PROGRESS REPORT : NOVEMBER 1990 - JUNE 1991

KENYA - BELGIUM PROJECT IN MARINE SCIENCES
"HIGHER INSTITUTE FOR MARINE SCIENCES"
VLIR - KMFRI PROJECT

&

CEC PROJECT
"DYNAMICS AND ASSESSMENT OF KENYAN MANGROVE ECOSYSTEMS"
n^{0} TS2-0240-C (GDF)

COMPILED BY Dr. K. DELBEKE

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KENYA-BELGIUM PROJECT IN MARINE SCIENCE
VLIR - KMFRI PROJECT

P.O.Box 81651
Mombasa, Kenya
Tel. Fax : 254/11/742215

Director Kenya - Belgium Project : Prof. Dr. P. Polk
Director KMFRI : Dr. E. Okemwa
Residential Manager : Dr. K. Delbeke

&

CEC PROJECT
"DYNAMICS AND ASSESSMENT OF KENYAN MANGROVE ECOSYSTEMS"
n^{0} TS2-0240-C (GDF)

Participating laboratories :

Kenya :
K.M.F.R.I. (Dr. Okemwa)
Nairobi University : Dept. Zoology (Dr. Ntiba)

Belgium :
V.U.B. - ANCH (Dr. Dehairs)
V.U.B. - ECOL (Dr. Daro)
R.U.G. - Marine Biology (Dr. Vincx)
R.U.G. - Botany (Dr. Coppejans)

The Netherlands :
Delta Institute for Hydrobiological Research (Dr. Hemminga)
Catholic University Nijmegen : Aquatic Ecology (Prof. den Hertog)

Coordinating laboratory :
V.U.B.- ECOL : Prof. Polk
Vrije Universiteit Brussel,Pleinlaan 2, B-1050 Brussels, Belgium.

Acknowledgements

We hereby thank the Kenyan and Belgium Governments for giving us the financial support and facilities to continue with the research project. We also thank the "Flemish Interuniversity Council" (VLIR) for their scientific support. We thank also the Commission of the European Communities, Directorate-General XII for their financial support. We are furthermore grateful to the Belgium Embassy and Cooperation in Nairobi and to the Belgian Consulate in Mombasa for their kind cooperation. We also thank SAREC and ROSTA, for their financial support in providing a scholarship for a researcher. Last but not least we are grateful to VVOB and to the Ministry of Science and Technology for their support by creating a link between KBP - KMFRI and VVOB.

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1. INTRODUCTION

This report aims to give an overview of the results obtained over the last year in the frame of the VLIR project and the cooperating EEC project "Dynamics and Assessment of Kenyan Mangrove Ecosystems" (CEC Project nr TS 2-0240-C (GDF)).
The Mangrove ecosystem in Gazi has been intensively investigated. The researchers of the different subproject are most often working in a coordinated way. A comprehensive set of data is now available and presented in this report.
The Kenyan coastal area has especially been investigated for species distribution and coverage of marine algae and corals at different sites along the Kenyan coast.
Most recently a pollution project, supported by UNEP, in collaboration with Kenyan Government chemist, was started. The first information on pollution sources and pollution loads have been obtained. The first data on monitoring of the pollution levels and their environmental impact, for the area around Mombasa are presented in this report.
The aquaculture department is still small, nevertheless preliminary research is being done with success on fish culturing. The Oysters Commercial cultivation has started, is it on a very small scale. All information is now available to start real oyster farming.
The Kenya - Belgium project was furthermore involved in the organization of a symposium: "Status and future of Large Marine Ecosystems", to be held in between 2nd and 7th August 1992.

2. VISITING RESEARCHERS AND ORGANIZATION

1.	Mr. A. Melles: Ethiopie	V.U.B. Student in the FAME course Collection of coral samples in the frame of a masters' thesis for the FAME course 4th - 30th November 1990
2.	Mr. D. Martens and Mr. M. Maes Belgium	Belgian Diving experts assisting in the collection of coral sample 30th October - 19th November 1990
3.	Prof. Dr. M. Best The Netherlands	National Museum of Natural History Lecturer in the FAME course (VUB) Coordination and discussion of the sampling programme and research of Mr. A. Melles. 12th - 19th November 1990
4.	Prof. Dr. P. Polk: Belgium	V.U.B. Director VLIR project and Director EEC project "Dynamics and Assessment of Kenyan Mangrove Ecosystems". 17th - 29th November 1990, 29th May - 27th June 1991 March - April 1991
5.	Prof. Dr. J. Symoens: Belgium	VUB, Professor at the Laboratory for botany. Discussions and visit of the Institutes (in Mombasa and Kisumu) in the frame of a research proposal submitted to VLIR. 15th - 18th November 1990
6.	Dr. E. Van den Berghe: Kenya	VVOB Lecturer University of Nairobi Lecturing of "Biostatistis" to the KMFRI researchers. November 19th - 23rd 1990
7.	Mr. J. Mwaniki: Kenya	Student at University of Nairobi Sampling in the frame of a masters' thesis on the Mangrove Oyster, Crassostrea cucullata. 21st - 28th November 1990
8.	Prof. R. Van Grieken: Belgium	Universitaire Instelling Antwerpen Discussion and visit of the Institute in the frame of a research proposal submitted to VLIR 23rd December 1990 - 4th January 1991

9.	Mrs. E. Burke: Canada	International center for Oceanographic Development (ICOD) - Canada Discussion on possibilities for cooperation between KMFRI - VLIR and ICOD 24th February - 3rd March 1991
10.	Mr. B. Demeulenaere: Belgium	V.U.B. Student in the FAME course Sampling in the frame of a masters' thesis on benthos, for the FAME course. 10th February - 9th March 1991
11.	Mr. J. Tack: Belgium	V.U.B. PhD. student at the Laboratory for Ecology. Sampling in the frame of a PhD thesis on the Mangrove Oyster, Crassostrea cucullata. 11th March - 31st March 1991
12.	Mr. N. Dankers: Mr. D. Rjkeren Mr. O. Klepper The Netherlands	Rijkssinstituut voor Naturbeheer (RIN) Netherlands. Discussion on possibilities for collaboration between KMFRI and RIN in the frame of coral reef management. 13th March 1991
13.	Dr. I. Gordon: Kenya	Senior lecturer in Ecology - University of Nairobi. Exploratory visit in the frame of the research project on handedness of UCA. March 1991
15.	Dr. T. Orekoya: Kenya	FAO Discussion and finalization of the UNEP programme "Assessment and Control of Pollution of the Kenyan Coastal and Marine Environment". 2nd - 3rd April 1991
16.	Mrs. A.F. Woitchick: Belgium	V.U.B. Belgium representative of EEC project February - 4th March 1991 1st May - 27th July 1991
17.	Mr. J. Githaiga: Kenya	PhD student at University of Nairobi. Sampling in the frame of a PhD programme on Mangrove Oysters 2nd - 3rd April 1991

18.	Dr. M. Ngoile : Tanzania	Director of Institute for Marine Sciences - Zanzibar Discussion on collaboration with KMFRI 13th - 19th May 1991
19.	Dr. R. Getzinger: Mrs. A. Wilson Auerbacher USA	American Association for Advances in Sciences (AAAS) - USA Discussion on possibilities for collaboration. 18th May 1991
20.	Dr. Z. Hussain: Mr. G.M. Kinyanjui: Kenya	FAO mangrove Consultant Provincial Forest Officer - Kenya Discussion on management of Mangrove forest and possibilities of collaboration. 21st May 1991
21.	Mr. De Gregorio: Italy	FAO Agricultural division mapping consultant FAO mapping consultant discussion of collaboration with EEC/ VLIR project 31st May 1991

3. SAMPLING DONE

WORKPLAN: SAMPLING DONE IN THE MONTH OF NOVEMBER 1990

DATE	TIDE	DEP.TIME	AREA	RES.OFFICER	TRANSPORT	ACTIVITY
Thu 1	HT:15:07	8.00	Makupa	Kairu	Car	Coastal Erosion (VLIR)
Mon 5	LT:11:33	10.00	Kanamai	Oyieke	Car	Algae (VLIR)
			Kanamai	Mutere		Corals (VLIR)
			Kanamai	Wakibya		Seaweed (KMFRI)
Tue 6	LT:12:15	10.30	Vipingo	A.Melles	Car	Corals (VLIR)
Thu 8	LT:13:57	11.00	Nyali	Wijnant	Car	Bacteriology (VLIR)
	LT:13:57	10.00	Nyali	Wakibya	Car	Seaweeds (VLIR)
Mon 12	HT:12:57	11.00	Tudor	Wynant	Car/boat	Bacteriology (VLIR)
Tue 13	HT:13:58	9.00	N.Coast	Best et.al	Car/boat	Corals (VLIR)
Wed 14	LT:08:37	8.00	KMFRI	Omolo		Sea urchin (KMFRI)
	LT:08:37	7.00	Gazi	Ohowa	Car	N_2 Fixation (EEC+VLIR)
	LT:08:37	9.00	South Coast	Best et.al	Car/boat	Corals (VLIR)
Thu 15	HT:15:24	9.00	Malindi	Mutere & Best et.al	Car/boat	Corals (VLIR)
Fri 16	HT:15:57	9.00	Vipingo	Oyieke	Car	Marine Algae (VLIR)
		9.00	Malindi	Best et.al	Car	Corals (VLIR)
Sat 17	HT:16:26	18.00	Gazi	Ntiba et.al.	Car	Fisheries (EEC)
Sun 18	HT:16:52	15.00	Gazi	Ntiba et.al.	Car	Fisheries (VLIR)
Mon 19 to Fri 23		9.00 to 6.30 course statistics by Dr. Van den Berghe				
Mon 26	HT:18:55	15.00	Tudor	Wynant	car	Bacteriology (VLIR)
	HT:18:55	9.00	Shimoni	Mwangi & Omondi	Car	Art. & Sard. Fisheries (KMFR)
			Shimoni	Wakibya		Seaweed (KMFRI)
Tue 27	HT:11:25	9.00	Gazi	Wynant	Car	Bacteriology (VLIR/EEC)
			Gazi	Wawiye		Phytoplankton (EEC/VLIR)

WORKPLAN: SAMPLING DONE IN THE MONTH OF DECEMBER 1990

DATE	TIDE	DEP.TIME	AREA	RES.OFFICER	TRANSPORT	ACTIVITY
Mon 3	HT:16:58	12.00	Gazi	Kazungu	Car/boat	Nutrient/(EEC+VLIR)
			Gazi	Wawiye		Phytoplankton/(EEC+VLIR)
			Gazi	Wijnant		Bacteriology/(EEC+VLIR)
Tue 4	HT:17.42	14.00	Gazi	Okemwa et.al	Car/boat	Zooplankton(EEC+VLIR)
			Gazi	Nguli & Onyango		Hydrograpy(EEC)
			Gazi	Slim		POM(EEC)
Wed 5	LT:12.11	9.00	Gazi	Wakwabi	Car/boat	Fisheries/(EEC+VLIR)
			Gazi	Ruwa		Meiobenthos(EEC)
			Gazi	Ohowa		N2 Fixation(EEC+VLIR)
	LT:12.11	9.00	Kwale	Munga et.al	Car	Pollution (VLIR)
Fri 7	LT:13.02	11.00	Vipingo	Mutere	Car	Corals(VLIR)
			Vipingo	Wakibya		Seaweeds (VLIR)
Mon 10	HT:10.03	9.00	Tudor	Wynant	Car/boat	Bacteriology (VLIR)
Thu 13	HT:14.19	9.00	Gazi	Kazungu	Car/boat	Nutrients(EEC+VLIR)
			Gazi	Wawiye		Phytoplankton(EEC+VLIR)
			Gazi	Wynant et.al		Bacteriology(EEC+VLIR)
Fri 14	HT:15.05	9.00	Gazi	Okemwa et.al	Car/boat	Zooplankton(EEC+VLIR)
			Gazi	Slim		POM (EEC)
	LT:8.57	8.00	Tudor	Munga et.al	Car	Pollution(VLIR)
Mon 17	LT:10.36	8.00	Kanamai	Wakibya	Car	Seaweed (KMFRI)
Tue 18	LT:11.01	9.00	Mtwapa	Kazungu	Car/boat	Nutrients (VLIR)
Wed 19	LT:11.34	10.00	Kikambala	Munga et.al	Car	Pollution (VLIR)
			Tudor	Wakwabi	Car/boat	Fisheries (VLIR)
Thu 20	LT:12.05	9.00	Gazi	Wakwabi	Car/boat	Fisheries (EEC+VLIR)
			Gazi	Ruwa		Meiobenthos (EEC)
			Gazi	Ohowa		N2 Fixation (EEC+VLIR)
	LT:12.05	10.00	Tudor	Wynant	Car/boat	Bacteriology (VLIR)
Fri 21	LT:12.36	10.00	Diani/ Msambweni	Munga et.al	Car/boat	Pollution (VLIR)
			Diani	Wakibya		Seaweed (KMFRI)
	LT:12.36	10.00	Mombasa	Kimani	Car	Fish Biology (VLIR)

WORKPLAN: SAMPLING DONE IN THE MONTH OF JANUARY 1991

DATE	TIDE	DEP.TIME	AREA	RES.OFFICER	TRANSPORT	ACTIVITY
Mon 7	HT:08:32 LT:14:36	8.00	Tudor	Wynant et al	Car/boat	Bacteriology (VLIR)
Tue 8	HT:09:21 LT:15:22	9.00	Gazi	Slim & Gwada	Car	Litterfall (EEC)
Thu 10	HT:12:19 LT:17:50	8.00	Gazi Gazi	Okemwa et al Slim	Car/boat	Zooplankton (EEC+VLIR) POM (EEC)
Fri 11	HT:13:54 LT:07:49		Gazi Gazi Gazi	Kazungu Wawiye Wynant et al	Car/boat	Nutrients (EEC+VLIR) Phytoplankton (EEC+VLIR) Bacteriology (EEC+VLIR)
Mon 14	HT:16:04 LT:09:59	8.00	Tudor	Wynant et al	Car/boat	Bacteriology (VLIR)
Tue 15	HT:16:34 LT:10:28	8.00 9.00	Mtwapa Gazi	Mwacheria & Kimani Slim	Car/boat Car	Fisheries (KMFRI) Litterfall (EEC)
Wed 16	HT:17:04 LT:10:57					
Thu 17	HT:17:33 LT:11:23	8.00 8.30	Gazi Tudor	Slim Kazungu	Car Car/boat	Litterfall (EEC) Nutrients (VLIR)
Fri 18	HT:18:03 LT:11:50	9.00	Gazi	Slim	Car	Litterfall (EEC)
Mon 21	HT:19:37 LT:13:16	8.00	Tudor	Wynant et al	Car	Bacteriology (VLIR)
Tue 22	HT:07:41 LT:13:49	9.00	Gazi Gazi	Slim & Gwada Mwachirya & Kimani	Car/boat	Litterfall (EEC) Fisheries (KMFRI)
Thu 24	HT:08:17 LT:15:12	14.00	Tudor	Mwatha	Car/boat	Fisheries (VLIR)
Mon 28	HT:15:22 LT:09:10	11.00	Gazi Gazi Gazi	Kazungu Wawiye Wynant et al	Car/boat	Nutrients (EEC+VLIR) Phytoplankton (EEC+VLIR) Bacteriology (EEC+VLIR)

Tue 29	HT:16:09	13.00	Gazi	Okemwa et al	Car/boat	Zooplankton (EEC+VLIR)
	LT:09:55		Gazi	Slim		POM(EEC)
		9.00	Ngomeni	Mwatha	Car	Aquaculture (VLIR)
Wed 30	HT:16:49	8.00	Tudor	Wynant et al	Car/boat	Bacteriology (VLIR)
	LT:10:34					

WORKPLAN: SAMPLING SCHEDULE FOR THE MONTHS OF FEBRUARY & MARCH 1991

DATE	TIDE	DEP.TIME	AREA	RES.OFFICER	TRANSPORT	ACTIVITY
Fri 1	LT:11.42	9.00	Gazi	Mwachireya & Kimani	Car/boat	Fisheries(KMFRI)
	HT:18.03		Gazi	Omolo		Echinoderms(KMFRI)
			Malindi	Kairu	Car	Coastal erosion (VLIR)
Sat 2	LT:12.12		Malindi	Kairu	Car	Coastal erosion(VLIR)
	HT:06.12					
Mon 4	LT:13.16	11.00	Mtwapa	Omolo	Car	Echinoderms(KMFRI)
	HT:07.17	11.00	Tudor	Omondi	Car/Boat	Artisanal Fisheries (KMFRI)
Tue 5	LT:13.48	11.00	Gazi	Gwada	Car/Boat	Litterfall (EEC)
	HT:07.48		Tudor	Kazungu	Car/Boat	Nutrients (VLIR)
Wed 6	LT:14.22	13.00	Tudor	Wynant et.al	Car/Boat	Bacteriology(EEC/VLIR)
	HT:08.23	12.00	Kanamai	Wakibya	Car	Seaweed (EEC+VLIR)
Thu 7	LT:15.01	14.00	Vipingo	Oyieke	Car	Marine algae (VLIR)
	HT:09.08		Vipingo	Omolo		Echinoderms (KMFRI)
			Gazi	Wakwabi et.al.	Car	Fisheries (KMFRI)
Fri.8	LT:16.23	14.00	KMFRI	Omolo	Car/Boat	Echinoderms (KMFRI)
	HT:10.38					
Mon.11	LT:09.15	13.00	Gazi	Wawiye	Car/Boat	Phytoplankton (EEC +VLIR)
	HT:15.22		Gazi	Wynant et al		Bacteriology (EEC+VLIR)
		9.15	Bahari	Wakibya	Car/boat	Seaweed (VLIR)
Tue.12	LT:09.46	13.00	Gazi	Osore	Car/Boat	Zooplankton (EEC+VLIR)
	HT:15.52		Gazi	Kazungu		Nutrients (EEC+VLIR)
		8.00	Tudor	Omondi	Car/Boat	Artisanal Fisheries (KMFRI)
Wed.13	LT:10.12	8.00	Gazi	Kairu	Car/Boat	Geology (EEC)
	HT:16.13		Gazi	Oyieke		Mar. Algae (VLIR)
			Gazi	De Meulenaere		Benthos (VLIR)
		9.00	Tudor	Wynant et.al.	Car/boat	Bacteriology (VLIR)
		9.00	Tudor	Wynant	Car/Boat	Bacteriology (VLIR)
		14.00	Kilindini	Wakwabi	Car/boat	Fisheries (VLIR)
Thu.14	LT:10.37	9.00	Fort Jesus	Oyieke	Car	Marine algae (VLIR)
	HT:16.45		Fort Jesus	Omolo		Echinoderms (KMFRI)
			English point	De Meulenaere	Car/Boat	Benthos
			Tudor	Wynant et.al.		Bacteriology (VLIR)
			Tudor	Wakwabi	Car	Fisheries (VLIR)

