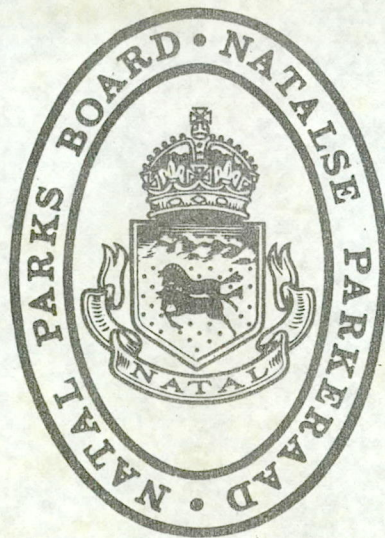


ST LUCIA DOCUMENT COLLECTION



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THE ST. LUCIA LAKE SYSTEM :ASPECTS OF BIOLOGY, MANAGEMENT AND RESEARCHby A. T. Forbes.
(1979)INTRODUCTION

St. Lucia is the largest of the South African coastal lakes. It is a recognized game reserve under the administration of the Natal Parks, Game and Fish Preservation Board. It has long been a favoured area for holidaymakers and particularly anglers. Despite being a Reserve the area has probably been more influenced by human activities than any of the other coastal water bodies and the lake and its management have long been the subject of research, argument and discussion at all levels.

It is not possible in this brief review to cover the voluminous literature on the St. Lucia system which now exists. Available information has been collated and is housed at the Natal Parks Board Research Centre at St. Lucia estuary. This paper describes the major physical and biological features of the system, aspects of management and research, and finally some possible future lines of research development.

The Habitata) Position, Shape, Area and Depth :

The Lake lies on the east coast of South Africa between 27°52'S and 28°24'S. The system is H-shaped (Fig.1) running North/South parallel to the coast and nowhere more than 7 km from the sea. Maximum width is 22 km but generally 3 - 8 km. Maximum length of the lake is about 45 km. Connection to the sea is via a 21 km channel (The Narrows) which gives a total axial length of about 66 km. The Narrows vary from 100 - 400 m in width.

The total area is variable from about 417 km² during a wet year to as little as 225 km² in a dry year. Most estimates range between 300 and 350 km² (Begg, 1978).

Mean depth of water in the lake is less than 1 m with the lake floor lying between 1 - 1,25 m below sea level. Maximum depth in the lake will vary with water level but rarely exceeds 2 m. The Narrows are 1 - 2 m deep but this partially reflects dredging operations.

