KENYA AQUATICA

Bulletin No. 2
May, 1984

A BULLETIN OF
KENYA MARINE & FISHERIES
RESEARCH INSTITUTE

CONTENTS

EDITORIAL NOTES:

This is the second issue of KENYA AQUATIC. The original idea was to publish the bulletin annually. The present issue has come after five months, because of our anxiety to release the accumulated material. The Kenya Aquatic aim is to treat Aquatic Science from a wider perspective and present compiled and well-documented information.

Efforts will be made to report activities related to Aquatic resources through KENYA AQUATIC. This will include scientific communications, critical reviews, seminar proceeding and other publications. This comprehensive coverage will be possible only through co-operative of various institutions, Departments, universities, societies and individuals who are concerned with aquatic resources.

KENYA AQUATICA is a technical and extension series for rapid dissemination of information on aquatic resources and allied information from Research Officers, Fisheries Officers and any individual for transfer of Technology to the fishermen and industry and any other relevant information 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 the articles, notes, summary, news briefs etc. It is our aim to see that this publication receives wide acceptance from the reading public and those interested in aquatic both within the country and abroad. It is hoped that this issue will stimulate further contributions from the readers.

We appeal to all concerned to send us regularly such Publications, at the following address:-

The Director,
Kenya Marine & Fisheries Research Institute,
P.O. Box 81651,
MOMBASA, Kenya, E. Africa.

EDITORIAL NOTES:

This is the second issue of KENYA AQUATIC. The original idea was to publish the bulletin annually. The present issue has come after five months, because of our anxiety to release the accumulated material. The Kenya Aquatic aim is to treat Aquatic Science from a wider perspective and present compiled and well-documented information.

Efforts will be made to report activities related to Aquatic resources through KENYA AQUATIC. This will include scientific communications, critical reviews, seminar proceeding and other publications. This comprehensive coverage will be possible only through co-operative of various institutions, Departments, universities, societies and individuals who are concerned with aquatic resources.

KENYA AQUATICA is a technical and extension series for rapid dissemination of information on aquatic resources and allied information from Research Officers, Fisheries Officers and any individual for transfer of Technology to the fishermen and industry and any other relevant information 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 the articles, notes, summary, news briefs etc. It is our aim to see that this publication receives wide acceptance from the reading public and those interested in aquatic both within the country and abroad. It is hoped that this issue will stimulate further contributions from the readers.

We appeal to all concerned to send us regularly such Publications, at the following address:-

The Director,
Kenya Marine & Fisheries Research Institute,
P.O. Box 81651,
MOMBASA, Kenya, E. Africa.

Editorial Group
R.M. Nzioka
J. Ogari
J.I. Ochieng
E.Okemwa

THE NATIONAL OBJECTIVES AS A BASIS FOR WORKING OUT RESEARCH REQUIREMENTS AND PRIORITIES.*

Peter Gacii, Secretary, National Council for Science and Technology, Kenya.

** *Now Permanent Secretary Ministry of Lands, Settlement and Physical Planning at time of going to press.*

In the modern world, research constitutes a powerful instrument for accelerating the pace of development and no nation can afford to neglect it. Research and experimental development (R & D) are being made to serve in an ever increasing degree the socioeconomic needs of society and human welfare in its varied aspects. The present inadequacy of information for developmental purpose has highlighted the vital role of research and the need to orient it to serve developmental objectives. The question of identification of problems and assigning of priority then become a national concern which should be related to the resource endowments and the overall national perspectives.

The need to relate research to national objectives cannot be overemphasized. Research should be seen in a broad perspective which involves the allociation of meagre resources between many demanding causes and as such there should be criteria through which research can be justifiably supported. These research activities leading to practical innovations such as new or improved materials, products, devices and process would normally rank high in priority when viewed against development objectives. There is, however, a general agreement that for research to serve developmental objectives, there should be a conscious effort to structure and coordinate it. This raises the question as to what extent research can be institutionalized and structured without affecting the initiative, drive and the creativity of scientists. Proper research planning and management can help to overcome this difficulty by offering a balanced approach to these two aspects of research.

Research planning should be realistic with a clear understanding that programmes should be within the capabilities of the executive research organizations, infrastructure and the scientists. Furthermore, the programmes should be capable of adjusting to changing needs and strategies. There is a common.complaint that most developing countries perpetuate programmes which were developed by the colonial regimes without any modifications to cope with the changed situation. This dynamic nature of research programmes then requires constant reappraisal and readjustment.

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

Another important factor to bear in mind in planning research for developmental purposes is the need to avoid a fragmented approach which has proved in many instances to be too costly and ineffective especially when viewed against the urgency of the problems to be solved. It is often found that a multidisplinary approach is more successful in bringing about results of relevance and applicability to the problem at hand. This approach calls for a national framework of research organization, and a lot of coordinated effort in establishment of research priorities and, programmes. It is needless to say that this in turn calls for policy and research institutions, qualified researchers and adequate financial allocation.

In Kenya, the need to relate research to national objectives has led to the creation of a number of institutions (Government of Kenya Science and Technology Act 1980). The National Council for Science and Technology is expected to advice the Government on matters related to science and technology including scientific research. At another level the sectoral advisory research committees are expected to advise the relevant ministers on matters related to the details of research programmes including research priority in their area of operation. To complete the scheme of institutions, government departments and parastatals and institutes of higher learning carry out research in the country. Private enterprise also undertakes specific research projects related to productive processes.

The Government sets national development objectives and these should be used as a basis for establishing research priorities. These objectives are further elaborated on by the Science and Technology Report of the NCST (1980). It has already been stated that research is a vital component in achieving national developmental objectives. However, this should not be taken to mean that there should be a one way system where research priorities are established at one level and then flow to the other levels. Rather, the national development objectives should give guidance to the role research is expected to play in achieving these objectives. The results obtained in these research activities should also be utilized in guiding and modifying policy decisions, thus the two are interdependent.

For a country like Kenya with pressing developmental problems, research resources should be allocated to programmes in matters of socio-economic relevance and this will favour the applied research. However, this does not mean that basic research should not be supported. On contrary, basic research should also be supported as it makes a contribution to the applied research. It is often found that some development in basic research can cause a revolution in applied research. Priorities can also be established in basic research according to the country's developmental objectives. The broad national objective as stated in the development plan is the alleviation of poverty through creation of more income-earning opportunities, increasing the output and quality of services and better management and more efficient use of resources (Government of Kenya 1979).

In the area of Marine and Fisheries, the overall objective is to develop the fishing industry and ensure proper exploitation of all available fisheries resources for the improvement of the diet of the population and for increasing the cash incomes of those Kenyans engaged in the fishing industry. There is considerable fisheries potential as indicated by the 640 Km coastline, 10,000 Km of lakes and numerous fish bearing rivers. The objective is further stretched to cover other water resources. There is therefore need to evaluate the marine and other aquatic environment and resources with a view to establishing appropiate policies for their use and management.

The implications of the United Nations Law of the Sea to research requirements need some evaluation. Research programmes should be geared to cater for this aspect of Kenya marine resources. The addition of the 200 miles belt call for modifications to the research programmes.

In carrying out research in these areas of national importance, there is need to cooperate with other countries in the region. Some aspects like oceanography can be best understood if the region is taken as a whole. Some cooperation is already envisaged in such organizations as the Cooperative Investigation in the north and centre Western Indian Ocean (UNESCO 1976).
Translated into research priorities, the above objective should cover such important areas as the fish, fishing water ecology, (both marine and freshwater), chemical and physical oceanography, geological aspects, climatic factors, pollution and socio-economic considerations related to exploitation of marine and inland water resources.

Groundwork for institutional arrangement to support research in water resources has already been laid down. The recently established Kenya Marine and Fisheries Research Institute (Government of Kenya, Science and Technology Act 1980) is expected to carry out research in the areas mentioned above. In adition some capability for research in this area exists in the University

of Nairobi, Kenyatta University College, The Fisheries and the Meteorological departments
In the foregoing paragraphs, it has been indicated that there is need to relate research planning and programming to the developmental objectives. Regarding the Kenyan situation, it is found that broad objectives do exist which can be used to examine and design new research strategies aimed at meeting the basic socio-economic human requirements of the majority of the people. In doing so, consideration should be given to building research capabilities. It is further hoped that in the course of the discussions, due consideration will be given to identification of priorities, allocation of resources according to the pressing nature of the problems, constraints in the present institutional and organizational mechanisms and the overall coordination. Realistic assessment of the current research capabilities and requirements will be a very usefull guide in deciding what can be successfully tackled at this time.

NOTES

For the purpose of this paper applied research is defined as that research which is concerned with the application of scientific facts and principles while basic research is defined as research which is concerned with production of scientific facts and principles and it is undertaken without preconception of utility and value of its results.

REFERENCES

1. Government of Kenya, (1979). Development Plan 1979-1983, Nairobi: Government Printer.

2. National Council for Science and Technology, (1980), Science and Technology for Development - A Report of the National Council for Science and Technology NCST no. 4. Nairobi: NCST.

3. Government of Kenya, (1980). Science and Technology Act, Laws of Kenya, Chapter 250. Revised Edition. Nairobi: Government Printer.

RESEARCH AND DEVELOPMENT: INFORMATIONS REQUIRED AND THEIR UTILIZATION

S .O ALLELA

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE, MOMBASA

Fish is one of the world most valuable resources, and discussion on its status more often solicit a lot of interest. It is obvious though that commercial fisheries operate between two poles. It is never viable without both suitable stock of fish and a fully functioning market for the products produced. In between, there are many parameters of equal importance ranging from research, development and growth. The correct informations are needed at all levels of operation.

This paper will try to outline the nature of fishery development, the benefits consequential on such development, and some of the more important techniques and methods which promotes its development or growth. The provision of informations related to or affecting growth constitute research and development enhanced by marketing of resultant products included. This consideration apart is not possible therefore within the scope of this paper to discuss in detail research and development and attendant problems which are to be overcome in the promotion and expansion of the fishing industry.

Fishery development in this context, must nonetheless relate to the expansion of the total production in a given fishery, irrespective of other factors, leading to increased growth which in turn should provide essential benefits as the case may be. Such benefits may include provision of food. In a country such as Kenya the provision of cheap protein food is still considered very important and fish can be considered as a cheap source of protein food.

It is also true that fisheries resources, if well managed, are most valuable to the economy of a country.The apparent perpetual benefit of a managed fishery is further enhanced if the products can also be exported, in addition to providing direct and indirect employment, if for example the development of a particular fishery can also lead to development of other infrastructures. There are of course other benefits accruing from a developed fishery such as providing rescue and defence services, the latter can if is a sensitive, contribution, but it is obvious that fishermen can play a major role in formal and *ad hoc* rescue services. It is now a common knowledge that during the second world war,experienced fishermen and the crafts they operated played extensive and important role in the defence service of various nations. In a developing country such as Kenya this aspect of the role of fishermen is not always obvious, and the apparent subtle and significant difference in attitude between developing countries such as Kenya, has in a way kept greater input into the fishing industry by developing countries.

In such countries. as already indicated fishery development is regarded essentially as part of an effort to provide the much needed nutrition. Perhaps because of the changing pattern of defence requirements the attitude prevailing in the developing countries is the right one. Research into problems affecting the fishing industry starts with the basic characteristics of fishery resources in relation to development. More often fisheries research include the study of the existing fishery, and as such it concerns itself with the state of existing status of the industry. Informations required therefore, must be relevant to operations either in existence in that which is planned in so far as the known stock is concerned. In planning fishery development in this instance, it is important to have a fair knowledge on the fully exploited, the unexploited and partially exploited stock. In all such cases opportunity for development may still exist, if informations are also available on such other parameters as the operational methods, which perhaps when modified can give rise to an increased productivity directly or by reduction in loses.

It is realised that for the essential informations referred to be made available, knowledge about certain characteristics of the stock must be made available. Such informations may include:-

i) Location, distribution, behaviour and abundancy of resources and includes preditiction of these characteristics.
ii) Weather conditions.
iii) Markets and
iv) Technological matters.

Technological matters referred is most important in the case of hitherto unexploited fishery due to limitation on gears and crafts available. In this regard there is need for development of new fishing technique, sometimes using newly developed fishing gears and vessels. Such are the types of informations required on known stock. However, in a completely new field, brought about sometimes as a result of the newly acquired exclusive economic zone of two hundred nautical miles, other types of research activities may be called for. In instances such as these there is need for both exploratory and experimentary fishing, conventional parameters being considered as well as a matter of routine. It suffices though to reiterate on important point, and that no commercial fishery can thrive and survive in this economic returns. Informations therefore must be made available which will facilitate the disposal of the catches. Characteristic of marketing may therefore be envasess briefly. Some of the obstructions that can prevent development or improvement of existing new fishery must therefore, be looked into such, such essential include:-

i) Consumers preferance; some consumers because of cultural traditions, habit, low incomes or other reasons may be reluctant to consume particular kind of fish.

ii) Market restrictions ineffective distribution channels.

iii) There may be ineffective processing methods.

iv) There may be lack of port harbour facilities.

v) There may be restricted access to capital markets which prevents individual from being provided with enough finance or

vi) There may be just lack of interest in fishery development by a government agency with the responsibility of encouraging such economic deveopment.

Research and development can be seen therefore as a wholesome state of fishery development, which in final analysis is affected too by the attitude of management as elucidated when discussing some characteristics of marketing system as a tool for growth. In most developing countries information referred to above are either already available or being acquired through national and bilateral efforts.

The problem appears to be somewhere, unwillingness and readiness by those charged with the responsibility of management to appreciate and utilize the available informations, particularly if such informations are obtained as a result of research work carried out by indigenous research officers. Sometimes, this apathy towards utilization of research findings is extended to also results obtained as a result of technical aided projects. The result of this approach by management can, and has lead to greater waste of meagre resources that could perhaps would have been used elsewhere. Besides, this attitude can contribute to numerous duplication of effort and loss of interest and faith by indigenous scientists as well as useless and repeatative research surveys and projects giving out informations already available.

As earlier indicated it is not possible for a paper of this nature to cover in detail what is probably a very broad subject. However, what discussed above may warn us to be rather realistic. It is not posssible that we are having gaps simply because we have not been relating our research and development and to the national policy? We should therefore examine in detail the types of informations now remaining to be acquired in relation to the type of information now at our disposal. It is possible, we have been repeatedly acquiring during the past twenty years similar informations with the result that the Kenya Marine fishery sometimes providing no guidelines which can enhanse development, with the result that Kenya Marine Fishery sector has still to take off.

AQUATIC RESEARCH IN KENYA: PROSPECTS AND PROBLEMS*

Mohamed Hyder, Gecaga Institute of Tropical Comparative Endocrinology,
Department of Zoology, University of Nairobi,
Nairobi, Kenya.

The object of this contribution is to give this gathering some background understanding of the ratio nal of this symposium and to set, if you like, a frame of reference for the discussions to follow.

At the risk of sounding pedagogic and pedantic, it is important to remind ourselves repeatedly that the most important single function of the Kenya Marine and Fisheries Research Institute which has primarily stimulated this present gathering, is of course to plan and conduct aquatic research. It has to be abandantly clear to all of us who are involved in executing such policies and priorities that whatever else the institute does, the primary justification for its existence is to conduct aquatic research. There is nothing very complicated about this and the need for its constant reiteration especially at this neonatal state of our existance, is only because we need to remind those of us on the board of management and the executives of the institute that on final analysis we will be judged nationally and internationally by two basic parameters:

1. What research we have conducted; and
2. of what consequence that that research has been in the realization of the peoples of Kenya in the maximization of the rational exploitation of the aquatic resources that nature has endowed us with.

It is for this reason that the research and scientific committee of the board of management of the Kenya Marine and Fisheries Research Institute which I have the honour to chair to organize this workshop with the following primary objectives:

1. To bring into focus as many aspects of aquatic research as possible;
2. To review the state of the art in the specific Kenyan situation;
3. To highlight our achievements and shortcomings in each of these areas of aquatic research;
4. To synthesize a comprehensive vision of aquatic research for Kenya;
5. To define priotities and programmes of aquatic research in Kenya taking account all the above as well as financial and manpower constraints.

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

This distinguished gathering of scholars and researchers is meant to test not only our intellects, but also our consciences. We are not just asking you to help us formulate programmes of research in a political void and financial utopia. We are asking each one of you to take a hard look at the aquatic resources that are available to us in Kenya, to identify them where need exists for so doing, to estimate there potential for a rational and where possible renewable exploitation, identify what steps are needed in the realization of their exploitation as translated and crystallized into priorities and programmes of practical pursuits that will demonstrably pay for themselves in economic terms.

Those of my colleagues who are from academic environments might feel that I have perhaps been less than faithful to the cause of pure fundamental research and that I might have laid it down the line rather heavily in favour of applied research and economic spin-offs. I feel that I should clarify my point of view on this leaving my interpretation open to honest enquiry and indeed disagreement from both my academic and board of management colleagues. To begin with, let me state that I have no real ambivalence about this issue because I believe that the supposed antagonism between pure and applied research is more often imagined than real. The critical word to note here is "antagonism" and while I do not propose to sidetrack the discussion today into an examination of the merits and de-merits of pure and applied research in a developing country such as ours it is imperative that we consiciously formulate a philosophical frame of reference that allows for a vigorous interplay of both.

In the context of the political realities of a developing country such as ours, we should clearly understand that there is need for both long-term applied research. An institute such as this has responsibility to produce manifest results that can be seen to benefit Kenya. In other words, the institute must not content itself in producing reams of printed matter on the number of scales that constitute the lateral lines of the Serranids of the Kenya Coast or the extent of the furrow on the carapace of the peneidae found here. What we have to seek to do at the institute is to visibly increase the number of *Chewas and Kamba* that are landed and reach the consumers. I know that I am oversimplifying the work on the institute in getting my message across. But we must not forget that to-date, African science has done little to capture the imagination of the African politician and to generate public enthusiasm. We need to have a decisive impact - the kind of impact no less than that generated by the first sputnik in 1957 on American science. We are not going to achieve that type of impact by concentrating on producing reams of inedible abstrusity. That does not (and I stress not) mean that the institute should be either oblivious or blinkered-visioned about many important fundamental aspects of its work. It can of itself do and should do fundamental research, but it should constantly be wary of its public accountability by translating as fast as possible its results into material benefits: be those material benefits economic, social or nutitional. Only then will we earn the licence to pursue fundamental research without eroding public confidence.

