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9. ABSTRACT

The University of Dar es Salaam hosted this conference on marine resource development as a major step toward founding a center for marine resources at the university. Included in this conference report are the opening and closing addresses, and the papers presented with their supplementary comments. These papers were divided into three main groups: 1) marine resource potential and needs of Eastern Africa, 2) marine resource programs at the University of Rhode Island and their possible applicability to program development, and 3) planning an institute for marine sciences for Eastern Africa. Following the presentation of papers, the participants formed four groups: 1) a steering committee; 2) a marine affairs, coastal management and marine advisory services workshop; 3) a resource economics, sociology, and food and nutrition workshop; and 4) a marine sciences and ocean engineering workshop. The function of these groups was to present general recommendations for the implementation of the marine resource development center. These recommendations also are included in this report.

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Dar es Salaam, Tanzania
April 4-9, 1974

Editors
A. S. Msangi
J. J. Griffin

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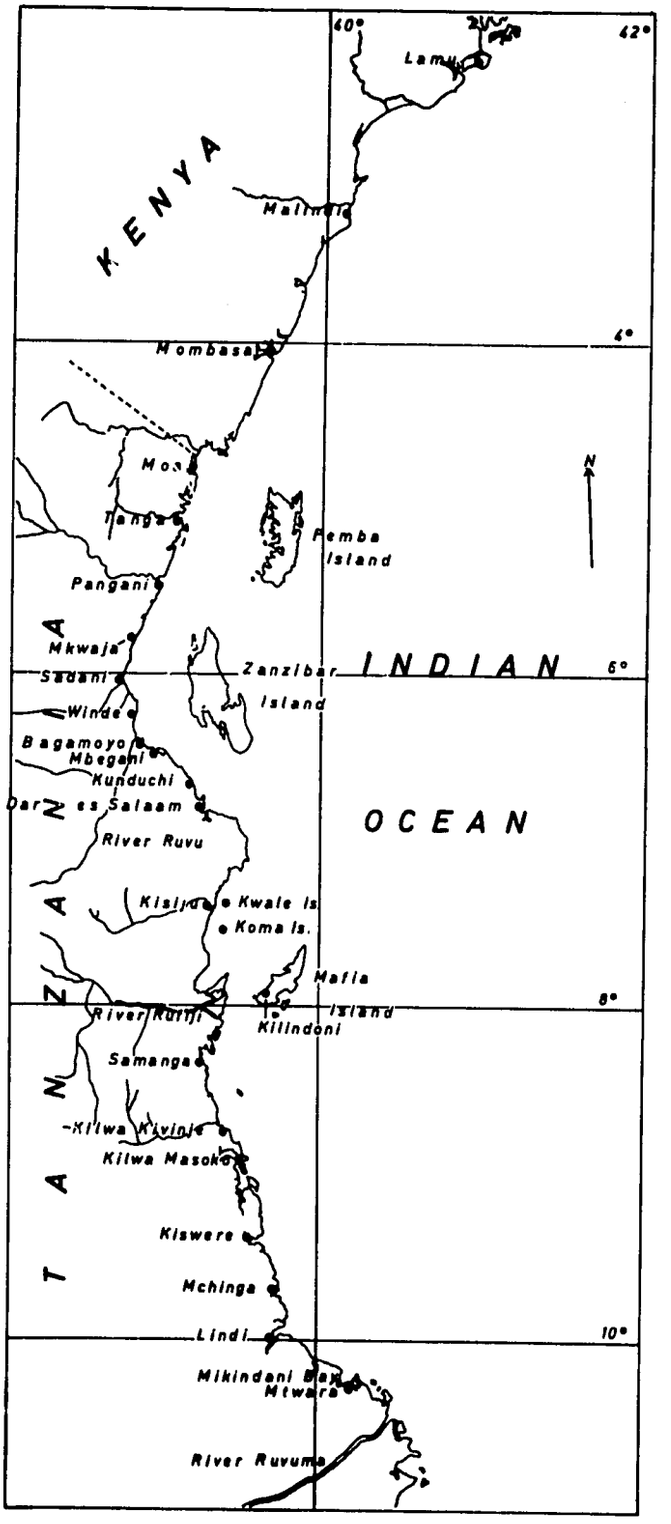
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River Ruvuma

Preface

The idea of assessing the needs for and capabilities of marine resources development in Eastern Africa through an area conference with outside participants evolved over a considerable length of time. It was developed through extended discussions on the part of the University of Dar es Salaam and the University of Rhode Island and ultimately involved a widening circle of individuals and organisations from many nations. But it was soon apparent in discussions that while some conceptual and technical input from the outside university, foundations and international communities could be effective in advancing area marine resources development, Eastern African interest, impetus and detailed knowledge would be the keystone of success.

Therefore, the International Conference on Marine Resources Development in Eastern Africa was convened April 4, 1974, at the University of Dar es Salaam, where international and area attendees with interdisciplinary marine interests addressed themselves to the problem.

The results of their deliberations became specific recommendations for the establishment of a centre for marine resources development in Tanzania. This centre would establish a knowledge base for conservation and rational utilisation of both human and material resources for national purposes and with application to regional needs. These recommendations are presented in section one.

The Rapporteurs' summary in section one provides a concise statement of conference input, output and deliberations, while sections two and three document the rich data presented by the conference participants upon which subsequent actions were based. Supplementary comments which were not given as formal papers have been summarised for intent, as have the discussions.

Section four gives the flavour of the conference deliberations and shows the cooperative give-and-take in the evolutionary development process. The truly international composition of the conference can be seen from the list of participants in the appendix.

It is hoped that this documentation of efforts will not only serve the needs of specific marine resources development in Eastern Africa, but will also provide details of the first steps of a working model applicable to the worldwide need for sharing technologies.

Acknowledgements

The University of Dar es Salaam and the University of Rhode Island are deeply grateful to the numerous individuals and organisations who helped make this International Conference on Marine Resources in Eastern Africa an outstanding success.

Concurrent with the conference, visits to the fine facilities of the university, the Fisheries Division, the general marine community and the Tanzanian water world (both above and below the surface) served to enhance the contribution of the outside participants. Special thanks go to the government of Tanzania and its many manifestations involved with the successful conduct of the conference.

Special thanks are extended to AID for grants to assist in the publication of these proceedings.

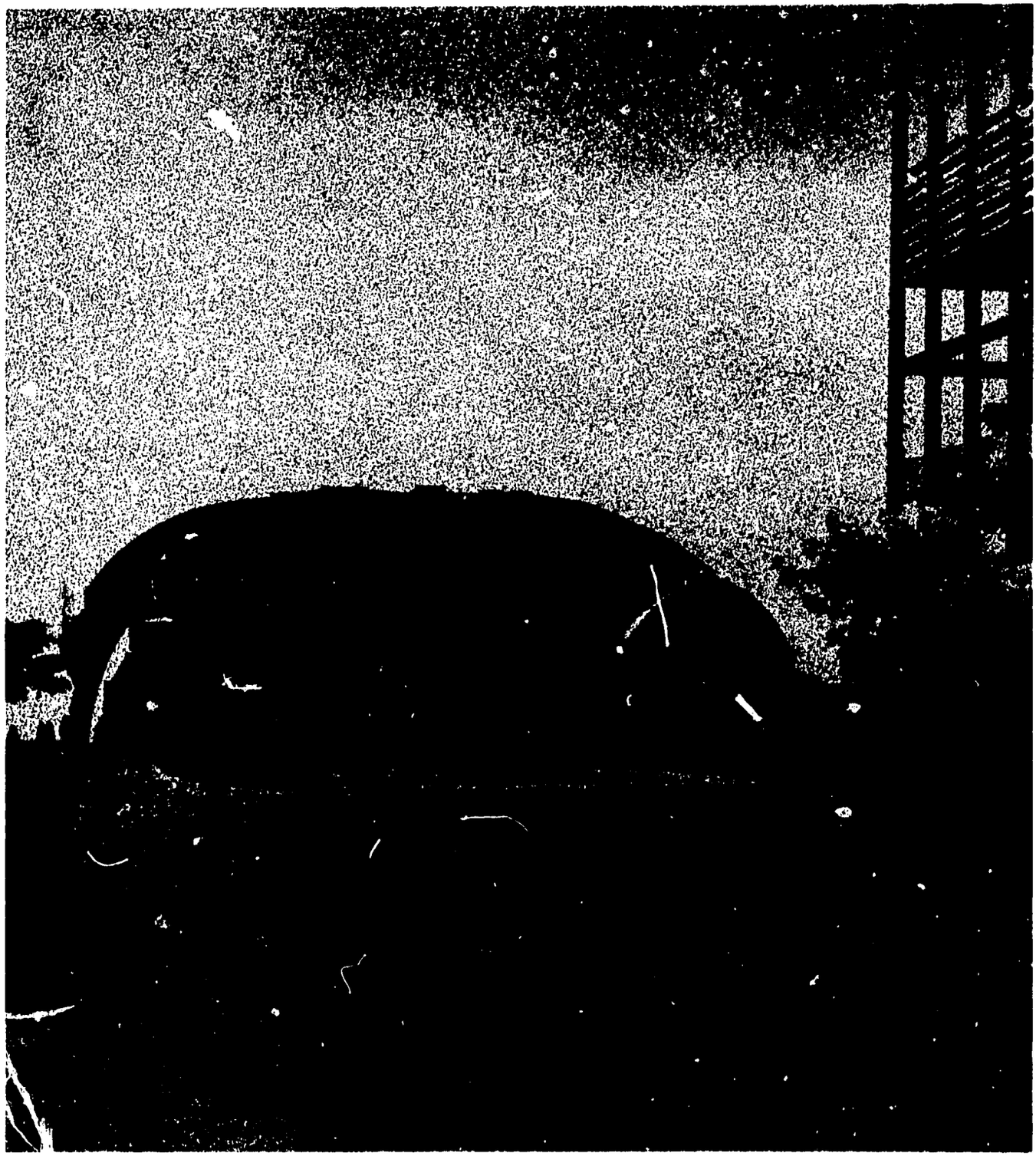
The monumental task of preparing the papers for publication involved substantial effort from the authors, especially Dr. R. Pollnac, W. B. Rudman and Dr. D. C. Krause, detailed editing by L. Anderson assisted by J. Alexander, and massive typing efforts by M. Carman, V. Bowerman and S. Pazis.

Additional copies of this publication are available from the Marine Advisory Service, University of Rhode Island Narragansett Bay Campus, Narragansett, Rhode Island 02881 USA

To the people of Tanzania and their future—
uhuru, umoja na maendeleo
(freedom, unity and progress)

Introduction

1



Conference Recommendations

Following the presentation of papers, the participants in the conference formed into four groups: (1.) a steering committee, (2.) a marine affairs, coastal management and marine advisory services workshop, (3.) a resource economics, sociology, and food and nutrition workshop, and (4.) a marine sciences and ocean engineering workshop. The function of these groups was to present general recommendations for the implementation of a marine resource development centre at the University of Dar es Salaam.

General Recommendations

The steering committee made the following recommendations, which were accepted by participants in the conference:

To foster a growing capability for developing the marine resources of the eastern coast of Africa, the University of Dar es Salaam should establish a centre for marine resources studies.

The centre should be established in response to the commitment by the university and by the government of the United Republic of Tanzania to serve the region in marine resources studies of broad scope. It should also serve as an educational supporting unit for staff in marine resources research and administrative programs along the east coast.

While under the control of the University of Dar es Salaam, the Centre for Marine Resources Studies should be organised so as to assure that neighbouring institutions in the region, including universities and government departments, participate in its activities.

The centre should be organised within the University of Dar es Salaam as a coalition of faculty participants from as many different departments as might be interested in and capable of contributing to the diverse aspects of marine resources studies. Further, the provisions for such participation should be open-ended to take advantage of expanding interests when funding support and opportunities permit. Initially, the university departments and faculties most concerned would be botany, chemistry, sociology, zoology, law, geology, economics, engineering and geography.

A broader scope of faculty capability could, and should, be realised by establishing, under proper academic controls and in all cases attached to existing academic departments, adjunct or affiliate faculty positions for persons with needed expertise in the employ of programs outside the university.

High priority should be given to developing capability at the university to meet local needs in the marine resources area. But in the beginning it will be necessary to attain initial competence by having a well-conceived program of training abroad in advanced studies, and also by having faculty members from abroad serving the university in advanced education and in local academic staff development.

It would be appropriate that the centre be headed by a director who with a staff should have such responsibilities as: (1.) working through the Vice-Chancellor's office to refine and otherwise work out the details of the broader organisational concepts presented herewith; (2.) coordinating university departments, affiliates and visiting academicians; (3.) exerting leadership for curriculum and research programme planning within the university to achieve the goals of the centre, and (4.) promoting the overall development of the centre, its programmes and facilities.

The most efficient means of implementing this programme would be to amalgamate into the proposed centre all the marine facilities at Kunduchi. It is hoped that negotiations with the Fisheries Division could be undertaken as soon as possible. This would provide an ideal start-up physical plant, with the addition of an appropriate docking facility such as a pier or a jetty.

The conference welcomes the plans of the East African Marine Fisheries Research Organisation (EAMFRO) to set up a substation adjacent to the university's Kunduchi Marine Station. Expressed intentions that this substation have aquaculture among its priorities would seem highly compatible with the priorities of the centre.

Such country planning documents as the upcoming

five-year plan should incorporate the development of the centre.

Refinement of implementation suggestions should be the responsibility of a working group set up under the auspices of the University of Dar es Salaam. This group would work out a development programme based on the broad recommendations of the conference and the submissions of the working groups, taking account of the buildings, equipment and manpower now available and likely to be available in the near future, including sources of assistance from outside.

The various workshops also presented general recommendations for the implementation of a marine resource development centre at the University of Dar es Salaam. Among these recommendations were the following:

The University of Dar es Salaam should carry out an assessment of previous and ongoing research in marine resource development in Tanzania. This assessment should include information pertaining to all relevant areas (e.g., marine sciences, ocean engineering, marine affairs, coastal management, resource economics, food and nutrition, and sociology). This information is to be obtained from all relevant institutions and agencies.

The mechanisms of cooperation between the institute and other organisations such as the Fisheries Institute, the University of Nairobi, Makerere University, EAMFRO, the Indian Ocean Fisheries Commission, etc., should be strengthened. Cooperation in this context means the exchange of scientific information among these various institutions and organisations.

A function of the University of Dar es Salaam should be to catalyse the programs in training, research and extension in the field of marine sciences.

While the institute shall address itself to national problems, it would be useful to find out the extent to which neighbouring countries such as Somalia, Kenya and Uganda could participate in its programmes.

Recognising that long-term viability and success of the institute rest on the availability of and commitment by local staff, a programme should be established to attract, recruit and train nationals who will constitute the *core personnel* of the institute. Consequently the role of expatriates will be to augment the work of the local staff. Furthermore, it is suggested that facilities at the institute be made available to visiting scientists who with their own funding desire to work there.

The institute at the university should arrange national seminars to get all people involved in exchanging ideas and setting directions. Frequently these should be held with fishermen.

It is recommended that the director of the institute and his advisory committee study the background papers presented in this conference to extract relevant information for the selection of the institute's activities.

All activities at all levels should be related to the goals of Tanzania.

Guideline Recommendations

The workshops made further recommendations pertaining to their specific areas of interest. These recommendations are to be viewed as guidelines and should not constrain any creative efforts on the part of the institute itself.

Marine Affairs, Coastal Management and Marine Advisory Services Workshop

It was felt that a centre for marine resources at the University of Dar es Salaam would be useful in three areas: marine affairs, coastal management and marine advisory services.

Marine Affairs—by undertaking research, providing training and giving advice to the government in sciences dealing with marine resources and adjacent subject areas, including ecological, economic, sociological and legal aspects thereof, utilisation of non-renewable natural resources, etc. This advice could be a basis for the conservation, management and utilisation of coastal and marine resources.

Coastal Management—by undertaking inter-disciplinary coastal and marine surveys which would lead to rational utilisation of the renewable natural resources on sustained yield bases as well as the exploitation of non-renewable resources and other development schemes compatible with the renewable ones.

The "coastal zone" as a resource covers interacting terrestrial and marine habitats including coastal plains, estuaries and mangrove forests. Moreover, river basins and their utilisation are of importance to the productivity of coastal and marine resources. Management of coastal and marine resources includes restoration, conservation and utilisation programmes dealing with these resources.

In addition to economic and sociological considerations in development planning of coastal and marine areas, ecological considerations have to be included with due regard to the relations between resources, such as estuaries, mangroves and coral reefs, on one side and pelagic and benthic living populations of marine organisms on the other, through food chains and the various habitats which these populations use during different life stages.

Marine Advisory Services—by disseminating all kinds of information derived from the work of the institute through appropriate channels.

Marine Science and Ocean Engineering Workshop

Suggested disciplines of development include, among others: fisheries biology and mariculture; chemical, biological, physical and geological oceanography; and ocean and environmental engineering.

Resource Economics, Sociology and Food and Nutrition Workshops

Economics. It is recommended that the centre pursue the following areas of research in development: (a.) production economics and various exploitation systems with a view toward assessing the economic potential of all renewable and non-renewable marine resources; (b.) marketing technology and economics of marketing to identify marketing failures and required technology and development, and (c.) social and economic infrastructures required to support marine resource development at the community level. It is important to recognise that all the above activities be integrated.

The development of marine resource potentials is at best a compex task. Whatever the immediate development objectives—improving fishermen's incomes, producing additional protein at low cost or earning hard currency through export—a fundamental appreciation of present systems is required. This appreciation must include information regarding the economic and social structure of the community, inasmuch as the institutions and relations among groups must often be changed in the national or community interest. In addition, there are a host of economic parameters that, apart from institutional structures, must be known to permit effective criticism of practice as well as the evaluation of plans. Whatever the ultimate use of the information, it must encompass a spectrum of interests from the fundamental issues of local community units to those of the largest corporate structure.

The training of research workers to the Master of Science level with specialties in agricultural economics would be a useful starting point.

The program of research should at the outset focus on either the marketing and distribution system or production and vessel operations. Both are in need of research effort. As time permits, careful consideration needs to be given research into the social and economic infrastructure of marine-related communities.

These studies could provide a factual basis for evaluating the prospect of change and its feasible directions by pinpointing technical shortcomings, institutional failures and human interests. In further assessing such aspects of the marine economy, the researcher girds himself for the more difficult task of evaluating possible changes in the system.

It is after all our concern in development to make matters "better" in some sense consistent with aspirations of the people. Normally "more protein" is consistent with their interest and aspirations. However, such apparently straightforward objectives rarely prove tractable in any simple sense. The task of evaluating alternative ways of achieving such a goal is that of social scientists in cooperation with their natural science colleagues; the final determination of policy by the nation or region will, we hope, gain from the effort.

Food Science and Nutrition. A food science and technology department should be established at the university. Its role would be training, research and extension work. It would also work closely with governmental and other agencies related to food and nutrition in the country.

Fish handling, processing, product development and marketing acceptability studies should continue to take place in collaboration with the centre. High level manpower should be trained for coordinating training and extension work in the field of food science and technology. Research priorities should be set in collaboration with agencies working in the same field. Research and training priorities in this field should follow the course indicated by Mr. Maembe in his paper at this conference.

Sociology. It is recommended that socio-cultural studies be conducted in a wide range of marine-related communities (e.g., stratified on the basis of degree of involvement in fishing, success or failure of *ujamaa* projects, etc.). These studies should include assessments of: (a.) general socio-cultural data such as age, sex, education and occupational structure of the population; (b.) social structure (e.g., power relationships, communication networks, etc.), and (c.) attitudes toward the present technology and technological change.

The existing data should be assessed as soon as possible, and research should be initiated to provide relevant information that is not available. It is further suggested that these investigations be conducted during various stages of the developmental process to evaluate factors associated with the success or failure of the specific programmes.

As noted above, these recommendations are to be understood as guidelines for the implementation of a marine resources development centre at the University of Dar es Salaam. Refinement and implementation suggestions should be the responsibility of a working group set up under the auspices of the University of Dar es Salaam.

Rapporteurs' Summary

D. Krause, *UNESCO, Paris,*
W. B. Rudman, *University of Dar es Salaam*

The University of Dar es Salaam hosted this conference on marine resource development as a major step toward founding a centre for marine resources at the university. Such a centre would provide essential research, advice and personnel needed for the development of Tanzanian marine resources and could have strong cooperative ties with sister universities in Kenya and Uganda and with the East African Marine Fisheries Research Organisation.

The core of the conference consisted of discussions between Tanzanian representatives and advisors led by Professor A. S. Msangi, head of the Department of Zoology at the University of Dar es Salaam, and representatives of the University of Rhode Island (URI), led by Professor Nelson Marshall, director of the URI International Center for Marine Resource Development. The discussions concerned the application of the experience and expertise of the University of Rhode Island to an evaluation of Tanzanian resources and problems, both natural and human, and to recommendations for a centre to meet those problems.

The conference also provided a forum for representatives from other East African universities and governments; from the Economic Commission for Africa (ECA); from United Nations specialised agencies, such as the Food and Agriculture Organisation (FAO), Educational, Scientific and Cultural Organisation (UNESCO), and the Environmental Program (UNEP), and from funding organisations of Canada and the United States.

The first two days of the conference consisted of the presentation of the status of Tanzanian marine resources followed by a presentation of the organisation and programmes of the University of Rhode Island. The third day was devoted to workshops concerned with the establishment of the proposed centre. Finally, the last day was devoted to reports and recommendations.

Conference Keynote Address

In the conference opening, the Honourable S. E. Chiwanga, Minister of National Education, emphasised that the key to using Tanzania's potential wealth to improve the lot of her people is through the proper use of science and technology. He expressed hope that the conference would come up with a way to develop Tanzania's considerable marine resources to contribute to her economic stature.

The Honourable H. Makame, Minister of Natural Resources and Tourism, strongly emphasised the importance the Government of Tanzania attaches to this conference and the topic under discussion. All participants were assured that their expertise, advice and proposals would be considered seriously by the government.

Marine Resource Development in Tanzania

The presentation of Tanzanian marine resources centered about her fisheries and the diversity of her coastal resources and their uses. For example, the artisan fisheries of Tanzania are mainly concentrated on the well developed fringing coral reef and its "lagoon," which parallels most of the Tanzanian coast. Although the fringing reef is very productive, its area is small. Hence, fishing pressure is high with the result that unsound fisheries practices have developed (i.e., dynamiting) which threaten the reef itself. The reef fisheries do consist of highly diverse fauna, and over a very long period of time the artisan fishermen have evolved diverse and specialised techniques to use there.

But with the high fishing pressure on the reef and lagoon, simple modern improvements such as mechanisation through the use of outboards will not greatly increase the catch. Hence, the pelagic and demersal fisheries of the open, but narrow, shelf and beyond must be developed if the catch is to be greatly increased to provide protein for the national diet and to provide foreign exchange. At present the coastal fisheries provide much less fish than do the large inland lakes like Victoria and Tanganyika.

The country's estuaries and mangrove forests also are important to marine productivity because of their role in the food chain and as habitats for organisms which pass later life stages offshore.

Moreover, in terms of potential resources, a deep-sea fishery for tuna in the Western Indian Ocean evidently exists, but would require a highly technical operation for exploitation. Potential marine turtle and dugong resources were emphasised. It was suggested that a survey of their status in Eastern Africa should be undertaken which would lead to a programme of restoration, conservation, management and utilisation on a sustained yield basis.

The final area of potential concerns mariculture. The coastal mangroves, estuaries and shallow lagoons and bays form good habitats for mariculture. A Japanese team has recommended two areas as initial experimental sites: Udofu Creek near Tanga and Msinga Creek near Dar es Salaam.

All of the above fishery resources and potential resources require a base of research and personnel for exploitation and management. The reef fisheries are in urgent need of management; this not only requires a knowledge base that is lacking, but also requires new policies. The marine reserves are an important aspect of such management, not only for conservation and tourism, but also for the natural recruitment of fisheries stock. In the latter case, the reserves need only be a fraction of the total reef. (A simplified equation was introduced to estimate the state of exploitation of the fisheries.)

The hydroelectric project of the Rufiji River presents a strong probability of changing the sedimentational and hydrological regime of the delta and, hence, its prawn fishery; thus, its potential environmental effects should be carefully investigated. The shelf and open-sea fisheries are largely unknown, and a thorough assessment is required to define how exploitation is to proceed. The habitats of the coastal area need to be thoroughly investigated in support of experiments in mariculture.

Fisheries development can go forward only in close harmony with processing and marketing. Much waste occurs through inadequate processing so that a real increase in available protein can occur through proper handling, storage, sterilisation, packaging, etc. However, great care must be maintained so that the price of the fish is not increased out of reach of the general population. Mariculture does not generally produce low-cost protein; however, it needs little foreign exchange, hard currency capital or foreign technology and is especially appropriate to a developing nation.

The programme for boat mechanisation and new boat construction does recognise that fisheries development must include an assessment of marketing and processing problems.

Finally, it was brought out that the coastal area has abundant other resources and uses—harbours, beaches, sand and gravel, minerals, building sites, etc. The problems of pollution from petroleum (both local and high seas), sewage, industrial waste and dredge dumping need evaluation. All of these aspects also require a knowledge base and personnel for exploitation and/or management.

Marine Resource Programmes

Science. The structure and operation of the marine resources programme at the University of Rhode Island were outlined. The URI programme is broadly interdisciplinary, cutting across the entire structure of the university and including such diverse disciplines as basic oceanography, fishermen training, resource economics, international law and sociology. This wide programme gives URI a focus usually lacking in a conventional university set up.

Different universities have found it necessary to adopt other models because of varying local conditions. The most successful models are those with strong support from the given university. The URI model has numerous aspects which seem relevant to the situation at the University of Dar es Salaam, and three points appear essential in developing a sound marine sciences programme in East Africa:

1. The adoption of an interdisciplinary approach drawing on staff from both inside and outside the university.

2. The strengthening of the cooperative relationship existing among the universities of the region through sharing of training and research facilities on marine sciences.

3. The development of mutually beneficial links with institutions and universities in other parts of the world.

It was pointed out that one area for strengthened cooperation already exists. Ship time and other facilities of EAMFRO are available to University of Dar es Salaam staff when possible.

The marine experiment station at Rhode Island operates in the field of marine sciences, in particular marine biology, fisheries biology, other marine experimental work and aquaculture. In comparison, the present activities of the Kunduchi Marine Biological Station are concentrated in four areas considered of greatest concern: plankton, coral reefs, benthos and fisheries biology.

An ocean and environmental engineering programme can divide problems into four classes conferees were told: (1.) availability and use of resources, (2.) design and use of structures and machinery, (3.) information gathering and transmission, and (4.) pollution. Plans for developing the study of geology at the University of Dar es Salaam were outlined, including some of the possible fields of exploitation of the marine environment in Eastern Africa—in particular oil exploration both offshore and inshore and the mining of beach gravels and sands.

Economics. The importance of involving economists very early in the planning of any development programme was emphasised. It was felt that it was not enough to call in an economist to show where programmes went wrong or to choose the best of two bad alternatives. The economist should be as much involved in the early planning of a programme as the biologists, engineers and sociologists.

An economist and planner working in Tanzania must not have a scheme which needs a large team of trained manpower—these people are not available. Four priority areas were suggested:

1. Basic information must be gathered. The days of exploration of Tanzania's marine resources have just begun. Not only must new resources be found, but more knowledge about known resources must be obtained.

2. Both the research workers and those who benefit from the research should learn something.

3. Manpower in existing institutions must be used effectively.

4. Studies must be integrative.

Fishermen must be assisted in integrating their occupation with another, as fishing is no longer a full-time occupation. Moreover, ways of providing facilities and services to fishing communities must be found.

Coastal Management. The discussion of coastal management emphasised its broad interdisciplinary nature, including the place of marine science in the structure. These matters are the concern of the University of Rhode Island's Coastal Resources Center and its Ma-

rine Affairs curriculum, and these appear relevant to Tanzania's needs in handling her escalating interest in pollution, exploitation of coastal resources, etc.

The pertinence of a UNESCO report due in 1975 was discussed in response to its resolution 1802 (L V), which requests area plans for coastal development.

Food. A general review of the world food problem and the relevance of the work of the University of Rhode Island in this area included four points:

1. The world food problem is becoming more severe because of improper distribution, waste and improper utilisation. Many countries with severe malnutrition problems have an abundance of available animal protein in their areas. However, utilisation is either poorly developed, or much of the protein is exported to the well-fed nations of the world.

2. Within the field of marine food science and technology, URI is studying the utilisation of marine species either for direct human consumption as fresh food or in preserved form. Emphasis is on the problems of developing nations.

3. Through its International Center for Marine Resource Development (ICMRD), URI has joined four other universities in a Consortium for the Development of Technology (CODOT). The activities of CODOT deal with improving the general area of food science and technology in developing nations. Others involved are the University of Washington, University of California, University of Wisconsin and Michigan State University.

4. The food science programme at URI is interdepartmental, involving five departments interested in food and nutrition.

Nutrition and food technology problems facing Tanzania in developing and utilising marine resources as sources of protein are these: (1.) lack of a continuous supply of fish prevents consumers from making a habit of eating it; (2.) the marketing and distribution system is very poor; and (3.) the quality of landed fish and processing and preservation are poor.

Sociology. Sociological insights appear to be a most important aspect of implementing any plans for the development of marine resources. Without taking account of the people, their community structures and traditional methods, any programme of fisheries development will fail.

The conference felt that the purpose of fisheries development is helping people, not just harvesting fish. In Africa there are many sociological reasons why fishermen have not been willing to accept and use new innovations. It was suggested that indigenous sociologists may be able to help get such projects carried out. The *ujamaa* village (cooperative system) in Tanzania also appears to have a great chance of succeeding in implementing development projects.

General

The University of Dar es Salaam has attached great importance to the development and exploitation of the marine resources of Tanzania. The existing cooperative approach between the Kunduchi Marine Biology Station and other institutions (e.g., Fisheries Division, EAMFRO and other East African universities) should be extended. The university expressed full support for the establishment of a marine resources centre and hopes that it will be seriously considered for incorporation into the new United Nations University.

The conference strongly favoured an interdisciplinary approach but after probing the need, recommended the establishment of a new marine resources centre. No conflict was seen between the University of Dar es Salaam's need for an institute to serve Tanzania and other Eastern African interests, as well as current fisheries research programmes and institutions.

Statements of support for the establishment of a centre for marine resources at the University of Dar es Salaam were given at the conference by groups including the Economic Commission for Africa, the University of Nairobi, FAO, UNESCO, UNEP, International Development Research Centre, Ministry of Tourism and Wildlife (Kenya) and EAMFRO.

The logical extension of such a centre was suggested from increasing regional applicability to a candidate institution for affiliation with the United Nations University.

In summary the following points clearly arose during the conference:

The proposed centre should be multidisciplinary in approach. It should be a centre of the University of Dar es Salaam, and it should maintain contacts with and seek advice from interested bodies throughout the world. But the centre should probably start modestly

as a national organisation and gradually develop into a regional organisation.

Aquaculture presents an opportunity for development beyond its apparent immediate productivity since it requires only a limited import of overseas technology and funds. Nevertheless, the improvement of fishing technologies for exploiting near-shore and offshore fish stock will also provide increased protein production, but will require substantial import of overseas technology and funds.

The conference urged the Government of the United Republic of Tanzania to recognise the existing danger to the coral reefs of Tanzania and to implement plans rapidly for the development of marine conservation areas.

Opening Address

Hon. S. E. Chiwanga, *Minister of National Education, United Republic of Tanzania*

Let me first of all extend to you all a most warm welcome to Tanzania and to Dar es Salaam. It is raining now, but all the same I do hope you will have an enjoyable stay in our country.

It gives me much pleasure to have the honour and privilege of opening this important conference organised by the University of Dar es Salaam in collaboration with the Ministry of Natural Resources and Tourism and with the co-operation of the University of Rhode Island. This kind of co-operation not only makes it possible for us to arrive at more balanced deliberations than would have been the case had we been working separately and independently, but it also cements the working relationship between intellectuals and academic communities.

I also see from the list of participants that there is a wide cross-section of interests and of geographical and institutional representation. Given the wide-ranging topics that will be discussed, I have no doubt there will be a very thought-provoking exchange of ideas and, at the end of it, profound recommendations.

It is a happy coincidence that your conference is being held at a time when the question of exploitation of marine resources is a very "live" one here. The general cry in this country is, "Why don't we have sufficient supplies of marine products?"

As you all must be aware, we in Tanzania are engaged in a great struggle to improve the lives of our people socially, culturally and healthwise. We know that we can only do this by raising the general standard of living of our people and that this in turn will depend on our being able to make full use of all of our economic resources to the best advantage. You also have no doubt heard that this is one of the 25 poorest countries in the world. It should and must be understood that this statement is only true if one is talking in terms

of available or fluid wealth as opposed to potential wealth.

So far as potential resources are concerned Tanzania is one of the better-placed countries in Africa. We have rich agricultural land with a variety of climates which makes it possible for us to be able to grow almost any type of agricultural crop; we have extensive and rich grazing land; we have some mineral deposits; we have about the richest terrestrial wildlife both in variety and in numbers that you can find in the world; we have extensive and rich forests, and we have numerous and extensive bodies of fresh water and a large area of ocean all abounding in natural resources. In short, what I am saying is that although in actual production Tanzania is among the poorest countries, potentially it is undoubtedly one of the richest in the world. We in Tanzania are in the paradoxical position of living in great poverty amid plenty. It is our government's resolve and determination to fight and remove this paradox at all costs. But we also know that the only way to remove the paradox is by the proper application and utilisation of science and technology.

Now let me turn to the subject of your main concern at this conference, i.e., the development of marine resources in Eastern Africa. I must admit that I am not expert in this field, but from general experience and from what I have been told by those who know, the East African inshore and offshore waters are, in terms of fauna, among the richest in the world. Taking Tanzania as an example, our marine resources are very extensive. The country has a coastline of about 500 miles. This gives an estimated surface area of 50,000 square miles or more. The biological resources alone contained in such a vast area of ocean must be very considerable. It is a regrettable fact however that because of a limitation in basic scientific knowledge concerning these resources and because we do not have the technology and the means for its proper exploitation, this vast wealth remains largely untapped. Having said that, however, I should add that our government, with limited financial resources at its disposal, has ambitious projects, some already operative, concerning the development of fisheries and marine resources in general. I have in mind such projects as *ujamaa* village fishing schemes, the creation of marine reserves and the establishment of fishing corporations.

I would like to end these remarks by wishing you a fruitful and most successful conference. It is my hope that you will come up with practical ideas and suggestions as to how best we can apply new scientific ideas and technology for the fullest development of our considerable marine resources to contribute to the economic development of the East African countries. Of course, we also need to develop marine parks and, in general, conserve marine resources. I am sure the conference will take care of both aspects. As I have said before, perhaps our problem now is to harvest rather than to plant.

Marine Resource Potential and Needs of Eastern Africa

A. S. Msangi, *Chairman*

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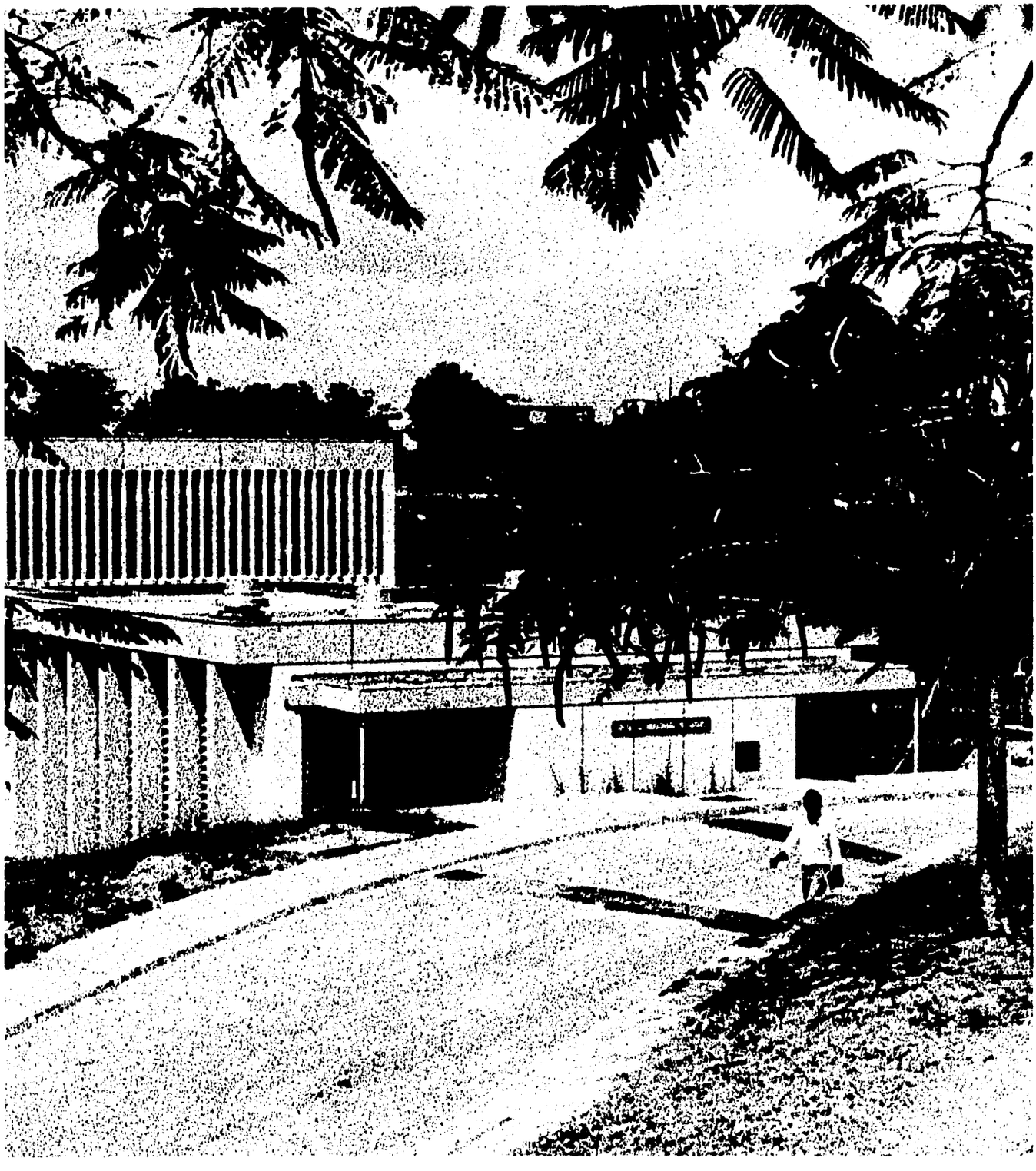


Shore and Reef Fisheries

J. J. Kambona, *Principal Secretary, Ministry of Information and Broadcasting (formerly Principal Secretary, Ministry of Natural Resources and Tourism)*

This paper discusses the condition of the fisheries in Tanzania and the tropical waters of Eastern Africa. There has been no prolonged scientific investigation of these coastal waters, and almost all prior work has been conducted by expeditions passing through or near the region. Data are therefore scanty. The paper attempts to describe the existing conditions in the fishing industry and the fisheries development plans of the Tanzanian government.

General acknowledgment and appreciation are extended to all staff members of the Fisheries Division, Ministry of Natural Resources and Tourism, Tanzania, and particularly to Mr. W. A. M. Sichone, Acting Director of Fisheries, and N. S. B. Singh, Fisheries Officer, who have given encouragement and much helpful advice. Mr. Singh also critically reviewed the manuscript and made suggestions for improvement. Mr. John W. Semainda handled the tedious task of typing and proofreading the manuscript.

Introduction

Fisheries are a common property resource, and entry limitations to the industry in Tanzania are almost negligible in contrast to agriculture where the land must be "owned" whether by a village under customary law, by a public corporation or privately by other entrepreneurs. A concept like ownership does not exist in the fishing industry with the small exception of the ownership of fishponds and some inland sport-fishing areas. The only limitations imposed on exploitation of our fishery resources are perhaps the recently introduced government licenses and their use in conservation policy. It is, I think, partly because of this lack of ownership that the poorest groups in the community in many parts of the world have drifted into fishing. Under this condition the industry has always tended to attract too many producers or to stimulate a rate of production that is too high.

However, rather than continue the discussion in this vein of socio-economic problems, let me turn my attention to the scientific problems and what I do know about the hydrographical conditions prevailing along our coastline, the geological nature of our coast, the potential of our fishery stocks, the present status of the fishing industry, and the steps which the government has or is taking in order to promote the development of the shore and reef fisheries in Tanzania.

Topography, Hydrology and Primary Production

Topography of the Coastline. In all Indian Ocean coastal waters, except the relatively wide shelf areas in the eastern sector of the Arabian Sea, the eastern sector of the Bay of Bengal and the north-northwest coast of Australia, much of the continental shelf and the adjacent seas is extremely narrow and in places precipitous. Along the East African coast the 200 metre-depth contour line is in many places less than four kilometres from the shore. In addition to the narrow shelf, coral reefs and coral outcrops are found throughout the area, especially along the African coast.

Tanganyika has over 600 kilometres fronting the Indian Ocean, including the island of Mafia and other smaller offshore islands. The continental shelf varies from a minimum of six kilometres to a maximum of 60 kilometres at two points which include Mafia and Zanzibar Islands. Pemba Island does not form part of the shelf and is separated by a deep channel 56 kilometres wide and 800 to 1000 metres deep.

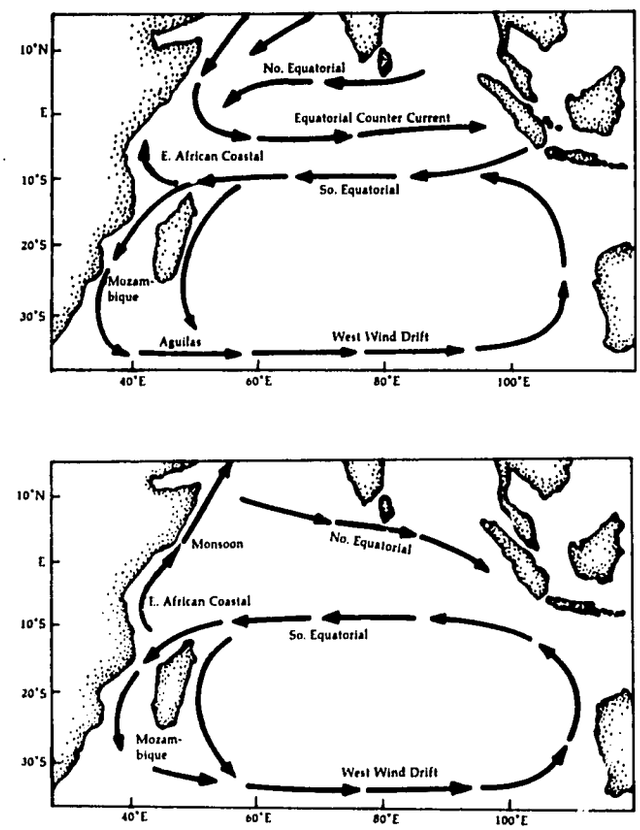
Area of shelf and upper continental slope on the Western Indian Ocean, in '000 km² (from Moiseev 1969).

Area	*Shelf 0-200m*	*Upper Slope 200-1000m*
South Africa, east of 30°E	140	100
Mozambique	120	180
Tanzania/Kenya	10	160
Somalia	120	160

Source: The Fish Resources of the Oceans, *J. A. Gulland.*

Hydrography: Currents. The striking feature of the surface currents in the Indian Ocean (figure 1) is the reversal occurring in the northern parts (Arabian Sea and the Bay of Bengal) following changes in the wind system with the monsoons. It is reputed that this has no parallel in the other oceans.

Figure 1. Surface currents in the Indian Ocean during southern summer (top) and winter (bottom). After Newell, B.S. 1947. A preliminary survey of the hydrography of the British East African coastal waters. Col. Off. Fish Publ 9. HMSO, London.



The current system in the southern Indian Ocean is similar to that of the Pacific and the Atlantic. The South Equatorial Current flows westward at around 10° south, dividing as it approaches the African coast. The southward flowing arm branches around each side of Madagascar, uniting to form the Agulhas Current further south. The West Wind Drift, a weak and rather confused northward-flowing current off western Australia, completes the counterclockwise gyre in the southern Indian Ocean.

In the northern Indian Ocean during the Southwest Monsoon (April-September), the East African Coastal Current flows northward along the east coast of Africa as a swift and narrow current; speeds as high as seven knots have been reported (Swallow 1965). Its width at the Equator has been estimated at nine kilometres, and the current widens to about 74 kilometres farther north. At the height of development it reaches as far north as 12° north latitude; however, most of the water leaves the coast and flows in an easterly direction as the Monsoon Current south of 10° north latitude.

The Northeast Monsoon (October-March) brings considerable changes in the circulatory pattern, especially in the northern seas. The East African Coastal Current reverses direction and flows southerly from December through February.

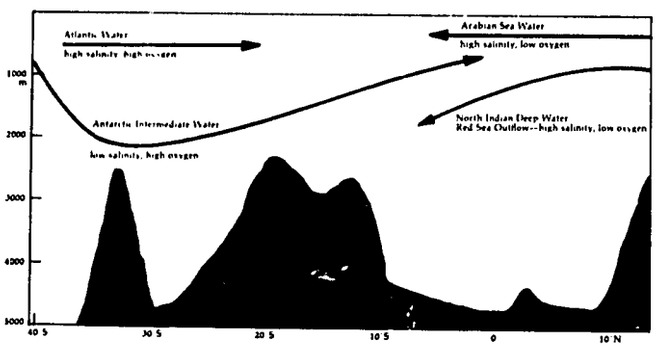
Hydrography: Upwelling. Although zones of upwelling have been discovered in various locations throughout the Indian Ocean, it would appear that these do not exist along the East African coastline. In the Arabian Sea, one of the most pronounced occurs in the waters off the South Arabian Sea from Kuria Maria Bay to Ras al Haad during the Southwest Monsoon. A second occurs in the waters off northern Somalia within 40 kilometres of the coast (Swallow 1965). Although the cold water is rich in nutrients, there is little evidence of a high level of biological activity. A high standing crop of plankton is evident only in the northern part of the cold water area in the vicinity of Cape Guardafui.

Primary Production. Much of the zooplankton data collected during the International Indian Ocean Expedition are still being processed and analysed. It is doubtful, however, that these are sufficient to give more than a generalised view of zooplankton distribution in the coastal waters of the Indian Ocean.

The standing crop in the Indian Ocean was included in the world summary given by Bogorov *et al.* (1968). These studies show few rich areas in the Indian Ocean. A density of 200 milligrams per cubic metre, found in most of the fertile areas of the North Atlantic and North Pacific and a large part of the upwelling areas off western America and West Africa, is reached in the Indian Ocean only within a narrow band along the West Indian peninsula and off southern Arabia. The general level in the coastal areas is 100 to 200 milligrams per cubic metre.

The waters washing the coastal waters of Tanganyika are strongly influenced by the East African Coastal Current, which is the northerly branch of the South Equatorial Current that divides off the northern tip of Madagascar, and Arabian Sea waters which penetrate

Figure 2. **Stratification of the western Indian Ocean. After Newell. Tropical surface water is high temperature, high salinity, oxygen-saturated.**



south as far as our waters. The East African Coastal Current, however, is poor in nutrients, reaching the coast as the Southeast Equatorial Current after a passage of 6000 kilometres across the Indian Ocean. No doubt this deficiency delimits the quantities of plankton grown and, therefore, affects the chain of marine foods. (See figure 2.)

