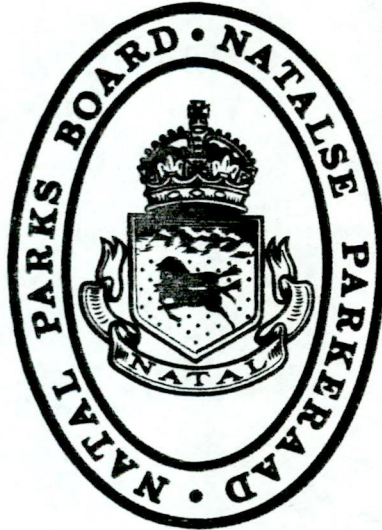


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A.C. POOLEY

Introduction

The ecology of the Nile crocodile has not been studied in Lake St Lucia and its river system. We have field experiences of population census problems, population estimates from a limited number of aerial counts, field notes on mortality and breeding, seasonal movement, distribution of the animals in the lake and limited data on feeding behaviour, diet and predation. These data compiled from the field reports of staff, a limited amount of published material and the observations of the writer are contained in this report.

Crocodiles are important predators of fish in the Lake St Lucia system, and of the shoreline fauna. They fertilise the waters with nutrients processed from their prey species. They seasonally produce large clutches and the eggs and live young in turn provide food for several species of mammalian, avian, reptilian and other predators. The breeding colonies of the lake are important for conservation purposes because they fall within a protected area. On the other hand crocodiles can pose a threat to humans in recreational areas. Newly discovered nesting colonies along the Umfolozi Link Canals need careful monitoring, for any increase in the population in the adjacent estuary area could lead to crocodile - human safety problems.

1 Population census

Because of the size of the lake and differences in habitat, shoreline counts, counts from a boat and/or with the aid of a spotlight at night, are not practical. The problems of aerial census of crocodile populations are discussed in Graham (1968); Parker & Watson (1970) and Watson et al (1971).

Nevertheless aerial counts do provide information not obtainable otherwise and reveal seasonal movement patterns. The tendency is invariably to under-count, particularly when the animals are in large tightly packed basking groups, which disperse and spread out when the aircraft descends lower than about 100 m. It is advisable to photograph these groups from a high altitude and then count from the photographic negatives.

The accuracy of aerial counts depends upon many factors. (see section 3). Animals below 1 m. in size are almost impossible to detect from a fixed-wing aircraft because of their cryptic colouration, their tendency to shelter in aquatic vegetation, and because of other factors such as wave action, discoloured water, and variable visibility and flying conditions. The accuracy of counts may be determined by sudden changes in wind direction and velocity affecting the flying capability of the aircraft. There may be changes in cloud conditions over the three to three and a half hour time period necessary to cover the area, and the experience and efficiency of the personnel involved is of importance. There are also seasonal variations in behaviour of the animals eg the times of emergence to bask and the egress back to water are markedly different in summer and winter, so that the seasonal timing of the aerial counts is of importance.

1.1 Population estimates

There is no doubt that in earlier times the lake and the rivers flowing into it harboured an impressiv crocodile population. Steedman (1835) describes how "the ford of the Black Mfolozi where our travellers crossed on 7th March 1828 was infested with alligators".

Baldwin (1852) describes crocodiles as being numerous in the Umfolozi river and St Lucia Bay.

Dunn (1886), Durnford (1882) and Ashe (1880) all describe the Umfolozi river as swarming with crocodiles.

Findlay (1903) found the Hluhluwe river and the lake to be infested with crocodiles and Braadveldt (1921) observed numerous crocodiles in the Mkuze river.

The results of 19 aerial counts from a fixed-wing aircraft over a period 1973 to 1981 are shown in Table 1. From these data it will be seen that the highest number of crocodiles counted was on 3/7/1977. The likelihood is that the highest counts may be underestimated by as much as 20% when taking into account the problems of counting and the seasonal movements and behaviour of the animals. Therefore the population of crocodiles above 1 m. in size may be between 517 and 620 for Lake St Lucia.

Over the period 13/7/1967 to 29/1/1976 a total of 486 young crocodiles, hatched from eggs harvested at the Lake, were returned to the system. These varied in age from 5 to 18 months but we have no idea of survival rate. See Pooley (1981) for data on ages and localities where the animals were released.

