Reprinted from the Pubbl. staz. zool. Napoli 33 suppl., 45-60 (1964).

A seasonal study of living OSTRACODA in a Texas bay (Redfish Bay) adjoining the Gulf of Mexico

by

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INTRODUCTION

This report is based on a field study of living ostracods. The investigation was designed to emphasize features of ecologic interest such as (1) seasonal and spatial variations in ostracod abundance and community composition, (2) the relationship of ostracod distributional patterns to certain environmental factors, and (3) a comparison of the composition of living ostracod populations with assemblages of empty ostracod carapaces in the sediment.

LOCATION AND DESCRIPTION OF AREA

Narrow, elongate barrier islands are separated from the mainland coast of Texas by a system of estuarine and lagoonal bays (Fig. 1). Redfish Bay is a small bay situated near the Institute of Marine Science, The University of Texas, which was the base of operations for this study. The bay is approximately 16 km long and 4 wide; its area is about 64.7 km^2 and its volume at mean tide level is about 22.30 million cubic meters (COLLIER & HEDGEPETH, 1950). The northwestern border of the bay is the Texas mainland. It is separated from Aransas Bay on the north east and Corpus Christi Bay on the south by low-lying marshy islands. Harbor Island, a tidal delta, and St. Joseph Island, a barrier island, lie between Redfish Bay and the Gulf of Mexico. The bay is bisected diagonally by a discontinuous chain of linear, man-made islands once used to support a railroad (Fig. 2).

As in most Texas bays, Redfish Bay is quite shallow, having a maximum depth of about 2 m. Under certain wind and tide conditions a considerable part of the bay bottom is almost exposed. Water temperature in the shallow bay closely follows air temperature which ranges from 0° C in the winter to

[1] The writer gratefully acknowledges the assistance received from Dr. CHARLES WISE, Mr. CHARLES KING, Dr. STUART GROSSMAN and Dr. JOHN CONOVER in this study. The work was supported with funds received from the National Science Foundation (NSF-G-5473; NSF-G-10869) and from the Office of Naval Research [Contract Nonr 2119(04)].

40° C in the summer, and averages annually about 25° C. Summer temperatures tend to be more or less constant at about 29° C, moderated by strong southeast winds. In the winter, the temperature may drop as much as 20° C within 24 h,

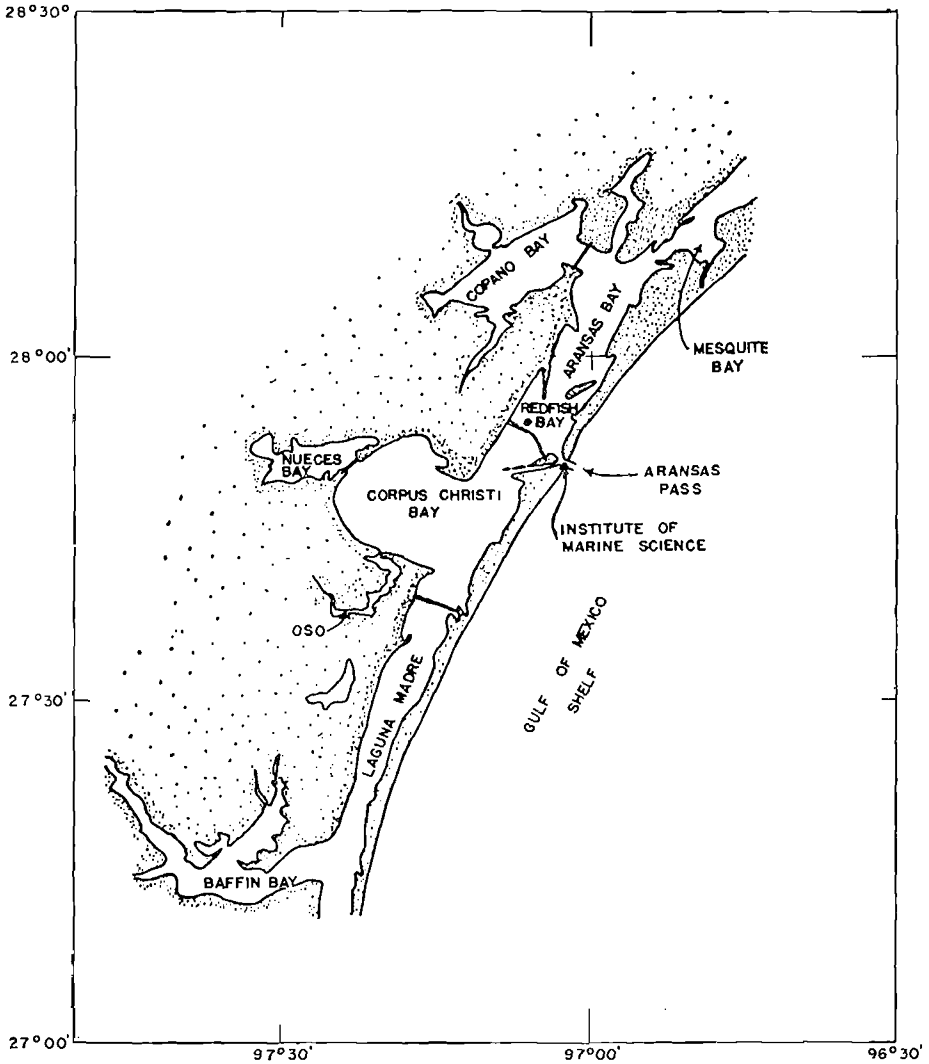


Fig. 1. Map showing location of Redfish Bay.

