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Ecology of OSTRACODA in the northwestern part of the Great Bahama Bank

by

LOUIS S. KORNICKER

(From the Texas A & M University, U. S. A.)

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INTRODUCTION

The Bahamas consist of several flat-topped banks. The largest of the banks is the Great Bahama Bank with which the present paper is concerned. The first study of ostracods on the Great Bahama Bank was made by BRADY, who in 1869 described several species from New Providence Island which is located on the northeastern part of the Bank. The investigation being reported upon at this time was made in the vicinity of the Bimini islands, the largest group of islands on the northwestern part of the Bank (Fig. 1). Field work for this study was conducted in 1955 and 1956. Reports on the MYODOCOPA, PLATYCOPA and BAIRDIIDAE were published in the years 1958, 1959, 1962, and 1963. The purpose of this presentation is to summarize the general ecology of the area with special emphasis on the OSTRACODA.

Climate

The climate of the Bahamas may be considered subtropical. The average winter temperature is about 22° C, and the summer averages about 28° C. The average rainfall is about 118 cm and the most rain occurs during September and October. Freezes do not occur in the Bahamas and minimum temperature is about 7° C. The subtropical climate is maintained by warm West Indian waters which bathe the area as they move north. The major components of the current move through the Florida Straits, where it is called the Florida Current.

Geographic setting

The Bimini islands consist of three islands partly enclosing a central lagoon (Fig. 2). North Bimini, which forms the western margin of the lagoon, is a narrow island 8 km long having a maximum elevation above sea level of about 7 m. East Bimini forms part of the eastern margin of the lagoon and is composed mainly of mangrove swamps and ancient beach ridges. South Bimini forms the southern margin of the lagoon and is covered by a dense growth of mangrove. Four small islands lie within the lagoon: Tokas Cay, Pigeon Cay, Alec Cay and Big Mangrove Cay. Water depth in the lagoon is less than 2 m except in a natural channel that parallels the eastern shore of the southern tip of North Bimini.

A narrow submarine shelf that slopes unevenly to a depth of about 60 m, and then drops precipitously to a marginal escarpment forming the eastern edge of the

Florida Straits, border the western shores of North and South Bimini. Water depth on the broad level platform east of this shelf seldom exceeds 4 to 5 m.

Reference will be made in this paper to three mangrove surrounded inlets with

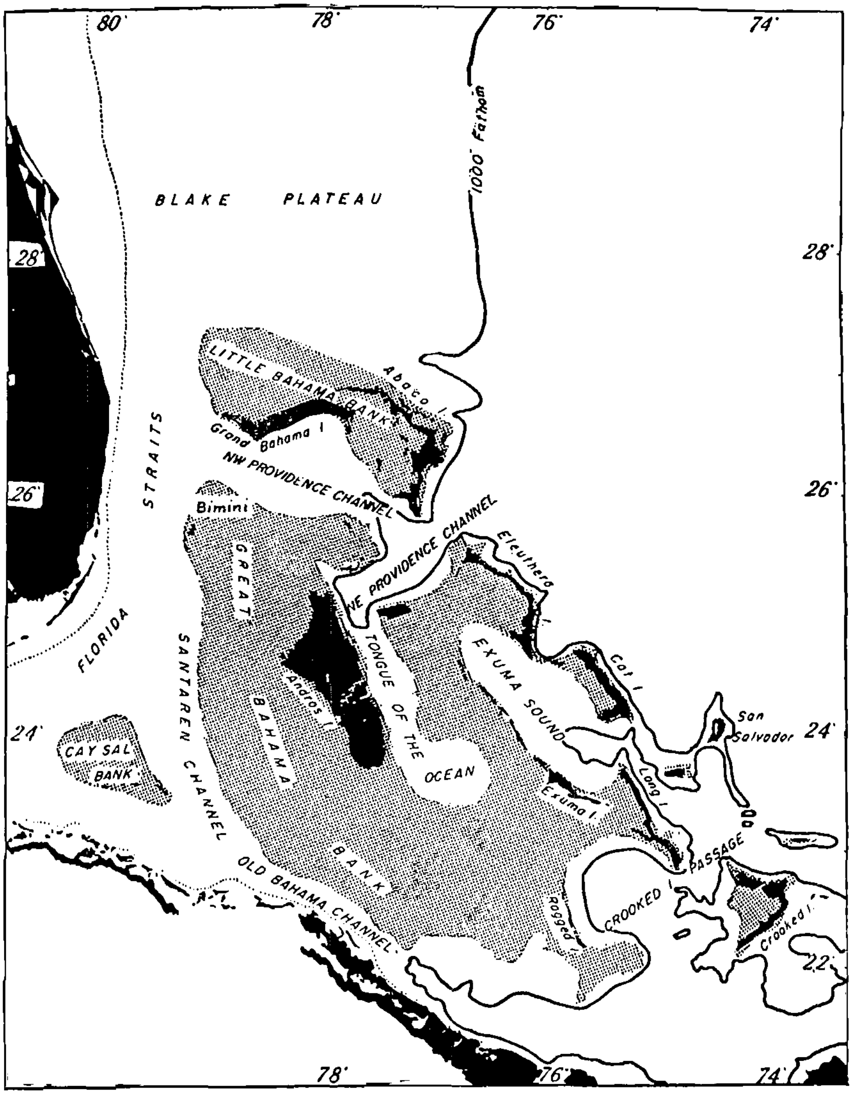

FIG. 1. Map of the Bahamas showing location of the Bimini Islands.

water depths of about a meter. These are Curlew Cove in East Bimini, Massey Creek and Cavelle Pond in South Bimini. Also of particular interest is the upper third of the lagoon called North Sound where the water is about a meter deep near the lower end and shoals rapidly northward.