Table 1

Results of 19 aerial counts of crocodiles, Lake St Lucia/Umfolozi River, Estuary

South Estuary	Narrows	South Lake	North Lake	False Bay	Total Count	Date
-	5	59	151	8	223	12/ 3/1973
69	2	74	226	4	375	7/ 8/1973
66	17	67	240	11	401	5/ 7/1974
10	0	11	20	5	46	4/ 2/1975
26	2	7	5	-	40	4/ 3/1976
32	6	21	53	6	118	1/ 4/1976
46	48	94	171	12	371	5/ 5/1976
22	88	93	211	20	434	7/ 6/1976
78	73	82	253	-	486	1/ 7/1976
81	6	171	249	10	517	3/ 7/1977
62	24	79	150	13	328	22/ 5/1977
100	10	83	163	-	356	27/ 7/1977
35	5	91	111	-	242	15/ 8/1977
17	8	85	164	10	284	19/ 9/1977
23	10	52	161	22	268	9/11/1977
15	19	23	54	10	121	15/ 2/1978
85	37	117	196	10	435	9/ 6/1978
Distribution was not recorded					74	4/ 9/1980
Distribution was not recorded					226	16/ 1/1981

No quantitative data are available on population recruitment. Figures varying from a 2% to a 5% survival rate from the egg stage to breeding maturity have appeared in the literature on the Nile crocodile, but these are mere guesses.

Assuming that all 143 females at known nests breed each year, with an average clutch of 45 eggs, 6435 eggs should be laid each season. A 2% survival to maturity from an estimated population of 517 to 620 animals would be 10 to 12, whereas a 5% survival rate would be 31 to 103 animals, and it is doubtful if annual recruitment is this high.

These figures however do not take into account the unknown number of crocodiles between hatching and 1 m in size and up to about 3 years of age, not observed in aerial census. This size group may represent a significant percentage of the total population.

Cott (1961) and Graham (1968) supply data indicating a sex ratio of 1:1 of adult crocodiles. Sexually mature males may service from 3 to 5 females in a nesting territory so that the active breeding population is in the region of 143 females, plus 28 to 47 males.

It has been discovered from studies of known age captive animals that they commence breeding at an age of 10 years. No data are available indicating at what age adults cease to breed, or of longevity and our information on overall mortality is meagre.

1.2 Mortality

Commencing in 1951, a decision was taken by the Natal Parks Board to shoot crocodiles appearing in the vicinity of rest camps, public jetties and angling sites. Some years later in 1957, following the fatal attack on a European youth in False Bay Park, and because of the tremendous public outcry afterwards, a ranger was employed specifically to shoot crocodiles. (See NPB Annual Reports No. 3 of 1950/51; No. 6 of 1953/54; No. 10 of 1957/58 and No. 11. of 1958/59).

Data on numbers destroyed, extracted from rangers reports, are contained in Table 2. Of the 104 mostly adult crocodiles destroyed over the period 1950-1981, 92 were destroyed during 1957/58. A large number were also shot by locals (Percy Jackson, Gus Brits and Peter Yeld pers. comm.). Many animals were wounded and may have died, so that if one considers the present day estimated population to be 517 to 620 animals, the impact of the shooting campaign was severe.

Table 2.

Crocodiles destroyed in the Lake St Lucia System 1950 to 1981.

St Lucia Estuary	Mapelane (Mfolozi R.)	Charters Creek	Fanies Island	False Bay Park
41	7	21	26	9

Prior to the introduction of the Reptiles Protection Ordinance No. 32 of 1968, crocodiles were classed as vermin in Natal. Numbers were destroyed by farmers because of the danger to livestock and old residents of the Mfolozi area report how they used baited hooks attached by a steel cable to a floating drum to snare crocodiles in this river.

Mr Percy Jackson pers. comm., estimates that over a period of some 20 years, mainly in the 1950's, he shot in the region of several hundred crocodiles in lakes, rivers, pans and streams connected to the St Lucia system, and other week-end hunters operated on the Mfolozi river and in the Monzi area.

In Table 3, data on other forms of mortality are recorded for the period 1950 to 1981. Unfortunately, crocodiles are cannibals and thus it is unusual to find carcasses of animals that may have died from natural causes, and because of the huge surface area of the lake and the almost impenetrable swamps the chances of finding carcasses are small.