which sometimes results in below freezing temperatures of short duration. These cold spells occasionally cause the death of large numbers of fish (Gunter & Hildebrand, 1951). Seasonal variation of salinity in Redfish Bay is controlled primarily by temperature and rainfall. Low winter salinities are caused by low evaporation rates and seasonal rainfall. The average annual rainfall is about

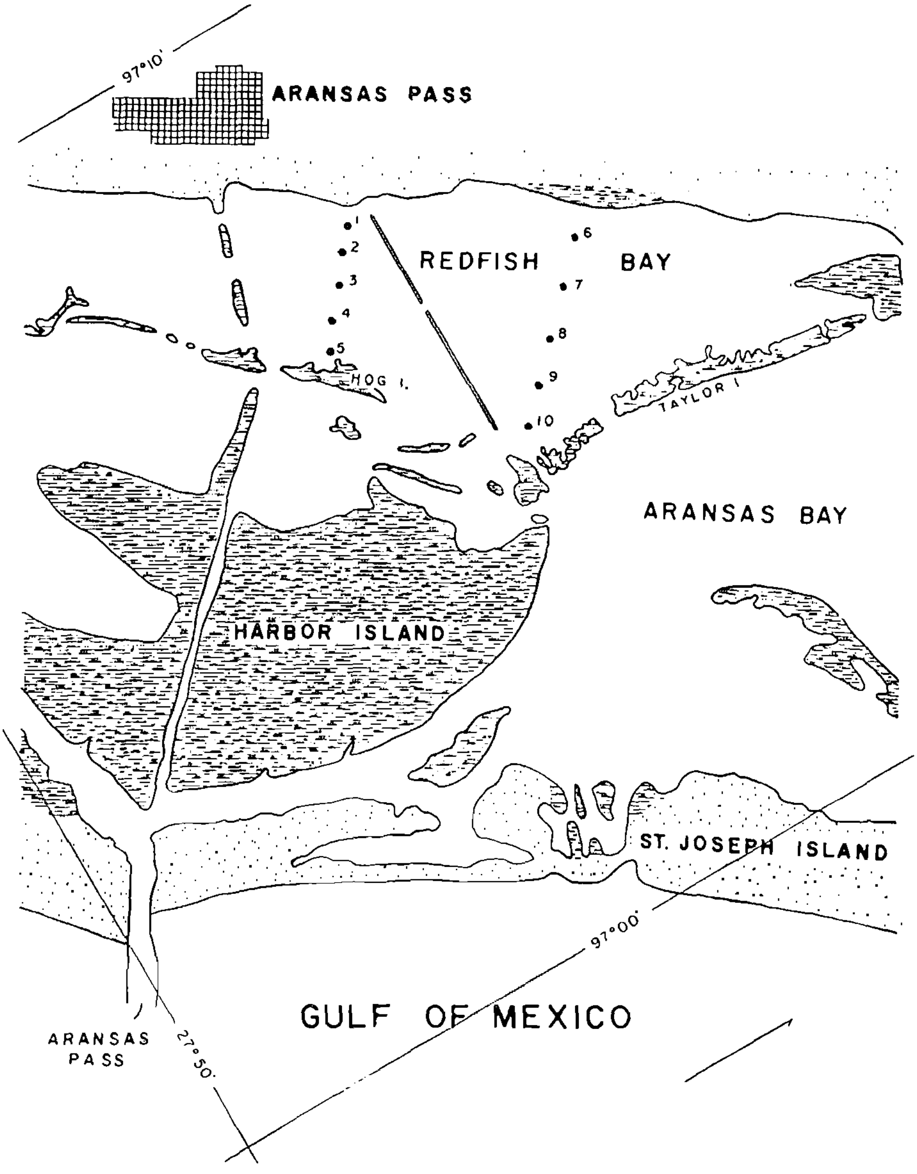


FIG. 2. Map showing position of sample stations in Redfish Bay.

100 cm. The climate according to THORNTHWAITE's classification (1948) is « dry subhumid ».

Methods

In order to be certain that samples could be collected from the same location repeatedly, cedar posts were installed at each sampling locality. Five posts were erected about 0.4 km apart on two transects oriented perpendicular to the shore. Transect I is about 4.8 km from Transect II. Sample stations on Transect I were numbered 1 to 5, and stations on Transect II were numbered 6 to 10. Stations 1 and 6 are closest to the shore.