I firmly believe that at this stage of our political and intellectual development, the scientist in the research institute should have no amblivalence in his pursuits. Fortunately, for us, the field of aquatic resources offers numerous opportunities for development. This conference has concentrated a lot on the development of fisheries as an aquatic resource. Through the use of cage culture and/or ranching, the Kenya sector of Lake Victoria alone is potentially capable of producing some 250 million tons of fish per annum. Compared with the actual landing of some 20,000 tons, this is indeed a significant increase by any standard! If we add to these then unharnessed resources of the rivers, other lakes like: Turkana, Baringo, Bogoria, the estiarine areas, the Tana River, dams and the immediate off-shore resources not to mention the largely untapped underground aquatic resources, we can see that the prospects are indeed great. Furthermore, this workshop has not seriously considered water itself as a primary aquatic resources rather than a supporting medium for fish. I am referring to the use of water in the terrestial context: for supporting human activities and settlements, for supporting irrigation of his crops, for supporting re-afforestation and the implications of that in fighting desertification, in supporting livestock and in supporting a carefully planned mixture of all these activities together with aquaculture. The prospects are therefore quite considerable. The technology is also fortunately mostly available. The resources to begin the operations in a modesty way are already with us now. We need the will and the vision to begin and given such will and such vision, a gathering could help draw up practical programmes and priorities of how to tackle the problems of realization of these objectives.

Finally, let me share with you briefly my vision of the nature of fruitful co-operation between academics and the Kenya Marine and Fisheries Research Institute and in the process perhaps strike a better balance between the pursuit of pure and applied research. I see the University of Nairobi carrying out programmes of fundamental research on a long-term basis in all aspects of the aquatic environment: geologocal, physical, chemical, hydrobiological and biological. But those who know the realities of University research would also know that funds are not exactly flowing. This could be a blessing in disguise for the institute in as much as it maximise the opportunities to influence fundamental research in areas that the institute is interested in. I can give this conference many examples of academics who have capabilities and keen interest in pursuing aquatic research in many aspects of the aquatic, but who lack funds to do so. If the institute were to seek and grant funds for such research they will of course reap considerable rewards rather cheaply since they wil be able to make use of relatively high-powered academic resources without having to engage them or multiply the facilities already available to them at the university. Again, through the training support of institute staff sent for higher degrees, the university would be playing an important supporting role. The participation of the university staff in the counsels of the institute and advisory gatherings such as this are also of help to the institute. My hope is that one day (not too distant) we will see a formal bond between the university and and the institute, allowing staff of both to have honorary status with the complimentary body. We have done this before and we can do it again. By so doing, the university need not replicate facilities of the institute nor would the institute try to become a mini-University.

All these are exciting prospects. I hope this conference will be a first step in helping each other to do what is our responsibility to do in the development of the aquatic resources of this country and in so doing to create a climate of acceptability for Kenya scienc.

POOSIBLE DIRECTIONS FOR SHORE-BASED MARINE BIOLOGICAL RESEARCH IN KENYA*

P.S. Rainbow and A.C. Campbell, Department of Zoology and Comparative Physiclogy, Queen Mary College, University of London, U.K.

SEA F.SHERIES

The development of Sea Fisheries should without doubt be a priority for any marine research laboratory. However, because we feel that more can be gained at this point by stimulating thought along some less obvious lines of marine research, we are devoting relatively little time to this topic which has already been well treated. (Gulland and Carros 1968; Kambona 1974; Morris 1974). East Africa has a well respected history of fisheries research carried out under the auspices of the now defunct Fisheries Research Organization of the East African Community. It would be unfortunate if such data already collected could not be utilized to serve as a baseline for future investigations.

Here then we mention only some general points regarding the potential of the sea fisheries off the Kenya Coast. Sea Fisheries can be considered under the following regional divisions:-

1. Reef and Inshore;
2. Continental Shelf;
3. Open Ocean beyond the Continental Shelf.

Coral Reefs and inshore waters around reefs are inhabitated by many fish suitable for commercial explitation including snappers (lutjanids), seabream (sparids), parrotfish (scarids), wrasse (labrids) and rock cod (serranids). The very nature of coral reefs, however, makes the catching of large numbers of fish very difficult and it is necessary to resort to techniques such as hand lines, traps, or spear fishing; all inefficient by comparison with the use of nets in sein, purse-seining and trawling. These latter techniques are used worldwide, particularly over continental shelves, but these fisheries of our second division are almost unavailable to Kenyan fishermen. Apart from the hazard to any nets of coral outcrops, the continental shelf itself is extremely narrow, the edge being only about four kilometers from the shore. Hydrographical conditions are also against local near-shore fishermen since the nutrient-poor East African current of upto four knots may be too strong for sailing craft and capital investment in motorised craft is of enormous expense.

Open ocean fisheries would similarly require investment in mechanized craft, but special fisheries may be exploitable, for example, shark, tuna or seasonally migrating fish. Of most exciting potential is the region of upwelling in the Arabian Sea to the north of the Kenya coast during the southeast (SE) monsoon between April and September: a region that is as yet underexploited.

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

Investigation into potential marine fisheries should consider the problems of marketing which could be severe on account of the climate, the distribution of major centres of population far from the sea, customs of eating and the possible effects of competition with better established freshwater fisheries on the Lakes of the Rift Valley and Lake Victoria.

Another important area for research which could have far reaching benefits on the continental shelf and open ocean fisheries relates to the hydrography of the region. All possible information on the manner in which the local currents and physical conditions of the water affect the breeding and recruitment of fish stocks should be investigated.

MANGROVE SWAMPS

Mangrove Ecosystem

The mangrove ecosystem is one of the most productive in the world and certainly plays an important part in the ecology of near-shore waters. Mangrove fauna and flora have been extensively reviewed by Macnae (1968). Populations of exploitable organisms such as shrimps and crabs are associated with the swamps. In addition mangrove swamps often act as breeding grounds, or rearing ground for larvae, of commercially important marine fish and crustaceans normally captured away from the shore. Potentially illuminating lines of research could investigate the temporal and geographical variation in the distribution of larval, juvenile and adult shrimps and crabs in and off the mangrove swamps. Such work would involve seasonal plankton surveys in the field and the laboratory culture of the organisms to enable identification of the developong stages in later field programmes. Similar field studies could follow the immigration and emigration of the larvae and adult of local fish species which are associated with the mangroves at some particular stage in their life cycles.

The mangrove trees themselves, especially memebres of the genus Bruguiera, are cropped for timber in Kenya where the timber is used in the building industry and mangrove poles are also exported for example by dhow from lamu to Arabia. The implications of the selective and unselective removal of trees for this or any other purpose should be investigated. In order to produce the best results and to conserve the mangrove environment, observations should be made to devise the most efficient means of commercial exploitation of the timber resources, and to keep the mangrove swamps in good order so that they can be exploited for other purposes.

The significant of mangrove swamps as a resource, and as an ecosystem as yet poorly understood, was recognized by the Commonwealth Government of Australia when it is set up the Australian Institute of Marine Science near Townsville in Queensland. Here pure research on mangrove related topics, including mangrove ecology, is being carried out and may lead to important discoveries of potential commercial importance. Despite studies by Macnae in

South Africa and Mozambique (Macnae 1963; Macnae and Kalk 1962) very little is known of the mangrove ecology of Kenya and we believe that this should have high priority on the topics to be investigated by the Kenya Marine and Fisheries Research Institute (KMFRI).

Shore and reef collecting and mariculture.

The potential for shore and reef collecting of marine organisms of commercial value is probably limited. Large red and brown seaweeds are collected worldwide for industrial purposes, but these reach their densities in temperate regions and no suitable large algae beds are easily accessible on Kenyan shores. Macrophytic brown algae are a source of alginates which are used in the manufacture of rubber, paper, adhesives and in the pharmaceutical and cosmetic industries. Local supplies of *Sargassum* and *zturbinaria* might be able to support amall scale industries if the need arose, but, locating them and harvesting them would be difficult. Similarly, large red algae are a source of agar-agar, a gelatinous used widely in the food industry as well as in the manufacture of cosmetics and soaps. A potential algae suitable as a source for this is Gracilaria which is available in limited quantities on Kenyan shores.

Angiosperm seagrasses such as *Cymodocea* and *Thalassia* are very abundant on the Kenyan coast. It is doubtful, however, if they could be of any commercial significance in the country, for here there is little local shortage of plant material suitable for animal litter, and little need of it in any case on farms where stock can be kept out of doors all year round. In Malta, where stock can be kept indoors for part of the year and where grass is at a premium, *Posidonia* is collected from the shore then washed up and used for cattle bedding. It is also used for manure and packing material.

Certain invertebrates might at first seem of promise for explitation. Of the molluscs the local bivalve *Donax* which inhabits sandy shores might be a potential food source. The gastropod sea snails are probably of more commercial value. Many cowries *(cypraea)* and conches *(strombus)*, cameo shells *(cypraecassis)* and helmet shells *(cassis)*) are collected for sale to tourists. In the Red Sea, the coneshell *Lambis truncata* is collected for food (Ormond 1977). The large top shell Trochus niloticus was the basis of the button industry until mother-of-pearl buttons were superceded by plastic. The gastropod may still be of small value as a source of mother-of-pearl for ornaments and jewellery. It is relatively conspicuous and easily collected.

Among the crustaceans, the large crabs and spiny reef lobsters, *(Panulirus)* are in local demand as a luxury food product. Sanders (1973) published a report on the feasibility of establishing a fishery for reef lobster in Sudan, but found that the stocks were modest. Reef walking appeared the most satisfactory method of capture in this tideless area. Neve and Al-Alidy (1973) dealtwith the same subject in Saudi Arabia. The export of black sea cucumbers *Holuthuria scabra* was for some time a commercial proposition in the Sudan. The animals were marketed in China as Beche-de-mer, but the state of the market is now questionable.

The state of the market of all these invertebrate commodities should be investigated and their maximum sustainable yield should be assessed to prevent overcollection prior to the start of any industry based upon them.

A less obvious but possible fruitful line of investigation concerns the exotic compounds which have been extracted from a range of marine organisms. Seagrasses, sponges and coelenterates, for example, have been found to contain chemicals of pharmaceutical interest. Imperial Chemical Industries and Roche have been experimenting with marine invertebrates from the Red Sea and Australia and it is quite likely that the coastal flora and fauna of Kenya support organisms of interest in this respect.

It should be mentioned here that the practice of exporting tropical marine fish for purchase by aquarists in Europe and America is thought to be most undesirable (Ormond 1977). Apart from the very low survival rate of exported fish and the high costs of collection and maintenance prior to export, fish catching can have a serious effect on the rarer, and thus the more desirable species. Fish catching does present a conservation threat, especially to territorial species.

Turning to mariculture, the potential here seems considerably greater. The aims of mariculture appear to divide into two general categories which;

1. produce a food source that may, for example, alleviate a local protein deficiency;
2. produce a luxury product such as pearls or an expensive food item.

Kenya seems to have the potential to increase mericultural yields for either purpose. Locations such as enclosed creeks, shallow lagoons and rich waters by mangrove swamps are available and both invertebrates and fish could be reared. Bardach, Ryther and McLarney (1972) provide excellent introductory accounts of culture methods for many organisms. Oysters such as *crassostrea gigas*, and prawns like *Penaeus Japonicus* are available for import and fish-like mullet (Mugil) catfish (*Trachurus*) and milkfish *Chanos)* are quite common in certain localities locally. Feasibility studies and research programmes should be set up to investigate the maricultural potential of such species. It is known that euryhaline freshwater fish of the genus *Tilapia* already under culture in Kenya, can be grown in coastal ponds.

The coasts of Kenya are renowned worldwide as a tourist attraction The three marine parks at Watamu, Malindi and Shimoni deserve their international fame and are a testimony to the farsightedness of the Kenya government. They are, however, treasures to be quarded and such guarding should involve careful monitoring of factors such as freshwater run off with its associated sedimentation and low salinity that are a deathknell to growing coral. The reefs at Malindi may already be in danger from such influence. Monitoring should lead to the recognition of possible causes of visible effects such as the selective demise of certain coral species or other shifts in the floral and faunal populations. The intrusion of bathers, outboard motors and reef walkers can all have deleterious effect (Ormond 1977); the first two because they can affect sedimentation, and the third because of damage to growing coral colonies. Dragging anchors and anchor blocks may also be the cause of damage to erect and branching coral colonies (Campbell and Rainbow, personal observation at Watamu and Malindi). Top soil erosion of cultivated soils is a problem in many areas and can lead to heavy sedimentation in estuaries and surrounding marine habitats. It is a topic which should involve government authorities and departments responsible in various areas, including agriculture and land use, river and drainage in addition to marine, and provides an important example of how cooperation is necessary between institutions of apparently unconnected administrations combining research interests to the benefit of all. It will be appreciated therefore that a continuing programme of reef monitoring should ensure the maintenance of a high standard of tourist attraction, and at the same time provide opportunities for pure academic research into the coral environment. Ormond (undated) sets out oriteria for maintaining coral reef areas.

It may be beyond KMFRI's terms of reference to draft recommendations concerning the conservation of large marine vertebrates, such as turtles and dugongs and rare invertebrates such as certain molluscs which are sought for their shells, but the staff should be willing and able to provide information on the status of most marine organisms so that endagered species can be protected.

Pollution

The word pollution covers a multitude of sins, but is useful as a general topic to head the range of subjects on which we wish to finish. An obvious pollutant is oil, spills of which will damage marine ecosystems. The weathered oil droplets cast up on Kenya's oceanic tourist beaches are usually no longer toxic and their effect is generally aesthetically unpleasant, rather than biologically dangerous to marine habitats. The oil though can still clog settlement sites for marine organisms and cause mortality in seabirds. Of more serious ecological effect will be the chronic introduction of newly released toxic oil into an enclosed marine habitat such as Kilindini Harbour, and such a situation should be carefully monitored for effects on the distribution of organisms.

In addition to oil there are other effluents caused by man's activities that are potentially dangerous to marine habitats, and as such these should be monitored carefully; These are sewage products and poisons such as heavy metals or organic pesticide residues like organochlorines. Kenyan near-shore waters are likely to be carrying an increasing burden of such poisons. Via nutrient enhancement sewage can cause eutrophication which in turn leads to algal blooms and the utilization of all available oxygen to produce a poisonous anoxic situation. In time the ecology of the marine region would be altered for the worse. There is a danger of such effects in a few localised areas, such as populated creeks and harbours. It is therefore necessary to set up programmes to monitor changes in the distribution of marine organisms and in the biological oxygen demand and nutrient levels of the water at such sites.

Sufficient concentrations of heavy metals such as cadmium, mercury, lead, copper and zinc will be toxic to marine organisms. The presence of toxic concentration of such metals in the sea is often associated with heavy industry discharging into shallow encloses seas via rivers and estuaries. It is unlikely that problems of this sort will be too severe along Kenya coasts,except perhaps again in such areas as Kilindini Harbour. One interesting possibility does arise and it can be considered along with the final effluents mentioned: the organic residues of pesticides. The obvious examples here are DDT and PCBs (polychlorinated biphenyls). DDT is a compound that is biologically resistant and able to cause toxic effects far from its original site of application. The nature of the Kenyan climate, with seasonal heavy rain ensures that at certain times of the year much top soil from agricultural land is transported to the sea, for example, to the estuaries of the Athi and Tana rivers. There thus exists a direct route for organic pesticide residue to become incorporated into marine sediments with little fallout on the way because of the high energy of the water flow. The same applies to toxic heavy metal residues, originally applied to the agricultural land as pesticides, for example, copper-based fungicides and mercury seed assessings. Toxic heavy metals and organic compounds might then be expected to build up in the sediments of estuaries and adjacent areas. A monitoring programme should, therefore, investigate the gradients of such toxic compounds in estuarine and marine sediments in an attempt to recognize and /or predict toxic effects on the marine ecosystems. Possible monitor organisms useful for revealing local heavy metal build up would be bivalves such as the oyster *Crassostrea, cucullata* or barnacles like *Balanus amphirite*

In conclusion, therefore, our main aim has been to bring to your attention various regions of shore-based marine research that might have a part to play in future research programmes of the KMFRI. If after consideration particular avenues of research do not seem worthy of persuit, our aim would still have been realized in that discussion will have been provoked and decisions on priorities made.

REFERENCES

1. Bardach, J E, Ryther, J.H. and Mclarney, W.O. (1972). Aquaculture: The farming and husbandry of freshwater and marine organisms. New York, London, Sydney, Toronto: Wiley - Interscience, 868 pp.

2. Gulland J. A. and Carroz, J. E. (1968). Management of fishery resources Adv. mar. Biol. 6: 1 - 7

3. Kambona, J.J. (1974). Shore and reef fisheries, International Conference, on Marine Resources Development in Eastern Africa eds. Msangi A. S. and Griffin, J.J. University of Der es Salaam Tanzania pp. 15 - 23

4. Macnae, W. (1963). Mangrove swamps in South Africa, J. Ecol. 51: 1 - 25

5. Macnae, W. (1968). A general account of the fauna and flora of mangrove swamps and forests in the Indo-West-Pacific region Adv. Mer. Biol. 6 : 73 - 270

6. Macnae, W. and Kalk, M. (1962). The ecology of the mangrove swamps of Incha Island, Mozambique. J. Ecol. 50 : 93 - 128

7. Morris, R. E. (1974). Priorities in development of shelf fisheries, International conference on Marine Resources Development in Eastern Africa. eds. Msangi, A.S. and Griffin J.J., University of Der es Salaam, Tanzania. pp. 37 - 41.

8. Ormond, R.F.G. (1977). Requirements and progress in marine conservation in the Red Sea. Progress in underwater science 3 : 165 - 176.

9. Ormond, R.F.G. (undated). Report on the need for management and marine parks in the Egyptian Red Sea. 34 pp. Mimeographed report to Egyptian Government.

