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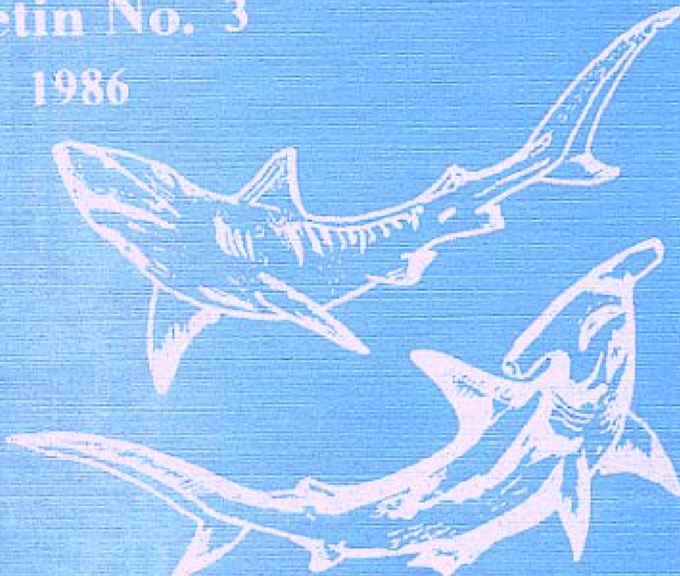

A BULLETIN OF
KENYA MARINE & FISHERIES
RESEARCH INSTITUTE

EDITORIAL NOTE

KENYA AQUATICA: This is a technical and extension series for rapid dissemination of information from Research Officers, Fisheries Officers and any individual for transfer of Technology to the fishermen and industry and any other relevant information on aquatic resources needed for National Development.

The Editor wishes to invite comments and suggestions from readers with a view to improving the bulletin in the choice and arrangement of articles. The aim is to see that this publication receives wide acceptance from readers. Articles can be sent to:

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NATIONAL OBJECTIVES - FISHERIES

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PRESENT SITUATION

Kenya has considerable fisheries potential which is indicated by the presence of over 10,000 km of lakes, mostly fresh water, and a coastline of 640 km. In addition to these, there are numerous fish bearing rivers, streams and several thousand fishponds. It is estimated that there is a potential to land 150,000 metric tons of fish yearly. The forecast for 1983 fish landing is about 50,000 metric tons. Clearly, fisheries potential is highly underutilized. This is significant especially when viewed together with the high rate of malnutrition due to protein deficiences. Furthermore, Kenya is a net importer of fish and fish products in terms of volume.

Marine fisheries is the least developed. Currently it constitutes only 10% of the fish landed. There is great room for improvement here as marine fisheries represent half the country's potential.

The main constraints to fisheries development appear to be technological, financial, social and cultural. Future development should take all these into consideration. The potential which exists in fisheries calls for increased attention in government's development objectives.

TECHNOLOGY POLICY

To realize the above objectives, it is necessary to introduce fishing vessels and gears capable of exploiting both shallow and deep waters. This further calls for improved infrastructure such as landing, storage and marketing facilities. The introduction of bigger and better vessels should be balanced with the need to protect the indigenous fishermen. It also calls for continuous assessment of the available fish stock, including studies of its environment in order to provide a basis for optimum level of exploitation.

A lot has been happening lately at the international level as regards the law of the sea. Some achievements have been made and Kenya should make adjustments to existing laws and practices in order to reap maximum benefits from the new agreements.

To spearhead development of commercial fishing, expecially in deepfishing, there is need for creation of a body or an agency specializing in provision of financial assistance in order to stimulate investment in fishing sector. It is, however, recognised that deep sea fishing requires larger vessels and higher trained personnel. The personnel requirement is quite crucial, more so because in the past Kenya has not invested in training fisheries personnel. Development of fisheries calls for a correction in the training strategy.

Fish farming should be promoted and commercialised. Land under fish farming should be expanded and the yield per unit of land increased. Emphasis should be on propagation of fish seed from those species with high growth rates. Extension services should be enhanced in order to provide fishermen and fish farmers with information aimed at maximizing returns from fish farming. Liason with the extension service of the ministries of Agriculture and Livestock Development should be established.

Losses due to bacteria and insect pasts are high. In order to minimize these losses, mechanisms are required for synchronizing processing and handling methods with post-processing and handling methods with post-processing storage and marketing fascilities required to maintain fish in good quality.

Research should play an important role in solving the problems of fisheries. Studies on the dynamics of the exploited and underexploited fish populations should be undertaken in order to assess the impact of different techniques on fish populations.

PROBLEMS REQUIRING ATTENTION:

Until 1977, long-term fisheries research in the country was carried out by the East African Community. With the demise of the community, research plans have been disrupted and there is an urgent need for reorganization.

Although some short-term studies have been undertaken by a few local scientists, the major ones have usually been done by foreign scientists assigned to specific projects commissioned under technical assistance programmes funded by foreign donors. Consequently, development of local research capability has been very slow. Further, lack of scientific knowledge on available resources and their environment makes rational exploitation and management difficult.

In the past, Kenya has relied on foreigners fishing in the coastal water to supply important statistics. It is not possible to ascertain the correctness of these statistics. For proper planning and exploitation, there is need to evolve reliable data gathering procedures. Development of fisheries has further been hampered by:

1. Inadequate institutional arrangement to foster fisheries development.
2. Lack of technology such as fishing techniques and handling facilities;
3. Inadequate capital investment in fisheries which limits fishing activities to shallow waters both in lakes and at sea; and,
4. lak of adequate infrastructure in terms of landing facilities, preservation techniques, marketing and distribution.

There is a general tendecy among fishermen to exploit fisheries resources to produce maximum short-term yields without considering the conservation of stocks. As a result, some of the resources in the shallow accessible waters are in danger of being overfished within a short period.

Proper development of fisheries requires adequate supply of qualified and experienced personnel in various cadres including scientists, engineers, and extension service agents. All these are in short supply in the country. As a result output from fisheries has remained low and per capita consumption is only 3 kg per annum.

Fishermen loan schemes introduced in the past have had some serious problems. These have included management problems and failure of the fishermen to draw maximum possible benefits from the scheme. lack of securities need to secure loans was a contributor to this failure. Cooperatives, which could be used to channel funds to fishermen, have not been very successful.

PROGRAMMES OF ACTION

The recently established Kenya Marine and Fisheries Research Insitute should carry out research in marine and fresh water fisheries, aquatic biology, environmental and ecological studies, and chemical and physical oceanography. More specifically the Institute should:

1. Carry out research on fish population dynamics and general water ecology, including identification of commercially important species and their distribution and stock assessment procedures;
2. Collect and disseminate scientific information on fisheries resources which will form the basis for utilization;
3. Study and develop important species for fish culture both in marine and fresh waters and their rearing procedures;
4. Establish a marine and fresh water reference collection to be used for research and training purposes;
5. Carry out studies on other marine and fresh water resources including algae and minerals;
6. Offer facilities for training of personnel;
7. Monitor pollution in fresh and marine waters; and,
8. Carry out socio-economic research on topics related to fisheries.

Amend the existing Continental Shelf Act or replace it with a new act in order to define Kenyan territorial waters and have means to control available resources.

The Fisheries Department should:

1. Institute appropriate management measures including rules, regulations and administrative principles that ensure utilization of fisheries resources on sustainable basis;
2. Pioneer the exploitation of the newly established 200 nautical miles exclusive economic zones through mechanization of fishing vessels with capacity for exploiting untapped resources, especially in deep waters;
3. Streamline fish marketing to ensure proper distribution throughout the country and, in conjuction with other agencies (e.g., The Kenya Ports Authority) improve the infrastructure by building landing jetties and facilities for fish collection, preservation, processing and transportation;

4. Establish a pilot marine fish culture to provide evaluation and viability of marine culture at the coast;

5. Stengthen the programme in fish farming by introducing high yielding species and by increasing the area under fish farming; and

6. Strengthen fisheries cooperatives and extend credit to small-scale fishermen in order to enable them to acquire modern fishing equipment and proper facilities for fish handling preservation and marketing.

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MARINE BOTANICAL RESOURCES OF KENYA COAST.

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ABSTRACT

Investigations have shown that Kenya coast botanical resources are underutilized and have not been realized as exploitable resources. Apart from the mangroves which are heavily exploited, algae and marine angiosperm resources are the least exploited. In a step to realize these as future exploitable resources their current uses in Kenya and how they could be used is discussed. A review of research work which could be seen as a prelude to further research is also included.

MARINE BOTANICAL RESOURCES OF KENYA COAST

Aquatic marine macrophytes and mangrove shrubs comprise the major marine botanical resources. The term macrophytes encompasses the algae and marine angiosperms. Macrophytes and mangroves form the colourful canopy of the coastal waters, the former being very conspicuous on the intertidal zone especially on a spring low tide day whereas mangroves are confined to creeks and estuaries.

There are already various initial scientific studies that have been undertaken. Identification of different types of species of the blue-green algae (Cyanophyta) green algae (Chlorophyta), red algae (Rhodophyta) and brown algae (Phaeophyta has been done by Isaac (1967, 1968 and 1971) and he published the species lists. In connection to this, some notes on the types of algae have been given by Lind (1956); Gerloff (1960); Lawson (196) Moorjani (1970, 1978, 1980) who even wrote a key for identification and Knutzen and Jasuund (1979) creating a good foundation for further scientific investigations. Isaac (1968 b) gave the species list to the Kenya marine angiosperms. Graham (1929), Lewis (1956) and I (1968) made descriptions of the types of Kenya mangroves further facilitating marine botanical research which like any other biological research discipline requires prior accurate identification of the type of species being studied.

**This paper is adapted from Proceedings of the workshop of KMFRI on Aquatic Resources of Kenya, July 13-19, 1981*

To date Kenya botanical studies have been qualitative. However, field observation have shown that the macrophytes show seasonal abundances related to the northest (NE) and southeast (SE) monsoon (Isaac 1968, Moorjani 1978 and 1979) due to the contrasting changes in the climate, hydrography and tidal patterns during these seasons as documented by Newell (1957, 1959) and Brakel (1980). The harvestable Rhodophyta which dominate the flora in number of species show two peaks both in N.E and S.E monsoons: Phaeophyta are more abundant towards the end of the the SE monsoon period in September and October whereas Chlorophyta show maximum growth in December/January during the NE monsoon and July/August during the SE monsoon. In general, there is better algae growth and angiosperms during the SE monsoon (Isaac and Isaac 1968; Moorjani 1978, 1979).

The reproduction biology of algae, some marine angiosperms and mangroves has been done. Moorjani (1969, 1978) discussed the fruiting phenology of the algae. Various reproductive structures of mangroves have been described by Isaac and Isaac (1968). Kay (1971) studied the floral structures of marine angiosperms *Cynodocea serrulata* and *Thalassodendroin ciliatum (Cymodocea ciliata* at Mida creek. Some studies on the flowering of other marine angiosperms *Halophila stipulacea; Syringodium isoetifolium, Zostera capensis, Cymodocea serulata and Thalassia hemprichii* have been carried out under controlled conditions by McMillan (1980 a) and (1980 b).

Botanical resources are broadly important in two ways, namely ecologically and economically. The ecological importance of macrophytes and mangroves are as follows:

1. They are the primary producers and produce the food which is the key maintenance of the ecosystem;

2. Offer shelter to many invertebrates, e.g., echinoderms; crustecea, molluscs, epiphytes etc;

3. They are sediment binders and builders; e.g., sand binder *Rhizoclonium* spp. roots of various angiosperms, especially *Thalassia* and *Cymodocea* help to hold soil particles together, creating suitable microhabitats for organisms that would be easily swept away by current; mangrove roots help the accumulation of sediments which accommodate various detritivores which release various nutrients.

No other botanical resource at the Kenya coast other than mangroves have been used as resources of acquiring income. Mangroves are used in various ways notably as:

1. Poles which are used for building and even exported to other countries, e.g., in the Middle East;

2. Charcoal;

3. Tannin used for treating leather, have formed a good trade.

The marine angiosperm *Enhalus acoroides* which has long tough leaves and rhizomes found around Lamu is used in two ways:

1. Its leaves are used for weaving mats;

2. Its rhizomes are eaten notably by the Lamu people. Various types of brown algae like *Cytoseira* spp. *Turbinaria* spp. and *Sargassum* spp. red algae, e.g., *Hypnea* spp. and green algae, e.g., *Ulva* spp. are used as baits in traps to catch herbivorous fish at various parts of the Kenya coast. Indeed a comparison of the worldwide uses of the types of aquatic macrophytes also found in Kenya (table 1) shows clearly how our resources have been underutilized. In Tanzania the brown algae *Sargassum, Turbinaria* and red algae *Eucheuma, Hypnea* and *Glacilaria* are being exploited and *Eucheuma* is actively picked, especially around Pemba, Zanzibar and Mafia (Matthes 1974).

Different types of uses of aquatic macrophytes products have been documented by many authors and the following uses summarized from Dawnson (1966); Levrin, Hope and Schmid (1969) and Kumar and Singh (1971) Phaeophyta are the sources of alginic acid and alginates which are salts of the latter. The types of algae from which these are extracted and which are also found in Kenya shores are indicated in table 1. Alginic acid and alginates have been variously used in the following ways:

1. They are used in preparation of products of human consumption, e.g., soup and antibiotic capsules among other things.

2. Alginates are used as thickeners in cosmetic, textile and pharmaceutical industries and as emulsfying agents in preparation of polishes and paints.

Rhodophyta are notably known algae source of agar extraction. Agar is used as:

1. A culture media for, among other things, bacteria and fungi in various medical and institutional researches;

2. As stabilizers in food, cosmetics and leather.

The use of aquatic marine macrophytes for food and fertilizer is due to the high valuable mineral elements they accumulate. Phaeophyta are rich sources of soda, potash, iodine and can yield a good amount of ammonia, tar and charcoal when carefully processed. Rhodophyta yield more iodine than any other types of algae. Iodine is used for treatment of goiter. Marine macrophytes are also rich in copper, iron, zinc, cobalt, vanadium, molybdenum, manganese, boron and chromium, which is all the more reason why they are used as fertilizers. Another reason why they are useful in agriculture is that they increase the water holding capacity because the fragments of algae hold much water providing valuable small reservoir of water in close contact with the roots of cultivated plants. Furthermore, the bulky organic substances decay slowly in the soil and form humus.

Periodically, large masses of marine macrophytes are cast at various places of the Kenya coast shore and are not used. Indeed these could be used as fertilizers.

Why the macrophytes are not popular exploitable resources in Kenya could be due to the facts that they:

1. are not locally used for food;
2. have not been known to be fertilizers;
3. have not been considered as worthwhile money earning resource to support livelihood and probably that is why it has been overlooked to suggest collecting, process and export to countries in need of the macrophytes raw materials or products.

At this juncture, needless to further stress, even though there is little local use of marine macrophytes unlike the over exploited mangrove shrubs and whose importance for conservation and need for research has been discussed by one of the participants, Dr. W.H. Brakel, at this symposium, algae and marine angiosperms could be used in the various ways stated. A small project could be carried out to show the importance of marine macrophytes casts as good fertilizers and secondly, ways in which they could be picked and marketed to utilizers who would buy at profitable prices and how this would create an interest into their exploitation. Whereas now we are faced with an unrealized underexploited resource, whose importance has been overlooked, at this current pace of various identification for potential exploitable resources will definitely be realized and used. Moreover, since meaningful exploitation inevitably requires scientific research, quantitative biomass assessment, mineral content composition and culturing need to be undertaken. Apart from Imbamba (1972) there have been no other studies on the mineral content of the Kenya marine algae a further study which is now essential in order to identify the unique marine macrophytes that could be efficiently used as fertilizers or for various further useful extracts. Based on the various stated uses of marine macrophytes, this new area of resources definitely calls for research.

Table: 1 Various uses of the types of algae that are also found in Kenya intertidal zone.
(Summarized from: Dawnson (1966); Levring, Hoppe and Schmid (1969), and Kumar and Singh (1971).

Type of Algae	Utilization of product	Place of production or Utilization
A. Chlorophyta		
1. *Caulerpa*	food	Mediterranea countries, Asia
2. *Chaetomorpha*	food	Asia
3. *Enteromorpha*	salad and food for animals	India
B. Rhodophyta		
1. *Eucheuma*	Raw material of agar	Japan
2. *Gelidium*	" "	World wide
3. *Gracilaria*	" "	" "
4. *Ceramium*	" "	Eastern countries
5. *Hypnea*	Hypnean	Subtropic and tropical countries
6. *Lithothamnion*	Powdered and used in place of lime in conditioning soil	Asia

C. Phaeophyta

1. *Cystoseira*		alginic acid and alginates	Worldwide
2. *Sargassum*	(a)	Alginic acid and Alginates	"
	(b)	Food	Asia
3. *Turbinaria*	(a)	Alginic acid and alginates	Worldwide
	(b)	Fertilizer for Coconut plantations	Phillipines and India
4. *Padina*		fertilizer	Phillipines

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ENDANGERED FISH SPECIES OF KENYA'S INLAND WATERS WITH EMPHASIS ON LABEO SPP.

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ABSTRACT

The importance of water masses, natural or otherwise, in supporting fisheries, and the importance of fish as human food, cannot be over emphasized. The inland waters of Kenya act as habitats for fish, harbouring many different fish species. It has been observed with interest that certain fish species have decreased in numbers over the years within the inland waters. the decline has been at a rate which if left unchecked, will eventually cause total dissapearance of the species concerned. Thus those species/ have been correctly termed "endangered". Among them are *Labeo, Schilbe, Alestes, Clarias* and *Barbus* spp.

Most attention is drawn to *Labeo* spp occuring in Lake Victoria and other inland water systems, namely Lakes Turkana, Baringo and River Tana. The species found in Lake Victoria is *Labeo victorianus,* in Lake Turkana *Labeo horie,* in Lake Baringo *Labeo cylindricus.* In River Tana are found *Labeo gregorii* and *L. cylindricus.*

Records have been shown to illustrate that there is a decline in numbers of *Labeo* spp, especially in Lake Victoria. What is now called for is an effort to curb down this decline, through research that will effect an understanding of the biology of the species in question, which will subsequently be used in management and policy making. Recommendations are given that can help transform the now "endangered" species of "flourishing" species, again more emphasis being laid on *Labeo* spp. Previous workers on *Labeo* have attributed the decline to cultural practices, namely overfishing and the use of the wrong gear. This paper explores the possibilities of establishing other causes of decline such as pollution, diseases, parasites and food.