It had been the intent at the beginning of the investigation to quantitatively sample the ostracod population in the upper centimeter of sediment cores. However, it soon became apparent that an insufficient number of living ostracods would be

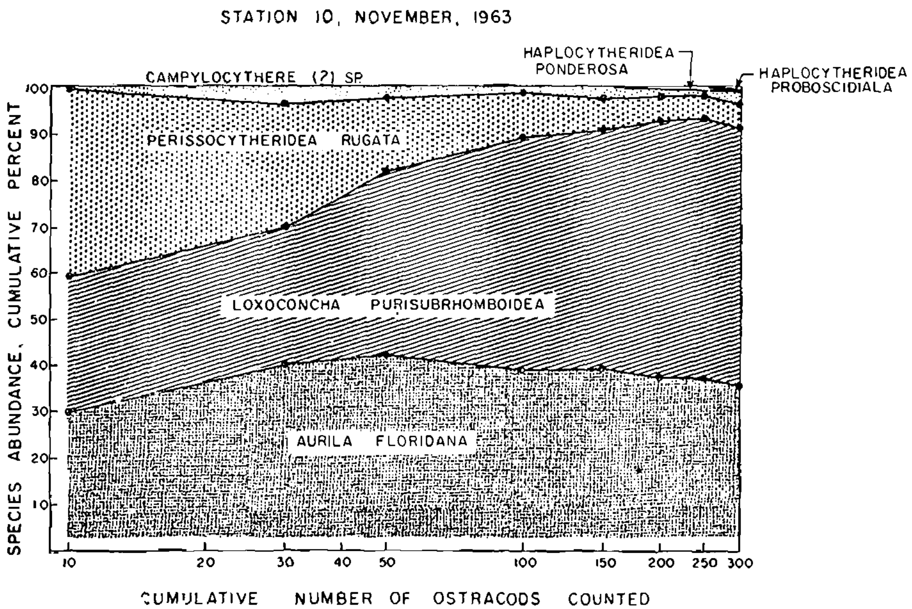


FIG. 3. Variation in population structure as larger numbers of specimens in a sample are counted.

obtained using this procedure without collecting an impractical number of cores. Therefore, the following sampling procedure was developed: A trawl with a flat bottom, about a half meter wide, was pulled in a circle having an estimated radius of 15 m around each cedar post. A weight suspended on a rope stirred up the sediment in front of the trawl, and the leading edge of the trawl scraped the top of the sediment. Sediment and ostracods entering the trawl were caught in a fine-mesh nylon net and ultimately deposited in a 250 ml bottle attached to the back end of the net. After the sampling circle was completed, clay in the sediment was washed from the sample by repeatedly immersing the net in the water. The sample was concentrated in this manner until the sample from each station consisted of 250-500 ml.

In the laboratory, each sample was wet sieved through a screen having a mesh size of 125 μ, and 300 living ostracods were removed under a dissection microscope. It was found that by keeping samples cool while in the boat and in the laboratory, ostracods could be kept alive at least 24 hours. Removing ostracods during this time is made easy because their location is detected by movements. The ostracods removed from samples were placed for future study in vials containing alcohol as a preservative. If only part of the sample was picked by the time 300 ostracods were removed, the number of ostracods in the unpicked part of the sample was estimated in order to arrive at a figure representing the total number of specimens in the sample.

Problems of sampling. Several problems are encountered in collecting representative samples of ostracods because of the need for a sufficient number of specimens to minimize sampling error. The effect of the number of specimens included in a

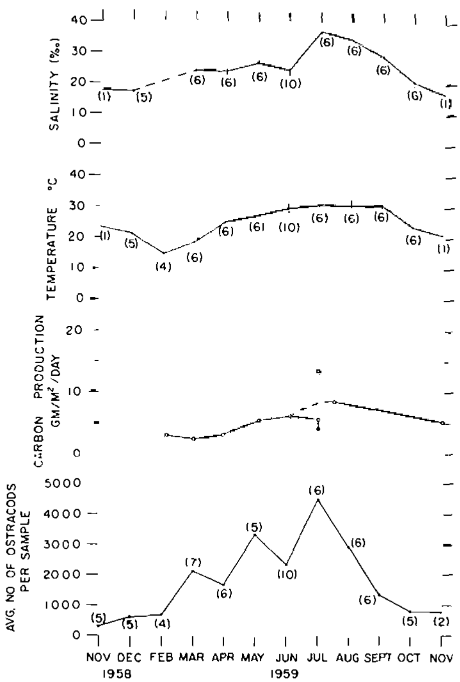


FIG. 4. Average monthly salinities, temperatures, carbon production and ostracod abundance in Redfish Bay. Carbon production figures were supplied by Dr. H. T. ODUM. Ostracod abundance based on average of all samples.

sample on population structure is illustrated in Fig. 3. This figure is based on one sample containing a total of 300 ostracods. It shows the apparent change in composition of the population as the number of specimens picked from the sample increased from 10 to 300. Note that the population structure becomes more or less stabilized only after about 150 specimens are counted. Also note how the number of species increases as more and more specimens are included. In the present study 300 specimens were picked from each sample, but in a few cases it was necessary to be satisfied with 150 specimens. Three of four samples with fewer than 150 specimens were considered inadequate samples and not used in studying population structure.

Sampling difficulties also arise when attempting to ascertain the number of ostracods living in a given area. With some organisms such as bacteria or FORAMINIFERA this problem is not as acute since they are usually more abundant than ostracods. Unfortunately, it is seldom that as many as 10 living ostracods are encountered in an average size core; and, unless the ostracods are evenly deposited on the bottom, the number of ostracods in a single core will not be representative of ostracod abundance in a given area. The use of larger diameter cores may provide a solution, if mechanical problems usually encountered when using large-diameter coring tubes are solved.

