Holocene history

Whole report

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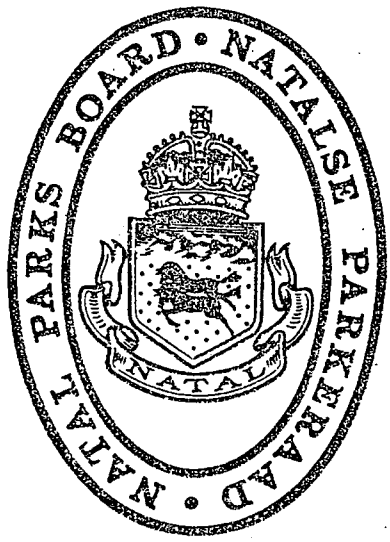
0.5 - 1 m between the samples in the cores

ST LUCIA DOCUMENT COLLECTION



Author PHLEGER F B

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HOLOCENE ECOLOGY IN ST.LUCIA LAGOON, ZULULAND BASED ON FORAMINIFERA

F.B. Phleger

Scripps Institution of Oceanography

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Fred B Phleger

Scripps Institution of Oceanography
La Jolla, California 92093, USA

ABSTRACT

The foraminifera in seven long sediment cores from St. Lucia Lagoon have been analyzed for ecologic implications. They suggest marked temporal variations in organic production and thus variations in river runoff and salinity during the Holocene. Foraminifera in the lower parts of some cores suggest a different geography of the lagoon than at present.

St. Lucia Lagoon is located on the Indian Ocean in Zululand in northeastern South Africa. The geography of the area has been described by Orme (1972). The lagoon is important as a game reserve primarily for crocodiles, hippopotami and water birds, and also is extensively used for recreation by sports fishermen and others. Occasionally runoff of the rivers entering the lagoon is very low, due to relatively low rainfall in the drainage basins. When this occurs the water level in the basin is low, there is a constant net flow of sea water into the basin, and the inner reaches of the lagoon become hypersaline. Many of the crocodiles become "sick" and some die and large flocks of water birds migrate elsewhere. It is apparent that the quality of the environment deteriorates under these conditions.

It is the purpose of this paper to attempt to determine whether variations in salinity (quality of the environment) also occurred during the Holocene (approximately 11,000 years) while the lagoon was developing to its present

condition, as well as during historical times. Such information should be useful in considering techniques for effective management of the ecology of the area.

The foraminifera were studied in sediment samples from seven long cores taken in the St. Lucia area, most of which are presumed to penetrate the Holocene and into older cycles. These cores vary in length from about 7.5 m to 33.5 m (Fig. 2) and are located so that they give a rather wide coverage of the lagoon environments (Fig. 1). The cores were taken at the request of R.S. Crass, Principal Scientific Officer of the Natal Parks Board. Sediment samples were supplied to me by Dr. D. K. Hobday of the Department of Geology of the University of Natal in Pietermaritzburg. Their cooperation is gratefully acknowledged.

The modern assemblages of foraminifera in St. Lucia Lagoon were studied previously (Phleger, in press) as indicators of the ecological processes in the area, and these results form a basis for interpretations of the core faunas. In the earlier study, it was found that the present-day fauna of foraminifera is composed mostly of Ammonia beccarii (Linné) other species are rare or absent in most places except in the lower basin and in the long inlet where they are introduced from the open-ocean.

Organic productivity, indicated by the size of the standing stock of foraminifera, is relatively high in the lower part of the St. Lucia basin based on the large populations of living foraminifera when the collections were made. High production in this place is believed to be a result of constant re-supply of sea water containing nutrients by tidal excursions; the lower part of St. Lucia basin is the inner limit of significant tidal effect as shown by foraminifera and tidal measurements. Large standing stocks in most of False Bay and off the Mkuzi River are interpreted as due to abundant nutrients supplied by river and swamp runoff. Elsewhere in the lagoon the standing stocks are much smaller than in these areas. Hypersalinity in itself probably does not directly affect the well-being of the crocodiles and water

birds during periods of drought. The basic problem during hypersaline conditons is believed to be a reduced supply of nutrients because of low river and swamp runoff, and this results in a low food supply in the inner basin, primarily fish for the crocodiles and water birds. In the lower basin the relatively large standing stocks of foraminifera and fish appear to remain constant, even during low runoff. This is because the constant re-supply of nutrients from the open ocean remain constant.

Determination of the environmental quality (salinity and food supply) indicated by the foraminifera in the cores has been based upon estimates of relative organic production indicated by these faunas. The size of the population of empty tests in a sample may be a partial measure of organic productivity if the sediment samples are of equal size and the rate of deposition of the inorganic fraction of the sediment is constant. Constancy in rates of deposition is unlikely; nevertheless, relative size of population is taken into account in judging relative amounts of production.