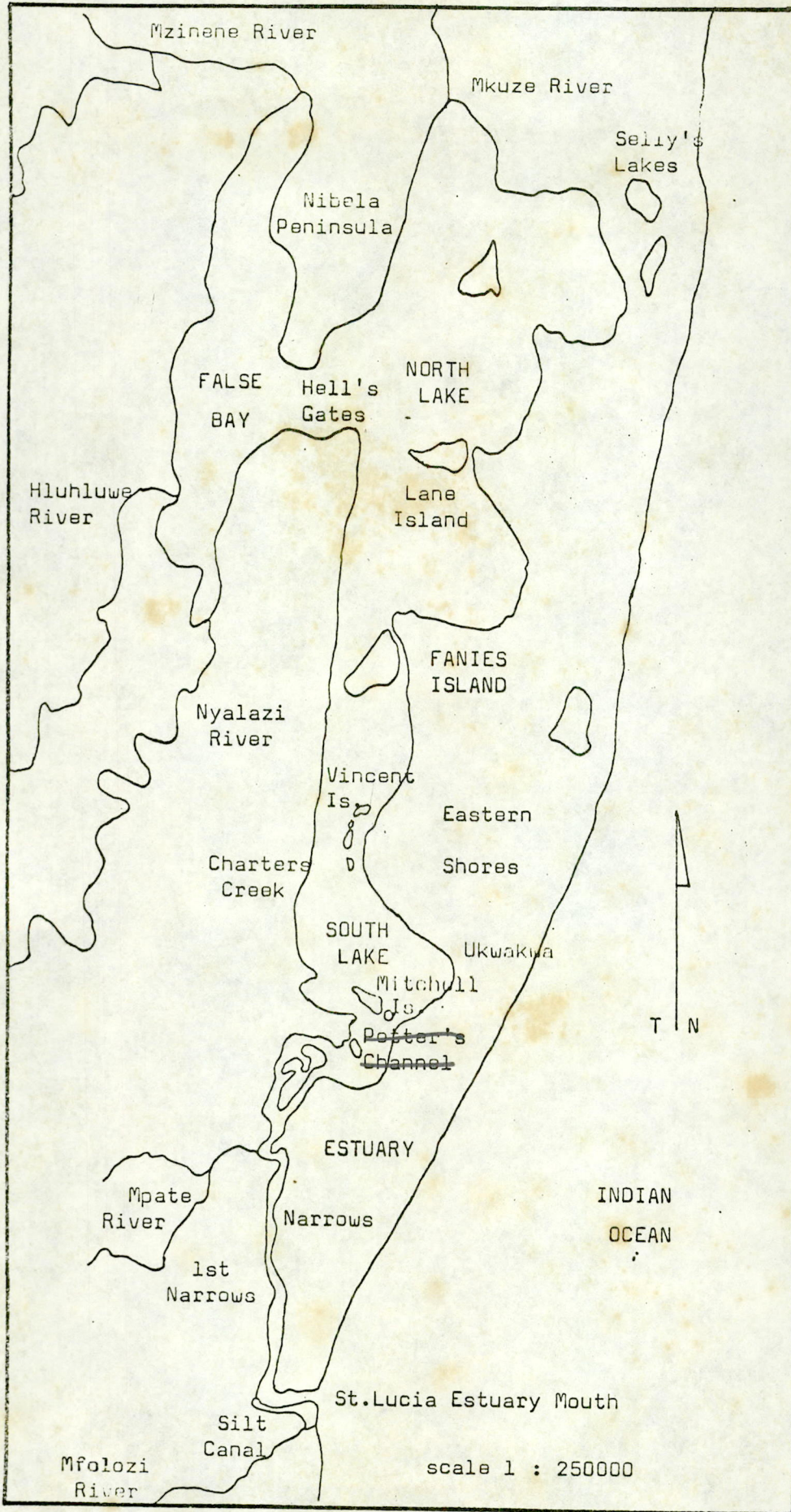


Fig. 1 : The St. Lucia System.

b) Origin and Sediments

The origin of the lake appears to have been similar to that of the northern Natal lakes Sibaya and Kosi, (Hill, 1975). Sediments extend to 33,5 m below present sea level (van Heerden, 1976) and indicate a long period of siltation. Unlike the other lakes St. Lucia is fed by four rivers, the Nyalazi, Hluhluwe, Mzinene and mainly the Mkuzi in the north. This has resulted in extensive siltation the rate of which is said to be increasing because of accelerating erosion in the catchment areas (Begg, 1978).

The input of river borne material has resulted in the bottom consisting largely of soft mud in the northern and western areas of the lake and in the Narrows. By contrast much of the eastern shore consists of open sandy beaches with interspersed areas of reeds where a layer of organic material may overlie the sand.

c) Water - Origin, Movements and Salinity

The water in the lake derives from the sea entering through the Narrows, local rainfall and the incoming rivers. The relative inputs from these different sources combined with evaporation determine the salinity regime in the lake. Under normal (non-flood) conditions water movements in the lake and Narrows are affected by tidal and wind action. These two influences may combine or tend to reduce one another. Tidal currents are clearly apparent through the Narrows as far as the south end of the lake but changes in water level in the upper Narrows are negligible and there is no influence on the lake level.

Movements of water in the lake are primarily wind-driven. The long axis of the lake is roughly parallel to the prevailing winds with the result that seiches of up to 30 cm occur particularly in summer. As much of the shore at the northern and southern ends shelves very slowly this can lead to exposure of extensive mud flats.