Fri.15	LT:11.01	8.00	Port Reitz	Kairu	Car	Geology (VLIR)
	HT:17.15		Ngomeni	Wakibya	Car	Seaweed (VLIR)
Sun.17	LT:11.51	9.00	Diani	Kairu	Car	Coastal erosion(VLIR)
	HT:18.10		Diani	Omolo		Echinoderms (KMFRI)
Mon.18	LT:12.18	11.00	Tudor	Wynant el.ol	Car/Boat	Bacteriology (VLIR)
	HT:18.38		Tudor	De Meulenaere		Benthos (VLIR)
		11.00	Diani	Wakibya	Car/boat	Seaweed (VLIR)
Tue.19	LT:12.48	9.00	Gazi	Mwachireya	Car/Boat	Fisheries (KMFRI)
	HT:06.46			& Kimani		Litterfall (EEC)
			Gazi	Gwada		
			Gazi	Demeulenaere		Benthos (VLIR)
		11.00	Tudor	Omondi	Car/Boat	Art.Fisheries (KMFRI)
				Kazungu		Nutrients(VLIR)
Wed.20	LT:13.13	11.00	Kilifi	Oyieke	Car	Marine algae (VLIR)
	HT:07.19		Kilifi	Omolo		Echinoderms (KMFRI)
		10.00	Shimoni	Wakibya	Car/boat	Seaweed (VLIR)
Thu.21	LT:13.54	11.00	Kanamai	Omolo	Car	Echinoderms (KMFRI)
	HT:07.55	10.00	Mambrui	Wakibya	Car	Seaweed (VLIR)
Fri.22	LT:14.36	11.00	Malindi	Omolo	Car	Echinoderms (KMFRI)
&Sat.23	HT:08.43		Lamu			
Mon.25	LT:08.08	9.00	Gazi	Wawiye	Car/Boat	Phytoplankton (EEC+VLIR)
	HT:14.23		Gazi	Wynant et. al.		Bacteriology (EEC+VLIR)
		8.00	Tudor	Omondi	Car/Boat	Art. Fisheries (KMFRI)
Tue.26	LT:09.01	13.00	Gazi	Osore	Car/Boat	Zooplanton (EEC+VLIR)
	HT:15.15		Gazi	Kazungu		Nutrients (EEC+VLIR)
Wed.27	LT:09.42	8.00	Tudor	Demeulenaere	Car/Boat	Benthos (VLIR)
	HT:15.56		Tudor	Wakwabi et.al.		Fisheries (VLIR)
		9.00	Florida			
			club	Wakibya	Car	Seaweed (VLIR)
Thu.28	LT:10.16	8.00	Likoni	Oyieke	Car	Marine algae (VLIR)
	HT:16.33					
Fri.1	LT:10.47	8.00	Gazi	Mwachireya	Car/Boat	Fisheries (KMFRI)
	HT:17.08			Kimani		
				Wakwabi et.al.		Fisheries (EEC+VLIR)
			Kanamai	Wakibya	Car	Seaweed (VLIR)

Mon.4	LT:12.12	9.00	Tudor	Wynant et al	Car/Boat	Bacteriology (VLIR)
	HT:18.36		Tudor	Demeulenaere		Benthos (VLIR)
Tue.5	LT:12.41	9.00	Gazi	Gwada	Car/Boat	Litterfall (EEC)
	HT:19.03		Gazi	Omolo		Echinoderms(KMFRI)
			Gazi	Demeulenaere		Benthos (VLIR)
		11.00	Tudor	Omondi	Car/Boat	Art. Fisheries (KMFRI)
			Tudor	Kazungu		Nutrients(VLIR)
Wed.6	LT:13.09	12.00	Fort Jesus	Omolo	Car/Boat	Echinoderms (KMFRI)
	HT:19.31		Tudor	Wakwabi et.al.		Fisheries (VLIR)
Thu.7	LT:13.37		Vipingo	Oyieke	Car	Marine Algae(VLIR)
	HT:07.42		Vipingo	Omolo		Echinoderms (KMFRI)
Fri.8	LT:14.06		Tudor	Demeulenaere		Benthos (VLIR)
	HT:20.44		English point			
Mon.11	LT:08.04	9.00	Gazi	Wawiye	Car/Boat	Phytoplankton (EEC+VLIR)
	HT:14.18		Gazi	Wynant et al		Bacteriology (EEC+VLIR)
		8.00	Tudor	Omondi	Car/Boat	Art.Fisheries (KMFRI)
Tue 12	LT:08.46	12.00	Gazi	Osore	Car/Boat	Zooplankton (EEC +VLIR)
	HT:14.15		Gazi	Kazungu		Nutrients (EEC+VLIR)
		9.00	Malindi	Kairu	Car	Coastal erosion(VLIR)
Wed.13	LT:09.15		Malindi	Kairu	Car	Coastal erosion (VLIR)
	HT:15.22		Kilindini	Wakwabi et.al.	Car/baot	Fisheries (EEC+VLIR)
Thu.14	LT:09.41	8.00	Tudor	Wynant et.al.	Car/Boat	Bacteriology (VLIR)
	HT:15.50		KMFRI	Omolo		Echinoderms (KMFRI)
			Diani	Wakibya	Car/boat	Fisheries (VLIR)
Fri.15	LT:10.04	8.00	Mtwapa	Mwachireya & Kimani	Car/Boat	Fisheries (KMFRI) Echinoderms (KMFRI)
	HT:16.19		Mtwapa	Omolo		
		8.00	Port Reitz	Kairu	Car	Geology (VLIR)
			Florida club	Wakibya		Seaweed (VLIR)
Mon.18	LT:11.22	9.00	Tudor	Wynant et al	Car/Boat	Bacteriology (VLIR)
	HT:17.43			Omondi		Art. Fisheries (KMFRI)
			Shimoni	Wakibya	Car/Boat	Seaweed (VLIR)

Tue.19	LT:11.53	9.00	Gazi	Gwada	Car	Litterfall (EEC)
	HT:18.14		Gazi	Kairu		Geology (EEC)
			4 days Lamu			
			Mambrui	Oyieke	Car	Marine algae (VLIR)
			Malindi	Omolo		Echiroderms(KMFRI)
			Watamu	Wakibya		Seaweed (VLIR)
			Ngomeni			
			Kilifi			
Wed.20	LT:12.20					
	HT:18.41					
Thu.21	LT:12.57					
	HT:07.03					
Fri.22	LT:13.35	10.00	Gazi	Wakwabi et.al.	Car	Fisheries (EEC+VLIR)
	HT:07.42					
Mon.25	LT:18.39	9.00	Tudor	Wynant	Car/Boat	Bacteriology (VLIR)
	HT:12.48		Tudor	Omondi		Art. Fisheries (KMFRI)
Tue.26	LT:07.48					
	HT:14.06					
Wed.27	LT:08.37	8.00	Bahari	Wakibya	Car	Seaweed (VLIR)
	HT:14.54					
Thu.28	LT:09.15	10.00	Gazi	Wawiye	Car/Boat	Phytoplankton (EEC+VLIR)
	HT:15.35		Gazi	Wynant et.al.		Bacteriology (EEC+VLIR)
		8.00	Gazi	Wakwabi et.al.	Car	Fisheries (VLIR)
Fri.29	LT:09.49	11.00	Gazi	Osore	Car/Boat	Zooplankton (EEC+VLIR)
			Gazi	Kazungu		Nutrient (EEC+VLIR)
	HT:16.10	8.30	Diani	Kairu	Car	Coastal erosion (VLIR)
			Diani	Omolo		Echinoderms (KMFRI)
		8.00	Tudor	Wakwabi et.al.	Car/Boat	Fisheres (VLIR)

WORKPLAN SAMPLING DONE IN THE MONTH OF APRIL 1991

DATE	TIDE	DEPT. TIME	AREA	RES. OFFICER	TRANSPORT	ACTIVITY
Tue. 2	LT:11:44	9.00	Gazi	Gwada	Car/boat	Litterfall (EEC)
	HT:18:04		Gazi	Wakwabi et al		Fisheries (EEC+VLIR)
			Gazi	Mwachireya + Kimani		Fisheries (KMFRI)
		9.00	Port Rietz	Kairu	Car	Geology (VLIR)
Wed.3	LT:12.11	10.00	Vipingo	Wakibya	Car	Mar. algae (VLIR)
	HT:18.29	9.00	Tudor	Wijnant et al	Car/boat	Bacteriology (VLIR)
			Tudor	Kazungu		Nutrients (VLIR)
Thu.4	LT:12.39		Gazi	Githaiga	Car	Oyster (VLIR)
	HT:18.57	10.00				
		10.30	Kamamai	Mutere	Car	Corals (VLIR)
Fri.5	LT:13.07					
	HT:07.16	10.00	Gazi	Githaiga		Oyster (VLIR)
Mon.8	LT:16.24					
	HT:10.37	11.30	Gazi	Wakwabi et al	Car	Fisheries (VLIR)
			Gazi	Gwada		Litterfall (EEC)
Tue.9	LT:18.57					
	HT:13.04	10.00	Gazi	Kazungu	Car/boat	Nutrient(EEC+VLIR)
Wed.10	LT:07.48	10.00	Gazi	Wawiye	Car/boat	Phytoplankton (EEC+VLIR)
	HT:13.59	7.00	Makupa	Munga, Delbeke		
				Wynant	Car/boat	Pollution(VLIR)
Thu.11	LT:08.25	12.00	Gazi	Osore	Car/boat	Zooplankton (EEC+VLIR)
	HT:14.37		Gazi	Kazungu		Nutrients (KMFRI)
Fri.12	Lt:08.56	8.00	Nyali Beach	Oyieke	Car	Mar. algae (VLIR)
	HT:15.11	8.00	Tudor	Omondi	Car/boat	Art. fisheries (KMFRI)
Mon.15	LT:10.24					
	HT:16.47	8.00	Vipingo	Wakibya	Car	Seaweed (VLIR)
Tue.16	LT:10.57	9.00	Gazi	Gwanda	Car	Litterfall (EEC)
		8.00	Kilindini	Munga/Wynant /Delbeke	Car/boat	Pollution(VLIR)
	HT:17.19	8.00	Tudor	Omondi		Art. fisheries (KMFRI)

Thu.18	LT:12.08	11.00	Kanamai	Oyieke	Car	Mar. algae (VLIR)
	HT:18.34		Kanamai	Wakibya		Seaweed (VLIR)
			Kanamai	Mutere		Corals
		11.00	Tudor	Kazungu	Car/boat	Nutrient (VLIR)
Fri.19	LT:12.48	7.00	Sabaki	Ohowa	Car	Nutrients (KMFRI)
	HT:19.17					
Mon.22	LT:16.24	8.00	Tudor	Omondi		Art. fisheries (KMFRI)
	HT:10.14					
Wed.23	LT:07.04	9.30	Gazi	Wawiye	Car/boat	Phytoplankton (EEC+VLIR)
	HT:13.30					
	HT:14.23	7.00	Baraki	Munga, Delbeke Wynant	Car/boat	Pollution (VLIR)
Fri.26	LT:08.42	8.00	Gazi	Kazungu	Car/boat	Nutrients (EEC+VLIR)
	HT:15.05	8.00				
Sat.27	LT:09.18	8.00	Gazi	Wakwabi	Car	Fisheries (EEC+VLIR)
		8.42	Gazi	Ntiba et al (U.N.		Fisheries (EEC)
Mon.29	LT:10.21	9.00	Gazi	Kudoja (UN)		Nutrients (EEC)
	HT:16.45	9.30	Diani	Kairu	Car	Coastal erosion (VLIR)
		9.00	Kanamai	Mutere	Car	Corals (VLIR)
Tue.30	LT:10.51	9.00	Gazi	Gwada	Car	Litterfall (EEC)
	HT:17.12	9.00	Tudor	Wakwabi et al	Car/boat	Fisheries (VLIR)
			Tudor	Omondi		Art. fisheries (KMFRI)
			Tudor	Kazungu		Nitrient (VLIR)
Wed.1/5	LT:11.20	10.00	Diani	Oyieke	Car	Mar. Algae (VLIR)
			Diani	Wakibya		Seaweed (VLIR)
	HT:17.39	9.00				
Thu.2/5	LT:11.50	10.00	Vipingo	Oyieke	Car	Mar. Algae (VLIR)
			Vipingo	Omolo		Echinoderms (KMFRI)
			Vipingo	Mutere		Corals (VLIR)
	HT:18.05	9.00	Gazi	Gwada	Car/boat	Nutrient (VLIR)
Fri.3/5	LT:12.19	10.00	Msambweni	Oyieke	Car	Mar. Algae (VLIR)
	HT:18.36		Gazi	Gwada	Car	Litterfall (EEC)

WORKPLAN: SAMPLING DONE IN THE MONTH OF MAY 1991

DATE	TIDE	DEP.TIME	AREA	RES. OFFICE	TRANSPORT	ACTIVITY
Mon 6	LT:14:20 HT:08:30	8.00	Tudor	Delbeke/Munga/ Wynant	Car/boat	Pollution (VLIR)
Wed 8	LT:17:25 LT:11:33	2.00	Meeting pelagic system			
Fri 10	LT:07:12 HT:13:40	11.30	Gazi	Okoth	Car/boat	Zooplankton (EEC+VLIR)
Tue 14	LT:09:57	8.00	Gazi	Gwada	Car/boat	Litterfall (EEC)
			Gazi	Wakwabi et.al		Fisheries/EEC/VLIR
Wed 15	LT:10:37 HT:17:04	9.00	Gazi	Kazungu	Car/boat	Nutrients (EEC+VLIR)
			Tudor	Munga/Wynant	Car/boat	NUtrient (VLIR)
Thu 16	LT:11:18 HT:17:46		Gazi	Osore	Car/boat	Zooplankton (EEC+VLIR)
Fri 17	LT:12:00 HT:18:29	9.00 10.00	Tudor	Kazungu	Car/boat	Nutrient (VLIR)
Sat 18	LT:12:46 HT:19:19	8.30	Gazi	Ntiba (U.N.)	Car/baot	Fisheries (EEC)
Tue.21	LT:16:13 HT:10:09	11.30	Gazi	Wakwabi et.al	Car/boat	Fisheries(EEC/VLIR)
Wed 22	LT:17:47 HT:11:29	9.00	Gazi	Kazungu	Car/boat	Nutrient (EEC)
Thu 23	LT:19:07	8.30	Gazi	Wawiye	Car/boat	Pbytoplankton (EEC+VLIR)
	HT:12:42	8.00	Mombasa coast	Munga/Wynant	Car/boat	Pollution (VLIR)
Fri 24	LT:07:13 HT:13:42	12.00	Gazi Gazi	Osore Kazungu	Car/boat	Zooplankton(EEC+VLIR) Nutrient (EEC+VLIR)
Mon 27	LT:09:23	8.00	Tudor	Wynant	Car/boat	Bacteriology (VLIR)
	HT:15:50	8.00	Gazi	Woitchick	Car	N2 fiadra
Tue 28	LT:09:59 HT:16:21	9.00	Gazi Gazi	Gwada Wakwabi et.al	Car Car/boat	Litterfall (EEC) Fisheries(EEC/VLIR)
Wed 29	LT:10:33	9.00	Port Reitz	Kairu	Car	Geology (VLIR)

	HT:16:51	9.00	Vipingo	Mutere	Car	Vipingo (VLIR)
			Vipingo	Wakibya	Car	Seaweed (VLIR)
Thu 30	LT:11:04					
	HT:17:20	9.00	Tudor	Omondi	Car/boat	Nutrient (VLIR)
Fri 31	LT:11:36	8.00	Vipingo	Wakibya	Car	Seaweed (VLIR)
	HT:17:51		Vipingo	Mutere	Car/boat	Corals (VLIR)
Wed 29			Gazi	Kazungu	Car/boat	Nutrients (EEC+VLIR)
	24 hours		Gazi	Wawiye		Phytoplankton
ticl	cycling					(EEC+VLIR)
Fri.31			Gazi	Osore		Zooplankton (EEC+VLIR)

4. RESULTS ON ONGOING RESEARCH

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4.1. RESEARCH IN THE FRAME OF THE VLIR AND EEC PROJECT "ASSESSMENT AND DYNAMICS OF KENYAN MANGROVE ECOSYSTEMS"

4.1.1. Primary production in Mangroves, using biomass increments and litterfall

By: P.Gwada and Slim F.J.
with the field assistance of M. Kodjo

INTRODUCTION

It has only recently been appreciated that the mangrove forest is not an independent ecosystem isolated from the other littoral tropical ecosystems, but links the barrier reef, exposed shores and estuaries into a highly integrated network, whose complex structure we are only beginning to understand. In response to this, the EEC has sponsored an interdisciplinary project "Dynamics and Assessment of Kenyan Mangrove Ecosystem" at Gazi. The EEC project aims at the description and assessment of the mangrove ecosystem and estimation of the energy and matter flow through the system and its exchange with the ocean.