Relative abundance of large and small specimens of Ammonia beccarii, which includes almost all of the foraminifera in these samples, has been used as the primary indication of relative organic production. Lankford (1959) has recorded very large standing stocks in his deltaic marine facies in the eastern Mississippi Delta, an area of very high organic production. He found that specimens of Bolivina lowmani Phleger and Parker and Nonionella opima Cushman, the dominant species, are much smaller in size in the areas of large standing stock (and thus high production) than elsewhere. Bradshaw (1957) has reported that specimens of Ammonia beccarii which are grown under optimum conditions in the laboratory reproduce rapidly and the average size of specimens is smaller than those cultured under less favorable conditions. Recently I have studied the foraminiferal faunas in Alvarado Lagoon, Mexico, which are dominated by Ammotium salsum (Cushman and Bronnimann). Where the standing

stocks are large in this area, the average size of specimens is smaller than elsewhere. In St. Lucia Lagoon most specimens of Ammonia beccarii are very small in areas where there are now very large standing stocks of this species, such as in False Bay and near the effluent of the Mkuzi River.

Bradshaw (1957) demonstrated in cultures that specimens of Ammonia beccarii which are grown at temperatures of 15°C continued to increase in size but did not reproduce for the duration of the experiments. Specimens grown at optimum temperatures and salinities reproduced at a small size. Those grown at a salinity of 50 °/oo likewise increased in size and did not reproduce for the duration of the experiment. It seems likely that there must also be a level of food supply which will permit slow growth but inhibit reproduction, at least until the parent is relatively large. It is observed that the modern samples from St. Lucia which are from areas of low standing stock, and low organic rpoduction, contain mostly or entirely large specimens of Ammonia beccarii.

The estimates of high, low or moderate organic production in the cores (Fig. 2), is thus based on the estimated relative abundance of small specimens of Ammonia beccarii (high production) and of large specimens (low production). A secondary consideration is relative size of the population in each sample. Times of high production are assumed to indicate large food supply resulting from high runoff and hyposaline conditions. Times of low production, conversely, represent low food supply, low runoff and hypersalinity in the lagoon, at least in the inner reaches of the lagoon.

Core 1 from northern False Bay shows considerable variation in presumed production as might be expected from its location. High production is indicated in the upper 2 m or more of sediment, and there are five times of high production separated by lower production periods. The

bottom 14.5 m of this long core is interpreted as indicating continuous low production. There is faunal evidence for invasion of marine water at 14.5 m and in much of the core below that depth. The fauna at 21.5 m suggests free access of abundant open-ocean water and again especially at 33.5 m.

Core 2 at Hell's Gate, the channel which connects the main St. Lucia basin with False Bay, contains seven layers of high production faunas separated by low production layers. Faunal evidence for some marine water influence is recorded between 4.5 and 5 m, and at 31.25 m, the bottom of the core, there is abundant evidence for open-ocean influence along with high production. Abundant gypsum crystals occur at 18.5 m and at 25.5 m along with assemblages of Ammonia beccarii which indicate low production. The gypsum appears to be evidence of intense desiccation.

Core 3 in the southern part of False Bay generally shows low production except for one sample at 3 m in which high production is indicated. This low production is not common at present in False Bay, based on the previous study. It is of interest, however, that one surface sample at about the same location as the core has a very small standing stock of foraminifera.

Core 4, adjacent to Selleys Lakes, shows evidence for high production in most of the core except in the bottom 2 m where low production is indicated. This is in a location where most of the surface samples have a small standing stock, but there is a large standing stock at an occasional station.

Core 5 has two samples which indicate high production, but most of the faunas show evidence of low production. This core is from an area in the upper St. Lucia basin where there are relatively small standing stocks at the present time. The core penetrates into sediment apparently from a previous cycle at 10.5 m.

Core 6 was collected in the southern basin of the lagoon where productivity is high at the present time. Most of the upper 4.5 m has evidence of high production, and at 4.75 - 6.75 m low production is apparent. At 7.25 m the core penetrated sand from a previous cycle.

The upper 14.5 m of Core 7 contains faunas showing low production. The presence of abundant plant debris suggests that this material may have been deposited in or near a marine marsh; the occurrence of a few specimens of Trochammina sp. tend to confirm this. Evidence for high production occurs at 15 m, and below that level the absence of foraminifera suggests either a previous cycle or a fresh water marsh.