Adequate numbers of ostracods for studying population structure were obtained in this investigation by using a trawl, but the use of this method for ascertaining

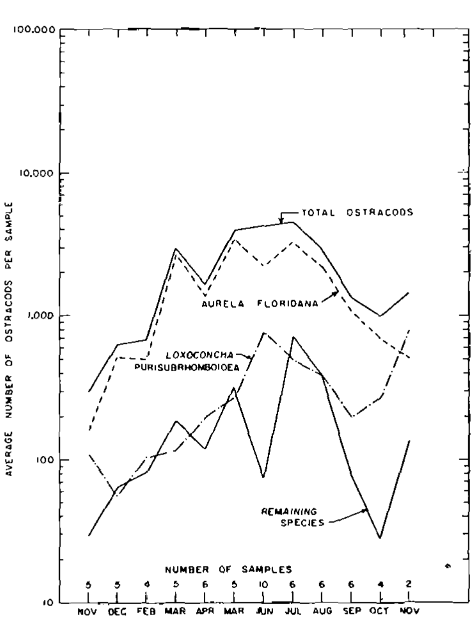


FIG. 5. Average monthly abundance of all ostracods, *Aurila floridana, Loxoconcha purisubrhomboidea,* and « remaining species » in Redfish Bay. Ostracod abundance based on samples containing not less than 150 specimens.

the abundance of ostracods living in a given area leaves much to be desired. Duplicate samples collected with the trawl contained numbers of ostracods of the same order of magnitude; however, rough estimates of the number of ostracods in the path covered by the trawl obtained by taking several cores indicate that the trawl captures only a small fraction of the ostracods in the area over which it passes. Therefore, the abundance of ostracods in a trawl sample gives, at best, an index of ostracod abundance. It is also probable that a trawl will capture a different percentage of ostracods in its path when passing over one type of sediment than over another, so that indices of ostracod abundance may not be accurate when comparing areas containing different sediments. Variations in abundance of vegetation may affect the depth at which a trawl will dig into the sediment and therefore, the number of burrowing ostracods captured.

Another sampling problem exists because all species of ostracods do not have the same living habits. For example, some species prefer burrowing in sediment, whereas others prefer crawling on vegetation. A sample obtained from a coring tube that pushes vegetation aside will contain fewer plant crawlers than live in the area sampled by the coring tube. On the other hand, a sample from a trawl that rides on the vegetation will contain too few sediment burrowers.

Clearly, obtaining an unbiased and adequate sample is one of the major problems confronting students of living ostracods. In the data presented in this paper, ostracod

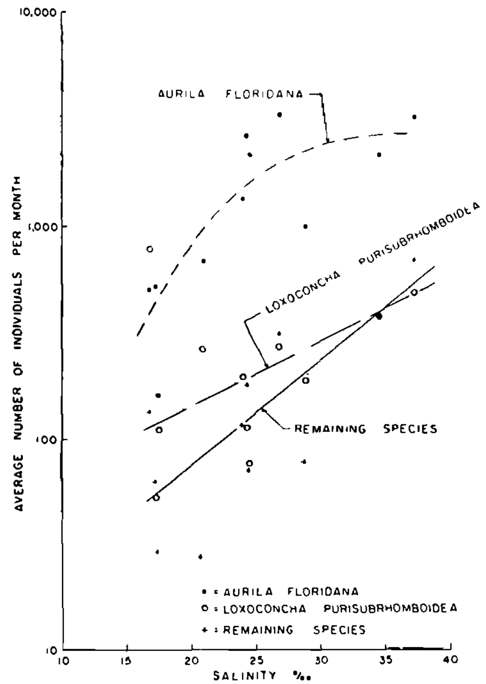


FIG. 6. Relationship between abundance of *Aurila floridana*, *Loxoconcha purisubrhomboidea*, « remaining species » and salinity.

abundances at stations sampled have been averaged for each month; and it is hoped that trends established are real and not the result of imperfect sampling procedures.

SEASONAL DISTRIBUTION OF OSTRACODS

Fig. 4 shows the average monthly values for salinity, temperature, carbon production and ostracods at stations sampled. The number next to each datum point indicates the number of measurements used in obtaining averages.

During winter months the water in Redfish Bay has low salinities, low temperatures, and low carbon production. During summer months, salinities approach that of normal marine water, and temperatures and carbon production increase. Carbon production is considered here as a measure of food available for ostracod consumption.

The graph of ostracod abundance in Fig. 4 was derived by averaging samples collected during a given mouth. All samples were included in this average regardless of the number of ostracods per sample. Samples contained as little as 24 to as many as 8000 ostracods. The ostracod abundance curve suggests that more ostracods are present in Redfish Bay during summer months than during winter months. Ostracods are more abundant when the water has normal marine salinities, high temperatures, and high carbon production.