The aim of this research is to conduct a detailed study of the standing biomass of the mangroves in Gazi and the primary production. The products of this study should be incorporated in the total program of the E.E.C.

METHODOLOGY

The study site and a map detailing it (Gazi) have been presented previously (First E.E.C report, E.Slim contribution) Based on the initial observations of a four-day ground survey of aerial photographs (I.T.C., Netherlands, taken 15 years ago!), two sampling plots were chosen (one in a Ceriops tagal stand and the other in a Rhizophora mucronata stand) for comparative studies.In these two sites intensive work on biomass estimation, productivity and litter fall is being done. These plots measure 20*20 meter and are enclosed by boundary ropes and also by marked edge trees. For C. tagal the plot is sub-divided into 16 sub-plots (squares) for replicate sampling within the plot.

Determination of primary production in the mangrove is being assessed from measurements of standing crop biomass increment. In a clip-test several parameters deemed to have a bearing on standing crop like: crown diameter, tree height, trunk circumference at 30, 75, 150 and 200 cm were computer tested in regression analy · get the best regression coefficient for our stand biomas: ɜsment in the 5*5 square. For C. tagal the circumference at . and for R. mucronata the circumference at 150 cm gave good ɐlations.

A phenological approach to litter fall is running and this will augment the litter fall traps in elucidating the amounts and rates of litterfall. In this phenological work six branches of C. tagal spread in a tree at three levels, namely top, middle and bottom in relation to tree foliage distance and also in relation to tree height from ground, are replicated in 20 trees, spread out in a representative area within the plot. Fortnightly observations are made for status of leaves (new and lost) and floral units(flower buds, flowers, propagules) and their transition values computed. This work is to be followed for two years.

By combining the results from the biomass assessment per square, the phenology study (leaf turn-over) and biomass partitioning in the tree it is possible to calculate the litter (leaf) fall per surface area in the C. tagal vegetation. In order to do so leaves, branches, trunk and above ground roots were sampled separate for each individual tree in the above mentioned clip-test. Also samples for fresh/dry weight relation were taken.

RESULTS

After testing the results from a small series of sampling by means of simple linear regression analysis it was found that the circumference at 30cm for C. tagal and the circumference at 150cm for R. mucronata showed the best correlation with total above ground biomass (see tab. 1).

Parameter	Regression	Biom. (kg) = par*a+b)
Ceriops trees		a b
circ. at 30cm(mm)	**0.90** n=26	mm * 0.103 - 8.344
circ. at 75cm(mm)	0.87 n=23	mm * 0.182 - 14.682
tree height (cm)	0.51 n=26	cm * 0.118 - 14.252
crown diam. (cm)	0.67 n=26	cm * 0.195 - 16.818
Rhizophora trees		
circ. at 150cm(mm)	**0.90** n=25	mm * 0.365 - 22.625
circ. at 200cm(mm)	0.91 n=22	mm * 0.400 - 19.310
height (cm)	0.69 n=25	cm * 0.147 - 38.572
number of p.root	0.59 n=25	no * 2.824 - 13.632

Tabel 1: Results of linear regression analyses for first small series of sampling [biom = biomass, par = parameter, circ. = circumference, diam = diameter, p.root = prop root]

For C. tagal the sampling series was enlarged up to 116 trees ranging from 15 mm to 511 mm in circumference. Enlarging of the sampling series for R. mucronata has still to be done. For the final analysis, as is common in literature, an LN LN relation was worked out for tree circumference versus tree biomass (see tab. 2 and fig. 1). For seedlings of C. tagal a relation was worked out between shoot length and total fresh weight (see tab. 2) in order to estimate the amount of biomass present in the plots as seedling.

Ceriops tagal trees LN(biomass in gram) = 2.31 * LN(circ. at 30cm in mm) - 3.02 range of circumference: 15 - 511 mm n = 116; R^2 = 0.98
Ceriops tagal seedlings LN(biomass in gram) = 1.49 * LN(length in cm) - 2.55 range of length: 20 - 99 cm n = 69; R^2 = 0.93
Rhizophora mucronata trees LN(biomass in gram) = 2.25 * LN(circ. at 150cm in mm) - 8.03 range of circumference: 42 - 230 mm n = 25; R^2 = 0.93

Tabel 2: Overview of final regression equations on biomass estimations for Ceriops tagal and Rhizophora mucronata.

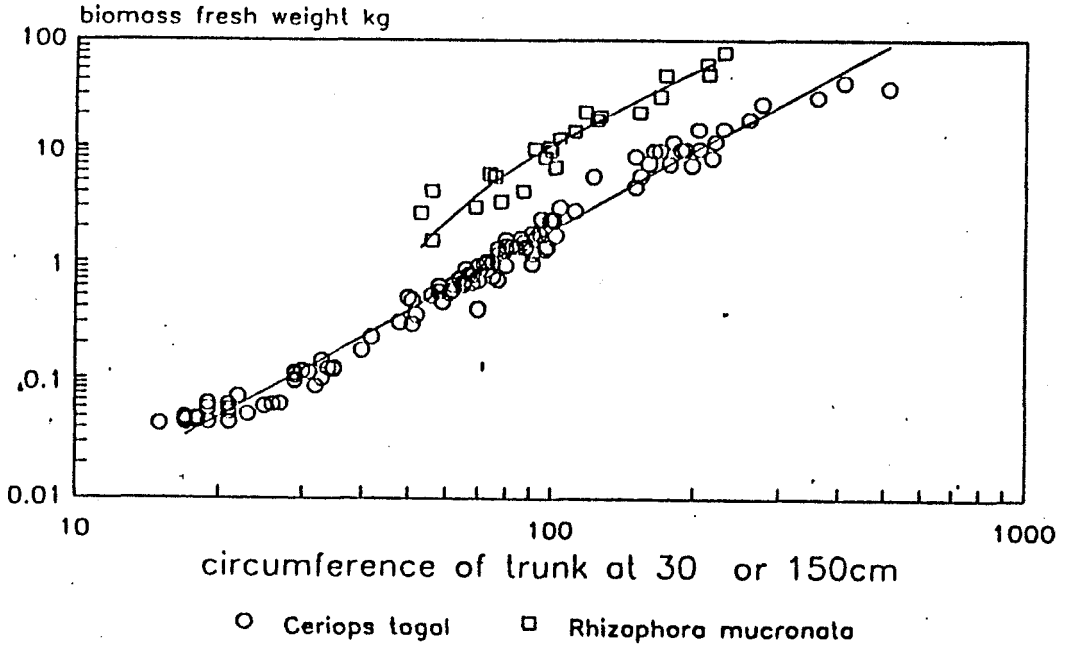

Figure 1: Biomass fresh weight versus trunk circumference at 30cm for C. tagal and at 150cm for R. mucronata.

The biomass partitioning for C. tagal and R. mucronata as percentage of the total tree fresh weight was found to be:

	Ceriops tagal (n=22)	Rhizophora mucronata (n=16)
(prop)root	32.5 ± 9.6	46.9 ± 9.8
trunk	22.9 ± 6.7	23.4 ± 5.4
branches	24.7 ± 8.2	12.5 ± 2.9
leaves	19.9 ± 8.3	17.2 ± 4.3

Estimation of the standing biomass was done for the Ceriops tagal plot by "subsampling" 9 of the 16 squares. For all the individual trees in the squares the circumference at 30cm was recorded and by using the regression equation the total biomass per square was calculated (see tab. 3).

square	kg	square	kg	
SQ-2	122.0	SQ-9	106.9	Avg. biomass per square:
SQ-3	215.6	SQ-10	200.9	168.3 ± 36.0 kg
SQ-5	174.8	SQ-12	174.1	
SQ-7	163.8	SQ-14	157.1	Biomass per ha:
SQ-8	199.0			67.3 ± 14.4 ton

Tabel 3: Overview of biomass estimations on trees in the Ceriops tagal plot per square and calculated average biomass per square and per hectare.

square	gram	square	gram	
SQ-2	113.4	SQ-9	303.4	Avg. biomass per square:
SQ-3	471.2	SQ-10	549.7	535.2 ± 375.3 gram
SQ-5	50.8	SQ-12	602.7	
SQ-7	552.7	SQ-14	1201.0	
SQ-8	970.9			

Tabel 4: Overview of biomass estimations on seedlings in the Ceriops tagal plot per square and calculated average biomass per square.

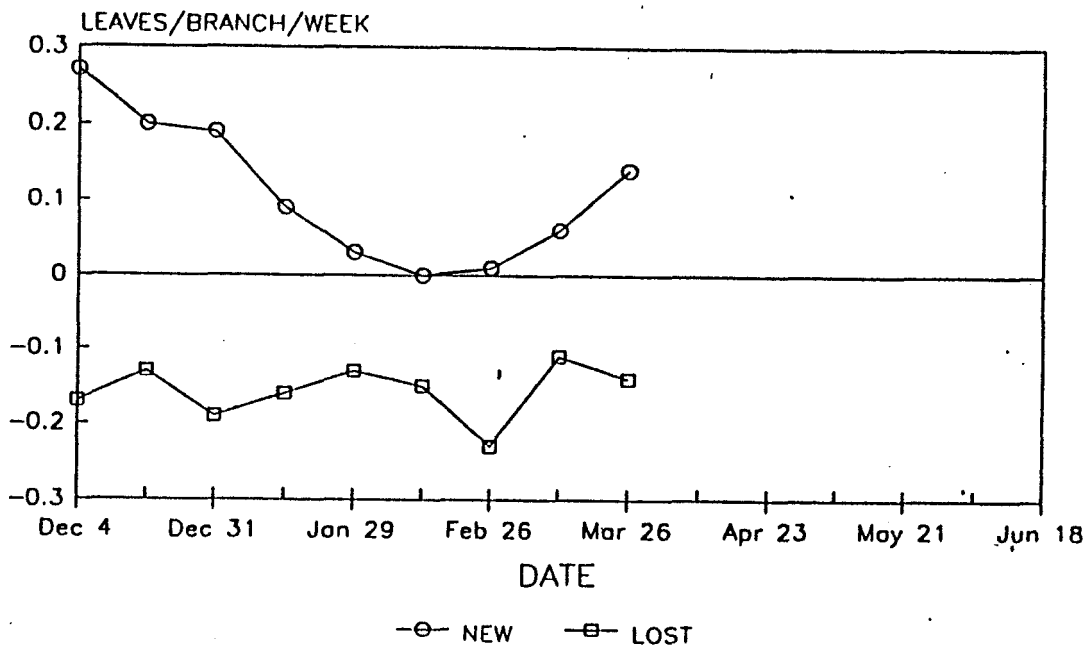

Figure 2: Average number of lost and new formed leaves per branch for Ceriops tagal.

The combination of biomass information and leaf phenological data are worked out to give litter fall rates and amounts in the C. tagal plot. The results and procedural information are as presented below.

From page 3 it is seen that 19.9% of the stand biomass is invested on leaves. So we can calculate the average biomass on leaves per square:

average biomass per square * 0.199 =
average biomass on leaves per square

number of leaves/square =
(biomass on leaves per square)/1.41[a]

From the phenology data it is possible to translate the number of fallen leaves per branch per week into fallen leaves per leaf present.

(lost leaves/branch/week) ÷ avg. number of leaves/branch =
lost leaves/leaf/week

As litterfall is normally presented in literature as dry weight per hectare per year some other factors should be added in the calculation:

litterfall [g dry]/square/week =
(lost leaves/square/week) * 0.49[b]

[[a]: avg. fresh weight of individual leaf, [b]: avg. dry weight of individual leaf]

Biomass/square is between 132.2 and 204.3 kg (see table 3)

	l/br	l/br/w	l/l/w	leaf biomass per square (kg)	
DATE	All	lost	lost	min	max
04-Dec	9.3	0.17	0.02	26.31	40.65
17-Dec	10.3	0.13	0.01	29.14	45.02
31-Dec	10.3	0.19	0.02	29.14	45.02
15-Jan	10.3	0.16	0.02	29.14	45.02
29-Jan	10.2	0.13	0.01	28.86	44.58
12-Feb	10.0	0.15	0.02	28.30	43.71
26-Feb	9.7	0.23	0.02	27.45	42.40
12-Mar	9.2	0.11	0.01	26.03	40.21
26-Mar	9.1	0.14	0.02	25.75	39.78

	leaves per square (number)		lost leaves per square/week (number)		litterfall gram dry weight square/week	
DATE	min	max	min	max	min	max
04-Dec	18663	28830	341	527	167	258
17-Dec	20670	31930	261	403	128	197
31-Dec	20670	31930	381	589	187	289
15-Jan	20670	31930	321	496	157	243
29-Jan	20469	31620	261	403	128	197
12-Feb	20068	31000	301	465	147	228
26-Feb	19465	30070	462	713	226	349
12-Mar	18462	28520	221	341	108	167
26-Mar	18261	28210	281	434	138	213

Calculated out of the above tabel the average litterfall is between the 154 and 238 gram dry weight per square per week. On an annual basis this will be:

minimum 154 * 52 * 10000/25 = 3.20 ton/ha/year

maximum 238 * 52 * 10000/25 = 4.95 ton/ha/year

DISCUSSION

Our use of measurements incorporating the two regression equations of circ. 30 (C. tagal) and circ. 150 (R. mucronata) is consistent with what appears in literature for the use of dbh (diameter at breast height) and height in predicting stand biomass. Circ. 30 for C. tagal proves better on two grounds: for one it gives a high accuracy of prediction (R^2 = 0.98 in ln:ln), and two the scrubby nature of the plot does not favor the use of dbh. Circ. 150 similarly gives a high accuracy (R^2 = 0.93) and encompasses the majority of observations. The prop root development in the R. mucronata exclude the availability of stems at lower levels. Despite the good fit in circ. 200, it presents practical handicaps for its use and will in addition exclude several trees.

The biomass distribution in C. tagal seedling is so diverse (biomass per square = 0.54 ± 0.38 kg per square) that no conclusive remarks can be advanced now. Instead a call for further research in the line of seedling dispersal, growth and survival strategies is made.

From our phenological analysis for the period December 1990 to March 1991 the calculated dry weight of litterfall is in the region of 3.20 to 4.95 ton per hectare per year. This amount is some 6% of the dry weight stand biomass (52.9 to 81.7 ton/ha). Our estimate of 3.2 to 4.95 ton/ha/yr corresponds to what has been referred to as basin mangroves in related work by Twilley R.R et al.(1986) in the mangal wetlands of S.W. Florida. Indeed C. tagal has all the characteristics discussed for basin type mangroves. Basin mangroves have lower water turn-over, occupy inland sites that are less frequently inundated by tides and it is hypothesized that these sites have organic matter and nutrient cycles characteristic of more closed mangrove ecosystems. At a later stage it would be interesting to see if the values for R. mucronata also corresponds to the fringe and overwash type.

The links between primary productivity and storage and/or export forms another theme of this project which will give a good insight to the budget of the production. The stored component is to sustain the living system while the export component supports the off-shore productivity through nutrient enrichment (remineralization), detritus food chain, and DOM. Backed with this it is also possible to tell the health of a stand, whether progressing or dying.

4.1.2. Relative importance of mangrove litter as nutrient source: preliminary results.

By: A.F.Woitchik(1), J.Kazungu(2), R.G.Rao(1) and F.Dehairs(1)

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(2) K.M.F.R.I., Mombasa, Kenya

INTRODUCTION

Within the context of this EEC project we are studying the relative importance of mangrove litter as energy source to secondary and tertiary producers. This subject is not well assessed presently, especially in East Africa. Our objectives are to investigate on the nutritive value of mangrove litter and its decomposition as potential source of nutrients in the ecosystem. The project focusses on the mangrove of Gazi Creek, situated 50 km south of Mombasa.

Our first step to study the input of nutrients by litter decomposition was to analyze the C and N composition of leaves of the same physiological age of the main species of the mangrove leaves in situ and in the laboratory and its nitrogen enrichment by biological nitrogen fixation.

RESULTS

C and N composition of mangrove leaves

In November 1990, fresh leaves of Ceriops tagal, Rhizophora mucronata, Bruguiera gymnorhiza, Avicennia marina and Xylocarpus granatum were collected from Gazi Creek. To obtain leaves of the same physiological age, we always took the second new leave on a branch, and this for different trees of the same species. Leaves were dried at 80°C and brought back to Belgium for analysis of C and N with a Carlo Erba NA 1500 Nitrogen Analyzer.