10. Neve, P. and Al-Aiidy, H. (1973). The Red Sea fisheries of Saudi Arabia. Bull. Mar. Res. Centre. Saudi no.3.

THE EVALUATION OF MARINE FISHERIES RESOURCES OF KENYA

R.M. NZIOKA

Kenya Marine and Fisheries Research Institute, Mombasa

The Marine Fisheries of Kenya are supported by pelagic and demersal fishes which are exploited by varied crafts and gear. The fishing industry is passing through a phase of changing over from traditional to the modern methods of exploitation, from the use of indegenous sailing crafts and rather less affective gear to fishing with the help of mechanised crafts and the larger powered vessels operating with more efficient types of fish gear and other auxiliary equipment such as radar, fish finders etc. Exploration and harvesting of the Kenya fisheries resources of the ocean and a more intensive applied fisheries research is of considerable importance of the country. The objective of this paper is to present a brief account of the recent findings on the seasonal distribution of the major exploited marine fishery resources, potential fisheries resources available for exploitation and on the influence of the monsoons on the availability of fisheries resources.

The ecological relationship between fishes and their environment is of great practical application in fisheries. For any large scale development of our fishery resources a better understanding of the environmental factors influencing the resources is essential. The marine biological and oceanographical investigations in recent years have provided very interesting information on biological and non-biological factors influencing fisheries include winds, monsoons, currents, nature of bottom, light, temperature, salinity, PH, nutrients, salts etc. Influence of the Southwest monsoon on the surface water is manifested by lowering the thermocline, along the East African Coast. It has been found that the monsoon intensities have direct influence on the fisheries. In view of this it is desirable to discuss the fluctuation in fisheries.

Marine fish production:

Surveys on Marine fisheries resources of Kenya dates back from 1951 when East African Marine Fisheries Research Organization was formed, during which time the emphasis was on pelagic fishes. During the surveys on pelagic fishes between 1951 and 1954 catches of 0.54 kg/line/hr were obtained for 22% of the total catch were mainly *Scomberomorus commerson* (Williams 1956). In the same survey it was observed that tunas especially the yellow-fin tuna *Thunnus albecares* was present throughout the year, but with marked increase during the Southeast monsoon and very close to the shore upto 4 km off-shore. Other tunas which were found in the area were *Thunnus alalunga*, frigate mackerel *Auxis hazard*, the bonito *Gymnosarda Unicolor*, small tuna *Euthynnus affinis*, and skipjack *Katsuwonus pelamis* Although these species were found within the Kenya water, they are unexploited. The stripped marlin ‾ *Tetrapterus audax* has been found to form heavy concentration near the northern tip of Pemba Island and around Malindi. Catch rates have been 0.87/100 hooks/hr and at the peak of the season during the N.E. monsoon catch rates have reached 9.2/100 hooks/hr with average weight of 45 kg. per fish. Majority of the catches have been made below the thermocline (22 -23 C). These heavy concentrations during the N.E. monsoon are associated with postspawning feeding migration. The black marlin *Makaira indica* and the blue marlin *Makaira nigricans*, are mostly caught by sport fishermen during the S.E. monsoon close to the shore.

Kenya has a coastline of about 640 km. The annual marine fish production landed along the coast in Kenya for 1978 - 1981 has been estimated as 4634 (1978), 4070 (1979), 5336 (1980) and 5967 tons in 1981. The overall picture of the present status of the eploited marine fish products give an idea on the fluctuations in fisheries.

In Table 1, some facts on our exploited marine fishery resources are given in order to highlight the trends in marine fish production.

Table 1: FISHERIES DEPARTMENT MARINE FISH CATCH (1978-81) (TONES):

	1978	1979	1980	1981
Demersal	2220	2110	2587	2831
Pelagic	1049	997	1150	1103
Elasmobranchs			21	25
Crustacean	366	256	400	384
Molluscs	17	26	21	25

Fishing is mainly confined to the coastal waters up to 50 metres depth. At Ungwana Bay, fishing has been extended to grounds up to 200 metres for deep water lobster, prawns and demersal fishes.

The larger pelagic fishes comprise of the tuna and tuna-like species and the larger carangids which are caught in large number between 15 - 200 metres depth mostly in June and July. Some of them especially the round scad (*Decapterus spp*) and horse mackerel (*Trachurus spp*) have vertical migration concentrating at the bottom during the day, and rise to the surface as schools at depths between 20 and 40 metres below the surface at dusk. Although there are some good catches of sardines and anchovies, amall schooling pelagic fishes are never predominant over areas as in the case of carangids. The local fishermen catch these fishes using deep nets at night and cast net early in the morning. Demersal fishes of importance comprise rabitt fish (Siganidae), the scavengers *Lethrinidae*, rock cod (*Serranidae*) snappers (*Lutjanidae*) The spiny lobster are common off Ungwana Bay in 200 - 250 metres in June, July and November.

Decapterus macarellus, have been observed to yield 500 kg/hr in June, 532 kg and 1344 kg/hr of D. *Kiliche*. in July. The larger carangids *Gnathodon speciosus*, *Carangoides melabaricus*. and *Selar crumenopthalmus*. yeld between 150 - 230 kg/hr in July. Spawning grounds of these species have not been located and it is possible that spawning takes place in deeper waters, further offshore. Gonad ripening in the ground scads (*Decapterus spp* is observed in January, July and November, spent gonads are observed in March. It is possible that there are two spawning seasons among the carrangids - April to June and September to October but the peak of spawning seems to be in May - June along the coastline.

2. Demersal fishes

The red snappers (Lutjanidae) are very prominent in Kenya and yield catches of up to 220 kg/hr in December, January and March, particularly on the part of the shelf adjacent to the southern part of North Kenya Banks and Ungwana Bay have been recorded during the cruises of R.V. "Professor Mesyastev". Other times of the year the snappers are scarce on the shelf. The emperors (Lethrinidae) are never particularly abundant and catches are around 40 kg/hr on the shelf only in January, March and November. The emperors (Lethrinidae) are never particularly abundant and catches are around 40 kg/hr on the shelf only in January, March and November. The barracudas (Sphyranidae) are very abundant in Kenya waters, the dominant species being *Sphyraena* japonicus. In January yields of 1,080 kg/hr to 2,170 kg/hr have been obtained but in July this drops to 114 kg/hr. *S. Jallo* has given yield of 13 - 26 kg/hr in January, June and November.

The (Pomadasyidae) grunts are prominant in Kenya at all times with good catches in November. The silver bellies (Leiognathidae) are very abundant and form dense local schools. Catches of the commonest species *Leiognathus equulus* are 30 - 270 kg/hr in January. The goat fishes, Mullidae especially *Upeneus* sulphureus yield as much as 1,200 kg/hr in July and 562 kg/hr in November. Other species are more sparsely distributed like with yield of 141 kg/hr in January, during cruises of R.V. "Professor Mesyasterv" in December 1975 - June 1976 and July 1977 - December 1977. The spotted sicklefish *(Drepane punctata)* found around Malindi gave yields of up to 500 kg/hr during the 1979 to 1981 offshore trawling survey of R.V. "Ujuzi".

Artisanal Fishery

The situation of the artisan fishery may be considered as critical to such an extent that the importance of reliable forecast is very important. A preliminary survey carried out at Kilifi area aimed at providing an account of the trends of the traditional fishery was started in 1981 by the Kenya Marine Fisheries Research

Institute. Data collected over a period of 12 months in 1982 were analysed. The annual landing of major groups of fish in 1982 was 51.1 tonnes which showed a monthly variation from 0.76 tonnes in July to 11.6 tonnes in May. The fishermen were estimated to spend 6 to 9 hours a day from fishing to landing the fish. Minimum time spent in the sea was in June and July, which could be attributed to bad wather during the S.E monsoon; during this time the few boats ventured into the sea.

The chief crafts employed for fishing were canoes 4 - 5 metres long with a crew of 2 people and gear employed were shark gill nets,traps and hanlings. From Table 1 it can be noticed that a large variety of fishes support the fishery and fish landings could reflect the gear commonly used. In fact some of the gear are designed to catch a particular group of fishes such as rabbit fish (Siganidae) which enter traps baited with seaweeds and placed in intertidal langoons. The average annual landing for this group at Kilifi was 25.2 tonnes, forming 49.3% of the total fish landed. These fish were landed through the year with best catches in April, May and June. Good landings of rays were in January and February when the sea is calm and fishermen can venture further from shore, scavengers (Lethrinidae) were abundant in December to February and the kingfish from January reaching peak in March. The little tuna, *Euthynnus affinis,* bonito. *Sarda sarda* , sailfish Instiophorus gladius, and the stripped marlin *Tetrapterus audax* were caught in January to March and November to December only, which is due to seasonal migration. Sardines were landed in February when heavy shoals are observed in creeks. There was generally low catches during the S.E. monsoon months (Fig. 1-3) probably due to the prevailing weather conditions. Seasonal migration of fish in and out of the fishing areas and the state of weather conditions at sea restricting most of the fishermen going out at certain periods, is a factor that accounts for the low catches since almost all the kinds of gear and boat the fishermen use are affected by waves and currents at sea.

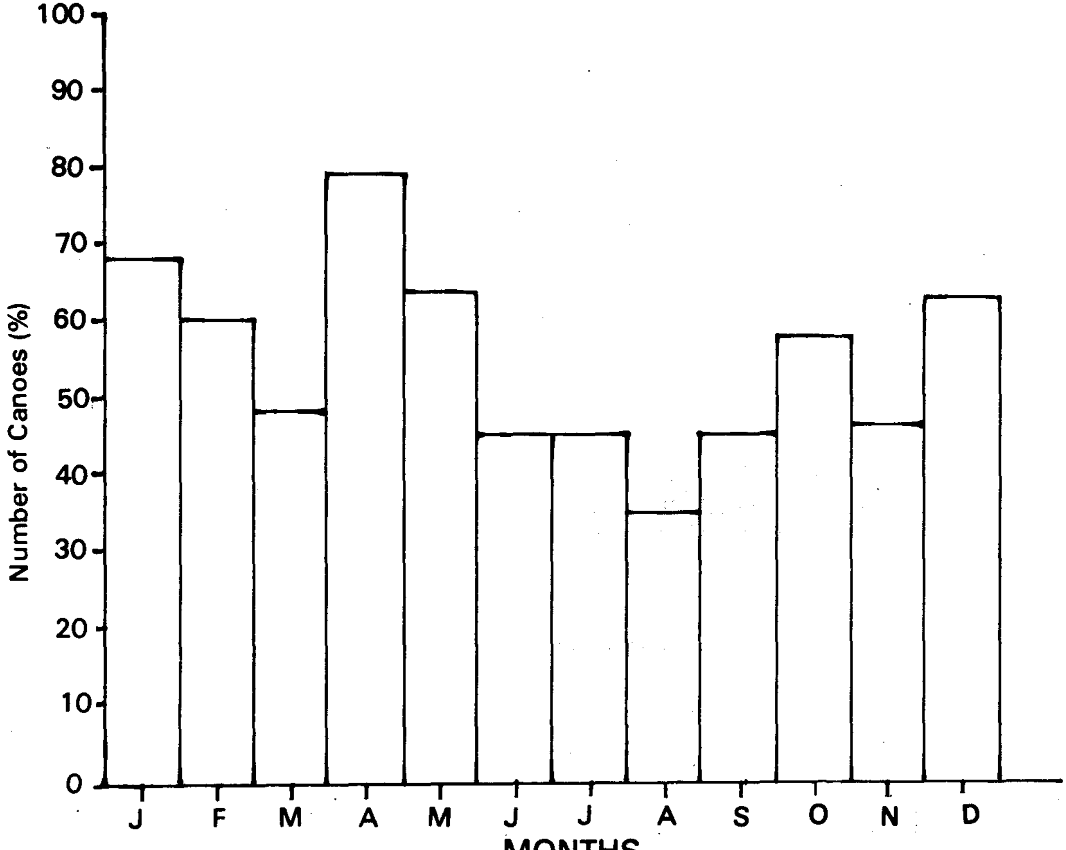

Fig 1 ACTIVE NUMBER OF CANOES 1982

REFERENCES

Anon. 1982 Offshore trawling Survey. UNDP/FAO/KEN 74/023.

Final Report on the Cruises of R.V. "Ujuzi" 1979-1981.

Birkett. L. (1979) Tech. Rep. Indian Ocean Programme (26): 97 pp. Western Indian Ocean Fishery Resources Survey. Report on the Cruises of R/V "Professor Mesyatsev" December, 1975-June 1976/July 1977-December, 1977.

Williams, F. (1956) Preliminary Survey of the Pelagic fishes of East African Waters. Fish. Publi. London No. 8 p. 68

Potential Fishery of Nile Perch Lates Niloticus Linne (Pisces: Centropomidae) in Nyanza Gulf of Lake Victoria, East Africa *

Ezekial N. Okemwa

INTRODUCTION

*Lates*s *niloticus* s (Linne) is not a native *fish of Lake Victoria, although the* fossil record shows the presence of *Lates* spp. during the Miocene period in the area now occupied by this lake (Greenwood, 1951). In the 1950's *Lates* was introduced into Lake Victoria (Uganda waters) to prey on *Haplochromis spp..* which were in abundance and not consumed by local fishermen (Hamblyn,1960). Stonman & Rogers (1971) reported that the first large quantities of *Lates* appeared in fishermen's catch in 1964 in Uganda waters. In Nyanza Gulf, *Lates* began appearing in the fishermen catches in the late sixties and early seventies. In 1966, a 34.5 Kg *Lates* was caught off Rusinga Islands (Fig. 1) (Arunga, 1981b). Kodhongania & Cordone (1974 reported for 1969 a catch rate of 2 kg/h in shallow water (0-10m). Later, Muller & Benda (1981) found that *Lates* catch rates in Nyanza Gulf had increased to 23.8 kg/h

Kongere (1979)reported a total of fishermen catch of 203 metric tons in 1977 from Nyanza Gulf. Arunga (1981a), found a total gillnet production in Nyanza Gulf of 36 533 metric tons for 1981, and 60% of that was *Lates*

Lake Victoria fisheries have changed considerably during recent years. *Sarotherodon esculentus*, previously the fish of greates commercial importance, has virtually disappeared from the Lake (Marten, 1979). Numerous other species have declined drastically during the past decade, particularly those that migrate into streams to spawn such as *Barbus*. *Labeo*. *Alestes* and *Momyrus*. because of the use of small mesh-size gill nets and traps at the mouth of the rivers (Marten, op. cit.). Okemwa (1981a) reported that the fish species composition of Nyanza Gulf changed drastically in the last five years.

The Haplochromines which used to dominate all other fish catches in this Gulf have disappeared. Other fishes like *Clarias, Bagrus, Protopterus* and *Synodontis spp.* are now rare (Okemwa, op. cit.). On the other hand, *Lates* has now colonised the whole of Nyanza Gulf.

This paper discusses the importance of the *Lates* fishery and its potential in Nyanza Gulf using data obtained from recent studies.

Study area

The study area is shown in Fig. 1. A description of the study area is given by Rinne & Wanjala (1982). Nyanza Gulf is a shallow bay with a depth range of 0-30 m, and a mean depth 6m.

Material and Methods

To assess the potential of the *Lates* fishery in Nyanza Gulf, a bottom trawl programme (see Okemwa,

* This paper is adopted from Hydrobiologia 108, 121-126 (1984)

1981a) was conducted. Fourteen sampling sites throughout the Gulf (Fig. 1) were determined by the feasibility of trawling. The draught of the research vessel allowed trawling at depths under 3 m.

All hauls were made with an 85 hp diesel powered trawler using an otter trawl with a 13.7 m headrope and 38 mm mesh. The hauls were usually of 30 min duration. Trawling speed was 2.5 knots. Trawl catches were adjusted to one hour hauls. Sampling was carried out monthly from January 1979 to December 1981. Three sets of replicate hauls were taken in each station. The catch was sorted to species and weighed.

Gulland (1970) noted that the rate of exploitation of a virgin stock can increase to quickly that the fish population is endangered before fisheries scientists can assess the situation by classical methods.

Table 1. Estimated mean numbers and mean of 25 monthly samples in kg/h of *Lates* from 14 stations in Nyanza Gulf for the period January 1979 to December 1981.

	Lates numbers		Catch rates kg h					
Year	1981		1979		1980		1981	
Station	No.	S.D.*	kg h	S.D.	kg h	S.D	kg h	S.D.
1. Kaloka	156	94	51.1	30.5	19.3	9.3	104.3	100.2
2. Usare	165	56	36.0	28.9	41.9	23.6	60.0	48.3
3. Dunga	77	17	23.2	19.0	37.6	17.9	64.2	42.9
4. Open Water (Ndere)		93	55.4	53.2	35.4	12.9	116.4	35.0
5. Kendu Bay	65	42	25.8	17.2	151.9	145.9	57.8	29.3
6. Sango	73	37	10.3	5.6	8.1	2.7	7.8	5.0
7. Homa Bay	207	144	68.6	23.4	70.9	45.3	101.4	79.8
8. Mirunda Bay	230	159	122.0	60.7	438.9	602.8	200.6	109.6
9. Luanda Naya	300	17	141.1	28.4	292.1	157.7	148.5	75.2
10 Mbita	110	49	12.8	9.2	19.5	11.7	52.9	57.8
11. Naya (Open water)		166	141.1	96.0	292.1	127.6	148.5	35.0
12. Homa Point	14 900	536	9.0	6.6	227.2	184.3	689.4	57.0
13. Asembo Bay	838	138	60.6	2.8	57.5	29.8	168.1	97.5
14. Main Lake	19	8		0.0	0.0	0.0	4.3	2.8

*S.D. Standard deviation.

Consequently, he developed a rough but quick estimate of potential yield (Y_{max}), including total mortality coefficient (Z) and exploited standing stock (B). This relationship us used in the present paper. It is given by the equation:

$Y_{max} = 0.5\ ZB'$

Results

Lates was present in all stations sampled (Fig. 1). Its abundance varied from station to station and from month to month (Table 1 and Fig 2), but always was the vast majority. More than 90% of the catch by weigh was Lates followed by *Oreochromis niloticus* (formerly Tilapia nilotica) Trewavas, 1981. *O. niloticus*, was more numerous in the shallow water near the edge. *Lates* was not found in the main Lake at 30 m depth (Fig. 1) in 1979 & 1980, and appeared in low numbers in 1981. Homa point (Fig. 1), had a higher concentration of *Lates* than other sampling stations (Table 1). The general pattern of distribution of *Lates* in Nyanza Gulf between 1979 and 1981 is given in Fig 1. Its standing stock was estimated at 9.1 kg/ha in 1979 and rose to 61.8 kg/ha in 1981. Homa point and Mirunda Bay had the highest average catch rate with 689.4 57 and 200.6 109.6 kg/h , respectively (Table 1). The main lake had the lowest catch during the same period (Table 1). About 90% of the *Lates* caught by trawl-net had a wight ranging from 1 to 70 kg. Table 2 lists the mean catch rates (kgh^{-1}) by species in Nyanza Gulf in 1981 by bottom trawl.