Variations in fresh water input affect lake levels and total water area. Mean lake level is 0,17 m above sea level. During a five year period of closure (1951-1956) levels varied from 0,6 m below sea level to 1,06 m above sea level. (Crass, 1970). Between March 1975 and October 1976 when the mouth was open, levels fluctuated between 0,1 m below sea level and 0,85 m above sea level. (Whitfield, 1977). Fluctuations in water level are generally associated with fluctuations in salinity which is probably the major factor affecting animal distribution and plant abundance. High lake levels are associated with essentially fresh water conditions which may prevail not only in the lake but also in the Narrows to within one kilometre of the sea. These levels are also associated with increased total water area and inundation of shore line vegetation. As the water level drops the area of the lake declines and the shore line becomes more

clearly defined. This coincides with rising salinities due to evaporation and entry of seawater into the system to compensate for the falling levels. Under extreme conditions a reversed salinity gradient may develop. The North Lake is thus subject to greatest salinity fluctuations varying from fresh water as in 1977 to 116^o/oo at the end of a series of dry years as in 1972 (van der Elst, 1972). Salinities in the South Lake were moderated by the influence of sea water and rarely exceeded 50^o/oo.

d) Temperature

The extent of temperature fluctuations in the system varies and there is a clear moderating influence of the sea in the lower Narrows. Temperatures in the lake may reach 35-38^oC in the shallows and bottom temperatures at depths of about 0,5 m commonly attain maxima of 30-33^oC for 3-4 months over summer. Temperatures in excess of 33^oC were not recorded in the Narrows. (Forbes & Bickerton, unpublished data). Minimum temperatures in the Narrows varied from 16-18^oC. Minimum temperatures in the lake regularly dropped to 15-17^oC and there are records of 12^oC in False Bay in June 1976 (Blaber & Whitfield, 1976) and 10,5^oC at Charters Creek in July 1979 (Forbes & Bickerton, unpublished data). Water temperature data are not extensive but air temperature records at Charters Creek from 1970-1978 show that winter minima below 10^oC occur regularly between May and September so that the above minimum water temperatures are probably not uncommon. The annual range in the lake is thus approximately 25^oC while in the Narrows it is at most 16-18^oC. Daily fluctuations are in the region of 6^oC in the lower Narrows and up to 8^oC in the lake.

e) Transparency

Water transparency is affected by flooding, turbulence and tidal currents particularly near the mouth. During flood periods the water carries much suspended matter and light penetration is accordingly low. In the lake transparency varies with season and locality. Most of the lake bottom is above effective wave base so that resuspension of bottom sediments occurs readily particularly during summer although this may be reduced where weed beds are sufficiently extensive to dampen wave action. On the western shores of the lake during summer secchi disc readings were generally less than 20-30 cm and frequently less than 10 cm. Turbidity decreased towards the eastern shore in South Lake due to shelter provided by vegetation, a more sandy substrate or greater shelter from prevailing winds. Readings of 40-60 cm were obtained at Vincent Islands and up to 1 m at Ukwakwa. Greater clarity associated with less turbulence was characteristic of the calmer winter months. Reading of up to 50-60 cm were recorded on the western shore increasing to over 1 m on the eastern shore. Unseasonal calm days in summer did

occur and resulted in higher than normal secchi readings. In the Narrows secchi readings were always very low - very rarely over 30 cm at any season. Exceptions occurred near the mouth where incoming sea water on a high tide occasionally gave readings up to 2 m. Although wave action in the Narrows is less than in the lake (Forbes & Bickerton, unpublished data) the bottom is almost entirely fine silt which is easily suspended by tidal currents with a consequent reduction in transparency.

Major Vegetation Types

The two major woody plants associated with the system are the mangroves Avicennia marina and Bruquiera gymnorhiza. Mangroves are at present spreading in the Narrows following extensive destruction during dredging activities (Ward, 1976). A.marina is the pioneer species and several substantial stands occur from a point just within the mouth as far as Potters Channel. B.gymnorhiza is common from First Narrows and occurs patchily in the lake as far north as Fannies Island. Hibiscus tiliaceus occurs at a higher level than the mangroves and extends from the Narrows up the western lake shore as far as Hells Gates. Barringtonia racemosa is less common occurring on the eastern lake shore where there are several seepage areas (Ward, 1976). A very significant component of the shore line vegetation is the reed Phragmites australis which dominates many of the islands and much of the shore line of the main lake. Scirpus littoralis occurs in localised areas of the lake and Narrows while Juncus kraussi is more common along the periphery of the Narrows. Three grasses are important along most of the shore line of the lake and False Bay. These are Sporobolus virginicus, Paspalum vaginatum and Stenotaphrum secundatum (Ward, 1976).