Resource Assessment

An objective assessment of the fisheries resource is the fundamental prerequisite to any development programme. Until this is done, expectations regarding any great extension and improvement of the fishery must be tempered with due caution.

Very little experimental bottom trawling has been conducted in this area. For the most part the results have been negative, leading to the conclusion that trawl gear cannot increase substantially the fish yields in East African waters. The lack of success has been attributed to the extensive coral outcroppings in the area and to the narrowness of the continental shelf. Trawling, however, should not be ruled out since most of it has been done by fairly large vessels working in shallow depths. It is possible that success could have been achieved with small trawlers. A similar situation existed in the Gulf of Thailand where only after the introduction of offshore trawling with small boats and nets did the fishery flourish (Tiews 1966).

Potential demersal resources of the shelf regions of the Western Indian Ocean.

Region	*Area 2 '000 km*	*Density kg/ha/yr*	*Potential '000 tons/yr*
South Africa, east of 30°E	140	25	350
Mozambique	120	25	350
Madagascar	210	25	525
Tanzania/Kenya	10	10-20	10-20
Somalia (2°S-5°N)	50	10-20	50-100
Somalia (north of 5°N)	70	50	350
Arabia and Gulf of Aden	80	50	400

Source: The Fish Resources of the Ocean, *J. A. Gulland.*

In further examining the nature of the resources found in these waters, we shall be better able to appreciate the complexity of the problems which have to be solved. In addition to the difficult topography outlined earlier, poor hydrographical conditions exist in the waters along our coastline. But our waters, similar to many other waters in the tropics, are paradoxically endowed with large numbers of species, but not in sufficient concentrations, to ensure that a fishing enterprise with high daily expenses can take enough fish to make a reasonable profit.

Fish Stocks and Fisheries

It is estimated that the catch from the Indian Ocean and the adjacent seas is about two million tonnes per year. On the basis of yields per surface area, this is only about 20 percent of Atlantic or Pacific yields (Shomura *et al.* 1967). The commercial fisheries yield of the Indian Ocean is based mainly on coastal species, which make up 80 percent of the entire catch. There are possibilities for further yield increases in the boundary area between upwelling abyssal waters and surface waters created by the monsoons. Considerable amounts of fish can be expected to be found in the convergence of tropical currents and equatorial waters, that is, of the currents of Somalia and Australia with the equatorial waters, along the southern boundary of the South Equatorial and the North Equatorial Currents.

Fishing in Tanzania, as in many parts of the coastal waters of the Indian Ocean and especially along the African coast, is still carried out in non-motorised boats with simple gear. Much of the relatively low yields can be attributed to the low level of fishing effort and the

use of inefficient gear of the type employed in subsistence fishing. Tanzania's annual production is estimated to be just under 30,000 tonnes per year and is almost all confined to immediate coastal waters. Presently the fish species widely exploited include *Sardinella*, seerfishes, sharks and various demersal fishes and seasonal runs of migratory pelagic fishes. In addition, small but highly valuable quantities of prawn, lobster, bêche-de-mer, sea shell and seaweed contribute to the catch.

Marine fish production in Tanzania (metric tonnes).

Product	*1968*	*1969*	*1970*	*1971*	*1972*
Fish	20,900	15,374	17,492	20,904	27,563
Crustacea	507	597	585	391	330
Bêche-de-mer	105	130	277	202	147
Seaweed	260	205	252	135	195
Sea shell	533	769	478	479	696
Total production	22,305	17,075	19,084	22,111	28,931
Value of catch in shillings	34,389,300	28,653,600	27,779,000	32,796,598	46,886,528

Detailed and accurate statistics are hard to come by in a developing country such as Tanzania, and the limited scientific assessments which have been undertaken make questionable any scientific conclusions concerning the fishery potential of the area. At the moment it is correct to speak not of the scarcity of biological resources in the tropical waters, but of the inadequate knowledge of these vast spaces.

At first sight it appears that there have been no significant increases in the catch, the range being only from 17,000 tonnes to a high of 28,000 tonnes in 1972. Even granting the assumption that the increase may not be real, but a result of improvement in the collection of statistics, one thing is certain: a firm foundation has been laid in preparation for future development. The most important catalyst has now been found, and this is the general awareness of the importance of this resource and the urge to exploit more and more the marine resources of our waters.

Status of marine fisheries in Tanzania.

	1968	*1969*	*1970*	*1971*	*1972*
Fishermen	4844	5361	6719	8243	8531
Vessels	1694	1960	2639	2981	3113
Inboard engines	8	9	8	8	12
Outboard engines	48	51	56	137	103
Type of fishing gear					
Gill nets	1125	1702	2203	1749	3875
Shark nets	766	908	1136	1134	2050
Sine nets	490	149	479	617	505
Cast nets	165	300	433	158	218
Long lines	1214	2252	1500	1954	—
Hand lines	—	—	1454	1728	—
Basket traps	2302	3261	3990	2558	7419
Fixed traps	—	882	251	33	283

The number of fishermen shows an upward trend from about 4,800 in 1968 to 8,500 in 1972. A similar trend can also be detected in the number of vessels, outboard engines and the different types of fishing gear now in use. The small increase in the catch is perhaps an indication of the fact that we might be over-exploiting the same waters and that the time has now come for venturing farther afield as well as improving our techniques; taking more stringent measures in combating wasteful fishing methods, such as dynamiting; and studying the effects of industrial pollution on our coastline.

Development Strategies

The government has established a Fisheries Department charged with the responsibility of administering, managing and developing the biological resources of our waters. The structure of the department is now fairly well established in five coastal administrative regions: Tanga, Coast, Dar es Salaam, Lindi and Mtwara. Trained fisheries personnel have been stationed in almost all of the important fishing villages not only to try to collect as much vital data as possible about the fisheries but also to attempt to introduce new ideas to fishermen in order to increase their overall efficiency.

Since it is widely recognised that the lack of efficient gear and seaworthy vessels is the biggest bottleneck to increased exploitation of fisheries resources, the government has wisely set up three boatbuilding yards at Mikindani-Mtwara in the south, Dar es Salaam in the centre and Pangani in the north. A major boatyard is being developed at Bagamoyo-Mbegani for the training

of boatbuilders and marine engineers in order to ensure that the fleet developed under this programme is kept as efficient as possible. In Dar es Salaam we also have a fish-net factory capable of meeting all net-making requirements.

The next big obstacle the government is trying to surmount to increase exploitation is that of preservation of the highly perishable catch from the fishing grounds, in the vessels and to the consumer. Commendable steps have been taken. Ice-making machinery and refrigerated cold rooms, ranging in capacity from three to five tonnes, for preserving fish can now be seen or are currently under construction at Moa, Tanga, Pangani, Bagamoyo, Dar es Salaam, Mafia, Kilwa Masoko, Lindi and Mikindani. It is hoped that out of these harbours, modern fishing ports and a flourishing fishing industry will develop.

Development plans, however, tend to become just declarations of intent or, at the most, pious aspirations unless they are backed by an effective training programme. In order to translate wishes into such a programme, Tanzania has two training institutions catering to the manpower needs of the country. So far 162 students have taken the Certificate Course offered at Mbegani, and 74 officers have been graduated from the Diploma Course at Kunduchi. Every opportunity is taken to make use of the scholarships and bursaries offered by friendly nations, and so far 47 Tanzanians have been trained by using offers from Japan, Canada, the Netherlands, Norway, the United Kingdom and the Indian Ocean Fisheries Commission, and 15 more are in Norway taking specialised courses in navigation and marine engineering.

Mbegani is destined to play an increasingly important role as a result of the Norad/Tanzania Coastal Fisheries Development Project which plans to set up a full-fledged modern fishing harbour and undertake an exhaustive resource survey and boatbuilding programme.

Hand in hand with these developments is the recent establishment of a major fishing concern, Tanzania Fisheries Corporation (TAFICO), an undertaking which shows the hope which the government has in the future of this industry. This new corporation will be concerned with all the commercial aspects of fishing, marketing and boatbuilding so that the Fisheries Division can concentrate on administration, staff development, research, management and law enforcement.

Prospects for Future Development

In many of the developing countries, and Tanzania is by no means an exception, poverty in its widest sense is the most basic handicap to fisheries development. We suffer from a fundamental scarcity of almost all factors of production: capital, enterprise, skilled labour. With respect to those resources that appear relatively plentiful (e.g., unskilled labour or fishery products), we are in a situation whereby we cannot apply them immediately to productive use. We are simultaneously aware of the need for development and of our potential for it, but our present poverty is a barrier to it.

The identification of the main reasons for the present underdevelopment of the existing and proven fishery resources and the way in which these are all interconnected requires critical examination.

In our case it would appear that both knowledge and equipment are deficient. There is a lack of knowledge about fishing grounds, about their location and quality. There is a lack of adequate boats, of manpower to operate boats and fishing gear and equipment, and of more efficient methods of catching fish. Furthermore, there is the widespread lack of knowledge about the best methods of handling, preserving, processing and distributing the product.

Fishermen are largely confined to nearby inshore fishing grounds. The occupation is controlled by the hazards of the weather and of the market. At times there is a glut of fish, and at others an acute shortage. The fishermen operate on a pitiful margin without much incentive to improve the operation of the industry. The lack of a large and stable demand for their products is commonly recognised.

The Fisheries Division is the result of post-Independence awakening, and is, thus, young, weak, inadequately staffed, inexperienced and ill-equipped. Regrettably not much attention is paid to this industry. Statistics and other information on the industry are lacking, and this makes the task of planning, forecasting and devising conservation measures very difficult.

However, the picture is not as dismal as it has been painted here. Where all or most of these difficulties have been overcome, remarkable development in the fisheries has resulted.

Of the countries situated in the tropics, India deserves special mention. She has come a long way since

the Second World War, and she is now the world's eighth biggest fish producer with an annual landing of well over one and one-third million tonnes of fish. Another country within the tropics that has made significant strides is Indonesia, which now produces about one million tonnes of fish. Outside Asia, Peru continues to hold top place in the world fish catch with landings in the order of well over eight and three-quarters million tonnes. In all of these countries one thing is clear: government assistance has played a very significant part in the development of this vital industry.

It would be safe to conclude that in Tanzania, like in most developing countries, the area covered by fisheries could be greatly extended. The techniques of marketing and production could be radically improved, and fish production could be much better utilised. The amount available for consumption could be greatly increased by preventing or reducing waste, which is very heavy, through the extension of better processing methods and storage and refrigeration facilities. In the range of products for human consumption, outlets which are now restricted by many prejudices and consumer habits could be opened by judicious publicity.

Discussion

Tanzania, like many of her developing sister nations, lacks financing, management and skill to exploit fully her fishery resources, i.e., to catch and process fish on a large industrial scale. The domestic market alone is not sufficiently attractive nor is it able to encourage development, and as a result many areas which have the greatest need for fish protein are those least well supplied. The increased production of fish protein depends not only on nutritional need, but on effective economic demand. This means that to be successful, development efforts cannot and should not be limited to increasing supply only. The expansion of markets and consequent commercial production of food are in the final analysis related to overall economic growth.

The fisheries experts are unanimous in their conclusions that since problems in fishery development are complex, deep-rooted and inter-related, no single programme can by itself make any significant impact. Fisheries development projects should only be undertaken as an integrated package in a comprehensive and carefully phased fisheries adjustment and development programme.

In examining many successful fishing nations, the following ingredients which have contributed to their success can be identified.

1. Exploration of Fisheries Resources. The reefs are among the most unknown ecological zones and, thus, information must be sought about the nature, size and location in both time and space of usable concentrations of fish without regard to the extent of current exploitation. The discovery of unused populations and the monitoring of heavily exploited fisheries must be simultaneous. The estimation of the size of the stock and its potential to support a fishery is the underlying aim of these investigations.

This exploration intelligence is necessary in order to establish a fishery where none existed before, to expand or develop an existing fishery and to maintain a position in a heavily exploited fishery. The exploration, if associated with design and development of gear suitable for the purpose, can act as a very good catalyst to rapid development.

2. Management of Fish Population. In our coastline the reef and shore fisheries have been the mainstay of the fishing industry since time immemorial, and it is likely that the resource is of such a limited size and the demand is so great that there is some danger of conflict developing between the harvesting of fish and the recruitment of young fish.

Wasteful and dangerous methods of fishing have also cropped up (e.g., the use of dynamite), and industrial development has brought with it problems of pollution. In an undeveloped fishery, moreover, there is the ever-present danger of applying unneeded restrictive regulations, of doing too little too late or even of applying an inappropriate procedure. Any management policy, whether restrictive or permissive, must be supported by both the biological facts about the animal population and the socio-economic facts of the fishery. The biological facts cannot be changed in this case, but the socio-economic facts do change with time, either by design or otherwise.

3. Control of the Environment. In fish population management the objective is to encourage maximum exploitation or the best use of existing stocks as conditions indicate. In environmental control one is concerned primarily with the productive capacity of the environ-

ment and its role in promoting reproduction and growth within a given species. The main aim is to maintain the environment or change it toward better production.

Rapid and large industrial expansion and population growth are now catching up with us here in East Africa, and this makes the task of controlling the environment difficult. Our coastline will continue to be polluted, making increased fish production difficult, if not impossible.

4. Research or Improvement of Fishing Methods. Continuous small improvements in fishing efficiency result from trial-and-error operations. However, with the present advance in scientific technology, such development proceeds much faster and more efficiently when it is backed by applied research programmes.

One of the basic requirements for fishing efficiency is an understanding of the environments of the various fisheries resources and of the different types of fishing operations. Our research institutions at Kunduchi, Mbegani, Zanzibar and Mombasa should constantly seek information on the nature of the bottom of the ocean, the geology, the temperature conditions including seasonal changes, as well as observe the efficiency of different types of fishing gear, etc. Such information will assist in forecasting and will provide the budding modern fishing fleet with valuable information on the timing and location of suitable conditions for commercial fishing.

The work of the fisheries biologist is becoming increasingly important in describing the distribution of species, stocks, and species and populations within stocks. The resulting information on the where, why and when of fish concentration will permit increased catches at reduced costs. Good prediction is the key to fishing success.

Our research on the environment, natural resources and fishing operations, and on their inter-relationships, should contribute to the development of improved fishing techniques and more effective gear.

5. Industrial Development and Improvement of Shore Facilities. The handling of fish aboard a fishing vessel is the first of many steps in the processing of the raw material into a finished product. The introduction of ice into the fishing industry has done a lot to improve the quality of the landed fish especially in hot climates such as ours.

The general improvement in plants, equipment, refrigeration and freezing, handling methods, sanitation and quality-control practices and programmes will all contribute to the production of better quality fresh or frozen fish with a long storage life.

The other processing preservation methods of salting, smoking, canning and production of fish meal should also benefit from modern advances in technology.

The opening of areas which have fisheries potential is another aspect of government interest in this vital industry. Quick means of communication are necessary in handling a perishable product such as fish. Public expenditure in harbours and marine aids to navigation, telephones and improved roads are all necessary ingredients in developing a fishery.

6. Financial Aspects in Fisheries Development. Indebtedness is a permanent feature among the coastal fishermen and is detrimental to any prospects for fishery development. It kills incentives because the fisherman fears constantly that any increase in his effort will be immediately appropriated by the middlemen, either in the form of repayment of debt or through lowering of prices. The solution of this incentive problem is very important, and Tanzania's efforts at improving fishermen's economic status through communal ownership and cooperative effort deserve special attention.

Special financing arrangements have been required in almost every fishing nation to meet expansion or modernisation requirements. In many cases, special arrangements have also been made to meet normal capital and operating needs. These special needs arise from: (a.) the traditional organisation of the industry into a large number of widely disposed small-scale enterprises, (b.) the rate of return on investments being inadequate to provide an accumulation of capital for expansion and modernisation, and (c.) the relative high degree of uncertainty associated with the industry.

Conclusion

Techniques for production, preservation and marketing of fish products in a developing nation like Tanzania must be developed step by step. Introduction of modern techniques will take considerable time since the old and established, but inefficient, methods must be replaced with new and improved methods.

Consideration must first be given to relatively simple improvements such as the increased use of outboard

motors or small diesel engines and the development of more efficient methods of smoking, salting and drying fish. Later, as other segments of the national economy are improved, additional changes such as the use of motorised fishing vessels and the construction of sophisticated processing plants can be considered. At this point exports of the luxury and valuable products, such as prawn and lobster, can provide a significant contribution to the economy.

There can be no blueprint for fishery development, but it would appear that ideally the first phase of our programme for industrial development should include, at a minimum, the following steps: (1.) a full-scale resource investigation to develop an inventory of shore and reef resources; (2.) improvement of existing fishing gear through better design and use of better material; (3.) education of fishermen to instill in them a new sense of purpose and incentive and give them information on the best uses and tactics of contemporary fishing gear and methods; (4.) training of net repair and vessel repair teams and of other necessary infrastructure service units; (5.) planning for construction of shore facilities for processing, storage and distribution of catch in the second phase of the fisheries programme; (6.) training of cadres in outboard and marine engines' maintenance and boat construction; (7.) education of fishermen in better fish handling, sanitation techniques and improved traditional methods of processing; and (8.) training of the most promising local young men for the administration of the second phase of fisheries development.

It is implicit that the scale of any fishery development must be closely tied to the existing resource base, i.e., to the human and physical factors involved. Thus a total strategy is required which will permit the accelerated use of aquatic food resources without incurring unnecessary or excessive allocations of scarce national financial resources.

Regardless of the plan and the path chosen, either building upon the traditional industry or introducing revolutionary change, or taking some combination of the two approaches, the many critical factors which interact and constrain each other in fishery development require a broad-based, integrated approach to ensure a phased growth of the fishery both as a systematic whole and in relation to the overall growth of the economy and society.

Today Tanzania and other developing nations are in a position where a rational choice can be made from among the wide range of technological achievements available to them simultaneously, rather than in a historic sequence as was the case in Europe and North America. Scientific research has provided a better understanding of the distribution and movement of desirable fish species as well as improved techniques for their harvesting, storage, processing and distribution.

There is no doubt that the future will bring many improvements in the full use of aquatic resources. The success of the fishery development programmes will depend on the capacity and quality of the technicians involved in this challenging task and on the national effort expended, rather than on the blueprint suggested. Concern for the totality of development is required to adapt scientific knowledge and techniques to the needs and aptitudes of a non-technological culture. That is why the establishment of a marine resources institute in this part of the world deserves the support of all those interested in the exploitation of aquatic resources.

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Supplementary Comments

N. Marshall, *University of Rhode Island*

Earlier contact with our speaker, John Kambona, helped to direct our attention to the Tanzanian coast. In addition a former faculty member, Leif Landberg, had spent 18 months in Kigombe and showered us with glowing accounts as to the challenges of this coast. Professor Saul Saila also visited here when he was on leave with UNESCO and was asked to review the prospects for coral reef parks. Finally my own attention was drawn to the region simply by looking at a map while wondering where we might approach the fisheries problems of a typical coral reef coast.

Later in the course of our deliberations we tried to project the gross fisheries potential of this coast. Scattered data from coral reefs, turtle grass and mangrove areas around the world, coupled with our plotting of the dimensions of the area, suggested that, with proper management of the capture fisheries and with accompanying mariculture, one might readily realize at least a fourfold increase in the coastal fisheries resource.

Promising? Yes, but what are the constraints? Some of the more effective harvest methods such as trawling are greatly hampered by reefs; species diversity leads to marketing difficulties; and the populations tend to run to large numbers of small fish rather than the more advantageous larger types easier to process and distribute. Besides all this are staggering problems of processing, distribution and marketing. In fact the entire supporting infrastructure and financing needs attention. Finally, and most staggering of all, is the need to develop the know-how to learn, to plan for this development and to communicate and execute the plans. To lay the background for this is a central mission of our present sessions.

Discussion

1. Separate but interlocking research needs were pointed out for three coastal biomes—the coral reef, the mangrove forests and the estuary. This research should attempt to make specific quantitative comparisons and should address itself to things like use of the coastal area as nursery grounds for pelagic fishes. It was noted that some work on inshore productivity is already underway at the University of Dar es Salaam.

2. The offshore oceanic water productivity of the East African area, as defined by Cushing and others, is relatively high—approximately one gram carbon per square meter per day—especially during the northerly monsoon.

Tanzanian National Parks and the Marine National Parks

D. N. Bryceson, *Director of National Parks*

The idea of setting up marine national parks in order to protect and conserve marine flora and fauna was put into action in 1967. With assistance from various United States-based foundations, Dr. Carleton Ray, a marine biologist and assistant professor at Johns Hopkins University, made a survey of the situation here. His report, published in October, 1968, made a number of recommendations about the places and method of setting up these parks.

In order to carry out his recommendations, regulations were incorporated into the new Fisheries Act passed in 1970 to restrict or ban certain activities along our coastline. The Minister for Natural Resources and Tourism, who is responsible for fisheries development, and the caretaker Ministry for National Parks announced the government's intention to set up marine parks in the budget session of Parliament in June, 1971. To date no further action has been taken, and the publication of the necessary regulations setting up the areas to be protected is still awaited.

At the beginning of 1973, regulations concerning the licensing of fishing boats and fishing, which included a ban on the use of spear guns, were published. UNESCO sent out a small mission to check on the Ray recommendation and came to the same conclusions about methods.

The coastline of Tanzania lies between 4.6° and 10.7° south and is about 800 kilometres in length. Inshore there are coral reefs all along this coastline at intervals as well as around the offshore islands. Usually the coral reefs are in very shallow water, and in many places they actually come out of the water at low tide. The reefs themselves are inherently very rich in flora and fauna and include many different species of coral and other marine animals. The first areas chosen for protection were the reefs around the islands lying close to Dar es Salaam and the coastal tourist hotels, plus the remarkably beautiful area around Mafia Island.

Although the practice has been forbidden by law for many years, using dynamite as a fishing method is still common along the coastline, and terrible damage to the reefs is being done. In spite of much discussion, action attempted to stop this by the Fisheries Division of the Ministry of Natural Resources and Tourism and the Marine Police has so far been completely ineffective. Attempted propaganda campaigns to teach the fisherman about the damage done to his long-term prospects by this practice has similarly been ineffective. Unfortunately also, despite regulations and licensing, it is still easy to obtain dynamite from illegal sources. If this situation continues much longer, the reefs may be damaged beyond the possibility of restoration except in the very long term. Already some of the reefs chosen for protection around Dar es Salaam, and especially those near the coastal tourist hotels, are severely damaged and are likely to take at least ten years to recover to an extent that they will again be ranked high among tourist attractions.

In the beginning, in 1967-68, there was some difference of opinion on the right way to set up marine parks. Holders of one school of thought wanted the areas to be set aside like national parks on land under the National Parks Act of Parliament and to exclude all human rights within those areas, particularly fishing. Others wanted to obtain long-term support for the concept and the park areas, and to do this they thought it essential to win the support and cooperation of the fishermen. Moreover, as long as certain fishing methods were used, they seemed to think there was no danger in allowing fishermen to continue to fish. In fact, one of the intentions behind the design of the new Fisheries Act of 1970 was to make marine park development a cooperative effort between the Fisheries Division and National Parks, the one overseeing the whole coastline, the other taking special measures to protect and develop a few specified tourist areas.

Apart from insisting on proper fishing methods designed for particular areas and situations, it is intended to enforce the total ban on spear-gun fishing and to ban the collection of live shells and corals. Once a control over the misuse of dynamite is established, it is likely the rest will follow quite simply and with a minimum of cost. The revenue which could be attracted

by tourism in these areas could be significant, since the coral reefs may be seen in conjunction with a safari to the animal parks at not too much extra cost to the tourist. Thus, economically it is very much in the interest of the country to take effective steps against this problem without further delay. From the scientific and environmental angles, it is also clearly of first importance that action be taken along the lines proposed and that it receive international support. And in terms of food supply, clearly it is also necessary to learn more about and take advantage of our offshore marine resources.

Supplementary Comments

D. N. Bryceson

The primary question to be addressed regarding marine parks is, "What must be preserved and protected and for what purpose?" The coral reefs themselves need protection for economic reasons like tourism and fisheries, and for cultural reasons, like education.

Many areas which appeal to tourists have good beaches and good beach hotels. Few have, like Tanzania, good adjacent reefs. These reefs are currently being damaged by bad fishing practices, especially dynamiting, which has been a long-term problem. Dynamiting, while illegal, has been perpetuated by the easy availability of explosive materials and relative impunity from punishment. One significant practical step in minimising damage is to convince the reef fishermen that the use of explosives is disastrous in terms of their long-term best interests.

Protection is also required, as in land parks, both for the tourist and from the tourist. The environment must be protected from floral and faunal damage. For example, the collection of live shells as curios must be stopped and heavy traffic controlled, especially as tourism escalates.

Another question that must be addressed is how to protect the reef area. Tanzania presently has three organisations involved with protection: the fisheries division of the government, whose broad responsibilities have been defined in the Fisheries Act; the marine police section of the Tanzanian Police Force, responsible for law enforcement; and the national parks organisation, which is presently extending special controls over specific marine reserves and parks selected for their coral reefs. In a general sense, the current organisations involved in the process should continue to improve their equipment and training, and have their position reinforced by appropriate governmental and legal support.

Supplementary Comments

S. B. Saila, *University of Rhode Island*

The concept of protecting marine reserves is compatible with, even necessary for, rational exploitation. The diverse reef environments are vulnerable to such problems as nutrient enrichment from sewage pollution, which causes proliferation of attaching algae, as well as smothering by excessive sedimentation.

The following observations have general application to reef environments:

1. Most coral reef fishes have pelagic eggs and larvae. Knowledge of nearshore water circulation patterns could allow proper selection of locations for marine reserves such that they could serve as sources of eggs and larvae for re-population and reclamation of damaged areas.

2. Management considerations for preservation and exploitation, such as fisheries and tourism, must take account of the fragility of the reef environment. Training of management personnel should be broadly based on this premise and should incorporate such diverse topics as: (a.) familiarity with local taxa (for conservation purposes and in order that officers may serve better as educators); (b.) marine safety procedures (for such things as diving and boating activities); and (c.) natural resource management (to recognize the implications of reef area boundaries and effects of progressive change).

3. Undisturbed reefs make good baseline areas or points of reference for studies comparing the effects of pollution on similar areas elsewhere.

4. Other research questions which national reserves could be used to help answer include: (a.) the amount of energy contributed from ocean zooplankton drifting onto the reef; (b.) the abundance of fish which feed directly on algae, and (c.) the optimum harvest strategy (interspecific or non-selective) at various trophic levels.

The marine national park concept can contribute to solutions of these and other problems and thereby materially assist rational exploitation of marine resources. The concept of harvesting can be made compatible with the reserve approach, and, I believe, activities like shellfish exploitation can be rationally permitted under such controlled conditions.

Discussion

1. The danger of excessive sedimentation with its mechanical and light effects on proper coral reef growth is not only due to natural causes (flooding and natural erosion of river systems) but may be enhanced by erosion from man's land-use activities up river. Kenya has some legislation regarding control of these activities that may be appropriate for consideration in Tanzania.

2. Spear-gun fishing in the marine reserve area should be limited or eliminated because it not only menaces certain coral reef species but also substantially changes fish behavior, making them more retiring and harder to observe. Early legislation on this point is desirable with the expected increase in spear-gun fishermen along with tourists.

3. A good example of the effective development of a marine park intermeshing with complementary activities is Buck Island Reef in the Caribbean, which should be studied for its applicability.

Coastal and Estuarine Aquaculture: a Case for Introducing Prawn Culture in Tanzania

C. Sankarankutty, *Department of Zoology, University of Dar es Salaam*

Aquaculture was practised even in ancient times. But its importance as a source of much needed additional protein has become increasingly clear in recent years, a fact which is reflected in the rising number of books being published on the topic. For e. mple, two recent additions to the literature of fisheries science are *Coastal Aquaculture in the Indo-Pacific Region* edited by T. V. R. Pillay (1972) and *Aquaculture* by Bardach *et al.* (1972).

Aquaculture, mainly as a polyculture involving more than one species, has been practised in the Indo-Pacific region for many centuries. A recent assessment by the FAO (1972) estimates 400,000 hectares under exploitation and an additional 1.5 million hectares with potential for development.

Tanzania, with a long coastline of 800 kilometres, has many important rivers which create conditions ideal for development of estuarine aquaculture, especially prawn culture. Notwithstanding the fact that the resources from the ocean fisheries, both pelagic and demersal, remain under-exploited, emphasis on aquaculture should be encouraged to utilise vast areas of swamp which are now fallow and unproductive.

Although no study has so far covered this important aspect of the development of the fishery of Tanzania, a recent survey of a Japanese team comprised of Drs. Yamashita, Taki and Kawahara recommended in no uncertain terms the possibility of starting aquaculture on an experimental basis at two localities: Udofu Creek near Tanga and Mzinga Creek nead Dar es Salaam.

This paper attempts to review certain aspects of prawn culture based mainly on the available information from the literature. Another paper will cover finfish.

Prawn Culture

Aquaculture, in essence, has been an operation which involves trapping, holding and growing. In many parts of the Indo-Pacific this simple method is still practised to a large extent. However, some breakthroughs have been made in Japan in rearing prawn from the egg to the adult stage entirely under artificial conditions, and artificial prawn culture in Japan has become a reality and has shown commercial potential.

Suitable Areas

Large areas of mangrove swamps, which are otherwise unproductive, can be converted into ponds suitable for aquaculture provided they satisfy the following requirements.

Ideal soil conditions. The substratum best suited for prawn culture is largely clayey with a mixture of sand and organic detritus. Areas where extensive silting occurs are to be avoided although a maximum of 50 centimetres of silt can be tolerated. Too much of an accumulation of organic matter is also harmful, as its decay promotes anaerobic conditions.

Tidal range. A wide tidal range is advantageous since the ponds can be flooded and drained as often as required for stocking and fishing.

Salinity. The optimum range recommended is from 24 to 30 parts per thousand.

Freshwater inflow. The availability of a river from which freshwater can be drawn to control pond salinity is a prerequisite for successful pond culture.

Pollution. Areas which are already subjected to pollution and areas which are likely to be affected by it are to be avoided.

Availability of juveniles. Juveniles of species intended for culturing should be available in adequate quantity and for a large part of the year.

Suitable Species

Four species are known to constitute a fishery for prawns along this coast. They are *Penaeus indicus* (H. Milne-Edwards), *P. monodon* (Fabricius), *P. Semisulcatus* (De Haan) and *Metapenaeus monoceros* (Fabricius). Of these, *P. indicus* dominates commercial landings.

Investigations conducted by the East African Marine Fisheries Research Organisation (Zanzibar) have revealed the existence of *P. japonicus* (Bate) in commercial quantities at irregular intervals. The report also mentions the presence of juveniles and young stages of *P. latisulcatus*, kishinonye. A study of Kunduchi Creek also has confirmed the existence of this species in that region.

All of the species mentioned are suitable for pond culture, and they are being successfully harvested elsewhere from pond culture.

Life History of Prawns

All four commercial species of the area are known to undertake regular migration into the estuary as juvenile forms and later into the open sea as adults for spawning. After mating, females lay their eggs in the open sea where further development takes place.

Stage		*No. of hours*	*No. of moults*
From	*To*		
Egg	Nauplius	13-14	—
Nauplius	Protozoea	36	6
Protozoea	Mysis	120	3
Mysis	Post-larva	120	3
Total (Egg to Post-larva)		289-290	12

Once the larvae hatch into the post-larval stage, they settle to the bottom and begin their migration into the estuary where they grow into the adult stage.

Conclusions and Recommendations

Before attempting to place Tanzanian aquaculture on a commercial scale, a preliminary investigation should be undertaken to cover the following aspects of the estuarine system: (1.) nature of the bottom, (2.) availability of freshwater throughout the year, (3.) salinity, (4.) tidal range, and (5.) availability of young stages of desirable species. Economic aspects, such as availability of trained manpower, should also be evaluated.

As mentioned, the survey by the Japanese team which covered various creeks near Tanga, Dar es Salaam and the Rufiji area has favoured the establishment of experimental prawn culture at two localities—Udofu

Creek near Tanga and Mzinga Creek near Dar es Salaam. The Rufiji Delta also is expected to hold promise.

In conclusion, I wish to point out that although aquaculture is not a substitute for open-water fisheries, any attempt to convert large swampy areas which are otherwise unproductive would be worth undertaking.

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Coastal and Estuarine Aquaculture

H. Matthes, *Kunduchi Fisheries Institute*

With the bountiful fish potential of the lakes and a not inconsiderable production from the sea, it may appear premature to many in East Africa to talk about marine aquaculture. This may seem true especially in view of the fact that commercial fishing enterprises are barely starting to develop their activities in this region. However, a sober analysis of our marine resources and their potential may usefully clear up some popular fallacies, such as an "Indian Ocean, teeming with fish."

The Indian Ocean, insofar as presently explored, is less productive than either the Atlantic or the Pacific Oceans, with a potential yield of about 14 to 15 million tonnes, as against 56 million in the Atlantic and 42 million in the Pacific (Gulland, 1970). Moreover, that portion of the western Indian Ocean which touches East Africa has that ocean's lowest primary and plankton productivity (International Indian Ocean Exploration reports) and thus its lowest potential. The fact that foreign fleets, especially Japanese, that were fishing in international offshore waters mainly for tuna and sharks, have recently abandoned this area or at least considerably decreased their activities in it, does not augur well for the future.

In addition, various highly detrimental fishing and collecting methods have dangerously depleted certain coastal resources in recent years. In particular, the extensive use of dynamite on the reefs has led to widespread destruction, especially in the vicinity of Dar es Salaam. The numerous beach seines, which catch a lot of juvenile fish, particularly in the weed beds, also take their toll, and finally, indiscriminate and heavy collecting of mollusks, seaweeds and edible sea cucumbers *(Holothuria)* at low tide, has further plundered the reefs, tidal flats and rocky shores to the extent that some are now quasi-deserts, biologically-speaking.

Moreover, even where protective legislation has been enacted, its implementation has largely failed so far (except for Kenya's marine parks). And as yet undiscerned dangers which require serious consideration may lie in the large-scale cutting down of mangroves, which are a refuge for many species and the juvenile stadia (e.g., *Penaeid* prawns).

If this somewhat dismal picture can be improved to a certain extent by proper management, it still remains hard to see how, even with present technology, basic productivity can be increased. Therefore, timely consideration and development of other sources of production, i.e., mariculture, are essential.

In this paper only a broad review can be given of what this entails in East Africa. Reference is made to those publications which deal in detail with the requirements and techniques necessary to a successful venture in this field. Much research will still have to be done, but some pilot and experimental projects should be started now, and guidelines to do these will be given here.

This review will exclude prawn and crab culture since this has been covered in another paper.

Organisms

These can be divided into five broad categories: edible seaweeds, mollusks (oysters, clams, etc.), crustaceans (prawn, crabs, lobsters), sea cucumbers and fishes.

The basic requirements of these organisms can be considered under the headings of zonation (depth), substrate, water quality (e.g., salinity), food supply and reproduction.

Naturally the species to be cultured will have to meet certain criteria which are essential to their profitable exploitation. A major one is rapid growth to marketable size. Other important factors are selection of species with resistance to diseases and parasites, as well as to other environmental factors (e.g., fluctuations in salinity, turbidity); an easy food supply; reasonable production costs, and high market value.

Suitable Areas

Potentially suitable areas in East Africa can be categorised to include all estuaries and their vicinities (except for those which are too exposed, e.g., Pangani), all mangroves and creeks, leeward shores with extensive shallows, and lagoons and shallow bays.

Even a cursory examination of the Admiralty marine charts will show that areas of the above nature are abundantly present along the East African coast, although access may be difficult in some cases (e.g., the Rufiji Delta). Of course the actual sites of any mariculture projects will have to be chosen carefully and surveyed.

Potential for Aquaculture

Edible Seaweeds

The commercially most valuable types, the brown *(Phacophyceae)* and red *(Rhodophyceae)* algae, are not particularly abundant here, attaining their maximum development in somewhat colder waters (Chapman, 1970). However, certain algae are regularly collected in East Africa and exported as well, usually sun-dried. Exports from Tanzania totalled 39.8 tonnes (dry) in 1972 (Annual Financial Report, 1972).

Among the brown seaweeds, only *Sargassum* and *Turbinaria* could be exploited locally because most other species are too small to collect economically. Red seaweeds are somewhat better represented, with *Eucheuma* quite abundant and *Hypnea* and *Gracilaria* exploitable genera (Mshigeni, 1970). *Eucheuma* are actively collected, especially in Pemba, Zanzibar and Mafia, where they seem more abundant than along the coast. Mshigeni reports, however, that the harvest per unit effort was already seriously declining in 1969, principally owing to poor picking methods, and he made a series of recommendations regarding harvesting, drying, sorting (identifying), marketing, managing, engaging in further research, etc., which are worth considering.

Furthermore, in view of the increasing world demand for algal by-products, especially in the food, pharmaceutical and cosmetic industries, it appears obvious that Mshigeni's survey should be enlarged upon to include other species of eventual potential. Location of adequate sites for starting experimental culture and determination of the biological requirements of the commercial species and of their regenerative properties, as well as a study of their life cycles and determination of the best harvesting periods are all elements of prime

importance to consider if algal culture is going to be attempted with any success.

Experimental culture in the lab and later in ponds or enclosures where water conditions can be controlled should be attempted before taking the final step of farming them in the sub-tidal zone in clear waters (e.g., on the offshore islands), where they seem to attain their peak abundance and size. Certainly with the modern technology now available (scuba gear) this should not present any great problems. Suitable mechanical harvesting devices, operated from a boat, also can be designed and/or adapted for use here, as is done in the United States, for example (Iversen, 1968).

Certain algae, e.g., sea lettuce *(Ulva)*, collected locally for baiting *Madema* (fish traps), and the abundant turtle-grasses, mainly of the sublittoral zone, also might merit investigation into their commercial properties.

Mollusks: Oysters

Some research has already been done on the East African oyster *Crassostrea cucullata* (Born), the most important edible species (Van Someren, 1960, Van Someren and Whitehead, 1961). In addition, results of research elsewhere on species with similar requirements (*Ostrea tulipa* in West Africa) as well as one species from many temperate countries (Japan, Yugoslavia, the Netherlands) can be of practical application here.

The techniques are well known (Iversen). Suggestions on starting a pilot project in East Africa are given below. Further research, especially on the biology and ecology of the common *C. cucullata* and later on other suitable species (*Ostrea amasa*, which is very common on exposed cliffs), should be initiated simultaneously with a pilot project on the culture of *C. cucullata*.

Pilot project prosposal: C. cucullata. In Tanzania the site should be either Kunduchi Creek or Mbegani Bay. Although numerous other suitable sites are available, these two have the advantage of being close to fisheries institutions. The importance of site choice must be stressed since, for instance, good spat collecting areas are not necessarily good growth areas. Hence, young oysters may have to be moved. Ease of access to the sites and proximity to markets are also priority considerations.

The spat collectors, in order of preference with regard to efficiency, availability and cost, are: asbestos sheet (Bati), rejects (i.e., broken pieces), tiles (broken rejects), oyster shells (cultch), mangrove sticks and twigs, plywood (scrap) and bamboo.

The best method to start with should be the cheapest and simplest. This will avoid having to abandon the project owing to lack of funds to solve unforeseen difficulties.

Spat can be collected on strings (nylon) to which are attached, at about 15 centimetre intervals, different materials (collectors), such as pieces of asbestos sheeting, oyster shells, plywood and even old tins, of about 50 square centimetres. These strings can be suspended at about 30-centimetre intervals from one-inch-diameter ropes five- to ten-metres long and strung at about one-metre intervals between strong poles set in the bottom, or between floats made of petrol drums suitably painted with anticorrosive/antifouling paint. Water depth at lowest tide levels should be about three metres at least, since the string will be about that long. This entails siting the project in a deep channel within the creek, and access would have to be by boat.

One advantage of the above method is that there is little moving to be done. Moving involves only the scraping of spat off the limed collectors (e.g., tiles) and seeding the young oysters on a suitable substrate in the growing area. Moreover, the materials required are locally available and not too costly. The oysters will be constantly immersed, if desired, with no dry periods during low tides, and hence faster growth will be promoted. If fixed poles are used, the ropes may be suspended so that the oysters hang at different depths. Some may be dry during low tides allowing for continuous experimentation on comparative growth rates at different depths and immersion times. Further advantages are that oysters thus suspended are reasonably safe from predators which are mostly benthic (starfish), their shape develops more regularly (round shells) and inspection is easy with the strings having only to be pulled up into a boat or raft for the necessary weeding operations. Moreover, the culled oysters eventually can be set out on suitable substrates (hard sand, rocks) of the intertidal zone if these are available. Finally, apart from the initial installation and the later occasional weeding to prevent crowding, the oysters need little attention so that the staff in charge of the project can concentrate on further research and experimentation.

As experience is gained, this basic method can be refined, and other more costly, but also potentially more productive, methods can be introduced, such as collecting spat on the most suitable substrate material (probably asbestos sheeting) and raising the oysters on wire trays.

Scale will have to be determined more precisely, since it involves the economics of the oyster market and depends basically on the wholesale price which can be obtained for them. In any case, the cost of materials and labour involved will have to be covered for at least five years with the initial capital investment, since it takes oysters at least three years under favorable conditions to grow to marketable size. In the absence of precise economic data, it appears safe to assume an initial annual production of about 200,000 oysters, which would require roughly 35 petrol drums, assuming low production of no more than about 200 oysters per string, 500 metres of one-inch rope, 4000 metres of string (monofilament nylon), a lorry-load of scrap materials for cultch and about ten gallons of paint—no doubt the most expensive item. Under proper conditions of siting and operation this production can be doubled using no more materials.

Mollusks: Mussels

Just as for oysters, culture techniques are well known (Iversen, 1968), and successful culture is more a matter of implementation than research, although suitable species for East Africa will have to be determined, probably from among the genera *Mytilus, Septifer* and *Modiolus* which occur in some concentration on certain rocky ledges or hard sandy bottom. Mussels, however, do better in colder waters. It is doubtful whether adequate growth rates can be obtained here. Because the waters are not generally very productive, food supply is likely to be a problem. It is necessary therefore to investigate species, site selection, growth and food supply before initiating any experimental culture. But nowhere in East Africa have any significant concentrations of large (marketable) mussels been observed or recorded, and it does not appear that their culture has much future here.

Mollusks: Clams and Others

Several species are of potential interest here. (1.) *Anadara antiquata* is very common on mud/weed flats of the intertidal zone and regularly collected, mainly by women, for food. (2.) *Donax* spp. (mainly *D. faba*). These occur in large concentrations on beaches and sand banks, mostly toward the bottom of slopes, and despite their small size (not exceeding one inch usually) are highly edible. They are much appreciated in Mediterranean countries, but at present are totally unutilised in East Africa. They appear to be seasonal to some extent, possibly migrating slightly, depending on the amount of wave action, and are especially abundant on beaches where fish are cleaned. (3.) Finally, the beautiful gastropod *Cypraea tigris* which is very much in demand for ornamental purposes and now reaching a stage of serious depletion here from overcollecting, could conceivably be cultured quite easily since it is an adaptable species found on all types of reefs and rocks, in weed beds and even on muddy flats and on mangroves. It feeds mainly on a variety of algae, and there are indications that it grows fairly fast, reaching adult size within a year or so after metamorphosis. The eggs could be hatched in well-aerated tanks without major difficulties. If the larvae can be cultured until metamorphosis, profitable raising of this species would be ensured. Hence research should concentrate on the larval and very young stages.

A number of other mollusks are either edible or of ornamental value, but none of these are either common enough, sufficiently adaptable or fast enough growing to warrant consideration now, except possibly *Cypraecassis rufa*, the cameo shell, with an ecology similar to *C. tigris*. All these potential species will require a considerable amount of research on their biology before it is decided whether or not their culture is worthwhile, and no doubt technical difficulties will arise as well.

For the immediate future, therefore, it is advisable to go ahead with oyster culture and gradually devote research efforts to other potential species at a later date. It may be useful, however, to promote at least the raising and marketing of *Donax* spp., which are at present completely unutilised.

Crustaceans: Lobsters

Two families are considered under this heading, *Palinuridae* (genus *Palinurus*), the spiny lobsters, with

seven species in East Africa, and *Scyllaridae* (genus *Thenus*), sand-lobsters, with three species here. The commercially important species, however, for reasons of size and/or abundance are only four, *Palinurus ornatus*, *P. versicolor*, *P. longpipes* and *Thenus orientalis*.

For as yet unexplained reasons, the spiny lobster cannot be caught in any traps yet devised, despite numerous trials conducted at Kunduchi Fisheries Institute (Heath, 1970). Trapping *Thenus* has apparently not been tried yet. The present fishery, therefore, relies on divers using spear guns or the older method of hand net plus octopus (or white rag) and on tangle nets or gill nets set near the reefs. Despite the apparent inefficiency of these methods, catches in Tanzania have declined in recent years (also evidenced by a similar decline in the Kunduchi Fisheries Institute gill net catches). It is possible that extensive dynamiting of the reefs has contributed to this decline. Providing the lobsters with suitable shelters might contribute to restoring this very profitable fishery. A research program, now unfortunately stopped, was started at Kunduchi in 1972 to investigate the feasibility of setting up artificial reefs or shelters in suitable locations.

Although the creation of artificial habitats cannot be labeled an aquaculture practice, strictly speaking, it is a step in the right direction. Preliminary findings are promising. Actual culture of spiny lobsters would involve their successful raising from the egg. Despite a number of trials, this has not been done to date (Iversen). Moreover, the little that is known of their growth rate indicates that it is slow, making it uneconomical to raise them in captivity (Heath; Fielder, 1964). No data on *Thenus* species appear to be available. Little is known about their habits and requirements except that they live on sandy bottoms in depths of five to twenty metres, bury themselves in the sand during daytime, are active at night, and possibly migrate seasonally (for breeding?). A large percentage are berried in August to September or October and occasionally this happens at other times. Young *T. orientalis*, from two centimetres upward, have been dredged in five to twelve metres along reefs and edges of weed beds in the Kunduchi area (June-September, 1970).

A short summary of the experiments with artificial habitats may be useful in this context.

Based on continuous—mainly diving—observations on lobsters in their natural habitat, the characteristics of their natural shelters were recorded with a view toward producing artificial ones of the most desirable type, with cost as a factor in the study.

Three types of shelters were considered: (a.) old wrecks (cars, boats, etc.), abandoned because of poor durability (Carlisle *et al.*, 1964); (b.) used tyres, which showed the quickest results, and (c.) cement blocks (46 x 23 x 15 centimetres) and tiles (50 x 50 x 10 centimetres and 80 x 80 x 10 centimetres), requiring installation by divers as artificial reefs.