INTRODUCTION

In the world today the general outcry is how to feed the human populations, not only with the correct quantity of food, but also the correct quality. Fish is a major source of protein which is an important part of the human diet. Fish has an advantage over other types of meat in as much as it is cheaper where available (Mathew and Chichester 1979).

**This paper is adapted from the proceedings of the workshop of KMFRI on Aquatic Resources of Kenya, July 13-19, 1981.*

The problem of nutrition centres around protein, especially animal protein, (Lerner and Donald 1966). It thus becomes quite easy to see the importance of fish in our aquatic ecosystems.

What can be said about the world can also be said about Kenya. The water system of this country have acted, and still act, as sources of food. Fishing has been going on for many years now, many metric tons of fish being produced each year, of various species. As the exploitation continues, some of the waters have been overfished and some of the fish have faced a threat of becoming extinct in these waters, if the situation is not brought under control. A very typical example is the Lake Victoria, which according to records, once supported flourishing fisheries of certain species which have now almost disappeared from the Lake. There are five major fish species in the lake that are endangered, namely *Labeo, Barbus, Schilbe, Alestes* and *Clarias,* as pointed out earlier.

The species *Labeo victorianus* found in Lake Victoria belongs to the family Cyprinidae. It is an andromous fish moving up rivers of the Lake Victoria and passing into floodwater pools to spawn. This migration occurs during the two rainy seasons in a year.

THe fish measures 20 cm to 30 cm in length (Greenwood 1966). Of all the anadromous fish of Lake Victoria, *Labeo victorianus* is the most commercial important (cadwalladr 1964). This fact is firmly supported by personal communication with the local fishermen. Indeed, the populations living around the Nyanza Gulf of Lake Victoria consider the fish a delicacy, and give a high price for it.
Unfortunately, the numbers of *Labeo victorianus* in Lake Victoria have been declining over the years, as indicated by catch records for various locations in the Lake and for different years (table 1). Cadwalladr, in 1964 described *Labeo victorianus* as a fishery which "at one time was flourishing, but which has now almost disappeared". In 1965, the East African Freshwater Fisheries Research Organization research coordinating committee meeting in November stressed that catches for *Labeo* had continued to decline over the previous 12 months hence it was agreed that more research was needed into the breeding biology of the species and the effect of fishing methods upon its populations (Annual Report 1965).

There are abundant records that authenticate the decline of *Labeo* in Lake Victoria. Table 1 shows the catch per net (CPN) records for Homa Bay and Port Victoria made by the Lake Victoria Fisheries Service from 1953 to 1962, as quoted by Cadwallard (1964).

Table 1
Catch per net of *Labeo victorianus* for Homa Bay and Port Victoria stations within the Nyanza Gulf and Lake Victoria.

Location	Year	Catch per net
Homa Bay	1953	4.0
	1954	4.5
	1955	6.6
	1956	1.8
	1957	1.6
	1959	1.2
	1960	1.1
	1962	0.7
Port Victoria	1952	10.0
	1959	3.3
	1960	0.73
	1962	1.2

Undoubtedly there was a clear decline in CPN from 4.0 in 1953 to 0.7 in 1962 for Homa Bay, and from 10 in 1952 to 1.2 in 1962 for Port Victoria.

The records for Homa Bay are representative of catch at the mouth of River Awach while those of Port Victoria represent catch at the mouths of Rivers Sio and Nzoia.

This decline in numbers of *Labeo* in Lake Victoria has been illustrated not only in the Kenya waters, but also elsewhere. For example, the CPN figures for River Kagera mouth dropped from 13.6 in 1954 to 0.5 in 1963 (Fryer 1973).

Recent data by the Fisheries Department of *Labeo* catch in Lake Victoria (Kenya waters) are also available from 1968 to 1980 (table 2).

Table 2. *Labeo* catch in metric tons in Lake Victoria, Kenyan part from 1968 to 1980

Year	1968	1969	1970	1971	1972	1973	1974	1975
Weight (Tonnes)	595	467	296	228	310	141	59	94

Year	1976	1977	1978	1979	1980
Weight (in Tonnes)	12	62	148	443	482

There was a decline from 595 tons in 1968 upto 228 tons in 1971. The catches rose a bit in 1972. It is interesting to observe that there was a rather sudden rise in 1979. This rise in 1979 and 1980 may be explained perhaps by increased numbers of gillnets of smaller mesh size and beach seines, used especially at river mouths. If this is the case then, it may not be surprising to find a drastic fall in catches by 1982.

The decline in number of *Labeo* in Lake Victoria, Kenya waters has been attributed main to cultural practices which interfere with the breeding biology of the species. Cadwalladr in 1964 reported that there was overfishing at the vicinity of river mouths, a practice which removed sexually mature fish (hence potential spawners) before they spawned. This is due to the fact that *Labeo*, being anadromous, migrates upstream to spawn. Alongside overfishing was the extensive use of gillnets, a fishing gear which was more efficient than the weirs and barriers previously in operation.

The species that inhabits Lake Turkana is *Labeo horie* and occurs in relatively small numbers (Hopson 1975). The fish occurs up to a depth of 9.4 m at Allia Bay. During the 1974-75 studies by Hopson, 66.9 kg were caught per 100 m of net per night in Ferguson's Gulf, this being the highest catch in the lake. Generally, *Labeo horie* and *Barbus bayinni* are doing well and producing good yields although at the expense of other immature fish.

In Lake Baringo is found *Labeo cylindricus* Peters, which is one of the four fairly common species. The other three are *Tilapia nilotica, Barbus gregorii* and Clarias mossambicus. Among other fish occuring here are *Harbus tanensis* and *B. hindii.*

The Tana River is the largest river system in the country, supporting substantial fisheries. It is a habitat for a variety of species including *Alestes, Clarias, Barbus* and *Tilapia,* to mention but a few. Two *Labeo* species are found in the Tana, namely *Labeo cylindricus* and *L. gregorii.* Both migrate into lateral water at the time of the first floods (mann 1965).

THE FUTURE FOR THE ENDANGERED SPECIES: NEED FOR MORE RESEARCH TO SAVE THEM.

Having appreciated the fact that the endangered species are trully declining in numbers (as shown in the case of *Labeo),* and acknowledging the existence of their demand, we should try and work out methods of not only stopping the decline, but also restoring these fisheries to where they were in the 1940s.

Cadwalladr (1964) quoted Garrod as having pointed out in 1961 the need for research on the population dynamics of *Labeo victorianus,* and it is not improper to stress that need even here. It is only through comprehensive research of the populations that knowledge can be acquired of the cause of the decline and consequently find solutions to the problem.

In this regard, the following recommendations are made;

1. The difficulty of carrying out research on all the inland waters of Kenya at one particular time is acknowledged, consequently priority should be given to Lake Victoria and later other lakes and rivers. Also, it must be admitted that all the endangered species in Lake Victoria cannot be studied together at once, but that they should be studied individually at a time. Selected locations should be dealt with during a particular period instead of longing to cover the entire lake at once. In this connection, studies of *Labeo* in Lake Victoria ought to be conducted on Rivers Nzoia and Sio. The two rivers are preferred due to the fact that they have adequate numbers of *Labeo* to provide meaningful data, as opposed to, say Rivers Nyando and Sondu, where in a preliminary survey, only four Labeo were caught in two nights.

2. Investigations should be centred around the breeding, biology and population dynamics. A knowledge of the species in a relation to its environment ought to be stressed. Previous work has attributed the decline of *Labeo* in Lake Victoria to overfishing and use of efficient gillnets at river mouths. It is high time more research was conducted to look into possibilities of the existence of other causes of decline. Enquiry should be made, for instance, into the effect of pollution on *Labeo,* with work being concentrated on the River Nzoia. Parasites, food and feeding behaviour should also be investigated.

3. Ways need to be tried of restocking Lake Victoria with *Labeo* and for it to become a success, the Fisheries Department should use the authority vested in it to administer the programme. In this regard, proper fishing should be enforced and any gear likely to remove fingerlings should be banned at the river mouths, not only during certain periods but throughout the year.

4. The knowledge about *Labeo* in Lake Victoria should then be applied o other waters (lakes and rivers), with modifications as appropriate.

POLLUTION AS A POSSIBLE CAUSE OF DECLINE OF LABEO

With increased industrialization and modern farming techniques where various chemicals are used as pesticides and for disease control, there is a high likelihood for our water systems to be polluted. The effluents from industries, together with these chemicals contain organic or inorganic compounds that are lethal to fish.

A water system faced with the threat of pollution is the Nzoia River. It passes through agricultural areas where farm chemicals are in use. During the rains, these are washed down by rainwater and get access into the river. Besides that, industries along the river may be sources of pollution. There is the Webuye paper factory and the Mumias sugar factory, both of whose effluents find their way into the river. It is possible that the effluents not only alter river composition, but also fish behaviour as well.

Effluents from Webuye paper factory may be altering the chemical and physical conditions on the water, thus causing biological pollution. For example, samples of water taken from the river showed that there was a marked increase in temperature and a fall in pH on release of effluents, while turbidity, biological oxygen demand (BOD) and dissolve CO_2 rose (Balirwa and Bugenyi 1980).

Balirwa and Bugenyi (1980) quote Fox as having stated that pulp-mill effluents deplete oxygen, are toxic to aquatic life and give the water a taste and an odour. Effluents from Webuye paper mills contain an organic compound (a-terpinol), a monoterpene alcohol which is supposed to be responsible for the taste and odour.

Thorough investigations are, therefore, needed because the River Nzoia is not only a habitat for *Labeo,* but also a nursery for other fish as well. The method of investigation should involve studying the water chemistry of the river from the mouth upstream. This will be done with much help from the chemist at KMFRI Kisumu Laboratory. Such phenomena as BOD, pH, dissolved CO_2 and turbidity of the water will be determined for different points along the river. This will be done at various times of the year, on a monthly basis.

Internal organs ad muscles of *Labeo* will also be studied to find out whether they contain pesticides or heavy metals. The results obtained from the study of the water chemistry and the fish themselves will be compared with catch of *Labeo* (this may also apply for other fish) at various times and locations. it is hoped a correlation may be found.

SUMMARY

It is clear, from the records given, that there is definitely a decline in the number of *Labeo.* It is also clear that there is a necessity to do something if this fishery has to be saved from extinction, especially in Lake Victoria. Thorough investigations into the biology of *Labeo,* together with management polices are the only hope for this species. Research should be directed to those areas that have not been explored yet, to explain the cause of the decline. The implementation of the recommendations made in this paper will go a long way to rescue our endangered fish both in the Lake Victoria and other inland waters of Kenya.

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SARDRINE FISHERY IN KENYA

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ABSTRACT

This paper gives an overview on the Kenya sardine fishery as a research area for the future development and management marine resources. The fishery is viewed in the context of an industry and the need for research into it as an ecological indicator and for commercial exploitation is emphasized.

INTRODUCTION

Fishing, fish processing and marketing are all included in the term fishery. The benefit of a fishery are the resultant balance between the output and inputs into the fishing, processing and marketing of the fish (fish used to include any aquatic resources).

Technology availability of the fish stock and capital needed are major limiting factors in the development and management of a fishery. Depending on the exploitation rate, a fishery is either commercial or artisanal; where quantities landed, vessel-gear coupling and effort employed are the most determinat factors.

SARDINES

These are small - sized fish, rarely reaching 20 cm in length. They are variously refered to as herrings, and belong to the family Clupeidae (suborder clupeoidei). All are characteristically migratory forming heterogenous (sometimes homogenous) shoals of varying sizes and densities. The shoals are only formed during migration, but are broken off during feeding, spawning and at night (in dark). The shoaling has protective advantages for these most preyed on fishes. The shoals sometimes contain larvae or younger mackerels which are also pelagic. Sardines ~~are~~ plankton feeders.

Of the 38 Indian Ocean clupeidae species (Whitehead 1972) 10 are represented along the East African Coast (Losse 1968). These are included in the four general:*Sardinella, Harklosichtys, Pellona and Hilsa.* The sardinella genus is represented by six species: *S. longiceps, S. sirm, S. leiogaster, S. albella S. gibbasa* and *S. melanura.* This last one has not been recorded in East Africa, but in the Red Sea

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(Gulf of Aden) as *Herklotsichthys vittatus* Whitehead (1965), Losse (1968). The *Herklotsichthys* genus on the other hand has two species earlier classified as one; *H. punctatus* forms A and B. However, these have been renamed separately as *H. quadrimaculatus* (form B) and *H. spilurus* (form A).

The genus pellona is represented by *P. ditchella* and Hilsa by *H. kelee* All these species have been described and classified by various workers in the region. EAMFRO (1962) Losse (1964, 1966, 1968), Whitehead (1972) and FAO (1974).

The biology of the sardine (herrings) has also received quite a coverage, though most of the works are outside the East African waters (Blaxter Holliday 1965; Losse 1968). Losse also outlines the spartial distribution and relative occurance and abundance of the sardines along the East African coast.

Two major sardines found off the Kenya waters are *Sardinella gibbosa* and *Herklotsichthys quadrimaculatus.* From market samples all along the Kenyan coast, the two species have been shown to dominate in the catches and seem to alternate in occurance, but both appearing throughout the year in varying quantities. These two were therefore prefered for the on going research programme on the feeding biology, catch composition, protein content and seasonal variations on which basis, their natural histories are to be constructed.

Though, the prevalence of the two species has to be further studied to exploit any existing loopholes and ascertain without doubt which of them dominates the other. A general survey is therefore underway to study the general fishing abilities and methods employed in the sardine fishery. The dominance can otherwise be due to the selective fishing: Preference of species or fishing grounds.

RESEARCH

Very little can be said on the history of the sardine fishery. Of worth were "night time" catches made during the EAMFRO's surveys with the purse seine in 1961 (EAMFRO 1961). The catches were as high as one ton per shot (more than three tons per night at an average of three shots per night). The project was to assess the potential of the shoals and surveys were carried out at daytime. Sardines were found shoaling around the lit up near waters due to bright light from the research vessels and using the purse seine, they were found easily landed in large quantities. The catches varied with time of the year, e.g., off Zanzibar, landings were 90% sardines (*Sardinella* and *Amblygaster)* in March but dropped to 25% in the latter months of the year (EAMFRO 1961).

Other research work have since been conducted and taxonomic work have met with success though some have not been fully identified due to lack of proper taxonomic features, especially where only colouration has been used as a major distinguishing feature.

For any enterprise, the balance between the costs and the benefits is a major in determining the need for continued development, management and investment in the enterprise. It is common practise along the Kenya cost to record amounts and value of fish landed. These records, however, overlook one major aspect in fishing; the effort employed. It is difficult to evaluate the benefits of the fishery without information on the effort spent to land the fish. Efforts to get any data on this are usually frustrated since the fishermen are not willing to identify themselves.

Sardines, however, are an important resource of food to man and other fish. Improving on their fishery can cause an increase in the amount landed and give rise to a commercial activity. Their stock may also be used to improve on the fishery of, predator fish and of those fish which coexist with them, e.g., mackerels, carangids and scombriods.

CONCLUSION

Most of the Literature on the sardines is based on fisheries outside our waters. Fisheries on the Herring, *Clupea harengus L.;* Califonian sardine, *Sardina caerulea* Girard; the Indian oil sardine, *Sardinella longiceps* (Val); the Japanese sardine, *Sardinops melanosticta* Schlegel, and the European sardine, *Sardina pilchar dus* Walbaum, to mention but a few are good examples of various works on the great fisheries of the world.

A research programme at the Kenya Marine and Fisheries Research Institute, Mombasa, has been undertaken to study the life histories of sardines (clupeidae) of the Kenyan coast. Information on the seasonal variations (size and catch composition), is being gathered for the evaluation of the factors influencing their distribution. Taxonomic works are also being undertaken though earlier investigations as those undertaken by among others, Losse (1968) and Whitehead (1972) are acknowledged here. There is need for a deeper insight into the biology of the sardines as this would help us undersatand other surface schoaling fish which depend on sardines for food. Of importance is the migration patterns which reflect hydrographic changes and fluctuations of fish sizes.

Stomachs of *Sardinella gibbosa* and *Herklotsichthys quadrimaculatus* are being examined for food content. The occurance and points methods (Hynes 1950) are employed in the study of the stomach contents. The two methods were prefered due to the smallness of the stomachs and the forage organisms. By giving some arbitrary figures to the observed stomach (volume or degree of fullness and its contents analysed into specific forage organisms the time and frequency of feeding and forage organisms as relatively fed on will be deterined. This coupled with data on zoo-plankton in the fishing ground are useful information. Data is also being gathered from market samples on catch compositions (by size, species, sex, age etc.).

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CATCHES

Data on sardine landings along the Kenya coast show seasonal flactuations with drastic variations which reflect the impact of weather changes. Of particular interest is the synchrony between the abundance of sardines on the market during the November-April period when the Northeast (NE) Monsoons prevail along the coast. During the same season analysis on the primary productivity and plankton abundance have shown peaks. Low catches during the remaining part of the year show the impact of the prevailing Southeast (SE) Monsoons. It is noted that during the NE Monsoons, an upwelling developes in the northern Kenya banks which should be contributing to the productivity level during the season. Information provided by the Fisheries Department on monthly landings (for 1979 and 1980) show seasonal fluctuations in catches (figure 1, 2 and 3. Percentage of sardines landed to total landings indicate that during the good fishing season (NE Monsoons) when rains are heavy and long, the sardine landings are high. Figure 2 gives the landings in metric tonnes per month. During the SE Monsoons (May - October) when the conditions are rougher due to strong winds there is a fall in grand catches (figure 3). The low catch during the period is attributed to either lack of fish stock or difficulty of operating local craft in rough waters. The landing of sardines, therefore, depends on skilled operations: The ability (of the fisherman) to identify surround and trap a shoal is a major advantage. The EAMFRO annual report recommended the use of purse seines for shoaling pelagic fish as the only way to commercially exploit the fishery (EAMFRO 1953).