The results are presented in the Table below:

C/N atomic ratio

Species	mean $\pm \sigma$	N
Rhizophora	80 ± 10	20
Bruguiera	71 ± 10	18
Ceriops	69 ± 5	20
Xylocarpus	40 ± 8	20
Avicennia	28 ± 6	20

N = number of leaves

The ratios of the main mangrove species of Gazi, Rhizophora, Bruguiera and Ceriops, are higher than C/N ratios for surface

sediments from Gazi Creek (C/N on average: 40, Oteko, FAME thesis, 1987). This indicates either that other sources (seagrasses, phytoplankton) are important in supplying organic matter to the sediments, or, in case that mangrove leaves are the main source of organic matter, N-enrichment of the fallen leaves occurs during their decomposition. This will be assessed in further experiments.

In situ decomposition experiment

Two sampling plots were selected in the mangrove area as representative of the mangrove vegetation: a pure Ceriops tagal, on sandy sediment, and a pure Rhizophora mucronata, on muddy sediment.

A preliminary decomposition experiment of leaves of Ceriops tagal was done in the Ceriops plot in October-November 1990. Litterbags (mesh 1mm), each one containing 5 senescent leaves taken from the trees were placed in the plot and attached to the Kneeroots of Ceriops. They were collected randomly after 1 day, 3 days, 6 days, 9 days and 15 days, dried and weighed. Analyses of C and N were made as previously described.

After 15 days of decomposition, we observed a loss of 16% in dry weight.

Concerning the C/N ratios, we observed the following:

1) A rising of C/N ratio from 69 in fresh leaves to 219 in senescent leaves. That shows a resorption of 69% of N by the tree before leaves fall down.

2) No clear trend of C/N variation with time. Similar experiments will be done again in 1991 but decomposition time will be prolonged.

FURTHER PLANS

A 3 months in situ decomposition experiment with litterbags will be conducted from May to July 1991 in the 2 representative plots of the mangrove. Litter will be assessed for biological nitrogen fixation by the acetylene reduction technique. Leaves will be incubated for 2 to 6 hours in gas-tight enclosures under 10% (by volume) of acetylene. Gas samples will be analyzed every 30 minutes by gas-chromatography to check for reduction of acetylene in ethylene. This will be done using the new gas chromatograph installed in KMFRI in the laboratory set up in February 91. Leaves will also be dried, weighed, and saved for later analyses in Brussels.

In the same period, decomposition of senescent leaves of Ceriops and Rhizophora will be studied in vitro. Leaves will be incubated in inclosures filled with estuarine water of Gazi Creek. Water will be sampled daily for analysis of PON, POC, NO_3, NO_2 and NH_4. At the end of the incubation, biological nitrogen fixation will be measured and leaves will be dried, weighed and analyzed for C and N content.

Concerning the study of the transfer of C and N from primary to secondary and tertiary producers using the natural stable

isotope ratios, we are presently installing at the V.U.B. the new trapping box, linking the C and N analyzer to the mass spectrometer (Delta E, Finnigan Mat). J. Kazungu, senior scientist at K.M.F.R.I. will spend 3 months in our laboratory to learn the technique of mass spectometric analyses and to perform the first measurements of stable isotope ratios in different levels of the food chain in the mangrove ecosystem.

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4.1.3. Nutrient dynamics in a tropical Mangrove Ecosystem (Gazi Creek)

By: J.M.Kazungu

INTRODUCTION

In order to understand the productivity of any marine or freshwater ecosystem, a study of nutrients availability and dynamics is of paramount importance.

Gazi Creek which is situated about 50 km South of Mombasa Island is essentially a mangrove swamp ecosystem. Mangrove species of the type: Avicennia marina, Rhizophora Mucronata, Xylocarpus granatum, Ceriops tagal and Bruguieria gymnorrhiza make up about 90% of the vegetation in the region. During low tides most parts of the creek are completely exposed and receive water only during high tides.

To the north, the creek is fed by River Kidogoweni which has been established as a seasonal river. River Mkurumuji which is located to the south of the creek empties its load to the open waters next the creeks entrance. However, theory has it that some of this load is ultimately washed into Gazi creek during high tide. If this were true, then the nutrients dynamics of Gazi Creek would actually be controlled by three sources, namely; River Kidogoweni, River Mkurumuji and the endogenic contribution mainly from bacterial decomposition of mangrove litter and seagrasses.

The present study which is still in its preliminary stages will focus on understanding and accessing the mangrove nutrient contribution to the ecosystem.

MATERIAL AND METHODS

To start with it was very important to know the distribution of carbon and nitrogen contents in various fresh mangrove leaf species. For this, mangrove leaf species of Ceriops tagal, Xylocarpus granatum, Rhizophora mucronata, Avicennia Marina and Bruguieria gymnorrhiza were sampled and analyzed for carbon and nitrogen content. Samples were collected taking into consideration different physiological ages of the leaves.

As from January 1991. Sampling has been going on to establish nutrient levels within the water column of Gazi creek. Four stations G1-G4 (fig. 1) were established longitudinally across the creek.

RESULTS AND DISCUSSIONS:

For the mangrove leaf samples, it was established preliminary that there is no significant differences in carbon contents of leaves of specific species regardless of physiological age differences. However, older leaves were found to have less nitrogen contents (ref. earlier report).

Figure 2 gives a general picture of the nutrients profile in Gazi creek during the dry period. Generally, there seems to be an increase in nutrients from station 1 to station 4. If we assume that all this water is from the open sea which only fills in during high tide, then the nutrient levels are supposed to be uniform. The relatively high levels noticed in the inner part could only mean that there is an additional source of nutrients in the inner part of the creek. The higher nutrient levels could be attributed to River Kidogoweni being the only river in the northern part. This will have to be confirmed during the rainy season which have just started. The low nutrient levels between St.2 and G3 could be due to relatively higher consumption of nutrients by phytoplankton.

Figure 3 gives change of nutrients levels with time at St. G3. Sampling was started at low tide (February) and samples taken every two hours till high tide. Low tide was at 10.00am while high tide was at 3pm. At low tide when there was no influence of open sea water in the creek, relatively high nitrate, nitrite and ammonia values and low values of silicate and phosphates were observed. At high tide, the reverse was noticed. This implies that during high tide, water rich in phosphates and silicates and poor in nitrogen compounds is supplied into the creek.

FURTHER RESEARCH:

Sampling will be done across the mouth of the creek (transect between Chale Island and River Mkurumuji entrance) to establish how much organic matter and nutrients get into the creek during low tide. Longitudinal transects will also be made deeper into the inner parts of Rivers Mkurumnji and Kidogoweni and also across their openings into the Gazi creek to establish their seasonal input into the creek. Mangrove nutrient contribution will be assessed by following the decomposition rates of different mangrove leaf species and also changes in natural Isotopic ($^{15}N/^{14}N$) changes.

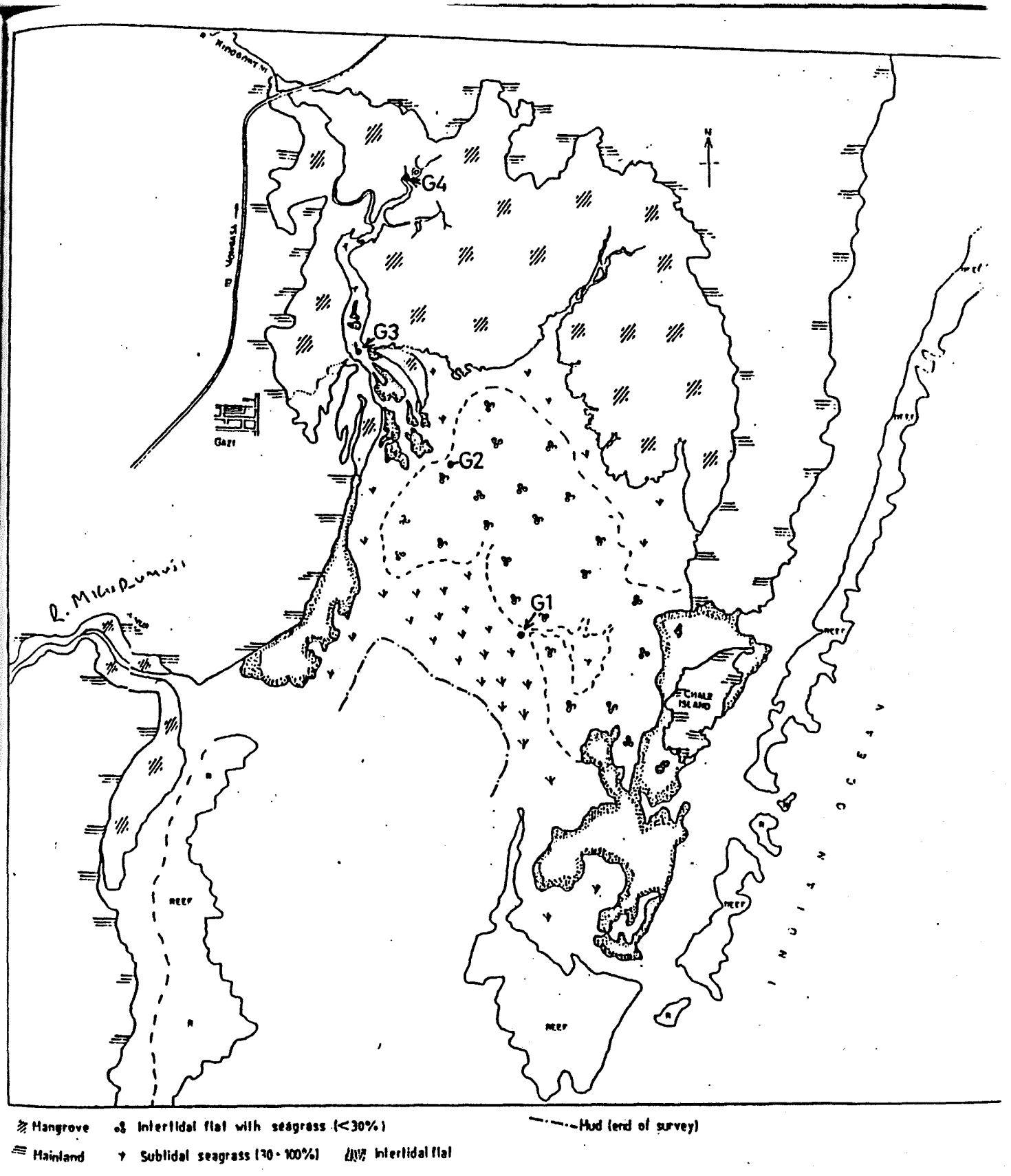

Figure I Sampling Stations (GI -G4) in Gazi Creek.

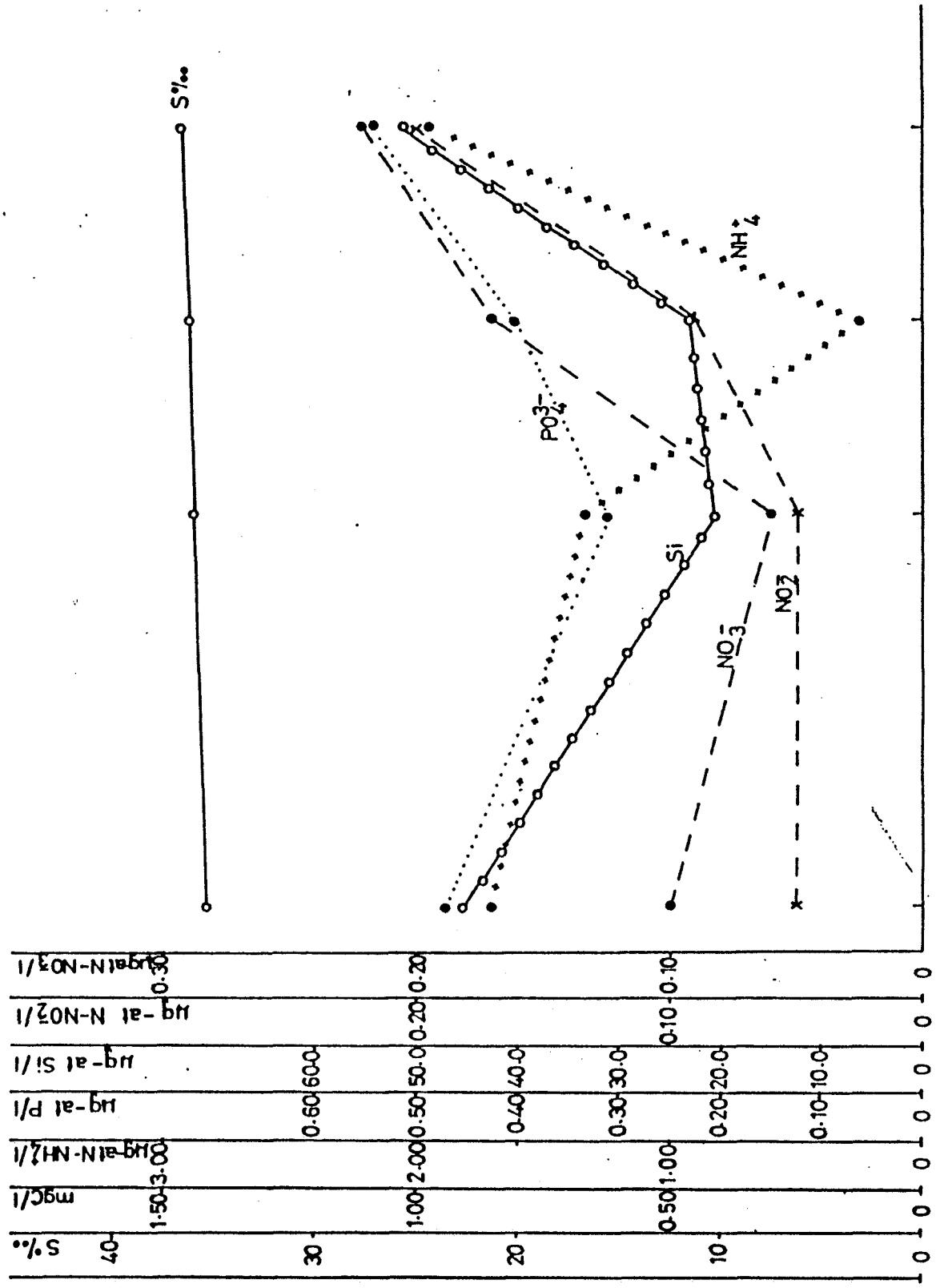

Figure 2. General picture of the nutrient profiles in Gazi Creek during dry period (February 1991).

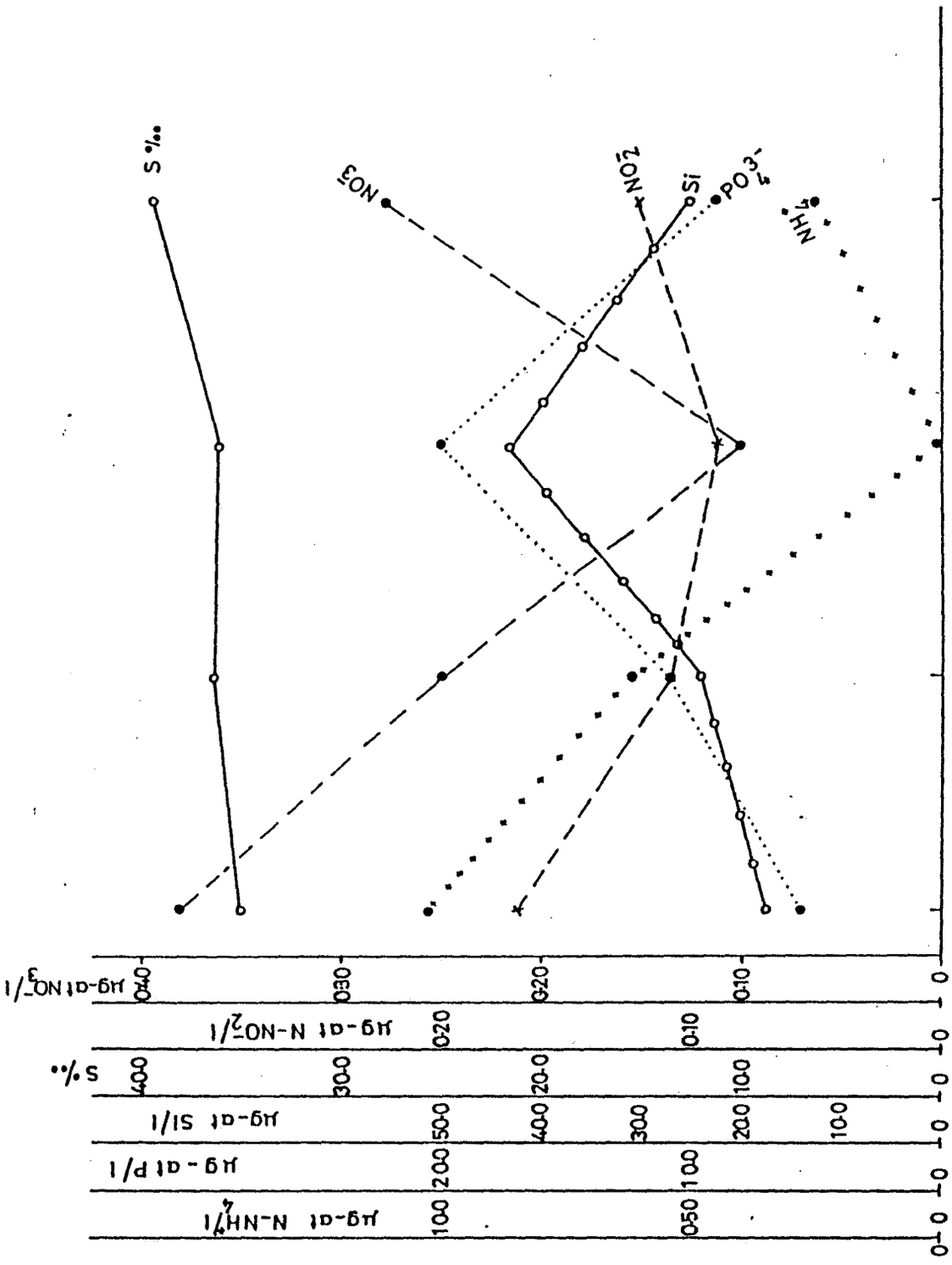

Fig. 3 Changes of nutrient levels against time at station 3. Low tide was at 10.00 A.M while high tide was at 3.00 PM. (February 1991)

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4.1.4. Species composition and primary production of Phytoplankton at Gazi Creek

By: P. Wawiye

INTRODUCTION

Three representative station have been established along the creek at the mouth (Oceanic), fish landing point and the head (inner mangrove). At each of the three stations measurements are carried out for primary production using the Winkler method. Measurements for biomass are also carried out using chlorophyll estimations. In addition other physico-chemical parameters like salinity, temperature and transparency were taken simultaneously. Samples for species composition and diversity were also collected through point sampling. This report includes a note so far w.r.t. productivity and the abiotic parameters. The average productivity of the three stations have been computed to represent the creek productivity.

