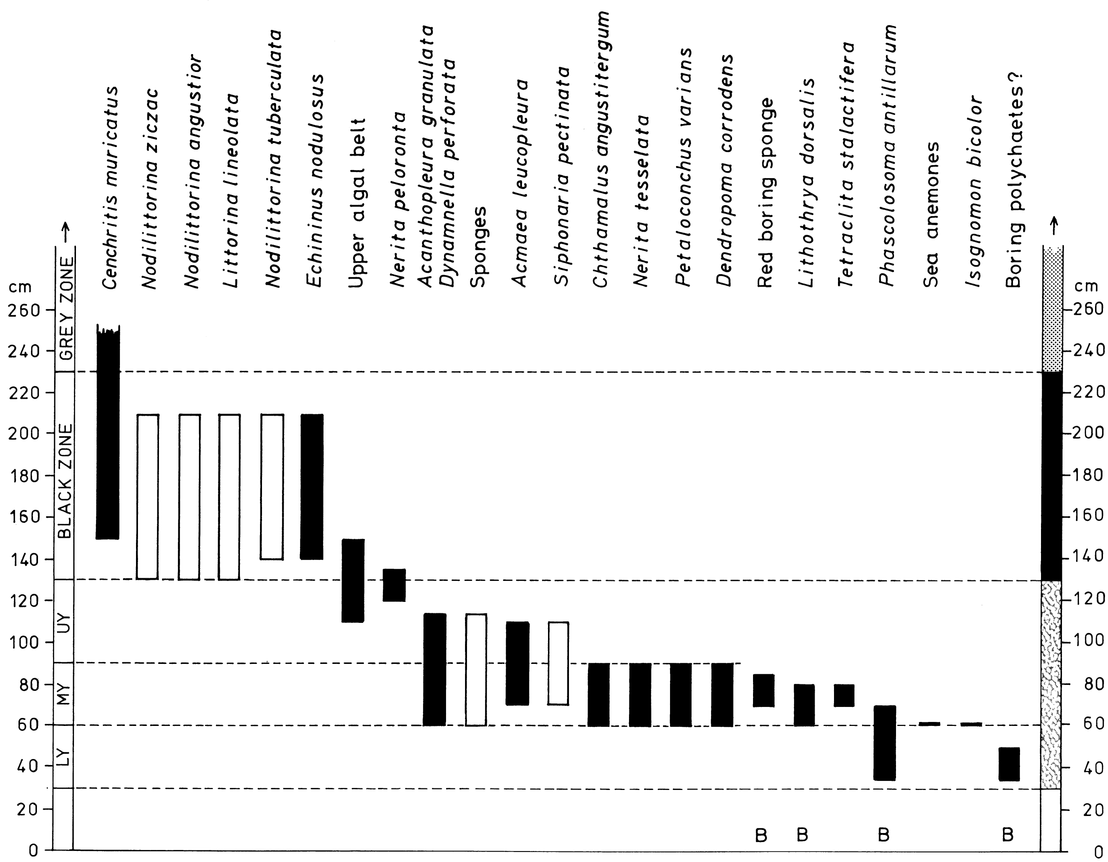


Fig. 52. Beak Cay, Stn 96-67, vertical distribution of the species. B = boring species.

est. At the beach-rock stations three Stomatopoda, five Ophiuroidea, and two Tunicata were found, taxa not represented by identified species at the vertical stations. Boring organisms of different taxa were mainly found at the beach-rock stations, which probably is due to softer rocks at these stations.

Other groups were overrepresented at the beach-rock stations, for example 11 Anthozoa (corals) against 8 at the vertical stations, 7 Sipuncula against 4, 12 Anomura against 4, 35 Prosobranchia against 23, 17 Bivalvia against 6, and 13 Echinodermata against 3.

Since the beach-rock stations had relatively many species it was astonishing to see how barren they looked, especially Stn 12-67, which also had the lowest number of species of the three. The reason for this poverty was that the rocks, because of their flatness, at low tide were exposed to the hot midday sun, 35 °C being measured on the surface of Stn 12-67, when the tide was out and the rocks bare and conditions simply became too unfavorable for algae.

Also many animals were prevented from living on the surface of the rocks because of the high temperature, but if the beach-rock slabs were broken up a network of cavities was disclosed below the slabs. In this cavity system, in which algae cannot grow because of lack of light, was a rich animal life far inland and high

Table 1. Number of identified species found at the nine stations.

Stn no.	16-67	26-67	38-67	41-67	48-67	53-67	57-67	87-67	96-67
Algae	-	1	3	2	7	5	8	4	1
Animals	18	22	11	12	22	12	36	11	31
Total	18	23	14	14	29	17	44	15	32

Table 2. Number of identified species at the three beach-rock and nine vertical stations.

Number of algae only taken at the beach-rock stations	1	11
Number of algae taken at both types of stations	10	
Number of algae only taken at the vertical stations	5	15
Total	16	
Number of animals only taken at the beach-rock stations	74	124
Number of animals taken at both groups of stations	50	
Number of animals only taken at the vertical stations	21	71
Total	145	

up. Even the high number of animals registered from these stations is a minimum number, because some species, especially crabs, escaped when the slabs were removed.

At the beach-rock stations the algae thus were the losers. Of the 12 species found, 7 were in fact not taken in the stations but from the innermost part of the reef-flat, which practically always is covered with water.

Factors determining the zonation of algae and animals

The vertical distribution of the shore organisms is the result of a combination of physical and biological factors.

Physical factors

The tides play a primary role for the establishment of the coloured zones and the belts of species on the shores. However, if tides were the only factor responsible for the zonation pattern, this would be about the same at all stations in the same area, the only difference being that the populated areas would be wider and found at higher level the greater the tidal amplitude is.