The present *Lates* harvest of 21.807 metric tons (Arunga, 1981a) was considered as the exploited standing stock B . Okemwa (1982b) found total mortality to be 1.0. Using Gulland's equation the potential yield estimate of *Lates* in Nyanza Gulf is thus near to 11 000 metric tons. This indicates that exploitation rates are over the maximum and therefore, there is overfishing of Lates in Nyanza Gulf.

Discussion

The results show there is a good stock of *Lates* in Nyanza Gulf. Gee (1969) has indicated that in Lake Victoria *Lates* is piscivorous and feeds mainly on *Haplochromis* spp. Ogari (pers. comm.) finds that, in Nyanza Gulf it feeds on Shrimps of the genus *Caridina* on *Engraulicypris spp.* and on its own progeny.

Table 2. Mean catch rates (kg/h) by species in Nyanza Gulf in 1981 by bottom trawl.

Depth (m)		(0-10)
Number of hauls		273
Average	kg/h	S.D.
Species		
Bagrus docmac	0.3	0.2
Clarias mossambicus	0.1	0.1
Haplochromis spp.	0.0	0.0
Labeo victorianus	0.02	0.01
Lates niloticus	169.0	70.9
Protopterus aethiopicus	0.1	0.04
Synodontis	0.2	0.1
Oreochromis niloticus	15.6	8.4
Sarotherodon variabilis	0.2	0.03
Tilapia zillii	0.0	0.0
Mean weight/haul in kg/h	185.52	80.0

Caridina forms about 40% by number of the food of *Lates* It is, however, interesting to note that *Lates* is a shallow water species, limited to inshore waters. These habitats are similar to those favoured by *Engraulicypris*, (Shallow, well oxygenated waters).

In 1978, Okedi (1982) using Anchor Chinese pressure lamps of 350 candle power (14.10^5 Jcm^2 sec), estimated the biomass of *Engraulicypris* in Tanzania waters of Lake Victoria to be 73 151 tons which, extrapolated for the whole lake, is about 150 000 tons.

There is therefore likely a direct predator-prey interaction between the two species (Okedi, 1982). As other species are on the decline (Payne, 1976; Marten, 1979; Muller & Benda, 1981; Arunga, 1981b; Okemwa, 1981a) and become increasingly unavailable, the success of *Lates* in Lake Victora is dependent on three species viz, *Engraulicypris*,, *Caridina* and *Haplochromis spp*.The abundance and growth of *Lates* in Nyanza Gulf will be determined in time by the availability of these preys. When this food resource is exhausted, *Lates* will prey on its own progeny, and finally finish itself. But since *Lates* is now being overfished the preys are not likely overconsumed.

The largest recorded specimen (2.0 m in length) was a female weighing nearly 200 kg. It was caught in a beach Seine at Luanda Naya beach in 1978. The second largest *Lates*,also a female was caught at Homa Point (Fig 1.) at 7 m depth on 15.10. 1981. It weighed 165 kg and measured 1.9 m in total lenth. Female *Lates* are usually larger than males. *Lates* offers a larger amount of flesh per unit weight than the preffered *Tilapia* group (Kongere, 1979).

The consumption of *Lates* around the lake poses a problem. Nile Perch is not popular and considered unpalatable compared to indigenous Sarotherodon esculentus (Ngege) which has now disappeared from Nyanza Gulf. But *Lates* is considered a delicacy elsewhere. It should, therefore, be possible to encourage the fishing of Nile Perch by developing markets to areas where they are worth many times what they are locally, while people should be educated on better methods of preserving and cooking Nile Perch. Marketing data around Nyanza Gulf show that the price of Nile Perch fluctuates between 1.00-2.00 shillings per kilogram, whereas at the Kisumu Fish Market a kilogram of Fillet Sells for 15.00-20.00 shillings, and still more in other towns. The remains of carcass of Nile Perch at Kisumu Market sells for 1.00-2.00 shilling a kilogram. If the carcass could be processed into fish meal and poultry feeds, the returns could be more profitable than the present wholesale prices.

Using the data obtained from Nyanza Gulf, the annual production of *Lates* amount to about 11 000 metric tons in 1981 (Arunga, 1981a). At 2 000 Kenya shillings per ton (rate of exchange in 1982, US$ 1=11 Kenya shillings) this gives a total annual earning of 22 000 000 Kenya shillings (US$2 000 000). This is a remarkably productive fishery. A *Lates* fishery also exists in Lake Kioga (Ogutu and Twongo, pers. comm.). In early 1950's, *Lates* niloticus and three prey tilapias - *Sarotherodon leucostictus Oreochromis niloticus and Tilapia.*

biomass estimate of the major demersal fishes in lake victoria. Afr. J. trop. Hydrobiol. Fish. 3: 15-32.

Marten, G. G., 1979. Impact of fishing on the inshore fishing of lake Victoria (East Africa). J. Fish. Res. Bd. Can. 36: 891-900.

Muller, R. G. & R. S. Benda, 1981. Comparison of bottom trawl stock densities in the inner Kavirondo Gulf of Lake Victoria. J. Fish. Biol. 19:399-401.

Okedi, J., 1982., Standing crop and biomass estimates of Lake Victoria 'Dagaa' (Engraulicypris argentus Pellegriu). Makerere University, Ms., 6 pp.

Okemwa, E. N., 1981a. Changes of fish species composition of Nyanza Gulf of Lake Victoria. Proceedings of the Workshop of the Kenya Marine & Fisheries Research Institute, on Aquatic Resources of Kenya. July 1981, Mombasa, Kenya, pp. 138-156

Okemwa, E. N., 1981b. The population dynamics of demersal fish species of Nyanza Gulf of Lake Victoria. K.M.F.R.I.,Report: 18 pp.

Payne, a. I., 1976. The exploitation of African fisheries, Oikos 27: 356-366.

Rinne, J. N. & B. Wanjala, 1982. Observation on movement patterns of Tilapia spp. in Nyanza Gulf of Lake Victoria East Africa. J. Fish. Biol. 20:317 322.

Stonenab, J. & Rogers, 1971. Exotic fishes. Occasional Paper no. 3, Uganda Fisheries Department.

Trewavas, E.,1981. Nomenclature of the tilapias of Southern Africa. J. Limnol. Soc. Sth. Afri. 7 (1): 42 pp.

Worthington, E. B., 1940. Geographical differentiation of fresh waters with special reference to fish. In: The New Systematics, Oxford

A CASE STUDY OF THE LAKE VICTORIA NILE PERCH LATES NILOTICUS FISHERY.

J.O. Arunga, Department of Fisheries, Kisumu, Kenya

INTRODUCTION

During the past few years, there has been concern about depletionary tendencies of the Lake Victoria endemic fishery, e.g. *Tilapia* spp. *Haplochromis* *Protopterus* and the catfish. On the other hand the nonendemic species such as *Lates niloticus* and *T. nilotica* continue to establish rather rapidly as an important fishery. This steady growth in importance of the latter as opposed to the former fishery has made it imperative that studies and investigations be instituted by researchers and fishery managers alike into this fishery to be able to offer a better understanding of its ecology, biology and its possible effect on Lake Victoria fishery.

Archeological records indicate a long existence of *Lates* fishery in the continental waters. Fossils of Nile Perch were first found on Lake Edward dating back to Pleistosine period. On Lake Victoria, Fossil records were found on Rusinga dating back to Maosine period (25 Million years ago), (Greenwood 1966). It is, however, not very clear what influenced the present geographical distribution of *Lates niloticus* on the continent.

Records avaialble show that the Nile perch has two patterns of occurence. It is endemic in lake Albert, lake Turkana (Rudolf), Lake Chad and Lakes Sharma and Abaya in Ethiopia. In the river systems, *Lates* is found in the Volta and the Nile. In nonendemic environment the Nile Perch occurs in Lake Kioga, Lake Victoria and the Kabaka's Lake in Kampala.
It would appear from the above that the continental distribution of the Nile perch is in large part limited to the north of the equator save Lake Victoria which stands astride it as its occurence southwards has not been recorded, (Gee 1965). This is a trend which may have been influenced by the general depth of the southern lakes and the lower temperatures that characterise them *Lates* tend to prefer medium or higher temperatures.

Pattern of Introduction

The introduction of Nile Perch was first concieved in the early 1950's (Fryer 1960). In arguing for the beneficial effects of such an introduction, proponents of the idea made much of the concept of cropping small species specifically the *Haplochromis* by the large predators. With a view to achieve this goal, it was decided first to introduce Nile Perch in Lake Kioga to serve as a preliminary experimental base before finally introducing it into Lake Victoria. It was

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

expected to feed on *Haplochromis* whose population in the Lake at the time was very high. Possibilities of adverse influence on the other species was not envisaged, at the time, by those who supported the idea of introduction.

Nile Perch was, therefore, first introduced into Lake Kioga in February 1954 and in October 1955 by Alexander, Rhodes and Stonman of the Uganda Fisheries Department (Amaras, personal communication).

General Occurence

The Perch was first caught in Lake Victoria in May 1960 at Jinja point above Ripon Falls and again in November 1960 at the same place. In Lake Kioga the perch began appearing in the fishermen catches in 1958. It continued to play a very important role in the fishery of Lake Kioga, subsequently assuming about 50% of the total commercial catch in the 1960s. In 1970 the perch assumed 60% of the total catch and about 62000 metric tons were recorded in the same year. In Lake Victoria the perch began appearing in the fishermen's catch in 1964 when it was caught in large quantities in Uganda waters (Stonman and Rogers 1971). *Lates* however, seem not to have established well in Uganda part of Lake Victoria and has continued to confine itself to the shallow waters. The occurence of the perch in the Tanzania waters was recorded shortly after its appearance in Uganda waters, establishing prominently in the late 1960s. In the Nyanza Gulf the perch began appearing in the fishermen's catch in the late 1960's. In 1966, a 76 lb. *Lates* was caught off Rusinga Island. *Lates niloticus* started establishing in the gulf in the second half of the last decade (see figure 1) and in 1980 it formed about 16.0% of the total commercial catch compared to 1974 when it was only about 0.8% of the commercial catch, (see table1).

Geographical distribution

In general the Nile Perch prefers the shallow waters and around river inlets. In the Ugandan part of Lake Victoria it occurs mostly within five meters of water, but has been known to extend sparsely to 20 metres of water. In Lake Turkana the perch has been caught at depths of about 50 metres, but it is reported that the species caught was a smaller one which is known to be endemic to the lake (Gee 1965).
The distribution of the perch extends among others in the region, to Sesse, Buvuma and Kome Islands. In Tanzania the concentration of perch has been recorded in, among other places, the Speak Gulf and around Ukerewe Islands.

In general the perch is now very well established in the gulf, although limited to certain specific areas (See figure 2). The highest concentration is found on a ridge that runs from Homa point to Uyoma point, areas around Ndere Islands in Seme and parts of the gulf proper, mainly in the sandy bays. The sand is also sparsely spread all along the gulf shoreline apart from its occurence around the major islands in the gulf such as Rusinga, Mageta and Sumba. Figure 3 further shades some light as to the catch trends along the gulf beaches which tend to relate to its areas of concentration. Its concentration around Home point, may be attributed to salty waters in the area as affected by the ground salt adjacent to the shores of the lake.

Ecological impact

A disappointing trend has been observed on Lake Kioga fishery since the introduction of the Nile Perch in the 1950's. There has been gradual, but notable disappearance of the endemic fishery such as *Haplochromis* *Tilapia* *Protopterus* and Bagrus docmac as the Nile Perch fishery continued to flourish in the lake. Originally there was a flourishing fishery of *T. Variabilis* and *T. esculenta, Clarius species* *Bagrus docmac* *Protopterus, aethiopicus* in Lake Kioga (Stonman and Rogers 1971). *Tilapia* nilotica on the other hand seem to have achieved a level of co-existence with the perch in the lake, a phenomenon which is yet very well understood. The situation, however, seem to have a bearing on variation in inches occupied by the two species. From observation it appears that *Lates niloticus* tend to favour the waters around steep-shelving shores, for instance, Homa-Uyoma point in the gulf and Namone point in Uganda (Fryer 1973). *Tilapia* niloticus on the other hand tend to occupy swampy regions of the lake while the fry confine themselves to the littoral zones (Fish 1955).

Recent studies have revealed significant occurence of *Engraulicypris*, species in the guts of Nile Perch as opposed to earlier observation when the other declining species were still dominant. In Lake Albert a similar trend has been observed to a lesser degree, however, in this case the *Haplochromis*, species seem to have withdrawn into the deeper water, areas less infested by the Nile Perch. It would appear that the Lake Albert fishery in general, being endemic, the species involved have adopted and are able to coexist with the endemic Nile Perch in spite of its vigorous predatory nature. Since there was no particular introduction of the new species into the lake, the fishery seem to exhibit a reasonable level of stability. In the Nyanza Gulf a similar trend as that observed in Lake Kioga is currently reflected in the fishery. A general decline of T. esculenta and other indigenious *Tilapia species*, has been observed, followed by a gradual disappearance of *Haplochromis* species which hitherto had formed the greater percetage of the gulf catch was followed by rapid growth of Nile Perch fishery (see figure 1). The population of *Haplochromis* in the gulf proper is alamost totally depleted. *Haplochromis* are found in the deep and open waters particularly around the main islands and the open waters adjacent to our territorial border areas which have not been seriously infested by Nile perch (see figure 2). The lung fish is almost disappearing in the gulf and the ones which are caught now are mainly found in the peripheral swampy and muddy areas with scattered occurence in the open waters.

DISCUSSION

In recent years there has been considerable controversy as to the role of *Lates nilotica* a in L. Victoria in view of the changing trends of the gulf fishery. The apparent decline of some of the endemic species have partly been attributed to predatory activity of Nile Perch (Oyugi-Aseto 1979). However, Kongere (1979) contends that those concerned with such allegation seem to ignore the successful *Lates* fishery in Lake Turkana and Lake Albert where it is endemic and has continued to coexist with other *Tilapia* species over the years. Ironically it is the same group of people who have spoken and written negatively about *Lates* who also trek to the distant and remote waters of lake Turkana in search of Nile Perch catches in order to have a share in the lucrative current trade in Nile perch fillet (Kongere 1979).

The endemic fishery of Lake Kioga such as Tilapia *Protopterus aethiopicus* , *Clarias mossambicus* *Bagrus docmac* and *Haplochromis* have shown a progressive decline almost to total depletion as *Lates niloticus* continued to establish in the Lake during the last two decades (ogutu, persoanl communication'. In the gulf the trend has been more or less the same, but the depletion of *Protopterus aethiopicus* *Haplochromis* species and endemic *Tilapia* species have been rather rapid since *Lates* took root within the last few years and precisely during the last half of the past decade (see figure 1). Endemic predators such as *Clarias* and *Bagrus* *mossambicus* B. *docmac* and *Synodontis* species have also shown gradual decline. The former two species of catfish now occur or appear in the fishermen's catch mainly during the rainy season, but have in large part withdrawn into the open and deeper waters. This withdrawal into the deeper water is more prominent with *Synodontis* species, which is now largely caught around Kaksingri, Karungu and Mihuru Bay.

In Lake Turkana where Nile Perch is endemic, the fry which still retain traces of the yolk-sac have been observed in marginal waters over sandy bottom including aquatic vegetation which tend to indicate possible spawning sites. Gee (1965) made similar observations on Lake Albert and Kabaka's Lake. At the time of study, withdrawal of other fish species in L. Turkana into the deeper waters leaving *Lates* on the sandy shallower part has also been observed (Ogari personal communication). It would appear from these observations that *Lates niloticus* tend not to emigrate far from territorial grounds for the purposes of spawning. Ogar (op. cit) in his studies has made similar observation in the gulf.

The early studies, by Gee (op. cit.) implied that Nile Perch feed primarily on Haplochromis followed by momyrids. Present studies conducted by Ogutu of the Research Laboratories Jinja and Ogari of the Kenya Marine and Fisheries Research Institute agree that the feeding habit of Lates is rather broad-bases and may not be narrowed to certain specific species. Examination of stomach content of the gulf perch have revealed a whole spectrum of Lake Victoria fish species and invertebrates in significant numbers, as opposed to earlier studies.

In both Lake Victoria and Lake Kyoga there seem to have been no significant effect of Lates on Engraulicypris fishery. While all the other endemic Lake Kioga fishery have tended towards depletion over the years, Engraulicypris fishery continued to flourish since it did not form an aimportant part of perch feed. In the recent past, however, as the other species declined, stomach content studies of Lates now reveal reasonable quantities of Engraulicypris. Such occurence in the stomach of gulf Lates still remain neglegible. However, from Lake Kioga experience, it is likely that as a result of a continued depletiom of the other dominant endemic species, Lates may resort for its food to Engraulycypris. The initial selective feeding that avoided Engraulycypris in the case of the two lakes is likely due to Engraulycypris species being pelagic, found hardly a metre below the water surface and Lates, on the other hand, being a bottom fish (Hamblyn 1966).

Table 1. Percentage contribution of the various of fish to total annual catch in the Kenya water of Lake Victoria 1970-80

Species	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Alestes	0.07	0.13	0.01	0.02	0.01	0.08	0.01	0	0.15	0.08	0
Bagrus	6.65	7.08	5.35	8.60	6.42	8.38	5.49	5.90	5.85	5.78	2.39
Barbus	1.29	1.60	1.68	1.09	0.74	1.71	0.97	0.95	0.83	1.36	1.56
Clarias	9.71	12.48	17.04	15.65	12.87	15.58	13.42	9.08	7.25	9.90	4.54
Engraulyspris	3.20	5.09	7.85	21.79	27.43	27.75	30.26	34.68	36.51	30.47	35.09
Haplochromis	32.66	31.91	29.04	33.16	35.01	27.86	34.09	27.82	30.47	21.57	13.51
Labeo	1.80	1.52	1.52	1.94	0.84	0.35	0.65	0.66	0.62	1.45	1.79
Lates	0.17	0.31	0.24	0.87	0.79	0.31	0.52	1.05	4.47	14.01	16.01
Protopterus	9.93	12.05	11.98	12.05	12.69	8.86	5.01	3.99	2.57	1.54	1.38
Mormyrus	0.60	0.49	0.48	1.08	0.52	0.35	0.48	0.53	0.56	1.17	1.24
Schilbe	0.42	0.38	0.44	0.95	0.18	0.33	0.31	0.67	0.50	1.05	0.44
Synodontis	1.14	0.74	1.26	1.30	1.14	0.76	1.02	1.60	0.65	1.58	1.44
T. esculenta	22.48	16.14	9.26	1.81	.0.33	0.17	0.26	0.22	0.75	0.31	0.33
T. nilotica	5.02	4.93	5.56	2.90	2.39	1.22	2.25	2.40	4.08	3.14	4.40
Other Tilapia	4.96	5.15	7.87	5.36	2.84	2.48	2.87	4.80	6.09	5.50	13.89
Small mixed fish				3.75	1.93	3.83	2.38	1.48	1.37	1.09	1.99
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

O means No. less than half the unit shown

A STATE OF FISHERY IN NYANZA GULF OF LAKE VICTORIA, EAST AFRICA

Ezekiel N. Okemwa,
Kenya Marine & Fisheries Research Institute, Mombasa.

