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THE ROLE OF ZOOPLANKTON IN THE ST LUCIA ESTUARY SYSTEM

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INTRODUCTION

This report is an attempt at a synthesis of the information obtained on the zooplankton of the St Lucia system from studies of 220 samples taken between 1948 and 1980. This brief presentation concentrates on the quantitive role of zooplankton in the St Lucia estuary system. Emphasis is placed on imformation that might cotribute to an overall understanding of the system.

Studies of the zooplankton of St Lucia were carried out as part of a long term programme of research on the plankton of South African estuaries. This work was funded largely by the South African National Committee for Oceanographic Research. Samples of plankton were studied from 101 estuaries around the coast of southern Africa from Angola to Mozambique. Some of these estuaries were sampled only once while otheres were studied more intensively. St Lucia is one of the estuary systems that has received prolonged study. Work was carried out irregularly over a long period including observations of seasonal and long-term changes. This research is intended to contribute to an understanding of the overall ecology of the St Lucia system including the ecological responses of the system to major environmental fluctuations.

Accounts of the environmental changes which occurred and of the changes made by man during the sampling period have been presented elsewhere and are not described in detail here. A final report on the zooplankton of the St Lucia system is nearly complete and will be submitted for publication shortly.

METHODS

Zooplankton was sampled at stations throughout the St Lucia estuary system between 1948 and 1980. Most sampling was done at night. Several different nets and samplers were employed. Most qualitative zooplankton samples were taken with a 36cm diameter zooplankton net and quantitive zooplankton samples with a Clarke-Bumpus plankton sampler. The species composition and abundance of the plankton in the samples was analysed on the basis of sub-samples in the laboratory. The period covered by samples studied is now 34 years. The earliest samples available were collected in 1948. Samples are available from 1948, 1949, 1951, 1954, 1955, 1956, 1957, 1964, 1965, 1967, 1969, 1970, 1972, 1973, 1974, 1976, 1978, and 1980. The samples thus cover a number of major and significant environmental changes including the opening and closing of the mouth and great salinity fluctuations.

To supplement the information provided by field studies and to explain as far as possible these findings, various laboratory studies were carried out. These included studies of vertical migration behavior, salinity and temperature tolerance, feeding and reproduction. Biomass was calculated from settled volumes of zooplankton. It has been shown that a significant correlation exists between settled volume and dry biomass with a correlation coefficient significant at the 1% level. The regression line was calculated and found to be y=18.6x (Grindley & Wooldridge, 1974).

To assess variation in zooplankton communities in different areas and to assess changes in these zooplankton communities with time and changing environmental conditions recourse to computer analysis was necessary. Affinities between zooplankton samples from all positions and all dates were assessed using the programme CLUSTER (Field, 1971). Similarities between samples were determined from the species composition and abundance of the zooplankton organisms in each sample. A matrix of similarities was built up using the Czekanowski coefficient (Bray & Curtis, 1957) and group average sorting (Lance & Williams, 1967) was then used to erect hierarchies or dendrograms of percentage similarity. The dendrograms cluster the samples according to similarities in the zooplankton communities in the samples which are related to environmental differences due to both the geographic position of stations and due to conditions of salinity and other parameters prevailing at the time of sampling.

When the groupings were established, information statistic tests (Field, 1969; Velimirov *et al*, 1977) were used to compare neighbouring groups. Using the tests, species occurring stastically more frequently than expected in one of the two communities are revealed, and the species characteristic of each community thus established.

RESULTS

Seasonal variations in zooplankton biomass.

The mean zooplankton biomasses recorded for each season for the five main areas of the St Lucia system are presented in Table 1. It may be seen that the highest values for all areas are recorded in the autumn months. Lower values are recorded in the winter months, even lower in the spring and the lowest values are recorded in the summer.

TABLE 1: Mean zooplankton biomass for each season for the five main areas of the St Lucia system and for the whole system

AREA	SUMMER (Dec-Feb)	AUTUMN (March-May)	WINTER (June-Aug)	SPRING (Sep-Nov)
False Bay	-	122.9	86.4	18.4
North Lake	-	135.0	112.1	44.1
South Lake	27.1	66.3	38.8	38.3
Narrows	-	19.7	(6.0)	-
Mouth & Est.	7.6	25.6	16.4	17.3
Whole system	24.5	86.9	66.6	32.6

(Values based only on a single measurement indicated in parentheses)

The mean zooplankton biomass recorded for the whole system given in the final row mirrors this trend with a mean summer biomass less than a third of the autumn mean.