Table 3

Recorded Mortality: Natural and other causes, Lake St Lucia 1950 to 1981

Snared, killed in gill nets, fish traps	Combat	Hyper-saline conditions	Anglers, outboard motors
20	5	40	12

In recent years there has been an increase in illegal gill netting activities in the Nyalazi river, along the shoreline of the Nibela peninsula and particularly in the Mkuze swamps. Mortality of crocodiles drowned in these in these nets may be higher than we realise.

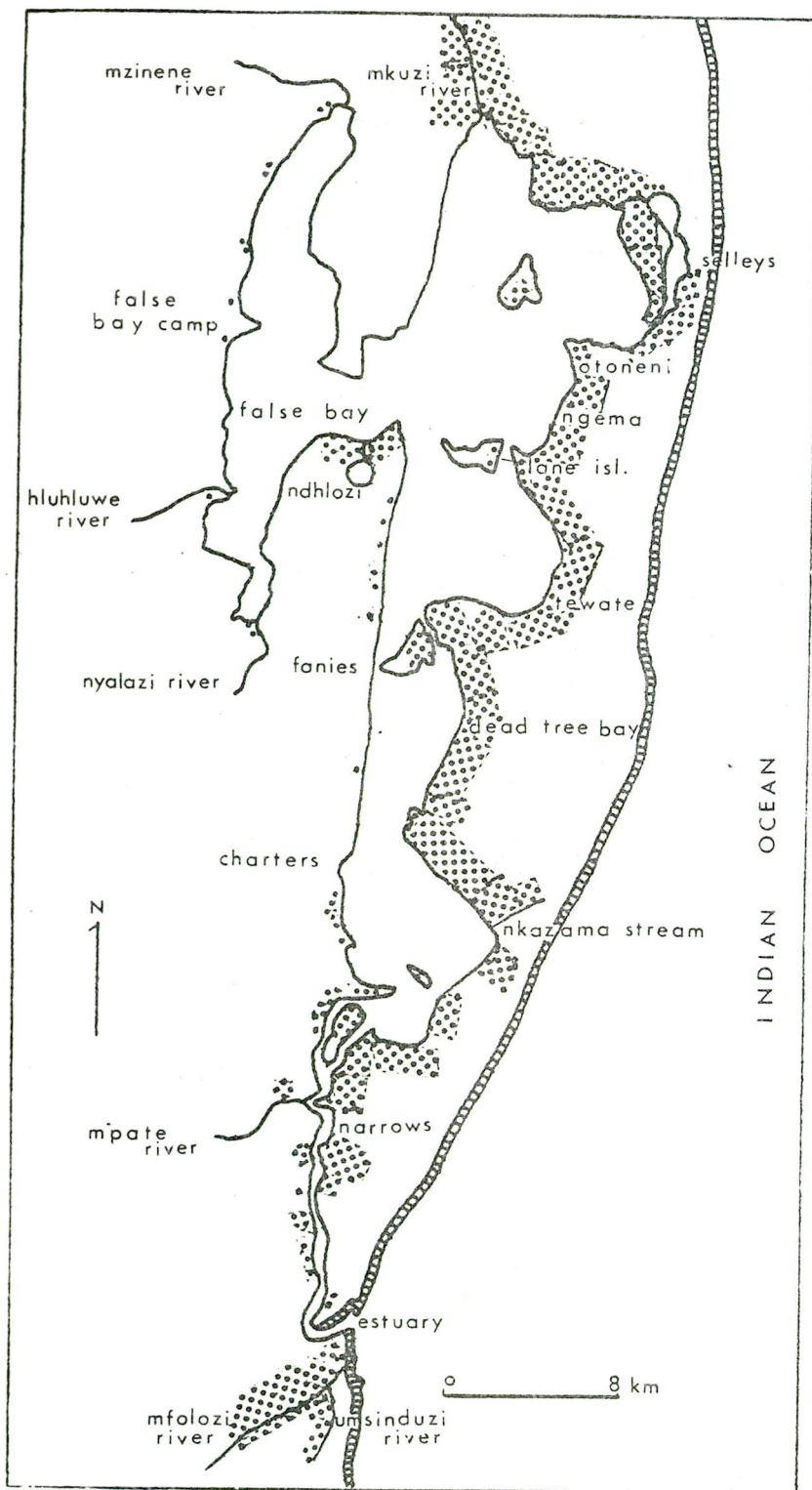


Figure 1. Crocodile Basking Grounds
Aerial Surveys (19) 1972 - 1981

2 Population distribution

The overall distribution of crocodiles and their regularly used basking sites is reflected in Figure 1.