RESULTS

In the present study both the highest and the lowest productivity occurred during the SE monsoon period, the lowest productivity occurring just after the long rains during the month of April 1990 (28.01 mg c/m /hr), while the highest productivity occurred well into the SE monsoon during the month of June 1990. (272.24 mg c/m /hr). It must be noted however that there were no values for the month of May. The average productivity of the Creek during the study period was found to be 129.02 mg c/m /hr.

The SE monsoon period was found to have a slightly higher average productivity (136.23 mg c/m /hr) than the NE monsoon period (109.44 mg c/m /hr).

The average water temperature during the SE monsoon was only slightly lower (29.1 C) than that recorded during the NE monsoon period (30.7 C).

Measurement of salinity recorded only a minor change in average salinity during the SE (35%) as compared to the NE (36%) monsoon period.

Rainfall was high in March 1990, October 1990 and December 1990. In November 1990 their was a fall in Rainfall and the month of February 1991 was very dry. This showed some inverse relationship to the productivity which was low during the March - April 1990 (40.35 mg C/m /hr) and Sept. - Oct. 1990 (95.34 mg C/m /hr) period. In November 1990 their was a slight peak in productivity (156.17 mg C/m /hr) which fell until January 1991 (57.14 mg C/m2 /hr) to rise again in February 1991 (127.06mg C/M2/hr)

DISCUSSION

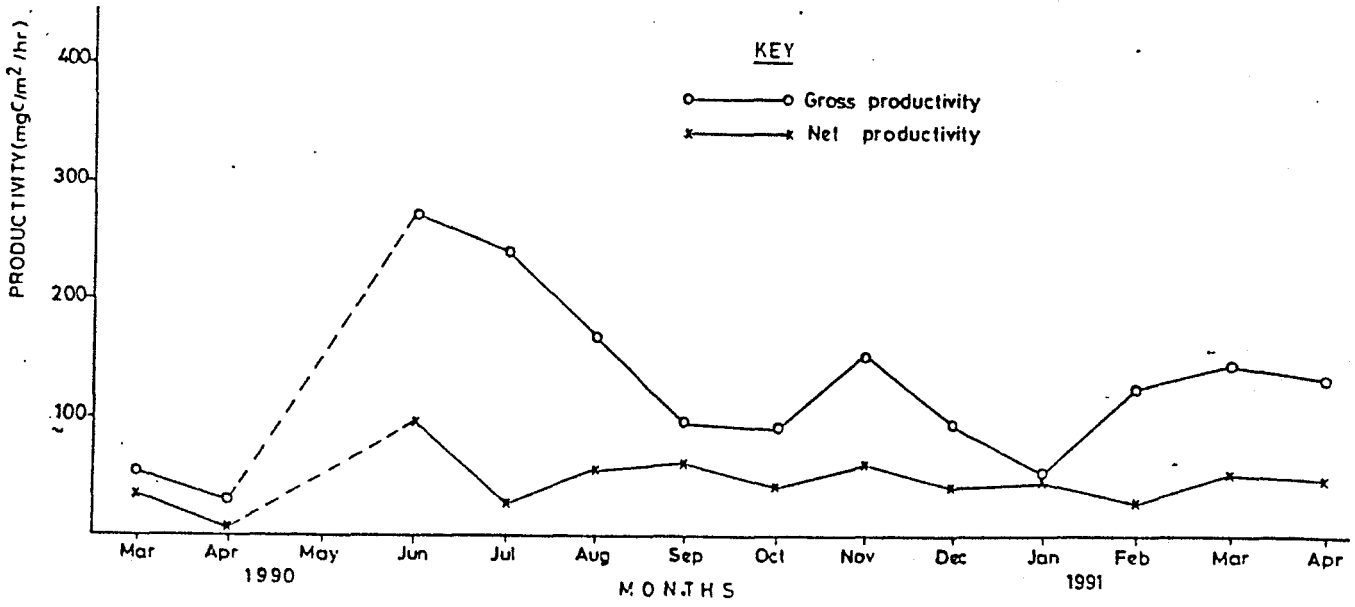
The NE monsoon period is characterized by clearer sky and greater solar insolation than the SE monsoon period, however, it seems that the magnitude of radiant energy during the SE and NE monsoon seasons has no effect on the productivity. Had this not been the case then the surface waters of the NE monsoon period would have had higher productivity than SE monsoon period or if surface inhibition were occurring during the NE monsoon period then the bottom waters of NE monsoon period would be expected to show higher productivity than the bottom waters of SE monsoon period. This as can be seen from the table below is not the case.

This may lead us to hypothesize that as neither salinity nor temperature fluctuate between levels which would have deleterious effects on the endemic phytoplankton population thereby affecting productivity (except probably salinity fluctuations in the immediate locality of the two rivers), during the period of rain, the higher than usual cloud cover together with the increased turbidity resulting as a consequence of runoff both from land and river effect the productivity negatively. However immediately after the rains, the turbidity is less and the nutrient input from runoff can now come into play to increase the productivity. As the river discharge and terrestrial runoff is greater during the long rains as compared to that during the short rains, not only does the period following the long rains show greater productivity, but in addition, the period during the long rains should show the lowest productivity. This may possibly explain why the SE monsoon should have the highest productivity and simultaneously show the lowest productivity.

Table 1: Mean xeasonal variation in productivity and abiotic parameters at Gazi Creek

PERIOD	TEMPERATURE(°C)	SALINITY(‰)	SURFACE G.P (mg C/m³/hr)	BOTTOM G.P (mgC/m³/hr)	SURFACE N.P (mgC/m³/hr)	BOTTOM N.P (mgC/m³/hr)
SE MONSOON March'90 - Oct'90	29.1	35	96.96	73.26	39.26	20.45
NE MONSOON Nov'90 - Feb'91	30.7	36	92.64	49.03	39.75	22.27

Figure 1.: Monthly variation in gross and net primary production at Gazi



Period in which no sampling was done is shown using dotted line.

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4.1.5. Zooplankton studies in a Mangrove Creek System, Gazi

By: E.Okemwa, J.Mwaluma and M.Osore

OBJECTIVES

To examine the species composition of the zooplankton community in the mangrove creek of Gazi
To determine the geographical and temporal abundance and distribution of different zooplankton groups
To measure hydrographic parameters of pH, salinity, temperature, turbidity and dissolved oxygen and relate their effects on zooplankton population

STRATEGY

Sampling stations are located at the creek mouth (stn 1), in the inner creek (stn 3) and intermediate (stn 2). Sampling is done twice a month; it starts from station 1 through stn 2 up to stn 3. A 335 um mesh size net is towed in near surface water for 5 minutes and the sample preserved in 5% formaldehyde. At the same time the hydrographic parameters are measured. Laboratory analysis of the sample involves sorting out the zooplankton into taxa and counting under the Wild Heerbrugg M3C microscope.

RESULTS

Hydrological Features:

Temperature - Maximum surface water temperature of 32.3°c was attained in March. The minimum 25.5°c occurred in August. Station 3 recorded the highest temperature and stn 1 the lowest. The annual temperature fluctuation was low, typical of tropical waters. Temperature was high between December and March (Fig. 1).

Dissolved oxygen - This varies within the range of 3.87 and 6.90 mg/L. stn 2 maintained somewhat a higher D.O. than stn 1. The lowest D.O. levels are recorded after the rains in June and January (Fig. 2).

Salinity - It is fairly constant at about 35% except in the rainy season (April and December) when it decreased (Fig. 3).

pH - Fluctuation was within the range of 7.50 and 8.63. Similar patterns existed between the pH of the 3 stations. Generally, the pH drops during the rainy season (Fig. 4).

Biological Features:
Total zooplankton - The zooplankton is rich and abundant at Gazi and about 40 taxa have been recorded (see Table 1). Monthly average abundance varies between 25 and 425 organisms/m . The copepoda group is the most important constituent of the zooplankton, it forms 31% to 98% of the total monthly zooplankton population (Table 2(a) - (c)). Other abundant taxa include brachyuran zoea, chaetognatha, amphipoda and appendicularia.

Each station displays peak zooplankton abundance of varying magnitudes (Fig. 5). Stn 1 displays a major peak in June and another smaller one in December. Stn 2 has a major peak in March and a smaller one in May. Stn 3 has two major peaks in March and January and a series of smaller ones in May, July and October.

Diversity of zooplankton community - On the Margalef Index, the diversity ranged between 2.00 and 4.53 units. The highest diversity (4.53) was observed at stn 1 in August. On average, stn 3 had the lowest diversity of zooplankton (Fig 6).

DISCUSSION

Gazi Creek supports a diverse zooplankton community which is largely dominated by copepods. Other dominant crustaceans include brachyuran zoea, chaetognatha, amphipoda and appendicularia. Abundance is higher during and just after the rains (March-April-May and November-December) and low during the dry season (August).

Occasionally, there is an inverse relation between zooplankton diversity and abundance, suggesting either a dominance by few species or an influx of many species. This phenomenon occurs in different stations independently. Since the hydrography between stations along Gazi Creek does not vary significantly, it is evident that water quality does not affect the distribution and composition of the zooplankton community; at least not in the dry season when there is no surface run-off. The determining factor may be that the organisms actively choose their environment using their body shapes.

At low tide, little water remains in small pools along the creek (much so in stn 3). Organisms that can resist (due to their body shapes or otherwise) the pull of the currents, will remain in these pools (or even in the sediments) till the next high tide. The organism will therefore tend to be localized in that station in large numbers or will consistently appear in each sample. The dominant taxa during such occasions; brachyuran zoea, Oithona spp. and Acartia spp. (stn 1) and Pseudodiaptomus spp., Oithona spp. and Acartia spp. (stn 3) could be possessing a common special ability. Investigations continue.

APPENDIX

TABLE 1 Zooplankton taxa recorded at Gazi

TAXA	STN 1	STN 2	STN 3
Annelida			
Polychaete larvae	XX	X	XX
Polychaetes	XX	X	XX
Amphipoda			
Hyperia	XXX	XX	X
unidentified	XX	X	X
Appendicularia			
Oikopleura	XX	X	X
unidentified	X	X	X
Brachiopoda			
Cladocera	X	X	X
Chaetognatha			
Sagitta spp.X	XX	X	X
unidentified	X	X	X
Cirripedia			
cirripedia nauplii	XX	X	X
Cnidaria			
siphonophora	XX	XX	X
Hydromedusae	X	X	X
Cumacea			
cumacea	XX	XX	XX
Copepoda			
calanoida	XXX	XXX	XXX
copepodid	XXX	XXX	XXX
cyclopoida	XXX	XX	XX
Harpacticoida	X	X	XX
Monstrilloida	X	X	X
Decapoda			
penaeidae	X	X	X
sergestidae	X	X	X
Decapod larvae			
Anomuran Zoea	X	X	X
Brachyuran Zoea	XXX	XX	X
Brachyuran Megalopa	XX	X	X
Caridean larvae	XX	X	X
Insecta	X	X	X
Isopoda			
Paragnatha	XX	XX	XX
unidentified	X	X	X
Mollusca			
Bivalve larvae	XX	XX	XXX
Gastropod larvae	X	X	XX
Pteropoda	X	X	XX
Heteropoda	X	XX	X

TAXA	STN 1	STN 2	STN 3
Mysidacea			
Mysids	X	X	XX
Nematoda	X	X	XX
Ostracoda	XX	XX	XX
Pisces			
Fish eggs	XXX	XX	XX
Fish larvae	XX	XX	XX
Stomatopoda	X	X	X

XXX = abundant XX = common X = rare

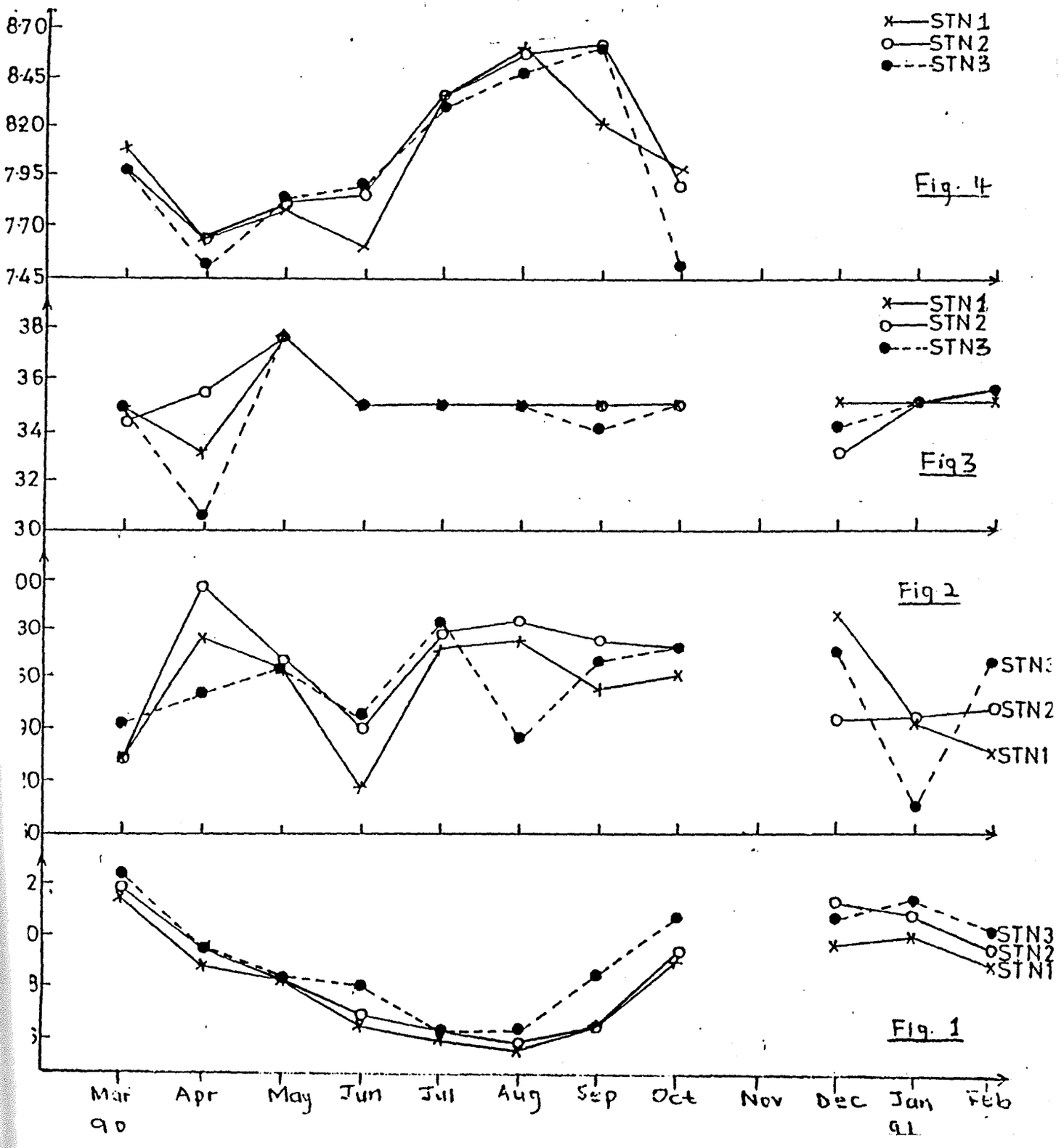


Figure 1,2,3,4: Monthly variation of temperature, dissolved oxygen, salinity and pH at Gazi between March 1990 and February 199 1.

Table 2a: Monthly percent composition of important zooplanktons in stn 1.

