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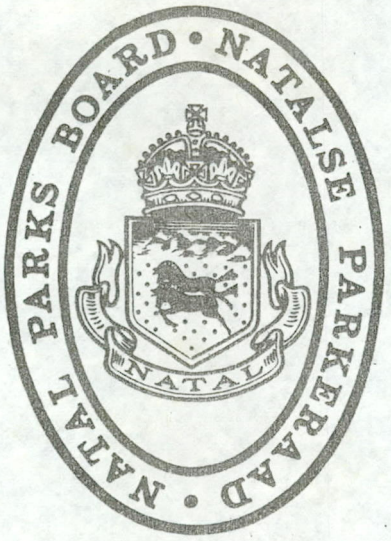

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REPORT BY PROFESSOR J. H. DAY (ZOOLOGY DEPARTMENT, CAPE TOWN UNIVERSITY) ON A VISIT TO ST. LUCIA ESTUARY, JULY, 1948.

INTRODUCTION.

This preliminary report is based on a visit to St. Lucia Estuary by a party of eight biologists during the first three weeks of July, 1948. This survey of St. Lucia, which is part of a much larger project covering all the main estuaries of the Union of South Africa, will not be completed until we have visited the estuary at the other seasons of the year. This Natal part of the Union survey is being financed from two main sources: the cost of the major equipment was met from a grant of £900 made by the Carnegie Foundation and the field expenses were paid from a grant of £1,000 made by the Natal Parks, Game and Fish Preservation Board.

The members of the expedition were Professor Day, Dr. G. J. Broekhuysen, Dr. N. Millard, Mr. W. Macnae, Mr. A. Harrison and Mr. R. Liversidge, of the staff of the Zoology department of the University of Cape Town, and Messrs. R. Jeffry, A. Parkin and H. Taylor, who are senior students in the same department. This report is thus the result of team work rather than the efforts of a single individual.

EQUIPMENT AND METHODS.

From experience gained in previous surveys it was known that a considerable amount of gear is necessary to obtain a clear picture of the physical conditions of an estuary and its plant and animal population. This gear, with the necessary camping equipment and personal effects, was carried in a panel van converted into a caravan-cum-laboratory. Boats were obtainable at various convenient points, but an outboard motor was necessary. The collecting gear included two small-mesh seine nets, a six-foot beam trawl (which was afterwards modified so that it could be dragged by hand through the shallows), a light "D" net with a D-shaped frame mounted on runners attached to a 1 mm. mesh bag, a small dredge and the usual hand nets, plankton nets, and the inevitable spade. The test gear comprised of thermometers, water-sample bottles and salinity set, a colourimetric pH outfit and a Secchi disc to test turbidity.

The party arrived at St. Lucia on July 2nd, and worked there until July 21st. A base was made at the old S.A.A.F. station near Charters Creek from which parties were sent out to various points up and down the estuary. Some of these trips lasted three days and we also spent shorter periods at Richards Bay and Kosi Lake. This latter trip was arranged by Dr. G. Campbell, leader of the Tongoland Expedition, to whom we wish to express our thanks, and we also wish to express our great appreciation of the help and kindness of Captain Potter and his staff, of the Natal Game Reserves, without whose assistance and forethought our trip would not have been so fruitful or so pleasant.

A GENERAL DESCRIPTION OF THE ESTUARY AND ITS SURROUNDINGS.

The coastal area of Zululand in which Lake St. Lucia is situated is a low-lying, flat or gently undulating plain some ten to fifteen miles wide with steep bush-clad sand-dunes along its seaward edge. The surface of the plain is mainly loose sand which reaches a height of 300 feet in the coastal dunes, and the whole area was once covered by bush and scrub palm. There were a few open grasslands but there were extensive marshes along the margins of the lake. Much of the bush has now been cut down to grow sugar cane or else it has been devastated by the periodical veld fires so that it is only in the immediate vicinity of the lake that the former beauty remains.