The inflow of summer flood waters not only dilutes the plankton concentration but introduces detritus and phytoplankton nutrients allowing peak zooplankton biomasses to develop in the autumn months. It appears that in the cold winter months and in the dry spring months when there is a minimal inflow the zooplankton biomass gradually declines to the summer minimum value.

Monthly variations in zooplankton biomass.

The mean zooplankton biomasses for the five main areas of the St Lucia system for separate months for the period between 1967 and 1974 are presented in Table 2. It may be seen that the highest mean biomass for each area is recorded in the month of May. A general but irregular decline towards low mid-summer biomass values is apparent. However significantly increased mean biomasses are already apparent by March in all three areas of the lake. It seems that the zooplankton starts to increase in abundance soon after the rains in the newly introduced water, rich in detritus and nutrients.

Geographical variations in zooplankton biomass.

The mean zooplankton biomasses recorded for the five main areas of the St Lucia system for the period between 1967 and 1974 are presented in Table 3. The highest mean biomass

TABLE 2.

Mean zooplankton biomass for five main areas of the St. Lucia system for separate months between 1967 and 1974.

(mg m^{-3} dry biomass)

AREA	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
False Bay	-	-	78.2	-	196	125	9.0	-	22.6	-	16.0	-
North Lake	-	-	69.1	-	283	112	-	-	81.3	-	34.0	-
South Lake	12.2	23.6	25.0	19.4	125	61.2	25.3	(104)	51.6	(6.7)	33.2	(22.3)
Narrows	-	-	1.5	-	(77.4)	-	-	6.0	-	-	-	-
Mouth & Estuary	(15.5)	2.6	12.7	17.2	36.3	(17.9)	(14.9)	-	(19.3)	-	16.8	(6.7)

(Values based only on a single measurement indicated in parentheses)

TABLE 3: Mean zooplankton biomass for five main areas of the St Lucia system for the period 1967 - 1974

(mg m^{-3} dry biomass)

AREA	SECTORS	MEAN	RANGE
False Bay	J,K & L	74.2	(3.7 - 297)
North Lake	G,H & I	90.5	(6 - 394)
South Lake	D,E & F	50.7	(2.7 - 491)
Narrows	C	28.3	(1.5 - 77)
Mouth & Estuary	A & B	18.7	(1.5 - 104)

was recorded in the North Lake but all three sections of the lake supported substantially higher biomass than the Narrows, Estuary and Mouth. A regular decrease in recorded mean biomass is apparent for the North Lake through the South Lake and Narrows to the Mouth. It must be noted however that these mean values are based on widely and erratically different values as indicated by their wide range. Plankton biomass varies greatly in time and space and the irregular series of samples available from St Lucia do not provide statistically reliable values.

Annual variations in zooplankton biomass

The mean zooplankton biomasses recorded for seperate years for the whole St Lucia system including the Narrows, Estuary and Mouth are presented in table 4. The irregular nature of the samples available for analysis is apparent. In 1967 there was only one series of samples and in 1972 and 1974 only two series in each year. In the remaining years certain months were missed and some other months are based on a single sample. In this and the following table the number of values on which each mean is based is indicated in parentheses below the mean.

Because of the irregular nature of the samples the pattern of fluctuations is somewhat erratic and trends are not as clear as in tables 1 2 and 3. Even the mean biomasses for all 6 years are rather inconsistant with anomalously low values in April, July and October. The mean values based on all data for each year do, however, indicate a clear and interesting trend with a steady increase in biomass over the eight year period. The increase amounts to an order of magnitude. High and increasing values appeared in the reduced salinities pertaining after the great floods of May 1971.

TABLE 4.