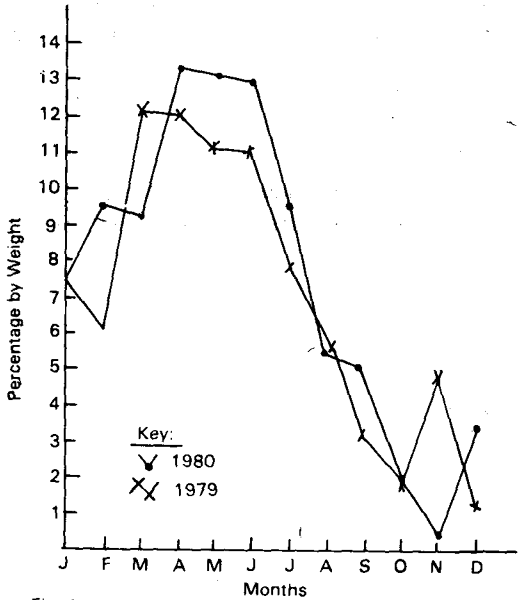

Fig. 1 A direct comparison of the sardine landings to grand total landings by months for the years 1979 & 1980. Note the peak.

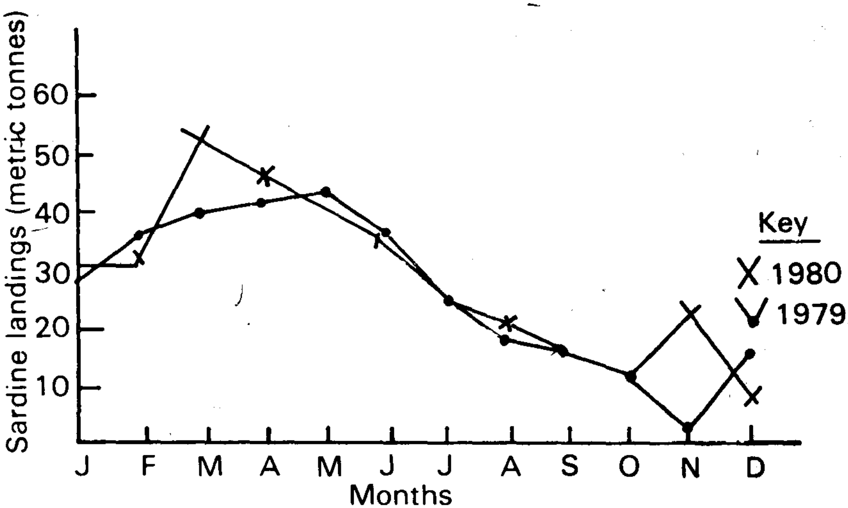

Fig.2. Sardine landings along Kenya coast in metric tonnes (1979 & 1980).

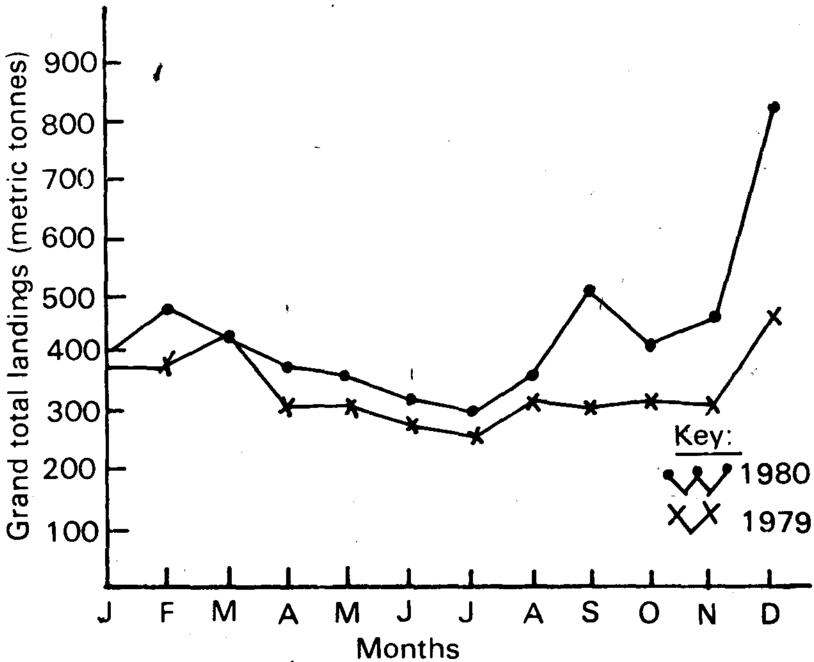

Fig.3 Grand total landings of fish along Kenya coast in metric tonnes. (1979 - 1980)

THE NEED FOR AQUATIC POLLUTIONS STUDIES IN KENYAN INLAND WATERS

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ABSTRACT

The need for baseline data on pollution studies to the aquatic biota of Kenyan Inland waters is of profound importance. Aware of the possible contamination of our rivers and Lakes with heavy metals, pesticides and other pollutants used around them for the control of tropical diseases and treatment of agricultural crops, a monitoring programme is necessary. For instance, aquatic plants (e.g., algae) which form part of the food of certain fish, e.g., tilapia are known to accumulate heavy metals.

Lake Victoria and other lakes in Kenya make an interesting area for studies of the accumulation of pollutants, since they form almost closed systems and, especially since these lakes are surrounded by different crops, e.g., cotton, cane sugar and coffee, and also numerous other industrial activities.

In Lake Victoria, several important fish species have declined recently, particularly tilapia, *Protopterus aethicopicus, Clarias, mossambicus,* and *Bagrus docmac* (Powell 1977). Further decline of fish species such as *Sarotherodon esculentus, Barbus, labeo, Alestes* and *Mormyrus* have been reported (Maten 1979). A total fresh weight of 26, 914 metric tonnes of fish valued at KShs. 56.7 million to the fishermen was landed around the beaches of Lake Victoria (Kenya) during 1980. This represents a decline of approximately 12% compared to that of 1979. What are the possible causes of our seemingly declining fisheries?

In essence, the limnology and environmental research programme (Onyari 1981) is proposed to try and get information on the threat of aquatic pollution to our Lakes, which provide a valuable food source and income for our people. In this discussion paper the sources and effects of several pollutants to the aquatic environment are highlighted. Further, a monitoring programme and its objectives are proposed.

Any proper and sensible exploitation of our fishery resources can only be done through scientific planning; but planning demands as a prerequisite the availability of sound scientific data. Hence this programme aims at providing the basic data upon which present and future plans can draw strategies for pollution control, resources exploitation and management.

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INTRODUCTION

Kenya's total land area is 569,252 Km^2 of which 13,391 Km^2 is covered with water of which 3,831 Km^2 is occupied by the largest lake in Africa, Lake Victoria, situated in the Western part of the country. On the Southeast part of Kenya, you find the Indian Ocean with 300 neutical miles of coast line (Adero et al. 1981).

Human activity has profoundly affected streams and lakes in all parts of th world. The pollution of water resources by man's domestic waste, his industry, his agriculture and other activities is a phenomenon experienced in all parts of the world. This pollution is an inevitable accompaniment of population expansion, burgeoning industry, increasing urbanization and a surge toward a higher standard of living (Pearson 1965). The biological effects of water pollution may not only be disastrous to the surrounding water flora and fauna, but also produce more subtle changes which may upset the balance of nature in many rivers, resulting in equally disastrous effects on the piscine populations (Mawdesley-Thomas 1968).

The mechanisms of river pollution are complex, and whereas most effluents can be treated, they are seldom so innocuous as not to lead to some alterations in the receiving waters (Hynes 1963). The need for baseline data on pollution studies to the aquatic biota of Kenya lakes and rivers is therefore of utmost importance. Baseline data is prerequisite to pollution evaluation. Since even "natural" streams may show the characteristic signs of pollution, that is, "natural" pollution may also faithfully reproduce the effect of the addition of industrial pollutants to water (Hynes 1963).

Elsewhere, excessive pollution of rivers, lakes, and tidal estauaries by sewage and industrial wastes has resulted in diterioration of commercial fishing, fish kills, and injury to water fowl. The damage to water fowl results from the distruction by pollution of the feeding and breeding grounds. This may be brought about by soils, greases, foams, insecticides, and excessive depletion of dissolved oxygen by decompositing organic wastes (Camp and Meserve 1974).

Statistics on fish catches, both commercial and sport, have often been used to show that pollution is the cause of declining catches. Fisheries statistics, indeed are valuable tools in assessing the effects of pollution, but they must be complete and must be considered along with other factors in order to avoid unreliable conclusions (Tellefson 1961). In some parts of the world, the tonnage of commercially important fish has been reduced drastically over the past 50 years. This has been attributed to the more desirable fish species being unable to spawn in the grossity polluted tributaries (Beetin 1965). In Lake Victoria, several important fish species have, similarly been showing a declining trend.

Scientific literature is replete with reports of studies of the aquatic environment and its inhabitants. Fish are usually employed as sensitive indicators of toxic pollution. The dissolved oxygen (DO) is of utmost importance to aquatic life, since it determine whether or not the water can sustain a desirable variety of aquatic organisms (Ethan 1970). Fairly high levels (i.e., 5.0 mg/l) of oxygen are required to maintain a desirable population of organisms, including the aerobic bacteria that consumes waste material in the wate. Low levels of DO (i.e. 1.0mg/l) mark the transition to an aerobic conditions which are often denoted by odours of organic sulfides, blackening of the water and destruction of desirable fish species and many other aquatic organisms. (Ethan 1970).

Fish depend upon dissolved oxygen for respiration, and they will smother and die with an inadequate supply. Under actual stream conditions, a fish must maintain its position against the current, find, pursue and catch its food, avoid its enemies, and reproduce (Tarzwell 1957). All these activities require oxygen in such amounts that oxygen levels at which the fish can just survive are unsatisfactory. Generally, fry and younger fish have a higher metabolic rate and require more oxygen than adults. Because of increased activity and their physiological condition, fish require more oxygen at the spawning season (Tarzwell 1957)

The oxygen requirements of fish are affected by the temperature and pH of the water as well as its carbon dioxide and dissolved solids content. The oxygen uptake of any species of fish increases two or threefold with each 10°C increase in temperature. On the other hand, high carbon dioxide concentrations interfere with the ability of fish to utilize DO, as do high and low pH values (Camp and Meserve 1974).

For a well-rounded warm-water fish population, the DO must not be below 5 ppm for more than eight hours of any 24 hour period, and at no time should it be below 3 ppm. For instance, salmonoid fish are not usually found where DO is less than 4 to 5 ppm, and its eggs and fry require a minimum of 6 ppm (Tarzwell 1957, 1958). However, warm-water species can live for considerable periods during cold weather at DO levels of 1 to 2 ppm (Tarzwell 1958).

Studies done, indicate that the turbidity of water must be very high (20,000 ppm or more) to be directly harmful to fish (Tarzwell 1957). Consequently game fish which feed by sight are at a disadvantage in muddy waters when competing with Catfish and with Carp, buffalo, and Suckers, which employ a suction type of feeding. Since algae, are the basic food materials for aquatic life, turbidity indirectly affects fish production by reducing nest-building and spawning areas (Tarzwell 1957).

Further, pH values from 5 to 8.5 have not been shown to be detrimental to fish. However, pH values below 5 and above 9 seriously affect the abilities of some fish to extract oxygen from the water. It is no surprise, therefore, that streams carrying acid coal-mine wastes are not inhabited by fish (Tarzwell 1957). Generally, in more productive streams, the pH is in the range of 6.5 to 8.5

The presence of dissolved salts in water influences the toxicity of certain substances. The presence of calcium ions in solution will appreciably reduce the toxic effects of heavy metals such as lead and Zinc. High concentrations of Sodium, Calcium and Magnesium prevent the toxic effects of heavy metals probably by complex formation mechanism. For instance, 1 mg/1 lead in a soft water is rapidly fatal to fish, but in a hard water of say 150 mg/l calcium hardness, 1 mg/1 of lead may not be harmful (Oporor, undated)

According to annual reports of the United States Public Health Service on the effects of pollution the greatest number of fish were killed by industrial wastes, followed closely by agricultural poisons. Domestic sewage and wastes from mining operations were other major causes. Of the agricultural poisons, the most frequently reported causes were rotenone, DD7, 2, 4-D, and endrin, whereas, cyanide and metallic ions were the principal causative agents in industrial wastes (Camp and Meserve 1974).

Fish are, particularly sensitive to low concentrations of insecticides. Chlorinated compounds, including DDT, endrin, dieldrin, BHC and toxaphene, constitute the group most toxic to fish (Webb 1962). According to experimental studies of sublethal exposures of fish to organic phosphorous insecticides for periods upto 24 hours, fish brain enzyme, *Acetylcholine esterase* (AchE), is inhibited with concentrations of 0.1 mg/1 (ppm) or less depending upon the compound and the fish species (Weiss 1959).

DDT and other related chlorinated hydrocarbons are fat soluble and are accumulated and stored in organs rich in fatty substances, e.g., adrenais, castes, and thyroid, in the liver and kidneys, and in the fat of the large protective mesenteries that enfold the intestines. An intake of as little as 0.1 ppm in the diet results in storage of about 10 to 15 ppm, an increase of 100 - fold or more (Carson 1962). Evidence of aerial dispersion of pesticides, other than by direct air-spraying applications have been reported (Cohen at al, 1962). It has further been demonstrated that long distance movement of pesticide-laden particles are also possible (Cohen and Pinkerton 1966).

Quite a large number of potentially harmful metals and elements are known pollutants. Heavy metals are very rapidly trapped in biological systems and many accumulate in the sediments. Aquatic plants (e.g., algae) are also known to accumulate heavy metals (Bukenyi 1979). The heavy metals in solution are highly reactive, hence their trace level concentrations. A lot of Swedish lakes are reported to have high mercury levels (Ginsbugr et al. 1974). Spot checks on specific elements are, therefore, necessary on fish caught in suspect areas. The elements of most concern are "cumulative poisons" i.e, those that cause injury to health through progressive and irreversible accumulation in the body as a result of ingestion of repeated small amounts. Hence analysis of some heavy metals of current major concern as potential aqueous polluters will be considered. These include mercury, cadmium, lead, selenium and arsenic.

The effects of potentially toxic materials is normally determined by their action on fish as demonstrated by some form of bioassay experiments. The procedure involves the use of a seiles of dilutions of the suspected material to which test fish are exposed under standard conditions. The prescribed measures of toxicity is the median tolerance limit (TLm), often referred to as 50% lethal dose (LD50). This is the concentration of material under test at which 50% of the test fish are able to survive for a specified period of exposure (usually 48h or 96h).

SOURCES OF POLLUTION

Today, Kenyan inland surface waters are threatened by pollution and eutrophication. Three major sources of pollution, namely domestic/urban wastes, agricultural wastes and industrial wastes will now be considered.

DOMESTIC AND URBAN WASTES'

The discharge of domestic sewage with varying degrees of treatment into lakes and rivers may lead into major qualitative and quantitative changes in the biota. The water may become a health hazard, uninhabitable by desirable fish or aesthetically unpleasant. The symptoms of stress in fresh water bodies caused by loading with treated or untreated seawge are outlined below (UNESCO 1972).

1. Low dissolved oxygen levels caused by biological oxidation of organic matter and increased concentrations of refractory organic matter in this water.

2. Stimulation of algae growth and shift of algal type to obnoxious blue greens. This may lead to large accumulations of algae, often characterized with massive production of floating algal scums. Later as these decompose, DO levels will be lowered.

Thus sewage loading is accompanied by structural changes in ecosystem components in addition to contributing towards the total input of organic and inorganic materials to freshwater bodies. In a municipal sewage of medium strength, the total solids content may amount to about 800 mg/ l of which about 300 mg/ l is suspended and about 500 mg/ l is colloidal and dissolved. About two thirds of the suspended solids are organic and the remainder are mineral. The organic matter is about 50% carbohydrate, 40% nitrogenous matter and 10% fat.

When organic matter is added to a stream, it is immediately attacked by bacteria, which breaks it down to simpler substances, and in so doing uses up oxygen. Sewage being well inoculated with bacteria and adequately supplied with a wide range of compounds, gets broken down relatively easily. However, some materials, notably wood pulp are very poor bacterial foods and are decomposed very slowly. These will normally exert a lower oxygen demand, but for a longer period of time (Hynes 1963). The biological oxygen demand (BOD) of a sample of sewage, industrial wastes of polluted water is a measure of the concentration of decomposable organic matter in the sample.

AGRICULTURAL WASTES

Today, fairly large amounts of insecticides, herbicides and fertilizers are used in Kenya. Large amounts of DDT and other pesticides are used by the public health bodies for the control of disease such as maralia, sleeping sickness and river blindness.

Pesticides are also used in agriculture, especially on coffee plantations and in cotton growing areas. The vast plantations of sugar-cane in western Kenya also make much utility of fertilizers. Widespread use of inorganic fertilizers may cause an increase in the nutrient level of run-off water, particularly nitrates, which may contribute towards unwanted production of certain algae in the receiving waters.

The biocides used in agriculture and forestry find their way into the aquatic environment by drift or run-off. The latter may be enhanced by irrigation. By products of agriculture, e.g., silage, effluent and wastes from dairies and pig and poultry farms may be discharged into streams (UNESCO 1972). Insecticides applied on land may cause destruction or decimation of aquatic invertebrate populations, and may accumulate in the food chains to poison fish, birds and humans.

Herbicides emanating from the land may destroy the aquatic plants which for the basis of food chains of direct or indirect significance to man.

INDUSTRIAL WASTES

The appearance of new synthetic compounds such as poly-chlorinated biphenyls (PCB) and changes in distribution, concentration and form of naturally occuring substances, e.g., zinc and cyanides in the environment due to the disposal of industrial wastes has led to increased and differential mortality of populations, impairment of reproduction and disruption of species composition and balance (UNESCO 1972)

Industrial effluents comprises of several pollutants. including heavy metals, some of which are extremely toxic. Table 1 shows the general distribution of heavy metals in particular industrial effluents (Stumm and Morgan 1970). Industrial effluents which contain only chemical reducing agents, e.g., ferrous salts or sulphides, take up oxygen by purely chemical action. They do this repidly exerting what is sometimes known as immediate oxygen demand (Hynes 1973).

The chlor-alkali industry is the largest consumer of mercury, which is the most serious polluter of the aquatic environment. Consumption of fish containing high levels of methyl-mercury can have serious consequences, as demonstrated in the Minamata and Niigata disasters in Japan (Wfrei 1975). In Kenya, we have reasonable industrial establishments manufacturing a wide spectrum of goods, e.g., sugar, textile and paper. Furthermore, new ones are coming up, e.g. the molasses industrial complex which will produce power alcohol (ethanol) besides other products such as citricK acid, vinegar, dry and fish baker's yeast, sulphuric acid, methane, oxygen and gypsum.