The tyres were placed in about two-metre and five-metre depths, below spring low tide level, and in the weed beds along the coast at Kunduchi. They were occupied by adult lobsters and moray eels within days. Young lobsters of less than 13 centimetres only rarely entered tyres, possibly because of the presence of the predatory eels. Most commonly, *P. versicolor* and *P. ornatus* with an occasional other species (*P. longpipes*) were found in the tyres. The experiment lasted only a few weeks after which the tyres (although their emplacement was unmarked) were stolen. However, a similar set-up at Silversands Hotel nearby produced an approximate daily catch of zero to three lobsters per tyre (personal communication, Mr. M. Fainsilber). These tyres, simply placed on the bottom weeds, soon filled up with silt, so that they had to be lifted and cleaned at intervals of a few months or so, depending on water turbulence. An improvement on the method might be to cut them transversally in two, since it is very difficult to catch the lobsters in a whole tyre because they keep scooting round full-circle or escape from a hand net wedged into the tyre before the net can be removed.

In the blocks and tiles experiment, after frustrating delays, a few simple shelters were installed in about an eight-metre depth below spring low tide level on hard sand in a clear area in the weed beds. After 11 days there were no lobsters but plenty of fish; after 17 days two lobsters (one small, approximately ten centimetres, and one adult) were observed sharing a shelter made of a row of three blocks with two tiles leaning at an angle (approximately 30°) against them. Soon after this, one of the Institute vessels pulled a trawl right through the site and the experiment was stopped. However, a block and tile shelter built in a marine zoology laboratory aquarium at Kunduchi showed that lobsters prefer a natural coral block shelter, even if overcrowded, to the artificial one, although after about a month some of

them did go into the new shelter, and all went there immediately after removal of the coral blocks a little later.

Scanty as they are, these results do show great promise—on the one hand of using old tyres as a combination trap and shelter and, on the other, of constructing simple undersea reef-shelters which might prove adequate for lobsters which can then be more easily cropped and managed there. With the present costs of materials (e.g., cement is 11 shillings a bag) and labour, it is a very feasible project, and the returns, provided theft is kept under control, would be highly profitable.

Sea Cucumbers (Holothuroidea) or Bêche-de-mer

Only *Holothuria scabra* appears to be collected in Tanzania, as far as is known, although other edible species probably occur as well. These are usually sun-dried, sometimes after boiling, and exported, mainly to China. In 1972, 49.4 tonnes (dry weight) were exported.

Although there has as yet been no attempt to culture bêche-de-mer commercially, it may be useful to investigate the biology of *H. scabra* as well as the possibility of collecting young (small) individuals and raising them to marketable size in suitable areas, such as Msasani Bay, where they appear to be more common than anywhere else around Dar es Salaam. Since these are detritus-feeders, it may even be feasible to provide them with some form of low-cost feed to obtain faster growth.

Simple low-stake enclosures could be set up easily with local materials, since sea cucumbers are not very active. Meanwhile research, particularly on their breeding biology, could be carried out to determine whether or not they can be raised commercially.

Fishes

As a first step toward marine culture of fishes, the brackish-water or estuarine species appear the most likely subjects. In East Africa, the following species are the ones considered to be of potential value: (1.) *Chanos chanos* (Orsk.), milkfish, which, however, is not particularly abundant; (2.) *Tachysurus dussumeri* (Val.), *hongwe*, a catfish, is very common, especially around river mouths, and (3.) *Mugil cephalus* (Linn.), grey mullet, is common in estuaries, bays, creeks and lagoons.

Other suitable species, such as *Elops, Megalops, Anguilla* spp., and *Trachynotus*, at present are not farmed anywhere on a large scale, but should be considered at some future time. None of these fish has yet been bred in captivity, so this may present serious problems. Fry have to be found in large concentrations at suitable periods, so a first requirement is to determine their breeding season. Areas of fry concentration have to be pin-pointed, except for *Tachysurus*, which is a mouth-brooder and probably less difficult to breed in ponds.

Techniques of capturing live fry and transporting them, as well as of pond and enclosure construction and fish-rearing, are sufficiently known and in the literature, so there is no need to elaborate on these at present.

The culture of *Tachysurus* has not yet been attempted, as far as known, but the great success in recent years of channel catfish *(Ictalurus punctatus)* culture in the United States, and developments in the culture of other catfish (e.g., *Clarias*) seem to open up vast new possibilities in this particular field. There is no reason why the East African countries should not pioneer in the field here with what appears to be a highly suitable species.

Naturally, initial investments in marine fish culture are far higher than, for instance, in oyster culture. The preliminary research and experimentation also will necessitate a large contribution. Suitable sites are plentiful, especially around estuaries, but food requirements and supply will have to be carefully studied, apart from the points already mentioned about obtaining fry.

Conclusions and Recommendations

Although present fishery development priorities in East Africa are geared to expansion and modernisation of the fishing fleets, the potential of mariculture should be recognised now and steps taken to incorporate it in planning. As this will practically be a completely new field for the region, initial planning and funding for preliminary research and experimentation should be carefully considered, and it is hoped that the following recommendations will serve as useful guidelines. From this review, it is clear that although culturing techniques are usually sufficiently known to try them, the biological requirements of the eligible organisms are not, and will require further research, which is costly and time-consuming. To obviate this to some extent, the pilot-

project proposals should be considered on a high-priority basis. It is therefore recommended that:

1. A comprehensive development plan for mariculture in Eastern Africa be drawn up during this year. Funding sources (also external) should be contacted now in order to determine what amounts can be made available and when, since this will reflect directly on priority of implementation.

2. Priorities should be clearly laid down with a time schedule as a part of the overall plan as soon as funding is assured.

3. Suggested priorities (independent of funds) are: (a.) starting a pilot project for oyster culture as suggested under the heading Oysters, (b.) continuing and expanding the experimental lobster shelter project (see Lobsters) for which a separate, detailed report is in preparation, (c.) investigating the biological requirements and feasibility of culturing other species mentioned in this review. Naturally these priorities are independent of proposals regarding prawns and crabs which are not covered in this paper. Prawns, in fact, possibly merit the highest priority in the whole field of mariculture in Eastern Africa.

4. The most logical approach appears to be the establishment of an international FAO/UNDP project, in order to achieve coordinated development.

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Supplementary Comments

H. Matthes

Recent information indicating that oysters can be relatively simply and inexpensively reared to marketable size within ten months, rather than three years, raises them on the priority list of marine aquaculture possibilities.

Fisherman's education in proper cropping methods for collection of both wild and cultured organisms could be of material assistance in quicker species regeneration.

A survey of regional organisms suitable for culture is being conducted by the University of Dar es Salaam.

With regard to the rearing of mollusks, i.e., mussels or clams, research and experimentation are needed in techniques and equipment, and especially in the rearing of larvae. In general, more knowledge of marine biology is needed to rear an organism than to crop it from the wild. Among the more esoteric organisms that could be considered for artificial rearing for export are the *Cypraea* species and certain conchs.

Research is currently being conducted at Kunduchi on shelters for local lobster species. Shelters not only increase the number of available habitats in an area, but also tend to alleviate somewhat difficulties generally experienced in trapping crustaceans. While car tyres have proven efficient collectors, catch extraction is difficult. The current research, which involves various building-block construction designs and attempts to evaluate preferences in shape, spacing and placement (typically eight to twenty metres of water near the edges of reed beds), has shown early promise. The research needs to be expanded to be of practical value.

Supplementary Comments

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Commenting on aquaculture in general, it was pointed out that in Africa there are few traditional aquacultural practices. Consequently, immediate extension success of any effort is not to be expected. Aquaculture has, however, been successfully improved in areas where traditionally practised, such as Southeast Asia.

From studies in these areas, several important factors have been suggested as priority items to be taken into consideration in developing aquaculture. They are: (1.) a good supply of seed (eggs, etc.) must be established; (2.) there must be an adequate source of cheap feed for fish; (3.) emphasis should be placed on non-predatory fish (herbivorous or carnivorous), since the goal is to increase efficiently available protein for human consumption; and (4.) considerable estuarine areas should be available for bivalve culture (oysters, mussels, clams, etc.).

Most critical, however, is the fact that marine fisheries usually need foreign exchange to purchase deck machinery and electronic fish-finding devices that require substantial maintenance to be fully effective, and often this technical backup must be conducted by nonnationals. In aquaculture, however, less equipment is required and little foreign exchange, so one can have a predominantly national enterprise which avoids the problem of ending up in competition with one's benefactors.

Tanzanian aquaculture potential can be developed in a broad range of environments: the inshore area (in the reef and along the coast), the estuary, and the brackish-water coastal lagoons.

High-technology aquaculture, such as for shrimp and lobster, may be rather difficult at present even in areas where high technological assistance is readily available. The culture project objectives—low-cost protein for food as compared with high-value products for export—can be married when the earned exchange from the high-value product is used as a subsidy for the low-cost, high-protein product of which the culture is designed to produce food for people.

Considerable advantages can be obtained by rearing oysters, considered a practical crop, in areas where they will grow efficiently but not reproduce. Freedom from excess crowding of the spat encourages growth, which could be inhibited by over-settlement.

With regard to the already-described problem of reef preservation, the inherent difficulties in convincing the fisherman not to destroy the reefs for his immediate gain can be materially assisted if marine culture enterprises are provided to re-direct people to more profitable and acceptable alternatives.

Discussion

1. Africa has not had a long history of aquaculture, as has the Far East. Realizing its potential requires vigorous action. A recommended approach to initiating highly labor-intensive aquaculture would be to pick four or five of the most promising, least sophisticated candidates, such as the oyster, and proceed with small-scale development, saving the most sophisticated organisms to be exploited as competence develops. The needs of aquaculture and the capture fishery overlap in that both require development and expansion of their common supporting infrastructure, i.e., processing, handling, marketing.

It seemed to be felt by the group that aquaculture, defined as a deliberate effort by man to increase productivity and harvest under controlled conditions, should be segregated from making improvements to the capture fisheries, such as providing artificial habitats.

2. In research being conducted at the University of Rhode Island on *Homarus americanus*, the indigenous New England lobster, it was found that the territorial New England lobster is definitely habitat-limited, probably due to sensitivity during ecdysis.

After evaluating various block configurations of habitats for these lobsters, the candidate design selected was a streamlined dome with a horizontal semi-elliptical opening. The heavy-walled habitat is made of pumice. The design permits adjustment of the habitat's specific gravity for substrate configuration and loading.

In field experiments habitats were fully occupied within two weeks after emplacement, even when located in unoccupied sand areas up to one kilometre from the nearest source of organisms.

A minimal spacing between habitats of approximately three metres was found optimal. In matrices of habitats where the distance was less than optimal, only the habitats at the edge were occupied. Larger lobsters required more space and larger openings. Opening sizes were based on elbow-to-elbow distances required to accommodate the extent of the chelapods, not on carapace dimensions. Habitats must be carefully designed and placed to minimize dispersal under strong storm surges. Trawler (net) fishermen can suffer substantial net loss from picking up mislocated habitats.

3. Present techniques of haphazard capture of East African lobsters reflect little attention to good conservation practices. A technique used in the West Indies of collecting up to 40 gregarious juvenile lobsters in perforated 55-gallon drums for tagging in order to subsequently determine migration patterns may be applicable.

4. Increased production of fish in East Africa may well require an increase in people's desire to eat fish and fish products. East Africans are the poorest fish consumers on the continent. For all of Africa the average fish

consumption is 7.7 kilograms per person per year, but for Western Africa, 19.1; Central Africa, 11.8; and East Africa, 4.0. It was emphasised that high-value cultured species should not be targeted for local consumption by man or animal, but reserved for export earnings.

5. The Philippine Development Bank has established evaluative criteria for anticipating return-on-investment and other financial criteria for aquaculture enterprises that may be relevant to East African needs.

Priorities in Development of the Shelf Fisheries

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In this paper, under the term "shelf fisheries" I have limited myself to a discussion of the demersal, including crustacean, fisheries of East Africa down to the 500-fathom line, and have not considered the extensive pelagic fish which live over the continental shelf. These latter fisheries, more amenable to mechanisation, I have briefly reviewed elsewhere (Morris ms., 1974).

Two geographical factors inescapably limit our demersal fisheries. First, the continental shelf is extremely narrow. Apart from the channels and the North Kenya Banks, it does not exceed five miles in width. Second, there is a rich profusion of coral growth in all but the sub-estuarine areas which precludes "industrial" fishing methods such as trawling. A third major "geographical" feature does not present an insurmountable problem: that the East African coastal current flows up to four knots off the coast. This is too strong for the navigation of small sailing craft, and these craft, which form the bulk of our fishing fleet, are therefore prevented from reaching the outer limits of even our narrow shelf. Introduction of larger mechanised craft should overcome this problem. But solving this problem leads to a fourth problem, the extremely low capitalisation of all our fishing industry.

Total marine fish catches in 1970 were around 40,000 tonnes for Tanzania (including Zanzibar) and Kenya. Of this total, about 50 percent were demersal fish. This ratio is interesting, considering that at least 70 percent of the fishing effort concentrates mainly on demersal species. These figures are "guestimates" arrived at by extrapolations from the relevant government annual reports, and EAMFRO's own figures for Zanzibar. Average vessel productivity per day for Tanzania in 1970 was around 30 kilograms for demersal and pelagic fish combined. From market surveys off Zanzibar, I find that productivity per vessel per day in hand

line and *dema* fisheries is usually less than one-third of this figure.

Fisheries by Area

The Inshore Reefs and Islands

The general coastal pattern of Tanzania and Kenya is that of an elevated fringing reef. In many areas there is a continuous chain of small offshore islands, presumably formed by fragments of the elevated crest of a previous reef. Between these small islands and the coast, extensive coral beds (*Acropora* spp.) are to be found. This pattern is repeated, on a larger scale, in the main island channels of Zanzibar and the Mafia Islands. The bulk of Tanzanian and Kenyan demersal fisheries concentrate on these sheltered areas which, essentially, can be considered analogous to lagoons. The main outer reef face is probably little fished, owing to the strong currents previously mentioned, and to the steepness of the reef face.

The exposed reef flat is exploited for octopus, a highly prized food item; for shells, formerly eaten, now usually sold to tourists; for small oysters and clams, usually boiled then smoked; for bêche-de-mer, exported; for seaweeds, similarly exported for agar agar; and for bait for other fishing operations. Stake traps are sometimes situated on sandy areas but are more commonly placed in estuaries and sub-estuarine areas.

In the *Acropora* coral areas, the most frequently used items of equipment are the dema trap and the hand line. The dema trap is a hexagonal basketwork structure and is usually placed on smooth sand bottoms close to coral growths. The hand line is used from small boats anchored over the coral growth areas. Most *dema*-trap fishermen also employ hand lines, and it is difficult to determine which method was used for an actual catch. Overall the dominant species in the catches are *Scolopsis bimaculatus, Lutianus johnii, Lethrinus chaerorynchus, Nemipterus nemurus, Parapeneus* spp., and *Callyodon* spp.

A broader spectrum of true coral species is taken by spear fishermen using snorkel apparatuses. Probably the Callyodontidae form the largest part of their catch, but large *Epinephelus* spp., species of Pomacentridae and rock lobsters, *Panulirus* spp., are also very important. Information on the rock lobster fishery is contained in Hall (1961) and Mutagyera (ms., 1974).

Use of the "Juya" seine from the shore in Zanzibar has been banned by Presidential Decree on the grounds that large numbers of immature fish were taken, and extensive areas of live coral were trampled during its use. In the Zanzibar fisheries, it is now mainly used on certain offshore sand banks for semi-pelagic fish—usually small carangids, barracudas and *Caesio* spp.

Sand and Grass Beds

Between coral outcrops, mainly in the channel areas, are found extensive areas of sand bottom, clothed to a greater or lesser extent with turtle-grass beds. Close to coral outcrops, these areas seem to house populations of *Lethrinus* spp. in great variety but most particularly *L. chaerorynchus*. Small *L. miniatus* and *L. nebulosus* seem to become more common in deeper areas. Dema traps set in the grass beds away from coral and baited with weed, seem to take exclusively *Siganus oramin*. Bottom-set nets are quite extensively used; characteristically they take small sting rays *Taeniura lymma*, marine catfish *Tachysurus feliceps* and black runners *Rachycentron canadus*, which are less frequently caught but highly prized. Rock lobsters, *Panulirus* spp., are often taken. Wood (personal communication) reports very successful use of light tangle nets off Tanga for the capture of rock lobsters. EAMFRO has employed bottom longlines in these areas and taken moderate catches of small sharks and marine catfish. Generally speaking, these areas are too broken up by coral heads to be trawled.

Estuarine and Sub-estuarine Areas

These areas, where coral growth is suppressed by silt and brackish water, contain the main resource to be taken by trawls off the coast. The main areas are off the Rufiji and Sabaki Rivers, with lesser areas off Bagamoyo, Saadani and Pangani. These fisheries are, I believe, dealt with in detail elsewhere in this conference. I will, however, mention two points. First, the prawn trawl fisheries take a considerable "by catch" of which 50 percent is probably marketable as table fish. *Otolithes ruber* is particularly important (Morris ms., 1971), and the remainder could be converted to fish meal or sold as "soup fish." Second, Bruce (1972) reports the

extension of prawn fisheries into much deeper waters than previously supposed. Catches of *Penaeus latisulcatus* and *Parapenaeus fissurus*, both marketable species, have been taken at 100 fathoms in the trawl. Larval studies indicate the presence of richer substantial deep-water stocks.

The Submerged Reefs

These are in a series of banks situated principally at the mouths of the Zanzibar and Mafia Channels. The inner portions of the North Kenya Banks, studied by Morgans (1961) can also be considered in this category owing to the similarity of its fish fauna. The banks, which are extremely rocky, rise up from sandy bottoms in about 30 fathoms to about nine fathoms. Characteristically the fish fauna consist of large (two-kilogram) specimens of *Lutianus bohar, Aprion virescens, Lutianus rivulatus, Lutianus sanguineus, Lethrinus miniatus* and *Lethrinus nebulosus*. Many other species are of course taken, notably *Epinephelus tauvina* and *E. leprosus*. Yields are generally in excess of ten kilograms per line per hour. Attempts to use longlines have generally failed, but certain mechanised fishing reels imported from Iceland are now being used with moderate success.

The Continental Slope and Shelf Areas Below the Thermocline

These fisheries are also discussed by Morgans (1961) and Smith (1965). Certain deeper water areas (below 50 fathoms) seem to be characterised by an extremely rich gorgonian coral and sponge fauna. Such areas have so far been located off South Zanzibar, Shimoni, and on the outer part of the North Kenya Banks (Benbow ms., 1972). Stocks appear to exist of the deeper water Lutianids including *Pristipomoides* spp., *Etelis* spp. and *Aphareus* spp. and the denticids *Polysteganus* spp. and *Chiemerius nufar*. No commercial means of exploiting these species, except at the shallower end of their range (Morgans, 1961), has so far emerged, but the electric reels mentioned above offer promise.

Water Fertility, Standing Stocks and Maximum Sustainable Yield

Extreme species diversity and lack of terrain suitable for "calibrated" commercial fishing methods have rendered stock assessment almost impossible. Attempts that have been made have relied on productivity studies and on comparison with better known analogous areas —e.g., Dibbs (1964), Cushing (1971) and Marshall (ms., 1972).

Plankton productivity studies indicate that the waters of the "Azanian Sea" are quite rich. Cushing (1971) indicates a considerable area of upwelling off the coast with an effect particularly marked during the Northeast Monsoon. Wickstead (1962, 1963) made a series of plankton hauls along the entire coastline and also made continuous plankton observations in the Zanzibar Channel. I have used Cushing's methods (op. cit.) and Wickstead's figures, combined with International Indian Ocean Exploration results, to determine secondary and tertiary production in the channel areas and on the North Kenya Banks (Morris ms., 1974). The resulting figures are in the accompanying table. I have no way of assessing the additional production resulting from benthic plant life, or of assessing the proportions of this tertiary production represented by pelagic fish, demersal fish and nonutilisable forms. The figures can at best be taken as index figures of relative fertilities of different shelf areas. They should not, of course, be used for comparison with production of oceanic areas similarly calculated, where the proportion of secondary production converted to utilisable food fish is likely to be much lower. An extreme example may illustrate the point. Tertiary production in the South Equatorial Current/ Equatorial Counter Current sheer zone is calculated by Cushing at one to two tonnes wet weight x 10^6 per 5° square in the Northeast Monsoon 180-day period. The only species group taken from this area is the oceanic tuna, which might be considered as being from the fourth production level. Thus we could estimate quaternary production by taking ten percent of the tertiary figure, i.e., 1 to 2 x 10^5 tonnes per 5° square. From figures published by Suda (1973), tuna harvest for the area in question seem to work out at about 7 x 10^2 tonnes per 5° square. Thus, with high fishing pressure, in this particular case we seem to be harvesting less than one percent of the theoretical quaternary production.

The most feasible comparison for harvestable demersal resources seems to be with the figures of Wheeler and Ommaney (1953) which indicated that certain areas in the Mauritius/Seychelles Island arc were capable of sustained production of 4.7 metric tonnes per square

Secondary and tertiary production in the Channel areas and North Kenya banks.

Region	Area hectares	Zooplankton mg/mm³		Tertiary Production metric tons	
		NE Monsoon	SE Monsoon	NE Monsoon	SE Monsoon
Mafia Channel	825,600	60	30	32,000	16,000
Zanzibar Channel	619,200	60	30	24,000	12,000
Pemba Channel	619,200	*	*	12,000 (est.)	8,000
North Kenya Banks	688,000	100	60	134,000	80,000
Marsden Sq.331 5° sq. 1	20,640,000	30	20	2,000,000	1,300,000
Marsden Sq.331 5° sq. 1	30,960,000	30	10	3,000,000	1,000,000

* *No figures available.*

kilometre (recalculated figure taken from Marshall ms., 1972). This can be compared with a present annual figure from East African shelf areas of 1.2 tonnes per square kilometre. Wheeler's figures, however, were for what he termed "fishable areas." For the Seychelles Bank, he deduced that out of a 10,000 square mile area, only 3,000 square miles were "fishable." Broadly speaking, it was the raised outer edges of the oceanic banks which supported rich fisheries. Extensive barren areas were found in the "body" of the bank. These findings have been confirmed by EAMFRO during a cruise visiting the Seychelles in 1971 (*Manihine* Cruise Report 317). The outer edges of the oceanic banks correspond closely to the offshore banks found off the Zanzibar and Mafia Channels, which comprise only a small fraction of our shelf area. It is worth noting that the fish groups taken in abundance by Wheeler are essentially similar to those described above for the offshore banks.

It must also be remembered that present East African catch figures are almost certainly underestimates. Fish are landed at a thousand small villages and islands along the coastline, and it is impossible to monitor each station for 24 hours per day. Fishermen also tend to avoid statisticians, even when assured that their presence is not part of a taxation scheme. About one year ago, the Zanzibar government introduced comprehensive fish-weighing and recording facilities at the main fish-landing place. It is the writer's subjective impression that fish landings at this particular station declined sharply at the introduction of weighing and have yet to fully recover!

Market surveys made at Zanzibar confirm that the outer banks areas are little exploited, and the large lethrinid, lutianid and serranid species form only a small proportion of the catch. The landings do, however, show large numbers of small fish, most of which admittedly mature at small size. Gonad examinations show that existing fisheries land a considerable proportion of immature fish. Illustrative data are available which show the size and sexual maturity analysis of a catch of 70 *Lethrinus chaerorynchus* monitored in October 1970.

Conclusions

All the above information is extremely subjective and, as previously pointed out, virtually no hard and fast information is available on stocks and yields. Nevertheless, it appears to the writer that the artisan fisherman, *in areas where he fishes,* is exploiting demersal stocks at around their optimum level, if not above it. This fishing area is limited by the nature of the craft the fishermen use, but in any case does not seem suitable for exploitation by "industrial" means.

Leaving aside the pelagic fisheries over the shelf and the "trawlable" areas, it seems that increased catches will need to come from areas not presently exploited. Such areas as the offshore banks and the North Kenya Banks are reasonably extensive and appear to have rich fisheries comparable to those described by Wheeler for the Mauritius/Seychelles arc.

The distance of these areas from main ports supports the use of mothership-and-dory as the system of exploitation. The mothership should probably be around 100 feet in overall length and have equipment for production of frozen fish fillets, etc., which can either be sold on East African city markets or exported to coun-

tries of inland Africa. The actual fishing units should be small rowing or outboard-propelled vessels, and the fishermen should use hand lines as they do at present. No new skills are required for start-up, other than those for the parent vessel. Other later required skills for exploitation of very deep waters can be imparted during fishing operations.

This is not to say that the artisan demersal fisherman should receive less attention. The most significant improvement to his lot will, however, be brought about by improved processing and distribution of his catch and elimination of waste. To justify the infrastructure needed for this, it will be necessary to centralise landings to a degree, and this does, therefore, seem to support the case for introducing small mechanised craft having ice compartments. Suitable vessels are described by Alverson (ms., 1973). Such vessels will be able to remain on the fishing grounds for much longer periods than the present craft, and catch per unit of effort should therefore rise. It is hoped that this will be offset by the diversion of part of the labour force into semi-industrial fisheries, such as the dory system described above, mechanised pelagic fisheries and mariculture schemes.

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Supplementary Comments

S. B. Saila, *University of Rhode Island*

Of the approximately 40,000 tons of marine fish caught per year in Tanzania, 50 percent are pelagic. This statistic is interesting, inasmuch as 70 percent of all effort is apparently directed toward the demersal fish catch, implying perhaps that the pelagic fisheries' potential is higher than anticipated and that more effort should be applied in this direction.

A better knowledge of the movements of offshore migrating species may permit more extensive and effective fishing effort at the time when stocks are closest to Tanzanian shores. Knowledge of the nature of the thermocline and its oscillations may also contribute to fishing efficiency. Also, deep water or mid-water trawling for large pelagic fish with wire line and mechanical depressors could help. Continental slope areas and deep waters have a higher potential for shrimp, and there is a greater depth distribution of shrimp than has been previously realized.

It is also suspected that the reef fisheries (dugout canoe and outrigger) using traps and hand lines may be at or near an optimum level of exploitation in their present areas of activity. However, no firm evidence for this is at hand. The concept of enhancing natural yields of rock lobsters (*Panulirus* spp.) in these areas by the use of artificial habitats should be examined and evaluated.

The knowledge and application of the maximum sustainable yield (MSY) concept and its significance in setting goals and priorities in fisheries development need discussion. The amount of research needed to determine average M, estimating vital statistics for application of the Beverton-Holt yield equation is questionable. A simpler approach for yield optimization based on K. Radway Allen's efforts as described by W. Knight in "A Possible Optimization Experiment in Fishery Management" (*J. Fisheries Research Board of Canada* 27(5): 961-963, May, 1970) is a suggestion for application to Tanzania's present need for quantitative stock assessment. This approach could be applied to individual species or ecologically similar groups. The assumptions involved in any mark-and-recapture experiment apply to this work.

It seems that additional empirical information is highly desirable on the relative productivity of coastal reef areas and their levels of exploitation.

Discussion

1. One of Tanzania's Fisheries Department's approaches in assisting the artisan fisherman to work farther from the shore is to encourage the use of onboard ice to avoid spoilage on the way to the beach. In the short term the use of trawlers is not being emphasized; however, the mothership concept mentioned is under consideration.

2. Estimates of the potential of beyond-the-reef stock assessment should probably be divided into the separate but interrelated categories of deep-slope benthic and pelagic stocks. Very little information is presently available on either, and even estimates of the potential of offshore banks, approximately 4.7 metric tons per hectare, are based on simply transferring information from the Mauritius/Seychelles Bank fishery. A figure of ten kilograms per line-hour has been recorded in this area.

The suggested potential yields were considered high, due primarily to variability in productivity. In the Caribbean area an average of 1.5 to 2 metric tons per square kilometer appears more appropriate than the maximum figure of 4.7 metric tons per square kilometer.

A note of caution was expressed regarding optimism about the projected catch based on experience in the Mauritius/Seychelles area where increased promise brought extensive fishing pressure from corporations from developed countries. The value of a good survey which encourages careful exploitation, rather than overinvestment and consequent overexploitation, should be encouraged.

3. New techniques of stock assessment being applied at Lake Tanganyika and in Peru were mentioned. A high frequency echo sounder with an integration unit now being tested should be considered for applicability. Assessments of applicability of advanced equipment are within EAMFRO's present mission.

4. A recent position paper on world tuna stock assessment listed the Indian Ocean as the one major ocean which has unrealized potential for catches of major tuna-like fishes. The available increase in bonito and sarda alone may be as high as 200,000 metric tons per year. (S. B. Saila and V. J. Norton. 1974. Resources for the Future. Program of Intl. Studies of Fishery Arrangements Paper 6, Washington, D.C.)

5. The question of whether or not the small size of pelagic organisms can be related to questionable shore and nursery area exploitative practices (overbearing reef fishing pressure and gear selectivity) remains open.

Fishing Boats and Equipment

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The paper reviews the present status of mechanisation of fishing boats in Tanzania and justifies the need for increased development in view of the country's fast-expanding fishing industry. The phases of fishing vessel development have been outlined, and mention is made of its two major lines: middle-distance and traditional fishing vessels, and far-distance, or deep sea, fishing vessels.

Four possible ways of modernising fishing boats are described: (1.) adding an outboard or inboard engine; (2.) adapting suitable designs to modify the present boats; (3.) adopting foreign designs, or (4.) constructing boats of new national types.

Of these, the fourth choice is most desirable; it would produce boats of types suited to local conditions and, in addition, develop local expertise in construction and maintenance. However, any modernisation of boats has to be based on economic considerations.

Present Situation

The following statistics illustrate a slow but marked development of mechanised fishing craft in Tanzania:

	All Craft Total	Mechanised Craft: Inboard Engine	Mechanised Craft: Outboard Engine
1968			
Freshwater	9,031	5	310
Marine	1,694	8	48
Total	10,725	13	358
1969			
Freshwater	13,198	6	329
Marine	1,960	9	51
Total	15,158	15	380
1970			
Freshwater	12,531	8	340
Marine	2,639	8	56
Total	15,170	16	396
(cont.)			
1971			
Freshwater	15,263	8	167
Marine	2,422	10	141
Total	17,685	18	308
1972			
Freshwater	14,878	9	231
Marine	3,113	12	103
Total	17,991	21	334

The unpowered craft on the coast consist mainly of these different types: the dugout canoe *(Mtumbwi)*, the catamaran *(Ngalawa)*, the outrigger canoe, and the dhow. Of these, only the dhow—with some modification and added longitudinal strength—could be mechanised. Most of the recently built mechanised boats are from FAO-prepared designs, and some are imported steel vessels.

General Considerations

Although the form of the vessels varies greatly, the construction methods are rather similar in principle —dugout or simple planking—and offer development problems of the same nature. The drawbacks of the traditional craft are: (1.) low mobility, (2.) poor seaworthiness, and (3.) unsuitability as working platforms.

As I do not yet have adequate knowledge of specific local conditions, the rest of this paper is based on general international experience. In most countries mechanisation of crafts has proved beneficial in increasing economic efficiency of the fishermen. The rate of mechanisation, however, is rather slow; difficulties of many kinds are encountered. The low level of technical education and know-how in fishing communities makes the programmes expensive and slow. It cannot be stressed enough that the development of a fishery and a fishing industry is mainly accomplished by practical experience. The theoretical knowledge required to skipper an offshore or deep-sea trawler is easily gained in on year, but to gain the practical experience required to make a successful skipper takes at least five to six years.

The capital equipment required for the catching unit, i.e., vessels and gear, in an integrated fishing operation is about two-thirds of the total investment. The

remaining one-third goes to processing plants, harbours, etc. In spite of the relative importance of the craft in the economics of fishing operations as a whole, the vessel itself, in most areas, is a very much neglected factor. In view of the large investment in vessels and gear, it would seem obvious that more emphasis should be placed on their improvement and development in order to save capital and, thus, increase profitability.

In many developing countries it is not just technical competence that is lacking, but the realisation of the need for technical advice. Subjects like naval architecture usually get low priority in government educational programmes as well as in the staffing of fisheries administrations. Another reason for the somewhat casual treatment of fishing vessel development in developing countries is the age-old structure of the fishing industry. The traditional pattern is one single vessel, owned by an individual fisherman, delivering the catch to fish markets. The lack of firmly organised groups of vessel owners or larger companies with technical and economic resources often prevents systematic and purposeful development.

Fishing Vessel Development

The development of new vessel types or the improvement of existing vessels requires careful scrutiny of a wide field of influencing factors. The fishing vessel is an important link in an integrated fishery operation, and therefore vessel development cannot be isolated. The problem is not to design and construct an ideal fishing boat but an economical and efficient craft that will contribute to making the overall fishery more economically viable.

The first step in a vessel development programme is to have a multi-disciplinary expert team make an investigation in the region or country concerned. This study should cover nearly all aspects of a fishery, including general information on fish resources and markets.

New designs in construction or equipment often tend to increase both the initial cost and the operating cost (i.e., the installation of an engine). The idea, of course, is that the higher cost should be outweighed by increased productivity. However, this is not always the case because the problems of changing the operational patterns of fishermen are sometimes overlooked. For example, in order to pay for an engine a fisherman may have to go to more remote fishing areas, fish partly during the monsoon period, or change his fishing techniques. In theory this should not be difficult, but in practice it is often troublesome. These factors have to be taken into account when planning for vessel development; otherwise, modernisation may turn out to be a burden rather than an improvement.

When planning a project in a country or a subregion, the highest priority should be given to activities showing good prospects of sound economic progress. Changing fishermen's attitudes and getting them to adapt to new equipment and techniques are much simpler and quicker if there is no doubt about the benefits of the introduced changes. The execution of a pilot project is considered the most effective means of proving the benefits of changes in vessel type and fishing methods. Concentrating efforts on small pilot projects can stimulate wider groups of the fishing population.

Boats and Fisheries, and Phases of Development

Middle-Distance and Traditional Small-Boat Fisheries. These two levels of fishing effort can be considered together, since the difference between them is not so much of principle as phase of development. The development of a traditional small-boat fisheries should not be an aim in itself but must be considered a basis from which a subsequent development to a middle-distance fisheries can be effected.

Far-Distance, or Deep-Sea, Fisheries. Development of a far-distance fishery calls for a high order of management, technical know-how and a considerable background of services which most developing countries cannot provide at present. It is also considered unlikely that this type of development could benefit substantially from a UNDP-type of project, but would be better served, where required, by bilateral or direct assistance from industry. Thus, no attention is given in the following paragraphs to development of vessels suited for a far-distance fishery.

In general, four different phases of vessel development are apparent: (1.) mechanisation of traditional crafts by fitting outboard or inboard engines, (2.) design adaptation of existing craft by introducing changes in shape and construction, (3.) introduction of foreign boats, and (4.) development of new boat types. The

merits and feasibility of each of the four development steps have to be carefully assessed during an identification process. Apart from estimates of costs and earnings, the information required extends to availability of skilled labour and mechanics, local materials and imported equipment, repair and maintenance facilities, etc. The Fisheries Division of the government of Tanzania has taken steps to oversee the proper training for all trades connected with fishing by the establishment and further development of the Mbegani Fisheries Development Centre. This will contain a fully equipped training centre with service facilities for all types of vessels and a pilot plant for fish receiving, processing and freezing.

Mechanisation. By mechanisation we mean the simple addition of motor power to the otherwise unchanged boat. The power could be in the form of an outboard or an inboard marine engine. The choice of inboard engine is widened by the availability of both petrol and diesel types. The outboard motors available require petrol in the absence, as yet, of a suitable diesel outboard.

This addition of motor power sounds simple, but unfortunately it is not. The boats which concern us here have been built traditionally as sailing or rowing boats. Their construction is rarely strong enough longitudinally to support the installation of an engine, due to the stresses set up by the engine in motion and the interaction between propeller and hull. Therefore, it will usually be necessary to strengthen the hull structure of the boat to avoid costly breakdowns.

Should an inboard engine be considered, the hull would have to be strengthened by the addition of substantial floor timbers (timbers running across the keel and "tying" the two halves of the boat together). This can be done by fitting a number of internal stringers, which as closely as possible follow the bulge of the bilge if such is apparent, and by securely fastening long engine bearers, or stringers, to the hull through the floors.

An outboard motor would require less substantial strengthening, but the fittings required to attach the motor to the hull would have to be very strong and made to absorb the most vibrations set up by the motor in motion. A flimsy mounting for an outboard might easily result in its loss at sea.

Before any such mechanisation is attempted, the boats being considered should under all circumstances be inspected by an expert. It is not possible to mechanise every boat successfully; certain types of craft can more readily be adapted to inboard mechanisation, while others like catamarans can only be considered for use with outboards. Further, it is important to assess whether or not the possible increase in economic return will be enough. The economics of operation must be considered because the addition of an engine to an indigenous boat often represents an investment equal to or higher than the original cost of the boat. It is evident that the resulting catches of fish must be considerable in order to just pay for the engine. If this payment is all that results, mechanisation would hardly be called for. But mechanisation should have the secondary result of allowing the firsherman to increase his standard of living (albeit slowly) and pave the way for later developmental phases.

Design Adaptation. The natural step to follow any pure mechanisation programme would be an attempt to improve existing boat designs by adapting them to support an engine. This would mean providing members of sufficient longitudinal strength from the beginning, as well as possibly readjusting the boat's dimensions for efficient mechanical propulsion.

This approach offers a number of considerable advantages since it allows for the introduction of a well-conceived boat which, nevertheless, closely resembles what the fishermen have been used to. At one time it was thought that this latter point was so important that design adaptation of indigenous craft would be the only successful way of introducing larger, more efficient boats into traditional coastal fisheries in many countries. However, this development phase depends entirely on the initial availability of a boat that lends itself to being improved and expanded in the way described above. It is hardly credible that any headway could be made by trying to redesign the dugout or some of the other local craft.

Foreign Designs. In places where no local boats can be found for mechanisation, an attempt is often made to introduce foreign designs in order to quickly establish a mechanised fleet. While this is definitely a tempting thing to do, it is also very dangerous because the selection of the type of foreign vessel to be introduced is often made by insufficiently experienced people.

This approach can be executed in two ways: by introducing complete boats, built and purchased abroad;

or by buying the design and having the boat built locally. Of the two, the second way holds less potential danger than the first. On the other hand, one may advocate the import, under strict control, of larger vessels, such as steel trawlers or purse seiners, for experimental purposes if no substantial shipbuilding industry is available locally.

New National Types. Wherever possible, this last development phase will give the most lasting success because a developing boatbuilding industry will provide the important advantage of providing continuous employment. And at the same time the industry is developing, its workers are being trained to become highly qualified specialists in the construction of wooden-steel or ferro-cement fishing boats. Obviously, those who develop new national fishing boat types will have to consider modern trends elsewhere. They will have to watch closely the needs and capabilities of local fishermen to avoid giving them too advanced a tool to start with, and they will have to work in very close collaboration with such national institutions as fisheries research stations, oceanographic laboratories, fisheries training institutes, etc. Under all circumstances, the work should be entrusted to an experienced naval architect who knows the prevailing local conditions and is capable of taking into account any limitations that might be imposed by the geography or human element of the area.

It has been found by experience that fishermen are generally quite ready to accept a completely new type of boat, provided any experimentation necessary is not carried out by them. They want the finished product with a guarantee that it will work. Recognising this, it should no longer be necessary to develop distinctly local types of boats, but development should be on a regional basis. The development of new national fishing boat types is always a time-consuming affair. It is largely a matter of trial-and-error, since it is not possible to design a boat on paper with a guarantee that it will be a success. Its performance will be proven only under operating conditions. It is the naval architect's job to see that the first prototype is near to the optimum. If he is sufficiently experienced, he will often hit the mark with the first try. But since we speak of development, and planned development at that, the builders must not stop if the first prototype is reasonably successful, but must improve immediately upon it. Naval architects themselves are hardly ever satisfied with what they produce and firmly believe that what seems good enough today may well be improved upon tomorrow. This can be hard on planners at times, but it should be borne in mind by them that only this ever-searching approach will guarantee the eventual production of an optimal boat for a particular purpose.

Conclusion

Each of the four phases described above has a place in the development of a fishing industry, but foreign design should be used as sparingly as possible to avoid the technical pitfalls concealed and because of the generally exacting demands in the foreign exchange situation of countries employing foreign design.

Likewise, the introduction of modern boats will have to go hand in hand with the introduction of modern fishing methods and gear required for increased catch efficiency. Thus it appears of utmost importance that boat development schemes should first be started in localities where capable fishermen can be found who would be able to take the fullest advantage of the improved basic tool that will be put at their disposal. The combination of training centres for fishermen with boat development projects is definitely a very good idea and should be encouraged wherever possible. Such combined projects would have the decided advantage of becoming a catalyst in a developing industry and their influence would spread very fast with every batch of trainees leaving the establishment and being re-absorbed into the industry.

Equally important to developing a boat of suitable size and characteristics is the consideration of mechanical equipment. In the initial phases of mechanisation, it is of utmost importance that this be of simple and sturdy design and high quality. As necessary competence is gained, more sophisticated equipment can be introduced.

Another must for a developed fishery is the need for periodic planned maintenance. This cannot be overemphasised, as it has been proven time and time again that the need for maintenance is often overlooked, resulting in costly break-downs and long "dead time" periods awaiting spares. Lack of proper maintenance has been one of the worst difficulties in introducing mechanised fishing. Yet without it, it will never be possible

to get the promised economic result. Maintenance is simplified by standardisation of engine types and mechanical equipment.

Disraeli once said, "You can never have economy without efficiency," and this has proven so true.

Supplementary Comments

H. C. Lampe, *University of Rhode Island*

Historically, artisanal fishermen have not accumulated capital. Middlemen have and, therefore, they have often been the principals in fleet development. However, to improve and expand vessels, other sources of capital need to be developed.

Since fishermen have no accumulated capital, either low cost loans or government ownership are required. With low cost loans, but no equity, owners feel less responsibility. Cooperative ownership with participation of all fishermen, on the other hand, requires careful and close supervision of fishing operations and maintenance. State ownership with fisherman-control also requires careful supervision of maintenance. Whatever the structure, the maintenance of vessels is crucial.

Vessels will not in general be optimal. From a design or operational viewpoint, cost considerations dictate using existing designs for long periods. Optimal designs, regional or national, are possible in a technical sense but not generally in an economic sense. For domestic vessels (built in the country), design changes cannot be dramatic without careful instruction of boatbuilders.

With fuel costs developing as they are, even more careful consideration must be given to the trade-offs between power-design and gear. Specifically high-power trawling may lose out to low-power gill netting even though the catch rates are lower.

Other Uses and Problems of the Coastal Area

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East African Harbours Corporation

The paper attempts to briefly sketch the extent to which coastal areas can be utilised to society's best advantage. It warns against uncontrolled and unregulated pollution of the coastal waters and the possibility of destruction of the marine environment by commercial developments like harbours and industries. The necessity for a more integrated study of the problem is emphasised, including a recommendation for some sort of international law to protect the coastal areas of Eastern Africa.

Uses of Coastal Areas

Coastal areas and beaches offer facilities of importance to the inhabitants of coastal towns and the hinterland in a variety of ways. A number of papers which have been presented to this conference deal adequately with some of these. It will suffice here to list their main points: sports—boating, yachting, swimming, fishing competition, rock climbing, etc.; commerce—port development, industries, fishing, tourism, hotels, etc.; defense—navies and naval installations; and waste disposal—sewage and trade waste.

The hinterland of the East African coast consists of developing countries. Hence, each of these types of facilities is still being developed and the dangers associated with them are not in a serious state. Opportunities still exist for early study, where necessary, and we may be able to avert the danger of destruction to the coastal environment if possible by enacting suitable laws.

Brief History of East African Port Development

Earliest Times. Recorded history shows that the coastal areas of East Africa have been in almost constant touch with the outside world for close to 2000

years. Since the dawn of history and long before the voyage of the Portuguese sailor Vasco da Gama to India via the Cape of Good Hope in the closing years of the 15th century, traders from Ancient Egypt, Persia and Persian Gulf areas, Arabia and India sailed along the coast of East Africa.

These ancient mariners were attracted not only by trade, which in those days consisted mainly of ivory and other natural resources and later slaves, but also by East Africa's good natural harbours with deep water, protected from violent waves by narrow entrances or islands. The latter is the case in Dar es Salaam and Mombasa. Settlements sprung up along the coast around these natural harbours, the remains of which can still be seen in Kilwa Masoko, Mombasa, Lamu and other places.

Modern Development. The development of modern ports along the East African coast follows the pattern to a large extent of the ancient ports. Advantage is taken of natural sheltered lagoons with deep water. The majority of these lagoons or creeks are remnants of river mouths which used to drain the hinterland until the period of geological activity which created the highlands of Eastern Africa. These stretch almost unbroken from Ethiopia to Table Mountain in Cape Province of the Union of South Africa. Such rivers were probably not unlike the present Rufiji in southern Tanzania and River Tana in northern Kenya. Due to this geological configuration, East African ports have virtually no "back-up" area behind them. Land rises very quickly to an average of 75 metres above sea level, usually in a distance of only 300 to 400 metres from the shore.

The East African Harbours Corporation, which came into being in 1969, controls the four ocean trading ports of Mombasa, Tanga, Dar es Salaam and Mtwara. Mombasa is situated on the Kenya coast and is at present the largest port; the other three are in Tanzania. In addition, there are several other minor ports for coastal trade of which the best known are Malindi and Lamu in Kenya and Mikindani, Kilwa Masoko, Kilwa Kivinje, Lindi, Mafia Island, Bagamoyo and Pangani in Tanzania. The main ports of Mombasa, Tanga, Dar es Salaam and Mtwara serve Kenya, Uganda, Tanzania, Ruanda, Burundi, Zaire (partly) and Zambia. These have a total population of over 40 million.

Environmental Effects

The tidal and wave regimes now existing along the coastal areas have been established over millions of years. Observations of them made to date have not been wholly systematic or even scientific.

The creeks and lagoons forming the present developed ports along the coastal areas of East Africa are self-cleaning with a present tidal range of approximately ten metres, which eliminates the necessity for expensive dredging to keep the port areas deep enough for ocean-going ships. The effect of this phenomenon on marine life is at present under study by various organisations. The World Bank and UNDP are anxious to avoid the destruction of the natural marine environment by port development, and the UNDP has financed the first attempt to ascertain the effects of port development on the marine environment in the present Dar es Salaam Port Development Study. The author's opinion is that this study will not yield conclusive results as far as the marine environment is concerned because the pressure on the East African Harbours Corporation for port extension due to increased traffic is so great that not enough time can be given to determining the expansion's effects on the marine environment. The emphasis is on economic factors rather than marine biological or ecological effects.

A separate study is, therefore, necessary. This study should cover the whole east coast of Africa and, if possible, be conducted in conjunction with other organisations interested in east coast development.

Pollution of Coastal Areas

There are four main sources of pollution of the coastal areas: (1.) the human environment—sewage disposal, (2.) trade wastes—toxic and other solid wastes dumped into the sea at the coast, (3.) port development —operations of cargo discharging and loading which can pollute the harbour areas and subsequently the neighbourhood of the port; this is especially true of bulk cargo, e.g., sulphur and other substances, which is harmful to marine life, (oil spillages or deliberate discharges from ships are sources too), (4.) oil spills at sea which pollute coastal areas through the action of waves and tides. These include the dumping of chemicals out at sea.

In general, the sea, having two times the world's land surface and an astronomical volume of water, is the recipient of materials from all land-cleansing operations making it ideal for the disposal for all kinds of wastes. The salt content of the sea is the most important natural sterilising compound known. In terms of this knowledge, let us examine each source of pollution briefly.

