

Instituut voor Zeewetenschappelijk onderzoek  
Institute for Marine Scientific Research  
Prinses Elisabethlaan 69  
8401 Bredene - Belgium - Tel. 059 / 80 37 15

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# KENYA

## REPORT

JULI 1986.



## LABORATORIUM VOOR EKOLOGIE EN SYSTEMATIEK

FAKULTEIT WETENSCHAPPEN  
VRIJE UNIVERSITEIT BRUSSEL

PLEINLAAN 2  
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18635

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# KENYA

## REPORT

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Prof. Dr. Polk, Ph.  
Mombasa, July 1986



## 1. Foreword

This is the first review report on the Kenyan-Belgian Project in Marine Ecology (KBP).

It explains our approach and methodology : the linkage between equipment, education and research. Interaction between fundamental and applied research.

Real co-operation between Kenyan and Belgian Scientists.

We are always accessible to remarks and advices and hope to be able to continue.

leave to work as a director and co-ordinator for the project.

The Authorities of KMPRI, who provided the necessary help to welcome the project, who helped us finding our way and gave us the necessary room to develop the project in an optimal way.

Prof. Dr. Polk, Ph.

Mombasa, July 1986

The N.V. Volvo, who lend us, via the VUB, a splendid car for the project. The work done up to now, is due for an important part to the use of the Volvo. Unfortunately the Kenyan driver had an accident with it and the car was totally destroyed.

The N.V. Olivettei, who via the help of the VUB, gave us a typewriter and a Computer. The fact that we need a second computer and a word-processor, shows that the equipment is used in an optimal way.

Thanks to the Belgian experts who, together with their Kenyan homologues, worked very hard and conscientious and by doing so implanted a scientific spirit in the KBP.

The Kenyan technicians, sampling and analysing day and night are at least as important as the scientists.

Thanks to Ingrid, the administrative help, who succeeded in setting right the administration of the project, which was a complete chaos before her arrival.

Els, who came at the moment I had to go to hospital and who assured the continuity and organisation of the scientific work during my absence.

All these synergies of different phenomena made that the Belgians are feeling at home in Kenya, at 8000 km from their country.

But only an 8 hour flight away with SABENA, who always gave us a good service.



## 2. Acknowledgement

We like to thank, in the first place, both governments, the Kenyan and the Belgian, for initiating a program on Marine Sciences and to put confidence in the Kenyan and Belgian Scientists.

We thank the administrations who made it possible to work out and run the project.

We are also grateful to the Authorities of the Free University of Brussels (VUB), who gave me the opportunity to go on partial leave to work as a director and co-ordinator for the project.

The Authorities of KMFRI, who provided the necessary help to welcome the project, who helped us finding our way and gave us the necessary room to develop the program in an optimal way.

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### 3. Introduction

The aim of the project was to develop a program on Marine Ecology and the Management of the Coastal Zone (living and non-living resources).

We started the inventory and descriptions of the different Marine biotopes and their trophic levels. This fundamental research guided us to initiate applied research : we started a small-scale oyster culture to prevent the loss of the high primary production of the mangrove creeks. By doing so we provided work for the local population and used only local materials for the building of the rafts.

Both, the fundamental and the applied research must go on with the present project as backbone. Other, subprograms, fitting in the framework of the KBP, will be added. A common project between Kenyan and Belgian Universities will be worked out and submitted to the EEC, on specific mangrove research.

The Belgian experts will submit an interuniversity program for fundamental research to the National Science Foundation.

And in collaboration with the KMFRI and the Kenyan and Belgian Universities, we will organise a Regional Course on Marine Biology, with the support of UNESCO and UNEP.

In this way, we will cover most of the aspects of Marine Ecology, needed for the Management of the Coastal Zone.

4.8. Dr. Somers, E.\* (May 10 - 26, 1985) University of Ghent  
Law of the Sea.

4.9. Dr. Bergmans, M.\* (April 12 - May 16, 1985) University of Brussels - Taxonomy, Harpacticoids.

4.10. Prof. Dr. Ronday \* (May 1985) University of Liège - Physical Oceanography.

4.11. Dr. De Greve, J.P.\* (June - July 1985) University of Brussels - Computer Sciences.

4.12. Dr. Coppejans, E.\* (June 21 - July 28, 1985) University of Ghent - Phycology.



#### 4. The Belgian Experts and the Kenyan Homologues

4.13. Drs. Revis, N. (September 12 - October 10, 1985) University of Limburg - Taxonomy & Copepods.

The residential expert, Prof. Dr. Polk, arrived in Kenya on the 17th of December 1984. When he has to leave Kenya in order to fulfill his obligations in Belgium (for courses and examinations at the Free University of Brussels or important meetings of the National Science Foundation, EEC, etc.) he has, each time, been replaced by a Belgian expert.

Thus, up to now, the following experts have worked in Kenya :

- 4.1. Prof. Dr. Declair, W.\* (January 3 - January 27, 1985) University of Antwerp - Ecophysiology.
- 4.2. Prof. Dr. Egghe, L.\* (January 27 - February 13, 1985) University of Limburg - Librarian Sciences.
- 4.3. Drs. Pissiersens, P.\*\* (January 27 - February 13, 1985) University of Brussels - Computer Sciences.
- 4.4. Dr. Heip, C.\* (February 1 - 23, 1985) University of Ghent - Benthos.
- 4.5. Dr. Dehairs, F.\* (February 1 - 23, 1985) University of Brussels - Marine Chemistry. (see annex 1 & 7).
- 4.6. Dr. Daro, N.\* (March 15 - April 12, 1985) University of Brussels - Plankton.
- 4.7. Dr. Frijdal, A. (April 6 - 19, 1985) University of Brussels Computer Sciences.
- 4.8. Dr. Somers, E.\* (May 10 - 26, 1985) University of Ghent Law of the Sea.
- 4.9. Dr. Bergmans, M.\* (April 12 - May 16, 1985) University of Brussels - Taxonomy, Harpacticoids.
- 4.10. Prof. Dr. Ronday \* (May 1985) University of Liège - Physical Oceanography.
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- 4.12. Dr. Coppejans, E.\* (June 21 - July 28, 1985) University of Ghent - Phycology.



- 4.13. Drs. Revis, N. (September 12 - October 10, 1985) University of Limburg - Taxonomy & Copepods.
- 4.14. Dr. Coppejans, E. & Drs. Beeckman, T. (January 8 - February 8, 1986) University of Ghent - Phycology . (see 4.12.)
- 4.15. Dr. Daro, N.\* (January 30 - February 27, 1986) University of Brussels (see 4.6.)
- 4.16. Dr. Martens, E. (April 20 - July 30, 1986) University of Limburg
- 4.17. Drs. Tackx, M. (May 23 - June 21, 1986) University of Brussels - Plankton & Seston.
- 4.18. Dr. Dehairs, F.\* (June 21 - July 28, 1986) University of Brussels - Marine Chemistry.

\* Several of the short-term experts developed specific programs with the Kenyan counterparts. (see 8.2.1)

\*\* Drs. Pissiersens, P. is currently employed by KMFRI. He is doing our computer work and, with his practical knowledge, is a great asset to the project. (see annex 1 & 7).

We also had the assistance for the research done on underwater ecology (coralreef ecology & marine algae) of the divers Martens D., Elskens, H. and Sweefelt, J. from Vilvoorde, Brussels.

We hope to develop in the near future, with their help, a Scientific Diving Centre.

will participate in the programs and use the equipment, can be fully informed on the present infrastructure. (annex 2).



## 5.2. Transport

### 5. Equipment

#### 5.1. Laboratory Equipment

The equipment provided by the Belgian Government, is mentioned in annex 2.

There is a basic equipment for Marine Research and extra material is bought in function of the research.

The equipment is now stored in two air-conditioned labs at KMFRI. When this equipment is needed for research, it is registered and used by the scientist who remains responsible for it. When he doesn't need the instrument anymore, it is checked and put back in the store.

Nevertheless, equipment regularly used in the field, is ruined too fast due to the high temperature, the humidity and salinity of the environment. The fast substitution of the field equipment is unavoidable. So, extra responsibility is asked from the scientists and technicians.

At present the Computer Section is functioning very well. We plan to buy a second, bigger computer, a word processor and a photostat, as the input of scientific data, the documentation centre and the administration of the project are growing fast.

But we request urgently the Kenyan Authorities to provide a generator, to prevent the spoiling of programs and work due to power failure, as happened before.

As the present equipment is listed on computer, and the listing is regularly updated, other African and European Scientists who will participate in the programs and use the equipment, can be fully informed on the present infrastructure. (annex 2).

and is still broken down.

To assure the continuity of the work, we rented a car on our own expenses. Indeed, if some ecological work is not done at certain moments, we are losing a whole year.

Our remarks on this matter are pertinent: what will happen



## 5.2. Transport

The difficulties of transport the project is facing, are tremendous. We insist on both governments to find a solid solution for this primordial problem.

### 5.2.2. The Boats

#### 5.2.1. The Cars

The Kenyan-Belgian Project used to have two cars. One car given by the Belgian Government (Renault 9) and one lent to the University of Brussels for the project, by the N.V. Volvo.

As sampling at different biotopes at the same time is sometimes necessary (e.g. spring-tides), the two cars were used in an optimal way. But unfortunately, the Kenyan driver appointed by the Institute had an accident and the Volvo was totally destroyed. He drove too fast, was blinded by oncoming cars and crashed at full speed into a lorry, stationed on the road without lights nor reflectors. Luckily he was driving a Volvo, otherwise he would have been killed on the spot.

When asked for help to the Belgian Co-operation Section in Nairobi we got the answer we had to wait until the mixed commission meets in October 1986. But in the meantime the project has to go on, and for that regularly sampling has to be done in different places along the coast.

From the Ministry in Brussels we got the original and friendly telex saying : "... look for another maecenas!!!"

No written reply came from the Kenya Authorities although Article 6.4. of the Agreement is very clear on this matter. KMFRI gave at the disposal of the project a fourwheel-drive. Two weeks later, this car was also damaged in a car accident and is still broken down.

To assure the continuity of the work, we rented a car on our own expenses. Indeed, if some ecological work is not done at certain moments, we are losing a whole year.

Our remarks on this matter are pertinent: what will happen



with the destroyed car?

To be able to do our research in an optimal way, the project needs two safe, solid, all-roads cars.

## 6.1. Introduction

### 5.2.2. The Boats

The Kenyan-Belgian Project needs at the moment a small boat with an outboard motor. At KMFRI there is one, in a very bad condition, another one has been stolen. Our work is badly hampered by this.

It is also unacceptable in view of safety standards that there is only one boat that can be used for the sampling in Tudor Creek.

This principle was worked out and explained to the Librarian of KMFRI, by Prof. Dr. Egghe (University of Limburg). In collaboration with Mrs. Mwobobia, Librarian at KMFRI, we were able to start the Documentation Centre.

## CONCLUSION

If the Kenyan-Belgian Project wants to succeed in all her aims and if it will become the nucleus of a Centre with Regional importance, then a solution for the transport (cars and boats) must be worked out. This is only possible if both parties take their responsibilities.

The listing of the literature present is found in annex 3.

## 6.3. Extension of the Project

The KBP Documentation Centre is extending its scope: at the moment, we are doing the same work, with the same methodology for the Marine Scientists of the University of Nairobi and



## 6. The Documentation Centre

### 6.1. Introduction

Up-to-date literature is a sine qua non for research. We need the necessary recent publications related to the research-objects, but financially we can't afford a complete overview of Marine Publications.

Magazines, where only a few articles a year are of direct interest, are too expensive in the actual situation. Therefore, we opted for an as complete as possible 'SELECTIVE SYSTEM'. We need and purchase the adequate literature for the ongoing research.

This principle was worked out and explained to the Librarian of KMFRI, by Prof. Dr. Egghe (University of Limburg). In collaboration with Mrs. Mwobobia, Librarian at KMFRI, we were able to start the Documentation Centre.

### 6.2. Present Situation

At present we have more than 25.000 pages of scientific literature, regarding the ongoing research. The literature has been bound, registered and dispatched to the scientists. The listing of the literature present is found in annex 3.

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## 7. Education

the Regional Dugong Project of IUCN (International Union for the Conservation of Nature). To develop the present Centre into a Regional Centre, we have to establish a practical catalogue (keywords, computerisation, dispatch facilities etc.). To work out these aims, we will send Mrs. Mwobobia to the University of Limburg - Belgium (Prof. Dr. Egghe).

During the Regional Course of UNESCO (see 7.5.) we will have the opportunity to convert the Centre into a Regional one. Established personal collaboration in the laboratory or the field, with the Kenyan homologues during their stay. If necessary, we try to obtain fellowships to send African Scientists to a Belgian Laboratory for up-to-date specialisation (see 7.3). Some of those collaborations result into full programs. (Annex 15)

### 7.2. Kenyan Scientists working in the KBP

7.2.1. At the occasion of the visit of Mr. Beck, Head of the Co-operation Section at the Belgian Embassy in Nairobi, at the KBP, every Kenyan Scientist working in the framework of the project, gave a seminar on his work. (see annex 4).

7.2.2. An important contribution to the International Congress on Tropical Aquatic Ecosystems (UNESCO - October 1985 in Nairobi), was presented by several Kenyan Scientists. Their conferences belonged to the best ones and their data were on an international level. (annex 5)

7.2.3. UNEP funded two fellowships for East-Africa for the International Workshop on Coralreef Ecology. (Phillipines, Manila May 1986). One of them was for a member of the KMFRI-staff working in the KBP. (Annex 16)

## CONCLUSION

As in every Institute, anywhere in the world, we have at KMFRI some very good, motivated scientists whom merit the necessary help and facilities to continue their research.



## 7. Education

### 7.3. Fellowships

We consider "education" as a combination of 'theory' and 'praxis'. Which is of course only possible when we have the equipment.

The Belgian Government, provided us, after discussion with the Kenyan Authorities, the necessary fellowships.

#### 7.1. Visiting Experts

Each visiting expert gave one or several seminars on his own speciality, to the scientific community of KMFRI. They established personal collaboration in the laboratory or the field, with the Kenyan homologues during their stay. If necessary, we try to obtain fellowships to send African Scientists to a Belgian Laboratory for up-to-date specialisation (see 7.3). Some of those collaborations result into full programs. (Annex 18)

The Kenyan students of KMFRI are Mr. Odido and Mr. Oteko.

On the request of the Kenyan Authorities, there will be one

#### 7.2. Kenyan Scientists working in the KBP

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work of the project, gave a seminar on his work. (see annex 4).

In 1985, a fellowship was offered to Mr. Kazungu (KMFRI-KBP),

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Their conferences belonged to the best ones and their data were on an international level. (annex 5)

In 1986, specialisation in Marine Ecophysiology (Prof. Dr. Declair - University of

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(Prof. Dr. Egghe - University of Limburg).

## CONCLUSION

As in every Institute, anywhere in the world, we have at KMFRI some very good, motivated scientists whom merit the necessary help and facilities to continue their research.



### 7.3. Fellowships

#### 7.3.1. The Belgian Government

The Belgian Government, provided us, after discussion with the Kenyan Authorities, the necessary fellowships.

##### 7.3.1.1. Long-term fellowships

The Belgian Government provided two long-term fellowships for Kenyans, to follow the Postgraduate two years course 'FAME' (Fundamental and Applied Marine Ecology). This Postgraduate course on an interuniversity basis results into a Masters Degree. (Annex 17)

The Kenyan students of KMFRI are Mr. Odido and Mr. Oteko. On the request of the Kenyan Authorities, there will be one specialisation in Physical Oceanography and one in Marine Pollution (Prof. Dr. Ronday and Dr. Baeyens (Phys. Ocean.) and Dr. Dehairs - Marine Pollution)

##### 7.3.1.2. Short-term fellowships

In 1985, a fellowship was offered to Mr. Kazungu (KMFRI-KBP), who specialised in nutrient-determinations, during three months. He came back with extra equipment in order to continue his work in Kenya. (Dr. Dehairs, Lab. For Analytical Chemistry, University of Brussels). (annex 6)

In 1986, two fellowships are offered for a five month specialisation in Marine Ecophysiology (Prof. Dr. Declerck - University of Antwerp). The Kenyan Scientists are Mrs. Okoth and Mr. Omolo. They left Kenya on May 19, 1986.

Another fellowship is promised to Mrs. Mwobobia, Librarian for computerisation of the Documentation Centre (Prof. Dr. Egghe - University of Limburg).



#### 7.4. The Kenyan Universities and the KBP

In March 1986, the students of the University of Nairobi (Dept. of Zoology) visited the experimental oyster cultures at Gazi.

#### 7.3.2. Belgian Government and Internatinal Organisations

For the end of 1986, a mixed fellowship (airticket from UNESCO and a two months stay in Belgium from the Belgian Government) is offered to Mr. Ruwa, R.K. (KMFRI-KBP) for specialisation in Quantitive Ecology (Dr. Heip - University of Ghent).

#### 7.3.3. International Organisations

In 1986 a fellowship is offered by UNEP to Mrs. Muthiga, KMFRI-KBP for a workshop in the Phillipines on Coralreef Ecology. (see also 7.2.3.) (Annex 16)

### **CONCLUSION**

In 1985 and 1986 we obtained from the Belgian Government, scholarships for 7 scientists for specialisation in Belgium and 6 return tickets Nairobi-Brussels-Nairobi.

The International Organisations gave us two airtickets and a two week stay.

We like to thank the people in the different Institutions who were responsible for delivering these fellowships. We can assure those people that these grants are being used in an optimal way. We hope we will have the same or even a better cooperation in the future.

Assistance and collaboration was asked by:

Mr. Little, M. U.K. Plymouth Technical High School. Mangrove area as spawning and nursery grounds.

Mr. Orr, D. Canada. Feeding mechanisms by shrimps. FAO-project in Malindi.

Mr. Weston, J. U.S.A New York. Total Environmental Study of the oyster cultures.

### CONCLUSION

The KMFRI and the KBP are de facto becoming very important for Marine Sciences in East Africa.



#### 7.4. The Kenyan Universities and the KBP

In March 1986, the students of the University of Nairobi (Dept. of Zoology) visited the experimental oyster cultures in Gazi. Prof. Dr. Polk gave a field course on the theoretical and practical scientific approach on oyster cultures and Mangrove biotopes.

In April 1986, the teaching staff of Kenyatta University (Dept. of Zoology) visited Gazi. Mr. Ruwa (KMFRI-KBP) gave them a field course on oyster cultures.

In May 1986, the students of the Naivasha Fisheries and Wildlife Training Institute, visited Gazi & KMFRI. Mr. Ruwa and Dr. E. Martens gave them an introduction on mangrove systems and a contribution in the field.

#### 7.5. Regional seminar on Fundamental and Applied Marine Ecology

UNESCO-Nairobi requested the KBP to organise in 1986 a Regional Seminar on Fundamental and Applied Marine Ecology. We'll organise this course in Mombasa at KMFRI in collaboration with the Kenyan and Belgian Universities (extra funds have been asked from the Belgian Government and the International Organisations. We'd like to organise the seminar with a regional follow-up.

#### 7.6. Cooperation between KBP and other scientists

Assistance and collaboration was asked by:

Mr. Little, M. U.K. Plymouth Technical High School. Mangrove area as spawning and nursery grounds.

Mr. Orr, D. Canada. Feeding mechanisms by shrimps. FAO-project in Malindi.

Mr. Weston, J. U.S.A New York. Total Environmental Study of the oyster cultures.

#### CONCLUSION

The KMFRI and the KBP are de facto becoming very important for Marine Sciences in East Africa.



PROJECT	KENYAN RESPONSIBLE	BELGIAN RESPONSIBLE
General Supervision	Mr. Allela, S.O.	Prof. Dr. Polk, Ph.
Computer Section	Ms. Ogaye, W.	Mr. Pissiersens, P.
Documentation Centre	Mr. Onyango, H.	
Mangrove Ecology	Mrs. Mwobobia, J.	Prof. Dr. Egghe, L.
Plankton Ecology	Mr. Ruwa, R.K.	Dr. Heip, C.
	Mr. Okemwa, E.	Dr. Daro, N.
	Ms. Kimaro, M.	Drs. Tackx, M.
	Ms. De Souza, M.	
Phycology	Mrs. Oyieke, H.	Dr. Coppejans, E.
		Drs. Beeckman, T.
Marine Chemistry	Mr. Kazungu, J.	Dr. Dehairs, F.
Coralreef Ecology	Mrs. Muthiga, N.	Prof. Dr. Polk, Ph.(1)
Prawns Biology	Mr. Wakwabi, E.O.	Prof. Dr. Polk, Ph.(1)
Fish Biology	Mr. Nzioka, R.M.	Prof. Dr. Polk, Ph.(1)
Ecophysiology	Mrs. Okoth, B.	Prof. Dr. Declair, W.
	Mr. Omolo	
Oyster Culture	Mr. Ruwa, R.K.	Prof. Dr. Polk, Ph.
	Mr. Okemwa, E.	
Biochemistry in Marine Organisms (Food Quality)	Ms. Abubaker, L.	Prof. Dr. Polk, Ph.(1)
	Mr. Oduor	

### 8.2.1. General Research

#### (1) Provisional

The Kenyan and Belgian Experts are working in the biotopes

See also Annex 8 (1-11) : ongoing work

Each ad hoc individual research program has to be integrated in a holistic model, indicating the pathways and quantities of energyfluxes through the Ecosystem.

The following Scientific Programs are in progress:



### 8.2.2. Specific Research on Oyster Culture

## 8. Research

### 8.1. Introduction

The interaction between fundamental and applied research must enable us to obtain a global long-term management of the Coastal Zone. The priorities are:

- a) an increase of protein production or other valuable sea-products.
- b) to put a halt to the degradation and destruction of the marine environment for short-term profits.

To fulfill these aims in a pragmatic way, we consider four different biotopes, going from land to the sea:

1. The Mangrove areas
2. The Inshore Waters
3. The Coralreef
4. The Outshore Waters

### 8.2. Ongoing Research

#### 8.2.1. General Research

The Kenyan and Belgian Experts are working in the biotopes 1, 2 and 3.

Each ad hoc individual research program has to be integrated in a holistic model, indicating the pathways and quantities of energyfluxes through the Ecosystem.

The following Scientific Programs are in progress:



### 8.2.2. Specific Research on Oyster Culture

The Kenyan and Belgian Authorities insisted, after studying our intermediate reports, to focus on oyster culture.

We can fully approve this for the following reasons:

1. The watercolumn in the Mangrove creeks has a very high primary production (more than 100 ton a day for Kenya). This potential high valued "food" is at the moment washed out in the Ocean without use.
2. Culturing oysters in a tridimensional biotope, we can have a conversion up to 20%, 7.5 X more efficient than culturing cattle.
3. 1.000 oysters/M<sup>2</sup> can be cultured, or 10 million per ha. (Kenya has 52.000 ha of mangrove area).
4. Oyster cultures are labour-intensive and can provide work for the local villagers.
5. The necessary investment is very low: only local material is requested (mangrove poles, nylon strings, marine cement, local labour) besides research.
6. There is already a home-market for oysters due to Kenya's tourist industry. But, as this market of collecting wild oysters becomes insufficient, the culture of oysters is needed.
7. The oyster biotopes in the industrialised world are deteriorating more and more, due to industrial pollution. The demand for oysters is increasing on the world market.
8. A first class road along the coast from Malindi to Tanzania, an International Airport in Mombasa and a direct railway communication Mombasa-Nairobi facilitates the transport of oysters.
9. Oysters are protein-rich sea products. With the modern communication network (newspapers, weeklies, broadcastong and television) and publicity techniques, we can try to integrate this product in the local food-customs (annex 9).



10. In the sheltered Mangrove Creeks, the possibilities of destruction of the infrastructures by tempates, as in the Far East, are low.

1. Non-encrusting Macroalgal Zonation on Rocky cliffs around Mombasa, Kenya.

8.2.3. Scientific Publications (Annex 15)

If scientific results are consistent, we publish them in the Kenyan Journal of Science and Technology Series, the African Journal of Ecology or in Hydrologia, so that they are accessible for the scientific community.

Kimaro, M.

8.2.3.1. Accepted Scientific Papers

1. The Autecology of the Edible Oyster Crassostrea cucculata Born, 1778 : Size realted distribution at Mkomani, Mombasa, 1986, Kenyan Journal of Science and Technology Series.  
Okemwa, E.; Ruwa, R.K. & Polk, P. (annex 10)
2. Some observations and remarks on Mangrove Distribution in Kenya. Kenyan J. Science & Techn. Series.  
Ruwa, R.K. & Polk, Ph. (Annex 11)
3. The biology of Marine Copepods in Kenya Waters.  
Planktonic Copepods from Coastal and Inshore Waters of Tudor Creek. Kenyan J. Science & Techn. Series.  
Okemwa, E. & Revis, N. (Annex 12)
4. Changes in Kenyan Coralreef community structure and function due to exploitation. Hydrologia.  
McClanahan, T.R. & Muthiga, N.A. (Annex 13)
5. Changes in the population structure of the sea urchin Echinometra mathaei de Blainville at Diani Beach, Mombasa Kenya. African J. of Ecology.  
Muthiga, N.A. & McClanahan, T.R. (Annex 14)



#### 8.2.3.2. Submitted Papers

##### 9. Future and extension of the Kenyan-Belgian Project

1. Non-encrusting Macroalgal Zonation on Rocky cliffs around Mombasa, Kenya.

Oyieke, H.A. & Ruwa, R.K. (Annex 15)

##### 9.1.1. The Belgian Ministry of Cooperation

#### 8.2.3.3. Papers in preparation

1. The Diurnal Cycle of Zooplankton in Tudor Creek during the Southeast Monsoon.

Kimaro, M.

2. Relative abundance, diurnal and seasonal variation of the zooplankton entering and going out of Port Reitz Creek,

Mombasa, Kenya.

Okemwa, E.

3. Aspects of the biology of the reef fish Scolopsis bimaculatus (Ruppell 1828) in Kenya. II Age, growth and mortalities.

Nzioka, R.M.



## 10. The "Belgian House" in Nyali

### 9. Future and extension of the Kenyan-Belgian Project

#### 9.1. Belgium as the backbone for the project

and his family. The house, located in Nyali, has hosted not

##### 9.1.1. The Belgian Ministry of Cooperation

African, European and American scientists used the infrastructure of the Belgian House.

The Belgian Ministry of Co-operation gave us the opportunity to start the Kenyan-Belgian Project and as, it has been insisted we will stress the present project on oystercultures. (see 8.2.2) Presently, 150.000 oysters (May 1986) are growing at Gazi. It only depends on the possibilities of investment to increase this number and to start, after discussions with the authorities, a semi-commercialisation or even a big-scale commercialisation. But we have to switch, as soon as possible, from an incomplete oysterculture (culturing wild oysters) to an integral oysterculture (from spatfall till marketable oysters). To collect spat ad-illimitum seems succesfull (May-June '86). The possible bottle-neck from spat till marketable size has to be studied and tested out (1987-88), as well as the fauling problems (June-July '86).

We hope that the Ministry of Co-operation will give us those possibiblities and remains the backbone for the follow-up and extension of the project.

We also asked our Ministry of Co-operation an extra subvention for the organisation of the regional course, to be used for the Belgian experts.



## 10. The "Belgian House" in Nyali

Untill now , the KBP-staff had no serious health problems. The Kenyan Government offered housing to the Belgian Resident and his family. The house, located in Nyali, has hosted not only all the Belgian Experts, but also African, European and American scientists used the infrastructure of the Belgian House. At the moment (July '86) our visitor's book has exactly 111 signatures and nearly as many creative suggestions, remarks or proposals. We hope that the Kenyan and Belgian Governments will give us the possibility to continue this melting-pot of International Scientific creativity and friendship.

"When I'm in Belgium and if I need to undergo an operation, I'll come back to Mombasa Hospital!"

Prof. Dr. POLK



## 11. Health-Care & Medical Services

Untill now, the KBP-staff had no serious health problems. For minor health problems of the permanent resident, hisly, children or the Belgian Experts, the Kenyan Authorities or fullfilled totally their obligations.

When the Director of the KBP had to undergo an operation, everything happened in optimal conditions with a very helpfull-administration. With his overspecialised scientists, this

Our congratulations to the Kenyan Authorities and the staff of the Mombasa Hospital. lead to a better Management of an

important part of a not-yet-totally-destroyed environment in East-Africa, then we would like to continue this work.

For some years...

"When I'm in Belgium and if I need to undergo an operation, I'll come back to Mombasa Hospital!"

Prof. Dr. POLK



## 12. Post-Scriptum

As the responsible for the KBP, I'm happy to send this report to those persons who followed the experiences attentively, who helped us often in an enthusiastic way, practical or spiritual.

If the results of the KBP will lead to a stronger cooperation between Kenya, this beautiful country with so many potentialities, and Belgium, with his overspecialised scientists, this will be positive for both countries.

And if the results will lead to a better Management of an important part of a not-yet-totally-destroyed environment in East-Africa, then we would like to continue this work. For some years...

### 2. Zooplankton in the Tudor Creek

Kimaro, M.

### 3. Phycology study at Mackenzie Point, Mombasa

Oyieke, H.A.

### 4. Study on the nutrients in Kilindini and Tudor Estuaries.

Kazungu, J.M.

### 5. Study on mayor Peneidae shrimps in Tudor Creek.

Wakwabi, E.O.

### 6. The estuary fishes of Kenya.

Nzioka, R.M.

### 7. Fish quality parameters in Mombasa markets.

Oduor, P.M.

### 8. Biochemical levels in oysters.

Abubaker, L.U.

### 9. Mangrove ecology.

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### 10. Gazi oyster project.

Ruwa, R.K.

### 11. Coral Reef Ecology.

Muthiga, N.

### 9. Articles of Reuters on the oyster culture : Kenya, Belgium, Malaysia.



10. The autecology of the edible oyster Crassostrea cucullata

1778 : size related vertical distribution at Mkomani,  
Mombasa.

13. Annexes

1. Computer Section : Activities. Pissiersens P.; Ogaye W. & Onyango H.
2. List of the laboratory equipment (21/7/86)
3. List of the publications available in the Library of KMFRI.
4. Lectures given during visit of Mr. Beck.
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9. Articles of Reuters on the oyster culture : Kenya, Belgium, Malaysia.



10. The autecology of the edible oyster Crassostrea cucullata Born, 1778 : size related vertical distribution at Mkomani, Mombasa.

Okemwa, E.; Ruwa R.K. & Polk, P.

11. Some observations and remarks on mangrove distribution in Kenya.

Ruwa, R.K. & Polk, P.

12. The biology of Marine Copepods in Kenyan waters.

Okemwa, E. & Revis, N.

13. Changes in Kenyan coral reef community structure and function due to exploitation.

McClanahan, T.R. & Muthiga, N.A.

14. Changes in the population structure of the sea urchin

Echinometra mathei de Blainville at Diani Beach, Mombasa/Kenya  
Muthiga, N.A. & McClanahan T.R.

15. Non-encrusting macroalgal zonation on rocky cliffs around Mombasa, Kenya.

Oyieke, H.A. & Ruwa R.K.

16. Report on the workshop on Coral Reef Ecology in the Phillipines  
Muthiga, N.

17. F.A.M.E. : Program of the courses.

18. Instruction Manual on Field and Laboratory Sampling work for Laboratory Assistants.

Dr. Martens, E. Pissiersens, P.

#### c/ Word processing

Following the collection and treatment of the data, Scientific reports and articles have been and will continue to be written. To enable the Scientists to present decent publications, typed within a short period, the Computer Section offers a Word-Processing service. ( Since June 1986 )



## ANNEX 1

### 13. Annexes

#### **KENYA - BELGIUM COOPERATION IN MARINE SCIENCES**

##### Activities of the KBP-KMFRI Computer section

###### **1/ Introduction**

The computer section is active in three fields : Administration , Science and Word-processing .

###### **a/ Administration**

As the Institute currently employs over 680 people , divided over 4 stations ( Mombasa , Kisumu , Turkana , Sangoro ) , handles over 5000 accountancy vouchers a year and has more than 1500 items on the stores inventory , automation of the Administration has become a must . Until the installation of the Computer Section , all the information had to be handled manually . Due to the time , consumed by the treatment of all these data , valuable time was lost for management in general .

As good management and Scientific Research have to go together in an Institution of this size , it was decided that Salaries Section , Personnel Section , Stores Section and Accounts were to be computerised .

###### **b/ Science**

There are now 36 Research Officers in the Institute ( Mombasa ) . If they work at their full capacity , a lot of valuable Scientific information is produced .

They work in different fields : Marine chemistry ( Nutrients , Pollution ) , Phytoplankton , Zooplankton , Coral Reef ecology and Fisheries , corresponding with the different trophical levels . Furthermore , there are Geologists and Physical Oceanographers .

If we combine the data , collected by the different groups , we can start making an ecological model ( as it has been done in Belgium for the Mathematical Model for the North-Sea and the Scheldt Estuary ) . As it has been proven in many parts of the World such Models can be of great importance to the Fishing Industry , Fisheries Management and Coastal Management , the prime task of this Institute .

###### **c/ Word processing**

Following the collection and treatment of the data , Scientific reports and articles have been and will continue to be written . To enable the Scientists to present decent publications , typed within a short period , the Computer Section offers a Word-Processing service . ( Since June 1986 )



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  11. Coral Reef Ecology. Muthiga, N.
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### 3/ Future

After completion of the Stores Program, we will continue with writing a  
2/ History and present of the Computer Section

At the same time we will start with the Scientific data-base. The importance of  
Thanks to the arrival of an Olivetti M21 microcomputer ( with 640 KBRAM and  
2x 360 KB floppy -disks ), donated by the Free University of Brussels, the  
computer Section started its activities around March 1985. In March 1985 and  
May 1985, experts from Belgium ( Dr. J.P de Greve & Mr. P.Pissierssens, Free  
University of Brussels ) came to Mombasa to give a first introduction to the use  
of the equipment.

In October 1985, a Belgian APOS volunteer ( Peter Pissierssens ref.nr  
704745 ) was employed by the Institute for two years to set up the Computer  
section and train local staff. of the Free University of Brussels ( Faculty of  
His Kenyan counterparts are Miss Winnie Ogaye and Mr. Hezborne Onyango.  
Furthermore, several employees of each section concerned ( Salaries, Personnel  
, Stores, Accounts and Science ) have been or will be trained to use the  
computer(s).

Another computer ( Kaypro 1 ) was donated by UNESCO. This unit is to be used  
for introductory lessons in BASIC computer language. Due to its memory  
limitations and less powerful processor it can not handle big tasks.

These will enable us to handle the Scientific data in the  
able to handle all the described tasks. For the Scientific-data base, for the

In October 1985 we started the activities of the Section with the design of a  
Store Mangement system ( using software package Open Access ) for the Equipment  
and chemicals, purchased by the Kenya Belgium Project ( Oceanography ). This  
enables us to keep a continuous record of the quantities in stock. Furthermore  
, we can foresee running-out of chemicals in advance so they can be purchased in  
time. To visiting experts, we can give an updated list of equipment and  
chemicals ( and send it to Belgium before their visit ) so they can plan their  
visit, according to the present equipment and bring with them what is missing.

Around December 1985, we started writing the Program for the Payroll of the  
Institute. This program calculates the salaries, prints pay-slips, generates  
reports, prints vouchers which are sent to the banks, performs cash-breakdown  
for cash-payments etc. We started using the Program fully from May 1986 on.  
To enable employees from Salaries section and Personnel section to operate the  
Program, a detailed User's Manual was written ( see attached ).

Around February 1986, Researchers have started coming to the Computer  
Section with Scientific data. To handle these data, small Scientific data-  
bases were set-up, together with Graphics and Statistical Analysis Software.  
Through the Faculty of Applied Science and Faculty of Science ( Section  
Informatics ) we will probably get even more software for this purpose !

In July, we have started writing programs for the Stores section, which  
will handle the complete inventory, produce monthly reports on the Stock  
balance and keep track of all of the inventorised items. Purchase orders will  
be printed automatically as well.



DE	DESCRIPTION	UNIT	REMBAL	ISSUED	NEWBAL
ETAC	ACETIC ACID	ML	1000.0	100.0	900.0
CTAN	ACETON	ML	40000.0	43420.0	16580.0
NO3	SILVER NITRATE	gram	700.0	200.0	500.0
172	3/ Future IZARIN RED	gram	100.0	0.0	100.0
SCAC	ASCORBIC ACID-L(+)	gram	400.0	211.5	188.5
112	After completion of the Stores Program , we will continue with writing a Program for Accounts .	gram	500.0	0.0	500.0
112	At the same time we will start with the Scientific data-base . The importance of this was already described above .	ml	1000.0	0.0	1000.0
112	Furthermore,in cooperation with the University of Limburg ,Belgium ,a Scientific Publication Data-base will be set-up ( The Librarian , Mrs. Janet Mwobobia will visit the LUC (Prof.Dr.L.Egghe)in a few months to learn how to use this data-base , which was created in the LUC and has been used there for some time )	amp	1.0	0.0	1.0
112	Thanks to the cooperation of the Free University of Brussels ( Faculty of Science , Faculty of Applied Science , Faculty of Economic , Social and Political Science ) we received a considerable package of computer software ( language compilers for PASCAL,COBOL,C , SPSS ( Statistical Package for the Social Sciences ) ) . These will enable us to handle the Scientific data in the most advanced way .	gram	1250.0	750.0	500.0
112	However , it has become clear that the present computer hardware will not be able to handle all the described tasks . For the Scientific-data base, for the SPSS program as well as for the Scientific Publication data-base , a Hard-disk is neccessary as information storage medium .	ml	2500.0	1450.0	1050.0
112	Therefore , we have planned the purchase of an Olivetti M24 SP microcomputer with a 20 MB HDU around August , this year , if approved by ABOS. If later more M24-units would be purchased , a Local network is possible .	gram	50.0	50.0	0.0
112	Computer Section staff :	ml	60000.0	56000.0	4000.0
112	Mr. B.A.H Onyango ( KMFRI )	gram	250.0	50.0	200.0
112	Miss W. Ogaye ( KMFRI )	gram	0.0	0.0	0.0
112	Mr. P. Pissierssens ( KMFRI,ABOS )	gram	1000.0	257.4	992.6
112		gram	1000.0	12.7	987.3
112		gram	500.0	500.0	0.0
112		gram	500.0	0.7	499.3
112		gram	0.0	0.0	0.0
112		gram	600.0	105.0	495.0
112		gram	1000.0	0.0	1000.0
112		gram	1000.0	1.0	999.0
112		gram	250.0	1.0	249.0
112		gram	2724.0	0.0	2724.0
112		gram	1816.0	0.0	1816.0
112		gram	2500.0	0.0	2500.0
112		gram	1000.0	0.0	1000.0
112		gram	250.0	250.0	0.0
112		gram	500.0	0.0	500.0
112		gram	2000.0	865.0	1135.0
112		gram	1000.0	0.0	1000.0
112		gram	1000.0	0.0	1000.0
112		gram	100.0	54.0	46.0

kmfri-kbp computer section



CODE	DESCRIPTION	UNIT	REQBAL	ISSUED	NEWBAL
PACETAC	ACETIC ACID SULPHATE	ML	1000.0	100.0	900.0
PACTON	ACETON METASILICATE	ML	60000.0	43420.0	16580.0
PAgNO3	SILVER NITRATE	gram	700.0	200.0	500.0
PALIZARINRED	ALIZARIN RED	gram	100.0	0.0	100.0
PASCAC	ASCORBIC ACID L(+)	gram	400.0	211.5	188.5
PBaCl2.2Aq	BARIUM CHLORIDE	gram	0.0	0.0	0.0
PBGLYPDINA5LT	Beta-GLYCEROLP04-di-Na-salt	gram	500.0	0.0	500.0
PBr2	BROMIDE HYPOCHLORITE	ml	250.0	0.0	250.0
PBUF6	BUFFER pH 6	ml	1000.0	0.0	1000.0
PBUF6.4-amp	BUFFER AMPOULE pH 6.4	amp	1.0	0.0	1.0
PBUF8-amp	BUFFER AMPOULE pH 8	amp	1.0	0.0	1.0
PC2H5OH/.96	ETHANOL 96 %	ml	25000.0	17405.0	7595.0
PC2H5OH/.99	ETHANOL 99 %	ml	3000.0	3000.0	0.0
PCaCO3	CALCIUM CARBONATE	gram	500.0	536.0	464.0
PCd	CADMIUM GRANULATED	gram	1250.0	750.0	500.0
PCHCl3	CHLOROFORM	ml	2500.0	1450.0	1050.0
PCLEAN	LASER MULTIPURPOSE CLEANER	ml	100000.0	19000.0	81000.0
PCu(II)S04	COPPER (II) SULPHATE	gram	1500.0	123.0	1377.0
PCu(II)S04.5Aq	COPPER(II)SULPHATE.5HYDRATE	gram	1500.0	93.0	1407.0
PDIFASA-Ba-slt	DIPHENYLAMINESULFONIC AC.Ba-slt	gram	5.0	0.0	5.0
PDIFASA-Na-slt	DIPHENYLAMINESULFONIC AC.Na-slt	gram	5.0	0.0	5.0
PEDTA	ETHYLENEDIAMINETETRAACETATE	gram	50.0	50.0	0.0
PFORMOL/.37	FORMALDEHYDE 37 %	ml	60000.0	56000.0	4000.0
PGLUC/D	D-GLUCOSE	gram	1000.0	30.0	970.0
PGLYC/.87	GLYCEROL 87 %	ml	1000.0	1000.0	0.0
PH2O2	HYDROGEN PEROXIDE	ml	835.0	15.0	820.0
PH2S04/.95	SULPHURIC ACID 95-97%	ml	15000.0	6520.0	8480.0
PH3P04/.85	ORTHO-PHOSPHORIC ACID 87 %	ml	5000.0	206.0	4794.0
PHCl-amp/.1N	HYDROCHLORIC ACID AMPOULE 0.1N	amp	1.0	0.0	1.0
PHCl/.37	HYDROCHLORIC ACID 37 %	ml	10000.0	8912.0	1088.0
PHNO3/.65	NITRIC ACID 65 %	ml	1000.0	1000.0	0.0
PI2	IODINE	gram	250.0	50.0	200.0
PIDRANAL	IDRANAL	gram	0.0	0.0	0.0
PK2Cr204	POTASSIUM CHROMATE	gram	1000.0	257.4	992.6
PK2Cr207	POTASSIUM DICHROMATE	gram	1000.0	12.7	987.3
PKCl	POTASSIUM CHLORIDE	gram	500.0	500.0	0.0
PKDIAMTART	POTASSIUM DIAMM.TARTR.	gram	500.0	0.7	499.3
PKH2P04	POTASSIUM-di-HYDROGEN PHOSPHATE	gram	0.0	0.0	0.0
PKI	POTASSIUM IODIDE	gram	600.0	105.0	495.0
PKNa06C4H4.4Aq	POTASSIUM SODIUM TATRATE.4HYDR	gram	1000.0	0.0	1000.0
PKN02	POTASSIUM NITRITE	gram	1000.0	1.0	999.0
PKN03	POTASSIUM NITRATE	gram	250.0	1.0	249.0
PMARAGAR	MARINE AGAR 2216	gram	2724.0	0.0	2724.0
PMARBROTH	MARINE BROTH 2216	gram	1816.0	0.0	1816.0
PMCAGAR	MAC CONKEY AGAR	gram	2500.0	0.0	2500.0
PMETAMNFENSUL	4-(METHYLAMINO)PHENOLSULPHATE	gram	1000.0	0.0	1000.0
PMgcl2	MAGNESIUM CHLORIDE	gram	250.0	250.0	0.0
PMgS04	MAGNESIUM SULPHATE	gram	500.0	0.0	500.0
PMNS04.1Aq	MANGANESE SULPHATE.1HYDR	gram	2000.0	865.0	1135.0
PNa2B407.10Aq	di-SODIUMTETRABORATE.10HYDRATE	gram	1000.0	0.0	1000.0
PNa2CO3	SODIUM CARBONATE ANHYDR.	gram	1000.0	0.0	1000.0
PNa2Fe(CN)5NO	SODIUM NITROPRUSSIDE	gram	100.0	54.0	46.0



CODE	DESCRIPTION	UNIT	REQBAL	ISSUED	NEWBAL
PNa25203.5Aq	SODIUM THIOSULPHATE	gram	250.0	-517.6	767.6
PNa25i03.5Aq	SODIUM METASILICATE	gram	500.0	0.0	500.0
PNa2504	SODIUM SULPHATE	gram	1000.0	270.0	730.0
PNa2W04.2Aq	SODIUM TUNGSTATE	gram	250.0	0.0	250.0
PNaAC	SODIUM ACETATE	gram	1000.0	0.0	1000.0
PNaCITR	SODIUM CITRATE	gram	1000.0	400.0	600.0
PNaCl	SODIUM CHLORIDE	gram	690.0	1603.4	396.6
PNaHOC1	SODIUM HYPOCHLORITE	ml	5000.0	1500.0	3500.0
PNaMo	SODIUM MOLYBDATE	gram	250.0	125.0	125.0
PNaNO3	SODIUM NITRATE	gram	500.0	263.0	237.0
PNaOH	SODIUM HYDROXIDE	gram	1500.0	953.4	1046.6
PNaFDSu1	SODIUM PEROXODISULPHATE	gram	500.0	0.0	500.0
PNEDADCL	N-NAPHTYL-ETHYLENEDIAMM.DICHL.	gram	25.0	0.4	24.6
PNH3/.25	AMMONIA 25%	ml	2500.0	0.0	2500.0
PNH4CL	AMMONIUM CLORIDE	gram	1000.0	528.0	472.0
PNH4Fe504	AMMONIUM-IRON(II)SULFATE	gram	1000.0	0.0	1000.0
PNH4Mo	AMMONIUM MOLYBDATE	gram	1250.0	-119.0	1131.0
PNH4504	AMMONIUM SULFATE	gram	500.0	0.0	500.0
PNUTAGAR	NUTRIENT AGAR	gram	2724.0	0.0	2724.0
PNUTBROTH	NUTRIENT BROTH	gram	1696.0	0.0	1696.0
POXALAC	OXALIC ACID	gram	500.0	90.0	410.0
PPAPLITBLU	BLUE LITMUS PAPER INDICATOR	box	2.0	0.0	2.0
PPAPLITRED	RED LITMUS PAPER INDICATOR	box	2.0	0.0	2.0
PPHENOL	PHENOL	gram	1000.0	150.0	850.0
PSbKOC4H406	ANTIMONY POTASSIUM(+)TARTRATE	gram	0.0	0.0	0.0
PSFNAMID	SULFANILAMID	gram	250.0	15.0	235.0
PSiGEL	SILICA GEL	gram	20000.0	112.0	20000.0
PSTARCH	STARCH INDICATOR	gram	2500.0	60.0	2440.0
PTHYMOL	THYMOL	gram	100.0	0.0	100.0
PTRINaCITR.2Aq	tri-SODIUM CITRATE.2HYDR	gram	0.0	0.0	0.0
PTSTAQMKNH4	AQUAMERCK TEST AMMONIUM 150 tst	box	3.0	3.0	0.0
PTSTAQMKN02	AQUAMERCK TEST NITRITE 50tst	box	10.0	4.0	107.0
PTSTAQMKN03	AQUAMERCK TEST NITRATE 50 tst	box	10.0	5.0	105.0
PTSTAQMKP04	AQUAMERCK TEST PHOSPHATE	box	3.0	3.0	100.0
PTSTAQMKSi	AQUAMERCK TEST SILICA	box	3.0	3.0	0.0
PTSTAQQTN02	AQUAQUQNT TEST NITRITE 14424	box	1.0	1.0	0.0
PTSTMIQTSi	MERCK MICRQUANT TEST SILICA	box	1.0	1.0	0.0
PTSTSPQTSi	MERCK TEST SPECTROQUANT Si	box	1.0	1.0	0.0

kmfri-kbp computer section

kmfri-kbp computer section



CODE	DESCRIPTION	UNIT	REQBAL	ISSUED	NEWBAL
SBAT1.5AA	SIZE AA 1.5 VOLT BATTERY ALKAL	NR	12	12	0
SBAT1.5D	SIZE D 1.5 VOLT BATTERY	NR	62	62	0
SBAT9	9 VOLT BATTERY	NR	4	4	0
SBULB605CR	BULB 230V/60W SCREW fr SPROCON	NR	5	5	0
SCORKRUB	RUBBER CORK	NR	400	47	353
SCOVSLIP	COVER SLIPS MICROSC. 20 MM SQ.	BOX	100	8	92
SDISHPETRI	PETRI DISH PLASTIC	NR	953	264	669
SFILMEM/.2	MEMBR.FILTERS 0.2 MICR. 100/BX	BOX	4	0	4
SFILMEM/.45	MEBR.FILTERS 0.45 MICR. 100/BX	BOX	5	0	5
SFILMEM/.8	MEBR.FILTERS 0.8 MICR. 100/BX	BOX	5	0	5
SFILPAPGFC25	WHATMAN FILT.GF/C 25 MM 100/BX	BOX	10	6	4
SFILPAPGFC47	WHATMAN FILT.GF/C 47 MM 100/BX	BOX	50	38	12
SLABEL	GUMMED LABORATORY LABELS	PCK	13	7	6
SMICRSLID	MICROSCOP. SLIDES 50/BX	BOX	10	8	2
SNEEDPT	POINTED TIP NEEDLE	NR	20	8	12
SNEEDRE	ROUND EYE TIP NEEDLE	NR	10	-1	10
SPAPTISSUE	KLEENEX TISSUE BOX	BOX	53	46	7
SPARAFILM	PARAFILM	BOX	10	8	2
SPIPATIP1	AUTOPIPET YELLOW TIP 20-100 MICR	NR	5000	0	5000
SPIPATIP2	AUTOPIPET BLUE TIP 200-1000 MICR	NR	5000	1000	4000
SPIPPASTEURLT	PASTEUR PIPETS LONG TIP 2500/BX	BOX	2500	1	2499
SPLGAUZ100	PLANKTON GAUZE 100 MICR.	MET.	5	5	0
SPLGAUZ200	PLANKTON GAUZE 200 MICR.	MET.	5	5	0
SPLGAUZ50	PLANKTON GAUZE 50 MICR.	MET.	5	5	0
SPLGAUZ500	PLANKTON GAUZE 500 MICR.	MET.	5	5	0
SSBLD1	SURGICAL BLADE TY25	NR	200	112	88
SSBLD2	SURGICAL BLADE TY21	NR	20	20	0
SSURGLOV	SURGICAL GLOVES 50/BX	BOX	20	4	16
STUBGAS9/17	GAS TUBE 9/17	MET.	10	0	10
STUBPVC4/6	PVC TUBE 4/6	MET.	10	2	8
STUBPVC6/10	PVC TUBE 6/10	MET.	10	1	10
STUBSIL	SILICON TUBE	MET.	10	0	10
STUBVAC5/15	VACUUM TUBE 5/15	MET.	10	1	10
DESSIC30	DESSICATOR GLASS 30 CM+TAP		2	0	2
EVAPSEV5	EVAPORATING DISH ENAIL SMALL		1	0	1
EVAPSEVQL	EVAPORATING DISH QUARTZ LARGE		14	0	14
EVAPSEVQS	EVAPORATING DISH QUARTZ SMALL		19	0	19
DISP	DISPENSER BOTTLE PLASTIC 500 ML		10	1	9
ERL10	ERLENMEYER 2000 ML WIDE MOUTH		10	0	10
ERL13	ERLENMEYER 100 ML		10	0	10
ERL15	ERLENMEYER 250 ML		10	0	10
ERL7	ERLENMEYER 500 ML (WIDE MOUTH)		10	0	10
ERL9	ERLENMEYER 1000 ML		10	0	10
ERLC5	ERLENMEYER FOR CONDENSER 250 ML		2	0	2
ERLFI11	ERLENMEYER FOR FILTRATION 5000 ML		3	0	3
ERLFI9	ERLENMEYER FOR FILTRATION 1000 ML		5	0	5
FI18A	FILTER BASE MILLIPORE		5	0	5
FI18A	FILTER CLAMP MILLIPORE		5	0	5
FI18A	FILTER FUNNEL MILLIPORE		5	0	5
SYRSYS	SYRINGE 50 ML FOR GFYSYS		2	0	2
SYRSYS	MILLIPORE SYRINGE FILTER SYSTEM		2	0	2



CODE	DESCRIPTION	REQBAL	LOSS	ISSUED	NEWBAL
GBEKG8	GLASS BEAKER 600 ML	10	1	7	2
GBEKG9	GLASS BEAKER 1000 ML	10	0	6	4
GBEKP7	PLASTIC BEAKER 500 ML	10	0	10	0
GBEKP9	PLASTIC BEAKER 1000 ML	12	0	9	3
GBOTD	DROPPER BOTTLE	12	0	7	5
GBOTG2	BOD BOTTLE 50 ML	10	0	10	0
GBOTG3	BOD BOTTLE 100 ML	100	0	49	51
GBOTG5	BOD BOTTLE 250 ML	100	0	68	32
GBOTG7	BOD BOTTLE 500 ML	50	0	23	27
GBOTG9	BOD BOTTLE 1000 ML	50	1	20	29
GBOTP3	PLASTIC SAMPLE BOTTLE 100 ML	200	0	200	0
GBOTP5	PLASTIC SAMPLE BOTTLE 250 ML	228	0	228	0
GBOTP9	SAMPLE BOTTLE 1000 ML	10	0	10	0
GBOTPSPEC	SPECIMEN BOTTLE PLASTIC (vial)	340	0	27	313
GBOTPSPEC5	SPECIMEN BOTTLE PLASTIC 250 ML	500	0	180	320
GBOTPSPEC9	SPECIMEN BOTTLE PLASTIC 1000 ML	50	0	21	29
GBUCP	PLASTIC BUCKET GRADUATED 12L	4	0	4	0
GBUR	BURET 50 ML	2	0	2	0
GBURA	AUTO BURET + RESERVOIR	2	0	0	2
GCONPL	LARGE PLASTIC CONTAINER	2	0	2	0
GCONPS	SMALL PLASTIC CONTAINER	2	0	2	0
GCONS	SPIRAL CONDENSER	2	0	0	2
GCOVSH	HAEMA COVER SLIP	20	0	18	2
GCUV1	SPECTRO CUJET 10x10x45 BOX OF 3	1	0	0	1
GCUV2	SPECTRO CUJET 10x40x45 BOX OF 3	1	0	1	0
GCUVMATCH1	CUVETS MATCHED ref.5G 10 00 82	2	0	2	0
GCYLMG1	MEASURING CYLINDER GLASS 25 ML	10	0	6	4
GCYLMG3	MEASURING CYLINDER 100 ML	10	0	10	0
GCYLMG7	MEASURING CYLINDER GLASS 500 ML	10	0	2	8
GCYLMG9	MEASURING CYLINDER GLASS 1000 ML	5	0	0	5
GCYLMF3	PLASTIC MEASURING CYLINDER 100 ML	5	0	0	5
GCYLMF7	MEASURING CYLINDER PLASTIC 500 ML	5	0	1	4
GCYLMF9	PLASTIC MEASURING CYLINDER 1000 ML	5	0	2	3
GDESSIC30	DESSICATOR GLASS 30 CM+TAP	2	0	1	1
GDISEVES	EVAPORATING DISH EMAIL SMALL	1	0	0	1
GDISEVQL	EVAPORATING DISH QUARTZ LARGE	14	0	0	14
GDISEVQ5	EVAPORATING DISH QUARTZ SMALL	19	0	0	19
GDISP	DISPENSER BOTTLE PLASTIC 500 ML	10	1	9	0
GRL10	ERLENMEYER 2000 ML WIDE MOUTH	10	0	0	10
GERL3	ERLENMEYER 100 ML	10	0	10	0
GERL5	ERLENMEYER 250 ML	10	0	10	0
GERL7	ERLENMEYER 500 ML (WIDE MOUTH)	10	0	6	4
GERL9	ERLENMEYER 1000 ML	10	0	2	8
GERLC5	ERLENMEYER FOR CONDENSER 250 ML	2	0	2	0
GERLF11	ERLENMEYER FOR FILTRATION 5000 ML	3	0	0	3
GERLF9	ERLENMEYER FOR FILTRATION 1000 ML	5	0	2	3
GFIBA	FILTER BASE MILLIPORE	5	0	4	1
GFICLA	FILTER CLAMP MILLIPORE	5	0	2	3
GFIFUN	FILTER FUNNEL MILLIPORE	5	0	2	3
GFISYRSYR	SYRINGE 50 ML FOR GFYSYRSYS	2	0	0	2
GFISYRSYS	MILLIPORE SYRINGE FILTER SYSTEM	2	0	0	2



CODE	DESCRIPTION	REQ.	REQBAL	LOSS	ISSUED	NEWBAL
GFLVOL2	VOLUME FLASK 50-55 ML	10	2	0	0	8
GFLVOL4	VOLUME FLASK 200-220 ML	1	10	0	1	5
GFLVOL6	VOLUME FLASK 400-440 ML	5	1	0	0	0
GFUNG1	GLASS FUNNEL 100 MM	4	4	0	0	2
GFUNG2	GLASS FUNNEL 200 ML	5	4	0	0	4
GFUNM	METAL FUNNEL	4	1	0	0	1
GFUNP1	PLASTIC FUNNEL 100 MM	3	6	0	0	0
GFUNP2	PLASTIC FUNNEL 150 MM	1	3	0	3	1
GFUNP3	PLASTIC FUNNEL 260 MM	4	3	0	0	2
GHCM	HAEMACYTOMETER	10	5	0	0	3
GKOL9	KOLVE FLAT BOTTOM 1000 ML	20	10	0	0	9
GKOL5C	KOLVE FOR SPIRAL CONDENSER 2000 ML	2	2	0	0	2
GPETS	PETRI SLIDES BOX OF 100	2	7	0	0	7
GPIP1	MEASURING PIPET 1 ML	1	18	0	0	8
GPIP10	MEASURING PIPET 10 ML	1	20	0	1	15
GPIP2	MEASURING PIPET 2 ML	5	20	0	0	11
GPIP20	MEASURING PIPET 20 ML	2	12	0	0	12
GPIP5	MEASURING PIPET 5 ML	2	20	0	0	17
GPIPB10	BULB PIPET 10 ML	2	3	0	0	0
GPIPB25	BULB PIPET 25 ML	290	5	0	0	4
GPIPB50	BULB PIPET 50 ML	5	5	0	1	2
GREDCOL	REDUCTION COLUMN + TAP	2	10	0	0	3
GREDFUN	REDUCTION FUNNEL	2	9	0	0	3
GRESG	GLASS RESERVOIR 20 L	10	2	0	0	1
GRESGT	SPARE TAP FOR GRESG	5	1	0	0	1
GRESPL	PLASTIC RESERVOIR 20 L	10	10	0	0	0
GRESPS	PLASTIC RESERVOIR 10 L + TAP	2	3	0	0	0
GROD	GLASS STIRRING ROD	1	16	0	0	13
GTAPP	PLASTIC TAP	5	1	0	0	1
GTHOM	TISSUE HOMOGENIZER (POTTER)	3	2	0	2	0
GTUBC1	CENTRIFUGE TUBE 15 ML CONICAL	2	200	0	31	135
GTUBC2	CENTRIFUGE TUBE 100 ML	10	10	0	0	1
GTUBT	TEST TUBE	3	973	0	0	973
Totals:	All	3	0	0	3	0
GPIPAOL	PIPET HOLDER	2	0	0	0	2
GPIPBAL	PIPET BALL	5	0	0	7	3
GPIPCON	PIPET CONTAINER	10	0	0	2	8
GPIPST	PIPET STAND PLEXIGLASS	5	0	0	1	4
GPIPWASHB	PIPET WASHER BASKET	2	0	0	2	0
GPIPWASHC	PIPET WASHER CONTAINER	2	0	0	2	0
GPLATMET	METAL PLATE STAINLESS	1	0	0	1	0
GPLNETR55	PLANKTON NET + RES. 55 MICR.	2	0	0	2	0
GPLUGSQP	TOP PLUG SQ. PIN	12	0	0	8	4
GPROCON30	PROTECTING CONTAINER 30	1	0	0	1	0
GPROCON40	PROTECTING CONTAINER 40	2	0	0	2	0
GPROCON50	PROTECTING CONTAINER 50	1	0	0	1	0
GRACDRY	DRYING RACK FOR GLASSWARE	2	0	0	2	0
GRACU8T	RACK FOR TEST TUBES 4x12	5	3	0	6	2
GRACU8TS	RACK FOR TEST TUBES 3X8	5	0	0	0	5
GREFRAC	REFRACTOMETER ATAGO 0-100 PPM	4	0	0	2	2
GR00NA12X55	MAGNETIC STIRRER 12 X 55	5	0	0	1	4
GR00NA7X25	MAGNETIC STIRRER 7 X 25	10	1	0	1	10

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CODE	DESCRIPTION	REQ.BAL	LOSS	ISSUED	NEWBAL
SBLDHOL	SURGICAL BLADE HOLDER	10	0	14	6
SBOR	CORK BORER SET OF 12	1	0	1	1
SBOXSLID	SLIDE BOX	5	0	1	4
SBRUWL	LARGE BRUSH WASHER	4	0	2	2
SBRUWS	SMALL BRUSH WASHER	5	0	3	2
SBULBHOL	BULB HOLDER SREWFIT fr SPROCON	4	0	8	0
SBUR	GAS BURNER	3	0	0	3
SBURNALL	ALL PURPOSE GAS BURNER	1	0	0	1
SCABL	ELECTRIC CABLE FOR SPROCON	4	0	3	1
SCLMPRETST	CLAMP FOR RETORT STAND	10	0	4	14
SCLP	CLIP FOR RUBBER TUBE	20	0	0	20
SCOUNTER	COUNTER 1 CHAN. HAND	2	0	0	2
SCUT	CUTTER	2	0	1	1
SCUVHOL1	REF.CUVET HOLDER 1 CM SPECTRO	1	0	1	0
SCUVHOLL	CUVET HOLDER LONG PATH	1	0	0	1
SDISKIT	DISSECTING KIT	5	0	5	0
SDISTRIVAR500	DISTRIVAR 500	2	0	0	2
SDIVBACPAC	DIVING BACK PACK	2	0	2	0
SDIVREG	DIVING REGULATOR	2	0	2	0
SFILPOC	FILING POCKET FOR MET.CABINET	290	0	290	0
SGAUZTRIP	GAUZE FOR TRIPOD	5	0	0	5
SGCUT	GLASS CUTTER	2	0	0	2
SGMARK	GLASS MARKER ( INK TYPE)	2	0	1	1
SHOLN	NEEDLE HOLDER	10	4	8	6
SHYGRO	HYGROMETER(HAIR) 0-100 %	5	0	3	2
SKOLCLMP	KOLVE CLAMP	10	0	6	4
SMAFMIL	SAMPLING MANIFOLD MILLIPORE 12 HOL	2	0	0	2
SMECAB	METAL CABINET MEWAF	1	0	1	0
SMULPLUG5QP	MULTIPLUG 5Q.PIN	5	0	4	1
SNABOT10	NANSEN BOTTLE 10 L	3	0	1	2
SPINCCOVSLIP	COVER SLIP PLINCERS	2	0	1	1
SPINCFI	FLAT END PINCERS	10	0	1	9
SPIPA20-100	AUTOMATIC PIPET 20-100 MICL	3	0	1	2
SPIPA200-1000	AUTOMATIC PIPET 200-1000 MICL	3	0	3	0
SPIPAHOL	AUTOMATIC PIPET HOLDER	2	0	0	2
SPIPBAL	PIPET BALL	5	0	7	3
SPIPCON	PIPET CONTAINER	10	0	2	8
SPIPST	PIPET STAND PLEXIGLASS	5	0	1	4
SPIPWASHB	PIPET WASHER BASKET	2	0	2	0
SPIPWASHC	PIPET WASHER CONTAINER	2	0	2	0
SPLATMET	METAL PLATE STAINLESS	1	0	1	0
SPLNETR55	PLANKTON NET + RES. 55 MICR.	2	0	2	0
SPLUG5QP	TOP PLUG 5Q.PIN	12	0	8	4
SPROCON30	PROTECTING CONTAINER 30	1	0	1	0
SPROCON40	PROTECTING CONTAINER 40	2	0	2	0
SPROCON50	PROTECTING CONTAINER 50	1	0	1	0
SRACDRY	DRYING RACK FOR GLASSWARE	2	0	2	0
SRACTUBT	RACK FOR TEST TUBES 4x12	5	3	6	2
SRACTUBTS	RACK FOR TEST TUBES 3X8	5	0	0	5
SREFRAC	REFRACTOMETER ATAGO 0-100 PPM	4	0	2	2
SRODMA12X55	MAGNETIC STIRRER 12 X 55	5	0	1	4
SRODMA7X25	MAGNETIC STIRRER 7 X 25	10	1	1	10

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CODE	DESCRIPTION	REQ. BAL	LOSS	ISSUED	NEW BAL
ROD PUMP	AQUARIUM AIR PUMP RENA 301	3	0	1	4
RODMA9X35	MAGNETIC STIRRER 9 X 35	10	0	2	8
RODMAG	MAGNETIC ROD	2	0	2	0
SAFGLAS	SAFETY GLASSES	2	0	0	2
SCIS	SCISSORS	3	0	3	0
SPATSMIC	SPATULA SEMI MICRO	5	0	5	0
STARODBAS	STAND ROD + BASE ( RETORT STAND)	5	0	3	2
SWATCH	STOP WATCH	2	0	2	0
THERMALC100	ALCOHOL THERMOMETER 100 C	2	0	0	2
THERMHG110	MERCURY THERMOMETER 110 C	14	5	13	6
THERMHIQ	THERMOMETER 0.1 C PRECISION	2	0	0	2
TONGCRUC	CRUCIBLE TONG	5	0	0	5
TRIST	TRIPOD STAND	3	0	0	3
Totals: All					
FREEZLIEB	CENTRIFUGE ALC 4226	1	0	1	0
FREEZLIEB	FREEZER LIEBHERR	1	0	1	0
GENKAW	GENERATOR KAWASAKI 220/12 V-2600 W	1	0	1	0
INCUBMT30	INCUBATOR MEHRT T30 53 L	1	0	1	0
MAGSTIR	MAGNETIC STIRRER PLATE CENCO	2	0	1	1
MAGSTIRMOT	MAGNETIC STIRRER + HOT PLATE	1	0	1	0
MICLLABD	MICROSCOPE LEITZ LABORLUX D	1	0	1	0
MICLLDMICH	MICROMETER FOR LEITZ LABORLUX D	1	0	1	0
MICLLDMOC	MEASURING OCULAR FOR LEITZ LABLUXD	1	0	1	0
MILLPUMP	MILLIPORE VACUUM PUMP/COMPRESSOR	3	0	2	1
MOPRO	OVERHEAD PROJECTOR	1	0	1	0
MOVENMTV150	OVEN MEHRT TV 150 34 L	1	0	1	0
MOXNETCQZ80	OXYGEN METER CONSORT Z80	1	0	1	0
PHANETOR231	PH METER ORION 231	1	0	1	0
PHPARAMIX	TEST TUBE MIXER PARAMIX JULABO	1	0	0	1
PHPHMETELOR231	PH METER ORION 231 COMB. ELEKTRODE	2	0	1	1
PHPHMETOR231	PH METER ORION 231	1	0	1	0
RADNORIL	MOBILE RADIO UNIDEN	4	0	4	0
RADNORILAMP	MOBILE RADIO AMPLIFIER MOSQUITO	4	0	4	0
REFRFRIZ	REFRIGERATOR ZOPPAS	1	0	1	0
SPECTRO	SPECTROFOTOMETER SHIMADZU	1	0	1	0
STILL	WATER DISTILLER VEL 7Q	1	0	1	0
WUPUMP	WATER PUMP JL 130 + TUBE	1	0	1	0
WUBATHW350	WARM WATER BATH MEHRT W350	1	0	1	0

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Annex 3

CODE	DESCRIPTION	REQ.BAL	LOSS	ISSUED	NEWBAL
HAQPUMP	AQUARIUM AIR PUMP RENA 301	5	0	1	4
HAUTOCLAV	AUTOCLAVE	1	0	1	0
HBALANAL	ANALYTICAL BALANCE SARTORIUS	1	0	1	0
HBALELEC	ELECTROBALANCE CAHN C29	1	0	1	0
HBALELEACC	ACCESSORIES CAHN BALANCE	1	0	1	0
HBATCHARGE	BATTERY CHARGER TELWIN	1	0	1	0
HBINOWM3	STEREOMICROSCOPE WILD M3	3	0	3	0
HBINOWM5	STEREOMICROSCOPE WILD M5	1	0	1	0
HBINOWM5MICM	MICROMETER FOR WILD M5	1	0	1	0
HBINOWM5MOC	MEASURING OCULAR FOR WILD M5	1	0	1	0
HCAMNIK5BAG	BAG FOR CAMERA NIKONOS 5	1	0	1	0
HCAMNIK5BODY	CAMERA NIKONOS 5 BODY	1	0	1	0
HCAMNIK5FLASH	FLASH FOR CAMERA NIKONOS 5	1	0	1	0
HCAMNIK5OBJ	OBJECTIVE LENS FOR CAMERA NIKONOS 5	1	0	1	0
HCENTRIF	CENTRIFUGE ALC 4226	1	0	1	0
HFREEZLIEB	FREEZER LIEBHERR	1	0	1	0
HGENKAW	GENERATOR KAWASAKI 220/12 V-2600 W	1	0	1	0
HINCUBMT30	INCUBATOR MEMMERT T30 53 L	1	0	1	0
HMAGSTIR	MAGNETIC STIRRER PLATE CENCO	2	0	1	1
HMAGSTIRHOT	MAGNETIC STIRRER + HOT PLATE	1	0	1	0
HMICLLABD	MICROSCOPE LEITZ LABORLUX D	1	0	1	0
HMICLLDMICM	MICROMETER FOR LEITZ LABORLUX D	1	0	1	0
HMICLLDMOC	MEASURING OCULAR FOR LEITZ LABLUXD	1	0	1	0
HMILPUMP	MILLIPORE VACUUM PUMP/COMPRESSOR	3	0	2	1
HOPRO	OVERHEAD PROJECTOR	1	0	1	0
HOVENMTV15U	OVEN MEMMERT TV 15U 34 L	1	0	1	0
HOXMETCOZ80	OXYGEN METER CONSORT Z80	1	0	1	0
HPAMETOR231	PH METER ORION 231	1	0	1	0
HPARAMIX	TEST TUBE MIXER PARAMIX JULABO	1	0	0	1
HPHMETELOR231	PH METER ORION 231 COMB.ELEKTRODE	2	0	1	1
HPHMETOR231	PH METER ORION 231	1	0	1	0
HRADMOBIL	MOBILE RADIO UNIDEN	4	0	4	0
HRADMOBILAMP	MOBILE RADIO AMPLIFIER MOSQUITO	4	0	4	0
HREFRIZ	REFRIGERATOR ZOPPAS	1	0	1	0
HSPECTRO	SPECTROFOTOMETER SHIMADZU	1	0	1	0
HSTILL	WATER DISTILLER VEL 7Q	1	0	1	0
HWPUMP	WATER PUMP JL 130 + TUBE	1	0	1	0
HWWBATHMW350	WARM WATER BATH MEMMERT W350	1	0	1	0

Yours sincerely,

*J.K. Maobobin*  
 J.K. Maobobin  
 For DIRECTOR.