Mean zooplankton biomass for separate years for whole St. Lucia system including the Narrows, Estuary and Mouth

(mg m^{-3} dry biomass)

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
1967	-	-	-	-	-	-	-	-	-	-	15.3	-	15.3
(n)											(13)		(13)
1969	-	5.2	10.9	23.1	31.6	17.9	8.9	37.9	19.3	6.7	12.0	14.5	17.2
(n)		(2)	(8)	(2)	(4)	(1)	(4)	(3)	(1)	(1)	(2)	(2)	(30)
1970	13.8	52.5	21.4	13.4	22.4	79.6	47.6	-	35.7	-	62.5	-	29.6
(n)	(4)	(2)	(11)	(2)	(2)	(2)	(1)	-	(1)		(1)		(26)
1972	-	-	-	-	-	-	-	-	51.3	-	43.9	-	47.6
(n)									(12)		(12)		(24)
1973	-	-	67.3	-	-	90.5	50.6	83.3	-	-	24.7	-	62.1
(n)			(12)			(12)	(1)	(1)			(11)		(37)
1974	-	-	91.0	-	198.8	-	-	-	-	-	-	-	150.9
(n)			(12)		(15)								(27)
All Years	13.8	34.0	57.4	18.2	153	82.6	16.7	49.3	47.9	6.7	27.8	14.5	
	(4)	(4)	(43)	(4)	(21)	(17)	(6)	(4)	(14)	(1)	(39)	(2)	

The number of values on which the mean is based is indicated in parentheses below the mean.

Annual variations in Lake zooplankton biomass.

The mean zooplankton biomasses recorded for separate years for the St Lucia Lake system excluding the Narrows, Estuary and Mouth are presented in Table 5. An irregular pattern of fluctuations generally similar to that of the whole system given in Table 4, is apparent. Anomalously low values are apparent again for the months of April, July and October where sampling was inadequate. The mean values for each year separately do again indicate a clear trend of steady increase in biomass over the eight year period. In the Lake the increase was substantially greater than an order of magnitude. The significance of the reduced salinities and the inputs of flood waters would have been greater in the Lake than in the whole St Lucia system including the Narrows, Mouth and Estuary where salinities remained relatively constant.

Secondary productivity.

I have no data on secondary production in the St Lucia estuary system but estimates may be made on the basis of biomass data. The maximum rate of zooplankton production in Richards Bay was estimated at 4.4g $m^{-3}y^{-1}$ (Grindley & Wooldridge, 1974). This gave a P/B ratio of 0.4 per 24 hours or 13 per year. It was suggested that potential gross secondary productivity for *Pseudodiaptomus stuhlmanni* on the basis of egg ratio might be 115mg $m^{-3}d^{-1}$.

Hart & Allanson (1975) using Windberg's method of estimating production studied the population of *Pseudodiaptomus hessei* in Lake Sibaya. The mean standing stock of 5.7mg (dry mass) m^{-3} gave a mean production of 0.634 mg (dry mass) m^{-3} day $^{-1}$. The daily P/B ratio was 0.11 which they noted was high compared to other copepod values. However Burgis (1971) reported a mean daily production of *Thermocyclops hyalinus* 750 times as great on a unit volume basis in eutrophic Lake George in Uganda.

Trophic relationships.

The trophic relationships of the zooplankton of the St Lucia system are not yet clear. *Pseudodiaptomus stuhlmanni* appear to consume nannoplanktonic flagellates, diatoms and detritus with bacteria. The mysids are apparently involved in the detritus cycle. Nutrient and other environmental factors influencing the phytoplankton and nannoplankton must have secondary effects on the zooplankton but these relationships are not yet clear. The zooplankton must serve as a food source for a variety of invertebrates and fish but few

TABLE 5.

Mean zooplankton biomass for separate years for St. Lucia lakes system excluding the Narrows, Estuary and Mouth

(mg m^{-3} dry biomass)

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
1967	-	-	-	-	-	-	-	-	-	-	14.5 (11)	-	14.5 (11)
1969	-	8.9 (1)	11.8 (6)	16.4 (1)	31.6 (4)	-	6.9 (3)	55.1 (2)	-	6.7 (1)	3.0 (1)	22.3 (1)	19.3 (20)
1970	12.2 (3)	101.2 (1)	21.3 (10)	22.3 (1)	29.8 (1)	157.7 (1)	47.6 (1)	-	35.7 (1)	-	62.5 (1)	-	35.3 (20)
1972	-	-	-	-	-	-	-	-	51.3 (12)	-	43.9 (12)	-	47.6 (24)
1973	-	-	67.3 (12)	-	-	90.5 (12)	50.6 (1)	83.3 (1)	-	-	24.7 (11)	-	62.1 (37)
1974	-	-	91.0 (12)	-	237.3 (12)	-	-	-	-	-	-	-	164.2 (24)
All Years	12.2 (3)	55.0 (2)	61.6 (40)	19.4 (2)	176.7 (17)	86.7 (16)	17.1 (5)	64.5 (3)	49.8 (13)	6.7 (1)	39.0 (35)	22.3 (1)	