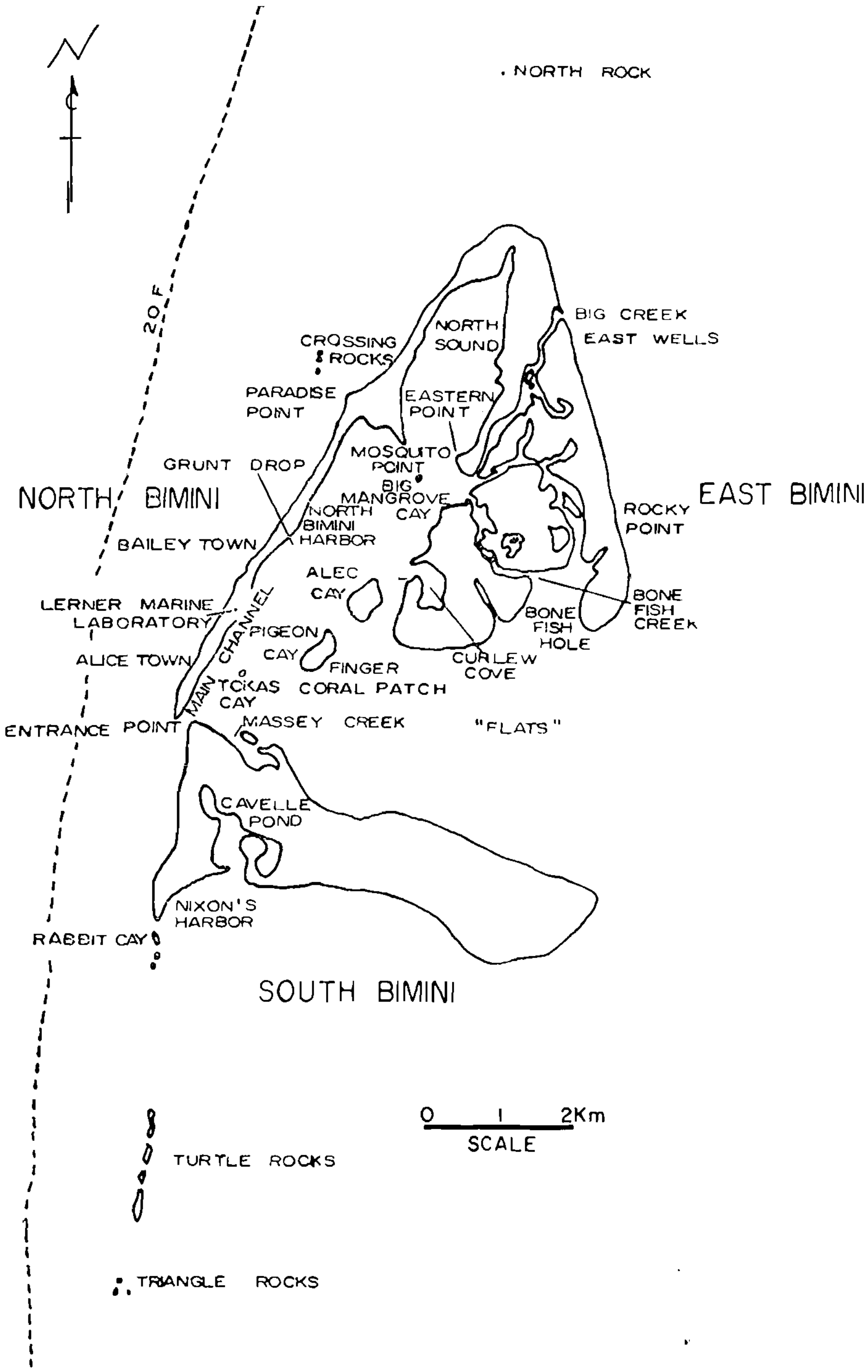

FIG. 2. Map of Bimini Islands showing place names.

Water circulation, Salinity, Temperature

Water circulation is the key to the delineation of environmental provinces on the Great Bahama Bank. On the unprotected shelf west of Bimini, which

Fig. 3. Map showing generalized direction of currents during an incoming tide in the vicinity of Bimini. (Lengths of arrows do not reflect current velocity).

is bathed by the eastern edge of the Florida Current, summer salinities are in the order of 35.8 ‰. Movement of water on and off the part of the Bank east of the outer shelf is almost entirely controlled by tides which have a range of about a meter in the Bimini area. During flood tide shelf waters move eastward onto the Bank and concurrently enter the Bimini lagoon through both Entrance Point and a wide shallow opening between East and South Bimini (Fig. 3). High evaporation rates on the Bank and in the lagoon result in a rapid increase in water salinity. During ebb tide, water is incompletely drained off the Bank and out of the lagoon so that salinity values tend to build until they are eventually lowered through dilution during rain squals. Water salinities east of the Biminis are in the order of 37.5 ‰. In the lower two-thirds of the lagoon the salinity increases from about 36.1 ‰ near Entrance Point to 39.4 near the entrance to North Sound. During a tidal cycle the water in North Sound is only partly exchanged with water in the lower lagoon with the result that salinity values in North Sound range from about 40.0 ‰ at the lower end to 46.5 and higher at the upper end (TUREKIAN, 1957). Inlets such as Curlew Cove, Massey Creek and Cavelle Pond, where water exchange is restricted by narrow entrances, also tend to have high salinities.