Floating plants are relatively unimportant. Of the submerged macrophytes the alga Enteromorpha sp. is conspicuous at times but the main species are Zostera capensis, Ruppia spiralis, R.maritima and Potamogeton pectinatus. Ward (1976) considers that R.maritima is typical of shallow pans adjacent to the lake and not in the main body. The distribution of Z.capensis, R.spiralis and P.pectinatus largely follows changes in the salinity regimes. P.pectinatus extends southwards during periods of low salinity but retracts northwards and is replaced by R.spiralis and Z.capensis during increasing salinities. Submerged macrophytes are absent from the Narrows and may disappear from the lake altogether during high salinity periods although under favourable conditions they may proliferate sufficiently to seriously limit boating activities.

In the north of the system the Mkuze swamps cover an area of 120 km² dominated by papyrus (Cyperus papyrus). Access is difficult and the area is poorly known.

Major Faunistic Features

The St. Lucia system is a recognized game reserve under the control of the Natal Parks, Game and Fish Preservation Board. It supports a population of about 600 hippopotamus (Taylor, 1976) and a minimum of 400 crocodiles. This is the largest population in southern Africa and is particularly valuable because some of the breeding grounds rank among the largest in Africa that fall within a completely protected area (Pooley, 1976). The bird life of the area has long been a tourist attraction and about 90 species of water associated birds have been recorded (Whitfield, 1977) although Greater Flamingo (Phoenicopterus ruber) and White Pelican (Pelecanus onocrotalus) make up 80% of the bird biomass (Berruti, pers. comm.) In addition the lake is a major bird breeding area for species such as Goliath Heron (Ardea goliath), Great White Egret (Casmerodius albus), Grey Headed Gull (Larus cirrocephalus) and both White (Pelecanus onocrotalus) and Pink-backed Pelican (P. rufescens).

Utilisation and Human Pressures on the System

The lake is divided into areas accessible to the public and "Wilderness" areas where access is either prohibited or permitted only under Natal Parks Board supervision. This includes the entire lake north-east of a line drawn from a point approximately at the northern tip of Fannies Island to the south end of the Nibela peninsula. Access to the northern 12 km of the Narrows is by Natal Parks Board launch tours only. The major form of recreational use of the area is fishing and the extent of this activity can be gauged by the 300,000 "visitor nights" recorded during 1976 (van der Elst, 1978) most of whom would have been anglers. The fishing effort is to some extent controlled through minimum sizes and bag limits but there is no limit on the number of anglers. Bait collecting is prohibited but the Natal Parks Board runs a bait fishery for penaeid prawns which are sold to anglers. This fishery has yielded a mean harvest of approximately 15,000 kg annually since 1967 (Champion, 1976). Other relatively minor activities include bird and game viewing and photography.

Management Problems

Human access and direct exploitation of the St. Lucia lakes seldom result in serious problems of management although fish poaching using gill nets in the North lake and False Bay has caused concern (Whitfield, 1976). Man induced modifications of the catchment have however resulted in changed drainage and siltation patterns and exacerbated the problems of hyper-salinity during drought years which promises to cause many more serious problems in the future. Hutchison (1976) estimated that 20% of the original annual freshwater input each year is now lost

through damming of incoming rivers and afforestation. Drainage and canalisation of the swamps along the lower Umfolosi River combined with poor land management in the catchment (Weiss & Midgley, 1976) has resulted in siltation problems in the lower reaches of the St. Lucia estuary which originally shared its access to the sea with the Mfolozi River. Fluvial sediments were deposited in the Narrows which finally closed in 1951 (Begg, 1978). Rerouting the Mfolozi to a new more southerly position did not help to open the mouth which remained closed until 1956. A dredging programme in the estuary and Narrows and construction of a groyne at the mouth now assists in maintaining an open connection with the sea but not without cost to the system. Dredging activities and spoil disposal resulted in the destruction of large areas of mangroves while levees built up along the banks in parts of the Narrows have altered drainage patterns, the final effects of which are still unknown. At present a dredged but artificially plugged channel connects the Mfolozi River to a point on the estuary about 2 km upstream from the mouth. A further channel is now being dredged to connect the Mfolozi to a point on the Narrows about 8 km upstream from the mouth. These channels are designed to permit access of fresh water into the Narrows and dilute incoming sea water during periods of low lake levels thus slowing development of hypersaline conditions.