JK/et.

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KENYA MARINE & FISHERIES RESEARCH INSTITUTE

LIBRARY DEPARTMENT

13th March, 1986.

Ref: KMF/PUB/13

Dear

Attached is a list of references covering Fisheries and Oceanography received from Belgium between January 1985 and December 1985. Documentary Informations is a project which was promoted under the umbrella of Kenya - Belgium project in Biological Oceanography based at KMFRI, Mombasa, with the objective of making scientific Literature available to researchers. The project is financed partly by the Free University of Brussels (V. U. B.) and partly by Limburg University Centre (L.U.C) Belgium. The online searches and interlibrary lending services are realized in Belgium (L.U.C.) and references sent to our Library by Airmail.

Yours sincerely,

*J.K.Mwobobia*  
J.K. Mwobobia  
For DIRECTOR.

JK/et.



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FROM: Librarian TO: Prof. Polk - Director KBP

REF: KMF/PUB/13/119 DATE: 29th July 1986.

00657 Marrow, J.E. 1954.  
SUBJECT: LITERATURE RECEIVED UNDER THE AVSPICES OF KBP  
from East Africa. Copeia (1): 14 - 16.

00658 Hatchell, G.W. 1954.  
Attached is a list of literature we have received between March and  
July 1986 from L.U.C. and Free University of Brussels in Belgium.  
A total of 139 (2785 pages) articles have been received.

00659 The sport fishery for sail fish at Malindi, Kenya,  
1958-1968; with some biological notes.  
00660 Bull. Mar. Sci. 20: 830-852.

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- C. Infrastructure  
- Regional Centre - Buildings
- D. Varia  
- State of affairs in relation to the exhibition on  
"Oceanography" organised by the French Embassy.



Visit of Mr. Beck, Head of the Development / Co-operation Section at the Belgian Embassy in Nairobi, to the "Kenyan - Belgium Cooperation in Marine Sciences" project in Mombasa from December 9 to 15, 1985. K.M.F.R.I.

Library KMFRI, 9:15 a.m.

Proposed Agenda

Monday December 9: - Arrival 9:35 a.m. - Hotel  
- 2 p.m. : discussion agenda

Tuesday December 10: - Trip to Gazi - Discussion on the Oyster culture  
Departure time will depend on the tides.

Wednesday December 11: - Trip to Kanamai - Discussion on Seepage  
Departure time will depend on the tides.

Thursday December 12: - Seminars on the Kenyan-Belgian Project done by the  
Kenyan counterparts.  
- 2:30 p.m. Visit to the Laboratory, the Documentation  
Centre and the Store room at K.M.F.R.I.

Friday December 13: - Discussion on the present situation and the perspectives  
of the project with Mr. Allela, Director K.M.F.R.I.

A. Research

- Regional Centre - Documentation Centre
- Pollution heavy metals
- Mangrove Project
- Algae culture
- Oyster culture
- Project Primary Production (Ms. De Souza)
- Project Secondary Production (Mr. Okemwa - Mrs. Kimaro)
- Project Coral Ecology (Ms. Muthiga)
- Project Seepage (Prof. Van Der Beken)
- Project Geology (Prof. Paepe)
- Diving Centre

B. International Contacts

- State of affairs in the contacts with EEC, UNEP, FAO,  
UNESCO, Ministry of Wildlife

C. Infrastructure

- Regional Centre - Buildings

D. Varia

- State of affairs in relation to the exhibition on  
"Océanography" organised by the French Embassy.



Afternoon Session: Contributed Papers on Current Research 4/10/85

SEMINARS GIVEN BY THE KENYAN COUNTERPARTS ON DECEMBER 11, 1985

02.00 - 02.20

Prosobranchs at the Kenya Coast.

Library KMFRI, 9:15 a.m.

TOPIC

PRESENTED BY

02.20 - 02.40

Changes in the Population Structure of a Sea Urchin  
(Echinometra Mathaei de Blainville) on an Exploited  
Reef.

1. Introductory speech The Director, Mr. S.O. Allela

2. Literature retrieval Mrs. M. Muthiga

3. Computerisation Ms. W. Ogaye

4. Effects of seepage on  
distribution of mangro-  
ves and oyster culture Mr. R. Ruwa

02.40 - 03.20

5. Distribution of Macro-  
algae Mrs. H. Oyieke

6. Primary Production in  
creeks Ms. De Souza

03.00 - 03.20

Tea break

Massive Fish Kill within the Nyanza Gulf of Lake Victoria,  
Kenya.

7. Coral reef ecology and  
importance of creating  
a diving centre Ms. N. Muthiga

03.20 - 03.40

8. Relevance of short term  
fellowships Mr. J. Kazunga

9. Aspects of biology of  
Siganus Mr. M. Ntiba

10. Ecology of copepods Mr. E. Okemwa

03.40 - 04.00

11. Biology of zooplankton  
in Tudor creek Mrs. M. Kimaro \*

12. Conclusion Prof. Dr. P. Polk

04.00 - 5.00

Discussion of Future Aquatic Research Priorities for East  
Africa.

\* is on leave, the topic will be presented by Prof. Dr. Polk

05.00

Closing Remarks and Adjournment.



ANNEX 5 : INTERNATIONAL CONGRESS ON TROPICAL AQUATIC ECOSYSTEMS

UNESCO 1986

Afternoon Session: Contributed Papers on Current Research 4/10/85

02.00 - 02.20

The Dynamic Zonation of Three Neritid Rocky Shore Prosobranchs at the Kenya Coast.

X  
R.K. Ruwa and Victor Jaccarini.  
Kenya Marine and Fisheries Research Institute  
Mombasa, Kenya.  
and  
Department of Zoology  
University of Nairobi, Nairobi, Kenya.

02.20 - 02.40

Changes in the Population Structure of a Sea Urchin (Echinometra Mathaei de Blainville) on an Exploited Fringing Reef at Diani Reef, Mombasa.

X  
Nyawira Muthiga and Tim R. Mcclanahan  
Kenya Marine and Fisheries Research Institute  
Mombasa, Kenya.  
and  
Friends World College,  
Machakos, Kenya.

02.40 - 03.20

Abundance and Exploitation of Small Pelagic Fish in Marine and Fresh Waters of Tanzania.

L.B. Nhwani and D.B.R. Chitamwebwa,  
Tanzania Fisheries Research Institute  
Dar Es Salaam, Tanzania.

03.00 - 03.20

Massive Fish Kills within the Nyanza Gulf of Lake Victoria, Kenya.

Peter B.P. Ochumba  
Kenya Marine and Fisheries Research Institute  
Kisumu, Kenya.

03.20 - 03.40

Distribution, Biology and Fishery of the Introduced Fish Procambarus ClarkII Girrard in Lake Naivasha, Kenya.

A. Olouch and M. Litterick  
Department of Zoology  
University of Nairobi, Nairobi, Kenya.

03.40 - 04.00

Fish Yield of Kilifi Coral Reef in Kenya.

X  
Raphael M. Nzioka  
Kenya Marine and Fisheries Research Institute  
Mombasa, Kenya

04.00 - 5.00

Discussion of Future Aquatic Research Priorities for East Africa.

05.00

Closing Remarks and Adjournment.



THE DYNAMIC ZONATION OF THREE NERITID ROCKY SHORE PROSOBRANCHS  
AT THE KENYA COAST

by

R. K. Ruwa and V. Jaccarini

Kenya Marine & Fisheries Research Institute, P.O. Box 81651, Mombasa  
and

Dept. of Zoology, University of Nairobi, P.O. Box 30197, Nairobi, Kenya

Abstract

The rocky shore Indo-Pacific prosobranch Nerita undata is shown to have a dynamic zonation similar to that of its two co-occurring congeners, N. plicata and N. textilis, and the zonation of the three species is analysed quantitatively. The mean vertical resting position of all three species exhibits a spring-neap cycle, with the animals resting at higher levels ( $P = 0.001$ ) around spring tide days than around neaps. These spring-neap migrations are of larger amplitude during the rough southeast monsoon (SEM) and in exposed situations, than during the calmer northeast monsoon (NEM) and in sheltered situations. N. textilis always rests at a significantly lower position ( $P = 0.001$ ) than the other two species and lies within the upper eulittoral. Though there is always some overlap between the populations of the two higher level species, N. undata and N. plicata, which is more extensive around spring tide days, the mean resting position of N. undata is higher ( $P = 0.001$ ) than that of N. plicata during the SEM. During the NEM they occupy the same zone. These two species exhibit in addition a seasonal monsoon cycle superimposed on the spring-neap movements with the animals resting higher ( $P = 0.001$ ) during the SEM than during the NEM. In more exposed shores all three species exhibit the usual uplift of zonation as compared to more sheltered situations. This uplift is seen only during the rough SEM. Within each species the vertical zonation is related to the size of individuals but in different ways. Downward feeding migrations take place during night ebb tide. Most of the above features can be interpreted as a response to the degree of wave energy.

FISH YIELD OF KILIFI CORAL REEF IN KENYA

BY

RAPHAEL M. NZIOKA

THE FISH YIELD OF KILIFI REEF, WHICH IS ABOUT 4.0 KM<sup>2</sup>, WAS ESTIMATED FOR THREE YEARS. IT WAS FOUND THAT THE YIELD ON THE REEF RANGED FROM ABOUT 5.07 T/KM<sup>2</sup>/YEAR TO 12.9 T/KM<sup>2</sup>/YEAR, WITH A MEAN OF 8.8 T/KM<sup>2</sup>/YEAR. THE MAJOR GROUPS OF FISH CAUGHT WERE MOSTLY SIGANIDAE, SCARIDAE, LUTJANIDAE, SERRANIDAE, CARANGIDAE, PLECTRACHIDAE, SCOMBRIDAE, SPHYRAENIDAE AND CAESIODIDAE. THERE WERE MORE FISH CAUGHT DURING THE NORTHEAST MONSOON WHEN THE SEA WAS CALM THAN DURING THE SOUTHEAST MONSOON WHEN THE SEA WAS ROUGH.



CHANGES IN THE POPULATION STRUCTURE OF A SEA URCHIN (*ECHINOMETRA MATHAEI* DE BLAINVILLE) ON AN EXPLOITED FRINGING REEF AT DIANI BEACH, KENYA

BY

NYAWIRA A. MUTHIGA AND TIM R. MCCLANAHAN  
KENYA MARINE & FISHERIES RESEARCH INSTITUTE,  
P. O. BOX 81651, MOMBASA, KENYA

AND

FRIENDS WORLD COLLEGE, P. O. BOX 526, MACHAKOS, KENYA

ABSTRACT

A COMPARISON OF *E. MATHAEI* DENSITY AND SIZES WAS MADE ON AN INNER REEF LAGOON AND AN OUTER REEF EDGE AT DIANI BEACH, KENYA. *E. MATHAEI* DENSITY AND AVERAGE LENGTHS WERE SIGNIFICANTLY HIGHER ( $P < 0.01$ ) IN THE INNER REEF LAGOON ( $X = 14.2/M^2 + 15.8$ ,  $N = 90$ ;  $X = 40.8 \text{ MM} + 7.4$ ;  $N = 14$  RESPECTIVELY) THAN IN THE OUTER REEF EDGE ( $X = 1.7 + 1.0/M^2$ ,  $N = 60$ ;  $X = 31.2 \text{ MM} + 6.7$ ;  $N = 68$ , RESPECTIVELY). A COMPARISON WITH DENSITIES AND AVERAGE LENGTHS MEASURED 15 YEARS PREVIOUSLY (KHAMALLA, 1971) SHOWED INCREASES IN THE NUMBERS AND AVERAGE LENGTHS (AVERAGE LENGTH;  $P < 0.05$ ) *E. MATHAEI* IN THE INNER REEF AND A DECREASE IN AVERAGE LENGTHS ( $P < 0.05$ ) IN THE OUTER REEF EDGE. A CORRELATION OF AVERAGE LENGTHS VERSUS WEIGHT  $= 2.1 \times 10^{-3} Y^{2.64}$ ,  $R = 0.96$ ;  $N = 144$ ) INDICATED AN INCREASE IN BIOMASS  $424 \text{ G/M}^2$  ON THE INNER REEF AND A DECREASE OF  $81 \text{ G/M}^2$  ON THE OUTER REEF. THE DISTRIBUTION OF *E. MATHAEI* ALONG THE TRANSECTS CORRELATED SIGNIFICANTLY ( $R_s = 0.69$ ;  $F = 82.2$ ,  $P < 0.01$ ) WITH PERCENT HARD SUBSTRATE ON THE INNER REEF LAGOON WHERE THE AVERAGE DENSITY OF HARD SUBSTRATE WAS 41% AND NOT ON THE OUTER REEF EDGE WHERE THE HARD SUBSTRATE DENSITY WAS MUCH HIGHER (83%). IT IS SUGGESTED THAT THE POPULATION OF SEA URCHINS IN THE INNER REEF LAGOON IS REGULATED PRIMARILY BY BIOTIC INTERACTIONS (COMPETITION AND PREDATION) AND BY PHYSICAL FACTORS (WAVES AND TIDES) IN THE OUTER REEF EDGE. WE ATTRIBUTE THE INCREASED BIOMASSES OF SEA URCHIN IN THE INNER REEF LAGOON TO INCREASED FISHING AND SHELLING WHICH REDUCES COMPETITORS AND PREDATORS OF THE SEA URCHIN.

FISH YIELD OF KILIFI CORAL REEF IN KENYA

BY

JOHNSON M. KAZUNGA  
RAPHAEL M. NZIOKA

THE FISH YIELD OF KILIFI REEF, WHICH IS ABOUT  $4.0 \text{ KM}^2$ , WAS ESTIMATED FOR THREE YEARS. IT WAS FOUND THAT THE YIELD ON THE REEF RANGED FROM ABOUT  $5.07 \text{ T/KM}^2/\text{YEAR}$  TO  $12.9 \text{ T/KM}^2/\text{YEAR}$ , WITH A MEAN OF  $8.8 \text{ T/KM}^2/\text{YEAR}$ . THE MAJOR GROUPS OF FISH CAUGHT WERE MOSTLY SIGANIDAE, SCARIDAE, LUTJANIDAE, SERRANIDAE, CARANGIDAE, PLECTORHYCHIDAE, SCOMBRIDAE, SPHYREANIDAE AND CAESIODIDAE. THERE WERE MORE FISH CAUGHT DURING THE NORTHEAST MONSOON WHEN THE SEA WAS CALM THAN DURING THE SOUTHEAST MONSOON WHEN THE SEA WAS ROUGH.



Annex 6

CONTENTS

1. NUTRIENTS

1.1 Determination of Ammonia

1.2 Determination of Nitrate

NUTRIENTS AND PARTICULATE ORGANIC CARBON STUDY

1.3 Determination of Phosphate

1.4 Determination of Silicate

2. PARTICULATE MATERIAL

Determination of particulate organic carbon

FREE UNIVERSITY OF BRUSSELS

SEPTEMBER-DECEMBER  
1985

JOHNSON M. KAZUNGU



# DETERMINATION OF AMMONIA IN SEAWATER ( BERTHELOT REACTION )

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### A. INTRODUCTION

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### Reagents.

#### PHENOLS :

Phenols that undergo the Berthelot reaction normally have an unsubstituted para-position although some Phenols with vacant para-positions may not react if there is steric hindrance from adjacent groups. Other phenolic compounds are sometime used in place of Phenol. However, only Thymol and Sodium salicylate have been found to give somewhat good results comparable to Phenol.

#### HYPOHALITE SOURCE :

The formation of Monochloramine as the first stage ( see the reaction mechanism ) is usually achieved in the presence of Hypochlorite.

#### CATALYSTS :

Sodium nitroprusside is used as a catalyst because it provides a more rapid colour development and a stable colour.

1. Add 10 ml of 1% solution of phenol to 10 ml of 0.1% solution of sodium hypochlorite and 10 ml of 0.1% solution of sodium nitroprusside and swirl the mixture.

2. Allow the mixture to stand at room temperature ( 20-25°C ) for one hour. The colour of the mixture should be a deep blue. During this period, the colour should be stable. The colour should be stable for about 24 hours after the reaction period.

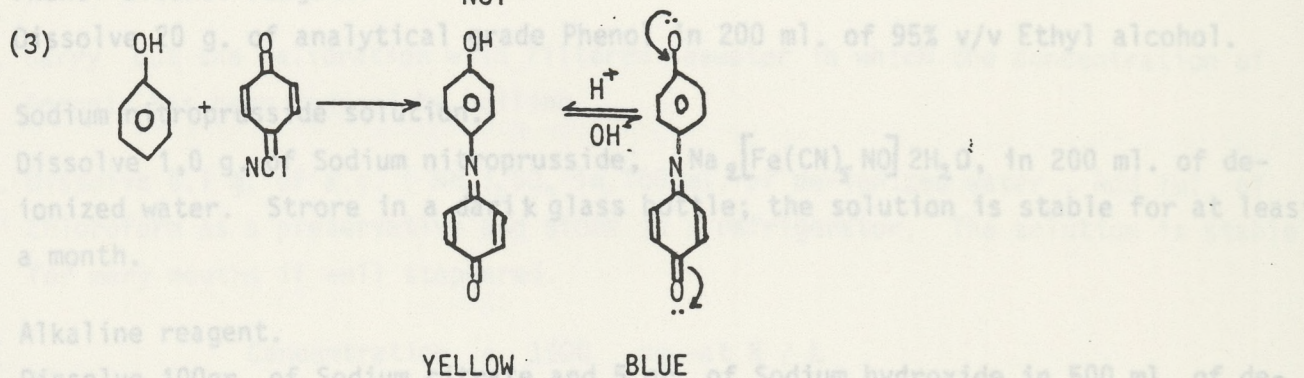
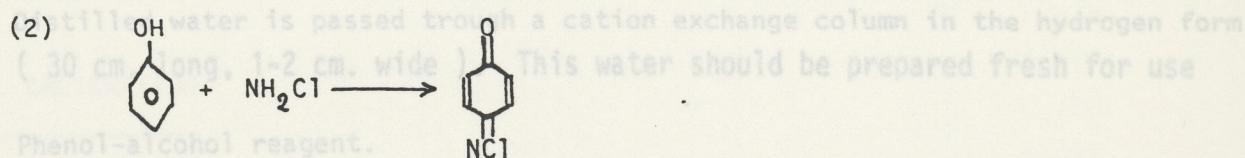
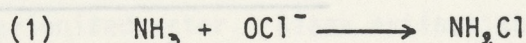


# DETERMINATION OF AMMONIA IN SEAWATER ( BERTHELOT REACTION )

## A. INTRODUCTION

The Berthelot reaction is the name given to the reaction of Ammonium ions and Phenol, which, under suitable oxidizing conditions, results in the formation of an Indophenol dye. These dyes are highly conjugated and absorb between 620 and 720 nm.

### Nature of reaction. (reaction mechanism)



### Reagents.

#### PHENOLS :

Phenols that undergo the Berthelot reaction normally have an unsubstituted para-position although some Phenols with vacant para-positions may not react if there is steric hindrance from adjacent groups. Other phenolic compounds are sometime used in place of Phenol. However, only Thymol and Sodium salicylate have been found to give somewhat good results comparable to Phenol.

#### HYPOHALITE SOURCE :

The formation of Monochloramine as the first stage ( see the reaction mechanism ) is usually achieved in the presence of Hypochlorite.

#### CATALYSTS :

Sodium nitroprusside is used as a catalyst because it provides a more rapid colour development and a stable colour.

Add 2ml. of phenol solution, swirl to mix, and then add in sequence 2 ml. of Nitroprusside and 5 ml. of oxidizing solution; mix after each addition by swirling the flask.

2. Allow the flask to stand at room temperature ( 20-27°C ) for one hour. The top of the flask should be covered with parafilm during this period. The colour is stable for about 24 hours after the reaction period.



## B. ORDER OF ADDITION OF REAGENTS

---

In most methods the Phenol is added prior to the Hypochlorite and at high concentration of Hypochlorite, little or no Indophenol is produced if the Hypochlorite is added first. At lower concentrations the Hypochlorite can be added first with no loss of sensitivity and this order of reagent addition fits the proposed reaction sequence.

## C. REAGENTS PREPARATION

---

### 1. De-ionized water.

Distilled water is passed through a cation exchange column in the hydrogen form ( 30 cm. long, 1-2 cm. wide ). This water should be prepared fresh for use.

### 2. Phenol-alcohol reagent.

Dissolve 20 g. of analytical grade Phenol in 200 ml. of 95% v/v Ethyl alcohol.

### 3. Sodium nitroprusside solution.

Dissolve 1.0 g. of Sodium nitroprusside,  $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}] \cdot 2\text{H}_2\text{O}$ , in 200 ml. of de-ionized water. Store in a dark glass bottle; the solution is stable for at least a month.

### 4. Alkaline reagent.

Dissolve 100 gr. of Sodium citrate and 5 gr. of Sodium hydroxide in 500 ml. of de-ionized water. The solution is stable indefinitely.

### 5. Sodium hypochlorite solution.

Use commercially available Hypochlorite ( e.g. "Chlorox" ) which should be about 1.

### 6. Oxidizing solution.

Mix 100 ml. of reagent 4 and 25 ml. of reagent 5. Keep stoppered while not in use and prepare fresh every day.

## D. EXPERIMENTAL PROCEDURE

---

### 1. Add 50 ml. of seawater to an erlemeyer flask from a 50 ml. measuring cylinder.

Add 2 ml. of phenol solution, swirl to mix, and then add in sequence 2 ml. of Nitroprusside and 5 ml. of oxidizing solution; mix after each addition by swirling the flask.

### 2. Allow the flask to stand at room temperature ( 20-27°C ) for one hour. The top of the flask should be covered with parafilm during this period. The colour is stable for about 24 hours after the reaction period.



## RESULTS

3. Read the extinction ( absorbance ) at 640 nm. in a spectrophotometer using a 10 cm ( or 1 cm. ) cell length.
4. Correct the measured extinction for the reagent blank and calculate Ammonia-nitrogen from a prepared standard calibration graph.

Blank

1 µg.-at N/L

### E. DETERMINATION OF BLANK

Carry out the method exactly as described in sections D1 to D3 above using 50 ml. of de-ionized water. Blank extinction, should not exceed about 0.075 on a 10 cm. cell ( 0.0075 on a 1 cm. cell ).

### F. CALIBRATION

1. Carry out the calibration with filtered seawater in which the concentration of Ammonia has been reduced by boiling.
2. Dissolve 0.1 g. of a.g.  $(\text{NH}_4)_2\text{SO}_4$  in 1000ml. of de-ionized water. Add 1ml. of Chloroform as a preservative and store in a refrigerator. The solution is stable for many months if well stoppered.

$$\text{Concentration} = 1500 \text{ } \mu\text{g.-at N / L}$$

This implies that

For calibration purposes, dilute this stock solution ( using Ammonium-free seawater and prepare working standards with the following concentrations :

1 µg.-at N/L , 5 µg.-at N/L , 7 µg.-at N/L , 10 µg.-at N/L , 15 µg.-at N/L  
20 µg.-at N/L , 25 µg.-at N/L , 35 µg.-at N/L , 45 µg.-at N/L ,  
55 µg.-at N/L .

Accuracy calculation

Absorbance for the 10 µg.-at N/L solution was 0.140

$$\text{ABS} = 0.0265$$

$$\therefore \text{Concentration} = \frac{0.140}{0.01667}$$

$$= \frac{0.140 + 0.0265}{0.01667}$$

$$= 9.988 \text{ } \mu\text{g.-at N/L}$$



RESULTS

Accuracy =  $\frac{10 - 9.988}{10} \times 100 \%$

CONCENTRATION	ABSORBANCE ( ABS )	( ABS - BLANK ABS )
Blank	0.006	
1 µg.-at N/L	0.015	0.009
5 "	0.047	0.041
7 "	0.073	0.067
10 "	0.146	0.144
15 "	0.240	0.234
20 "	0.331	0.325
25 "	0.410	0.404
35 "	0.593	0.587
45 "	0.761	0.755
55 "	0.840	0.834

To check whether the Berthelot reaction method could be applied in estuary conditions Figure 1 shows a graph of Absorbance v/s Concentration. It is clearly indicated that the maximum concentration value which obeys Beer's law is 47.50 µg.-at N/L. From the graph, the linear regression equation is :

Results :  $y = 0.01667 x - 0.0265$

This implies that

1. 5 µg.-at N/L      5%      0.038  
2.      "      10%      0.039  
3.      "      20%      0.040  
4.      "      30%      0.041  
5.      "      40%      0.041  
6.      "      50%      0.041

$$\text{ABSORBANCE} = 0.01667 \text{ CONCENTRATION} - 0.0265 \quad (I)$$
$$\therefore \text{CONCENTRATION} = \frac{\text{ABS} + 0.0265}{0.01667} \quad (II)$$

Accuracy calculation

Absorbance for the 10 µg.-at N/L solution was 0.140

From our results, it appears that salinity difference does not affect our ABSORBANCE values very much, that "salinity effect" can be neglected for Ammonia measurements in estuaries.

$$\therefore \text{Concentration} = \frac{\text{ABS} + 0.0265}{0.01667}$$
$$= \frac{0.140 + 0.0265}{0.01667}$$
$$= 9.988 \text{ µg.-at N/L}$$

It is important that samples for Ammonia determination should be analysed immediately after collection and stored in glass bottles.



## DETERMINATION OF NITRATE

$$\text{Accuracy} = \frac{10 - 9.988}{10} \times 100 \%$$

$$\text{A. Introduction} = 0.12 \%$$

## Detection limit calculation

For detection limit calculation, prepare 10 blank samples and run them. Then using the absorbance values, calculate the standard deviation  $\sigma$ . Then multiply the standard deviation by 3. Insert the value  $3\sigma$  as absorbance in equation (II) and get the corresponding concentration value. This value is the detection limit.

## SALINITY EFFECT

To check whether the Berthelot reaction method could be applied in estuary conditions a standard sample of 5  $\mu\text{g.}$ -at N/L was prepared by diluting 1 ml. of the stock solution to 300ml. with artificial seawater of different salinities.

## Results :

Concentration	Salinity	Absorbance
1. 5 $\mu\text{g.}$ -at N/L	5‰	0.038
2. "	10‰	0.038
3. "	20‰	0.039
4. "	25‰	0.038
5. "	30‰	0.040
6. "	35‰	0.041
7. "	40‰	0.041

From our results, it appears that salinity difference does not affect our ABSORBANCE values very much. This implies that "salinity effect" can be neglected for Ammonia measurements in estuaries.

## SAMPLE STORAGE

It is important that samples for Ammonia determination should be analysed immediately after collection and stored in glass bottles.

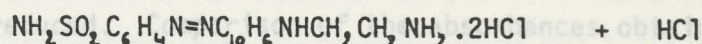
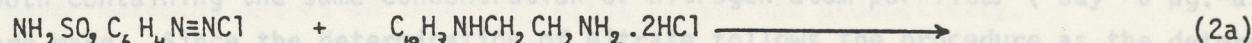
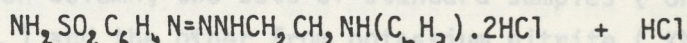
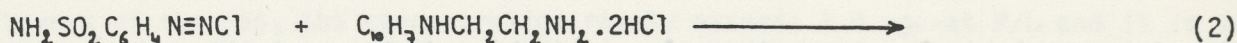
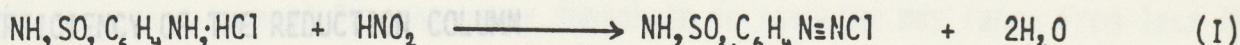


# DETERMINATION OF NITRATE

## A. Introduction

Nitrate in seawater is reduced almost quantitatively to Nitrite when a sample is run through a column containing Cadmium filings coated with metallic Copper. The Nitrite produced is then determined by diazotizing with Sulfanilamide and coupling with N-(1-naphtyl)-ethylenediamine to form a highly coloured azo dye which can be measured spectrophotometrically. Any Nitrite initially present in the sample must be corrected for.

Possible suggested equations for the diazotization and coupling of the reaction.

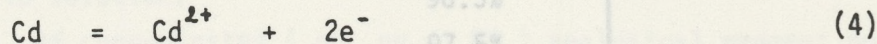


note : The product of the coupling reaction is not definitely known but equations (2) and (2a) represent possibilities.

## Results :

### Interferences ( Reductor column )

The mechanism of reduction must involve the oxidation of Cadmium metal as given in the redox reactions (3) and (4) ;



Anything that can change the ultimate rate of electron transfer or the redox potential of reaction (4) can possibly interfere with the analytical method. Other metal ions and ligands can change the redox potential of (4) and hence possibly decrease or increase the electron availability which could show up as a positive or negative interference in the method. Alternatively inorganic or organic complexing agents can interfere by associating with Cadmium ions formed at all the metal surface, so providing a block to most active reducing sites.



## B. METHODOLOGY

For the experimental procedure, refer " A manual of Chemical and Biological Methods for Seawater Analysis ". By Timothy R. Parsons, Yoshiaki Maita and Carol M. Lalli. is used, then the sample should be analysed within the first eight hours.

## C. RESULTS

Figure 2 shows the calibration graph obtained by plotting concentrations values (  $\mu\text{g.-at N/L}$  ) of a set of standard Nitrate samples against their absorbance values after being reduced in the column. The linearity conforms with Beer's law

## D. EFFICIENCY OF THE REDUCTION COLUMN

To check the efficiency of the reduction column, two sets of standard samples ( one prepared from Potassium nitrate (  $\text{KNO}_3$  ) and the other from potassium nitrite (  $\text{KNO}_2$  ) both containing the same concentration of nitrogen atom per liter ( say  $6 \mu\text{g.-at N/L}$  ) are made. Since the determination of Nitrate follows the procedure as the determination of Nitrite once the Nitrate has been reduced. Comparison of the absorbances obtained from the  $6 \mu\text{g.-at N-NO}_3/\text{L}$  with those obtained from the  $6 \mu\text{g.-at N-NO}_2/\text{L}$  will help one calculate efficiency.

Results :

For the  $\text{NO}_2^-$ , the mean absorbance for the  $6 \mu\text{g.-at N-NO}_2/\text{L}$  was 0.283.

For the  $\text{NO}_3^-$ , the absorbance for the  $6 \mu\text{g.-at N-NO}_3/\text{L}$  were;

1. Ammonium Molybdate solution.

Absorbance	% Efficiency	
1. 0.275	97.2%	} 96.5%
2. 0.280	99.0%	
3. 0.273	96.5%	
4. 0.276	97.5%	
5. 0.276	97.5%	
6. 0.274	96.8%	
7. 0.263	93.0%	
8. 0.277	97.9%	
9. 0.265	93.6%	
10. 0.271	95.8%	

From the above figures, the mean efficiency of the reductor column is found to be about 97%.



## E. SAMPLE STORAGE

----- 34 gr. of Potassium antimonyl-tartrate ( tartar emetic ) in 250 ml. of water, warming if necessary. Store in a glass or plastic bottle. The solution is stable for many months.  
Samples should be analysed immediately after collection. In case this is difficult, 40 mg./L Mercuric chloride should be used as a preservative. If the preservative is used, then the sample should be analysed within the first eight hours.

## DETERMINATION OF PHOSPHATE

### C. EXPERIMENTAL PROCEDURE

#### A. Introduction

The concentration of Phosphorus as Phosphate in seawater may range from less than about 0.01  $\mu\text{g.}-\text{at P/L}$  in surface waters to over 3  $\mu\text{g.}-\text{at P/L}$  in deep water. In the upper layers of the sea, the concentration rarely exceeds 1.0  $\mu\text{g.}-\text{at P/L}$  and it is in these layers that Phosphate is taken up by the phytoplankton and enters the marine food chain. Changes in the Phosphorus content of the seawater may be used as indicators of the water movement and as an index of plant growth and productivity.

In the following Phosphate determination method, the seawater sample is allowed to react with a composite reagent containing Molybdic acid, Ascorbic acid and trivalent Antimony. The resulting complex is reduced to give a blue solution which is measured at 885 nm.

### D. DETERMINATION OF BLANK

#### B. SPECIAL REAGENTS

Use distilled water in place of a sample and carry out steps 1-3 above to obtain the reagent blanks.

1. Ammonium Molybdate solution. Reagent blanks should be less than 0.002 on a 1 cm. path.  
Dissolve 15 gr. of analytical reagent grade Ammonium paramolybdate  $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}$  in 500 ml. of distilled water. Store in plastic bottle away from direct sunlight. The solution is stable.
2. Sulfuric Acid solution.  
Add 140 ml. of concentrated ( sp. gr. 1.82 ) analytical reagent quality Sulfuric acid to 900 ml. of distilled water. Allow the solution to cool and store it in a glass bottle. Store in dark bottle with 1 ml. of Chloroform; the solution is stable.
3. Ascorbic Acid solution.  
Dissolve 27 gr. of Ascorbic acid in 500 ml. of distilled water. Store the solution in a plastic bottle frozen solid in the freezer. The solution is stable for many months but should not be kept at room temperature for more than one week.

With each sample, repeat steps 1-3 of section C. After correction for the blank reagent, plot a graph of Absorbance against Concentration ( in  $\mu\text{g.}-\text{at P/L}$  ).



#### 4. Potassium Antimonyl-Tartrate solution.

Dissolve 0.34 gr. of Potassium antimonyl-tartrate ( tartar emetic ) in 250 ml. of water, warming if necessary. Store in a glass or plastic bottle. The solution is stable for many months.

#### 5. Mixed Reagent.

Mix together 100 ml. Ammonium molybdate, 250 ml. Sulfuric acid, 100 ml. Ascorbic acid and 50 ml. of Potassium Antimonyl-tartrate solution. Prepare this reagent when needed and discard any excess.

### C. EXPERIMENTAL PROCEDURE

1. Warm the samples to room temperature ( 15-30°C ). Measure the turbidity of a sample at 885 nm. ; if this value is greater than 0.01, a correction should be applied to the final extinction value ( step 4 ).
2. To a 100 ml. sample, add 10 ml. of mixed reagent using a syringe- type pipette and mix at once.
3. After 5 min. and preferably within the first 2-3 hours, measure the extinction in a 1 cm. cell against distilled water at 885 nm.
4. Correct the extinction with the reagent blank ( and turbidity blank if necessary ) and get the corresponding Phosphate concentration from a standard calibration graph ( see below ).

### D. DETERMINATION OF BLANK

Use distilled water in place of a sample and carry out steps 1-3 above to obtain the extinction of the reagent blank. Reagent blanks should be less than 0.002 on a 1 cm. cell.

### E. CALIBRATION

1. Molybdate reagent.  
Dissolve 0.136 gr. of anhydrous potassium dihydrogen Phosphate,  $\text{KH}_2\text{PO}_4$ , in 1 L of distilled water. Store in dark bottle with 1 ml. of Chloroform ; the solution is stable for many months.

Concentration = 1000  $\mu\text{g}$ -at P/L

2. Ascorbic acid.  
From this stock solution prepare standard working samples of 1  $\mu\text{g}$ .-at P/L, 3  $\mu\text{g}$ .-at P/L, 5  $\mu\text{g}$ .-at P/L, 7  $\mu\text{g}$ .-at P/L and 10  $\mu\text{g}$ .-at P/L. and dilute to 1 L. with distilled water. With each sample, repeat steps 1-3 of section C. After correction for the blank reagent plot a graph of Absorbance against Concentration ( in  $\mu\text{g}$ .-at P/L ).



Figure 3 shows the calibration graph obtained. Note the linear relationship between the absorbance and the concentration as expected in the Beer's law. By preparing many standards, the linearity range may be found.

#### F. STORAGE OF SAMPLES

Samples should be analyzed immediately after collection otherwise preserved with Chloroform.

### DETERMINATION OF SILICATE

#### A. Introduction

Many natural waters contain less than 10 mg./L Silica, though some may approach 60 mg./L. A Silica cycle occurs in many bodies of water containing organisms such as diatoms that utilize Silica in their skeletal structure. The Silica removed from the water may be slowly returned by re-solution of dead organisms. Though there are quite a number of methods for the determination of Silica in seawater the Heteropoly blue method seems to be used the most. In this method, the seawater sample is allowed to react with Molybdate under conditions which result in the formation of Silicomolybdate, Phosphomolybdate and Arsenomolybdate complexes. A reducing solution, containing Ascorbic acid, is then added which reduces the Silicomolybdate complex to give a blue colour and simultaneously decomposes any Phosphomolybdate or Arsenomolybdate. The resulting extinction is measured using a 1 cm. cuvette.

#### B. SPECIAL REAGENTS

##### 1. Molybdate reagent.

Dissolve 4.0 g. of analytical reagent quality Ammonium paramolybdate,  $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ , in about 300 ml. of distilled water. Add 12 ml. of concentrated Hydrochloric acid (12 N), mix and make to volume of 500 ml. with distilled water. Store the solution in a polyethylene bottle and keep out of direct sunlight.

##### 2. Ascorbic acid.

Dissolve 17.6 g. of reagent grade quality Ascorbic acid in 500 ml. of distilled water containing 50 ml. of Acetone. Mix and dilute to 1 L. with distilled water.



3. Oxalic acid solution. The solution is stable and consist of ;

Prepared saturated Oxalic acid by shaking 50 g. of analytical reagent quality Oxalic acid dihydrate,  $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$ , with 500ml. of distilled water. Decant the solution from the crystals for use; the solution may be stored in a glass bottle and is stable indefinitely.

4. Sulfuric acid solution 50 % v/v.

Pour 250 ml. of concentrated Sulfuric acid (sp. gr 1.82) into 250 ml. of distilled water. Cool to room temperature and make the volume to 500 ml. with a little extra water.

5. Reducing reagent.

Mix 100 ml. of the Ascorbic acid with 60 ml. of Oxalic acid solution. Add slowly with mixing, 60 ml. of the 50 % Sulfuric acid solution and make the mixture up to 300ml. with distilled water. The solution should be prepared each time for immediate use.

#### A. OUTLINE OF METHOD

#### C. EXPERIMENTAL PROCEDURE

The method described is essentially for analysing organic Carbon in sediments. A

1. Samples should be at room temperature ( 18-25°C ). Add 10 ml. of Molybdate solution to a dry 50 ml. graduated cylinder fitted with a glass stopper. Pipette 25 ml. of the seawater sample into the cylinder, stopper and mix by inverting; allow to stand for 10 min. , but not for more than 30 min.
2. Add the reducing reagent rapidly to make 50 ml. and mix immediatly.
3. Allow the solution to stand for 2-3 hours to complete the reaction. Measure the extinction for the blank and read the corresponding Silicate concentration from the standard calibration graph. ( see below ).

#### D. DETERMINATION OF BLANK

Use distilled water, which has been collected in a polyethylene container, in place of seawater and carry out steps 1 to 3 in section C.

#### E. CALIBRATION

Standard Silica Solution ( Stock Solution )

Weight 1.44 g. of Sodium metasilicate monohydrate,  $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$ , and dissolve in 100 ml of distilled water. Dilute to exactly 1000 ml., mix, and transfer the solution to a



polyethylene container for storage. The solution is stable and consist of ;

$$1 \text{ ml.} = 5 \text{ } \mu\text{g.-at Si}$$

By diluting certain quantities of the stock solution, prepare the working standards of concentrations : 1  $\mu\text{g.-at Si/L}$  , 5  $\mu\text{g.-at Si/L}$  , 10  $\mu\text{g.-at Si/L}$  , 50  $\mu\text{g.-at Si/L}$  and 100  $\mu\text{g.-at Si/L}$ . Using these working standards, instead of the seawater, repeat steps 1 to 3 of section C. After correcting for the blank reagent plot a graph of absorbance vs. concentration. Figure 4 shows the calibration graph obtained using the above working standard.

Analytical reagent grade (70%) Phosphoric acid.

### C. EXPERIMENTAL PROCEDURE

#### DETERMINATION OF PARTICULATE ORGANIC CARBON

1. Weigh out about 250 ml. (u.25 g. ) of the sample and put it into a 30 ml. beaker.
2. Add 1.0 ml. of Phosphoric acid and 1.0 ml. of distilled water. Mix and place in a 100-110°C for 30 min., cover with a water glass during this period.
3. Add 10 ml. of Sulfuric acid-dichromate oxidant and 4.0 ml. distilled water.

#### A. OUTLINE OF METHOD

4. The method described is essentially for analysing organic Carbon in sediments. A certain amount of the particulate matter is weighed and put into a 30 ml. beaker.
5. Carbon is then determined by " wet-ashing " with Dichromate and concentrated Sulfuric acid. The decrease in extinction of the yellow Dichromate solution is taken as a measure of the oxidable Carbon.
6. Range : 10 to 4000  $\mu\text{g.-at C/L}$

7. Correct the resulting extinction for the absorbance of trivalent Chromium by the expression :  $E = 1.1 E_p$  , where  $E_p$  is the extinction found by difference in 6 above.

Calculate the particulate Carbon in  $\mu\text{g.C/g}$  from the expression :

$$\mu\text{g C/g} = \frac{E \times F \times v}{W} \quad \text{where } W \text{ is the weight of sample used in grams,}$$

$$v \text{ is the volume of oxidant used ( 10 ml. )}$$

$$F \text{ is the factor as described below.}$$

#### D. BLANK DETERMINATION

Blank determinations should be carried out exactly as described in steps 2 to 5 above, using 1 ml. of Phosphoric acid , 10 ml. of oxidant and 4 ml. of distilled water. The blank extinction measured against distilled water should be between 1 and 1.1 . The blank should then be used in step 6 , section C above.



## B. SPECIAL REAGENTS

### 1. Sulfuric acid-dichromate oxidant.

Dissolve 4.84 g. of Potassium dichromate,  $K_2Cr_2O_7$ , in 20 ml. of distilled water. Add this solution a little at a time to about 500 ml. of concentrated Sulfuric acid (analytical quality grade) in a 1000 ml. volumetric flask. Cool the mixture to room temperature and make to volume with more concentrated Sulfuric acid. Store in a glass-stoppered bottle protected from dust; the solution is stable indefinitely.

### 2. Phosphoric acid.

Analytical reagent grade (70%) Phosphoric acid.

## C. EXPERIMENTAL PROCEDURE

1. Weigh out about 250 ml. (0.25 g.) of the sample and put it into a 30 ml. beaker.
2. Add 1.0 ml. of Phosphoric acid and 1.0 ml. of distilled water. Mix and place in a block heater at 100-110°C for 30 min., cover with a water glass during this period.
3. Then, add 10 ml. of Sulfuric acid-dichromate oxidant and 4.0 ml. distilled water.
4. Mix by swirling and place a cover glass over each beaker. Heat for 60 min. at 100-110°C.
5. Cool the mixture and transfer the solution to a 50 ml. volumetric flask. Rinse the sides of the beaker with distilled water and make the flask up to volume with distilled water. Stopper and mix by inverting; allow to stand at room temperature to cool.
6. Measure the extinction of a blank solution against the sample at 440 nm. using a 1-cm. cuvette.
7. Correct the resulting extinction for the absorbance of trivalent Chromium by the expression :

$$E = 1.1 E_F, \text{ where } E_F \text{ is the extinction found by difference in 6 above.}$$

Calculate the particulate Carbon in  $\mu\text{g.C/g}$  from the expression :

$$\mu\text{g C/g} = \frac{E \times F \times v}{W} \quad \text{where } W \text{ is the weight of sample used in grams,}$$

$$v \text{ is the volume of oxidant used ( 10 ml. )}$$

$$F \text{ is the factor as described below.}$$

## D. BLANK DETERMINATION

Blank determinations should be carried out exactly as described in steps 2 to 5 above, using 1 ml. of Phosphoric acid, 10 ml. of oxidant and 4 ml. of distilled water.

The blank extinction measured against distilled water should be between 1 and 1.1.

The blank should then be used in step 6, section C above.



## E. CALIBRATION

### 1. Standard Glucose solution.

Dissolve 7.50 g. of pure glucose and a few crystals of mercuric Chloride,  $\text{HgCl}_2$ , in distilled water and fill up to a volume of 100 ml. The solution is stable for many months in the refrigerator but should be discarded if any turbidity develops. Dilute 10 ml. of the concentrated solution to 1 L with distilled water.

$$1\text{ml.} = 300 \mu\text{g of Carbon}$$

### 2. Procedure.

Put 1 ml. of Phosphoric acid into a beaker. Then add 10 ml. of oxidant and 4 ml. of diluted Glucose solution to the beaker. Continue the method as in section C, steps 4 to 7. Calculate the factor F as

$$F = \frac{120}{E_s}$$

where  $E_s$  is the average of three standard extinctions corrected for the trivalent Chromium absorption at 440 nm.

## F. RESULTS

The following is the result of organic Carbon measurement for a sediment sample collected near the Kenya Meat Commission (K.M.C.) in the Tudor creek. The core sample was sectioned into nine parts and marked A1 to A9. The results are expressed in mg. C per gram of sample analysed, (mg.C/g).

CORE SECTION	DEPTH (cm)	CORRECTED ABS	mgC/g
A1 A1	0 - 3.0	0.252	32.58
A2 A2	3.0 - 5.5	0.272	35.17
A3 A3	5.5 - 8.0	0.209	27.07
A4 A4	8.0 - 10.5	0.266	34.39
A5 A5	10.5 - 12.0	0.185	23.92
A6 A6	12.0 - 13.0	0.059	7.63
A7 A7	13.0 - 14.0	0.111	14.35
A8 A8	14.0 - 15.0	0.156	20.17
A9 A9	15.0 - 16.0	0.150	19.40



Average Es = 0.3375

Absorption of blank against distilled water was 0.999

From the results obtained we observe a general decrease with depth of the organic Carbon content. This decrease is mainly due to bacterial degradation.

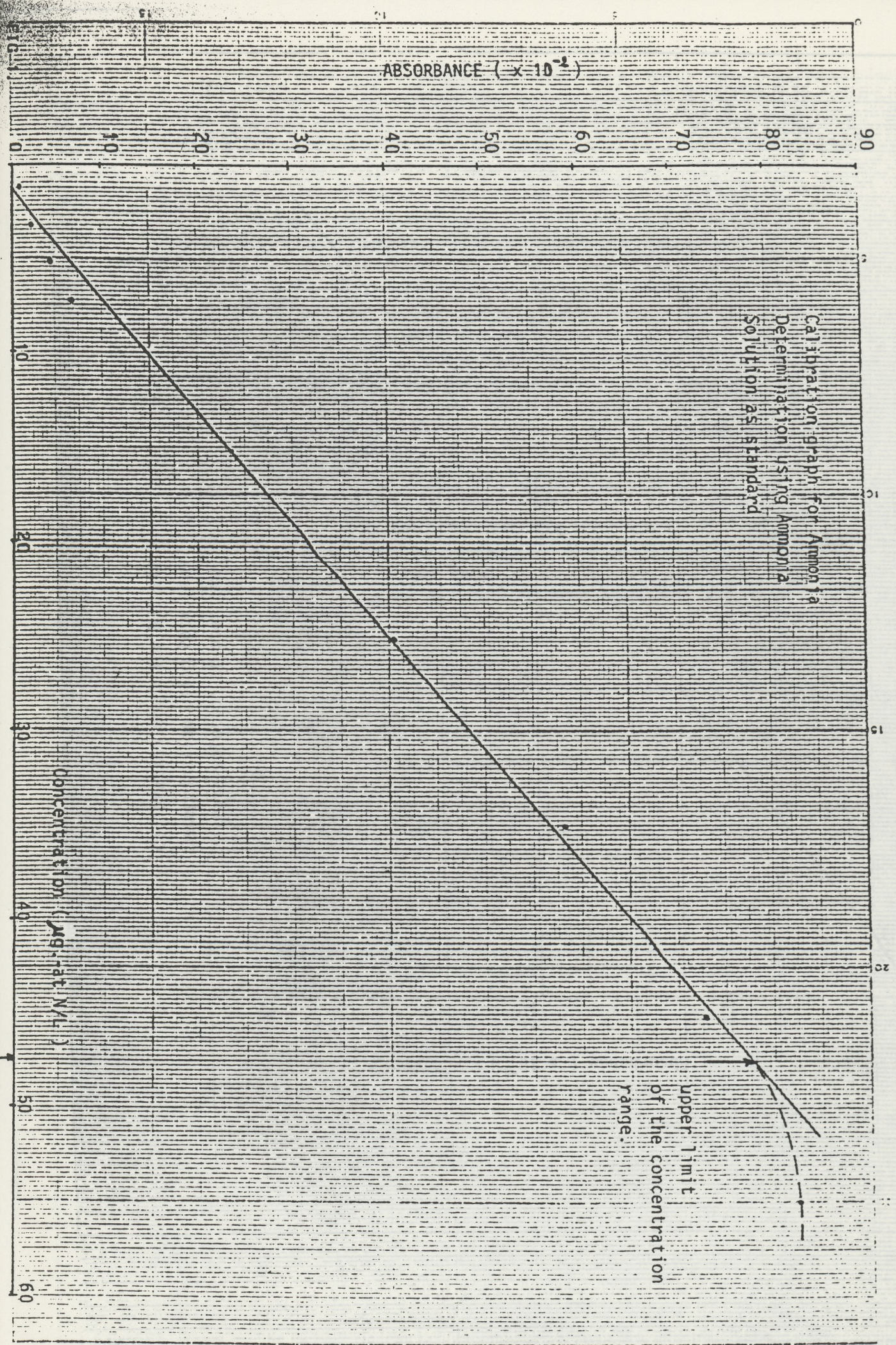
## CONCLUSION

---

For nutrients analysis, the most difficult part is with sample storage prior to analysis. In most cases samples have to be analysed immediately after collection. This is usually difficult due to the number of samples often collected. Freezing of the samples immediately after collection has been found to be the best way for preserving the samples. Sample poisoning is also another way of preserving samples for nutrient analysis. For Ammonia determination, it is recommended that samples should be treated with a 0.49 100 ml<sup>-1</sup> of Phenol immediately after collection. Samples for Nitrate-Nitrite determination should be preserved with 40 mg/L mercuric Chloride. For Phosphate and Silicate determinations samples should be preserved with Chloroform and stored in plastic bottles. For proper Nitrate analysis, it is quite important that the efficiency of the reduction column is always above 95%. In case it falls below 95%, then the Cadmium-Copper reductor should be re-activated. For Ammonia determination, we have established that the "salt-effect" is negligible. This implies that the determination method can also be applied for estuary studies. However for Nitrate-Nitrite determinations, it is essential that the standard calibration is done, using prepared artificial seawater.

For the determination of particulate organic Carbon, the most difficult part is the heating stage. A proper temperature of 100°C should be maintained for all the samples to be analysed. Slight changes of temperature affect very much the colour intensity of the solution making one record wrong absorbance values.







Calibration graph for Nitrate  
Determination using Potassium  
Nitrate solution as standard.

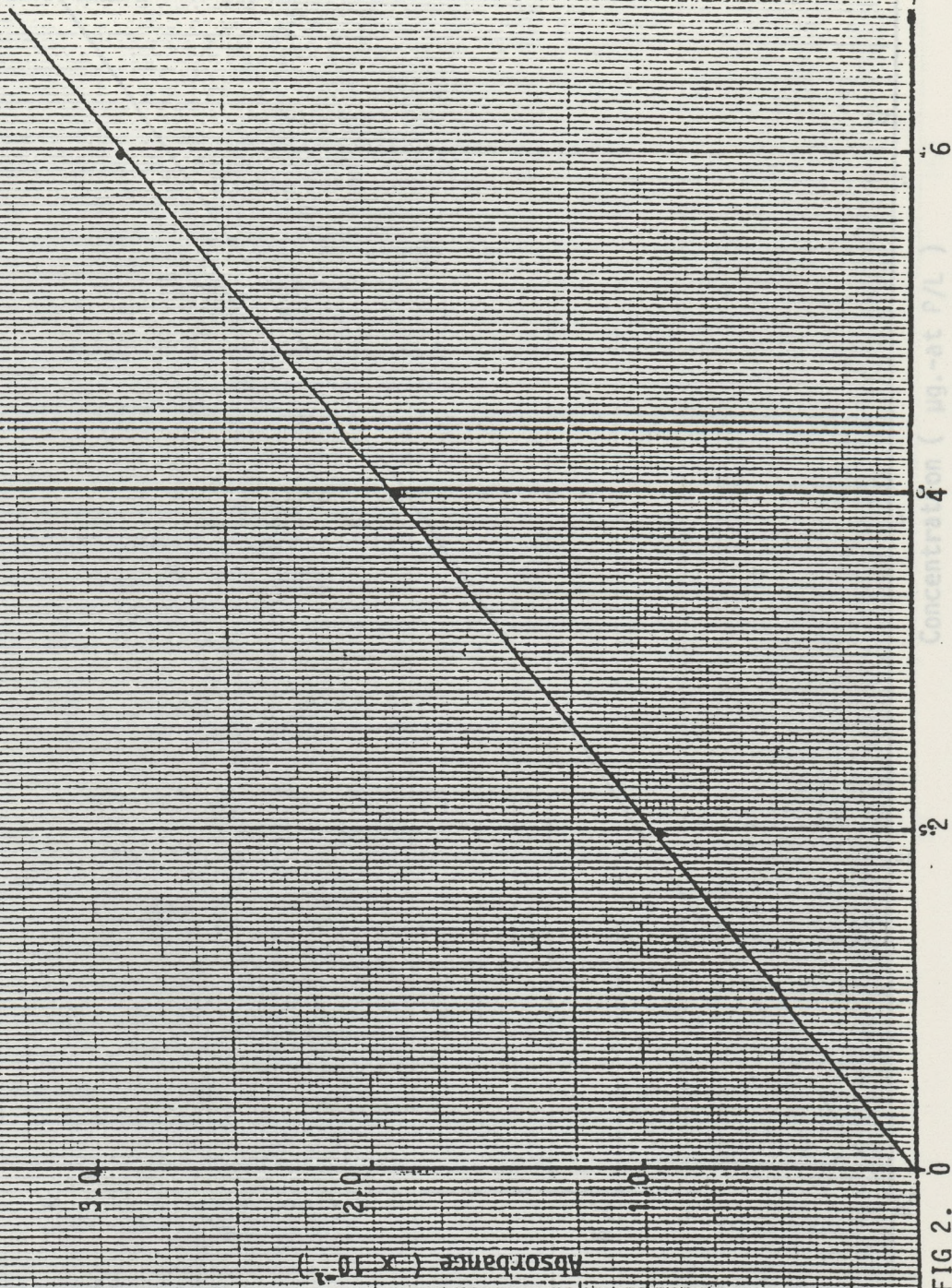


FIG 2. 0



Phosphate calibration graph using  
Potassium Dihydrogen Phosphate  
solution as standard.

24.0

12.0

6.0

Absorbance (  $\times 10^{-2}$  )

FIG. 3

2

4

6

8

10

Concentration (  $\mu\text{g. at P/L}$  )

10

8

6

4

2

0

10

8

6

4

2

0

10

8

6

4

2

0

10

8

6

4

2

0



Silica calibration graph  
using Na<sub>2</sub>SiO<sub>3</sub> solution  
as standard.

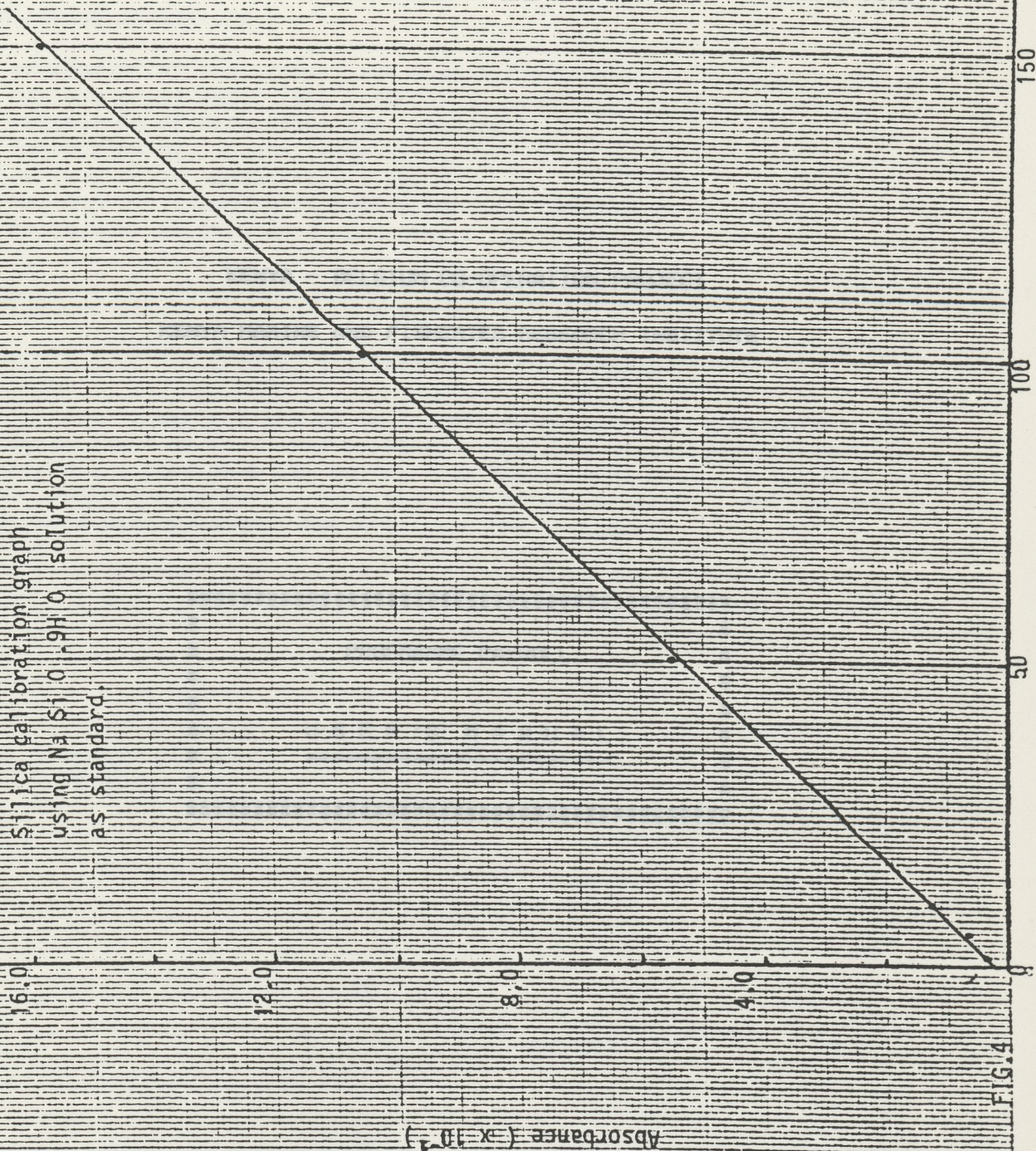


FIG. 4



## ANNEX 7

KENYA - BELGIUM CO-OPERATION PROJECT

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

```

*****
*                                     *
*          PROGRAMME PAYROLL          *
*                                     *
*                                     *
*                                     *
*                                     *
*   DATE OF PAYROLL   USER'S MANUAL   *
*   MONTH OF PAYROLL   =====       *
*   STATION            *
*****

```

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Pissierssens P, KMFRI , MOMBASA KENYA  
Onyango B.A.H , KMFRI , MOMBASA KENYA



### Introduction :

this information and RETURN, the first menu will appear on the screen (fig 2.) You can choose between 2 options :

The Program 'Payroll' was written for the Kenya Marine and Fisheries Research Institute staff payroll. It can be used with the following dimensions :

- maximum nr of employees ( per disk ) : 300
- maximum nr of deductions : 40
- maximum nr of deductions per employee : 15
- maximum nr of banks : 60
- maximum nr of +deductions : 10
- maximum nr of insurance policy per employee : 3
- maximum nr of Insurance companies : 20

## PART - I

### PAYROLL MENU

### SANGORO STATION

#### CHAPTER I : Initiating the program

After inserting the payroll disk and switching the computer , the program must be initiated : first, the date of the payroll must be entered , ( this date can differ from the current date ! ) followed by the month (in letters), and the name of the station. (Not necessary for Hard Disk version). See fig.1 for the procedure.

-----  
I N I T I A T E      Output : Reports and payroll      STATION  
-----

DATE OF PAYROLL (MMDDYY) : ? \_\_\_\_\_  
MONTH OF PAYROLL (LETTERS) : ? \_\_\_\_\_  
STATION : ? \_\_\_\_\_

Choice ? : ?

-----  
MENU    PRINT    CHANGE    KALKUL    DO  
-----

Fig.2

-----  
MENU    PRINT    CHANGE    KALKUL    DO  
-----

Exercise : enter 1 , then RETURN

Fig.1

Note : Some screens will not be illustrated because they are just slight variations of the ones illustrated. After a

Note : A part from the bottom line, the \_\_\_\_\_ indicate where to enter a variable. The next question only appears after the previous variable has been entered, followed by a RETURN.