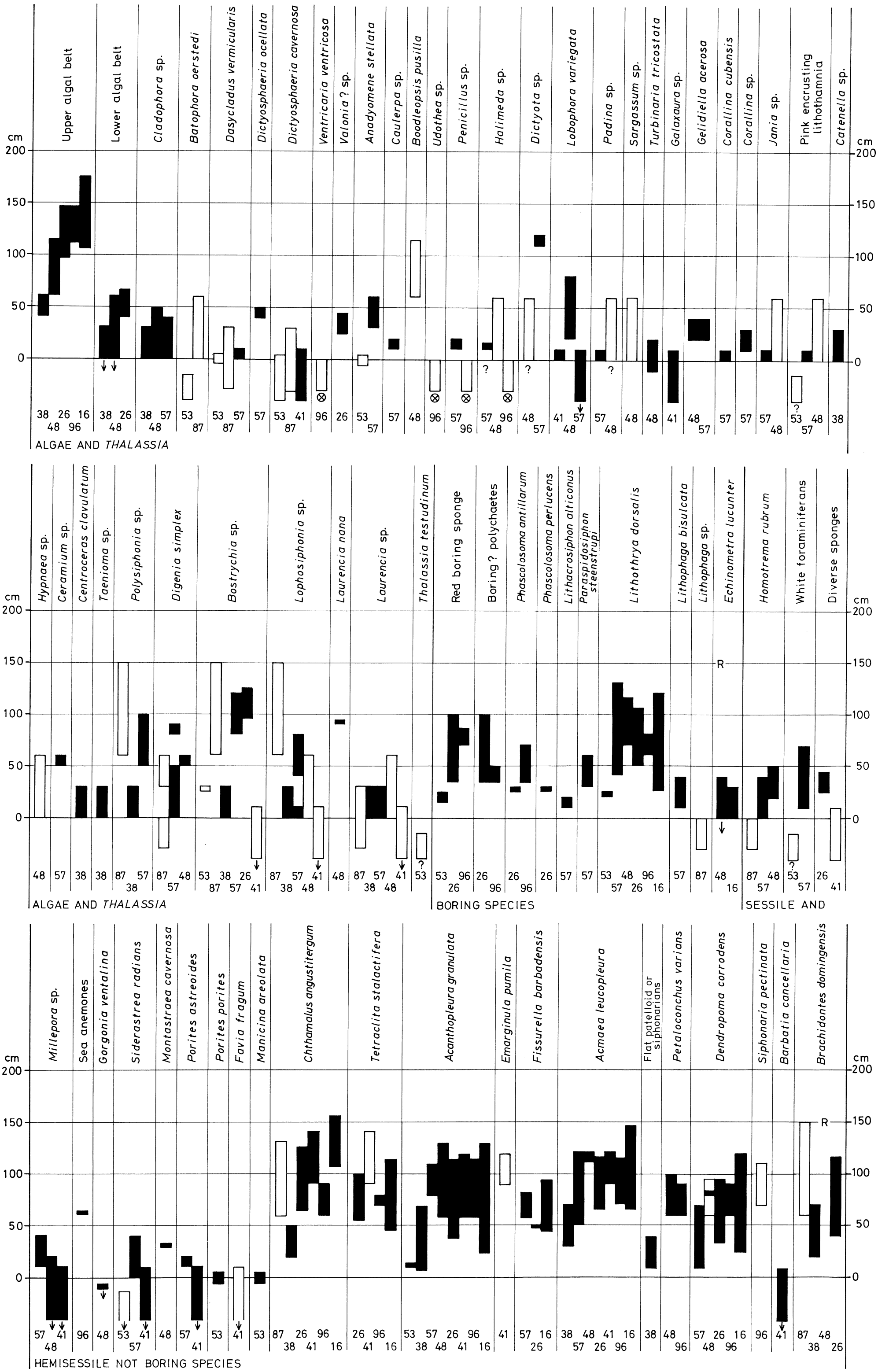
Another decisive factor for the vertical distribution of the species is exposure, the lowest common denominator for wind, waves, splash, and spray. It acts in the same way as the tides. The best indicator of the degree of exposure is the organisms themselves. The higher up on the shore they live, the more exposed the locality. Since each species has its own demands on the environment there are many lower and upper limits on the shore, but because many species stop at the same level, more or less distinct parallel belts develop. Most important is the limit between the yellow and black zones, a limit which is often very distinct. Because it marks a change in colour it is a good reference line. In the lower right corner of Fig. 53 the stations are ordered after the height at which the yellow/black zone limit was found, from 25 cm at the very sheltered Stn 53-67 to 150 cm at the most exposed Stn 16-67. The figure also shows that some stations were too low for a grey zone above the black. Accordingly some species don't reach as high up as they could, had the rocks been higher. Fig. 13 is a good example.

Together tides and exposure are responsible for the general zonation pattern. Other physical factors, often hard to disclose, cause deviations in the general pattern. One important such factor is sand-scouring, which can be decisive for the lower limit of both algae and animals. Another factor is the nature of the rocks. Most borers are found in soft rocks. Such rocks also often

Table 3. Number of species recorded at the three beach-rock stations described in Part 1 and the nine rocky stations in this paper.*

Taxon	Part 1	Part 2
Algae		
Chlorophyta	8	7
Phaeophyta	1	2
Rhodophyta	3	6
Animals		
Protozoa	1	1
Porifera	1	1
Hydrozoa	1	1
Anthozoa	11	8
Sipuncula	7	4
Cirripedia	2	3
Decapoda Natantia	2	1
Decapoda Anomura	12	4
Decapoda Brachyura	14	12
Isopoda	3	1
Stomatopoda	3	0
Insecta	1	1
Polyplacophora	2	1
Prosobranchia	35	23
Pulmonata	0	1
Bivalvia	17	6
Ophiuroidea	5	0
Echinoidea	5	2
Holothurioidea	3	1
Tunicata	2	0
Number of algae	12	15
Number of animals	127	71
Total number of species	139	86