The geological history of the plain and of the lakes within it was sketched by Anderson in 1904. He states that during the Cretaceous period the sea covered the whole plain and lapped the slopes of the Lebombo Mountains, which are now well inland. The sediments then laid down contained corals and the shells of many species of gastropods, Ammonites and Nautilus, so that these are now found as fossils in the rocky banks of St. Lucia Lake. The Cretaceous sediments were covered by sands during the Tertiary and Pleistocene periods and at the same time the whole plain was elevated above the sea level. He suggests that this deposition of sand accentuated the contours of the lakes, whose shapes had previously been determined by depressions in the sea floor. Professor Walker, however, has pointed out that as the St. Lucia lakes are very shallow it is improbable that they are as old as the Tertiary or even Pleistocene and suggests that they may have been formed in recent times.

There is also another method whereby the St. Lucia lake system may have been formed. A glance at the map shows that the St. Lucia lakes, in common with most of the others on the Zululand coast, run parallel with the shoreline, whereas the upper reaches of the rivers which feed them cut directly through the Lebombo Mountains on their way to the sea. It may be that this sudden change in course is due to the configuration of the underlying rocks, but it may equally be due to the fact that the whole lake system was formed as a series of lagoons during the spasmodic upraising of the coastal plain. The data at present available is insufficient to determine which hypothesis is true.

Anderson also discusses the accounts of the lake given by early hunters and explorers dating back to 1853. This makes very interesting reading in relation to the present silting of the lake and the proposal to cut a separate exit for the Umfolosi, but these matters are better reserved for the final discussion at the end of this paper.

The climate of the coastal plain is sub-tropical and the temperature varies from 18 deg. C in winter to 24 deg. C in summer. The average annual rainfall for the mountainous drainage area to the west is about 36 inches, but there is considerable variation as indicated by figures for the ten-year period 1936-45:—

1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
36.30	36.61	33.67	42.96	37.60	24.90	43.40	49.52	29.50	29.65

From these it will be seen that there was a severe drought in 1941, floods in 1942 and 1943 and droughts again in 1944 and 1945.

Figures for more recent years are not available but residents report that 1946 and 1947 were abnormally dry. Apart from this annual variation the monthly averages show that two-thirds of the rain falls in the months December to March so that the rain when it does come causes flooding in the lakes.

THE TOPOGRAPHY OF THE ESTUARY.

The estuary system is fed by four large rivers. The largest is the Mkuzi, which enters the northern end of Lake St. Lucia. Next in importance are the Hluhluwe, the Nyalazi and the Mzeneni, which empty into False Bay. Finally there is the Umpate, which joins the estuary channel about ten miles from the sea.

The whole estuary system is about forty miles long and stretches from north to south in the shape of a rough letter H. The left limb of the H is formed by a lake called False Bay, which is sixteen miles long, two miles wide and about six feet deep in the centre. The cross bar of the H is a strait between two cliffs known as Hell's Gates.

The right limb of the H is Lake St. Lucia, which is twenty-five miles long but almost cut in two by Fanie's Island, which separates the northern portion joined to False Bay from the southern portion which empties into the estuary channel. The northern half of Lake St. Lucia is six miles across and an average of five feet deep in the centre. It contains three reedy islands, of which the largest is appropriately called Bird Island. The junctions between the northern and southern halves of Lake St. Lucia are two channels on either side of Fanie's Island. The western channel is a hundred yards wide and over ten feet deep but the eastern one is a very narrow winding stream between extensive swamps. The southern half of Lake St. Lucia is two to three miles wide with an average depth of three feet. However there are three basins over six feet and the largest of these is opposite Charters Creek and the abandoned S.A.A.F. flying boat station. The southern half of the lake also contains several islands and at its southern end where it joins the estuary channel it is beset with shallows and mud banks. From among these the main channel winds in and out between a number of muddy islands covered with reeds and scatterings of small mangrove before it deepens and is joined by the Umpate River. From here on to the hotels the channel is between a hundred yards and a quarter of a mile wide and has an average depth of seven feet in mid-stream. Just below the hotels the channel turns sharply east and from here on it is choked with soft mud which has been brought down by the Umfolosi River, which joins the channel from the south. On the north bank immediately opposite the junction of the Umfolosi there is a large reed bed and between this and the beach there is a long narrow tongue of water. The reed beds and this blind inlet are surrounded by high sand dunes which on the landward side are covered with bush, and from Anderson's account it would appear that the whole of the area enclosed by these sand dunes was once a large lagoon named St. Lucia Bay. Indeed there is a record that H.M.S. "Goshawk" entered St. Lucia Bay on December the 18th, 1884, to claim Zululand for Britain.