INTRODUCTION:

Earlier studies on the ichthyofauna of Lake Victoria (Bergstrand & Cordone 1971; Cordone & Kudhongania 1972; Kudhongania & Cordon 1974 and Marten et al., 1975) reported that the bionomic and commercial contribution of the *Lates niloticus* to the ichthyofauna of Lake Victoria was insignificant, whereas *Haplochromis* spp. were significant. Cordone & Kudhongania (op. cit.) and later Kudhongania & Cordone (op. cit) observed that their sampling vessel "Ibis" was too large to operate in waters shallower than 6 m which meant that more than 50% of the surface area of Nyanza Gulf which is les than 6 m deep, was not trawled.

The importance of the Nyanza Gulf to the nutrition of the Kenyans around the Lake Basin region has shown that freshwater fish represents the largest single source of animal protein consumed. About 60,000 people depend directly on the fishery of the gulf (Jansen, 1976). There are nearly 2,000 fishing boats (Canoes) within Nyanza Gulf and about the same number outside the Gulf (Wanjala & Marten, 1974). There is, however, a greater emphasis on seines inside the Gulf and large mesh gillnets ouside the Gulf (Wanjala & Marten, op. cit.).

With the increasing human population in Western Kenya, it is of great importance to compare trawl catch rates in Nyanza Gulf, to find out whether there are changes in the fish stocks requiring different management techniques for maximum sustainable yield.

MATERIAL AND METHODS:

The study area is shown in Fig. 1. A description of the study are as given by Okemwa 1983.

Fish were collected with an 85 hp diesel powered fibreglass trawler utilizing a conventional bottom trawl with a 13.7 m headrope and 38 mm mesh throughout. Three sets of replicate hauls were taken monthly in each of the fourteen sampling locations in Nyanza Gulf of Lake Victoria (Okemwa, 1981). Sampling was carried out monthly from January, 1979 to December, 1981. The catch was sorted to species and weighed.

Mean monthly catches for each fish species were tabulated in kilogramms and means, variances and standard deviations calculated. Due to the heteroscendasticity of standard deviations a logarithmic transformation, was utilized to permit the use of a two way analysis of variance (ANOVA) model II to test simultaneously the differences among several populations and assigning to the various factors which affect the measured character their relative roles. A hierarchical model was formed to show the relationship between the factors and the fish species. Sokal & Rohlf, (1969) was used for all statistical methods.

RESULTS AND DISCUSSION:

Tables 1 through 3 list the yearly mean catch rate in kg h by species and by zones in Nyanza Gulf for the period January, 1979 to December, 1981 and shows that some species are increasing, while others are declining. The mean catch rates for the fishes in all zones show a decrease during the time the study was undertaken except for exotic species (*Lates niloticus* and *Oreochromis niloticus*) which increased (Table 1-3). More than 90% of the catch by weight was *Lates* in zones I and II, during the period this study was undertaken. Nested ANOVA with unequal sample sizes was calculated on a hierarchical model on species and seasons in Nyanza Gulf.

The following summarized differences were determined.

1. Catches in zones. A significant zonal difference by species was found with Fs =9.014 and Fo.o1 (2,11)=7.21. The zones show an added variancce among fish species in this study and may be caused by ecological factors.

2. Catches in Seasons. There was a difference among species which was significant Fs =19.979 with Fo.o1 (11,42) =2.70.

The seasons in this case show an added variance among fish species in Nyanza Gulf.

The Two-way Analysis of variance was also used to test differences among locations, fish species and time. The result is summerized below:

1. Total Catch. There were differences in total catch in all locations during the period 1979 to 1981(F =7.701 and 1.821; df =14 and 70; P<0.001). Time had a great influence in the course of the difference.
2. *Lates* Catch. *Lates* showed a significant difference among the locations and the months of (1979-1981) (F = 3.804 and 3.817; df = 2 and 12; P<0.001).
3. *Haplochromis* spp. Catch. There was a significant difference in mean monthly catch rate of *Haplochromis* spp. in all locations during the period (1979-1981) (F = 32.271 and 11.034; df = 5 and 14; P<0.001).

Haplochromis spp., *Bagrus docmac* *Clarias*, mossambicus and *Protopterus* aethiopicus were collected in most hauls in 1979 from all zones in Nyanza Gulf, except *P. aethiopicus* which was not collected from zone I and III In 1981, *Haplochromis* spp., C. mossembicus were collected infrequently and in very low numbers from zones I and II whereas they appeared in great numbers in zone III (Tables 1-3).

Bergstrand & Cordone (1971) recorded a mean catch of 200.2 Kg/h^{-1} from 19 hauls made in zone I with a 38 mm codend. Marten et al. (1975) trawling in the same zone got a mean catch of 231.9 kg/h^{-1} from 69 hauls, whereas the present survey caught a mean value of 45.5 kg/h^{-1} from 433 hauls using a similar net. Non-cochlids constitute over 9.0% by weight of Nyanza Gulf Samples. Another comparison of the total mean catch rates for this study and 63 hauls from zone 1

and 11 (Benda, 1981) showed an increase in catch rate. The increases were 3 and 2 times for zone I and II respectively.
Predator fishes like *Bagrus*, and *Clarias* constitute over 3% of 1981 mean catch rate (86.2 kg h) in zone 1, but reached 14% of the same year mean catch rate (91.4 kg h^{-1}) in zone III . The decline of *Clarias* and *Bagrus* in Nyanza Gulf may be attributed to competition from the introduced *Lates* which may be occupying the same niche with them. The efficient predator is likely to dominate the area, and it seems *Lates* is proving to be the one. The catch rate of 63.9 kg h in zone III in 1981 (Table 3) was obtained at Luanda Naya and Mbita (Shallow areas (0-10 m)) and not in deep waters (20-30 m).
Sarotherodon esculentus , previously the fish of greatest commercial importance in Nyanza Gulf in the 1950's (Garrod, 1960), has virtually disappeared from much of the Lake. During this study two specimens of *S. esculentus* were caught.

S. leucostictus was found in zone III at 3 m depth.
S. variabilis and *Tilapia zillii* were found in the depth range of (0-14) m in all zones.
Very few numbers of *Alestes* spp., *Mastacembalus frenatus* and *Schilbe Mystus* were caught in the Gulf during the period 1979-81. *Xenoclarias* spp. was only found in zone III in 30 m depth, while *Mastacembelus frenatus* had the narrowest bathymetric distribution (0-4) m in zones I and II

Fish total catch has been increasing during the three years of study. This increase is attributed to *Lates* . *Lates* is accepted as a food fish by the inhabitant of the Lake Basin (Okemwa, 1984). Since the rest of the fish species are declining drastically (Garrod 1960; Mann, 1966; Wanjala & Marten, 1974; Benda, 1979;Muller & Benda, 1981; Okemwa, 1981), *Lates* alone cannot continue to sustain the fishery of Nyanza Gulf because of about 60,000 people who depend directly on the fishery of the gulf (Jansen, 1976). It is suggested here that fishing of *Lates* can continue, meanwhile the people around the Lake shores are encouraged to establish fish ponds around Nyanza Gulf and use Lake Victoria water and its surrounding rivers.

Research needs:

To give a clear explaination why endemic fishes in Nyanza Gulf have disappeared is difficult. Secondly no previous ecological baseline studies are available upon which to base any argument and comparisons.

Table 2. Mean of 30 monthly samples in kg/hr^{-} by fish species in Middle Nyanza Gulf for the period January 1979 - December 1981.

Location	Middle Nyanza Gulf						
Year	1979		1980		1981		
Number of months	10		10		10		
Number of hauls	138		148		170		
	Mean	S.D	Mean	S.D	Mean	S.D	F-test
Bagrus docmac	9.1	4.4	1.1	1.0	0.3	0.3	14.40*
Clarias mossambicus	1.0	1.0	0.6	0.6	0.3	0.4	0.95
Haplochromis spp.	10.2	5.6	1.0	1.4	0.0	0.0	12.09*
Labeo victorianus	0.7	0.4	0.7	1.4	0.1	0.0	0.5
Lates niloticus	43.1	37.4	74.1	69.8	124.2	97.4	1.05
Protopterus aethiopicus	4.3	7.5	0.2	0.4	0.2	0.3	1.32
Synodontis afrofischeri	0.5	0.6	0.6	0.5	0.1	0.2	1.25
Synodontis victoriae	0.8	1.4	0.2	0.3	0.1	0.1	3.53
Oreochromis niloticus	1.4	0.7	7.0	6.8	11.9	9.7	1.80
Sarotherodon variabilis	0.6	0.7	1.0	1.7	0.1	0.1	0.67
Tilapia zillii	0.4	0.4	0.2	0.3	0.02	0.05	1.45
Total mean catch in kg/hr	72.1	41.2	86.7	183.5	137.3	48.8	0.50

* Calculated F-values greater than tabulated F-values at $\alpha = 0.05$ (1).

Therefore, this calls for research on food chain dynamics to enable us to understand the interpret changes in fisheries, and eventual effect from pollution.

The fishery of Nyanza Gulf now depends on *Lates* . For better management of *Lates* its biology and ecology must be understood. The fecundity of the species need to be better defined. Spawning location and substrate need to be defined by consistent and temporal sampling for a year or longer period.

Migration pattern and distribution of the fish species should be studied in Lake Victoria. This calls for a co-ordinated research amongst the East African states which own the waters of Lake Victoria.

REFERENCES:

Benda, R.S., 1979. Analysis of catch data from 1968 to 1976 from nine fish landings in the kenya waters of Lake Victoria. J. Fish Biol., 15: 385 -388.

Benda, R.S., 1981. A comparison of bottom trawl catch rates in the Kenya waters of Lake Victoria. J. Fish Biol., 18: 609-613.

Bergstrand, E. & A.J. Cordone, 1971. Exploratory bottom trawling in Lake Victoria. Afr. J. Trop. Hydrobiol. Fish. 1:13-23

Cordone, A.J. & A.W. Kudhongania, 1972. Observations on the influence of codend mesh size on bottom trawl catches in Lake Victoria, with emphasis on the *Haplochromis* population. Afr. J. Trop. Hydrobiol. Fish., 2: 1-19.

Garrod, D.J., 1960. The histroy of the fishing industry of Lake Victoria, East Africa, in relation to the expansion of marketing facilities. E. Afr. Agric. For J., 27: 95 - 99.

Jansen, E.G., 1976. The development of the Lake Victoria fisheries and possibilities for Norwegian participation. Norwegian - Kenya project Report: 210 pp.

Kudhongania, A.W. & J.A. Cordone, 1974.
Bathospatial distribution patterns and biomass estimates of major demersal fishes in Lake Victoria. Afr. J. Trop. Hydrobiol. Fish., 3: 15 -31.

Mann, M.J., 1969. A resume of the evaluation of the Tilapia fisheries of Lake Victoria upto the year 1960.
EAFFRO Ann, Rept., 1969: 21 - 27.

Marten, G.G., B. Wangale & L. Guluka, 1975. Exploratory trawling of Lake Victoria fishery in Kenya during 1975. Afr. J. Trop. Hydrobiol. Fish., (in Press).

Muller, R.G. & R.S. Benda, 1981. Comparison of bottom trawl stock densities in the inner Kavirondo Gulf of Lake Victoria. J. Fish Biol., 19: 399 - 401.

Okemwa, E.N., 1981. Changes of fish species composition of Nyanza Gulf of Lake Victoria.
Proceedings of the workshop of the Kenya Marine & Fisheries Research Institute on Aquatic Resources of Kenya, July, Mombasa, Kenya: 138 - 155 pp.

Okemwa, E.N. (1983).
Stock Assessment of fish species in Nyanza Gulf of Lake Victoria. M.Sc. Thesis, Free Univ. Brussels (VUB), Belgium. pp.30

Okemwa, E.N., 1984. Potential fishery of Nile perch Lates niloticus Linne (Pisces: Centropomidae) in Nyanza Gulf of Lake Victoria, East Africa. Hydrobiol. 108 (2); 121 - 126 pp.

Sokal, R.R. & F.J. Rohlf, 1969. Biometry. The principles and practice of statistics in biological research. San Francisco: W.H. Freeman & Co: 776 pp.

Wanjala, B. & G. Marten, 1974. Survey of the Lake Victoria fishery in Kenya. E.A.F.F.R.O. Ann Rep., 1974: 81 - 85 pp.

A REVIEW OF LAKE TURKANA FISHERIES.*

James Ogari, Kenya Marine and Fisheries Research Institute, Kisumu.

INTRODUCTION

Lake Turkana lies in an enclosed basin in the northern extension of the east branch of the great rift valley. Its approximate altitude is 400 m above sea level. The lake is nearly 260 km in length and varies from 14 km to 44 km in width, with a mean depth of about 30 m. The maximum depth already recorded is 115 m and the total surface area, estimated from an aerial survey is 8011 km.

Shorelines tend to shelve more steeply in the central sector than in the north and the inshore zones are correspondingly narrower. Shallow bays are found on the east coast, for example, Allia Bay.

Prior to the upper pleistocene period the lake level was higher and its waters overflowed to the northwest into the River Nile via the Sobat River (Worthington 1932). This past connection with the River Nile system is shown by the presence in the lake of a characteristic nilotic fauna. Since separation from the Nile the water of Lake Turkana has become increasingly alkaline. The conductivity was found to be in the region of 3,600 microhos over most of the lake. In the north it varied considerably during the year depending on the volume of freshwater entering the lake from the River Omo, the only permanent inflowing river.

ALGAE AND PRIMARY PRODUCTIVITY

Phytoplankton populations in the open water of Lake Turkana were dominated by blue-green algae and were characterized by a low species diversity. The algae were not uniformly distributed and there were marked differences in species composition between the north and the south. Primary productivity and algae biomass both showed a distinct gradient along the axis of the lake, from high values in the north to very low in the extreme south, as illustrated by the following values of gross production rate in g /m /day: northern sector 1315 - 6220; central sector 194 - 3936; and southern sector 259 - 293.

Daily rates of production varied considerably with location and with season. Primary productivity rose to a peak during the postflood season in the northern sector when Microcystis was the predominant species. This increase was due to the input of nutrients into the lake during the River Omo flood session.

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

The open water phytoplankton of Lake Turkana was almost entirely uncropped by either fish or crustacea. Postlarval Engraclicypris stellae of up to 9 mm which grazed Surirelia and similar diatoms, were the only habitual phytoplanktons in the open lake. When zooplankton populations were seasonally low in the northern sector Micralestes acutides switched to algae food and successfully assimilated Microstis. A very high proportion of the organic carbon produced by the photosynthetic activity or open water algae thus passed through a process of decomposition before it becomes available to the zooplankton in the form of detritus, and an extra step is thus added to the food chain.

Ferguson's Gulf in common with other similar inshore areas proved to have an algal flora which was quite distinct from that of the open lake. The phytoplankton was chiefly composed of blue green algae dominated by Anabaena circinalis. The gross rate of primary production was relatively high, averaging 4147 g /m /day and was thus similar to values observed in the northern sector of the main lake. However, in Ferguson's Gulf, Sarotherodon *niloticus* grazed the phytoplankton heavily, and as a result of this direct link with the primary producer, fish yields were phenomenally high.

On the sublitorial fringes of the lake rich communities of attached algae, often containing a wide diversity of species, occured on a variety of surfaces including mud, sand, rock and the leaves and stems of macrophtes. Although generally absent from loose substrates on high energy shorelines, epilithic algae grew profusely on rock surfaces subject to strong wave action. In the southern basin where phytoplankton densities were very low, attached littoral algae made a significant contribution to primary productivity and were grazed extensively by Sarotherodon and Tilapia.

The failure of fish to utilize phytoplankton in the open waters of the lake may be due to the relatively low algae concentrations. In deeper water, although primary production on an area basis is usually comparable with adjacent marginal situations, the algal cells are spread over a much greater vertical range. It seems likely that as a result of the diffusion of algal food resources in the open lake, concentrations fall below a threshold at which it is possible for phytoplanktivorous fish such as *Sarotherodon* species to feed efficiently. Results on study of anchovy larvae have revealed that, the larvae requirements include the phytoplankton density to be between 20 mg and 40 mg/l, sixe of phytoplankton species as food. The larvae could only do well in areas of high chlorophyll concentration, with no patches of phytoplankton. Unfavourable weather (Strong current) tends to disrupt the phytoplankton into patches. This may support the nonutilization of the phytoplankton within the open waters of Lake Turkana.

Zooplankton

In the absence of a well developed benthic fauna, the proportion of fish feeding on zooplankton in Lake Turkana is usually high. *Trophodiaptomous baforanus* a calanoid coppod, was the dominant species of secondary production. *Mesocyclops leuckarti* a cyclopoid copepod, was also common and ubiquitous.

Production rates of *T. banforanus* im mg dry wt/m /day for the three sectors of the lake were estimated as follows: north 13.5; central 6.2 and south 1.7. These results show that as with primary productivity there is a marked decrease from north to south. Although there was considerable regional and seasonal variation in zooplankton densities, there was general tendency for biomass to be lower in the southern sector as illustrated by mean concentration for *T. banforanus* in no/1: north 56 central 30 and south 31.