The shallow areas with impeded circulation have water warmer in the summer and cooler in the winter than that of surrounding areas where surface temperature are in the order of 24 - 28° C.

On the basis of water qualities caused by restrictions in circulation, four environmental provinces may be delineated; an Open Shelf provinee which is bathed by normal marine waters of the Florida Current; a Restricted Shelf province where water movement is controlled primarily by tidal currents; a Restricted Lagoon province where water exchange is considerably decreased because of the lagoon being partly enclosed, and a Hypersaline Lagoon province which includes upper North Sound and the several shallow inlets with partly obstructed entrances (Fig. 4).

OSTRACOD ABUNDANCE

The number of empty ostracod carapaces in the sediment increases as water circulation becomes more and more restricted (Fig. 5). The environmental provinces may be listed in order of increasing ostracod abundance as follows: Outer Shelf, Restricted Shelf, Restricted Lagoon, Hypersaline Lagoon. An anomalie exists in the Restricted Shelf province because very few ostracods are contained in oolitic sediments. Reasons for this anomalie will be discussed later.

Although living ostracods were not collected in sufficient quantities to compare accurately the relative abundance of ostracods living in each environmental province, the collections suggest that more ostracods live in the Hypersaline Lagoonal province than in other provinces. However, the distribution of living ostracods only partly accounts for the greater abundance of empty carapaces in restricted environments. Another, and perhaps more significant con-

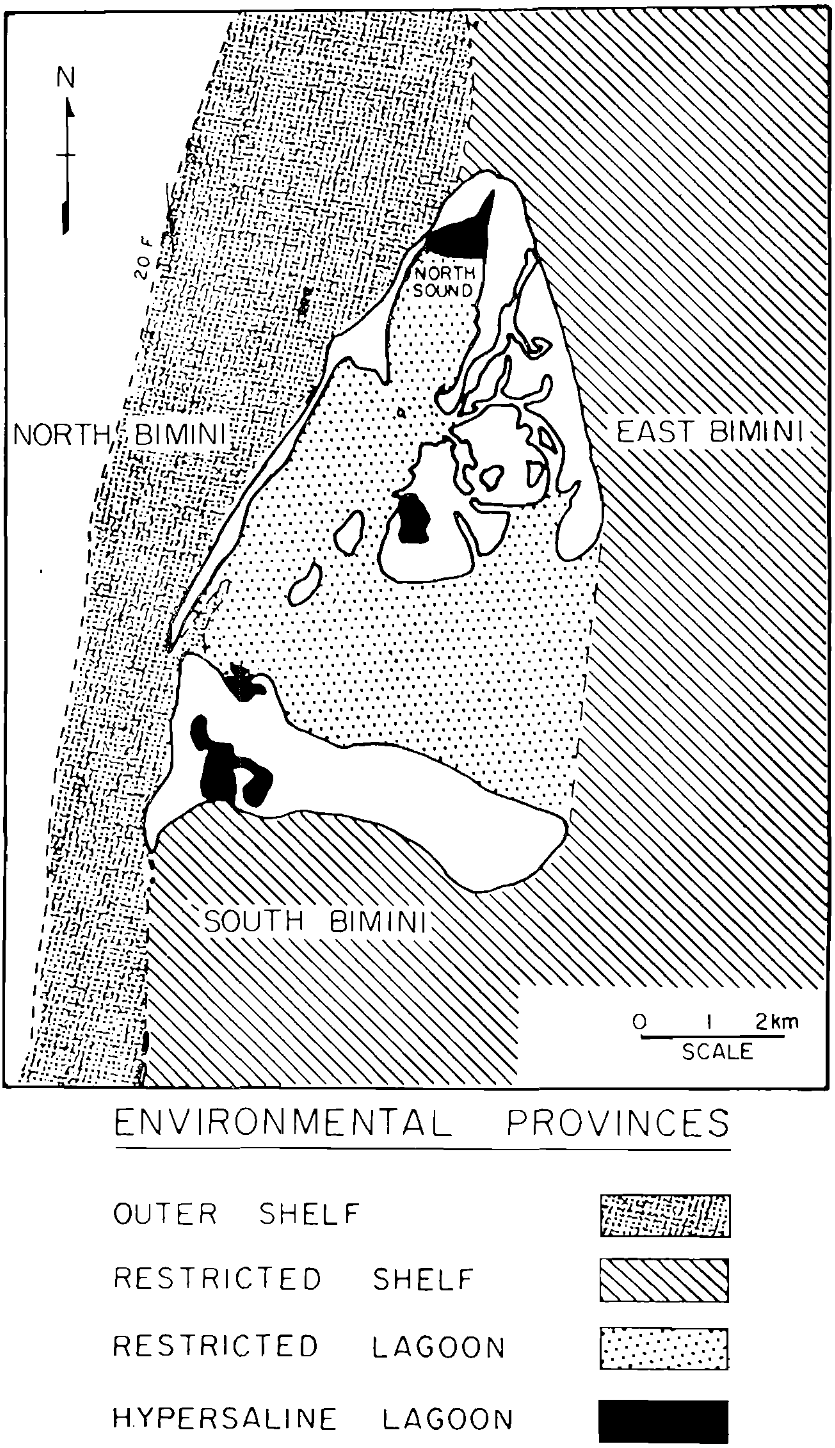

FIG. 4. Environmental provinces in the vicinity of the Bimini Islands.