The lagoon, which had a narrow exit, was liable to floods during the rainy season and would then burst through the retaining sand dunes to the sea. All that now remains of the lagoon is the above-mentioned narrow inlet, the reed beds to the north and acres of soft mud and mangrove swamps to the south. At low tide there is only a narrow central channel which is not more than fifty yards wide and five feet deep at the mouth.

THE PHYSICAL CHARACTERISTICS OF THE ESTUARINE WATERS.

There are five factors which have a marked effect on estuarine life. These are water movements, temperature, salinity, pH and turbidity. A brief discussion of these will indicate the conditions of life in St. Lucia. WATER MOVEMENTS within the estuary are slight. During the winter there is little or no water coming in from the rivers and the sea exit is so narrow that tidal effects are slight and restricted to the lower channel. Thus the maximum rise and fall during spring tide at the Estuary Hotel is about 13 inches. It should be noted, however, that the winds cause sufficient wave action within the lakes to keep a good deal of bottom mud in suspension and to prevent any noticeable water layering. TEMPERATURE: Since the air is warm and air temperatures do not vary greatly from summer to winter the estuarine water temperatures are very similar to those of the open sea, though naturally more variable. Our winter records show that Lake St. Lucia averaged 20° C as compared with local sea temperatures of 22.5° C. Probably the summer records will show a slightly higher temperature in the lake than in the sea. SALINITY: During July, 1948, the estuary was more salt than the open sea and what was more surprising was that the salinity increased in the upper lakes, reaching a maximum of 52.6 parts per thousand in False Bay as compared with 35 parts per thousand in the open sea. pH: The estuary is slightly more alkaline than the sea, the average pH being 8.6 as compared with a normal value of about 8.2 for the sea. It is reasonable to suppose that this greater alkalinity is due to the calcareous rocks over which the rivers flow: TURBIDITY: Most of the water is a muddy grey. This is most evident at the entrance of the Umfolosi and again at the top of Lake St. Lucia near the mouth of the Mkuzi. In these cases the turbidity is due to the inflow of rivers, but it must also be remembered that the lakes are shallow and the bottoms are covered in many places with fine silt which is easily stirred up by wind so that the clarity of the water varies greatly from day to day. Residents also report that the water is much browner in summer when the rivers are in flood.

THE FLORA OF THE ESTUARY.

Due to the turbidity and the high salinity the aquatic vegetation is scanty. There are reed beds round the margins of False Bay and the northern half of Lake St. Lucia and although the reeds do not now extend into the water, the dead stumps indicate that they did so when the water was less saline. Thus the only macroscopic vegetation actually growing in these upper lakes is *Enteromorpha,* and even that is scanty. From Fanie's Island down through the lower half of Lake St. Lucia to the islands at the top of the channel a few reeds appear in the water margins and *Zostera* beds may be found in sheltered areas. The *Zostera* is restricted to depths between 6 and 18 inches and is often luxuriant; many patches are heavily epiphytised by small filamentous algae and among the islands it may be mixed with the brak grass *Ruppia.* In the channel below the islands there appears to be no aquatic vegetation though there are reeds along the margin and mangroves at the water's edge. These, incidentally, were first seen as low bushes and stunted trees among the islands but lower down the channel they are better grown. Finally on the south bank near the pont and opposite the hotels there are well developed mangrove swamps. The only other aquatic vegetation in this area is a thin film of the ubiquitous *Enteromorpha* on the surface of the soft mud; there is no sign of *Zostera.*

THE FAUNA OF THE ESTUARY.