After entering this information and RETURN, the first menu will appear on the screen (fig 2.) You can choose between 2 options :

```

2.1 Menu
1/ Input
2/ Output
  entering 1, the Modify menu will appear ( fig.3 ). Here
you have 11 options :
- Input contains all the routines which will change the records of the
1/ employee, whereas output includes all the reports, payroll and other
  print-outs.
- If you choose to quit, then the program will be terminated.
3/ Enter the choice as a number from 1 to 3 and press RETURN.
4/ Process records : this will update the unused values in the
  records . This procedure will be used after the last print-out ,
  -----
5/ Reset unused values to 0 : this will reset the values
  of unused values to 0 .
  -----
6/ Add employee : to add an employee to the file .
7/ Kill employee : to remove an employee from the file .
8/ Transfer employee : to transfer an employee to another station
  (file) .
9/ Modify salary scales : to change the salary scales .
10/ Modify tax rates : to change the tax rates .
11/ Return to main menu : to return to menu ( fig.2 ) .
  Make your choice :
    1/ Input : Modify variables
    2/ Output : Reports and payroll
Enter your choice as a number from 1 to 3 and press RETURN .
Exercise : Enter 3, then RETURN .
  
```

```

  Modify M E N U                      SANGORO STATION
  -----
  Make your choice ? : ? _
  -----
  MENU 1/ PRINT 2/ CHANGE 3/ KALKUL DO
  1/ Update personnel sheets
  2/ Update deduction variables
  3/ Process records (use before PAYROLL or OPTIONS)
  4/ Reset unused values to 0
  5/ Add employee
  6/ Kill employee
  7/ Transfer employee
  8/ Modify salary scales
  9/ Modify tax rates
  10/ Return to main menu
Exercise : enter 1, then RETURN
  
```

**Note :** Some screens will not be illustrated because they are just slight variations of the ones illustrated. After a little practice, you will be at home with them .

```

  Choice ? : ? _
  -----
  MENU 1/ PRINT 2/ CHANGE 3/ KALKUL DO
  1/ Update personnel sheets
  2/ Update deduction variables
  3/ Process records (use before PAYROLL or OPTIONS)
  4/ Reset unused values to 0
  5/ Add employee
  6/ Kill employee
  7/ Transfer employee
  8/ Modify salary scales
  9/ Modify tax rates
  10/ Return to main menu
  
```

Fig.3



## 2.2 Starting or Adding CHAPTER II : Modify

2.1 Menu If starting a file, then adding an employee will be the first instruction . After entering 6 in menu ( fig.3 ) you will then get screen ( fig.4 ) .

After entering 1, the Modify menu will appear ( fig.3 ). Here you have 11 options :

- 1/ Update paysheets : to change the information which will be used to calculate the salary .
- 2/ Update personnel sheets : to change the personal information of the employee.
- 3/ Update deductions : to change the label information of the used deductions.
- 4/ Process records : this will update the unused values in the records . This procedure will be used after the last print-out , every month or before the first updating the following month .
- 5/ Reset unused values to 0 : this can be used to reset the values of unused to 0 .
- 6/ Add employee : to add an employee to the file .
- 7/ Kill employee : to remove an employee from the file .
- 8/ Transfer employee : to transfer an employee to another station (file) .
- 9/ Modify salary scales : to change the salary scales .
- 10/ Modify tax table : to change the tax rates .
- 11/ Return to main menu : to return to menu ( fig.2 ) .

Enter your choice as a nr from 1 to 11 , and press RETURN .

Exercise : Enter 6 , then RETURN .

```
-----
Modify M E N U                                SANGORO STATION
-----
MENU PRINT CHANGE KALKUL DO
Make your choice :

1/ Update paysheets
2/ Update personnel sheets
3/ Update deduction variables
4/ Process records (use before PAYROLL or OPTIONS)
5/ Reset unused values to 0
6/ Add employee
7/ Kill employee
8/ Transfer employee
9/ Modify salary scales
10/ Modify tax table
11/ Return to main menu

Choice ? : ?
MENU PRINT CHANGE KALKUL DO
```

Fig.3



## 2.2 Starting or Adding a file

If starting a file, then adding an employee will be the first instruction. After entering 6 in menu (fig.3) you will then get screen ( fig.4 ) .

```

A D D employee          SANGORO STATION
-----
Personnel nr : 7 446  <<

Job group       : 7 B<<      First D.O.A : 7 070993<<
-----
A D D employee          SANGORO STATION
-----

Employee nr : 69          Name : .
                        Bank : 7 CASH
Personnel nr : .          Bank acc. nr : 7 ---

Job group      : .          First D.O.A : .
Job            : .          T.O.E       : .

CHANGE(F6),SAVE(F10)

MENU__PRINT____CHANGE_____KALKUL__DO__
  
```

Fig.5

Bank : .  
Bank acc. nr : .

The option line now gives 'CHANGE(F6) , SAVE(F10)' : 'change' for more changes , 'save' to store the record as you have now entered it. If you now OK, push F10 . You will see the little red light on Disk drive 2 come on and hear the disk turn. After this, the option line shows 'CONTINUE(F10)' . It is only one option, so press :

```

MENU__PRINT____CHANGE_____KALKUL__DO__
  
```

You can continue the above procedure for all employees .

Fig.4

>>Important : Always make sure you have entered the job group. Omitting this information will give problems when you try to update the 'Employee nr' gives the number at which the new employee's details will be stored (this nr will further be called the Payroll nr ). At the bottom of the screen you can see the choices for the function keys : 'CHANGE(F6) , CONTINUE(F10) ' . The F6 corresponds with the function key ( top row on th keyboard ) F6 , the F10 with the corresponding function key F10 .

As you wish to change the values for this employee ( it is now an empty record ) , press F6. Now , for every variable to enter, limiters '<<' will appear ( fig.5 ) :these indicate the maximum length of that variable . If you make the 'word' longer then the extra characters or numbers will be left out ( ignored ).

After the entry of each variable , push RETURN . Fig.5 also shows a finished screen.



A D D employee

SANGORO STATION

## 2.4 Update Paysheets

Fig.6 gives the update paysheets screen.

Employee nr : 69 Name : ? OWIDI C.A. <<

Personnel nr : ? 446 << SANGORO STATION

Job group : ? B<< First D.O.A : ? 090983<<

Job : ? AUX.STAFF << T.O.E : ? PF <<

Make your choice :

1/ Selected sheet

2/ More sheets

3/ Return to menu

Bank : ? CASH <<

Bank acc. nr : ? ---

CHANGE (F6), SAVE (F10) Choice ? : ?

MENU PRINT CHANGE KALKUL DO  
MENU PRINT CHANGE KALKUL DO

Fig.5

Choices are 'Selected sheet' or 'More sheets'. Whereas for 'selected sheet' The option line now gives 'CHANGE(F6) , SAVE(F10)' : 'change' for more changes , 'save' to store the record as you have now entered it. If you think the record is now OK, push F10 . You will see the little red light on Disk drive 2 come on and hear the disk turn. After this, the option line shows 'CONTINUE(F10)' . It is only one option, so press it.

You can continue the above procedure for all employees .

>>Important : Always make sure you have entered the job group. Omitting this information will give problems when you try to update the paysheet later ( ERROR !! ).

## 2.3 Update Personnel Sheets

If you want to change the personal information after adding the employee , you must use 'Update personnel sheets' to do this. Choice nr 2 of the modify menu.

After entering this option , enter the payroll nr of the employee you want to change . See 'Add employee' for further instructions.

MENU PRINT CHANGE KALKUL DO

Fig.7



## 2.4 Update Paysheets

Fig.6 gives the update paysheets screen. The information which will be used to generate the payslip later.

----- should be 0  
UPDATE PAYSHEETS SANGORO STATION  
-----  
with your new file, but may sometimes have strange effects.

The bottom ( option ) line gives MENU(F2), PRINT(F3), CHANGE(F6), and CONTINUE(F10) Make your choice :

>>Important : For 1/ Selected sheet a highlighted nr and a normal video nr. The 2/ More sheets the value now stored on the disk , while the other one 3/ Return to menu calculated unused ( = old val. + new unused or - used )

If you push F2 you will be returned to the 'Modify menu' ( fig.3 )

- F3 will give a print-out copy Choice ? : ? \_ , and

- F6 will MENU \_ PRINT \_ CHANGE \_ KALKUL \_ DO \_

Push F6 : a '?' will appear after the D.O.A (Date of appointment) ; it asks for the last date of job-group change.

Fig.6

Choices are 'Selected sheet' or 'More sheets'. Whereas for 'selected sheet' after the updating is finished, you will return to the menu, 'more sheets' will return you, after updating, to the next screen ( fig.7 ).

nr : 446 Bank : CASH  
Terms of empl : PF Bank Account : ---

-----  
Earning Update More sheets calculation SANGORO STATION ions :  
-----

Job group : B Round down : 45.00 +NSSF 45.00  
Basic Pay 725.00

Current number of entries = 68

GROSS PAY Payroll number of employee ? : ? \_

Tax deduc. 00.00

Net Pay : 700

Tot ded. : 300.00

MENU(F2), PRINT(F3), CHANGE(F6), CONTINUE(F10)

----- MENU \_ PRINT \_ CHANGE \_ KALKUL \_ DO \_

----- MENU \_ PRINT \_ CHANGE \_ KALKUL \_ DO \_

Fig.7



If the employee was given 'increments', this date must be decremented by a number of years equal to the number of increments. If your choice is 'selected sheet' then push 1 followed by RETURN.

This screen ( fig.8 ) gives you the information which will be used to generate the payslip later.

All variables which were not entered in the 'Add' routine should be 0 ( zero ). If not ,then there was still information left from a previous file, which had not been erased. This will not interfere with your new file, but may sometimes have strange effects.

The bottom ( option ) line gives 'MENU(F2), PRINT(F3), CHANGE(F6), and CONTINUE(F10)'

>>Important : For unused you can see a highlighted nr and a normal video nr. The highlighted nr is the value now stored on the disk , while the other one is the currently calculated unused ( = old val. + new unused or - used )

If you push F2 you will be returned to the 'Modify menu' ( fig.3 )

- F3 will give a print-out copy of the screen, and

- F6 will enable you to update this record :

Push F6 : a '?' will appear after the D.O.A (Date of appointment) ; it asks for the last date of job-group change.

Payroll sheet nr : 1      Name : OWIDI C.A.      D.O.A : 090983      D: 063086  
First date : 090983

Personnel nr : 446      Bank : CASH  
Terms of emplm : PF      Bank Account : ---

Earnings :	Tax calculation :	Deductions :
Job group : B	Round down : 45.00	+NSSF 45.00
Basic Pay 725.00	.	.
.	.	.
.	.	.
.	.	.
GROSS PAY : 1000.00		

Tax deduc. 00.00

Net Pay : 700

Tot ded. : 300.00

MENU(F2),PRINT(F3),CHANGE(F6),CONTINUE(F10)

-----MENU-----PRINT-----CHANGE-----KALKUL-----DO-----

Fig.8



If the employee was given 'increments', this date must be decremented by a number of years equal to the number of increments. Alternatively, if the employee was demoted, this date must be incremented by the number of years of decrement.

The top line gives you the employee's name, payroll nr, and current date.  
**>>Important :** If the D.O.A exceeds the current date, then the Basic Pay will be zero (0).

After entering the D.O.A, press RETURN. You will notice that not every variable can be changed. Some variables on personal information can only be changed through the 'Update personnel sheets' routine, whereas others cannot be changed by you because they are calculated by the computer.

Remark : Deductions are updated in the next screen ( fig.9 )

After entering all variables the bottom line gives the following options : CHANGE(F6), CALCULATE(F9), SAVE(F10)

Use F6 if you want to make more changes,  
 - F9 if you want to calculate the salary with the updated variables,  
 and  
 - F10 to save the updated values.

>>Important : It is possible to redefine the names of the deductions. Refer to the Appendix for more information.

```

-----
D E D U C T I O N S      OWIDI C.A.      Paynr: 1 # Ded.: 4
-----
+NSSF:      45.00      Petty cash:
+NHIF:
+H.PUR.(Woodventure): enable you to ch      +S.A.Y.E: lary, calculated with
+H.PUR.(Argos):      uctions. Onthis screen      House mortg.loan: ible to make
+H.PUR.(Bic.KNTC): F10 after this will return you to the 'Number of
employee ?' screen ( fig.7 ).
  
```

Note : Subsequent deduction screens are similar to fig.9

## 2.4 Update Deduction Variables

```

Harambe loan/inter: all records,      Miscallenous 2: the 10.00 ion
CHANGE (F6), CONTINUE (F10)      uctions. This will enable you later to use
the 'Split Deductions' routine in the      SUBTOTAL DEDUCTIONS : 274.80
3 in the      ( fig.3 )      CHANGE      KALKUL      DO
  
```

U P D A T E deduction variables SANGORO STATION

Fig.9

Current number of entries : 68

### Remark :

- 1/ This F10 here, will only save the personal information, plus entered information : deductions and calculations are not saved.
- 2/ If you 'changed' and 'calculated' several times, you will have to 'save' several times as well. Changing and calculating more than five times may cause problems. Avoid it !



## 2.5 Deduction Screen

After 'saving' you will get the 'Deductions' screen ( fig.9 ). The top line gives you the employee's name, payroll nr, and current nr of deductions, while the bottom line gives you the choice between CHANGEing(F6) or CONTINUEing(F10) :

- F10 will continue back to the menu so you can do something else,

- F6 will allow you to make any changes in the deductions :

On pushing F6 , a '?' will appear next to +NSSF. If you don't want to change the value which is there , then push RETURN; if you want to change the value, enter the new value followed by a RETURN. Continue this until the last deduction.

The option line gives the options to CHANGE(F6) again , or SAVE(F10) this information.

**Remark :** Several deductions have a '+' as the first character. This indicates that these deductions are 'labelled' : other information is attached to them. See 2.6 for further information.

>>**Important :** It is possible to redefine the names of the deductions.

Refer to the Appendix for more information.

Now, if your choice at screen ( fig.6 ) was 'Selected sheet', then F10 will return you to the menu. If , however , your choice was 'More sheets' then after F10 a new option line will appear : MENU(F2), and RETURN TO PAYSCREEN(F10).

Pushing F10 will enable you to check the salary , calculated with the changed deductions. On this screen it is again possible to make change. Entering F10 after this will return you to the 'Number of employee ?' screen ( fig.7 ).

Note : Subsequent deduction screens are similar to fig.9

## 2.6 Update Deduction Variables

After entering all records, you can update the deduction variables for the '+' deductions. This will enable you later to use the 'Split Deductions' routine in the output section. Now enter choice 3 in the 'Modify' menu ( fig.3 ). This gives screen ( fig.10 ).

-----  
U P D A T E deduction variables SANGORO STATION  
-----

Current number of entries : 68

Payroll nr of employee ? : ?

-----  
MENU\_\_PRINT\_\_CHANGE\_\_KALKUL\_\_DO\_\_  
-----

Fig.10



Enter the payroll nr of the employee to update. This gives screen ( fig.11 ).

-In the top line, you will find the Payroll nr, Name and Personnel nr,  
-Line 2 gives the nr of deduction in the payslip and the name of the deduction,

then :

- Variable 1 : this , depending on the deduction, can be a PLC nr or an Insurance policy nr.
- Variable 2 : this, depending on the deduction, can be an Account nr, NSSF nr, NHIF nr or Insurance Company name.

1/ If you want to change the current info, then push F6. Else pushing F10 will advance you to the next deduction or, if there are no other deductions, to the next screen.

4/ Push F6 : now, the limiters appear. Enter the new info. If you don't want to change , just push RETURN.

6/ Personnel list

**Remark :** For variable 1 ,the range is 10 characters, and for variable 2, 20 characters. However, if necessary, the length of variable can exceed 10 to be 20. This, however might result in problems in the output routines. Therefore, it is advisable not to exceed 10.

Select and enter your choice as a nr from 1 to 9, and press RETURN

-----  
U P D A T E deduction variables    SANGORO STATION    CHANGE  
-----

Payroll nr : 1    OWIDI C.A.    Pers.nr : 446

Ded.nr : 1

1/ Generate payroll (+ report )  
2/ Report ( without generating payroll )  
3/ Pay +NSSF bank or cash )  
4/ Split bank payments  
5/ Split deductions  
6/ Personnel list  
Variable 1 (PLC nr ) : ? variables    <<  
7/ (Insur.pol.nr) card for current year

Variable 2 (Account nr ) : ? menu    <<  
(NSSF nr )  
(NHIF nr )  
(Insurance cy ) : ?

-----MENU    PRINT    CHANGE    KALKUL    DO-----  
-----MENU    PRINT    CHANGE    KALKUL    DO-----

Fig.11

After Add employee, Update Paysheets and Update Deductions, you should be ready to proceed to the output routines. Sometimes, however, more changes are necessary : Remove employee or Transfer employee. If you don't need these, you can proceed to PART II.



### 3.1 Generate payroll ( + report ) **PART - I I**

This choice will generate the payslips for the employees. On entering this choice, you will get a screen like the one shown in fig.2. This part deals with the second option of the 'payroll menu' (fig.2) choice 1, or generating part of the payroll ( plus a report on that part of the payroll ) - choice 2.

#### CHAPTER III: Payroll Options

On entering choice 2 followed by a RETURN, the 'payroll options' menu will appear on the screen (fig.36). There are 9 possibilities here

- 1/ Generate payroll ( + report )
- 2/ Report ( without generating payroll )
- 3/ Paylist ( bank or cash )
- 4/ Split bank payments
- 5/ Split deductions
- 6/ Personnel list
- 7/ Check deduction variables
- 8/ Tax deduction card for current year , and
- 9/ Return to payroll menu

Select and enter your choice as a nr from 1 to 9, and press RETURN

```
-----MENU-----PRINT-----CHANGE-----KALKUL-----DO-----
PAYROLL O P T I O N S                SANGORO STATION
-----
Make your choice :
1/ Generate payroll (+ report )
2/ Report ( without generating payroll )
3/ Paylist ( bank or cash )
4/ Split bank payments
5/ Split deductions
6/ Personnel list
7/ Check deduction variables
8/ Tax deduction card for current year
9/ Return to main menu

Salary for JUNE 1979:
Personnel nr : 446
Terms of employment : PF
Name : OMIDI C.A.
Choice ? : 2 : CASH
B.acc.: ---
-----MENU-----PRINT-----CHANGE-----KALKUL-----DO-----
-- same as fig.8 --
```

Fig.12

Choice 9 will return you to the 'payroll menu' (fig.2)

**Note :** all choices are followed by a RETURN ; thus 'entering' hereafter means " typing your choice, followed by a RETURN "



3.1 Generate payroll ( + report ) pushing any key, a report will be generated. This report will comprise :

This choice will generate the payslips for the employees. On entering this choice you will get screen (fig.13 ). Here again there is a choice between generating the whole payroll ( plus a full report ) - choice 1, or generating part of the payroll ( plus a report on that part of the payroll ) - choice 2. Pushing F(2) will halt printing and return you to 'payroll options' menu. Otherwise the generation continues.

```

-----
Generate payroll ( choice 2 ) will give 'SANGORO STATION' screen .
You have the choice of generating payslips for individual employees,
each at a time, or a few at a time. To generate a few, enter the
Number of entries : 68
at the 'First nr : ' prompt, and also at the 'Second nr : ' prompt.
Enter appropriate values at both prompts to generate payslips
for a few employees.
Make your choice :
1/ All
2/ Partly
Remark : A report is generated after every 'generate' has been
effectuated.
Note : - that the current nr of Choice ? : ? indicated,
- that before printing starts, you are asked to 'activate'
the printer. Make sure if the printer is 'activated'
otherwise you may be forced to start running the program
a fresh !
-----
MENU PRINT CHANGE KALKUL DO
-----

```

Fig.13

3.2 Report ( without generating payroll )

'Generate all' ( choice 1 ) will commence the generation of the whole payroll, printing payslips ( fig.14 ) for all employees in the station - either 'bank' or 'cash' as the case may be. After the completion of the printing of the payslips, you will be prompted to 'Adjust paper and push any key'. This allows you to adjust the printer paper to top of page if it had gone below. The report is printed out.

Remark: The time taken to produce the report without generating payroll is as follows:

```

=====
report KENYA MARINE AND FISHERIES RESEARCH INSTITUTE
SANGORO STATION
=====

```

3.3 Paylist: This choice will generate a 'Paylist' screen. The 'Paylist' screen will show the following information:

```

Salary for JUNE 1986
Normally a payroll is required for a Name : OWIDI C.A.
for record. On choosing 3, the 'Paylist' screen will appear. This gives
Personnel nr : 446 Bank : CASH
Terms of employment : PF B.acc.: ---
1- Paylist for record
2- Paylist for cash payments (signature column) ; and
3- return to main menu - same as fig.8 -

```

```

-Choice 3 returns you to 'main menu'
-Choice 1 gives a payroll for 'Bank' or 'Cash'. For cash payroll this
choice gives a payroll for 'Bank' or 'Cash'. For cash payroll this
signature column is given by the cashier.
-Choice 2 gives a payroll for 'Bank' or 'Cash'. For cash payroll this
signature column is given by the cashier.
Payroll nr : 1 only a Payroll sheet nr : 4 which is also
=====

```

Fig.14



After adjusting the paper and pushing any key, a report will be generated. This report will comprise :  
i. breakdown of all payments to all employees, and  
ii. breakdown of all deductions from all employees.

The options line gives 'STOP PRINT F(2)'. Pushing F(2) will halt printing and return you to 'payroll options' menu. Otherwise the generation continues.

'Generate part' ( choice 2 ) will give the 'Generate part' screen . You have the choice of generating payslips for individual employees, each at a time, or a few at a time.  
To generate for an individual, enter the individual's payroll nr at the 'First nr :' prompt, and also at the 'Second nr :' prompt. Enter appropriate payroll numbers at both prompts to generate payslips for a few employees.

**Remark :** A report is generated after every 'generate' has been effectuated.

**Note :** - that the current nr of entries is indicated,  
- that before printing starts, you are asked to 'Activate the printer !'. Make sure you do if the printer wasn't, otherwise you may be forced to start running the program out of bank calling name, payroll nr, personnel nr, bank, bank account and net pay.

### 3.2 Report ( without generating payroll )

Choice 2 of the payroll options will give the 'Report without generating payroll' screen . The report is generated without the payslips being printed. In the mid-section of the screen the current number of record being processed is indicated until the last record. After all the records are processed, the report is printed out.

**Remark:** The time taken to produce the report without generating payroll is about the same as the time taken to produce the report with the payroll ( 3.1 ).

### 3.3 Paylist

Normally a paylist is required for a quick check of errors, and for record. On choosing 3, the 'Paylist' screen will appear. This gives you 3 choices:

- 1- Paylist for record
- 2- Paylist for cash payments (signature column), and
- 3- return to main menu.

-Choice 3 returns you to 'main menu'  
-Choice 1 gives a paylist for 'Bank' or 'Cash'. For cash payroll this choice doesn't give a column for signatures of the payees: this signature column is given by  
-Choice 2, which gives only a paylist for 'cash' in which is also included the cash breakdown for each payee, to facilitate easy payment by the cashier.



After a payroll for cash with signature column has been produced, a "Certificate of Paying Officer" is generated followed by a "Totals of cash breakdown". This cash breakdown helps the cashier when withdrawing from the bank to know how much of 100's, 50's, etc. notes or coins to take.

**Remark:** The paylists are arranged according to the order of sorting e.g. Name, Personnel number etc (see 3.6 for details on sorting).

### 3.4 Split Bank Payments

This option works only with bank payments. It breaks down the payees to their banks and then makes paysheets for the banks, plus by a voucher for recommendation and approval. The voucher also has spaces for 'voucher number' and 'cheque number'. Also, verification and examination are done on these paysheets (as is done on all paysheets).

- on entering this choice, a sorting of the banks is done, and shown on the screen. The option line gives "MENU F(2), HARD COPY (F3) and CONTINUE (F10)
- F(2) returns you to the 'payroll options' menu.
- F(3) gives a print-out of the sorted list of banks, after which the option line gives the same options.
- F(10) will enhance the splitting of the bank payments and print-out of bank lists detailing name, payroll nr, personnel nr, bank, bank account and net pay.

**Note:** If you want a sorted list of banks, press F(3) before 'continuing'.

### 3.5 Split Deductions

This choice does essentially the same thing as the split bank payments except here the split is according to the different deductions. The print-outs are lists of all deductions with all the employees contributing to each. The format is the same.

- On entering this choice, the screen of all deductions appears. The option line gives F(2), F(3) and F(10).
- F(2) returns you to payroll options menu.
- F(3) gives a print-out of the deductions, yielding same options again.
- F(10) allows you to continue with the splitting.

**Note :** If you want a print-out of the deductions, press F(3) before F(10).

On pushing F10 to continue, the option line gives 'SPLIT SELECTED(F6), SPLIT ALL(F10)'.

You have a choice of splitting all the deductions one after the other automatically (F10), or splitting (a) selected deduction(s) one at a time (F6). On pushing F6 to split a selected deduction, the option line will ask you 'Which number (1-38) ?' : you will enter your choice as a nr from 1 to 38 as on the deductions screen.



After entering your choice, the deduction you have chosen will be highlighted on the screen which also informs you about current nr of entries. Splitting will commence, giving a print-out similar to that one of 'bank split'. The main difference will be the deduction name in place of the bank name, and of course the differences in personal details.

After finishing, the option line will give MENU(F2), HARD COPY(F3), and CONTINUE(F10) on screen.

You can opt to quit by going back to menu (F2), make a hard copy (print-out) of the screen (F3), or continue (F10) which will allow you to choose between selected split or split all again. You can do this until all the deductions you wanted split are finished.

### 3.6 Personnel List Card for the current year

This choice 6 of the payroll options will generate two types of personnel lists:

- i - the list of employees who have their salaries paid to their banks : this list details for each such employee, list nr, (bank) payroll nr, name, personnel nr, bankers and bank account nr, and
- ii - the list of employees who are paid in cash, detailing their list nrs, (cash) payroll nrs, name, and personnel nrs.

These are just routine lists for checking details on both types of payroll. On entering this option, a screen giving total nr of entries, and the order to which the Personnel list will be sorted : this can be name, personnel nr, date of appointment, payroll nr, first date of appointment, terms of employment, job group or bank (for bank payroll only). The option line gives you 'CHANGE SORT(F6), and CONTINUE(F10)' :

- Change sort (F6) will allow you to change the order to which the list is sorted (as given on the screen). If you push F6 you will be prompted to choose the sorter option among those 8 above or to go back to the Personnel list menu. Choose the order to which you want the list sorted and enter. The sorting will be done and you will be returned to the Personnel list menu. From here you can now
- Continue (F10) to print a list sorted according to last order of sorting. The date of printing as well as the station (and bank or cash) also appear on the list for reference.

### 3.7 Check Deduction Variables

This option is something between a 'Deduction split' and a 'Personnel list'. It works only with the +deductions, and gives splits for these deductions detailing employees' (contributors') name, PLC nr, ( or insurance policy nr ), and Account nr, ( or Insurance company name ).

These lists are merely for checking if the details are correct for the contributors before generating the payroll and the reports to accompany such contributions to the companies concerned.



TO: ALL RESEARCH OFFICERS &amp;

30TH MAY, 1986

## TECHNICIANS.

On entering this choice, before the printing of the lists, you will have the choice of returning to the menu without the lists (F2), making a hard copy of the +deductions which will appear on screen (F3), or continuing (F10). F(10) will allow the lists to be printed.

On pushing F10 you will have a list on screen, of all the +deductions and a prompt for the +deduction you have chosen to split. After finishing splitting one +deduction, you will have the choice to go back to 'MENU(F2)' or 'SPLIT ANOTHER DEDUCTION(F10)'.  
1345

You can get all the splits for all the +deductions in the same manner, and quit by 'MENU(F2)'.

Details on Insurance Premium splitting will be appended. on 15 - 20 minutes

on the topics shown against their names:-

## 3.8 Tax Deduction Card for the current year

1. This option will produce, for every employee on an annual basis, a card detailing all his/her taxation records for the year.

2. Mr. Oduor: Plankton Ecology (Coastal)  
3. Again as you will have realised by now, the program is very easy to use i.e user friendly, since you are aided by suggesting prompts at every stage.

You can try this option as an exercise to see if you have mastered the procedures. You can also try out the other options not covered in both parts e.g Kill employee, Transfer employee etc etc.

6. Mr. Makubis: Population Dynamics of Penaeid Shrimps in Tudor Creek.

7. Mr. Nzioka: GOOD LUCK

8. Mr. Oduor: Fish quality Control.

9. Mr. Ruwa: Mangrove Ecology.

10. Ms. Iathiga: Coral Reef Ecology.

11. Miss Abubakar: Nutritive Value of Oysters.

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TO: ALL RESEARCH OFFICERS &  
TECHNICIANS.

30TH MAY, 1986

EZEKIEL OKENWA

## ZOOPLANKTON RESEARCH

SEMINAR MEETING.

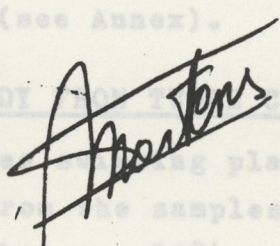
## 1.1 ZOOPLANKTON STUDY FROM LIKONI FERRY

This is to inform you that there will be a seminar meeting on Friday, 13th June, 1986 in the library as from 9.00 am.

The following officers will deliver a speech for between 15 - 20 minutes on the topics shown against their names:-

1. Dr. Tackx Mickey: Overview of the research in oceanography.
2. Mr. Okenwa: Plankton Ecology (Copepods)
3. Mrs. Kimaro: Zooplankton ( Fish eggs & Larvae)
4. Mr. Kazungu: Marine Chemistry (Nutrients, POC, Salinity, Oxygen in Tudor Creek)
5. Mrs. Oyieke: Phycology
6. Mr. Makwabi: Population Dynamics of Penaeid Shrimps in Tudor Creek.
7. Mr. Nzioka: Research on fishes.
8. Mr./ Oduor: Fish quality Control.
9. Mr. Ruwa: Mangrove Ecology.
10. Ms. Muthiga: Coral Reef Ecology.
11. Miss Abubaker: Nutritive Value of Oysters.

P.O. BOX 100  
NCT: DUTCHMAN





## KENYAN/BELGIAN BIOLOGICAL OCEANOGRAPHY PROJECT.

2.1 RESPIRATION EXPERIMENT

EZEKIEL OKEMWA

## ZOOPLANKTON RESEARCH

1.1 ZOOPLANKTON STUDY FROM LIKONI FERRY

Data are drawn from six 24-hours samplings taken in a series once a month and every after two months for a year starting in April, 1985 to February, 1986.

Zooplankton samples were collected from a car ferry using the Clarke-Bumpus high speed sampler having a mouth area of 0.017 m<sup>2</sup>. Tows were conducted every two hours for the duration of the crossing (about 4 minutes) by the car ferry with a 480 hp diesel power engine.

Total zooplankton abundance averaged 2000/m<sup>3</sup>. The magnitude of annual changes was small. Calanoid increased five fold in the South-East monsoon than North-East. The copepoda were clearly the dominant taxa throughout the six 24-hours cycles.

In the evening there is a sudden increase which holds on during the night. In the morning there is a sudden drop. We can attribute this to vertical migration of copepoda and some other taxa.

However, the magnitude of the difference and the pattern of catch-rates over 24 hours varied on each of the six occasions. Some of the variability appeared to be linked to the high-low tidal cycle (see Annex).

1.2 COPEPODA STUDY FROM TUDOR CREEK

Fifty-two free swimming planktonic copepod species were identified from the samples collected from three stations in Tudor Creek between 1984 and 1985. This appears to be the first systematic account of copepods reported from the coastal and inshore waters of Kenya (see Annex 12)



## 2.1 RESPIRATION EXPERIMENT

The aim is to measure the amount of food required by an animal for maintenance. Further it is also a rough method to sketch the kind of food web we are dealing with in Tudor Creek.

Zooplankton samples were collected on four occasions (12th February, 19th March, 2nd May, and 6th June, 1986) from Fort Jesus near Mombasa. Zooplankton were selected for respiration experiment. Respiration rates were measured using Winkler method, and related to dry-weight of the animals.

The respiration rate for the Zooplankton ranged from  $0.57 \mu\text{g O}_2/12 \text{ hours/animal}$  to  $130.2 \mu\text{g O}_2/12 \text{ hours/Animal}$  with a mean value of  $13.6 \mu\text{g O}_2/12 \text{ hrs/animal}$  (see Table 1).

All these respiration results show different features: Most of the species have a much higher respiration rate at night than at day. We can conclude that zooplankton are much more active at night than at day.

SPECIES	Day	Night	Day	Night
<i>Centropages ornithi</i>	2.4	3.15	8.07	
<i>Acartia</i> sp.	0.57	8.16		
<i>Acartia</i> sp.	2.79	6.6		
<i>Eucalanus</i> sp.	5.61	34.98	3.12	25.8
<i>Macrosetella</i>	3.06	2.91	8.82	3.6
Crab larvae	0.78	3.12		
<i>Acrocalanus</i>	28.74		3.39	21.63
Decapod larvae	25.41			
<i>Calanopia elliptica</i>		2.85	9.27	
<i>Oncaea</i> sp.			2.79	
<i>Gyrodinium aureolum</i>				45
<i>Hemistriella</i>				31
Ostracod				27
<i>Undinula vulgaris</i>				130.2



Table 1. Respiration of zooplankton from Fort Jesus expressed in  $\mu\text{gO}_2/12 \text{ hrs/}$   
Animal.

	DATE	February 12th, 1986	March 19th, 1986	May 3rd, 1986	June 6th, 1986
	PERIOD	Day Night	Day Night	Day Night	Day ni
<b>SPECIES</b>					
<u>Temora turbinata</u>		3.07 11.25	2.69 13.47	3.33 10.47	
<u>Centropages orsinii</u>		2.4		3.15 8.07	
<u>Acartia</u> sp.		0.57			
<u>Acartia</u> sp <sub>2</sub>		2.79 11.25	3.42 6.69	1.5 8.16	
<u>Eucalamus</u> sp		5.61 34.98	3.12 25.8	5.07 24.33	
<u>Macrosetella</u>		3.06	2.91 8.82	3.6 18.36	
Crab larvae		0.78 3.12			20
<u>Acrocalanus</u>		28.74		3.39 21.63	1006 6.
Decapod larvae		25.41			
<u>Calanopia elliptica</u>			2.85 9.27		8.
<u>Oncaea</u> sp				2.79	
<u>Sygnathus cynospilus</u>					45.
<u>Hemisiriella</u>					31
Ostracod					27
<u>Undimula vulgaris</u>					130.2



An attempt was made to estimate the organic carbon weight of the animal and respiration expressed as a function of the unit weight/day; and carbon respiration as a function of carbon weight. Table 2 lists the dry weight in  $\mu\text{g}$  per animal, Respiration in  $\mu\text{g}$  carbon and percentage of body carbon weight used by respiration.

Carbon losses were expressed by respiration as a function of the body carbon and we find that there are higher losses for the herbivores (30-49%) than for the carnivores (20%) (Table 2).

Table 2:

Respiration and dry weight of zooplankton from Fort Jesus expressed as a function of the unit weight/day; and carbon respiration as a function of carbon weight.

Date: 12.2.1986

Species	Dry weight in $\mu\text{g}$	Respiration in $\mu\text{g C}$	% of body carbon weight used by respiration.
<u>Temora</u>	28.9	4.47	34
<u>Eucalanus</u>	74.7	12.68	38
Crab larvae	13.4	1.22	20
<u>Acartia</u> sp <sub>2</sub> .	22.5	4.39	43
<u>Date: 19.3.1986</u>			
Species			
<u>Eucalanus</u>	55.8	9.04	37
<u>Calanopia</u>	27.58	3.79	31
<u>Date: 3.5.1986</u>			
Species			
<u>Temora</u>	28.9	4.31	33
<u>Centropages</u>	23.8	3.51	33
<u>Date: 6.6.1986</u>			
Species			
<u>Acrocalanus</u>	10.03	2.23	49



Table 3. Mean dry weight and mean length of Groups

## 2.2 COPEPODS' WEIGHTS AND LENGTHS MEASUREMENTS

Table 3 shows the mean weight per individual animal and the corresponding mean length per individual for the copepods on each planchet from the three stations in Tudor Creek.

<u>Undinula vulgaris</u>	stn 1/27.8.1985	10	1.81 ± 0.11	90.94
<u>Undinula vulgaris</u>	Estimation of biomass is going to be made after more data has been acquired.			
<u>Undinula vulgaris</u>		10	1.92 ± 0.08	114.82
<u>Calanopia elliptica</u>	stn 1/27.8.1985	10	1.11 ± 0.12	42.24
<u>Centropages orsinii</u>	For accurate analysis it is better to work on formalized samples. So a series of measurements is being carried out on individual species to know the weight loosed in formaline			
<u>Centropages orsinii</u>		9	0.73 ± 0.08	11.97
<u>Acartia</u>	"	10	0.93 ± 0.07	10.89
<u>Centropages orsinii</u>	stn 1/27.8.85	10	1.05 ± 0.05	5.03
<u>Acrocalanus</u>	stn 2/12.2.1986	10	0.82 ± 0.08	8.7
<u>Calanopia elliptica</u>	stn 2/27.8.85	24	1.35 ± 0.05	33.0
<u>Temora turbinata</u>	"	14	0.73 ± 0.02	9.2
<u>Canthocalanus pauper</u>	"	11	1.05 ± 0.02	19.8
<u>Undinula vulgaris</u>	"	5	1.92 ± 0.03	94.6
<u>Undinula vulgaris</u>	"	7	2.23 ± 0.13	111.4
<u>Calanopia minor</u>	"	7	1.21 ± 0.06	25.8
<u>Calanopia minor</u>	"	10	1.19 ± 0.08	24.7
<u>Centropages orsinii</u>	"	15	1.05 ± 0.03	13.1
<u>Centropages orsinii</u>	"	15	1.13 ± 0.04	15.2
<u>Calanopia elliptica</u>	"	33	1.27 ± 0.03	42.43
<u>Centropages orsinii</u>	"	18	1.07 ± 0.05	14.12
<u>Canthocalanus pauper</u>	stn 3/27.8.1985	35	1.04 ± 0.05	18.36
<u>Temora turbinata</u>	"	64	0.74 ± 0.04	8.93
<u>Temora turbinata</u>	"	39	0.77 ± 0.05	9.35
<u>Undinula vulgaris</u>	"	9	1.75 ± 0.09	64.20
<u>Calanopia elliptica</u>	"	10	1.10 ± 0.15	28.85
<u>Calanopia minor</u>	"	13	0.88 ± 0.02	10.70



Table 3. Mean dry weight and mean length of Groups of copepods from Tudor Creek.

Species	Location/Date of collection	Number of animals	Mean length (mm)	Mean weight ( $\mu$ g)
<u>Undinula vulgaris</u>	stn 1/27.8.1985	10	1.81 $\pm$ 0.11	90.94
<u>Undinula vulgaris</u>	"	10	2.23 $\pm$ 0.08	151.33
<u>Undinula vulgaris</u>	"	10	1.92 $\pm$ 0.08	114.82
<u>Calanopia elliptica</u>	stn 1/27.8.1985	10	1.11 $\pm$ 0.12	42.24
<u>Centropages furcatus</u>	"	10	1.10 $\pm$ 0.11	20.34
<u>Centropages orsinii</u>	"	10	1.11 $\pm$ 0.05	14.28
<u>Temora turbinata</u>	stn 1/4.3.86	9	0.81 $\pm$ 0.09	11.66
<u>Temora turbinata</u>	"	9	0.73 $\pm$ 0.08	11.97
<u>Acartia</u>	"	10	0.93 $\pm$ 0.07	10.89
<u>Centropages orsinii</u>	stn 1/27.8.85	10	1.05 $\pm$ 0.05	5.03
<u>Acrocalanus</u>	stn 2/12.2.1986	10	0.82 $\pm$ 0.08	8.7
<u>Calanopia elliptica</u>	stn 2/27.8.85	24	1.35 $\pm$ 0.05	33.0
<u>Temora turbinata</u>	"	14	0.73 $\pm$ 0.02	9.2
<u>Canthacalanus pauper</u>	"	11	1.05 $\pm$ 0.02	19.8
<u>Undinula vulgaris</u>	"	5	1.92 $\pm$ 0.03	94.6
<u>Undinula vulgaris</u>	"	7	2.23 $\pm$ 0.13	111.4
<u>Calanopia minor</u>	"	7	1.21 $\pm$ 0.06	25.8
<u>Calanopia minor</u>	"	10	1.19 $\pm$ 0.08	24.7
<u>Centropages orsinii</u>	"	15	1.05 $\pm$ 0.03	13.1
<u>Centropages orsinii</u>	"	15	1.13 $\pm$ 0.04	15.2
<u>Calanopia elliptica</u>	"	33	1.27 $\pm$ 0.03	42.43
<u>Centropages orsinii</u>	"	18	1.07 $\pm$ 0.05	14.12
<u>Canthocalanus pauper</u>	stn 3/27.8.1985	35	1.04 $\pm$ 0.05	18.36
<u>Temora turbinata</u>	"	64	0.74 $\pm$ 0.04	8.93
<u>Temora turbinata</u>	"	39	0.77 $\pm$ 0.05	9.35
<u>Undinula vulgaris</u>	"	9	1.75 $\pm$ 0.09	64.20
<u>Calanopia elliptica</u>	"	10	1.10 $\pm$ 0.15	28.85
<u>Calanopia minor</u>	"	13	0.80 $\pm$ 0.02	10.70



### 2.3: ZOOPLANKTON COUNTINGS

A vertical net haul is being taken twice a month at Fort Jesus (station one on Tudor Creek for identification of the most important zooplankton species.

Regular sampling of zooplankton is carried out on Tudor Creek on 5 stations Gazi Creek, and at English Point(near KMFRI).

### 2.4: STUDIES ON OYSTERS

Plankton sampling at ENGLISH POINT and Gazi are carried out twice every week and oyster larvae are observed and enumerated in the laboratory.

### 2.5 WATER CHEMISTRY

A monitoring programme on water chemistry has been set out, one sampling station at English Point, is carried out daily, and 5 stations on Tudor Creek are sampled four times monthly.

Salinity and Temperature are measured daily during working days in a week at English Point. Dissolved Oxygen, PH,  $\text{SiO}_2$  are also measured twice a week at English Point. All the parameters mentioned above are measured twice monthly during day and night of one spring and one neap tides respectively.

In addition to the monitoring programme, nutrient analysis are carried out on the 5 stations on Tudor Creek by Mr. Kazungu.

### 2.6 Algae and Primary Production

Samples for algal species composition, biomass, chlorophyll analysis and Primary Production measurements are planned on a monthly basis on the 5 stations on Tudor Creek.



KENYAN/BELGIAN BIOLOGICAL OCEANOGRAPHY PROJECT  
KENYA MARINE AND FISHERIES RESEARCH INSTITUTE,  
P. O. BOX 81651,  
MOMBASA.

TIME	0630			1830
DAY	Oyster culture. Measure $O_2$ Secchi			carry out measurements of physical and chemical parameters, at English point
	pH, salinity, $NO_3$ Temperature ... etc.			Data analysis.
THURSDAY	during low and high tides.			
	Wash and prepare sample bottles			
	data files, and note books.			

WORK PLAN ON DAILY BASIS:

TIME	0630 — 1230	1230 - 1400	1400 — 1830
MONDAY	Collection of plankton (pass 200 lts of water through 55 $\mu$ m mesh - Net). Take measurements of physical and chemical parameters ( $PH$ , $O_2$ , salinity, Temperature, secchi disk measurement, $SiO_2$ , $NH_4$ , $NO_3$ .....) at English point (pool water Brackish water).	LUNCH	Oyster culture experiment in wet Lab and at the Jetty and at the Pillars on Mkomani Beach. Measure physical and chemical parameters at KMFRI and pool water and Brackish water. Collect plankton. Write labels and enter the findings.
TUESDAY	Collect oyster larvae during low and high tide at English point. Take measurements of physical and chemical parameters: $O_2$ , pH, salinity, Temp., secchi disk measurement. Enter data in files.	LUNCH	Take measurements of physical and chemical parameters at English point during low and high tide. Data processing. Oyster experiment in the wet lab. and at English point and at the Pillars on Mkomani Beach.
WEDNESDAY	Take observations on water pool, pass 100 lts of water through 55 $\mu$ m mesh. Net. Measure $O_2$ , pH, $NO_2$ , $NO_3$ , $NH_4$ , $SiO_2$ , salinity, Temperature, Secchi disk. Oyster culture experiment in wet Lab. Data analysis.	LUNCH	Measure physical and chemical parameters at English point. Carry out Oyster experiment. Data analysis.



TIME	0630 ---- 1230	1230-1400	1400 ----- 1830
DAY	Oyster culture. Measure O <sub>2</sub> Secchi disk, pH, salinity, No <sub>3</sub> Temperature ... etc. during low and high tides. Wash and prepare sample bottles. up data files, and note books.	LUNCH	carry out measurements of physical and chemical parameters, at English point Data analysis.
THURSDAY			
FRIDAY	Take plankton samples from English point (pass 200Lts of sea water through 55 $\mu$ m mesh-Net). Measure and count oyster settlement on the control packets at Oyster platform A & B during low tide. Monitor O <sub>2</sub> , pH, Salinity, Temp., Secchi disk measurement ... etc at English point. Oyster experiment in the Aquaria in wet Lab.	LUNCH	Take plankton samples at English point. Measure physical and chemical parameters also at English point. Oyster experiment at wet Lab. and English.
	<u>PERSONNEL:</u> 1. Mr. Stephen Muiro (Technician) 2. Mr. Jospha Kitonga       " 3. Mr. Joseph Kilonzo       " 4. Mr. James Anunda       " 5. Mr. Nicholas Maroko     "		<u>NOTE:</u>  The success of experiment calls for the spirit of <u>TEAM WORK</u> .



The composition, distribution and abundance of near-surface zooplankton throughout a one year cycle (November 1984-October 1985) was studied by the analysis of monthly samples taken at three fixed stations. THE COMPOSITION, DISTRIBUTION AND ABUNDANCE OF NEAR SURFACE ZOOPLANKTON IN TUDOR CREEK, MOMBASA, KENYA. The abundance of selected groups was determined by counting using a Bogorov tray under a Wild (Heerbrugg) M3C stereomicroscope. The selected groups were chaetognaths, copepods, molluscan larvae, crustacean decapod larvae (excluding brachyuran larvae), brachyuran larvae, fish eggs and fish larvae. Station 1 was located at the mouth of the creek, station 2 was about 2 km from station 1 in the middle reaches of the creek and station 3 was about 2 km from station 2 in the upper reaches of the creek.

BY

Mercy Mghoi Kimaro

Zooplankton sampling was carried out by horizontal tows with a plankton net of 335 micron mesh size at an approximate depth of 1.3 m. The composition, distribution and abundance of zooplankton were measured. Abstract of a thesis to be submitted in part fulfilment for the degree of Master of Science, University of Nairobi.

On two occasions (24th-25th June, 1985 and 23rd-24th September, 1985), 24 h sampling was carried out at two hourly intervals at a fixed station (English point) in Tudor Creek, in order to determine the diel cycle of near-surface abundance of the selected groups. The composition, distribution and abundance of zooplankton and the hydrographic parameters monitored, showed seasonal changes closely related with the two monsoon seasons (northeast monsoon season: November-March; southeast monsoon season: May-September; intermonsoon periods: April and October). The surface water temperature was high during the northeast monsoon with a maximum value of 29.0 °C recorded from January to March at all stations. During the southeast monsoon, the surface water temperature declined reaching a minimum value of 26.0 °C at station 1 from July to September and the same minimum at stations 2 and 3 in October. The annual range of surface water temperature at the three stations was therefore small (3 °C) characteristic of tropical waters. The surface water salinity was 35 ‰ at all stations throughout the northeast monsoon except in February when the maximum value of 36 ‰ was recorded at all stations.

During the southeast monsoon the surface water salinity declined reaching minimum values in May at all stations coinciding with a peak in rainfall. The minimum value differed between stations: 33 ‰ at station 1, 31 ‰ at station 2 and 30 ‰ at station 3. Station 1 experienced the least annual salinity change (3 ‰) whereas stations 2 and 3 experienced the largest (5 ‰ and 6 ‰ respectively) as would be expected from their locations in the creek. The largest Secchi disc readings were recorded at station 1 and ranged from 12.3 m in December to 2.3 m in June. At station 2 smaller Secchi disc readings were recorded at station 3 which ranged from 3.3 m in January to 1.5 m in October. Station 1 had the least amount of suspended particulate matter as shown by the large Secchi disc readings and station 3 had the most as shown by the small Secchi disc readings. Station 2 had intermediate amounts. The Secchi disc readings recorded at all stations during the northeast monsoon were larger than those recorded during the southeast monsoon. Therefore



there was less suspended particulate matter during the northeast monsoon. The composition, distribution and abundance of near-surface zooplankton throughout a one year cycle (November 1984-October 1985) was studied by the analysis of monthly samples taken at three fixed stations in Tudor Creek, Mombasa. The biomass was measured by displacement volume of fixed material. The numerical abundance of selected groups was determined by counting using a Bogorov tray under a Wild (Heerbrugg) M3C stereomicroscope. The selected groups were chaetognaths, copepods, molluscan larvae, crustacean decapod larvae (excluding brachyuran larvae), brachyuran larvae, fish eggs and fish larvae. Station 1 was located at the mouth of the creek, station 2 was about 2 km from station 1 in the middle reaches of the creek and station 3 was about 2 km from station 2 in the upper reaches of the creek.

Zooplankton sampling was carried out by horizontal tows with a plankton net of 335 micron mesh size at an approximate depth of 1.3 m. Surface water temperature, surface water salinity and turbidity were measured at the same time as the zooplankton was being collected. On two occasions (24th-25th June, 1985 and 23rd-24th September, 1985), 24 h sampling was carried out at two hourly intervals at a fixed station (English point) in Tudor Creek, in order to determine the diel cycle of near-surface abundance of the selected groups.

The composition, distribution and abundance of zooplankton and the hydrographic parameters monitored, showed seasonal changes closely related with the two monsoon seasons (northeast monsoon season: November-March; southeast monsoon season: May-September; intermonsoon periods: April and October). The surface water temperature was high during the northeast monsoon with a maximum value of 29.0°C recorded from January to March at all stations. During the southeast monsoon, the surface water temperature declined reaching a minimum value of 26.0°C at station 1 from July to September and the same minimum at stations 2 and 3 in October. The annual range of surface water temperature at the three stations was therefore small (3°C) characteristic of tropical waters. The surface water salinity was 35‰ at all stations throughout the northeast monsoon except in February when the maximum value of 36‰ was recorded at all stations.

During the southeast monsoon the surface water salinity declined reaching minimum values in May at all stations coinciding with a peak in rainfall. The minimum value differed between stations: 33‰ at station 1, 31‰ at station 2 and 30‰ at station 3. Station 1 experienced the least annual salinity change (3‰) whereas stations 2 and 3 experienced the largest (5‰ and 6‰ respectively) as would be expected from their locations in the creek. The largest Secchi disc readings were recorded at station 1 and ranged from 12.3 m in December to 2.3 m in June. At station 2 smaller Secchi disc readings were recorded at station 3 which ranged from 3.3 m in January to 1.5 m in October. Station 1 had the least amount of suspended particulate matter as shown by the large Secchi disc readings and station 3 had the most as shown by the small Secchi disc readings. Station 2 had intermediate amounts. The Secchi disc readings recorded at all stations during the northeast monsoon were larger than those recorded during the southeast monsoon. Therefore



there was less suspended particulate matter during the northeast monsoon than during the southeast monsoon.

The selected groups of zooplankton showed different patterns of near-surface abundance in different months whereas in the diel cycle, most of the selected groups showed a similar pattern of near-surface abundance.

The chaetognaths occurred at all stations during the study period and showed maximum abundance during the northeast monsoon. The mean monthly abundance during the northeast monsoon was 10 / cub.meter ( $\pm 3.67$  SE) at station 1, 8 / cub. meter ( $\pm 2.53$  SE) at station 2 and 9 / cub.meter ( $\pm 3.96$  SE) at station 3 and during the southeast monsoon the values were 3 / cub.meter ( $\pm 0.65$  SE) at station 1, 2 / cub.meter ( $\pm 0.20$  SE) at station 2 and 3 / cub.meter ( $\pm 0.49$  SE) at station 3.

Copepods were an important component of the zooplankton especially in samples collected from station 1. Copepods reached maximum abundance during the northeast monsoon. The mean monthly abundance of copepods was 154 / cub.meter ( $\pm 44.42$  SE) at station 1, 66 / cub.meter ( $\pm 22.78$  SE) at station 2 and 90 / cub.meter ( $\pm 60.17$  SE) at station 3 during the northeast monsoon and 22 / cub.meter ( $\pm 5.55$  SE) at station 1, 16 / cub.meter ( $\pm 2.04$  SE) at station 2 and 28 / cub.meter ( $\pm 14.17$  SE) at station 3 during the southeast monsoon.

The crustacean decapod larvae (excluding brachyuran larvae) showed maximum abundance during the northeast monsoon. The mean monthly abundance was 12 / cub.meter ( $\pm 2.53$  SE) at station 1, 142 / cub.meter ( $\pm 100.79$  SE) at station 2 and 221 / cub.meter ( $\pm 167.91$  SE) at station 3 during the northeast monsoon and 18 / cub.meter ( $\pm 2.12$  SE) at station 1, 23 / cub.meter ( $\pm 4.44$  SE) at station 2 and 22 / cub.meter ( $\pm 6.40$  SE) at station 3 during the southeast monsoon.

The brachyuran larvae showed a mean monthly abundance of 27 / cub.meter ( $\pm 6.78$  SE) at station 1, 292 / cub.meter ( $\pm 103.65$  SE) at station 2 and 328 / cub.meter ( $\pm 127.90$  SE) at station 3 during the northeast monsoon and 186 / cub.meter ( $\pm 112.22$  SE) at station 1, 180 / cub.meter ( $\pm 107.77$  SE) at station 2 and 155 / cub.meter ( $\pm 72.14$  SE) at station 3 during the southeast monsoon.

Fish larvae were more abundant at station 2 and 3 than at station 1. The mean monthly abundance of fish larvae was 2 / cub.meter ( $\pm 0.61$  SE) at station 1, 6 / cub.meter ( $\pm 3.31$  SE) at station 2 and 3 / cub.meter ( $\pm 1.02$  SE) at station 3 during the northeast monsoon and 1 / cub.meter ( $\pm 0.40$  SE) at station 1, 2 / cub.meter ( $\pm 0.33$  SE) at station 2 and 1 / cub.meter ( $\pm 0.40$  SE) at station 3 during the southeast monsoon.

Fish eggs were more abundant at station 1 than at stations 2 and 3. Station 1 had an equal value of mean monthly abundance in both seasons: 4 / cub.meter ( $\pm 0.78$  SE) during the northeast monsoon and 4 / cub.meter ( $\pm 0.73$  SE) during the southeast monsoon. Stations 2 and 3 had low numbers of fish eggs during the northeast monsoon with a mean monthly abundance of 1 / cub.meter ( $\pm 0.20$  SE) at station 2 and 1 / cub.meter ( $\pm 0.69$  SE) at station 3. The number of fish eggs at stations 2 and 3 increased during the southeast monsoon with a mean monthly abundance of 6 / cub.meter ( $\pm 3.84$  SE).



## THE DISTRIBUTION OF BRACHILARIA AROUND MOMBASA AND THEIR OPTIMAL PERIOD OF GROWTH.

Mrs. Dyleke.

at station 2 and 3 / cub.meter (  $\pm 0.69$  SE ) at station 3 .

The molluscan larvae were more abundant during the southeast monsoon than during the northeast monsoon . The mean monthly abundance was 4 / cub.meter (  $\pm 1.30$  SE ) at station 1 , 3 / cub.meter (  $\pm 1.02$  SE ) at station 2 and 1 / cub.meter (  $\pm 0.32$  SE ) at station 3 during the southeast monsoon and 1 / cub.meter (  $\pm 0.98$  SE ) at station 1 , 1 / cub.meter (  $\pm 0.53$  SE ) at station 2 and more at station 3 .

Thus all the selected groups of zooplankton except molluscan larvae showed maximum abundance during the northeast monsoon .

The biomass and numbers exhibited a seasonal cycle closely related to the rainfall pattern . Major peaks in numbers occurred in December , April and a minor peak in July/August at all stations . The peaks in December occurred a month after the short rains in November . The peaks in April occurred a month after the onset of the long rains in March . The peak in numbers in June occurred a month after peak rainfall in May . Probably , the increased nutrient input into the creek during the heavy rains enhances phytoplankton growth which in turn leads to higher biomass and numbers of zooplankton in the peaks that we see . The lag time between heavy rainfall and zooplankton abundance was about two to four weeks . The biomass and numbers of zooplankton reached the lowest values during the dry months of both monsoons : January-February in the northeast monsoon and September-October in the southeast monsoon .

The diel variations in the hydrographic parameters monitored were small . The diel range of surface water temperature was 2 C in June and 1.5 C in September . The lowest surface water temperatures were recorded at night and the highest during the day on both occasions . The diel range of surface water salinity was 1 ‰ on both occasions . However , the instrument used ( a refractometer with 1 ‰ graduations ) was not precise enough in order to measure small subtle but significant differences in the diel cycle of surface water salinity .

The values of the silica content of the water were higher in June ( 0.08 - 0.2 ppm ) than in September ( 0.06 - 0.10 ppm ) . The pH values ranged from 8.05 ( 07.30 h ) to 8.31 ( 11.30 h ) in June and 8.30 ( 07.30 h ) to 8.60 ( 11.30 h ) in September . The lowest and the highest pH values on both occasions occurred at the same time in the diel cycle . The pH values recorded in June were lower than those recorded in September .

There was less zooplankton caught near the surface during the day than during the night on both occasions . Most of the selected groups of zooplankton showed maximum near-surface abundance at night between 19.30 h and 23.30 h on both occasions . The pattern observed was accounted for by the classical pattern of vertical migration . The results point firstly to light as the major timing factor and secondly , that the tidal cycle has no discernable effect on the diel cycle of near -surface abundance .



THE DISTRIBUTION OF GRACILARIA AROUND MOMBASA AND THEIR OPTIMAL PERIOD OF GROWTH.

Mrs. Oyieke.

A study on the Phycology of the Kenyan Coast is being carried out in which 5 sampling stations have been selected around Mombasa: Mackenzie Point, Kanamai Beach, Shelly Beach, Tiwi Beach and Bamburi Beach (Reef Hotel). From the five stations all the Gracilaria species are to be identified and their different habitats described. Transects will be taken from the intertidal to the sublittoral zone, and any other algae that grow together with the Gracilaria will be identified.

A biomass study has to be done for every Gracilaria identified so as to find out: which of the Gracilaria species occurs in economically harvestable quantities, which is the regeneration time for each Gracilaria species, when it is the best moment to harvest them with respect to dry or rain season, and which is the best method for harvesting with the "holdfast" or just above it.

The extraction of agar will be done for the different Gracilaria species in order to establish which of them is richest in agar, when it is best to harvest for agar, and whether the habitat has any influence on the quantities of agar produced.

So far the work has been confined to Mackenzie Point (due to availability of transport to go to outer stations...).

At Mackenzie Point the following work has been going on for the past 3 months (February, March, April 1986):

1. A transect study has been done, the dominant Gracilaria species is G. salicornia. Its habitat as well as of all the other algae in the transect have been recorded. The sampling of this transect is done once a month.

2. Sites for biomass study have been located and biometric observations have been made. The initial biomass of G. salicornia was taken and the regeneration time is being monitored.

3. At each sampling specimens have been used for agar extraction.

The transect under investigation is located at a place where the land ends in a cliff. The cliff gives way to a sandy beach which stretches for about 10 m, then followed by rocky pools of various sizes whose bottoms consist of sand. The pools stretch for about 30 m before reaching the low water line. The area is sheltered from surf activities.

5. This is a sublittoral zone. The height of water level at low spring tide is about 1 m.

G. salicornia grows in patches scattered all over. The thallus cushions are about 2 cm high on rocky surfaces and on sandy areas up to 5 cm high.

Thalassia hemirhiza (sea grass) is abundant. Centroceras clavulatus is also common.



February 1986.

Zone 1

Remarks as in February

Remarks as in February

Zone

Remarks on

Remarks on other

Gracilaria.

common

algae.

1. This zone consists of shallow rock pools with sandy bottoms. The pools are 5-10 cm deep

G. salicornia is the main Gracilaria species. is the most abundant algae growing on the edges of the pools. The thallus are about 3 cm high and are cushion forming.

Enteromorpha kylinii is quite common on exposed surfaces of rocks. Lyngbya sp. is very common in the pools.

2. The rock pools here are 10-15 cm deep.

G. salicornia is still the most abundant algae growing on the edges of the pools. The thallus size is about 3 cm forming cushions.

E. kylinii is still common on the rocky surfaces. Lyngby sp. is common in the pools and Laurentia venusta occurs in thick cushions on the edges of the pools.

3. The rock pools here are deepest: 15-20 cm deep.

G. salicornia is still most abundant on the edges as well as on the bottom of the pools. The thallus of those in the pools are 10-15 cm high.

The common algae occurring here are Boodlea composita (on edges of pools), Cystoseira myrica (in pools) and Laurencia papillosa (in pools).

April 1986

Zone 1

As in March

As in March

4. This is a flat surface without pools. The substrate is rock covered with little sand.

G. salicornia still dominates but growing in very small forms in cushions of about 1 cm high

Other common algae are: Acrocystis nana, Ulva pestusa, Centrocerus clavulatum, Laurencia venusta.

5. This is a sublittoral zone. The height of waterlevel at low spring tide is about 1 m.

G. salicornia grows in patches scattered all over. The thallus cushions are about 2 cm high on rocky surfaces and on sandy areas up to 5 cm high.

Thalassia hemprichii (sea grass) is abundant. Centrocerus clavulatum is also common.



# March 1986

Zone	Remarks as in February	Remarks as in February
Zone 1	There is no <u>Grecilicia</u> in this zone	<u>E.kylinii</u> is the most common algae on the
Zone 2	Idem	Other common algae are <u>Chaetomorpha crassa</u> and <u>E.kylinii</u> .
Zone 3	<u>G.salicornia</u> occur in Idemes here but are not the most abundant algae. They grow in cushions, about 2 cm high.	<u>Padina boriana</u> is very Other algae commonly found are <u>C.crassa</u> and <u>E.kylinii</u> . the edges. <u>Hypnea nidulans</u> and <u>E.rauulosa</u> are also
Zone 4	Idem	Other common algae are <u>Boodlea composita</u> , <u>E.kylinii</u> and <u>Hypnea pannosa</u> .
Zone 5	<u>G.salicornia</u> occur only in dispersed patches, are not the most Idem abundant algae. Thallus size about 4-6 cm high.	Other algae occurring: <u>Thalassia hemprichii</u> and <u>Centroceras clavulatum</u> .
Zone 4	Cushions of <u>G.salicornia</u> dominate the platform. The thallus are about 1 cm high.	<u>Centroceras clavulatum</u> are very common together with <u>U.pertusa</u> .

# April 1986

Zone 1	As in March	As in March
Zone 2	As in March	Sea grass <u>Thalassia</u> As in March's most abundant.
Zone 3	The thallus size of <u>G.salicornia</u> is slightly smaller: about 7-10 cm high.	As in March
Zone 4	As in March	As in March
Zone 5	As in March	As in March



May 1986

Biometric studies at Mackenzie Point

Zone 1 is a study on the rocky holdfast. Quadrats 3 and 4 had G. salicornia removed about 1 metre quadrats. There is no Gracilaria in this zone. E. kylinii is the most common algae on the rocky surfaces. Monostroma sp. also occurs frequently.

Quadr. nr.	Date	Wet wt (kg)	Dry wt (g)	% Cover
Zone 2	24-2-86	0.94		
2	24-2-86	0.88		
3	24-2-86	1.22		
4	24-2-86	1.26		
1	25-3-86	Not ready for harvest		
2				
3				
Zone 3				
1	24-4-86	Not ready for harvest		
2				
3				
Zone 4				
1	23-5-86	Not ready for harvest		
2				
3				
4				
Zone 5				

G. salicornia occur in patches here but are not the most abundant algae. They grow in cushions, about 2 cm high.

Padina boriana is very common in the pools and Laurencia papillosa occurs on the edges. Hypnea nidulans and E. ramulosa are also quite common.

G. salicornia occur only in dispersed patches, are not the most abundant algae. Thallus size about 4-6 cm high.

Pools dominated by Ulva reticulata and E. ramulosa.

Cushions of G. salicornia dominate the platform. The thallus are about 1 cm high.

Centroceras clavulatum are very common together with U. pertusa.

G. salicornia occur in cushions on the rocky surfaces.

Sea grass Thalassia hemprichii is most abundant.



# WATER MASS ANALYSIS IN RELATION TO PRIMARY PRODUCTIVITY IN Biometric studies at Mackenzie Point

This is a study on the regeneration period of G.salicornia . There are 4 one metre quadrats . Quadrat 1 and 2 had G.salicornia removed with the holdfast. Quadrats 3 and 4 had G.salicornia removed above the holdfast.

J.M.Kazungu.

Quadr. nr.	Date	Wet wt (kg)	Dry wt (g)	% Cover	Agar	Remarks
1	24-2-86	0.945	75	58	trace	Experiment
2	24-2-86	0.88	80	50	trace	set on.
3	24-2-86	1.225	105	63	trace	Thallus
4	24-2-86	1.26	110	68	trace	size 10-15 cm high.
1	25-3-86	Not ready for harvest		5		New growth has
2				5		already started
3				10		Thallus size
4				8		1-2 cm high.
1	24-4-86	Not ready for harvest		15		Growth continues
2				13		Thallus size
3				30		2-5 cm high.
4				23		
1	23-5-86	Not ready for harvest		20		Growth continues
2				19		Thallus size
3				38		4-7 cm high
4				33		

## Period of study.

This study is to be conducted in both the wet and the dry seasons. This would place us in a better position of understanding the effect of the monsoon rains on the river input of nutrients and organics in the creeks.



WATER MASS ANALYSIS IN RELATION TO PRIMARY PRODUCTIVITY INKILINDINI AND TUDOR ESTUARIES.

J.M.Kazungu.

Introduction.

Kilindini and Tudor Estuaries form a very interesting area for Oceanographic study. As pointed out in my earlier research project proposal, it is not clear as to why Kilindini estuary—though not scientifically proven—has relatively more fish than the Tudor creek. This implies that primary productivity in Kilindini estuary is higher than that of Tudor creek. The present study is therefore centered on the identification of various water types which might be existing within the estuaries and try to relate them to primary productivity. To do this the study is divided into three sections, namely:

1. Analysis of the nutrients (phosphates, silicates, nitrates, ammonia) distribution within the estuaries.
2. Analysis of particulate organic carbon (POC) distribution both within the estuaries water column and the bottom sediments.
3. Analysis of the salinity and oxygen distribution within the creeks.