Selection of the basking sites along the eastern shores may be due to a number of interrelated factors:

This shoreline is, for the most part, gently sloping and well protected by stands of reeds marginal to the shore, creating conditions sheltered from wind and wave action on the landward side.

Hippo paths and wallows provide easy access to the shore, and fresh water in times of saline, drought periods is available from streams and seepage from inland vleis.

The fact that seepage from the eastern shores tends to persist throughout the dry season enhances its importance in providing a narrow low salinity habitat around the eastern edges of the lake (see Hutchison & Pitman, 1973.) Taylor (1976), also noted that in the lake itself the majority of the hippopotamuses are to be found along the eastern shores, probably because of the freshwater supply.

There are also sheltered beaches just above the shoreline, mostly protected by dense coastal dune forest, providing adequate shade, and the water offshore is of sufficient depth for concealment. Almost the entire length of the eastern shore is undisturbed and largely inaccessible and this too may be an important factor.

From Fig. 1. it can be seen that the Estuary and South Narrows are little used. For several kilometres from the mouth this area is disturbed by activities of fishing boats, launches, dredgers, maintenance craft and shrimp boats. For most of this section the banks are steep from dredging and mangrove communities with few basking sites are a feature of the shoreline. The south Narrows to about the Mpate river is also subjected to tidal current with strong inflow and outflow.

The western shore of the lake from just north of Brodie's Crossing almost to the mouth of the Mkuze river is in most parts steeply banked with few suitable basking beaches. There are very few stretches where stands of reeds offshore provide shelter from wind and wave action. Data provided by Hutchison & Pitman (1973) on percentage frequency of wind by direction and velocity confirm that over the period 1969 to 1973 the strongest winds were SW to SSW and NE to NNE.

Both Modha (1967) and Graham (1968) noted that crocodiles tend to avoid windswept shores and rough surf conditions. The direction of local winds would therefore create unfavourable conditions along the western shore.

This shoreline has few streams or seepage veins where fresh water is available in times of high saline levels and another disadvantage is perhaps the disturbance factor of fishing boats and tourist launches operating from camps at Charter's Creek, Fannies Island and False Bay Camp.

3 Seasonal movement

The thermal requirements of crocodiles in the sub-tropics leads them to spend much of their time in basking over the winter months. They gather in large groups on suitable sandspits or islands usually inaccessible and undisturbed, yet where there is still a sufficient depth of water off-shore, to allow for concealment. Locally the movement to traditionally used sites usually commences in late autumn. It may be triggered by lowered water levels, a rise in salinity levels, climatic changes or attuned as well to feeding patterns.

Typical winter basking sites are the lower reaches of the Umfolozi river, the island at the confluence of the Umfolozi and Umsinduzi rivers, and in the link canal south of the estuary. Highest winter counts to date were of 100 animals on 27/2/1977 and 85 on 9/6/1978 at these sites (See Table 1).

During the early summer months, again in response to changes in climate and in water levels etc., the animals become more active. A movement away from the winter basking grounds to the breeding areas precedes courtship, competition for nesting territories and egg-laying. In the area south of the estuary, for instance, the animals move downriver to nest on the high ground of levees almost at the river mouth. Aerial counts over the nesting season showed for example, only 10 crocodiles on 4/2/1975 and 15 on 15/2/1978. These low counts can be explained by the fact that the females were nest guarding, lying up under shade and not visible from the air. Ground observations confirmed the presence of crocodiles in the area, and these seasonal movements have been previously observed at the main breeding grounds in the lake, (Pooley 1973, 1976).

Over summer periods of river floods crocodiles may move upriver to feed and scavenge. These are considered to be displaced adult males and subadult animals. The flooding of the Umfolozi-Umsinduzi rivers is responsible for a dispersal of animals and they may appear along the beaches

and in the sea. There is a record entered in the longbook of the S.S. Kathiawar (1917) of a crocodile sighted an estimated 11 km out to sea of the St Lucia Estuary. (see Ann. Report NPB No. 7).

During river flooding, hatchlings are swept downstream and many are picked up along the beaches as far north as Cape Vidal and southwards to Cape St Lucia lighthouse. Natal Parks Board staff and visitors found the following: 1974 (21); 1975 (34); 1976 (178); 1977 (37); 1978 (15); and 1979 (12).