The largest aquatic animals are hippopotami and crocodiles. Both were found all over the estuary from the sea mouth to the entrance of the Mkuzi but their numbers were much smaller in the lakes than in the neighbouring rivers. Altogether twenty-five species of aquatic birds were identified: gulls and terns were common on the open lakes and sea eagles were often seen. In the weedy shallows were pelicans, flamingoes, kingfishers, ducks, geese, cormorants and goliath herons. On muddy shores were more herons, ibises, spoonbills, plovers and avocets. This list therefore shows that the bird fauna is fairly well represented.

Our knowledge of the fish population was limited by our gear. We had a small (20 yard) seine, a 6 foot beam trawl and various smaller nets so that we could net small fishes but large ones could only be obtained by rod and line. We found the angling poor, and other anglers nearby reported the same. The edible fish included "Salmon" or kabeljaauw (*Sciaena hololepidota*), grunter (*Pomadasys operculare*). Net catches included over 40 species

but relatively few individuals and again the total weight of the catches was low. There were many tiny *Austrosparus*, mullets, mud bream (*Tilapia mossambica*), Cape soles (*Solea capensis*), tobies (*Tetrodon immaculatus*), glass nose anchovies (*Thryssa vitrirostris*), Atherina, Syngnathus, Gobius spp., but surprisingly no young kabeljaauw or grunter, although we were on the look-out for them. From our results we judged that St. Lucia in winter is no longer an angler's paradise nor are the fry of the larger fishes to be found there.

Three species of Penaeid prawns were common and one shrimp (*Leander pacificus*) but it was noticeable that these are commonest in the *Zostera* beds with the fish fry so that in False Bay and the upper half of Lake St. Lucia where *Zostera* is absent only three or four prawns belonging to the species *Penaeus indicus* were taken. Again bottom-living animals are poorly represented probably because silt chokes their burrows or clogs their gills. Thus there were no burrowing prawns such as *Callianassa* or *Upogebia*, which are so important in many other South Afrian estuaries. Only a very few burrowing bivalves were found, no cockles, only two small species of gastropods, and a few Polychaet worms. There are however over a dozen species of crabs, of which two, the large swimming crab *Scylla serrata* and the small *Hymenosoma orbiculare*, are important in the lakes, while the rest are mainly shore forms or mangrove dwellers from the lower channels. Mention should, however, be made of the oyster beds in the estuary channel about a mile from the sea. The beds look like small islands just above the mud banks of the Umfolosi and though the shells are often covered with this mud the animals look quite healthy. Plankton nettings during the daylight produced little more than the large Rhizostomid jellyfish so common in many South African estuaries. Night tows as usual gave better results but even so the plankton was not rich. However, that was to be expected since the floating life of a normal estuary is being washed out to sea, and the basic plant food is the attached forms, particularly *Zostera*, which with its epiphytes and their breakdown products provide nourishment for various small herbivores such as shrimps, prawns, bivalves, worms and young fish. These in turn are the food of the larger carnivorous fish. Thus in St. Lucia where the aquatic vegetation is so scanty it is not surprising that the fishing is poor.

THE NATURAL DIVISIONS OF THE ESTUARY.