Groups	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Jan	Feb
Copepoda	90,31	58,36	75,60	92,54	71,15	77,71	31,80	76,54	88,27	71,43	75,15
Medusa	0,38	1,02	0,00	0,00	0,00	0,00	0,00	0,26	0,00	0,00	0,37
Brach. Zoea	2,04	17,50	4,31	1,24	7,84	1,45	42,40	4,35	0,86	2,23	4,75
Caridea	0,56	0,61	0,84	0,25	4,25	2,17	11,61	3,56	0,19	0,00	4,49
Chaetognatha	0,75	0,61	3,36	0,25	3,76	1,98	1,01	6,13	0,79	0,00	2,50
Ostracoda	0,47	1,63	0,11	0,13	0,31	0,30	0,51	0,29	0,08	0,45	0,51
Mollusca	0,53	3,26	0,63	2,49	5,10	5,71	1,52	2,13	0,19	0,45	1,25
Fish larvae	0,16	0,00	0,11	0,25	0,31	1,14	0,51	0,27	0,11	0,00	0,00
Nauplii	1,30	3,79	0,00	0,13	0,96	3,58	1,01	0,99	8,46	3,13	3,50
Amphipoda	1,06	0,00	0,32	1,86	0,96	1,41	1,01	0,29	0,19	12,50	0,51
Appendicularia	1,35	4,16	0,53	0,00	0,00	0,00	0,00	3,00	0,00	0,00	2,74
Polychaeta	0,36	3,51	0,53	0,13	1,97	1,03	0,51	0,27	0,08	1,79	0,51
Isopoda	0,16	0,00	0,11	0,50	0,63	0,99	0,51	0,45	0,19	0,89	0,51
Fish eggs	0,28	1,02	12,62	0,13	1,03	0,80	5,05	0,51	0,08	2,23	0,51
Cumacea	0,00	0,61	0,00	0,13	0,70	0,00	0,51	0,00	0,08	0,45	0,27
Stomatopoda	0,00	0,00	0,11	0,00	0,00	0,15	1,01	0,27	0,00	0,00	0,27
Penaeidae	0,07	0,00	0,11	0,00	0,00	0,11	0,00	0,15	0,00	0,00	0,00
Cirr. Nauplii	0,00	1,88	0,00	0,00	0,00	0,00	0,00	0,15	0,11	2,23	0,27
Brach.Megalopa	0,00	1,02	0,63	0,00	1,03	1,37	0,51	0,00	0,11	0,00	0,74
Siphonophora	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27
Euphausia	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sergestidae	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,89	0,51
Others	0,20	1,02	0,00	0,00	0,00	0,08	0,51	0,40	0,22	1,34	0,51

Table 2b: Montnly percent composition of important zooplanktons in stn 2.

Grouos	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Jan	Feb
Copepoda	95,94	86,68	80,17	80,17	80,03	73,27	62,97	77,82	67,64	67,17	77,75
Medusa	0,39	0,00	0,70	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Bracn. Zoea	0,75	9,32	39,89	1,48	10,87	2,01	15,06	1,68	9,23	0,69	3,61
Caridea	0,39	0,00	2,62	0,50	4,33	2,19	0,69	0,86	0,74	0,69	2,50
Chaetognatha	0,51	0,80	1,57	0,99	5,67	0,66	0,69	0,82	0,74	3,49	0,56
Ostracoda	0,08	0,31	0,00	0,00	0,49	0,58	0,69	1,09	0,74	0,69	0,56
Mollusca	0,39	0,77	0,70	8,41	7,11	11,69	0,69	1,91	2,45	0,00	2,22
Fish larvae	0,02	0,00	0,18	0,00	0,97	0,04	2,05	1,13	0,74	0,69	4,17
Nauplii	0,41	0,20	0,52	0,50	1,46	1,06	2,05	1,01	0,74	2,79	1,67
Amphipoda	0,18	0,57	0,00	2,47	1,44	2,56	2,05	2,18	1,96	13,30	1,94
Appendicularia	0,26	0,80	1,92	0,50	1,90	0,00	0,00	0,82	0,47	0,69	0,56
Polychaeta	0,06	0,00	0,18	0,50	1,43	2,26	0,69	0,82	0,74	0,69	0,56
Isopoda	0,14	0,00	0,18	0,99	0,49	0,77	0,69	1,05	1,71	2,10	0,56
Fish eggs	0,16	0,23	0,87	0,99	2,38	1,39	9,59	0,57	6,66	0,00	0,00
Cumacea	0,31	0,00	0,00	0,99	0,49	0,47	0,00	1,61	1,24	0,69	0,56
Stomatopoda	0,00	0,00	0,00	0,00	0,48	0,00	0,69	0,57	0,00	0,00	0,28
Penaeidae	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27	1,46	0,00	0,00
Cirr. Nauplii	0,00	0,23	0,00	0,00	0,00	0,00	0,00	0,27	0,00	1,41	0,00
Brach.Megalopa	0,00	0,00	0,35	0,50	0,48	0,77	0,69	0,82	0,74	0,00	0,83
Siphonophora	0,00	0,00	0,18	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Eupnausia	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sergestidae	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,56
Others	0,02	0,09	0,00	0,00	0,00	0,00	0,69	0,52	1,98	4,89	1,11

Table 2c: Monthly percent composition of important zooplanktons in stn 3.

Groups	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Jan	Feb
Copepoda	82,43	73,10	35,66	76,97	84,24	73,35	70,33	98,19	73,25	71,10	91,87
Medusa	0,00	0,17	0,88	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Bracn. Zoea	0,17	13,10	42,67	0,52	0,91	3,42	3,69	0,03	1,84	4,65	0,87
Caridea	0,12	0,00	4,38	2,62	3,45	2,23	0,94	0,07	0,90	0,36	0,13
Chaetognatha	0,03	1,03	2,41	0,52	1,83	0,52	0,00	0,06	0,46	6,96	0,25
Ostracoda	0,04	0,68	0,44	0,00	0,18	1,06	0,94	0,03	0,90	0,07	0,25
Mollusca	0,12	2,22	4,82	12,05	3,69	3,86	11,11	0,16	6,73	0,21	0,50
Fish larvae	0,17	0,00	0,44	0,00	0,91	0,05	0,94	0,03	0,46	0,07	0,00
Nauplii	16,58	2,38	0,88	0,00	0,71	7,74	3,69	0,75	1,28	13,86	0,50
Amphipoda	0,12	0,34	0,66	0,52	0,18	1,06	0,94	0,13	0,90	0,21	1,37
Appendicularia	0,06	3,41	0,88	2,09	0,42	0,00	0,00	0,04	0,43	0,14	0,13
Polychaeta	0,04	1,36	1,09	0,52	0,42	0,87	0,94	0,04	2,30	0,00	0,50
Isopoda	0,03	0,00	0,66	2,62	0,00	1,20	0,94	0,18	2,74	0,14	1,50
Fish eggs	0,00	0,51	1,09	1,05	2,12	0,30	3,69	0,04	2,35	0,14	0,37
Cumacea	0,01	0,00	0,00	0,52	0,18	1,41	0,00	0,10	1,36	0,00	0,25
Stomatopoda	0,03	0,00	0,00	0,00	0,00	2,04	0,00	0,06	0,00	0,00	0,00
Penaeidae	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,00	0,00	0,00
Cirr. Nauplii	0,01	1,03	0,00	0,00	0,00	0,00	0,00	0,00	0,46	1,79	0,00
Brach.Megalopa	0,00	0,00	0,44	0,00	0,18	0,90	0,00	0,03	0,90	0,00	0,37
Siphonophora	0,00	0,17	0,00	0,00	0,24	0,00	0,00	0,00	0,00	0,00	0,00
Euphausia	0,00	0,00	2,63	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sergestidae	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,00	0,07	0,00
Others	0,03	0,51	0,00	0,00	0,00	0,00	1,85	0,06	2,76	0,21	1,13

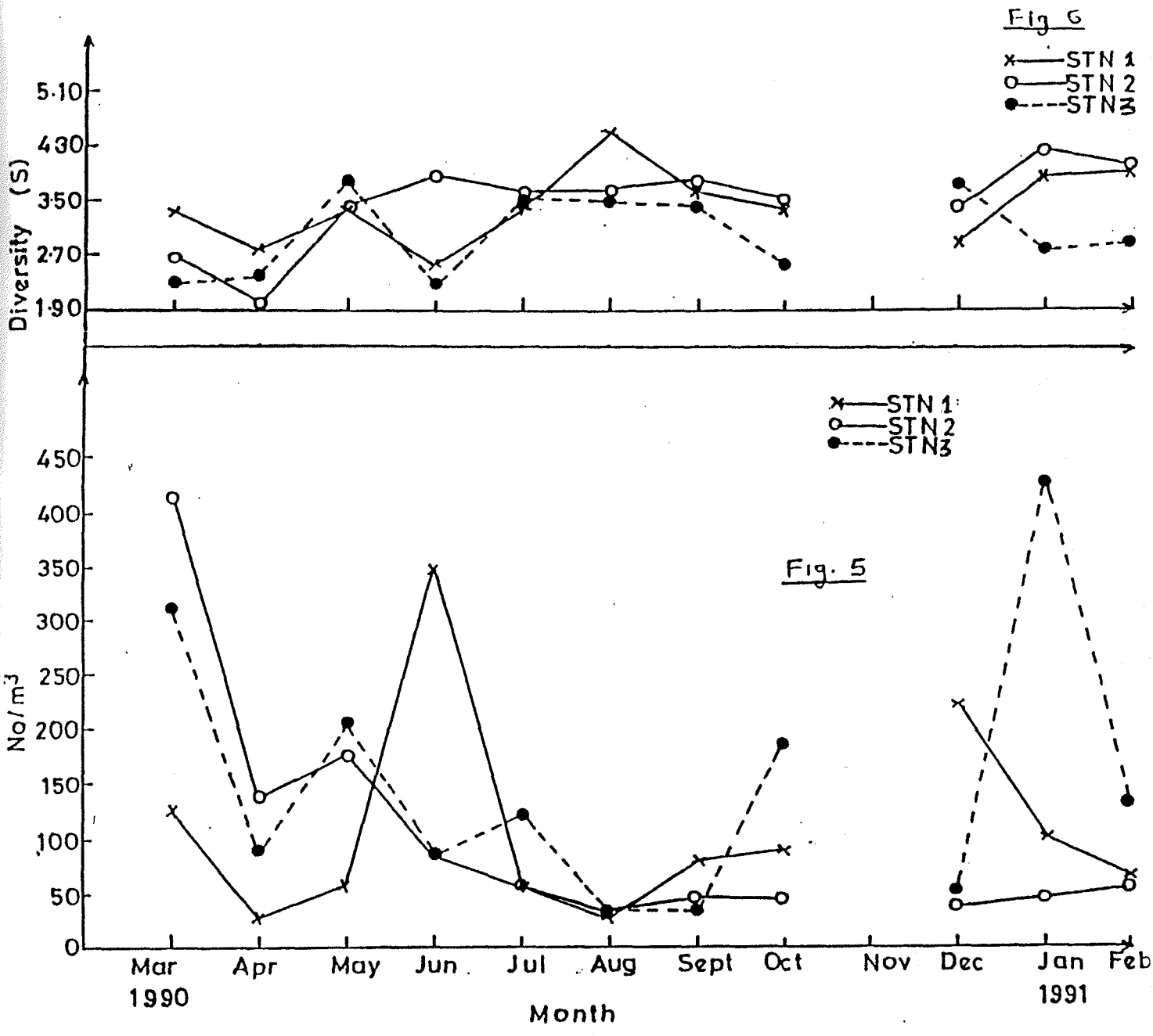


Figure 5,6: Average monthly variation in zooplankton population (nr/m3) and diversity of taxa at Gazi between March 1990 and February 1991.

4.1.6. Fundamental and Applied bacteriology in tropical marine waters.

By: J.Wijnant,S.Mwangi and M.Owili

INTRODUCTION

The study of the bacterial population,its activity and the pool of organic matter in the ecosystem is extremely important from a pollution and a public health view point,specially in regions with increasing tourist industries.
Growing evidence show the quantitative importance of planktonic bacterial heterotrophic activity in the carbon cycle in marine ecosystems.
Although it has often been assumed in the past that most of the produced organic matter flows through the zooplankton-fish tropic chain,it now becomes evident that planktonic bacterial activity constitutes,at least in some marine environments,a very important bypass.
Therefore it is important in ecological research to have some knowledge of the basic relationships between organic matter and bacterial heterotrophic activity.Bacteriological research should emphasize two fields:
1*the enumeration of marine pathogenic microbial populations
2*organic matter and activity of the microbial populations.

1.Infectious organisms

At this point we cannot discuss whether treatment plants,from an economic point of view,are effective in destroying infectious organisms,or whether other means of sterilization might be applied.Since it is desirable to keep the sea coasts hygienically clean as recreational beaches,the removal of communicable organisms from effluents in coastal areas is often more important than the reduction of the organic effluent load.
Particularly strict bacteriological requirements must be met in those areas where there are shellfish cultures in the vicinity of effluent drain pipes.Mussels and oysters filter bacteria out of seawater and often store them without the vitality of the bacteria suffering.
Disease-causing organisms can only be found in bodies of water if prevalent in the human population.
Escherichia Coli is under normal circumstances a non-pathogenic bacterium living in the intestine of man of warm-blooded animals,occurring in the faeces and therefore used as an index organism,along with some other faecal microorganisms.Faecal coliform germs are used to monitor sewage pollution and to asses health risks from drinking water,from food stuff,and from bathing.
Escherichia Coli is always present in excrement and fecal effluents.Naturally,the presence of E.Coli in a body of water does not indicate anything beyond the fact that fecal effluents

are present in a diluted form.
Civil health authorities in many countries of the world consider a ban on swimming if concentrations of Escherichia Coli higher than 100-1000 per 100ml are found in freshwater.
Bacteria-eating unicellular organisms are in all likelihood hardly specialized in intestinal bacteria.However,they contribute among other influences to the elimination of Escherichia Coli because,under normal conditions,this intestinal bacterium cannot multiply in marine environment(Enzinger and Cooper 1976).When, however, seawater contains more than 100mg/l of organic substance, E.Coli grows and holds its own against marine bacteria.

Technique
The membrane filtration technique is now used as the best method for the enumeration of different pathogenic bacteria (method:see Wijnant et al.VLIR July 1990).

2.Biodegradable Organic Substances
Man,like all animals,consumes organic foodstuff and leaves undigested organic remains behind in the faeces.In the preparation of his food organic substances are also left over as garbage,whether in the commercial processing of foodstuffs or as household waste.In natural environments,decomposers exists:organisms which specialize in the breaking-down of a dead organic substance.More precisely,they are organisms which satisfy their energy needs from dead organic substance.For the most part,they are bacteria and micro-fungi.
Under ideal conditions,the cycle of carbon and oxygen is balanced in nature.When effluents from a city are introduced into a body of water,this means an additional supply of dead organic substances,and the question is whether or not it can be absorbed by nature.The number of bacteria in bodies of water can respond to the amount of available organic substance.However,bacteria consume oxygen in their respiration process.To serve as a rule of thumb,the Population-Equivalent Unit has been created;one unit represents the amount of oxygen that is consumed to break down during a 5 days experiment the readily degradable fraction of the faeces and garbage produced by 1 person per day.This figure is called Biochemical Oxygen Demand (BOD5).
The term BOD describes either a quantity of organic wastes,or it refers to water quality(mgO2/l).
To identify the BOD of a water sample,first the oxygen concentration is analyzed,then the sample is maintained for 5 days at a temperature of 20 C in a closed bottle,and the oxygen concentration is again measured.From the difference between the two measurements one calculates the amount of free dissolved oxygen which has disappeared,the BOD.
Within 5 days a reasonable fraction of the degradable organic matter in the sample is degraded by water bacteria.What is left

over are organic substances which are difficult to degrade;they could be analyzed by chemical methods(COD,Chemical Oxygen Demand).

3.Ultrafiltration and carbohydrates

We can also study the relationship between organic matter and heterotrophic activity in aquatic ecosystems by determining their in situ concentrations and utilization rates of "directly usable low molecular weight molecules".
Because in the most ecological methods it is assumed that heterotrophic activity is directly proportional to the "total organic load"determined as "biological oxygen demand(BOD)",chemical oxygen demand(COD) or total organic carbon,most of the organic load in sea water is known to exist as "dissolved organic matter"(such as sugars and amino acids).
Dissolved organic matter can occur by phytoplankton and zooplankton excretion and detritus hydrolysis by exoenzymes.
However organic matter in seawater consists of macromolecules with molecular weight higher than 400 or 500 Daltons.
The penetration of an organic molecule across a bacterial wall is an active process occurring with the intervention of specific enzymes called permeases.Only low molecular,weight organic molecules (monomers or small polymers)can therefore be taken up,the oxidation of the DOM happens through oxidants like oxygen and nitrates.
Only through the production of exoenzymes,for example exoamylase,exoprotease,particles of H.M.W. molecules can be ultimately absorbed by bacteria.
Phagocytosis of particles is not developed by bacteria.Therefore the pool of directly usable organic matter is the pool of L.M.W. molecules.
So ultrafiltration of different samples on different membranes of different sizes will give us an idea about the concentration of carbohydrates in the different fractions of molecular weight

RESULTS AND DISCUSSION

1.Results for the BOD 5 days and Dissolved oxygen

The results are obtained by using the Winkler method.The method gives information about the total rate of oxygen consumption by the plankton community.So the results give us an idea of the nutrient mineralization in 5 days.
The method is based on the calculation of the oxygen concentration
(method:see Wijnant et al;VLIR JULY 1990)

1.1 BOD5 values TUDOR

The values mostly ranged between 120-500 mgC/m3 in the four sampling points.However there were high peaks in Oct.90 and Feb 91 where the values were as follows:

st1:60 mgc/m3 in Oct 90
    788 " Feb 91
    600 " May 91
st2:600 " Oct 90
    555 " Feb 91
st3:60 " Feb 91
st4:60 " Sep 90
    645 " Feb 91

(See graph 1,2,3,4,5)

1.2. Dissolved oxygen - TUDOR

Among the four sampling points in Tudor creek there was no marked variation in dissolved oxygen as given per sampling date (see graph 6)

In all the stations,the amount of dissolved oxygen was between 5,00 and 7,00 mgO2/l except in very few occasions where the values were higher (10,24 mgO2/l in station 1 ;8,32 mgO2/l in station 2 ;8,96 mgO2/l in station 3 ; 7,68 mgO2/l in station 4 "November" and 8,48 mgO2/l "Feb 91)

In general ,the average dissolved oxygen values were not very high but there were notable high peaks in November 90 and in December 90.There is also a small peak in February 91.