Human Environmental Pollution

Coastal towns usually dump their raw sewage into the sea for economic reasons. For moderately populated towns, up to a half-million people, this sewage may not be of much consequence to the marine environment. However it could be a nuisance to bathers on the beaches under certain tidal conditions. Cities of a million people or more using waterborne sanitation should at least partially treat their sewage before dumping it into the sea.

A proper study is lacking for tropical conditions, such as those in Eastern Africa. Such a study is necessary if beaches in the main cities like Dar es Salaam and Mombasa are to have their marine life safeguarded and continue to attract bathers.

Trade Waste Pollution

Trade wastes from factories are most dangerous to marine ecology. Their effects are more detrimental if the waste materials are heavier than seawater. In this case they sink to the sea floor where marine life predominates and where most breeding grounds are to be found. Trade waste pollution may not be apparent or even affect other users of the coastal areas unless the quantity of waste is excessive. The marine environment can be affected further by trade wastes which, while not necessarily chemical or toxic, have an unacceptably high discharge temperature for the local marine life.

Port Development Pollution

Causes include: (1.) spillage of dangerous cargo from ships; (2.) sewage and other ship waste disposal; (3.) sewage and other wastes from built-up areas; (4.) trade wastes from industries; (5.) dredging, and dumping of dredged materials, in areas critical to marine ecology; (6.) development of coastal oil terminals and refineries; and (7.) in the case of the East African coasts, changes in the regimes of creeks and lagoons, such as maintenance, dredging and their effect on marine biology and the environment.

Oil Spillage at Sea. On occasion tankers spill oil at sea either accidentally or deliberately when cleaning the holds. The worst oil pollution occurs when an accident involves large tankers or an offshore oil well discharges oil into the sea.

Spillage from Cargo Ships. In spite of tremendous efforts being made by port industries throughout the world to persuade shippers and manufacturers to pack cargo securely, there is still much waste at the ports during loading and unloading. Secure packing and the packages which go with it are expensive; therefore, shippers, importers and exporters always seem to allow for a certain amount of port loss rather than bear the extra packing cost. A great deal of bagged and bulk material, therefore, end up in the waters of the harbours. Estimates vary, but losses may be as high as 40 percent in some ports.

All these spillages find their way into the water of the harbour. Foreign material dumped into seawater can destroy some forms of marine life while causing others to thrive. No accurate knowledge is available at present to arrive at the actual level of harbour pollution from ship cargo spillages. Certain toxic materials handled in bulk or bags, such as the raw material for fertiliser industries, can be quite harmful. The affected areas are generally found close to the ships' berths and permanent anchorages. Where harbours are situated in a large bay the total effect would be minimal. However, in an enclosed lagoon like Dar es Salaam harbour with 12-hour tidal cycles, the cumulative effect needs to be investigated.

Sewage and Other Waste Disposal from Ships. A ship is a small town, and as such has the problem of waste disposal from her living areas. In fact a single cargo ship, without passenger accommodations, can accumulate much waste. In some locales there are regulations against dumping a ship's wastes into the inner harbour. However, ships tend to operate as economically as their owners can possibly manage. Hence, normally no space is provided for sewage storage. Because of this narrow, enclosed ports receive substantial quantities of raw sewage from ships at certain times.

While sewage is not harmful to all forms of marine

life, at a certain level of concentration oxygen is used up at a rate which kills fish and other higher forms of marine life. And dumping of sewage from ships has also been known to be one of the causes of spreading epidemics. For this reason, international regulations are long overdue to force ship owners to have storage compartments for on-board sewage. The dumping of kitchen waste and ordinary "trash" in the harbour is generally forbidden merely because of their unsightly appearance.

The problem of port pollution from sewage and other ship garbage is attracting the attention of port authorities and government agencies throughout the world. To this end, an International Conference on Marine Pollution was held in London in October, 1973, to try to formulate an international convention for the prevention of pollution from ships. The annexes to this convention are of interest. The main headings are as follows: Annex I—regulations for the prevention of pollution by oil; Annex II—regulations for the control of pollution by noxious liquid substances in bulk; Annex III—regulations for the prevention of pollution by harmful substances carried by sea in packaged form, or in freight containers, portable tanks or road and rail wagons; Annex IV—regulations for the prevention of pollution by sewage from ships; Annex V—regulations for the prevention of pollution by garbage from ships. Annexes I and II were considered "mandatory" while III, IV and V were "optional."

More details on the results of this conference can be found in the reference listed at the end of this paper (Smith, 1974). A reporter representing the International Association of Ports and Harbours, Mr. A. J. Smith of the British Ports Association, was present at the conference. His conclusion was that the adoption of the convention will mean that port authorities will be obliged to provide disposal facilities for sewage and other garbage from ships. The facilities could be quite expensive to provide, depending on the type of ship and the design of ships' holds for sewage and other similar pollutants.

Sewage and Other Waste from Built-up Areas. Mention has already been made that local coastal area authorities allow the use of the sea for sewage disposal. In this connection, the City Council of Dar es Salaam and the Municipal Council of Mombasa are using their respective harbours for dumping raw sewage from parts of their urban areas. These two major ports employ a total of 20,000 people in the port area on a daily basis. The magnitude of the foul effluent sent into the sea can be gauged from that number.

While Mombasa may still be able to neutralise the sewage dumped into the harbour for some time to come, Dar es Salaam harbour is beginning to show signs of pollution. The City Council uses Kurasini Creek and also dumps sewage into the harbour at two adjacent points. There may very well be other outfalls.

Of course Dar es Salaam City Council has a major outfall extending beyond the coral reef at the entrance to the harbour. For the volume involved, mixing appears efficient. No complaints have been received from beach bathers.

Although the effect of sewage dumped into coastal waters from cities and towns along the Eastern African coast has never been studied (except for possible work by the University of Dar es Salaam), valuable results have been obtained from exhaustive work elsewhere. Work carried out by Best, Ainsworth, Wood and James in Liverpool Bay, England, yielded very interesting results. But the project was expensive like all field research. Similar studies were presented to the Twenty-third International Navigation Congress in Ottawa in July, 1973, by research workers from several countries. Mathematical analyses and models have been tried to obviate the high cost of field work, but these have to be tested in laboratories, and limited field work is necessary. Some of these were presented during the Fifteenth Congress of the International Association for Hydraulic Research in Istanbul, Turkey, in 1973.

Sewage treatment is one of the most expensive municipal undertakings, and local authorities always try to avoid it. They should nevertheless be persuaded, by legislation if need be, at least to adopt primary treatment of sewage before dumping it into our coastal waters.

Trade Wastes from Industries. With the development of ports, industries tend to be sited near the coast to avoid excessive transportation costs. Some of the industries are port-related and, in any case, they generally take advantage of the proximity of the sea to dispose of their wastes. Pollution from industries is still small along the East African coast and, except for closed lagoons, will not reach dangerous proportions in the very near future. There is, therefore, ample time for an integrated study and institution of controls before the danger point is reached.

Dredging and Dumping of Dredged Materials into the Sea. Capital development for the construction of a port is so high, averaging about 300,000 shillings per metre of berth frontage, that economic considerations outweigh all others. In order to obtain suitable deep water for ship manoeuvres and berthing, dredging or even blasting often has to be resorted to.

For economic reasons no attempt is made to protect marine ecology. Such protection is not only virtually impossible but its attempt also consumes vital capital required in actual construction. Moreover, until comparatively recent times, port development was preceded by few or no master planning studies.

The first attempt made in Eastern Africa to investigate the effects of port development on marine biology was made during the present United Nations Development Programme Master Plan Study for the port of Dar es Salaam. The main aim of this minimal study was future port development and not finding the effects of port development on marine biology.

Under Professor Msangi of the University of Dar es Salaam, valuable research into marine life along the East African coast is going on. At the time of this writing, the author has neither read any of the university findings nor received the consultants' report on the Dar es Salaam Port Development Study. I believe, however, that after this conference the University of Dar es Salaam may see further scope for their research into this field. Research works carried out elsewhere will be found in the references at the end of the paper.

Preliminary findings from the UNDP Dar es Salaam Port Study reveal that, apart from dredging disturbances, the dumping of dredged materials also adversely affects the existence of marine biological life. Coral reefs have been noticed to begin to disintegrate in the vicinity of dumped materials from dredged areas. The long-term effects of dredging cannot be known without extensive research. Port authorities, whose main consideration is economic, cannot be relied upon to invest in such studies except in conjunction with other bodies or, in acute cases, by legislation. For this reason the UNDP insisted that ecological studies be included in the Dar es Salaam Port Development Study.

Development of Oil Terminals and Refineries. The demand for oil, especially petroleum, has gone up by more than 500 percent since 1946. Both major ports of Mombasa and Dar es Salaam have shown a steady increase in oil imports year by year. In addition, the sizes of tankers carrying the bulk oil cargo have also increased. Some of the monster tankers of 250,000 tons dead-weight have not started to visit the East African ports and, in fact, cannot be accommodated in any of our present facilities. In the case of Dar es Salaam, tankers larger than about 25,000 tons dead-weight cannot enter the harbour except at very high tides. This has necessitated the construction of an offshore tanker terminal in Mjimwema Bay, which is a single buoy mooring capable of berthing tankers up to 100,000 tons dead-weight.

Refineries have also been established in the vicinity of the two major ports of Mombasa and Dar es Salaam. Here too there is more or less constant expansion. The Tipper Refinery at Dar es Salaam is connected to the above mentioned single buoy mooring at Mjimwema Bay by an undersea pipeline which continues overland to the refinery. Oil is pumped from large tankers directly into the refinery, and from there some of the crude oil is pumped to Ndola in Zambia.

A serious risk associated with a coastal oil complex is pollution of the beaches in the event of an oil spill. The East African Harbours Corporation takes extreme precautions to avoid oil spills during discharging of tankers moored either within the inner harbour at Kurasini oil jetty or at the single buoy mooring. Expensive equipment has been purchased and is kept ready to fight oil spills in single buoy mooring operations.

However, unscrupulous tanker captains sometimes permit cleaning of their tank holds either in the port itself or within the port areas. Whenever such an offender has been caught, legal action has been brought against him.

Pollution of the East African coastline has occurred from time to time from oil spilled from far-away tankers and brought onto the local beaches by Southeast Monsoon winds. The south coast of Mombasa suffers each year from about March to June from such pollution by oil slicks. Apart from being a nuisance, this form of pollution is not yet a serious threat on the coasts.

Changes in the Regimes of Lagoons Forming the Natural Harbours. For purely ecological and other marine biological reasons, port developments within the confines of a natural lagoon, such as Dar es Salaam, do cause changes in the marine life balance within that area. The normal flow of tidal water into the lagoon

brings in and takes out a certain volume of water at set intervals. The area's marine biology develops within and below these tidal limits.

Port development changes the geometry of the lagoons and perhaps with that the volume of water which can be accommodated therein at all tidal stages. This is done by shaping the edges of the lagoon for berths and dredging the channel, both in the entrance and in the inner harbour, to admit larger ships. This action also disturbs the *status quo* of the natural environment within the lagoon. It is not usually regarded as being harmful to higher forms of fish life except where it interferes with breeding grounds. It is suspected that the rapid expansion of Dar es Salaam port is in the process of destroying known shellfish spawning areas at the southern end of the creek. Supporting data were not available to the author at the time of writing, but the area appears to need study, probably with the collaboration of local fishing industries.

Conclusions

Research. Any conclusions to be drawn from this brief paper should start by emphasising the importance of making a proper study of the environment around the coastal areas of Eastern Africa. With the launching of the United Nations Environment Programme and the recent conference held in Nairobi, the attention of all mankind has been drawn to the impending danger to his own existence created by man himself. The studies must be directed to the solution of problems connected with rapid urbanisation, port development, industrialisation and the preservation of marine ecology and fishing industries. As a starting point, the establishment of the United Nations Environment Programme with its headquarters in Nairobi is the most important step man has ever made toward finding ways of preserving his habitat. This organisation should be utilised as the coordinating organisation for any study that is undertaken in order to facilitate pooling of efforts and exchange of data.

A specific study which should be done involves a problem the port authority has been concerned with for many years—the effect of attacks by marine organisms and chemicals on marine structures and floating crafts. Even though port structures are very expensive, designs often have unreasonably short life spans. While concrete waterfront structures may deteriorate due to bad design, steel and timber deteriorate according to the composition of the material. These kinds of attacks on marine structures by either chemicals in the water or marine organisms have been observed at all the corporation's ports, but no formal study has ever been made. The results of such a study could lead to economic use of timber piles for berths catering to light craft in the coastal trade.

Messrs. Best, Ainsworth, Wood and James have shown that research work in the marine environment requires teamwork, with a working party consisting of multi-disciplined experts. These should include civil and public health engineers, biologists, chemists, oceanographers, hydrographers, geologists, agriculturists and other scientists specialising in the marine environment. The composition of such a team shows the magnitude of the task and gives an insight into the probable cost of the undertaking. Hence, the poor countries of Eastern Africa may find that without financial and technical help, doing a study similar to that in Liverpool Bay may be beyond their resources, and yet the work is necessary.

Funds. We expect that the United Nations should provide assistance for any large-scale study. For this reason, a regional set-up is ideal. Already East African UN agencies support various research programmes such as the East African Marine Fisheries Research Organisation and the Virus Research Programme. East African governments and their statutory bodies should be persuaded to support the study of marine resources just as they support these other research efforts.

If legislation is required, it would probably be best to direct it to organisations and communities which derive the most benefit from coastal areas such as port authorities, local authorities and industries. These bodies could be encouraged to allocate a fraction of their revenues to assist the research on marine resources of the East African coast.

Of the organisations deriving the most benefit from coastal areas, only the fishing industries and, to some extent, local authorities would be interested in conducting such studies on their own. Industries and other commercial organisations such as port authorities and refineries are generally guided in their decisions by economic priorities and, unless coerced into it, are reluctant to spend valuable money on research in marine resources.

Probably the most efficient and convenient way of tackling the financial problems of research into the

effects of development (such as port construction) on the marine environment is to include the environmental study in the feasibility study normally required for new works. It can be made a condition that permission for implementation from government and other local authorities will be given only when a study, which includes the marine environment, satisfactorily demonstrates that the new facilities will have an insignificant influence on the natural balance of marine life and the ecology.

This method has already been adopted by several industrialised countries. The best known study was carried out in Australia in connection with the construction of a four-kilometre-long causeway between the mainland of Western Australia and Garden Island. In this case the authorities suspected that this structure, once constructed, would restrict the flow of water into a bay to a point which might significantly affect the marine ecosystem. This study, together with others on similar topics, was presented to the Twenty-third International Navigation Congress.

Warning on Applying the Results of Research. Clearly it is dangerous to apply the results of research from one area to places in distant lands even if they are geographically similar. Marine environments have so many variables that can differ with location that most research must be carried out at the place of application. Any mathematical model or analysis should be based on the conditions prevailing in the subject area.

Moreover, although it is not yet known accurately, a naturally balanced marine environment in any one place changes with time. Worse still, coastal environments, which have been encroached upon by man, are in a continuous state of change. Hence, any research work carried out in the field should either be followed up at frequent intervals with subsidiary studies to check on and up-date results, or better still, a continuous monitoring capability should be built into the original research.

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Marine resource development is a comparatively new science, and little work has been done in East Africa so far. A total of five references listed are primarily papers and reports dealing with port development in East Africa to which the author referred during the preparation of this paper. The remaining references are on work carried out elsewhere but which have relevance to the conference.

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Supplementary Comments

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Mr. Abura's paper deals most competently with the problems of the use of coastal areas. A marine resources centre dealing with such problems should be of substantial benefit to neighbouring coastal countries. In this commentary I will cover the natural resources of marine reptiles and mammals not mentioned elsewhere.

Marine turtles represent a potentially high-value resource and one in which the organism (meat, oil, leather and carapace) is nearly fully utilised. Out of seven global marine turtle species, at least four frequent the East African shore—the green, sea turtle, leatherback

and loggerhead. But this resource is already depleted and in need of restoration before use.

Population surveys, determination of egg deposition areas, and selection of replacement release sites (ranging from South Africa to Somalia) for those lost to development are needed. In addition to restoration of natural populations, a constructive long-range conservation and utilisation programme should be included. Artificial breeding is being done in the Caribbean, Ceylon and Southeast Asia, where safe release methods are being developed for implementation in selected new sites appropriate for reproduction. Stock build-up will be slow with such a slow-growing organism.

The dugong represents another potential resource which is also in need of restoration. It can be found living along the East African coast and around much of the rest of the Indian Ocean, especially in Australia and the Red Sea. It is an extremely useful and important potential food resource as netted by fishermen. A survey and restoration effort similar to the turtle program is needed, probably combined for efficiency.

Discussion

1. There is an apparent lack of specialised East African fishing ports, or terminals, designed for service, processing and storage associated with newly contemplated fishing boats and equipment. While a wide distribution of port sizes and types already exists in the area, a need for these specialised ports, which are intermediate in size between those of the lesser developed countries and the advanced countries, is apparent. Site selection and status surveys are underway, starting in Dar es Salaam and shortly to be extended to the smaller ports along the coast. The Dar es Salaam port survey will be available shortly.

2. The subject of encouraging interest in pollution control was discussed. A method of assessing cost to the polluter as is done in Auckland, New Zealand, was suggested as applicable. However, ways to identify more accurately the source of many pollutants will have to be developed. For instance, pollution at sea can be sensed at low concentrations and traced to the source by chromatographic signatures and trace elements.

High concentration of hydrocarbons (two kilograms per 100 square metres or higher) has been found on shore from ocean polluters. Possibly overflights and remote sensing can be developed sufficiently to provide information which can lead to legal action. The Stockholm Conference addressed itself to this item and results will be of high interest in the East African area.

3. Marine resource development inter-relationships were first clearly brought out in this discussion of coastal area problems. Conflicts between potential nonliving resources can be expected—for example, between industrial developments such as sand and gravel, offshore petroleum, manganese nodules mining, and storm barriers and living space, tourism, economic and social development and other zone needs. Mechanisms must be established to deal with these problems.

Processing and Marketing Marine Fish—Possible Guidelines for the 1975-1979 Period

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Fish processing and distribution methods may differ considerably in use of capital and local labour. Due to the disparity between the costs of certain forms of capital and local wage rates, the different processing and distribution methods will result in varying production costs and retail prices. When considering the promotion of specific processing and distribution methods, it is necessary to show the extent to which they contribute to the economic goals of Tanzania.

In this paper the recorded fishing effort and yield, and processing and marketing activities are briefly described and discussed. In order to arrive at an estimate of future fish landings (when, where, how much, what type of fish), the potential development of motorised fishing and demand for fish are examined. Three "market areas" are identified and several processing methods considered in terms of their economic characteristics.

Introduction

For some time the Fisheries Division of the Ministry of Natural Resources and Tourism has been working on guidelines for the development of Tanzanian fisheries during the next five-year plan period. This paper includes part of the analysis which has been carried out with respect to marine fisheries with an emphasis on processing and marketing. The paper does not represent the "end of the road." The tentative conclusions presented will be subject to continued analysis in the Division.

Goals for Development. Guidelines for development have been eloquently presented for Tanzania. The most well known are those contained in the Arusha Declaration. With these guidelines in mind, the Fisheries Division suggests that the development of fisheries should aim at: (1.) creation of employment (especially for active fishermen and their families), (2.) an increase in real incomes (improvement in efficiency), (3.) an increased supply of fish (with priority for rural, low-income groups), and (4.) within the constraints imposed by the first and third goals, minimisation to maximisation of net spending (inflow) of foreign exchange.

Fishing Areas, Effort and Yield

Average annual landings of marine fish in Tanzania during the four-year period 1969-1972 were about 21,000 metric tonnes. For the calendar year 1972 the landings are estimated to have totalled as much as 28,000 metric tonnes. In the beginning of the 1970s marine fishermen were estimated to number about 8,000. They were fishing mainly from non-motorised craft using shark nets, hand lines, traps and seine nets. In 1971 the traditional fishing craft numbered about 3,000.

The continental shelf area on which most of the easily accessible fishing grounds are located is unevenly distributed along the coast of Tanzania. The shelf is narrow from north of Pangani to the Kenya boundary. South of Pangani the shelf widens and encircles Zanzibar. South of Zanzibar the edge of the shelf again draws near to the shore, and is only a few miles distant outside Dar es Salaam. South of there the shelf expands to include Mafia Island and the Rufiji Delta. South of the Rufiji Delta the edge of the shelf is generally between one and three nautical miles from the coast. This uneven distribution of continental shelf areas results in considerable variations in conditions for inshore fishing along the coast of Tanzania (table 1). And there are marked differences in fishing effort from one part of the coast to another (table 2). Fishing areas north to south include the Regions of Tanga, Coast, Lindi and Mtwara.

Table 1. Fishing areas north to south.

	Regions				
	Tanga	*Coast*	*Lindi*	*Mtwara*	*Overall*
Number of marine fishermen[1]	2523	2679	1381	1248	7831
Continental shelf area (km²)[2]	2200	8100	1550	310	12,160
Distance of coastline (km)[3]	120	380	275	65	840
Continental shelf area per km of coastline (km² per km)	18.3	21.2	5.6	4.8	14.4

[1] *Average number of fishermen 1970-1972.*

[2] *Areas of continental shelf are estimated from Admiralty Charts, Nos. 3310, 3309 and 3308.*

[3] *The length of the coastline represents the kilometres a vessel would have to sail going from the Kenya/Tanzania border south to the Tanzania/Mozambique border, calling at landing centres not more frequently than every 40 kilometres.*

Table 2. Average yearly fishing effort and yield, 1970-1972.

	Regions				
	Tanga	*Coast*	*Lindi*	*Mtwara*	*Overall*
Number of marine fishermen	2523	2679	1381	1248	7831
Number of km² of continental shelf per fisherman	0.9	3.0	1.1	0.25	1.5
Number of fishermen per km of coastline	21	7	5	19	9
Total fish landings in 1000 metric tonnes	5310	6420	8900	1350	21,980
Metric tonnes landed per fisherman per year	2.1	2.4	6.4	1.1	2.8
Metric tonnes landed per km² of continental shelf per year	2.4	0.8	5.7	4.3	1.8
Number of canoes and other craft	912	835	779	385	2911
Number of fishermen per fishing craft	2.8	3.2	1.8	3.2	2.7
Metric tonnes landed per fishing craft per year	5.8	7.7	11.4	3.5	7.5

The number of square kilometres of shelf area per fisherman is much higher in the Coast Region than in the areas north of the Zanzibar Channel and south of the Mafia Channel. The continental shelf is fished most intensely along the northernmost 100 kilometres of the coast (north of Pangani) and in the southernmost 60 kilometres. In the southernmost Mtwara Region in 1971 there were five fishermen for each square kilometre of continental shelf area.

In contrast, during the same year there were almost three square kilometres of shelf area per fisherman in the Coast Region, supporting the observation that fishing intensity is highest in the north and extreme south.

In this connection it should be emphasised that the fishery is constantly changing. Fishermen are known to migrate, particularly in the south. In the north, fishermen from Zanzibar and Pemba fish from Coast landing centres from time to time.

There are also remarkable geographical differences in yield. For example, while the fisherman's yearly catches during 1971 were lowest in Mtwara Region, the fishing intensity was the highest. Whether or not a relationship exists between high fishing intensity and low catches is presently unknown. It is possible that biological productivity in the Mtwara Region is lower than that further north.

The yield in the Lindi Region is high when compared with that recorded for the Coast Region. A possible influence is boat availability. While three fishermen in Lindi Region have on the average two craft (*mashua, ngalawa, dhow* or *mitumbwi*) at their disposal, three fishermen in the Coast Region have only one boat among them.

Formulation of an estimate of the fish yield the continental shelf waters can produce per year could provide an estimate of the upper limits of the future fish supply. In addition to the inter-regional variations in catch data which already have been mentioned, it is likely that variations occur within regional waters. As we do not have any reliable systematic knowledge of such variations, we must base projections of future continental shelf production on recorded regional averages.

Keeping in mind the regional catch rates (in metric tonnes per square kilometre of continental shelf per year) recorded in line 6 of table 2, let us assume that (1.) production off the Tanga Region can be increased from 2.4 to 5 tonnes per square kilometre per year; (2.) production off the Coast Region can be increased from .8 to 4 tonnes per square kilometre per year; (3.) production can be maintained at approximately 6 tonnes per square kilometre per year in the Lindi Region, and (4.) production can be increased from 4.3 to 6 tonnes per square kilometre per year in the Mtwara Region.

The resulting hypothetical yearly catch is indicated in table 3. It represents an increase of almost 34,000 metric tonnes per year. If realised by 1979, it would represent an annual per capita supply of marine fish of about eight to nine kilograms above that realised in 1971. Most of the increase would be obtained from fishing off the Coast Region. This possibility is supported by the belief that productivity is slightly higher in the more protected waters of the Zanzibar and Mafia Channels than elsewhere.

Table 3. Hypothetical catches of fish in waters above the continental shelf off the coast of Tanzania.

	Regions				
	Tanga	*Coast*	*Lindi*	*Mtwara*	*Overall*
Assumed landings in metric tonnes per km² per year	5	4	6	6	4.5
Continental shelf area (km²)	2200	8100	1550	310	12,160
Landings in metric tonnes per year	11,000	32,400	9300	1900	54,600
Percent increase over average landings in 1970-1972	107	400	5	40	150
Increase over landings recorded in 1971 in metric tonnes	6100	25,900	800	900	33,700

In the long run any considerable increase in fishing effort on the continental shelf would appear to have the best chance of giving a proportionate increase in catches if it were centred on the Zanzibar and Mafia Channels.

Preservation, Processing and Distribution

Observations in this section are based mainly upon data from 1971 and 1972.

No statistics are available, or indeed collected, concerning processing of fish once landed. Opinions vary concerning the amount of fish that is processed. The Fisheries Department considers that most of the marine fish landings on the coast are disposed of in fresh form.

Some companies, established in the main coastal towns, use modern methods for preservation and processing. Four companies in Dar es Salaam are engaged in freezing and exporting shrimp. They collect shrimp from as far north as Sadani and as far south as Nduntatava in the southern part of the Rufiji Delta. The shrimp are stored on ice in insulated boxes to await shipment to Dar es Salaam and freezing. According to published records, the companies have collected and exported from 300 to 400 tonnes of crustaceans (head-on) per year.

In the beginning of 1974 two of the companies were also engaging in trade with iced fish. While this fish was exported during 1971 and 1972, export of frozen fish is now prohibited. Together the companies have handled about 300 to 400 tonnes of fish per year, most of which is sold in Dar es Salaam. Small quantities are sent inland to Morogoro and other population centres. One private company in Tanga trades in fish, cold-storing it before transporting to Arusha and Moshi. Another company, Pangadeco at Pangani, trades in shrimp and fish using a few chest freezers for both freezing and storage. All in all, these companies handle about 1000 tonnes (fresh weight) of shrimp and fish a year, less than five percent of the total estimated landings of marine fish.

Ice is almost non-existent on marine fishing craft. Two to three boats (less than 32 feet), sailing from Dar es Salaam to Mafia for trips of one to two weeks' duration, bring ice in boxes and return with their catch preserved in ice. Generally, however, when fish cannot be disposed of in fresh form, it is dried, smoke-dried or grilled. In areas where the supply of fresh fish is frequently above the quantity that can be consumed fresh (e.g., the offshore islands: Koma, Kwale and Mafia) these types of processing are common.

Existing facilities for preservation and processing are few (see table 4) and are heavily concentrated in Dar es Salaam. These facilities are not located close to fish-landing centres. Even at centres where modern processing facilities would be useful (Tanga, Lindi, Mtwara), they are inadequate.

The Fisheries Division staff collects market statistics in major coastal markets such as Mtwara, Lindi and Tanga. The markets are supplied with both fresh and cured fish. Total quantities of fish passing through these markets, excluding Dar es Salaam, are presented in table 5 (deliveries of 40 tonnes from Mafia during 1972 have been excluded). In the years under review between two to four percent of total landings passed through these markets.

Most marine fish is sold in coastal regions. Only a fraction leaves the regions; deducting exports of the crustaceans, only five percent of annual landings leave. The amount of fish going from one region to the other is probably also quite small. Existing means of transport and communications makes such trade unreliable and costly. Naturally some fish, mostly in cured form, is attracted to the major coastal markets. According to previously cited data, the quantities involved are small.

Table 6 shows calculations of two levels of "apparent" supply of marine fish per inhabitant in the coastal

Table 4. Fish processing facilities along the Tanzanian coast, February 1974.

Location	Ice Production (metric tonnes per 24 hr) Type	Capacity	Ice Storage (m^3)	Fish Storage at 0°C (m^3)	Freezing (metric tonnes per 24 hr) Type	Capacity	Storage (—18°C to —25°C) (m^3)
Moa		—	—	8		—	—
Tanga	B	8	—	20		—	—
Pangani		—	—	—		—	a few chest freezers
Bagamoyo		—	—	8		—	—
Kunduchi	F	2.5	2				
Dar es Salaam[1]							
Private	B	6	20 + ?		PF	3.5	
Public		—		—	BF	4.5	130
						—	—
Kilwa Masoko		—	—	8		—	—
Lindi	B	.5	—	8		—	one 36 ft³ chest freezer
Mikindani (Mtwara)	B	3[2]	?	8[2]			two 36 ft³ chest freezers
Mafia				8[2]			
Total	F B	2.5 12.5	22 + 2 ?	68	PF BF	3.5 4.5	130 m³ and 6 chest freezers

Key: B = block ice; F = flake ice; PF = plate freezer; BF = blast freezer

[1] *Only those dealing exclusively in marine products.* [2] *Not yet assembled.*

Table 5. Supply of fish to major coastal markets, excluding Dar es Salaam.

	Supplies (metric tonnes) 1971	1972	Remarks
Fresh marine fish	170	170	
Processed marine fish	100	270	
Processed freshwater fish	?	320	All to Tanga[1]
Total supply of marine fish[2]	486	960	
Total weight (wet) of marine fish passing through coastal markets (percent of total landings)	2.0	3.8	

[1] *Processed freshwater fish is sold also in Dar es Salaam and Mtwara markets.*

[2] *Processed fish is estimated to weigh one-third of the same fish when fresh.*

regions in 1971. The apparent annual per capita supply of marine fish in that year (excluding consumption by the fishing community) was generally below ten kilograms per person. It is not significantly lower even if we assume that consumption in the fishing community is double that stipulated in table 6. For example an increase in annual consumption from 240 to 480 kilograms per fisherman family would only result in a decrease in availability to about 0.7 kilogram annually per coastal inhabitant.

Paradoxically the supply of fish per regional inhabitant is lowest where the fishing effort is quite intense, that is, in the Tanga and Mtwara Regions. In Lindi the annual per capital supply is considerably higher than in the other regions. In fact, if it were deemed desirable to move fish from one coastal region to another at present, the Lindi Region is the only one with an exportable "surplus."

There are few businesses, or government-run organisations, which assist in the marketing activities of

Table 6. Apparent supply of marine fish (fresh-weight) to inhabitants of the coastal region in 1971.

	Tanga		*Coast*		*Lindi*		*Mtwara*		*Total*	
Assumed consumption per year per member of fishermen family (kgs)	60	80	60	80	60	80	60	80	60	80
Number of marine fishermen	2599	2599	2929	2929	1172	1172	1543	1543	8243	8243
Number of members in fishermen community	10,396	10,396	11,716	11,716	4688	4688	6172	6172	32,972	32,972
Total landings (metric tonnes)	4883	4883	6537	6537	8520	8520	967	967	20,905	20,905
Consumption in fishermen community (metric tonnes)	632	831	702	937	281	375	370	494	1977	2639
Number of inhabitants (thousands)	854	854	876	876	448	448	691	691	2870	2870
Supply of fish per person, excluding fishing community (kgs)	5.0	4.8	6.8	6.5	18.6	18.4	0.9	0.7	6.7	6.4

fishermen and wholesale and retail merchants. The only businesses which fall into this category would be public and private transport companies. Conspicuously absent are public warehouses, markets for wholesale trade in cured fish products and an agency collecting and distributing marketing information concerning trade in fish.

Plans for Expanding Fishing Effort

Type of Boats. Only marginal improvements can be achieved with the non-motorised fishing craft now in use. Improved fishing boats must be introduced to achieve substantial overall improvements in catch and earnings per fisherman. They should be powered, provide increased safety, larger onboard working areas and an increased range of operations. Such craft should be plank-built, powered by inboard diesel engines and above 25 feet in length overall. They should be designed to handle both pelagic and demersal gear.

Twenty-five-foot boats are already being built at Mbegani and Mikindani boatyards. The Fisheries Division is presently considering how to go about constructing and introducing boats between 32 and 40 feet in length. Some of these boats will be built in wood and some in ferro-cement. They will be used for fishing in waters on the continental shelf.

Fishing off the continental shelf will require different equipment than fishing on the shelf. Due to an absence of upwelling and a deep thermocline in the East African Coastal Current (Bell, 1969), relatively unproductive waters stretch for considerable distances offshore (50 to 200 miles). Beyond this belt a possibility exists for a tuna long-line fishery for scombroid fishes, particularly yellow-fin tuna, albacore, bigeye tuna and billfish. Due to the distance to the fishing areas and the need for preserving the fish, considerably larger vessels than those on the continental shelf will be needed. Harbours suitable for a tuna long-line fleet are found in Dar es Salaam and possibly Tanga. The Mtwara Harbour is deep enough, but investments would have to be provided in shore facilities.

At the moment the main argument in favour of developing a Tanzanian tuna fishing fleet is that it would increase the supply of fish. However, it would add only marginally to employment. To the extent that tuna would be exported, the goal of increased supplies of fish for consumption in Tanzania would not be realised.

Boat Operators. A fisherman who has been fishing in a *ngalawa* or in a *dhow* must be trained in handling boat, gear and engine before he can take out a 32- to 40-foot boat of his own. It is envisaged that "crash" courses for inshore fishermen will be given at Mbegani Training Centre, starting not later than the beginning of 1975.

Fishing Areas. In this section we will only consider fishing areas for boats between 32- and 40-feet long. These craft will probably fish in trips of one day's duration, thus limiting the operating range of the boats to some 40 kilometres away from any one landing centre (disregarding currents).

Good fishing areas are to be found between the Rufiji Delta and Mafia (the Mafia Channel) and in the Zanzibar Channel. Shrimp are found in both these areas, as are several species of *Sardinella* (Bell, 1969). Most of the Zanzibar Channel (Tanzanian waters) is in the Coast Region as is the whole of the Mafia Channel. At present these waters appear to have the lowest intensity of exploitation of all continental shelf waters off the Tanzanian coast (see table 2). In the Rufiji Delta and off Sadani, shrimp are caught in shallow waters, mostly inside the 11-fathom depth contour line (Sankarankutty and Subramaniam, 1974). In like areas devoid of corals and other obstructions, it is possible to trawl for shrimp from boats in the 30- to 40-foot category.

Sardine can be exploited by light attraction in combination with purse seine or dip net. Both shrimp and *Sardinella* fisheries need to be exploited.

North of Pangani and south of Samanga (close to the border between the Coast and Lindi regions) the use of shark nets and hooks will probably continue to be the main fishing methods for some time to come. Light attraction for mackerel is believed to be a possibility for small boats in the sheltered waters at Kilwa.

Data in table 7 imply that large stretches of the shoreline and vast areas of the continental shelf cannot be reached in day trips with boats in the 25- to 40-foot category. Three areas which cannot be reached are indicated in table 8.

Table 7. Landing centres for motorised boats along the Tanzanian coast.

No.	Distance (km)[1]	Existing Centre for Motorised Boats	Access by All-weather Road[2]	Possible Future Landing Centre	Present Facility for		
					Boats	Catch[3]	Electricity[4]
1	12	Moa	yes	Moa	jetty	cold store	no
2	52	Tanga	yes	Tanga		(freezer)	yes
3	96	Pangani	yes	Pangani	quay boatyd.	(freezer)	yes ?
4	136	—	no	Mkwaja			no
5	170	—	no	Sadani			no
6	224	Mbegani	yes	Mbegani	slipway boatyd.		no
7	274	Dar es Salaam	yes	Dar es Salaam[5]			yes
8	369	—	no	Kisiju	jetty		
9	399	—	no	(Rohungu)[6]	—	—	no
10	—		no	Kilindoni (Mafia)		(cold store)	
11	474		no	(Ndundatava)[6]	—	—	no
12	494		no	Samanga	—	—	
13	568	Kilwa Masoko	yes	Kilwa Masoko	jetty	cold store	yes ?
14	643	—	no	Kiswere	dilapidated jetty	—	no
15	723	Lindi	yes	Lindi	jetty	ice plant cold store	yes
16	793	Mikindani (Mtwara)	yes	Mikindani	jetty boatyd	cold store ice plant	yes ?

[1] *This is an approximate estimate of the distance sailing from landing centre to landing centre. Zero kilometres is taken at the Kenya-Tanzania border.*
[2] *Lindi and Mikindani are connected with each other by road and with commercial ports and airports. Kilwa is similarly connected.*
[3] *A parenthesis indicates that the facilities have not been completed.*
[4] *Tanzania Electrical Supply Company.*
[5] *Mainly until Mbegani is fully developed.*
[6] *Road access is very difficult even in the dry season.*

Table 8. Coastal areas not accessible from motorised boats (25- to 40-feet) operating on day trips from recognised landing centres.

No.	Area	Distance by boat (kms)[1]	Length of inaccessible coast (kms)	Possible landing centres	Priority area of investigation	Priority centres within areas
1	Pangani to Mbegani	128	38	Mkwaja Sadani	Second	Sadani Mkwaja Mbuyuni
2	Dar es Salaam to Kilwa Masoko	294	204	Kisiju (Mchungu) Kilindoni Ndundatava Samanga	First	Kilindoni Ndundatava Samanga Mchungu Kisiju
3	Kilwa Masoko to Lindi	155	65	Kiswere Mchinga	Third	Kiswere Mchinga

[1] *This is the distance of the shoreline in the area; for example, in area 1 this means from Pangani to Mbegani.*

In these three areas it is a priority task to identify and establish landing centres. In this context, a landing centre is understood as a location meeting two conditions: (1.) boats can either moor alongside protected quays and jetties or they can load and offload onto jetties or straight onto the beach at high tide, and can ride at moorings in sheltered waters, and (2.) the centres are either accessible by all-weather road or are served by fish collection boats during the major part of the year.

It is most urgent to create a landing centre to provide access to the fishing grounds in the Mafia Channel, and particularly to grounds in the Rufiji Delta. From a national point of view priority has been given to a fish-landing centre somewhere in area 1 from Dar es Salaam to Kilwa Masoko. We hope that the most suitable location for such a centre will be identified by a detailed survey now under consideration in the Fisheries Division.

Apart from fuel and safe anchorage (and of course the possibilities of disposing of catch), boats must have access to repair facilities. South of Dar es Salaam repair and maintenance facilities specifically intended for fishing boats are available at Mikindani. Such facilities must also be provided in area 1, possibly at Mafia Island.

Landing centres at Tanga, Pangani, Mbegani, Kilwa, Kiswere, Lindi, Mikindani, and others to be identified and established in the Kisiju-Mafia and the Ndundatava-Samanga areas may expect daily landings from motorised boats to average between five and ten metric tonnes per day within the next five-year period. The landing at Mbegani and at the centre in southern Rufiji may very well exceed these figures. Few fish are landed at Mbegani from motorised boats, and almost none from such boats in the Rufiji area. These two centres may expect the most concentrated and rapid development.

Plans for Processing and Marketing Marine Fish

Demand for and Supply of Fish in Coastal Areas. Demand for marine fish is high. Retail prices in the principal coastal markets are generally high. In some areas (Tanga, Dar es Salaam and Mtwara, for example) cured freshwater fish is "imported" from inland regions. Simultaneously fresh marine fish is occasionally sent inland from both Tanga and Dar es Salaam. Most observers seem to agree that if an increased supply and improved distribution of marine fish were available, consumption would increase considerably without a reduction in beach prices.

During the rainy season some landing areas, particularly in priority area 1 of table 8, get cut off, and not all fish can be disposed of in fresh form. This is reported to have happened at Kilwa, which is a major coastal consumer centre. In order to maintain a constant supply of fish per person per year in the four coastal regions (based on a long-term average of 21,000 metric tonnes), landings must increase by about 500 tonnes per year. To increase the overall supply of fish in the coastal regions by one kilogram (fresh-weight) per person per year will require an increase in landings of about 3200 tonnes. Thus to increase the consumption during 1974 by one kilogram over the apparent supply during 1971, landings should increase by about 3700 tonnes. However, in order to increase supply in all regions, landings must increase in all areas, not just the major centres (Tanga town, Dar es Salaam, Kilwa and Mtwara).

In table 6 the annual per capita supply of marine fish was found to be about 6.5 kilograms. What would happen if the annual per capita supply was increased by a quarter, that is by some 8000 tonnes, to 8.5 kilo-

grams? Would prices fall? Although no studies are known to the Fisheries Division concerning the price and income elasticities of demand for marine fish in Tanzania, it is likely that both of these are high. If true, an increase in the present supply of marine fish will lead to a less than proportionate fall in price. In fact, due to present "imperfections" in the market, an increase need not lead to any fall of prices on the average if combined with improvements in fish-marketing facilities and practices.

A calculation which assumes 2.5 percent population increase, unchanged relative price for fish, one percent increase in disposable real income per person per year, and one percent income elasticity of demand for fish shows an increase in demand of about 735 metric tonnes per year. For every further one percent rise in real disposable income (with other conditions constant), the total demand will rise by about 215 metric tonnes.

In those coastal areas where the communication and transportation infrastructures are not sufficiently developed to permit regular trade with major coastal and interior consumer areas (see table 8), it is unlikely that fishermen are working to full capacity. Any improvement of communication and transport is likely to lead to a considerable improvement in terms of trade for the fishing community. The resulting improvement in real incomes of the fishermen and their families will lead to two tendencies regarding production (or fishing effort) on the part of the fishermen—substitution and expansion. We believe that the tendency toward increased production will be the stronger and that a considerable expansion of fishing effort and landings can be expected.

Isolated fishing centres can be "opened up" from the sea or from land. Opening up from the sea, through a coastal shipping service, is cheaper than opening up from the land through construction of roads. At least it will call for less capital development expenditure. Nevertheless, a road provides transportation and communication facilities within easy reach of those living further inland along the new road. Also, villagers are likely to have more flexibility in moving persons and goods when using road transport than when using boats.

In the Rufiji area, the coastal area from Samanga north to Ndundataa appears to be the least difficult to penetrate to the coast from existing roads.

Market Areas for Marine Fish. The coastal population has settled unevenly along the coast; in some areas this population density is higher than in others. There are few inhabitants on the Tanzanian side of the Zanzibar Channel, that is from Pangani to Bagamoyo (Morgan, 1969). People have settled in most of the coastal area between Dar es Salaam and Mtwara. However, the density is higher around Kilwa than around Lindi. The stretch from Lindi to the border with Mozambique is also densely populated.

The coast and its hinterland naturally divide into three principal consumption areas for marine fish: (1.) Tanga Region, north of the Pangani River, Arusha and Moshi; (2.) Dar es Salaam to Morogoro with Bagamoyo and Kisarawa districts, and (3.) Lindi Region, south of the Mbwemkuru River and the Mtwara Region.

Of these three areas only the Tanga Region has a considerable freshwater fishery (the Nyumba ya Mungu dam) within its boundaries. All three are traditionally supplied with cured freshwater fish mainly from Lake Victoria and Nyumba ya Mungu. Dried *dagaa* from Lake Tanganyika can even be found in Dar es Salaam markets.

It would seem reasonable to keep the transportation of fish at a minimum. Therefore, the policy of the country should be that fish landed north of Mkwaja (landing centre 4 in table 7) should be marketed mainly in area 1. Surplus fish, from Mkwaja south to Kilwa (landing centre 13 in table 7), may move toward Dar es Salaam and Morogoro, while fish landed south of Kiswere should be marketed in the Lindi and Mtwara regions and in their hinterland. These policies are not expected to reverse any established flows of fish.

Cost Comparisons of Fish Processing Methods. The choice of processing methods to be recommended at any particular landing centre will depend upon several factors, some of which are related more closely to economic factors than others. The cost of producing, transporting, and storing fish according to various methods will play a decisive part in deciding by whom the fish is likely to be bought.

It would seem useful to divide the costs into fixed (stemming from investment in fixed assets) and variable. When variable costs are high and fixed costs low, it is easier to have viable operations at landing centres where catches are irregular or seasonal and communications and transports to markets are difficult than when fixed

Table 9. Cost comparisons of fish processing methods for Tanzania.

Method	Assumed beach price (shs per kgs)	Processing costs (x) as a percent of beach price		Fixed costs (y) as percent of total processing costs		Cost of Storage	Cost of Transport
		1 tonne per 24 hrs	5 tonnes per 24 hrs	1 tonne per 24 hrs	5 tonnes per 24 hrs		
Traditional sun-drying	1.00	$x<5$[1]	$x<5$[1]	close to zero	close to zero	negligible	small
Improved sun-drying	1.00	$x<10$	$x<10$	negligible	negligible	small	small
Improved smoke-drying	1.00		$70<x<90$		$30<y<50$[2]	small	small
Icing fish	1.50	$30<x<50$	$10<x<20$	$20<y<30$	$15<y<25$	medium	medium
Freezing fish	1.50	$50<x<70$	$40<x<60$	$20<y<30$	$15<y<25$	high	high
Canning fish	1.00		$x<100$[3]		$25<y<30$	small	medium

[1] *A large part of these processing costs are probably paid in kind.*
[2] *This figure is based on a six metric tonne per-day tuna cannery. A large part of variable costs normally are made up of the cost of cans.*
[3] *Based on operation of a "curing estate" where ice is available and final products are packed in plastic bags. Fixed costs include three-quarters of staff salaries.*

costs constitute a larger part of the total cost of operation.

In addition, the relative importance of costs incurred in processing, storage, and transport of any particular type of fish product is vital. These costs will influence, considerably, the type of processing which may be suitable for any particular landing centre. Present estimates of the importance of processing, storage and transportation costs are indicated in table 9 for a number of fish processing methods. The table also gives an indication of the proportion of fixed costs out of the total production costs.

The tentative estimates quantified in table 9 support what is intuitively perceived: (1.) the smaller the annual landings expected, the less suitable are icing and freezing of fish; (2.) the more isolated the centres, and the more seasonal the supply, the better are the traditional methods, and (3.) due to the costs incurred in processing, transporting and storing frozen fish, it is unlikely that freezing fish can be done on such a large scale that the product will become economically accessible to the majority of the population within the foreseeable future.

Fish Processing Methods: Other Considerations. Apart from costs incurred in processing, storing and transporting fish, several other factors should be considered when establishing guidelines. Among the most important would seem to be availability of factors of production (particularly machinery and electricity), transportation and communications, climate, type of fish landed, and effect upon employment.

A tentative comparison of five methods of processing fish, taking the above factors into account, is made in table 10.

Sun-drying and smoking are vulnerable to climate both during production and storage of the finished product. The degree of vulnerability can be reduced. Usually a smoke-dried or sun-dried product is produced over several days. A smoke-dried product can however be produced over a period of 18 to 20 hours if drying racks and concrete kilns are used. During storage the finished product is vulnerable to beetle infestation. The risk for this may be reduced by packing the product in plastic bags and subsequently storing it in specially designed "go-downs" at fish landing centres.