OTHER POLLUTANTS

The sugar, paper and coffee industries are major pollutants in Kenya. Unfortunately, no serious restrictions are in force as concerns control of their effluents, which are normally discharged almost at will into waterways. I will now address myself to other inorganic compounds that are potential threats to the ecosystem balance in Kenya. These include, flourspar, cement, asbestos and calcium flouride. The flouride ion is formed by dissolution of flourspar. When its concentration exceeds 0.8 ppm in drinking water, it will affect the bone systems of all animals, making them soft. It will even hydrolyse most peptide bonds. The ultimate result of flouride poisoning is death (Wandiga 1980). On the other hand, the high particulate emission from cement and absestos are objectionable because of their effect on the respiratory systems.

The insecticide, toxaphene is a chemical currently used in cattle dip tanks for control of ticks on cattle. Toxaphene is an organochlorine insecticide which acts on the nervous system, with symptoms depending on exposure, varying from slight behavioural and growth pathology to death. If carelessly handled and accidentally allowed to spill into streams it may result in great mortalities of fish and other inhabitants of the aquatic regime.

MONITORING PROGRAMME

Ideas about pollution indicator species are almost as numerous and diverse as are the people concerned with them. These range from the simplistic quest for an all purpose aquatic "canary" that will warn of pollution to the complex mathematical models of community interrelationships. Indeed, no one index or model can be depended upon to describe a community completely. Rather a balance of many techniques incorporating studies on species compositions, population sizes and physico-chemical environments to which they are exposed, must be employed (Hart et al. 1974)

The species and media appropriate for sampling and analysis must be carefully selected. Species of which individuals move over considerable distances, either for feeding or on migration, may give information difficult to interpret as the pollutants may not have been ingested in the area in which the specimens were collected. Ideally, freshwater fish which remain in the lake over a complete life-span or invertebrate which move relatively short distances should furnish information relevant to their local environments.

A further important consideration in the choice of species for monitoring is that sufficient individuals must be available for sampling at the required time, without having significant influence on the total population. In practice, in order to obtain a reasonably accurate estimate of the mean level of contamination in any one population, a large number of individuals must be sampled.

The collected samples must be truly representative of the environment under consideration. This is aimed at achieving the goals of the monitoring study. Therefore the sites, techniques and frequency of sampling and the size and number of samples must allow the analytical results to be statistically evaluated and replicated at a later time for confirmation.

A "biotic index" based on the macro-invertebrate fauna has been proposed (Beak 1965). Six distinct stages in the change from a normal fauna to no fauna, corresponding with increasing degrees of pollution and relative "biotic index" and fisheries potential are displayed in table 2.

With these ideas in mind, a monitoring programme has been suggested to Kenyan waters of Låke Victoria. These are outlined in figure 1. The pollution indicators to be employed are fish, invertebrates and water criterion. Fish species used by the surrounding population as a source of protein will be chosen as an important link in the food chain and as an indicator for the degree of pollution of the lake. particularly to be of interest will be the riverine fish species. Such a general survey may also unfold possible aerial fallout from distant sources of pollution.

In determining admissible pollution, determination of both physico-chemical properties of Lakes Victoria, Naivasha, Turkana and rivers on both the eastern and western part of Kenya will be embarked on. The usual parameters employed in water pollution studies, e.g., dissolved oxygen, pH, conductivity, BOD and chemical oxygen demand (COD) will be monitored routinely at the suggested stations (figure 1). Other physico-chemical parameters, e.g., colour, turbidity, hardness, alkalinity, nitrates, phosphates, sulphates, chloride, flouride, sodium, potassium, iron, manganese, calcium and magnesium will also be considered.

The content, distribution and accumulation of heavy metals and pesticides in Lake Victoria, and its effluent rivers is little known in our country. Fish will be used in this monitoring programme, and later plankton, invertebrates and bottom sediments analysis will be considered. An exhaustive working plan has been proposed (Onyari 1981). This has been divided into five phases as follows:

1. Determination of physico-chemical and biological pollution indices in among others Lakes Victoria, Naivasha, Turkana and Nakuru including their effluent rivers.
2. Evaluation by bioassays of the toxicity to tilapia species and other endangered fish species of industrial and municipal effluents.
3. Determination of the concentration of mercury and other heavy metals in lake Victoria and all other Kenyan Lakes.
4. Determination of pesticides (e.g., DDT) residues in among others, Lakes Victoria, Naivasha, Nakuru and Baringo.
5. Determination of the nutritive values, e.g., fats and proteins of various species of fish from, among others, Lakes Victoria, Turkana, Naivasha.

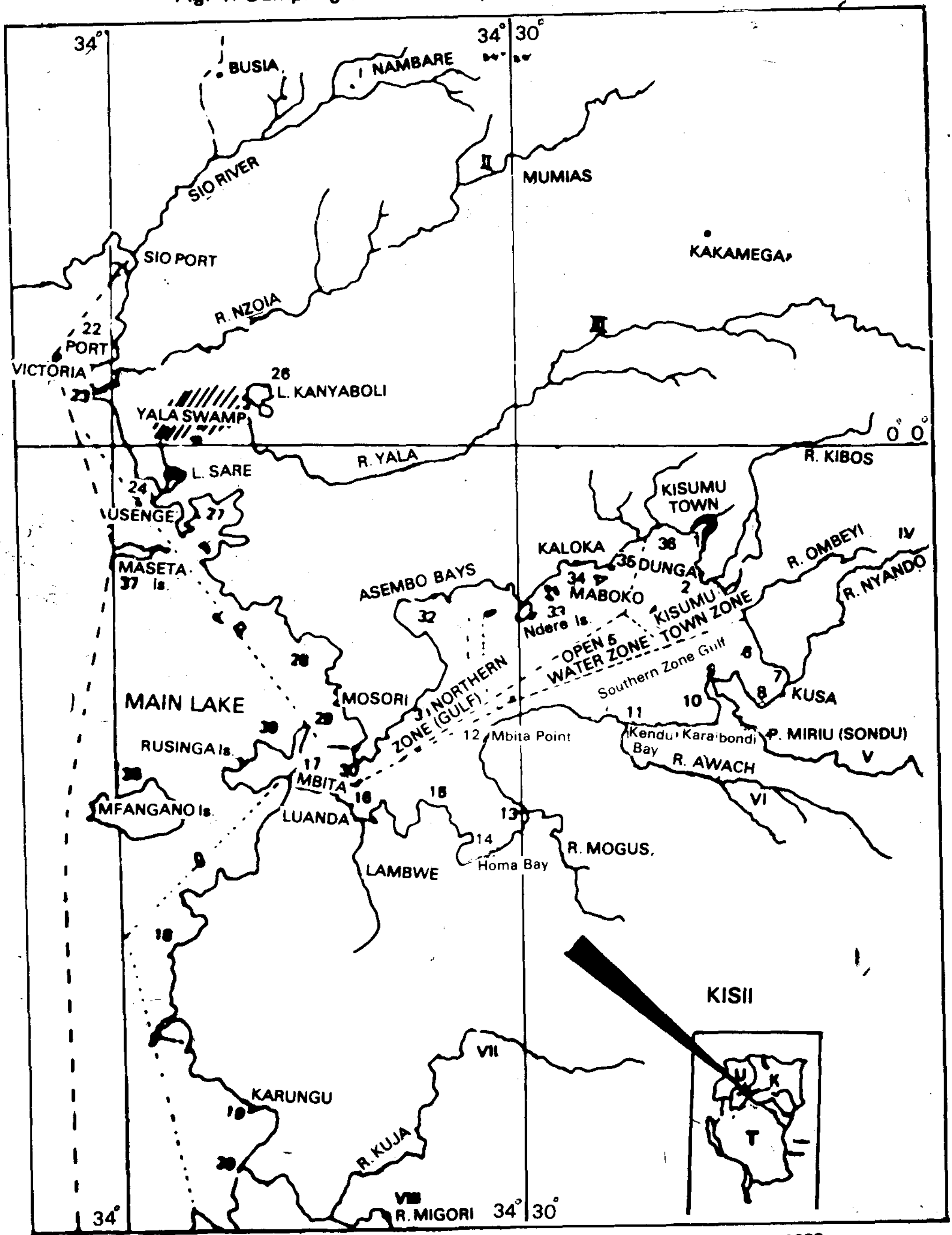
OBJECTIVES

The limnology and environmental research programme will look into the causes and nature of aquatic pollution in Western Kenya. It further aims at providing basic baseline data on water quality characteristics upon which future levels of pollution will be guarded against. Pollutants and their effects on aquatic organisms (plankton, benthos and fish) will be studied and remedial action will be recommended where possible. The programme intends to:

1. identify the sources and nature of common pollutants, and advise on its preventation;
2. assess the acceptability of industrial wastes for lake and river disposal;
3. determine toxicity values of urban, and agricultural industrial pollutants;
4. study the likely short-term biological effects of the pollutants on fish;
5. establish the present composition and degree of purity (water quality) of Kenyan rivers and lakes, so as to provide baseline data upon which future studies can be compared to;
6. determine the nutritive values, quality of Kenyan fish species with regard to marketibility, particularly for local and export purposes; and

7. postulate same explanations for the declining trend of some fish species in Lake Victoria.

Fig. 1. Sampling areas in Kenya waters of Lake Victoria.



LIMNOLOGY AND ENVIRONMENTAL RESEARCH PROGRAMME 1:250000

DISCUSSION

Today, pollution has relatively not reached any alarming proportions in Kenya, despite the alarming and very often exaggerated reports by our national newspapers. Ideally, therefore thorough baseline chemical and biological studies should be done, for purposes of establishing standards upon which subsequent detection and monitoring of aquatic pollution can be based on. Phase one of the proposed research programme has already been launched. Preliminary observations on aquatic pollution has been in progress and routine monitoring still continues. These studies cover in part pH, colour, turbidity, iron, total hardness, total alkalinity, conductivity, dissolved oxygen, flouride, phosphate, nitrates and sulphates.

Whereas, the analysis of chemical pollutants in Kenya has been carried out by several parties, the results of most of these analyses, however, are unknown. Of late the threat to the Lake Nakuru ecosystem by the production of copper-oxy-chloride has been greatly exaggerated. Analysis of the Lake Nakuru water (Wandiga 1980) reveals that the concentration of copper (2-8 mg/1), a major inorganic poison is far below the threshold limit. Likewise, pesticide studies have been done for several species of birds and fish of this lake. The results obtained for DDT, DDE, DDD, dieldrin and endrin, range from 0.001 mg/g to 0.64 mg/g (Koeman et al. 1972). Subsequent analyses of Chlorinated pesticides residue in cope pods (Lovelula spp.) reveal low concentrations of DDT (0.003 mg/g) and DDE (0.007 mg/g). The analysis of algae and mud samples from the same lake gave no detectable DDT or DDE (Wandiga 1980).

In Lake Victoria, analysis of one sample of bass (fish) by the University of Stockholm indicates the presence of a wide range of chlorinated hydrocarbons in the lake. The results (in ppb) obtained were DDT (0.02); BHC (0.06); Heptachloroepoxide (0.07); Aldrin (0.04); Dieldrin (0.13); HCB (0.03); PCB (0.04) (Jensen and Odhiambo 1977). These results indicate the need for further and more intensified monitoring as discussed in the monitoring programme (figure 1).

There is need for biological and chemical studies to be carried out on River Nzoia in particular, to evaluate the direct effects of the pulp and paper mill wastes on its resources. The paper industry has a history full of dead rivers all over the world. In the United States, this industry is credited with the death of most rivers in the Tennessee and Mississippi valleys, although credit must be given to the same industry for the research it has done in improving its own technology (Wandiga 1980). Those of you who have paid a visit to Pan African Paper Mill factory, situated in Webuye will probably remember the stench around the town. The "awful stench" is mainly sulphur dioxide which interracts with the moisture in the air to form sulphurous and sulphuric acids. These chemicals all irritate the respiratory systems and at higher concentrations may gradually cause death (Wandiga 1980). Hence this area provides a target priority area for research into the nature of the discharges and their effects on the entire ecosytem.

Kenyan living marine and inland water resources may face the danger of extreme depletion if pollution and physical alteration of the water is allowed to take full effect. Athi River offers an excellent example of the rapid deterioration in water quality of lotic aquatic systems in tropical Africa due to industrialization and urbanization. The results of the physico-chemical analysis and examination of the macro-fauna and riverine flora describe a river unable to cope up with the heavy pollution load from the city of Nairobi and its upper reaches (Njuguna and Gaudet 1979).

The construction of dams along a river will normally be accompanied by a number of changes within the river, which may affect the fisheries in several ways (Okedi et al. 1974).:

1. The river flow will be interrupted in the dam sites and the dam wall becomes an obstacle to fish movements, making it difficult for fish to reach their breeding grounds.

2. Creation of lake environment above the dam with its new flooded habitat and the destruction of the breeding grounds.

3. Separation of fish populations into those below and above the dam.

4. Changes in physico-chemical characteristics of the water, this depending upon the flooded area, water depth, decomposition, temperature and rainfall regimes. The physico-chemical changes may ultimately affect the flora and fauna in the system.

5. The new habitat (lake) may eliminate old fish species or modify their habits or may support an entirely different plant and animal communities.

6. Disturbance of the entire food chain dynamics which the aquatic inhabitants had established, i.e, breakdown (collapse) of the natural ecosytem feeding pattern.

Several rivers in Kenya are reported as being potential sources for local power supply. The potential energy of the Tana, calculated from rainfall and elevation is reported as 15,3000 million kWh a year of which about 2,700 million kWh can usefully be exploited; a small station (2,000 kW) on the Kurja; and feasibility for the development of a five megawatt station at Broderick falls on the River Nzoia (Fadel 1979). However, in the construction of these and other dams, the decision makers should not overlook the possible effects enumerated above on the ecosystem, many of which may be irreversible in the long run.

In recent years the insecticide, toxaphene commonly used in cattle dip tanks has been responsible for fish and bird mortalities.

In August 1978 a large number of fish were reported dying in the Hluhluwe river in Natal, South Africa, due to pollution by toxaphene from a cattle dip tank (Brooks and Gardner 1980). Hence, we in Kenya ought to exercise caution in its use and handling to avoid such undesirable consequences.

Perhaps one of the sources of great concern in Kenya is the pollution of the water systems by spillage of the human wastes into the waterways. it is reckoned that schistosomiasis (bilhaeziasis) and to a lesser extent leishmaniasis remain two of the major health problems in the tropics. In Kenya, it is estimated that one out of every five peoplde suffers from schistosomiasis (Wandiga 1980).

Narrowing up, observations of changes in plankton, invertebrates and fish communities are necessary in evaluating the impact of enrichments on our aquatic environment. If we are aware of the usual seasonal succession, diversity and species interrelationships, any subsequent modifications of the ecosystem will be readily detectable.

Considerable damage has been done to Italian lakes by combined discharges of sewage and industrial wastes including synthetic textile works. Some of these lakes are now eutrophic to a high degree. Fish losses have been reported in Lake Balaton (Hungary) due to a discharge of a pesticide. Whereas, in the south of Norway, the waters have low mineral content 1.5 mg CaO to 4.0 mg CaO/1 and acid rain water derived from atmospheric pollution in northern European countries is thought to have caused the pH values to fall to harmful levels (Holden and Lloyd 1972). Consequently we in Kenya must know with much greater certainty what we are doing to the aquatic environment and the degree and extent to which it is being damaged in order to properly understand their effects on our fisheries. These pollution studies and limnological studies will greatly enhance the management and developement of Kenyan inland fisheries.

Table 1 General distribution of heavy metals in particular industrial effluents.

Industrial effluents	As	Cd	Cu	Fe	Hg	Pb	Ag	Zn
General Industrial & Mining	—	—	X	X	—	X	—	X
Plating	—	X	X	—	—	X	—	X
Paint products	—	—	—	—	—	X	—	—
Fertilizers	—	X	X	X	X	X	—	—
Insecticides/Pesticides	X	—	X	X	X	—	—	—
Tanning	X	—	—	—	—	—	—	—
Paper products	—	—	X	—	X	X	—	X
Photographic	—	—	—	—	—	—	X	—
Fibers	—	—	X	—	—	—	—	
Printing/Dyeing	—	—	—	—	—	X	—	—
Pipe corrosion	—	—	X	—	—	X	—	—
Chlor-alkali and pulp mills					X			

Note: X = Presences
— = Absence
no information

Table 2: Biotic index: Index of water pollution based on the study of the biota

Biotic Pollution Index Status		Type of macro-invertebrate community	Fisheries potential
6	Unpolluted	Sensitive, facultative and tolerant predators, herbivores, filter and detritus feeders all represented, but no species in excessively large numbers.	All normal fisheries for type of water well developed.
5 or 4	Slight to moderate pollution	Sensitive predators and herbivores reduced in population density or absent. Facultative predators, herbivores and possibly filter and detritus feeders well developed and increasing in numbers as index decreases.	Most sensitive fish species reduced in numbers of missing
3	Moderate pollution	All sensitive species absent and facultative predators (Hirudinae) absent or scarce. Predators of family pelopiinae and herbivores of *Tindipe didae* present in fairly large population densities.	Only coarse fisheries maintained
2	Moderate to heavy pollution	Facultative and tolerant species reduced in numbers if pollution toxic, if organic few species insensitive to low oxygen present in large numbers.	If fish present only those with high toleration of pollution
1	Heavy pollution	Only most tolerant detritus feeders (Tubificidae) present large numbers.	Very little, if any fishery.
0	Severe pollution usually toxic	No macro-invertebrates present	No fish

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THE FOOD OF SOME NERITID PROSOBRANCH MOLLUSCS FOUND AT MKOMANI MOMBASA, KENYA

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INTRODUCTION

The rocky shores of the Kenya coast at Mkomani, Mombasa support a wide variety of organisms. One of the common organisms is the gasteropod prosobranch mollusc *Nerita*. Three species of *Nerites* are found i.e *Nerita plicata N. undata* and *N. textilis,* at different heights on the rocky shore.

Various studies have been carried out on the Nerites and their ecological, zonational and migrational patterns and discussed by several workers. Thus, amny aspects of the life of the Nerites are known, however little has been done on the nature of the food of these organisms. It is known that they are herbivorous and browse upon the algae found on the rocks by utilizing the powerful radula to scrape the food off (Ruwa and Brakel 1981). Little other information is available on the food of these molluscs. Details of the algal species, quantities and qualities of the contents have not been revealed.