Period of study.

This study is to be conducted in both the wet and the dry seasons. This would place us in a better position of understanding the effect of the monsoon rains on the river input of nutrients and organics in the creeks.



Discussion.

So far little can be said due to limited data. However, it is noticed that for the Tudor Creek, lowest concentrations of nitrate, phosphate and silicates were found at the mouth of the estuary near the open sea, whereas high concentrations were found upstream. Figs. 2 and 3 show representative graphs of nutrients concentration Vs sampling stations for the Tudor and Kilindini Estuaries respectively. As indicated in Fig.2 the highest nutrient concentrations for the Tudor Creek were found around station A6 near the river mouth, while the lowest were recorded at station A2 near the open sea. As expected, salinity concentrations decreased upstream. The highest silicate, nitrate and phosphate concentrations were 186.0  $\mu\text{g-atSi/l}$ , 28.50  $\mu\text{g-at N/l}$ , and 4.12  $\mu\text{g-at P/l}$  respectively, while the lowest were 65.50  $\mu\text{g-at Si/l}$ , 5.20  $\mu\text{g-at N/l}$  and 0.64  $\mu\text{g-atP/l}$  respectively.

For Kilindini Estuary (Fig.3), the situation was different. Salinity and silicate concentrations behaved as expected, with salinity decreasing upstream and silicate increasing. However, it is surprising to find phosphate concentrations decreasing upstream. Nitrate concentrations oscillated between 0.2 and 0.5  $\mu\text{g-at N/l}$  except station B1 which had 1.80  $\mu\text{g-at N/l}$ . It is also surprising to discover that nutrients concentrations are higher in Tudor than in Kilindini Creek which is thought to be having a higher fish stock.

RESULTS FOR THE FIRST TWO MONTHS		Date: 08/04/86	
STATION		$\text{NO}_3^-$ $\mu\text{g-at N/l}$	$\text{NO}_2^-$ $\mu\text{g-at N/l}$
A1	(0m)	1.02	0.04
	(5m)	1.56	-
A2	(0m)	2.98	0.05
A3	(0m)	1.78	0.05
A4	(0m)	1.70	0.05
A5	(0m)	2.05	0.02
	(2.5m)	1.80	
A6	(0m)	6.80	0.15



Date: 22/4/86

Estuary: Tudor

RESULTS FOR THE FIRST TWO MONTHS

STATION	NO <sub>3</sub> <sup>-</sup> μg-at N/l	NO <sub>2</sub> <sup>-</sup> μg-at N/l	NH <sub>4</sub> <sup>+</sup> μg-at N/l	Si μg-at Si/l	PO <sub>4</sub> <sup>-</sup> μg-at P/l	S o/oo
Date: 08/04/86 Estuary: Tudor						
A1 (0m)	0.15	0	0	4.00	0.30	36.36
(5m)	0.37	0	-	3.50	0.50	36.36
A2 (0m)	NO <sub>3</sub> <sup>-</sup> μg-at N/l	NO <sub>2</sub> <sup>-</sup> μg-at N/l	NH <sub>4</sub> <sup>+</sup> μg-at N/l	Si μg-at Si/l	PO <sub>4</sub> <sup>-</sup> μg-at P/l	36.26
A3 (0m)	3.10	0.06	2.65	13.40	0.70	34.09
A4 (0m)	3.40	0.08	2.70	20.00	0.95	32.25
A1 (0m)	1.02	0.24	- 50	6.000	0.35	12.41
(5m)	1.56	- 22	-	17.80	0.25	34.63
A2 (0m)	2.98	0.05	- 0.65	8.050	0.35	1.11
A3 (0m)	1.78	0.05	-	12.0	0.35	
Date: 22/05/86						
A4 (0m)	1.70	0.05	-	15.50	0.25	
A5 (0m)	2.05	0.02	-	28.50	0	
(2.5m)	1.80					
A2 (0m)	5.20	0.05	-	65.50	0.64	25.07
A6 (0m)	6.80	0.15	-	105.00	0.55	
A3 (0m)	9.30	0.05	-	116.00	0.68	18.53
A4 (0m)	17.80	0.05	-	163.50	1.46	11.29
A5 (0m)	22.50	0.05	-	186.00	1.92	5.66
A6 (0m)	28.50	0.08	-	180.50	4.12	0.72



Date: 22/4/86

Estuary: Tudor

STATION	NO <sub>3</sub> <sup>-</sup> μg-at N/l	NO <sub>2</sub> <sup>-</sup> μg-at N/l	NH <sub>4</sub> <sup>+</sup> μg-at N/l	Si μg-at Si/l	PO <sub>4</sub> <sup>-</sup> μg-at P/l	S o/oo
A1 (0m)	0.15	0.04	0	4.00	0.30	36.36
(5m)	0.37	0	-	3.50	0.50	36.36
A2 (0m)	1.60	0.04	0	5.00	0.70	36.26
A3 (0m)	3.10	0.06	2.65	13.40	0.70	34.09
A4 (0m)	3.40	0.08	2.70	20.00	0.95	32.25
A5 (0m)	9.25	0.24	8.50	70.00	1.20	12.41
(5m)	1.90	0.22		17.80	0.95	34.63
A6 (0m)	9.25	0.64	10.65	71.50	0.10	1.11
Date: 22/05/86						
A1 (0m)	-	0.04	-	16.00	0.66	32.97
(5m)	0.75	0.13	-	14.00	0.86	33.33
A2 (0m)	5.20	0.05	-	65.50	0.64	25.07
A3 (0m)	9.30	0.05	-	116.00	0.68	18.53
A4 (0m)	17.80	0.05	-	163.50	1.46	11.29
A5 (0m)	22.50	0.05	-	186.00	1.92	5.66
A6 (0m)	28.50	0.08	-	180.50	4.12	0.72



Date: 06/05/86

Estuary: Kilindini

STATION	$\text{NO}_3^-$ μg-at N/l	$\text{NO}_2^-$ μg-at N/l	$\text{NH}_4^+$ μg-at N/l	Si μg-at Si/l	$\text{PO}_4^-$ μg-at P/l	S ‰
A1 (0m)	0.30	0.04	-	4.00	0.90	34.99
(5m)	0.30	0.04	-	4.00	0.56	35.53
B1 (0m)	1.80	0.00	-	6.70	0.66	34.45
(5m)	0.60			4.00	0.66	34.81
B2 (0m)	0.25	0.00	-	7.20	0.52	34.09
(5m)	0.50	0.04	-	5.70	0.48	34.99
B3 (0m)	0.53	0.05	-	8.30	0.56	34.27
(5m)	0.80	0.04	-	8.80	0.52	38.42
B4 (0m)	0.40	0.05	-	8.80	0.42	33.55
(5m)	0.80	0.10	-	11.80	0.71	33.91
B5 (0m)	0.55	0.07	-	24.00	0.38	31.17
(5m)	1.00	0.08	-	23.50	0.86	31.71
B6 (0m)	0.40	0.04	-	16.00	0.66	32.97
(5m)	0.75	0.13	-	14.00	0.86	33.33



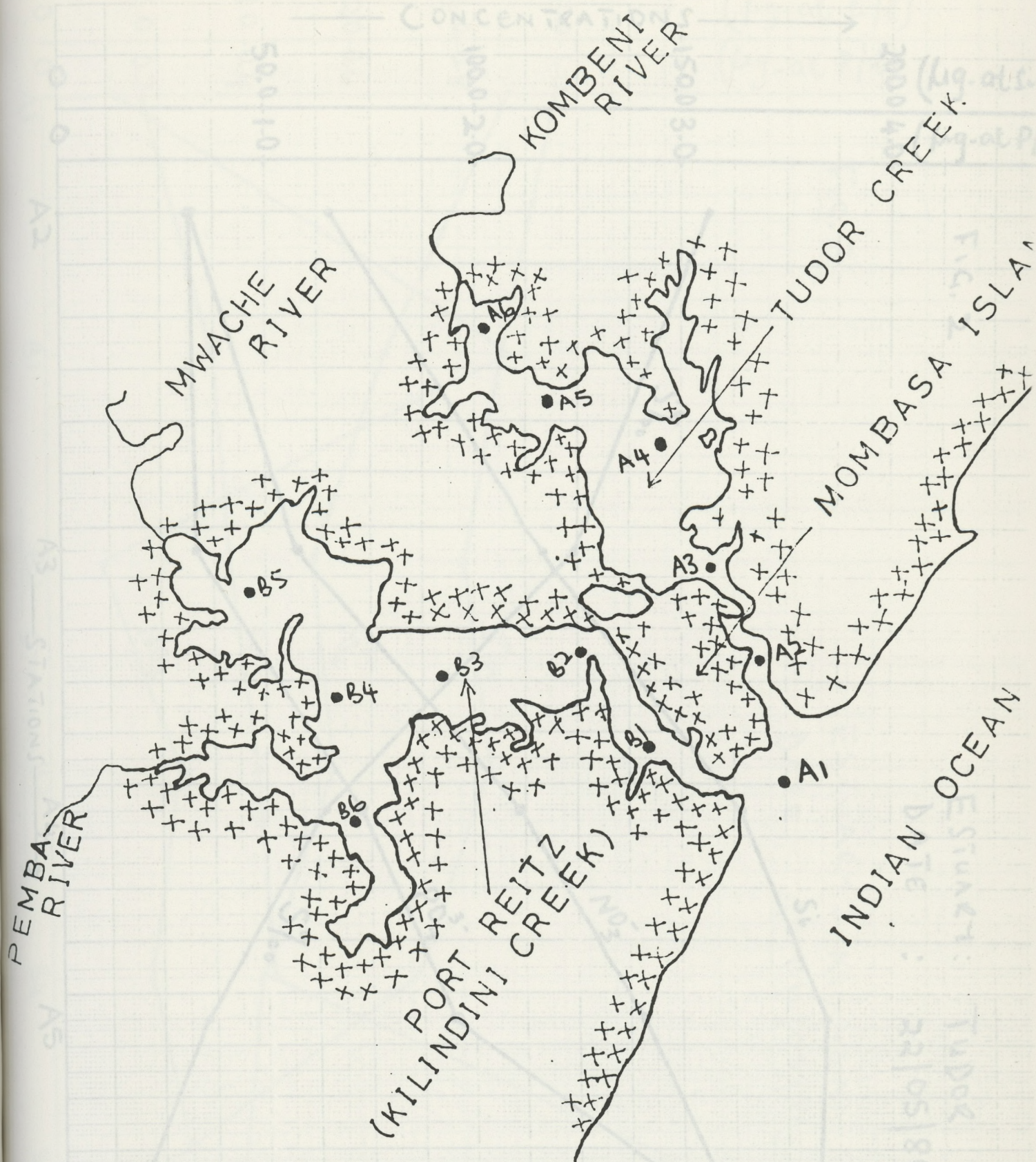


FIG. 1  
 A1 - A6 (TUDOR CREEK)  
 B1 - B6 (KILINDINI CREEK).



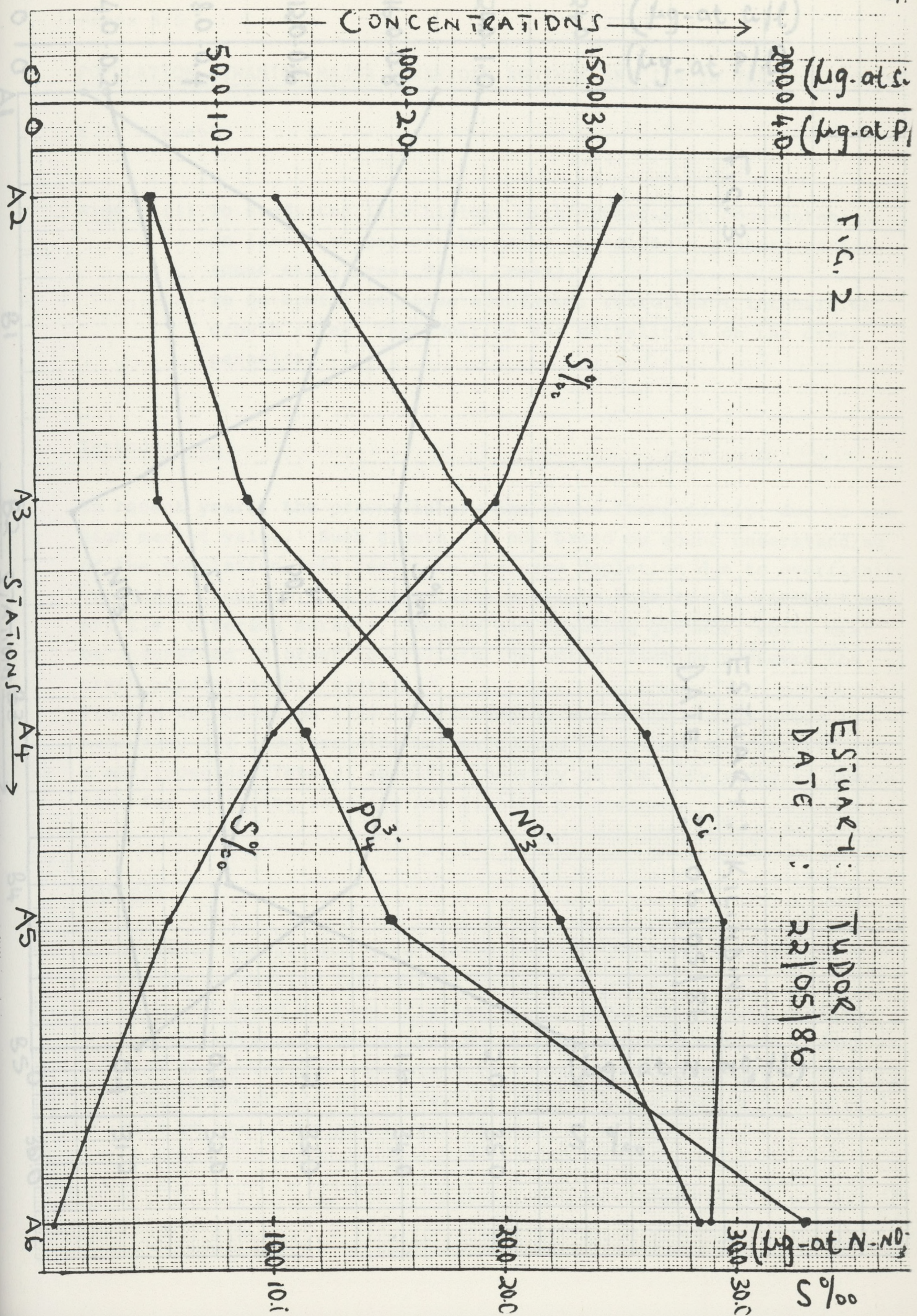


FIG. 2

ESINAK-1: TUDOR  
DATE: 22/05/86



(CONCENTRATIONS) →  
( $\mu\text{g-at Si/l}$ )  
( $\mu\text{g-at P/l}$ )

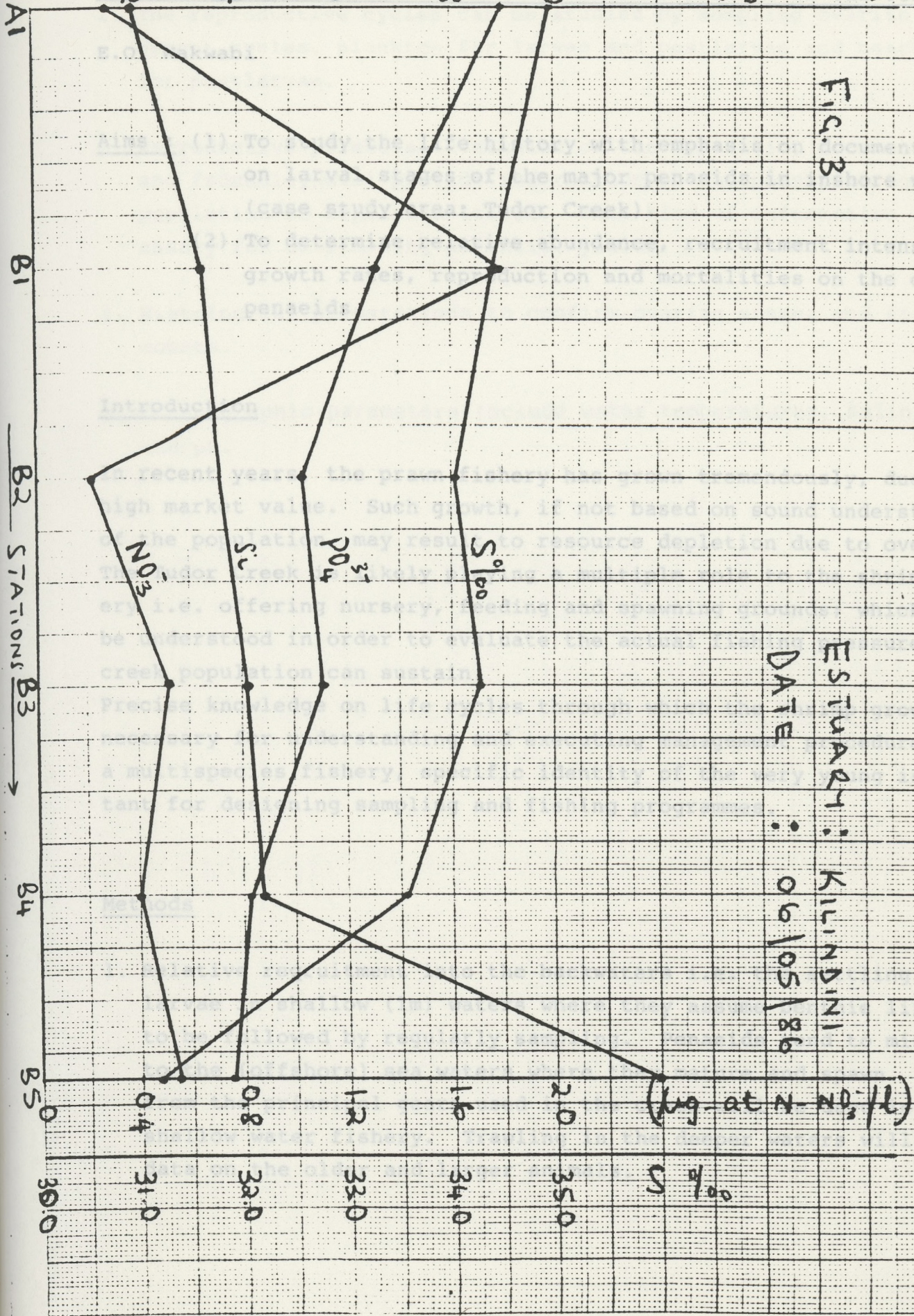


FIG. 3

ESTUARY: KILINDINI  
DATE: 06/05/86



## POPULATION DYNAMICS MAJOR PENAEIDAE SHRIMPS SPECIES IN THE TUDOR CREEK

2. The reproductive cycles can be studied by sampling ovarian development, plankton for larvae and postlarvae and beachseining for postlarvae.

Aims : (1) To study the life history with emphasis on documentation on larval stages of the major penaeids in inshore waters (case study area: Tudor Creek). Kind of information is necessary.  
(2) To determine relative abundance, recruitment intensities, growth rates, reproduction and mortalities on the creek penaeids.  
4. Histological preparations to confirm ovarian stages and fecundity counts.

### Introduction

Abiotic parameters include water temperatures, salinities and pH.

In recent years, the prawn fishery has grown tremendously, due to the high market value. Such growth, if not based on sound understanding of the population, may result to resource depletion due to overfishing. The Tudor Creek is likely playing a multiple role to the shrimp fishery i.e. offering nursery, feeding and spawning grounds; which must be understood in order to evaluate the actual fishing pressure the creek population can sustain.

Precise knowledge on life cycles through which the shrimp grows is necessary for understanding and executing management procedures. In a multispecies fishery, specific identity of the very young is important for designing sampling and fishing programmes.

### Methods

1. Relative recruitment into the backwaters i.e. the settling post-larvae in shallow (1m) waters where they assume benthic life, has to be followed by regularly sampling. Penaeids tend to migrate to the (offshore) sea waters where they mature and spawn. Samples from the principal gears used in the creek will be used in the shallow water fishery. Trawling in the deeper waters will afford data on the older and larger animals.



2. The reproductive cycles can be studied by sampling ovarian development cycles, plankton for larvae and postlarvae and beachseining for postlarvae.
3. Reproductive potential - studies on the sex ratio, size at maturity and fecundity will provide information on the potential for the population to replanish itself. This kind of information is necessary for determining potential yields.
4. Histological preparations to confirm ovarian stages and fecundity counts.
5. Oceanographic parameters include water temperatures, salinities and pH.

#### DATA ANALYSIS : 1) Catch Sampling

Date	Gear	Total Catch (kgm)	Sample kgm (indiv.)	% Species Composition
1/1/86	castnet	1.8	1.8 (383)	1. 2% <u>P. indicus</u> 2. 90% <u>P. monodon</u> 3. 6% <u>M. monoceros</u> 4. 2% others (non Penaeids)
6/1/86	castnet	1.3	1.3 (412)	1. 4% <u>P. indicus</u> 2. 86% <u>P. monodon</u> 3. 8% <u>M. monoceros</u> 4. 2% (non penaeids)
21/1/86	castnet	3.7	3.7 (959)	1. 18% <u>P. indicus</u> 2. 80% <u>P. monodon</u> 3. 2% <u>M. monoceros</u>
23/2/86	castnet	10	1.6 (402)	1. 53% <u>P. indicus</u> 2. 39% <u>P. monodon</u> 3. 0.2% <u>M. monoceros</u> 4. 8% <u>P. semisulcatus</u>
11/3/86	castnet	5.5	3.0 (912)	1. 58% <u>P. indicus</u> 2. 34% <u>P. monodon</u> 3. 3% <u>M. monoceros</u> 4. 4% <u>P. semisulcatus</u>
11/4/86	castnet	4.0	2.5 (337)	1. 54% <u>P. indicus</u> 2. 41% <u>P. monodon</u> 3. 3% <u>M. monoceros</u>



DATA ANALYSIS : 1) Catch Sampling

Date	Gear	Total Catch	Sample kgm	% Species Composition	Sex ratio F/M	Mean size (x̄) (CL mm)	Maturity (♀)
Date	Gear	Total Catch (kgm)	Sample kgm (indiv.)	% Species Composition	Sex ratio F/M	Mean size (x̄) (CL mm) ♀ , ♂	Maturity (♀)
1/1/86	castnet	1.8	1.8 (383)	1. 2% <u>P. indicus</u> 2. 90% <u>P. monodon</u> 3. 6% <u>M. monoceros</u> 4. 2% others (non Penaeids)	-0.84 0.96	17.5, 17.4	Juveniles
6/1/86	castnet	1.3	1.3 (412)	1. 4% <u>P. indicus</u> 2. 86% <u>P. monodon</u> 3. 8% <u>M. monoceros</u> 4. 2% (non penaeids)	0.70 0.99	12.4, 10.7 16.4, 16.2	Juveniles Juveniles
21/1/86	castnet	3.7	3.7 (959)	1. 18% <u>P. indicus</u> 2. 80% <u>P. monodon</u> 3. 2% <u>M. monoceros</u>	0.94 1.20	14.3, 13.8 17.1, 16.2	Juveniles Juveniles
23/2/86	castnet	10	1.6 (402)	1. 53% <u>P. indicus</u> 2. 39% <u>P. monodon</u> 3. 0.2% <u>M. monoceros</u> 4. 8% <u>P. semisulcatus</u>	- 1.24	- 20.6, 20.1	- Juveniles
11/3/86	castnet	5.5	3.0 (912)	1. 58% <u>P. indicus</u> 2. 34% <u>P. monodon</u> 3. 3% <u>M. monoceros</u> 4. 4% <u>P. semisulcatus</u>	1.18 0.99	13.6, 13.8 17.8, 17.9	Juveniles Juveniles
11/4/86	castnet	4.0	2.5 (337)	1. 54% <u>P. indicus</u> 2. 43% <u>P. monodon</u> 3. 3% <u>M. monoceros</u>	0.90 1.20	13.0, 12.6 23.2, 21.9	Juveniles Sub-adults



# 2. Plankton, Beach seining : Hydrography

Date	Gear	Total Catch (kgm)	Sample kgm (indiv.)	% Species Composition	Sex ratio F/M	Mean size (x̄) (CL mm)	Maturity (♀)
Date	Station	type	So/oo	pH	Total catch	Species composition	Size range (mm)
28/4/86	castnet	10	4.7	1. 36% <u>P. indicus</u>	0.68	15.0, 13.4	Sub-adults
10/1/86	1	Plankton	(1111)	2. 39% <u>P. monodon</u>	0.84	21.3, 19.8	Sub-adults
	2	net		3. 21% <u>M. monoceros</u>			
	3	"	29	4. 0.3% <u>P. semisulcatus</u>			
	4	"	29	5. 2.7% non penaeids			
	5	"	29				
10/5/86	castnet	3.0	3.0	1. 58% <u>P. indicus</u>	0.73	13.4, 12.9	Juveniles
	1	Beach	(784)	2. 21% <u>P. monodon</u>	1.32	22.0, 22.0	Sub-adults
		seine		3. 6.0% <u>M. monoceros</u>			
	2	Beach	29.5	4. 14% <u>P. semisulcatus</u>			
		seine		5. 1% non penaeids			
12/5/86	castnet	2.1	2.1	1. 53% <u>P. indicus</u>	1.39	18.3, 18.8	Adults
			(355)	2. 32% <u>P. monodon</u>	0.79	21.5, 19.5	Sub-adults
				3. 8% <u>M. monoceros</u>			
				4. 4% <u>P. semisulcatus</u>			
	3	beach	30.5				
		seine					
28/1/86	1	Plankton	28	35	7.83		
	2	net	28.5	36	7.72	No	
	3	"	29	35	7.47	Penaeids	
	4	"	29	35	7.32	recorded	
	5	"	30	35	7.18		
	2	Benthic trawl in 1-2m depth with 500 µm mesh 5 tows	-	-	-	110	
						78 <u>P. indicus</u>	1.4 - 3.5
						5 <u>P. monodon/semisulcatus</u>	1.3 - 3.5
						26 <u>M. monoceros</u>	1.0 - 3.8
						1 <u>Acetes erythreus</u>	4.0



2. Plankton, Beach seining : Hydrography

Date	Station	Gear type	T°C	So/oo	pH	Total catch	Species composition	Size range (mm)
10/1/86	1	Plankton	28	35	7.82			
	2	net	28	35	7.61	No		
10/3/86	2	Benthic	29	35	7.48	Penaeid	<u>P. indicus</u>	8 - 32 (TL)
	4	trawl	29	35	7.18	larvae		
	5	tows	29	30	7.07			
	1	Beach seine	28.5	-	7.82	7	5 <u>P. semisulcatus</u> 2 <u>Acetes</u> sp.	3.20 - 8.25 -
	2	Beach seine	29.5	30	7.61	83	68 unidentified Penaeids 5 Juveniles - 4 <u>P. latisulcatus</u> 1 <u>M. monoceros</u>	0.7 - 4.11 11.2 - 22.0 6.7
28/3/86	2	2 tows	-	-	-	66	7 caridians 3 <u>Acetes erythreus</u>	- -
	3	beach seine	30.5	25	7.48	181	148 <u>P. semisulcatus</u> 23 <u>P. latisulcatus</u> 1 <u>P. monodon</u> 6 <u>Acetes erythreus</u> 3 Caridians	0.5 - 15.7 (CL) 0.8 - 4.7 (CL) 4.55 - - 10.0 (CL) -
28/1/86	1	Plankton	28	35	7.83			
	2	net	28.5	36	7.72	No		
	3	benthic trawl	29	35	7.47	Penaeids	<u>M. monoceros</u>	4 - 16 CL (9.5)
	4	500 µm mesh	29	35	7.32	recorded	<u>P. indicus</u>	8 - 15 CL (11.6)
	5	combined	30	35	7.12			
	2	Benthic trawl in 1-2m depth with 500 µm mesh 3 tows	-	-	-	110	78 <u>P. indicus</u> 5 <u>P. monodon/semisulcatus</u> 26 <u>M. monoceros</u> 1 <u>Acetes erythreus</u>	1.4 - 3.5 1.3 - 3.5 1.0 - 3.8 4.0



Date	Station	Gear type	T°C	S‰	pH	Total catch	Species Composition	Size range
25/4/86	3	Benthic trawl in 1-2m depth with 500 µm net 2 tows	31	35	7.69	8	6 <u>P. semisulcatus</u> 1 <u>M. monoceros</u> 2 <u>Acetes erythreus</u>	5.8 - 8.3 4.3
10/3/86	2	Benthic trawl, 2 tows with 500 µm net	31	-	-	15	8 <u>P. indicus</u>	8 - 32 (TL)
	3	Benthic trawl 3 tows	31.5	-	-	46	23 <u>P. semisulcatus/monodon</u> 23 <u>P. indicus</u>	12 - 23 (TL) 9 - 14 (TL)
28/3/86	2	" 2 tows	-	-	-	66	<u>P. indicus</u> <u>P. semisulcatus</u> <u>P. latisulcatus</u>	- - -
9/5/86	stream	Benthic trawl towed up & down stream 60 m one way	-	-	-	508	91 <u>P. semisulcatus</u> 4 <u>P. monodon</u> 6 <u>M. monoceros</u> 349 <u>P. indicus</u> 58 non-identified	1.8 - 15.2 (CL) 7.0 - 11.8 (CL) 5.1 - 19.4 (CL) 2.0 - 10.0 (CL) -
9/4/86	stream	" beach seine 0.5cm mesh+ benthic trawl 500 µm mesh combined	-	-	-	265	51 <u>P. semisulcatus</u> 155 <u>P. monodon</u> 26 <u>M. monoceros</u> 33 <u>P. indicus</u>	6 - 17 CL (13) 6 - 14 CL (10.9) 4 - 16 CL (9.5) 8 - 15 CL (11.6)

TL = total length  
CL = carapace length



## THE ESTUARINE FISHES OF KENYA.

R.M. Njocke.

Date	Station	Gear type	T°C	S‰	pH	Total catch	Species composition	Size range
25/4/86	2	beach seine 0.5cm mesh one tow	-	34	7.88	1	1 <u>P. latisulcatus</u> (stocked)	-
	3	beach seine one tow benthic trawl- 1mm net	-	27	7.67	23	stocked	-
				"	"	1	<u>P. monodon</u>	-
	stream	one tow 2mm benthic net	-	35	7.62	704	263 <u>P. semisulcatus</u> 65 <u>P. monodon</u> 6 <u>M. monoceros</u> 111 <u>P. indicus</u> 236 others (caridians)	5 - 20 (11.9) 5 - 14 (8) 9 - 14 (11) 5 - 11 (7) -
9/5/86	2	beach seine 4mm mesh	-	33	8.59	0		
	3	"	-	32	8.41	4	1 <u>P. monodon</u> juv. 2 <u>P. latisulcatus</u> 1 gravid <u>Macrobrachium</u> sp.	- -
	stream 60m	2mm mesh benthic trawl on rectangular mouth	-	33	8.33	1	<u>M. monoceros</u> sub-adult	

TL = total lenght  
CL = carapax lenght



Table 1. Fish species caught in the Estuaries in 1985. (% of total catch)  
 THE ESTUARINE FISHES OF KENYA.

Leiognathidae	<i>Leiognathus equulus</i>	: 27.1
	<i>L. fasciatus</i>	: C
	<i>L. berbis</i>	: 11.4
	<i>L. splendens</i>	: C
	<i>L. lineoletus</i>	: 5.8

R.M.Nzioka.

The East African Coast supports an extremely diverse fish fauna which has been studied taxonomically in considerable details but only little in terms of its biology and ecology. The need for this type of research has developed progressively during the last decade due to decline in availability of certain species in response to commercial fishing and environmental degradation. Furthermore, concern over the state of the fauna and the lack of the research has been stimulated by an increasing awareness that it constitutes a valuable national asset. In view of the diversity of the fauna and its environment, great care had to be taken to set research priorities so as to investigate the most serious problems first. It was decided that priority should be given to fishes living in endangered and degraded habitats rather than to individual species subjected to heavy exploitation. This was based on the conviction that serious long-term and sometimes irremediable damage can result from the former, whereas exploited species have a natural ability to recover if fishing effort is reduced. Primarily sampling was started in February 1985 and followed by intensive monthly sampling. This work is to continue for three years.

Sampling was concentrated in Port Reitz and Tudor Creeks.

The main fish groups were Leiognathidae, Scianidae, Mulidae, Pomadasyidae, Sphyraenidae, Clupeidae, Lutjanidae, Carangidae, Drepanidae and Teraponidae. Numerous other species were present in small quantities.

In many species juveniles exceeded the number of adults. Examples are Scianidae, *Jolinops dussumieri*, *J. sina*; Gerridae, *Gerres oyna*, *G. filamentosus*; Pomadasyidae, *Pomadasys opercularis*, *P. maculatus*, *P. maculatum*; Sphyraenidae, *Sphyraena obtusata*, *S. japonicus*; Lutjanidae, *Lutjanus setae*, *L. fluviatilis*; Drepanidae, *Drepane punctata*; Carangidae, *Rhabdosargus sarba* and *Terapon jarbua*. In other important species juveniles do not appear to predominate in the same extent but are nevertheless extremely abundant; examples being *Sardinella albella*, *Herkloticichthys quadrimaculatus*, *H. puncta*, *Tryssa vitrirostris*, *Pellona ditchella*, *Leiognathus equulus*, *L. bindus*, *L. fasciatus*, *L. splendens*, *L. berbis*, *L. lineoletus*. It is also important to record that in a number of species which are less common in the creeks, it is again the juvenile stage which occurs in great numbers. These include Carangidae, *Carangoides chrysophrys*.

An interesting feature of the length composition of a number of species is the rapid decline in catch as size increases. The most likely factors responsible for this are mortality within the estuarine environment and emigration from it.



Table 1. Fish species caught in the Estuaries in 1985. (% of total catch)

Leiognathidae	<u>Leiognathus equulus</u>	: 27.1
	<u>L.fasciatus</u>	: C
	<u>L.berbis</u>	: 11.4
	<u>L.splendens</u>	: C
	<u>L.lineoletus</u>	: 5.8
	<u>L.bindus</u>	: 7.8
	<u>Gazza minuta</u>	: 8.7
	<u>Secutor insidiator</u>	: 7.7
Scianidae	<u>Joliniops dussumieri</u>	: 2.7
	<u>J.sina</u>	: C
Gerridae	<u>Gerres oyena</u>	: C
	<u>G.filamentosus</u>	: 7.4
Mullidae	<u>Upeneus vittatus</u>	: 2.1
	<u>U.sulphurus</u>	: 1.1
Pomadasyidae	<u>Pomadasyops opercularis</u>	: C
	<u>P.maculatum</u>	: C
	<u>P.maculatus</u>	: C
Sphyraenidae	<u>Sphyraena obtusata</u>	: 1
	<u>S.japonicus</u>	: C
Clypeidae	<u>Sardinella albella</u>	: 3.7
	<u>Herklotichthys quadrimaculatus</u>	: 4.7
	<u>H.punctata</u>	: C
	<u>Thryssa vitrirostris</u>	: 1.8
	<u>Pellona ditchella</u>	: C
Lutjanidae	<u>Lutjanus setae</u>	: C
	<u>L.fluviiflamma</u>	: C
	<u>L.russeli</u>	: C
Carangidae	<u>Carangoides chrysophrys</u>	: C
	<u>Alectis indicus</u>	: C
	<u>Rhabdosargus sarba</u>	: C
	<u>Pseudorhambus arsius</u>	: C

\* C : common

## METHODS

For protein content, the Kjeldahl method was used (Maynard and Johnson 1970). The fish were bought from the market fresh and 1 gram from each fish species was used.



- 2 -

SOME FISH QUALITY PARAMETERS OBSERVED IN MOMBASA MARKETS

P.M.Oduor.

SUMMARY:

For fat content, the Soxhlet method was used (Winsor and Barlow instead of diethyl ether. The fish were bought from the market, sun-dried and muscle from each used. The fish were five months before being analysed and the results were representative. Crude protein contents of most fish species analysed ranged and between 14.0% to 22.0% of protein on weight basis per gram of muscle. storage and handling of fish, Majengo, Mwanba Teyari, Kilifi and Old town markets were visited.

Crude fat content seems to have a role in the rate of deterioration of dry salted fish.

Moulds, Insects, rodents play different roles in spoilage of sun-dried, dry salted and smoked fish.

INTRODUCTION:

The major nutrient in fish are proteins. Preservation of fish to prevent any losses nutritionally is the key to improving the nutritional status of a population. It is important to ensure that potentially available fish nutrients reach the consumer. Nutritional loss in this case can be defined as the nutrients from, and the value of fish which is available potentially for human consumption but fails to be consumed or sold as traditionally cured products. These losses are due to spoilage rendering the fish or fish product unfit to eat, to physical destruction and to lowering the nutritional value of the product. (FAO fishing technical paper No. 219).

METHODS

For protein content, the Kjeldahl method was used (Maynard and Johnson 1970). The fish were bought from the market fresh and 1 gram from each fish species was used.



# CRUDE FAT:

For fat content, the soxhlet method was used (Windsor and Barlow (1981). Petroleum spirit Boiling point 80 - 100°C was used instead of diethyl ether. The fish were bought from the market, sun-dried and 5 g of muscle from each used. The fish took five months before being discarded and observations were organoleptic. For storage and handling of fish, Majengo, Mwembe Tayari, Kilifi and Old town markets were visited.

## R E S U L T S:

### PROTEIN CONTENT

#### NAME

### CRUDE PROTEIN CONTENT/

#### gram wet weight

Lutjenus bohar	14.30%
Octopus	8.80%
Cuttle fish	9.60%
Getarin getarinus	15.40%
Pomadysis maculatus	15.80%
Tilapia (Bamburi fish farm)	17.90%
Leognathus aquala	16.70%
Lethrinus harak	18.10%
Lethrinus miniatus	18.40%
Lethrinus nebulosus	18.80%
Cephalophorus argus	18.20%
Siganus canaliculatus	18.0%
Upeneus bensasi	18.30%
Shark	19.50
Epinephelus tauvina	22.80%



CRUDE FAT:

<u>NAME</u>	<u>FAT CONTENT/5g DRY WEIGHT</u>	<u>ORGANOLEPTIC ASSESSMENT.</u>
King fish	Old town	Brining
Trichinotus blochii	2.50% Majengo, Tazari Killifi, Old Town	After 5 months, no sign of spoilage
Heminipherous far	7.80% Majengo Killifi	Ants invaded this 1 the 4th month.
Drepane punctata	9.50% Majengo, Killifi	No signs even during 5th month.
Pseudoprism plagiodesmus	11.50%	After 3 months, slight signs of deterioration noticed some mouldy growth observed towards 4th month covering $\frac{1}{8}$ of body, extending to cover $\frac{1}{3}$ of the body during the 5th month Ants also prevalent.
Monodactylus argenteus	14.50%	1 month 3 days, mould growth covering about $\frac{1}{3}$ of the body seen to spread.
Pseudoparus fratesculus	14.80%	1 month 3 days, ants appeared eating the muscle, mouldy growth seen to be similar to in Monodactylus argen- teus.

DISCUSSION:

The lowest protein content was observed in the cuttlefish, octopus and Epinephelus tautoga the highest. The highest fat content was observed in Pseudoparus fratesculus and the lowest in Trichinotus blochii. The storage life of sun-dried fish varied with fat content in that the higher the fat content, the faster was the rate of deterioration. Ants were not observed to attack the fish indiscriminately. Epinephelus were attacked by ants which sources at the market after 2 - 3 months and fed from within the storage placed at night, rats mainly ate the fish, (cooked) was not affected but this could be due to the time they take in the markets - they takes less than being sold. King fish did not show any signs of deterioration when still brined in the 'wall' In fact the storage period according to the dealers could extend into 5 years. The sharks were affected



# STORAGE:

<u>NAME</u>	<u>MARKET</u>	<u>TYPE OF PRESERVATION</u>
King fish	Old town	Brining
Shark	Mwembe Tayari Kilifi, Old Town	Dry salting
Clarius	Majengo	
Protopterus	Kilifi	Smoking
Nile Perch		
Eungalocypris	Majengo, Kilifi	Sun-drying

All observations made were organoleptic; the fish had been brought to the market ready for sale hence source where processing commenced was not reached.

## DISCUSSION:

The lowest protein content was observed in the cuttle fish and octopus and Epinepheros tauvina the highest. The highest fat content was observed in Pseudopeneous frateculus and the lowest in Trichinotus blochii. The storage life of sun-dried fish showed some correlation with fat content in that the higher the fat content, the faster was the rate of deterioration. Ants were however seen to attack the fish indiscriminately.

Eungalocypris were attacked by worms which sources at the markets said appeared after 2 - 3 months and fed from within the fish. In the storage placed at night, rats mainly ate the fish. The Nile perch (smoked) was not affected but this could be due to the short storage time they take in the markets - they takes less than 2 weeks before being sold. King fish did not show any signs of deterioration when still brined in the 'well' Infact the storage period according to the dealers could extend unto 5 years. The sharks were affected



(after a fairly short time almost two months within drying) by beetles and moulds (not identified), and destroyed the muscle. Clarius, protopterus only affected by cockroaches on a minor scale and by rats only when stored at night. They stay in the market for a short time before being sold and during the day, they are exposed outside to the sun in the markets.

The fat content relation to spoilage was seen to be appreciably significant considering the lowest fat content observed on Trichinotus blochii (2.50%) and Pseudopeneus frateculus (14.80%).

It is obvious therefore that the higher the fat the faster the rate of deterioration and vice versa. This could be due to the fact that a high fat content in the flesh will act as a barrier to diffusion of water from the centre of the fish to the surface hence spoilage due to high water activity in fish suitable for microbial growth. (FAO Tech. paper No. 219). The fact that the smoked Nile perch is not attacked in any way though it is fatty is partly explained by the short time they take in the market and also due to a possibility of the phenolic substances found in wood smoke having an anti-oxidant activity (preventing rancidity) and/or provide some protection for the fat. (FAO fisheries tech. paper). This could hold time for Clarias and protopterus which do not undergo visible spoilage though they also take a short time in the market. Cockroaches, Rats are their major attackers.

The King fish which are brined in a big well for a long time survived without any attack. Possible explanation here is that the salty conditions are too adverse for any of the pests to survive. Their consumption rate has to go up after removal from the well as they are fatty and the ones which had been removed from brine for some time were being attacked by some beetles.



For the dry salted sub-dried shark, first they are as many in the markets, packed closely together especially at Mwanbe Tayari market under damp conditions. The damp conditions encourage the mould spores to proliferate due to high water activity possible (FAO paper No. 219;). The fish are packed closely together and this aids spread of moulds. They are fed on by adult beetles indiscriminately all three year round and these could also spread the spores when the spores stick on their legs. The environment favours the breeding of beetle larvae being wet, filthy, with all kinds of wastes from this fish markets. Some of the sharks which were being dried near the markets were attacked by some fly larvae.

4. FAO Fisheries Techn. Paper No. 219 (Page 6)

Where as the fish studied have very high content of proteins, for this to be available, improvement on traditional curing methods are necessary. It is almost convenient to smoke fatty fish to minimize spoilage or to brine them. Sun dried salted fish should be spaced to avoid rapid attack by moulds and other agents, pesticides or other such sprays could be used; to eradicate the beetles; removal of fish wastes from the storage premises as these may contribute breeding sites for pests. Use of traps to prevent rodents. However, different factors play different roles in fish spoilage and one or a combination of two can not be seen as a major source of spoilage.



A study of the biochemical levels in commercial oysters,  
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Crassostrea cucullata Barr. - also factor 1.35 to obtain the

## REFERENCES

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1. FAO Fisheries Techn. Paper No. 219 page (1)

### Abstract.

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2. Introduction to Fishery By - Products (By Malcolm Windsor & Stuart Barlow; Page 133 - 154. necessary for a balanced diet.

3. Maynard & Johnson (1970) - Methods in Food analysis  
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4. FAO Fisheries Techn. Paper No. 219 (Page 6)  
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The present study describes the biochemical composition during the growth period of *C. cucullata* grown on mangrove poles at Gazi oyster culture (= experimental culture project)

### Material and methods.

Samples were pooled from at least 20 individuals of uniform size between March and May 1986, and analysed for their food value. In general, the methods elaborated by Giese (1967) for invertebrates were followed for both preparation and biochemical estimations. For the biochemical composition, the levels (in % dry weight) of protein and carbohydrate were estimated. The water level (in % wet weight) was determined by drying at 100°C to constant weight. The levels of protein and carbohydrate were estimated using previously dried sample. The total nitrogen value



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Results.

Abstract.

The nutritive value of *Crassostrea cucullata* Barr was investigated in March and May 1986. The study indicated that this species is rich in protein and carbohydrate which are necessary for a balanced diet.

Composition	<i>C.cucullata</i>	<i>C.virginica</i>	<i>C.gigas</i>	beef	eggs
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Introduction;

Oysters and other bivalves are a low-cost subsistence food of the coastal people. The molluscan resources of this coast are largely unexploited as only a minority of people eat them, consumption being restricted to tourists. The oyster meat is unknown to many Kenyans especially those inland. However, it is believed that oyster fishery will have a good commercial potential in the country once the meat becomes acceptable to the locals. Thus an understanding of the biochemical composition and stage of development when nutritional value is optimum are prerequisite for planning large scale culture.

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Adanson (1757), in the Lagos area, Nigeria.  
 Aquaculture 21: 129-137.



as determined by the semi-micro Kjeldahl method (Joslyn, 1970) was multiplied by the conversion factor 6.25 to obtain the total protein value. The total carbohydrate (in % glucose of dry weight) was estimated by the Anthron method (Seigter et al, 1950).

Maynard A. Joslyn 1970. Methods in food analysis.

### Results.

8th edition, Chemical analysis of foods.

The table below shows the result obtained compared with C.virginica (Galtsoff, 1964), C.gigas (A.C.Giese), local beef and eggs.

% composition	<u>C.cucullata</u>	<u>C.virginica</u>	<u>C.gigas</u>	beef	eggs
protein	56.08	49	9.8	18.7	45.4
carbohydr.	7.58	10.5	4.5	0.5	1.0
water	75.6	80.5	-	64.7	66.3

Water levels in % wet weight. Protein and carbohydrate levels in % dry weight.

In May 1986 the results are as follows for C.cucullata:

Protein: 49.9 %, carbohydrate: 0.38 %, water: 87 %

The table shows that oyster meat is as nutritive as local chicken eggs.

In May there is a fall in the protein and carbohydrate levels. This could be the time when the oysters have spawned as the reserve nutrients have been converted to gamete material. However, more analyses should be done on weekly bases in order to arrive at a definite conclusion.

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R.K. Ruwa

153.

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Mangroves are important for nutrient release, offer habitats for several organisms, protect shores and in terms of human economic uses they are used for building purposes, fuel etc. Beside mangrove ecosystems mariculture projects are in practice. But even with this knowledge mangroves have not been exonerated from the myth that they are idle forests.

In Kenya, although they are protected under the Government Forest Act, they have been cut down in some areas for the construction of salt and mariculture ponds. The mangrove ecosystems in Kenya are also faced with an eminent degradation of their environments due to the dumping of sewage and solid wastes from fast growing coastal towns, some of which a couple or three decades ago were villages.

Since ecological information on mangrove ecosystems in Kenya, which could be used for conservation purposes and direct or indirect planned exploitation of this resource, is lacking, this project was initiated. It is geared to gather information (a) regarding species diversity in mangrove forests (b) their role as suitable mariculture sites and in our case e.g. oyster culture, and (c) their role in protecting shorelines from erosion which is very common in Lamu District.

### 1.1. Mangrove Environment

Mangrove seedlings germinate in brackish water environment. Brackish water conditions are therefore prerequisites for mangrove development and occurrence. In Kenya the brackish water conditions



## MANGROVE ECOLOGY

R.K. Ruwa

A survey on the intertidal environment of various parts of the Kenya coastline showed that there is considerable amount of underground Mangroves are important for nutrient release, offer habitats for several organisms, protect shores and in terms of human economic uses they are used for building purposes, fuel etc. Beside mangrove ecosystems mariculture projects are in practice. But even with this knowledge mangroves have not been exonerated from the myth that they are idle forests. g. Bamburi, Kanamai, Mida etc. (see also annex 11).

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### 1.1. Mangrove Environment

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are created by river discharges and seepage of underground water into the intertidal zone.

A survey on the intertidal environment of various parts of the Kenya coastline showed that there is considerable amount of underground fresh water seeping into the intertidal zone which therefore creates the brackish water environments. The fresh water mixes with marine salts in the sediments or mixes with the sea water as indicated by the salinity records in Table 1. This seepage phenomenon has now explained the existence of mangroves on areas without any river flowing into the sea e.g. Bamburi, Kanamai, Mida etc. (see also annex 11).

### 1.2. Species diversity

Since the Kenya coastline has brackish water biotopes with and without mangroves, the role of the latter in increasing species diversity in Kenya can be evaluated. Thus beginning with the Crustacea, a faunal species composition of the crabs was initiated.

The current areas of study are :

- (a) Kanamai beach, where there is a muddy shore with considerable seepage but, has no mangroves
- (b) Bamburi and Mkomani, where there are small mangrove patches growing on brackish environments created by seepage only.
- (c) Gazi mangrove forest, where the brackish water environment is created by seasonal rivelets and seepage (see also annex 11).

To date, the species composition is as shown in Table 2. From the latter Table there is a clear indication that mangrove vegetation increases species diversity in brackish water biotopes. Further work is in progress to establish the relative abundances of various species in relation to forest size or area of seepage and the micro-habitat description preferred by each species.



Table 1 : Salinity (‰) measurements at various points where water was seeping from underground into the intertidal zone. The measurements were done at low tide when it was not raining.

Point of seepage	Gazi	Nyali	Bamburi	Kanamai	Mkomani	Shelly	Tiwi
1	16	18	25	22	16	33	6
2	18	19	26	26	17	34	7
3	21	23	28	28	-	35	9
4	-	-	30	29	-	-	12
5	-	-	31	-	-	-	10
6	-	-	-	-	-	-	15
7	-	-	-	-	-	-	17
8	-	-	-	-	-	-	20
9	-	-	-	-	-	-	24
10	-	-	-	-	-	-	29
11	-	-	-	-	-	-	32

Date	2/6/85	4/6/85	5/6/85	8/7/85	11/7/85	21/8/85	22/8/85



**Table 2 :** Occurrence of various types of brackish water crabs at Gazi, Kanamai, Bamburi and Mkomani. (x) indicates that the species was seen and (-) indicates: not seen to date, 18/6/86.

Out of the four localities sampled it is only Kanamai beach swamp that has no mangroves.

SPECIES	Gazi	Kanamai	Bamburi	Mkomani
1. <u>Uca annulipes</u>	x	-	x	x
2. <u>U. chlorophthalmus</u>	x	-	x	x
3. <u>U. marionis</u>	x	x	x	-
4. <u>U. vocans</u>	-	x	x	-
5. <u>U. tetragonon</u>	x	x	x	x
6. <u>U. inversa</u>	x	-	-	-
7. <u>U. urvillei</u>	x	-	-	-
8. <u>U. dussumieri</u>	x	-	-	-
9. <u>Macrophthalmus</u>	x	x	-	-
10. <u>M. milloti</u>	x	x	-	-
11. <u>M. consorbrinus</u>	-	x	x	-
12. <u>M. bosci</u>	-	x	-	x
13. <u>Thalanita crenata</u>	x	x	x	x
14. <u>Scylla serrata</u>	x	x	-	-
15. <u>Metopograpsus messor</u>	x	-	x	x
16. <u>Sersana elongatum</u>	-	-	-	x
17. <u>S. impressum</u>	-	-	x	-
18. <u>S. guttatum</u>	x	-	-	-
19. <u>S. plicatum</u>	x	-	-	-
20. <u>S. eulinene</u>	x	-	-	-
21. <u>S. meinerti</u>	x	-	-	-
22. <u>S. catenata</u>	x	-	-	-
23. <u>Pseudograpsus elongatus</u>	x	-	-	-
24. <u>Cardisoma carnifex</u>	x	-	-	-
25. <u>Eurycarcinus natalensis</u>	x	-	-	-
26. <u>Varuna litterata</u>	x	-	-	-
27. <u>Xanthid</u> sp.	x	-	-	-
28. <u>Ilyograpsus paludicola</u>	x	-	-	-
Total No of species	23	9	9	7



reversed, having now the first shell uppermost and the last tenth one lowermost in descending order. This was done on the 26th May

GAZI OYSTER PROJECT I. GROWTH OF OYSTER CRASSOSTREA CUCULLATA BORN.

far, the sizes of the growing oysters on the coconut shells are not yet suitable for removal without high risks of mechanical

R.K.Ruwa. The oysters are therefore still being nursed on the shells

#### Introduction.

The growth of oysters from the time of settlement is being monitored at Gazi Creek. This study is started to :

1. provide an idea on their patterns of growth at different levels on the shore
2. determine the suitable size and age for transplanting them without high risks of mechanically damaging them when cementing
3. study the effects of intraspecific and interspecific competition on their growth.

#### Methods.

Strung coconut shells whose surfaces have been entirely cemented with marine cement were suspended vertically on oyster racks in the intertidal zone. The surfaces of the coconut shells were used as sites for settlement of oyster spats. The shells were spaced at 10 cm intervals. The level of the first shell at the bottom was 1.1 m above datum, whereas the highest shell 2 m for the strings of 10 shells and 1.5 m for those of 5 shells. The strings were suspended on the racks on the 17th March 1986.

#### Observations and remarks.

Counts of the oyster spat that settled on the coconut shells were made. Their growth was followed by measuring their maximum shell lengths using a vernier calipers (Table 10). The measurements of their shell lengths showed that the oysters on the lower shells grow faster than those on the higher ones.

Barnacles were observed to be the only competitors for space on both the upper and the undersides of the coconut shells. The barnacles were mainly Balanus amphitrite and occasionally Euraphia withersi. Counts of the barnacles showed that the higher level coconut shells supported more specimens than the lower level ones (Table 2)

The oyster spats settled more abundantly on the lower level shells and also more on the underside of the shells than on the uppersides (Table 3). Since the oyster settlement at the lower levels were higher and the growth was faster, and since there was less competition for space with barnacles, it was found more suitable to hang shorter strings of 5 coconut shells in the level 1.0-1.5 m above datum to collect the oyster spats.

Further studies were done to find out the significance of the relationship between their height on the shore and their growths. The sequence of the shells on one of the monitored strings was



reversed, having now the first shell uppermost and the last tenth one lowermost in decending order. This was done on the 26th May 1986 and the experiment is still in progress.

So far, the sizes of the growing oysters on the coconut shells are not yet suitable for removal without high risks of mechanical damages. The oysters are therefore still being nursed on the shells.

C was not measured on the 9th May 1986.

Nr. of coconut shell	Elevation (m) above datum	1st April 1986			16th April 1986		
		A	B	C	A	B	C
1	1.1	1.6	2.1-3.2	1.5	0.7-2.8	1.2-6.4	0.4-5.0
2	1.2	2.0	1.9	1.2	1.2-5.5	3.5-4.9	0.6-2.4
3	1.3	0	0	1.3-2.7	1.0	1.1	1.0
4	1.4	0	0	0	0.8	0.7-1.5	1.6-1.8
5	1.5	0	0	0	1.0-1.5	0	1.0-1.8
6	1.6	-	0	0	-	2.0-2.1	0.5
7	1.7	-	0	0	-	1.0	0
8	1.8	-	0	0	-	0	0
9	1.9	-	0	0	-	0	0
10	2.0	-	0	0	-	0	0

Nr.	29th April 1986			9th May 1986		21st May 1986		
	A	B	C	A	B	A	B	C
1	1.7-8.0	1.6-10.6	1.0-4.4	1.2-9.1	1.0-14.0	1.0-11.7	1.5-15.5	1.3-10.2
2	1.0-10.7	1.1-8.0	1.2-4.0	1.5-17.1	1.4-13.0	1.0-19.0	1.0-14.8	1.3-10.7
3	1.5-2.0	1.0-2.0	1.0-9.6	1.6-3.4	1.0-3.4	2.3-5.4	1.6-5.7	1.5-15.5
4	1.1-1.7	1.0-2.2	1.5	1.2-5.2	1.0-5.8	1.0-6.0	1.6-8.0	1.5-4.8
5	1.1-3.2	1.2-2.2	1.0	1.7-5.3	1.2-5.8	1.0-4.6	2.0-6.0	1.7-7.0
6	-	1.6	1.4-4.2	-	1.3-4.0	-	1.3-6.2	1.3-7.3
7	-	1.4-2.5	1.5	-	1.2-3.6	-	1.6-3.9	1.8-4.0
8	-	1.2	0	-	1.0-2.6	-	1.5-3.0	1.5-3.8
9	-	1.0	0	-	0	-	2.0-3.0	0
10	-	0	0	-	0	-	0	0



Table 1.

Ranges of shell lengths (in mm) of the oysters on coconut shells suspended on the racks on 17th March 1986.

A, B and C denote the strings.

Note: some dark silting sometimes concealed some oysters in the lower levels. C was not measured on the 9th May 1986.

Nr. of coconut shell	Elevation (m) above datum	1st April 1986			16th April 1986		
		A	B	C	A	B	C
1	1.1	1.6	2.1-3.2	1.5	0.7-2.8	1.2-6.4	0.6-5.0
2	1.2	2.0	1.9	1.2	1.2-5.5	3.5-4.9	0.6-2.4
3	1.3	0	0	1.3-2.7	1.0	1.1	1.0
4	1.4	0	0	0	0.8	0.7-1.5	1.6-1.8
5	1.5	0	0	0	1.0-1.5	0	1.0-1.8
6	1.6	-	0	0	-	2.0-2.1	0.5
7	1.7	-	0	0	-	1.0	0
8	1.8	-	0	0	-	0	0
9	1.9	-	0	0	-	0	0
10	2.0	-	0	0	-	0	0

Nr.	29th April 1986			9th May 1986		21st May 1986		
	A	B	C	A	B	A	B	C
1	1.7-8.0	1.6-10.6	1.0-4.4	1.2-9.1	1.0-14.0	1.0-11.9	1.5-15.5	1.3-10.2
2	1.0-10.7	1.1-8.0	1.2-4.0	1.5-17.1	1.6-13.0	1.0-19.0	1.0-14.8	1.3-10.7
3	1.5-2.0	1.0-2.0	1.0-9.6	1.6-3.4	1.0-3.4	2.3-5.4	1.0-5.7	1.5-15.5
4	1.1-1.7	1.0-2.2	1.5	1.2-5.2	1.0-5.8	1.0-6.0	1.8-8.0	1.5-4.8
5	1.1-3.2	1.2-2.2	1.0	1.7-5.3	1.2-5.8	1.0-4.6	2.0-6.0	1.7-7.0
6	-	1.6	1.4-4.2	-	1.3-6.0	-	1.5-6.2	1.3-7.3
7	-	1.4-2.5	1.5	-	1.2-3.6	-	1.6-3.9	1.8-4.0
8	-	1.2	0	-	1.0-2.6	-	1.5-3.0	1.5-3.8
9	-	1.0	0	-	0	-	2.0-3.0	0
10	-	0	0	-	0	-	0	0



Table 2 3.

Relationship between settlement of barnacles and the oyster *Crassostrea cucullata* Born shells on the B coconut strings (as in Table 1 and 3).

The counts were made on the 26th May 1986. <sup>1</sup>ed some oysters in the lower levels.

The numbers in parantheses represent the numbers of barnacles. <sup>2</sup> surfaces of the shells.

Numbers in parenthesis represent the numbers of oysters settled on the upper surfaces of the shells.

Nr.coconut shell	Elevation (shell above datum	Underside of coconut shell			Upperside of coconut shell		
		1st April 1986			16th April 1986		
shell		A	B	C	A	B	C
1	101	( 13 )		9	( 0 )		
2	1.1 66	( 31 ) (2)	4 (2)	1 (10	( 4 ) (1)	26 (9)	4 (8)
3	1.2 31	( 71 ) (0)	4 (1)	3 (16	( 2 )	5 (5)	8 (0)
4	1.3 84	( 110 ) (0)	0 (0)	2 (18	( 0 )	1 (0)	2 (4)
5	1.4 117	( 270 ) (0)	0 (0)	0 (17	( 7 )	16 (3)	2 (0)
6	1.5 87	( 89 ) (0)	0 (0)	0 (18	( 33 )	0 (0)	2 (0)
7	1.6 81	( 155 )	0 (0)	0 (28	( 80 )	3 (0)	7 (0)
8	1.7 59	( 1075 )	0 (0)	0 (14	( 167 )	2 (0)	0 (0)
9	1.8 12	( 870 )	0 (0)	0 (0	( 288 )	0 (0)	0 (0)
10	1.9 0	( 665 )	0 (0)	0 (0	( 51 )	0 (0)	0 (0)
10	2.0	-	0 (0)	0 (0)	-	0 (0)	0 (0)



Table 3.

Patterns of settlement of the oyster *Crassostrea cucullata* Born on cemented coconut shells.  
A, B and C denote the strings.

Note: some dark silting sometimes concealed some oysters in the lower levels.

Numbers represent the numbers of oysters settled on the inner surfaces of the shells.

Numbers in parenthesis represent the numbers of oysters settled on the upper surfaces of the shells.

Nr.coconut shell	Elevation (m) above datum	1st April 1986			16th April 1986		
		A	B	C	A	B	C
1	1.1	1 (2)	4 (2)	1 (1)	15 (21)	26 (9)	4 (8)
2	1.2	1 (0)	4 (1)	3 (0)	4 (8)	5 (5)	8 (0)
3	1.3	0 (0)	0 (0)	2 (0)	6 (0)	1 (0)	2 (4)
4	1.4	0 (0)	0 (0)	0 (0)	8 (2)	16 (3)	2 (0)
5	1.5	0 (0)	0 (0)	0 (0)	8 (0)	0 (0)	2 (0)
6	1.6	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)	7 (0)
7	1.7	-	0 (0)	0 (0)	-	2 (0)	0 (0)
8	1.8	-	0 (0)	0 (0)	-	0 (0)	0 (0)
9	1.9	-	0 (0)	0 (0)	-	0 (0)	0 (0)
10	2.0	-	0 (0)	0 (0)	-	0 (0)	0 (0)



## Annex 8/11

Table 3

Nr.shell	28th April 1986			6th May 1986			15th May 1986		
	A	B	C	A	B	C	A	B	C
1	155 (22)	81 (11)	29 (3)	141 (24)	91 (0)	32 (0)	149 (31)	72 (7)	56 (5)
2	25 (11)	51 (13)	42 (0)	29 (8)	72 (0)	33 (2)	33 (11)	46 (6)	34 (0)
3	21 (8)	14 (0)	10 (0)	25 (5)	16 (2)	15 (9)	29 (6)	14 (2)	15 (17)
4	31 (2)	18 (0)	5 (0)	37 (2)	26 (6)	12 (0)	33 (1)	47 (3)	21 (0)
5	26 (1)	7 (0)	7 (0)	37 (0)	68 (6)	15 (3)	28 (0)	93 (4)	26 (2)
6	-	22 (1)	35 (1)	-	64 (0)	61 (2)	-	68 (10)	37 (0)
7	-	7 (0)	10 (2)	-	41 (0)	31 (23)	-	51 (9)	24 (2)
8	-	6 (0)	1 (0)	-	17 (0)	6 (3)	-	4 (0)	8 (0)
9	-	2 (0)	3 (0)	-	0 (0)	7 (0)	-	6 (0)	3 (0)
10	-	0 (0)	0 (0)	-	0 (0)	2 (0)	-	1 (0)	0 (0)

Method.

- (1) Spot check method: consists of swimming along a reef slope reef crest or reef flat and recording any new species of coral encountered and the biotope and depth.
- (2) For more detailed study of the community structure, a transect line is laid along or across a zone and any coral underlying this line is measured and recorded.

The following sites were studied:

<u>Location</u>	<u># of sites</u>
Kiunga Marine National Reserve	5
Malindi Marine National Park	4
Mida creek	2
Kanamai	2
Bamburi	1
Nyali	1
Tiwi	2
Diani	2
Shimoni (Kisite Island)	3

A wide range of reef types including mainland and island fringing reefs, intertidal and submerged reefs were studied.



## Annex 8/11

Results of the survey.THE DISTRIBUTION AND ABUNDANCE OF CORALS ALONG THE KENYA COAST.

N. Muthiga.

Introduction.

In view of the importance of coral reefs to the littoral ecology of adjoining coasts, a coral reef project was started with the following objectives.

- (1) To survey the Scleractinia and other anthozoans in various biotopes along the Kenya coast.
- (2) To select suitable corals for growth studies, the main criteria being dominance within the various biotopes and a morphological structure allowing for quick and easy measurement of growth.

Method.

- (1) Spot check method: consists of swimming along a reef slope reef crest or reef flat and recording any new species of coral encountered and the biotope and depth.
- (2) For more detailed study of the community structure, a transect line is laid along or across a zone and any coral underlying this line is measured and recorded.

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A wide range of reef types including mainland and island fringing reefs, intertidal and submerged reefs were studied.



### Results of the survey.

A tentative checklist was compiled (Appendix I) which includes corals identified in the field, and corals that are part of the K.M.F.R.I. collection and the University of Nairobi, Zoology Dept collection. The corals identified includes 50 genera and more than 144 species.

The Kenyan coast is therefore relatively rich in coral species comparable to reefs in the South East Asian region which have the greatest abundance and diversity of hermatypic corals. Most of the reefs visited were fairly shallow (20 m) and therefore with deeper areas being explored, more species could be discovered. Other corals not included in the Order Scleractinia also occur along the Kenyan coast including the families Tubiporidae, Helioporidae, Milleporidae and Stylasteridae. Appendix II shows the distribution of the most abundant genera along the Kenyan coast. *Acropora*, *Pocillopora*, *Montipora*, *Porites*, *Favites*, *Platygyra*, *Pavona* and *Echinopora* are the most common genera, while *Auopora* and *Favia* had the most number of species. From the spot checks, the Malindi Marine National Park, Mida creek and Shimoni had the highest abundance of genera.