* The pink encrusting algae, the boring sponge, *Millepora*, and snapping shrimps were not counted in Part 1 but are counted here.


cm
200
150
100
50
0
Upper algal belt
Lower algal belt
Cladophora sp.
Batophora oerstedi
Dasycladus vermicularis
Dictyosphaeria ocellata
Dictyosphaeria cavernosa
Ventricaria ventricosa
Valonia? sp.
Anadyomene stellata
Caulerpa sp.
Boodleopsis pusilla
Udothea sp.
Penicillus sp.
Halimeda sp.
Dictyota sp.
Lobophora variegata
Padina sp.
Sargassum sp.
Turbinaria tricostata
Galaxaura sp.
Gelidiella acerosa
Corallina cubensis
Corallina sp.
Jania sp.
Pink encrusting lithothamnia
Catenella sp.
ALGAE AND THALASSIA
Hypnaea sp.
Ceramium sp.
Centroceras clavulatum
Taenioma sp.
Polysiphonia sp.
Digenia simplex
Bostrychia sp.
Lophosiphonia sp.
Laurencia nana
Laurencia sp.
Thalassia testudinum
Red boring sponge
Boring? polychaetes
Phascolosoma antillarum
Phascolosoma perlucens
Lithacrosiphon alticonus
Paraspidosiphon steenstrupi
Lithothrya dorsalis
Lithophaga bisulcata
Lithophaga sp.
Echinometra lucunter
Homotrema rubrum
White foraminiferans
Diverse sponges
ALGAE AND THALASSIA
BORING SPECIES
SESSILE AND
R
Millepora sp.
Sea anemones
Gorgonia ventalina
Siderastrea radians
Montastraea cavernosa
Porites astreoides
Porites porites
Favia fragum
Manicina areolata
Chthamalus angustitergum
Tetraclita stalactifera
Acanthopleura granulata
Emarginula pumila
Fissurella barbadensis
Acmaea leucopleura
Flat patelloid or siphonarians
Petaloconchus varians
Dendropoma corrodens
Siphonaria pectinata
Barbatia cancellaria
Brachidontes domingensis
HEMISESSILE NOT BORING SPECIES

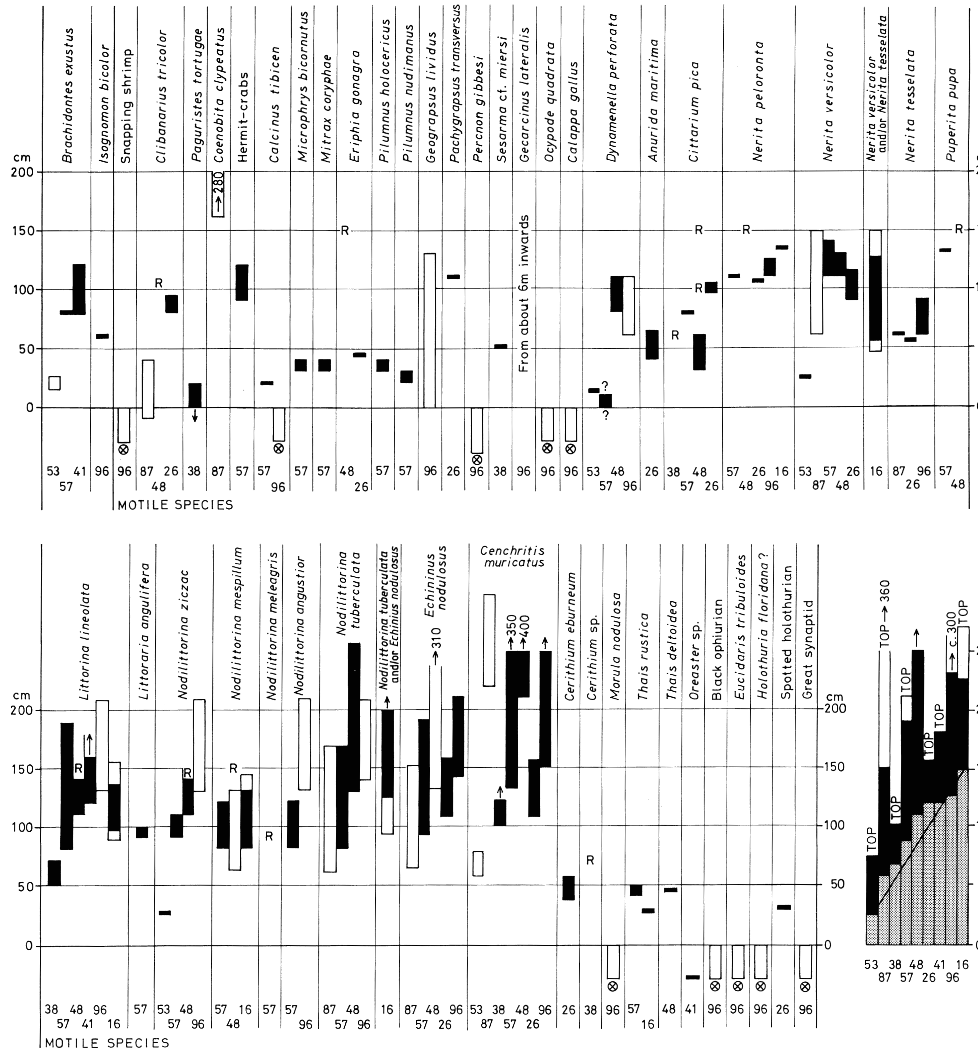


Fig. 53. Summary of the vertical distribution of the species. Black bars show the distribution of the respective species, white bars the areas somewhere within which the species were taken without notes made on exact level. In the lower right corner the stations are ordered with the least exposed to the left, the most exposed to the right. Grey colour = the yellow zone, black = the black zone, and white = the grey zone. Stations marked TOP were too low to permit a grey zone to develop. At such stations the upper limit for some species would have been found higher up if the rocks had been higher

have many holes, fissures, and rock pools, which are water-filled, wet or humid, even when the tide is low and the surrounding rock dry. In such mini-biotopes many algae and animals can live at higher levels than on smooth rock. In rock pools organisms are often found high above their normal level of occurrence (cf. Fig. 36).