Pelagic fish densities were much higher in the central sector of the lake than in the south and it is clear that the observed level of zooplankton concentration in the central sector was the result of heavy predation. In the southern sector pelagic fish were scarce and the relatively high ratio of density to production in *T. banforanus* may be attributed to low predation rates. The results suggest that zooplankton densities in the south are close to a limiting level below which it becomes inefficient for pelagic fish to feed.

In the extreme north of the lake, population of zooplankton fell during the flood season. This may have been due to adverse effect caused by lowered salinity. However, exceptionally concentrations of zooplanktovorous fish, poarticularly *A. minutus* were noted in the area and the dearth of zooplankton may have been partly the result of overpredation. In the absence of normal food, many fish were found to have ingested scales.

The efficiency with which algal food is utilized by *Sarotherodon niloticus* in the gulf of the resultant extremely high rates of fish production were unmatched by any other area of comparable size in Lake Turkana. Thus in 1976 the production of *S. niloticus,* from an area of 10 Km in Ferguson's Gulf amounted to over 1600 tonnes.

The present studies prove conclusively that population of zooplankton over most of the lake are cropped heavily by fish and secondary producers to higher trophic levels.

Primary production in the southern sector was locally high in communities of attached algae which thrived in the littoral region down to depth of two to three metres. The algae occured ubiquitously on all shores in the southern basin, including precipitous coasts to the southwest of the lake, and were grazed extensively by *A. niloticus* and *T. zilii*

FISH SPECIES

Forty eight fish species have been identified in Lake Turkana. Twelve of these were riverine and confined to the region of the Omo River delta. The remaining 36 occur regularly within the actual lake.

The fauna is well adapted to the environmental conditions and all major trophic niches appear to be occupied, with the exception that no species of fish grazed regularly on the open water phytoplankton dominated by blue-green algae, S. niloticus which is capable of assimilating Microcystis species, the chief algal genus, is restricted to inshore areas of Lake Turkana.

Synodontis schall occured as a demersal species both inshore and offshore and fed on benthic organisms such as ostracods and molluscs. The results indicate that it was principally pelagic in distribution. The dominant demersal fish in the deeper areas of the lake was *Bagrus bayad* a species widespread in shallow riverine situation elsewhere. *A. minutus* and *A. ferox* formed the midwater scattering layer and the depth or the layer below the surface varied from one to two metre in extremely turbid water to over 30 m in the clear water of the southern sector. *Alestes baremose* and *Hydricynus foskalii* predominated in the surface waters, and *Lates longisponus* and *Schilbe uranoscope* were the principal species in a zone below the scattering layer. Further offshore, the water column between the communities describe above and the bottom was populated mainly by well dispersed adult *Engraulicypris stellae* and mature prawns, *Macrobranchium niloticus* and *Caridina nilotica*. In terms of biomass A minutus proved to be the predominant species of fish in the lake and formed an important link in the pelagic food chain between the zooplankton and predatory fish such as *Synodontis schall, Hydrocyrius forskalii* and *Lates longisponus*. The acoustic survey indicated a mean stock density of approximately 37 tonnes/km for pelagic fish in open lake at depths greater than 10 m. Estimates of the standing stock of small crustacea of the zooplankton in Lake Turkana which range with locality from 80 to 200 tonnes/km, with a mean of 120 tonnes/k^2.

Fish production and biomass varied considerably from area to area within the lake. There was an obvious tendency for stock density to decrease from north to south, which clearly parallels similar falls in primary and secondary production. The indications are that high rate of primary and secondary production led to significantly greater areas densities of fish in the northern sector than in more southerly areas, particularly inshore demersal forms such as *Labeo horie* and adult *Barbus, bynni*

Pelagic fish, which predominated in the central sector, were chiefly concentrated in the western half of the lake between the 10 m and 30 m contours. Off shore demersal populations, with *Bagrus bayad* contributed throughout the deeper waters.

Overall densities of fish were generally low in the southern sector of the lake chiefly as a result of dearth of pelagic species.

Four main communities of fish have been recognized in the main lake:

1. Littoral;
2. Inshore demersal;
3. Offshore demersal;
4. Pelagic.

Their boundaries shift seasonally and are determined chiefly by amount of illumination. A reduction in underwater illumination during the turbid flood season stimulates fish living in the subsurface layers to move near to the surface and closer inshore. Communities of littoral and inshore demersal fish are subdivisible on the basis of substrate.

1. Littoral community are restricted to an inshore belt between the lake margin and the four metre contour. *Sarotherodon niloticus*, *Clarias lazera* occur throughout. *Tilapia zillii* prefer rocky or stony shores. *Sarotherodon galilaeus* prefer soft sunstrate.

2. Inshore demersal community are bottom living fish restricted to inshore areas of the lake between the four metre contour and a depth of between 10 and 15 metres. *Labeo horie Citharinus citharus*, *Distichodus niloticus* Within this community the fishery involves mainly bottom set gillnets. The principal species are *Hydrocynus forskalii*, *Citharinus cithanus*. *Distichodus niloticus*, *Labeo*, *horie*, *Barbus bynni* and *Lates niloticus* The area of the lake is between Rivers Kerio and Todenyang; it extends offshore to the 1.5 metre contour and lies chiefly on the west coast of the lake. This is due to the prevailing southeasterly winds which has resulted in high concentrations of a small pelagic fish *Alestes minutus* and *Alestes ferox* together with their predators. There is a continual replenish supply of zooplanktonic food. It seems likely that such concentration of prey, as a result of wind action, has enabled stock densities of pelagic fish in Lake Turkana to be maintained well above levels which an evenly distributed zooplankton would support. The distribution of littoral fish was also influenced by the direction of the prevailing winds and high energy beaches on the west coast which support much smaller populations than the sheltered east coast where sublittoral beds of potamogeton developed. Although fluctuations of annual catches varied between 2,800 tonnes and 3,800 tonnes during the period 1970 - 1975 they indicated relatively stability although species composition of the catch has changed considerably. Thus the proportion of the total yield formed by *Citharinus citharus* fell from 80 in 1970 to 0.3% in 1975. This decline is attributed partly to exploitation and partly to

environmental changes in the River Omo where the spawning grounds are situated. The reduction in the discharge of the River Omo which had led to the recent net fall in lake level, is believed to have had an adverse effect on the recruitment of *C. citharus* during present decade. It seems likely that nursery grounds on the flood plains of the river have shrunk considerably as a result of the diminished flow.

In Lake Turkana total catch has been maintained at its current high level due to expansion into new areas, but chiefly by reduction in mesh size which has tended to increase the species diversity of the catch (table 1). Thus in 1974 Labeo horie and Bagrus bynni caught mainly in five and six inches nets, together contributed 41% of the total catch. With the attraction of unusually high catches in Ferguson's Gulf, fishermen began to move into the area from communities throughout the entire inshore fishery. By mid-1975 over 75% of all Lake Turakana fishermen had concentrated in Ferguson's Gulf as a result, fishing effort fell considerably in the inshore gillnet fishery. Future developments clearly depend on the stability of the *Sarotherodon* fishery in Ferguson's Gulf, but if it fails, fishermen will return to the inshore fisheries of the main lake. It is considered that the effects of the current reduction of efforts will be beneficial to the inshore gillnet fishery. As recommended below legislation should be introduced to limit stretched mesh size to a minimum of six inches.

Tilapia Fishery

Since early 1975 an exceptionally important gillnet fishery for *Tilapia*, (*Sarotherodon nilotics*) have developed in the Ferguson's Gulf area which has attracted a high proportion of the total fishermen in the lake. Thus by August 1976 a total of 121 canoes and 420 rafts were operating an estimated total of 6,332 gillnets within the confines of the gulf. Catches increased considerably with a total of 1,966 tonnes in 1975 increasing to an estimated 16,100 tonnes in 1976. Since the fish are concentrated in an area of approximately 10 sq. km this represents a yield of 16,610 tonnes/sq, km. During 1975 a variety of stretched mesh sizes principally from three to five inches, were in use, but during early 1976 legislation was introduced which limited mesh sizes to a minimum of five inches.

This was largely due to the annual increase in water level of approximately one metre which occured between late July and October within the marginal areas of the lake as a result of the Omo River floods. On shorelines where flat terrain fringed the lake as at Ferguson's Gulf and at Kerio, a zone upto 800 metres wide was thus inundated annually. In certain years, when the lake shores were lightly grazed by domestic stock, extensive areas of grassland were covered into shallow temporary marshes by the rising water and provided a source of shelter for fish particularly young *niloticus*

During 1974 it was estimated that a total of 304 tonnes of large cichlids were caught in seine nets on the east coast. A minimum mesh of five inches stretched mesh should be employed.

Table 1. Annual fish catches in Lake Turkana

Year	Metric tonnes
1974	5731
1975	4236
1976	17044
1977	15473
1978	15560
1979	13731

REFERENCES

1. A.J. Hopson (1975). Bottom trawling in Lake Turkana. Symposium on the hydrobiology and fisheries of Lake Rudolf. Molo 25th - 29th May, 1975.

2. E.B. Worthington (1932). Scientific results of the Cambridge expedition to the East African lakes 1930 -1931. Introduction and station list, J. Linn. Soc. Zool.

Table 3. Mean of 30 monthly samples in kg/hr by fish species in Outer Nyanza Gulf for the period January 1979 - December 1981.

Location	Outer Nyanza Gulf						
Year	1979		1980		1981		
Number of months	10		10		10		
Number of hauls	122		132		152		
	Mean	S.D	Mean	S.D	Mean	S.D	F-test
Bagrus docmac	9.2	8.3	4.7	8.0	4.1	4.5	0.68
Clarias mossambicus	0.4	0.5	0.2	0.3	8.4	3.1	10.94*
Haplochromis spp.	57.4	27.6	10.2	14.4	9.5	15.8	4.92
Labeo victorianus	1.9	0.7	0.8	0.8	0.4	0.2	0.62
Lates niloticus	0.4	0.1	0.1	0.1	63.9	78.7	1.09
Protopterus aethiopicus	0.0	0.0	0.1	0.1	0.0	0.0	1.88
Synodontis afrofischeri	0.2	0.1	0.1	0.1	0.1	0.1	0.49
Synodontis victoriae	1.4	2.0	0.8	1.2	0.6	0.5	0.37
Oreochromis niloticus	0.2	0.1	17.3	22.6	4.4	7.5	1.22
Sarotherodon variabilis	3.0	3.6	0.6	0.9	0.02	0.05	2.09
Tilapia zillii	0.0	0.0	1.9	2.5	0.0	0.0	0.00
Total mean catch in kg/hr	74.1	13.7	36.8	12.2	91.4	70.0	0.37

* Calculated F-values greater than tabulated F-values at α 0.05 (1)

A REVIEW OF SOME LIMNOLOGICAL ASPECTS OF LAKE TURKANA

Fred Wambayi - KMFRI Turkana Laboratory

HYDROLOGICAL BALANCE

The influence of the inflow from river Omo on the general Lake level is very significant since in a year when its discharge is of low magnitude or even short duration, the Lake may rise slightly or remain stationery, and when the discharge is high as was the case in 1961 a rise in level of as much as 100/cm may be observed, reports Butzer (1971).

In general however, observations of the years 1949-1962 (Butzer 1971) and 1972-1973 (Hopson 1974 indicate that the Lake drops at a rate of 17-18/cm a Month from July to december, this is most likely due to evaporation and underground trickling since no surface outflow exists. If the figure of 18/cm is extrapolated to cover the whole year, it is envisaged that there is a loss of water of approximately 16 x 10 /m per annum and therefore river Omo, being the biggest source of discharge, should discharge into the Lake a volume of similar magnitude every year to counter the loss.

From this figure of discharge, it is calculated that the residence time of Lake Turkana is approximately 13 years. And the critical residence time is about 1.4 years. On the basis of these information one can predict that, if the discharge from river Omo is held back, as is partially the case at the moment, then it will take a little over 13 years for the Lake to dry out completely. An indicator to the fast drying out can be about 2/3 in the last eight years from a size of 35 sq. km reported by Hopson in 1974.

LAKE TEMPERATURE

Lake Turkana with its great depth shows a small range of water temperature between the surface and the bottom as shown below:-

Temperature Range (C)		
Surface	*(0.5 m)*	*27 - 28.9*
Subsurface	*(5.0 m)*	*26 - 27.7*
Bottom	*(80 m)*	*25.5 - 26.1*

Surface temperature are however greatly influenced by insolataion and wind induced turbulence so fluctuations may be very high even within two successive days. Thermal stratification is occasionally observed, but the thermoclines are usually temporary, forming quickly on calm days and breaking up rapidly when the conditions are rough.

The absence of chemical stratification in the Lake is manifested of the polymictic nature of Lake Turkana. The only exception, however is the Ferguson Gulf which is protected from wind disturbances and is therefore permanently stratified.

LAKE CONDUCTIVITY

Lake Turkana does not exhibit a big conductivity gradient from one portion of the lake to the other. Vertical stratifications are also absent. There is however seasonal variation in conductivity due to the influx of water from river Omo at flood time in which case the values of conductivity particularly in the Northern part of the Lake may drop considerably. The freshwater then spreads gradually Southward thus affecting the conductivities of the Central and Southern portions of the Lake.

The mean values of conductivity are between 3400-3700 uS/cm, but the Ferguson's Gulf maintains a value of 4700uS/cm. The Northern sector during the flood period records as low as 200uS/cm. (Hopson 1982). Compared to other alkaline saline Lakes in Rift Valley, namely Bogoria, Elmenteita and Sonachi, it is found that conductivity values of Lake Turkana are very low.

These three shallow Lakes have similar hydrological patterns as Lake Turkana and also share a similar range of PH, and sodium is the principal as in Lake Turkana (Mellack et.al 1982). Below is a comparison of mean value of PH and conductance of the four Lakes.

	PH	CONDUCTANCE (uS/cm)
Lake Sonachi	9.6	4650
Lake Bogoria	10.1	18,800
Lake Elmenteita	10.4	71,000
Lake Turkana	9.3	3,500

For a Lake that has an enclosed basin like Lake Turkana and which has been in existence for over 7500 years, very high conductivity values would be expected. Infact derivation from residence time of the Lake and ionic loading into the Lake by river Omo, suggests that there is supposed to be annual increase of conductivity in the Lake of 6 us/cm/year. Geological evidence however reveals that the rate is in the region of 0.45 us/cm/year (Hopson 1975), which infact is more realistic. That the rate is curtailed from 6 uS/cm/year may be attributed to excessive infiltration of ions into the Lake sediments and therefore maintaining a relatively low Lake conductivity level.

Bouchardeau (1962) reports that a similar phenomenon was observed in Lake Chad which also has an enclosed basin. The rate of increase in conductivity of 0.45 uS cm year is considered to be very minimal and is unlikely to affect the Lake fishery in the near future.

LAKE WATER CHEMISTRY

Lake Turkana is regarded as an alkaline saline Lake because of its sodium, carbonate, and chloride dominated nature (Beadles 1932, Talling & Talling 1965, Fish 1954, Mellack 1981). The sodium ions form 95% of the major cations, followed by Potassium, Calcium and Magnesium in that order. It may be of interest to note that the Sodium dominated nature of the Lake owes its origin from the river Omo whose catchment area produces water rich in Sodium (Hopson 1982). Being a closed basin, it is likely that salinity of Lake Turkana will continue to increase, but it is difficult to predict what changes will occur due to the increase and at what rate the changes will take place. Like many alkaline Lakes in E.Africa the anionic composition of Lake Turkana is predominated by bicarbonate and carbonate (Mellack 1982). About 90% of the inorganic carbon must therefore be in the form of bicarbonate since the Lake Turkana PH is about 9.3 (Hutchison 1957).

Chloride is the other important anion but sulphate, phosphate and floride are in minute quantities

BIBLIOGRAPHY

1. Beadles, L.C. (1932) - Scientific results of the cambridge expedition to the East African Lakes 1930-31. The waters of some East African Lakes in relation to their fauna and flora. J.Linn. Soc. (Zool), 38: 157-211.

2. Bouchardeau, A. (1962) - The polders of Lake Chad: physical aspects of their development. CCTA/CSA London.

3. Butzer, K.W. (1971) - Recent history of Ethiopian delta. Univ. Chicago Dept. Geog. Res. paper No. 136, Chicago.

4. Fish, G.R. (1954) - Chemical analysis of L. Rudolf E.Afri. Fish. Res. Org. Rep. 1953: 27.

5. Hopson, A.J. (1974) - Progress report of 1974 on Lake Turkana project.

6. (1975) - Bottom trawling in Lake Turkana. Symposium on the hydrobiology and fisheries of Lake Rudolf. Molo 25th-29th May, 1975

7. (1982) - A report on the findings of the Lake Turkana project 1972-1975. Overseas Dev. Adm. London 1982, Vol. 1-6.

8. Hutchisons, G.E. (1957) - A treatise on Limnology, Vol. 1, New York: Willey.

9. Mellack, J.M. (1981) - Photosynthetic activity of phytoplankton in tropical soda Lakes. Hydrobiol. 81: 71-85 (1981). Dr. Junk Publ. The Hegue: Netherlands.

10. Mellack, J.M., Kilham, P., Fisher, T.R. (1982) Response of phytoplankton to experimental fertilization with Ammonia and phosphate in an African soda Lake. Oecologia (Berl) (1982) 52:321-326.

11. Talling J.F. Talling - I.B (1965) - the chemical composition of African Lakes. Int. Rev. Ges. Hydrobiol. 50: 421 - 463.

THE RELEVANCY OF METEOROLOGY TO THE DEVELOPMENT AND UTILIZATION OF AQUATIC RESOURCES *

E.A. Mukolwe, Kenya Meteorological Department, Nairobi, Kenya

INTRODUCTION

The importance of aquatic resources in the world today is recognized but there is an urgent need to refine the efficiency of the application in practice of meteorological knowledge and information in the field of aquatic resources.

Those aquatic resources that need meteorological input for their development and utilization can be classified as follows:-

1. Aquatic life - which can be developed and utilized for food, clothing and tourism.
2. Aquatic deposits - which include mineral resources such as fossil fuels.
3. Ocean water - which can be used as a source of fresh water and energy.

The different activities and processes that are required in development and utilization of these aquatic resources determine the meteorological consideration that come into play. In this espect, this paper discusses the meteorological input in the development and utilization of the various aquatic resources, each of which is considered separately.