For more detailed work, transects were laid along the reef crest, slope and flat at North reef at the Malindi Marine National Park (as described above). The data that was collected will be included in a paper for publication similar work is carried out on other reefs including Mida creek and Shimoni. The data collected thus will give us an idea of the community structure of these reefs including species diversity and abundance. This data can be used as a base for future monitoring of these reefs.

### Results of Growth Studies.

Six coral colonies of the genera *Acropora* were tagged with insulated electrical wire (5 branches each) and subsequent measurements were made. The average growth rate was 5 cm in seven months. As growth measurements were not taken frequently, we cannot deduce whether the growth rate changes due to changes in the environment (i.e. cooler water, less sunlight, lower salinity etc.). As Malindi is far away from the Marine station, having a steady schedule is difficult to maintain. However with transport readily available, more corals need to be tagged on different parts of the reef.



## APPENDIX I: A TENTATIVE CHECKLIST OF HERMATYPIC CORAL SPECIES FOUND

ALONG THE KENYA COAST.Systematics:

Order SCLERACTINIA

Bourne, 1900

Suborder Astrocoeniina

Vaughan &amp; Wells 1943

Family Thamnasteriidae

Wells, 1956

Genus Psammocora

Dana

P. haimana

Milne - Edwards &amp; Haime, 1851

P. nierstrazi

Horst, 1921

P. explanulata

Horst, 1921

P. contigua

Esper

Family Astrocoeniidae

Koby

Genus Stylocoeniella

Yabe &amp; Sugiyama, 1935

S. armata

(Ehrenberg, 1834)

Family Pocilloporidae

Gray, 1842

Genus Pocillopora

Lamarck, 1816

P. damicornis

(Linnaeus, 1758)

P. verrucosa

(Ellis &amp; Solander, 1786)

P. eyedouxi

Edwards &amp; Haime, 1860

Genus Seriatopora

Lamarck, 1816

S. hytrix

Dana, 1846

S. caliendrum

Ehrenberg, 1834

Genus Stylophora

Schweigger, 1819

S. pistillata

Esper, 1797

Family Acroporidae

Verrill, 1902

Genus Acropora

Oken, 1815

Acropora formosa

Dana, 1846

Acropora pharaonis

Milne - Edwards &amp; Haime

Acropora humilis

Dana, 1846

Acropora rotumana

Gardine

Acropora secale

Studer, 1878

Acropora florida

Dana, 1846

Acropora palifera

Lamarck



<u>A. granulosa</u>	Milne - Edwards & Haime, 1860
<u>A. clathrata</u>	Brook, 1891
<u>A. cuneata</u>	Dana, 1846
<u>A. millepora</u>	Ehrenberg, 1834
<u>A. ocellata</u>	Klunzinger Haime, 1860
<u>A. hyacinthus</u>	Dana, 1846
<u>A. cytherea</u>	Dana, 1846
<u>A. hemprichi</u>	Ehrenberg
<u>A. aculeus</u>	Dana, 1846, 1830
<u>A. variabilis</u>	Klunzinger Haime, 1851
Genus <u>Astreopora</u>	Blainville, 1830, 1860
<u>A. myriophthalma</u>	Lamarck, 1816
<u>A. incrustans</u>	Bernard, 1896
Suborder <u>Fungiina</u>	Verrill, 1865
Family <u>Fungiidae</u>	Dana, 1846 Wells, 1943
Genus <u>Cycloseris</u>	Edwards & Haime, 1849
<u>C. cyclolithes</u>	Lamarck, 1801
<u>C. patelliformis</u>	Boschma 1847
Genus <u>Diaseris</u>	Edwards & Haime, 1849
<u>D. distorta</u>	Michelin, 1843
Genus <u>Fungia</u>	Lamarck, 1801
Subgenus <u>Fungia</u>	Lamarck, 1801
<u>F. (F.) fungites</u>	Linnaeus, 1758
Subgenus <u>Vevrillofungia</u>	Wells, 1966 Haime, 1849
<u>F. (V) repanda</u>	Dana, 1846
<u>F. (V) granulosa</u>	Klunzinger, 1879
<u>F. (V) plana</u>	Studer & Pillat, 1974
Subgenus <u>Pleuractis</u>	Verrill, 1844
<u>F. (P) scutaria</u>	Lamarck, 1801 Haime, 1849
Genus <u>Herpolitha</u>	Eschscholtz, 1824
<u>H. limax</u>	
Genus <u>Halomitra</u>	Dana, 1846
<u>H. philippinensis</u>	Studer, 1918
Genus <u>Po</u>	Edwards & Haime, 1849
<u>P. crustacea</u>	Pallas, 1766 Wells, 1943
Family <u>Faviidae</u>	Gregory, 1900
Genus <u>Favia</u>	Oken, 1815
<u>F. stelligera</u>	Dana, 1846



- Family Poritidae Gray, 1842
- Genus Porites Link, 1807
- P. lobota Dana, 1846
- P. compressa Dana, 1846
- P. lutea Edwards & Haime, 1860
- P. nigrescens Dana, 1846
- Porites (Synaraea) convexa Verill
- P. sp 1 & P.sp 2
- Genus Goniopora de Blainville, 1830
- G. stokesi Edwards & Haime, 1851
- G. lobota Edwards & Haime, 1860
- G. columna Dana, 1846
- Genus Alveopora Blainville
- A. mortenseni Crossland
- Family Siderastreae Vaughan & Wells, 1943
- Genus siderastrea
- \* Siderastres sp.
- Family Agariciidae Gray, 1847
- Genus Pavona Lamarck, 1801
- P. frondifera Lamarck
- P. varians Verrill, 1864
- P. maldivensis Gardiner, 1905
- P. esplanulata Lamarck, 1816
- Genus Pachyseris Edwards & Haime, 1849
- P. rugosa Lamarck 1801
- P. speciosa Dana, 1846
- Genus Gardinoseris Scheer & Pillai, 1974
- G. planulata Dana
- \* Genus Coscinaraea Edwards & Haime, 1848
- C. monile Forskal, 1775
- Genus Agariciella Gardiner
- A. minikoiensis
- Genus Coeloseris Vaughan, 1918
- C. mayeri Vaughan, 1918
- Suborder Faviina Vaughan & Wells, 1943
- Family Faviidae Gregory, 1900
- Genus Favia Oken, 1815
- F. stelligera Dana, 1846
- Genus Hydnochora
- H. rigida



- F. laxa  
F. pallida  
F. favus  
F. speciosa  
F. maxima  
 Genus Favites  
F. abdita  
F. pentagona  
 Genus Goniastrea  
G. retiformis  
G. australiensis  
 Genus Platygyra  
P. daedalea  
P. lamellina  
 Genus Leptoria  
L. phrygia  
 Genus Oulophyllia  
O. crispa  
 Genus Leptastrea  
L. purpurea  
 Genus Cyphastrea  
C. serailia  
C. chalcidum  
C. microphthalma  
 Genus Echinopora  
E. lamellosa  
E. gemmacea  
 Family Trachyphyllidae  
 Genus Trachyphyllia  
T. geoffroyi  
 Family Rhizangiidae  
 Genus Culicia  
C. cuticulata  
 Family Oullinidae  
 Genus Galaxea  
G. clavus  
G. fascicularis  
 Family Merulinidae  
 Genus Hydriophora  
H. rigida
- Pallas, 1766  
 Lamarck, 1816  
 Ehrenberg, 1834  
 Ellis and Solander, 1786  
 Dana, 1846  
 Veron, Pichon & Wijsman-Best, 1977  
 Link, 1807  
 Ellis & Solander, 1786  
 Esper, 1794  
 Edwards & Haime, 1848  
 Lamarck, 1816  
 Yabe, Sugiyama & Aguchi, 1936  
 Edwards & Haime, 1848  
 Ehrenberg, 1834  
 Ellis & Solander, 1786  
 Ehrenberg  
 Edwards & Haime, 1848  
 Ellis & Solander, 1786  
 Saville-Kent, 1871  
 Edwards & Haime, 1848  
 Lamarck, 1816  
 Oken, 1815  
 Edwards & Haime, 1848  
 Pallas, 1766  
 Oken, 1815  
 Edwards & Haime, 1848  
 Pallas, 1766  
 Vaughan & Wells, 1943  
 Gray, 1847  
 Lamarck, 1816  
 Quelch, 1886  
 Lamarck, 1816  
 (Milne-Edwards and Haime, 1848)  
 Esper, 1775  
 Milne-Edwards and Haime, 1848  
 Lamarck  
 Verrill, 1901  
 Milne-Edwards and Haime, 1851  
 Edwards & Haime, 1848  
 Ehrenberg, 1834  
 Audouin, 1826  
 Vaughan & Wells, 1943  
 Gray, 1847  
 Lesson, 1834  
 Klunzinger  
 Ehrenberg, 1834  
 Gray, 1847  
 Dana  
 Oken, 1815  
 Ehrenberg  
 Dana  
 Edwards & Haime, 1848  
 Spengler, 1751  
 Verrill, 1866  
 Milne-Edwards and Haime, 1848  
 Fischer de Waldheim, 1807  
 Oken, 1815  
 Dana, 1846  
 Esper, 1794



<u>H. exesa</u>	Pallas, 1766
<u>H. microconos</u>	Lamarck, 1816
Genus Merulina	Ehrenberg, 1834
<u>M. ampliata</u>	Ellis and Solander, 1786
Family Mussidae	Ortman, 1890
Genus Acanthastrea	Edwards & Haime, 1848
<u>A. echinata</u>	Dana, 1846
Genus Lobophyllia	Blainville, 1830
<u>L. hemprichii</u>	Ehrenberg, 1834
<u>L. costata</u>	Dana
<u>L. hataii</u>	Yabe, Sugiyama & Eguchi, 1936
Genus Symphyllia	Edwards & Haime, 1848
Symphyllia sp.	
Family Pectiniidae	Vaughan & Wells, 1943
Genus Echinophyllia	Klunzinger, 1879
<u>E. aspera</u>	(Ellis & Solander, 1788)
Genus Oxypora	Saville - Kent, 1871
<u>O. iacera</u>	Verrill, 1864
Genus Mycedium	Oken, 1815
<u>M. elephantotus</u>	Pallas, 1766
Genus Pectinia	Oken, 1815
<u>P. lactuca</u>	Pallas, 1766
Suborder Caryophylliina	Vaughan & Wells, 1943
Family Caryophyllidae	Gray, 1847
Genus Physogyra	Quelch, 1886
<u>P. lichtensteini</u>	(Milne - Edwards and Haime, 1848)
Genus Plerogyro	Milne - Edwards and Haime, 1848
<u>P. sinuosa</u>	
Genus Gyrosmilia	Milne - Edwards and Haime, 1851
<u>G. interrupta</u>	Ehrenberg, 1834
Suborder Dendrophylliina	Vaughan and Wells, 1943
Family Dendrophylliidae	Gray, 1847
Genus Tubastraea	Lesson, 1834
<u>T. coccinea</u>	Ehrenberg, 1834
<u>T. diaphana</u>	Dana
<u>T. micrantha</u>	Ehrenberg
Genus Heteropsammia	Edwards & Haime, 1848
<u>H. cochlea</u>	Spengler, 1781
<u>H. michelini</u>	Milne - Edwards and Haime, 1848
Genus Turbinaria	Oken, 1818
<u>T. peltata</u>	Esper, 1794



## APPENDIX II: THE DISTRIBUTION OF CORAL GENERA ALONG THE KENYAN COAST.

T. frondens

Dana, 1846

T. crater

Pallas

T. stellulata

Lamarck, 1816.

Genera	Indi	Maida Creek	K	Bamburi	Nyali	Tlwi	Diani	Shimoni
Psammocora	1	1	1	1		1		
Stylophora	1	1	1					1
Seriatophora	1	1	1			1		1
Pocillopora	1	1	1	1	1	1	1	1
Acropora	1	1	1	1	1	1	1	1
Astropora	1	1		1		1		1
Nontipora	1	1	1	1	1	1	1	1
Pavona	1	1	1	1	1	1	1	1
Coeloseris			1					1
Pachyseris	1	1	1	1	1	1	1	1
Fungia	1	1	1		1		1	1
Merculitha		1			1			1
Soniopora	1	1	1	1		1		1
Porites	1	1	1	1	1	1	1	1
Alveopora		1	1	1		1		1
Savia	1	1	1	1	1	1	1	1
Savites	1	1	1	1	1	1	1	1
Platygyra	1	1	1	1	1		1	1
Leptoria	1	1						1
Hydnophora	1	1	1		1		1	1
Leptasteroa	1	1	1	1				1
Cyphastrea	1	1	1	1		1		1
Echinopora	1	1	1	1	1	1		1
Lobophyllia		1	1					1
Nycedium		1	1					1



APPENDIX II: THE DISTRIBUTION OF CORAL GENERA ALONG THE KENYAN COAST.

	Kiunga	Malindi	Maida Creek	Kanamai	Bamburi	Nyali	Tiwi	Diani	Shimoni
Genera									
Psammocora	†	†	†	†			†		
Stylophora	†	†	†	†					†
Seriatophora	†	†	†	†			†		†
Pocillopora	†	†	†	†	†	†	†	†	†
Acropora	†	†	†	†	†	†	†	†	†
Astreopora	†	†			†		†		†
Montipora	†	†	†	†	†	†	†	†	†
Pavona	†	†	†	†		†	†	†	†
Coeloseris				†					†
Pachyseris	†	†	†		†	†	†	†	†
Fungia	†	†	†			†		†	†
Herpolitha		†				†			†
Goniopora	†	†	†	†	†		†		†
Porites	†	†	†	†	†	†	†	†	†
Alveopora		†	†	†			†		†
Favia	†	†	†	†	†	†	†	†	†
Favites	†	†	†	†		†	†	†	†
Platygyra	†	†	†	†	†	†		†	†
Leptoria	†	†							†
Hydnophora	†	†	†			†		†	†
Leptasterea	†	†	†	†					†
Cyphastrea	†	†	†	†			†		†
Echinopora	†	†	†	†	†	†	†		†
Lobophyllia		†	†						†
Mycedium		†	†						†



# Oysters: Kenya's underexploited food resource

Tubastrea

Turbinaria

Millepora

Appendix 2.

By OGEE KOFI

in a secluded creek beside the Indian Ocean, a marine biologist from Belgium toils in the brackish water and dreams of a new high-protein food for Africa's undernourished masses — oysters.

"The snob assemblage attached to oysters should be destroyed," Professor Philip Polk, Dean of Biology at the Free University of Brussels, said as he worked with two Kenyan assistants in the green water of Gazi Creek, South of Mombasa. "The protein content of Oysters is far superior to that of any red meat or even fish, and here, are oysters in inexhaustible quantities."

## Agencies

Polk, stripped to the waist and burned brown by the fierce equatorial sun, said he wanted the world's private and international development agencies such as the United Nations Children Fund to think about oysters seriously. "Third World families should be encouraged to feed their babies with oysters. Oysters as a food are versatile and easily transportable. They can be dried, packed canned or mixed with other foods", he said.

Polk came to Kenya 18 months ago to supervise 20 Belgium-funded marine and aquaculture projects ranging from coral reef protection to plankton and algae classifications. He found oysters flourishing wild, growing in mangrove outcrops in the estuaries and fresh water idlers that dot the Kenyan coast.

The lush tropical vegetation marking the shoreline where fresh and sea water meet has helped

create a natural reservoir of brackish water which is clogged with plankton and other nutrients, forming a perfect habitat for oysters, other molluscs and crustaceans, says Polk. "What you see here is the beginning of viable, lucrative industry for this country," Polk says with the sweep of his arms over 80,000 young oysters that he and Kenyan assistants, Robinson Ruwa and Michael Ngaa are cultivating.

From this collection of wooden frames in the mud beside the sleepy waterfront of Gazi, Polk hopes to see Kenya break the dominance of Japanese, French and Spanish producers in the world's annual 800,000 tonnes oyster market.

The wild Kenyan oyster is about half the size of the European variety because of the Mombasa coast's crowded oyster colonies and is unsuitable for export. Polk is seeking to change this. "We transplant them onto culture beds where each oyster has room to expand. They should grow as big as, if not bigger, than the European or Japanese variety," he said.

## Tourists

He aims to sell his initial harvests to the dozens of luxury tourist hotels along the coast where some 300,000 affluent West Germans, Italians, Britons and Scandinavians holiday each year. "The hotels have expressed keen interest. But we have a year to go before our first harvest," said 32-year-old Ruwa, who is preparing for

ecology under Polk.

The cash earned with the first harvests would then be used to teach villagers living on the creeks and estuaries to create oyster beds which could later be expanded into shrimp and lobster farming, according to Polk.

## Villages

Polk, who says he loves "the sea, French and French cuisine — in that order," is an ardent conservationist. He would like to see the young men in the villages, who make their living from collecting and selling sea shells to tourists, switch to oyster farming. "But you cannot urge the government to ban the sale of these rare shells unless you have a more lucrative alternative for the mostly unemployed school leavers," he said.

Asked if he was not being too ambitious Polk said: "In 1970 South Korea did not produce a single commercial oyster. Today it is the world's fourth biggest producer, harvesting over 70,000 tonnes a year both for exports and the home market."

Polk believes Kenya and other African states venturing into commercial oyster production would have a big advantage because European oyster beds are being contaminated by industrial waste and pollution. "Very soon, European consumers will ditch European and Japanese produce for Africa's," he told Reuters.

Senegal is the only African country which produces oysters commercially, harvesting about 300 tonnes annually, mostly culled from the wild.

— Reuters.



# Oysters: Kenya's underexploited food resource

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By OSEI KOFI

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Senegal is the only African country which produces oysters commercially, harvesting about 200 tonnes annually, mostly culled from the wild.

— Reuter.

SUNDAY MAIL  
18th May 1986



SUNDAY MAIL  
18th May 1986

# food woes

GAZI, (Kenya) : In a secluded creek beside the Indian Ocean, a marine biologist from Belgium toils in the brackish water and dreams of a new high-protein food for Africa's undernourished masses — oysters.

"The snob appeal attached to oysters should be destroyed," said Professor Philip Polk, Dean of Biology at the Free University of Brussels, as he worked with two Kenyan assistants in the green water of Gazi Creek, south of Mombasa.

"The protein content of oysters is far superior to that of any red meat or even fish, and here are oysters in inexhaustible quantities."

Professor Polk, stripped to the waist and burned brown by the fierce Equatorial sun, said he wanted the world's private and international development agencies such as the United Nations Children's Fund (Unicef) to consider oysters as a basic food.

"Third World families should be encouraged to feed their babies with oysters. Oysters as a food are versatile and easily transportable. They can be dried, packed, canned or mixed with other food," he said.

Professor Polk came to Kenya 18 months ago to supervise 20 Belgian-funded marine and aquaculture projects ranging from coral reef protection to plankton and algae classifications.

He found oysters flourishing wild, growing in mangrove outcrops in the estuaries and freshwater inlets that dot the Kenyan coast.

The lush tropical vegetation on the shoreline where fresh and sea water meet has helped create a natural reservoir of brackish water swarming with plankton and other nutrients, a perfect habitat for oysters, other molluscs and crustaceans, says Professor Polk.

"What you see here is the beginning of a viable, lucrative industry for this country," he says with a sweep of his arms over 90,000 young oysters that he and Kenyan assistants Renison Ruwa and Michael Ngao are cultivating.

From this collection of wooden frames in the mud beside the sleepy waterfront of Gazi, Professor Polk hopes to see Kenya break the dominance of Japanese, French and Spanish producers in the world's annual 800,000 tonne oyster market.

The wild Kenyan oyster is about half the size of the European variety because of the Mombasa coast's crowded oyster colonies and is unsuitable for export.

Professor Polk is seeking to exploit the

oyster both for export and domestic consumption.

"We transplant them onto culture beds where each oyster has room to expand. They should grow as big as, if not bigger, than the European or Japanese variety," he said.

He aims to sell his initial harvests to the dozens of luxury tourist hotels along the coast where some \$300,000 affluent West Germans, Italians, Britons and Scandinavians holiday each year.

"The hotels have expressed keen interest. But we have a year to go before our first harvest," said 32-year-old Ruwa, who is preparing for his doctorate in marine ecology under Professor Polk.

The cash earned with the first harvest would then be used to teach villagers living on the creeks and estuaries to create oyster beds which could later be expanded into shrimp and lobster farming.

Professor Polk, who says he loves the sea, beach and French cuisine, is also an ardent conservationist. He would like to see the young men in the villages who make their living from collecting and selling sea shells to tourists switch to oyster farming.

But you cannot urge the Government to ban the sale of these rare shells unless you have a more lucrative alternative for the mostly unemployed school leavers," he said.

Asked if he was not being too ambitious, Professor Polk said: "In 1978, South Korea did not produce a single commercial oyster. Today it is the world's fourth biggest producer, harvesting over 70,000 tonnes a year, both for export and the home market."

He believes Kenya and other African states venturing into commercial oyster production would have a big advantage because European oyster beds are being contaminated by industrial waste and pollution.

Senegal is the only African country which produces oysters commercially, harvesting about 200 tonnes annually, mostly culled from the wild.

At present, Kenyans themselves do not eat oysters. Professor Polk is all in favour of encouraging them to develop a taste.

He firmly believes a change of menu would be of enormous benefit to coastal dwellers, and is trying to persuade the government to sponsor a programme to help promote oyster cultivation for local consumption.



Annex 10

THE AUTECOLOGY OF THE EDIBLE OYSTER CRASSOSTREA CUCULLATA BORN, 1778:

SUMMARY SIZE RELATED VERTICAL DISTRIBUTION AT MKOMANI, MOMBASA.

The littoral *Crassostrea cucullata* occurs between 1.05 - 3.35 m, with the highest density occurring between 1.85 - 2.75 m above datum. Its

E. Okemwa<sup>(1)</sup> size related as R.K. Ruwa<sup>(1)</sup> by computation of correlation coefficients (r) and regression equations. The shell lengths (i.e. maximum linear dimension) decreases in an upshore direction. The analyses

show high r-values which are significant at  $p < 0.001$ . The equations

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## SUMMARY

The littoral Crassostrea cucullata occurs between 1.05 - 3.35 m, with the highest density occurring between 1.85 - 2.75 m above datum. Its distribution is size related as demonstrated by computation of correlation coefficients ( $r$ ) and regression equations. The shell lengths (i.e. maximum linear dimension) decreases in an upshore direction. The analyses show high  $r$ -values which are significant at  $p < 0.001$ . The equations and the  $r$ -values are as follows: (i) for the lower level oysters between 1 - 1.85 m:  $y = 43.64 - 6.49 x$ ,  $r = -0.659$  (ii) for the mid-level oysters between 1.86 - 2.75 m:  $y = 62.67 - 17.14 x$ ,  $r = -0.941$  and (iii) for the high level oysters between 2.76 - 3.35 m:  $y = 91.44 - 24.85 x$ ,  $r = -0.899$  where  $y$  stands for the mean shell length (mm) and  $x$  is the mean height (m) above datum. The elevation and density related effects on the shell lengths of the oysters are discussed.

have demonstrated that they may be size-related both interspecifically and intraspecifically (Vermeij 1972, 1973; Kuwa and Brakel 1981).

Similar quantitative studies on Crassostrea cucullata are non-existent to the best of our knowledge. Since this is an economically important species which can be cultured (van Soneren and Whitehead 1963) the following study was also geared to define the levels which support large sizes of oysters and where they are found in highest densities on the cliffs.

The tides on which the oysters depend for their filter feeding (Porton 1977) exhibit a large range in this portion of the Western Indian Ocean and are semi-diurnal. According to Brakel (1982), the average tidal ranges at



## INTRODUCTION

Crassostrea cucullata is a littoral oyster found on the trunks, stilt roots and pneumatophores of mangrove plants and rocky substrata in brackish-marine environments. Zoogeographically it is an Indo-West Pacific species (Day 1974). The ecological studies of this species done in the Western Indian Ocean in Seychelles (Taylor 1968); Aldabra (Taylor 1970); Tanzania (Hartnoll 1976); Somalia (Chelazzi and Vannini 1980) and Kenya (Ruwa 1984) indicate that it is abundantly found in the upper eulittoral zone following the shore terminology of Lewis (1964) and Hartnoll (1976). In some cases its upper limit is known to be slightly (0.3 - 0.5 m) above the mean high water spring tide level, probably changing with wave action (Hartnoll 1976, Chelazzi and Vannini 1980).

Various studies on vertical distribution of molluscs on the sea shores have demonstrated that they may be size-related both interspecifically and intraspecifically (Vermeij 1972, 1973; Ruwa and Brakel 1981).

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The tides on which the oysters depend for their filter feeding (Morton 1977) exhibit a large range in this portion of the Western Indian Ocean and are semi-diurnal. According to Brakel (1982) the average tidal ranges at



at spring tide days and neap tide days are 3.2 m and 1.0 m respectively.

The extreme high water spring (EHWS) is 4.0 m; mean high water spring (MHWS), 3.5 m; mean high water neap (MHVN), 2.4 m; mean low water neap (MLWN) 1.4 m; mean low water spring (MLWS), 0.3 m; and the extreme low water spring (ELWS), - 0.1 m.

#### MATERIALS AND METHODS

The study was carried out at Mkomani rocky cliffs, Mombasa (figure 1) on a randomly chosen population of Crassostrea cucullata covering an area measuring about 4 x 2.5 m on a vertically rising cliff in March/April 1985. The shell lengths (i.e. maximum linear dimension) of all live oysters in this population were measured using vernier callipers to the nearest 0.1 mm in consecutive 10 cm vertical bands going perpendicularly upwards to the base of the cliff to as far as the oysters were encountered. From several measurements of the time at which the water level reached the base of the cliff during the calm water around neap tide days, the height of the base above datum was determined according to the Kenya Ports Authority (1985) tide tables. This enabled the heights of the oyster bands to be expressed above datum.

#### RESULTS

A total of 1470 oysters were measured. From these measurements a frequency table for each oyster band was made at the following size intervals: 1.0 - 10.9 mm; 11.0 - 20.9 mm; 21.0 - 30.9; 31.0 - 40.9 mm; 41.0 - 50.9 mm and 51.0 - 60.9 mm, to study the changes of the modal class from one level of the oyster band to the other. From these data percentages



were worked out and used for constructing the histograms (figure 2).

The histograms showed that the modal class shifts left-wards, towards the y-axis when traced from the lowest to the highest oyster levels. The modal class shifted from size range 31.0 - 40.9 mm at the levels between 1.0 - 1.10 m and 1.80 - 1.90 m to size range 21.0 - 30.9 mm at the levels between 1.90 - 2.00 m and 2.20 - 2.30 m. It then subsequently shifted to 11.0 - 20.9 mm at the levels between 2.30 - 2.40 m and 3.00 - 3.10 m and finally to size range 1.1 - 10.9 mm at the levels between 3.10 - 3.20 m and 3.30 - 3.40 m.

The mean heights (elevation) of the oyster bands and the mean shell sizes of the oysters were computed. The mean shell sizes were then plotted against elevation (figure 3). The plot showed that three linear regressions could conveniently be fitted to describe the relationship. The regression equations were calculated and fitted. The correlation coefficients ( $r$ ) were all significant ( $p < 0.001$ ) and negative.

A further comparison was made to find out if there were density related effects on the mean shell lengths of the oysters with height on the cliffs. To facilitate the comparisons plots of the number of oysters per band at each mean height or elevation were plotted along with their values of mean shell lengths in figure 3. The densities at the peaks and troughs indicated with the alphabetical letters A to J were used for comparisons.



The area between 1.85 and 2.75 m above datum had the highest density of oysters. The comparisons showed that even for almost similar numbers of oysters e.g. Band E, C and J, D and F; the samples B, C and D at lower levels had bigger mean shell lengths than their counterparts. Similarly, even for situations where e.g. D and G, F and I, H and J where D, F and H are lower level samples with larger numbers of individuals than their counterparts they still showed bigger mean shell lengths. These results indicate that the changes in mean shell size between the lower and higher level oysters are independent of their densities.

#### DISCUSSION

The high negative correlation coefficients ( $r$ ) significantly ( $p < 0.001$ ) demonstrate that Crassostrea cucullata exhibits size related patterns in its vertical distribution with an upshore reduction in shell length. The results clearly show that the upshore reduction in shell length is caused by the abundance of small sized oysters in the upper levels whereas conversely, the lower levels support a larger number of relatively bigger sized oysters. A similar type of size gradient was described in the filter feeding mussel Mytilus edulis L. populations by Newcombe (1935) and Seed (1968). They showed that the growth rate in this mussel at lower levels was greater than at higher levels. Thus the lower level mussels grow



to larger sizes than the higher level ones. From our study we do not have data on growth rates and of ages of the oysters for comparison. However from the knowledge that oysters are filter feeders which depend on the high tides for their feeding action to take place (Morton 1977) and that the duration of continuous submersion and frequency of the latter decrease in an upshore direction, the causes and consequences are the same as those of the equally filter feeding mussels. The longer duration and higher frequency of submersion allows the lower level oysters to acquire more food because they can feed for longer periods and consequently grow faster than their higher level counterparts.

There are demonstrations that in some littoral bivalves density may affect their growth rates and size (Trevallion et al 1970). In our study it can be notably seen that at non-successive levels the mean shell size is still larger for oysters in comparatively lower levels even for situations where the lower level samples have larger numbers of individuals than the higher level samples. The difference in size between the lower and higher level oysters may therefore principally be due to the differences in the duration and frequency of feeding periods rather than their differences in densities.



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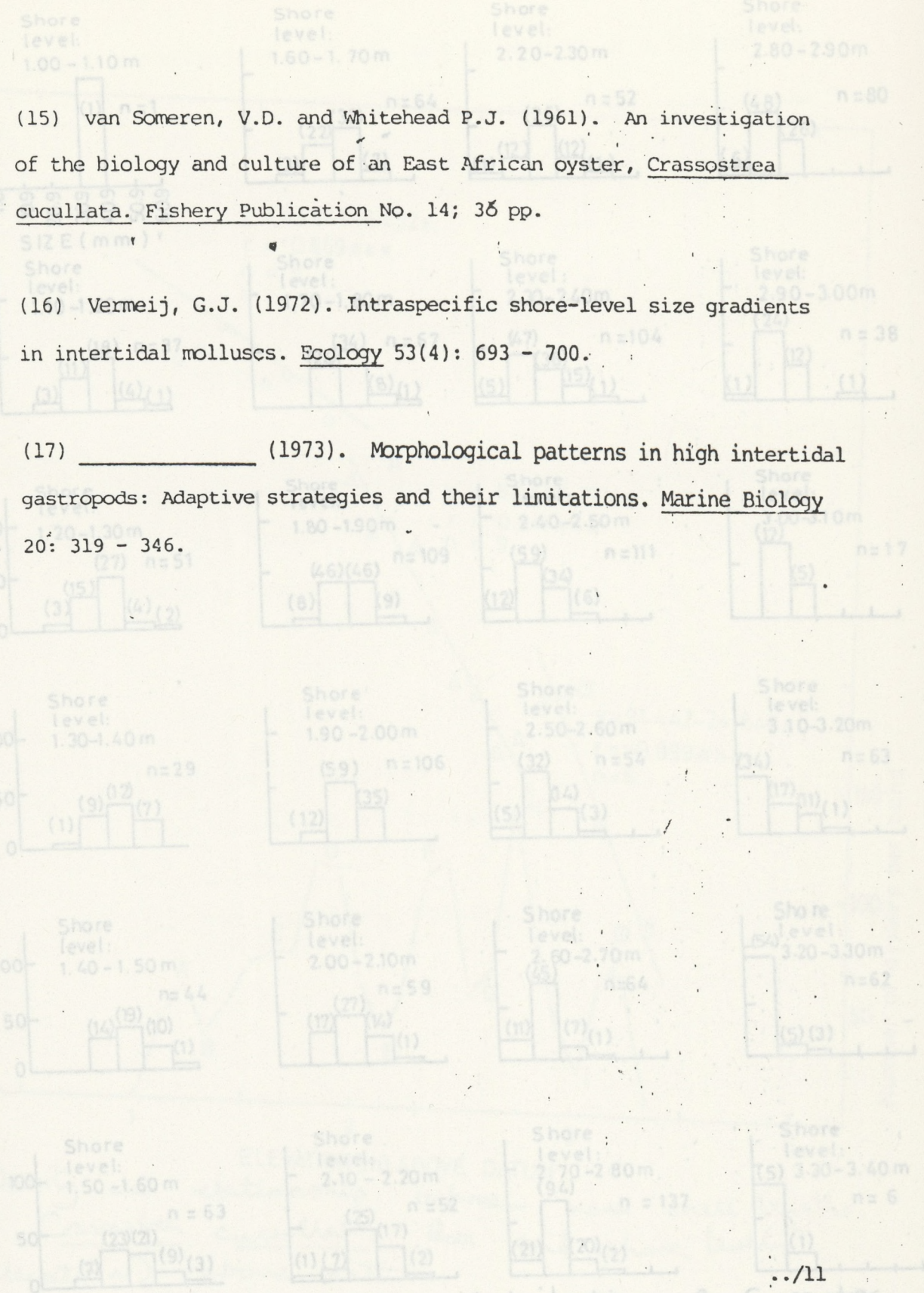


Fig.2. Histograms to show distribution of Crassostrea cucullata Born by size classes in various levels of the cliffs. The number of oysters in each size class are shown in parentheses and n stands for total number of oysters.



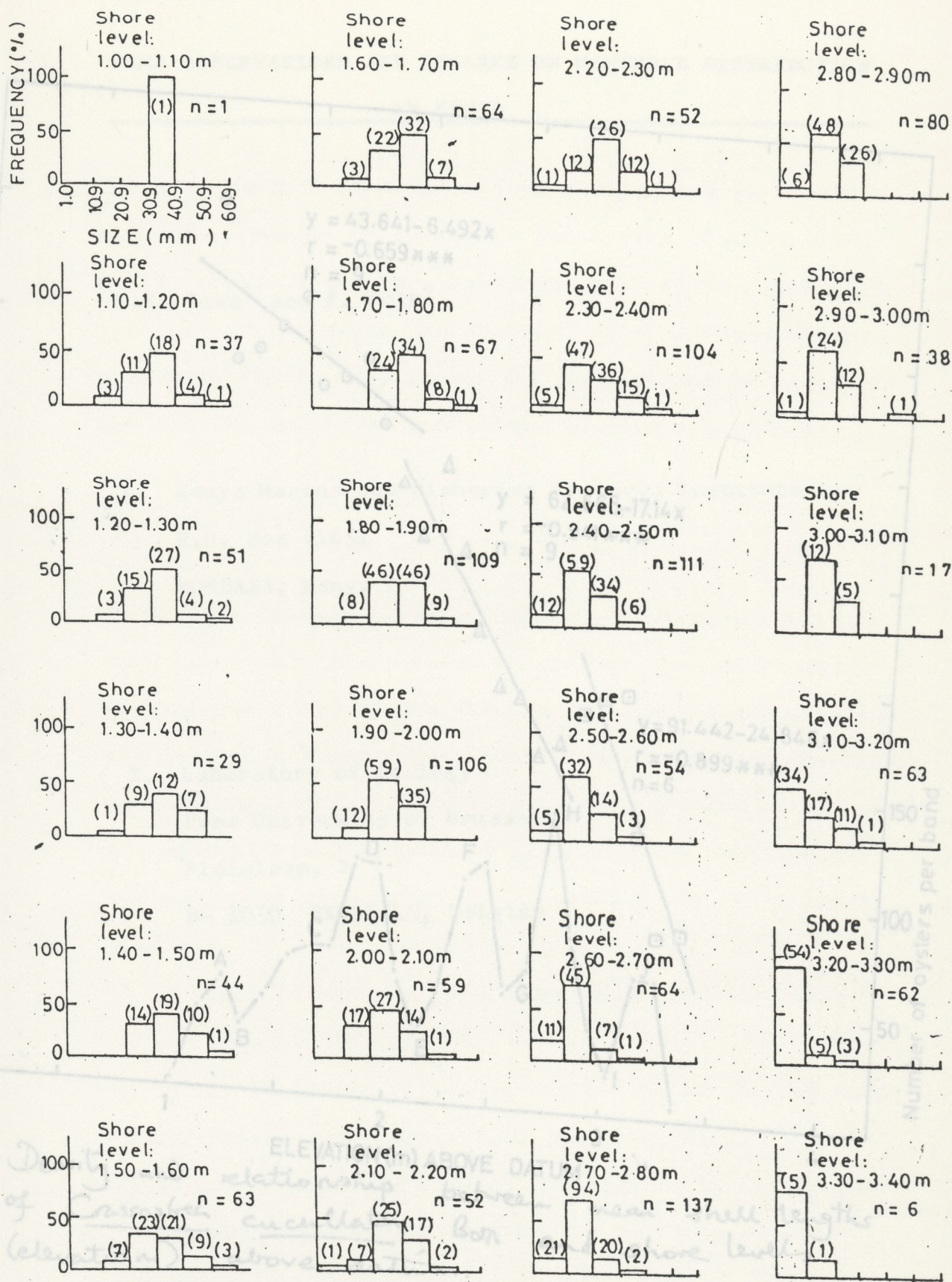


Fig.2. Histograms to show distribution of *Crassostrea cucullata* Barn by size classes in various levels of the cliffs. The number of oysters in each size class are shown in parentheses and n stands for total number of oysters.



## SOME OBSERVATIONS AND REMARKS ON MANGROVE DISTRIBUTION

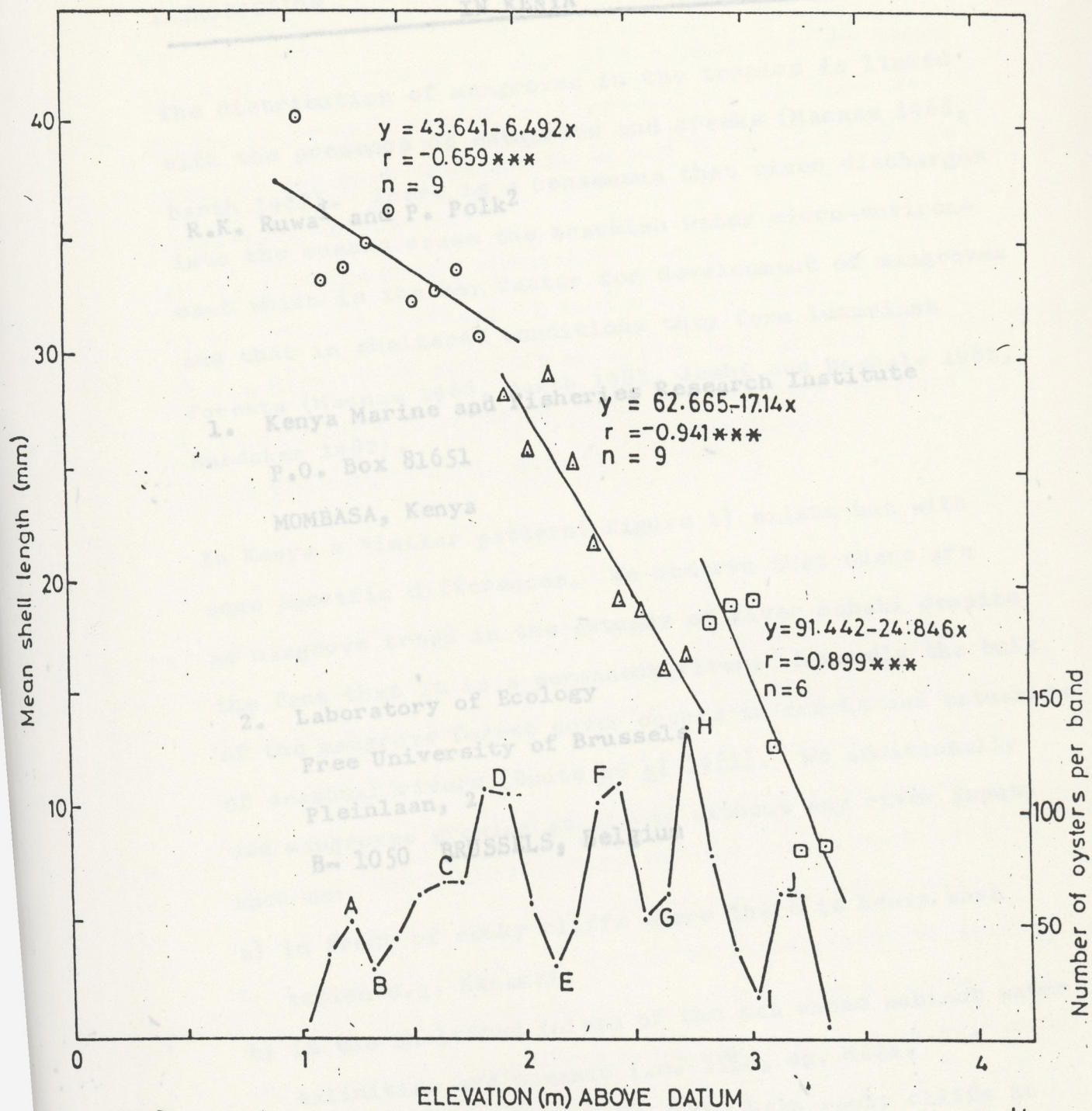


Fig.3 Density and relationship between mean shell lengths of Crassostrea cucullata Bora and shore levels (elevation) above datum.



SOME OBSERVATIONS AND REMARKS ON MANGROVE DISTRIBUTION  
INTRODUCTION  
IN KENYA

The distribution of mangroves in the tropics is linked with the presence of estuaries and creeks (Macnae 1968, Barth 1982). There is a consensus that river discharges into the oceans cause the brackish water micro-environment which is the key factor for development of mangroves and that in sheltered conditions they form luxuriant

forests (Macnae 1968, Barth 1982, Joshi and Baskin 1982, Snedaker 1982).

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In Kenya a similar pattern (figure 1) exists but with some specific differences. We observe that there are no mangrove trees in the estuary of River Sabaki despite the fact that it is a permanent river. Secondly the bulk

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see mangroves growing at places without any river inputs such as:

- a) in front of rocky cliffs where there is heavy wave action e.g. Kanamai;
- b) in the sheltered inlets of the sea whose ambient water salinities are oceanic i.e. 35‰, eg. Mida;
- c) in a sheltered site behind the high rocky cliffs at Bamburi where some mangroves are thriving successfully.



## INTRODUCTION

The distribution of mangroves in the tropics is linked with the presence of estuaries and creeks (Macnae 1968, Barth 1982). There is a consensus that river discharges into the oceans cause the brackish water micro-environment which is the key factor for development of mangroves and that in sheltered conditions they form luxuriant forests (Macnae 1968, Barth 1982, Joshi and Boshale 1982, Snedaker 1982).

In Kenya a similar pattern (figure 1) exists but with some specific differences. We observe that there are no mangrove trees in the estuary of River Sabaki despite the fact that it is a permanent river. Secondly the bulk of the mangrove forest cover occurs in creeks and estuaries of seasonal rivers (Boute et al 1981). We additionally see mangroves growing at places without any river inputs such as:

- a) in front of rocky cliffs where there is heavy wave action e.g. Kanamai;
- b) in the sheltered inlets of the sea whose ambient water salinities are oceanic i.e. 35‰, eg. Mida.
- c) in a sheltered site behind the high rocky cliffs at Bamburi where some mangroves are thriving successfully.



These niches occupied by some of the mangroves in Kenya appear to be exceptional at first sight. As these exceptions are most interesting we set forth to study the micro-environments of:

- a) the lone mangrove of Kanamai;
- b) the estuarine system of Gazi mangrove swamp;
- c) the Mida creek mangrove ecosystem with an aim of explaining the observed local distribution patterns of the mangroves in Kenya.

#### METHOD AND RESULTS

The site where the lone mangrove Sonneratia alba J. Sm. at Kanamai is thriving remains wet throughout the low tide period. Carefull observations on the micro-environment under the mangrove reveals small trickles of water coming out from the underground. The salinities at these discharge points including those of neighbouring pools in the vicinity of the mangrove tree were measured using a refractometer. They were measured during ebb tide and at high tide on a sunny day. The salinities at high tide were constantly 35‰ i.e. fully oceanic salinity. The results of the measurements during ebb tide are as shown in figure 2. Other salinity measurements were carried out at the Maftaha Gazi Bay,



b) on beaches e.g. Kanamai, Tiwi etc.  
Gazi mangrove biotope (figure 3). Almost all the water  
c) in creeks e.g. Gazi, Mida etc.  
in the bay is replaced in each daily tidal cycle. There  
are two seasonal rivers discharging into this bay namely,  
Although Isaac and Isaac (1968) and Knutzen and Jasuund  
Mkurumuji and Kidogoweni. During the dry season (January  
(1979) mentioned about the seepage in Kenya they neither  
to April) they are almost non-existent but they discharge  
measured the salinities of the seepages nor did they study  
heavily during the rainy season in May and June. The sali-  
their consequences to the marine life.  
nities were taken on a sunny day during the daytime low  
tide at areas 1, 2, 3, 4, 5 and 6 (see Table 1 and figure  
3). At site 2 (figure 3) three seepage points were de-  
tectected during low tide. These had the following sali-  
nities: 16, 18 and 20‰. At high tide the salinities  
in the bay were 33 - 35‰. Further salinity measurements  
were carried out at the Mida mangrove biotope. The sali-  
nities were measured during low tide, in the daytime on  
a sunny day. The salinities at various seepage points  
were 29, 30, 31 and 32‰. Almost all the water in this  
creek is also replaced in each daily tidal cycle.

#### DISCUSSIONS AND CONCLUSIONS

Seepage of underground water into the sea is very common  
in the lower eulittoral zone:

- a) at the bases of high rising rocky cliffs e.g. Kanamai,  
Mtwapa, Bamburi, Mombasa Island, Tiwi, Msambweni etc.



b) on beaches e.g. Kanamai, Tiwi etc.

c) in creeks e.g. Gazi, Mida etc.

Although Isaac and Isaac (1968) and Knutzen and Jasuund (1979) mentioned about the seepage in Kenya they neither measured the salinities of the seepages nor did they study their consequences to the marine life.

From our data on salinities it is clear that seepages of underground water to the seashore change the micro-environmental conditions from oceanic to brackish water, creating suitable micro-habitats for colonization by mangrove seedlings and therefore offer suitable habitats for mangrove development. Ituli's (1984) flow model for underground water flow in the Athi and Tana River basin indicates that the Mida area is one of the places exhibiting highest flow rates into the sea. The latter may explain the existence of a big mangrove forest at Mida without any river discharging into it. This seepage phenomenon was overlooked by Isaac and Isaac (1968) when describing the distribution of mangroves in Kenya.

The role of seepage in the mangrove colonization and development was reported by Macnae and Kalk (1962a, b) after observing that on the riverless Inhaca Island (Mozambique) mangrove forests were growing in areas without river discharge and were 30 km away from the



nearest river input on the mainland. At the sites of these mangroves there was flow of underground water into the intertidal zone. This underground water was fresh water because wells dug near the mangrove forest areas were yielding portable freshwater. This seepage was therefore evidently responsible for creating a brackish environment which allowed colonization by mangroves.

Similarly at the Kenya coast boreholes near mangrove forests give portable fresh water. In a semiarid zone like the Kenya coastal zone the presence of underground portable water near mangrove forests seems to explain why major villages and boreholes are concentrated around these biotopes. Indeed, in view of the information available we can even say that the mangroves are indicating where underground water is released into the sea and that seepage is playing an important role in the distribution of mangroves in this semi-arid Kenya coast.

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TABLE 1 : Salinity of isolated pools at Gazi mangrove biotope on a sunny day during low tide on 15/7/85. n = number of measurements at different points.

SITE	SALINITY ‰					
1. River discharge area	27 n=2	28 n=3	29 n=2	-	-	-
2. Pool	27 n=1	28 n=4	29 n=2	-	-	-
3. Pool	27 n=3	28 n=4	29 n=2	-	-	-
4. Pool	28 n=1	29 n=3	30 n=3	31 n=2	32 n=1	33 n=1
5. Pool	30 n=1	31 n=2	32 n=12	33 n=1	-	-
6. Pool	30 n=2	31 n=6	32 n=1	33 n=1	-	-

Figure 1 River systems and mangrove distribution along Kenyan coastline.



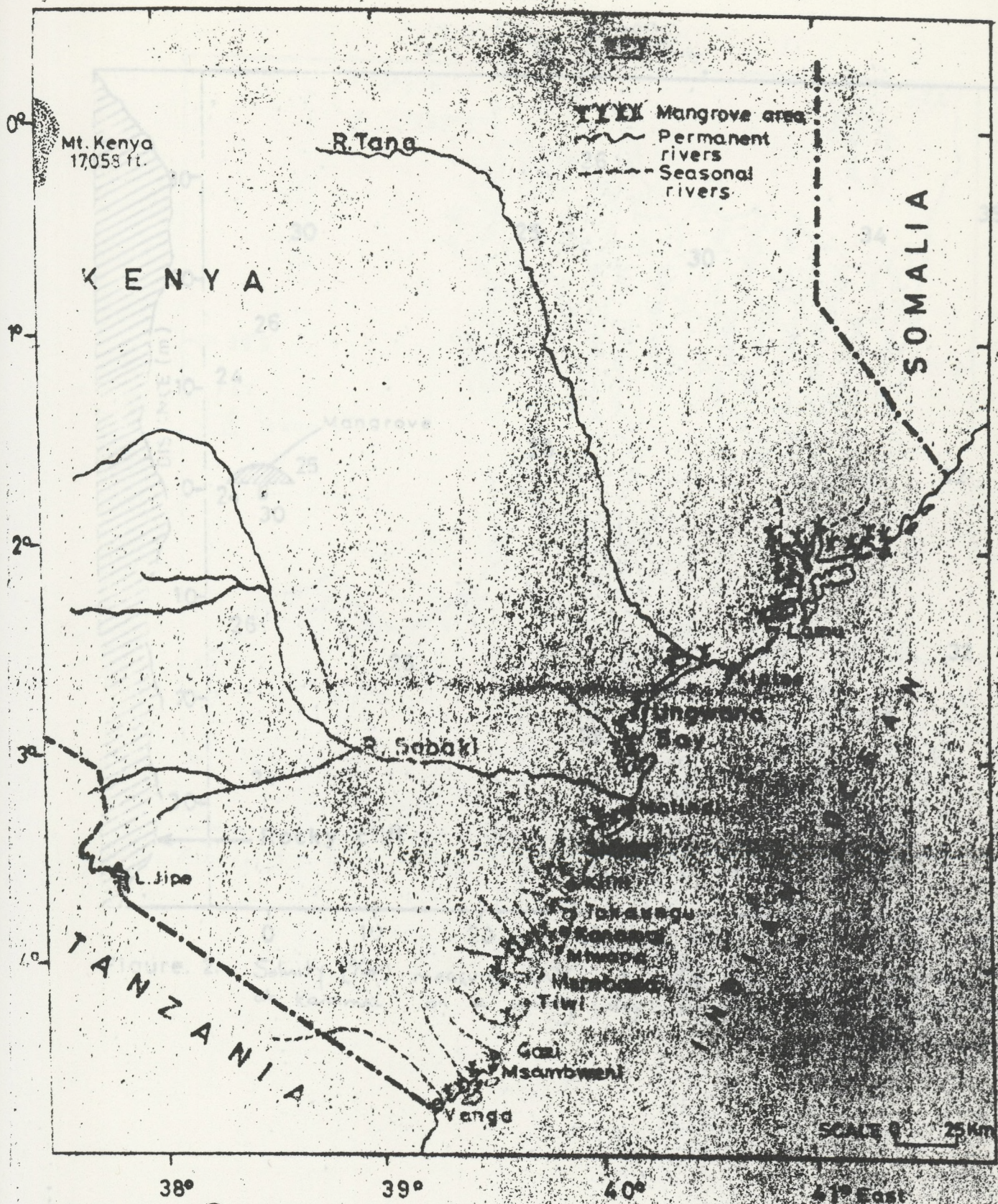


Figure. I River system and mangrove distribution along the Kenyan coastline.



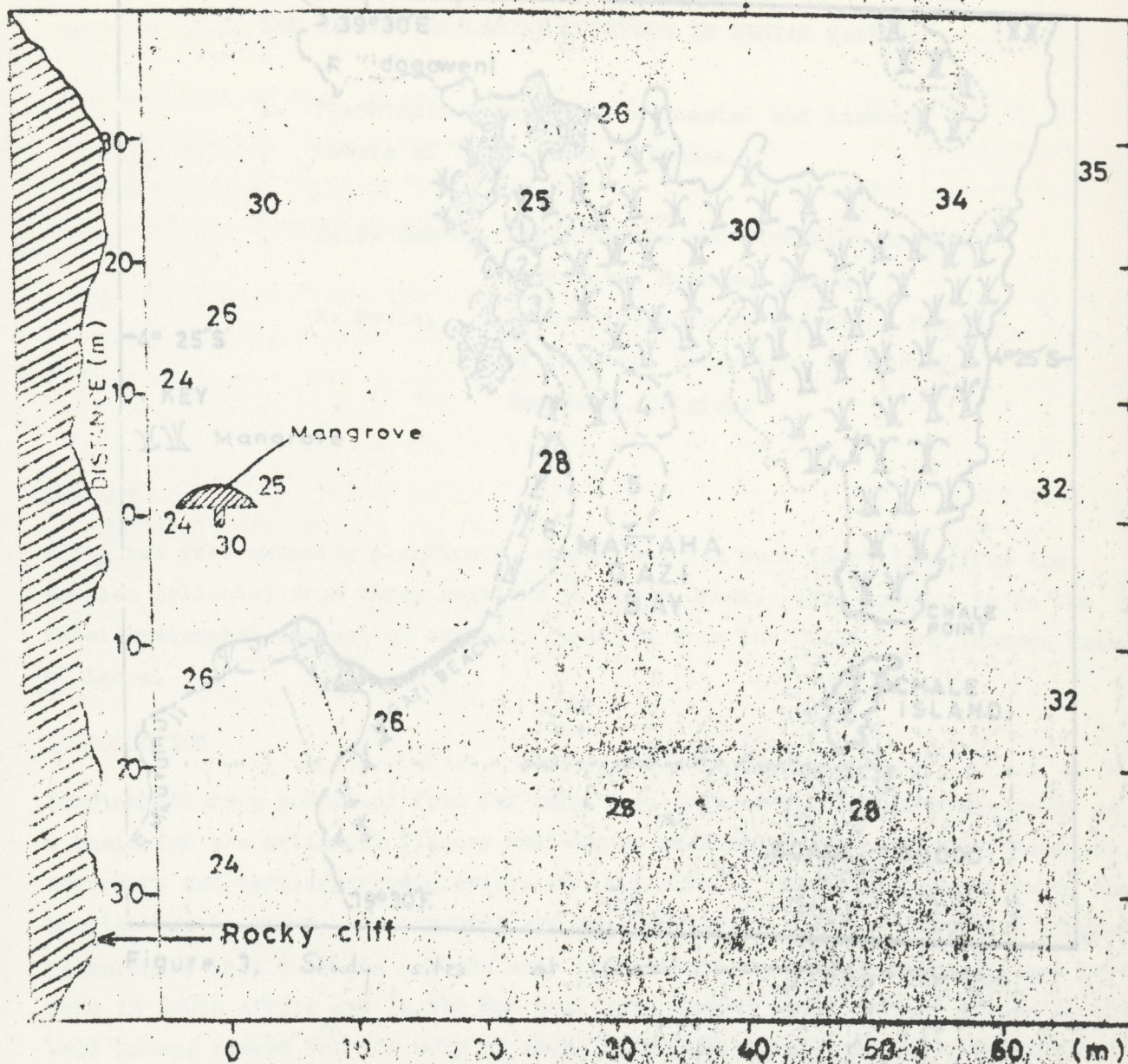


Figure. 2. Salinity (‰) measurements around the lone mangrove at Kanamai on a sunny day during ebb tide (6-8-1985)



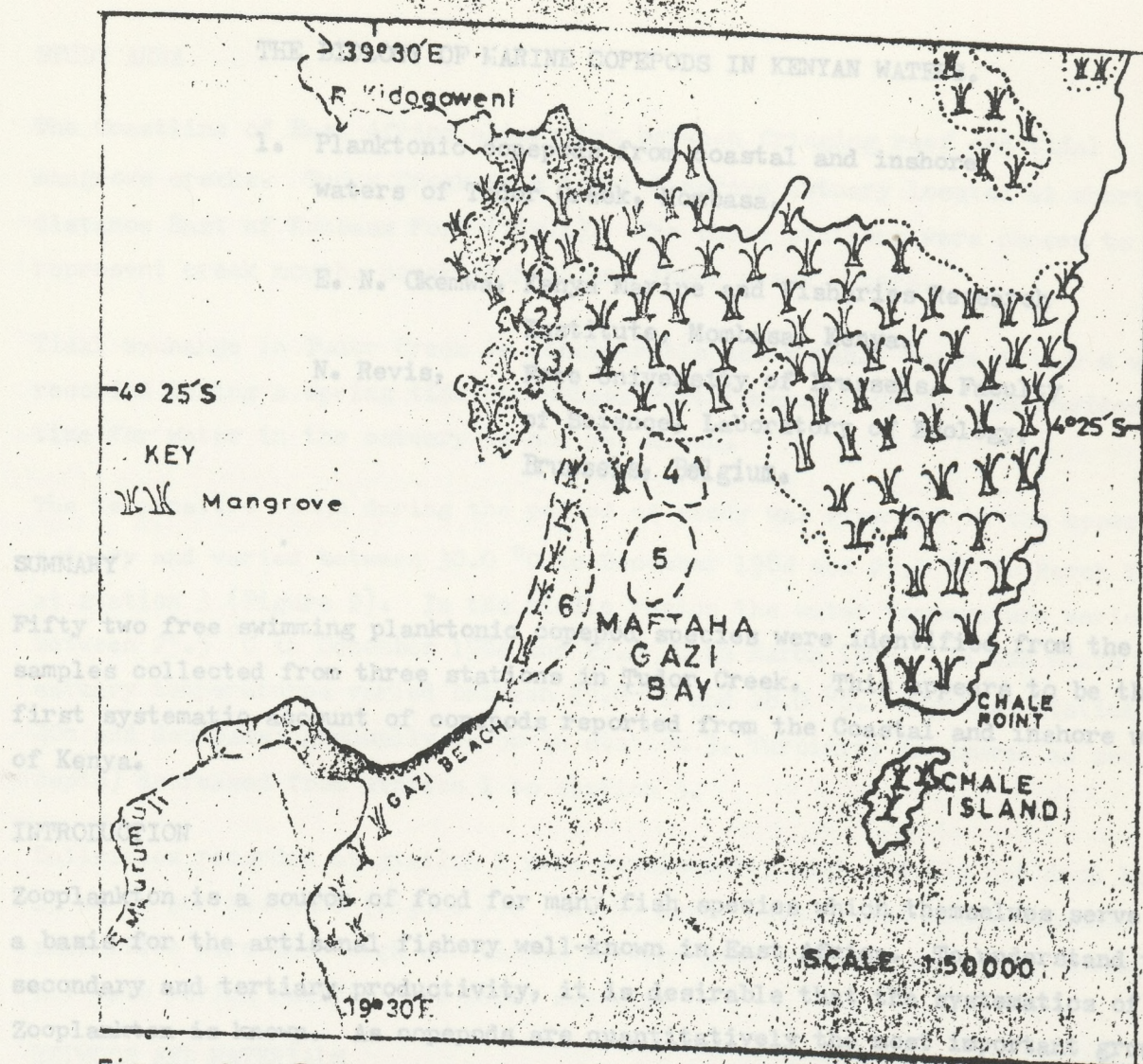


Figure 3. Study sites at Gazi mangrove swamps. This study was done in South Africa and in the Red sea. The Red sea is well known, except for the work of Lane (1981) and Lane and Lane (1981), who worked in the Western Indian Ocean in the Red sea creek waters. Wicksell (1969 & 1968) studied the zooplankton of the Okera (1974) examined the zooplankton of the Red sea. Roy and Kimaro (1984) wrote the first paper on zooplankton from the Red sea. This study demonstrated the possibility of seasonal, lunar and tidal influences on the abundance and composition of zooplankton at the mouth of Tadar Creek. Apart from that no attempt has been made to study the Marine copepod fauna in Kenya. The taxonomy of the free-swimming copepods of Kenya will also contribute to the knowledge of the zoogeography of this group.



# THE BIOLOGY OF MARINE COPEPODS IN KENYAN WATERS.

## STUDY AREA

1. Planktonic copepods from coastal and inshore waters of Tudor Creek, Mombasa.

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## SUMMARY

Fifty two free swimming planktonic copepod species were identified from the samples collected from three stations in Tudor Creek. This appears to be the first systematic account of copepods reported from the Coastal and inshore waters of Kenya.

## INTRODUCTION

Zooplankton is a source of food for many fish species which themselves serve as a basis for the artisanal fishery well-known in East Africa. To understand the secondary and tertiary productivity, it is desirable that the systematics of the Zooplankton is known. As copepods are quantitatively the most important group, research on this taxon is particularly significant. Although much work has been done in South Africa and in the Red sea, the copepod fauna of East Africa is not well known, except for the work of Sewell (1929, 1932, 1947, & 1948), and Smith and Lane (1981), who worked in the Western Indian Ocean, but did not include creek waters. Wickstead (1965 & 1968) published work on tropical plankton, and Okera (1974) examined the zooplankton of the inshore waters of Tanzania.

Reay and Kimaro (1984) wrote the first paper on zooplankton from Tudor Creek. This study demonstrated the possibility of seasonal, lunar and tidal influences on the abundance and composition of zooplankton at the mouth of Tudor Creek. Apart from that no attempt has been made to study the Marine copepod fauna in Kenya. The taxonomy of the free-swimming copepods of Kenya will also contribute to the knowledge of the zoogeography of this group.



## STUDY AREA

The Coastline of East Africa alternates between fringing reef and tidal mangrove creeks. Tudor Creek is a tidal Mangrove estuary located at short distance East of Mombasa Port (Fig.1). The three stations were chosen to represent creek mouth, creek channel and inner creek waters.

Tidal exchange in Tudor Creek is considerable and a tidal range of 4.0 m was recorded during a spring tide at Mombasa Port (Brakel, 1982). The residence time for water in the estuary is not yet known.

The temperature range during the period of study was greatest in the upper estuary and varied between 30.0 °C in December 1984 and 29.5 °C in March 1985 at station 3 (Figure 2). In the middle region the water temperature varied between 29.5 °C in December 1984 and 29.0 °C in March 1985. In the mouth of the estuary temperatures varied between 29.0 °C and 28.0 °C. Depth at station 1 was 40m and decreased gradually to 5m in station 3. Turbidity (measured as secchi depth) decreased from station 1 to station 3.

Salinities recorded at station 1 were consistently high and did not drop below 35 parts per thousand (Figure 2). In the upper estuary and middle channel salinities were also high and varied between 34.5 and 30.0 parts per thousand. All this period rainfall was below average.

## METHODS AND MATERIALS

The samples were obtained using a Bongo net fitted with a flow meter towed at 4.0m S<sup>-1</sup> for 15 minutes from a research vessel with a 210 hp diesel powered engine. The Bongo towing frame was fitted with two cylindrical - conical nets (Mesh diameter 335 m and 500 m), each 0.6m in diameter, connected by a central yoke to which the towing wire is attached. All the tows were horizontal to the surface and samples were taken at a mean depth of 1.4m.

The sample was immediately stored in a 5% formaline solution. Samples from 335 m net were analysed. Samples were taken only during day time, twice a month, between neap and spring tides. The work reported here began in December 1984 and goes till March 1985; the project is still in progress.



#### LABORATORY METHODS

Preparation for analysis involved passing the sample through a 42  $\mu$  mesh sieve and placing the residue in the petri dishes. The sub-samples were then sorted out under a binocular microscope and copepods were put separately in the petri dishes.

To identify the copepods to species level, it is necessary to dissect the animal and draw the antennae, antennules, mouth parts, thoracopods and furca. The keys and reference books by Giesbrecht (1892), Sars (1901), Sewell (1929, 1932, 1947 & 1948), Rose (1933), Bradford (1972), Owre and Foyo (1967), Frost and Fleminger (1968), and Fleminger (1973) were used.

#### RESULTS AND DISCUSSION

A total of 96 net tows was taken during the study period, of this number 8 hauls were made each month at each station. The Zooplankton is rich and abundant in the Creek. Copepods were dominant and present in all stations sampled (Table 1). From all stations, 52 species were identified. Forty one species were found at station 1, and 30 of those were specific for this station. In station 2, 20 species were found of which 7 were specific. In station 3 there were only 6 species found, of which 2 were specific for this station and this supports the gradient hypothesis. Apparently, there exists a gradient in diversity and each station has a more or less characteristic Copepod - fauna. Species diversity is directly related to the number of species unique to the station. A number of species was represented by only one individual so it is possible that such species were present, but undetected at another station.

Information on the abiotic environment from the series of stations in Tudor Creek is given in figure 2. These demonstrated increasing temperature and turbidity, and decreasing water depth from the mouth to the uppermost stations of the creek, with salinity remaining more or less constant.

Throughout the study period (December, 1984 - March, 1985) temperature fluctuation of almost 3  $^{\circ}$ C can be associated with a gradient of decreasing depth and the relative movement of 'Creek' and 'Coastal' waters in relation to the tides.



Table 1. Classified list of copepod species and their occurrence in three stations of Tudor Creek, Mombasa.

The implication is that the abiotic characteristics at any of the three stations in the system is faced with a complex state of flux in relation to tidal movement. Therefore, depending on the extent to which copepods are affected by the variations in abiotic factors observed, then this state of flux is also likely to apply to their diversity and abundance. An ecological gradient observed in Tudor Creek can be related to the observed gradients of increasing temperature decreasing depth and turbidity from the mouth inwards. It is interesting to observe that the diversity was high in station 1 and low in station 3.

Rhincalanus cornutus (Dana 1849)

In inshore waters of Dar-es-salaam in Tanzania, South East Africa, Okera (1974) observed Rhincalanus cornutus, Acartia danae, Centropages gracilis and Temora discaudata. Apparently there is higher diversity in Mombasa water than in Tanzania waters. This may be attributed to the productivity of the area. Ryther et al (1966) mapped the Western Indian Ocean and showed Mombasa to have a productivity of more than 1.00 g C/m<sup>2</sup>/day in contrast to Dar-es-salaam at 0.26-0.50 g C/m<sup>2</sup>/day. Since we don't have enough data on abiotic parameters, it is difficult to conclude precisely. Plankton distribution can vary greatly over very small distances: it has a very "patchy" distribution. Their distribution varies considerably with depth and time.