Spiky rocks (cf. Fig. 6) offer shelter and hiding-places for some animals, at the same time preventing others from living there (and biologists from walking and working there). A species can have different upper and lower limits in different parts of a station. This dependency on local variations in the substrate sometimes makes it difficult to find out where to place upper and lower limits of the species. Especially Figs 14 and 21 show how the limits can vary within a station.

An important factor on the shore is the temperature. Whereas a vertical rock may lie in shadow all day, a flat or sloping rock is constantly exposed to the sun, which in many cases makes the rock surface too hot for algae and animals. The beach-rock stations were of this type. In such cases the occurrence of holes and rock pools permits two different groups of organisms to live side by side at the same level, though in different mini-biotopes.

Biological factors

The time available for studying biological factors was too short, but there is little doubt that also competition, predators, available food, ways of food-intake, and other biological factors play a decisive role for the distribution and zonation of algae and animals on the shore.

The intertidal algae and animals risk drying when the sea ebbs and the rocks become exposed to air. How high up the respective species can live depends on their capacity for enduring dry periods and finding adequate food. Algae and softskinned animals are the most vulnerable. Since the algae are fixed, most are found low down on the shore, where splash and spray keep them wet for long periods. There is a sharp contrast between the rich lower and the poor upper algal belt.

Animals with soft skins such as the sessile sponges, sea anemones, corals, and echinoderms have partly the same problems as the algae. They are all forced to live at low levels, and the red boring sponge and other borers as the Sipuncula, *Lithothrya*, and *Lithophaga* are restricted to the yellow zone, mostly its lower half. Higher up their holes probably would dry out at LW.

The snapping shrimps and most hermit-crabs and crabs also keep to the yellow zone, though at least some crabs occasionally are found higher, some of them being more terrestrial than marine. Small crustaceans, like amphipods and isopods are tied to the algae of the lower algal belt. Other motile animals, which cannot find wet or humid crevices and holes in which to hide when the sea withdraws, are forced to live low down on the shore.

One would expect also the sessile animals to live low down where the substrate never dries completely and where most food is available, but on the contrary most species were found in the upper part of the yellow zone, *Chthamalus* even in the black. This species and *Tetraclita* can live that high up because they can close their shells and keep water captured inside these when the water withdraws.

The reason why the Cirripedia nevertheless cannot live highest up in the littoral is their way of food-intake. They skim the water for plankton with help of their cirri, and that is possible only when the body from time to time is covered with water. The reason why they are not found lowest down, where they would be covered for longer periods, can possibly be because the water movement there often is heavier, making the cirri less effective. Sand-scouring may be another reason. There is a similar problem regarding the sessile prosobranchs *Petaloconchus* and *Dendropoma*. Their way of catching food from the water with help of mucus, forces them, too, to live so low down that they are covered by water for a reasonable time, that means in the yellow zone, but like the barnacles not in the lowest part of the zone.

Acanthopleura and the hemisessile prosobranchs *Emarginula*, *Fissurella*, and *Acmaea* are mainly found in the upper half of the yellow zone, *Acanthopleura* and *Acmaea* occasionally also in the black. They, too, thus seem to avoid the lowest half of the zone.

The motile neritids and littorinids are the only groups which occupy the black zone, some also the grey. Since they meet no competition for food in these zones their numbers can be great. When the rocks become dry they fix themselves tightly to the substrate waiting for the next flood, thus being without food for a considerable time each tidal period.

Character species

When comparing the levels at which a species lives at different stations, levels expressed in cm cannot be used. For example six common fixed animal species at the very exposed Stn 16-67 had 5-35 cm higher upper limits than at the less exposed station 26-67 nearby. Nevertheless the six species at both stations occurred at the same relative level above zero, a level with the same degree of exposure.

As each species only is found where its special demands on the environment are met with, it is characteristic of just that level on the shore, but only a limited number of algae and animals taken at the nine stations can be used as character species, namely common and widespread species which through their size, shape, colour, and frequency are easy to observe and which set their mark on the level at which they occur.

Microalgae are probably good character species, but their rôle can not be discussed here. Such species were noted at some stations but could not be collected.

The following 17 species comply with the requirements for character species (numbers in brackets show number of stations at which the respective species were found).

Dasycladus vermicularis (4)
Lithothrya dorsalis (6)
Chthamalus angustitergum (6)
Tetraclita stalactifera (4)
Acanthopleura granulata (8)
Acmaea leucopleura (7)
Cittarium pica (4)
Nerita peloronta (4)
Nerita versicolor (6)
Nerita tesselata (4)
Littorina lineolata (6)
Nodilittorina ziczac (4)
Nodilittorina tuberculata (5)
Echininus nodulosus (6)
Cenchritis muricatus (8)
Dendropoma corrodens (5)
Brachidontes domingensis (4)

The species marked with an asterisk are sessile or borers. *Acanthopleura* and *Acmaea* are motile but don't make long excursions. The remaining nine species are more motile but nevertheless don't roam over wide areas. *Dynamenella* was found in the mantle grooves of *Acanthopleura* but is not treated as character species of the levels, where *Acanthopleura* was found, because it, according to Brattegard (1968), cannot be excluded that *Dynamenella* also may live at other levels apart from the chitons.