Sun-drying and smoking can be done along the en-

Table 10. Some critical factors in processing, transporting and storing fish.

	Processing, Transportation and Storage				
	Improved Sun-drying	*Improved Smoke-drying*	*Icing Fish*	*Freezing Fish*	*Canning Fish*
Factors of production					
machinery		local	imported	imported	mostly imported
electricity	—	—	essential	essential	essential
firewood	—	needed	—	—	—
Transportation	any type	any type	rapid and on schedule	at sub-zero °C temperature	any type
Climate	important	important	not important	not important	not important
Type of fish	preferably non-fatty	any type	table fish	table fish, crustaceans	uniform size, preferably oily
Employment	large	large	few	medium	large

tire coast. However, the coastal conditions are slightly better to the south than to the north of Kilwa. Mangrove, or forests, are available as a source of firewood, and the yearly rainfall is usually slightly less than further north.

At present frozen fish can be produced at Dar es Salaam. Within another 12 months facilities should exist at Tanga and Pangani. Also, within the near future it will be possible to handle iced fish at Mtwara and Mbegani in addition to Lindi and Tanga. Ice could also be manufactured at Kilwa as electricity is available. Elsewhere along the coast it is not conceivable to start trade in iced or frozen fish without first providing both electricity and transportation facilities. Furthermore, it has not been clearly demonstrated that freezing of fish meets present needs for preservation and distribution better than improved sun- and smoke-drying.

It is urgent to improve and popularise curing methods. Storage facilities should also be provided and improved. One of the major advantages with curing methods is that they can be introduced at small centres as well as those where considerable quantities of fish are landed. In small centres the improvements would consist of the introduction of racks and perhaps of smoking kilns and the provision of improved storage, while at larger centres fish may be cured in commercially organised fish-curing "estates." The feasibility and viability of such estates are now being studied by the Division of Fisheries.

Curing of fish is indispensable at those centres where communications with markets are deficient. Curing methods should be improved at these centres: offshore islands, the stretch of coast between Mkwaja and Bagamoyo and south of Dar es Salaam along most of the coast with the exception of Kilwa, Lindi and Mtwara towns. The return to fishermen and others can probably be increased also with improved packaging and storage.

Naturally, improvements must be gradual. For an investment of just under 100,000 shillings it is possible to provide drying racks and smoking kilns with the capacity of handling about three tonnes of (wet) fish per 24 hours. A full-fledged curing estate with ice plant, cold-storage and one truck should not need an investment in excess of a half-million shillings.

Where ice and cold-storage facilities are, or will be, available (Tanga, Pangani, Mbegani, Kilwa, Lindi, Mtwara) curing of fish should be introduced if the local market cannot absorb fresh fish. If fish can be sold fresh, there is usually little point in curing unless there are large seasonal or daily fluctuations in landings. However, if part of the landings, for reasons of taste or distance to markets, cannot be disposed of in fresh form, then curing becomes a natural alternative.

We can now indicate landing centres where, *a priori*, it seems possible to locate fish-curing facilities. When detailed field studies have been made, it will be possible to arrive at conclusions concerning timing, most suitable locations, layouts and organisations of yards.

The National Cold Chain Operations Ltd. (NCCO) has funds for providing these facilities which are needed urgently for trade in fresh, iced and frozen fish. Government funds must be made available to provide improved facilities for curing and smoking kilns.

At the moment no particular species of fish of uniform size is landed often enough in sufficient quantity to make a cannery feasible. Also, at this stage, the high price of marine fresh fish would make it seem unlikely that such a cannery could become viable. Only if a sardine or mackerel fishery (with purse seines) were developed could a cannery be supplied with the required quantities of fish. Further, there is no reason to believe that canning shrimp would be a superior alternative to exporting them frozen.

Possible Effects on Fishermen and Consumers of Improved Processing and Marketing. Let us recall that through improving marine fisheries in Tanzania what we in effect are striving to do is to increase the well-being of as many individuals as possible. In this context we will make a rough distinction between fishermen and consumers.

An increase of fish offered for sale in retail from 6.5 kilograms per person per year to 7.5 kilograms would be considered an improvement by most individuals, provided the real cost of fish is not increased to the extent that it is out of their reach. Nevertheless, a change of this order of magnitude is marginal to the well-being of most consumers. A consumer will grumble when he cannot find fish, but he will not suffer provided the supply of other foodstuffs is normal. However, an increase in beach prices by 20 percent is a considerable change for the much smaller number of fishermen. A reduction of his yearly catch (perhaps from increased competition) by 50 percent would be disastrous.

There are two ways, basically, in which fish supply can be improved: (1.) through reallocation and improved handling of existing supplies, and (2.) through an increase in landings. The supply can be reallocated both in time and space. Supply at landing centres can increase due to moderate improvements of existing fishing methods or the introduction of considerably more efficient methods. An example of the latter would be the introduction of trawling on demersal fishing grounds. In that instance the implementation of these methods will be accomplished usually by people who are familiar with them and will therefore not at first lead to much increase in employment opportunities for local fishermen. It would not be realistic to expect that either reallocation or increased landings would occur in isolation at any particular location. One change would seldom occur without at least a little of the other occurring simultaneously.

Improvements in supply are likely to influence consumers and fishermen in different ways. A schematic representation of this is given in table 11. Some individuals may experience an increase in real income; others may not.

Thus, there are two situations in which it may be doubtful that both consumers and producers (fishermen) will benefit from changes in distribution of fish. Some established consumers are in danger of experiencing an immediate decline in their real incomes when fish is redistributed in space, that is, when the fish which they used to buy at a certain price is offered for sale to other consumers at a higher price. An example of this would be the distribution of shrimp caught in the Rufiji Delta. They used to be consumed not far from where they were caught until a more profitable market was found for them in Dar es Salaam. Now they are too expensive for most of the "old" consumers close to the landing area. (Of course, from this fact it should not be inferred that export of shrimp does not have the approval of the Government of Tanzania.)

Established fishermen are in danger of being displaced for considerable periods when new and more efficient catching techniques are introduced on "their"

Table 11. Possible changes in real income due to "improved" fish distribution.

Improved distribution due to	*Will fishermen benefit?*		*Will consumers benefit?*	
	Old	*New*	*Old*	*New*
Reallocation				
in space	yes	yes	no	yes
in time	yes	yes	yes	yes
Increased landings due to				
modernisation of existing methods	yes	yes	yes	yes
introduction of new and more efficient catching techniques	no	yes	yes	yes

fishing grounds. The smaller the landing centre, the larger the risk that the market will become flooded resulting in a declining price for fish. Also, after some time, competition for fish may result in lower average catches.

These considerations seem to reinforce goals of the previous sections: a gradual improvement of boats and gear intended to include as many fishermen as possible, and a clear emphasis on improvements in traditional curing methods.

Marketing

Details about marketing of marine fish in Tanzania are not easily available. More is known about the marketing of fresh fish than of cured fish. Due to lack of ice, trade in fresh fish is limited to a few miles and a few hours from most landing centres. Trade with iced or frozen fish over long distances requires considerable capital, both for investment and for operating costs. Few persons or companies have the needed capital. Those who do have a good possibility of trading in a market situation which is close to a monopoly. Private companies, now trading in fresh fish, are experiencing competition from the NCCO, a parastatal company. The NCCO is processing and marketing fresh, iced and frozen fish.

In contrast, it is comparatively easy to become a retail merchant in cured fish. Little capital and few facilities are required. In the long run, competition should eliminate "excessive profits," in spite of individual pricing for larger fish and deficiencies in transportation and communication. These deficiencies may in time lead to monopolies. The wholesale merchant has a greater chance than the retail merchant to make undue profits when dealing in cured fish, especially if he can undertake arbitrage among several markets. At the moment of writing, the country does not have any government or other official organisation undertaking trade in cured fish products. Although the present trade may be efficient, given its conditions it can be improved. The responsibility should fall on the government for seeing that suitable improvements are carried out. Part of the improvements could be undertaken by, or under the guidance of, the Tanzania Fisheries Corporation (TAFICO). Possible areas for action would be: (1.) "curing estates" (joint ventures between TAFICO and local organisations—TAFICO would give technical advice and arrange finance); (2.) storage and transportation facilities for cured products (as a joint venture or operated solely by TAFICO), and (3.) collection, analysis and publication of marketing data related to trade in cured fish products.

Facilities for the Development of a Small Boat, Motorised Fishery

It is clear that a considerable part of the total amount of funds to be invested in developing a fishery with small motorised boats must be in the form of infrastructure, e.g., provision of roads, electricity and wa-

Table 12. Tentative requirements (roads and shore-based facilities) for development of a small-boat, motorised fishery.

Centre	*Road*	*Improved shore facilities for boats**	*Facilities for iced and frozen fish*	*Facilities for fish curing*
Moa	yes	—	iced	ccy
Tanga	—	yes	(freezer uc)	—
Pangani	—	—	(freezer uc)	ccy
Mkwaja-Winde	yes	yes	iced and cold store	ccy
Kisiju-Samanga major	yes	yes†	ice, freezing and storage	ccy
minor	—	—	—	improved facilities
Kilwa	—		ice and storage	ccy
Kiswere	yes	—	—	improved facilities
Lindi	—	—	—	—
Mikindani (Mtwara)	—	—	ice and cold store (uc)	—

uc = under construction; ccy = commercial curing yard
** Jetties or other arrangements.*
† Including maintenance and repair facilities for hulls and marine diesel engines.

ter. These investments are advantageous in the sense that they will benefit all of the inhabitants in the areas where they are made, not only the fishermen.

In table 12 tentative requirements for development of a small-boat, motorised fishery have been identified. The table reflects first thoughts about what is most urgently required. In fact, it is no more than a guideline for future detailed studies.

Fishing Operations Summary

We expect that:

1. Priority will be given to fishing in waters of the continental shelf from motorised boats (25- to 40-feet) designed for fishing with both pelagic and demersal gear.
2. The underexploited continental shelf area is available mainly in the Zanzibar and Mafia Channels.
3. Both the fishery for sardines and for shrimp probably can be considerably developed

It would seem to follow that:

1. At least one landing centre be identified and developed somewhere on the coast between Mkwaja and Winde.
2. At least one landing centre be identified and developed from which access can be had to the Rufiji Delta (most likely locations, Kilindoni on Mafia Island, or just south of the Delta in the Ndundatava Region).
3. Roads be improved to Moa and Kiswere.
4. Engine and hull repair be provided at the landing centre to be developed in the Rufiji Delta area.

Processing and Marketing Summary

We consider that:

1. There is a lack of fish in all the three "natural market areas" (Tanga up to Arusha and Moshi, Dar es Salaam to Morogoro, Lindi and Mtwara Regions).
2. Present facilities for icing and freezing fish can only handle a small fraction of present landings of fresh fish, partly due to the fact that landings are scattered over long distances.
3. When considering development and promotion of fish marketing, cured fish products have considerable advantages, both from the point of view of employment and flexibility of production and from that of low costs of storage and transportation, over iced or frozen fish at the majority of landing centres.
4. Fish should be made available to as many individuals as possible with priority for rural, low-income groups.
5. The absolute level of marine fish consumption in the coastal regions is low.
6. Therefore, considerably more fish probably can be consumed, in particular by rural populations, in the coastal regions than is the case at the moment.

It would seem to follow that:

1. Fish landed inside the three "natural market areas" should not be distributed outside those same areas.
2. The government should scrutinise trade in fresh and frozen fish to ensure that fish should not be reallocated from low-income consumer groups, mostly rural, to high-income town dwellers except in special circumstances.
3. Curing methods should not be replaced—they should be improved and expanded.
4. The possibility of introducing commercially organised "curing estates" should be studied, possibly through joint ventures between the newly established TAFICO and local organisations. These estates will be provided with drying racks and smoking kilns, and more modern "curing estates" will be considered for those landing centres where ice and cold storage facilities are available.
5. The introduction of drying racks and concrete smoking kilns should be promoted at several landing centres not having ice and cold storage facilities.
6. All long-distance trade in fresh or iced fish should be done in cooperation with the NCCO.

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Supplementary Comments

H. C. Lampe, *University of Rhode Island*

Mr. Wijkstrom presented a very good review of fisheries infrastructure guidelines. Among the development goals of consequence are the contrasting needs of improving the fishermen's income while at the same time making more protein available to the poor. An equitable solution to this dilemma implies either a substantial reduction in the cost of the protein or a diversion of resources (e.g., subsidy) from the normal market channels to people in need. Reduction in cost can result from technological changes which affect operations or through reduced marketing expenses, both of which depend on personal efficiency.

A very basic question raises itself—that of establishing government priorities to invest talent, attention and financial resources in either improvement of the large, sophisticated offshore fisheries or the small artisan fisheries. It is unlikely that both can be done concurrently.

Mr. Wijkstrom essentially advocates a marketing and distribution scheme which keeps the variable costs high and the fixed costs low, implying a large number of small decentralized, special purpose harbor centers. Such a relatively inflexible system however cannot respond efficiently to changes in production and distribution without losses in the utility of invested capital.

In regard to the pressing need for better preservation in processing, frequent proposals have been made for the establishment of a "cold chain" of refrigerated warehouses to be used with small-scale special-purpose ports. In order to protect against erratic input or other disturbances in production flow, it would be most desirable to arrange for complementary facility use, e.g., for non-fishing products. This could also allow increased plant size, thereby achieving economies of scale.

Trends in processing techniques appear to emphasize a transition from sun-drying to smoking techniques. Care must be exercised with smoking processes to avoid overheating which results in losses of processed protein.

While much research is needed in many aspects of marketing and processing, it must be tailored to particular institutional structures and specifically to both the political system and local situations.

Discussion

While much attention must be paid to methods of curing and processing such as smoking, sun-drying and salting, an equally important topic, that of handling prior to processing, should also receive substantial attention. The quality of a fish product progressively deteriorates the further from the water it gets, and processing can never improve the product above the condition that exists at process inception, so all steps, including those of travel and storage, must be considered if natural, wholesome fish products are to be made available to the consumer.

In Africa, probably more than any other global area, marketing and processing wastes are high. Up to 50 percent of the product is lost, the average being about 15 percent. Improvements in this area could substantially help rural food supplies with no production increase.

Difficulties can be expected in attempts to concentrate labour and optimise operations, starting from the African base of small-scale scattered family producers.

Other problems that need to be faced include: packaging improvement; establishment of relative priorities between marine and inland fish improvement programmes, based on both economic considerations and taste preferences; establishment of regional dry food storage sites; cost-benefit assessment of process losses to better direct emphasis; and production of standard, stable non-refrigerated products suitable for tropical areas. (FAO has a proposal for a standing committee for tropical fish products that may produce results of value to Africa.)

Marine Resource Programmes at the University of Rhode Island and Their Possible Applicability to Programme Development

N. Marshall, *Chairman*

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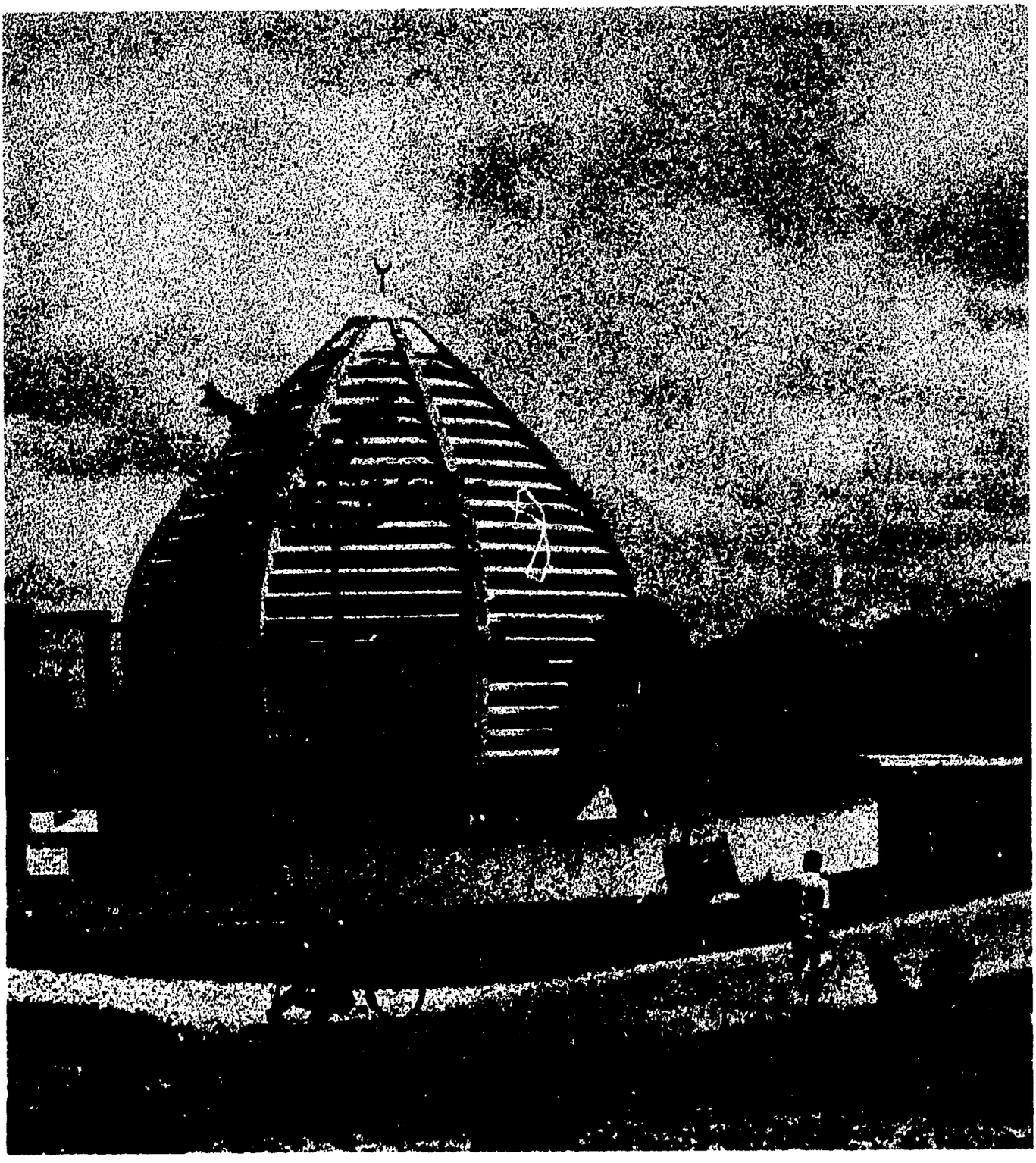

Marine Resource Programs at the University of Rhode Island: History and Composite View

N. Marshall, *Director, International Center for Marine Resource Development, and Professor of Oceanography*

The University of Rhode Island initiated in 1960 a significant shift from a marine sciences research activity with limited applied effort to a broad marine resources research program. This new approach includes a proportionate increase in applied work accompanied by supporting work in the social sciences plus an awareness of the need for a marine extension or advisory component. This broadened marine resources program ultimately has grown to include food technology and nutrition; various social sciences, including resource economics, sociology, anthropology and geography; political science, including Law of the Sea considerations and a wide scope of marine affairs and management interests; and ocean, coastal and environmental engineering. All of this activity has been unfolding in addition to the pursuit of the marine sciences as focused in what is now the University's Graduate School of Oceanography, and in addition to participation by what we think of as the traditional science departments such as zoology, botany, bacteriology, geology, physics, etc.

In developing in this manner, the University of Rhode Island has not simply expanded the faculty of its marine laboratory. Instead, the participation of faculty members has been encouraged across departmental and college lines and, in a very real sense, marine resource interests are tapped throughout the entire academic institution. Thus the growing program has been interdepartmental, inter-college and interdisciplinary, with the participants oriented to their own academic areas yet cooperating, sometimes closely, in broad projects bearing on marine problems.

This development at the University of Rhode Island has been concurrent with a growing awareness throughout U.S. academia that marine resource concerns are very broad and require diverse capabilities for comprehension and handling. This appreciation found its most tangible expression through the establishment of the Sea Grant Program in 1966, a national program funded by appropriations from the United States Congress enabling universities to develop further in the manner initiated in 1960 at URI. As a concept the sea grant approach is not by any means limited to the Program bearing the title, as will be seen in our further elaboration on URI activities. The words "sea grant" came into favor, we might note, largely because they suggest a marine effort paralleling the successful work of the land grant institutions that has served U.S. agricultural development so well through research, education and extension on an interdisciplinary basis. The similarity between "land grant" and "sea grant" ends at this conceptual level for we do not have a grant program involving the assignment of actual ocean properties in support of the marine program.

The fulfillment of the sea grant concept, spanning diverse marine resources interests, does not in any way detract from our earlier focus limited to the marine sciences; in fact, the energy and interest directed to marine sciences have increased concurrently with our broader consideration of resources. We now appreciate, however, that the pursuit of marine sciences as an end in itself can miss the mark when isolated from any conscious concern for resource interests. At the same time we have become increasingly conscious of what science has to offer and what aspects of science must receive further support in behalf of resource concerns. Finally, we have developed a keener sense as to what disciplinary pursuits must be brought to bear on marine resource problems if useful solutions are to be found.

The expanded marine resource approach has been handled differently in different institutions in the United States. The University of Rhode Island illustrates one extreme, with coordination ranging very broadly across and throughout the university organization. At the other extreme might be the pattern found in the College of Marine Resources at the University of Delaware which brings the broad cross-disciplinary effort under the canopy of a single college. It is also interesting to note that outside the university system we see parallel trends in research institutes and government agencies, with many broadening the scope of their involvement as they consider marine problems.

Table 1. Organization for marine programs—University of Rhode Island.

President

Vice President

Provost for Marine Affairs

Institutes, etc.

(Largely staffed by faculty members from departments in the various colleges.)

- Coordinator: Sea Grant Programs
- Director: International Center for Marine Resource Development
- Director: Marine Experiment Station
- Director: Marine Advisory Service and Information Program
- Director: Coastal Resources Center
- (Director: Law of the Sea Institute)

*University Colleges and Departments**

Dean Arts & Sciences	Dean Engineering	Dean Oceanography	Dean Home Economics	Dean Resource Development	Dean Pharmacy
Biochemistry	Ocean	Oceanography	Food & Nutritional Science	Animal Pathology	Pharmacognosy
Botany	Civil & Environmental	Biological		Animal Science	Pharmacology
Chemistry	Electrical	Chemical		Community Planning & Area Development	
Economics	Industrial	Geological		Fisheries & Marine Technology	
Geography	Mechanical	Physical		Food & Resource Chemistry	
Geology				Plant & Soil Science	
Marine Affairs (administered by Geography Department)				Resource Economics	
Microbiology					
Physics					
Political Science					
Sociology & Anthropology					
Zoology					

* *The departments listed are those with faculty members active in marine resource work; the degrees given by these departments are listed in table 3.*

Table 2. Role of institutes or institute-like units on the flow diagram.

Sea Grant Program. Promotes marine resources work through funding available under the National Sea Grant College and Program Act with some matching funds from the University.

International Center for Marine Resource Development. Promotes resource development activities overseas; funding from the U.S. Agency for International Development, the University and other sources.

Marine Experiment Station. Undertakes applied marine projects, often under contract agreements, requiring an experimental approach.

Marine Advisory Service. Offers advisory services to the fishing industry, to other marine enterprises and to the public in general; funded by Sea Grant, the University, and other sources.

Coastal Resources Center. Through the multiple capabilities of the University, advises the state's coastal zone authority and other state agencies in fulfilling their planning, decision-making and administrative responsibilities; funded by Sea Grant, the federal Coastal Zone Management Act of 1972 and other sources.

Law of the Sea Institute. Independent of URI, but administered through the University. It was organized to promote interest in and a greater understanding of international law of the sea problems.

Having been associated in one capacity or another with about every organizational pattern being tried in United States institutions, I should be able to answer questions over a wide range; however, I will stress the URI example. The flow of authority, activity and responsibility is shown in table 1. Table 2 indicates the scope and responsibility of the institute-like units functioning at the University. Tables 3 and 4 list degrees offered and representative departmental and project areas receiving attention which have marine resource implications. In the main the growth of the project areas, all bolstering the educational mission of the University, has stemmed from the initiative of the faculty.

Table 3. Participation—marine resources, by department.

Graduate School of Oceanography	M.S., Ph.D.
College of Resource Development	
Animal Pathology	M.S., Ph.D.
Animal Science	M.S., Ph.D.
Community Planning & Area Development	M.S.
Fisheries & Marine Technology	A.S.
Food & Resource Chemistry	M.S., Ph.D.
(Food & Nutritional Science)*	(M.S., Ph.D.)*
Plant & Soil Science	M.S.
Resource Economics	M.S., Ph.D.
College of Engineering	
Department of Ocean Engineering	M.S., Ph.D.
Other Engineering Departments	M.S., Ph.D.
College of Arts & Sciences	
Biochemistry	M.S., Ph.D.
Botany	M.S., Ph.D.
Chemistry	M.S., Ph.D.
Economics	M.S.
Geography	M.A.
Geology	M.S.
Marine Affairs (administered by Geography)	M.M.A.
Microbiology	M.S., Ph.D.
Physics	M.S.
Political Science	M.A., M.P.A.
Sociology & Anthropology	M.S.
Zoology	M.S., Ph.D.
College of Pharmacy	
Pharmacognosy	M.S., Ph.D.
Pharmacology	M.S., Ph.D.

* *This group is in the College of Home Economics but cooperates with Food and Resource Chemistry and other departments in graduate instruction.*

Thus the most basic need is to assemble a staff sensitive to overall objectives and capable of responding. Direction at the administrative level is subtle, with energies spent in catalyzing rather than overtly steering programs. To be sure the sources of funding in support of research have an influence on the projects that are proposed and pursued. Thus a faculty member seeking support for a basic inquiry would likely apply to the National Science Foundation, for a domestic applied problem to the Sea Grant Program, for an international development project to sources generated by U.S. AID. There are, fortunately, multiple and diverse sources, though never quite enough. Some project proposals, as for Sea Grant activities where we are backed by a lump sum for suitable internal use, are judged almost entirely within the University; some proposals are assessed entirely by outside peer groups; and there are combinations within these extremes. The important need is to have varied and, hopefully, ample sources available to back activities found to have merit. Also important, in the viewpoint cultivated at URI, is to have sufficient ongoing, assured support for the major staff positions, in our case the faculty, so the researcher is motivated in his quest for funding by a sense of purpose and need and does not become trapped in a desperate hunt applying for the funding of his own position.

It is appropriate to close with comments about how work in marine resources at the University of Rhode Island relates to other research in the area and to government. First of all, the university program provides the educational services needed to help develop competency for filling the ranks of these other activities. Next, the URI program constantly interacts with and complements government and other research. Reflecting on the broad spectrum of concerns to be dealt with in marine resource development, one can quickly identify responsibilities which are logically the province of government, research best carried out by regional organizations, and research best handled in a university setting. The fact that such divisions are not always clear or that some undertakings require a multiple impact can be an asset rather than a drawback as the overlap brings together the different participating organizations.

Thus, at the University of Rhode Island some of us serve in an advisory capacity to the state's coastal authority (see notes on the Coastal Resources Center), some work on projects of the National Marine Fisheries

Table 4. Representative departmental and faculty project areas having marine resource implications.

Biochemistry
Biochemical properties of marine organisms.

Biological Oceanography
Numerous projects dealing with basic productivity, food chains, basic and applied ecology, fisheries and aquaculture.

Botany
Ecological role of algae in coral reef coasts.
Algae as indicators of water quality.

Chemical Oceanography
Hydrocarbon and trace element pollution along the coast and on the open ocean.
Nutrient chemistry as background for biological oceanography studies.

Electrical Engineering, also Physics
Applications of underwater sound transmission.

Environmental Engineering
Waste water treatment and pollution control.

Fisheries and Marine Technology
New net design development.
Testing of new fishing techniques.

Food and Nutritional Science; Food and Resource Chemistry
Processing and handling of marine food products.
Nutrition from marine food products.
Development and use of marine food products.

Geography (including Marine Affairs)
Offshore boundaries.
Coastal and international marine law.

Geological Oceanography
Shoreline stabilization.
Sedimentology and coastal and offshore mineral resources.

Ocean Engineering
Breakwater construction.
Ocean monitoring systems.
Practical uses of underwater detecting devices.

Pharmacognosy & Pharmacology
Search for, experimentation with, and testing of drugs from the sea.

Physical Oceanography
Water exchange in relation to pollution.
Current studies relating to biological problems.

Plant & Soil Science
Functions of tidal marshes in coastal ecology.

Resources Economics
Infrastructure related to fisheries development.
Economic analyses of marine resources and their potential.
Assessment of multiple use and conflict in the marine resource area.

Sociology & Anthropology
Cultural characteristics and questions of adaptability of peoples in the fishing industry.

Service, and some collaborate with contract and endowed research institutes in the region; while some of the staff from government and research organizations come to the University for advanced study or as senior staff in residence for specialized research or educational pursuits. In a few instances, where it is mutually beneficial, workers from groups outside the University are given adjunct faculty status in which they retain their primary affiliation yet are formally recognized as contributing members with respect to the University's educational responsibilities.

I can readily appreciate that there are a number of ways in which you might organize for the pursuit of marine resources work in Eastern Africa. My main objective has been to introduce the nature and scope of this work and to hope you will take it from there. Since long-range and lasting gains will necessitate the development of competency in the region, I do hope you will tie your pursuits closely to the university structure of the region with effective links to both government and relevant research enterprise.

Response

A. S. Msangi, *Head,*
Department of Zoology, University of Dar es Salaam

Professor Marshall's interesting account is of very special importance and significance to us here at the University of Dar es Salaam where we are attempting to develop a centre for marine resources with aims, objectives and ambitions very similar to those that prompted the development of marine science studies at his own university. The paper is also of importance to the whole of the East African region, since it shows

clearly how a centre for marine resources such as the one we would like to see developed at this university could be organised, structured and governed to serve not only the academic needs of a university of a broad format, but also the resource development and extension service needs of the whole of the East African region. There is no doubt that such a broadly-based multi-interested institution with both an academic and applied-research outlook would be the ideal thing for Tanzania and, I daresay, for Eastern Africa in general. Here too academic activities are expected to have as far as possible meaningful objectives in terms of a country's economic and social development, and academic institutions are not expected to be ivory towers.

An aspect of the marine resources programmes of the University of Rhode Island which is of special attraction and interest to us at this university is the multidisciplinary approach in which practically every discipline in the university contributes to and participates in the programme activities. This approach not only ensures a thorough coverage and treatment of all aspects of the programmes, but it represents the most economical use of manpower and resources. With our very limited financial resources and trained manpower at the present time, we certainly need to adopt this approach even more than URI. If, therefore, there are lessons that we could learn with advantage from their experience, this is obviously one of them. One could even go as far as to say that a centre for marine resources such as we are envisaging for the University of Dar es Salaam would only be a practicable proposition in the foreseeable future if this approach were adopted.

One hardly need say that with the sort of constraints that we have in terms of qualified manpower and financial resources, it would be completely unrealistic to think of being able to operate in the foreseeable future on the scale and at the level of the University of Rhode Island. Ours will, I think, have to be at least for quite some time a modest undertaking. But there is no reason why, even with these limitations, we should not evolve in due course a centre for marine resources of a high standard, serving the needs of the whole of the East African region and making its fair contribution to the development of staff already existing in the various faculties of the university. With the active development of scientists and other qualified staff from government ministries and research institutions in the country and with the active cooperation of friendly institutions both within the region and outside, it should be possible to establish a broad-based and well-balanced centre for marine resources fulfilling a variety of functions and serving a wide geographical area.

Thus, in developing a sound marine resources programme at this university, it would appear that three things would be necessary:

1. The adoption of an inter-disciplinary approach cutting across departments and faculties and making use of all available staff, from inside and outside the university, who can make useful contributions to the overall programme. In this regard it would perhaps be pertinent to mention that some years ago the Faculty of Science of this university put forward a proposal that all research institutes in the country staffed by qualified personnel should be affiliated with the university. Although a few such institutions, e.g., the Serengeti Research Institute, are now so affiliated, there are still many outside the umbrella which could be persuaded to come under it.

2. The strengthening of the cooperative relationships already existing with the other universities in East Africa and the extension of such cooperation to other universities in the region, who should be invited to share the training and research facilities in marine sciences.

3. The development of a mutually beneficial relationship with friendly institutions in other parts of the world whose experience and expertise could be tapped to help in the development of a centre for marine resources in this university. From what was said by Professor Marshall this morning, it would seem that the University of Rhode Island has a lot to offer in this regard.

I hope that these few remarks, together with the introductory words of the Honourable Minister of Education and the Vice-Chancellor of this university, have made it clear that we in the University of Dar es Salaam, and in this country generally, are aware of the great need to develop our very considerable marine resources and desire to establish a broadly-based centre for marine resources as a means to that end.

Discussion

The use of adjunct professors from neighboring institutions can be a viable way to quickly obtain expanded staff capability even though effectiveness is often somewhat hampered by personnel time constraints.

The suggestion was made that the EAMFRO substations planned for Dar es Salaam and Mombasa establish close relationships with their respective national universities regarding personnel, ship time and facilities sharing.

It was pointed out that Tanzanian research is coordinated under a National Research Council and that research direction should best come from the university to cooperating institutions such as EAMFRO and Kunduchi Fisheries Station in order to provide coordination scientifically (not administratively) to achieve optimum use of limited funds. Erratic funding availability and research schedule interruptions are costly and tend to inhibit nationally responsive research.

The requirement to perform extensive administrative duties tends to detract from the effectiveness of both national scientific personnel and relatively expensive foreign experts. Possibly the use of para-professionals trained to bridge the gap between scientists and administrators would prove valuable in improving efficiency.

Problems continue to exist in establishing research priorities in which scientific needs must be balanced against political expediency. Governments must decide what has to be done immediately as related to the needs of the entire society, and scientific efforts must show relevance to those needs.

Assessments and projections of personnel requirements in all marine resource areas, especially the scientific, should be strongly considered and rationally scheduled. With evaluation of scientific research relevant to the needs of the country, care must be exercised that the broad research base for the future is not subordinated to, or eliminated by, endeavors with immediate technical returns.

Some nations, especially some in South and Central America, have built national scholarship relatively quickly by intensive training abroad in which work is accomplished on problems relating to the parent country. The University of Rhode Island is participating in a program in Brazil in which visiting U.S. professors are conducting research involving both Brazilian nationals and U.S. visiting students (and participating as major professors in degree programs) performing in-country research on problems significant to the state.

Fisherman Training, Fisheries Biology and Aquaculture

S. B. Saila, *Director, Marine Experiment Station, and Professor of Oceanography and Zoology*

The time-honored objective of fisheries biology has been to determine what level of fishing will produce the maximum sustainable yield. Today fisheries biology —its objective and method—is recognized to be more complex. For example, interactions between living resources and their environment as well as interactions among various species of organisms must be taken into account. In addition, biologically acceptable objectives of management are being challenged by economists, and social values in the fishing industry are of considerable relevance. Finally, fisheries as well as other natural resources can be managed for many different purposes. In order to establish guidelines for management, appropriate criteria must be identified and applied to judge the effectiveness of alternative programs; the primary criteria relate to biological, economic and social aspects of the managed fishery within the context of regional needs. These criteria can only be developed cooperatively.

At present, it is believed, the major roles of the fisheries biologist are (1.) to identify and describe the distribution and abundance of the resources and their variations in time and space, (2.) to estimate the harvest that each resource or group of resources can sustain, (3.) to understand the effects of man's activities (including fishing) upon the supply and to explain the effects of natural environmental variations, (4.) to forecast abundance and place and time of arrival upon the fishing grounds, and (5.) to develop other information that can be used to increase the supply, reduce fluctuations in abundance, or otherwise reduce the costs of locating and catching fish. Our approach has been designed to try to meet these formidable tasks.

In addition to the classical approaches of the fisheries biologist in resolving the above problems, the presence of and cooperative relations with an enlightened, well trained population of fishermen is a necessity.

The University of Rhode Island Approach in Fisheries

The University of Rhode Island's program in fisheries has evolved over more than two decades in the light of this background, and currently is divided into two major categories: (1.) a two-year undergraduate program leading to the Associate in Science degree, and (2.) research and course work at a graduate level leading to the Master of Science or Doctor of Philosophy degree in oceanography or zoology with specialization in fisheries. This latter graduate program is considerably less structured than the associate program.

A listing of the course work offered for the Associate in Science degree is shown in table 1, and its content is briefly described in this table. The Department of Fisheries and Marine Technology faculty of six is part of the College of Resource Development (formerly Agriculture), and their facilities include a training vessel as well as shore facilities.

A brief outline of the content of a graduate course in fisheries biology offered at the Graduate School of Oceanography is shown in table 2. The content is not rigid and is designed to meet current needs. The objective of the graduate degree program is to produce competent scientists capable of handling diverse problems. Additional course work in several disciplines—including, but not restricted to, mathematics, economics, experimental statistics, various engineering disciplines, zoology, botany and chemistry—is required of degree candidates. Courses are tailored to individual requirements.

A wide range of problems has been chosen for thesis research. Some theses have resulted from an interest in extending the knowledge derived from fisheries-related course work and others have developed from grant or contractual work by university personnel. There has been no restriction on the geographic location of field work, and some projects have been undertaken outside the United States.

The fisheries program attempts to respond to current problems and to use knowledge from other disciplines to further fisheries science to the extent possible.

There is already some parallel between the Fish-

Table 1. Fisheries and marine technology course work at the University of Rhode Island.

Two Year Program for the Associate in Science Degree

Seamanship
Basic shipboard terminology and orientation. Safety at sea. Characteristics and use of rope and wire, tackles, gear systems, stress factors. Shipboard maintenance. Ship handling. International rules of the road. Knots, bends, hitches, rope and wire splicing.

Vessel Operations
Practical laboratory course in the conduct and handling of vessels and small craft with emphasis on procedures and seamanship for safe and efficient operation. Work consists of actual operations in port and at sea.

Introduction to Commercial Fisheries
Commercial fisheries of the world, the United States and New England, including fishing grounds, resources, catch statistics and legislation. Introduction to fisheries biology with emphasis on the natural history of important commercial species and the food chain. Effect of fishing pressure and introduction to management of fishery resources. Utilization and principal catching methods for the various important commercial species, including vessels and gear.

Marine Technology
Application of basic physical principles of statics, dynamics, heat, light, sound, magnetism and electricity to problems encountered in vessel operation, fishing gear, navigation, fish finding, handling and storage of fish, engineering and electrical systems.

Shipboard Work I, II, III
Work aboard training vessels in port and at sea. Experience is gained in operating vessels and their equipment, in principal methods of fishing, in rigging and working common gear used in the commercial fishing industry, and evaluation of experimental fishing gear.

Fishing Gear I, II
Detailed study of bottom and mid-water trawls and other dragging gear. Emphasis on construction, repair and use of different rigs and net designs, including the seine net. Detailed study of the purse seine, gillnet, trap and longline. Emphasis on the construction, repair and use of the various arrangements and designs of each. Brief treatments of other fishing methods.

Fisheries Meteorology
Basic practical meteorology and weather forecasting for the mariner. The atmosphere, heat budget of the earth, hydrometeors. Fundamental pressure systems, air masses, formation of fronts and associated weather. Precursory signs, tracks and vessel conduct for tropical revolving storms. Ice, icebergs and icing-up conditions. World meteorological organization, coding and decoding of weather reports.

Marine Engineering Technology I, II
Diesel engine operation, maintenance, testing, timing, and overhaul. Basic principles of diesel designs in common use, including fuel systems, combustion chambers, piston and liner assemblies, camshafts and crankshafts, cooling systems, and lubrication systems. Introduction to hydraulics, including operation, maintenance, troubleshooting, installation and applications. Study of basic hydraulic systems, design of common hydraulic components, and selection of components for various applications. Study and application of mechanical and hydraulic diesel powered drive units. Layout and uses of shipboard water pumps.

Marine Electronics
Basic electricity applied to fishing. Basic solid state and vacuum tube electronics, DC and AC machinery, ship wiring, communications, depth and fish finders, radar, electronic navigation systems. Noise control, siting and preventive maintenance of equipment.

Navigation I, II
Fundamental rules and methods of chartwork. Chart projections and types. Position fixing, wind and tide allowance. Variation, deviation and compass error. Principle of transferred position line and doubling angle on the bow. Use of sextant angles, radar, hyperbolic, and celestial position lines for chartwork. Tidal theories and calculations involving parallel, plane and Mercator sailings. Elements of astronomy and spherical trigonometry applied to celestial navigation. Kepler's laws, the solar system, star recognition and study of time; the altitude/intercept method and sight reduction by various techniques.

Fishing Operations Practicum
Practical fishing vessel operation; planning and working nearby fishing grounds for principal commercial species; rigging and handling gear and vessel. Conducted at sea in nearby waters.

Ship Technology
Principles of naval architecture and ship construction applied to smaller vessels, with special emphasis on fishing craft. Basic ship geometry and calculations, stability, powering and propellers. Construction methods and materials, vessel planning.

Fishing Operations
Commercial fishing procedures as they relate to the vessel operator, in the use of navigation, engineering, vessel layout, economics, marketing, fishing gear, accounting, and on-board fish processing.

Marine Transportation
Marine transport and the carriage of seaborne cargoes: trade and cargo patterns, ship types, international and governmental organizations, business, legal and insurance aspects, position of U.S. merchant marine, ports.

Fish Preservation
Introduction to microbiology and biochemistry of fish spoilage. Preservation methods at sea and ashore including icing, mechanical refrigeration, freezing, salting, smoking, dehydration, canning, plant sanitation and quality control.

Industrial Fishery Technology
Utilization of industrial fish; production of fish meal, fish oil, condensed fish solubles, fish protein concentrate; handling, packaging, storage and transportation. Nutritive quality, market value and demand relationships for fish proteins.

Table 2. The course outline currently used in fisheries biology at the University of Rhode Island.

Oceanography 568—Fishery Biology

Highly recommended: Bartlett, M. S. and R. W. Hiorns. 1973. The mathematical theory of the dynamics of biological populations. 352 pp. (book).

Desirable: Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada. Bull. No. 119 (manual); Watt, K. E. F. Ecology and resource development. McGraw-Hill, 1964 (book).

The course outline below will be used as a general guide for the course.

I. Introduction
1. World fisheries, historical development and current status
2. Concepts of fisheries science and population dynamics
3. Aspects of production and cropping
4. Physical environment related to life history

II. Analysis of Subpopulations—stock separation
1. Genetic—environmental aspects—general
2. Meristic comparisons
3. Morphometric comparisons
4. Combined data—bivariate and multivariate approaches
5. Movement measured by subpopulation studies
6. Tagging experiments
7. Group comparisons in space or time
8. Faunal associations and diversity

III. Empirical Considerations
1. Growth
   a. The nature of growth processes—use of hard parts
   b. Calculated, logistic, Gompertz, Von Bertanlanffy functions
   c. Growth estimates from marking
2. Length-weight relationships
   a. Condition-allometry equation
3. Mortality estimation
4. Fishing power estimation
5. Mesh selection

IV. The Theory of Fishing
1. Fishing effects interpreted by mathematical models
   a. Model types
2. Optimum yield problem

V. Population Estimation
1. Principles
2. Single season experiments
3. Mutiple season data

VI. Methods and Principles of Fishery Regulation
1. Size limits
2. Bag limits
3. Quota regulations

VII. Migration and Movement
1. Models and assumptions

VIII. Fisheries Hydrography

IX. Stock-Recruitment Relations

eries and Marine Technology program at the University of Rhode Island and the fisheries training program in Tanzania. It seems desirable that some of the course work listed in table 1 might become incorporated into the Tanzanian fisheries training program in the future. The University of Rhode Island program in fisheries biology does not yet appear to have a counterpart at the University of Dar es Salaam. It is hoped that the description given above might aid in the decision to develop such a program.

Background for Aquaculture

The term aquaculture, as used here, refers exclusively to the controlled husbandry of economically important marine or brackish water organisms in coastal and brackish water regions.

The five major subtechnologies of aquaculture are considered to be (1.) transplantation, (2.) hatchery production and stocking, (3.) retainers or attachments using natural feed (embayment culture), (4.) ponds using supplemental feed and fertilizer, and (5.) ponds or containers using no natural feed (intensive culture).

Progress in aquaculture in the United States is proceeding rapidly although commercial-scale operations are still limited in number. High-priced species (so-called luxury foods) are the prime targets of aquaculture efforts in developed countries. Candidate species from a technological viewpoint include those with good growth rates, conversion efficiencies, and hardiness, as well as those able to use available feeds and with relatively simple larval developmental stages. From an economic point of view market volume, price and price flexibility are important criteria for species selection.

The goals of aquaculture in the developing countries may be quite different from those suggested above. Here the need for increased protein may be the principal factor to encourage aquacultural development.

It seems that the major problems still facing the widespread application of available aquaculture technology in developing countries are capital investment, cheap feed formulations, predator controls, and the availability of technical assistance. The usual competi-

tors of aquaculture in developed countries (agriculture, fishing and coastal zone development) are more supportive than competitive in the developing countries with agriculture providing fish feed, fishing providing spawning stock, and increased interest in coastal zone development helping to bring the infrastructure to aquaculture areas.

Aquaculture is not considered a panacea for malnutrition by being an almost unlimited source of protein. Rather it is suggested that greater consideration be given to aquaculture's potential contribution in raising the general levels of economic well-being in the developing countries including Tanzania.

University of Rhode Island Approach to Aquaculture

Aquaculture at the University of Rhode Island started in 1964 at the Marine Experiment Station in a very modest fashion. The prime interest was in enhancing growth and survival of pelecypod mollusks and in rearing salmonoid fishes. Aquaculture soon after became a significant part of the sea grant program at the University. The program of controlled husbandry developed for sea grant projects included reproduction and hatchery culture of marine vertebrates and invertebrates, as well as studies in growth and rearing, environmental and predator control, phytoplankton and other food organism culture, demand elasticity, cost of production and opportunity cost.

In view of the fact that aquaculture was a relatively new program at the University, some of the initial work has been modified or terminated and new projects initiated. The five continuing sea grant aquacultural research projects involve nutrition of selected marine species (especially salmonid fishes), pathology of marine species, culture of marine invertebrates, bacterial aggregation and larval nutrition and economic analysis of the aquacultural potential of selected marine species.

The project dealing with nutrition of selected marine species is directed by a professor in the Department of Animal Science. The immediate objective has been to develop practical and economical diets for salmonoids and related species. Longer range objectives include the study of (1.) interrelationships between dietary protein and energy requirements, (2.) protein utilization as a function of environment, (3.) the dietary interrelationships of certain unsaturated fatty acids, and (4.) interactions among light, metabolism and temperature.

The project dealing with culture of marine invertebrates is directed by a professor of oceanography. Its objectives are (1.) to develop techniques for culturing larvae and juveniles of economically important crustaceans and bivalve mollusks, (2.) to determine ecological and physiological requirements for larvae, juveniles and adults, and (3.) to apply knowledge gained from the above for development of methods and equipment for controlled production on a commercial scale.

A study of the role of bacteria—both beneficial (nutrient) and deleterious (inhibitory)—in larval development has been led by a professor of oceanography.

A marine fish culture-pathology project is directed by a veterinarian who is a professor in the Department of Animal Pathology. Its objectives include development of a clinical and histopathology laboratory and use of these facilities to study specific disease processes, and to aid investigators in related fields.