Management and Research

Management of the St. Lucia system has been a matter of perennial discussion at all levels from government down and the periodic deaths or disappearance of animals or plants during periods of flood or hypersalinity has only served to add fuel to the arguments and increase the number of suggestions and ideas to "save the system".

It is thus not surprising that a substantial amount of research effort has gone into the St. Lucia system and also that much of this research has been directed towards establishing the extent to which human influences have exacerbated or accelerated fluctuations in physical conditions particularly salinity or processes such as siltation. Early surveys of the system (Day, 1954) were subsequently extended by various workers to ascertain salinity tolerances of many of the animals and plants in the system and also the ability of different species to recolonise areas from which they had been excluded by very high or very low salinities.

Work up to 1976 has largely been summarised in a series of papers presented at the St. Lucia Scientific Advisory Council Workshop Meeting in February 1976.

a) Hydrology and Geology :

The hydrology of the system which has been extensively studied by the Hydrological Research Unit of the University of the Witwatersrand was described by Hutchison (1976) who has

developed models which point to deterioration in the system being due to diminution of fresh water inflows. Changes in the St. Lucia estuary due to man induced changes in the Mfolozi river described by Weiss & Midgley (1976) ultimately necessitated the estuary dredging programme but Hutchison (1976) considers that this has "lowered the mean level of the lake and narrowed the extreme fluctuations but has had little effect on the salinity regime". At the opposite end of the system the Mkuze swamps are an extremely important component of the system. The swamp was partly canalised during the very high salinity period of 1970-1972 in an attempt to alleviate conditions in the northern lake. This led however to serious erosion problems described by Alexander (1976) and the channel has since been blocked. He points out that possible deleterious results of canalisation on the swamps would far outweigh the minimal advantages to the lake and the swamps could be irreversibly damaged with further long term effects on the entire system.

Blok (1976) reviewed engineering progress and proposals regarding the two major physical problems in the St. Lucia system, viz. rate of sediment deposition and shortfall in fresh water supply. Re-routing of the Mfolozi mouth to reduce siltation, dredging to remove accumulated silt and stabilisation of the mouth by means of groynes has already been carried out. Various possibilities have been suggested to alleviate fresh water deficits or to reduce sea water inputs during low water periods. Many of these are impractical or extremely costly (Blok, 1976). Mercer (1976) discussed the engineering implications of obtaining a fresh water supply from the Mfolozi river and Hutchison (1976a) used a model to predict the effect of various proposals. His "supposedly 'ideal' state of health" must at this stage be questioned and the "significant improvements ... achievable by directing fresh water from the Mfolozi or Pongola rivers, or by drastically altering the geometry of the lake, or by interfering with the Mkuze swamp (possibly destroying the ecosystem in the process)" considered in a new light. In addition he suggested a cost-benefit assessment and the establishment of a dynamic lake management programme.

The past history of St. Lucia and in particular the extent of fluctuations to which the lake was subject before the influence of man would clearly be important in determining permissible extremes in conditions. van Heerden (1976) outlined the geological history of the area particularly during Pleistocene sea-level fluctuations which resulted in valley incisions, the development of the modern barrier dunes and subsequent siltation leading up to the present day situation. Phleger (1976) used foraminifera obtained from sediment cores in an attempt to determine whether variations in salinity and hence quality of the environment occurred during the Holocene (approximately 11,000 years) and also during historical times. He concluded that hypo- and hyper-saline conditions had occurred in the past although the nature of the core samples (50-100 cm apart) did not permit assessment of short term changes. He obtained evidence of marked marine influences which he suggested pointed to easier access of sea

water and hence that the present long link to the sea via the Narrows is relatively new. This interpretation is supported on geological grounds by Hill (1975).