Scolecithrix danae (Lubbock 1856)

Smith and Lane (1981) reported the occurrence and distribution of Paracalanus aculeatus, Acartia danae, clausocalanus farrani, Centropages furcatus, Scolecithrix danae, Canthocalanus, Pleuromamma piseki, Pleuromamma indica, Rhincalanus cornutus and Macrosetella gracilis in offshore waters of Somalia in the Indian Ocean. The Copepod fauna at station 1 can be regarded as Oceanic as defined by Smith & Lane (1981), and Sewell (1947) & (1948).

Pleuromamma piseki Farran 1929

The species found by Smith and Lane (1981) and Okera (1974) were found in our samples.

Centropages furcatus Dana 1849

Centropages gracilis Dana 1849

Centropages orainii Giesbrecht 1892

Fam. Lucicutiidae Sars 1902

Lucicutia flavicornis (Claus 1863)

Fam. Candaciidae Giesbrecht 1892

Candacia bispinosa Claus 1863

Candacia catula Giesbrecht 1892



Table 1. Classified list of copepod species and their occurrence in three stations of Tudor Creek, Mombasa.

	Station 1	Station 2	Station 3
<u>Candacia pachydactyla</u> Dana 1848	x		
<u>Candacia simplex</u> Giesbrecht 1892	x		
<u>Calanoidae</u> Sars 1902	1	2	3
CALANOIDA			
Fam. Calanidae Dana 1853	x	x	
<u>Canthocalanus pauper</u> (Giesbrecht 1888)	x	x	x
<u>Undinula vulgorie</u> (Dana 1849)	x	x	
Fam. Eucalanidae Giesbrecht 1892			
<u>Eucalanus</u> spp.	x	x	
<u>Rhincalanus cornutus</u> (Dana 1849)	x	x	
Fam. Paracalanidae Giesbrecht 1892			
<u>Acrocalanus Longicornis</u> Giesbrecht 1888	x	x	
<u>Paracalanus aculeatus</u> Giesbrecht 1892	x	x	
Fam. Pseudocalinidae Sars 1902			
<u>Clausocalanus farrani</u> Sowell 1929		x	
Fam. Euchaetidae Sars 1902			
<u>Euchaeta marina</u> (Prestandra 1933)	x		
<u>Euchaeta pubera</u> Sars 1907	x		
<u>Euchaeta tenuis</u> Esterly 1906	x		
Fam. Scolecithricidae Sars 1902			
<u>Scolecithrix danae</u> (Lubbock 1856)	x	x	
Fam. Temoridae Sars 1902			
<u>Temora discaudata</u> Giesbrecht 1888	x		
<u>Temora stylifera</u> Dana 1849	x		
<u>Temora turbinata</u> Dana 1849	x		
Fam. Metriidae Sars 1902			
<u>Pleuromamma indica</u> Wolfenden 1905	x	x	
<u>Pleuromamma piseki</u> Farran 1929	x		
Fam. Centropagidae Giesbrecht 1892			
<u>Centropages brachiatus</u> Dana 1849	x		
<u>Centropages furcatus</u> Dana 1849	x	x	
<u>Centropages gracilis</u> Dana 1849	x		
<u>Centropages orsinii</u> Giesbrecht 1892	x		
Fam. Lucicutiidae Sars 1902			
<u>Lucicutia flavicornis</u> (Claus 1863)	x		
Fam. Candaciidae Giesbrecht 1892			
<u>Candacia bispinosa</u> Claus 1863		x	
<u>Candacia catula</u> Giesbrecht 1892		x	



	Station 1	Station 2	Station 3
<u>Candacia longimana</u> Claus 1863	x		
<u>Candacia magna</u> Sewell 1912	x		
<u>Candacia pachydactyla</u> Dana 1848	x		
<u>Candacia simplex</u> Giesbrecht 1892	x		
Fam. Pontellidae Sars 1902			
<u>Calanopia elliptica</u> Dana 1849	x	x	
<u>Labidocera acuta</u> Giesbrecht 1892			
<u>Labidocera kroyeri</u> Brady 1883			x
<u>Labidocera detruncatum</u> Dana 1914		x	x
<u>Labidocera minuta</u> Giesbrecht 1892		x	x
<u>Pontellina plumata</u> Dana 1849	x		
<u>Pontellopsis herdmanni</u> Thompson & Scott 1903		x	
Fam. Acartia Sars 1903			
<u>Acartia danae</u> Giesbrecht 1889	x		
<u>Acartia bispinosa</u> Carl 1907	x	x	x
Fam. Tortanidae Sars 1902			
<u>Tortanus barbatus</u> (Brady 1883)			x
MONSTRILLOIDA			
POECILOSTOMATOIDA			
Fam. Monstrillidae Sars 1911			
Fam. Corycaeidae Claus 1863			
<u>Corycaeus</u> spp.	x	x	
Fam. Oncaeidae Giesbrecht 1892			
<u>Oncaea mediterranea</u> Claus 1863	x		
<u>Oncaea venusta</u> Philippi 1843	x		
Fam. Sapphirinidae Thorell 1859			
<u>Copilia mirabilis</u> Dana 1849	x	x	
<u>Copilia quadrata</u> Dana 1849	x	x	
<u>Sapphirina auritens</u> Claus 1863- <u>sinuicauda</u> Brady 1883	x		
<u>Sapphirina nigromaculata</u> Claus 1863	x		
<u>Sapphirina ovatolanceolata</u> Dana 1849-gemma Dana 1849	x		
Fam. Clausidiidae Embleton 1901			
<u>Saphirella tropica</u> Wolfenden 1905	x		



# CYCLOPOIDA

Fam. Oithonidae Sars 1913

Oithona plumifera Baird 1843

x

Oithona setigera Dana 1849

x

# HARPACTICOIDA

Fam. Ectinosomatidae Moore 1878

Microsetella rosea Dana 1849

x

Fam. Miracidae Dana 1846

Macrosetella gracilis Dana 1849

x

Fam. Tachidiidae Sars 1909

Euterpina acutifrons (Dana 1849)

x

Fam. Harpacticidae Dana 1846

Harpacticella spp.

x

# MONSTRILLOIDA

Fam. Monstrillidae Sars 1911

x

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## Changes in Kenyan coral reef community structure and function

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# Changes in Kenyan coral reef community structure and function

**Abstract.** A study due to exploitation urchin *Echinometra mathaei*, on a coral reef lagoon adjacent to a heavily populated Timothy R. McClanahan & Nyawira A. Muthigaase in the urchins' biomass over 15 years. A comparison with a lesser Friends World College, East African Centre, P.O. Box 526, Machakos, Kenya ish, less coral cover and a lower biomass of two species of sea urchin from the genus *Diadema*. A niche Kenya Marine and Fisheries Research Institute, P.O. Box 81651, study of these three species of sea urchin indicates that they Mombasa, Kenya.

may be ecologically separated by their predator avoidance strategies. As an explanation of the changes occurring on the **Keywords:** Coral Reefs, *Diadema*, *Echinometra mathaei*, exploited fringing reef lagoon, we suggest the hypothesis that Overfishing, Overshelling, Predation, Sea Urchins.

in the absence of predators, *Echinometra mathaei* populations increase and outcompete other sea urchin grazers because of their ability to feed closer to the reef substrate (due to their burrowing ability). Unrestricted by predators, their feeding behavior allows them to eat living coral and breakdown reef substratum. This eventually leads to a loss of live coral cover, topographic complexity, species diversity, biomass and ultimately the productivity of the reefs.



Abstract. A study of the burrowing sea urchin Echinometra mathaei, on a coral reef lagoon adjacent to a heavily populated tourist beach, showed a five fold increase in the urchins' biomass over 15 years. A comparison with a lesser exploited reef lagoon, showed that the more exploited reef had 10 times fewer fish, less coral cover and a lower biomass of two species of sea urchin from the genus Diadema. A niche study of these three species of sea urchin indicates that they may be ecologically separated by their predator avoidance strategies. As an explanation of the changes occurring on the exploited fringing reef lagoon, we suggest the hypothesis that in the absence of predators, Echinometra mathaei populations increase and outcompete other sea urchin grazers because of their ability to feed closer to the reef substrate (due to their burrowing ability). Unrestricted by predators, their feeding behavior allows them to eat living coral and breakdown reef substratum. This eventually leads to a loss of live coral cover, topographic complexity, species diversity, biomass and ultimately the productivity of the reefs.



(*Diadema setosum* (Leske), *Diadema savignyi* (Michelin), *E. mathaei*) was undertaken to determine if predation affected

There is a concern in tropical areas of the world that overfishing and shelling may be causing a subsequent increase in sea urchin populations (Hay, 1984). This in turn may cause an increase in biodegradation of coral reef substrate and a loss of habitat and coastal protection (Glynn et al., 1979). From these premises we studied the community structure of Kenyan fringing reefs in order to determine changes that occur due to exploitation.

Studies of the burrowing sea urchin *Echinometra mathaei* (de Blauville) were repeated after fifteen years on a fringing reef at Diani, Kenya. Diani is the most heavily populated tourist beach in East Africa. A large influx of tourists have used this beach for over twenty years and fishing and shelling rates have undoubtedly been high in order to supply the tourist industry. As a comparison, a similar study was undertaken on a less exploited reef of similar structure at Kanamai, Kenya. Measurements at both sites, on the outer reef edge and inner reef lagoon, included sea urchin sizes, densities (numbers per meter squared), biomass, percent live coral cover and fish population measurements. Studies of sediment in the gut and sediment defecation rates of *E. mathaei* were also undertaken. Additionally, a study of the major sea urchin species inhabiting hard substrate at Kanamai



(Diadema setosum (Leske), Diadema savignyi (Michelin), E. mathaei) was undertaken to determine if predation affected their niche separation.

A comparison of the E. mathaei population at Diani showed large increases in the density, size and biomass on the inner reef lagoon but not on the outer reef edge where mean sizes and biomass were actually lower than fifteen years previously (Table 1, 2). Comparing these observations with the E. mathaei population at Kanamai we found densities and sizes were also lower in the Kanamai inner reef lagoon additionally a large part of the urchin biomass was contributed by the two other Diadema species. On the outer reef edge, E. mathaei densities and biomass were lower than at Diani but there were also significant differences between transects on the outer reef at both sites unlike the inner reef lagoons. Therefore, the differences on the outer reef (between 1970 and 1985) may be due to sampling differences rather than actual changes. The fish catch per unit effort was similar on the two outer reef sites (Kanamai and Diani) which suggests that overfishing has not occurred on the outer reefs. In the inner reef lagoon the fish density is an order of magnitude higher at Kanamai than at Diani. The general conclusion of this study is that the outer reef has not been subjected to overfishing and shelling as much as the inner reef lagoon, and E. mathaei population levels reflect this exploitation.



The sea urchin niche study lends further insight into the mechanisms of these observed changes. The three main species of sea urchin, which inhabit the hard substrate, are all omnivores eating a variety of algae, coral, invertebrates and other organisms associated with hard substrate (Herring, 1972; Lawrence, 1975). Therefore, we suggest that these species are ecologically separated by their predator avoidance strategies (Table 3). D. setosum has long poisonous spines and lives in groups. Both are strategies which allow it to live in the open and avoid predation. On the other extreme E. mathaei is solitary, has short spines and lives in burrows, which in the inner lagoon may be created in order to escape predation. D. savignyi has an intermediate strategy. It lives in smaller groups, has intermediate length poisonous spines and lives in naturally occurring crevices. This niche separation normally occurs in coral reefs where predation is an active influence on the reef community.

Our suggested hypothesis, to explain the changes that have occurred in Diani, is that once predators are removed from the inner reef lagoon, by overfishing and shelling, the sea urchins can directly compete with each other for food. Most importantly E. mathaei can live outside of burrows and directly compete with the other two species of Diadema. We expect that the winner of this competition is the species which can feed closest to the substrate. E. mathaei has a



strategy of feeding close to the substrate and ingesting large quantities of sediment. This allows it to create and live in burrows. We observe in the Diani inner reef lagoon that E. mathaei no longer inhabits burrows and feeds freely in the open. As well, the densities of Diadema were below the sampling intensity suggesting that they may have been outcompeted.

The major environmental problem arising from this change in community structure is that once E. mathaei is no longer restricted by predators it feeds freely on living coral and breaks down the reef substratum. Reducing the amount of living coral reduces calcium carbonate deposition, and reducing reef substratum reduces topographic complexity, which in turn reduces the total number of available niches, and therefore species diversity, biomass and reef productivity (Levin & Choat, 1980; Talbot, 1965). From gut analysis and defecation rate studies we find that the rate of sediment defecation and sediment in the gut content is proportional to the weight of the urchin (gut sediment in grams =  $0.16 + 0.015 \text{ wet weight of urchin in grams}$ ,  $r=0.73$ ,  $n=28$ ; sediment defecation in grams =  $0.27 + 0.12 \text{ wet weight of urchin}$ ,  $r=0.50$ ,  $n=32$ ). Therefore, we suggest that the rate of substrate degradation is proportional to the biomass of E. mathaei. Measurements indicate that on Diani's inner reef the substrate degradation rate may be as high as  $3.6 \text{ kg/m}^2/\text{yr}$ . Since coral cover is low, it is



impossible for this substrate and structure loss to be replaced. Even if management strategies were implemented, it would take many years before the ecosystem could return to one of high topographic complexity, species diversity and productivity. Presently, the Diani reef lagoon has been reduced to a simple ecosystem in which the major form of primary productivity is algae, growing on the hard substrate, and secondary productivity is in the form of E. mathaei, presently a species of no commercial value to man. The present standing crop of 5340 kg/ha (wet weight, shell included) is an order of magnitude higher than the most productive rangelands in East Africa (Pratt & Gwynne, 1977). Through proper management a larger percentage of this biomass could be in a form utilizable by man.

Good news from the human environmental perspective is that E. mathaei populations have not increased on the outer fringing reef edge. The reason may be that the outer reef edge has not been overfished and shelled to the same extent as the inner reef lagoon, or that the rough physical conditions in this area limit E. mathaei as well as man's ability to fish and shell. Ecological release of E. mathaei in this area could be highly detrimental since the outer reef is the physical barrier which protects the shore from erosion caused by waves, tides and currents. It is critical for future coastal management to determine the factors controlling E. mathaei in



this area. As well, it will be necessary to determine whether gastropod or fish predators are more important in controlling

E. mathaei populations. As E. mathaei is a common sea urchin species throughout the Indo-Pacific, we suggest that the scenario presented in this paper may be common in many Indo-Pacific areas where overfishing and shelling occur.

Hay, M.E. 1984. Patterns of fish and urchin grazing in caribbean reefs: are previous results typical? Ecology 65: 446-454.

#### Acknowledgements

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Marine Laboratory. 1975. On the relationship between marine plants and sea urchins. Oceanogr. Mar. Biol. Ann. Rev. 13: 213-286.

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Table 2. Community structure data and *Echinometra mathaei*

Table 1. Data on *Echinometra mathaei* population structure and community structure on the inner fringing reef lagoons at Diani, Kenya 1971 and 1985, and Kanamai 1985.

	Kanamai 1985	Diani 1970 <sup>1</sup>	Diani 1985
<i>Echinometra mathaei</i>			
Density, #/m <sup>2</sup>	42.5 ± 7.1	43.7	31.2 ± 6.72 <sup>2</sup>
Diameter, mm	37.1 ± 8.0	32.7	40.8 ± 7.4 <sup>2</sup>
Biomass, g/m <sup>2</sup>	33	110	534
Burrowed, %	74.7 ± 32.8	-	7.3 ± 7.2***
<i>Diadema</i> sp., g/m <sup>2</sup>	54.4 ± 0.55	-	undetected
Coral cover, %	5.5 ± 13.6	-	<1 <sup>3</sup>
Fish density, #/100m <sup>2</sup>	69.8 ± 27.0	-	7.5 ± 4.7***

1 Data from Khamala (1971)

2 Diani 1970 is significantly smaller ( $p < 0.01$ ) than in 1985 and smaller than Kanamai, but Diani 1985 is not significantly different from Kanamai 1985.

3 Live coral cover was so low at Diani in 1985 that it was difficult to measure accurately but was usually one percent or less in the quadrats.



Table 2. Community structure data and Echinometra mathaei population data from the outer fringing reef at Diani 1970, 1985, and Kanamai 1985.

	<u>D. astopus</u>	<u>D. savignyi</u>	<u>E. mathaei</u>
	Kanamai 1985	Diani 1970	Diani 1985
Spine length, cm			
<u>Echinometra mathaei</u>			
Crevices or			
Density, #/m	0.5 ± 1.36	2.6 ± 11.4	1.7 ± 1.0**
Diameter, mm	42.5 ± 7.1	43.7	31.2 ± 6.72
Burrows, %	12.7	51	80
Biomass, g/m	20.1	116	31.1
Group size	3.0 ± 2.1	1.4 ± 0.8	1.0 ± 0.0**
Burrowed, %	100	-	100
In groups, %	78	22	0
Coral cover	3.6 ± 8.4	-	<1
Fish	Those individuals in areas with no crevices or crevices		
Catch/effort, kg/hr	1.46 ± 0.55	-	1.73 ± 0.7 NS

1 Data from Khamalat (1971) averages.

2 Diani 1985 is significantly smaller ( $p < 0.01$ ) than both Kanamai 1985 and Diani 1970.

3 Coral cover was so low at Diani that it was difficult to accurately measure but was usually one percent or lower.



Table 3. Niche separation study data for the three major species of sea urchin inhabiting hard substrate at Kanamai.

	<u>D. setosum</u>	<u>D. savignyi</u>	<u>E. mathaei</u>
Spine length, cm	15.6 $\pm$ 2.9	11.3 $\pm$ 2.2	2.0 $\pm$ 0.2**
Crevice or burrow width, cm <sup>1</sup>	28.4 $\pm$ 4.6	19.8 $\pm$ 11.4	8.8 $\pm$ 9.6**
In crevices or burrows, %	12.7	51	80
Group size	3.0 $\pm$ 2.1	1.4 $\pm$ 0.8	1.0 $\pm$ 0.0**
In groups, %	78	22	0

1 Those individuals in areas with no crevices or crevices greater than 30 cm wide were considered in the open but 30 cm was used in calculating the averages.



## ANNEX 14

### POPULATION CHANGES OF A SEA URCHIN (Echinometra mathaei) ON AN EXPLOITED FRINGING REEF.

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#### Summary

A comparison of Echinometra mathaei densities and sizes was undertaken on an inner reef lagoon and an outer reef edge on a densely populated tourist beach at Diani, Kenya. E. mathaei densities and average lengths were significantly higher (t-test,  $p < 0.001$ ) in the inner reef lagoon (density =  $14.2 \pm 1.7 \text{ \#}/\text{m}^2$ ,  $n = 90$ ; lengths =  $40.8 \pm 0.6 \text{ mm}$ ,  $n = 144$ ) than on the outer reef edge (density =  $1.7 \pm 0.13 \text{ \#}/\text{m}^2$ ,  $n = 60$ ; lengths =  $31.2 \pm 0.8 \text{ mm}$ ,  $n = 68$ ). A comparison with density and length data collected 15 years previously (Khamala, 1971) showed increases in the numbers and average lengths (t-test;  $p < 0.05$ ) in the inner reef and a decrease in the average lengths (t-test;  $p < 0.05$ ) on the outer reef edge. Using a correlation of the length and average weight of individual urchins (weight =  $0.0021 \text{ length}^{2.64}$ ,  $r = 0.96$ ,  $n = 144$ ) and the average length and density measurements ( $\text{\#}/\text{m}^2$ ), an increase of  $424 \text{ g}/\text{m}^2$  on the inner reef and a decrease of  $61 \text{ g}/\text{m}^2$  on the



outer reef edge was found over the past 15 years. Quantities of sediment found in the gut contents of the sea urchins (69.5% by weight) were positively correlated with the weight of the sea urchins ( $F = 67.5$ ,  $p < 0.001$ ,  $r = 0.73$ ) which suggests that reef substrate degradation rates are proportional to the urchin biomass. Therefore, we suggest that there has been an increase in reef substrate degradation rates on the inner reef lagoon but not on the outer reef edge.

The distribution of E. mathaei on the inner reef was positively correlated ( $F = 82.2$ ,  $p < 0.001$ ,  $r = 0.69$ ) with the percent hard substrate (dead coral and coral rubble) but not on the outer reef, where the availability of shelter appears to be of greater importance. We suggest that the population increase in the inner reef is due to ecological release of E. mathaei from competitors and predators due to increased fishing and shelling activities. On the outer reef the stressful physical environment may limit both the sea urchin populations and man's ability to fish and shell.

Methods

Introduction

Sea urchins have a variable role in the coral reef community. As grazers of benthic algae they reduce algal cover and break down reef substratum which creates topographic complexity and can enhance coral recruitment (Birkeland & Randall, 1981; number of E. mathaei were counted and the percent cover of Sammarco, Levinton & Ogden, 1974; Dart, 1972). However, some



coral, hard substrate (dead coral and coral rubble), and species of sea urchin feed on living coral and therefore reduce coral survival and calcium carbonate deposition (Glynn, Wellington & Birkeland, 1979; Bak & van Eys, 1975; Lawrence, 1975). Hay (1984) has shown that in Caribbean coral reefs the prevalence of sea urchins is proportional to the degree of fishing. From this premise we studied the population changes of Echinometra mathaei (De Blainville) over the last fifteen years in Diani Beach, Kenya which is the most heavily populated tourist beach in East Africa. E. mathaei was previously studied at Diani by Khamala (1971) and in Zanzibar by Herring (1972). From these studies it has been determined that E. mathaei is an omnivorous burrowing sea urchin which feeds mostly on fleshy benthic algae but also on other invertebrates, including corals, inhabiting the coral reef benthos.

#### Methods

The size distribution, population density and factors affecting the distribution of E. mathaei were studied along three transects (300 meters each) within the inner reef lagoon and four transects (150 meters each) on the outer reef edge at the same study site as Khamala (1971). One meter quadrats were established at 10 meter intervals within the inner reef lagoon, and at 5 meter intervals on the outer reef edge. The number of E. mathaei were counted and the percent cover of



coral, hard substrate (dead coral and coral rubble), and seagrass was estimated. Random collections of *E. mathaei* were made within the two locations, the shortest and longest test axes and wet weights of these urchins were measured. A length weight relationship was established for individual urchins. This combined with the urchin density (#/m<sup>2</sup>) and the average length of the urchins, at each time and site, was used to estimate and compare biomass changes. All measurements of variance are standard errors of the mean.  $F = 82.2, p < 0.001$ .

The quantity of sediment in the gut of *E. mathaei* was determined by dissecting the gut contents, drying, weighing, treating with a 10% hypochlorite solution (to dissolve off the organic matter) and then drying and weighing again.

The average size of the sea urchin tests (short + long Results were significantly smaller (t-test,  $p < 0.001$ ) on the

outer reef ( $31.2 \pm 0.81$  mm<sup>2</sup>,  $n = 68$ ) than on the inner reef. The average density (#/m<sup>2</sup>) of *E. mathaei* within the three inner reef transects was  $14.1 \pm 1.7$  individuals/m<sup>2</sup> ( $n = 90$ ) and did not differ significantly between transects ( $12.1 \pm 1.3$ ,  $18.1 \pm 2.1$ ,  $12.3 \pm 1.5$ ; ANOVA,  $F = 1.4$ ). Densities of *E. mathaei* on the outer reef ( $1.7 \pm 0.13$  individuals/m<sup>2</sup>,  $n = 60$ ) were significantly lower (t-test;  $p < 0.001$ ) than on the inner reef. However, there was also a significant difference in the densities between transects within the outer reef ( $2.9 \pm 0.35$ ,  $1.3 \pm 0.23$ ,  $1.5 \pm 0.22$ ,  $0.8 \pm 0.23$ ; ANOVA,  $F = 3.56$ ,  $p < 0.05$ ). The densities within the inner reef lagoon urchin density, determined that there has been an increase in



were nearly three times higher than those found in the 1970 study (5.3 individuals/m<sup>2</sup>) but were comparable on the outer reef edge (2.6 individuals/m<sup>2</sup>).

A comparison of the distribution of E. mathaei along the inner reef transects shows that the difference in densities is due to a large increase of E. mathaei in the inner reef lagoon (middle and seaward positions, Fig. 1). This difference is attributed to the distribution of hard substrate (Fig. 2) (t-test). It was determined that the greater fraction of the urchin's gut content is sediment (inner reef =  $72.9 \pm$  ; n = 90) with the densities of E. mathaei on the inner reef but not on the outer reef (Fig. 3).

The density of live coral cover was low on both the inner and outer reefs (< 1%).

The average size of the sea urchin tests (short + long axis/2) were significantly smaller (t-test,  $p < 0.001$ ) on the outer reef ( $31.2 \pm 0.81$  mm, n = 62) than on the inner reef ( $40.9 \pm 0.62$  mm, n = 144). This is the reverse of the 1971 study in which the outer reef urchins were significantly larger (43.7mm) than the inner reef urchins (32.7mm). A comparison between the 1971 study and the present study shows that the inner reef urchins are larger and the outer reef urchins smaller than in 1971 (t-test,  $p < 0.05$ , Fig. 4).

Changes in biomass determined from a regression of the average length versus weight of the individual urchins (weight =  $2.64 \times \text{length}^3$ ,  $r = 0.96$ , n=144, Fig. 5) and the average urchin density, determined that there has been an increase in



and shelling may be the major cause of the observed changes. biomass in the inner reef of 424 g/m<sup>2</sup> from 110 g/m<sup>2</sup> in 1970 to 534 g/m<sup>2</sup> (5340 kg/ha) in 1985. On the outer reef there has been a loss of 31 g/m<sup>2</sup> from 116 g/m<sup>2</sup> to 31.1 g/m<sup>2</sup> during the 15 year period.

Analysis of the gut content of the sea urchins showed no significant differences between the percent fractions of sediment and organic matter between the inner and outer reefs (t-test). It was determined that the greater fraction of the urchin's gut content is sediment (inner reef =  $72.9 \pm$  ; n = ; outer reef =  $66.0 \pm$  ; n = ). The total gut content and the sediment fraction were positively correlated (gut content,  $F = 89.5$ ,  $r = 0.78$ ,  $p < 0.001$ ; sediment,  $F = 67.5$ ,  $r = 0.73$ ,  $p < 0.001$ ) with the wet weight of the urchins (Fig. 6).

#### Discussion

The distribution and density of *E. mathaei* on the inner reef The results indicate that the major change in the *E. mathaei* population has occurred within the inner reef, and more specifically within the inner reef lagoon. All parameters of size, density and biomass show large increases in the last fifteen years. Since this section of the reef has comparably low physical and environmental stresses; such as tidal exposure, waves and currents, we would suspect that biotic factors such as competition and predation to be major determinants of the community structure. Because of the low physical stress and the areas proximity to the shore, fishing



and shelling may be the major causes of the observed changes. From the gut content studies, we find that sediment is a large fraction of E. mathaei's diet. Since the urchins are competitors, combined with the low physical stress factor has led to the observed population increase.

This conclusion is largely conjectural as direct measurements of predator and competitor population changes breakdown of the reef substratum. The quantity of sediment in have not been made. Yet, because of the close proximity of the gut content is also proportional to the urchin's weight tourists, which create a demand for finfish and shellfish, which would suggest that feeding and substrate degradation this hypothesis remains a likely explanation. An alternative rates are proportional to the urchin's biomass. Therefore, explanation is that the differences are due to the time and there has probably been an increase in reef substrate success of the sea urchin's last larval recruitment. This is degradation on the inner reef but not on the outer reef in the suspected to be a major force in the outbreaks of Acanthaster planci in the eastern Indo-Pacific (Birkeland, 1982). The structure for the protection of the shoreline, from waves and differences in E. mathaei sizes on the outer reef between 1970 other physical factors, it is good news from the human and 1985 may be a result of this factor.

The distribution and density of E. mathaei on the inner reef not increased in this area. As coral cover on the inner reef appears to be greatly dependent on the availability of hard substrate, unlike the outer reef population. A large part of the sea urchin's conversion of hard substrate into soft E. mathaei's diet consists of fleshy algae (Khamala, 1971) substrate may eventually limit their population by reducing which grows on hard substrate. E. mathaei on the inner reef the quantity of hard substrate. is therefore competing for fleshy algae which grows on the It is unknown whether or not these urchins are the cause of hard substrate. However, the sea urchins on the outer reef are the low coral cover, but E. mathaei is an omnivore eating restricted to sheltered areas (crevices and burrows). The numerous organisms including coral which inhabit hard rough physical conditions on the outer reef and the distance substrate (Herring, 1972). Its density within the inner reef from the shore may make it less inhabitable by E. mathaei and is also a function of the percent hard substrate or in other less susceptible to overfishing and shelling.



From the gut content studies, we find that sediment is a large fraction of E. mathaei's diet. Since the urchins are distributed on hard substrate we would suspect that a large proportion of this sediment is scraped from dead coral and coral rubble, and the urchins are greatly contributing to the breakdown of the reef substratum. The quantity of sediment in the gut content is also proportional to the urchin's weight which would suggest that feeding and substrate degradation rates are proportional to the urchin's biomass. Therefore, there has probably been an increase in reef substrate degradation on the inner reef but not on the outer reef in the last fifteen years. Since the outer reef is the critical structure for the protection of the shoreline, from waves and other physical factors, it is good news from the human environmental perspective that degradation rates have probably not increased in this area. As coral cover on the inner reef is low, calcium carbonate deposition is probably also low, and the sea urchin's conversion of hard substrate into soft substrate may eventually limit their population by reducing the quantity of hard substrate.

It is unknown whether or not these urchins are the cause of the low coral cover, but E. mathaei is an omnivore eating numerous organisms including coral which inhabit hard substrate (Herring, 1972). Its density within the inner reef is also a function of the percent hard substrate or in other



words dead coral. From personal observations on similar reefs, we suggest that this is a low value for coral cover and that some effect of exploitation and the ecological release of this sea urchin may be responsible.

The major environmental concern arising from this study is not the problem of reef substrate degradation but rather the change in the inner reef's community structure. The inner reef lagoon, which is usually a diverse community, has (from our observations on other invertebrate and fish species in this reef and other reefs within this area) been transformed into a simple ecosystem where primary productivity is being utilized almost exclusively by one sea urchin herbivore which is presently not utilized by men in East Africa. The *E. mathaei* standing crop of 5340 kg/ha is an order of magnitude greater than the values found on the most productive rangelands in East Africa (Pratt and Gwynne, 1977). Although, direct comparisons may not be possible, it is unfortunate that in Africa, where the availability of protein in most peoples diet is limited, such a large quantity of secondary productivity is in an unutilized form. Proper management of this ecosystem could render a larger fraction of this productivity for human consumption.

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Hay, H.E. (1984) Patterns of fish and urchin grazing on Caribbean coral reefs: are previous results typical? Ecology, 65, 446-454. refs in 1970 ( ) and in 1985 ( ).

The bars represent the 95% confidence intervals for the 1985 Herring, P.J. (1972) Observations on the distribution and data. Each point was calculated by averaging quadrats within feeding habits of some littoral echinoids from Zanzibar. J. nat. Hist., 6, 169-175.

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Figure 3. The density of E. mathaei as a function of the Lawrence, J.M. (1975) On the relationship between marine estimated hard substrate on the inner (solid line) and plants and sea urchins. Oceanogr. Mar. Biol. Ann. Rev. 13, 213-286. Open symbols represent a single data point, solid symbols represent multiple data points.

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E. mathaei on the inner and outer reef in 1970 (open blocks) Sammarco, P.W. Levinton, J.S. & Ogden, J.C. (1974) Grazing and 1985 (striped blocks).

and control of coral reef community structure by Diadema antillarum Phillipi (Echinodermata: Echinoidea): a preliminary study. J. Mar. Res. 32(1), 47-53. Figure 5. Correlation between the average length and wet weight of E. mathaei individuals.

Figure 6. Dry weight of the total gut content (solid line) and the sediment content (broken line) of E. mathaei as a function of its wet weight.



Figure 1

Figure 1. The density of Echinometra mathaei along transects calculated for landward, middle and seaward positions along the inner and outer reefs in 1970 ( ) and in 1985 ( ). The bars represent the 95% confidence intervals for the 1985 data. Each point was calculated by averaging quadrats within each location from the different transects.

Figure 2. The distribution of hard substrate and seagrass along the inner reef transects.

Figure 3. The density of E. mathaei as a function of the estimated hard substrate on the inner ( ;solid line) and outer reef ( ;broken line). Open symbols represent a single data point, solid symbols represent multiple data points.

Figure 4. Frequency histograms of the mean test diameters for E. mathaei on the inner and outer reef in 1970 (open blocks) and 1985 (striped blocks).

Figure 5. Correlation between the average length and wet weight of E. mathaei individuals.

Figure 6. Dry weight of the total gut content ( ;solid line) and the sediment content ( ;broken line) of E. mathaei as a function of its wet weight.



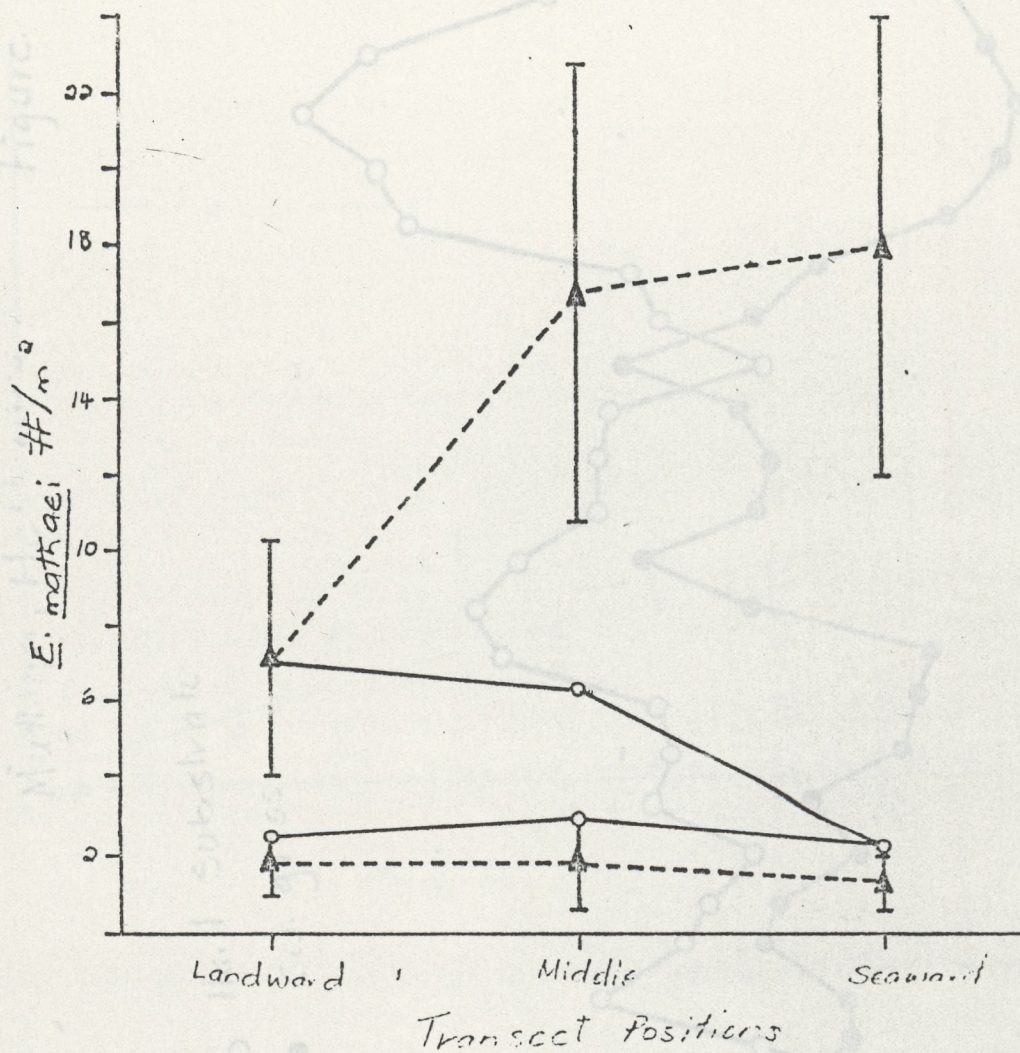
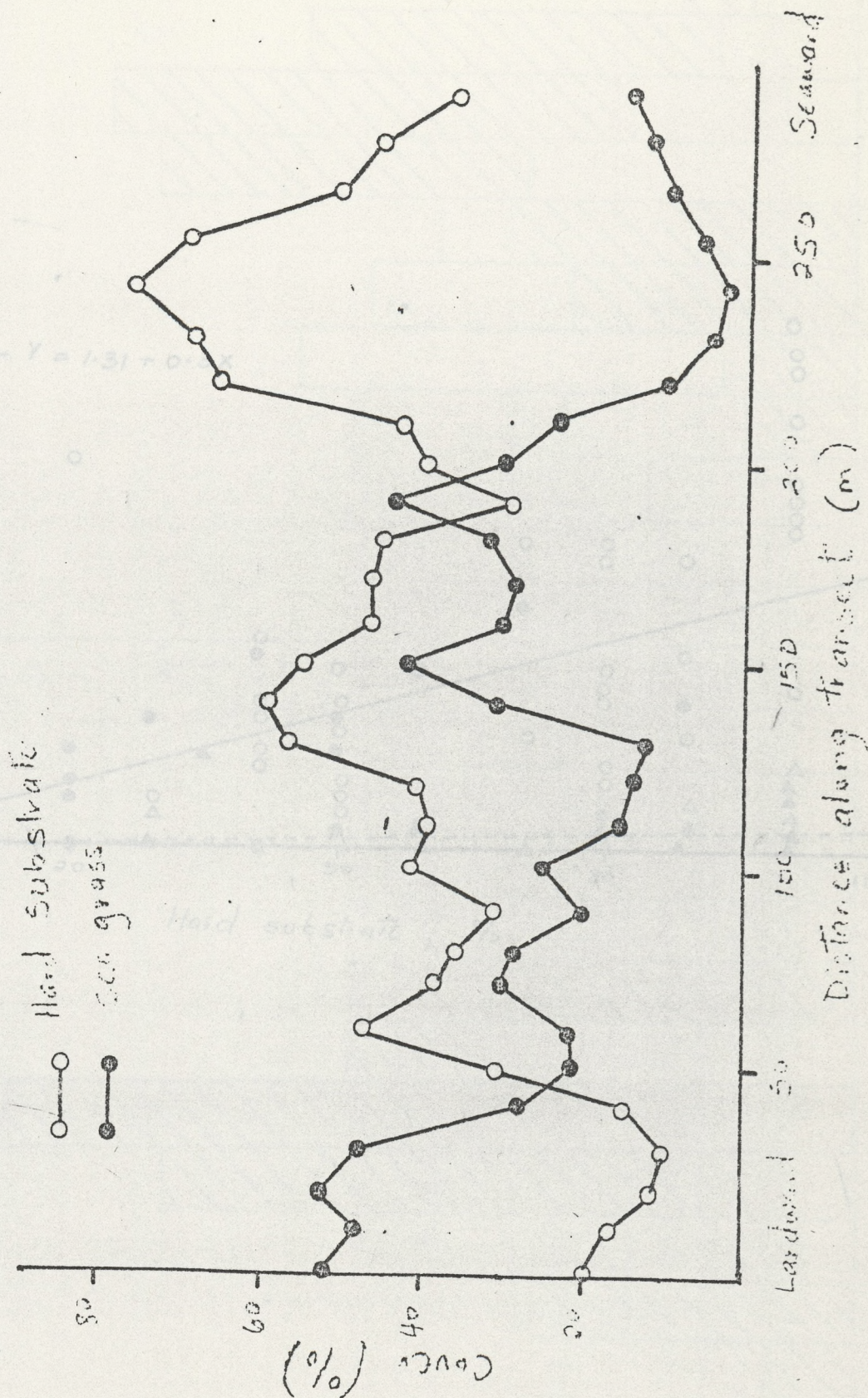


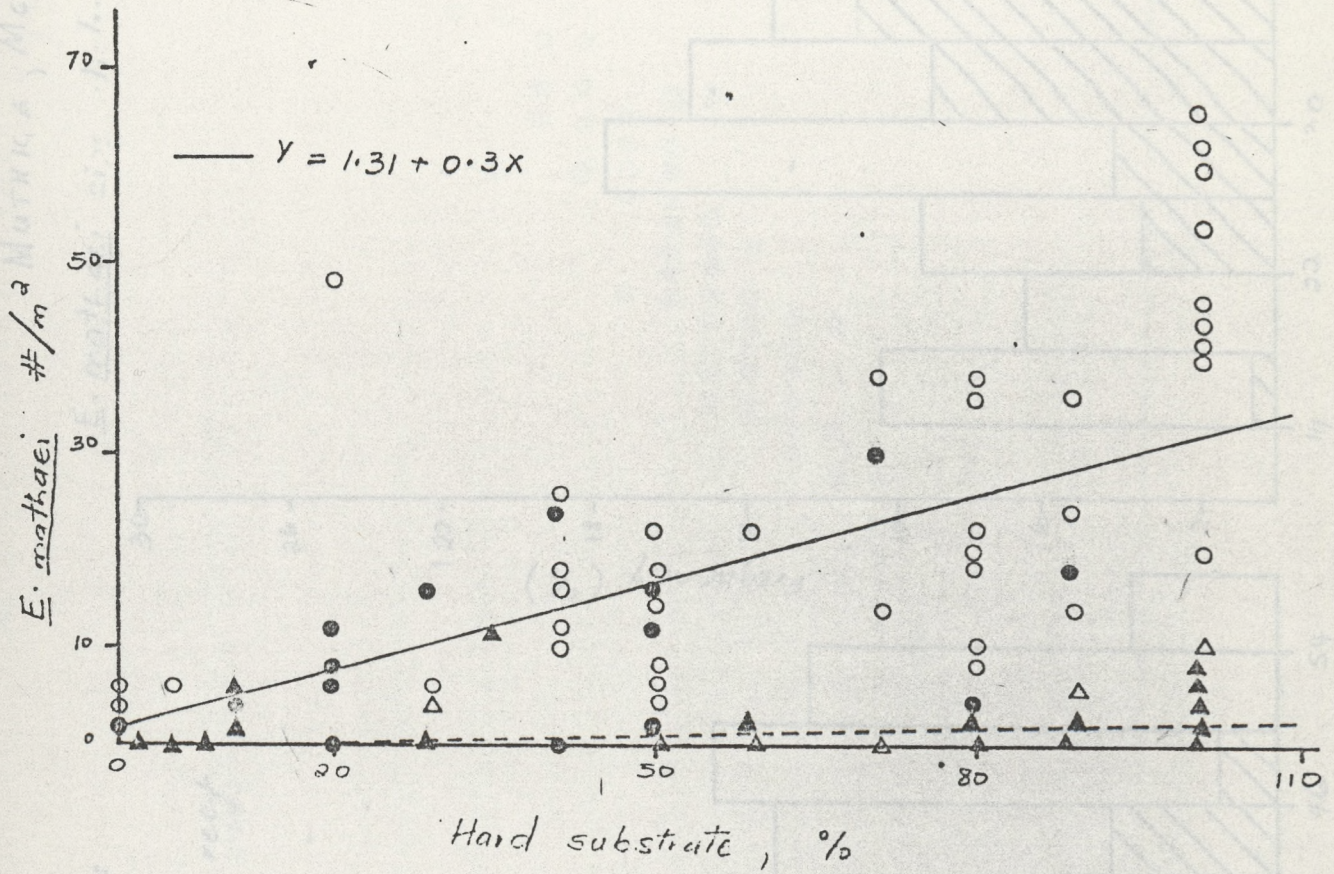


Figure 2

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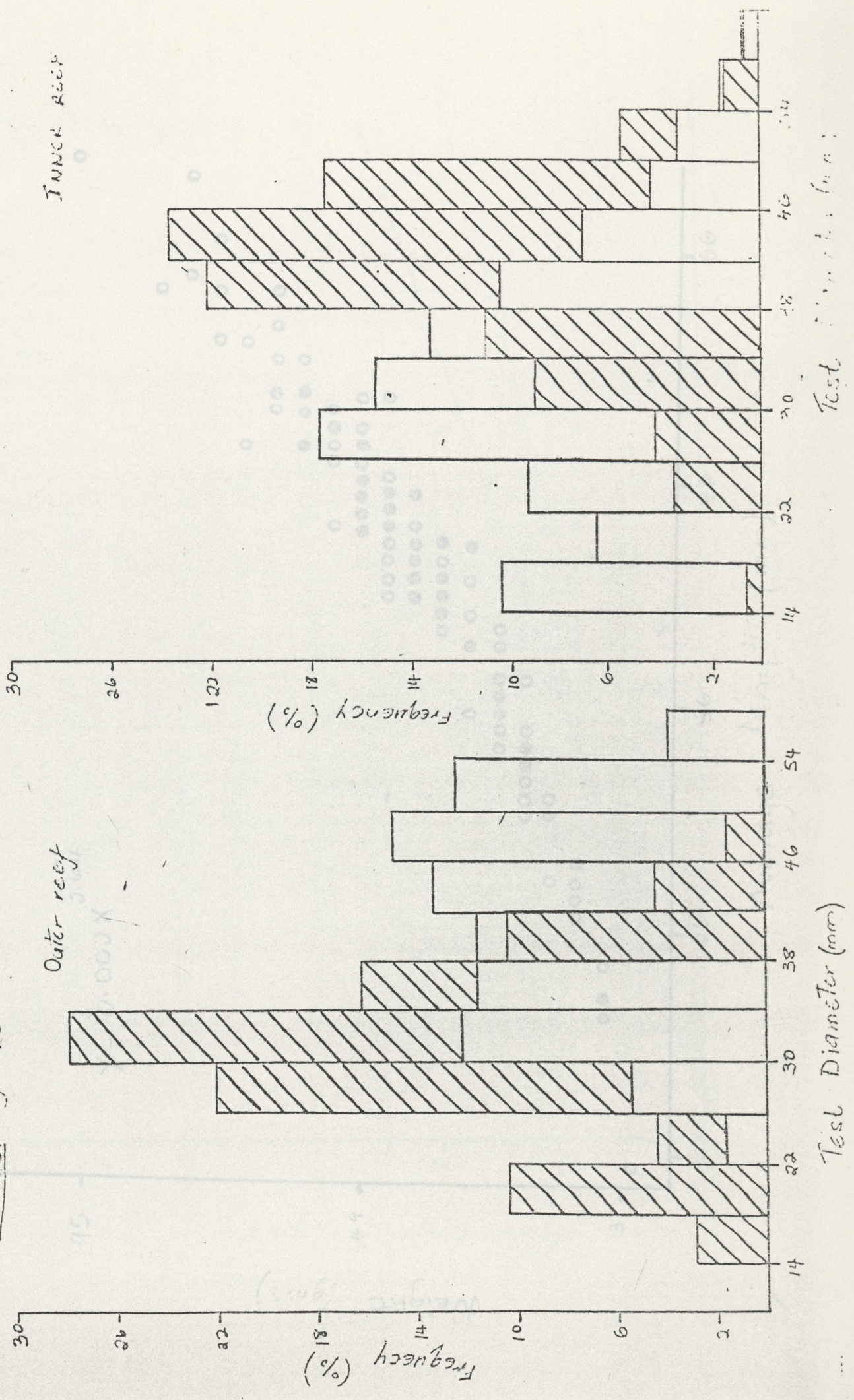






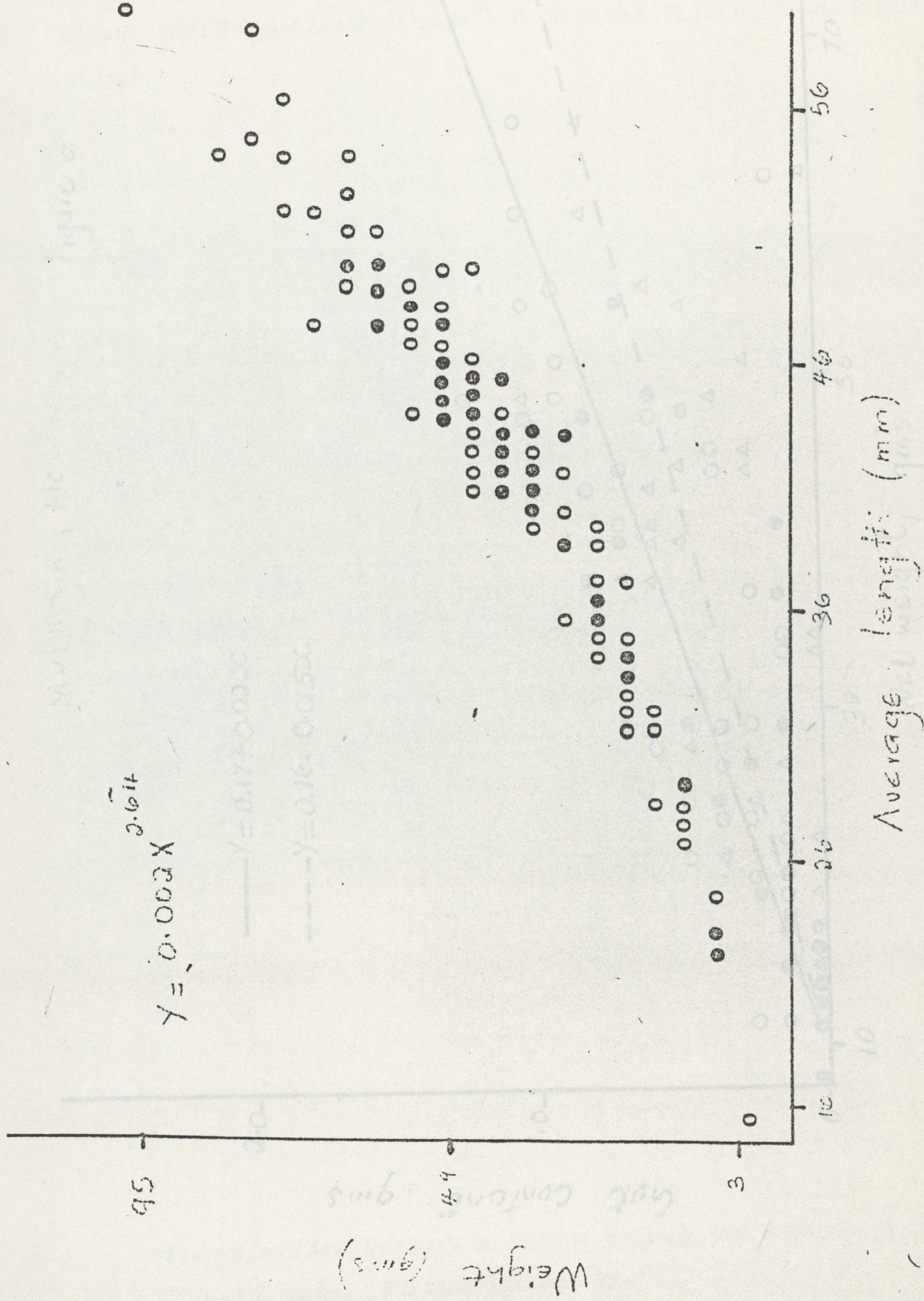
E. mathaei size distributions

E. mathaei size distributions



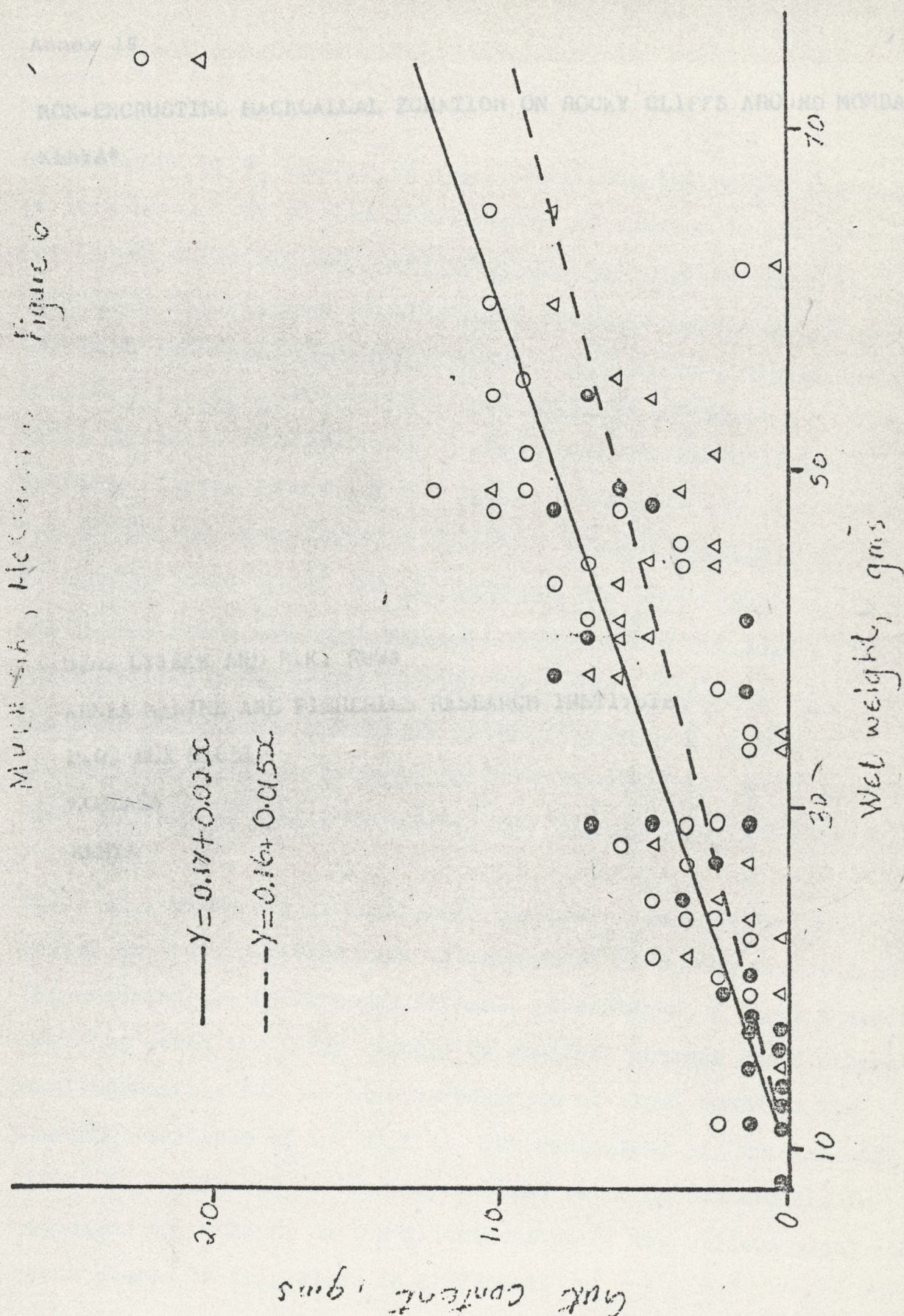


MUTHIGA, McClanahan Figure 5





MURKIN, MURKIN Figure 6



(Kenya/Belgium Project in Marine Ecology and Management of the coastal zone. Publication No. 4).



ABSTRACT

## NON-ENCrustING MACROALGAL ZONATION ON ROCKY CLIFFS AROUND MOMBASA,

KENYA\*

A total of 33 species of rocky cliff non-encrusting macroalgae is described. Out of this total number of species 10 are new records for Kenya; these are Caulacanthus ustulatus, Ceramium gracile, Colodiella pyricladia, Platycephonia minima, Pterocladia nana (Rhodophyta); Cladophora mauritiana, C. saviniana, Ulva portuensis, Valoniopsis festuclata (Chlorophyta) and Dictyota adnata (Phaeophyta). Using the shore terminology of Lewis (1964) and Hartnoll (1976) the patterns of distribution of the species which are seen frequently or abundantly are as follows; (a) Littoral fringe: Loxostichia hindii, H. tenella (Rhodophyta) and Chaetomorpha spp (Chlorophyta); (b) Upper eulittoral zone: Catenella opuntia, Caulacanthus ustulatus, Ceramium gracile, Platycephonia minima, Murayella pyricladia (Rhodophyta), Cladophora spp, Cladophora patenteramea, C. guineensis, Enteromorpha spp, E. raculosa (Chlorophyta); (c) Lower eulittoral zone: Dictyota nana (Rhodophyta) and Ulva portuensis (Chlorophyta).

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The cliffs which are predominantly limestone are heavily pitted and eroded frequently giving rise to overhangs. The pits are responsible for enabling the occurrences of small percentages of algal cover on surfaces which are fully exposed to sunlight whereas the overhangs are responsible for the high percentages of algal cover in the undercut surfaces of the cliffs. The ecological significance of these topographical variations combined with the differences in exposure to sunlight on the distributions of the various algal species encountered in this study is discussed.

\*(Kenya/Belgium Project in Marine ecology and Management of the coastal zone. Publication No. 4).



## ABSTRACT

The zonation of 33 species of rocky cliff non-encrusting macroalgae is described. Out of this total number of species 10 are new records for Kenya; these are Caulacanthus ustulatus, Ceramium camouii, Celidiella myriocladia, Platysiphonia miniata, Pterocladia nana (Rhodophyta); Cladophora mauritiana, C. saviniana, Ulva pertusa, Valonia fastigiata (Chlorophyta) and Dictyota adnata (Phaeophyta). Using the shore terminology of Lewis (1964) and Hartnoll (1976) the patterns of distribution of the species which are seen frequently or abundantly are as follows; (a) Littoral fringe: Bostrichia binderi, B. tenella (Rhodophyta) and Chaetomorpha spp (Chlorophyta); (b) Upper eulittoral zone; Catenella opuntia, Caulacanthus ustulatus, Ceramium camouii, Lophosiphonia reptabunda, Murayella pericladus (Rhodophyta), Caulerpe fastigiata, Cladophora patentioramease, C. sundanensis, Enteromorpha kylinii, E. ramulosa (Chlorophyta); (c) Lower eulittoral zone; Acrocystis nana (Rhodophyta) and Ulva pertusa (Chlorophyta).

The cliffs which are predominantly limestone are heavily pitted and eroded frequently giving rise to overhangs. The pits are responsible for enabling the occurrences of small percentages of algal cover on surfaces which are fully exposed to sunlight whereas the overhangs are responsible for the high percentages of algal cover in the undercut surfaces of the cliffs. The ecological significance of these topographical variations combined with the differences in exposure to sunlight on the distributions of the various algal species encountered in this study is discussed.

of the cliffs were measured.



## INTRODUCTION

Studies on the marine rocky cliff macroalgae of the Kenya coast deal mostly with their taxonomy and species lists rather than their ecology (Lawson 1969, Moorjani 1980). Due to their important role in the food chains of rocky cliff invertebrates, creation of microhabitats and competition for space with rocky cliff invertebrates, the following study on their patterns of zonation was carried out. The marine environment of this area has been reviewed by Kuwa (1984).

## MATERIALS AND METHODS

The studies were carried out at localities around Mombasa (Figure 1 a and b) from April to August 1985. The line transect - quadrat method was used to study the zonation patterns on cliffs which are cavernous and hence well sheltered from direct insolation and those which have no overhangs and are therefore exposed to direct insolation.

The type of sheltering varied. The Baobab cliff is completely sheltered by a thick terrestrial canopy whereas some of the Kenya Marine and Fisheries Research Institute (KMFRI) profiles are completely sheltered under the KMFRI building and the rest are sheltered by overhangs. The maximum heights of the undercuts of the cliffs were measured.



The sampling for the vertical profiles began from bases of the cliffs going perpendicularly upwards to as far as the non-encrusting macroalgae were encountered each time laying the quadrats consecutively. The sampling for the horizontal profiles also began at the bases of the cliffs but proceeded towards the sea till the point where the rock entered into a lagoon or pool.

The heights, above datum, of the bases of the cliffs were determined from several observations made during calm waters around neap tide days, using the Kenya Ports Authority (1985) tide tables. This enabled the heights of the algal zones to be converted and expressed as heights above datum. The universal shore terminology (Fig. 2) according to Lewis (1964) and Hartnoll (1976) was used to indicate the positions of the various species.

Along each 25cm wide transect the percentages of the algal cover at each 1m level were estimated using 25 x 25 quadrat which had 100 equal squares. The number of squares that had Rhodophytes and Chlorophytes were counted and recorded separately. After making the estimates, a sample of the algae was removed using a chisel and a hammer. These were placed in labelled specimen tubes and sent to the laboratory for identification using dissecting and compound light microscopes. The identification guides, used were those of Coppejans (1983), Jassund (1976) and Taylor (1960).



Rhodophytes exhibited largest algal cover under well sheltered conditions but on exposed cliffs they were almost exclusively confined in pit crevices and depressions. Some species e.g.

## RESULTS

*Bostrychia binderi*, *Catenella opuntia*, *Lophosiphonia radiata*

and *Burmannella pericladon* were most frequently encountered in

A total number of 28 transects were studied out of which 16 were cavernous conditions, whereas *Bostrychia tenella*, *Chalcidophora* *ustulatus* and *Ceramium sinuatum* were equally common in both vertical profiles, their species composition and the percentage cover of the Rhodophytes and Chlorophytes are as shown in tables

1 and 2 respectively and figure 3(a-l). The species composition for the sheltered vertical profiles are as shown in tables 3 and 4 while the percentage covers for the Rhodophytes and Chlorophytes are shown in figure 4(a-q).

species which most frequently occurred in cavernous conditions are:

*Bostrychia binderi*, *Chalcidophora pericladon*, *C. radiata* and

*C. viridula*, whereas *Chalcidophora sinuata*, *Bostrychia tenella*, *Kylindria*, *E. ramulosa*, *Chaetomorpha* spp and *Ulva portulacastrum* were almost

equally common on both cavernous and in crevices of exposed cliffs. However, *Chaetomorpha* spp grows very luxuriantly under full sheltered conditions. *Rhizoclonium* grande was mainly found on the

The pattern distribution of the algae on the vertical faces of

both sheltered and exposed cliffs was such that Rhodophytes exhibited higher percentages of algal cover than Chlorophytes.

However, on the other hand, the sloping horizontal platforms had higher percentages of Chlorophytes except those platforms which were fully sheltered e.g. Baobab profile (VI) and Kanamai (Xa) or those which were partially sheltered e.g. Tiwi (I) Florida (III) and Kanamai (Xb).

sea-water and fine sand. *Bryopsis pennata* was found on wet



Rhodophytes exhibited largest algal cover under well sheltered conditions but on exposed cliffs they were almost exclusively confined in pit crevices and depressions. Some species e.g. Bostrichia binderi, Catenella opuntia, Lophosiphonia reptans and Murayella pericladus were most frequently encountered in cavernous conditions, whereas Bostrichia tenella, Caulocanthus ustulatus and Ceramium camouii were equally common in both crevices and cavernous niches.

For the species of Chlorophyta some were encountered most frequently under cavernous conditions whereas others were almost equally common in both cavernous and, in crevices in exposed conditions. The species which most frequently occurred in cavernous conditions are: Caulerpa fastigiata, Cladophora maritima, C. patentiramea and C. saviniana, whereas Cladophoropsis sudanensis, Internormus kylinii, E. ramulosa, Chaetomorpha spp and Ulva pertusa were almost equally common on both cavernous and in crevices of exposed-cliffs. However, Chaetomorpha spp grows very luxuriantly under full sheltered conditions. Rhizoclonium grande was mainly found on the platforms.

Some species encountered in the transects were very rare and scanty and these are: Anadyomene wrightii, Boerhaavia forbesii, Valonia perrhopila, Pterocladia nana and Gracilaria salicornia. Boerhaavia forbesii and Valonia perrhopila were found in damp or wet habitats whereas Valonia fastigiata, Pterocladia nana and Gracilaria salicornia were encountered in small depressions which collected sea-water and fine sand. Bryopsis paenata was found on wet overhangs.



There were no attempts to describe the zonation of the Cyanophytes. However, it was noted that there was luxuriant growth of Lynceibia spp both on the vertical cliffs and exposed horizontal platforms of the cliffs in the upper eulittoral zone. Scytonema spp was common among the Bostrichia. As for the Phaeophytes, they were very scanty. Padina spp was found growing on an exposed horizontal platform with fine damp sand in the upper eulittoral zone at KMFKI. Dictyota adnata was found on a sheltered horizontal platform in the lower eulittoral zone at Baobab cliff.

#### DISCUSSION

Comparing the present list of species with the records of Isaac (1967, 1968 1971), Isaac and Isaac (1968), Knutzen and Jaasund (1979) and Moorjani (1980) the following 10 species are new records for Kenya: Caulacanthus ustulatus, Ceramium camonii, Celidicella myriocladia, Platysiphonia miniata, Pterocladia nana (Rhodophyta), Cladophora mauritiana, C. saviniana, Ulva pertusa, Valonia fastigiata (Chlorophyta), and Dictyota adnata (Phaeophyta).

The Rhodophyta dominates the upper eulittoral zone and Littoral fringe habitats which are shaded. The shading effect is provided by the numerous pits, crevices, vertical nature of the cliffs and their overhangs. The exposed steep surfaces of the cliffs do not receive as much insolation around midday as the equally exposed horizontal platforms receive. The latter tend to get warmer than the steep surfaces. Under fully sheltered conditions they grow luxuriantly (Taylor 1960). Exposed cliffs are almost bare



except in pits and crevices. The Chlorophyta dominate the Upper eulittoral zone and Lower eulittoral zone under exposed conditions especially where the cliff flattens to form a horizontal platform. The only green algal species encountered which does not flourish in exposed conditions but does in sheltered conditions is a Chaetomorpha spp. It may extend into the Littoral fringe under such suitable conditions.

Insolation creates high temperatures and consequently enhances dessication during low tide. Higher temperatures and dessication is greater in exposed than in shaded sites. Since high temperatures and dessication inhibit growth of algae (Lewis 1964) it is therefore not unexpected that larger algal cover occur in cavernous habitats and that in exposed surfaces growth is confined to crevices and depressions which offer shade against direct insolation.