(see graph 1,2,3,4,5)

Conclusion for Tudor: the concentration of biologically oxidizable organic matter present in Tudor creek is quite the same in the four stations and if we compare the results with those taken in the North Sea (640 mgC/m3) a couple of years ago we can conclude that the amount of biologically oxidizable organic matter is low.

From the data available,it is difficult to draw comprehensive conclusions on the relationship between dissolved oxygen and BOD5.Currently,the biomass of total heterotrophic bacteria is being determined in the sampling points in function of time.This will avail more information that will be useful in establishing a general trend in the creek.

1.3.BOD5 values GAZI

The values for BOD5 range between 120-500 mgC/m3 with some exceptions where the values are higher than 500 mgC/m3.In general station 1 (deep in the mangroves) reflected comparatively higher activity (see graph 7,11).
Like in Tudor creek it is difficult to draw comprehensive conclusions on the relationship between dissolved oxygen and BOD5.
As in Tudor creek the determination of the biomass of the heterotrophic bacteria is being carried out.

1.4. Dissolved oxygen - GAZI

The amount of dissolved oxygen ranged between 4,00-7,00 mgO2/l in the four sampling points except for june where the values are slightly higher than 7,00 mgO2/l and December where the values were higher than 8,00 mgO2/l.
In general,the average value of dissolved oxygen was about 6,00 mgO2/l except for a small peek in October and a higher one in December (see graph 12)
Stations 1 and 4 (both in the mangroves)registered comparatively higher values than the other stations 2 and 3.

2. Carbohydrates

The mean value for the concentration of carbohydrates in Tudor creek is 5000 mgC/m3 (5)
The following are the mean values:

station 1	6000 mgC/m3
station 2	4000 mgC/m3
station 3	4500 mgC/m3
station 4	4000 mgC/m3

The mean value for the concentration of carbohydrates in Gazi creek is 4500 mgC/m3 (4)
The following are the mean values:

station 1	6000 mgC/m3
station 2	6000 mgC/m3
station 3	3000 mgC/m3
station 4	3000 mgC/m3

These values are quite high when compared with the BOD5 values.This suggests that most of the dissolved carbohydrates are long chain molecules which are not easily acted on by bacteria. Further investigations will be carried out through ultrafiltration technique so as to determine the concentration of the easily degradable low molecular carbohydrates.

3. Pathogenic bacteria

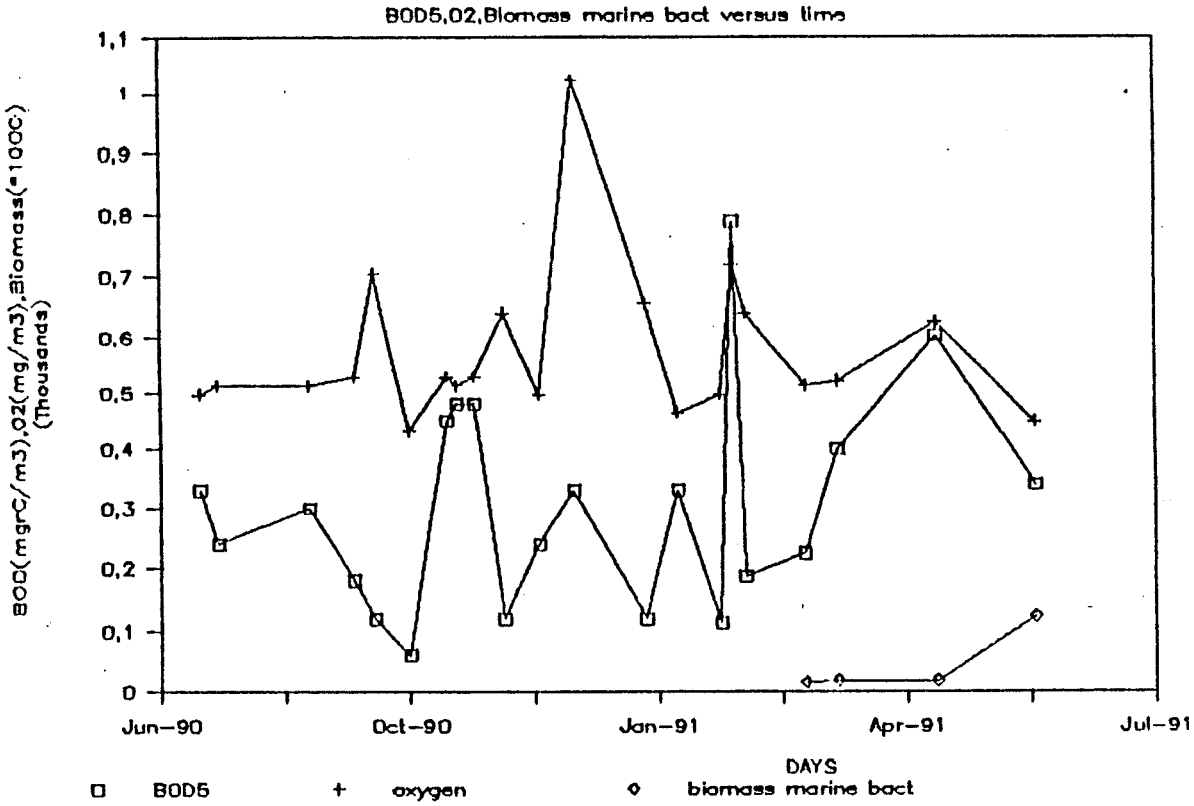
The mean values for the number of Escherichia Coli in Tudor creek are:station 1 21/100 ml (10)
station 2 10/100 ml (9)
station 3 37/100 ml (10)
station 4 12/100 ml (10)

The mean values for the number of Escherichia Coli in Gazi creek are:station 1 7/100 ml (4)
station 2 6/100 ml (4)
station 3 7/100 ml (4)
station 4 6/100 ml (4)

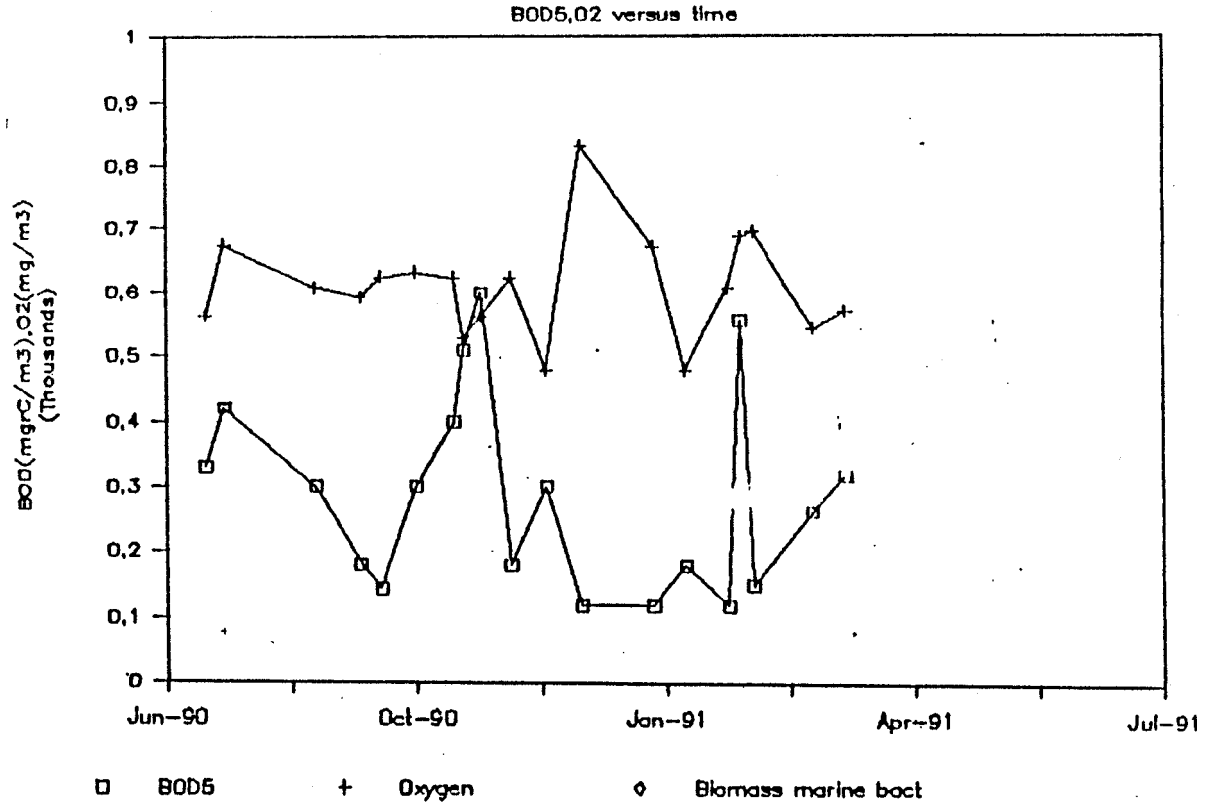
The world Health Organization (WHO,67)states that no water sample should contain more than 1000 total coliform group (TC)/100 ml and the EEC guideline (council of the EEC 75) says that no more than 500 TC or 1900 faecal streptococcal group per 100 ml

Conclusion:The number of E.Coli in Tudor is about 4 times higher than the number of E.Coli in Gazi creek.
The existence of the few E.Coli observed in Gazi creek is due to relatively lower human activity as compared to Tudor which receives a lot of effluents from Mombasa town.
In Tudor creek,a higher E.Coli count was observed in station 3 as compared to other stations.This could be due to possible discharge of sewage by the Coast General Hospital.