Aquatic life

These include, among others, fish, crocodiles and birds. Each species of life has its own suitable weather conditions for survival at its various stages of development, for example, those species whose life stages begin with the laying of eggs need calm waters with suitable temperatures (for incubation). By the time the eggs hatch, there must be sufficient food, possibly in the form of plant life (algae), for the young creatures that are incapable of fast movement. Similarly, the growth of such plants is determined by weather parametres such as temperature, light and water salinity.

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

It is important, however, to note that particular weather conditions may be favourable for more than one species of life. This is necessary for the species which prey on others for survival.

Meteorological input in the form of studies of surface wind systems and water temperature is definately vital for the development and utilization of these species. Through such knowledge, it is possible to map out breeding areas of any given species.

It is normal for some of these creatures to migrate from one area to another in search of food, hibernation and safety. In most cases, the time of migration is chosen to coincide with relatively strong prevailing winds and/or ocean currents for ease of movement towards the required grounds. If the weather conditions of the eventual settlement areas and those enroute are known, a good estimate on the population of those species can be made. It should be noted that in addition to mapping out the actual weather conditions, prediction (forecast) of weather conditions such as cyclones, cold or warm airmasses and frontal systems which may pass through breeding and settlement areas greatly helps in estimating the population yield of aquatic life. It is then possible to estimate the harvest for food or clothing and to plan and establish tourist resorts in advance.

In the case of species which do not migrate from their breeding area, there are certain weather conditions during which reproduction does not take place. Consequently, the harvest of such species should be planned carefully.

Having determined fishing areas, fishermen are kept informed of the existing weather conditions by the issurance of regular weather bulletins by meteorological centres. These bulletins include weather phenomena such as the prevailing wind direction and speed, thunderstorms. sea fog and visibility, and the general state of the sea. Accordingly, fishermen are able to plan their routes including amount of fuel required and the weight they can carry. Warnings of approaching storms and any adverse weather conditions are also issued on a regular basis to avoid disasters.

It might also be necessary to set up processing substations near fishing grounds. To establish such substations, weather conditions, including likely weather hazards (storms and rough seas),of the area have to be known. In this respect, accumulated climatological data presently available with the meteorological department can be used.

Aquatic Deposits

These include minerals (both suspended and dissolved in sea water, and also at the bottom of oceans) and oil.

Minerals are likely to be deposited and accumulated in regionswhere the seas are normally calm with a large deceleration of water flow. After predetermining sea areas where deposits are likely to be accumulated, surveys are often conducted to determine how much of the deposits are available and whether exploitation would be profitable. The surveys are normally carried out by sampling by ships, photography by aircraft or by satellite. If the survey is by ship, the shipping weather may be issued to the crew. In the case of surveys by aircraft which must fly low, special weather forecasts (as opposed to the usual forecasts for normal aviation purposes) must be issued. Areas with sea fog, low clouds, frontal systems (associated with adverse weather conditions), and low level jetsreams (associated with marked turbulence) are predicted in advance by the meteorologists and should be avoided by the crew. Photography by satellite is also possible where there is not much cloud over

Any installation should be strong enough to withstand adverse conditions of wind, temperature, water acidity and storms. Meteorological information on these conditions has to be available for any proper planning and construction. It should also be noted thst offshore drilling for oil depends very much on ocean wave systems. Studies have to be carried out to relate wind strength to the ocean waves which can also be harnesses to generate energy. The transportation of any product to the shore has to be planned to coincide with favourable weather conditions.

Ocean Water as a Source of Fresh Water and Energy

The fresh water processed from ocean water is used mainly for irrigation and domestic purposes. The processes involved are desallneaction and splitting of sea water molecules to provide energy. The required meteorological information are similar to the ones for installation of a site, as mentioned above.

Pollution

In all these aquatic activities, water pollution, as a result of factors such as oil spills, can be a major hazard, particularly to aquaric life and to the use of ocean water as a source of fresh water. The study of surface wind systems helps to predict the movement of pollutants over water surfaces and hence, helps prevent their spread over large areas.

Man-made emissions into the atmosphere significantly affect the chemical composition of the air and precipitation and hence, the ocean, lake and river waters. This has made it important to study the distribution of these emissions and to establish their natural concentration levels. To do thid, it is vital to carry out a study of atmospheric circulation.

It is important to note that, at present, the Kenya Meteorological Department is running a precipitation chemistry project and is playing a leading role in the setting up of a baseline pollution monitoring station on Mount Kenya.

CONCLUSION

It is clear that an understanding of marine meteorology is a necessary requirement in the development and utilization of aquatic resources. As a result of inadequate meteorological data over ocean areas, this branch of meteorology has lagged behind other branches of the science in this country, just like in many others. However, with the limited data now available throught satellite, bouys and ships, some of the difficulties are being overcomed and more meteorologists are becoming more and more interested in marine meteorology. It is consoling to note that the Kenya Meteorological Department has already taken steps to train personnel in the field of marine meteorology. This will definitely contribute to the development and utilization of aquatic resources in this country and, possibly, elsewhere.

What a welcome move, considering the fact that all human and animal activities are influenced, to a great extent, by meteorological factors!

APLICATION OF GEOPHYSICS TO AQUATIC RESOURCES EXPLORATION

J.M. Ndombi, Physics Department, University of Nairobi.

INTRODUCTION

Over recent years the need to identify, develop and utilize the available aquatic resources within the Kenya territorial waters have been recognized. The aquatic resources include the plants and animals that constitute aquatic life which may be utilized mainly as a source of food; the mineral fossil fuels that constitute the aquatic deposits which may be utilized mainly as a source of energy, the ocean water which may be utilized mainly as a source of fresh water as well as energy.

In order to achieve the goal of identifying, developing and utilizing the available aquatic resources it is first of all most important to understand the environment in which these resources exist. This includes the understanding of the physical characteristics of aquatic bodies. Geophysics plays an important role in mapping the geometry and spatial distribution of aquatic bodies. Geophysics techniques are used to map the depth of the water in an aquatic environment and hence the topography of the crust that underlies it. The topography of the bottom of an aquatic body has a direct bearing on the availability of plant and animal aquatic life forms.

Geophysical techniques are also used to map the geologic structure of the crust that underlies an aquatic body. It is known that certain geological structures are normally associated with the occurence of certain mineral deposits; for example, fossil fuels (oil and gas) are normally associated with geological anticlines in sedimentary rock. Thus by mapping the geological structure underlying an aquatic body it may be possible to detect the presence of certain mineral deposits.

A geophysical survey normally consists of a set of measurements, usually collected in a systematic pattern over the Earth's surface by land or sea. In many cases more than one method is used to survey the area of interest and an integrated interpretation of the data is made. The main geophysical techniques with application to the exploration of aquatic resources are outlined below. These include thermal, seismic, magnetic and gravitational techniques. There are other geophysical methods available for aquatic resource exploration, but these are of limited application and are not outlined here.

THE THERMAL TECHNIQUES

Temperature plays an important role in the development of both plant and animal aquatic life forms. Certain temperature ranges are suitable for the breeding and growth of certain plant and animal species while temperature below and above certain ranges retard the growth of or even ruin certain aquatic life forms.

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

It is therefore important to carry out temperature survey within the Kenya lake bodies as well as ocean waters to determine the temperature characteristics of these aquatic bodies and further to carry out studies of the relationships that occur between the temperature characteristics of these aquatic bodies to the quality and quantity of aquatic life forms in those bodies. It is from the results of such studies that we can determine what types of aquatic life are suited to what temperature environment. A temperature survey can be easily carried out by the use of temperature probes lowered from suitably constructed boats at predetermined locations.

From the deep aquatic environments the temperature at depth is influenced by the heat flow from the interior of the Earth. Diurnal and seasonal temperature variations have a less marked effect on temperature distribution. The heat flux from the interior of the Earth is determined by measurement of the temperature gradient at the bottom of aquatic body and the thermal conductivity of the rock at the bottom of the aquatic body. Survey to carry out such measurements from boats have been carried out in some of the Kenyan lakes and in the Indian Ocean.

Temperature and heat flow values have an influence on the type and rate of mineralization occuring in aquatic environments. For example, warm temperatures are favourable for the accumulation of fossil fuels, hydrothermal environments are suitable for the deposition of mercury etc. Some of these minerals occur in economically exploitable quantities; while others, if present above certain concentrations, may effect the safety of the aquatic life's utilization, e.g., as a source of food.

It is therefore, important to be able to identify the kind of temperature - related mineralization that may be present in an aquatic body and to evaluate its impact on the utilization of the available aquatic resources.

Current research is exploring ways of utilising the temperature gradient between the warm surface and the cold near bottom water in an aquatic environment for the generation of electrical energy. If advances in this area prove fruitful then data acquired from the thermal mapping of aquatic bodies could be readily utilized in determining suitable locations for siting such energy generating plants.

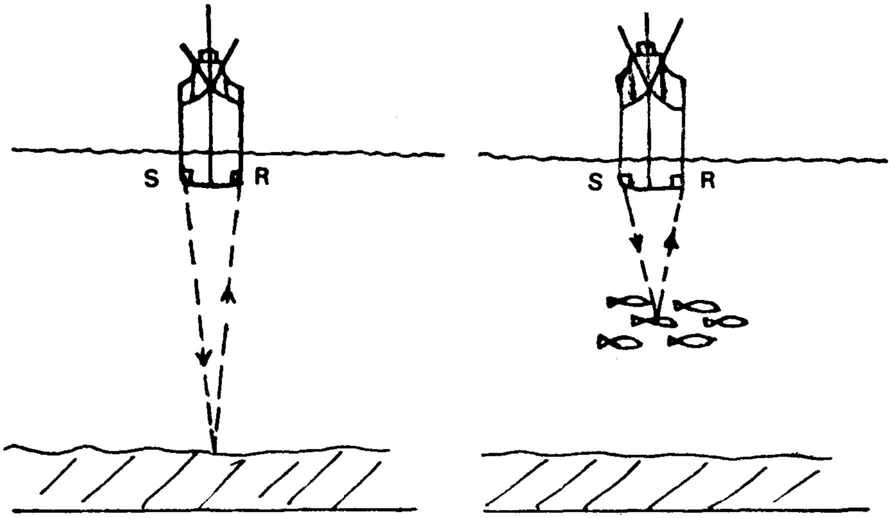

Figure 1. Ech-sounding in marine geophysics

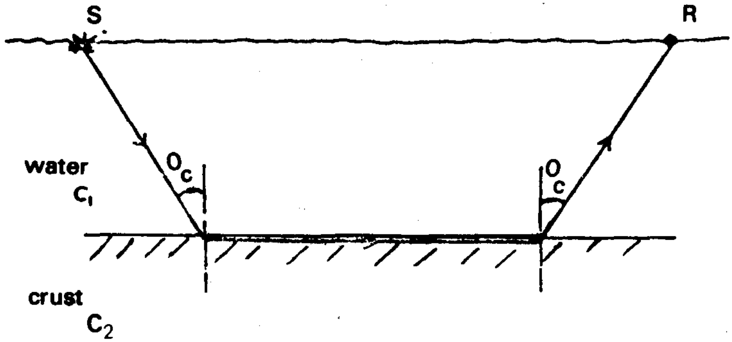

Figure 2. Critical ray path. The seismic signal travels in the crustal layer after refraction.

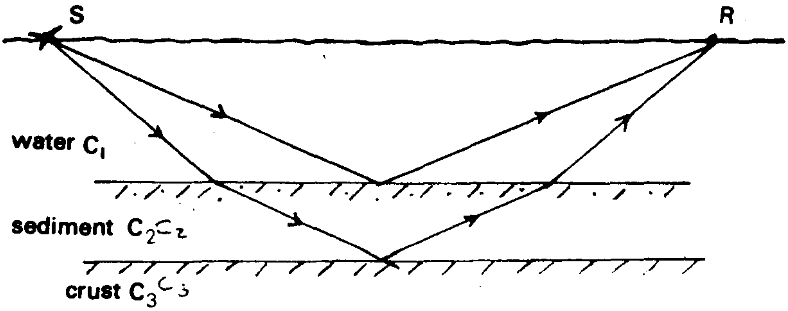

Figure 3. Seismic Reflection system

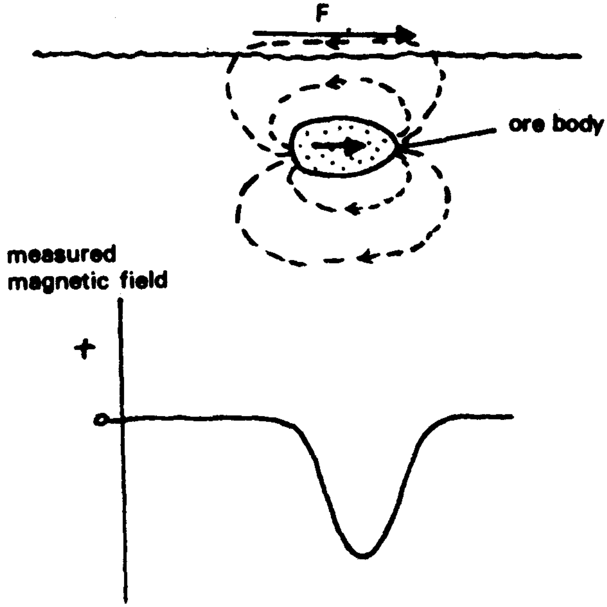

Figure 4a. Negative magnetic anomaly due to magnetization in direction of earth's magnetic field F.

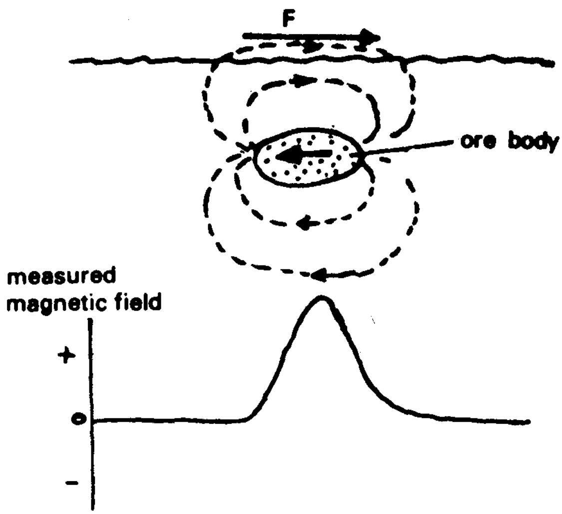

Figure 4b. Positive magnetic anomaly due to magnetization in opposition to F.

SEISMIC TECHNIQUES

The seismic technique is the most powerful geophysical tool used in determining the depth of an aquatic body as well as the geological structure of the underlying crust. It can also be used in fisheries to identigy shoals of fish. In the active seismic exploration technique elastic waves are normally genetated from a source such as explosion, placed at the water surface. These waves travel outwards in all directions. The elastic waves may travel directly to a detector, such as a geophone, known as the receiver. Other elastic waves may travel through the water and other striking an appropriate obstruction are reflected back to the receiver while others travel through the water and are refracted or reflected at the water crust and upon subsequent refraction or reflection they travel through water again to the receiver. In a seismic experimen the distance between the source and the receiver is accurately determined and the travel-time for the elastic waves from the sources to the receiver is accurately measured. This data is then interpreted in terms of the depth of the water, the thickness of the crustal layers underlying the water and the elastic wave velocities in the water and underlying crust.

An echo-sounder measures the time of seismic wave signal to travel from the source to an appropriate obstruction such as the sea floor or a schoal of fish (figure 1) and back to the receiver. The known elastic wave speed is then used to convert the travel-times to depths. A depth sounder normally consists of a seismic wave source and reciver located close to each other.

In cases where the source and receiver are some distance apart the elastic wave signal may arrive at the water-sediment interface at some critical angle Oc (figure 2). The signal will be refracted so as to travel within the underlying crustal layer parallel to the water/crustal interface. The signal later undergoes a second refraction so as to travel through the water to the receiver. If the elastic wave velocity C_2 in the underlying crustal layer is greater than the elastic wave velocity, C_1, in the water then beyond some critical distance between the source and receiver the refracted wave will be the first signal to arrive at the receiver. From accurate measurements of the travel time of this first arrival and the source-to-receiver separation at time-distance plot can be made. From this data the depth as well as the dip of the water-crustal interface can be determined. Values of the elastic wave velocities C_1 and C_2, in the water nd underlying crust can also be determined.

The seismic reflection method is used to measure elastic wave velocities as well as the thickness of the sediments constituting the crust immediately underlying an aquatic body. In a seismic reflection experiment many reflection transmission are used as the distance from the source to receiver is varied. From a record of the travel times and source to receiver separations the time-distance graphs are drawn. This date is used in constructing models of horinzontally stratified geologic sequence of the crust underlying an aquatic body with each layer having a characteristic elastic wave velocity.

The seismic method is used in exploring aquatic environment depends upon the problem to be solved. In the straight forward mapping of the depth to the water-sediment interface the echo-sounding method is adequate. It is by determining this interface that we can map the topography (bathymetry) of the crust underlying a particular aquatic body and if the topography is known then we can determine the most suitable sites for finding certain aquatic life forms and use this information to develop related industries such as fishing. The seismic reflection method offers a cross-check to the echo-sounding method as well as offering information on the physical properties of the sediments that immediately underlie the water in an aquatic environment. Over a period of time we can monitor the effect of the rate of sedimentation at selected lcations and their effect on the available aquatic resources.

The seismic reflection method is also used in determining the geologic structure of the crust underlying aquatic resources. It is used to map the deeper geologic structure underlying an aquatic body which may have some bearing to the occurrence of minerals or fossil fuel resources in that environment.

THE MAGNETIC TECHNIQUE

The geophysical technique is used to map any magnetic bodies that underlie aquatic bodies. The method relies on the fact that iron-bearing bodies tend to be more magnetic than the surrounding rock. In certain cases the concentrations of iron in such a body may be in large enough quantities to warrant economic exploitation.

The direction of magnetization in an iron-bearing rock will be either in the direction of the present arch's field or will be in a direction opposite to that of the present field depending on the time period which the rock acquired its magnetization .If the rock is magnetized in the same direction as the present Earth's field then its magnetization will act in opposition to that of the present field (fiigure 4a). However, if the rock is magnetized in a direction opposite to that of the present field then its magnetization will act in a manner that will reinforce the Earth's field (Figure 4b). Opposition to or reinforcement of the Earth's field due to iron-bearing body at a given location will result in the deviation of the measured magnetic field from its normally smooth regional trend in any given area. Such a deciaton is known as a magnetic anomaly.