Seasonal movement may occur over drought periods when natural vleis, pans, rivers, and streams run low or dry up. Crocodiles appear unexpectedly in irrigation canals, farm dams and ponds far from the lake habitat. Over 1974 to 1981 a number were reported from, or trapped and removed from farms in Uloa, Monzi and Mtubatuba districts.

It is largely because of these seasonal movements that aerial counts along the lake shore are estimated to be approximately 20% accurate.

4 Breeding

Physical conditions at two of the main breeding grounds have been described previously, (Pooley 1969, 1973) and the location of the 143 known nesting sites is shown in Figure 2. There may be some 10 to 25 nests not yet located up the river systems and around pans such as Demezana and Mpempe in the Mkuze swamps, which contribute to recruitment of the lake population.

Breeding success is variable from year to year and environmental hazards include low water levels, high salinity levels, river floods, a rise in lake levels, heavy rainfall or drought conditions. Comments on these hazards, on nest predation and predator species are contained in Pooley (1969, 1973, 1976) as well as records of duration of the breeding season, incubation period and clutch sizes. The Nile Monitor Lizard Varanus niloticus is locally the most important predator of eggs and young.

Additional data for other areas are contained in Cott (1961, 1971); Modha (1967); and Graham (1968). Parental care and behaviour of nesting crocodiles has been described by Pooley & Gans (1976) and Pooley (1977).

Of concern in recent years has been the disturbance of nesting crocodiles in the Mkuze river and lower reaches of the swamps, utilised by some 20 breeding females. Local blacks have infiltrated into the area and extensive reed-cutting, gill-netting, burning and fishing activities