The number of values on which the mean is based is indicated in parentheses below the mean.

details have yet been determined. Stomach contents of juvenile mullet (Mugilidae) have been found to include remains of Pseudodiaptomus stuhlanni, Acartiella natalensis and Mesopodopsis africana and gut contents of Penaeus indicus have included remains of Pseudodiaptomus stuhlamanni. Because the vertical migration behaviour of these estuarine plankton species takes them on to the bottom, they may be taken by bottom feeders as well as by flter feeders. The role of planktivorous fish in St Lucia has been studied by Wallace & Van der Elst (1975), Blaber (1979) and Heeg & Blaber (1979). The dominant copepod Pseudodiaptomus stuhlmanni provides 70% of calorific value of the plankton. The amphipod Grandidierella lignorum and veligers of Assiminea bifasciata are also important. The important plankton feeding fish are the whitebait Gilchristella aestuarius, juvenile glassies Thryssa vitrirostris and Kelee herring Hilsa kelee.

River input stimulating reproduction.

Evidence is accumulating which suggests that material introduced by river inflow stimulates reproduction in estuarine copepods and mysids.

In the series of samples taken in May, 1974, the percentage of Pseudodiaptomus stuhlamanni carrying eggs was calculated for me by Dr Wooldridge. Over large areas of the Lake the percentage of ovigerous females was less than 1% but in False Bay and North Lake near the mouths of the Hluhluwe, Mzinene and Mukuzi rivers the percentage of ovigerous females ranged up to 26.2%. High percentages of juvenile specimens also appeared in these areas.

In the May 1974 samples, the percentage of Mesopodopsis africana carrying eggs was mainly less than 2% but was 2.7% near the Hluhluwe mouth and 10.5% near the Mzinene mouth. The percentage of juvnile Mesopodopsis africana in False Bay reached 77.7%.

Zooplankton communities.

Several different zooplankton communities appear in the St Lucia system. There is a stenohaline marine component including, for example, species of Corycaeus which may penetrate with the tides into the mouth area. A euryhaline marine component including species of Paracalanus may penetrate somewhat further. Most of the system however, is dominated by a typical estuarine plankton. The most abundant copepods are Pseudodiaptomus stuhlamanni and Acartia natalensis but other copepods include Oithona brevicornis and Halicyclops species. The most abundant

Mysids are Mesopodopsis africana and Gastrosaccus brevifissura. In addition there are species of Isopoda, Amphipoda, Ostracoda, Cumacea, Tanaidacea and the larvae of many other groups of invertebrata. Small numbers of fish eggs and fish larvae appear in some samples. A fourth community of fresh water species such as species of Diaptomus and Cyclops (sensu lato) occurs in the mouths of the rivers and may penetrate the Lake during periods of low salinity.

A list of the species recorded from the St Lucia system and their distribution is presented in Table 6.

TABLE 6:

Zooplankton organisms recorded from the three major regions of the St Lucia System, the Estuary mouth area, the Narrows and the St Lucia Lake. Abundance is indicated by the number of + symbols (+= present, ++++= abundant) using the highest recorded abundance value from any sample in each region so giving an indication of maximum abundance.

	ESTUARY	NARROWS	LAKE
PROTOZOA			
Foraminifera			+
Noctiluca miliaris	++	++++	++++
Other dinoflagellates	+	+	
CNIDARIA			
Crambionella orsini	+	+++	+
Hydroid medusae	+	+	
Siphonophore sp.			+
CTENOPHORA			
Beroi forskali	+		
Ctenophore sp.			+++
Pleurobrachia pileus			+
NEMATODA			
Nematoda spp.			+
BRYOZOA			
Cyphonantes larva	+		
ANNELIDA			
Dendronereis arborifera	+	+	+
polychaete larvae	++	+	++
CHAETOGNATHA			
Sagitta spp.	+	+	+
OSTRACODA			
ostracod spp.	+		+