The belts and their species

The Tropic of Cancer crosses the Bahama Islands. The sea is warm, the sun hot, and at many places the shores are so sheltered that they not always become exposed to waves and splash. Therefore the flora and fauna of such shores are relatively poor, especially on the higher parts of the shore, which at LW will be too dry and hot. Life is thus concentrated to the lower levels which are covered by the sea or kept wet from wash and spray at least part of the day.

Alone or together algae and animals by their colour, shape, and frequency often constitute more or less distinct belts on the shore, mostly in the yellow zone. Fig. 34 from Chub Rock, Stn 48-67, is a good example of distinct belts, showing a well-developed algal belt lowest down, above which the holes of *Lithothrya* show another distinct belt.

If no belts are seen, this doesn't mean that the rocks are barren. Bar graphs will often show that belts really occur. The belts are Nature's response to the environment, in this case the degree of exposure. Species with the same demands occur at the same level and form a common belt.

At most stations two algal belts were seen, a lower one in the lower part of the yellow zone, and an upper, often indistinct algal belt in the upper part of the yellow zone and in the black. When the lower algal belt was fully developed it was rich in species, also of animals, and very characteristic. At most stations *Dasycladus vermicularis* was a character species. Of other algae *Dictyosphaeria cavernosa*, *Anadyomene stellata*, *Lobophora variegata*, pink encrusting lithothamnia, and *Digenia simplex* were taken at three stations, *Batophora oerstedi* and *Gelidiella acerosa* at two, and *Ventricaria ventricosa*, *Dictyosphaeria ocellata*, *Boodleopsis pusilla*, *Turbinaria tricostata*, *Corallina cubensis*, *Centroceras clavulatum* and *Laurencia nana* at one. Cyanophyta and unidentified species of *Cladophora*, *Valonia*, *Caulerpa*, *Avrainvillea*, *Penicillus*, *Halimeda*, *Dictyota*, *Padina*, *Cystoseira*, *Sargassum*, *Galaxaura*, *Jania*, *Catenella*, *Hypnea*, *Polysiphonia*, *Bostrychia*, *Lophosiphonia*, and *Laurencia* occurred, too.

The lower algal belt

The composition and appearance of this belt varied from station to station depending on which species were present. Where the rocks dropped steeply into the sea the belts were colourful (see Fig. 34), when bordering directly on the sand-covered reef-flat the algae often were heavily sand-encrusted (Fig. 4). At such stations the lover algal belt is a continuation of the algal community on the innermost part of the reef-flat. Overlapping with animal belts sometimes appeared confusing. The animals within a belt could dominate, but also in such cases bar graphs will reveal whether the algae were belt-forming or not. Later, when the algae of the year have grown up, they perhaps will dominate.

There was no lower algal belt at Stn 16-67. The lower part of the rocks were temporarily covered by sand, and the area above the sand was exposed to sand-scouring. – At 26-67 the belt was characterized by a mat of greenish and brownish algae, one probably being *Dasycladus*, the other a species of *Valonia*. – At 38-67 the belt consisted of a fine felt of filiform Cyanophyta and at least ten species of sand-encrusted higher algae, among them *Anadyomene* and *Centroceras clavulutum*. – At 41-67 the belt was characterized by two species of brown, branched algae and a few others, forming a distinct lower algal belt.

Stn 48-67 had a well-developed brownish lower algal belt with a dense growth of *Lobophora variegata*, *Turbinaria tricostata*, *Gelidiella acerosa*, and many other algae (see Fig. 34, lowest part). – At 53-67 the rock was heavily undercut (Figs 38, 39) with sand below the overhang. *Dasycladus* and a few other species were found, but there was no distinct lower algal belt. – Stn 57-67 had one of the best developed algal belts with a great many species, both identified and unidentified ones. Characteristic were pink encrusting lithothamnia and a number of small heavily sand-encrusted algae, giving the belt a yellowish colour. – At Stn. 87-67 the species in the lower part of the yellow zone were very few. No lower algal belt was developed. – At Stn 96-67 small slimy algae represented the lower algal belt.

The upper algal belt

This belt was found uppermost in the yellow and in the black zone. It was much poorer in species than the lower algal belt but was nevertheless often distinct.

At Stn 16-67 an unidentified alga of yellow-green colour formed an upper algal belt. No other algae were observed. – At 26-67 the belt was poorly developed, one of its species being a *Bostrychia* sp. – The belt at 38-67 was indistinct and represented by scattered spots of unidentified species inbetween the few animals. – The upper algal belt at 41-67 was characterized by a brown crustlike alga. – At 48-67 was an ill-defined light-green upper algal belt in the upper yellow sub-zone, consisting of a.o. *Boodleopsis pusilla*, *Lobophora variegata*, and *Laurencia nana*.

The only alga at 53-57 was a *Bostrychia* sp. in the black zone. – 57-67. *Anadyomene stellata* and *Digenia simplex* were found in the upper part of the yellow zone, together with several unidentified species, among them a *Bostrychia* sp. They formed a yellow-brown fluff in the black zone. Cyanophyta were noted in the black zone. – 87-67. The species were few and no distinct upper algal belt was seen. Uppermost in the yellow zone *Batophora oerstedi*, *Dasycladus* (also found in the lower part of the yellow zone), *Dictyosphaeria cavernosa*, *Digenia simplex*, and some unidentified species characterized the upper part of the yellow zone. In the black zone some Rhodophyta, among them a *Bostrychia* sp., constituted an indistinct upper algal belt. – 96-67. A *Bostrychia* sp. and some unidentifiable species formed an indistinct upper algal belt.

The above description of the two algal belts has its weak points. The stations had different size, the working conditions varied, and the time at disposal was not the same at all. Nevertheless there were real differences between the stations, but which factors are responsible for the differences cannot be stated from the available data. It seems without doubt, however, that the macroalgae, probably also the microalgae, mainly occur at two different levels on the shore, the lower being fairly rich in species, the upper with a few. A *Bostrychia* sp. often occurred at both levels.