tributing factor, is that the green alga, *Halimeda*, and corals are scarce in the Hypersaline Lagoon province. Lack of dilution of the sediment by remains

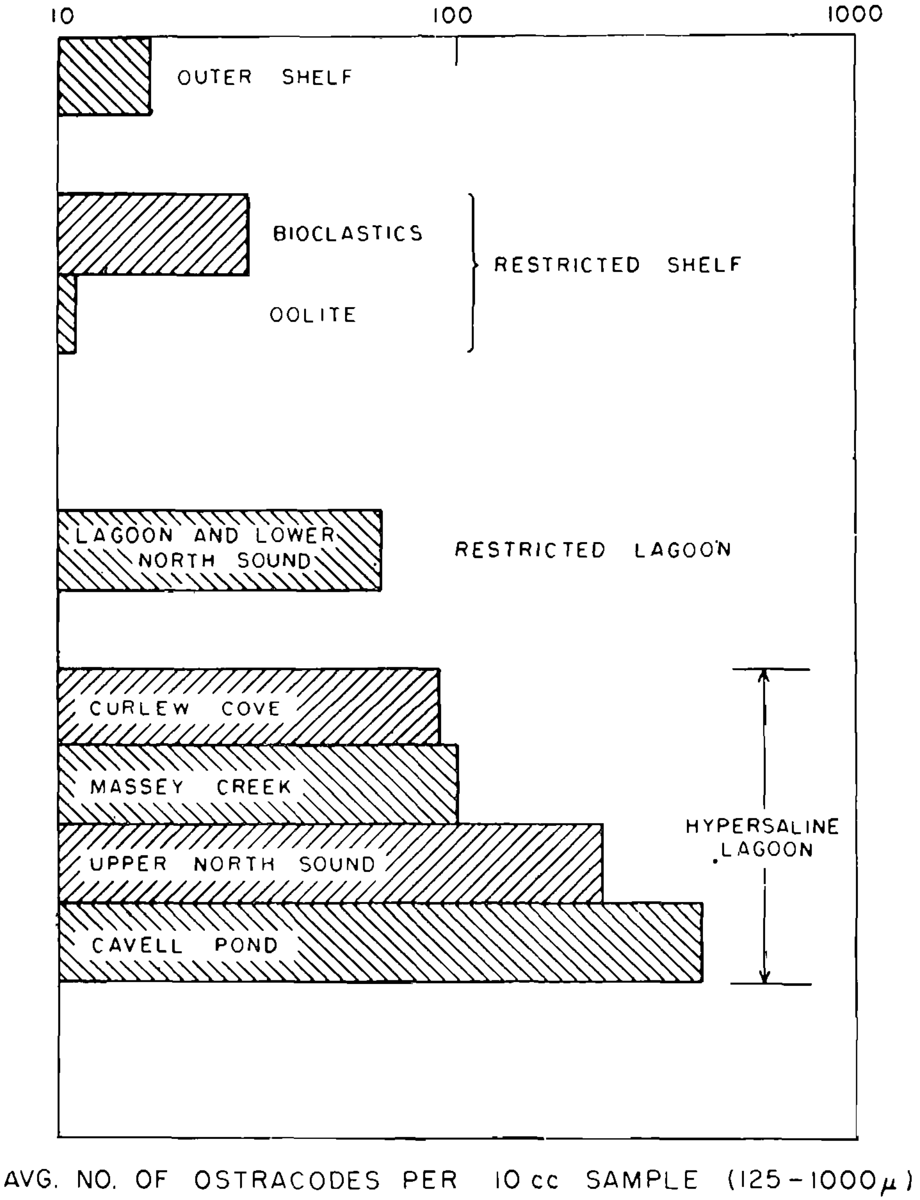

FIG. 5. Comparison of ostracod abundances in environmental provinces of Bimini.

of *Halimeda* and corals which dominate sediment in other areas enables ostracod carapaces to occupy a relatively larger volume of the sediment.

The data of BENDA & PURI (1962) obtained from investigation in the Cape Romano area, Florida, which is on the southwestern coast of the Florida