	ESTUARY	NARROWS	LAKE
COPEPODA			
Acartia natalensis	+++	+++	++++
Amphiascus sp.		++	
Calanus helgolandicus	+		
Centropages brachiatus		+	
Centropages chierchiae	+		
Centropages furcatus	+	+	
Clausidium sp.	+		
Clytemnestra scutellata	+	+	
Copepod nauplii	++++	+	++++
Copilia quadrata	+		
Corycaeus crassiusculus	+		
Corycaeus gibbulus	+	+	+
Eucalanus monachus	+	+	
Euchaeta marina	+		
Euchaeta spinosa	+		
Euterpina acutifrons	++	+++	+
Halicyclops sp.			++
Harpacticoid spp.	++	+	+++
Harpacticus gracilis	+	+	+
Hemicyclops sp.	+		+
Kellaria sp.			+
Labidocera acuta	+		
Macrosetela gracilis	+	+	+
Mecynocera clausii	+		
Microsetella sp	+++		+
Oithona brevicornis	+++	+++	++++
Oithona similis	+	+	+
Oncea venusta	++	+	+
Onychocorycaeus agiles			+
Paracalanus crassirostris	+		
Paracalanus parvus	+++	+++	++
Paracartia africana	+		+
Parasitic copepoda			+
Pontellid nauplii	+	+	
Pontellina plumata	+		
Pseudodiaptomus stuhlamanni	++++	++++	++++
Rhincalanus cornutus	+		
Spaphirella sp.	+		++
Saphirina sp.			++
Scolecithrix danae	+		
Tegastes sp.		+	+
Temora turbinata	+	+	+
Undinula vulgaris	+		

	ESTUARY	NARROWS	LAKE
CIRRIPEDIA			
Cirripede nauplii	+	+	+
Cypris larvae	++		+
MYSIDACEA			
Gastrosaccus brevifissura	+		+
Gastrosaccus gordonae			+
Mesopodopsis africana	+	++	++++
Tenagomysis natalensis			+
CUMACEA			
Cumacea spp.	+		+
Iphinoe truncata		+	+
ISOPODA			
Cirolana sp.	+	+	+
Parasitic isopod		+	+
TANAIDACEA			
Apseudes digitalis		+	++
AMPHIPODA			
Amphipod spp.	+	+	++
Caprella sp.			+
Eriopisa chilkensis	+		
Grandidierella bonneroides	+	+	++
Grandidierella sp.			+
Melita zeylanica			+
Paramoera capensis	+	+	+
DECAPODA			
Acetes erythraeus			+
Acetes natalensis			+
Brachyuran sp.			+
Carid sp.	+		
Caridina nilotica		++	
Hymenosoma orbiculare		+	+
Lucifer sp.	+		
Macrobrachium equidens	+++		
Megalopa larvae	+++	++++	+
Mysis larvae	++	+	+
Penaid larvae	+	+	+
Zoea larvae	+++	++	+++
INSECTA			
Chironomid pupae	+		+++

	ESTUARY	NARROWS	LAKE
MOLLUSCA			
gastropod larvae	+++	+	++++
lamellibranch larvae	+		++++
ECHINODERMATA			
Echinoderm larvae	+		
UROCHORDATA			
Oikopleura sp.	+		
PISCES			
Fish eggs	++++	++	++++
Fish larvae	+	+	++
Hemirhamphus sp.			+