The economic analysis of aquaculture projects is directed by a resource economist with the objectives of projecting production costs for alternative technologies and food rations, assessing market potential for selected salmonid species and evaluating the economic feasibility of selected types of salmonoid aquaculture.

It is clear from the above that aquacultural research at the University of Rhode Island involves a coordinated multidisciplinary approach to the development of techniques and systems for commercial operations. However, it is also clear that there is no formal course work in aquaculture offered at the University. Instead, investigators in several disciplines have chosen to apply their knowledge to the solution of aquacultural problems.

There are obviously a number of interdepartmental relationships involved in a program such as this. In addition, international liaison with aquacultural researchers in other countries has already been established in the case of nutritional studies and pathological studies.

The plans and projections for this program seem to suggest that certain elements of aquaculture, such as nutrition, genetics and pathology, will probably continue to be carried out in a university environment. However, it is hoped that other aspects of this work will be carried out ultimately by entrepreneurs.

It is suggested at this time that the relationship of this program to any developing program in Tanzania is not very close. The University of Rhode Island program

is directed toward high value north temperate species (such as salmon and nothern lobster) and is aimed toward an intensive, virtually closed system culture involving a high level of capital investment and technology. It is also oriented toward conversion of one form of protein into another rather than toward increasing protein production. It is suggested that aquaculture might initially become a portion of the fisheries technology program in Tanzania in order to respond to the goal suggested in the background material, and that the University program evolved at Dar es Salaam be tied to the investigation of aquaculture problems brought to light by technological developments.

Response

A. S. Msangi, *Head,*
Department of Zoology, University of Dar es Salaam

It would seem to me that, with a little modification to suit local conditions and needs, the programme in marine sciences at the University of Rhode Island could be adopted with advantage at the proposed centre for marine resources to be established here in this university. As Dr. Saila has pointed out in his paper, the URI two-year programme in Fisheries and Marine Technology for the Associate in Science degree is in many ways comparable to the two-year Fisheries Diploma course offered by the Fisheries Research and Training Institute of the Ministry of Natural Resources and Tourism. I would tend to agree with him that the inclusion of some of the course work offered in their programme would improve and enrich our Fisheries Diploma course. It is true that there is as yet no postgraduate course work offered by the University of Dar es Salaam which is comparable to their graduate course work in fisheries biology, although several of our postgraduate research students have been working in various aspects of marine biology. The Faculty of Science of this university, effective the next academic year, is going to offer various Master of Science courses in different fields which are relevant to the developmental needs of the country. There is no doubt that, provided there are enough postgraduates, a Master of Science course in fisheries biology would be most appropriate.

So far as research in marine sciences is concerned, the following would seem to be areas of immediate priority:

Plankton. Since the plankton are of such basic importance as the source of primary production in the sea and constitute the community in which almost all commercially important marine organisms pass their early life, their study is of very direct interest. At present we have a zooplanktologist among the staff of the marine biology station, and one of our postgraduate students is working on primary productivity in the phytoplankton.

Benthos-Coral Reefs. The coral reefs along the East African coast are some of the best in the world. They are very important as a tourist attraction, as a habitat for commercially important animals and for their function in protecting the shore. At present they are in great danger of over-exploitation, damage, and possibly pollution. Very little is known of their biology in this area. One of our postgraduate students is currently working on the ecology of coral reefs on the East African coast.

Benthos-Sandy/Muddy Bottoms. These areas, both littoral and sub-littoral, are the habitats of the most easily exploited commercial fish and shellfish. Little is known of the animal community that makes up the food chains or of the distributions of the different types of substrates. Last year a postgraduate student completed Master of Science studies on the ecology of the sandy/muddy shores around Dar es Salaam.

Fisheries Biology. This area is of course of top priority, but as there are several scientists in the Fisheries Research and Training Institute and in the East African Marine Fisheries Research Organisation working in this field, it is necessary to try to avoid duplication. What is needed is a cooperative and coordinated effort. In 1971, a postgraduate student in the Department of Zoology completed doctoral studies on plankton analysis relative to the feeding habits of *Sardinella* in Dar es Salaam waters, and last year another postgraduate student completed Master of Science studies on the biology of fishery potential of *Palinurid* lobsters in Tanzania.

Oceanography. Oceanographic data are essential for a proper understanding of season variations in commercially important species and of the movement and migration of marine organisms. A chemical hydrographer

would be a most useful addition to our marine biology station staff.

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Supplementary Comments

S. B. Saila, *University of Rhode Island*

The relationship among the existing program at URI, the national needs of the Republic of Tanzania and the program of the University of Dar es Salaam was briefly considered. It was the consensus that the best association might be found between the Department of Fisheries and Marine Technology at URI and the Kunduchi Fisheries Training Institute—also a two-year program. It was suggested that a direct transfer of staff, students and training materials between the above two groups would serve mutual interests and would be particularly helpful to Tanzania.

While some similarities were evident among the fisheries biology course work at URI, master's and doctoral research, and Tanzanian needs, the University of Dar es Salaam programs should be oriented, at least initially, toward assessment of natural history, ecology and breeding biology of commercially important organisms or organisms of potential economic value. Many important research projects seem appropriate in these areas. Among these, the assessment of fish stocks by approximate methods, which do not require costly measurements to establish all the parameters needed in classical modeling, seems to be of special importance.

A more extensive discussion of the potential of mariculture for Tanzania was held. It was clear that the highly technological aquaculture development programs at URI is not directly transferable at this time to satisfy the needs of Tanzania. However, the concept of labor-intensive, locally appropriate mariculture was considered extremely useful for the University of Dar es Salaam to pursue. This type of mariculture does not involve large capital investment and can proceed with available technology. It was thought that a sustained development of mariculture research and pilot programs by the University of Dar es Salaam and EAMFRO working in cooperation would seem especially useful.

A global survey by the UN/FAO projected substantial near-future improvements in infrastructure and technology for the developing world in the culture of shellfish, gastropods and herbivorous fish, indicating promise for future Tanzanian mariculture development. The current 60- to 70-million metric-ton global fish catch could be supplemented by as much as one-third by mariculture developments, thereby providing a substantial stimulus for these efforts.

Discussion

It was contended that some fish stocks formerly of great value in Eastern Africa have been fished virtually to extinction through improper use of equipment under unenlightened or non-existent management regimes. The question of whether some highly resilient stocks could be restored, both in average size and numerical abundance, and therefore numbered among the potentially high-value species, was discussed.

Examples given of successful reclamation, or replacement by closely related species include: the reintroduction and spectacular expansion of the anadromous salmonids into U. S. West Coast river systems, and current efforts to realize like improvements on the East Coast; the fivefold increase in total fish production of Lake Michigan by replacement of a steno-thermal lake trout by a eurythermal Coho salmon which feeds on a newly introduced available food-fish, and the elimination of the U. S. Great Lakes' sea lamprey, a voracious predator, by the introduction of a selective larvacide.

Ocean and Environmental Engineering

S. B. Saila, *Director, Marine Experiment Station, and Professor of Oceanography and Zoology*

It is believed that engineering problems related to the oceans include at least four separable classes of problems: (1.) availability and use of resources, (2.) design and use of structures and machinery, (3.) information gathering and transmission, and (4.) pollution.

The first of these topics relates directly to the desirability of entering into any technological development that might exploit the sea. Some of the ocean resources to be considered for this development include petroleum and minerals such as phosphate rock, manganese nodules, diamonds, and sand and gravel. The variety of organic products that can be made from living resources of the sea is impressive—fish for food, fish meal and flour; fish oils for diverse applications; seaweeds and industrial products from fish scales and mollusk shells such as pearl essence, poultry feed supplements and pearl buttons, and various other industrial products from the skin and bones of marine fish and mammals. All require engineering studies before and during operations.

The second major topic dealing with the design and use of structures and machinery is equally diverse. It includes a description and understanding of the static and dynamic forces that will be encountered when one places a structure (ship, submarine, undersea cable, undersea habitat) in the ocean and operates machinery there to do useful work. The marine vehicles and structures include ships for bottom and deep-ocean work, platforms for oil and gas exploration and submersibles of various types, as well as various types of living resource exploitation systems. Design and use studies involve materials, propulsion systems and control systems.

The third topic, information gathering and transmission, is also very broad. It should be recognized that almost any spatially- or temporally-varying physical phenomenon in some sense is available as either a source or a mode of information transmission. The obvious types are acoustic and electromagnetic energy transmission and their diverse applications, such as echo sounding and magnetic anomalies on the sea floor.

The fourth topic, pollution, is of more recent interest. It is clear that if oceanic resources are to be developed to permit man to sustain himself and his productive activities, pollution must be managed in such a manner as to assure the continuing health of living resources including man. Pollution abatement and management involve both engineering and other skills, but certainly ocean engineers have an important role in this area.

University of Rhode Island Activities

The University of Rhode Island has based its program in ocean engineering on marine-oriented research capabilities in the College of Engineering. A Department of Ocean Engineering is located within the College and it presently has a faculty of 13. Table 1 shows the course work offered by the Department. It should be pointed out that this is a *graduate* program offering a Master of Science and a Doctor of Philosophy degree. There are currently more than 80 students enrolled in the graduate program in ocean engineering.

The area specializations of the Department of Ocean Engineering include a host of specific projects—desalination of seawater, physical properties of marine sediments, sediment transport, bottom profiling and penetration, estuarine pollution abatement and waste disposal, mathematical modeling of estuaries, guidance and control of underwater vehicles, hydrodynamics of floating and submerged bodies, and scuba safety and work effectiveness.

Several of the faculty appointments are joint with electrical engineering, civil and environmental engineering, and chemical engineering. This is believed to be a strength rather than a weakness, because ocean engineering is a diverse subject. In addition there are other interdepartmental relationships. For example, a Sea Grant project, involving the Departments of Ocean Engineering and Resource Economics and the Graduate School of Oceanography in the development of an integrated model of Narragansett Bay incorporating physical, biological and economic submodels, has been in progress for several years. Cooperative research projects

among ocean engineers and the Department of Fisheries and Marine Technology are also underway. These involve determination of the drag characteristics of common fish net sections and pressure measurements in the vicinity of the mouth of a mid-water trawl model.

The Marine Experiment Station of the Graduate School of Oceanography is involved in applied oceanography and in fisheries and environmental studies which often need ocean engineering skills. Again there is an element of inter-departmental cooperation in this program with the Department of Ocean Engineering as well as with other departments with marine-related interests.

Sponsored research at the Marine Experiment Station currently involves hydrographic and biological modeling studies in the vicinity of a nuclear power plant, artificial lobster habitat evaluation, development and evaluation of electrical guidance devices in both marine and brackish environments, design of benthic invertebrate sampling surveys, artificial culture of fishes, population dynamics studies of regional fisheries—including the yellowtail flounder and surf clams—dredge spoil and solid waste research, and studies of the endurance of marine organisms in flumes. The Marine Experiment Station has a small staff and uses graduate students in some of its projects.

The plans and projections in ocean and environmental engineering call for significant growth due to the increased activity anticipated on the continental shelf in the near future. This activity involves both petroleum and mineral exploration and extraction.

It seems that the University of Rhode Island program in ocean engineering and its Marine Experiment

Table 1. Course offerings in ocean engineering at the University of Rhode Island.

Basic Ocean Engineering
Introduction for non-engineering students to the classic engineering disciplines as they relate to marine affairs. Course is descriptive and deals with current engineering practice.

Hydrodynamics of Floating and Submerged Bodies I, II
Hydrodynamic principles associated with floating and submerged bodies: resistance, propulsion, static and dynamic stability. Problems of maneuvering, control, and motions in waves.

Materials Technology in Ocean Engineering
Requirements for ocean engineering materials. Material characteristics, fracture toughness, notch sensitivity, energy absorption, speed of loading and fatigue in salt water. Steel, aluminum, titanium, plastics, concrete, and applicable regulations will be discussed.

Marine Structural Design
Includes the design of marine structures, consideration of marine construction materials, waterfront structures, ocean towers and underwater structures.

Underwater Power Systems
Low output power systems. Overall considerations appropriate to the determination of power requirements for underwater systems.

Coastal Zone Power Plants
Overall systems consideration for coastal zone power plants. Consideration of factors such as political and legal problems, thermal pollution, and multi-use of plants (aquaculture, etc.).

Underwater Acoustics I, II
Wave equation, energy, pressure and particle velocity. Acoustic properties of the sea. Elementary sources, refraction, reflection, ray theory, normal modes and scattering, with emphasis on sound propagation in the ocean. Transducers, radiators and receivers, directivity (array structures), equivalent circuits, efficiency; piezo-electricity, magnetostriction, sonar principles, measurements and calibration.

Advanced Course in Underwater Acoustic Propagation
Analysis of propagation from a concentrated acoustic source in the ocean by methods such as advanced normal mode theory, numerical integration and fast Fourier transforms. Applications to ocean features such as surface ducts, shadow zones, deep sound channel, etc.

Nonlinear Acoustics
Topics in the nonlinear acoustics of fluids. Propagation and interactions of finite-amplitude sound waves. Parametric sonar. Sound generation by turbulence. Cavitation noise. Shock waves. Underwater explosions. Radiation pressure and acoustic streaming.

Coastal Engineering Geology
Discussion of the interaction of geological factors and coastal structures. Shore materials, energy-material relationships, and the interference of man-made structures with the natural regimen emphasized.

Submarine Soil Mechanics
Soil mechanics principles as applied to submarine slope stability, heaving, sinkage and anchorage problems with emphasis on effective stress principle and selection of shear strength of marine sediments.

Engineering Ocean Mechanics
Applied concepts of ocean flow processes; waves due to gravity,

Station setup have directly transferable conceptual schemes for the University of Dar es Salaam. The mechanics and time schedule need to be resolved.

Response

P. Bomboe, *Professor of Geology, University of Dar es Salaam*

The essential considerations presented by Professor Saila on such a diverse subject as ocean engineering will have a helpful impact on our educational programmes and on our interdepartmental relationships. There is no doubt that the University of Rhode Island and its Marine Experiment Station have worked out and tested conceptual schemes of research and training in ocean engineering of great interest for our university.

Evidently the formal machinery for an appropriate and effective transfer of some conceptual schemes and technologies should be brought into operation as soon as possible because research and training on the environment and engineering in connection with natural resources utilisation are particularly suitable for this form of international cooperation.

A few considerations on specific features and possible engineering objectives along the coastal zone of Tanzania are presented to stress the importance and

wind, and layered media; large and small scale turbulence; prediction of flow instability; wave forces on structures.

Advanced Design
Advanced course coordinating engineering principles and economics in the design of a complete ocean engineering device. Problem investigated individually with the guidance of one or more instructors.

Corrosion and Corrosion Control
Chemical nature of metals, electrochemical nature of corrosion. Types of corrosion, influence of environment, methods of corrosion control, behavior of engineering materials, all with special emphasis on the ocean environment.

Advanced Course in Corrosion
The various types of corrosion problems occurring in modern industry. In-depth comparison of the various methods available to avoid, reduce, or eliminate corrosion. Continuation of course above.

Environmental Control in Ocean Engineering
Application of the principles of thermodynamics, heat transfer, and fluid dynamics to the requirements of human survival and engineering operations in deep and shallow water.

Introduction to the Analysis of Oceanographic Data
Design of oceanic experiments to determine spatial and temporal sampling rates, precision accuracy, signal-to-noise ratio, etc. Description of typical ocean data collection and analysis systems. Development of relevant techniques.

Ocean Laboratory I, II
Measurements, experiments, and the development of apparatus in the ocean from research vessels. Topics covered include statistical theory, planning multi-variable and sequential experiments, checking of data, error-propagation in multi-sensor experiments in the ocean, and at-sea operations. Physical, chemical, and biological measurements would be undertaken as well as application tests on models or full-size apparatus in Narrangansett Bay.

Planning long-term application or environmental experiments in the ocean. Carrying out a synoptic ocean measurement program over a month or more using vessels, buoys, underwater sensors, and locations of opportunity. The student would manage the experiment or measurement scheme so as to make a contribution to engineering or oceanographic knowledge in the area of operation. Preparation of a report on the experimental work.

Ocean Engineering System Studies
Systems engineering study of an advanced ocean engineering problem. Students will operate as a complete engineering team with specific subsystems designs done with individual faculty members.

Special Problems
Advanced work under supervision of a member of the staff and arranged to suit the individual requirements of the student.

Masters Thesis Research. Number of credits is determined each semester in consultation with the major professor or program committee.

Doctoral Dissertation Research. Number of credits is determined each semester in consultation with the major professor or program committee.

Ocean Engineering Seminar. Seminar discussions including presentation of papers based on research or literature survey.

significance of this cooperation in relation to the development of a centre for marine resources in this geographic area.

Specific Features of Coastal Tanzania. The coastal area of Tanzania is a peculiar zone in terms of sedimentation, marine incursions and development of the continental margin. The zone is a part of the tectonically active East African graben. The configuration of the coastline, as well as the inshore and offshore morphology, have been and still are controlled by recent tectonics. Stratigraphical evidence supports the geophysical conclusion that there is a long and gradual transition between the structure of the East African coastal zone and the structure of the deep ocean. The continental break should be placed far to the east. The geometry of geological fractures in the coastal zone and in the offshore islands indicates that a major fault system bounds the continental shelf, but no sharply marked continental edge can be drawn. Pemba and Zanzibar Islands represent continuations of positive structural trends in a deep-fractured structure. Mafia Island is a positive topographic feature opposite a subsiding area expressed mainly by the Rufiji Delta. The smaller islands are built by reef development and sedimentation activity on a bottom affected by differential and regional uplift.

If we also consider the distribution and dynamics of coastal currents; the injections of fresh water from rivers as Ruvumu, Rufiji, Ruvu and Pangani; the thickness and variety of coastal deposits and the effect of tides, we would have a very general picture of the complexity of this East African coastal zone, not only as the habitat of complex marine communities, but as the environment in which numerous engineering objectives must be satisfied.

Any human intervention in such a complex and sensitive system should be adopted on the basis that research is integrated and is not only able to evaluate the technological and economical results, but is capable of predicting and avoiding any basic disturbances and irreversible processes. We must work with nature instead of against it.

Engineering Objectives Nearest to Achievement. Many aspects of practical activity, including coastal mineral resources exploitation, petroleum exploration, navigation, cartography, port development, coastal hydraulic engineering and fishing technology, which have objectives of great importance to Tanzania, also have a strong impact on her marine environment.

Tanzanian beach deposits are very rich in several valuable minerals. The rich deposits are developed in narrow, but very long, strips along the shore, across the channels and in some islands. There is a possibility of finding additional deposits offshore. The present methods of mining and treatment of the beach sands are not particularly sophisticated. However, mining activity will spread shortly over large areas and thus stimulate additional technologies and industries. If we note that the deposits of heavy minerals extend northward to Malindi, Kenya, and perhaps beyond; southward across the entrance to Dar es Salaam harbour; down to the Mafia Island and Mtwara zone, and some far into the deep ocean, we can realise the size and significance of the potential impact of this industry on the marine environment.

The East African coastal zone—the large islands, as well as the offshore zone—should be considered an area with promising petroleum potentialities. Relatively little evidence of liquid and gaseous hydrocarbons has been found up to the present time within this region; however, the exploration programme has been quite meagre. Structural evidence and geological correlations with neighbouring zones support the probability of finding gas or petroleum resources within some inshore and offshore structures in East Africa. The impact of a petroleum industry on the marine environment has been experienced in other geographical areas. The results are well known.

Thinking about protecting the ocean environment never implies preventing the use of natural resources from the ocean. It only means the using of engineering competence in the development of such resources to obtain maximum benefits with minimum disturbance of the natural environment. It means promotion of those techniques, equipment and methods that prove to be the best suited to the hydrodynamical, morphological and biological conditions in a particular marine area.

Problems connected with development, use and maintenance of the natural harbour basin are particularly complicated and particularly pressing in Tanzania. Beside requiring new equipment and technical facilities, resolution of these problems should include dredging and related hydraulic studies, safety measures, and measurement of hydrodynamics, the silting rate and pollution levels. It means not only getting experienced

staff at the managerial level, but also technical staff with capabilities in the marine sciences and technology. Finally, we should mention the existing salt industry, the prospecting for island freshwater supplies and the need for their protection against salt water, and integrated studies on reef zones of great biologic and tourist interest.

Our training and research programmes have to anticipate the short-term effects of this increasing activity on the East African coastal zone and continental shelf.

New Facilities at the University of Dar es Salaam. In addition to the departments with academic tradition and research experience like botany, chemistry and zoology, the University of Dar es Salaam has new educational and research facilities.

First of all I refer to the new Faculty of Engineering, where the three departments of civil engineering, mechanical engineering and electrical engineering have been combined to make a significant attempt to orient themselves toward the technological needs of the country. The establishment of the Department of Geology, as well as a hydrology unit, marked also a reinforcement of interest in applied science programmes within the Faculty of Science.

In these circumstances a training and research programme in ocean and environmental engineering in a centre for marine resources could be easily carried out on an interdepartmental basis with the cooperation of the University of Rhode Island.

In the next two academic years, new courses will be offered in the Faculty of Engineering or by the Faculty of Science. Perhaps the following could be made more relevant to ocean engineering: general and engineering hydraulics, surveying, cartography, soil mechanics, sedimentology, marine geology, engineering geology, oceanography and oceanographic data processing, introduction to ocean engineering, harbour basins study and maintenance, pollution and water protection, and law of the water (including law of the sea). These courses could also be developed in the coming years at a postgraduate level.

Evidently ocean engineering means, as Professor Saila pointed out, a larger field than we have considered in the past. It may include materials technology in ocean engineering, guidance and control of underwater vehicles, technology in floating and submerged bodies, desalination of seawater, pollution abatement and waste disposal, and mathematical modeling in the marine environment.

It is not my intention to work out a curriculum in ocean engineering for our university here. I hope this curriculum will be worked out on a collective basis in the coming days. What I want to stress is that the suggestions presented by Professor Saila are made at an opportune time for our university. It is now able to accept and perform new tasks in the new scientific and technological fields.

Thanking Professor Saila for his remarkable synthesis, I should like to point out that the establishment of a research and training programme in ocean engineering, and in marine science as a whole, will mark a considerable strengthening of our scientific and technological resources.

Such a centre of excellence in marine science and technology in East Africa will strengthen international and regional cooperation and will fulfill a mission directed to the development of new technologies and the production of trained manpower for important sectors of infrastructural and economic development in this part of Africa.

Supplementary Comments

S. B. Saila, *University of Rhode Island*

An integrated research basis for coastal resources extraction, hydraulic engineering, and port development is suggested. Mineral resources are considered to be of relatively great value to the Republic of Tanzania. There is also some possibility of offshore petroleum resources off the coast.

Protection of the environment does not imply preventing rational use of mineral resources if sound engineering practices are applied.

A question was raised concerning the apparent erosion of sediments in the vicinity of Bahari Beach and in nearby coastal regions. The Geology Department was asked to consider this problem, and they have stated that perhaps erosion and deposition were related to improper agricultural practices.

There does seem to be general agreement that with the establishment of a Faculty of Engineering at the University of Dar es Salaam as well as the Department of Geology with a hydrology unit, the chances for accelerated development on coastal and environmental engineering even with the existing staff seemed very favorable.

Discussion

Several ocean engineering investigations appear worthy of immediate consideration in the Tanzanian framework. Among these are the applicability of dredging as applied to port development in Dar es Salaam, beach erosion in the Kunduchi area, and any relationship that might arise as a result of loss of reef protection due to dynamiting, riverborne sediments or storm waves.

Marine Resource Economics

H. C. Lampe, *Professor of Resource Economics*

As a discipline, marine resource economics is not well defined, nor does it represent—except at URI—a distinct program of study. However, more important than these facts is the rationale for the view that among economists we can hardly afford to be parochial in our concern for limited aspects of marine development, e.g. fisheries.

Very early in our research and teaching, it became clear to us that a large number of issues impinge on fisheries activities: pollution, transport, recreation, and even agriculture, to name but a few. Further, it is clear that these other marine-oriented activities often conflict with one another (see earlier papers) and these conflicts cannot easily be resolved in either purely political, technical, scientific or economic terms. Hence, it appears imperative that we concern ourselves with a broad range of marine resource problems and that we train students to understand them.

Among the more difficult issues to which we have directed our attention are those that relate to land use in the coastal zone. The nature of land use obviously can directly influence neighboring ecosystems that have either economic importance or value of another kind. The nature of land use can indirectly affect environments through the production of waterborne wastes—domestic and industrial. While certain uses of land do not require marine oriented sites, once established, they may obstruct essential marine activity for generations. Offshore mineral production of oil, sand and gravel, etc., requires shore-based sites; planning these needs and assessing their impact is also important. The requirements for shipping and a rational arrangement of ports are strangely enough often forgotten. The relation of agriculture to marine activity has often been ignored, although complaint has recently been publicly registered concerning insecticides. However, this is only one ele-

ment of consequence—sediments, animal wastes and water diversion can be locally important.

You have seen a conflict matrix that concerns itself with marine uses only; it is clear that such a matrix could be extended to a broader range of uses.

To treat many of these issues, it is essential that the implications of change in the structure of the economy of coastal land use be understood. It is of equal importance to consider the implications for economic development and its structure of restraints upon land use, pollution, etc.

In order to consider effectively the impact of alternative economic development strategies, the linkages between marine and non-marine oriented sectors of the system must be developed and some notion of the dynamics of these systems evolved. This is not to say that any particular methodology—such as input-output analysis—is imperative but often a fairly clear methodological set is necessary for orientation of any analysis of alternatives.

We all recognize that imposition of restraints or their removal can, and most often will, result in some changes in relative costs to various sectors. It is necessary for us to construct a framework within which the economics of various alternatives can be assessed and this assessment must include recognition of the linkages among marine related activities and the economy as a whole.

The Structure of Fisheries Economics

H. C. Lampe, *Professor of Resource Economics*

One may take several points of view in classifying research in fisheries economics. As professional economists we may categorize projects according to their theoretical sophistication and potential for publication in learned journals, or as ranging from applied to pure. Or, we might classify research according to that part of the industry with which it deals, e.g., production, marketing, consumption, etc. Further, we could consider research according to its orientation to operating enterprises (public or private) or to policy issues at a higher plane. Or perhaps we could classify research according to its contribution to our current body of facts or to our development potential.

But since these criteria are all applicable and important in one circumstance or another, and circumstances change, a categorization of research activities may not prove useful. Nevertheless, there are several more or less distinct kinds of research in which we have been engaged and which contribute to different requirements of our fisheries.

For example, a major effort has been made to develop research activities that will contribute to resource management policy. These activities have been distinguished by our efforts to integrate biological and economic activities, and their purpose has been in the main to illustrate the failings of present systems or to suggest alternatives. One of the more exciting projects in this vein addresses itself to the management of multispecies fisheries—a problem that has yet to yield to theory or practice. Specific management models have been completed for several species of fish and shellfish. An evaluation of world-wide pulsed fishing of tuna stocks has also been completed.

A project initiated this year that has implications for a number of areas deals with the economics of environmental improvement of lagoons for fish produc-

tion. Specifically we are investigating the conflicts in water use for irrigation and shrimp production in Mexican lagoons.

We have long been aware that many fish production programs have failed due to lack of understanding of marketing and distribution systems. Hence, our earliest inroads into fisheries economics were directed toward these problems. This area of research has ranged from the rather sophisticated modeling required to estimate demand elasticities to more pragmatic assessments of marketing and distribution costs. We have, of course, focused attention on both export and internal markets. Our purposes have been numerous but, in general, we have seen a need to evaluate the consequences of changing production systems on market structures and to judge market potentials. In other cases, we have been concerned with the efficiency of these systems.

We are studying currently the use of fish in institutions and the markets for fresh fish in the region with a view toward developing a training program that will improve distribution efficiency. We expect to analyze transport networks for interested suppliers of fish in the region.

An important effort has always been maintained in production research, where we have assayed problems ranging from the influence of ownership on crew size and efficiency to the feasibility of various types of trawl nets. This work has been of value in judging investment potentials and the influence of price changes on fleet composition and has provided insight into difficulties faced by fishermen.

Considerable effort has been made to provide producers with the results of research on the production of underutilized species. Data have been provided with the cooperation of vessel owners in test fishing and handling of relatively unknown species. We have worked to develop uniform accounting and recordkeeping for fishermen to provide them with better information and to develop more useful information for research.

Another area that has become more important recently is what might be called "development economics" —both domestic and foreign. Research of this kind is concerned with the potentials of exploiting underexploited resources, increasing production of currently exploited populations, or making other changes in the system. It is characterized generally by the fact that it must assay the implications of change for the whole system from producer to consumer and that it is the most pragmatic part of our work. This activity has expanded to include a substantial amount of international work in recent years.

An aspect of our research that may not seem to have immediate relevance to fisheries is that of coastal zone management, although it is clear that research in this area would have value to local government units with or without fisheries. The development of controls over the unfettered exploitation of these coastal areas has become increasingly important. But with many of the environments in the area playing an often important role in fisheries ecosystems, control over their exploitation can be of important consequence to fisheries. It is under this rubric that we conduct our work on pollution problems, recreation and land use planning. Regional systems for water supply and waste disposal are being examined as is the economic impact of waste disposal in the marine environment.

The broad areas of research noted above have developed in response to perceived needs of industry and the community at large interacting with faculty interests. Our commitment to applied research is obvious and it is felt that the "payoff" has been significant. The emphasis on applied research is not maintained by any overt control over research activities, rather it is assured at the time of bringing in new faculty.

This is not to say that work without immediate application to policy or industry is not done. It is indeed, and it is an imperative ingredient in providing the intellectual leaven that any research group needs to maintain its vigor and momentum.

It should be obvious from the nature of our program that economists at almost every turn must rely upon the cooperation of their colleagues in other disciplines. When issues relating to resource management arise, the aid of fisheries biologists and/or ecologists is essential. When problems of marketing and distribution are researched, the food scientist often plays a role. These interactions help not only the economist but other disciplines as well, since we sometimes discover the lacunae in their research output that would benefit from additional effort. The integration of research activity of the several disciplines concerned with fisheries is necessary for reasonably efficient use of funds. This is not to argue that no discipline can ever work alone, but it is to argue that where decisions—either public or private—are at

issue, the special talents of more than one discipline are almost always involved. It is often too late to amalgamate the products of individual research projects at a committee meeting held at the eleventh hour.

The mix of research outlined above represents the activities of nine men. This group was not assembled overnight. Research emphasis was first placed on marketing and demand; the next activity initiated was in production. With a firm footing in these areas, it was then possible to begin work on fisheries management; this was followed by coastal zone research and development economics, in that order. This list then is, in a sense, a view of priorities as they have appeared during the past 15 years. Were it possible to restructure this development, it is not clear that the priorities would have changed very much. Development economics would very likely arise earlier but it cannot be pursued effectively without many of the facts produced by marketing and production research. Hence, at best, development research can be pursued collaterally with these other activities but can hardly precede them.

One final consideration: it is not often a simple matter for one researcher to shift his activities from one area to another, even within economics. There are rare generalists, but they are difficult to find. A research program obviously is based upon the personnel who do it, and the selection and training of these persons will be indelibly stamped on any program as long as it is carried out by the same staff. Hence, it is dangerous to begin with ill-defined priorities or with those that claim our attention at the moment. These early mistakes can haunt us for years to come.

Education and Training Requirements

Different types of research in fisheries economics require different kinds of emphasis in education and training. However, whatever the research area, a minimum competence in intermediate micro-economic theory is necessary and for some activities advanced theory must be mastered.

The following summaries indicate the level of training and expertise required in several areas for an effective prosecution of research. Needless to say, experience often overrides academic qualifications.

MARKETING AND DISTRIBUTION

Degree: M.S. desirable, B.S. with additional training or experience possible. For work in demand analysis, Ph.D. desirable, M.S. with experience.

Specialization: fisheries marketing, agricultural marketing.

Training: Basic—intermediate micro theory, statistics (econometrics), agriculture or fisheries marketing. Desirable—food technology, consumer behavior, business management.

PRODUCTION

Degree: M.S. desirable.

Specialization: farm management, industrial engineering.

Training: Basic—intermediate micro theory, statistics, business management (farm management). Desirable—fishing methods and techniques, fisheries biology, marketing, linear programming.

DEVELOPMENT ECONOMICS

Degree: Ph.D. desirable with experience. M.S. or broad experience necessary.

Specialization: fisheries economics, agricultural economics.

Training: Basic—advanced micro theory, intermediate micro theory, econometrics (statistics), linear programming and input/output analysis, fisheries economics. Desirable—marketing economics, production economics. Some mastery or understanding of fisheries biology, food science.

FISHERIES MANAGEMENT

Degree: Ph.D. desirable.

Specialization: marine economics, agricultural economics, economics.

Training: Basic—advanced micro economics, econometrics (statistics), mathematical economics. Desirable—fisheries biology, political science, law of the sea.

Response

A. Mascarenhas, *Director, Bureau of Resource Assessment and Land Use Planning, University of Dar es Salaam*

I think the experience I have gained as director of an interdisciplinary bureau will be useful to your dis-

cussion at this conference. But, in addition, by coincidence I have had to attend three meetings in as many weeks connected with research and research institutions, and my experience there have led me to the thought that despite careful planning of institutes, they can operate in a very isolated fashion. Therefore, my comments are more in the line of how to make the proposed centre for marine resources relevant to Tanzania.

To begin with I will very briefly comment on Professor Lampe's paper. I think no model can be seriously considered in Tanzania unless it takes into consideration the politico-economic environment of the country to which the model is being applied. I underscore this point for it has to be appreciated that during the entire colonial period there was little in the way of fisheries development, and fisheries have not really moved out of the sector popularly known as "subsistence."

Any paper on fisheries economics in Tanzania has to be concerned with the problem of scale, from the point of view of cost, manpower, involvement, etc. But I looked in vain for the cost element of running an institute like the International Center for Marine Resource Development at the University of Rhode Island (URI). However, by implication I get the impression that the scale of operation at URI is so large and based on so much support from staff and institutions that it is not applicable to Tanzania.

Let me be specific. In his paper Professor Lampe states that a particular "mix of research outlined represented the activities of nine men." Even with hundreds of universities to draw from and thousands of graduates and scholars from whom to choose, URI did not find it easy to find the team, for we are cautioned that "this group was not assembled overnight." It is therefore only proper to fully appreciate this factor. The experiences of our two research bureaus—the Economic Research Bureau (ERB) and Bureau of Resource Assessment and Land Use Planning (BRALUP)—I think are more relevant in terms of what can or cannot be done here. In addition the caution expressed by President Nyerere in 1963 in his McDougal Memorial Lecture (FAO) applies equally today for the structure of fisheries economics as it then did to agricultural development: "In Tanganyika it is not much help producing a scheme which requires an army of skilled or educated agricultural workers because we do not have them now, and despite all our efforts we will not have them for years to come. Indeed, part of the change now is to enable us to train such people."

However, this is not to say that Tanzania has nothing to learn from URI. On the contrary there is a great deal with which scholars in Tanzania have to catch up. I am only stressing that major modifications will have to be made in any centre model based on URI's ICMRD as a model.

In Tanzania, then, we will have to begin on a smaller scale than the "ideal." Scientific institutions operating on a scale appropriate to developed countries soon isolate themselves and become more concerned with problems in the international arena than with genuine national needs. Working on a scale appropriate to local needs will generate creativity and initiative which are relevant to the development of marine resources in Tanzania. To reach the ideal scale we will have to learn to maximise existing resources. For example, while it may seem a good idea that the ICMRD has its own economist, I think in our present context it would be worthwhile to use economic and other expertise from existing institutions. Thus, Mr. Colin Barnes of ERB is already involved in studying aspects of the economics of fishing along the coast. Rather than taking the luxury of getting another economist, the centre could contract his services to extend the scope of his study or to contribute to an aspect not covered in his original study. Similarly, a member of BRALUP has studied the social aspects of fishing communities, and I am sure that there are others who could be similarly called upon to assist. In making this recommendation I am not overlooking the fact that there will be problems in using these arrangements.

A priority problem for our institute will be manpower. I think that there is too strong a tendency to try to hire postdoctoral candidates. I think what is most needed is that suitable graduate students from Tanzania be allowed to continue with postgraduate studies. The research and training involved in postgraduate studies and the research envisaged at the centre should be interrelated.

Postgraduate studies and research are not a luxury; they are a necessity. While not all entering postgraduate students will remain in university or research institutions (one hopes there will be selectivity), exposure to postgraduate studies by those who staff our other institutions will create an environment in which research

and development personnel and programmes can work together.

To offset the question of scale we have to develop priorities. Here once again I would disagree with Professor Lampe. I do not think that the first priority in Tanzania should be to develop research on resource management policy. One can only manage if one knows what and how much one has to manage. We immediately need to know about our marine resources in Tanzania and how to utilise them.

The days of exploration of marine resources have just begun for Tanzania. Recently beach sands have been exploited, and at the moment offshore investigation for petroleum is taking place. Even for the marine resources that we know about, such as fisheries and plant life, gathering reliable data and looking at the constraints which hinder maximum utilisation of these resources are a must. Whatever research is done, care has to be taken that the process is an educative one both to the researcher and to the exploiters of the resource. Thus it is not only necessary to know to what extent our coral reefs are being destroyed, but to educate the fisherman about the consequences of this destruction. It is within this context that we can mobilise our users to maximise the benefits of our resources.

What are Tanzania's other priorities? To integrate its studies, as stated in Professor Lampe's paper, is, I think, especially important in developing areas. It strikes me that there is a tendency to regard fishing and pastoralism as outside the mainstream of development. But we need to study ways to integrate the fisheries with other activities. For example, how can fishermen be employed full-time? To what extent is it true that fishermen only fish? How can we increase their incomes? We should also endeavour to see what types of services would make fishing communities viable. The tendency of talking about "ports" does not appeal to me, as it implies a scale of enterprise beyond the means of most fishing communities. How can the efforts of people be mobilised, be made more efficient? Perhaps we should explore the best sites that can be developed by the people with minimal outside assistance. Mr. Rudman, for instance, has talked of sites for beaching craft. In fact, I would like to suggest that instead of talking about fishing ports we talk about services to fishing communities. The difference between fishing ports and services for fishing communities is the same as the difference between state farms and *ujamaa* villages; the former requires high levels of manpower, is capital intensive, etc., while the latter mobilises the masses and brings improvement at the grass-roots level.

There is also need to have some concentration of efforts by area. The coastline of Tanzania is fairly extensive (800 kilometres). Here, I must express my disappointment that little has been said about the Rufiji Delta. The Rufiji is a major river in Eastern Africa and lends itself to all types of development. Other spatial areas needing attention include the estuaries and major creeks.

I share the apprehension of Professor Lampe that it takes time to build a team and that priorities change. As Director of the Bureau of Resource Assessment and Land Use Planning, I also appreciate the fantastic amount that needs to be done to develop our resources. I therefore welcome a concerted effort directed toward developing our marine resources. At the same time, I think one of the crucial elements of a research institute is to create *awareness* in its field of interest and integrate this field with other aspects of development. In this way work can go on even when priorities change. This conference has broken ground in the field of marine science, and a start has been made in creating this awareness. However, what we get in Tanzania will largely depend on what we ask for.

Supplementary Comments

H. C. Lampe, *University of Rhode Island*

The URI Resource Economics program grew slowly from a modest effort in marketing research. Starting about 14 years ago, initial efforts were born of a concern for the welfare of fishermen, particularly in marketing their products. A clear need for a full-time effort on fisheries matters developed, focusing on fishermen's operational activities. Later, concern developed for less developed countries with a major interest in improving the lot of artisan fishermen with concomitant interest in technical changes in production and marketing.

It was quickly evident that work in economics required collaboration with other disciplines. In addition it is necessary to develop a decent information base which requires extensive field work on the part of the economist and others. The researcher need not have doctoral-level training. In most instances, the master's or even the bachelor's degree with experience will suffice. We suggest beginning with one man either in marketing and distribution or production. Consideration of the fisheries management aspect can come a bit later, as can the lower priority coastal zone development planning.

Discussion

The Tanzanian government's marine resource development thinking should be expressed through the five-year plan. Therefore, it was strongly suggested that efforts be made to incorporate the establishment of a marine resources centre resulting from the recommendations of this conference in the up-coming Tanzanian five-year plan to be submitted for approval late in 1974.

Marine Affairs Programs

J. J. Griffin, *Executive Assistant to the Director, International Center for Marine Resource Development*

Coastal Management

In other elements of this paper, specific actions and applications of coastal zone management appear. In this segment, the more general aspects of overall coastal management and its relation to the University of Rhode Island will be discussed.

A workable definition of the coastal zone is included in the U.S. Coastal Zone Management Act of 1972:

> "Coastal Zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shoreline and includes transitional and intertidal areas, salt marshes, wetlands, and beaches . . . seaward to the outer limit of the . . . territorial sea. The zone extends inland from the shorelines only to the extent necessary to control those shorelands, the use of which have a direct impact on the coastal waters (U.S. Congress, 1972).

National concern in the United States for organized coastal zone planning was first voiced effectively in an organized sense in 1969 by a commission on marine science, engineering and resources (the Stratton Commission). As late as 1972 progress to implement the plan was described as minimal.

With the passage of the Coastal Zone Management Act of 1972, the first tentative federal attempts at organization and direction were made. The federal role of guideline definition and startup funding, with state or regional implementation and control, appears to allow adequate participation of involved interests once the distribution of authority and responsibility is resolved in practice.

Several state plans, e.g., Rhode Island and California, explore the peculiar requirements of developed

states with quite different physical, financial and human resources in widely spaced geographic locations. Both the specified definitions and control requirements do exhibit more similarities than differences (Bradley and Armstrong, 1972).

The University of Rhode Island has participated strongly in formulation of national and state plans and currently provides technical consultation and services to the state of Rhode Island through the URI Coastal Resources Center (described in detail in the following section), which has drawn funding from continuing national Sea Grant support, University matching funds and a number of small project-oriented grants. The Center acts as the principal planning group for the state in the area of marine resource management and maintains liaison with the state's management organization, the Coastal Resources Management Council, and the Statewide Planning Program. The University continues to participate in both national and international planning primarily through direct involvement of certain senior faculty members and through interfaces established under programs such as the U.S. AID 211(d) grant which makes the URI International Center for Marine Resource Development possible. The University helps support the Master of Marine Affairs program and Law of the Sea efforts too.

A summary of the present state of technical coastal zone planning and implementation in the U.S. was prepared for the 1972 Marine Technology Society Conference entitled *Tools for Coastal Zone Management*. The majority of the systems described required as a base a thorough inventory of state resources which would include (1.) a description including relationships of impinging interests; (2.) definition and assignment of responsibility and authority; and, most importantly, (3.) clear statements of objectives from the national, regional, state and municipal governments and the civilian participants involved. Adequate representation, legal precedence and necessary compensation were integrated with the above. Computer data retrieval systems and mathematical modeling of interrelating systems are both being pursued to the degree that funding permits.

With respect to international patterns, a UNESCO paper in 1972 entitled *Uses of the Sea* described worldwide aspects of the coastal zone. Excerpts from the conclusions of the report included the following:

> Overall growth rate of all coastal zone factors will increase the frequency of interacting operations. Potential conflicts will be concentrated in localized zones of intensive use—less than one percent of the total sea area. Conflict probability is increased by multiple area uses, degree of confinement, urbanization, industrialization, increased tourism and recreation, and close proximity between international neighbors. Specific resolution of local technical conflicts appears to depend on local marine conditions and economic priorities (United Nations, 1972).

Table 1 describes, in a general sense, the degree of potential interaction or conflict for a typical national jurisdiction and, perhaps, provides a framework that one should seek to fill in conjunction with actual development of a Tanzanian coastal zone plan.

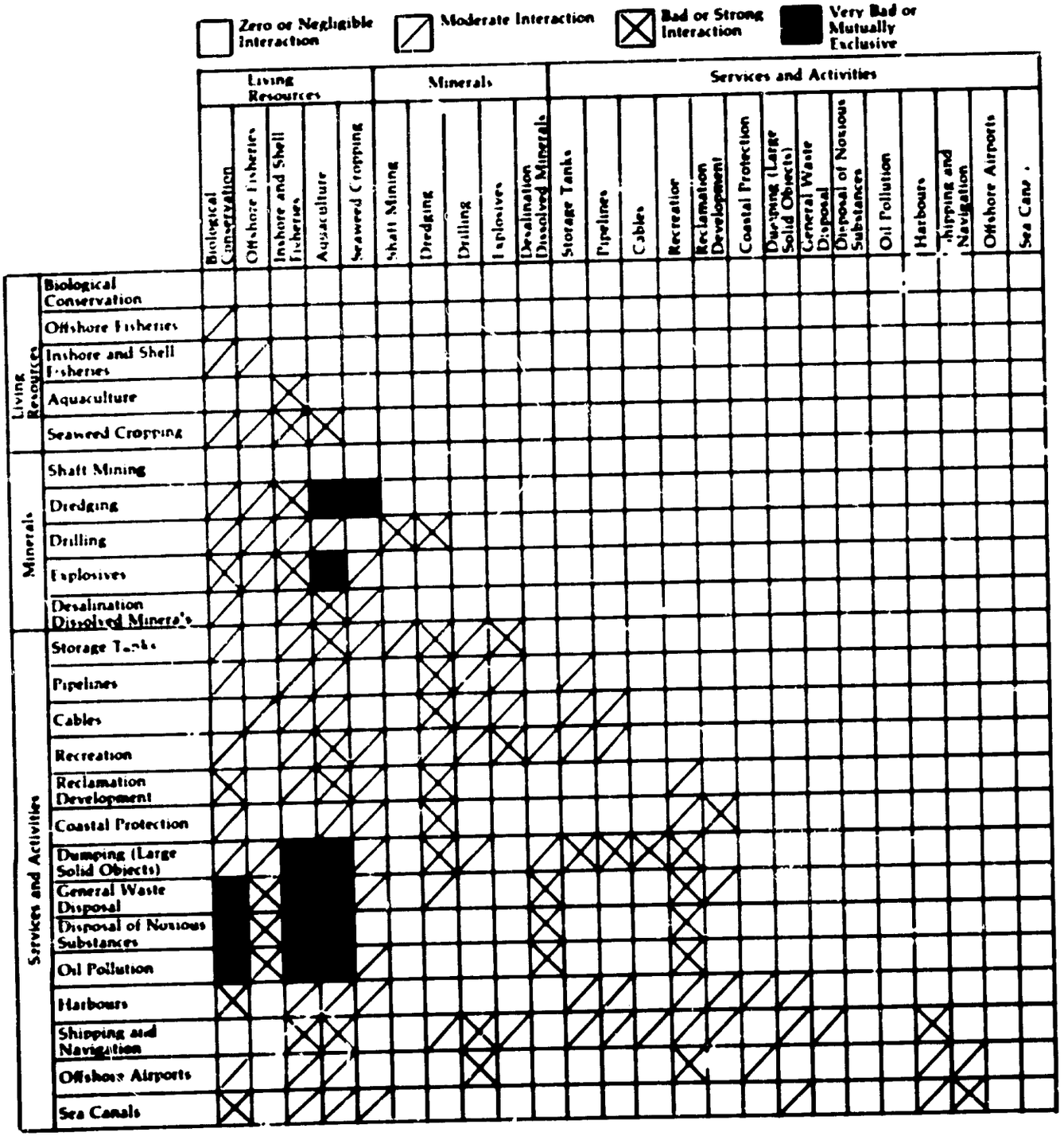
A 1971 study of technological development by Silverstein listed prerequisites for national science policy and administrative development applicable to coastal zone control. Within the national context Silverstein feels that the decision-making elite must display a favorable attitude toward rational economic action, be convinced that lack of planning has serious negative consequences, and agree on operational goals and perceived needs for technological input to improve production. It must be possible to mobilize complementary inputs and institutions to apply the favored technology. An analysis of physical, financial and human resources in science and technology, as well as the presence of research centers, decision centers and research programs, is required.