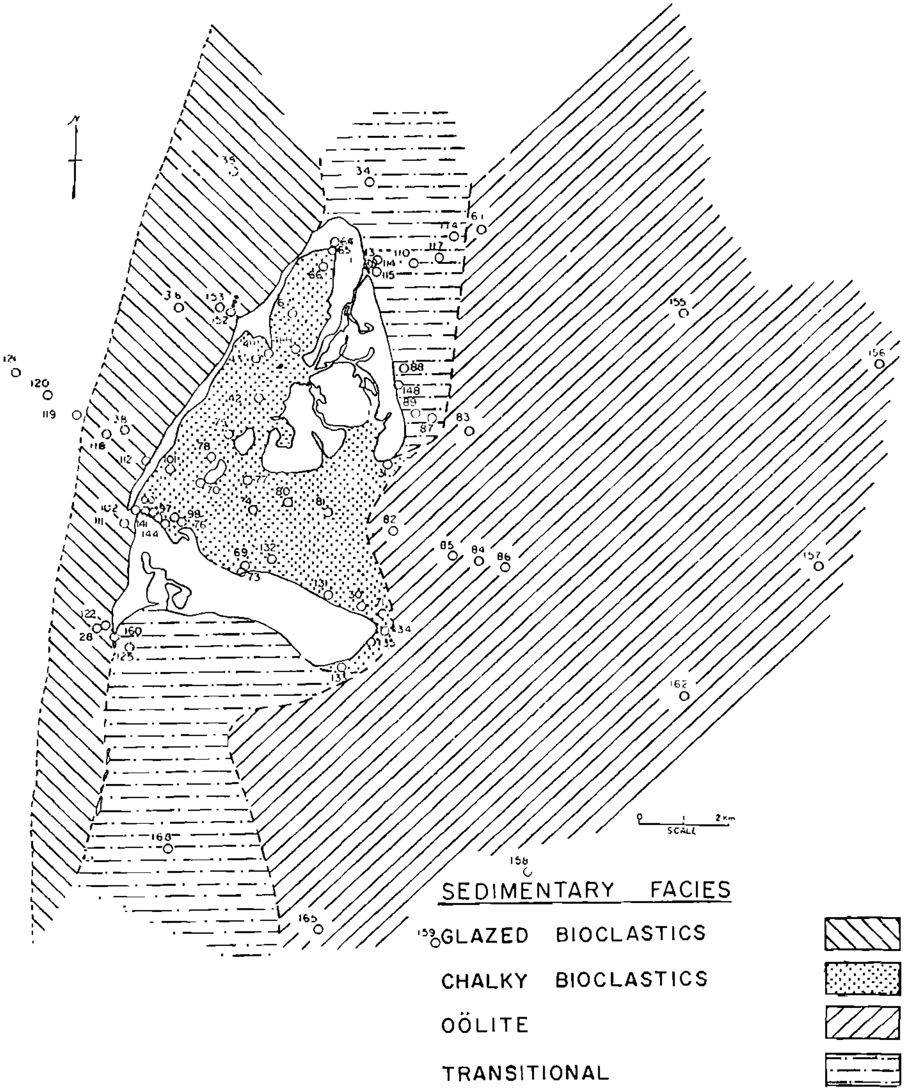

FIG. 6. Sedimentary facies map of Bimini Islands. Circles indicate sample positions and numbers.

Peninsula, also suggests a greater abundance of ostracod carapaces in restricted environments. Observations of this type should be useful to the paleoecologist interested in clues for detecting areas of restricted circulation.

SEDIMENTARY FACIES

Although requiring some simplification of the complex distributional pattern of sediments in the Bimini vicinity, it is possible to delineate four major sedimentary facies (Fig. 6). Sediments within the Bimini Lagoon consist dominantly of skeletal fragments having a chalky appearance and are designated the Chalky Bioclastic facies. Sediments on the outer shelf contain well rounded skeletal fragments with a high gloss, and are designated the Glazed Bioclastic facies.

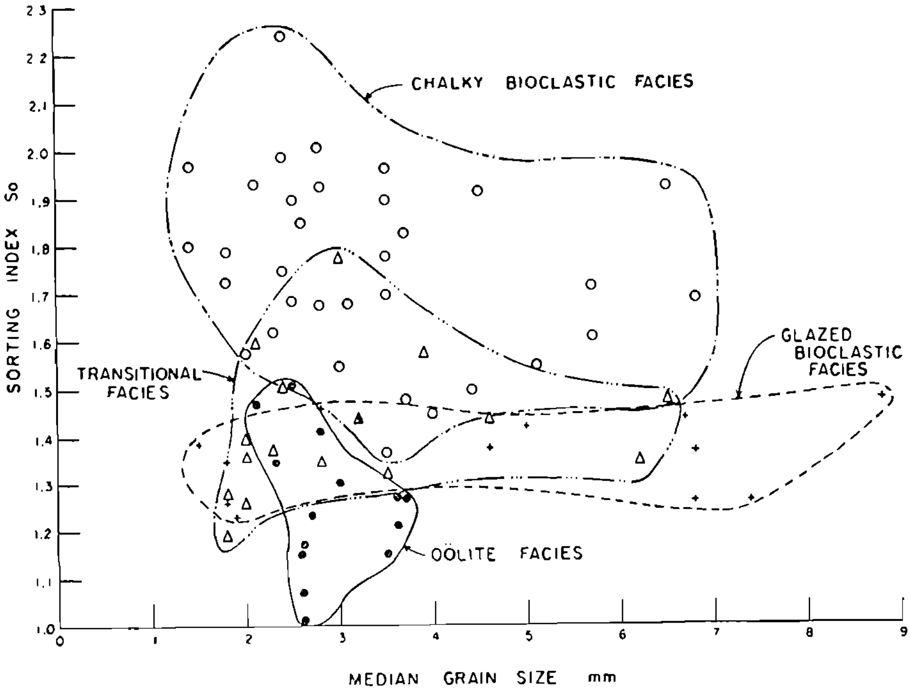

FIG. 7. Relationship between sorting index (So) and median diameter of sediments.

Sediments in which ovoid oolitic grains dominate cover an extensive area east and southeast of the islands and are designated the Oolite facies. Sediments in the area around Bimini between the outer shelf and the Oolite facies are designated the Transitional facies.

Size and sorting properties of sediments from each facies are compared in Fig. 7 in which diameter is graphed as a function of sorting index (So). The lagoonal sediments of the Chalky Bioclastic facies have about the same range of median diameters as sediments of the Glazed Bioclastic and Transitional facies, but are more poorly sorted. Sediments of the Oolitic facies are distinguished by being well sorted and having a narrow range of median diameters.