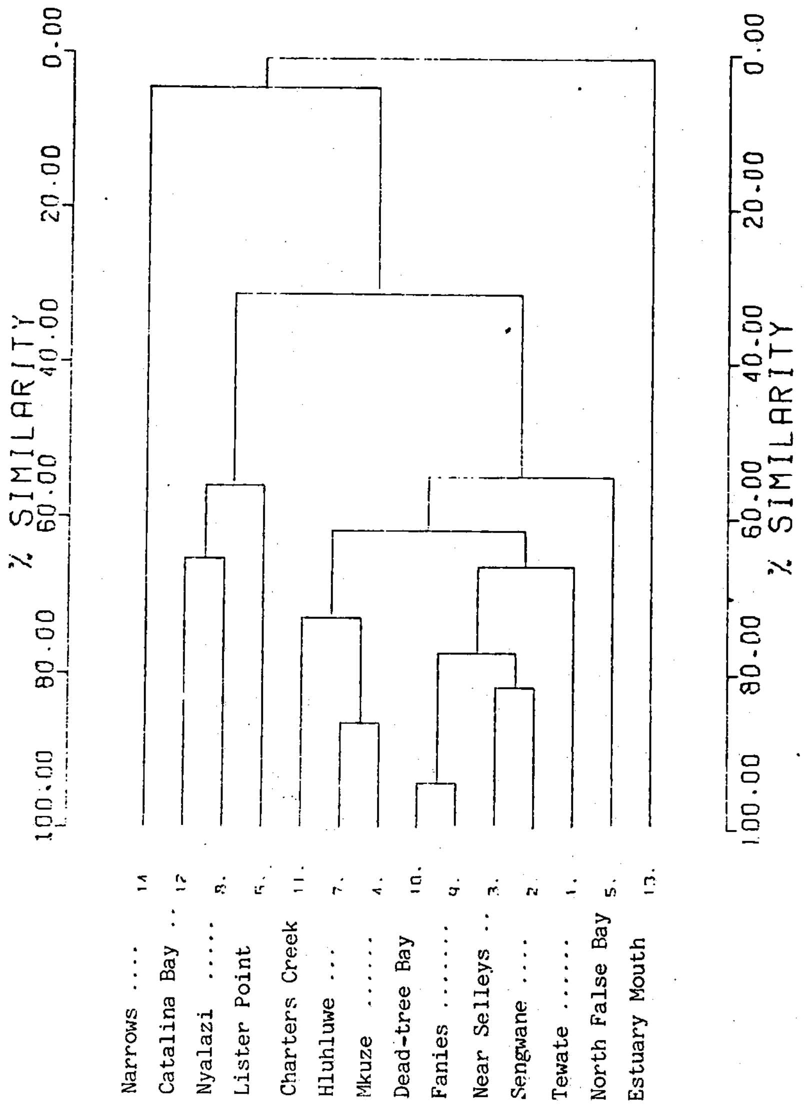
Regional variations.

A dendrogram resulting from a cluster analysis of quantitive (Clarke-Bumpus) samples from May 1974, is presented in figure 1. The percentage similarly between samples from fourteen different areas from the mouth and through the St Lucia system is indicated. All of the samples from positions in the Lake (samples 1 to 12) show a greater than 30% similarity. The remaining samples are more dissimilar. Sample 13 from the Estuary Mouth area shows the lowest similarity to samples from the Lake. Sample 14 from the Narrows shows less than 5% similarity to the Lake samples but is closer to the Estuary Mouth. The positions of the Lake samples were: 1 Tewate, 2 Sengwane, 3 Near Selleys, 4 Mkuze, 5 North False Bay, 6 Lister's Point, 7 Hluhluwe, 8 Nyalazi, 9 Fanies, 10 Dead-tree Bay, 11 Charter's Creek, 12 Catalina Bay. The apparent pattern of clustering within the Lake samples in this particular series must not be given too much significance. Small variations in zooplankton communities with time result in differing regional patterns of relationship. Various different relationships are apparent in the full dendrogram of 206 samples covering the period 1948 to 1974. However, the marked differences between the estuarine plankton communities of the Lake and the predominantly neritic marine community of the Mouth and Estuary is consistant. The Narrows normally have a somewhat intermediate zooplankton community including some more tolerant neritic marine species.

Plankton fluctuations.

During the periods of excessively high salinity in the period 1969 - 1971 most of the plankton disappeared in some of the northern parts of the St Lucia system and only the

LAKE ST.LUCIA : C.B. DATA



few species referred to in the section on salinity tolerance survived. Apart from this, a similar community of estuarine plankton species occurred throughout the St Lucia system except near the mouth. Considering the wide range of salinity conditions which prevailed during the 34 year period and the period of closing of the mouth it is remarkable that the plankton composition remained so little changed. Various seasonal and longer term changes in relative abundance of different species have been observed but the pattern of variation is complex. Details of the changes observed and the associated environmental conditions will be published in the forthcoming final report on this study of the zooplankton of the St Lucia system which will be submitted for publication shortly.

Variations with changing conditions.

A computer analysis of the variations in zooplankton communities in time and space for all samples from 1948 to 1974 produces a complex picture. The dendrogram of 2Ø6 samples distinguishes a multitude of sub-groups. The differences in species composition characteristic of these sub-groups was determined by means of information statistic tests. The dengrogram is too large and complex for presentation (1Ø5cm x 5Øcm, 2Ø6 lines) but some of the conclusions derived from this analysis can be presented here.