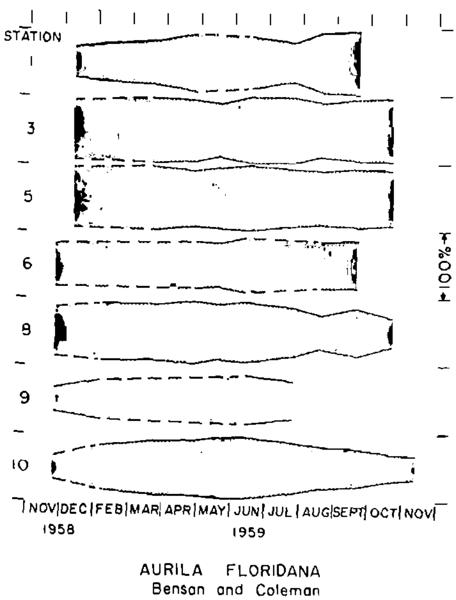


Fig. 7. Percent of *Aurila floridana* in samples.

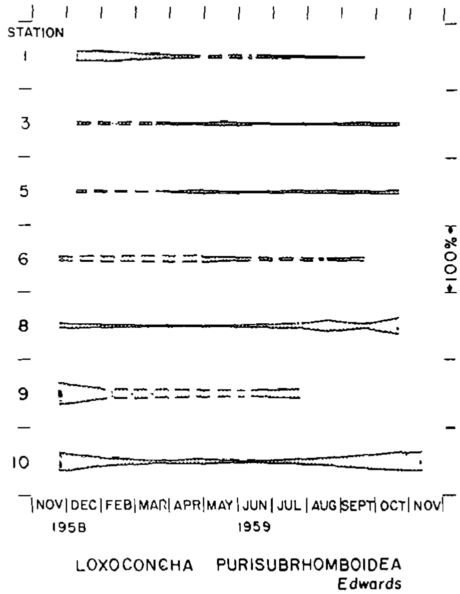


Fig. 8. Percent of *Loxoconcha purisubrhomboidea* in samples.

Fig. 5 shows the averaged monthly abundance of all ostracods and also of certain species. The curve for all ostracods has been smoothed by eliminating from averages samples containing fewer than 150 specimens. The omitted samples are considered to be in error due to faulty operation of the trawl. Although the total ostracod curve in Fig. 5 differs in detail from the curve in Fig. 4 which included all data, the trend showing more ostracods living in the bay during summer months has not changed.

The species that dominated almost all samples collected in Redfish Bay has been tentatively identified as *Aurila floridana* Benson & Coleman (1963). The species normally second to *A. floridana* in abundance and dominating a few samples has tentatively been identified as *Loxoconcha purisubrhomboidea* Edwards

(GROSSMAN, m. s.). The remaing 5-7 species found in samples were usually present in small numbers and here have been lumped together in « remaining species ». The curves in Fig. 5 indicate that the abundance of *A. floridana, L. purisubrhomboidea* and « remaining species » are all greater in summer than in winter.

It is difficult in a field study to determine which property of the environment is affecting the ostracod population. In the present study ostracods became more abundant as the salinity, temperature and carbon production increased. It is not possible to conclude with a degree of certainty that any one of these environmental parameters is more important than another. Also,

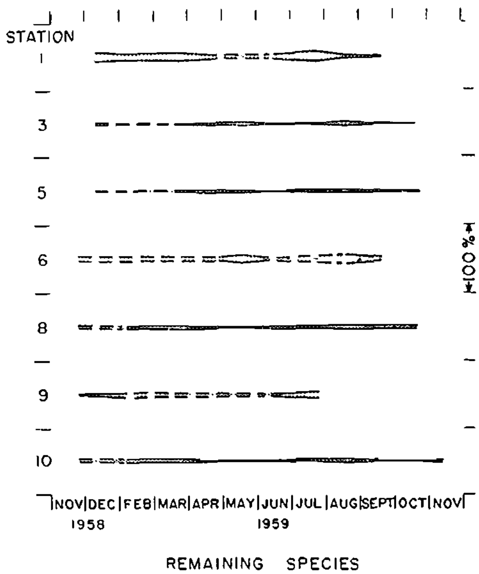
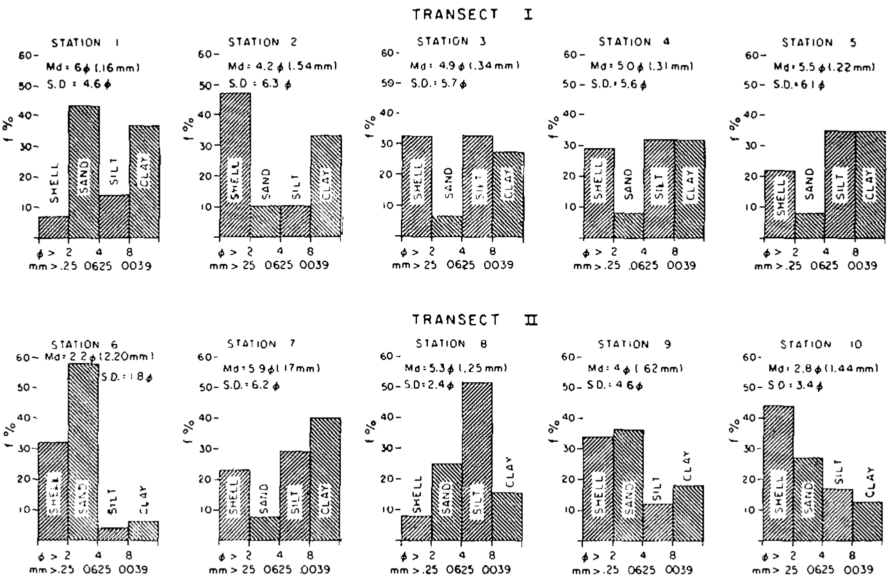