Another property of the sediment considered in this study is bulk density,

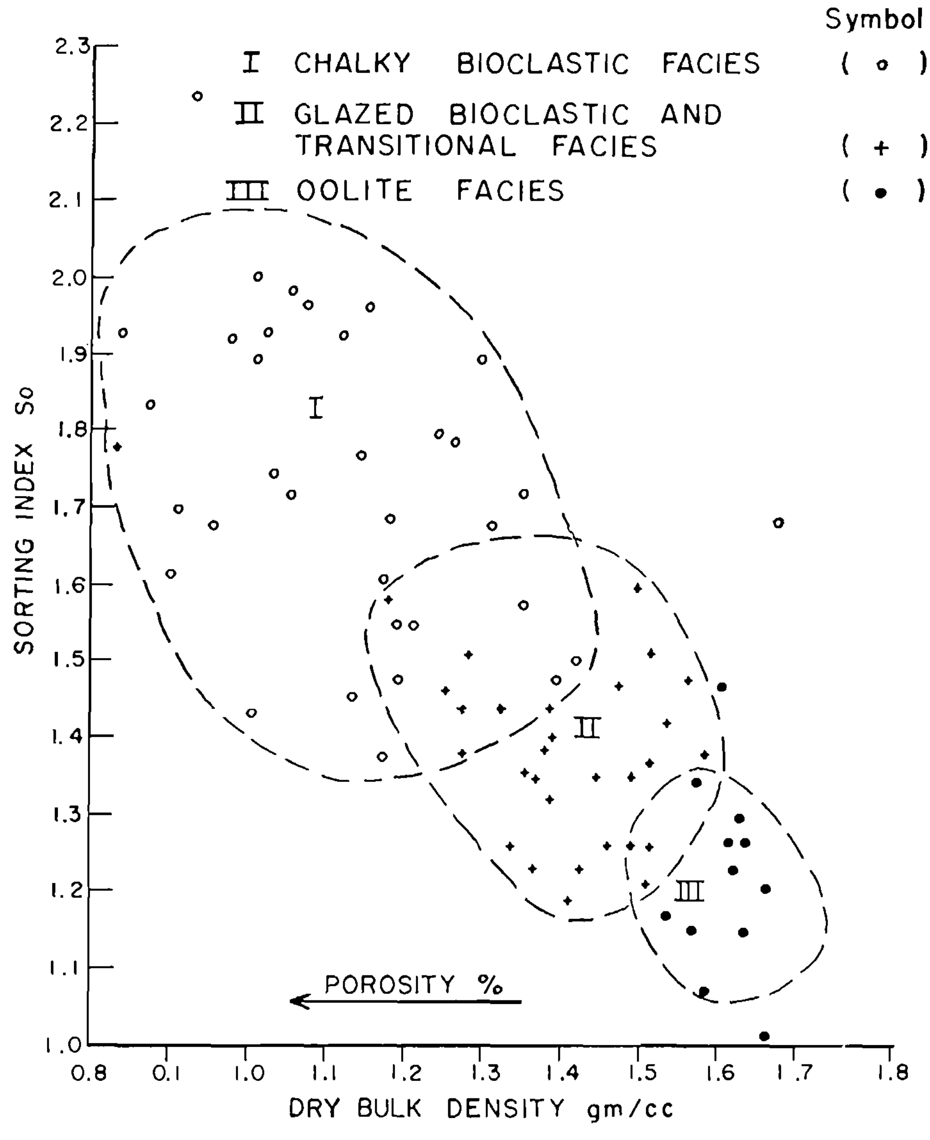

Fig. 8. Relationship between sorting index (So) and bulk density of sediments.

which varies inversely with porosity. Bulk density is high in the Oolite facies, low in the Chalky Bioclastic facies and intermediate in the Glazed Bioclastic and Transitional facies (Fig. 8). I consider bulk density to vary directly with the resistance of sediment to the burrowing of ostracods and could be considered as a burrowing index. The higher the bulk density the more difficult it is for an ostracod to burrow, although a threshold probably exists below which burrowing is not affected.

The scarcity of ostracods in the Oolite facies is contributed primarily to its not being favored by burrowing ostracods. Another contributing factor is the good sorting of the sediment and the smooth surface of grains. Certain ostracods such as members of the PLATYCOPA and the BAIRDIIDAE have difficulty crawling over smooth surfaces, and this may contribute to the scarcity of these forms in oolite sediment.

BIOTIC ZONATION

Some species in the Bimini area seem to have significance as environmental indicators. Species especially abundant in the Hypersaline Lagoon province have tentatively been classified as *Aurila floridana* BENSON & COLEMAN, and *Cyprideis floridana* PURI. *Cushmanidea elongata* (BRADY) is the only species that seems to prefer the Oolite facies of the Restricted Shelf province. *Protocytheretta daniana* (BRADY), *Pterygocythereis jonesi* (BAIRD) and *Paracytheridea tschoppi* BOLD typify species that although fairly common in most environmental provinces were not collected in the Hypersaline Lagoon province. The genera *Bairdia* and *Bairdoppilata* were also absent or scarce in the hypersaline environment.