Some of the factors that affect algal abundance and distribution have been discussed. But it should be further pointed out that other factors like grazing, effects of wave-borne sand etc. may change the patterns of abundance and distribution (Taylor 1960, Lewis 1964). These factors are relevant for the distribution and abundance of algae in Kenya because there are several types of grazers on the rocky cliffs (e.g. littorinids, neritids, chitons, patellids) <sup>(Rvwa 1984)</sup> and sand deposits are very common along the Kenya shoreline. To understand how the zonation of the species found on the Kenya rocky cliffs may change due to their response to various biotic and abiotic factors, in different time scales, further ecological studies need to be done.



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## LEGENDS FOR FIGURES

- Figure 1 (a) A map of Kenya coastline showing region of study  
1 (b) A map of Mombasa area showing localities studied.

Figure 2 Division of shore according to Lewis (1964) and Hartnoll (1976)

Figure 3(a - 1) Percentage distribution of Rhodophyta and Chlorophyta on exposed vertical cliffs. The acronyms LF, UEZ and LEZ stand for Littoral fringe, Upper eulittoral zone and Lower eulittoral zone respectively. The position of the base of the cliff is indicated by the acronym at the point of origin.

Figure 4(a - q) Percentage distribution of Rhodophyta and Chlorophyta on sheltered vertical cliffs. Arrows indicates heights of the undercuts above datum.

Figure 5(a - d) Percentage distribution of Rhodophyta and Chlorophyta on the platforms continuing from exposed cliffs.

Figure 6(a - f) Percentage distribution of Rhodophyta and Chlorophyta on the platforms continuing from sheltered cliffs.



Table I. The distribution of Rhodophyta on exposed vertical cliffs: (I) Tind (II) Shelly (III) Florida (IV) Mombasa Hospital (V) Fort Jesus (VI) Babab (VII) Kenya Marine and Fisheries Research Institute (KMFI) (VIII) Mkenzie Point (IX) Nyali and (X) Karamai. The alphabetical letters stand for profiles where more than two profiles were taken at one locality.

Species	Study sites												
	I	II	III	IVa	IVb	IVc	Va	VIa	VIIa	VIIb	VIII	IX	INFERENCE
<i>Acrotylis nana</i> Zanardini	-	LEZ	-	-	-	-	-	-	UEZ	UEZ	-	-	LEZ
<i>Bastrichia binderi</i> Harvey	-	LF	LF	-	-	-	-	-	LF	-	UEZ	-	LF
<i>Bastrichia tonella</i> (Vahl) J. Ag	LF	LF	LF	LF	LF	UEZ	UEZ	UEZ	LF	LF	UEZ	LF	LF
<i>Caloglossa lapourii</i> (Mont.) J. Agardh	-	-	-	-	-	-	-	UEZ	-	-	-	-	UEZ
<i>Catenella opuntia</i> (Goodenough & Woodw), Grev.	-	-	-	-	-	-	-	-	LF	-	-	-	LF
<i>Caulecanthus ustulatus</i> (Mart.) Kützling	-	UEZ	UEZ	-	-	LEZ	UEZ	UEZ	UEZ	UEZ	UEZ	UEZ	UEZ
<i>Centroceras clavulatum</i> (C. Ag) Montagne	-	-	LEZ	-	-	-	-	-	-	LEZ	-	UEZ	UEZ
<i>Ceramium canquii</i> Dawson	-	LEZ	-	UEZ	UEZ	-	UEZ	-	-	-	UEZ	UEZ	UEZ
<i>Gelidium myriocladia</i> (Sorgs) Feldmann et Hamel	-	-	-	-	-	LEZ	-	-	-	-	-	-	UEZ
<i>Gelidium pusillum</i> (Stackh.) Le Jol	-	-	-	-	UEZ	-	-	-	-	-	-	-	UEZ
<i>Gracilaria salicornia</i> (J. Ag) Dawson	-	-	-	-	-	-	-	-	UEZ	LEZ	-	-	LEZ
<i>Lophosiphonia reptatunda</i> (Suhr) Jaasund	-	-	-	-	-	-	UEZ	-	-	-	UEZ	UEZ	UEZ
<i>Lurayella poricladus</i> (C. Ag) Schmitz	-	-	-	-	-	-	UEZ	-	UEZ	-	UEZ	-	UEZ
<i>Platysiphonia miniata</i> (Ag) Borgesen	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Polysiphonia variegata</i> (Ag) Zanardini	-	-	-	-	-	-	-	UEZ	-	-	-	-	UEZ
<i>Pterocladia nana</i> Okamura	-	-	-	-	-	-	-	-	UEZ	-	-	-	UEZ
Position of base of cliff	LEZ	LEZ	LEZ	LEZ	LEZ	LEZ	UEZ	LEZ	UEZ	LEZ	UEZ	LEZ	



Species	Study sites										IX	Inference
	I	II	III	I/a	I/b	I/c	Va	VI	VIIa	VIIb		
Anadycomena wrightii Gray	-	-	-	-	-	-	-	-	-	-	-	-
Eoergesenia forbesii (Harvey) Feldmann	-	-	-	-	-	-	-	-	-	-	-	-
Bryopsis pennata Lamouroux	-	-	-	-	-	-	-	-	-	-	-	-
Caulerpa fastigiata Montagne	-	-	-	UEZ	-	-	-	-	-	-	-	UEZ
Cheatomorpha spp.	LF	LF	LF	LF	LF	UEZ	LF	LF	LF	LF	UEZ	LF
Cladophora mauritiana Kützting	-	-	-	-	-	-	-	-	-	-	-	-
Cladophora patentiramosa (Mont.) Kütz	-	UEZ	-	UEZ	UEZ	-	UEZ	-	-	UEZ	-	UEZ
Cladophora saviniara Borgesen	-	-	-	-	-	-	-	-	-	-	-	-
Cladophoropsis sundanensis Reinbold	LEZ	UEZ	UEZ	UEZ	-	-	UEZ	-	UEZ	-	UEZ	UEZ
Entaromorpha kyllini Blinding sensu Dawson	-	LEZ	LEZ	-	-	-	-	UEZ	UEZ	UEZ	UEZ	-
Entaromorpha raculosa (J.E. Smith) Hocker	-	-	-	-	UEZ	-	UEZ	UEZ	UEZ	UEZ	UEZ	-
Rhizoclonium grande	-	-	-	-	-	-	-	-	-	-	-	-
Ulva pertusa Kjellman	UEZ	-	UEZ	LEZ	-	UEZ	UEZ	UEZ	UEZ	UEZ	UEZ	UEZ
Ulva rigida C. Ag.	-	-	-	-	-	-	LEZ	-	-	-	-	-
Valonia aegropila C. Ag.	-	-	-	-	-	-	-	-	-	-	-	-
Valonia fastigiata Harvey	-	-	-	-	-	-	-	-	-	-	-	-
Position of base of cliff	UEZ	LEZ	LEZ	LEZ	LEZ	LEZ	UEZ	LEZ	UEZ	UEZ	UEZ	LEZ







Table 4 The distribution of Chlorophyta on sheltered vertical cliffs. The description of the localities (study sites) are as described in Table 1

Species	Study sites																
	I	II	III	IVd	IVe	Vb	Vc	VI	VIIc	VIIId	VIIIs	VIIIf	VIII	IX	Xa	Xb	INFERENC
<i>Anadyctena Wrightii</i> Gray	-	-	-	-	-	-	-	-	-	-	-	LEZ	-	-	-	-	LEZ
<i>Scolecocladia forbesii</i> (Harvey) Faldutann	LEZ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LEZ
<i>Eryopsis porrata</i> Lamouroux	-	-	-	-	LEZ	-	-	-	-	-	-	-	-	-	-	-	LEZ
<i>Caulerpa fastigiata</i> Montagne	LEZ	LF	LEZ	-	-	UEZ	-	LEZ	UEZ	-	-	-	-	-	-	-	UEZ
<i>Chaetomorpha</i> spp	-	UEZ	LF	LF	-	LF	UEZ	LF	LF	LF	LF	LF	UEZ	LF	LF	LF	LF
<i>Cladophora mauritiana</i> Kützeng	-	LEZ	-	-	LEZ	-	-	LEZ	-	-	-	-	-	UEZ	-	UEZ	UEZ
<i>C. patentiramosa</i> (Mont.) Kütz	UEZ	UEZ	UEZ	-	UEZ	-	UEZ	UEZ	-	UEZ	UEZ	-	UEZ	UEZ	-	UEZ	UEZ
<i>C. saviniara</i> Borgesen	-	-	-	-	-	-	-	LEZ	UEZ	UEZ	UEZ	LEZ	-	UEZ	-	-	LEZ
<i>Cladophoropsis sundanensis</i> Reinhold	UEZ	UEZ	UEZ	-	-	UEZ	LEZ	LEZ	-	-	-	UEZ	-	UEZ	-	-	UEZ
<i>E. kylinii</i> Blinding sensu Dawson	-	UEZ	-	-	UEZ	-	-	LEZ	-	-	-	-	UEZ	UEZ	-	UEZ	UEZ
<i>E. ramulosa</i> (J.E. Smith) Hooker	-	UEZ	-	-	UEZ	-	UEZ	LEZ	-	-	-	LF	UEZ	UEZ	UEZ	UEZ	UEZ
<i>Rhizoclonium grande</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ulva portuaca</i> Kjellman	LEZ	LEZ	LEZ	LEZ	LEZ	-	UEZ	LEZ	-	-	-	UEZ	LEZ	UEZ	-	UEZ	LEZ
<i>Ulva rigida</i> C. Ag.	LEZ	-	LEZ	-	-	UEZ	-	-	-	-	-	-	-	-	-	-	LEZ
<i>Valoniopsis asagapilla</i> C. Ag.	LEZ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LEZ
<i>V. fastigiata</i> Harvey	-	-	-	-	-	-	-	LEZ	LEZ	-	-	-	-	-	-	-	LEZ
Position of base of cliff	UEZ	LEZ	LEZ	LEZ	UEZ	UEZ	UEZ	LEZ	UEZ	UEZ	UEZ	LEZ	UEZ	UEZ	UEZ	UEZ	



Table 5. The distribution of algae on platforms continuing from the exposed vertical cliffs. The description of the localities (study sites) are as described in Table 1.

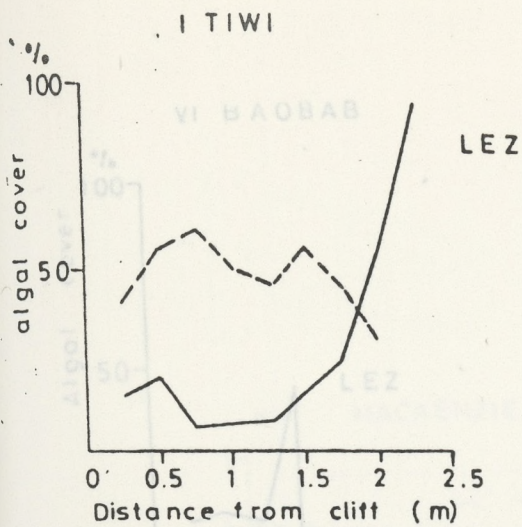
Species	Study sites			
Rhodophyta	VI	VIIa	VIIb	IX
<i>Acrocystis nana</i>	-	-	-	-
<i>Bostrichia binderi</i>	-	-	-	-
<i>Bostrichia tenella</i>	-	-	-	-
<i>Caloglossa lepreurii</i>	-	-	-	-
<i>Catenella opuntia</i>	-	-	-	-
<i>Caulacanthus ustulatus</i>	-	UEZ	-	-
<i>Centroceras clavulatum</i>	-	UEZ	UEZ	-
<i>Coranum carvuli</i>	-	-	UEZ	-
<i>Celidiella myriocladia</i>	-	-	-	-
<i>Celidium pusillum</i>	-	-	-	-
<i>Gracilaria salicorria</i>	-	UEZ	UEZ	-
<i>Lophosiphonia reptabunda</i>	-	-	-	-
<i>Murayella pericladus</i>	-	-	-	-
<i>Platysiphonia miniata</i>	-	-	-	-
<i>Pterocladia nana</i>	-	UEZ	-	-
<i>Platysiphonia mindan</i>	-	-	-	-
<u>Chlorophyta</u>				
<i>Boergesenia forbesii</i>	-	-	-	-
<i>Caulerpa fastigiata</i>	-	-	-	-
<i>Cladophora mauritiana</i>	-	-	-	-
<i>Cladophora patentirameae</i>	-	-	UEZ	-
<i>Cladophora saviniana</i>	-	UEZ	-	-
<i>Cladophoropsis sundanensis</i>	-	UEZ	UEZ	-
<i>Enteromorpha kyllini</i>	LEZ	UEZ	-	-
<i>Enteromorpha ramulosa</i>	LEZ	UEZ	UEZ	-
<i>Rhizoclonium grande</i>	-	UEZ	UEZ	-
<i>Ulva pertusa</i>	LEZ	UEZ	UEZ	LEZ
<i>Ulva rigida</i>	-	-	-	-
<i>Valonia aegropila</i>	-	-	UEZ	-
<i>Valonia fastigiata</i>	-	-	-	-



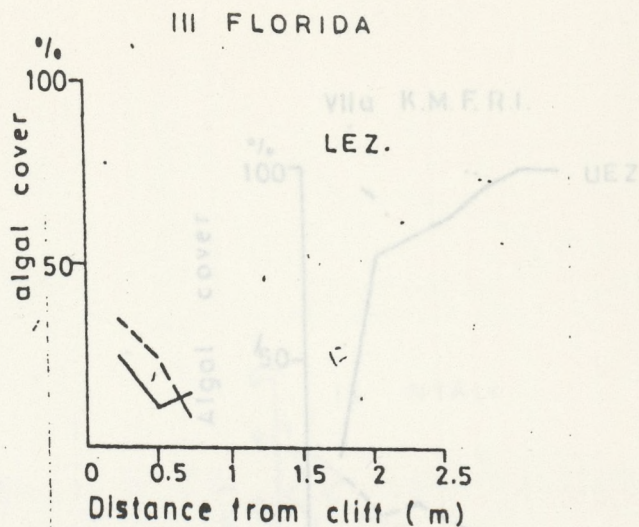
Table G. The distribution of algae on platforms continuing from the vertical cliffs. The descriptions of the localities (study sites) are as stated in Table I.

Species	Study sites					
Rhodophyta	I	III	VI	IX	Xa	Xb
<i>Acrocystis rana</i>	UEZ	-	UEZ	-	-	-
<i>Bostrichia binderi</i>	-	-	-	-	UEZ	-
<i>Bostrichia tenella</i>	-	-	UEZ	-	UEZ	UEZ
<i>Caloglossa leprourii</i>	-	-	UEZ	-	-	-
<i>Catenella opuntia</i>	-	-	UEZ	-	UEZ	-
<i>Caulacanthus ustulatus</i>	UEZ	UEZ	UEZ	UEZ	-	UEZ
<i>Centrocercus clavulatum</i>	-	-	-	-	-	-
<i>Coranum cornuti</i>	UEZ	-	UEZ	UEZ	-	UEZ
<i>Calidiella myriocladia</i>	-	UEZ	-	-	-	-
<i>Calidium pusillum</i>	UEZ	-	-	-	-	-
<i>Crucilaria salicornia</i>	-	-	-	-	-	-
<i>Lophosiphonia reptabunda</i>	-	-	-	UEZ	-	UEZ
<i>Curayella pericladus</i>	UEZ	-	UEZ	-	-	-
<i>Platysiphonia mindata</i>	-	-	UEZ	-	-	-
<i>Pterocladia rana</i>	-	-	-	-	-	-
<u>Chlorophyta</u>						
<i>Boopsea forbesii</i>	UEZ	-	-	-	-	-
<i>Caulerpa fastigiata</i>	UEZ	UEZ	UEZ	-	-	-
<i>Chaetomorpha</i> spp	-	-	-	-	UEZ	-
<i>Cladophora mauritiana</i>	-	-	UEZ	-	-	UEZ
<i>Cladophora patentiramea</i>	-	-	UEZ	UEZ	-	UEZ
<i>Cladophora saviniana</i>	-	-	UEZ	UEZ	-	-
<i>Cladophoropsis sundanensis</i>	UEZ	-	UEZ	UEZ	-	-
<i>Enteromorpha kylinii</i>	-	-	UEZ	UEZ	-	UEZ
<i>Enteromorpha ramulosa</i>	-	-	UEZ	UEZ	-	UEZ
<i>Rhizoclonium grande</i>	UEZ	-	UEZ	UEZ	-	-
<i>Ulva pertusa</i>	UEZ	UEZ	UEZ	UEZ	-	UEZ
<i>Ulva rigida</i>	UEZ	UEZ	-	-	-	-
<i>Valonia asagropila</i>	-	-	-	-	-	-
<i>Valonia fastigiata</i>	-	-	UEZ	-	-	-

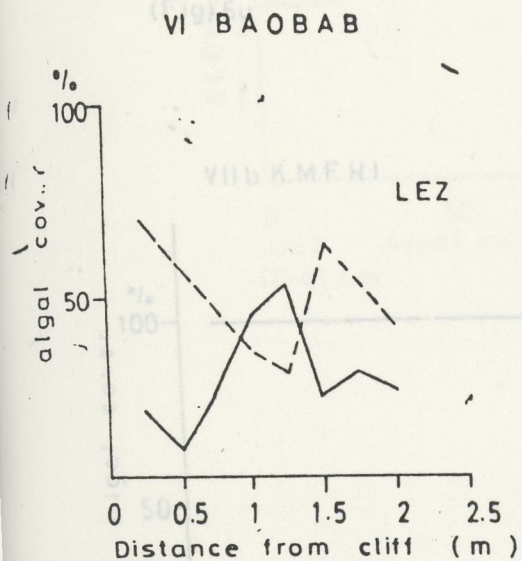




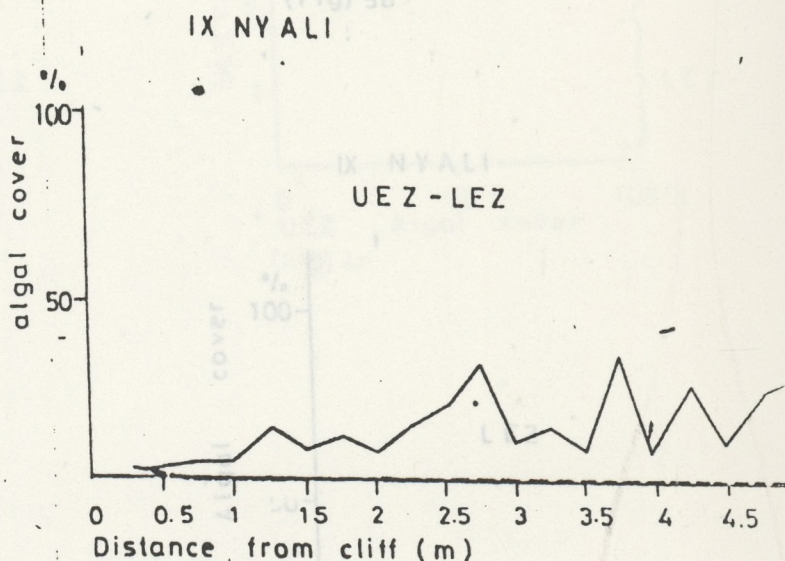
(Fig) 6a



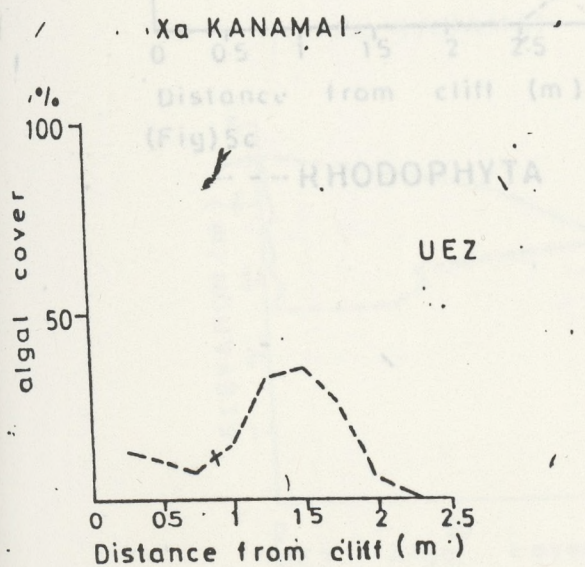
(Fig) 6b



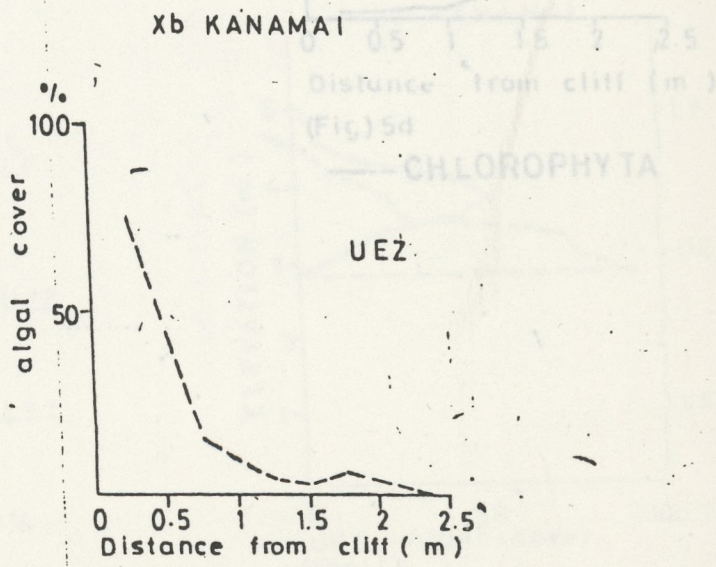
(Fig) 6c



(Fig) 6d



(Fig) 6e



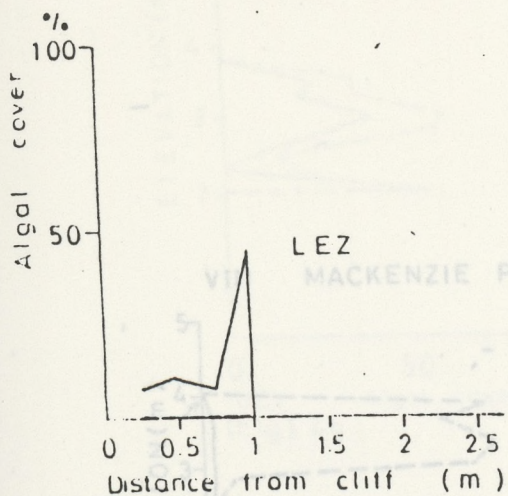
(Fig) 6f

--- RHODOPHYTA

— CHLOROPHYTA

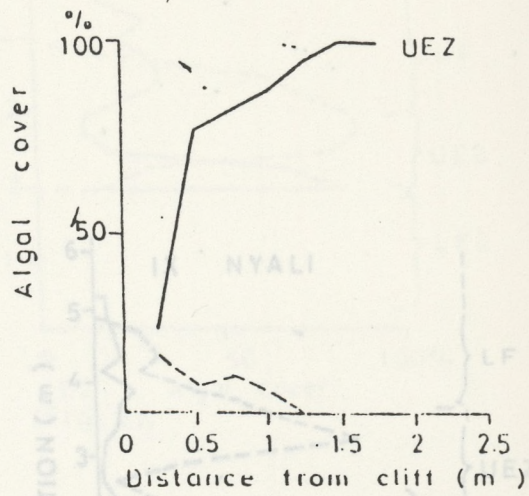


# VI BAOBAB



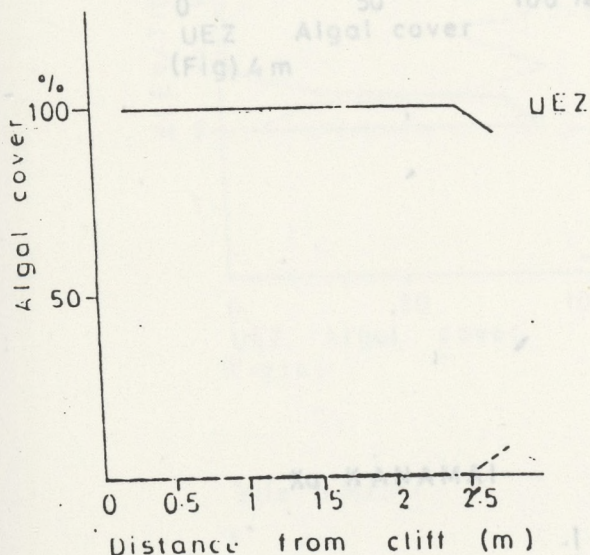
(Fig) 5a

# VIIa K.M.E.R.I.



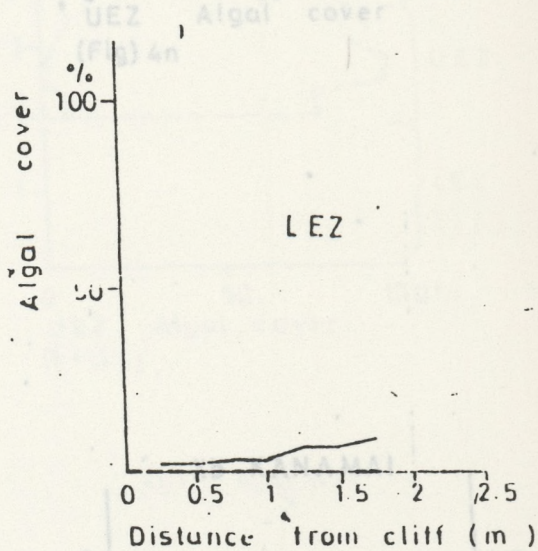
(Fig) 5b

# VIIb K.M.E.R.I.



(Fig) 5c

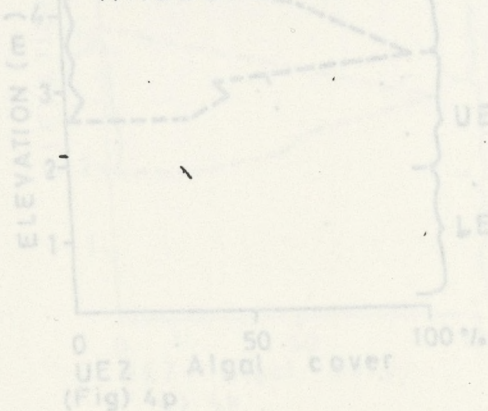
# IX NYALI



(Fig) 5d

--- RHODOPHYTA

--- CHLOROPHYTA



(Fig) 4p

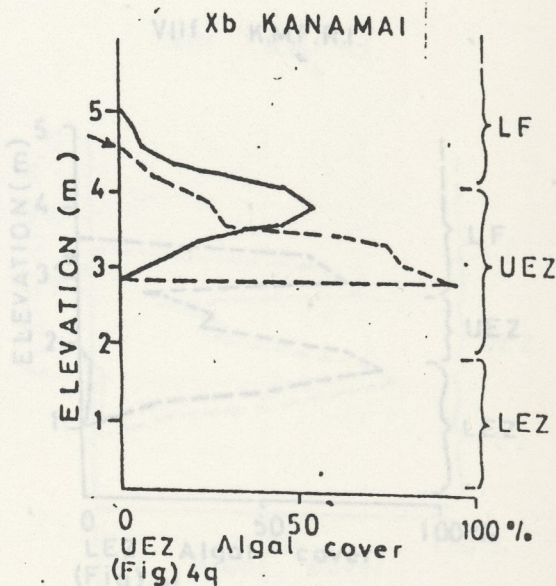
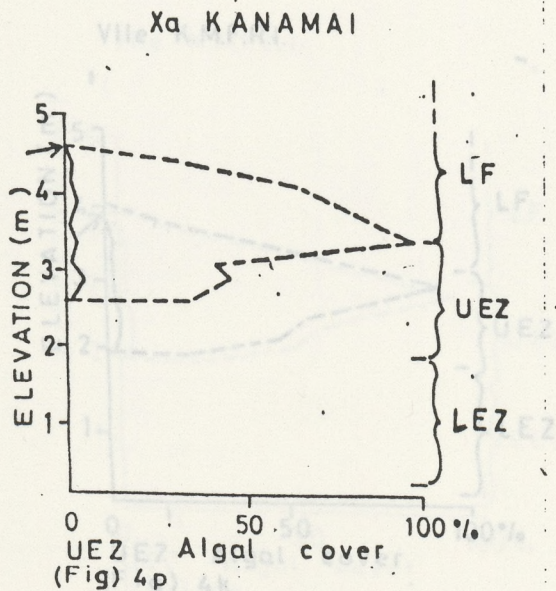
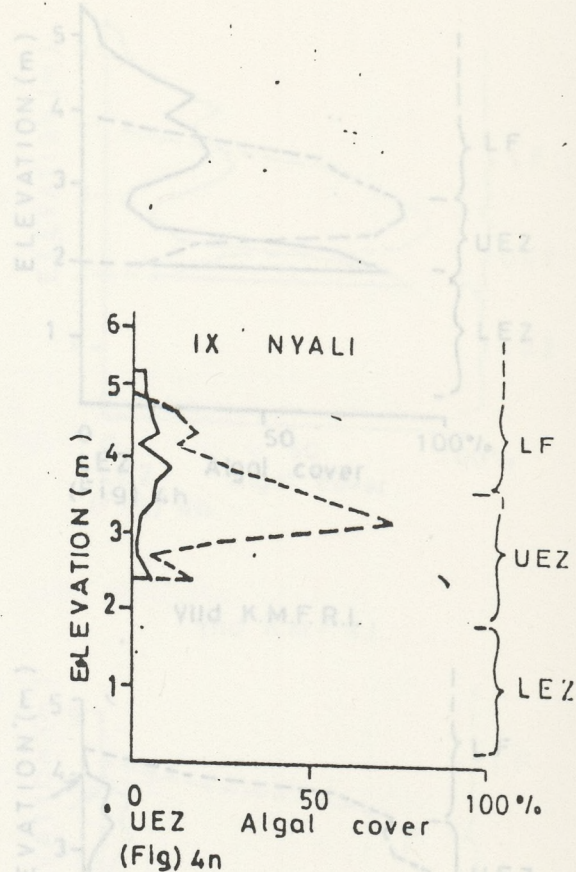
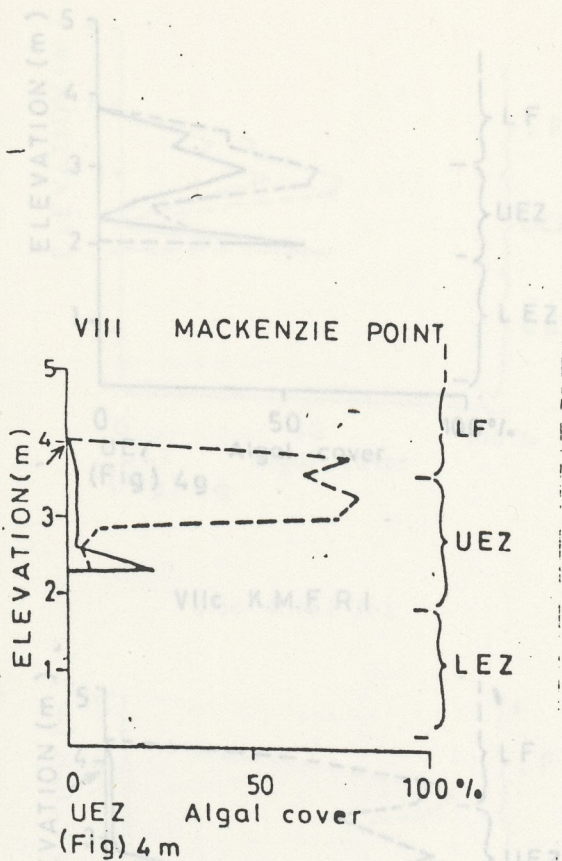


(Fig) 4q

--- RHODOPHYTA

--- CHLOROPHYTA



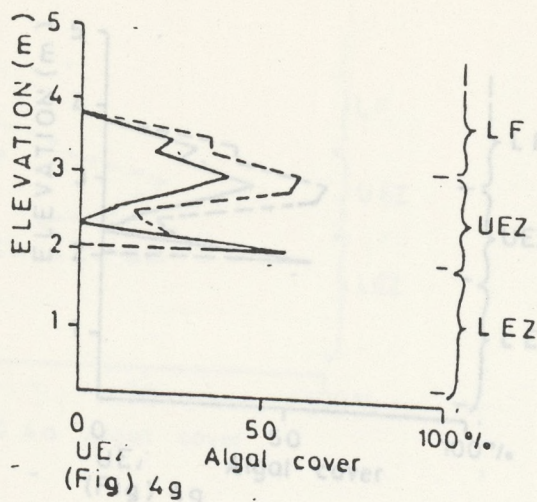


--- RHODOPHYTA

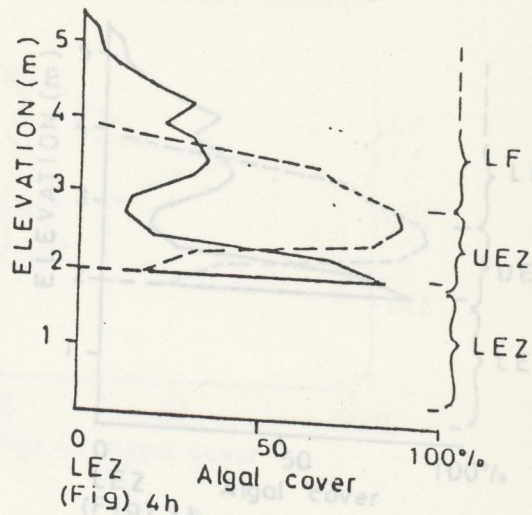
— CHLOROPHYTA



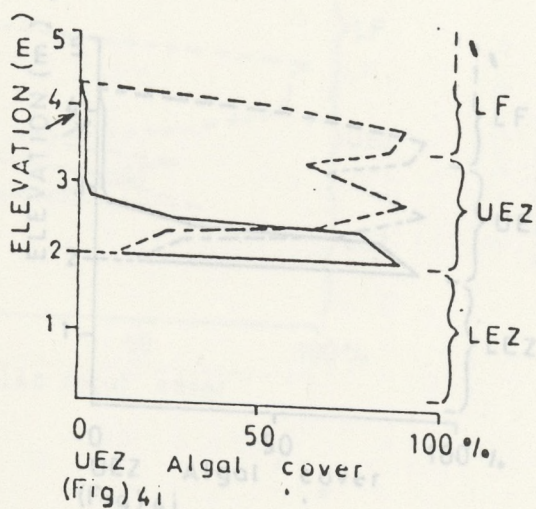
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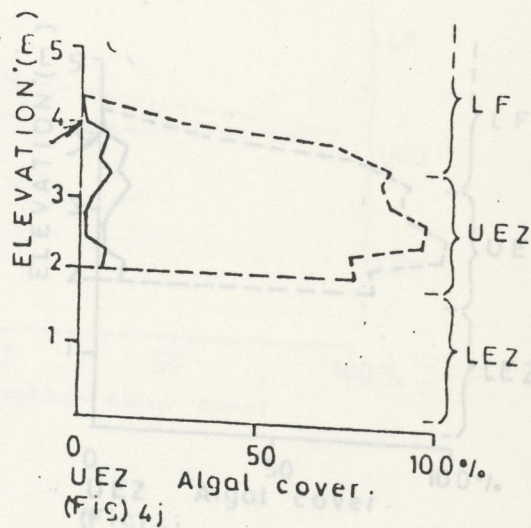
# VI. BAOBAB



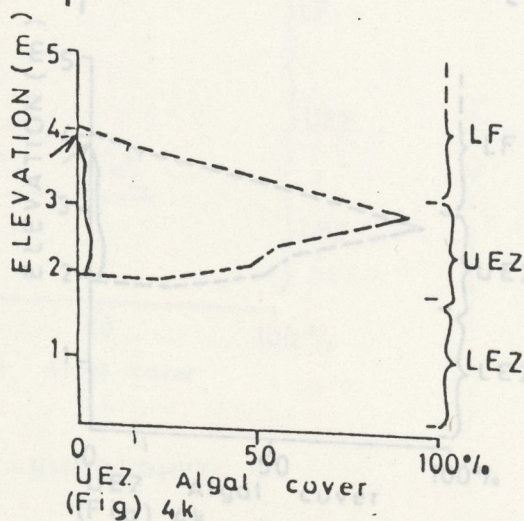
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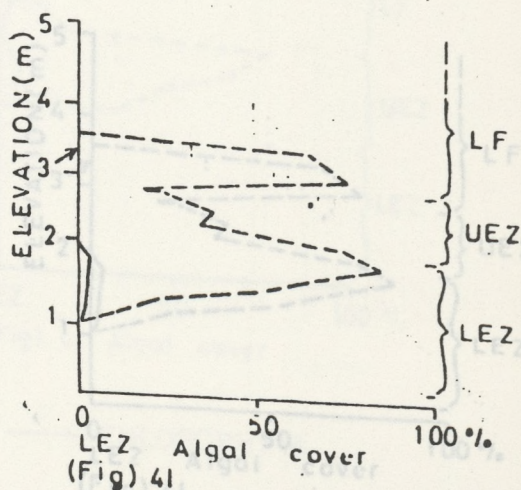
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# VIIe K.M.F.R.I.



# VIIIf K.M.F.R.I.

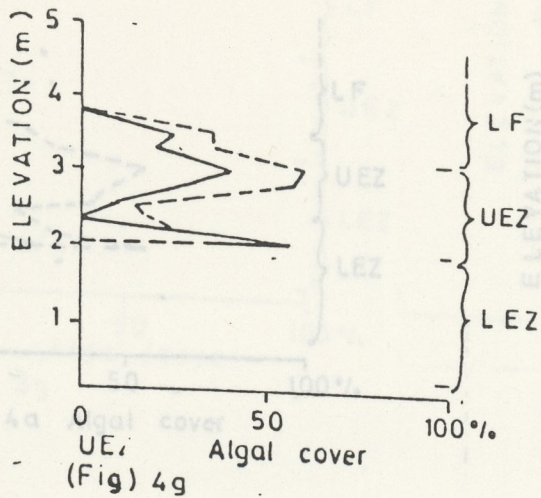


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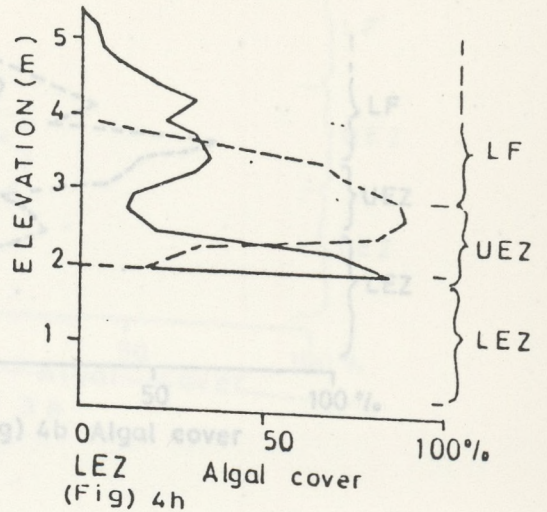
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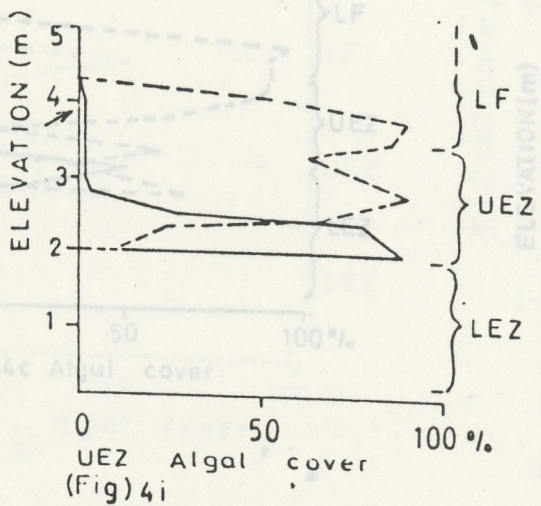
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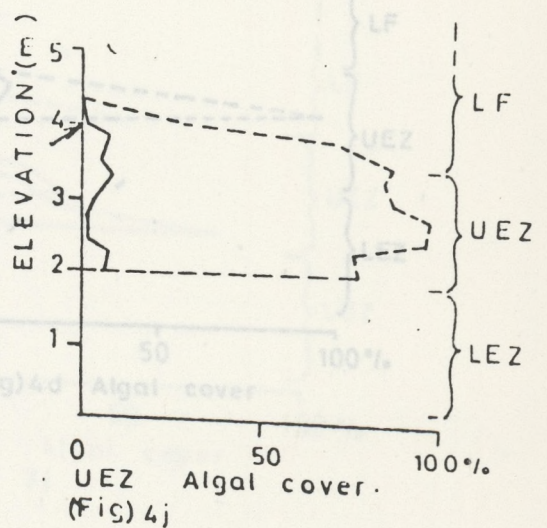
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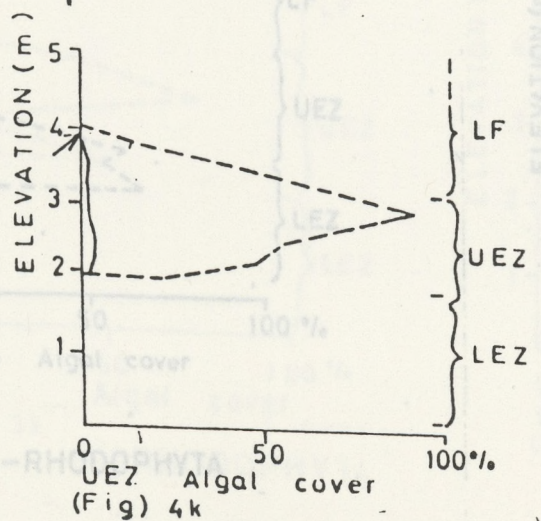
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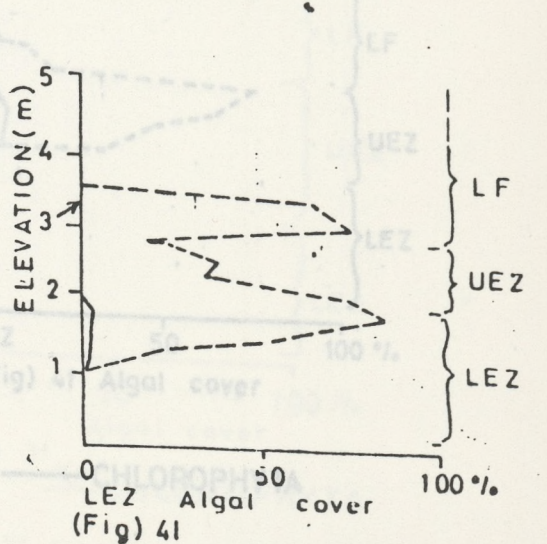
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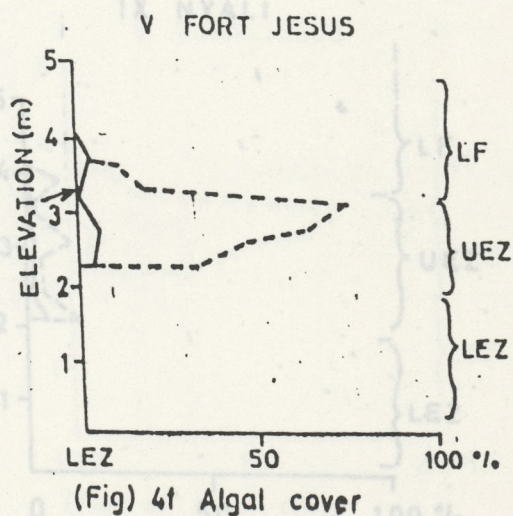
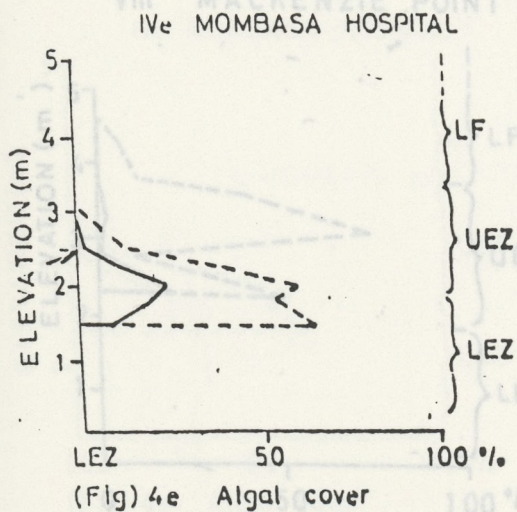
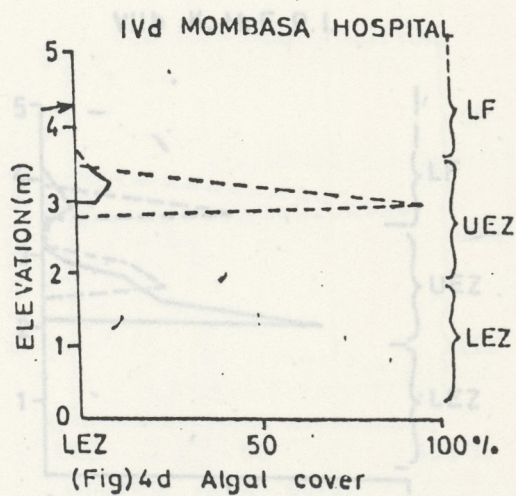
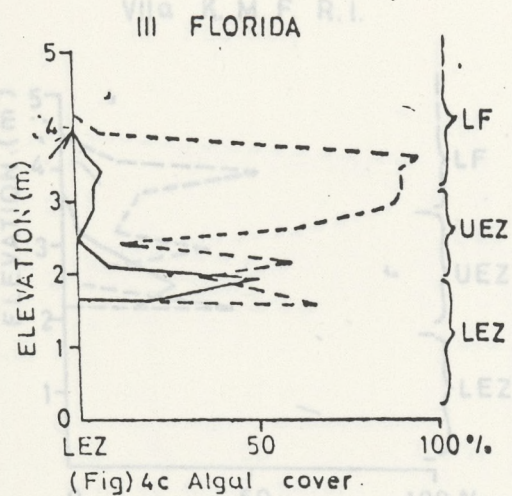
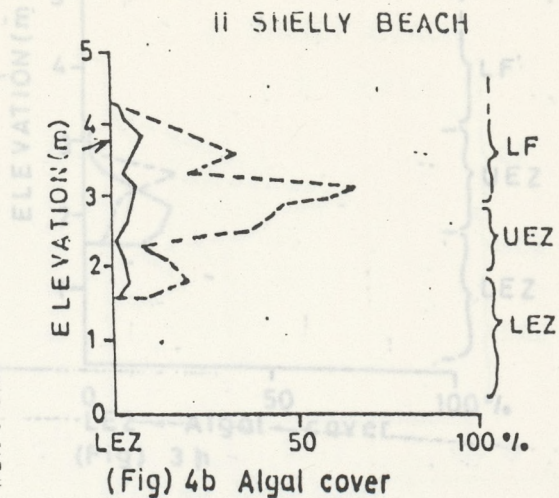
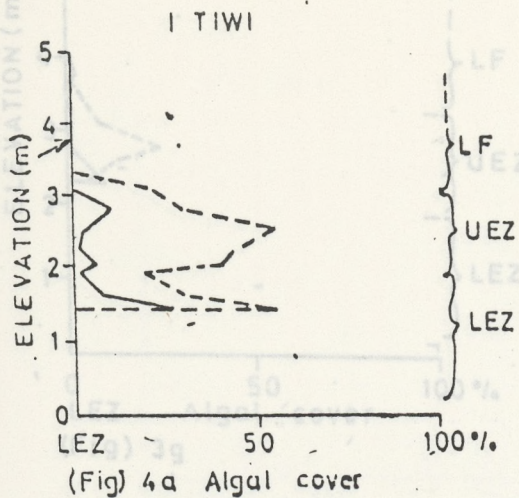
# VIII f K.M.F.R.I.



--- RHODOPHYTTA

— CHLOROPHYTTA

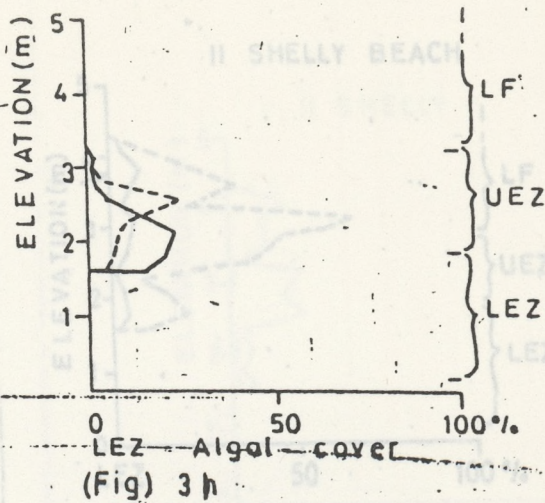
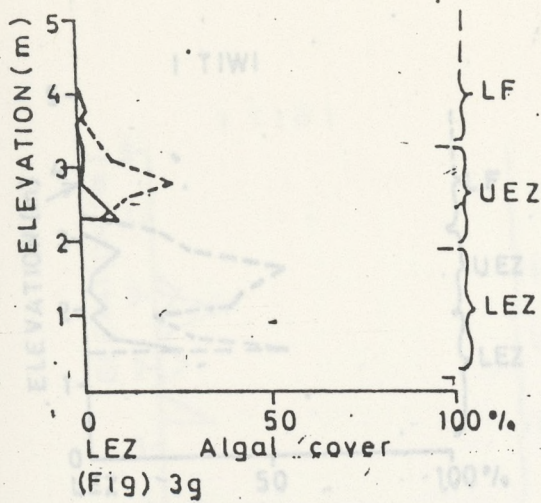




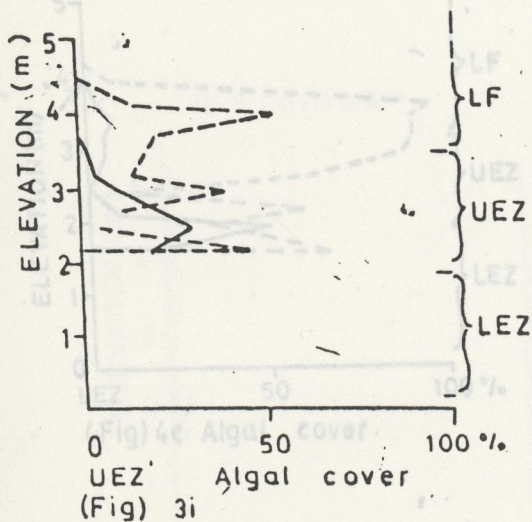
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— CHLOROPHYTA

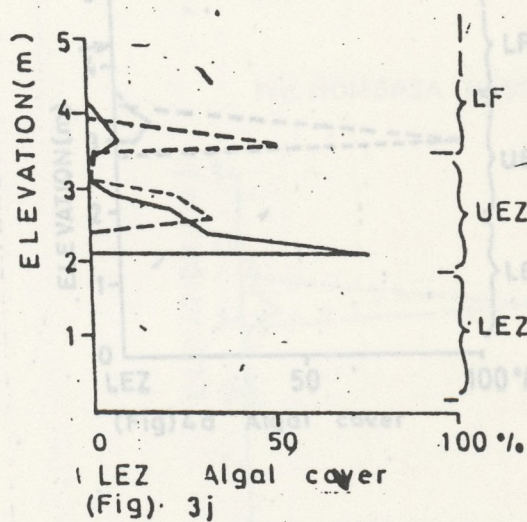




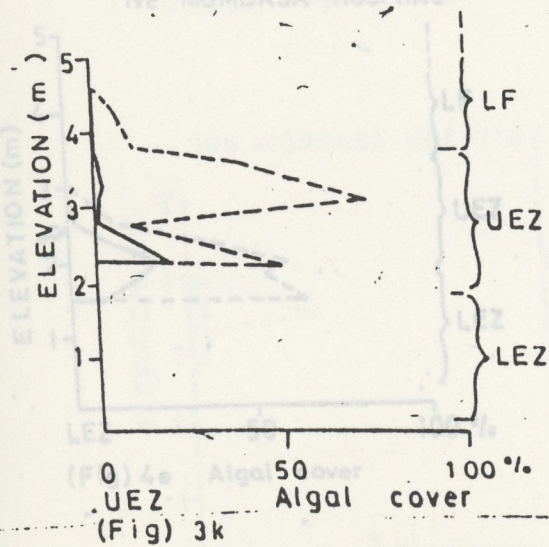
VIIa K. M. F. R. I.



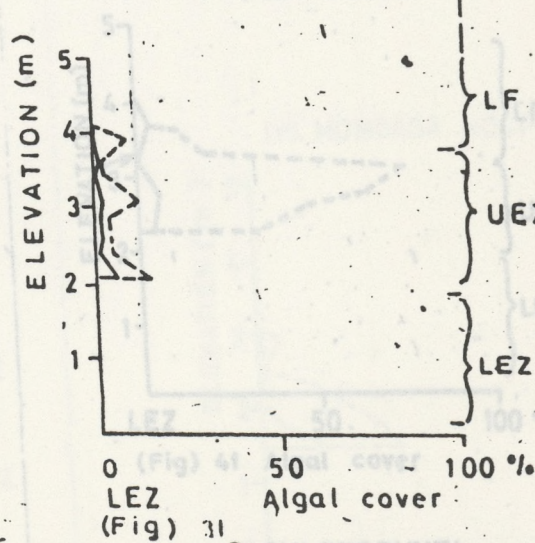
VIIb K. M. F. R. I.



VIII MACKENZIE POINT



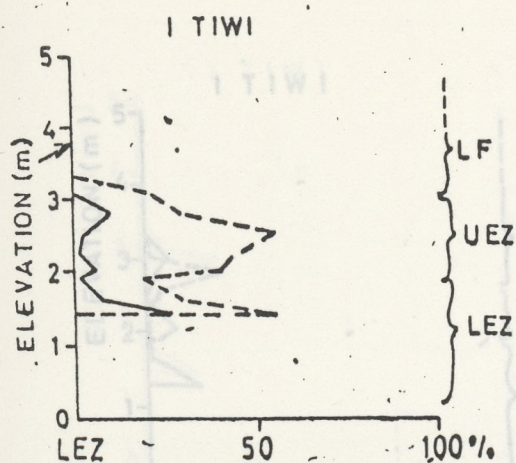
IX NYALI



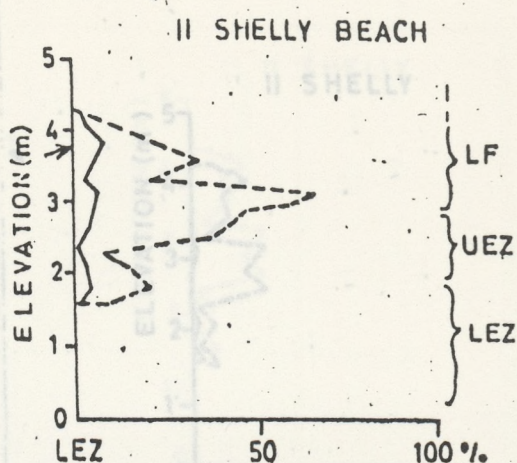
---RHODOPHYTA

---CHLOROPHYTA

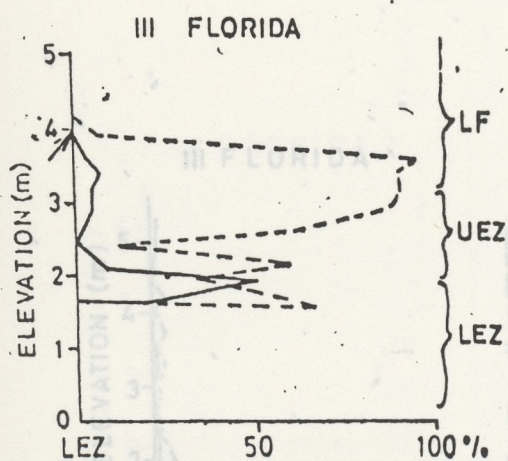




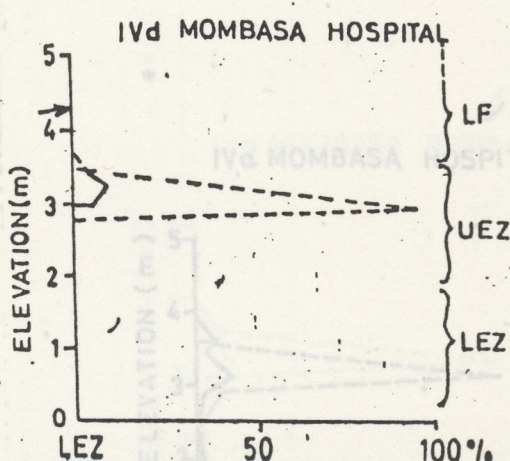
(Fig) 4a Algal cover



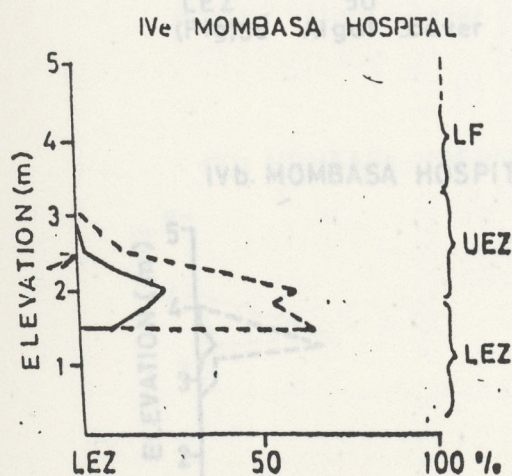
(Fig) 4b Algal cover



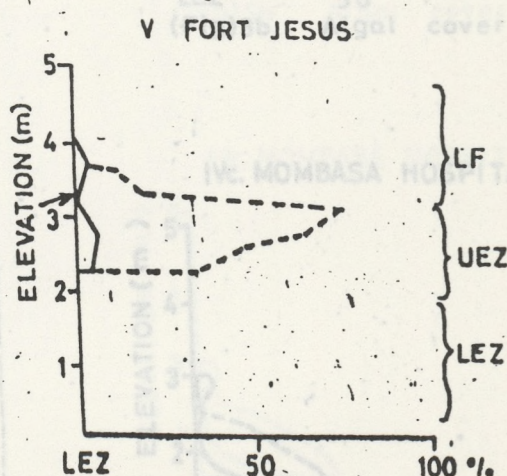
(Fig) 4c Algal cover



(Fig) 4d Algal cover



(Fig) 4e Algal cover

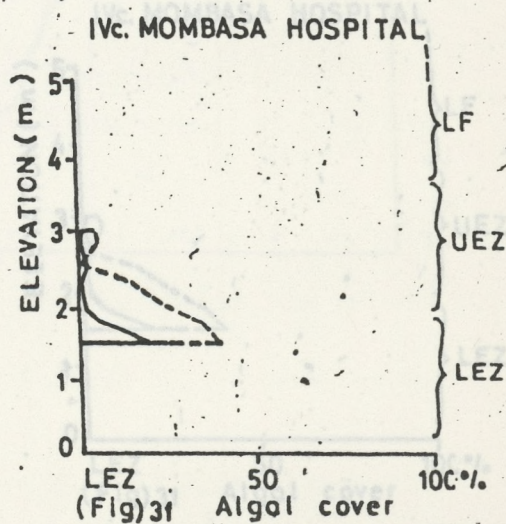
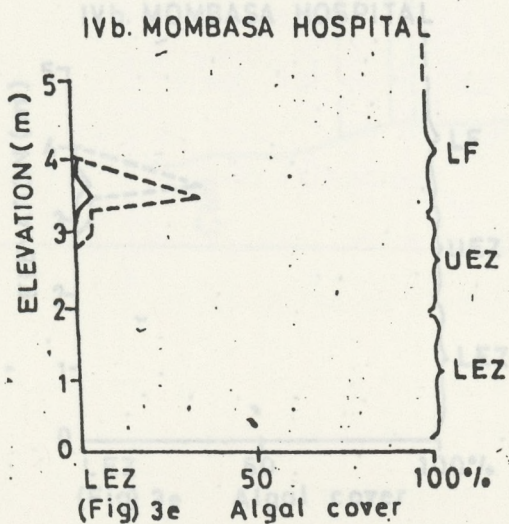
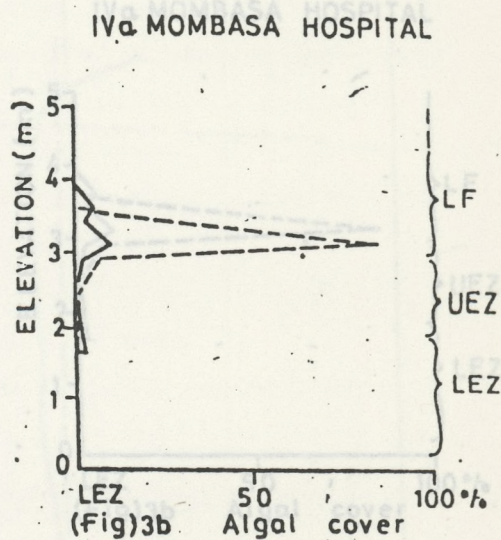
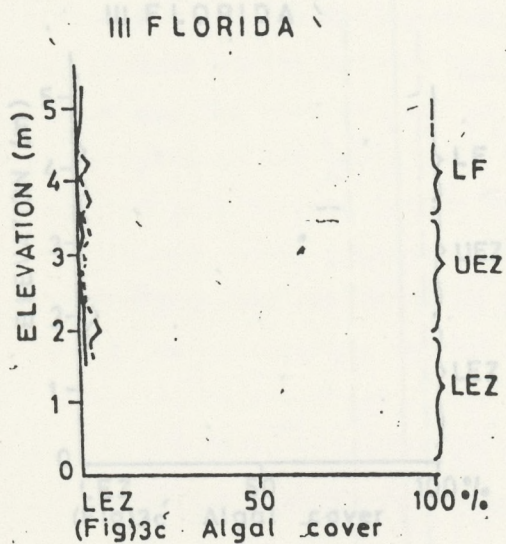
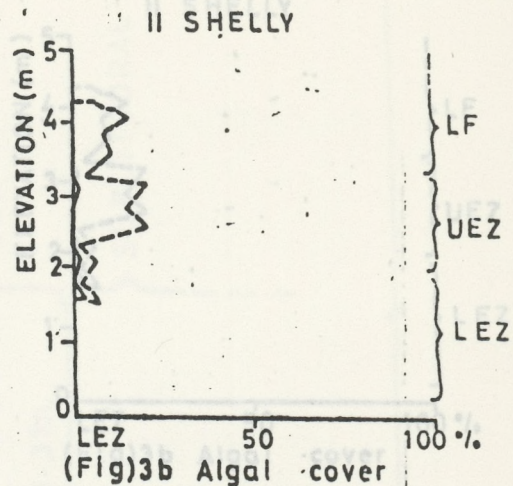
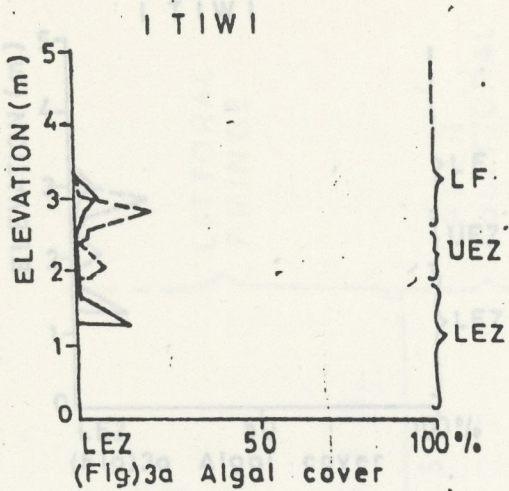


(Fig) 4f Algal cover

--- RHODOPHYTA

— CHLOROPHYTA

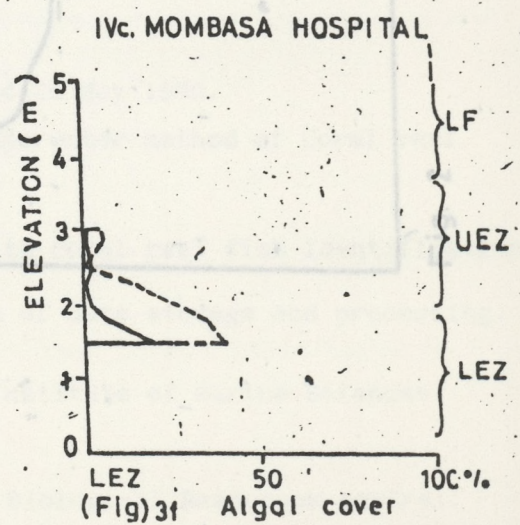
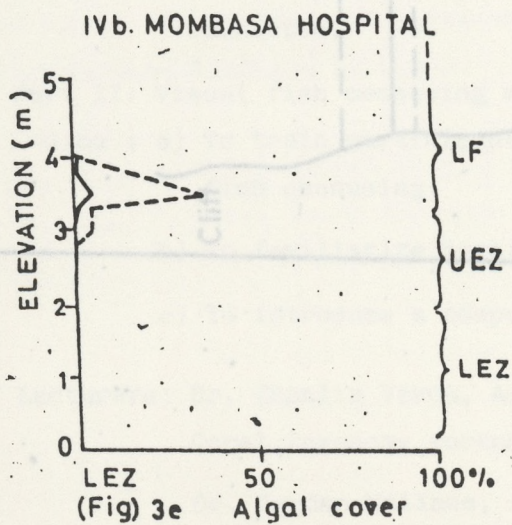
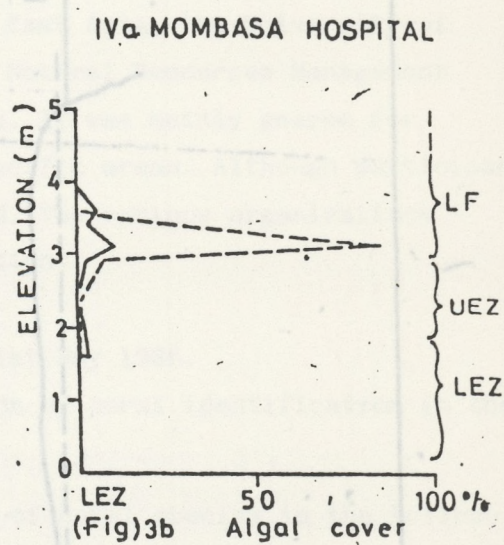
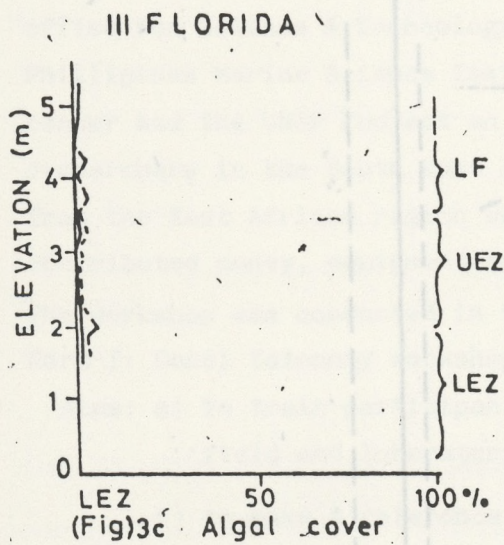
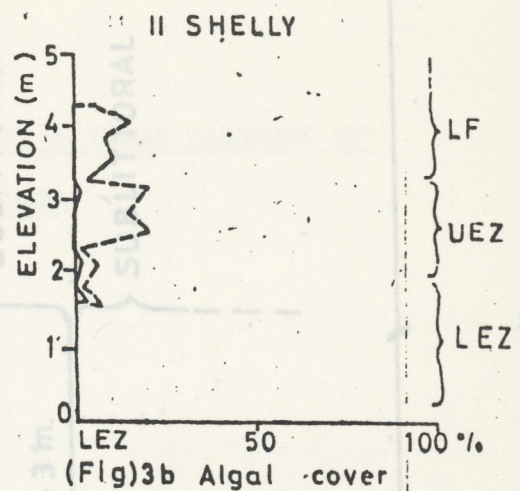
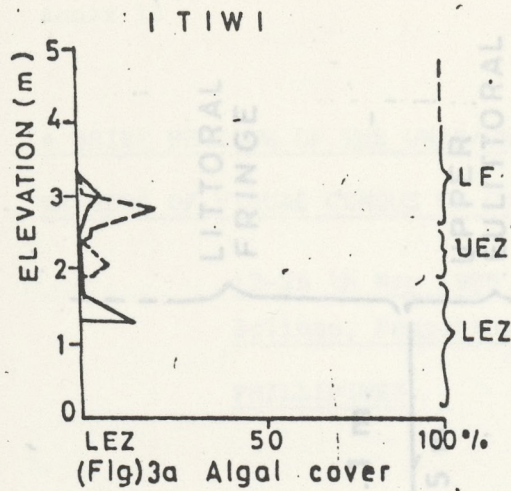




--- RHODOPHYTA

— CHLOROPHYTA





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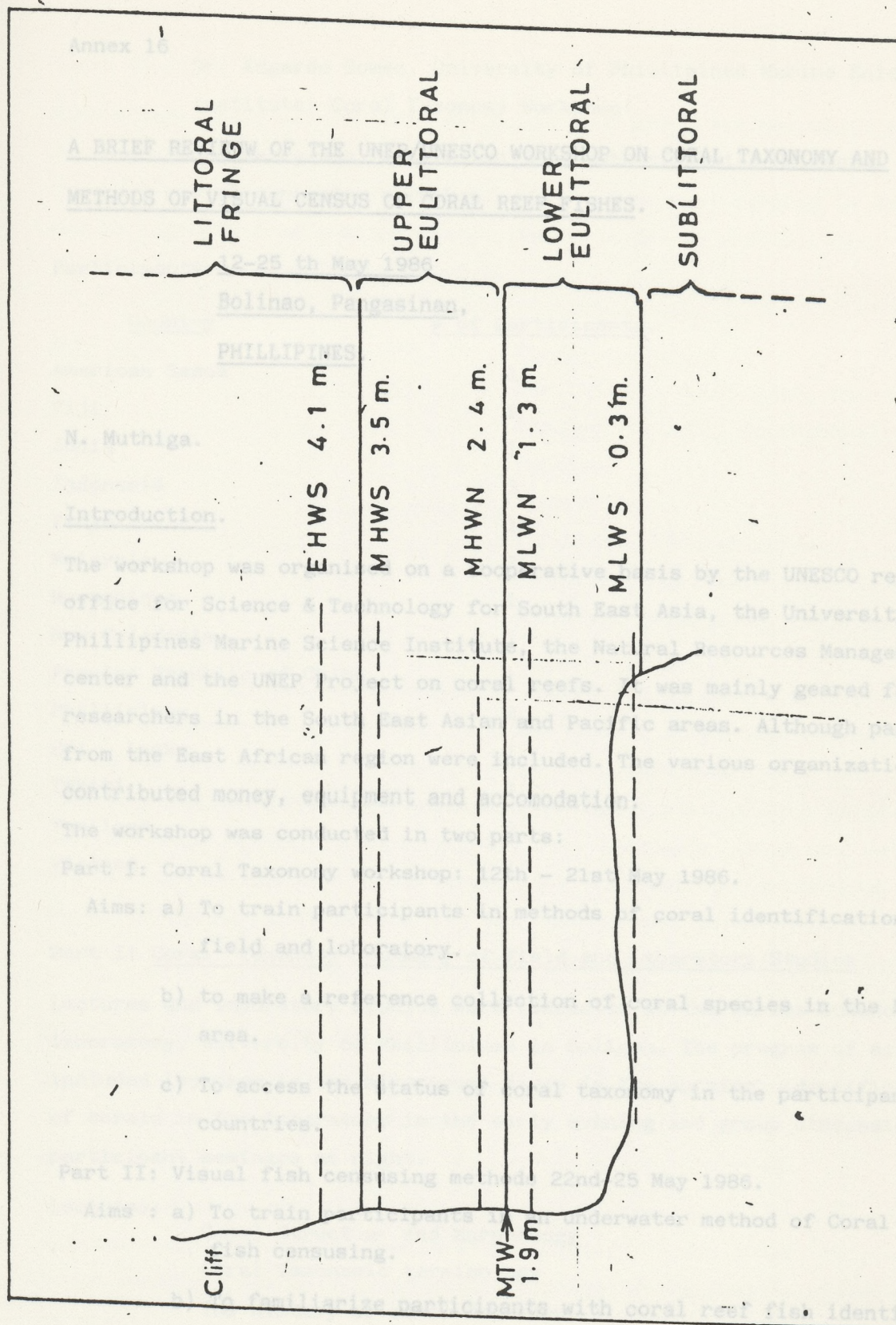


Fig. 2



## Annex 16

Dr. Edgardo Gomez, University of Philippines Marine Science  
Institute: Coral Taxonomy Workshop.