FIG. 9. Percent of « remaining species » in samples.

it is always possible that an important environmental parameter was not measured. The narrowing down of the effect of isolated environmental parameters such as temperature or salinity on ostracod abundance is best handled in the laboratory. Laboratory experiments reported by KORNICKER & WISE (1960) show that *A. floridana* (= *Hemicythere conradi* HOWE & MCGUIRT) collected from Redfish Bay does not tolerate temperatures lower than 6° C or higher than 36° C, and salinities lower than 6 ‰ or higher than 65 ‰. The salinities observed in Redfish Bay during the present study are well within the tolerance limits of *A. floridana,* and it is therefore inferred that the increase in salinity noted during summer months did not contribute directly to increasing the abundance of *A. floridana.* Nevertheless, it is possible to show a relationship between salinity and the abundance of *A. floridana* and other species. This has been done in Fig. 6 which shows ostracod abundance plotted as a function of salinity. Although a fair correlation exists between salinity and ostracod abundance, it is not necessarily a cause and effect relationship. If, for example, an increase in temperature results in an increase in ostracod abundance, salinity would also be found to correlate with ostracod abundance because high temperatures promote evaporation which in turn causes salinity to increase.

The range of temperatures observed during the sampling period was within the temperature tolerance limits for *A. floridana* observed experimentally; but



SEDIMENT CHARACTERISTICS AT REDFISH BAY SAMPLE STATIONS

FIG. 10. Histograms showing distribution of size classes in sediments at each station. Size class greater than 2 phi consisted mostly of shells.

measurements made between sampling periods show that, occasionally, during winter storms, the water of Redfish Bay reached a low of 2° C, which is 4 degrees below the tolerance limit of *A. floridana*. It is inferred, therefore, that low winter temperatures may be a factor in decreasing ostracod abundance during winter months. However, further work is necessary to document this hypothesis.

Little is known about the food tolerance limits of ostracods. It seems logical to assume that ostracods will increase in abundance if more food is made available. The increase in ostracod abundance with high carbon production suggests that food availability may be affecting ostracod abundance in Redfish

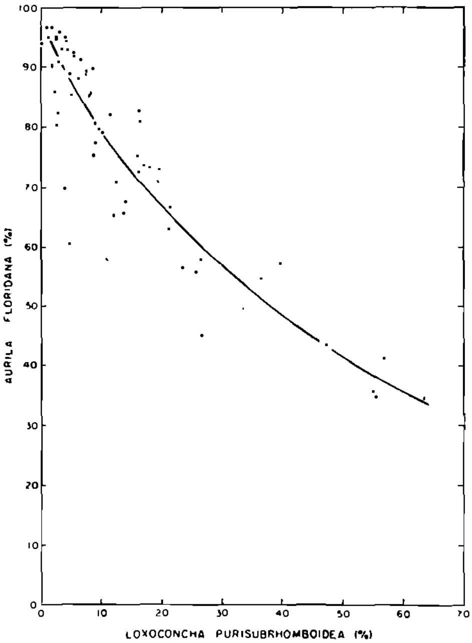


FIG. 11. Relationship between relative abundance of *Aurila floridana* and *Loxoconcha purisubrhomboidea*.

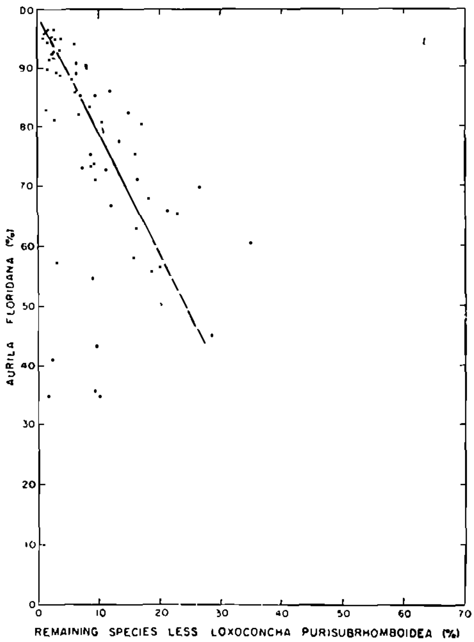


FIG. 12. Relationship between relative abundance of *Aurila floridana* and « remaining species ».

Bay. However, it is not possible to more than infer a cause-and-effect relationship between ostracod abundance and food availability at this time.