The estuary is a large one and the description thus far has been necessarily general. But using this background we can now consider parts of it in greater detail. And in fact the whole estuary system is naturally subdivided into parts each of which has a fairly uniform character and a homogeneous population. Thus False Bay and the northern half of Lake St. Lucia are both extensive sheets of highly saline and very turbid water with little aquatic vegetation, a poor bottom fauna, practically no prawns and few fish. Let us refer to this whole area as the False Bay Area for the sake of brevity. From Fanie's Island down the southern half of Lake St. Lucia past Charters Creek up to and including the islands at the mouth of the channel the water is clearer and less saline, and there are well developed *Zostera* beds and relatively numerous prawns, shrimps and small fish. This again is a fairly homogeneous area which we shall refer to as Charters Creek Area. Unfortunately we know little about the channel below the islands except that there was no sign of *Zostera* or any other waterplant but in spite of our ignorance we feel that this is another fairly uniform area, which we shall call The Channel. Finally in the last stretch between the pont and the sea there are vast areas of soft mud and well developed mangrove swamps with their characteristic if limited population. This we shall call The Muddy Lagoon. At the mouths of most estuaries there are usually large tidal banks of muddy sand overgrown by *Zostera* and colonised by a host of burrowing worms and shellfish. If such an area existed in what was once called "St. Lucia Bay" it has now been choked by mud.

Note: The detailed description of the conditions and fauna of these different areas is omitted from this brief preliminary report but will be included in the final publication.

DISCUSSION.

Scientific interest in St. Lucia is centred on two important questions. The first is silting and the second the high salinity. We feel that these phenomena are the basis of the scanty plant life, the poor fauna and the deterioration of the fishing.

Silting: Silting is by no means confined to St. Lucia, nor is this estuary as badly affected as some others on the Natal coast. For example, the Umzimvubu at Port St. Johns is probably worse and in both cases the cause is erosion in the upper reaches. Most of the mud enters the St. Lucia from the Umfolosi and the swamps at the lower end of this river where the silt was previously deposited have been canalized so

that sufficient current is maintained to carry the silt into St. Lucia Lagoon. Much of it is carried out to sea, where it is deposited as a large sterile mudbank offshore, but a lot is also caught by the rising tide and carried up the St. Lucia channel to form extensive sheets of mud opposite the hotels which is being colonised by mangroves. This mud may reduce the width and depth of the mouth but this is doubtful. In the first place the mouth is sandy, not muddy, and from Anderson's account it would seem that even fifty years ago the mouth was not more than fifty yards wide and five feet deep at low tide. What it undoubtedly is doing is to fill up the old "St. Lucia Bay" so that at low tide only one narrow channel remains. Moreover the silt in suspension cuts down the light whih is necessary for the aquatic plants and the deposited mud smothers both these and the bottom-living animals. We feel that it is this sterilising effect rather than the problematical choking of the mouth which has caused the poor fishing.

Whether the silting can be prevented is hardly a problem for a biologist. Suggestions have been made that a separate exit should be cut for the Umfolosi, and it has been said that a separate exit previously existed. The only record that we have found is that St. Lucia Estuary and the Umfolosi joined to form St. Lucia Bay, which had an exit which was liable to shift during floods. Nor does the present course of the Umfolosi indicate a separate exit as it leads north towards St. Lucia and not east towards the sea. Indeed if a separate exit is cut on its east bank the curent of the Umfolosi should be deflected by some barrier on its west bank to maintain the new opening. It should also be remembered that in the absence of any flow from down the estuary there is a danger that the St. Lucia mouth itself would close during the dry season.

Salinity: If silting is the cause of the poor fauna in the lower parts of St. Lucia this is not the cause in the lakes. In some places large clean sandbanks exist and in others it can be seen that the mudbanks have been cut vertically away. The presence of silt in suspension may be a contributory cause to the poverty of basic plant food but the prime cause must be the high salinity. There is much evidence that it has not always been so saline and indeed old oyster beds opposite Charters Creek and large banks of broken shells further up indicate that the lakes once had a rich bottom fauna. Again the rotting reed stumps and tales of difficulty in navigating the *Zostera*-filled shallows among the islands show that plant life once flourished. What then is the cause of this high salinity?