A BRIEF REVIEW OF THE UNEP/UNESCO WORKSHOP ON CORAL TAXONOMY AND  
METHODS OF VISUAL CENSUS OF CORAL REEF FISHES.

Participants: 12-25 th May 1986

Bolinao, Pangasinan,

Country of Participants.

PHILLIPINES.

American Samoa

1

Fiji

2

N. Muthiga.

1

Indonesia

3

Introduction.

1

The workshop was organised on a cooperative basis by the UNESCO regional office for Science & Technology for South East Asia, the University of Philippines Marine Science Institute, the Natural Resources Management center and the UNEP Project on coral reefs. It was mainly geared for researchers in the South East Asian and Pacific areas. Although participants from the East African region were included. The various organizations contributed money, equipment and accomodation.

The workshop was conducted in two parts:

Part I: Coral Taxonomy workshop: 12th - 21st May 1986.

Aims: a) To train participants in methods of coral identification in the field and laboratory.

b) to make a reference collection of coral species in the Bolinao area.

c) To access the status of coral taxonomy in the participants home countries.

Part II: Visual fish censusing methods 22nd-25 May 1986.

Aims : a) To train participants in an underwater method of Coral reef fish censusing.

b) To familiarize participants with coral reef fish identification

c) To introduce a computer method of data storage and processing.

Lecturers: Dr. Charlie Veron, Australian Institute of Marine Sciences:  
Coral taxonomy Workshop.

Dr. Carden Wallace, Australian Biological Resources centre:  
Coral Taxonomy Workshop.



Field study Dr. Edgardo Gomez, University of Phillipines Marine Science  
institute: Coral Taxonomy Workshop.

Participants were divided into group and each group was responsible  
for collect Dr. Garry Rus, Australian Institute of Marine Sciences:

the lecture Fish censusing workshop. visited (see map) ranging in depth  
and to pography from shallow sitty sites (1 - 3m) to vertical drop

Participants: per reefs (up to 30 m).

<u>Country</u>	<u># of Participants.</u>
American Samoa	1
Fiji	2
India	1
Indonesia	3
Kenya	1
Malaysia	3
Mozambique	1
New Caledonia	1
Peoples Republic of China	1
Phillipines	4
Sri - Lanka	1
Tahiti	1
Thailand	3
Vietnam	1

#### Part I: Coral Taxonomy Summary of Field and Laboratory Studies.

Lectures and laboratory studies were conducted at the Marine Science  
laboratory, University of Phillipines in Bolinao. The program of activities  
included lectures in the afternoon; dives in the morning; identification  
of corals in the laboratory in the early evening and group discussions and  
participant seminars at night.

- Lectures:
- Coral Structure and Morphology
  - Coral Taxonomic terminology
  - The history of coral Taxonomy
  - The ecomorph concept
  - Coral distributions patterns and what causes these patterns
  - The coral species concept
  - General coral reef ecology
3. Exposure to research from other countries was thought to be beneficial especially as exchange of contacts, publications and ideas could be encouraged.
4. However, the ecomorph concept and complication of keys for individual areas was thought to require more time.
5. Many of the participants felt that they benefited greatly from the workshop although it was felt that the time was too short for assimilation



### Field studies:

Participants were divided into group and each group was responsible for collection and identification of coral families covered during the lectures. Seven dive sites were visited (see map) ranging in depth and to pography from shallow sitty sites (1 - 3m) to vertical drop (16 m) and deeper reefs (up to 30 m).

### Dive site

### Family collected

1	Merulinidae, Oculinidae, Favidae
2	Trachyphilliidae, Dendrophyllidae
3	Fungidae
4	Acroporidae
5	Poritidae, Siderastreidae
6	Pocilloporidae, Astrocoeniidae, Agariciidae
7	Mussidae, Pectinidae, Caryophyllidae

A total of 83 species were identified comprising 39 genera in 14 families (refer to Appendix I checklist). A comparison of coral species collected in the Bolinao areas with corals from participants home reefs gave the general idea that Bolinao reefs were more diverse than Kenyan, French Polynesian and Sri-lankan reefs. The genera Euphyllia, Plerogyra, Cynarina, Cataphyllia and Lobophyllia are also found deeper than they were on the Bolinao reefs. Since most of the participants did not have extensive reference collections or checklists it was quite difficult to make more detailed comparisons.

### Participants reactions and comments.

1. Most participants including myself felt that they were more competent in coral identification especially in the laboratory and especially where groups like Acropora, Montipora and Goniopora are concerned.
2. It was also generally felt that most participants could now start a reference collection and compile a checklist for their areas. This was felt to be important for a biogeographical picture of the Pacific areas especially to be seen.
3. Exposure to researchers from other countries was thought to be beneficial especially as exchange of contacts, publications and ideas could be encouraged.
4. However, problems associated with the ecomorph concept and complication of keys for individual areas was thought to require more time.
5. Many of the participants felt that they benefited greatly from the workshop although it was felt that the time was too short for assimilation



Part II: Methods of Visual Census of Coral Reef Fishes.

Summary of Field and Laboratory Studies:

Lectures: the technique of visual fish censusing

Lenght-estimation

Transect method

Introduction to data storage and analysis

Field and Laboratory studies:

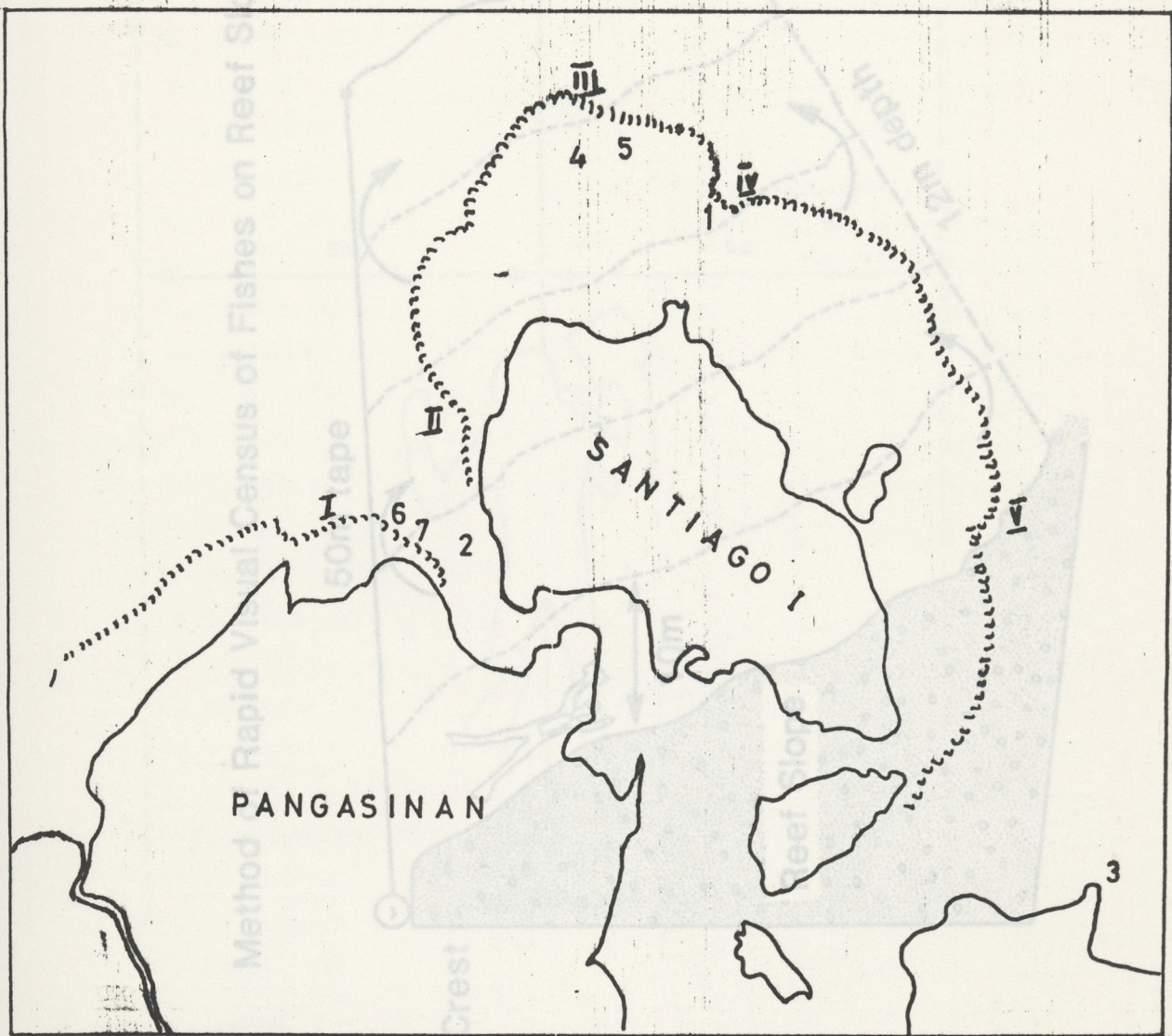
Laboratory studies included familiarization with identification of coral reef fish, lenght estimation training using models of various sizes. In the field a fish familiarization dive, followed by a lenght estimation exercise was conducted. Actual data was collected along transects or reef slopes and reef flats (refer to map). More time was put into learning the technique of fish censusing than actually learning the fish themselves. This method was therefore felt to be more useful for researchers who are already familiar with the fish and want to study their abundance, distribution and access their stock. It is a simple method of swimming along a transect and recording (see data sheet, appendix II) all fish, or those one is interested in along a certain distance (2 -5m) from the line on either side of the line. This can be done snorkelling or with SCUBA.

Participants comments.

1. Most participants felt that they could use the method competently though more practise was needed for lenght estimations.
2. However, although the focus was on learning the technique of visual fish censusing rather than identification of the fish, it was felt that pore time was required for familiarization with the fish before the technique could be meaningful.

*Map showing the dive sites for the Coral Taxonomy Workshop and the Fish censusing work shop (I - II)*



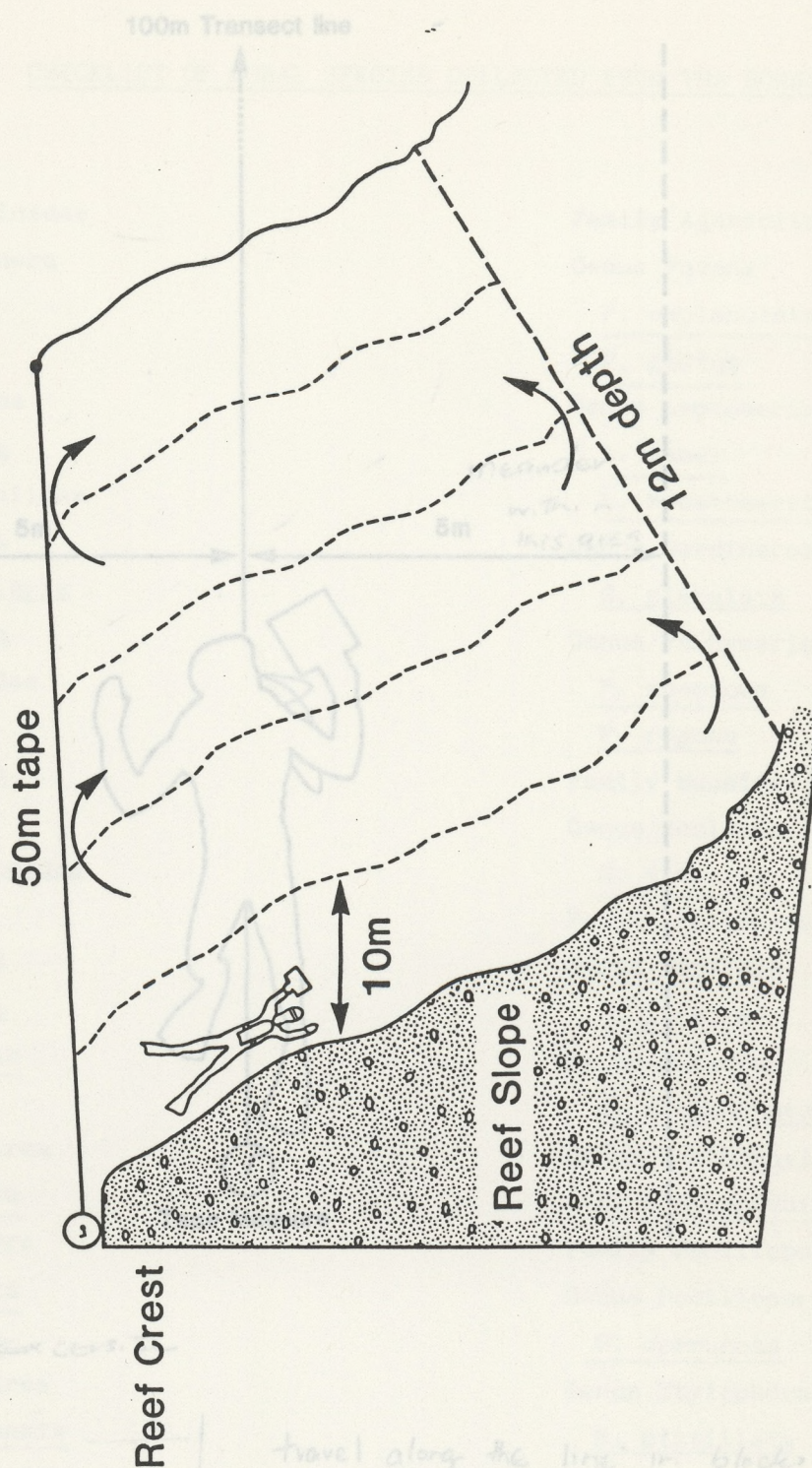


Map showing the dive sites for the Coral Taxonomy Workshop (1-7) and the Fish censusing workshop (I - V)



# Line Transect Method of Census of Fishes to be used with Collection of Coral Data

## Method of Rapid Visual Census of Fishes on Reef Slopes



Reef Crest

Reef Slope

10m

50m tape

12m depth

8m

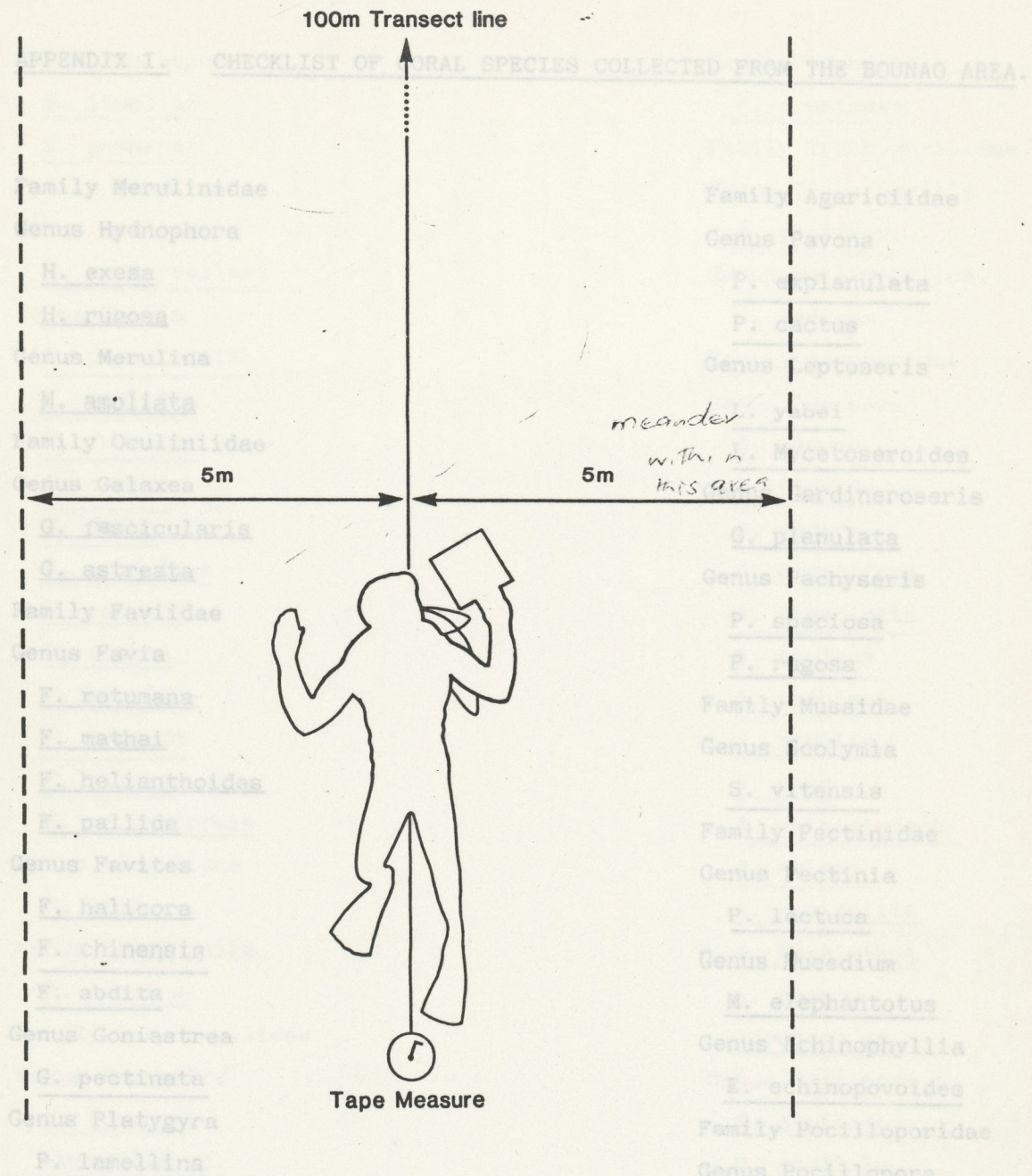
100m Transect line

travel along the line in blocks of 5m each.

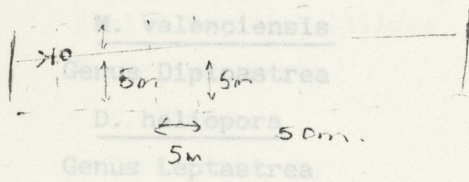
- ①. Lay line, move away from this area for 10m to allow fish to get used to the observer again.



# Line Transect Method of Census of Fishes to be used with Collection of Coral Data



Actual ~~excurs. 50~~ Excurs. 50



travel along the line in blocks of 5m each.

- ①. Lay line, move away from this area for 20 mins to allow fish to get used settle down again



## APPENDIX I. CHECKLIST OF CORAL SPECIES COLLECTED FROM THE BOUNAO AREA.

Family Merulinidae	Family Agariciidae
Genus Hydnophora	Genus Pavona
<u>H. exesa</u>	<u>P. explanulata</u>
<u>H. rugosa</u>	<u>P. cactus</u>
Genus Merulina	Genus Leptoseris
<u>M. ampliata</u>	<u>L. yabei</u>
Family Oculiniidae	<u>L. Mycetoseroides</u>
Genus Galaxea	Genus Gardineroseris
<u>G. fascicularis</u>	<u>G. planulata</u>
<u>G. astreata</u>	Genus Pachyseris
Family Faviidae	<u>P. speciosa</u>
Genus Favia	<u>P. rugosa</u>
<u>F. rotumana</u>	Family Mussidae
<u>F. mathai</u>	Genus Scolymia
<u>F. helianthoides</u>	<u>S. vitensis</u>
<u>F. pallida</u>	Family Pectinidae
Genus Favites	Genus Pectinia
<u>F. halicora</u>	<u>P. lactuca</u>
<u>F. chinensis</u>	Genus Mucedium
<u>F. abdita</u>	<u>M. elephantotus</u>
Genus Goniastrea	Genus Echinophyllia
<u>G. pectinata</u>	<u>E. echinopovoides</u>
Genus Platygyra	Family Pocilloporidae
<u>P. lamellina</u>	Genus Pocillopora
<u>P. sinensis</u>	<u>P. verrucosa</u>
Genus Montastrea	Genus Stylophora
<u>M. valenciensis</u>	<u>S. pistillata</u>
Genus Diploastrea	Genus Seriatopora
<u>D. heliopora</u>	<u>S. hystrix</u>
Genus Leptastrea	Family Fungiidae contd
<u>L. purpurea</u>	Genus Sandalolitha
<u>L. pruinosa</u>	<u>S. robusta</u>
Genus Cyphastrea	Genus Lithophyllon
<u>C. microphthalama</u>	<u>L. lobata</u>
<u>C. chalcidum</u>	
<u>G. stokesi</u>	
<u>G. djiboutiensis</u>	



## Genus Echinopora

E. lamellosaE. gemmacea

## Family Fungiidae

## Genus Cycloseris

C. sommervellaei

## Genus Fungia

F. paumatensisF. echinataF. fungitesF. coronaF. danaeF. granulosaF. repandaF. scabraF. concinnaF. horridaF. simplexF. actinoformis

## Genus Herpolitha

H. limax

## Genus Polyphyllia

P. talpina

## Family Caryophyllidae

## Genus Euphyllia

E. ancoraEuphyllia sp.

## Genus Plerogyra

P. sinuosa

## Family Dendrophylliidae

## Genus Turbinaria

T. frodensTurbinaria sp.

## Family Poritidae

## Genus Porites

P. rus

## Genus Goniopora

G. minorG. stokesiG. djiboutiensis

## Genus Podabacia

P. crustacea

## Family Trachyphyllidae

## Genus Trachyphyllia

T. geoffreyi

## Genus Wellsophyllon

W. radiata

## Family Acroporidae

## Genus Acropora

A. nasutaA. floridaA. asperaA. digitiferaA. divaricataA. aculeusA. excelsaA. nobilisA. nanaA. valencienensiA. selagoA. variabilisA. HyacinthusA. formosaAcropora sp.

## Genus Montipora

M. digitataM. stellataM. peltaformisM. arguituberculata







# APPENDIX II

Reefs:  
Other Information:

Habitat:

FISH CENSUS DATA SHEET  
Depth: length

Date:

Time:

Tides:

**'Target Species'**

		Estimate total lng.(cm) and/or actual counts					
I. SERRANIDAE (Groupers)							
1.	Cephalopholis urodelus						
2.	C. pachycentron						
3.	C. sexmaculatus						
4.	C. miniatus						
5.	C. argus						
II. LUTJANIDAE (Snappers)							
1.	Lutjanus decussatus						
2.	Lutjanus spp.						
3.	Macolor niger						
III. LETHRINIDAE (Emperor Bream)							
1.	Lethrinus harak						
2.	Lethrinus spp.						
IV. HAEMULIDAE (Sweetlips)							
1.	Plectrophychus chaetodontoides						
2.	P. goldmani						
3.	P. orientalis						
V. CARANGIDAE (Jacks)      SCOMBRIDAE (Tunas)							
VI. ACANTHURIDAE (Surgeonfishes)							
1.	Acanthurus bleekeri						
2.	A. mata						
3.	A. olivaceus						
4.	Acanthurus spp.						
5.	Naso lituratus						
6.	Naso spp.						
VII. SIGANIDAE (Rabbitfishes)							
1.	Siganus spinus						
2.	S. corallinus						
3.	S. vulpinus						
VIII. MULLIDAE (Goatfishes)							
1.	Parupeneus trifasciatus						
2.	P. barberinus						
IX. LABRIDAE (Wrasses)							
1.	Choerodon anchorago						
2.	Hemigymnus melapterus						
3.	H. fasciatus						
4.	Cheilinus celebicus						
5.	C. diagramma						
6.	C. rhodochrous						
7.	C. trilobatus						

**'Indicator Species'**

X. CHAETODONTIDAE (Butterflyfishes)		Actual Counts									
1.	Chaetodon adiergastos										
2.	C. baronessa										
3.	C. bennettii										
4.	C. citrinellus										
5.	C. kleini										
6.	C. mertensii										
7.	C. punctatofasciatus										
8.	C. speculum										
9.	C. trifascialis										
10.	C. vagabundus										
11.	Forcipiger longirostris										
12.	Heniochus acuminatus										
13.	H. chrysostomus										
14.	H. varius										
Numerically dominant Major Families		1	2-4	5-16	17-44	45-124	125-250	251-500	501-1000	1001-16384	
XI. ACANTHURIDAE (Surgeonfishes)											
1.	Ctenochaetus striatus										
2.	C. binotatus										
3.	A. glaucoparietus										
4.	A. thompsoni										
5.	Zebрасoma scopas										
XII. CAESIONIDAE (Fusiliers)											
1.	Pterocaesio pisang										
2.	C. cuning										
XIII. POMACENTRIDAE (Damselfs)											
1.	Chromis lepidolepis										
2.	C. margaritifera										
3.	C. ternatensis										
4.	Neopomacentrus spp.										
5.	P. thracotaenialis										
6.	P. lacrymatus										
7.	P. amboinensis										
8.	P. bankanensis										
9.	P. flavicauda										
LABRIDAE (Wrasses)											
1.	Anthias										
2.	Cirrhitilabrus spp.										
3.	Epibulus insidiator										
4.	Gomphosus varius										
5.	Thalassoma hardwickei										
6.	T. janseni										
7.	T. lunare										
XIV. SCARIDAE (Parrotfishes)											
1.	Centropyge vrolikii										
XV. POMACANTHIDAE (Anglefishes)											
1.	Centropyge vrolikii										

Other information

ie: % coral cover along line

% hard substrate

% Sgk corals etc.





# F.A.M.E.

POSTGRADUATE  
TRAINING COURSE  
ON **FUNDAMENTAL**  
AND **APPLIED**  
**MARINE**  
**ECOLOGY**



## ORGANIZATION :

**F.A.M.E.** is an interuniversity postgraduate training course for scientists from developing countries, sponsored by A.B.O.S., the Belgian Organization for Development Cooperation. Courses are given by specialists in marine ecology from different universities and institutes. The Free University of Brussels (V.U.B.) is the host institution. The courses are given in English and are organized every 2 years.

## PROGRAM :

During the first year, the students attend a number of theoretical courses on various ecological topics (see list). Visits to different laboratories and contacts with specialists allow the students to become acquainted with the different specializations in the field of marine ecology. The second year, students carry out a research program related to the requirements and possibilities of their own country. This leads to the writing of a thesis. At the end of the program, students obtain a degree of «Master in Fundamental and Applied Marine Ecology».

## REGISTRATION :

Candidates can obtain information and application forms at the belgian diplomatic office in their own country. Further information may be obtained at the **F.A.M.E.** secretariat :

V.U.B. (Fac. WE)  
Laboratory of Systematics  
and Ecology – V.U.B.

Pleinlaan 2

1050 Brussel – Belgium

Tel : (0)2/641.34.02 or 641.34.09

## CONDITIONS OF ADMITTANCE :

- Applicants should at least have B.Sc. degree plus experience or a M.Sc.
- Maximum age in principle 30.
- Good knowledge of English is required.

## PERSPECTIVES :

It is envisaged that, having obtained the Master's Degree, trainees return to their country to become employed in marine ecological research or management activities.

## LIST OF COURSES AND RESEARCH FIELDS :

### First Year

	Hours
1. General Oceanography	30
2. Biological Oceanography	15
3. Legislation and Ocean	15

### MARINE CHEMISTRY

4. Biochemical Cycles	15
5. Analytical Chemistry	15
6. Water-Sediment Interactions	15

### MARINE BIOLOGY

7. Population Dynamics	15
------------------------	----

8. Marine Bacteriology	15
9. Phytoplankton	15
10. Zooplankton	15
11. Marine Macrophytes	15
12. Marine Invertebrates	15
13. Benthos	15

## FISHERIES

14. Importance and Evolution of Fisheries and Fishery Techniques	15
15. Population Dynamics of Exploited Fish Stocks	15
16. Population Dynamics of Commercial Invertebrates	15

## PHYSIOLOGY

17. Endocrinology	15
18. Ecophysiology	15

## POLLUTION

19. Ecotoxicology	15
20. Biological Aspects of Pollution	15
21. Chemical Aspects of Pollution	15

## ESTUARIES

22. Biology of Estuaries	15
23. Hydrodynamics of Estuaries	15
24. Chemistry of Estuaries	15

## MARICULTURE

25. General Aspects of Mariculture	15
------------------------------------	----



26. Culturing of Algae and Mollusks	15
27. Biology and Culturing of Artemia	15
28. Culturing of Fishes	15

## **MARINE GEOLOGY**

29. Marine Stratigraphy	15
30. Sedimentology	15
31. Applied Oceanology	15

## **STATISTICS, COMPUTER SCIENCE AND MODELLING**

32. Introduction to Computer Science	15
33. Introduction to Computer Programming	30
34. Modelling and Management	15
35. Ecological Modelling	15

## **PRACTICAL EXERCICES AND FIELD WORK**

100

## **Second Year**

- 200 hours of courses chosen among the curricula of the organizing universities and approved by the organizing committee.
- 400 hours of thesis work chosen among the topics that will be proposed.



## **1. Equipment needed on the field for a total sampling.**

### **1/ - Cool-box with ice**

- Thermometer

- Refractometer

- Oxygen meter

- Tissue paper

- Paper, labels, pencil, water-proof marker pen.

### **2/ Primary production**

- 50 or 100 ml BOD bottles:-

- 3 f

- 3 bl

- 3 bottles for each depth : all these for incubation in situ,

- Strings and floater for the incubation in situ

- Magnesium sulphate (  $MgSO_4$  ) and Iodine (  $KIO_3$  ) solution

- 2 pipettes with pear ( 1 ml )

- Small box to store the fixed samples.

### **Part I**

1. If the filtration has to be done afterwards in the lab :

- 1 l plastic bottle

ii. If the filtration can be done immediately in the field :

## **Instruction Manual on Field and Laboratory Sampling work for Lab Assistants**

- measuring cylinder of 500 ml

- glass-fibre filters ( Ø: 4.7 cm )

- pincet ( without sharp points )

- aluminium foil and labels

- plastic bag

by: Dr. Els Martens

- distilled water to kmfri, mombasa

july 1986

### **4/ POC**

1. If the filtration has to be done afterwards in the lab :

- 500 ml plastic bottle

ii. If the filtration can be done immediately in the field :

- idem as for 3/ (ii).

### **5/ Seaton**

- clean 1 l glass bottles

- lugol solution

### **6/ Nutrients**

- 250 ml plastic bottles ( 2 for each analysis; when samples can be taken in duplicate then 6 bottles )

- Mercuric chloride solution for nitrate-nitrite fixation

- Phenol solution for ammonia fixation

- Chloroform and pipette of 1 ml with pear for phosphate-silicate fixation.

### **7/ Salinity**

- 250 ml plastic bottles ( 2 )

### **8/ Plankton**

- Plankton nets

- Sieve 55 micron

- Formalin 5%

- Specimen bottles.



## 1. Equipment needed on the field for a total sampling.

- 1/ - Cool-box with ice
- Thermometer
- Secchi disc
- Refractometer
- Oxygen meter
- Tissue paper
- Paper, labels, pencil, water-proof marker pen.

## 2/ Primary production

- 50 or 100 ml BOD bottles:-
  - 3 for time 0
  - 3 black pointed bottles
  - 3 bottles for each depth : all these for incubation in situ,
- Strings and floater for the incubation in situ
- Magnesium sulphate (  $MgSO_4$  ) and Iodine (  $KIO_3$  ) solution
- 2 pipettes with pear ( 1 ml )
- Small box to store the fixed samples.

## 3/ Chlorophyll

- i. If the filtration has to be done afterwards in the lab :
  - 1 l plastic bottle
- ii. If the filtration can be done immediately in the field :
  - millipore syringe
  - measuring cylinder of 500 ml
  - glass-fibre filters ( Ø: 4.7 cm )
  - pincet ( without sharp points )
  - aluminium foil and labels
  - plastic bag
- distilled water to rinse the syringe after each sampling

## 4/ POC

- i. If the filtration has to be done afterwards in the lab :
  - 500 ml plastic bottle
- ii. If the filtration can be done immediately in the field :
  - idem as for 3/ (ii).

## 5/ Seston

- clean 1 l glass bottles
- lugol solution

## 6/ Nutrients

- 250 ml plastic bottles ( 2 for each analysis; when samples can be taken in duplicate then 6 bottles )
- Mercuric chloride solution for nitrate-nitrite fixation
- Phenol solution for ammonia fixation
- Chloroform and pipette of 1 ml with pear for phosphate-silicate fixation.

## 7/ Salinity

- 250 ml plastic bottles ( 2 )

## 8/ Plankton

- Plankton nets
- Sieve 55 micron
- Formalin 5%
- Specimen bottles.



### III. Chlorophylls

## II. Primary Production

### 1/ Field-work

- i. Rinse the 50 ml or 100 ml BOD bottles twice with seawater just before sampling
- ii. Fill the bottles with the seawater
- iii. Close well without air bubbles
- iv. For time 0 ( to ) fix immediately :
  - +0.2 ml (0.4 ml for 100 ml sample)  $\text{MnSO}_4$
  - +0.2 ml (0.4 ml for 100 ml sample)  $\text{KINaOH}$Pipette just under water surface !  
Shake well after closing the bottle
- v. For incubation in situ at several depths, fix the string with the bottles ( at the raft ) with floater.
- vi. Fix the samples after 2 hours incubation for Gazi creek and 4 hours for Tudor creek ( see 4 ).
- vii. After fixation the bottles should be kept in the dark.

### 2/ Lab work

- i. After settlement of the precipitation, add 0.2 ml ( 0.4 ml ) concentrated  $\text{H}_2\text{SO}_4$
- ii. Close bottle and shake well
- iii. Titrate 50 ml with  $\text{Na}_2\text{S}_2\text{O}_3$  ( 0.01 N ) to light yellow
- iv. Add some starch : the solution becomes blue. Put a white blank paper under the Erlenmeyer to see better the colour change by further titration
- v. Titrate slowly further until colourless ( one drop  $\text{Na}_2\text{S}_2\text{O}_3$  can be too hot at much and will change the measurement )
- vi. Take the emptied syringe off and open it again
- vii. Repeat 3-6 till the 500 ml are filtered over the same glass fibre filter
- viii. Put the filter with the pincet in aluminium foil and label : date, time of sampling, and volume filtered.
- ix. Store the filters enveloped in aluminium foil in a plastic bag in the cool-box.



### III. Chlorophylls

#### 1/ Field-work

- i. Rinse twice the 500 ml plastic bottle with sea-water
- ii. Fill the bottle with sea-water
- iii. Store sample in cool-box with ice

#### 2/ Lab-work

- i. Filter sample on glass fibre filter with millipore vacuum pump
- ii. Put filter into centrifuge tube ( use a pincet ! ) + 10 ml 90% acetone
- iii. Store in a fridge for 24 hours
- iv. Centrifuge the tubes for 10 minutes at 3000 rpm ( see report by M. Tackx for use of centrifuge or manual )
- v. Take supernatant with pipette out of centrifuge tube and fill a spectrophotometer cell
- vi. Measure extinction of the sample at 630 , 645, 665 micron wavelengths

Reference and sample cuvet must always be placed in the spectrophotometer with same side facing the light beam ( see report by N. Daro for use of spectrophotometer )

If filtration can be done immediately in the field with a millipore-syringe, then :-

- i. Take 500 ml sea-water with measuring cylinder
- ii. Put carefully with pincet one glass fibre filter in the filter holder ( take care for the 2 orange rubber rings ! )
- iii. Open the syringe and fix it on the filter holder
- iv. Fill the syringe with sample water
- v. Filter this volume slowly, holding the system at the syringe and not at the filter holder ( top of syringe will break off by moving )
- vi. Take the emptied syringe off and open it again
- vii. Repeat 3-6 till the 500 ml are filtered over the same glass fibre filter
- viii. Put the filter with the pincet in aluminium foil and label : date, time of sampling, and volume filtered.
- ix. Store the filters enveloped in aluminium foil in a plastic bag in the cool-box.



#### IV. POC

##### 1/ Field-work

- i. Rinse the 250 - 1000 ml plastic bottles with sea-water
- ii. Fill the bottles with sea-water taken at about 0.5 m beneath water-surface
- iii. Store sample in cool-box with ice. Stir and shake, to give a light brown colour

##### 2/ Lab-work

- i. Filter sample on glass fibre filter (  $\phi=4.7$  cm )
- ii. Pack filter in aluminium foil. Label : date, time of sampling, tide, and volume filtered ) to be stored for a minimum of 3 days in a fridge for
- iii. Store in deep-freeze in petri-dish
- iv. Further analysis will be done by Mr. Kazungu, so inform him about the sampling.

Reduce the volume to less than 100 ml

- \* If filtration can be done immediately in the field with a millipore syringe then :-

- i. Take 300 ml sea-water with measuring cylinder
- ii. See ( III ), filtration method for chlorophyll )
- vi. Store in fridge for a minimum of 2 days
- vii. Reduce volume to 10 ml ( see 2 )
- viii. Store sample of 10 ml in closed glass container in the dark in the fridge ( = label ! )
- ix. Add some extra lugol every two weeks
- x. If stored for a longer period, ( more than 2 months ) add 1 ml 40% formaline



## V. Seston

The analysis of the samples should be carried out immediately after sampling. If not possible, they should be fixed and deep-frozen ( well labelled ).

### 1/ Field-work

- i. Rinse the 1 l glass bottle several times with sea-water
- ii. Fill the bottle with sea-water taken at about 0.5 m beneath water-surface
- iii. Add 2-3 ml lugol solution for fixation and shake, to give a light brown colour
- iv. Store samples in cool-box with ice

### 2/ Lab-work

- i. The samples have to be stored for a minimum of 3 days in a fridge for sedimentation of detritus and particles
- ii. Remove supernatant with pump, with tube-end just below the water surface in the bottle.  
Reduce the volume to less than 100 ml
- iii. Shake and pour into 100 ml measuring cylinder. Rinse bottle with tap-water ( few mls ) and add this to the measuring cylinder
- iv. Adjust the volume to 100 ml with tap-water
- v. Cover cylinder with aluminium foil ( + label ! )
- vi. Store in fridge for a minimum of 2 days
- vii. Reduce volume to 10 ml ( see 2 ) immediately once back from the field. The
- viii. Store sample of 10 ml in closed glass container in the dark in the fridge ( = label ! )
- ix. Add some extra lugol every two weeks
- x. If stored for a longer period, ( more than 2 months ) add 1 ml 40% formaline

### 1/ Field-work

- i. Rinse a 250 ml bottle several times with sea-water
- ii. Fill the bottle with sea-water
- iii. Store sample in cool-box with ice

### 2/ Lab-work

The analysis should be done in the lab immediately after sampling.



## VI. Nutrients

The analysis of the samples should be carried out immediately after sampling. If this is not possible, they should be fixed and deep-frozen ( well labelled ).

### 1/ Field-work

Rinse the 250 ml plastic bottles several times with the sea-water.

- i. Nitrate-Nitrite
  - a) Fill 250 ml bottle with sea-water
  - b) Add about 5 drops of Mercuric chloride solution
  - c) Store sample in cool-box with ice
- ii. Ammonia
  - a) Fill 250 ml bottle with sea-water
  - b) Add 1 ml chloroform ( with pipette )
  - c) Store sample in cool-box with ice
- iii. Phosphate and Silicate
  - a) Fill 250 ml bottle with sea-water
  - b) Add about 5 drops Phenol solution
  - c) Store sample in cool-box with ice

### 2/ Lab-work

The samples should be deep-frozen immediately once back from the field. The analysis will done by Mr Kazungu, so inform him about the samples.

## VII. Salinity

### 1/ Field-work

- i. Rinse a 250 ml bottle several times with sea-water
- ii. Fill the bottle with sea-water
- iii. Store sample in cool-box with ice

### 2/ Lab-work

The analysis should be done in the lab immediately after sampling.



KENYA MARINE AND FISHERIES RESEARCH INSTITUTE  
KENYA BELGIUM COOPERATION IN MARINE SCIENCES

Training courses for Laboratory Technicians

CONTENTS :

Introduction

Chapter 1 : Glassware

Part II/1.

Chapter 2 : Small Equipment

Chapter 3 : Heavy equipment

KMFRI, 1986

Chapter 4 : Chemicals

Course written by :

Chapter 5 : Laboratory safety

Mr. P. Pissierssens



KENYA MARINE AND FISHERIES RESEARCH INSTITUTE  
KENYA BELGIUM COOPERATION IN MARINE SCIENCES  
Training course for Laboratory Technicians

Introduction

During this training course you will become acquainted with different kinds of equipment, commonly used in Scientific Laboratories.

CONTENTS :

Introduction

CHAPTER 1 : GLASSWARE

Chapter 1 : Glassware

1.1. Glass

Chapter 2 : Small Equipment

Chapter 3 : Heavy equipment

Chapter 4 : Chemicals

Chapter 5 : Laboratory safety

1.2 Glassware

We will divide the glassware in 8 types :

- 1.2.a Bottles
- 1.2.b Beakers
- 1.2.c Kolves
- 1.2.d Volume flasks
- 1.2.e Measuring cylinders
- 1.2.f Burettes
- 1.2.g Pipets

We will also look at some special glassware :

1.2.h Filtration equipment

1.2.i To end some miscellaneous glassware



## Introduction

During this training course you will become acquainted with different kinds of equipment, commonly used in Scientific Laboratories. We will make distinction between Glassware, Small equipment and Heavy Equipment

### CHAPTER 1 : GLASSWARE

#### 1.1 Glass

There are 2 types of glass used for glassware : normal glass and heat-resistant glass ( also known under the brand-name PYREX ). You can always easily find out the type of glass a piece of glassware is made out : heat-resistant glassware is marked with a white circle or rectangle. Sometimes you find the 'PYREX' mark printed on the glassware.

In not heat-resistant glass you should never pour hot liquids or dilute strong acids or bases. ( This because heat is produced with the dilution process ).

#### 1.2 Glassware

We will divide the glassware in 8 types : a stopper completely. The internal pressure might cause the explosion of the bottle.

- 1.2.a Bottles
- 1.2.b Beakers
- 1.2.c Kolves
- 1.2.d Volume flasks
- 1.2.e Measuring cylinders
- 1.2.f Burettes
- 1.2.g Pipets

We will also look at some special glassware :

Kolves are used as reaction vessels. They come in 3 forms :

- 1/ Round kolve with flat bottom
  - 2/ Round kolve with flat bottom
  - 3/ Erlenmeyer
- 1.2.h Filtration equipment
- 1.2.i To end some miscellaneous glassware



### 1.2.c.1 Round kolve with round bottom

These are used to heat or boil liquids with gas burners or electric (distilling processes).

### 1.2.a Bottles

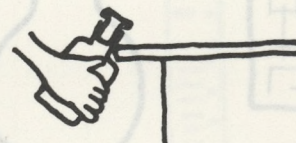
When boiling liquids for distillation, it is advisable to use

Bottles are used to keep liquid chemicals or to preserve samples. They are made of glass (usually normal glass, transparent or brown) or plastic (e.g. Polyethylene). The stopper can be a plastic stopper or a glass stopper. For chemicals, glass bottles and glass stoppers are preferred, especially with corroding liquids (acids!!). Organic solvents (e.g. acetone, hexane, toluene, ...) should not be kept or poured into plastic recipients, as the plastic will 'melt'. When carrying a bottle, never carry it only by the neck! Always support the bottom of the flask! Otherwise, the neck might break off, the chemical + the bottle landing on your feet and legs!!

Sometimes, glass stoppers get stuck in the neck of the bottle. In this case, knock the neck of the bottle and the stopper GENTLY against the edge of the table, while rotating the bottle.

If this doesn't help, put the bottle upside down in a beaker and leave it that way for a night. Next day, turn the beaker with the bottle and try to remove the stopper, if necessary with the 'knock method'.

When heating a liquid, never shut a bottle with a stopper completely. The internal pressure might cause the explosion of the bottle.



### 1.2.b Beakers

Beakers are used to take a volume of liquid, when the precision of the volume is not important. We have sizes of glass beakers and sizes of plastic beakers.

### 1.2.c Kolves

Kolves are used as reaction vessels. They come in 3 forms:

- 1/ Round kolve with round bottom
- 2/ Round kolve with flat bottom
- 3/ Erlenmeyer kolve

All the above kolves exist with two neck-types: normal and . The latter are used in combination with other glassware, which fits into the neck of the kolve.



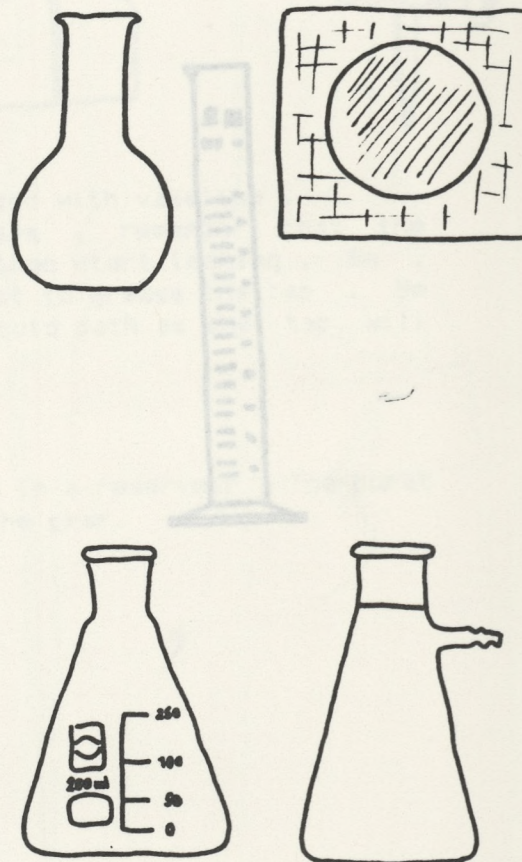
### 1.2.c.1 Round Robin

Remark : only use these flasks when you need to take a very precise volume : do not use them as storage flasks .

1.2.c.2 Round kolve with flat bottom

For heating these kolves with a gas burner , it is advisable to use asbestos frames , to protect the kolve against local overheating . This is not necessary when heating with electric hot plates .

### 1.2.c.3 Erlenmeyer kolves



• All the above kolves exist with two neck-types : normal and . The latter are used in combination with other glassware , which fits into the neck of the kolve .



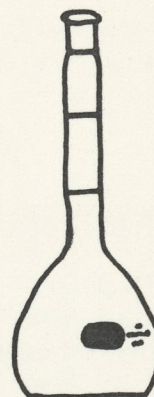
### 1.2.d Volume flasks

Volume flasks are used to take a very precise quantity of a liquid. For example : We have a volume flask for 50-55 ml : the precision is 0,01 ml. Furthermore , with this volume flask you can choose between two volumes : 50 or 55 ml ( see the marks )

Remark : remember the meniscus when reading the volume !!

Remark : only use these flasks when you need to take a very precise volume : do not use them as storage flasks .

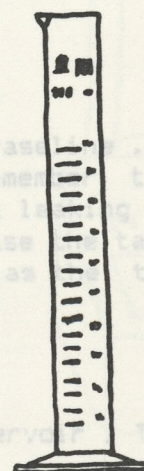
Preferably , do not use strong acids or bases.



### 1.2.e Measuring cylinders

Measuring cylinders are used to measure a volume of a liquid with a precision of  $\pm 0.75\%$  . They are available in plastic or glass .

Remark : When working in the field , it is advisable to use plastic measuring cylinders . (They don't break as easily as glass !! )



Making precise measurements :

Example : you have a volume of  $\pm 170$  ml . In which type of cylinder should you measure it ? You can choose between a cylinder of 500 , 1000 or 250 ml . Answer : use the 250 ml cylinder . If you use the 500 ml cylinder , the precision will be smaller .

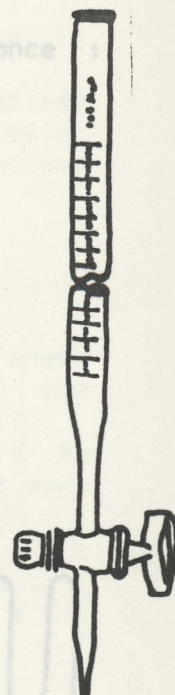
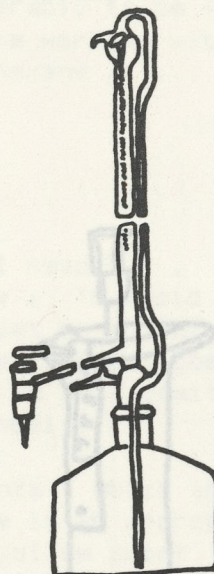


## 1.2.g Pipettes

### 1.2.f Burettes

Burettes are used for titrations . We have two types : simple buret and automatic buret .

- Measuring pipet
- Bulb pipet
- Automatic pipet



#### 1.2.f.1 Simple buret

Remark : the tap of the buret has to be greased with vaseline .

Warning : When using strong acids or bases , remember that the vaseline will be destroyed : the buret will then start leaking . So , when you finished your work , do not forget to grease the tap . Be careful though not to put grease in the liquid path as the tap will then be blocked .

#### 1.2.f.2 Automatic buret

In this type of buret , the liquid is forced in a reservoir . The buret can be filled with that liquid by pressing the pear.

Measuring pipet

Bulb pipet

Automatic pipet



### 1.2.g Pipettes

Pipets come in two materials : plastic (can only be used once : disposable) and glass (which have to be cleaned).

There are three different pipet types :

- Measuring pipet
- Bulb pipet
- Automatic pipet



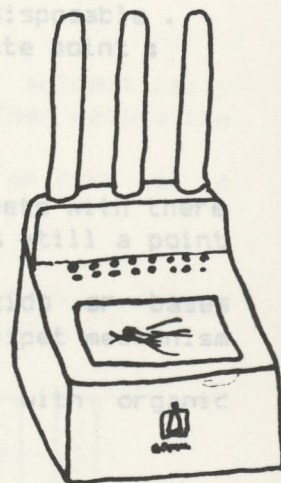
Measuring pipet



Bulb pipet



Automatic pipet





The automatic pipet is the most accurate ( if used the proper way ! ), the measuring pipet the least accurate . The accuracy of the pipet is always printed on the pipet .

Measuring pipets or bulb pipets are preferably to be filled and emptied with a pipet pear . Especially if you are working with strong acids or bases , organic solvents ( acetone , hexane , ... ) or poisonous liquids in general . you will find a

container for the pipets , which has to be filled with water and a Automatic pipets this container a pipet basket will be placed .

The automatic pipet has a 3 digit digital read-out . Turning the wheel you can set the volume you want to use . To avoid changes in the setting during use , you can lock the pipet by moving the lever .

Warning : If you want to change the setting and the wheel is hard to turn , then probably the lever is still in lock position . First move the lever to unlock before turning the wheel !!!

and put into the rinsing container .

Automatic pipets are used with pipet-points , which are disposable .

For every size of automatic pipet , there is an appropriate point :

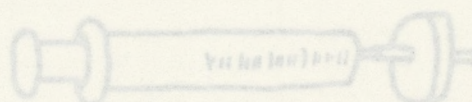
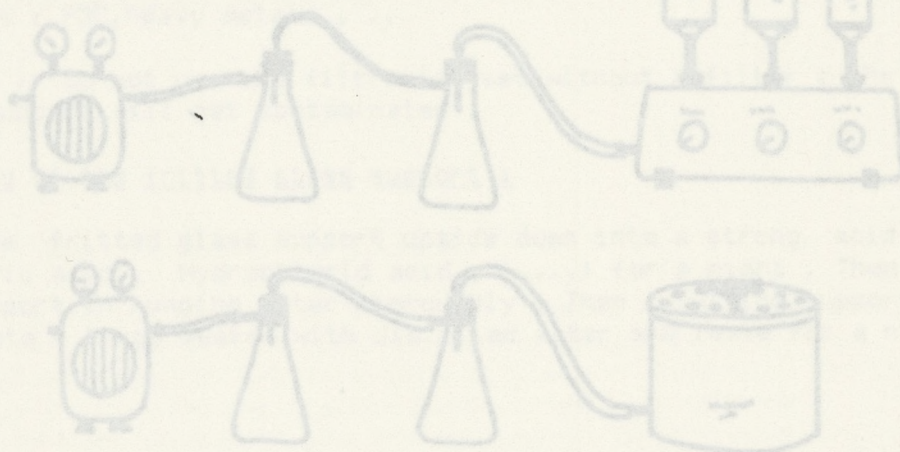
For example : pipet 20-100 microliter : yellow point is automatically emptied . pipet 200-1000 microliter : blue point . Then remove the

Do not exchange the types of pipet points . the pipets .

The pipets have now to be dried . This can be done in an oven at a Pipet stand (ref. SPIPAHOL ) : always use automatic pipets with there pipet stand when you are not using the pipet and there is still a point attached to the pipet .

**WARNING** : never lay a pipet , filled with strong acids or bases horizontally on a table : the liquid will leak into the pipet mechanism ,damaging the mechanics beyond repair .

**REMARK** : it is advisable not to use automatic pipets with organic solvents . The fumes might damage the mechanics .





As shown in the above figure, there are four filtration systems :

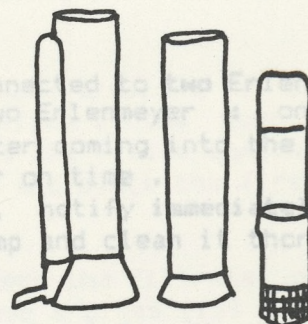
### Cleaning pipets

Plastic pipets are not be cleaned .

Pipet cleaning has to be performed in 3 steps :

1/ In both labs , you will find a container for the pipets , which has to be filled with water and a detergent . In this container , a pipet basket will be placed . When you have finished using a pipet , put it into the basket in the first container . In this container , the pipet will be cleaned by the detergent . After a day , the basket is taken out of the first container , and put into the rinsing container .

This container is connected to the water supply . The container , when completely filled with water is automatically emptied . Leave the system running for an hour or so . Then remove the basket from the rinsing container . Take out the pipets . The pipets have now to be dried . This can be done in an oven at a temperature of about 80 degrees Celsius .

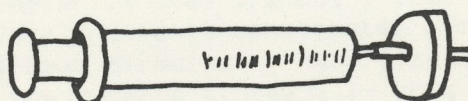
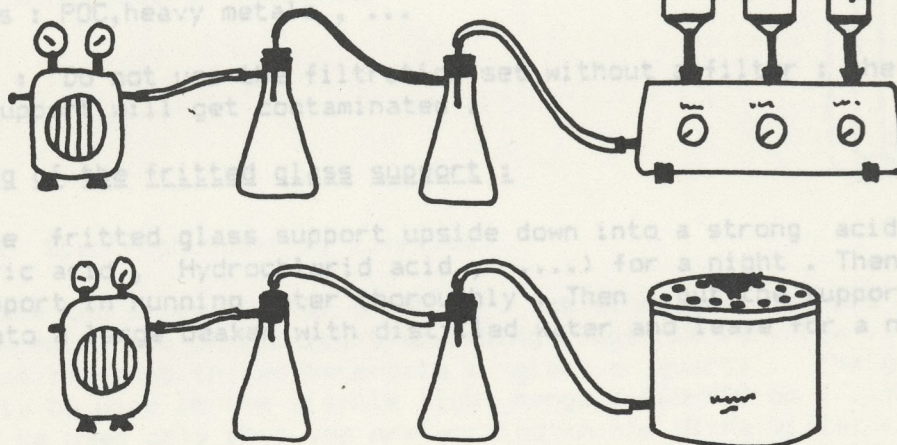


### 1.2.h Filtration equipment

The Millipore filtration system is used for filtration where no contamination is to occur .  
Filter to use : Any 47 mm filter ( Glass-fibre, Polycarbonate, ... )  
Analysis : POC heavy metals ...

**WARNING :** Do not use a filter without a fritted glass support . It is advised to use a safety Erlenmeyer ( see 1/ ) .

Put the fritted glass support upside down into a strong acid ( e.g. Sulphuric acid, Hydrochloric acid, ... ) for a night . Then , rinse the support with distilled water . Then , rinse the support upside down into distilled water for a night .





As shown in the above figure , there are four filtration systems :

- 1/ Gelman filtration set
- 2/ Millipore filtration set
- 3/ Millipore filtration manifold
- 4/ Millipore syringe filtration system

Filters to use : Whatman GF/C ( 25 mm ) or Polyacetate filters ( 25 mm )

#### 1/ Gelman filtration set

This is used with a Millipore vacuum pump . connected to **two** Erlenmeyer kolves of 2000 or 5000 ml . We stress on two Erlenmeyer : one to collect the filtrate , the second to avoid water coming into the pump if you forget to empty the collector Erlenmeyer on time . the first one

**WARNING :** if water should come into the pump , notify **immediately** the Chief Technologist !! He will dismount the pump and clean it thoroughly . Do not try to do this yourself .

The Gelman filtration set enables you to filter 3 samples at a time .

Filters to use : Whatman GF/C ( glassfibre ) , 47 mm diameter.

Analysis : Chlorophyl , POC ( if the POC concentration is high compared to the background of the contamination of the filter )

#### 4/ Millipore syringe filtration system

#### 2/ Millipore filtration set

This system is used with a Millipore vacuum pump . The Filtration set , composed of 3 parts is mounted onto a filtration Erlenmeyer ( 1000 or 2000 ml ) . It is advisable to use a safety Erlenmeyer ( see 1/ ) .

The Millipore filtration system is used for filtration where no contamination is to occur .

Filter to use : Any 47 mm filter ( Glass-fibre, Polyacetate, ... )

Analysis : POC, heavy metals , ...

**WARNING :** Do not use the filtration set without a filter : the fritted glass support will get contaminated .

#### Cleaning of the fritted glass support :

Put the fritted glass support upside down into a strong acid ( e.g Sulphuric acid , Hydrochlorid acid , .... ) for a night . Then , rinse the support in running water thoroughly . Then , put the support upside down into a large beaker with distilled water and leave for a night .

They can be found in two materials : glass or quartz . The glass type can only be used in the visible light range ( 400-800 nm ) . The quartz should be used only when you are working in the Ultra Violet range ( < 400 nm ) . Preferably do not use them when working in the visible range ( Quartz cuvettes are very expensive )

Remark : When the sides of the cuvettes are frosted glass , then there is no problem . If , however , they are not , then make sure you are inserting the cuvettes into the spectrophotometer correctly : On the windows , in the light beam direction , the size of the cuvette is printed . Do not insert the cuvette sideways : this might scratch the windows of the cuvette , making it useless !!



### 3/ Millipore Filtration Manifold

The Millipore filtration Manifold is used with a Millipore vacuum pump . It enables you to filter 12 samples at a time . It can be used in e.g Primary Production experiments .

Filters to use : Whatman GF/C ( 25 mm ) or Polyacetate filters ( 25 mm )

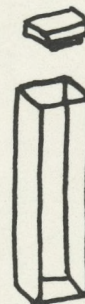
To filter , first block all the holes with rubber stoppers . Unblock the hole in which you are going to filter . Switch on the pump . Then pour in the sample . When the sample has passed the filter completely ( filter looks dry ) , pull out a second stopper and block the first one . Repeat this process for all holes .

REMARK : with this system , you can also keep the filtrate of all samples separately : Put in the filtration house a glass vial ( see fig . )

### 4/ Millipore syringe filtration system

This system is perfect for in situ filtrations : you don't need a pump : Open the filtration system and insert a filter ( glass-fibre or Polyacetate ) . Close the system ( firmly ) . Now fill a syringe ( volume 20 or 50 ml ) and connect to the filtration set . Now press the syringe : the liquid will be filtrated on the filter .

#### 1.2.i Miscellaneous glassware



##### 1.2.i.1 Spectrophotometric cuvettes

There are two sizes : 10 mm or 40 mm . The 40 mm cuvettes are used when the concentration of the light absorbing liquid is very low .

They can be found in two materials : glass or quartz . The glass type can only be used in the visible light range ( 400-800 nm ) . The quartz should be used only when you are working in the Ultra Violet range ( < 400 nm ) . Preferably do not use them when working in the visible range ( Quartz cuvettes are very expensive )

Remark : When the sides of the cuvettes are frosted glass , then there is no problem . If , however , they are not , then make sure you are inserting the cuvettes into the spectrophotometer correctly : On the windows , in the light beam direction , the size of the cuvette is printed . Do not insert the cuvette sideways : this might scratch the windows of the cuvette , making it useless !!