During the period 1972, 1973 and 1974 the salinity in the St Lucia Lake ranged from 12ppt. to 6Øppt. A broadly similar zooplankton community occurred during this period. All of these samples were bracketed in the dendrogram at the 55% similarity level. Included in this bracket were a few similar samples from the southern lake from 1949 and 197Ø. The species consistently conprising this community are listed in Table 7. Later samples from 1976, 1978 and 198Ø although not included in the computer analysis appear to fall into this group.

Within this first broad grouping the 1974 samples with lower salinities (12ppt. to 2Øppt.) had fewer *Acartia natalensis* than earlier samples.

In the northern Lake and False Bay in 1969 and 197Ø where salinities were high (45 to 64ppt.) differences in the estuarine zooplankton community were apparent. Chironomid larvae, *Noctiluca miliaris* and *Halicyclops* appeared frequently and harpacticoid copepoda became abundant. Some organisms such as polychaete larvae appeared less frequently. In general the zooplankton included many of the same species as before and *Acartia natalensis*, *Pseudodiaptomus stuhlmanni* and harpacticoid copepoda generally continued to be dominant in these communities.

TABLE 7. Normal St Lucia lake zooplankton community.

CNIDARIA		Crambionella orsini
		Hydroid medusae
CTENOPHORA		Pleurobrachia pileus
ANNELIDA		Polychaete larvae
CHAETOGNATHA		Sagitta spp.
COPEPODA	+	Acartia natalensis
		Halicyclops sp.
	+	Harpacticoid spp.
		Hemicyclops sp.
	+	Oithona brevicornis
	+	Pseudodiaptomus stuhlmanni
		Saphirella sp.
		Sapphirina sp.
	+	Copepod nauplii
CIRRIPEDIA		Cypris larvae
		Nauplius larvae
TANAIDACEA		Apseudes digitalis
MYSIDACEA		Gastrosaccus brevifissura
	+	Mesopodopsis africana
CUMACEA		Iphinoe truncata
AMPHIPODA	+	Grandidierella bonneroides
DECAPODA		Hymenosoma orbiculare
		Megalopa larvae
	+	Zoea larvae
INSECTA		Chironomid pupae
MOLLUSCA	+	Gastropod larvae
PISCES	+	Fish eggs
	+	Fish larvae

(+ Most abundant)

Many other organisms including hydroid medusae, *Hemicyclops* sp., amphipods, *Apseudes digitalis*, gastropod larvae, fish eggs and fish larvae also appeared at high salinities. In high salinities (up to 60ppt.) in False Bay in the period between 1954 and 1957 modified plankton communities were also apparent.

In the highest salinities (71ppt. to 79ppt.) recorded in 1970 Harpacticoid copepods were dominant. *Halicyclops* sp., *Oithona brevicornis*, *Acartia antalensis*, *Pseudodiaptomus stuhlamanni* and fish larvae continued to survive. The records indicate that 14 of the 95 species recorded from the St Lucia system can survive at salinities above 50ppt. A detailed account of the full cluster analysis and a chronological analysis of zooplankton changes between 1948 and 1980 appears in the forthcomming report.