The study of the food could provide information that would be of use in the study of other aspects of the rocky shore ecosystem, their position in the ecosystem.

LITERATURE REVIEW

The rocky shore environment and its associated organisms have been studied by several workers who have contributed much useful information on these shores. A comprehensive introduction to the ecology of rocky shores has been provided by Lewis (1964). Hartnoll (1975) worked on the rocky shore s of Dar-es-salaam and found *Nerita* spp. among the other rocky shore organisms. Taylor (1971) found *Nerita* spp. on the rocky shores at Aldabra.

Other studies on the *Nerita* spp. have been carried out by Vannini and Chelazzi (1978, 1981), Hughes (1971), Maxwell (1970), Warburton (1973). The local Nerite species have been studied by Ruwa and Brakel (1981) with regard to zonation and tidal periodicity while anatomy of some Nerites is described by Fretter (1965).

Little information is available on the food of the *Nerita* spp. Although it is known that they are herbivorous and feed upon algae, the exact nature of the food is unknown. Studies on the algae found on the Kenyan Coast have been carried out by a few workers. Species lists have been drawn up by Isaac (1967, 1968, 1971) Knutzen and Jaasund (1979), Kind (1956), Gerloff (1960), Moorjani (1980).

METHOD

In order to carry out the study of the food of the *Nerita* spp. the specimens had to be dissected, and the gut contents analysed microscopically. Three samples, one of each species, were collected daily as far as possible. The Nerites were then washed and the outer shell carefully cracked and removed. The mantle skirt and body cavity were cut away and the gut was uncoiled and gently pulled out onto a microscope slide. The gut materila was pressed out into distilled water and macerated thoroughly. Drops of this solution were examined microscopically, and the algae identified as far as possible.

For comparisons, fresh algal samples were collected from the rocky cliffs and examined microscopically. This helped in identification of the algae found in the gut. The relevant types of material found in the gut were identified and recorded.

TABLE I: Food Items found in stomachs of *Nerita* spp.

RESULTS

Food Item Algal Genus	*Nerita textilis*	*Nerita undata*	*N. Plicata*
BACILLAROPHYCEA			
Navicula	+	+	+
Meridion	+	+	+
Licmophora	+	+	−
Nitzchia	+	−	−
Cymbella	+	+	+
Cocconeis	+	−	−
Melosira	+	+	+
Achnanthes	+	+	+
Synedra	+		
CHLOROPHYCEA			
Chaetomorpha	+	+	+
Rhizoclonium	+	+	−
Enteromorpha	+	+	+
Scenedesmus	−	+	−
RHODOPHYCEA			
Bostrychia	−	−	+
CYANOPHYCEA			
Lyngbya	+	+	+

(+ indicates presence)

RESULTS

The results summarized in Table I show the types of algae consumed by each of the species. The algae was found macerated in small clumps and fragments due to digestion. This led to difficulties in identification, however, some algae remained intact and could be identified.

The Nerita spp. feed upon various types of algae, the different classes being the Cyanophycea, Chlorophycea, Rhodophycea and Basillariophycea. The exact quantities of each of these consumed was difficult to ascertain due to the mentioned identification problems. However, it was possible to identify the various classes consumed.

The diatoms were easily distinguished and were found in all the three species in individual, chain or colonial forms. They were identified by differences in frustule shape as well as pigmentation differences. The fresh algal materila was observed to have large numbers of epiphytic diatoms, some of them motile.

Some zooplanktonic organisms were also found ingested by the Nerita. These were thought to have some type of Nemertine worms, but identification was not certain.

CONCLUSION AND DISCUSSION

The Nerites were found to be herbivorous gasterpods feeding upon the algae off the rocky shores. The radula collected and rasped the material into fine particles that were digested in the gut. Any undigested algar was eliminated in the fecal material which was found to contain large amounts of algae. The algae in the gut of the Nerites corresponded closely to that found on the rocky cliffs, indicating that the Nerites derived their food primarily from the rocky cliffs. However, it was possible that some of the algae were phytoplanktonic. All the three Nerite species had similar algal material in their guts, this indicated that they fed upon the same algae from the rocky cliffs.

The amounts and types of algae found in the Nerites did not seem to differ greatly with each spring or neap tide cycle. This, however, is subject to quantitative confirmation. Each Nerite had to have some means of reaching the algae found at particular heights on the rocky cliffs. The migratory patters observed could be a method of obtaining the food.

Most of the algae found in the gut of the Nerites were thought to be part of the food of these organisms due to the numbers and frequency of occurence of the various types of algae. However, the zooplanktonic Nemertines were not thought to be part of the food due to their low numbers and infrequency of occurence. They were thought to have been accidentally ingested with the algal food material, and remained undigested in the gut.

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PARTITION OF PROTEIN FROM SEA URCHIN: DIADEMA SETOSUM IN DIFFERENT SALTS.

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INTRODUCTION

Sea urchins are classified in the Phyllum, Class, and Order of Echinodermata, Crinoidea and Regularia. They have radially symmetrical bodies made of calcareous plates, Arnold (1968); Clark and Rowe (1971) and are exclusively bottom-living, occuring both on hard and soft bottom, Ebert (1982); George and Jennifer (1979). Some species of sea urchins e.g. *Heliocidaris erythrogramma, Tripneustes gratilla* and *Pneustes ventricosus* are used as food in some parts of the world such as, Japan, Australia, Korea and Barbados, Jones and Endean, (1976). Some species of sea urchins are poisonous e.g. *Toxopneustes pileolus, Diadema setosum.*

Immers (1961b) and Ficg (1964) studied the protein synthesis of the female sea urchins. Iwata and Nakano (1981) and Miyachi et al (1984), have been working on protein of sea urchin characterization.

In this work protein partition by using different salts is investigated.

MATERIALS AND METHODS

Sea urchins were picked up by hand at K.M.F.R.I. station and stored at -10C to preserve them until it was convenient to dissect them.

The frozen samples were thawed at room temperature. The globiferous pedicellariae muscles and spine stalks, removed and put into another bottle with broken glasses in 0.1M sodium phosphate buffer 7pH. The bottle then shaken hard to remove and break off the flesh into smaller pieces. The particles were sieved off by 300M sieving mesh. 300 ml. of protein solutions then stored at-2 C.

25 ml. of protein solutions were divided into five test tubes, 5 ml; in each test tube and salts added (table 1)

The samples were left overnight at room temperature. The protein partition were observed the following day.

Table I. protein solutions with different salts.

Test tube	Grams of salts added	Salts
1	10	$(NH_4)_2SO_4$
2	10	Na_2SO_4
3	10	$Na_2S_2O_3\ 5H_2O$
4	10	$NaNO_2$
5	10	NaCO

RESULTS AND DISCUSSION

The protein partition by different salts are compared (fig 1) As may be seen from this table, the higher the molecular weight of the salts, higher the partition required for protein. Generally it might be expected that, the higher the molecular weight of the salts used, the higher the separation. This increase in concentration due to greater molecular weight is, however partly salts with higher molecular weight are required for protein partitions Albertsson (1960). This systems in test tubes 1, 2 and 3 have high top partition.

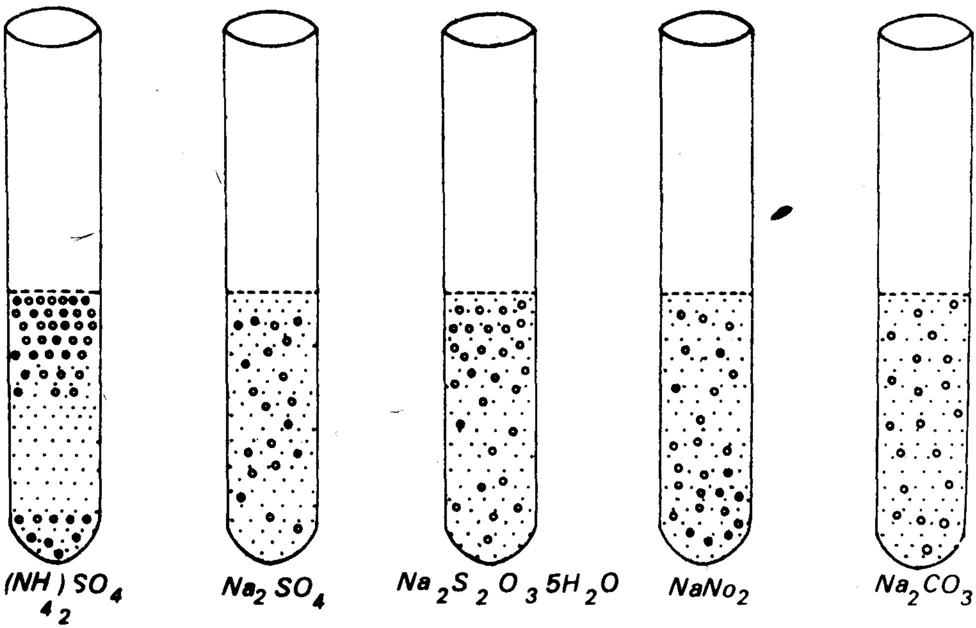

Fig 1 Protein partition in different salts

Influence of shaking: The salt particles were allowed to distribute by their own thermal motion. To achieve solubility quickly the systems were shaken, so that a close contact between the salt and protein molecules is obtained within a short time. During shaking the particles may be subjected to various mechanical forces supplying them with kinetic energy in addition to that of the thermal motion.

The time required for the protein to partition was the same. It depends not only on the difference in density between the proteins, but also on the time needed for the small droplets, formed during shaking to coalesce into larger drops. The settling time therefore slow in all.

Protein partition in mixture depends highly on both the ionic strength and the kind of ions present, Albertsson (1960). Thus, the mixture in low molecular weight salt show high turbidity, most of protein showing high dielectric constant values.

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FISH PROCESSING AND DISTRIBUTION IN KENYA

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ABSTRACT:

Kenya has a potential to land 150,000 metric tonnes of fish annually worthy U.S. $ 50 million.

The present annual fish landed is about 50,000 metric tonnes worth U.S. $ 16.7 million. Some of the fishing areas are near the main urban centres and fish landed is disposed of fresh. However, due to preservation and communication difficulties, fish from areas that are far from population centres are processed. About 5% of the annual total catch is processed as salted, sun-dried, smoked, chilled, frozen and filleted and as fish meal.

Fish processing is largely dominated by traditional methods of curing. Curing by smoking is the most widely practised method. Sun-drying without salting is widely practised inland while in the coastal areas sun-dried fish is salted. There is lack of adequate preservation facilities such as freezing and cold storage in the main fishing areas. However, steps are being taken by the Government to improve the various fish landing facilities by installation of ice plants and cold storage facilities in the main centres. Fish is transported to the urban area in refrigerated trucks or in ice boxes.

INTRODUCTION:

Kenya has a considerable fisheries potential which is indicated by the presence of 10,000 km of lakes, mostly freshwater and a coastline of 640 km. In addition to these there are numerous fish bearing rivers, streams and several thousand ponds (Fig. 1). It is estimated that there is a potential to land 150,000 metric tonnes of fish yearly. The forecast for annual fish landing has been about 50,000 metric tonnes which in the last few years, has nearly doubled in 1983 (Department of Fisheries Statistics 1983).

A total of 97,461 metric tonnes of fish were landed by local fishermen in 1983 which was an increase of 20.1% as compared to 1982. Lake Victoria contributed to 79.3%, Lake Turkana 10.4%, Marine 8.3%, Lake Naivasha 0.7%, Lake Baringo 0.4%, fish farming 0.6% and others

DISPOSITION OF CATCH

LAKE VICTORIA

In 1983 a total fresh weight of 77327 metric tonnes of fish valued at Kshs. 120.3* million to the fishermen was landed. This quantity increased by 26.9% while the valued declined as compared to 1982 (Table I).

This decline was brought about by the decrease in average prices of Nile perch *(Lates niloticus)* and *Engraulycypris* which fell from Kshs. 1.82 to Kshs. 1.39 and Kshs. 1.36 to Kshs. 1.09 per kg respectively. These two species contribute 89% of the total catch in the lake and 75.4% of the total value to the fishermen. 95% of the total catch was marketed while 5% was consumed locally around the landing beaches. The number of canoes involved in fishing is estimated as 5,000 with an estimated number of fishermen of 20,000.

LAKE TURKANA

A total of 10,113 metric tonnes of fish valued at Kshs. 13.6 million to the local fishermen was landed in 1983. This was a drop by 9% compared to the previous years catch of 11.040 metric tonnes, but the value rose by 12.6%, with Nile perch, Tilapia and Labeo dominating the catch. Lake Turkana Fishermen Co-operative Society purchased 45.3% of the fish landed while trade out of the area contributed 20.7% and the rest 34% was consumed locally. (Table II).

LAKE NAIVASHA

A total of 692 metric tonnes worthy approximately Kshs. 9.38 million was landed in 1983. There was an increase of 68.5% over 1982 in quantity and 63.5% in value. The increase in price was attributed partly due to the increase in number of fishing boats to just over 100 boats, and secondly there was no enough fish from members of Fishermen Co-operative Society of Naivasha due to poachers who took their fish to Nairobi.

The Co-operative Society collected only commission from Fishermen and left them to deal directly with fish traders. The bulk of L. Naivasha fish (Tilapia and Black bass) is marketed fresh to Nairobi and nearby towns. Crayfish amounted to 116 metric tonnes worthy Kshs. 2.7 million and was exported mainly to France and Netherlands. A matter of interest, fish from Lake Naivasha is more costly than (freshwater) fish from other part of the country apart from trout. Tilapia and Black bass sold at an average of Kshs. 11.40 and Kshs. 13.75 per kg respectively.

*1. U.S. $ - Kshs. 15.16 (October, 1984)

LAKE BARINGO

Lake Baringo landing dropped from 401 metric tonnes in 1982 to 352 metric tonnes in 1983 valued at Kshs. 648.000 to the fishermen. This drop might have been caused by the drought affecting the breeding grounds. Lake Baringo filleting factory which operated for most of the year, purchased a total of 98 tonnes of Tilapia. Out of this purchase the factory made 27.994 packets of 400 gm and 1831 blocks of 3 kg. This factory continue to be a major market for Tilapia to the fishermen (Table III).

The other major species i.e. *Barbus* and *Clarius* are transported fresh from Kampi ya Samaki Central Landing beach to Nairobi and near by towns. Price at the landing beach are Kshs. 2.00 for Tilapia and *Barbus* and Kshs. 1.00 for *Clarius* per kg.

FISH FARMING

A total of 585 metric tonnes of Tilapia, Carp and Trout worth Kshs. 15.9 million was harvested by local farmers in 1983. This reflects an increase of 33%, Trout 28.9% and Carps 22.5% and prices on average were Kshs. 11.50, 8.50 and 68.00 per kg respectively.

RIVERS AND DAMS

Rivers and dams contributed 267 metric tonnes of fish valued at Kshs. 1.87 million, which was a drop from last year (1982) when the quantity was 452 metric tonnes.

MARINE

From the coast 8125 metric tonnes valued at Kshs. 61.01 million was landed. Out of this 1732 metric tonnes worth Kshs. 4.9 was freswater from the lower Tana River. Marine Fish catch was 6393 metric tonnes worth Kshs. 56.1 million.

In the marine environment, demersal species contributed 48.5%, pelagic 17.1%, Game/Deep Sea Fish 10.8%, Crustacea 7.4%, Sharks 14.4% and others (oyster, becher-der-mer etc) 1.9%. On average demersal fish cost Kshs. 5.60, pelagic 7.45, Crustacea 22.75 and others 33.75 per kg.

EXPORTS AND IMPORTS OF FISH AND FISHERY PRODUCTS IN KENYA

In 1981 the quantity of fish and fishery products exported was 1460 metric tonnes which dropped to 911.8 metric tonnes in 1982 and rose to 1466 metric tonnes in 1983 valued at Kshs. 34.3 million

Exports were mainly live fish, fillets frozen and crustacea and molluscs fresh (Live and dead). The main importers were Netherlands (Holland), France, Singapore and Zaire (Table IV). Imports of fish and fishery products into the country increased from 1970 metric tonnes in 1982 to 1617 metric tonnes in 1983 valued at Kshs. 11.8 million.

Kenya imported more fish and fishery products than she exported. However, the value of the exports was much higher than the imports (Table V).

HANDLING PRACTICES

There is a considerable variation in methods of handling fish on board fishing vessels, and landing beaches Some trawlers are fitted with refrigerated fish holds while the majority are fitted with an insulated fish holds or ice boxes. local fishermen in their dug-out canoes or dhows do not have such facilities. They gut the fish and keep them in shade on the deck where water is constantly poured on them to keep them wet.

On the landing beaches, fish is off-loaded from vessels in boxes while in the canoes baskets are used, and at times the fish are thread through the gills in series keeping fishes of the same family together.

Once the fish have been off loaded, some are packed in wooden boxes in vans and taken to urban centres. Normally the box is lined with aluminium sheet. Layers of fish and ice are added alternatively until the box is full. Packing is usually very efficient and fish arrive in the market in excellent condition. Road transport is the most common method of transportation of fish in vans, lorries, buses and even bicycles. A few of the trucks are refrigerated for long distant journeys. In fishing areas far from the urban areas, fish are processed.

FISH PROCESSING

Fish Processing in Kenya varies considerably with area and fish species.

NILE PERCH *(LATES NILOTICUS)*

In Lake Victoria, Nile perch is processed in several ways. Small sized specimen (below 30 cm) is either sun dried or smoked, since at this size the fish does not have a lot of fat. Fish above 30 cm is nomally deep fried. The fish is first split open and the viscera is removed, then placed in a hot frying pan without oil so as to melt the fat in the fish.

After removing as much fat as possible, the fish is then cut into cubes of about 5 cm square. These cubes are then deep fried in cooking oil and when cooking oil is not available the fishermen use the fat extracted from the large specimen. When Nile perch is treated in this manner it becomes very tasty.

Large specimen are also transported to the urban centres in refrigerated trucks where fillets are removed and sold in packets of 300 gm. When fillets have been removed at the lake side, the carcass is sold at Kshs. 2.0 - 5.0 for soup. Smoking of Nile perch is sometimes carried out at the lake region but it is not popular due to the fat. In Lake Turkana, Nile perch is normally sun-dried hanged on strings. Since Lake Turkana area is dry and less humid, the fish dries within 2 days. The fish are salted before sun-drying.