The animals of the different zones and sub-zones

At Stns 53-67 and 87-67 the yellow zone could not be subdivided, in 38-67, 41-67, 48-67, and 57-67 it was divided in a lower and an upper sub-zone, and in 16-67, 26-67, and 96-67 in a lower, a middle, and an upper sub-zone. I will here only speak of a lower and an upper part of the yellow zone. This is justified because no alga and only five animals, all from 96-67, were found exclusively in the middle yellow sub-zone. At the other stations these species were found in the middle or upper yellow sub-zone or both, with some records also from the lower yellow sub-zone, at Stn 87-67 even from the black zone.

In the following description the species occurring in more than one zone or sub-zone are marked with an asterisk after the name in that zone or sub-zone, in which they dominated.

Lower part of the yellow zone

Character species were: *Lithothrya**, *Chthamalus**, *Tetraclita*, *Acanthopleura*, *Dendropoma*, and *Brachidontes domingensis*. Other important species at this level were: *Homotrema*, a red boring and other sponges, *Millepora* sp., corals*, *Phascolosoma antillarum*, *P. perlucens*, *Lithacrosiphon alticonus*, and *Paraspidosiphon steenstrupi*, snapping shrimps, a dozen hermit-crab and crab species, amphipods, isopods, *Dynamenella*, *Anurida maritima*, *Fissurella*, *Cittarium*, *Nerita tesselata*, *Cerithium eburneum*, *Thais rustica*, *T. deltoidea*, *Barbatia cancellaria*, *Lithophaga bisulcata*, *Isognomon radiatus*, *I. bicolor*, *Echinometra*, and a spotted holothurian.

Upper part of the yellow zone

Character species here were: *Lithothrya**, *Chthamalus**, *Tetraclita**, *Acanthopleura**, *Acmaea**, *Cittarium**, *Nerita peloronta**, *N. versicolor*, *N. tesselata*, *Littorina lineolata*, *Nodilittorina mespillum*, *Echininus*, *Cenchritis*, *Dendropoma**, and *Brachidontes domingensis**. A red boring sponge, *Paraspidosiphon steenstrupi*, *Dynamenella**, *Emarginula pumila*, *Fissurella*, *Nodilittorina mespillum**, *Petaloconchus**, and *Brachidontes exustus* were also found.

The black zone

Chthamalus, *Acanthopleura*, *Acmaea*, *Nerita peloronta*, *N. versicolor**, *N. tesselata*, *Littorina lineolata**, *Nodilittorina ziczac*, *N. angustior*, *N. tuberculata**, *Echininus**, *Cenchritis** and *Brachidontes domingensis* were character species.

Other species in the zone were *Dynamenella*, *Puperita*, *Littoraria angulifera*, *Nodilittorina mespillum*, *N. meleagris* (in a rock pool), and *N. angustior*.

The grey zone

Nodilittorina tuberculata, *Echininus*, and *Cenchritis* were the only character species. The hermit-crab *Coenobita clypeatus* and the crab *Gecarcinus lateralis* were common.

Suggestions for future littoral investigations

Since the overall plan for the cruises demanded that as many places as possible were visited in the time available, only a few hours could be spent at some of the nine stations visited. The exact places for carrying out the different projects were not determined in advance, only the area which each cruise should cover. We stopped on the way where we found good conditions for the different types of research. In this way I succeeded in finding some suitable localities, among them the nine "stations" treated in this paper and the three described in Part 1. I of course missed the opportunity to make preparations for the work at the different stations, and I should have liked to have more time for studying somewhat larger stations in order to minimize the risk of overlooking species. As a result my investigations thus came to fall in the first type of littoral research suggested by Lewis (1964), namely less detailed but widespread investigations of whole coast-areas.

My experience from littoral studies e.g. in Chile, Colombia, Panama, the Bahamas, and from the literature, has convinced me that the other type of investigations mentioned by Lewis, namely more detailed investigations of small areas, is desired. The reason why such studies are so few no doubt is that they cannot be carried out by just anybody. They are time-consuming and need teamwork and can best be carried out from a laboratory which can contribute with transportation, working place, equipment, and assistance.

In earlier littoral investigations the microalgae on the rocks were not or only to a small degree considered, in spite of the fact that these algae seem to be good and perhaps even better character species of the different levels on the shore than the higher algae and the animals. In many places colour changes in the rocks, sometimes very distinct, at other times only visible under special light conditions, indicate the existence of different zones, characterized by various microalgae. These are in fact the only organisms which characterize the zones in the upper parts of the shores where higher algae and animals are missing. Rock samples with microalgae ought always to be taken and the conditions illustrated by colour photographs (cf. the figures in Brattström 1980).

Since flora and fauna changes during the year, repeated investigations are necessary to get a true picture of the normal conditions. Studies of littoral zonation are thus very time-consuming and benefit from teamwork.

ACKNOWLEDGMENTS

I am deeply indebted to the late Dr. R. Mathewson, the then director of the Lerner Marine Laboratory, Bimini, and members of the Committee for the Survey of the Bahamas, for the invitation to Norwegian marine biologists to take part in the survey and for letting us use the R/V *James A. Oliver* one month each of the years 1967 and 1968. The survey was made possible by a grant ONR 552 (07) from the Office of Naval Research to the Bimini laboratory (Smith 1965), and travel grants from the Norwegian Research Council for Science and the Humanities.

This paper hadn't been possible to write without the unselfish help from many specialists in identifying the collections. I am especially in debt to the late Professor Egil Baardseth who offered much work in trying to identify the algae, most of which were too young to be identified to species. The animals were determined by the many specialists acknowledged in Part 1. I thank them all once again. For this paper Tore Høisæter and Tor Eiliv Lein have helped me with some nomenclature problems. I am extremely grateful to Mrs. Elin Holm for the many time-consuming and excellent drawings, and to Göran Brattström for correcting most of my English, and to two referees who have improved the MS considerably.