Population structure

Fig. 7, 8, 9 illustrate the sample content on a percentage basis of *A. floridana, L. purisubrhomboidea* and « remaining species » in monthly samples from

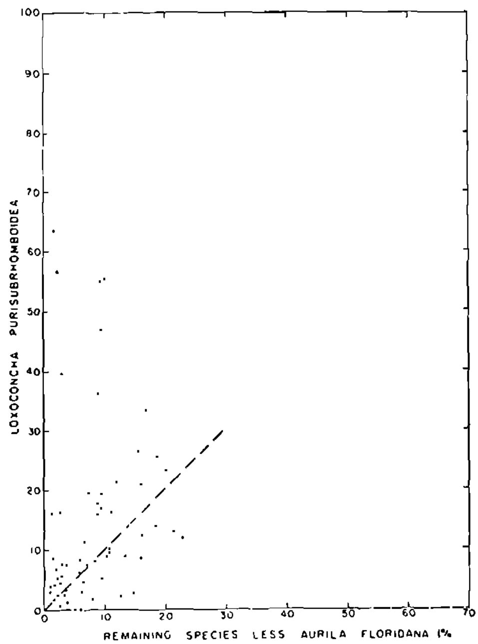


Fig. 13. Relationship between relative abundance of *Loxoncha purisubrhomboidea* and « remaining species ».

each station. These figures indicate that seasonal trends differ from station to station; but perhaps the most significant observation to be derived from these figures is the remarkable similarity in population structure within Redfish Bay. Although temperature and salinity are fairly uniform throughout the bay during any given time, differences in vegetation and sediments at each station might lead to predictions that populations vary considerably from station to station. The sediment, for example, as shown in Fig. 10, was considerably different at each station; but these differences had no readily apparent effect on the ostracod population.

Fig. 11, 12, 13 illustrate relationships between *A. floridana, L. purisubrhomboidea*, and « remaining species » in samples containg more than 150 specimens. The relative abundance of *L. purisubrhomboidea* and «remaining species» varies inversely with the abundance of *A. floridana,* whereas a direct relationship appears to exist between the relative abundances of *L. purisubrhomboidea* and « remaining species ». It is inferred from this that the changing environment has a greater effect on the total abundance of *A. floridana,* than it does on either *L. purisubrhomboidea* or « remaining species ». It is also inferred

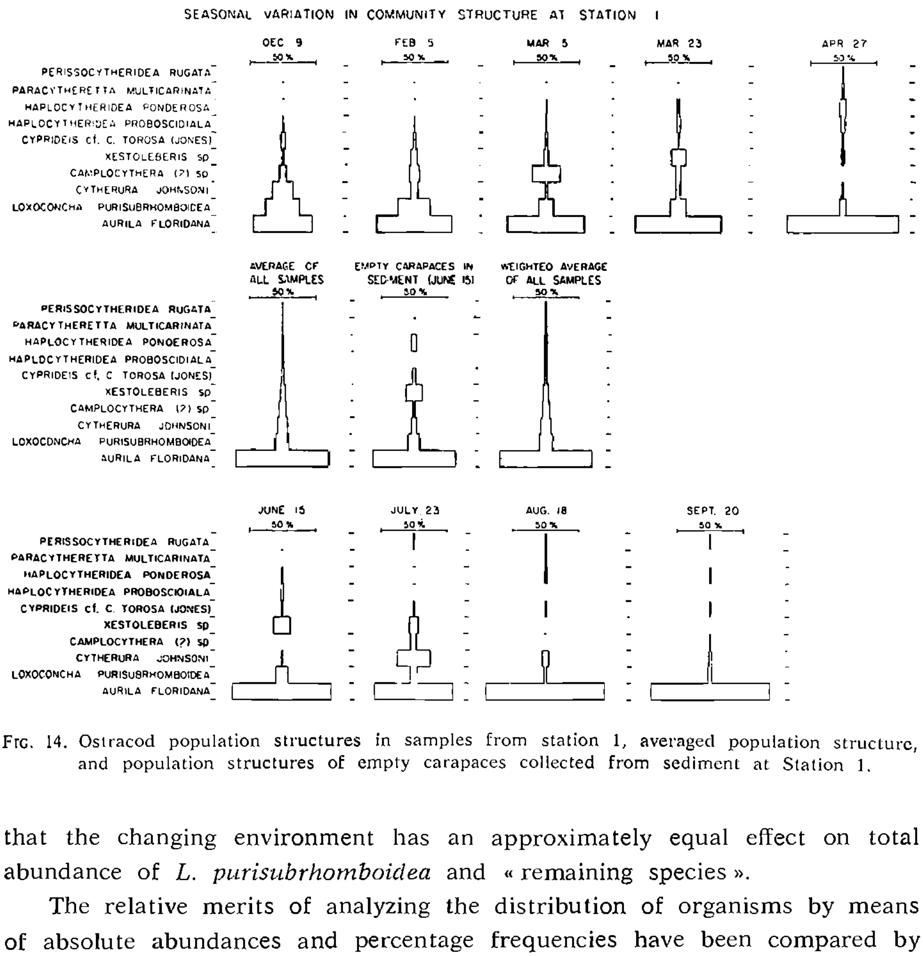


FIG. 14. Ostracod population structures in samples from station 1, averaged population structure, and population structures of empty carapaces collected from sediment at Station 1.

that the changing environment has an approximately equal effect on total abundance of *L. purisubrhomboidea* and « remaining species ».

The relative merits of analyzing the distribution of organisms by means of absolute abundances and percentage frequencies have been compared by several investigators (SAID, 1950; BENDA & PURI, 1962) who have concluded that absolute abundances are more useful than percentage frequencies.

In Redfish Bay seasonal environmental differences are reflected by changes both in absolute abundances and in percentage frequency. Therefore, it is suggested that in distributional studies both absolute abundances and frequency percentages be used independently as environmental indicators. In a study of fossil ostracods, a decrease in absolute abundance not accompanied by change in percentage frequency probably reflects a higher sedimentation rate rather than a change in environment.