According to the United Nations Advisory Committee on the Application of Science and Technology,

> Developing countries, faced by almost diametrically different conditions, will often find that a variant from the technology of the developed countries, and perhaps an altogether different technology, is more suited to their conditions. It is difficult for a developing country without a science and technology capacity of its own, and particularly without the trained people involved, to know what useful technology exists elsewhere, to understand it, to select it, to adopt it, to absorb, to re[illegible]nd maintain, to operate (Silverstein).

The University function bears a primary responsibility in building in-country competence, surveying available technology and management techniques and adapting them to satisfy national and regional goals. The management of the coastal zone provides an excellent focus for such efforts.

Table 1. Potential interaction of marine activities in close proximity.



Source: United Nations. 1972. Uses of the Sea

Among these techniques of coastal zone management are (1.) setting up information-gathering on the pilot scale, (2.) identifying participants and their viewpoints, (3.) devising techniques for adequate interest representation, and (4.) establishing the legal and decision-making processes and setting objectives for coastal zone management against future requirements. Cost-benefit projections may be balanced against less quantifiable options. Implementations of selected small-scale pilot operations in select areas representative of future problem classes and differing geo-political regimes may prove desirable.

With Eastern Africa's escalating coastal zone growth and increasingly incompatible multiple uses, there is little doubt that effective constraints in the availability of finances and technological skill, coupled with the need to accelerate development in order to survive and to narrow the techno-economic gap with the advanced countries, impinge on environmental or any other coastal zone control. Even if money were to be supplied by outside agencies, it could often be used more effectively in accomplishing deferred necessities.

If deemed necessary, preliminary studies, if internationally sponsored, could evolve into efficient planning for Eastern African coastal development with a minimum of country resource commitment, early enough to permit judicial involvement with on-going processes on a cost-effective basis, and in consonance with state and regional needs. A high degree of University contribution, local control and participation in the establishment of patterns of development of minimal coastal zone control required at different levels of complexity and different geographical locations should ensue.

Coastal Resources Center

The University of Rhode Island Coastal Resources Center, formed in 1971, is a technical unit assisted by the marine faculty of the University, the University's Marine Advisory Service and its Marine Experiment Station. The Center was conceived as a public service unit able to provide technical assistance in seeking solution of marine management problems for the state and its municipalities, and to take an active lead in the production of management plans for the Coastal Resources Management Council. The Statewide Planning Program, the state's chief planning agency, was designated to work with the Center so that all planning and scientific capabilities at the state agency and university levels could be coordinated.

The work of the Coastal Resources Center is supervised by an all-university executive committee consisting of the Provost for Marine Affairs, the directors of the Coastal Resources Center, the New England Marine Resources Information Program, the Marine Advisory Service, the Marine Experiment Station, and the International Center for Marine Resource Development, a professor of ocean engineering, and the Coordinator of the Sea Grant Program, all working through the Center's director.

Initial funding from the University Sea Grant program was used to obtain the services of two resource analysts to begin assembly of baseline data for a marine resources inventory required by the state's Coastal Management Act as a step toward a complete state program. Current sources include Sea Grant and matching contributions by the University, and monies received under the federal Coastal Zone Management Act of 1972.

Two resource analysts with skills and training in resource economics and planning were added during the years of development of the state management plan. Other personnel are drawn from the University staff or outside consultants are obtained as needed for special projects to round out the Center's total technical capacity.

Under the partnership arrangement with the Statewide Planning Program, from one to two planners are assigned as needed to work in concert with the staff of the Center. It is anticipated that this arrangement, which insures compatibility of coastal planning with statewide land use planning, will continue. The federal government (National Oceanic and Atmospheric Administration) is expected to increase support to the state for coastal planning.

The work of the Coastal Resources Center is moving along two linked pathways. The major route is development of a marine resources inventory containing baseline information, supporting maps, charts and reference materials. Included in each section are suggested guidelines for management of the resource. Broadly, there are two major parts of the inventory: natural features and socio-economic features. Where appropriate, they are cross-referenced to illustrate impacts. The inventory is being published in segments to get as much

information into the decision-making process as possible in the shortest period of time. The planning groups are aware that piecemeal release of material will necessitate continuous review of everything from management plans to regulations, but the dynamic pressures on the coastal region are such that delays are not deemed desirable.

The second pathway involves special reports on segments of the inventory material prepared in response to emergency situations or in anticipation of pressure before the total inventory and management plan has been developed and adopted. Reports of this nature are expected to continue throughout the planning process.

Table 2 shows the subject areas which are being covered in the Rhode Island marine resources inventory.

Marine Affairs Curriculum

Realization by the nation and the University of Rhode Island that academia, government, and industry had a growing interest in the complex interrelationships of the broadly ranging socio-economic, politico-legal and technological disciplines involved in management decision-making in ocean affairs, led to the establishment in 1969 of the University of Rhode Island's Master of Marine Affairs program.

This program seeks to educate to the master's degree level marine-oriented professionals, who are generally middle management, double-degree holders with present and planned professional capacities requiring interrelationships with other marine functions. The program focuses on marine policy problems at the local,

Table 2. Rhode Island coastal resources inventory, major subdivisions.

I *Physical Features*

1. Marine geology of Narragansett Bay and sea floor beneath Rhode Island coastal waters
   a. Geologic history
   b. Topography and sediments
   c. Active processes, transportation and deposition of sediments
2. Hydrography of Narragansett Bay and Rhode Island waters
   a. Tidal characteristics
   b. Temperature and salinity distribution
   c. Nontidal circulation
   d. Waves
3. Chemical properties of Rhode Island waters
4. Climate
   a. Range and means of temperature, humidity, rainfall and sunshine
   b. Storms and hurricanes

II *Biological Features*

1. Plankton and benthos
2. Wildlife: marine and shoreline birds and mammals

III *Fish and Fisheries*

IV *Shoreline Features, Land Use and Land Ownership*

The value and characteristics of principal habitats (marsh, coniferous forest, agricultural lands, etc.) also will be discussed

V *Environmental Quality*

1. Pollution
2. Refuse disposal
3. Appearance and design
4. Effects of geological and biological processes upon resource use

VI *Recreation*

VII *Public Facilities and Utilities*

1. Power, water supply, communications, sewage disposal, pipelines

VIII *Commercial and Industrial Activities (excluding fishing)*

1. Waterfront industry
2. Transportation and shipping
3. Ports

IX *Regulation and Acquisition*

X *Research*

1. What has been accomplished and is currently underway
2. Major needs present and future

XI *Managing the Coastal Zone and Marine Areas*

1. State of the art, problems and opportunities in Rhode Island

XII *Rhode Island and the Southern New England Region*

1. Integration of Rhode Island into the region's needs, problems and trends

state, regional, national and international levels. In considering the formulation of specific policies, students analyze factors central to the decision-making process; these include interest groups, shared jurisdictions, the decision-making agencies, bureaucratic obstacles, the formulation of viable alternatives, and the rationale behind final choices. With respect to implementation of policy, students consider the role of laws and institutions, the economic and social costs of implementation, and criteria for effective ocean management.

The competitively selected participants represent a broad spectrum of backgrounds—governmental (both civilian and military), and both U.S. nationals and foreign nationals (4 out of 29 in 1973, from France, Ghana, New Zealand, Chile). Specialists who have been in the program include oceanographers, ocean engineers, maritime lawyers, writers, businessmen, anthropologists, biologists, community planners, economists, financiers, fishermen, geographers, geologists, journalists, lawyers, marine cinematographers, marine transportation experts, marketing-management experts, naval architects, physicists, political scientists, public administrators, psychologists, sociologists and systems analysts. The interdisciplinary character of the program therefore is enhanced by the viewpoints and mature judgments of the participants as well as by the course content, seminar simulations and speakers. This interdisciplinary probing forces new considerations in the thinking of both faculty and outside speakers.

Core course work required of all students includes marine geography, marine resource economics, international law, ocean engineering, oceanography and a marine affairs seminar. Electives in the fields of particular interest include in-depth work in the core course areas as well as more expansive topics such as community planning, finance and political science. In most areas, considerable independent research is required, and an effort is made to tailor research to investigator's priority problem areas.

The marine affairs seminar, a two-semester effort with an accompanying major research paper, provides both a focus and a forum where the backgrounds, interests and course work are all brought to bear on marine issues ranging in scope from local to regional, national or international. Attendance at actual management sessions, as well as joint presentations by high-level, directly involved spokesmen representing widely divergent points of view, precipitates debate on timely critical issues. Questions and class discussions develop these issues.

Issue resolution is through simulated role-playing sessions in which both individual and organizational attitudes and positions are taken. For example, in 1973 simulations included a local coastal power plant siting decision and the probable British-Icelandic cod war outcome, if the International Court of Justice were asked to adjudicate the issue. In some cases, the projected decisions can be compared closely with subsequent developments after program completion.

While the program has been heavily oriented towards U.S. problems and approaches, a trend towards LDC (lesser developed countries) and international relationships and issues continues to grow. Consideration of LDC viewpoints from international students by attending U.S. nationals and vice versa permeates activities during the program and helps create close personal ties that are maintained.

The short length of time required for the program (nine months residence), availability of fellowships, and good post-graduate employment histories help to keep program interest high.

Planned evolution of the program includes both an undergraduate course and a doctoral program and an improved specialized library collection. Student papers have been published in the first issue of a marine affairs journal.

Participation by select Eastern African middle-high level management personnel in the URI type of program provides obvious advantages in present planning for and implementation of regional-national programs while laying a base for establishing a comparable, specifically tailored Eastern African version. The shift of emphasis and location to the Eastern Africa environment could help to concentrate teaching, learning, and research as significant factors in area development, enrich the institution faculty experience, and encourage cooperation and understanding among individual participants and their nations.

The Law of the Sea Institute

The Law of the Sea Institute was formed at the University of Rhode Island in 1965 to serve as a means for exchanging knowledge and ideas concerning the

sea and its resources, principally through conferences, workshops and publications. The stated policy of the Institute is to take no stand on issues, but to encourage free and open participation, the exchange of ideas and information and the expression of divergent points of view.

The Institute's funding is based broadly in foundation and government sources. While housed and administered at the University, it is an independent organization guided by a distinguished executive board (see table 3) of North American international attorneys, scientists, and educators in responsible controlling positions concerned with the totality of ocean activities. The Board sets objectives, approves and directs planning and reviews progress of all activities under executive control of its director.

The Institute meets each summer in the United States for a formal topical conference and convenes irregularly overseas to conduct regional workshops. It also publishes proceedings and bibliographies, distributes marine-related occasional papers, and maintains an extensive international mailing list of interested persons.

The themes of past conferences provide insight into the breadth and timeliness of topics:

1966—Offshore Boundaries and Zones
1967—The Future of the Sea's Resources
1968—International Rules and Organization for the Sea
1969—National Policy Recommendations
1970—The United Nations and Ocean Management
1971—A New Geneva Conference
1972—The Needs and Interests of Developing Countries
1973—The Emerging Regime of the Oceans

The 1972 conference, which was attended by 240 persons from 40 countries—indicative of both individual and national interest—discussed aspects of seabed mining beyond the limits of national jurisdiction; concepts in sharing of common heritage and wealth; allocation and exploitation of living resources of the sea; proposed international fishery regimes and the accommodation of major interests; and major problems, positions and

Table 3. Law of the Sea Institute Executive Board.

Prof. John King Gamble, Jr.,
Executive Director
Law of the Sea Institute
University of Rhode Island
Kingston, Rhode Island

Prof. Lewis M. Alexander
Department of Geography
University of Rhode Island
Kingston, Rhode Island

Prof. William T. Burke
School of Law
University of Washington
Seattle, Washington

Dr. Francis T. Christy, Jr.
Resources for the Future, Inc.
1755 Massachusetts Avenue, N.W.
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Dean Thomas A. Clingan, Jr.
School of Law
University of Miami
Coral Gables, Florida

Mr. Michael Hardy
200 Rue de la Loi
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Prof. Douglas Johnston
Dalhousie University
Faculty of Law
Halifax, Nova Scotia
Canada

Provost John A. Knauss
Graduate School of Oceanography
University of Rhode Island
Kingston, Rhode Island

Prof. Edward Miles
Institute of Marine Studies
University of Washington
Seattle, Washington

Prof. Giulio Pontecorvo
Graduate School of Business
Columbia University
New York, New York

Prof. David A. Ross
Woods Hole Oceanographic Institution
Geology & Geophysics Department
Woods Hole, Massachusetts

Dean Warren S. Wooster
Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, Florida

Richard Young, Esq.
Counsellor at Law
Van Hornesville
New York

viewpoints regarding needs and interests of the developing states.

The program of the 1973 Conference on the Emerging Regime of the Oceans (see table 4) illustrates both the approaches taken and the breadth and level of forum participation; many of the participants are direct contributors at the United Nations Law of the Sea Conferences and subcommittees.

The informal get-togethers and the anonymity of the working groups allow, and indeed encourage, free and open participation and exchange of ideas and information as well as expression of divergent and limit-probing ideas, often beyond the national or regional position expounded in more formal sessions.

While the intent of the Law of the Sea Institute Conference is truly international in scope, some bias towards topics of interest to the major contributors is inherent. A similar effort in Eastern Africa devoted to priority needs of the area with worldwide implications would be worth consideration. Campus participation and interest are encouraged by having the university as the site of such a conference; this in turn not only provides the conference a ready store of technological backup and interface, but enhances institutional prestige

Table 4. Law of the Sea, Eighth Annual Conference, the Emerging Regime of the Oceans.

Bloc Thinking about the Oceans: Accelerating Pluralism?

Paper: John K. Gamble, Jr., Associate Director, Law of the Sea Institute

Panel: Leigh Ratiner (Chairman), Advisory Group on Law of the Sea, U.S. Department of Defense

Kaldone G. Nweihed, Simon Bolivar University, Caracas

Arvid Pardo, Ocean Studies Program, Woodrow Wilson International Center for Scholars

Duke Pollard, Perm. Mission of Guyana to the United Nations

How Will the Deep Seabed Regime Be Organized?

Chairman: John A. Knauss, Provost for Marine Affairs, URI

Paper: Andres Aguilar, Ambassador of Venezuela to the United States

Technology Transfer

Chairman: Giulio Pontecorvo, Director, Ocean Research Management Program, Columbia University

Paper: Surendra Patel, Transfer of Technology Branch, United Nations

C. Weiss, Jr., International Bank for Reconstruction and Development

Panel: Warren Wooster (Chairman), Scripps Institute of Oceanography

Dahmouche Amar, Mission of Algeria to the United Nations

Emmanuel Bello, Consultant, International Oceanography

Herman Frenssen, Woods Hole Oceanographic Institution

Nelson Marshall, Director, International Center for Marine Resource Development, URI

International Organizations and Technology Transfer

Chairman: Giulio Pontecorvo, Director, Ocean Research Management Program, Columbia University

Paper: Ivan Silva, Indian Ocean Programme, FAO, Rome

Regimes for Special Situations

Chairman: Richard Young, Attorney and Counsellor at Law

Papers: "Islands"—Robert Hodgson, Geographer, U.S. Dept. of State

"Semi-Enclosed Sea"—Lewis Alexander, Law of the Sea Institute

"Superports"—Allen Hirsh, Marine Ecosystems Analysis Program, NOAA, U.S. Dept. of Commerce

Panel: Albert Koers, Institute of International Law, University of Utrecht

H. Gary Knight, Louisiana State University Law Center

Richard Young, Counsellor at Law, Van Hornesville, N.Y.

John Bailey, Law of the Sea Section, Government of Australia

Consequences of Intensive Ocean Utilization

Chairman: Thomas A. Clingan, Jr., University of Miami School of Law

Papers: "Flow of Ships"—Charles Bates, U.S. Coast Guard

"Insurance Companies' Perspectives"—George W. Handley, Marsh and McLennan, New York

"Offshore Oil"—John Albers, U.S. Geological Survey

The Scientific Aspects of Ocean Pollution

Chairman: William T. Burke, University of Washington School of Law

Paper: John A. Knauss, Provost for Marine Affairs, URI

Panel: John L. Hargrove (Chairman), American Society of International Law

Earle E. Seaton, Puisne Judge, High Court, Bermuda

Branko Sambrailo, Yugoslav Academy of Science and Arts

Raul Bazan, Permanent Mission of Chile to the United Nations

Bernard Oxman, Office of the Legal Adviser, U.S. Dept. of State

Closing Speaker

The Honorable Edmund S. Muskie, United States Senate

as well. Such a conference also furnishes a fertile site for implementation of programs to enhance institutional growth.

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Response

G. K. Libaba, *Acting Director of Fisheries, Ministry of Natural Resources and Tourism*

The paper reviews the physical nature and the coastal fisheries of Eastern Africa, a region which includes not only the offshore island states but also the associated landlocked states. The paper attempts to pinpoint the issues of coastal development and marine affairs as they relate to the previous Law of the Sea Conferences of 1958 and 1960. An approach to the control and management of living marine resources, possibly applicable to the coming Law of the Sea Conference, is advanced

The countries of Eastern Africa, the Republics of Somalia and Kenya, the United Republic of Tanzania and the dependent state of Mozambique, all share the Indian Ocean along their eastern shores with the insular states, the Malagasy Republic, the Comoros and the Seychelles. These coastal countries are surrounded by the six land-locked states of Uganda, Ruanda, Burundi, Zambia, Malawi and Rhodesia. All these countries which use the sea for the purposes of communication and trade today may later claim equal participation with the insular and littoral states in the exploitation of both living and non-living resources of the sea.

The marine environment and the living organisms which it supports are of vital importance to humanity. All people have an interest in ensuring this environment be so managed that its quality and resources are not impaired. This applies especially to coastal and insular states which have a particular interest in the management of coastal area resources.

Compared with other regions of the Indian Ocean, the seas bounding the countries of Eastern Africa are generally little developed. Management of coastal resources is therefore not a pressing problem. However this does not mean that management measures should not start right now. On the contrary, in order to apply systematic and proper management principles, such measures should be taken right now before chaotic exploitation and over-exploitation of coastal stocks begins.

The region of Eastern Africa is known for its narrow continental shelf. This shelf rarely exceeds 30 to 40 miles in width. It is on this narrow and shallow continental shelf that coral reefs occur. The reef areas are the main centres of marine life, but unfortunately the most difficult to exploit. The majority of the demersal fish stocks frequent these reefs. The closeness of the reefs to the surface allows the maximum rate of development of plant life on which the animal life depends. In the temperate climates the comparable areas are vast banks of mud and sand over which trawls can be dragged for hours without damage and with resulting high catches of cod, haddock, sole and other demersal fish stocks. Bottom long-lines containing hundreds of baited hooks can be set without fear of damage; whereas no trawl would last more than a few minutes in the reef areas.

The variation in the topography of the coastal areas, the presence of estuaries with mangrove forests in the intertidal zones, and the presence of mud, sand and shingle, bays and promontories all favour the occurrence of various fish stocks in this region. Various species of crustaceans, mullet fish and *Sardinella* abound in the shallow waters. The bulk of the fishermen's catches also come from the families of *Lutianidae* and *Lethrinidae*. Moving offshore beyond the reef areas, *Sardinella* stocks, billfishes *Istiophoridae* as well as shoaling kingfish *scomberomorids* are caught by gill-nets. In deeper waters, ranging from 70 to 100 fathoms, various types of sharks abound. This area is endowed with numerous species but in pathetically small numbers. When fishing in such waters, there is no question of going out for specific species of fish. What a trawler

sweeps and collects in its cod-end and what a purse seiner engulfs in its entangling nets are none of the fishermen's choice.

The waters bordering the eastern coast of Africa therefore appear to be relatively rich. The coastal environment, which at present is rarely polluted, sustains many of the fisheries. Production of food organisms is concentrated in areas very close to the coast. Many commercial fish stocks inhabit the coastal areas seasonally or at some stage of their life history. The vast majority of these coastal species depend on the coast as the nursery area for fry. Moreover, production of renewable resources over wide areas adjacent to the coast is largely the result of the interaction of land-related factors, such as drainage, estuarial mechanisms, local upwelling and regeneration. This inter-relationship between the sea and the land imposes certain responsibilities upon the coastal states to protect the coastal environment where such living resources are concentrated.

In addition to their responsibilities for environmental protection within the limits of their territorial seas, these coastal states in Eastern Africa also have the responsibility of protecting adjacent areas of the maritime environment from damage that may result from activities within their areas of sovereignty. The maritime environment is susceptible to serious degradation from riverborne pollutants such as insecticides and fungicides; from dumped refuse, e.g., the wash-off from sisal decorticating machines; and from waste from landfill projects as well as from direct and indirect pollution from industrial sources, e.g., the textile industries and oil refineries (in some countries of Eastern Africa such textiles and refineries are located extremely close to the shores of the Indian Ocean). The protective measures undertaken by the coastal states, sometimes at considerable cost, may benefit resource productivity in areas well outside the traditional limits of exclusive fishing rights. Because this is the coastal state's investment area, it should have a right to protect its investment. Responsibility here must be balanced by rights. We therefore note that the international community entrusts, as it were, custodianship of resources to the coastal and insular states.

Proper management of our resources will therefore mean controlling entry into the fishery, for it is our understanding that fishing and the conservation of living resources are interrelated. Since the resources in this region have not yet been fully exploited, it is important that we do not start off with too much fishing effort in terms of numbers and size of fishing vessels and gear. Proper selection of mesh sizes and the type of nets, proper control of breeding and nursery grounds, and a complete stop of the use of dynamite in fishing will all play a great role in the management of coastal fisheries. The introduction of marine reserves should have priority. In order to implement such objectives and lines of action, training of personnel in coastal management becomes vital. Training centres like those of Kunduchi and Mbegani and research institutes like the East African Marine Fisheries Research Organisation (EAMFRO) will go a long way toward the implementation of such management actions.

The special interests of the coastal state were already granted a degree of recognition in the 1958 Convention on Fishing and Conservation of the Living Resources of the High Seas. The recognition afforded by the Convention, however, is so hedged with limitations and restrictions that it does not afford the basis for an effective system of management by the coastal state. Further recognition and development of the Convention's principle are essential because the expansion of fishing operations by distant-water fishing states often undermines and even destroys the economic base of coastal communities dependent on fisheries as a source of income. What these distant-water fishing states forget is that while they are fishing very far from their coastal waters, they are menacingly close to, or in, the coastal waters of other states. This is why the coastal states of Eastern Africa have adopted the Exclusive Economic Zone Concept for management and control of their coastal resources.

Since this has been an important issue in the preparatory committee for the Law of the Sea Conference, let me go straight into the substance of the matter. As I have dwelt so much on the management of coastal living resources, I am tempted to state that for any proper management of marine resources, coastal and insular states should claim an exclusive economic zone. The concept is that the coastal state will have sovereign rights over the resources of the area to a distance not exceeding 200 miles from the coast. The coastal state should have a territorial sea of 12 miles, and beyond that, up to 200 miles, would be the economic zone. The

competence of the coastal state will extend also to regulation of scientific research and control of pollution because these have an intimate connection to resource management.

Countries of Eastern Africa are just beginning to expand their fishing effort in terms of numbers and size of their fishing vessels and gear. The large fishing vessels (motorised boats and highly mechanised trawlers) will increase the range and scope of their fishing grounds. The present fishing grounds for the artisan fishermen are confined to the narrow and coral-ridden continental shelf. Since these are breeding and feeding grounds, increase in the fishing effort there will put much pressure on the delicate living resources. Such factors compel the countries of Eastern Africa to expand juridical areas for fishing activities.

We may be criticised on applying a national exclusive economic zone concept on the grounds of lack of idealism regarding international resource control of fish migrations. But how can we control movements of migratory fish which move laterally in all directions from, say, Tanzania to Kenya and from the Tanzanian exclusive waters into the high seas beyond? Fish know no boundaries. The answer is that the boundaries which are contemplated are not meant for fish; they are meant for people who wish to catch the fish. What we wish to see is that fish are properly controlled in the exclusive economic zone area under national rules so that they are able to breed, grow and migrate under less of a growing threat. For the highly migratory species such as tuna we expect that the Indian Ocean Fisheries Commission (IOFC) should be the proper international organisation to influence member states to comply with proper stock management practices. The net effect of these regimes is proper management and exploitation of the resources. It is our understanding that state jurisdiction does not necessarily conflict with international principles of management and conservation. It takes no more than a cursory examination of state jurisdiction in the territorial sea to see that coastal states by and large apply international standards. This is true of the fisheries' regulations of Kenya and Tanzania. In fact they are better applied and observed in the territorial seas than in the so-called "high seas."

We do appreciate the work of international commissions and we would like to see their role enhanced. However the problem is the nature of enhancement. While the recommendations of the international commissions have been extremely useful, their enforcement has not been encouraging. We recall the International Whaling Commission (IWC) which recommended the reduction in the catch of Antarctic whales. Instead of adopting and implementing the recommendations, countries ferociously exploited the Antarctic whale. Later on it was coincidentally saved, not by following the recommendations of the IWC but because of the effect of the war on exploitation. The truth is then that greedy states stop fishing when there are no longer enough stocks to satisfy their desires. We would therefore prefer the international commissions to have powers of allocation of resources, licensing, inspection, arrest and punishment. But we know these cannot be achieved at the international level, and that being the case, we opt for coastal state control in the economic zone, a vital area to the coastal state.

Another possible criticism is that the exclusive economic zone will deprive the landlocked states and near-landlocked states of their rights to fish. The present rules do not recognize the rights of landlocked states to the living resources of the sea, but the exclusive economic zone concept gives them special treatment in the economic zone: (1.) they will have priority in this area over those who now exploit the entire ocean, and (2.) they can only gain something meaningful if they start with coastal rights. We only have to take the East African community to see how Uganda is enjoying rights to use railways, roads and harbour facilities. It is only after getting such rights and facilities that the landlocked states can make a useful start in the exploitation of living marine resources both in the economic zone and the high seas.

Such rights, however, will not be enjoyed by states still under colonial domination. The case of the law of the sea for developing countries can be likened to the struggle for existence in the presence of greedy nations who wish to enrich themselves at the expense of the less developed states.

While we may not be ready to have a special marine affairs unit to deal with law of the sea here at the university, there is every possibility of utilising the experience of the University of Rhode Island in studying questions of international affairs in law of the sea issues. It may be that scholars will gain more by studying marine affairs, as opposed to marine resources, for the

Table 1. Interest zones by country.

State	Territorial Sea (mi)	Special zones adjacent to territorial sea outer limits (measured from territorial sea baseline in mi): Exclusive Fishing Zone	Fishery Conservation Zone	Continental Shelf
Albania	12 (1970)	—	—	e
Algeria	12 (1963)	—	—	—
Argentina	200 (1966)	—	—	f
Bangladesh	12 (1966)	—	112 (1966)	
Brazil	200 (1970)	—	—	
Bulgaria	12 (1951)	—	—	e
Burma	12 (1968)	—	—	
Cameroon	18 (1967)	—	—	
Canada	12 (1970)	b	—	e
China	12 (1958)	—	—	—
Colombia	12 (1970)	—	—	e
Congo, People's Rep.	30 (1970)	—	—	
Costa Rica	12 (1972)	—	c	e
Cyprus	12 (1964)		—	—
Dahomey	12 (1968)		—	100 mi
Ecuador	200 (1966)	—	—	—
Egypt	12 (1958)	—	—	200 mi
El Salvador	200 (1950)	—	—	200 mi
Equatorial Guinea	12 (1970)			
Ethiopia	12 (1953)	—	—	
France	12 (1971)	—	—	e
Gabon	100 (1972)	—	—	
Gambia	50 (1971)	—	—	—
Germany, Fed. Rep. of	a			200 m depth
Ghana	30 (1972)	—	130	100 fathoms
Guatemala	12 (1932)	—	—	—
Guinea	130 (1964)	—	—	—
Honduras	12 (1965)	—	—	200 m depth
Iceland	—	50	—	—
India	12 (1967)	—	112 (1956)	200 m depth
Kenya	12 (1969)	—	—	e
Korea, Rep. of	—	20-200		
Lebanon	—	6	—	—
Liberia	12 (1967)	—	—	200 m
Madagascar	12	—	—	e
Maldive Isls.	6	100-150	—	—
Malta	6 (1971)	12 (1971)	—	—
Mauritania	30 (1972)	—	—	200 m depth
Morocco	12 (1973)	70 (1973)	—	200 m depth
Nicaragua	—	200 (1965)	—	—
Nigeria	30 (1971)	—	—	e
Norway	4 (1812)	12 (1961)		e
Oman	12 (1972)	50 (1972)	—	200 m
Pakistan	12 (1966)	50 (1973)	112 (1966)	100 fathoms
Panama	200 (1967)	—	—	—
Peru	—	200 (1974)	—	—
Poland	3 (1932)	12 (1970)	—	e
Portugal	—	12 (1966)	—	e
Senegal	—	122 (1972)	—	e
Sierra Leone	200 (1971)	—	—	e
Somali Democratic Rep.	12 (1967)	—	—	—
South Africa	6 (1963)	12 (1963)	—	e
Spain	6 (1970)	12 (1967)		
Sri Lanka	12 (1971)	—	112 (1957)	e
Sudan	12 (1960)	—	—	200 m
Tanzania	50 (1973)	—	—	—
Tunisia	6 (1962)	12 (1962)	—	—
U.K.	3 (1878)	12 (1964)		e
U.S.A.	3 (1953)	12 (1966)	—	e
Uruguay	200 (1969)		—	200 m
Viet Nam	3 (1965)	53 (1972)		200 m

a = in accordance with international law

b = prescribed area adjacent to coast

c = 200 mile special jurisdiction over Patrimonial Sea

d = power to set up explicitly bounded conservation zones

e = state a party to 1958 Convention on the continental shelf which came into force on 10 June 1964 and provides that the coastal state may exercise the sovereign right of exploring and exploiting the natural resources in the seabed and subsoil of submarine areas adjacent to its coast, but outside the area of the territorial sea, to a depth of 200 metres or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of such natural resources. For the purposes of the Convention, living natural resources include sedentary species only. The rights of the coastal state do not affect the legal status of the superjacent waters as high seas.

f = 200 metres or to where 100-fathom line under watershelf

Source: limits and status of the territorial sea, exclusive fishing zones, fishery conservation zones and the continental shelf. *Legal Office, FAO, Rome.*

Master of Marine Affairs degree at the University of Rhode Island than by having such a discipline started here in Eastern Africa. Knowledge of marine affairs goes a long way toward understanding issues related to the law of the sea. There are, therefore, convincing reasons to undertake such studies to assist us in proper planning, conservation and exploitation of marine resources for the benefit of our countries.

In conclusion I would say that during the previous Law of the Sea Conferences states have been devising various concepts motivated by national interests to control resources. The 1945 Truman Declaration in which President Truman declared that the United States regards the natural resources of the subsoil and seabed of the continental shelf beneath the high seas but contiguous to the coasts of the United States as appertaining to the United States subject to its jurisdiction and control is typical of such motivation.

What has been controversial is the method of demarcating these interest areas. The trend has been to devise complicated methods which have been very difficult to execute and implement. And this trend continues. What we feel should be the right course is to adopt a method of simplifying demarcation of these interest zones. Interest zones for various countries are listed in table 1. Though people may argue the simplest is not always the best, we feel that the less in number such zones are, the fewer the negotiations and the more thorough such negotiations can be. Probably the exclusive economic zone, or what we could probably call simply an economic zone, as we see it in Eastern Africa could go a long way toward serving what the international community has for long been struggling to accomplish. We need to strike a balance between national interest on the one hand and international interest on the other. The concept is coached in sound marine management and development principles, and as such it should be worthwhile to consider in the light of the problems of the regions in which we exist. The study of marine affairs plays a great role in the proper planning and implementation of development projects for the overall exploitation of marine resources.

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Discussion

Current applicable activity in the United Nations was outlined. The UN Economic and Social Council (ECOSOC) has requested the Secretary General to prepare a report on worldwide coastal area development in Resolution 1802 (LV). The resolution instructed the Secretary General to forward through the appropriate specialised agencies the report and applicable proposals to the ECOSOC in 1975. UNESCO's initial proposals and report have been already submitted.

Economic, cultural, political and scientific input are being incorporated. Specific topics that appear appropriate for this resolution include many that have been discussed at this conference, such as the importation of specialised strength in management and training in marine affairs and coastal planning; and continuity of science education and research through assistance from appropriate UN agencies.

Eastern Africa is one of the key geographic focal point areas selected. It would therefore appear desirable

for nations in the region to follow and support this activity with great interest and vigor.

The annual Law of the Sea meeting at the University of Rhode Island, at which over 30 countries were represented in 1973, encourages frank and open discussions on controversial topics under conditions of relative anonymity. For example, the U.S. offshore position unofficially discussed during the last LOSI forum may not be too far from that of Tanzania. Invitations are extended to Eastern African nations for future conference attendance as in the past. Funding from foundations may be available.

Marine Food Science and Technology

S. M. Constantinides, *Chairman, Food Science Program, Department of Food and Nutritional Science, and Department of Biochemistry*

Food from the sea has always given man satisfaction for both his nutritional needs and his gustatory appetites. Nevertheless, he continues to get only a small part of his food there—the present world catch of fish supplies about three percent of man's direct protein consumption, for example.

Protein malnutrition prevails in many developing countries. While animal source protein is lacking in these countries or is not used for direct human consumption, many have rich marine food resources which are not utilized or are improperly utilized. An example is the South American countries of Peru and Chile which have serious nutritional problems associated with lack of animal protein, while paradoxically they are blessed with an abundance of that animal protein in the form of marine life off their shores. Most of that animal protein is exported from these countries in the form of fish meal to satisfy the demand of the already well-fed nations for poultry and livestock feed. It is thus obvious that the distribution pattern of marine food on a worldwide scale is abnormal.

Japan is an example of a country that has solved its animal source protein problem by utilizing fish caught in all waters of the planet. The Japanese are making the best use of most edible portions of marine species, from the jelly fish to the tuna, and processing this marine food in a variety of ways.

Man's endeavor should be to utilize efficiently all edible species of marine life—animal and plant—and to use them for direct human consumption. A continuous attempt should be made to discover improved methods of preservation, preparation and distribution.

The Research Program at URI

The main objective of the marine Food Science and

Technology program at the University of Rhode Island is the utilization of marine species for direct human consumption and preservation of the marine foods obtained. The emphasis is on problems related to developing nations with rich marine food resources which are not being utilized. Both conventional and unconventional ways are being sought and developed in order to make marine species available and acceptable as food. Along with utilization, preservation is being studied from various points of view. Table 1 shows an outline of the general types of research that are being performed presently or are in the planning stages.

Conventional ways of processing and preparing fish are not generally acceptable to non-fish-eating populations. Furthermore, such processes are insufficient to accommodate an increase in fish consumption. Conventional methods of processing also tend to preserve the original identity of the raw materials. On the other hand, non-conventional processes which employ certain principles of marine food science can change the identity of the raw material, and the resulting new products may be palatable to people to whom the flavor of fish has not traditionally been acceptable.

A marine food product that would serve the purpose of not only developed countries but also developing nations is fish paste, similar to the Japanese gels but modified to suit Western or other consumer demands. Fish paste has no basic fish flavor or odor but can be prepared with spices or flavorings. This flavored, functional product can be used either to improve protein deficient diets or to add variety to diets.

Another important research effort is being directed towards underutilized species; for example, extensive work is underway which explores new methods of utilizing the crab. An improved method of extracting the edible portion of the crab by use of a hydraulic press has been found which results in a per-animal yield of 50 percent or two and one-half times that obtained by handpicking. Other advantages of this press are that all sizes of crabs can be processed; even crabs which have been deformed and compressed during transportation can be used profitably. This inexpensive method can be used to supplement handpicking. The shellcase waste obtained can be dried, milled and homogenized to form a gritty powder which can be incorporated in feeds, fish meal or fish feed used in aquaculture.

Although the Japanese, as mentioned above, are using most of the available edible marine species, other countries are not, especially the developed and well fed nations. In the United States we are not yet accustomed to eating squid, octopus, small bony fish, mussels, shark, etc. Therefore, other studies dealing with underutilized species include investigations exploring uses of such creatures as the sand shark, the shark, squid, menhaden and other oily fish, mussels, etc.

One grave problem in the total utilization of fish is waste, which can approach 80 percent of production costs in many cases. Improper handling, processing, storage, and marketing can result in these high losses, which man can ill afford. Not only should every possible edible portion be used in some way, but new types of foods should be developed which mix plant proteins with fish, using fish scraps, fish heads and even fish viscera. Research is being carried on in this area.

Another of the more significant problems related to marine foods is rapid spoilage of fish flesh due to improper handling procedures that start in the boat and continue in the marketplace. Parallel to the utilization and preservation investigations, a program on the handling of marine species for food is being launched in Chile, where the fish handling situation is being studied and new approaches are being initiated to improve these procedures. Moreover, improved methods of utilizing fish are being introduced. These include especially unconventional ones, such as the addition of potato to fish to produce an acceptable product.

In a country such as Chile, artisan fishermen represent more than 60 percent of the fishing population of the country. The economic status of these fishermen is very low. While they provide 80 percent of the fresh fish catch of the country, they suffer tremendous losses through poor handling conditions. It is hoped that these fishermen will learn to apply modern methods of fish handling through extension and special short course educational programs. Table 2 outlines the program in Chile.

Table 1. Research aspects of marine food science program at the University of Rhode Island.

Conventional and non-conventional methods of utilizing marine species for food (emphasis on underutilized species)

a. Chemical
b. Biochemical
c. Microbiological
d. Processing
e. New product development

Table 2. Outline of program in Chile: handling and utilization of marine species for human consumption.

1. Studies on storage life of fresh fish according to species, season, method of capture, and storage conditions
2. Extension of storage life using various methods
3. Utilization of underutilized species
4. Non-conventional ways of utilizing fish
5. Educating the artisanal fisherman
   a. Workshops on fish preservation
   b. Seminars
6. Educating the consumer
   a. Seminars
   b. Television, radio, newspapers

A thorough investigation is necessary to study the characteristics of each edible species from a marine food science standpoint and to find ways of utilizing them efficiently for human consumption. In Chile, a close collaboration is being maintained with government agencies, universities and research institutes in order to implement such investigation.

The University of Rhode Island is among the group of universities officially recognized by the United States Institute of Food Technologists as offering a curriculum in Food Science and Technology (see table 3). Students accepted into the Food Science and Technology Program need a broad background in biology, microbiology, chemistry, physics and mathematics. This preparation provides the necessary basis and prerequisites for the food-oriented courses in the third and fourth years. The four-year academic program leads to a Bachelor of Science Degree (table 3). The graduate program leads to a Master's Degree and then to the Doctor of Philosophy.

Table 3. Food Science and Technology Program at the University of Rhode Island (Bachelor of Science).

1. *Required Courses*
   Biological Sciences
   Botany
   Zoology
   Microbiology
2. *Chemistry and Physics*
   General Chemistry
   Organic Chemistry
   Physics
   Analytical Chemistry
3. *Mathematics*
   Algebra
   Trigonometry
   Calculus
4. *Courses in Major Area of Concentration*
   Introductory Food Science
   General Nutrition
   Biochemistry of Foods
   Food Processing
   Food Analysis
   Food Quality
   Food Microbiology
   Food Engineering
5. *Other courses selected from different related departments*

The areas of research are in marine food science and technology, industrial fisheries technology, human nutrition, nutrition surveys, new foods, food enzymology, food microbiology, carotenoids and food chemistry. The emphasis, however, is in marine food science and technology. Courses are selected from various departments to provide further competence in the area. The number of students in the undergraduate program is about 20, and in the graduate program, about 40.

The University of Rhode Island, through the International Center for Marine Resource Development (ICMRD), is actively involved in a consortium with four other universities in the United States in developing food science and technology in different countries that need it. Students from abroad study at URI and carry out research which is of importance to their own country. At times, this research is performed in the students' native countries.

A Program in Eastern Africa

The need for technologists is great in almost all developing nations. In such countries, technology can improve and expand the traditional ways of doing things. To accomplish this, a training mechanism should be set up where the curricula will vary according to circumstances.

Training in marine food science would require a bachelor's degree program based on chemistry, physics, mathematics, microbiology, biochemistry and engineering. Specific instructions would be in the area of food technology, food analysis, food engineering, nutrition, quality control, food regulations, food sanitation and other related areas. A practical training program in the industry could also be part of the program. In addition to the above courses, short courses and seminars could be offered to fishermen, students, technicians, etc. Any

such training program should be concerned with the specific needs of the country and should include an extension service to assist in solving the problems that arise and also to analyze local conditions.

Universities that have established programs can assist in the development of similar programs in developing nations by providing visiting professors to lecture and start research projects. The ultimate objective would establish both a local faculty to take over after a relatively short time and a self-sufficient training program. The local teachers at such an institution should be well trained with bachelor's, master's or doctoral degrees, and they should be capable of continually updating their technological knowledge—an absolute requirement for education and for industrial development.

An institute of marine resources as currently being considered in Tanzania should serve as a research station as well as a training center for technical staff, fishermen, extension workers, students and investigators from the region and from overseas. It is expected that the applied research to be carried out at the center, along with the intensive training and extension activities, will assist in the development of the fisheries industry in the region and in fisheries education at both the university and secondary education levels.

Response

T. W. Maembe, *Freshwater Fisheries Institute, Nyegezi*

The world today, particularly in developing countries, is faced with an acute shortage of food. FAO estimates indicate that approximately two-thirds of the world's people are suffering from various forms of malnutrition, the biggest problem being a deficiency of protein in their diets. The situation is especially serious for young children who need food for growth and repair. Children are fed more starchy local foods, e.g., maize, cassava, millet, bananas, rice, yams, or sorghum, than adults. While these foods can have enough protein, they are deficient in certain essential amino acids, particularly lysine and methionime. The introduction of animal protein to supplement the incomplete plant protein would solve most malnutrition problems. Fish, being a protein-rich food, could be an important factor in reducing the incidence of the kwashiorkor-type of malnutrition.

Marine Resources Potential

The Tanzanian mainland has approximately 800 kilometres (500 miles) of coastline including the islands of Mafia and some smaller offshore islands. Tanga, Dar es Salaam, Lindi and Mtwara are natural harbours, none of which has been developed as an up-to-date fishing port. The Rufiji River discharges to the sea through a complex delta system opposite Mafia Island while the Pangani, Wami, Ruvu and Ruvuma Rivers have important estuaries along the coast.

The continental shelf is narrow, with a width varying from a minimum of four miles to a maximum of forty at the area around Mafia Island and Zanzibar. The greater part of the sea floor along the continental shelf cannot be fished by conventional trawl methods because of coral formation.

The coast is affected by two currents, the East African Coastal Current, which is a northerly branch of the South Equatorial Current dividing off the north tip of Malagasy Republic, and Arabian Sea waters, which seasonally penetrate south as far as the Tanzanian coastal waters.

Limnological studies indicate that this ocean water is deficient in the growth of plankton and fish species, and this deficiency affects the chain of marine foods and consequently the distribution of marine resources that can be exploited.

The greater length of the Tanzanian coast is protected by coral formations which reduce the effect of heavy winds. Fishing villages are, therefore, not confined to natural harbours or sheltered estuaries, and there is little centralisation of fish landing sites.

Exploitation and Utilisation of Marine Resources. The exploitation of marine protein resources is limited by the traditional gear and craft utilised by local fishermen who usually cover a distance of about eight miles from the shore. It has been observed by the East African Marine Fisheries Research Organisation that demersal fish, which live close to the sea bed, although numerous in variety, have no large quantities of commercially important species. The small area of fishing grounds and difficult fishing conditions limit the amount of catch.

Pelagic fish such as the two species of Kingfish (*ngurli* in Swahili, *Scomberomous commersan*, and Kinadi, *Scom*) form the greater part of the inshore catch by gill nets, handlines and trawling. Species of tuna (*Thunnus albacra, Gymnosarda unicolor, Euthynnus affinis* and *Epilamis* species) are also caught as well as marlin, swordfish and sailfish. The presence of seasonally schooling pelagic fish over a wide area of the coast presents another potential for large-scale exploitation. The investigation of these fish schools is an important part of the research programme of EAMFRO and should be for the proposed centre for marine resources.

Sardinella species have been exploited with light fishing, using ring nets to haul in the catch.

The exploitation of crustaceans has been pursued on a commercial scale by Mwananchi Ocean Products, but not for local markets. In areas of main river estuaries, prawn are caught seasonally in very limited quantities by local fishermen.

Factors Hampering Expansion of Utilisation

Four factors hinder the expanded use of marine resources.

1. *Lack of a continuous supply of fishery products* which inhibits the creation of a fish-eating habit. This is especially critical in rural locations where lack of animal protein is a serious problem. Due to the fluctuations in fish supply, people in these rural areas have not developed a taste for fish, and thus when it occasionally appears, the demand is minimal.

2. *Undeveloped marketing and distribution systems*. Up to the formation of the development corporations and *ujamaa* fishing villages and their participation in fishery exploitation, the marketing of marine fishery products had been dependent on fishmongers, whose presence tended to elevate fish prices to levels prohibitive to would-be consumers. These procedures left fishermen poor, and potential fish consumers were forced to purchase low-cost starchy foods. In areas where fish is available on the market, the quality is low relative to the price. Rural marketing of fishery products lacks the advertising and publicity necessary to popularise fish consumption.

3. *Poor distribution channels and transportation systems*. Due to a lack of facilities, fishing villages are in most cases unable to supply good fishing gear and craft, storage, ice and means of transporting fresh fish. Where fish-receiving facilities have been provided, fishermen have been unable to make full use of them due to a limited and sporadic fish supply and the socio-economic inter-relationships between the fishermen and the fishmongers.

Where fish is processed at the village level, the quality of the product is low. Most processors start with already spoiled raw material. While the towns offer a good market for fresh and processed fish, consumers inland are deprived of getting even a low quality product because of the absence of transport and the apparent absence of demand. The establishment of the National Cold Chain Operations (NCCO) will ensure efficient distribution of fishery products, but even in this case the prices at present are prohibitive to potential low-income consumers.

4. *Poor processing and preservation*. Fish processing increases the shelf life of the fish. In most cases spoiled fish is processed to save the fishmongers and/or fishermen from loss. Improvement of the traditional processing methods will undoubtedly raise the quality of the fishery products available.

The Approach to the Problem

Statistical data on processed marine resources gathered in the period from 1966 to 1972 indicate that the exploitation of marine resources is far below the potential sustainable yield. There has been an increase in fishing effort (1972); however, the quantity available is far from meeting the demand.

While the Freshwater Fisheries Institute Nyegezi Mwanza has recently reviewed food science, nutrition and technology in relation to freshwater fisheries, much remains to be done for marine species. There is a need for defined priorities in order to economically harvest marine foods. The appended chart demonstrates one practical approach.