Biotic zonation among the ostracods in the Bimini area is most apparent when comparing the Hypersaline Lagoon province with the provinces having less restricted circulation of water. Sediments in the Hypersaline Lagoon province contain more individuals and have fewer and different species than sediments in other environments. The Open Shelf, Restricted Shelf and Restricted Lagoon provinces which may be readily separated on the basis of ostracod abundance are not easily distinguished by kinds of species. Lagoonal sediments for example contain a significantly larger number of ostracods than sediments of the Open Shelf or Restricted Shelf provinces, but differences in the kinds of species occupying these provinces are subtle and difficult to interpret.

The fact that the absolute abundance of ostracod carapaces in the sediment seems sensitive to environmental differences suggests greater use of this criterion in paleoecology. This measure has the advantage of being independent of the kinds of species involved. However, consideration of absolute abundances may be more significant in areas of carbonate deposition where sedimentation rates are not affected by terrigenous sediments.

ZOOGEOGRAPHICAL RELATIONSHIPS

The common genera of the Bahamas such as *Bairdia, Loxoconcha, Pellucistoma, Megacythere, Cushmanidea, Puriana, Bradleya, Aurila,* and *Protocytheretta* — to name but a few — are widely distributed marine forms numerous in most tropical and subtropical shallow water marine environments.

The Bahamas are separated from the Florida Peninsula and Cuba by deep channels and it is natural that these are barriers for some forms. An example

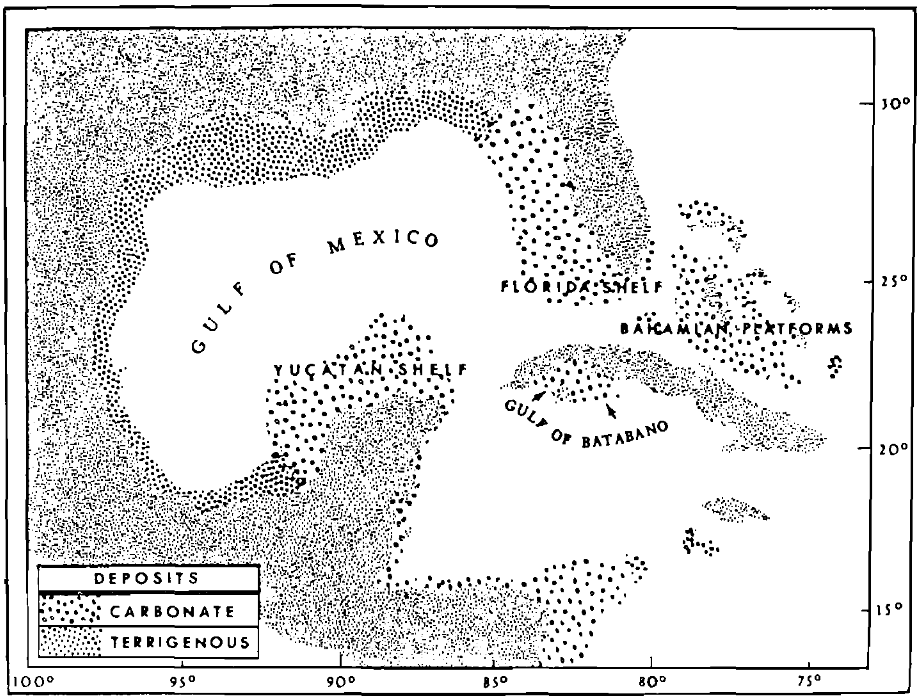

FIG. 9. Location of carbonate shelves and banks in the Caribbean Sea and Gulf of Mexico.

of this is the genus *Triebelina* which although common along the Florida coast and in the Caribbean does not seem to live in the Bahamas. Many species of MYODOCOPA seem endemic to the Bahamas, or at least have not yet been reported from other areas.

Comparison of the ostracod fauna of the Bahamas with that reported from the West Florida Coast and the Florida Keys by PURI (1960) and BENSON & COLEMAN (1963) and from the Caribbean region by VAN DEN BOLD (1946, 1950, 1957, 1958) shows that they are closely related. A similar relationship has previously been noted for corals by SQUIRES (1958) and for mollusks by VOSS & VOSS (1960). Several shallow carbonate shelves and banks are located in the Caribbean and Gulf of Mexico (Fig. 9); although the ostracod fauna is incompletely known from many of these regions, it is not unlikely that because of a similarity in existing environmental conditions the fauna will be found to be closely related.

SUMMARY

This paper is concerned primarily with environments and OSTRACODA in the vicinity of the Bimini Islands in the northwestern part of the Great Bahama Bank. On the basis of water qualities caused by restrictions in circulation, four environmental provinces may be delineated; an Open Shelf province which is bathed by normal marine waters of the Florida current; a Restricted Shelf province where water movement is controlled primarily by tidal currents; a Restricted Lagoon province where water exchange is considerably decreased because of the lagoon being partly enclosed, and a Hypersaline Lagoon province which includes upper North Sound and several shallow inlets with partly obstructed entrances. The number of empty ostracod carapaces in the sediment increases as water circulation becomes more and more restricted. The environmental provinces may be listed in order of increasing abundance of ostracods as follows: Outer Shelf, Restricted Shelf, Restricted Lagoon, Hypersaline Lagoon. An anomaly exists in part of the Restricted Shelf province because very few ostracods live in oolitic sediments. The scarcity of ostracods in the oolite sediments is attributed primarily to its high bulk density which makes burrowing difficult. Biotic zonation among the ostracods in the Bimini area is most apparent when comparing the Hypersaline Lagoon province with the provinces having less restricted circulation of water. Sediments in the Hypersaline Lagoon province contain more individuals and have fewer and different species than sediments in other environments. The Open Shelf, Restricted Shelf and Restricted Lagoon provinces may be readily separated on the basis of ostracod abundance but not on kinds of species.