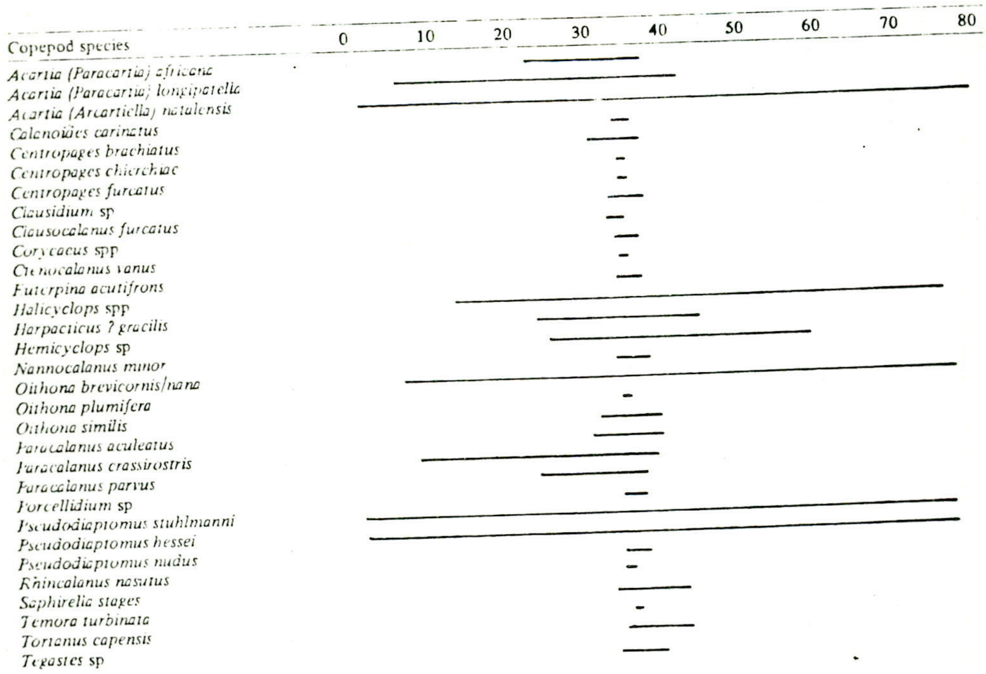
Salinity tolerance.

Tolerance to a wide range of salinities is important for the plankton of estuaries and particularly for the plankton of the St Lucia system. The wide range of salinities from which plankton samples have been taken indicates that this estuarine plankton community is adapted to a very variable environment. To investigate their range of tolerance survival experiments were carried out in the laboratory with the dominant species. *Pseudodiaptomus stuhlmanni* was found to survive in salinities from less than 5ppt. to more than 70ppt. Survival was best in salinities near 35ppt. although they are not found in the sea. The fact that they tend to dominate hypo- and hyper-saline parts of estuaries indicates that factors other than salinity preference influence their distribution. Probably they cannot compete with the wide range of species occurring in the sea water but in higher and lower salinities where there is little competion they flourish. Experiments were also carried out with the mysid *Gastrosaccus brevifissura* to determine the interaction of salinity and temperature on survival in this species.

Observations of salinity tolerance were possible during the period of exceptionally high salinity in 1970. At that time there was a gradient of salinity from about 40ppt. south of Charter's Creek to over 100ppt. in the extreme north. On the night of the 15th March 1970 a series of samples was taken from Lister's Point in False Bay where the salinity was 78.5ppt. to south of Charter's Creek where the salinity was 40ppt. By examining the reproductive condition of the various species in the samples obtained it was possible to determine not only the range of salinities inhabited by various species but also the range of salinity in which breeding continued to take place (figure 2).

Most of the estuarine species were found to tolerate salinities of above 40ppt. and many showed evidence of breeding activity. The species that were found to survive in salinities above 60ppt. included *Pseudodiaptomus stuhlmanni* (few above 70ppt., breeding to 60ppt.), *Acartia natalensis* (few above 70ppt., abundant to above 60ppt.) *Halicyclops* sp. (some above 70ppt.,breeding above 50ppt.),*Mesopodopsis africana* (few above 60ppt., breeding above 50ppt.), *Grandidierella bonieri* (rare above 60ppt., breeding to 60ppt.). Gastropod larvae, fish eggs and fish larvae (indet.) survived in salinities above 60ppt. A few species including another species of *Halicyclops*, two species of Harpacticoids, juveniles of the fish *Hyporamphus improvisus* and larvae of chironomid insects survived in salinities between 70ppt. and 80ppt. The *Halicyclops* and one of the Harpacticoids were ovigerous at salinities above 70ppt.

Figure 2: Recorded salinity range of copepoda.



Red water and midge swarms.

During July and August 1969, red water appeared in the northern Lake of the St Lucia estuary system. It was caused by proliferation of Noctiluca miliaris. Some dead fish washed up at that time and may have been killed by the red water. Salinities ranged from 42-48ppt. during this period. It was suggested that the period of hypersaline conditions earlier in the year which caused widespread mortality of fauna was a significant factor in the development of the red water. In addition as a result of the widespread mortality of their normal predators a plague of chironomid midges appeared and later myriads of spiders appeared catching them. In the Lister's Point area the spiders webs became so dense that plants and branches of trees were completely smothered and killed. Details of these observations have been published (Grindley & Heydorn, 1970).

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