The salt may have come from the land, leached out during the course of rivers or it may have come from the sea. The geological history does not indicate the deposition of salt in any quantity and many of the surrounding rivers are quite fresh. It is true there are small brak pans in the vicinity but there are many more fresh ones and indeed a very large fresh water lake, Lake Sibaya, occurs further north. Again Kosi Bay and Richards Bay are both fresher at the top than at the mouth. It is in fact evident that a terrestrial origin for the salt in False Bay is unlikely. If we accept a marine origin for the high salinity then the most likely hypothesis is as follows. The rate of evaporation from such an extensive series of shallow lakes in a subtropical climate is very great. In this case it has been so great that during the prolonged drought that has existed in Zululand over the past three years the water level has fallen considerably. The level of the lake is never much higher than the sea and now it is actually below so that the sea at high tide is flowing up the channel to replace losses from evaporation. During its slow upward passage further evaporation occurs and the salinity increases till it reaches a maximum in False Bay.

If this hypothesis is correct then a flood will quickly reverse the position and reports indicate that this has happened in the past and that the migratory fish in the lakes were then killed and the water was almost fresh enough to drink. The typically estuarine fauna can stand this change and two fish at least, *Tilapia mossambica* and *Monodactylus argenteus* are unaffected by transference into rain water. With lowered salinity the vegetation will be rapidly increased to form the basis of a new and flourishing community.

The effect of silting and salinity on the migratory fauna is an interesting one but one that cannot be solved in a single survey. To begin with it is uncertain which species do migrate and which do not and since animals usually move with the seasons this problem demands a prolonged study over a number of years. To prove that a fish or prawn does not migrate it is necessary to find all stages within the estuary from eggs to breeding adults. Conversely, to prove that it does migrate either to spawn or to feed definite seasonal movements must be proved. Obviously this could not be done in our three weeks' visit so that our ideas are merely tentative. However, from the presence of young fry, juveniles and adults it appeared that some of the mullet are estuarine, also the silver bream, *Anstrosparus sarba*, the mud bream, *Tilapia mossambica*, the Cape sole, *Soleo capensis*, and the common shrimp, *Leander pacificus*. The largest fishes such as the kabeljaauw or "salmon," *Sciaena hololepidota*, and the grunter, *Pomadasys operculare*, appear from other records at our

disposal to be migratory and we suspect that they come into the estuary to feed and not to spawn. Their movements appear to be linked with those of the Penaeid prawns. Although small numbers are present in the lake in winter, the large increase is in early summer following the appearance of the prawns.

The prawn form then the basic food of the larger fishes and their movements are of importance in the economy of the lake. It is known that these Penaeid prawns do not carry their developing eggs as do other Decapod crustaceans; they liberate the tiny eggs to hatch and develop on their own. Workers in the Southern United States and Dakin in Western Australia, where Penaeid prawns form an important fishery, have shown that breeding never takes place in estuaries but at the bottom of the sea. They are migratory. The young stages are found in marine plankton and during the spring when the young are about half an inch long they enter the estuaries in great numbers. They grow rapidly during the summer and in the autumn they migrate back to the sea, spawn and then presumably die. At any rate the spent prawns do not return to the estuaries. Our own evidence is very scanty. During our winter visit prawns were scarce but the rangers were all agreed that vast numbers of young "shrimps" appear at the mouths of the rivers in the spring and that during the summer they are plentiful. Finally *Penaeus japonicus*, one of the prawns we obtained from St. Lucia, was also dredged by the *Africana* from a depth of 42 metres off the Zululand coast in June, i.e. the Winter. Obviously a lot remains to be done but it will be surprising if the South African prawns are found to have different habits from others.

SUMMARY.

We have made one brief visit to St. Lucia and our conclusions are necessarily tentative. We hope to return at other seasons to continue the work. We have found high salinity in the lakes and silting at the mouths. These factors contribute to the scanty aquatic vegetation, poor bottom fauna and thus to the small number of fish. These questions have been discussed.