TILAPIA NILOTICA

This species is scarce in Lake Victoria and the few that are caught are eaten fresh. In Lake Turkana, they are eaten fresh, sun-dried and salted. Most of the fresh fish is taken to urban areas in refrigerated trucks. In Lake Baringo, the fish is taken to the fish factory where fillet is removed and packed in packets of 400 gms and blocks of 3 kg for export. Other species, especially *Bagrus* and *Clarias* are smoked without salt or eaten fresh in around Lake Turkana. *Engraulicypris* is sun-dried around Lake Victoria.

Along the coast, sharks are sun-dried without salt and large size shrimps are deep frozen and packed for export while the small sized shrimps are boiled in salt solution dried and then sold in the local markets.

CONCLUSIONS AND RECOMMENDATIONS

There is a need to look into all aspects of fishery production in the country and particularly to what happens to the fish landed.

Fish marketing and handling are important factors in the general development of fishery in Kenya. It is noted that at the moment the marketing of fish in the country is based on more or less traditional patterns and that fish handling and processing is still in a pre-mature stage with no information available on how best the fishermen can handle their products either at sea or just after landing. This state of affairs has invariably resulted in a very high degree of spoilage resulting in a lot of wastage with very minimal returns to the fishermen.

There is urgent need to improve handling and processing of fish so as to improve the fishermen's income and the quality of food consumed by the people in the rural areas, as well as having high quality products which can compete in aquatic products in world market.

TABLE 1. QUANTITY (METRIC TONNES) AND VALUE (KSHS. 1000) OF FISH TO FISHERMEN (1981-1983)

LOCALITY	1981		1982		1983	
	Quantity	Value	Quantity	Value	Quantity	Value
L. Victoria	38179	85346	60958	123400	77327	120315
L. Turkana	10529	10849	11040	12033	10113	13552
L. Naivasha	289	2531	411	5735	692	9379
L. Baringo	467	617	401	768	352	684
L. Jipe	340	981	409	1194	463	1262
L. Chala	110	314	90	288	10	63
Fish Farming	421	23747	440	23818	585	15880
Other areas	1070	2861	268	1700	1526	5442
TOTAL	51385	127246	74017	168936	91068	166577
Marine Fish						
Lamu	1393	4764	1298	5371	1346	5416
Tana River	69	244	26	109	22	97
Kilifi	801	4294	1284	7433	1070	8474
Mombasa	1860	11205	2330	172218	1854	15268
Kwale	810	4534	734	4769	818	15268
Sport fishing	613	4690	94	418	148	666
Others	-	-	844	5670	540	7561
TOTAL	5546	29731	6622	40988	5798	41249
Crustaceans						
Lamu	91	1103	83	562	69	1453
Tana River	8	66	4	29	3	34
Kilifi	40	636	33	798	35	1059
Mombasa	180	3794	234	5570	302	7201
Kwale	65	1159	72	1298	65	1031
TOTAL	384	6763	426	8257	474	10778
Other Marine Products						
Lamu	7	19	7	34	2	35
Tana River	-	-	-	-	-	-
Kilifi	10	26	14	70	19	17
Mombasa	10	198	37	37	1470	3958
Kwale	10	43	10	32	15	14
TOTAL	37	286	68	1606	121	4084
GRAND TOTAL	57352	164026	81133	219787	97461	222688
Retail Price	-	449002	-	657163	-	757115

TABLE II: EXPORT OF FISH AND FISH PRODUCTS IN 1982 - 1983 (QUANTITY - Q TONNES)
(VALUE - V KSHS '000)

CATEGORIES	SINGAPORE Q	SINGAPORE V	ZAIRE Q	ZAIRE V	NETHERLANDS Q	NETHERLANDS V	FRANCE Q	FRANCE V	OTHERS Q	OTHERS V	TOTAL Q	TOTAL V	QTY %
1982													
Live fish	—		—		50.6	1261	15.8	447	26.3	995	92.7	2733	10.2
Fresh fish or chilled fillets	—		—		—		—		39.5	94	39.5	94	4.3
Fresh fish (excluding fillets)	—		9.0	178	12.4	2354		—	0.2	16	21.6	429	2.4
Fresh fillets	—		—		—	—		—	8.0	432	8.0	432	0.9
Frozen fillets	5.6	356	—		—		49.3	1,008	351.8	5,544	406.7	6,908	44.6
Fish meal (fit for human conmsumption)	2.3	208	—		—		—		1.7	89	4.0	296	0.4
Cod (not in fillets, dried salted or not)	—		20.0	142	—		—		0.1	1	20.0	143	2.2
Dried fish (other than cod salted or in brine)	13.6	1.476	109.8	923	—		—		13.6	272	137.3	2670	15.1
Smoked fish	—		—		—		—		7.4	479	7.4	479	0.8
Fresh Crustaceans & Molluscs	7.7	830	—		—		—		161.2	6,321	168.9	7,151	18.5
Prepared & Preserved fish and Caviar	—			100	—		—		1.2	161	1.2	162	0.1
Prepared & Preserved Crustanceans			0.1										
& Molluscs	4.3	172	—		—		—		0.1	13	4.4	185	0.5
	33.5	3,042	138.8	1.343	63.0	1496	65.1	1,455	611	14417	911.7	21682	100
1983													
Live fish	—	—	—		107.1	1,581	72.6	194	74.2	4,090	25288	5,865	67.6
Fresh fish or chilled fillets	—	—	—		—	—	—	—	285.5	6460	285.5	6,460	7.6
Frozen fish (excluding fillets)	—	—	—		—	—	—	—	0.3	45	0.3	45	0.1
Fresh fillets	—	—	—		—	—	—	—	9.0	747	9.0	747	0.2
Frozen fillets	—	—	—		8.0	214	—	—	219.2	227	227.2	441	6.1
Fish meal (fit for human consumption)	1.0	145	—		—	—	1.0	39	0.9	24	2.9	208	0.1
Cod (not in fillets, dried salted or not)	—	—	—		—	—	—	—	0	0	0		0
Dried fish (other than cod salted or in brine)	29	2,002	—		—	—	—	—	178	1,672	207	3,674	5.5
Smoked fish	—	—	—		—	—	—	—	212.2	4,016	212.2	4,016	5.7
Fresh Crustaceans & Molluscs	28.2	1,901	—		—	—	—	—	235.4	6,821	263.6	8,722	7.0
Prepared and preserved fish and Caviar	—	—	—		—	—	—	—					
Prepared and Preserved Crustaceans and									1.1	34	1.1	3.4	0.03
molluscs	—	—	—	—	—	—	—	—	2.6	201	2.6	201	0.07
	58.2	4,048	—		115.1	1,795	73.5	233	961.4	24337	3740.2	30382.4	100

SOURCE: Kenya Customs and Excise Department.

TABLE III IMPORTS OF FISH AND FISH PRODUCTS IN 1982-1983 (QUANTITY - Q TONNES) (VALUE - V KSHS. '000)

CATEGORIES	SOMALIA		SUDI ARABIA		NETHERLANDS		SINGAPORE		OTHERS		TOTAL		QUANTIT
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	%
1982													
Live fish	—		—		0.2	40	—		0.1	13	0.3	53	0.08
Fresh fish or chilled fillets	1.2	5	—		2.4	40	—		—		3.6	45	0.4
Frozen fish (including fillets)	2.5	10	—		—		—		—		2.5	10	0.3
Fresh fillets	—		—		—		—		—		—		
Frozen fillets	—		—		—		—		—		—		
Fish meal (fit for human consumption)	1.2	23	—		—		—		3.6	144	4.8	167	0.5
Cod (not in fillets dried salted or not)	25.9	91	—		—		—		—		25.9	91	2.2
Dried fish (other then cod, salted or in brine)	109.6	416	50.1	322	—		—		18.4	7	178.1	745	19.5
Smoked fish	—		—		—		—		—		—		
Fresh Crustaceans and molluscs	0	1	—		—		—		0	0	0	1	0
Prepared and Preserved fish caviar	—		—		—		—		—		—		
Prepared & preserved Crustaceans & Molluscs	—		—		—		—		0.2	6	0.2	6	0.02
Fish meal (unfit for human consumption)	—		—		—		—		666.6	4622	656.6	4622	70.0
	140.4	545	50.1	322	2.6	80			744.9	5632	938.1	6580	100
1983													
Live fish	—		—		0.3	32	—		0.4	35	0.7	57	0.09
Fresh fish or chilled fillets	—		—		—		—		0		0		0
Frozen fish (excluding fillets)	—		—		—		—		—	—	—		
Fresh fillets	—		—		—		—		0		0		0
Frozen fillets	—		—		—		—		—		—		—
Fish meal (fit for human food)	—		—		—		—		0		0		0
Cod (not in fillets dried salted or not)	—		—		—		—		—		—	—	
Dried fish (other than cod) salted or in brine	154.8	597	—		—		—		36.7	148	191.5	745	11.8
Smoked fish	—		—		—		—		—		—		—
Fresh Crustaceans & Molluscs	—		—		—		—		—		—		—
Prepared & Preserved fish - Caviar	—		—		—		324.6	1,829	1.4	29	326	1,858	20.1
Prepared & Preserved Crustaceans & Molluscs	—		—		—		0		0	2	0.1	2	0.01
Fish meal (Unfit for human consumption)	—		—		—		—		1,099	9147	1,099	9147	68.0
	154.8	597	—	—	0.3	32	324.6	1,829	1137.6	9361	1617.3	11,819	100

SOURCE: Kenya Customs and Excise Department.

EDIBLE CRABS OF KENYA

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ABSTRACT

This is a short paper on the edible crabs of Kenya especially *Scylla serrata,* their present state of exploitation, distribution, abundance and biology. Preliminary investigations have shown that the crab resources are under exploited. Research is therefore needed into the available stocks, methods of harvesting processing, marketing and their biologies.

INTRODUCTION

The mud crab *Scylla serrata* (Forsk) is the common edible species of Kenya. However other portunids such as *Lypa pelagica, Portunus pelagicus* and *P. sanguinolenta* are also caught in small numbers, these are often consumed by the fishermen so rarely appear for sale.

Although man consumes many species of crab including species of the families; Lithodidae, Macidae, Caneridae, Portunidae, Xanthidae, Potamidae, Geryonidae, Gecarcinidae and Ocypodidae, and though many of these are found in Kenya, only certain species have the qualifications of an important food resource. These qualifications are that; the crabs must attain a reasonable size (otherwise eating them could be tedious); others are abundance, good flavour and a ready market. *Scylla serrata* attains a reasonable size and is reported to have a delicious flavour and has a ready market.

Though the crab fishery in Kenya is still in its infancy, it is underexploited. Research into the abundance, biology, ecology and distribution of the edible species is essential to its development.

DISTRIBUTION

Scylla serrata is found all along the mangrove swamps of the Kenya coast. The largest landings are at Shimoni, Vanga, Majoreni, Ngomeni, Gongoni and Karawa. Small landings also occur at Malindi, Kilifi and Lamu fish markets. *Lupa pelagica* has only been found at old port Mombasa fish market.

GENERAL BIOLOGY OF *SCYLLA SERRATA*

Scylla serrata (Forsk) (Swahili Kaa Koo) is a decapod of the family Portunidae (swimming crabs). It is a mangrove species which remains buried in its burrow during the day emerging to feed intermittently throughout the night. The feeding behaviour of this crab has been shown to be affected by factors such as temperature and salinity (Hill, B.J. 1980) these paremeters fluctuate with the seasons so that the abundance and distribution of these crabs and therefore their catchability will have a seasonality.

Although this crab is scavenger and herbivore it is a very efficient predator equiped with strong, sharp-toothed chela which are well adapted for rapid snapping movements required for capturing and crushing prey. Food handling is specialized, each of the dimorphic chelae performing a special function. The thrust delivered by its swimming paddles is also sufficiently great for it to be able to chase prey through the water or to dash from the bottom and size it. Preliminary studies done on stomach contents of a few crabs from Vanga revealed plant matter, shell fragments similar to the shells of the mussels attached to the mangrove roots and a great amount of amorphous matter.

Like most decapod crustaceans *Scylla serratas* is dioecious with slight sexual dimorphisms especially associated with the abdomen; male abdominal segments being narrower than female ones. This is a functional characteristic since female crabs carry their eggs underneath the abdomen. Measurements of some male and female chela from Vanga showed no significant difference in size between the sexes.

Due to the presence of an exoskeleton, growth in crabs proceeds in a series of moults. Since it is difficult to mark crabs and follow them through several moults, the question of how old a crab is, is a difficult on to answer The number of moults before a crab becomes full grown depends on the increment at each moult and the frequency of the moulting The increment at each moult is expressed as a percentage of a pre-moult dimension such as carapace width In this way a rough measure of the age of a crab can be calculated Since increments vary and do not remain constant during growth, usually becoming smaller as the crabs become larger this measure is not very accurate However the growth trends of *Scylla serrata* in Kenya have as yet to be studied. During moulting and just after when the crabs are in the soft shell stage, they are at their most unlnerable and high mortalities occur then. This is another important factor affecting the yields during the moulting season, since some of the crabs are preyed upon and most go into hiding.

Sexual maturity in crabs is hard to define, but is usually assumed to be that intermoult phase during which adult crabs can first mate successfully (Hartnoll 1969). Mating in tropical species may occur a number of times during the year and fertilization is internal. Egg laying usually occurs several days after mating due to the presence of plug on the spermathecea and the maturation of the ovaries. The females make a seaward migration to spawn and this may demonstrate a lunas periodicity especially around the time of the full moon.

Larvae are extruded and become part of the planton, these got through a number of larvae stages before migrating back inland as juveniles. The breeding behaviour of *Scylla serrata* is another area needing research since this also effects distribution and abundance and therefore the yields.

Handings of *Scylla serrata* recorded at Vanga from January 1981 to May 1981 showed the average size of marketable crab to be 138.6 mm carapace width with a range of 121 - 198 mm. The weights varied between ½ - 1½ kg. The sex ratio was 1 : 2.76 females to males which reflects some of the points mentioned above about breeding behaviours affecting distribution. Other factors that could be reflected by this ratio are behavioural differences and population movements involving one sex.

CRAB FISHERY

The biological characteristics of crabs puts some constraints on the method of capture, how they are held, processed and transported to market. It is essential to capture them with a method that does not cause bodily injury or loss of appendages since this reduce their value. Death or weakness causes irreversible changes of the flesh and adversely affects the texture, appearance and flavour of the meat. The season and time of capture is also very important since the quality and yield of post - moult crabs are low.

In Kenya most of the crabs are harvested using age old art i senal methods which are very labour intensive, so that crab fishing only supplements pisces fishing. Fishermen go out of their burrows. The chela are tied to avoid injury to the fishermen, customers and the crabs themselves and the crabs are packed into reed baskets. These baskets provide plenty of ventilation so the crabs don't suffocate before reaching market. Small numbers of crabs are caught in nets and traps set out fot fish by the fishermen. Experiments done in Tanzania by Heath (1971) indicated that the most effective traps for catching *Portunus pelagicers* was the local reed trap madema also commonly used in Kenya. No satisfactory trap design however was found for *Scylla serrata*. This is therefore another important area for research.

Although crabs can be sold alive, cooked fresh and frozen and as canned products the bulk of the crabs in Kenya are purchased live in which case the value of the crabs depends on their condition at the time of sale. When the journey to the market is long losses may be sustained. In areas like Vanga and Shimoni where yields are high but the market poor, crabs have to be transported long distances to the customers. Crabs can stay alive for a long time as long as the gills and soft parts of the shell are wet, so a well venticated box kept wet or a wet sack could be quite effective, ice could also be used. However the best method to be adapted is the cheapest which will ensure the arrival of the bulk of the crabs in good condition. In general this is achieved by packing the crabs closely to avoid jarring, and fighting. No special packing is needed since this represents an initial expense in both material and labour, an additional non-productive weight to be paid for in transit. This is important since the major markets are in the towns catering to the tourist hotels and restaurants and the fish shops.

Due to the low yields and also since crab is seen as an exotic meal by the majority of the local people, crab is quite expensive. It is hoped that with the development of this industry and the enlightment of the people to the delicious and also nutritions properties of crab, the price may become competitive with animal meat. However with the increased exploitation of crabs due to increased demand, certain regulatory measures will have to be ade to keep exploitation at an optimum level. Regulations for example should be made whereby undersized crabs, berried females and recently moultied crabs shall be returned to the sea. Soft crabs in any case do not keep well so it is to the interest of the fisherman that such returned crabs survive to be available for subsequent recaptures. Alternatively if the yield exceeds the needs of the local market, crab could be exported forming a valuable means of foreign exchange.

DISCUSSION

Through a great deal of information has been collected over the past decade on the distribution, abundance and availability of living resources along the Kenya Coast, very little information of this kind on crabs is available. There is therefore an urgent need for research into the biology, distribution, abundance, processing and marketing of crabs in Kenya and I have tried to outline some of these areas of research in this paper.

There is a strong market for crabs in the high income areas of the world and this market can be exploited by Kenya. Ways for increasing yields for example improved methods for harvesting and crab culture should be researched. Other possibilities include mass rearing of baby crabs for release in the sea to stimulate crab population.

Kenya is developing at a very fast rate and has a high population growth. Already a great deal of strain is being put on the development of animal protein. Fisheries development is therefore very important in the overall development of the country.

There is therefore a need to collect and collate information concerning the various stocks available and the status of exploitation. Therefore as the production of crabs increases there will be a need to improve the quality of the product as well as improve hardling distribution and marketing. However any improvements should be done bearing in mind the impact of changing fish technology on existing artisanal fishermen and the means of minimizing the detrinmental aspects of fisheries modernization on them should be proposed.

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PRELIMINARY STUDIES ON PRIMARY PRODUCTIVITY IN THE WINAM BAY OF L. VICTORIA

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ABSTRACT:

In 1984, water temperature and pH in the Winam Bay fluctuated little between the months. At any given time, the difference between surface and bottom temperature did not exceed 1.6 C.

Secchi disc visibilities were persistently low during the year with a maximum value of 0.71 m. Oxygen concentrations within the water column fell sharply below 1.5 m. The highest primary productivity by algae measured was 1.26g at 1200 hours. *Microcystis* was the most abundant algae encountered in the lake water.

1. INTRODUCTION:

Within the Winam Gulf, there has been no detailed study on the subject of primary productivity. The little information available has been based on a few samples Kalf 1983, Talling and Talling, 1965) or on data collected over short periods of time, less than a year Mellack, 1979).