It appears that organic productivity has varied from high to low several times in some places in the lagoon during the Holocene. It may be presumed that this variation resulted from variations in stream runoff as at present and that it also records hyposaline and hypersaline conditions in the lagoon. It is not possible to ascertain whether the range from brackish to hypersaline water was as frequent as at present because of the nature of the sedimentary record and the frequency of a sampling. Most of the core samples were 50 cm or 1 m apart, and it was not possible to recognize small-scale changes if they are recorded. There is considerable mixing of sediment in this type of environment by benthic organisms such as crustaceans, molluscs and worms, and also by waves and currents. It is expected that only variations in the environment would be recorded in the assemblages of foraminifera which were very pronounced and/or were of relatively long duration. There were times of rather long high or low productivity in some places, as recorded in Cores 4, 5, 6 and 7. The organic productivity varied in different parts of the lagoon on a pattern similar to the present variations. It is not possible to correlate the events shown in different cores, without adequate independent dating.

The geography of the lagoon must have been quite different from that of the present when the sediments in the lower parts of some of the cores were deposited. There is excellent evidence for marked marine influence in the lower parts of Cores 1 and 2, indicating relatively easy access of marine water while the lagoon characteristics of the microfauna were retained. This suggests that the present very long inlet did not exist when the lower sections of those cores were deposited. The inlet to the open-ocean may have been north of the present inlet at that time somewhere between St. Lucia Village and the southernmost exposure of sandstone beneath the barrier dunes on the beach, which is approximately 7 miles north of the present inlet. It seems unlikely that the earlier inlet was as long and narrow as the present one.

The low production indicated in the lower part of Cores 1, 4 and 6 suggests a general reduction in supply of nutrients to the lagoon at some time in the past. This may have resulted from a generally reduced runoff and/or the absence of large swamps in the delta areas of the tributary rivers.

The sequences of foraminifera in the Holocene sediments in the cores indicate climatic changes similar to those which have occurred during the last few years. It appears that significant variations in the quality of the environment within the lagoon have been occurring for the last few thousands of years, and may be normal for this type of area. The implications of this history should be considered carefully in planning for management of the lagoonal ecology.

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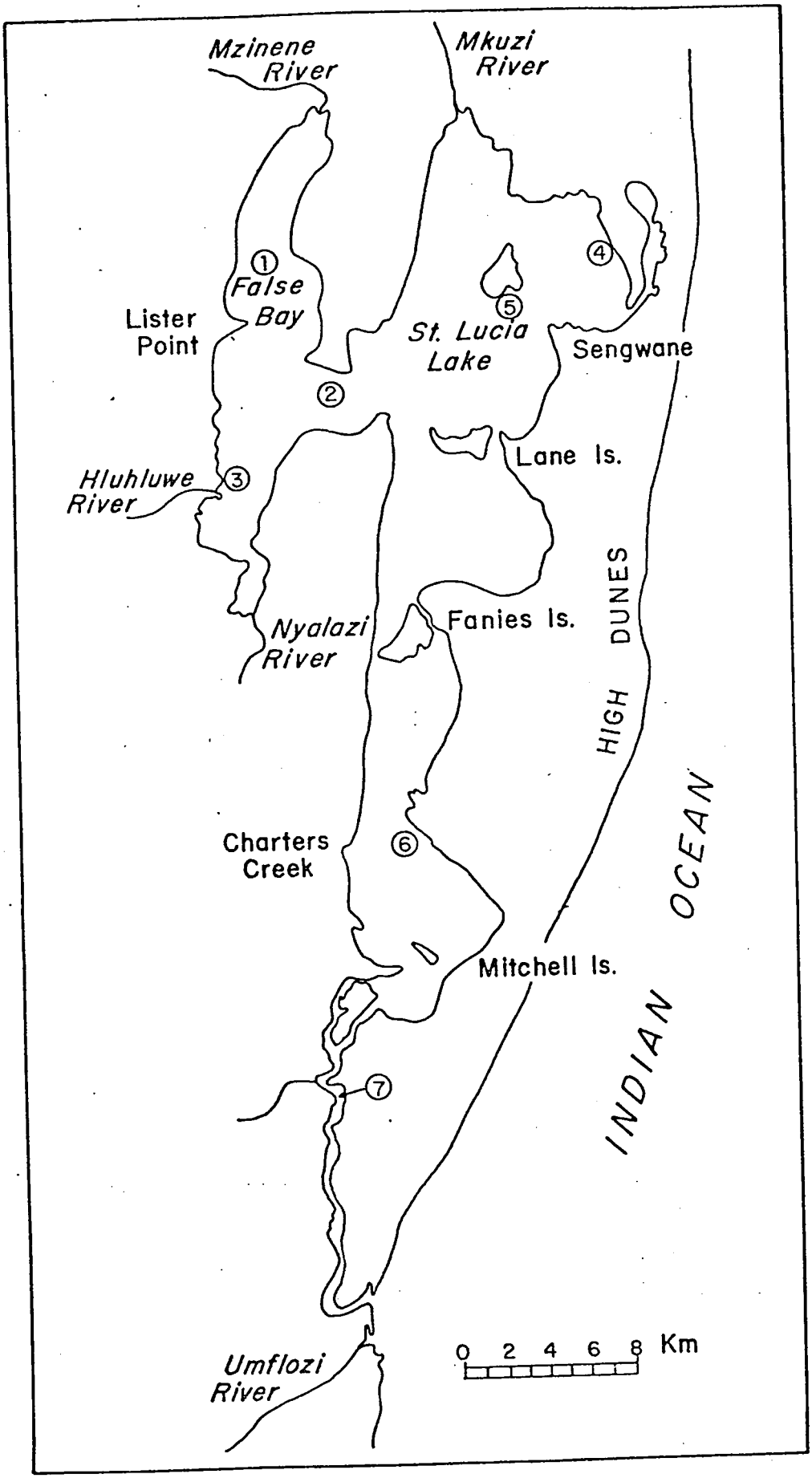