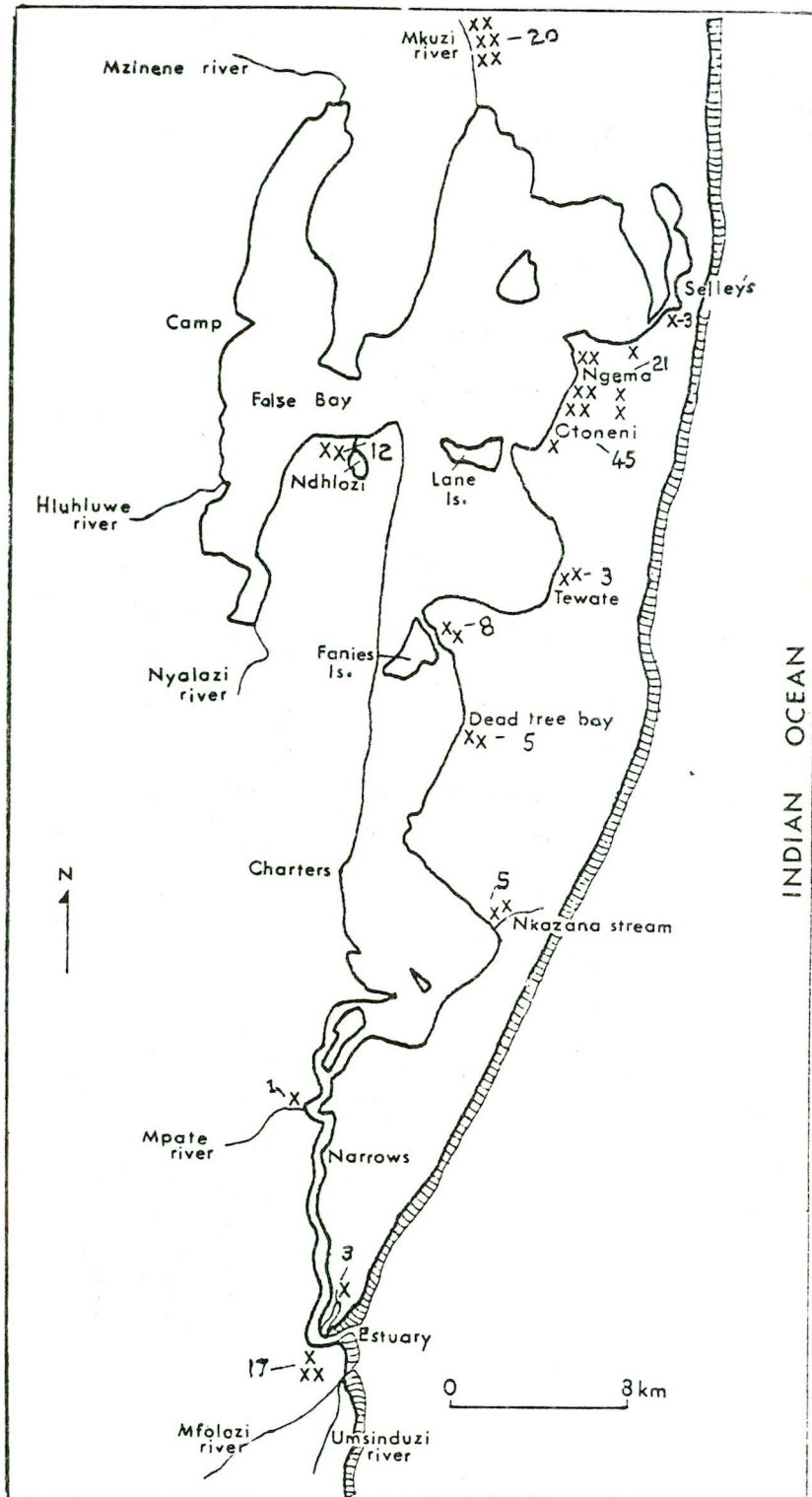


Figure 2. Crocodile Breeding Sites 1959 - 1981 (143) Indicated by 'x'

have disturbed this important colony.

5 Feeding behaviour and diet

The literature on both the feeding behaviour and the prey of the Nile crocodile is extensive and reaches far back into historical times. The most comprehensive accounts are contained in Cott (1961); Graham (1968); and Guggisberg (1972). For South Africa and Zululand specifically, the following are sources of data: Cott (1961); Diedrichs (1977); Steele (1968); Pienaar (1966); Stevenson-Hamilton (1947); Murray (1962); Rose (1950); Shutte (1968, 1970); Hitchins (1969); Oatley (1959); Kymdell (1968); Vincent (1970); Jones (1969); Dunsterville (1968); Dutton (1962); Crass (1964); Steedman (1835); Braadveldt (1949); Leslie (1875); Bruton (1979); Pooley (1962); Pooley & Gans (1976); Whitfield (1977); and Taylor (1976).

In the choice of prey the crocodile is an opportunist and thus its diet in different habitats depends on what prey species are available. Its diet changes progressively with age and size and whilst the young are almost wholly insectivorous, when adult they will take prey as large as full grown buffalo. Cott (1961) suggested that fish constituted some 70% of the crocodiles diet.

Crocodiles are mainly nocturnal in their feeding habits and thus there are few recorded observations on feeding behaviour in the lake system. Observations on their nocturnal hunting habits are contained in Cott (1971); Modha (1967); Mitchell (1968); Attwell (1959); Stevenson-Hamilton (1947) and Pienaar (1966).

The observations of several field workers resident at the lake suggest that crocodiles are influenced by shoaling of fish at times, in particular the immigrations and emigrations of mullet spp. (Family Mugilidae).

Over the period March to July 1976, aerial and boat counts (conducted by Dr S.J.M. Blaber, Mr A.K. Whitfield, myself and Natal Parks Board staff) showed a definite build-up in the crocodile population from the main lakes towards the Narrows and the estuary. This movement coincided with annual movements of mullet spp. in and out of the lake system. We found that crocodile numbers increased from less than 10 prior to the arrival of the mullet shoals to more than 80 when the shoals reached the Narrows, and a dispersal of crocodiles back to the basking grounds by August 1976. (Whitfield, 1977).

Other observers have commented on the movements of crocodiles during summer flooding of rivers into the lake,

in particular flooding of the Mkuze, Nyalazi and Hluhluwe rivers (T.P. Dutton, pers. comm. December 1970; R.M. Murray pers. comm. January 1968; and N. van Niekerk pers. comm. March 1971).

During high flood level periods the carcasses of domestic and wild animals caught on low lying ground and drowned by flood waters are washed down-river and freshwater fish, mainly Clarias gariepinus appear in numbers at the river mouths. Crocodiles thus appear to congregate at river mouths to scavenge as well as to prey upon fish populations not normally available.

6 Prey species

Prey species recorded for the lake have been extracted from reports of NPB staff over the period 1950 to 1981 and include personal and published records.