RIASSUNTO

Il presente lavoro riguarda principalmente gli ambienti e gli Ostracodi dell'area in prossimità delle isole Bimini nella zona Nord-ovest del Great Bahama Bank. Basandosi sulle caratteristiche dell'acqua, causate dalla limitatezza della circolazione, si possono delineare quattro provincie ambientali; una provincia «Open Shelf» che è bagnata dalle normali acque marine della corrente della Florida; una provincia « Restricted Shelf » dove il moto delle acque è controllato principalmente dalle correnti di marea; una provincia « Restricted Lagoon » dove la circolazione delle acque è notevolmente diminuita poiché la laguna vi è stata parzialmente inclusa ed infine una provincia « Hypersaline Lagoon » che comprende il North Sound superiore con molte basse insenature ad ingresso parzialmente ostruito. Il numero di carapaci completi di Ostracodi nel sedimento aumenta col diminuire della circolazione dell'acqua. Le provincie ambientali possono essere elencate in relazione all'incremento del numero di Ostracodi come segue:

« Outer Shelf », « Restricted Shelf », « Restricted Lagoon », « Hypersaline Lagoon ». Vi è un'anomalia in una parte della provincia « Restricted Shelf » poiché nei sedimenti oolitici vivono pochissimi Ostracodi. La scarsezza di Ostracodi nei sedimenti oolitici è attribuita sopratutto alla densità di tali sedimenti che rende difficile agli Ostracodi di rintanarvisi. Una zonazione biotica tra gli Ostracodi nell'area di Bimini è più evidente quando si comparino la provincia « Hypersaline Lagoon » con le provincie con

una meno ristretta circolazione d'acqua. I sedimenti nella provincia « Hypersaline Lagoon » contengono un maggior numero di individui ed hanno meno e differenti specie dei sedimenti degli altri ambienti. Le provincie « Open Shelf », « Restricted Shelf » e « Restricted Lagoon » possono essere facilmente distinte basandosi sull'abbondanza di Ostracodi ma non sulle specie.

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Dr. L. S. KORNICKER, Dept. of Oceanography and Meteorology, A. & M. University, College Station, Texas, U. S. A.

Present address: Smithsonian Institution, United States National Museum, Washington, D. C. 20560.

Discussion

MCKENZIE: I would like to ask if only adults were counted in your study?

KORNICKER: Specimens remaining on a 125 micron screen were counted. These included all adults and some juveniles.

MCKENZIE: What is the depth in the area investigated by you?

KORNICKER: It varies seasonally, our greatest depth was a little over two meters but during certain times of the year the vegetation in part of the area was out of the water and the bottom covered by only a few centimeters of water.

McKENZIE: How about your tidal range?

KORNICKER: The tidal range in the bays is less than a meter normally, but wind tides occasionally occur that raise or lower the water almost two meters.

McKENZIE: I noticed that you had shell in your first group. Was this included in your histogram or quartz only?

KORNICKER: Everything.

McKENZIE: I am not certain how the generally shallow depth would affect the histograms but in an environment with more depth variation histograms based a quartz alone would certainly be significant. In a uniformly shallow environment, however, I would expect that large mollusk shells and shell fragments form an important fraction of the sediment and if included in the histograms would distort them.

KORNICKER: Shell dominated the fraction larger than 0.25 mm, the finer fractions contained very little shell. But as far as the ostracod is concerned, I doubt that it matters whether it is shell or quartz.

McKENZIE: I had the idea that if carbonate was available in the environment the ostracod might be inclined to use it.

KORNICKER: Well, this is rather a small area and as far as the chemistry of the water is concerned, I don't believe the carbonate composition varies much from place to place.

McKENZIE: Did you have a crack at phosphate determinations? I know they are sometimes hard to obtain, but the data are usually of ecologic value.

KORNICKER: No, but eventually we will know more about the chemical components of the water.

HULINGS: Did the remaining species and the assemblages as a whole reflect similar distribution patterns or did you not have sufficient data to determine this? Seasonal distribution as far as abundance, etc.

KORNICKER: Some of the species seemed to vary in abundance seasonally.

HULINGS: I was particularly interested in the brackish-water forms.

KONRICKER: I do not recall the distribution of these off hand.

McKENZIE: Was there a lot of agitation, because this is maybe why you get your big *Aurila* population.

KORNICKER: Yes, there was occasionally a considerable amount of agitation by waves, and perhaps this is a factor to be considered.

ELOFSON: Dr. KORNICKER has shown us some very interesting diagrams and has told us about temperature and tolerances of different species. Now you know they interfere with one another and the influence on osmotic regulation so that one species can not stand the salinity and temperature of another. The question is in raising ostracods in acquariums if perhaps you have investigated the tolerance of temperature difference or salt content, etc. And also, did the ostracods migrate?

KORNICKER: It is difficult to determine whether variations in abundance are due to *in situ* variations or migrations. In the experiments Dr. WISE and I conducted, temperature was held constant and the salinity was varied and vice versa. These experiments should be continued by acclimating the specimens for longer and longer periods of time at various salinities and temperatures and seeing the effect of acclimatization on the tolerance of each species. I think this is a worth-while avenue of research and should be undertaken.

ELOFSON: Yes, I agree with you that it will make an excellent study.