In the magnetic method the magnetic field over the area of interest is measured either from an aeroplane (the aero-magnetic method) or from the land or water surface (ground magnetics). In an aquatic environment magnetic prospecting is done by towing a magnetometer behind a boat and the magnetic field is measured along predetermined profiles. The magnetic anomalies due to localized sources are separated from the smooth trending Earth's magnetic field in the surveyed region. The separated anomalies are then interpreted in terms of variations in magnetization in the sub-surface below the surveyed region. The amplitude and wave length of the magnetic anomalies will depend on the size, shape, depth of burial, and magnetic properties of the causative body. In a survey for iron-bearing deposits these physical parameters can be used to assess the economic potential of mining such an ore-bodu. In prospecting for fossil fuels the magneti method is mainly used to map the basement rock which is usually more magnetic than the overlying sediments. The shape and depth of the basement rock sheds some light on the thickness and shape of the overlying (fossil fuel bearing?) sedimentary layers.

THE GRAVITY TECHNIQUE

In this method the Earth's gravity field is measured over a given region and any variations in the gravity field is interpreted in terms of lateral variations in the subsurface densities which are in turn related to the geological structure. In the absence of lateral variations in density the gravity field ought to show a smooth regional trend. The presence of dense localized bodies will result in negative gravity anomalies, these anomalies can be isolated from the regional field and interpreted in terms of physical parameters of the causative bodies. The anomalous body may be an ore-bearing formation or a geologic structure suitable for fossil-fuel bearing environment. Geological and/or other geophysical information is needed as a constrain if useful solution are to be obtained.

CONCLUSION

The general application of the main geophysical techniques that are relevant to the exploration of aquatic resources are discussed. The application of each, or a combination of two or more, of these techniques will depend on the problem under investigation. Some of these techniques have already been applied for aquatic resource exploration in Kenya both in the lake bodies as well as the coastal waters. However, systematic and integrated geophysical investigation of the Kenyan aquatic resources is of prime importance in understanding our aquatic environment and assessing the economic potential of our aquatic resources.

A STATE OF FISHERY IN NYANZA GULF OF LAKE VICTORIA, EAST AFRICA

Ezekiel N. Okemwa,
Kenya Marine & Fisheries Research Institute,
P.O. Box 81651,
MOMBASA, Kenya,
East Africa.

Keywords: Nyanza Gulf, Mean catch rates,
Total catch, Lates niloticus,
Haplochromis, tilapia

Abstracts:
The endemic fishery in Nyanza Gulf of Lake Victoria has signs of severe overfishing. Bottom trawls were made in Nyanza Gulf from January, 1979 to December, 1981. Haplochromis spp. were collected infrequently in very low numbers and disappeared in Zone I and II in 1981. Lates dominated the catch. A hierarchical model showed that there are zonal and seasonal differences in Nyanza Gulf on fish species.

INTRODUCTION:

Earlier studies on the ichthyofauna of Lake Victoria (Bergstrand & Cordone 1971; Cordone & Kudhongania 1972; Kudhongania & Cordone 1974 and Marten et al., 1975) reported that the bionic and commercial contribution of the *Lates niloticus* to the ichthyofauna of Lake Victoria was insignificant, whereas *Haplochromis* spp. were significant. Cordone & Kudhongania (op. cit.) and later Kudhongania & Cordone (op. cit) observed that their sampling vessel "Ibis" was too large to operate in waters shallower than 6 m which meant that more than 50% of the surface area of Nyanza Gulf which is less than 6 m deep, was not trawled.

The importance of the Nyanza Gulf to the nutrition of the Kenyans around the Lake Basin region has shown that freshwater fish represents the largest single source of animal protein consumed. About 60,000 people depend directly on the fishery of the Gulf (Jansen, 1976). There are nearly 2,000 fishing boats (Canoes) within Nyanza Gulf and about the same number outside the Gulf (Wanjala & Marten, 1974). There is, however, a greater emphasis on seines inside the Gulf and large mesh gillnets outside the Gulf (Wanjala & Marten, op. cit.).

With the increasing human population in Western Kenya, it is of great importance to compare trawl catch rates in Nyanza Gulf, to find out whether there are changes in the fish stocks requiring different management techniques for maximum sustainable yield.

MATERIALS AND METHODS:

The study area is shown in Fig. 1 A description of the study are given by Okemwa 1983.

Fish were collected with an 85 hp diesel powered fibreglass trawler utilizing a conventional bottom trawl with a 13.7 m headrops and 36 mm mesh throughout. Three sets of replicate hauls were taken monthly in each of the fourteen sampling locations in Nyanza Gulf of Lake Victoria (okemwa, 1981). Sampling was carried out monthly from January, 1979 to December, 1981. The catch was sorted to species and weighed

Mean monthly catches for each fish species were tabulated in kilogramms and means, variances and standard deviations calculated. Due to the heteroscendasticity of standard deviations a logarithmic transformation, was utilized to permit the use of a two way analysis of variance (ANOVA model II to test simultaneously the differences among several populations and assigning to the various factors which effect the measured character their relative roles. A hierarchical model was formed to show the relationship between the factors and the fish species. Sokal & Rohlf, (1969) was used for all statistical methods.

RESULTS AND DISCUSSION:

Tables 1 through 3 list the yearly mean catch rate in kg h by species and by zones in Nyanza Gulf for the period January, 1979 to December, 1981 and shows that some species are increasing, while others are declining. The mean catch rates for the fishes in all zones show a decrease during the time the study was undertaken except for exotic species (Lates niloticus and Oreochromis niloticus) which increased (Tables 1-3). More than 90% of the catch by weight was lates in Zone I and II, during the period this study was undertaken.

Nested ANOVA with unequal sample sizes was calculated on a hierarchical model on species and season in Nyanza Gulf.
The following summarized differences were determined:
1. Catches in Zones. A significant zonal difference by species was found with Fs - 9.014 and Fo.ol (2,11) - 7.21. The zones show an added variance among fish species in this study and may be caused by ecological factors.

2. Catches in Seasons. There was a difference among species which was significant Fs - 19.979 with Fo.1 (11,42) - 2.70. The season in this case show an added variance among fish species in Nyanza Gulf. The Two-way Analysis of variance was also used to test differences among locations, fish species and time. The result is summarized below:-

1. Total Catch. There were differences in total catch in all locations during the period 1979 to 1981 (F - 7.701 and 1.821; df - 14 and 70; P<0.001). Time had a great influence in the course of the difference.

2. Lates Catch. lates showed a significant difference among the locations and the months of (1979-1981) (F - 3.804 and 3.817; df - 2 and 12; P<0.001).

3. *Haplochromis* spp. Catch. There was a significant difference in mean monthly catch rate of Haplochromia spp. in all location during the period (1979-1981) (F - 32.271 and 11.034; df - 5 and 14; P 0.001). *Haplochromis* spp., *Bagrus docmac*, *Clarias mossambicus* and *Protopterus aethiopicus* were collected in most hauls in 1979 from all zones in Nyanza Gulf, except *P. aethiopicus,* which was not collected from Zone I and III. In 1981, *Haplochromis* spp., *C. mossambicus* were collected infrequently and in very low numbers from Zone I and II, whereas they appeared in great numbers in Zone III (Tables 1-3)

Bergstrand & Cordone (1971) recorded a mean catch of 200.2 kg h from 19 hauls made in zone I with a 38 mm codand. Marten et al. (1975) trawling in the same zone got a mean catch of 231.9 kg h from 69 hauls, whereas the present survey caught a mean value of 45.5. kg h from 433 hauls using a similar net. Non-cichlids constitute over 9.0% by weight of Nyanza Gulf Samples. Another comparison of the total mean catch rates for this study and 63 hauls from zone I and II (Benda, 1981) showed an increase in catch rate. The increase were 3 and 2 times for zone I and II respectively.

Predator fishes like Bagrus and Clarias constitute over 3% of 1981 mean catch rate (86.2 kg h) in zone I, but reached 14% of the same year mean catch rate (91.4 kg h) in zone III. The decline of Clarias and Bagrus in Nyanza Gulf may be attributed to competition from the introduced Lates which may be occupying the same niche with them. The efficient predator is likely to dominate the area, and it seems Lates is proving to be the one. The catch rate of 63.9 kg h in zone III in 1981 (Table 3) was obtained at Luanda Naya and Mbita (Shallow areas (0-10m)) and not in deep waters (20-30 m).

Sarotherodon. esculentus, previously the fish of greatest commercial importance in Nyanza Gulf in the 1950's (Garrod, 1960), has vitually disappeared from much of the Lake. During this study two specimens of S. *S. esculentus* were caught.
S. leucosticus ostictus was found in zone III at 3 m depth. *S. Variabilis* and *Tilapia zilli* were found in the depth range of (0-9)m. *Oreochromis niloticus* inhabited a wider depth range of (0-14) m in all zones. Very few numbers of *Alestes* spp., Mastacambelus frenatus and *Shilbe mystus* were caught in the Gulf during the period 1979-81. *Xenodarias* spp. was only found in zone III in 30 m depth, while *Mastacambelus frenatus,* had the narrowest bathymetric distribution (0-4) m in zones I and II

Fish total catch has been increasing during the three years of study. This increase is attributed to Lates. Lates is accepted as a food fish by the inhabitants of the Lake Basin (Okemwa, 1984). Since the rest of the fish species are declining drastically (Gerrod, 1960; Mann, 1965; Wanjala & Marten, 1974; Benda, 1979; Muller & Benda, 1981; Okemwa, 1981), Lates alone cannot continue to sustain the fishery of Nyanza GUlf because of about 60,000 people who depend directly on the fishery of the gulf (Jansen, 1976). It is suggested here that fishing of Lates can continue, meanwhile the people around the Lake shores are encouraged to establish fish ponds around Nyanza Gulf and use Lake

Research needs:
To give a clear explanation why endemic fishes in Nyanza Gulf have disappeared is difficult. Secondly no previous ecological baseline studies are available upon which to base any argument and comparisons.
Therefore, this calls for research on food chain dynamics to enable us to understand and interpret changes in fisheries, and eventual effect from pollution.

The fishery of Nyanza Gulf now depends on Lates. For better management of Lates, its biology and ecology must be understood. The fecundity of the species need to be better defined. Spawning location and substrate need to be defined by consistent spatial and temporal sampling for a year or longer period.

Migration pattern and distribution of fish species should be studied in Lake Victoria. This calls for a co-ordinated research amongst the East African states which own the waters of lake Victoria.

ACKNOWLEDGEMENTS:

I am greatly indebted to the laboratory technicians, Master fisherman and the crew of Kenya Marine Research Institute for their help in the field.

My sincere thanks are also due to Dr. Meirte St. Royal Museum for Central Africa Tervuren, Belgium; and Dr. Herman of State University of Ghent, Belgium for statistical help.
Miss Mary Oula kindly typed the paper.

REFERENCES:

Benda, R.S., 1979. Analysis of catch data from 1968 to 1976 from nine fish landings in the Kenya waters of Lake Victoria. J. Fish Biol., 15: 385-388.

Benda, R.S., 1981. A comparison of bottom trawl catch rates in the Kenya waters of lake Victoria. J. Fish Biol., 18: 609-613.

Bergstrand, E. & A.J. Cordone, 1971. Exploratory bottom trawling in Lake Victoria. Afr. J. Trop. Hydrobiol. Fish., 1: 13-23.

Cordone, A.J. & A.W. Kudhongamia, 1972 Observations on the influence of codend mash size on bottom trawl catches in Lake Victoria, with emphasis on the Haplochromis population. Afr. J. Trop. Hydrobiol. Fish., 2: 1-19.

Garrod, D.J., 1960. The history of the fishing industry of Lake Victoria, East Africa, in relation to the expansion of marketing facilities. E.Afr. Agric. For. J., 27: 95-99.

Jansen, E.G., 1976. The development of the Lake Victoria fisheries and possibilities for Norwegian participation. Norwegian - Kenyan project Report: 210 pp.

Kudhongania, A.W. & J.A. Cordone., 1974. Bathospatial distribution patterns and biomass estimates of major demersal fishes in Lake Victoria. Afr. J. Trop. Hydrobiol. Fish., 3: 15- 31.

Mann, M.J., 1969. A resume of the evolution of the Tilapia fisheries of fisheries of Lake Victoria upto the year 1960. EAFFRO Ann. Rapt., 1969: 21-27.

Marten, G.G., B. Wangala & L. Guluka, 1975. Exploratory trawling of Lake Victoria fishery in Kenya during 1975. Afr. J. Trop. Hydrobiol. Fish., (in Press).

Muller, R.G. & R.S. Benda, 1981. Comparison of bottom trawl stock densities in the inner Kavirondo Gulf of Lake Victoria. J. Fish Biol., 19: 399-401

Okemwa, E.N., 1981. Changes of fish species composition of Nynza Gulf of Lake Victoria. Proceedings of the workshop of the Kenya Marine & Fisheries Research Institute on Aquatic Resources of Kenya, July, Mombasa, Kenya: 138-155 pp.

Okemwa, E.N. (1983)
Stock Assessment of fish species in Nyanza Gulf of Lake Victoria. M.Sc. Thesis Free Univ. Brussels (VUB), Belgium. PP.30

Okemwa, E.N., 1984. Potential fishery of Nile parch Lates niloticus *Linne (Pisces: Centropomidae) in Nyanza Gulf of Lake Victoria, East Africa. Hydrobiol. 108(2); 121-126 pp.*

Sokal, R.R. & F.J. Rohlf, 1969. Biometry. The princeples and practice of statistics in biological research. San Francisco: W.H. Freeman & Co: 776 pp.

Wanjala, B. & G. Marten, 1974. Survey of the Lake VIctoria fishery in Kenya.
E.A.F.F.R.O. Ann Rep., 1974: 81-85 pp.

Table 1. Mean of 21 monthly samples in kg|hr by fish species in Inner Nyanza Gulf for the period January 1979 - December 1981.

Location	Inner Nyanza Gulf						
Year	1979		1980		1981		
Number of months	7		7		7		
Number of hauls	107		161		73		
	Mean	S.D	Mean	S.D	Mean	S.D	F-test
Bagrus docmac	4.3	2.9	1.9	0.9	1.35	1.52	3.90*
Clarias mossambicus	3.5	3.4	11.9	0.9	1.4	1.5	1.41
Haplochromis spp.	6.6	10.3	0.6	0.4	0.0	0.0	2.24
Labeo victorianus	0.03	0.05	0.05	0.05	0.0	0.0	2.06
Lates niloticus	33.6	17.3	87.4	37.4	73.8	25.1	8.06
Protopterus aethiopus	0.0	0.0	0.05	0.05	0.67	0.16	0.73
Synodontis afrofischeri	0.3	0.4	0.1	0.1	0.03	0.05	1.67
Synodontis victoriae	0.10	0.1	1.3	1.9	2.1	3.1	1.35
Oreochromis niloticus	0.3	0.3	2.0	1.9	3.4	3.8	2.41
Sarotherodon variabilis	0.4	0.4	0.3	0.4	0.0	0.0	2.77
Tilapia zillii	0.1	0.2	0.02	0.04	0.0	0.0	1.67
Total mean catch in kg/h	46.1	26.1	93.9	36.6	86.2	22.1	4.71*

* Calculated F-values greater than the tabulated values at - 0.05 (l(

Table 2. Mean of 30 monthly samples in kg/hr by fish species in Middle Nyanza Gulf for the period January 1979 - December 1981.

Location	Middle Nyanza Gulf						
Year	1979		1980		1981		
Number of months	10		10		10		
Number of hauls	138		148		170		
	Mean	S.D.	Mean	S.D	Mean	S.D.	F-test
Bagrus docmac	9.1	4.4	1.1	1.0	0.3	0.3	14.40*
Clarias mossambicus	1.0	1.0	0.6	0.6	0.3	0.4	0.95
Haplochromis spp.	10.2	5.6	1.0	1.4	0.0	0.0	12.09*
Labeo victorianus	0.7	0.4	0.7	1.4	0.1	0.0	0.05
Lates niloticus	43.1	37.4	74.1	69.8	124.2	97.4	1.05
Protopterus aethiopicus	4.3	7.5	0.2	0.4	0.2	0.3	1.32
Synodontis afrofischeri	0.5	0.6	0.6	0.5	0.1	0.2	1.25
Synodontis victoriae	0.8	1.4	0.2	0.3	0.1	0.1	3.53
Oreochromis niloticus	1.4	0.7	7.0	6.8	11.9	9.7	1.80
Sarotherodon variabilis	0.6	0.7	1.0	1.7	0.1	0.1	0.67
Tilapia zillii	0.4	0.4	0.2	0.3	0.02	0.05	1.45
Total mean catch in kg/h	72.1	41.2	86.7	183.5	137.3	48.8	0.50

Table 3. Mean of 30 monthly samples in kg/hr by fish species in Outer Nyanza Gulf for the period January 1979 - December 1981.

Location	Outer Nyanza Gulf						
Year	1979		1980		1981		
Number of months	10		10		10		
Number of hauls	122		132		152		
	Mean	S.D	Mean	S.D	Mean	S.D	F-test
Bagrus docmac	9.2	8.3	4.7	8.0	4.1	4.5	0.68
Clarias mossambicus	0.4	0.5	0.2	0.3	8.4	3.1	10.94*
Haplochromis spp.	57.4	27.6	10.2	14.4	9.5	15.8	4.92
Labeo victorianus	1.9	0.7	0.8	0.8	0.4	0.2	0.62
Lates niloticus	0.4	0.1	0.1	0.1	63.9	78.7	1.09
Protopterus aethiopicus	0.0	0.0	0.1	0.1	0.0	0.0	1.88
Synodontis afrofrischeri	0.2	0.1	0.1	0.1	0.1	0.1	0.49
Synodontis victoriae	1.4	2.0	0.8	1.2	0.6	0.5	0.37
Oreochromis niloticus	0.2	0.1	17.3	22.6	4.4	7.5	1.22
Sarotherodon variabilis	3.0	3.6	0.6	0.9	0.02	0.05	2.09
Tilapia zillii	0.0	0.0	1.9	2.5	0.0	0.0	0.00
Total mean catch in kg/hr	74.1	13.7	36.8	12.2	91.4	70.0	0.37

* Calculated F-values greater than tabulated F-values at - 0.05 (l).