Marine Resources and Nutrition. Recent surveys indicate the lack of an adequate supply of protein has brought havoc to the young age groups where kwashiorkor is prominent. Fish could alleviate this problem as they are an excellent source of high quality protein; in fact, fresh fish consists of approximately 80 percent protein. Their nutritional value is higher than that of beef or poultry. Marine fish, while rich in fats, are said to

contain an anti-cholesterol which lowers the level of cholesterol in blood lipids.

Improved Production of Marine Resources. The traditional craft used by local fishermen should be better organised to increase the catch. This can easily be achieved by emphasis on the fishermen's training effort, improvements suggested under the auspices of the proposed centre for marine resources, improvements in fishing technique, and better handling and preservation through the use of ice and insulated containers. This can immediately be implemented in *ujamaa* fishing villages.

The basic factors that have to be considered when planning for increased production include:

1. The need to uplift the socio-economic welfare of the fishing community and the nutritional standard of the rural population. The fishermen should be able to get higher economic returns.

2. The existence of large fishery resources, which hitherto have been exploited haphazardly at the subsistence level. These resources although renewable are capable of complete destruction and exhaustion.

3. The widespread inadequacy of socio-ecological data necessary to effect properly organised and developed utilisation of the marine fishery resources.

Fish Handling and Preservation. Local fishermen should be induced to maintain a high standard of quality for fishery products. The organisation of fish landings on the beaches and the provision for fish-receiving facilities are items that the fishermen will have to be trained to appreciate and use. This can easily be achieved through: (1.) organised, well managed *ujamaa* fishing villages, development corporations, etc.; (2.) improvement of traditional methods of fish processing and preservation, and (3.) organised, well planned, efficient marketing and transportation systems to ensure high returns to the fishermen.

The formation of the Tanzania Fisheries Corporation (TAFICO) will go a long way in producing, marketing and distributing the much needed marine products.

Training in Marine Resources Utilisation and Development. To be able to utilise effectively the highly valued protein in our marine resources, technologists have to be trained to accomplish the priorities defined at the national level. While short courses have been offered in food technology, food analysis, microbiology, quality control, food engineering operations, industrial sanitation, marketing and transportation of fishery products to the present certificate and fisheries diploma students at Mbegani and Kunduchi, the students have ended up in administrative positions. There is a need to start utilising these trained people in extension services where they will be in direct contact with the fishermen. Short-duration courses can be offered to fishermen and fishery technicians to increase their performance in line with specific needs.

Mass education of the rural population through advertisement, short visits, etc., in which preparation of fish dishes, utilising readily available local foods as the major components, would be of much value.

Conclusion

This paper has reviewed some of the problems facing the development and utilisation of marine resources as a source of protein. Tanzania, like other developing countries, lacks the economic power to rapidly exploit, manage, and process marine resources on a scale that would satisfy the nutritional needs of the domestic market. Nevertheless, plans to increase the quantity of fish available to rural markets has to be given priority.

In summary then, priority needs are:

Improvement of traditional crafts and methods of fish processing to ensure high production of good quality fish.

Breaking the chain of fishmonger/fishermen interrelationships by utilising *ujamaa* villages, development corporations and the NCCO to ensure distribution of good quality fish at acceptable prices.

Education of fishermen/fish consumers on the nutritive value of fish and the importance of maintaining good quality through improved handling, processing and distribution channels.

Training to provide technologists who will assist *ujamaa* villages and development corporations on how best to utilise our marine resources.

Improvement of the marketing system to ensure a continuous supply of fish to rural areas. The rural population will at the same time need to be trained to incorporate fish in their local diet to ensure a complete eradication of malnutrition due to protein deficiency.

Organizing a Nutrition and Food Technology Programme in Relation to Marine Fishery Products*

Production	*Research and Training*	*Fish Processing and Engineering Operations*	*Distribution*
Fishing gear technology	Stock assessment, migration, etc.	Improved handling system (stop spoilage by rancidity and microbial action)	Cold and other appropriate transportation
Conservation of breeding stock	Preservation and processing	Quality control	Regulation of fish export
Marine fish culture	Product development	Expansion of storage facilities	Fish eating and nutrition campaign
Expansion of extension work to ujamaa villages and development corporations	Consumer research and recipe preparation	Improve traditional processing methods (drying, salting, frying, smoking)	Consumer education
Incentive to producer (e.g., price stabilisation and returns to fishermen)	Fish disease Other biological research Marine fisheries manpower planning	Expand modern methods (canning, filleting, freezing, fish flour, paste and other convenient fishery products)	Improve storage within marketing system
Stimulation of producer co-ops, ujamaa villages, etc.	Fishermen training	Training of marine resources technologists	Wholesale, retail pricing
	Training in nutrition and nutritive value of fish		Quality control
Quality control			
	Other research and training programmes		Improve distribution channels inter/intra regional flow

* *Although general, the list can be expanded and specified according to manpower availability, development, budgets, times, etc.*

Discussion

With the poor man there is almost total consumption of the food fish. As his affluence increases he tends to consume only the better cuts, i.e., fillets, and thereby increases the need for prepared products and animal feeds in order to effectively use the catch. This should be taken into account in planning.

Many developed and developing nations do not utilise trash fish or "inedible" species. Fish in this category, when caught, are thrown overboard. The regional situation for East Africa should be explored remembering that what is considered an inedible species may be acceptable in the future. It is a nutritional crime in areas of protein need to use the trash fish for fertiliser or any other reduction purpose if they could be made acceptable for human consumption. However, while such utilisation is recommended, careful attention must be paid to the problem of elimination of poisonous species which exist in most tropical areas.

As with mechanisation, the technologies involved with marine food processes and handling should be targeted for the technological capabilities and social constraints of the indigenous local population.

Sociology and Anthropology Applied to Coastal Communities

R. B. Pollnac, *Assistant Professor of Anthropology*

It is only natural that a great deal of the effort expended in a marine resource development program is directed at biological, physical, technological and economic aspects of the marine environment. Nevertheless, it is essential that we do not overlook the human behavioral element in the developmental process. This element is the ultimate determinant of the success of any developmental scheme, and it must be taken into account if we wish to apply the knowledge we generate. The payoff in marine resource development comes only when people act on the new ideas—mere exposure does not guarantee action.

Sociologists and anthropologists have long been interested in the sociocultural concomitants of technological change (e.g., Barnett 1953, Bernard and Pelto 1972, Foster 1973, Rogers and Shoemaker 1971). Most agree that an effective program of technological change consists of the following essential and interrelated ingredients: (1.) development by resource scientists of an innovation which is compatible with the target environ-

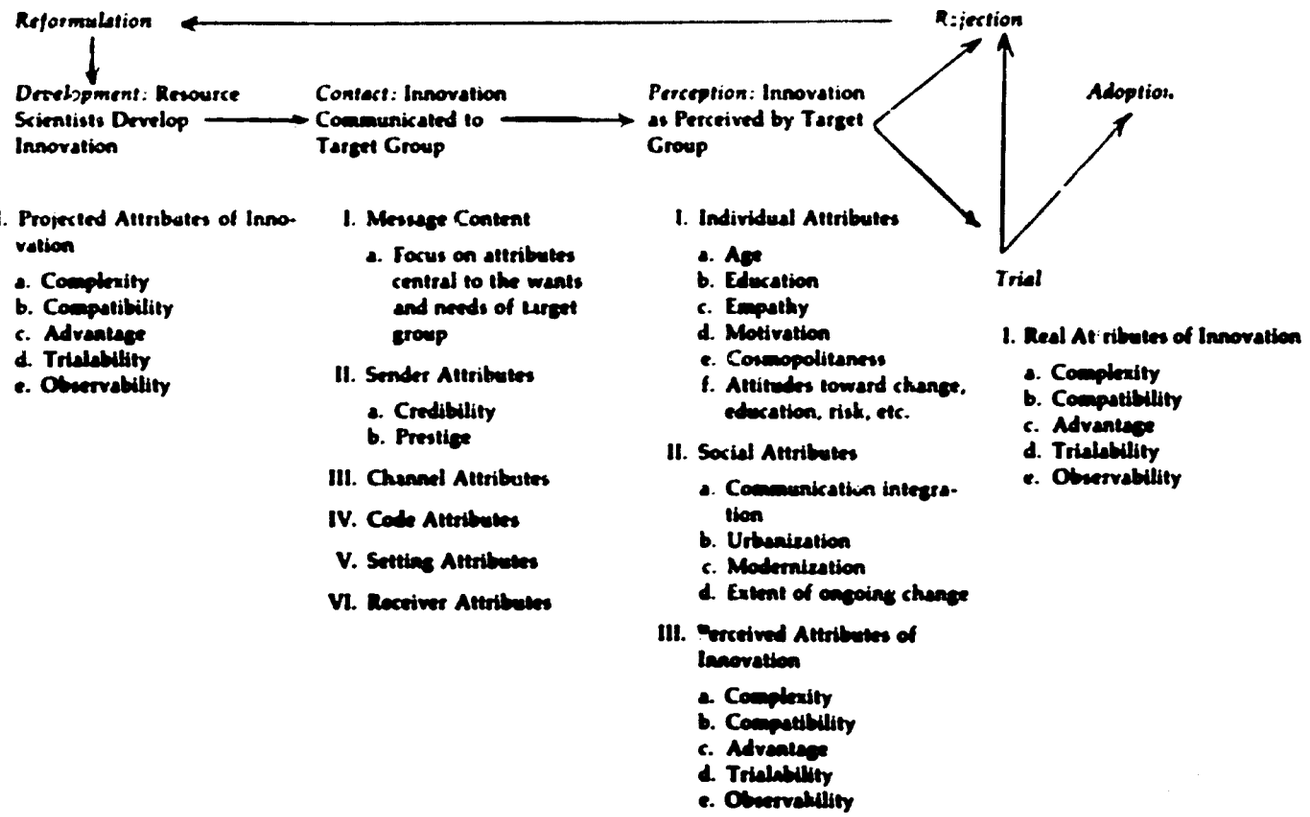

Figure 1. Factors influencing the diffusion of innovations.

ment and economy; (2.) effective communication of the new idea to the target population; (3.) recognition by the target group that the new idea will fulfill a perceived need and will be, or can be, made consonant with existing beliefs, values, attitudes, and status and role relationships. These three key ingredients form the first stages in the diffusion of an innovation as depicted in figure 1.

Figure 1 illustrates in diagrammatic form the factors which influence the diffusion of an innovation. Attributes of the innovation are listed at the starting point as well as under "perception" and "trial." In the first case they are the attributes projected by the development agents; in the second, they are those perceived by the target group, and in the third, those of the innovation undergoing trial. The more similar these three sets of attributes are, the more likely the developmental change program will be successful. One of the most crucial aspects of the role of the sociologist/anthropologist in the marine resource development program is to investigate the affected items in terms of their componential structure, in terms of the beliefs, values and attitudes associated with them, and in terms of their role in maintaining the social structure in the target group. This information is of great value in predicting the perceived attributes of the innovation and in adapting certain aspects of the innovation where necessary.

The sociologist/anthropologist also conducts investigations to determine the most effective techniques for communicating the new idea and pinpoints the most receptive audience. Finally, he investigates through time individual perceptions of the innovation during acceptance or rejection and relates this information to other resource scientists who will attempt modifications which could result in its successful adoption.

Educational programs dealing with the sociocultural facets of community development and technological change are used to both familiarize students with this important area of applied research and prepare them to deal with such situations in a changing society. An ideal program in applied marine sociology or anthropology builds on the existing educational facilities by providing marine related material in coursework dealing with sociocultural change and related topics. Additional fieldwork experience is provided by assigning student assistants to ongoing research projects in marine communities.

Sociology-Anthropology and Marine Resource Development at the University of Rhode Island

Consonant with the University of Rhode Island's interdisciplinary approach, we have integrated a concern for the sociocultural ramifications of marine resource development. At present we have four sociologists and two anthropologists conducting marine-related research. This research covers a wide spectrum of topics ranging from tourist utilization of Rhode Island beaches to a cross-national study of marine academy organization.

With respect to international research, a sociologist and an anthropologist have been involved in a fisheries and mariculture developmental project in Puerto Rico. The first stage of their research involved investigations of the interrelationships between attitudes toward change, occupational specialization and social stratification in a rural fishing community. A preliminary assessment of receptivity to change was found to be compatible with the project's objectives.

Further research by the sociologist has been extended to several fishing communities representative of varying degrees of complexity. He is investigating the interrelationships between these communities as well as their ties with other Puerto Rican communities. The complex networks of resource use including tourism, fishing activities, and trade relationships are being investigated along with other sociocultural attributes related to change. He has demonstrated intercommunity variation in the commercialization of activities which is related to status groupings and consequently to economic motivation, an important factor in developmental change.

Other factors related to change were also evaluated (e.g., perception of adequacy of activities and situations, support systems, personal and social values, community identification, etc.) and found to vary both between and within the communities. In sum, the sociologist's research suggests that any evaluation of the area's potential for developmental change must take into account the differences between the various communities as well as their interrelationships and location in the regional network of resource use. The findings argue cogently for a regional approach to marine resource development, taking into consideration the resources of both land and sea.

Cross-national differences in merchant marine training organizations are being evaluated by two sociologists. They have found that distinctive modes of nautical training are related to different social forces in the countries examined. These scholars have demonstrated the interrelationships between the merchant marine training institutions, the economic realities of the labor market and varying methods of organizational control and accountability. Their work clearly shows the responses of marine-related institutions to macro-economic and political factors, and therefore indicates the necessity of taking these factors into account when establishing such institutions.

Turning to University of Rhode Island research efforts in the continental United States a sociologist is involved in investigating various social and psychological aspects of sport fishing and bathing beach use in southern New England where tourism forms an important part of the economy. His studies provide a great deal of valuable information which can be used in campaigns to increase the tourist trade and in predicting resource use.

Several other sociologists and anthropologists are studying sociocultural aspects of commercial fishing in southern New England. Their research was initiated in response to projected changes in the commercial fishing industry in the United States. Studies have indicated that in order to prevent depletion of fish stocks, current open access to the fishing occupation must be restricted. In addition, certain changes must be made in the commercial fishing industry to alleviate these problems, yet maintain an adequate harvest of fish. An investigation of the occupational subculture of fishermen provides sociocultural information which can be used in minimizing the strains resulting from the dislocation of fishermen. A sociologist and anthropologist have conducted detailed surveys in several representative fishing communities regarding the wants, needs and occupational aspirations of commercial fishermen. These studies are being used to design workable programs for the retraining of the commercial fishing labor force undergoing technological change and the recruitment, retraining and retention of displaced fishermen. Further studies of the organizational strategies of cooperatives, risk and ritual, and economic gratification patterns of fishermen in southern New England have added immensely to our knowledge of this sector of the labor force and can be used in planning its future development.

Overall, the University of Rhode Island has used the resources of both sociology and anthropology in the implementation of a viable marine resource development program. Sociology and anthropology have been actively involved in a wide range of activities and have provided significant input to the study of the planned change of marine communities.

Applications to Marine Resource Development in Eastern Africa. The foregoing has outlined the important role that sociology and anthropology play in the development of marine resources. Plans for developing the fisheries, recreation and tourist attractions of the East African coast involve human interaction at all levels, from their inception to their effective implementation. As argued above, the human behavioral element will be the ultimate determinant of the successful application of these plans. The linguistic and sociocultural diversity of the peoples living on the East African coast add to the complexity of the situation. It is therefore essential that the sociocultural implications of these plans be investigated and taken into account to insure the ultimate success of the development of the marine resources there.

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Response

S. Ndawula-Kajumba, *Department of Sociology, University of Dar es Salaam*

To say that Professor Pollnac's paper is readable and is not as cumbersome as papers often presented to such international conferences may not be an unfair

statement. My general comments on this paper shall be on two areas, namely, (1.) the theory and its application to Tanzania, and (2.) the data in the study.

Pollnac rightly argues that marine resource development should be a joint venture between social scientists and natural scientists. But he sees the role of a social scientist as that of

> investigating the affected items in terms of their componential structure, in terms of the beliefs, values and attitudes associated with them, and in terms of their role in maintaining the social structure in the target group.

The natural scientist is the "resource scientist." The social scientist, according to Pollnac, studies the individual perception of the innovation and

> relates this information to the other resource scientist who will attempt modifications which could result in its successful adoption.

There are two criticisms here. It is all right to advocate a merger between natural and social sciences. But unless we accept that the material bases of society, namely, resources, technology, etc., directly support and influence the formation and development of social institutions, norms, values, etc., the merger between the two would tend to be temporary and would be bound to cease as soon as the project at stake is over. Another problem concerns what seems to be the author's static conception of society. This is a common pitfall to most diffusionists. In the precondition necessary for the process of the diffusion of innovation, Pollnac says that there must be

> recognition by the target group that the new idea will fulfill a perceived need and will be or can be made consonant with existing beliefs, values . . .

We must not underestimate the dynamics of society. New technological innovations in society have always given rise to new forms of social systems and institutions. Not only that, they have revolutionised and often simply changed the mode of production and the style of life. The idea that people cling to their unique traditional mode of living is intellectual staticism, for society is always an on-going process.

Using a glaring example of the colonial situation, it is clear that the reservation peasants (fishermen, pastoralists, agriculturalists, etc.) tend to project their structural strategies. Often new innovations which people tend to resist are superimposed on a particular society from outside. That is to say, such innovations are largely not a function of the material dialectics of that given society. The other point to bear in mind is that generally the ultimate objectives of alien innovations tend to be exploitive. For a society such as Tanzania where the noble principles of mass participation and egalitarianism have been declared, local technology, resources and ideas with a minimal external element of each would provide the most relevant and cumulative process of development.

Pollnac's paper is built upon the theory of the "diffusion of innovation." The diffusion of innovation is a social phenomenon which has been a subject of scholarship for some time. The central focus of the theory is the process through which new ideas spread in a society.

The paper argues that there are three aspects to such a process:

1. Development by resource scientists of an innovation which is compatible with the target environment and economy.

2. Effective communication of the new idea to the target population.

3. Recognition by the target group that the idea will fulfill a perceived need and will be or can be made consonant with existing belief.

I have already made certain comments on 1. and 3. above. Communication (2.) is perhaps the most deserving aspect in this theory. In the diagram in his paper under Contact and under Perception there is evidence to this effect. Most diffusionists tend to submit that the higher a member of a village or community ranks in what Pollnac calls the "sender attributes," "individual attributes" and "social attributes," the more innovative and appropriate agent of innovation he will be. This approach therefore will tend to favour the most prosperous or "progressive" farmer, fisherman, etc. Is this within the Tanzanian principles of development?

The paper reports that concerted efforts have been made at the University of Rhode Island to introduce sociology and anthropology into the study of marine resources development. One obviously appreciates learning the role sociology and anthropology are playing in

this area. However, in spite of the differences in levels of development, at both the material base and the ideological level of such countries as Tanzania and the societies the University of Rhode Island has studied, it would have been more interesting if we could have seen the data involved in these studies.

Discussion

1. In response to the comment that Pollnac's paper was based on a "static concept of society," it was pointed out that his model was dynamic, having feedback loops. The comment that the approach favours both the most prosperous or progressive farmer-fisherman was countered by the fact that the model could treat the establishment of a *ujamaa* village as an innovation, which in fact it is.

Punitive measures were singled out as being the most realistic at present in dealing with fishermen who use dynamite because there is no current means of providing a substitute technique with comparable returns. A combination of education, re-direction and punitive measures appears to be the most appropriate for the long-term resolution of the problem, however.

There are many social, structural and ethnic group barriers to the adoption of innovations. Although sociological studies have been conducted, they have not solved these problems. This failure may possibly be attributed to the fact that most studies have been done by outsiders. Perhaps the understanding of an indigenous sociologist may be needed.

A current effort in Ghana by the International Development Research Centre of Canada, embodying some of these considerations, is being conducted by a team of investigators including local sociologists. Tanzania will watch the results with interest.

In many community situations the social status of the fisherman is quite low. Efforts to elevate his prestige may well contribute as much to retention of capable fishermen as the more obvious approach of increased return.

2. The question was raised concerning the fisherman's attitude toward non-fishermen telling him how to fish. The approach taken in Rhode Island was suggested for consideration. There is a great deal of communication between the fishermen and the fisheries development people (who actually operate a fishing vessel of their own as well as participate with the fishermen in comparative studies) through forums, advisory services, etc.

Program Synthesis

N. Marshall, *Director, International Center for Marine Resource Development*

In winding up this session on marine resources, largely as illustrated by work at the University of Rhode Island, I will comment on the progress and accompanying opportunity evident from the input of the Tanzanians and others from Eastern Africa; I will offer a few words of cautious optimism suggesting that the Tanzanian input might be developed into a comprehensive marine resources program; and, finally, I will speak of marine advisory activity as the ultimate need if a program is to be meaningful.

Looking back over the contributions of the past two days, we see that our URI group—quite proud of the scope of its marine resources endeavors—has been matched at every turn by someone from this region speaking with authority in each of the diverse subject areas. To be sure not all participants are presently, or even potentially, on the University of Dar es Salaam roster, but the participation demonstrates that, should a comprehensive marine resource program be undertaken, a start can be made free of major gaps by the practice of selectively reaching out for assistance through, for instance, adjunct or affiliate professor arrangements.

Someone remarked that the URI all-out interdisciplinary approach to the marine areas can only be attempted with seemingly limitless funding resources. I hasten to point out that in 1959 we had only a marine lab with a complement of eight scientists at URI. When we had the opportunity for modest expansion into other academic domains, we elected to involve so-called outside departments, deliberately avoiding the alternative of appending individual outsiders to the existing marine laboratory group.

Thus we started our broadening by financing an assistantship so that one professor, in his role as a faculty member in what was then a Department of Agricultural Economics, could pursue fisheries economics studies. This was but a spark that burst into a flame of interest in that department which now has close to ten full-time-equivalent faculty working on marine problems. In time this involvement brought two successive changes in the identity of the department: first to Food and Resource Economics so as to embrace fisheries and later to Resource Economics as the group became involved in more resource problems beyond the food domain. Incidentally, one of the first students in this program was a Tanzanian, Ernest Mulokowzi, who is now General Manager of the Tanzanian National Development Corporation.

We have expanded in much the same way in arousing the interest of other departments. All this takes a growth in funding, of course, but interest is more important than money. Virtually every faculty member, even when faced with a heavy teaching load, can contribute something to feature programs such as our marine resources effort. A program needs to create the climate that arouses interest and, with the marine field being inherently fascinating, this is not difficult.

It goes without saying that all our accomplishments would be of little or no avail unless communicated to the prospective users. The great strides in agriculture in the United States did not stem from research accomplishments alone but from a remarkably effective interplay of accomplishment and advisory outreach—the latter being the extension activity so impressively developed by our agricultural colleagues. In the marine areas, we have been initiating this with the programs we have labelled Marine Advisory Services. We prepare popularized information releases and publications; we organize instructional forums for the public; and we have what in essence are marine extension specialists. Such specialists range widely in their contacts; also, when appropriate, they solicit willing cooperation from our researcher group. I gather that in Tanzania the extension force, at least with respect to the fisheries, is already constituted within the government's Division of Fisheries; nevertheless a supporting university role would seem essential.

Planning an Institute for Marine Sciences for Eastern Africa

The Hon. H. Makame, *Chairman*

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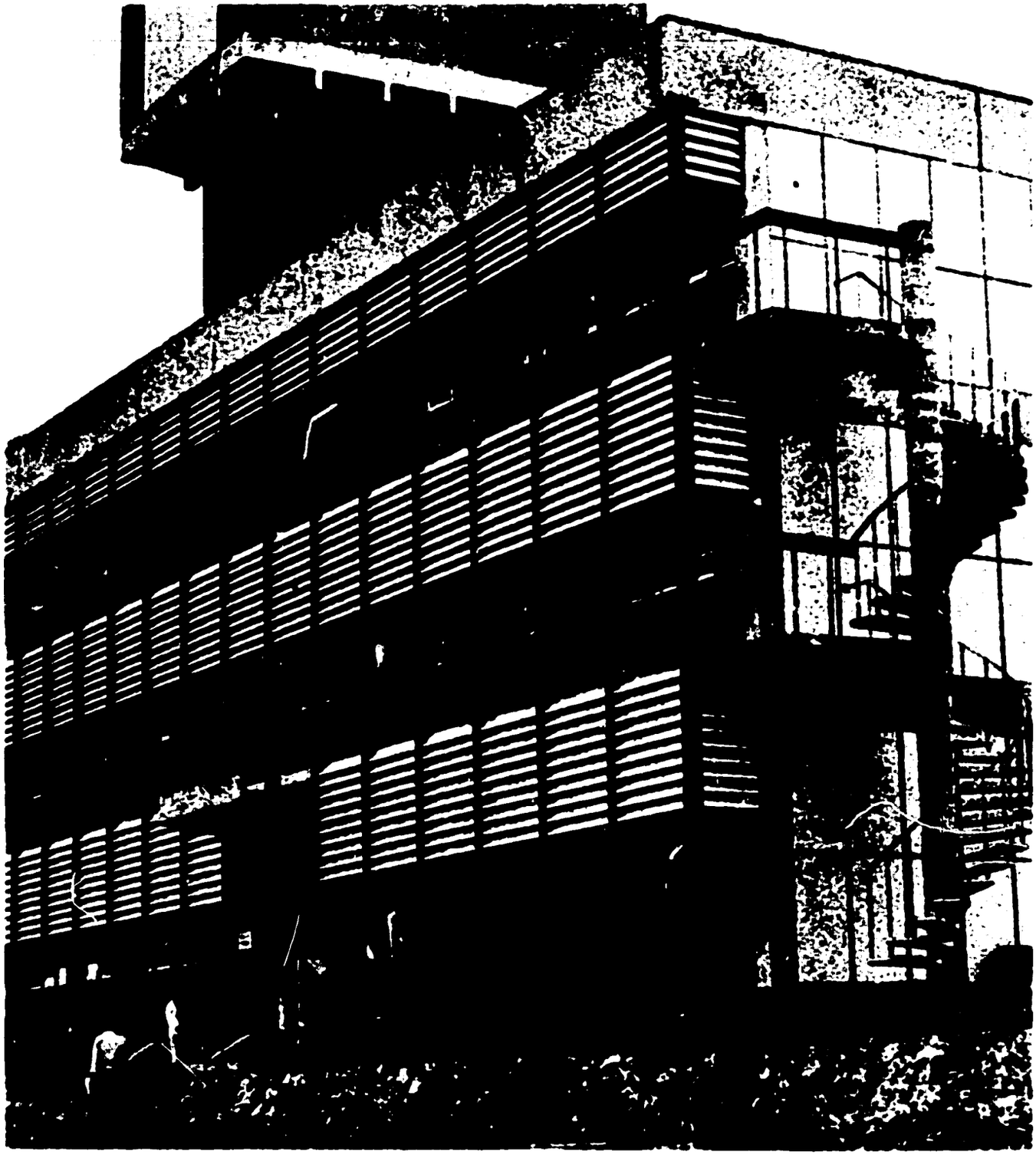

Address to Delegates

The Hon. H. Makame, *Minister of Natural Resources and Tourism, Tanzania*

It is a great pleasure to me to have the honour of chairing this important meeting of yours this morning. I call it an important conference because we in Tanzania both in government and in this university regard it as such. Let me make it quite clear that this conference is being held at the request and wish of the Ministry of Natural Resources and Tourism and the University of Dar es Salaam, and as such it has the fullest support of the Government of Tanzania. The participants in this conference were invited by us on the basis of their interest and potential capacity to help us design and develop means of exploiting our marine resources to the best advantage of our country. I would like at this juncture to thank all those who have favourably responded to our call and have come to attend this conference, especially those who have come from outside Tanzania.

I can assure you that your expertise, advice and proposals will be taken seriously by our government.

The Role of the University of Dar es Salaam and the Relationship of the Institute of Marine Sciences to the United Republic of Tanzania and to the Region

P. Msekwa, *Vice Chancellor, University of Dar es Salaam*

It should now be very clear from what has been said by several participants in this conference that there is need, indeed there is a great need, for the establishment of a marine sciences institute in Eastern Africa. Of all the natural resources in this part of the world, the marine resources remain the least studied and the most under-exploited. Yet it is known in a general sort of way that the living part of these resources alone, i.e., the biological part, if fully exploited, could contribute very significantly to the economic development of these countries and to the solution of the notorious and widely occurring problem of protein malnutrition. It is also probable that the non-living part of the marine resources of this region, the mineral part, is of equally great potential. It is obvious, however, that full access to these resources cannot be had without a good scientific understanding of their nature, the extent of their occurrence and the ecological and other factors influencing them. Such a scientific understanding of these resources can only come about as a result of pursuing a well planned research and training programme. The full utilisation of these resources will also depend on the development of efficient methods of exploitation or harvesting.

We in the University of Dar es Salaam have been more than aware of the need to concern ourselves with marine science studies for a long time, indeed since the establishment of a faculty of science in this university back in 1965. That is why in 1968 we established a marine biology station at Kunduchi next door to the Fisheries Research and Training Institute of the Ministry of Natural Resources and Tourism. The marine biology station started as a modestly-sized laboratory

which was modestly equipped, and it was at first used as a field and collecting station for our zoology undergraduate students during their marine ecology field courses. From this modest beginning the station has made steady, though still modest, progress over the years, and it has now a full-time scientific staff of its own engaged in ecological research and in the training of undergraduate and postgraduate students. To date three graduate students attached to the station have worked and obtained higher degrees of the university, and currently there are two more students working for such degrees. We expect to take in more students for postgraduate studies in marine biology during the coming academic year.

Right from the time the marine biology station was established, the university's attitude in making use of its facilities has never been parochial, and there have always been healthy and collaborative connections with the Fisheries Research and Training Institute of the Ministry of Natural Resources and Tourism, the other universities in East Africa and the East African Marine Fisheries Research Organisation. Examples of this healthy cooperation have been the organisation of undergraduate field courses in marine biology and the offering of postgraduate study facilities to students from the other universities in East Africa (one of the students currently pursuing postgraduate studies in marine biology at the station is from Kenya); cooperation with the scientific staff of the East African Marine Research Organisation in the supervision and examination of research students and the sharing of working space and equipment with the Fisheries Research and Training Institute. The station has offered research facilities to scientists from different parts of the world wanting to carry out studies in tropical marine biology. For example, only about ten weeks ago a team of Rumanian scientists completed a three months' intensive study of the benthic fauna of the shores around Dar es Salaam.

With these examples the University of Dar es Salaam is not boasting that it has done everything that needs to be done in planning for marine resources studies and development. Rather the examples are given to show that both in philosophy and outlook the foundations so far laid are sufficiently flexible and broad-minded to allow for the development of an institute of marine sciences in this part of the world which is broad-based in its academic and applied activities and which can serve local, regional and even international needs. There is no doubt that our modest efforts in the past in the scope of research and training and in organisational structure have left much room for improvement and extension. One would hope that in its resolutions this conference will have, among other things, concrete proposals as to how such improvement and extension could be effected. We at this university realise our special responsibility to the country and to the region in developing the marine resources of this part of the world, and we are willing to cooperate with institutions of goodwill in the region and in the world in discharging this responsibility. In this regard I was very interested to learn recently that the United Nations University, to be established in October this year with headquarters in Tokyo, Japan, will have marine sciences among its priorities and that there will be an institute of marine science affiliated with or as part of the UN University. In order that such an institute may make a maximum contribution to man's knowledge, perhaps it should be located in an area where marine sciences are not so well developed; the East African region is one such area. If you gentlemen as a group of experts in this field consider it reasonable and appropriate, I would like to suggest that the proposed institute of marine sciences of the UN University be based at the University of Dar es Salaam.

Let me end these remarks by reiterating that we at this university will be looking forward to some concrete proposals from this conference as to how an institute of marine sciences of international standing can be established at the University of Dar es Salaam.

Discussion in Support of Establishing a Centre

The Hon. H. Makame, Minister of Natural Resources and Tourism

"I agree with you, Mr. Vice Chancellor, that there is a need for the establishment of a marine resources centre in Eastern Africa, and as you propose, it should be in this university."

R. E. Morris, EAMFRO, Zanzibar

"For the last two days of the conference, we have had our horizons in this subject enormously broadened. We no longer think of marine resources as just fisheries and no longer are fisheries regarded as just capture fisheries. Now the community thinking has always been along very much the same lines as this, and already, for example, the scope of EAMFRO has been widened to include marine pollution matters. I think this will be an increasing trend.

"I think the meeting so far has underlined very much the importance of a cooperative and interdisciplinary approach to marine affairs, and this is something the partner states have always followed. This obviously is a method that has been brought to a pinnacle by the University of Rhode Island, and I think it reaffirms our faith in the system to see this. We strongly favour the cooperative and multi-disciplinary approach.

"Our program of building substations at Dar es Salaam, Kunduchi and Mombasa can only serve to very much further strengthen these relationships.

"With regard to the East African marine science institute, I am wondering whether we really need to go as far as this in view of the establishments that we have and the relationships that exist among them. It seems to be a bit difficult to define the relationships of such a body to other organisations; for example, the zoology departments, the fisheries division, the fisheries institute, EAMFRO, etc. I don't want to try to usurp the functions of our East African Council. It seems to me that to set up another community body like this would involve ourselves in administrative red tape and delays which we don't necessarily need to have. So I would rather see us work by strengthening the systems that we already have—the committees and institutes—which have been set up to foster an approach very similar to the one that has been shown to us at this conference by URI. We hope that we can cement very much stronger ties among the institutes and the committees that exist so that we may have an easy and informal exchange of ideas, people, facilities and expertise. We hope we can augment and amplify the proposals which we have already agreed upon in the bodies and decide exactly what we want to do, where we are going to get the personnel, how we are going to work profitably through the artisan fishermen and where we are going to get the money we need. And above all we hope that we can provide what has to be the real pay-off which is a great contribution from the sea for the health and welfare of the countries of East Africa."

D. Bryceson, Director of National Parks

"What we need is an institute set up under the auspices of the university. This institute would be part of the University of Dar es Salaam, and the other East African countries would collaborate with this institute as part of the university in the way that collaboration among the three universities of East Africa is carried out normally. There is a great deal of exchange and interchange among the three universities of East Africa as there was previously when the three were university colleges of one university. This tradition of coordination and cooperation is something that I think is vitally important to retain for the future development of East Africa and for the future development of our three now-universities.

"What we need here is an institute or centre or whatever you'd like to call it which will be a very broad-based institute serving the needs of, I hope, Kenya as well as Tanzania—certainly of Tanzania. I hope Kenya in the initial instances also, and perhaps of other East

African countries with a seaboard as well. This should be established here in Dar es Salaam or just outside Dar es Salaam and established under the auspices of our university here.

"Now we have at Kunduchi a marine biology station of the university, we have the Marine Fisheries Research and Training Institute of the Ministry of Natural Resources and Tourism, and I would have thought that here we already had a nucleus of such an institute. We have a number of people who may work at such an institute, continuing broadly the work they are doing now, maybe broadening their fields. Within the various departments of the university we have other professional experts in fields not directly related to the marine sciences but which impinge directly upon the application of those marine sciences in the field. When we come to the marine sciences we are looking to the application of those sciences in the field in order that we may have more fish for sale in the diets of the people of this country.

"This means that we need some economists' assistance, we need some sociologists' assistance—we need assistance from other fields than the marine science field. This sort of assistance is available from within the university community, and I hope that it will come about that such an institute as we are conceiving—I hope we are conceiving it now—may bring in these other departments of the university, the expertise in these other fields, so that we can produce something which is going to have good technical application in the production of fish for our people of Tanzania."

N. Marshall, University of Rhode Island

"I'm sure that people like myself, representatives here from the United Nations organizations—UNESCO, UNEP, FAO—the representative from U.S./AID, are all trying to find a way to make all of these things work. I'm sure that we don't see a conflict between a university's ambition and the ambitions of the fisheries research organizations, particularly EAMFRO. While their goals may overlap broadly, the important thing is that they can complement each other."

D. Wasawo, ECA, Addis Ababa

"The necessity for such an institute from the point of view of the UN system has been defined. In fact, one of the programs of the ECA is to help set up institutes of this nature for marine resources both in the Eastern African region as well as the West African region.

"Some seven years ago we decided that Africa should develop centres of excellence, and one of these centres that it was clear to us in importance to develop was a centre for marine sciences.

"To come down to the Eastern African region, we in the university, during the old days when we were working together very closely, felt in our various departments—department of zoology at Makerere, department of zoology at Nairobi, and department of zoology here—that we should develop research areas in which each of our universities would consider itself a centre of excellence to which students from other parts of Eastern Africa could go. We decided that Makerere should develop freshwater biology, Nairobi should develop land ecology, and that Dar es Salaam should develop marine ecology. Now this was a sort of general agreement. We in Kenya felt that we could have a small, well developed marine station on the coast for students, but that as a centre of excellence, the University of Dar es Salaam should develop marine resources and that we ourselves should develop land ecology. Such a centre would be regarded as one which the countries of the Eastern African region would look to as the place to send their students for higher technical experiences.

"There is a need for a centre like this. The University of Dar es Salaam has taken the lead and has called an international conference looking for a way in which they can set up a centre for themselves here. Let's see how we can get ahead with it and then discuss as a second issue ways in which such a centre can be regarded as a centre for the Eastern African region. We'll be glad to help in seeing that various organisations come together and discuss this as a second level of activity. Then if the nucleus is there I think we have a strong case in the Eastern African region to claim such a centre as part of the International University of the UN."

H. Matthes, Kunduchi Fisheries Institute

"I've come to the conclusion that ideally there should be one East African institution of marine resources. Let this be an offshoot of the university first, then let it grow. Let it be under one single department at first."

K. H. Bain, FAO, Dar es Salaam

"My organisation supports wholeheartedly the idea of establishing a centre for the development of marine resources. The exact form that this institute should take can, I hope, be resolved at today's discussions."

S. B. Saila, University of Rhode Island

"Why a marine research institute at the University of Dar es Salaam? The problems in marine science clearly transcend those of marine ecology and marine biology, and indeed I think that the results of this conference to date have clearly convinced me at least that your major problems are not marine ecology. The major problems are technological ones, to increase the exploitive capacity of your fishermen, to properly process your product, to properly contain pollution in your environment at the same time that you are developing your resources.

"The concept of an institute is a concept which can embrace all technology as well as science. It is extremely important for the facility which becomes the marine institute to have close proximity to the sea. Without this proximity it is good in name only because unless the scientists who are interested in marine problems have very easy access to the real problems of the sea, the growth of an institute will not be the best. I think here at Dar es Salaam you have the proximity of the university to the sea so that scientists, engineers, etc., who have an interest in this problem have ready access to the area. It is most important that the institute be readily accessible by land and air transport for scientists of other countries and indeed from throughout the world.

"There must be both university and national support on a long-term basis for such an institute. Without this commitment on the part of both the university and the nation for the growth of such an institute, I think it will fail.

"The concept of a marine institute at the university has a further advantage, and that is flexibility. The problems you face today will not be the problems you face tomorrow. They will change continuously, and the university environment is one that can adapt to these changes much better than a structure based on a more rigidly defined concept. I think we have the core, the nucleus of people here at the university whose only need is to re-orient some of their interests toward the problems of the sea.

"I do not personally believe that this concept would in any way be restrictive to or would adversely affect in any way the growth of EAMFRO or any other research organization that is concerning itself with the sea. I think that your need is a national one. You can serve the community, and unless your national interests and national goals are not only well defined but actually executed, no one will come to an institute that does not show its own leadership first."

D. Krause, UNESCO, Paris

"I make two points. First, I see no major conflict between the concept of having a strong institute here at the university and that of having strong research organizations within EAMFRO as long as good planning goes into it. There is such a model, for instance, in Canada—the University of Dalhousie which has very strong research interests and cooperates fully with the government's complete research station at Bedford Institute. The Bedford Institute provides many facilities for the university and vice-versa, and the two are strengthened by their relationship. I personally think there are models in the world that you can call upon to follow.

"Second, this idea of incorporating with the UN University is, I think, a laudable one. The full UN intentions for using these institutes are not known, but it is certain that the UN will work through these institutes, probably regional institutes. Now in this regard there is no such regional institute in Eastern Africa except EAMFRO and the Research Institute, and when action is taken, although policy has not been interpreted, it will be taken through people who will use their initiative. The university should go forward with this, and if it does, it should do it right away and take the initiative. This would not take many new resources but would call for simply recognizing the resources here which are considerable already and recognizing that the embryo of an institute—perhaps more than an embryo—certainly exists. Within that context I think that considerable progress can be made either directly within the university or along cooperative lines."

M. Hyder, Zoology Department,
University of Nairobi

"It ought to be clear to everyone that if we support any movement on the campus of the University of Dar es Salaam toward marine sciences, this support is not based on an ancient gentleman's agreement but is based on present-day assessment of the situation. For the other states this is a University of Dar es Salaam development. We would wholeheartedly support such an experiment, and it's an experiment from which we all stand to profit—certainly we all stand to learn from it. If the University of Dar es Salaam wants us and asks for our backing through the Government of Tanzania, then this is something it should do. We certainly go along with it and support it.

"I think the University of Rhode Island's role in this should be seen separately from the role of the government and the university. I would like to see URI's input in this being catalytical, mainly because having expressed an interest they've brought the situation along by bringing several elements within the university and within the government together."

K. Curry-Lindahl,
UN Environment Programme, Nairobi

"To speak now of how UNEP feels about this situation which is the main subject of this meeting, that of having an institute of marine resources here in Dar es Salaam, I can say that UNEP has much sympathy for this proposal.

"When discussing marine resources during the last governing council, the Secretariat got a mandate chiefly along the following lines: It was considered that there were so many on-going projects within the UN system in the field of marine resources that UNEP's role should at present be chiefly coordinative. Nevertheless, it also got a mandate to focus or concentrate on regional problems. And in this context, when we look at what is being suggested here, we feel that the institute, whether it be purely national—attached to the University of Dar es Salaam—or regional, will serve the East African coastline because the research here will obviously be used for coastal waters. And taken this way UNEP will follow with great interest what will happen here now after this conference has set the machinery in motion.

"I think the output of the institute here will have a very great impact on all the Eastern African coastline, and I emphasise here the word 'Eastern'—I'm more concerned about Eastern Africa. So in this kind of framework I feel very strongly that UNEP could be useful in several ways to the project here—as the project could be very useful to UNEP—because in our regional approaches to marine resources' problems around the world, similar set-ups are in fact planned in various parts of the world.

"The growth as I see it should be of course progressive and gradual at the start, from a rather modest size and incorporating gradually or associating the already existing institutions within the region in a kind of cooperation and association with a system of bodies and in that way stress the regional output not only the regional structure."

A. S. Msangi, Zoology Department,
University of Dar es Salaam

"We at the University of Dar es Salaam have never been thinking in terms of empire-building in putting forth these proposals for the establishment of a marine science centre for this part of the world. We have never been thinking of paying somebody to develop the university or taking over other people's activities or treading on other people's toes as we say. We have regarded ourselves as being a national institution, and it is our duty to advise our government of the most economical means to use available manpower and resources. We can develop the considerable marine resources which are available in this part of the world.

"The way in which we think we can develop a broadly based and multi-disciplinary institute of marine resources in this part of the world is largely by the use of manpower that's already available within the bounds of the university. Without such an institute it would not be possible for us, for example, to call upon the services of, say, economists, geographers, engineers, sociologists and what-have-you to help us solve these problems in marine sciences. But by the establishment of a centre such as is envisioned within the broad bases that are outlined in the paper I have referred to, it would be possible, with only a slight increase perhaps in the manpower that is already available and the cooperation

of expertise from outside, to develop an important marine resources centre which would serve the country.

"However, in regard to the question of regional aspects of the centre, here again we have never had in mind the implication, for example, that Nairobi should not develop interest in marine biology if they want to. But we have thought it our duty since these universities are young and since we are probably the first university in Eastern Africa to go into marine biology on an acceptable scale where we can provide post-graduate facilities and research facilities.

"We thought it was our duty in putting forth these proposals to take into consideration the needs of the other universities in Eastern Africa. Obviously as these countries develop I think the time will come when perhaps our own requirements—the requirements of this country—will be such that perhaps it will be too big a body for us to be able to satisfy completely the needs of these other countries in regard to marine biologists and research scientists in these fields.

"I think at the present stage of development of the Eastern African countries perhaps one would like to say that these services that would be provided by this institute, performed by this university, will for quite a considerable length of time to come be required by the other countries and by the other universities.

"I am not opposed to the proposal put forward by Professor Wasawo and supported by Professor Hyder that perhaps it will be best for us to first of all think in terms of establishing such a centre as purely an activity of the University of Dar es Salaam. But I don't think the University of Nairobi or Kampala or any other university in Eastern Africa would be opposed to the idea that when we put this proposal forward, especially in regard to extent of funding, that we would say that this centre will be prepared and will have the facilities for assisting the other countries in the region so far as their requirements in marine sciences are concerned.

"On the question of training, we also think that this centre would provide the best institute for the training of manpower that is required for the development of marine resources in this country."

W. H. L. Allsopp, International Development Research Centre, Vancouver

"Regardless of the means by which you endeavour to establish and eventually do establish an institute for further research into the marine environment and marine science, including fisheries—when this is established and where there are requests emanating from the government of Tanzania which fall within the perspectives and terms of reference which the International Development Research Centre has established in priority areas in its pragmatic approach for interests of rural communities in the semi-arid tropics and for food supplies and other matters which are of relevance to human needs and not just pure scientific research, we of the IDRC would be very happy to support any programs or requests for proposals as submitted.

"In our concept of things a country will only find the solution to its problems when these problems have been clearly defined by the country, by nationals of the country, who clearly understand the perspective and motivations and the priorities of the country. We feel that despite all the interest and sympathy that could come from outside, including the interests of institutions like my own and many others, there still must be clear capacity of the national institutions and regional institutions to determine clearly and precisely the priorities that are needed to satisfy its people and its regional impacts.

"The longest road will start with the smallest step, and I hope one takes a clear, firm and effective step as soon as possible."

W. N. Mbote, Ministry of Tourism and Wildlife, Nairobi

"We would certainly support the setting up of such a centre by the University of Dar es Salaam, and other departments in Kenya would also welcome such a centre. I would prefer that this type of an institution be started even if only in a small way by one institution."

R. E. Morris, EAMFRO, Zanzibar

"As a University of Dar es Salaam and Tanzanian national project, this seems to us admirable for doing that sort of thing."

Participants

Dr. S. A. H. Abidi, Kunduchi Fisheries Institute
Mr. J. E. Abura, East African Harbours Corporation, Dar es Salaam
Dr. W. H. L. Allsopp, International Development Research Centre, Vancouver
Mr. C. Barnes, Economic Research Bureau, University of Dar es Salaam
Mr. K. H. Bain, FAO, Dar es Salaam
Prof. P. Bomboe, Geology Department, University of Dar es Salaam
Mr. D. Bryceson, Director of National Parks, Dar es Salaam
Mr. I. Bryceson, Zoology Department, University of Dar es Salaam
Prof. S. M. Constantinides, University of Rhode Island
Mr. K. Curry-Lindahl, UN Environment Programme, Nairobi
Prof. R. Geigy, Swiss Tropical Institute, Basel
Mr. J. J. Griffin, University of Rhode Island
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