I also once again thank the crew of the R/V *James A. Oliver* for all help on board, and my colleagues and friends Torleiv Brattegard, Audun Fosshagen, Tore Høisæter, Tor J. Samuelsen, Thomas Schram, and the late Per Svendsen for their assistance in the field and the laboratory and not least for extraordinary good comradeship.

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Accepted 25 March 1999 – Printed 30 December 1999
Editorial responsibility: Ulf Båmstedt

Appendix. Algae and animals identified to species (+ four only determined to a higher taxon) found at the nine stations. Other organisms only determined to genus or a higher taxon are mentioned in the description of the zonation at the respective stations. The station numbers are abbreviated, the year 1967 being left out (16 thus = 16-67). * marks species which in the text usually are mentioned only with the generic name. L stands for the lower and U for the upper yellow sub-zone, B for the black, and G for the grey zone. R = species only taken in rock-pools above their normal level of occurrence, and S species taken just outside the zero line, most often in sand or on stones in sand. The collections are kept in the Zoological Museum in Bergen, Norway.

Species and (in brackets) number of each taxon / Station no.	16	26	38	41	48	53	57	87	96	L	U	B	G
CHLOROPHYTA (7)													
Batophora oerstedi J. Agardh	-	-	-	-	-	+	-	+	-	+	+	-	-
Dasycladus vermicularis (Scopoli) Krasser*	-	+	-	-	-	+	+	+	-	+	+	-	-
Ventricaria ventricosa (J. Agardh) Olsen & J. West	-	-	-	-	-	-	-	-	+	+	-	-	-
Dictyosphaeria ocellata (Olsen & Stojkovich)	-	-	-	-	-	-	+	-	-	+	-	-	-
Dictyosphaeria cavernosa (Forsskål) Børgesen	-	-	-	+	-	+	-	+	-	+	+	-	-
Anadyomene stellata (Wulfen) C. Agardh	-	-	+	-	-	+	+	-	-	+	+	-	-
Boodleopsis pusilla (Collins) Taylor, Joly & Bernatowicz	-	-	-	-	+	-	-	-	-	-	+	-	-
PHAEOPHYTA (2)													
Lobophora variegata (Lamouroux) Womersely	-	-	-	+	+	-	+	-	-	+	+	-	-
Turbinaria tricostata Barton	-	-	-	-	+	-	-	-	-	+	-	-	-
RHODOPHYTA (6)													
Gelidiella acerosa (Forsskål) Feldmann & Hamel	-	-	-	-	+	-	+	-	-	+	-	-	-
Corallina cubensis (Montagne) Kützing	-	-	-	-	-	-	+	-	-	+	-	-	-
Pink encrusting lithothamnia	-	-	-	-	+	+	+	-	-	+	-	-	-
Centroceras clavulatum (C. Agardh)	-	-	+	-	-	-	-	-	-	+	-	-	-
Digenia simplex (Wulfen) C. Agardh*	-	-	-	-	+	-	+	+	-	+	+	-	-
Laurencia nana Howe	-	-	-	-	+	-	-	-	-	-	+	-	-
PROTOZOA (l)													
Homotrema rubrum (Lamarck)*	-	-	-	-	+	-	+	+	-	+	-	-	-
PORIFERA (1)													
Red boring sponge	-	+	-	-	-	+	-	-	+	+	+	-	-
HYDROZOA (1)													
Millepora sp.	-	-	-	+	+	-	+	-	-	+	-	-	-
ANTHOZOA (8)													
Agaricia agaricites (L)	-	-	-	+	-	-	-	-	-	+	-	-	-
Gorgonia ventalina L.	-	-	-	-	+	-	-	-	-	+	-	-	-
Siderastrea radians (Pallas)	-	-	-	+	-	+	+	-	-	+	-	-	-
Montastraea cavernosa (L.)	-	-	-	-	+	-	-	-	-	+	-	-	-
Porites astreoides Lamarck	-	-	-	+	-	-	+	-	-	+	-	-	-
Porites porites (Pallas)	-	-	-	-	-	+	-	-	-	+	-	-	-
Favia fragum (Esper)	-	-	-	+	-	-	-	-	-	+	-	-	-
Manicina areolata (L.)	-	-	-	-	-	+	-	-	-	+	-	-	-
SIPUNCULA (4)													
Phascolosoma antillarum Grube & Oersted	-	+	-	-	-	-	-	-	+	+	-	-	-
Phascolosoma perlucens Baird	-	+	-	-	-	-	-	-	-	+	-	-	-
Lithacrosiphon alticonus ten Broeke	-	-	-	-	-	-	+	-	-	+	-	-	-
Paraspidosiphon steenstrupi Diesing	-	-	-	-	-	-	+	-	-	+	+	-	-
CIRRIPEDIA (3)													
Lithothrya dorsalis (Ellis)*	+	+	-	-	+	+	+	-	+	+	+	-	-
Chthamalus angustitergum (Pilsbry)*	+	+	+	+	-	-	-	+	+	+	+	+	-
Tetraclita stalactifera (Lamarck)*	+	+	-	+	-	-	-	-	+	+	+	-	-
DECAPODA NATANTIA (1)													
Snapping shrimp	-	-	-	-	-	-	-	-	+	+	-	-	-
DECAPODA ANOMURA (4)													
Calcinus tibicen (Herbst)	-	-	-	-	-	-	+	-	S	+	-	-	-
Clibanarius tricolor (Gibbes)*	-	+	-	-	R	-	-	+	-	+	+	-	-
Paguristes tortugae Schmitt	-	-	+	-	-	-	-	-	-	+	-	-	-
Coenobita clypeatus (Herbst)	-	-	-	-	-	-	-	+	-	-	-	-	+
DECAPODA BRACHYURA (12)													
Microphrys bicornutus (Latreille)	-	-	+	-	-	-	+	-	-	+	-	-	-