No quantitative data are available on the feeding habits of the lake crocodiles. Whitfield (1977) published data on the feeding capacity of captive crocodiles. It appears that fish, particularly Mugil spp. form the bulk of prey taken locally. We have no records of the diet of juveniles in this system.

6.1 Species list of prey animals.

Crustacea

Knysna crab
Crab

Scylla serrata
Sesarma sp.

Pices

Chondrichyes

Ragged tooth shark
Lesser guitarfish

Odontaspis taurus
Rhinobatus annulatus

Osteichthyes

Springer
Pike conger
Kob
Mullet spp.
Flathead mullet
River bream
Spotted grunter
Glassy
Mocambique tilapia

Elops machnata
Muraenesox bagio
Argyrosomus hololepidotus
Family Mugilidae
Mugil cephalus
Acanthopagrus berda
Pomodasys commersonni
Ambassis spp.
Oreochromis mossambica

Reptilia

Nile crocodile	<u>Crocodylus niloticus</u>
Nile monitor lizard	<u>Varanus niloticus</u>
Terrapin	<u>Pelusios sinuatus</u>

Aves

White pelican	<u>Pelecanus onocrotalus</u>
Hamerkop	<u>Scopus umbretta</u>

Mammalia

Hippopotamus	<u>Hippopotamus amphibius</u>
Bushpig	<u>Potamochoerus porcus</u>
Nyala	<u>Tragelaphus angasi</u>
Bushbuck	<u>Tragelaphus scriptus</u>
Southern reedbuck	<u>Redunca arundinum</u>
Natal red duiker	<u>Cephalophus natalensis</u>
Domestic bull	<u>Bos taurus</u>
Domestic sheep	<u>Ovis anes</u>
Domestic goat	<u>Capra hircus</u>
Domestic horse	<u>Equus caballus</u>
Domestic donkey	<u>Equus asinus</u>
Domestic pig	<u>Sus scrofa</u>
Domestic dog	<u>Canis familiaris</u>
Monkey	<u>Cercopithecus spp.</u>
Human	<u>Homo sapiens</u>

7 Management recommendations.

- 7.1 It is recommended that efforts should be made to pursue the establishment of the crocodile sanctuary in the Mkuze swamps. This was proposed by the IUCN Crocodile Specialists Group in March 1973. The aim is to safeguard a small strip of land along the western banks of the river to prevent further disturbance to the fauna and flora and in particular, the islands and shoreline utilised by some 20 nesting female crocodiles each season. To date the Department of Co-operation and Development who administer the land in question, have recommended to the KwaZulu Nature Conservation authorities to set aside such a sanctuary and it appears that all that is required is further liaison with this Department.
- 7.2 Aerial counts combined with photographic monitoring of the crocodile population should be continued over the lake system, and these counts should be undertaken more regularly. Over the period October to March counts should be carried out between 07h30 and 10h30, and from

April to September, between 09h00 and 15h30 because of the seasonal basking patterns of crocodiles.

- 7.3 A routine nest count should be continued as a method of determining any increase to, or decrease of the breeding population. The most satisfactory method is to employ a welding rod, 60 cm in length, which is used to gently probe for eggs at a suspected nest site. This is necessary because females may have two or three lie-up sites from where they guard their nests and these can be mistaken for true nests.
- 7.4 More data are required on feeding behaviour and diet. Staff are requested to record the length, weight, sex, stomach contents and locality of any carcass found, and to include observations on injuries or possible causes of death.

8 Further research required

The Nile crocodile is probably the most important predator in the lake system. We lack data on its prey species and the quantities it consumes. Taylor *et al* (1978) in Australia, developed relatively simple methods of obtaining stomach contents from live-trapped animals. In estuarine areas similar to Lake St Lucia they found the diet of young saltwater crocodiles *C. porosus*, to consist mainly of crabs (Sesarinae) and shrimps (*Macrobrachium* sp.) whilst adult animals fed on fish, reptiles, birds, mammals etc. (Taylor, 1979).

A similar investigation employing these techniques would yield valuable data for the St Lucia system.

A further advantage of such a capture-study programme would be the opportunity to sample the population for life table data, ie lengths, weights, sexes, population structure etc. Marked-released animals could supply information on movements and territories.

More refined aerial techniques, using bench markers to indicate size of animals, and photography as an aid to more accurate counts would aid us in estimating the crocodile population more accurately. This is considered to be important if we are to be able to gauge the health of the population over future years.

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