Figure 1. Locations of the cores

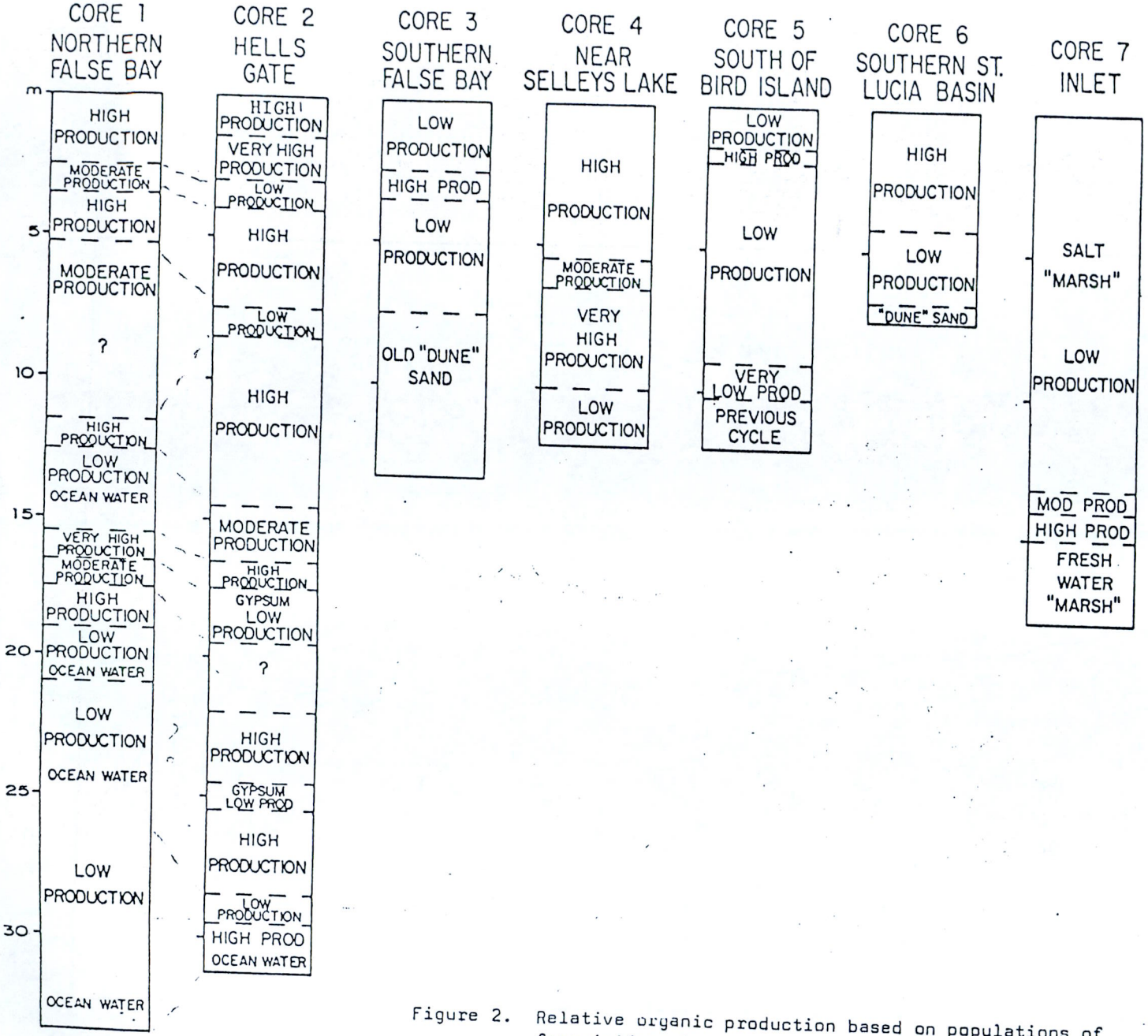

Figure 2. Relative organic production based on populations of foraminifera in the cores