Appendix. (continued)

Station no.	16	26	38	41	48	53	57	87	96	L	U	B	G
Mithrax coryphe (Herbst)	-	-	-	-	-	-	+	-	-	+	-	-	-
Eriphia gonagra (Fabricius)	-	+	-	-	R	-	-	-	-	+	-	-	-
Pilumnus holocericus Rathbun	-	-	-	-	-	-	+	-	-	+	-	-	-
Pilumnus nudimanus Rathbun	-	-	-	-	-	-	+	-	-	+	-	-	-
Geograpsus lividus (Milne Edwards)	-	-	-	-	-	-	-	-	+	+	+	+	-
Pachygrapsus transversus (Gibbes)	-	+	-	-	-	-	-	-	-	-	+	-	-
Percnon gibbesi (Milne Edwards)	-	-	-	-	-	-	-	-	S	+	-	-	-
Sesarma cf. *miersii* Rathbun	-	-	+	-	-	-	-	-	-	+	-	-	-
Gecarcinus lateralis (Freminville)	-	-	-	-	-	-	-	-	+	-	-	-	+
Ocypode quadrata (Fabricius)	-	-	-	-	-	-	-	-	S	+	-	-	-
Calappa gallus (Herbst)	-	-	-	-	-	-	-	-	S	+	-	-	-
ISOPODA (1)													
Dynamenella perforata Moore*	-	-	-	-	+	+	+	-	+	+	+	+	-
INSECTA (1)													
Anurida maritima (Guerin)	-	+	-	-	-	-	-	-	-	+	-	-	-
POLYPLACOPHORA (l)													
Acanthopleura granulata (Gmelin)*	+	+	+	+	+	+	+	-	+	+	+	+	-
PROSOBRANCHIA (23)													
Emarginula pumila (A. Adams)	-	-	-	+	-	-	-	-	-	-	+	-	-
Fissurella barbadensis (Gmelin)*	+	+	-	-	-	-	+	-	-	+	+	-	-
Acmaea leucopleura (Gmelin)*	+	+	+	+	+	-	+	-	+	-	+	+	-
Cittarium pica (L.)*	-	+	+	-	+	-	+	-	+	+	+	-	-
Nerita peloronta (L.)	+	+	-	-	R	-	+	-	+	-	+	+	-
Nerita versicolor Gmelin	(+)	+	-	-	+	+	+	+	-	-	+	+	-
Nerita tesselata Gmelin	(+)	+	-	-	-	-	-	+	+	+	+	+	-
Puperita pupa (L.)*	-	-	-	-	R	-	+	-	-	-	-	+	-
Littorina lineolata (Orbigny)	+	-	+	+	+	-	+	-	+	-	+	+	-
Littoraria angulifera (Lamarck)	-	-	-	-	-	-	+	-	-	-	-	+	-
Nodilittorina ziczac (Gmelin)	-	-	-	-	+	+	+	-	+	-	-	+	-
Nodilittorina mespillum (Mühlfeld)	+	-	-	-	+	-	+	-	-	-	+	+	-
Nodilittorina meleagris (Potiez & Michaud)	-	-	-	-	-	-	R	-	-	-	-	R	-
Nodilittorina angustior (Mörck)	-	-	-	-	-	-	+	-	+	-	-	+	-
Nodilittorina tuberculata (Menke)	+	-	-	-	+	-	+	+	+	-	-	+	+
Echininus nodulosus (Pfeiffer)	+	+	-	-	+	-	+	+	+	-	+	+	+
Cenchritis muricatus (L.)*	+	+	+	-	+	+	+	+	+	-	+	+	+
Petaloconchus varians (Orbigny)*	-	-	+	-	+	-	-	-	+	+	+	-	-
Dendropoma corrodens (Orbigny)*	+	+	-	-	+	-	+	-	+	+	+	-	-
Cerithium eburneum Bruguière	-	+	-	-	-	-	-	-	-	+	-	-	-
Morula nodulosa (C.B. Adams)	-	-	-	-	-	-	-	-	S	+	-	-	-
Thais rustica (Lamarck)	-	-	-	-	-	-	+	-	-	+	-	-	-
Thais deltoidea (Lamarck)	-	-	-	-	+	-	-	-	-	+	-	-	-
PULMONATA (1)													
Siphonaria pectinata (L.)	-	-	-	-	-	-	-	-	+	+	+	-	-
BIVALVIA (6)													
Barbatia cancellaria (Lamarck)	-	-	-	+	-	-	-	-	-	+	-	-	-
Brachidontes domingensis (Lamarck)	-	+	+	-	+	-	+	+	-	+	+	+	-
Brachidontes exustus (L.)	-	-	-	+	-	+	+	-	-	-	+	-	-
Lithophaga bisulcata (Orbigny)	-	-	-	-	-	-	+	-	-	+	-	-	-
Isognomon radiatus (Anton)	-	-	-	-	-	+	-	-	-	+	-	-	-
Isognomon bicolor (C.B. Adams)	-	-	-	-	-	-	-	-	+	+	-	-	-
ECHINOIDEA (2)													
Eucidaris tribuloides (Lamarck)	-	-	-	-	-	-	-	-	S	+	-	-	-
Echinometra lucunter (L.)*	+	-	-	-	+	-	+	-	-	+	-	-	-
HOLOTHURIOIDEA (1)													
Holothuria cf. *floridana* Pourtalès	-	-	-	-	-	-	-	-	S	+	-	-	-
Number of algae	0	1	2	2	6	5	8	4	1				
Number of animals	16	22	11	13	25	12	35	10	29				
Number of species	16	23	13	15	31	17	43	14	30				