Comparison of living and dead population structures

In Fig. 14, the population structure at station 1 is illustrated as a pyramid of species. The length of each horizontal bar is proportional to the percentage of the indicated species in a sample. These diagrams show that common species are present in all samples, but rare species appear to come and go. It is not unlikely that if a larger number of specimens were included in the samples, say 1000 instead of 300, most of the rare species would have been present in all samples. The center-left pyramid in Fig. 14 is the average of all samples, whereas the center-right pyramid is a weighted average of all samples. These pyramids should approximate the average annual population structure.

A question of considerable interest to paleoecologists is: How closely does an assemblage of empty carapaces obtained from the sediment resemble a population living in the area? For this reason, empty carapaces were picked from the sediment at station 1, and the pyramid shown in the center of Fig. 14 was constructed. Although the assemblage of empty carapaces differs from the living population, it is of sufficient similarity to be encouraging to paleoecologists.

Summary

Redfish Bay is a shallow bay having a maximum depth of about 2 m and is located between a barrier island in the Gulf of Mexico and the Texas mainland. Temperature ranges from about 0 to 40° C and salinity from 16 to 37 ‰. Living ostracods are more abundant during summer months when water has normal marine salinity, high temperature and high carbon production. Almost all samples of living benthonic ostracods are dominated by *Aurila floridana* Benson & Coleman. *Loxoconcha purisubrhomboidea* Edwards is usually second in abundance but occasionally is dominant. Ostracod populations are remarkably similar in composition within Redfish Bay. Seasonal environmental differences are reflected by changes both in absolute abundance and in percentage frequency of species. A comparison of the composition of the average annual population living at one station in the bay with an assemblage of empty carapaces obtained from the sediment showed them to be quite similar.

Riassunto

La Baia di Redfish è una baia poco profonda che ha una massima profondità di circa 2 metri ed è situata tra una barriera isolata nel Golfo del Messico e la costa del Texas. Il campo di variazione della temperatura è ca. da 0 a 40° C e quello della salinità dal 16 al 37 ‰. Gli Ostracodi vivi sono più abbondanti durante i mesi estivi quando l'acqua ha la normale salinità marina, alta temperatura ed alta produzione di carbonio. Quasi tutti i campioni ad Ostracodi bentonici vivi sono dominati da *Aurila floridana* BENSON e COLEMAN. *Loxoconcha purisubrhomboidea* EDWARDS è solitamente seconda in ordine di abbondanza ma è talora occasionalmente dominante. Le popolazioni di Ostracodi sono notevolmente simili per composizione entro la Baia di Redfish. Stagionali differenze ambientali producono variazioni sia nella abbondanza assoluta sia nella frequenza percentuale delle specie. Un confronto tra la composizione della popolazione media annuale vivente in una stazione nella baia con una associazione di carapaci completi ottenuti dal sedimento ha mostrato che esse sono totalmente simili.

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DISCUSSION

HARTMANN: You said the number of ostracods in restricted areas was very high. I suppose you mean the number of individuals, not the number of species?

KORNICKER: Yes.

HARTMANN: And then another thing: you named « province » and I think we should not use the name province for biotopes because this is solely for geographical purposes. When you say biotopes, it is more clear.

KORNICKER: I use the term province for the geographical area occupied by a particular environment. Do you feel that this would be incorrect also?

HARTMANN: If it is a certain geographical area that is occupied by a certain fauna then you can use it. For instance, in Central America, they have a Panamanian Province and a Guatemala Province.

BENSON: May I ask for a clarification in semantics? Do you regard biotope as an habitat or the community?

KORNICKER: Habitat.

McKENZIE: The discussion that we have had of provinces seems to suggest that they are rather large in area and can be defined by faunal relationships and FORAMINIFERA too. I wonder if for Bahamas Bank it might not be better to use the term subprovince within the larger area of the Caribbean Province.

KORNICKER: I would have to think about this.

BENSON: I would like to comment on something that Dr. KORNICKER said regarding the concentration of ostracods in a carbonate province. I used the term in the sedimentary sense. I think it was in about 1953 that DORIS CURTIS introduced into the ostracode literature the concept of energy levels in distribution of forms. I know that in my work in Todos Santos Bay I was impressed with the apparent control of wave base on shelly facies and shallow sediments. The distribution of certain ornate ostracods seemed possibly to be influenced by the coarseness of the material in which they lived. This of course was an idea that DORIS CURTIS intended to follow up, and in her 1960 paper on the Mississippi Delta she contended that there were many types of ornamentation as well as the productivity of these ornate forms that was in direct proportion to the coarseness to the material in which it lived. I would suggest, I think it was Dr. ELOFSON who wrote about endopsammose forms which are ornate burrowing ostracods. The ornateness sometimes functions as strengthening against breakage of the carapace according to simple engineering principles. And in some cases spines may extend like cats' whiskers enclosing the setae, to allow the form to work in and about in what I would assume would be like tumbling boulders in an unstable environment. And I was wondering what your thought son this hypothesis might be because the adaption of ornamentation and structure toward increasing energy levels or the instability of the substrate in which or on which the forms live, might be useful paleoecologic indicator.