There is thus a lack of information on the present status of primary productivity in the gulf, espeoially its seasonality and the influence of the dry and wet seasons. The present work is a preliminary study on the primary productivity of Lake Victoria.

In this study, most experiments were conducted near the K.M.F.R.I. pier, The water depths in the working station varied between 1.8 and 2.0 m.

2. MATERIALS AND METHODS:

The limnological parameters studied were water temperature, pH, transparency dissolved oxygen (DO) and photosynthetic rates of phytoplankton or primary productivity. Algal species composition of the lake water was also determined.

Water samples were collected using a 2-1 plastic Van Dorn Sample which closes at desired depths by a "messenger". Water temperatures were measured using a mercury thermometer, readable to 0.1 C while the PH was measured with a digital PH meter. Light penetration or transparency of the water was estimated using a 20 cm white secchi disc. Dissolved oxygen concentrations were determined at the surface, 0.5, 1.5 and 1.8 or 2 m depths bytitration of fixed water samples with 0.0125 M Sodium thiosulphate solution (Winkler method).

Photosynthetic rates of phytoplankton were estimated by *in situ* incubation of water samples in light and dark bottles. The light and dark bottles were filled with the sample and suspended at the depth of sampling for periods of 2-3½ hours. All experiments for primary productivity were conducted between 00090 and 1500 hours local time.

Examination of phytoplankton was made using a light microscope to determine the algal species composition of the surface water.

2. RESULTS AND DISCUSSION:

Water temperature fluctuated little between the months. The range of

Water temperature fluctuated little between the months. The range of surface temperature was 25.3 - 29.3 C, a variation of 15.8%. The former reading was recorded in August and the latter in September. At any given time, the difference between surface and bottom temperature was never found to exceed 1.6 C. Although thermal stratification has been reported in Lake Victoria, (Talling, 1957) it would not be expected to be marked at a shallow station as the one in question here, where even slight winds help to stir the water, thus creating nearisothermal conditions.

Like temperature, water pH varied little thoughout the water column. It ranged from 7.5 - 9 over the months. Secchi disc visibility was relatively low within the bay. The highest secchi depth of 0.71 m was recorded in the month of October. A value of 1.2 m was recorded near Maboko Island, a few kilometres from K.M.F.R.I. pier.

The turbidity which reduces visibility was due to algal growth and also due to suspended particles mainly as a result of mixing or stirring of the water column by winds. Lowest of secchi visibilities were found especially during the rains.

Figure 1 shows the dissolved oxygen concentrations at various depths in August which was characteristic pattern during the whole year. Concentration varied with depth, usually falling towards the bottom layer of the water column. Surface concentrations were invariably higher than concentrations lower down and fell rather sharply below 1.5 m.

The primary productivity or phytoplankton rates of photosynthesis is shown in Figure 2. A value of 0.47g O_2 / m^3/h was measured at the surface and a higher value of 0.60 g O_2/m^3/hi at 0.5 depth. The lower value at the surface can be attributed to photoinhibition, in which some of the algal cells at the surface are damaged by the ultra-violet rays of the sun impinging on the surface, thus reducing the photosynthitic rate. This is unlike lower down, at 0.5 m, where the effect of the ultra-violet light is reduced, thus allowing higher productivity. Below 0.5 m, the productivity drops again drastically, due to light limitation. The amount of light reaching the algae at these depths is not sufficient to support maximum algal photosynthesis

The graphs in Figure 3 shows the magnitude of surface primary productivity at various times of the day. Productivity rose from 0.54gO_2/m^3/h at 1000 hours to a maximum of 1.26g O_2/m^3/h at 1200 hours, falling again to 0.75gO_2/m^3/h 1400 hours and to 0.52gO_2/m^3/h at 1500 hours. Maximum productivity was thus at midday, when there was maximum light energy available for the process of photosynthesis by phytoplankton.

Before midday, the light intensity is limiting for photosynthesis while after that, the algal cells are in an "exhausted" state, so their photosynthesiszing rates fall. This general pattern was observed to be persistent most of the time at all depths of the water column as shown in Fig. 4. However, here it can be noticed that at 0.5m depths the productivity at 1500 hours is slightly higher than that at 1200 hours. This can be attributed to warmer conditions in the afternoon of the experimental days.

Examination of algae from the surface water revealed that *Anabaena flos-aquae* was the most abundant species. Others included *Cyclotella* and *Nitzchia* spp.

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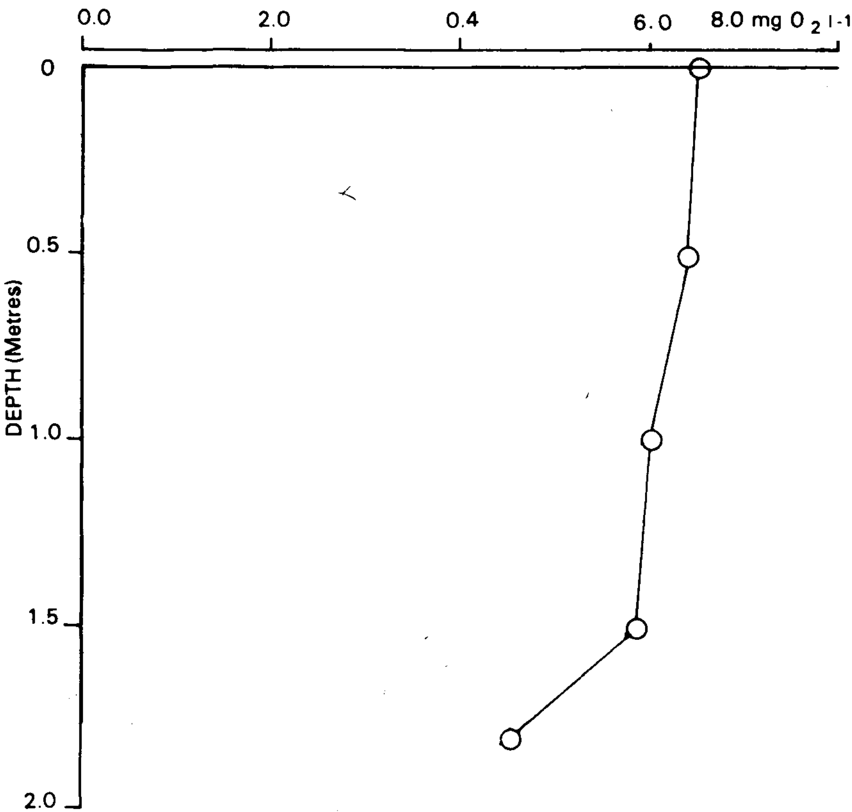

FIG 1
Mean oxygen distribution within the water column during August 1984

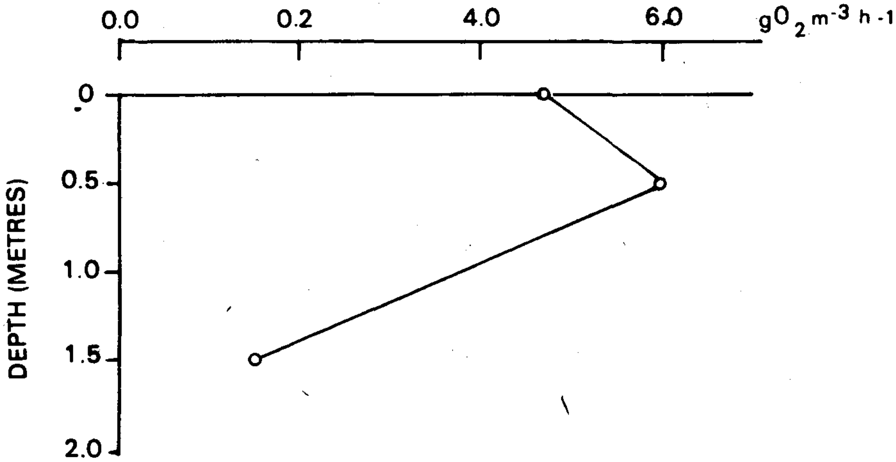

FIG 2: Mean Primary productivity at various depths of the water column in February 1984.

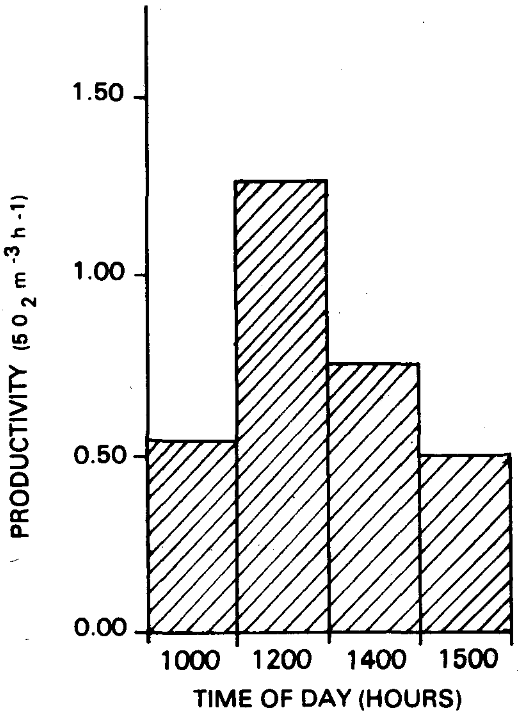

FIG: 3 Surface primary productivity at various times of the day

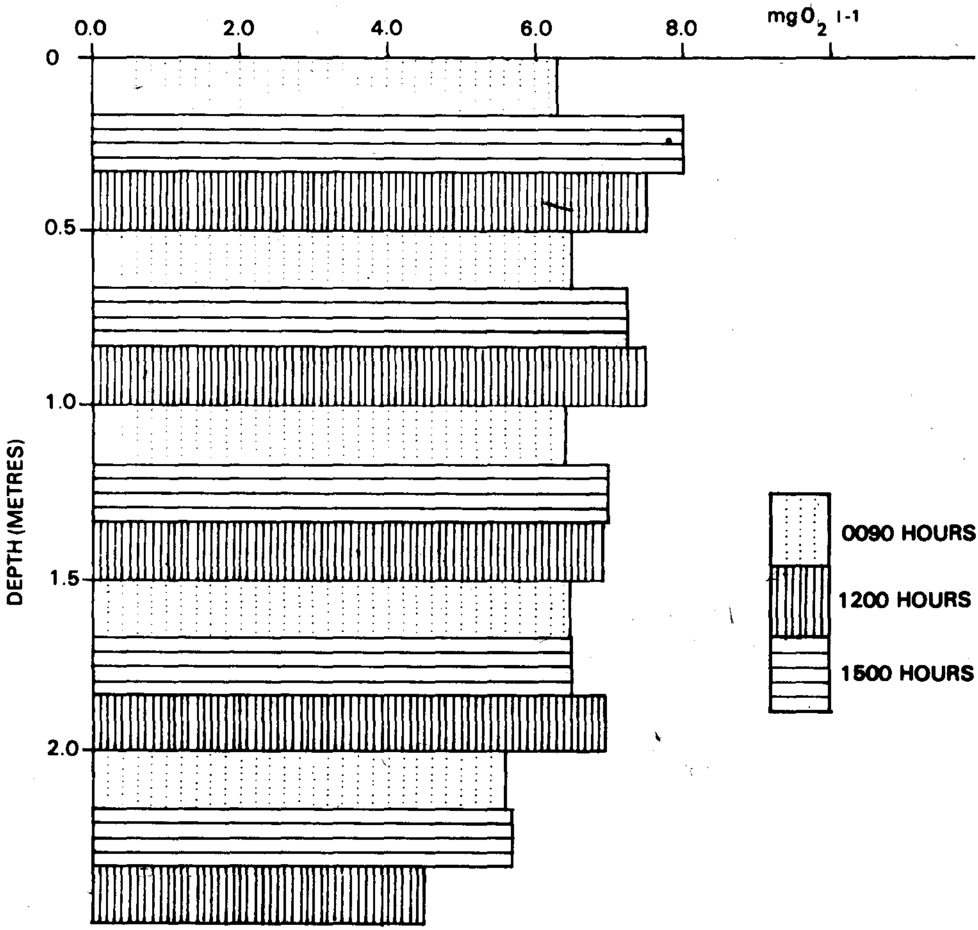

FIG: 4 Distribution of dissolved oxygen (DO) at various depths at different times of the day in September 1984.

THE EFFECT OF MARINE GREEN ALGAE, ULVA SP. AS COMPOST MANURE ON THE YIELD OF MAIZE (VAR. COAST COMPOSITE)

H.A. OYIEKE, K.M.F.R.I., MOMBASA LABORATORY

INTRODUCTION

Due to the heterogenous nature of the Kenyan coastline Kenya has a very rich algal flora which consists of about 300 species of algae (Moorjani, 1977). But it is unfortunate that this rich flora has not been made much use of. The value of seaweeds in fertilizing the soil was discovered early in the history of agriculture in coastal Asia and coasts and islands of northwestern Europe (Dawson, 1966).

In the Kenyan market there are different types of imported marine algae products some of which use the following trade names: Chase SM3 for crops and pasture, Chase Blend 14C for cattle and chase Blend 14P for poultry. Most of the Kenyan small scale farmers are not in a position to use large sums of money buying chemical fertilizers or the above cited seaweed has been effectively used directly as compost manure by farmers (Sepheson, 1957) it is important that the possibility of using seaweed as compost manure under the prevailing local conditions is investigated.

The present paper, therefore, investigates the effect that *Ulva* would have on the yield of maize (var. coast composite) under the conditions prevailing around Mombasa area. *Ulva* is genus of green algae (Chlorophyta) that is composed of species that are membraneous, entire or perforated sheets, strap - like or small rounded lobes forming roseltes. They flourish in the intertidal zone. This genus is abundant around Mombasa and collects in large quantities offshore, thus making it easy to collect in mass.

METHODS

A piece of land was prepared and the soil thoroughly mixed before dividing it into 9 plots of 4m by 4m by 4m each. Using randomised block design the plots were divided into 3 blocks each consisting of three plots. *Ulva* was collected from the shore around Mkomani area and thoroughly washed with fresh water to remove most of the salts and sand. The species of *Ulva* collected were *U. reticulata, U. pertusa* and *U. fasciata* with *U. fasciata* forming the bulk of the collection. This *Ulva* was burried in the soil in one plot randomly picked from each of the 3 blocks. It was applied at the rate of 1 kg. of fresh *Ulva* per hole where the seeds would eventually be sown. It was then left to decompose for two months before the seeds were sown.

At the time of sowing double superphosphate (P202) was applied in one plot chosen randomly from each of the three blocks. This was done at a rate of 100 kg/ha (approx.2.9g/plant). The remaining plots had seeds sown without any prior treatments. The sowing was done two weeks after the onset of the long rains. The plants that had chemical fertilizer had a top dressing calcium ammonium nitrate applied at a rate of 150 kg/ha (approx. 4.3g per plant); when the plants were 45 cm high. Weeding was done twice, the first one 4 weeks after germination and the second 5 weeks after the first weeding when the yield was ready, it was harvested and the dry weight per plot noted.

RESULTS

Table I Summarizes the observations made thoughout the trial whereas tables 2 and 3 show the statistical analysis of the results.

Table I: Effect of different treatments on germination, insect damage, weed cover and yield of coast composite.

	Treatments Double Superphosphate	Ulva Manure	Control
% Germination	90	93	90
% Insect damage	30	29	36
% Weed cover	67	33	75
Yield (Kg)	3.55 ± 0.41	3.8 ± 0.53	1.9 ± 0.66

Table 2:

F-Values resulting from comparisons of different aspects of the three treatments.

Table 2:

Aspects	Calculated F. Value	Tabulated F-Value 5% level
Germination count	0.75	
(block means)		
(block means)	0.25	
Insect damage	1.00	
(block means)	0.35	6.94
Weed cover	2.8	
(block means)	0.7	
Harvest weight	9.49*	
(block means)	0.6	

Table 3
t-values resulting from comparison of the yield of the three treatment.

Treatment	Calculated t value	Tabulate t value - 5% level
Ulva manure Vs. Chemical fertilizers	0.65	
Chemical fertilizers Vs. Control	3.7*	2.776
Ulva manure Vs. Control	3.91*	

The plants from the *Ulva* and chemical fertilizer treated plots showed healthy growth throughout the growing period and their yield also looked much healthier with very well formed grains as compared to the control.

Analysis of covariance of the three treatments show that germination count, insect damage count and weed cover estimations do not have any significant differences in their treatment means. But on the other hand the treatment means of their yields show significant difference between the yield from *Ulva* treated and control and that the chemical fertilizer treated yield also significantly differs from that of control. But on the other hand, there is no significant difference between *Ulva* treated and chemical fertilizer treated yields. The F values for the block means of all the aspects considered show no significant differences.

DISCUSSION

Quite a variety of marine algae are able to absorb a wide range of mineral elements dissolved in sea water and accumulate them into higher levels (Mshigeni, 1981). Duddington (1966) reported that seaweed manure contains about as much nitrogen as an equal weight of formyard manure, and about twice as much potash, thus making it suitable for soils lacking in potash. Trials with tomato plants have also showed that seaweed not only provides trace elements, but also makes it possible for the plants to take up more of these elements from the soil (Yamaha Fishery Journal No. 1 - 15).

Ulva species are suitable for fertilizing soils because of their high nitrogen content, since they grow in waters that are rich in nutrients (Levring et. al., 1969) Imbamba (1972) screened some Kenyan algae for nitrogen, phosphorus and potassium and among the species screened *Ulva* species were found to be having very high nitrogen contents. He also made an observation that the algae that ranked high in nitrogen also had high levels of phosphorus.

Apart from adding the necessary elements to the soils, seaweed also improves the water holding capacity of soils. The organic matter decay slowly in the soil and form humus which enriches the soil (Dawson, 1966). As the soils water holding capacity and crumb structure improves it leads to better aeration and capillary action and these stimulate the root systems of plants to further growth and hence stimulate the soil bacteria to greater activity (Stephenson, 1957).

All the above information gives possible reasons why the yield from the *Ulva* treated plants was not any significantly different from the chemical fertilizer treated one. Lack of significant difference in the block means and the other aspects considered show the difference in the yields was due to treatments.

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STUDIES ON THE WATER QUALITY OF RIVER RAMISI NEAR A SUGAR FACTORY

Danish Oteko
Mombasa Laboratory

INTRODUCTION:

The ocean due to its extended and volume (1370 X 106 km^3) is considered an ideal disposal site for most of the wastes produced by man. This had led to a grave state of ecological poisoning aggreveated by the long persistence of pollutants in the marine environment. The coastal and estuarine area are places where most ocean dumpings occur and is where most marine life is concentrated. Due to the area being shallow with least mixing there is less dilution of incoming effluents.