b) The Flora

The major vegetation types of the St. Lucia system, which have already been described are responsive particularly in the lake to changes in physical conditions amongst which Ward (1976) considers the more important to be turbidity, salinity and water level. Changes in these conditions lead to extension or regression of different species. Breen, Iverson & Rogers (1976) investigated the response of one of the important shore-line grasses Sporobolus virginicus to inundation and varying salinities. They found that seeds were not permanently affected by exposure to waterlogged saline conditions. Young plants were susceptible to inundation and salinity but tolerance increased with age suggesting that established plants would survive such conditions. Johnson (1976) investigated the phytoplankton and concluded that it is predominantly autochthonous and well-adapted to extremes of temperature and salinity such that the areas supporting the greatest populations are those subject to the greatest salinity changes. There do not appear to be any quantitative plant studies.

c) Invertebrate Fauna

Salinity effects are a sustained theme through most of the faunal research. Grindley's (1976) plankton studies indicated a "typical estuarine plankton" most of which disappeared from the northern parts of the system during the high salinity period 1969-1971. The plankton community was similar throughout the system and while most species survived salinities of 40⁰/oo, several copepods, an amphipod, gastropod larvae, fish eggs and larvae survived salinities of 60⁰/oo. He suggested that ecological fluctuations in the system are more likely to influence higher plants and animals directly than via indirect effects on lower trophic levels.

Benthic studies on the lake during and following a period of hypersalinity were carried out by Bolt (1975) and reviewed by Hill (1976). The work showed that most species survived salinities up to 55⁰/oo but at higher salinities only chironomids and ostracods were present. When salinities dropped to 30-40⁰/oo there was rapid colonisation particularly by species with short life cycles and planktonic larvae. Recolonisation occurred from the south lake where salinities did not reach the high levels characteristic of the more northerly areas. The most abundant benthic species was the gastropod Assiminea bifasciata. Bolt (1975) states that benthic biomass as a whole is low in St. Lucia compared with northern temperate lakes but as there are no production figures no estimate can be made of energy transfer

rates through the benthos. In addition information on macro-benthic species such as bivalves and crabs is very sparse.

Closely associated with the benthos are the penaeid prawns which despite supporting a bait fishery do not appear to have obtained the attention they deserve. Joubert & Davis (1966) describe the results of a sampling programme carried out between 1964 and 1965 while a further programme from January 1966 - February 1967 and from November 1967 - January 1969 which covered the start of the last high salinity period is described by Champion (1976). The bait fishery, which is dominated by Penaeus indicus did not appear to suffer to any great extent although there was a reduction in prawn numbers in those areas worst affected by high salinities. There was also a decline in the mean size of prawns in the bait catches but changes in catch per unit effort were difficult to establish. Various incidental bits of information were gathered during these surveys, e.g. species ratios in different areas, species size compositions, gut contents and migrations but there is still little quantitative information on prawn densities and aspects such as recruitment and the extent of emigration from the system.

d) Cartilaginous and Teleost Fish.

The only shark occurring throughout the system is Carcharinus leucas, the Zambesi shark. Young of this species are frequently produced either in or close to estuary mouths and they spend much of their time in brackish or even fresh water before moving out to sea. (Bass, 1976).

Research on the teleost fish of the St. Lucia system was conducted by the Oceanographic Research Institute from 1969-1972 as part of a programme on the biology of the estuarine fish of the east coast of South Africa. These results are summarised by Wallace (1976) who emphasised amongst a number of other points the importance of the lake to juveniles of several species. He also lists 19 common species of which 14 tolerated salinities up to 60‰ and 11 were found in salinities up to 70‰. Sarotherodon mossambica was recorded at 110‰ (van der Elst, 1972). Only 9 tolerated salinities much below 10‰. The generally more harmful effect on fish of low salinities combined with sudden falls in temperature which resulted in a substantial fish kill in June and July 1976, is described by Blaber & Whitfield (1976). The long term effects of varying salinities on the St. Lucia fish fauna are described by van der Elst et al (1976) who investigated the system during high salinity (1970 - 1971) and low salinity (1975) periods. There was a marked difference apparently arising from the different salinity regimes. Many species appeared to prefer particular salinities for, despite an overall increase in species number at low salinities some were more common under high salinity conditions including the important angling species Rhabdosarous sarba and Pomadasys commersoni. Species diversity was greatest in the south lake during high salinity periods indicating the importance of this area as a refuge to which fish can retire and as a reservoir for subsequently restocking the lake.

Advances on the basic fish distribution and relative abundance studies have involved investigations of the species composition and predation on the mullet (Whitfield, 1976), distribution, movements and fecundity of mullet (Whitfield & Blaber, 1978), feeding habits of juvenile mullet (Blaber & Whitfield, 1977) and the manner of food resource partitioning by Sarotherodon mossambica, Chanos chanos and the 11 species of mullet all of which are benthic feeders in St. Lucia. (Blaber, 1976; Whitfield & Blaber, 1978a). Van der Elst (1978) has recently produced an analysis of the St. Lucia sports fishery over the last 21 years based on Natal Coastal Anglers Union data. He has emphasised the four most important species, the spotted grunter (Pomadasys commersoni), the Natal stumpnose (Rhabdosargus sarba), the perch (Acanthopagrus berda) and the kob (Argyrosomus hololepidotus). Of the four species only the perch showed disturbing changes in abundance which he attributed mainly to overall estuarine degradation.

The 1976 workshop dealt in addition with the crocodile and hippopotamus populations of St. Lucia lake. Estimates of numbers of both species are now available and in addition seasonal movements, breeding season and breeding grounds for the crocodile are generally known (Pooley, 1976). Little is however known of their diets or other details such as growth rates. An artificial breeding programme is under way and 486 crocodiles were re-introduced to the lake between July 1967 and January 1976. A field study of hippopotamus was carried out between July 1973 and May 1975 with further observations in 1976 with a view to mapping the distribution, movements and major feeding areas. (Taylor, 1976).

A major knowledge gap on the bird fauna became apparent during the workshop meeting. This has been significantly filled by a series of papers on piscivorous birds (Whitfield & Blaber, 1978b, 1979, 1979a) and also by a general study of the birds of the system by Berruti (unpublished information).

Recent Research Directions

The aquatic research effort since 1976 has largely concentrated on fish feeding and predation particularly with regard to mullet and also more recently on the smaller planktivorous fish (Blaber, unpublished information), water bird distribution, abundance and feeding (Berruti, unpublished information) and finally a study of the prawns of the genus Macrobrachium (Forbes, unpublished information). Investigation of M. equidens was begun in 1976 when the prawn bait fishery was to some extent dependent on this species. Subsequent work has aimed at determining the abundance, distribution, breeding and growth patterns of this species and attempts have been made to estimate population densities and biomass using short-term mark-recapture techniques.

Assessment of Research to date and Future Lines of Development

Substantial advances have been made in recent years regarding the effects of physical conditions on the fauna and flora of the St. Lucia system such that it should be possible to predict what species are likely to survive particular sets of conditions. Major gaps do however exist regarding the extent of immigration and emigration from the system and the environmental cues involved. It is clear that these movements could involve substantial removal of energy from the system. The various studies on fish, birds, benthic organisms and plants suggest that while in the case of fish and birds, a variety of species occur in the system, the number of species making major contributions to the biomass and hence probably to energy movement patterns is in fact relatively small and the construction of food webs indicating the major energy pathways could be accomplished fairly easily. Browder (1977) has put forward a proposal to design an ecosystem study plan for the St. Lucia system although no attempt at any significant synthesis has been attempted to date. While it has been mooted in the past that management of the system should be such that "biological resilience" is maximised, and that this involved primarily maintaining a reservoir of organisms it is clear that these "refugees" or potential colonists are going to make certain energy demands of the area into which they are concentrated, and it would seem of importance to obtain a better idea of the carrying capacity of the reservoir area and also the dependence of particular species on areas of the lake which are not included in the reservoir area. This argument immediately pinpoints the knowledge gap that except in a very few instances, e.g. the benthos (Boltt, 1975), nothing is known of the biomass of most species, the carrying capacity and the extent of utilisation of different areas, or of basic primary organic input into the system whether autochthonous or allochthonous.

While the surface has been significantly scratched the potential for further research on this largest and most dynamic of our coastal lake systems remains immense.

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