River Ramisi flows into the Indian Ocean through Ramisi Sugar factory which empties its untreated effluents into the river. Cases of dead fish have been reported at the estuary during months of January to March and September to December. This study was initiated to study the quality of the water at the estuary where it flows into, which is adjacent to Funzi Bay one of the best fishing grounds for the artisanal fishermen.

MATERIALS AND METHODS

The river was divided into three sampling stations, station A at 2½ km upstream from the factory, Station B, one km after the discharge point downstream and Station C, at the estuary (Fig. I). Modified Winkler method was used. This method introduced the use of sodium azide (NaN_2) to arrest nitrite interference.

Surface temperatures at all stations were measured, salinity was measured using refractometer which was graduated with reading of salinity corresponding to the refractive index, PH was determined with standard PH paper indicator while odour and colour was checked by naked eye.

RESULTS & DISCUSSIONS

At Station A, it was observed that dissolved oxygen decreased with temperature (Fig. 2). The area between the straight line and the curve is the region where extremes of Dissolved Oxygen (DO) should operate unless some pollutants are introduced. The trend at this station is that of unpolluted water system with a DO limit in the region 7 - 9 mg/l. At this Station B, it was observed that DO increased with temperature at a rate of 0.2 mg/l/T. At this station the amount of DO was very low 1.3 mg/l which is most likely not the oxygen from the atmosphere but oxygen generated from organic material in the water. From Fig.

4 there is little increase in DO with increase in temperature which can be attributed to anaerobic/n bacterial activity. This is evident from the fact that there is a foul smell due to hydrogen sulphide (H_2S). At this Station dissolved oxygen was observed to decrease with time (Fig. 5). The annual averages of dissolved oxygen showed that there was a decrease in March, April and May which was due to the rainy season at station A. At station B, low DO averages were observed throughout the year which is explained by the discharge of effluents into the river by the Sugar Factory. The high DO averages in April, May and June observed were due to the fact that the factory was closed for cleaning during this period. In October and November when there is intense factory activity DO is lowest.

There was no significant salinity changes at station A, but with station B, highest salinity changes were in the last quarter of the year mainly due to factory wastes.

In general it can be concluded that River Ramisi is polluted most of the year by the wastes from the Sugar Factory and the Ramisi Sugar Factory authorities should introduce proper treatment of the wastes, before discharging into the river.

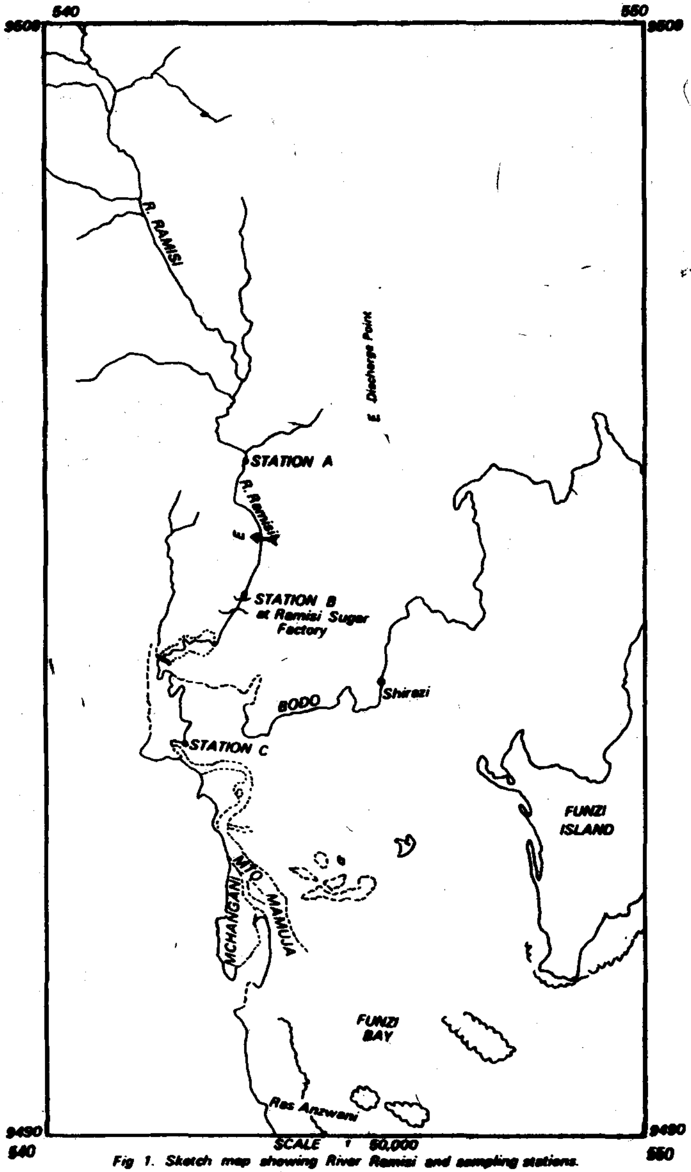

Fig 1. Sketch map showing River Ramisi and sampling stations.

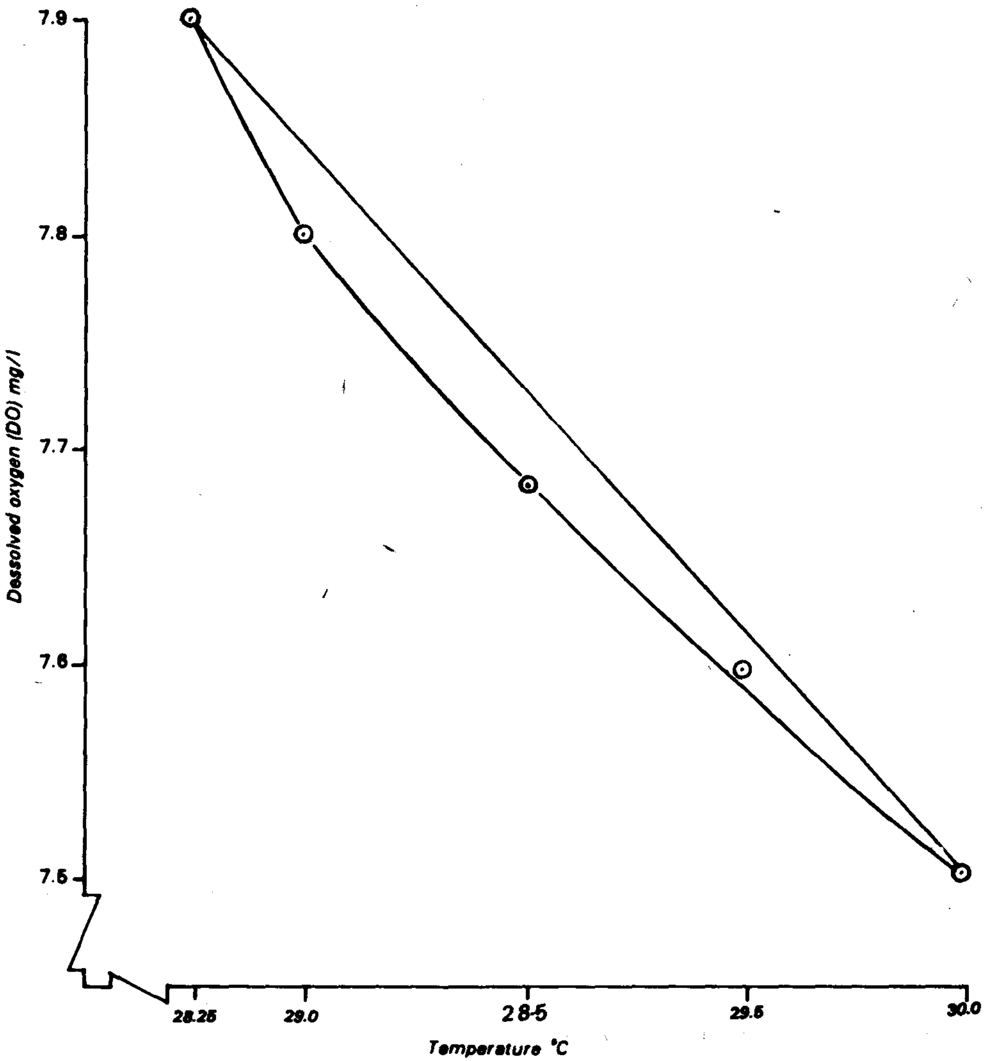

Fig. 2 Variation dessolved oxygen with temperature at Station A.

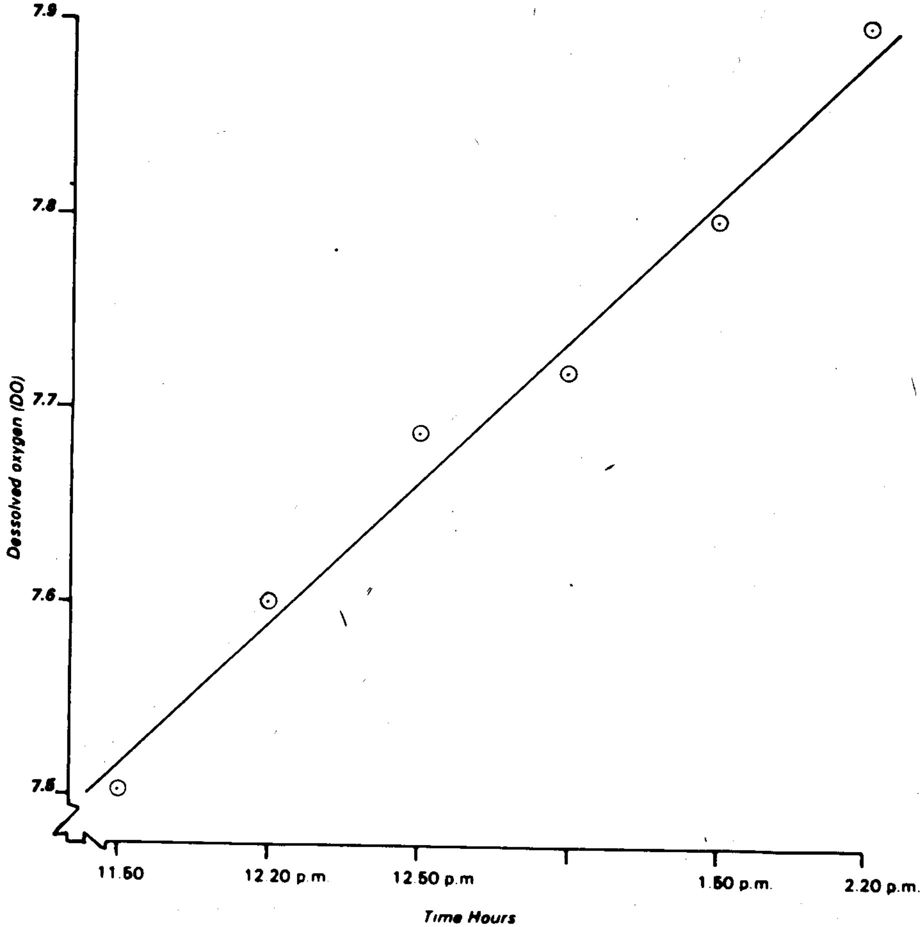

Fig. 3 Variation of dessolved oxygen with time at Station A.

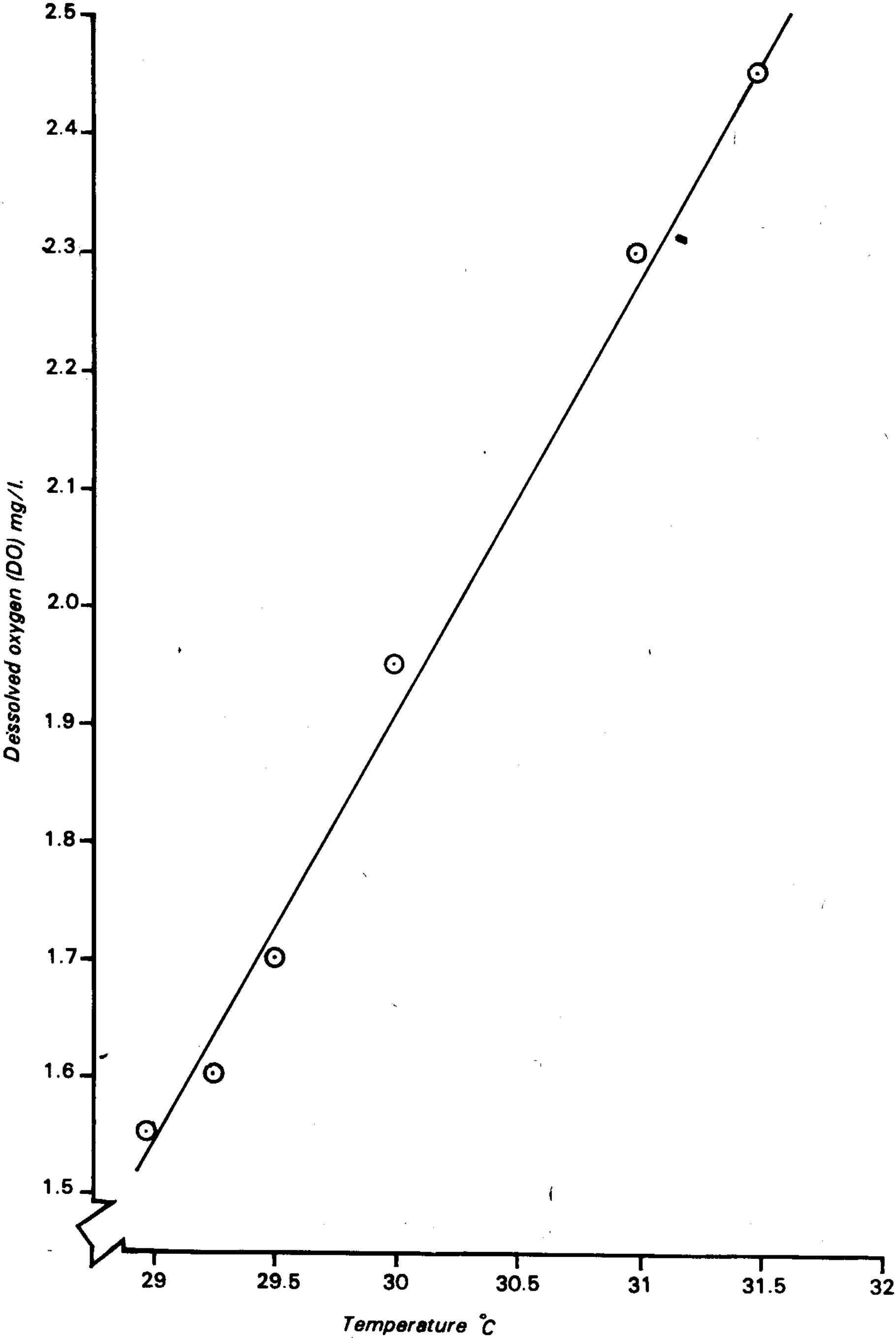

Fig. 4 Variation of dissolved oxygen with temperature at station B

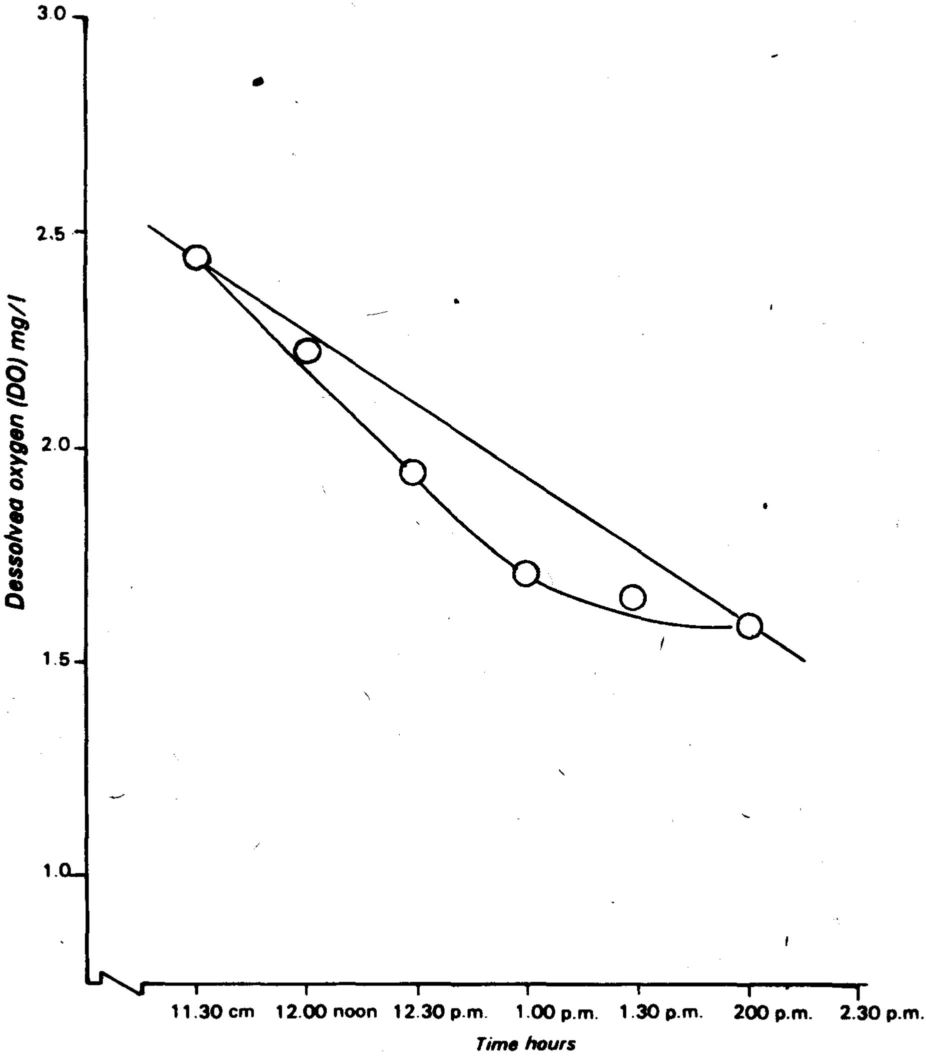

Fig 5 Variation of dessolved oxygen with time at station B