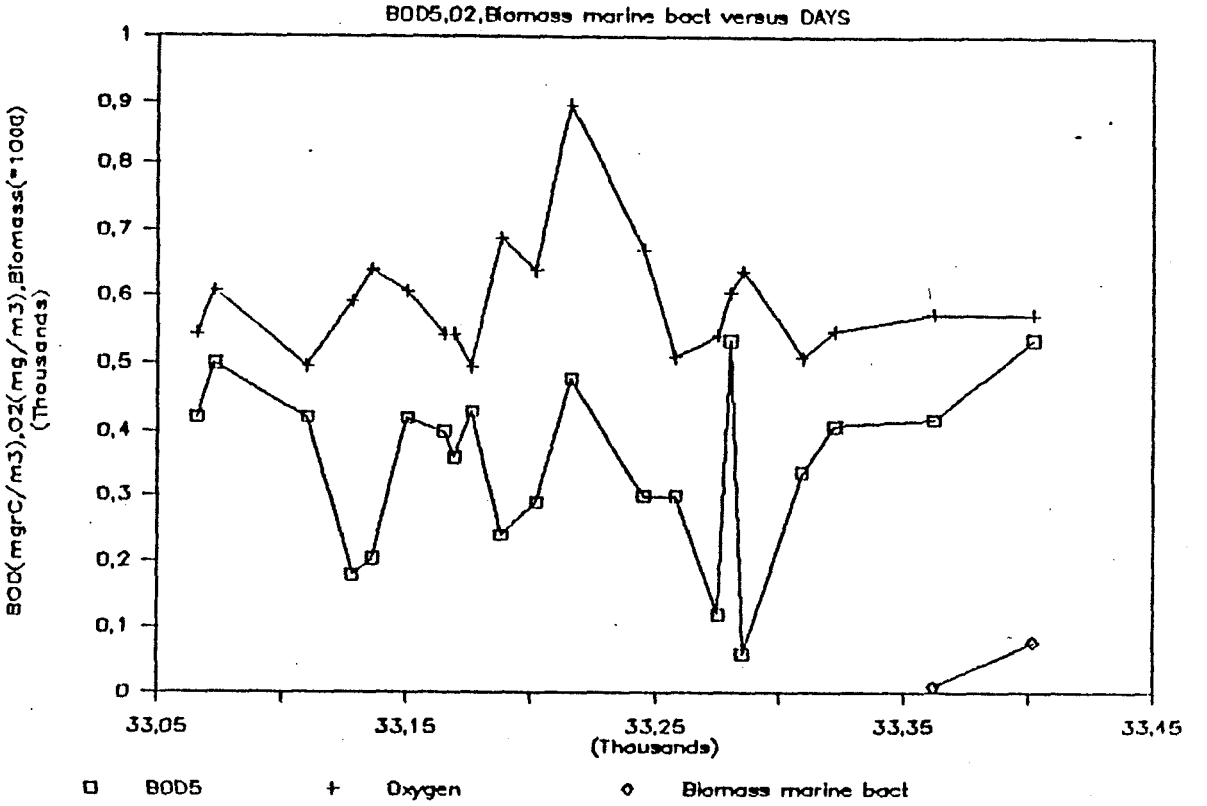
TUDOR STATION 1



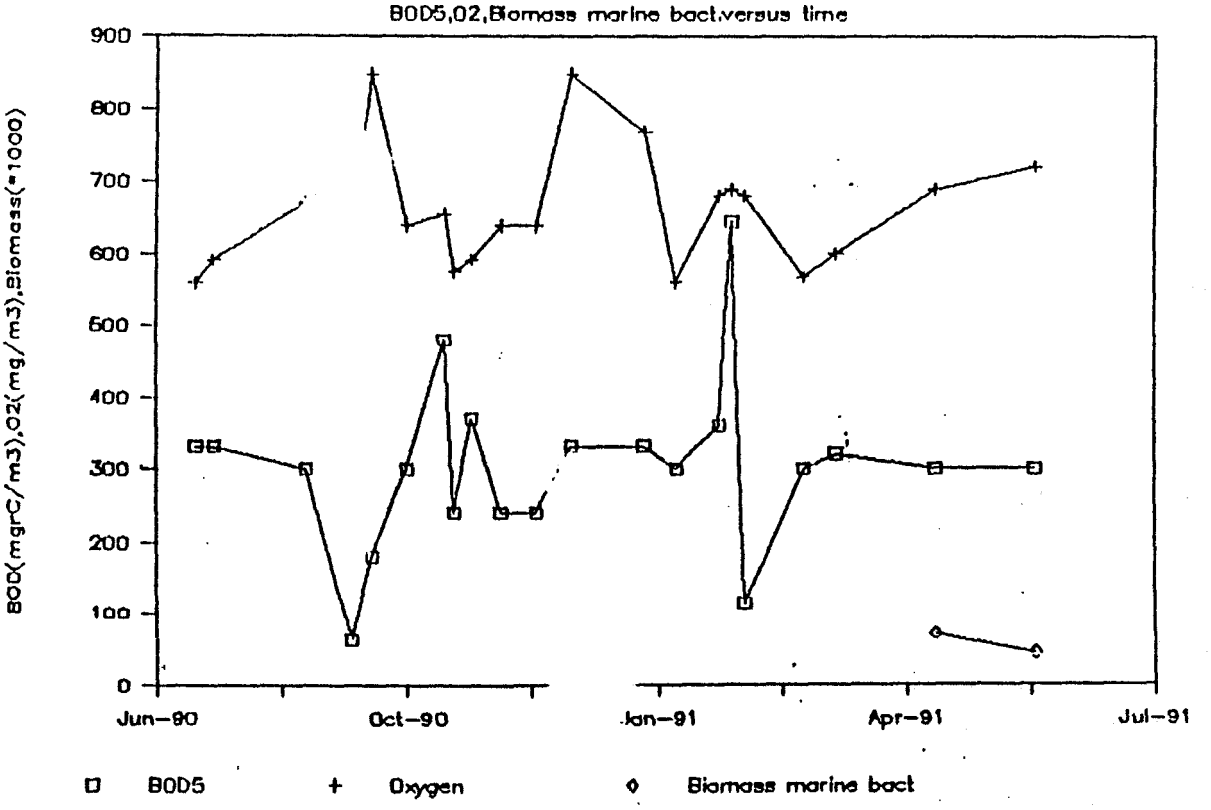
TUDOR STATION 2



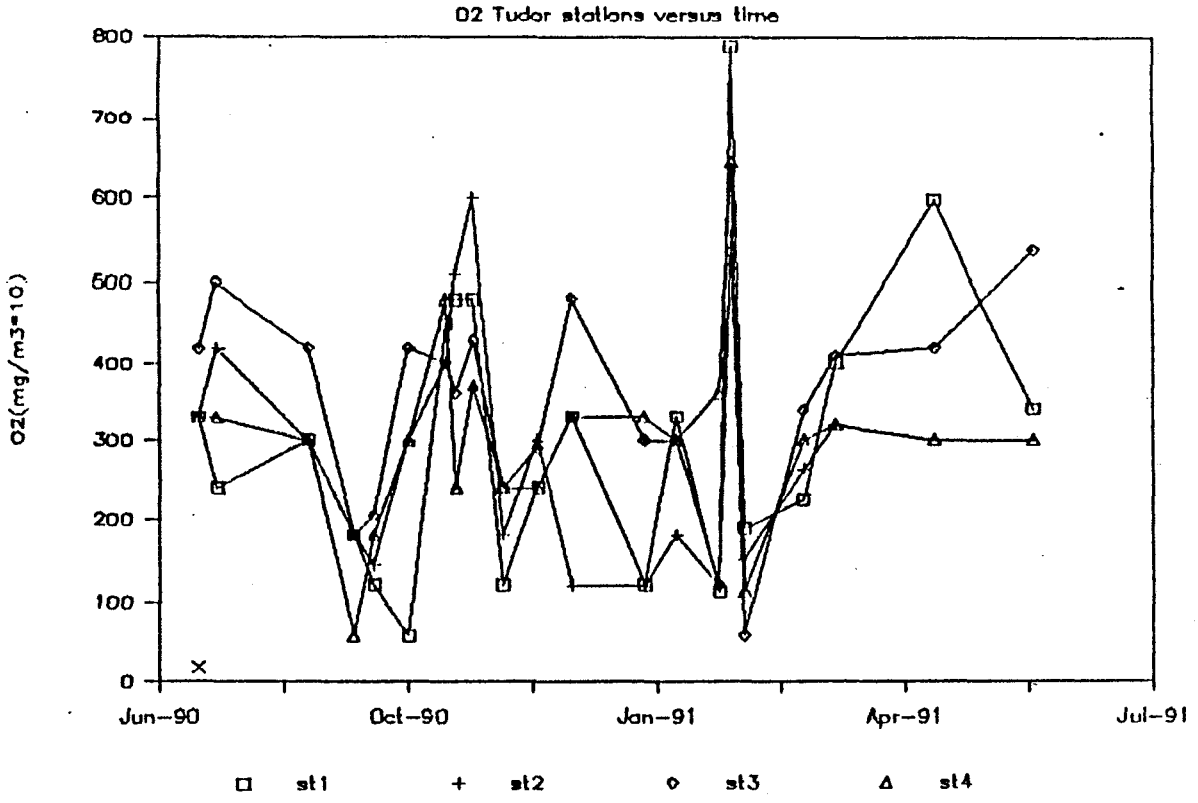
TUDOR STATION 3



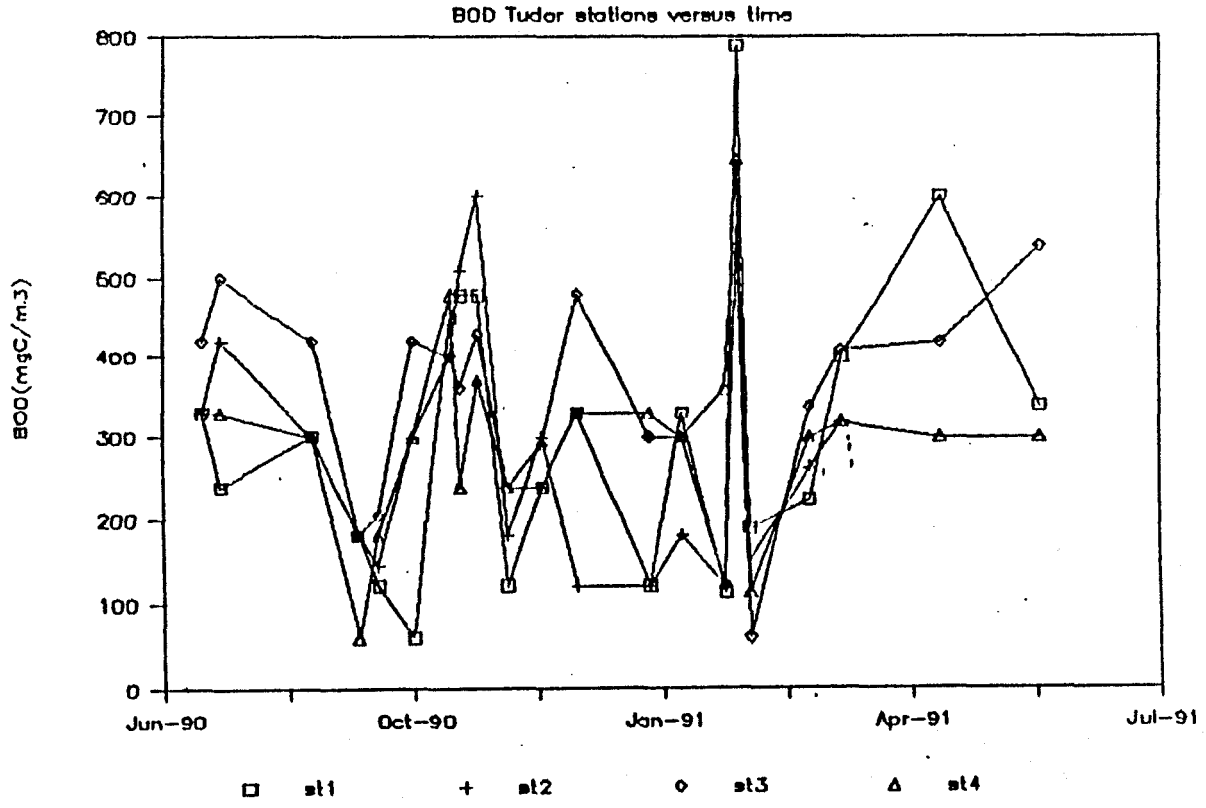
TUDOR STATION 4



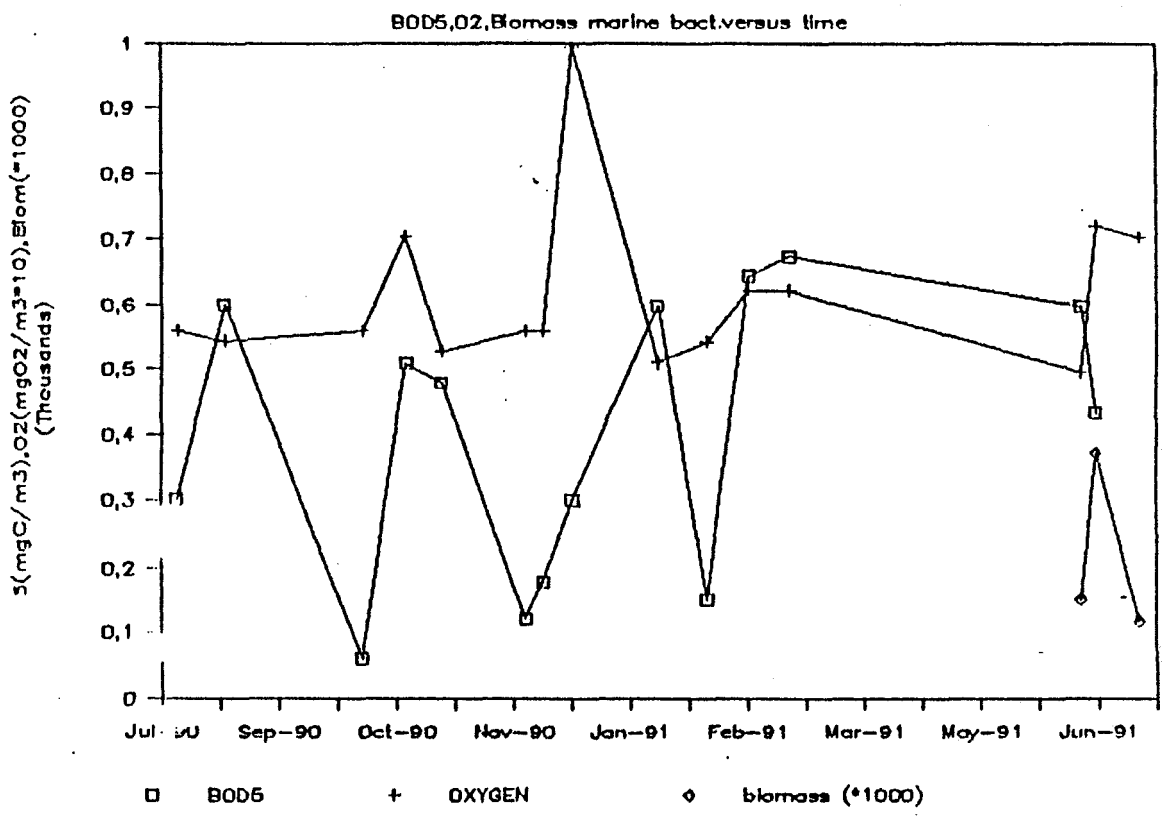
TUDOR STATION 1,2,3,4



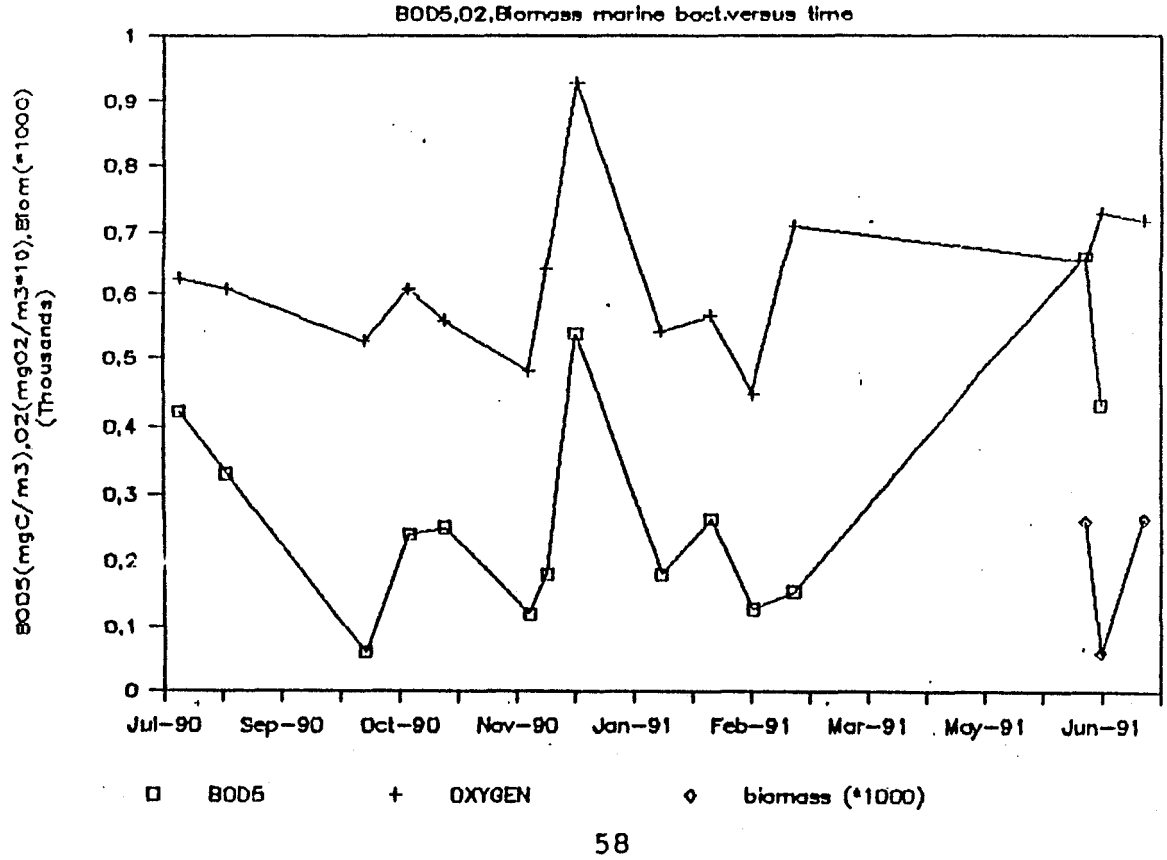
TUDOR STATION 1,2,3,4



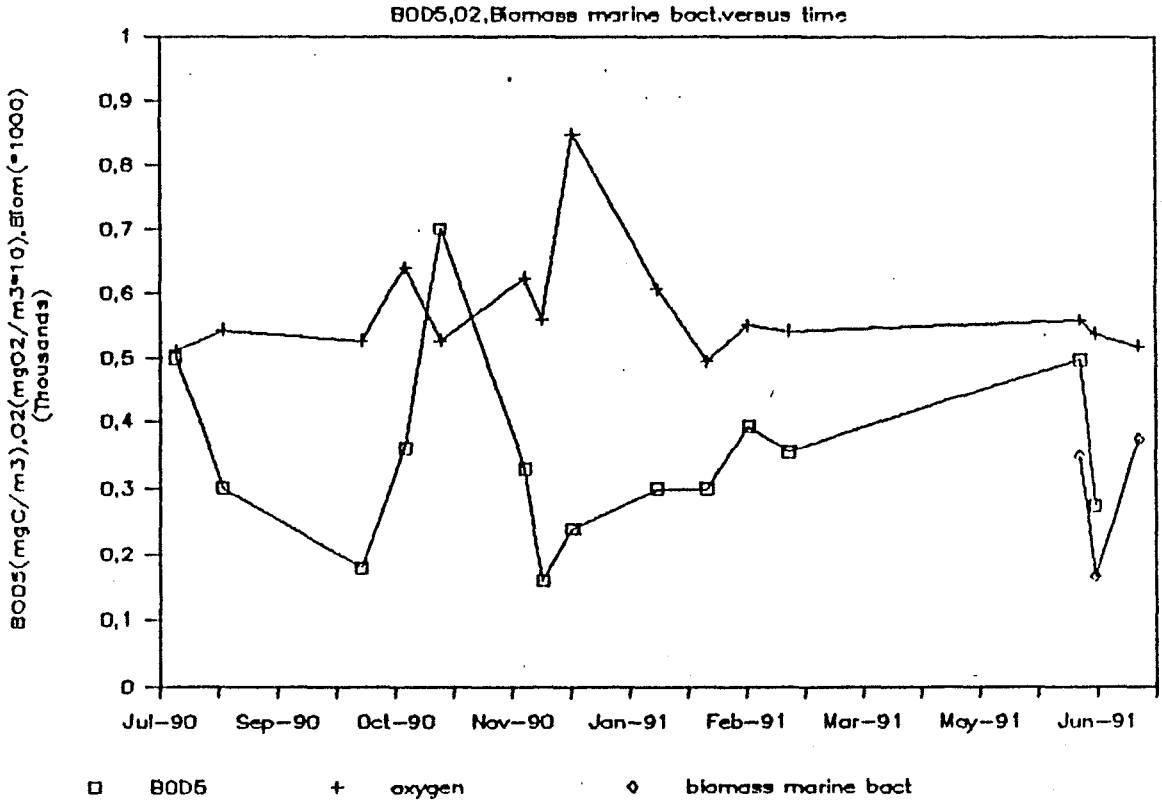
GAZI STATION 1



GAZI STATION 2

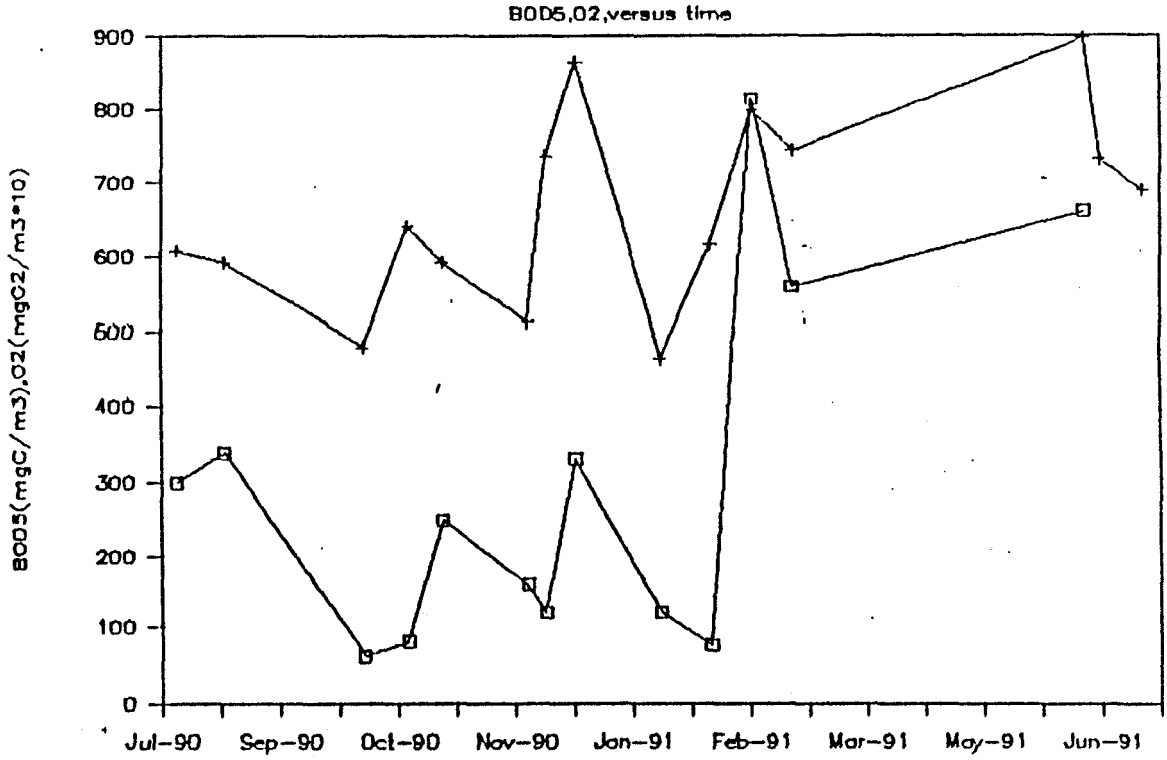


GAZI STATION 3



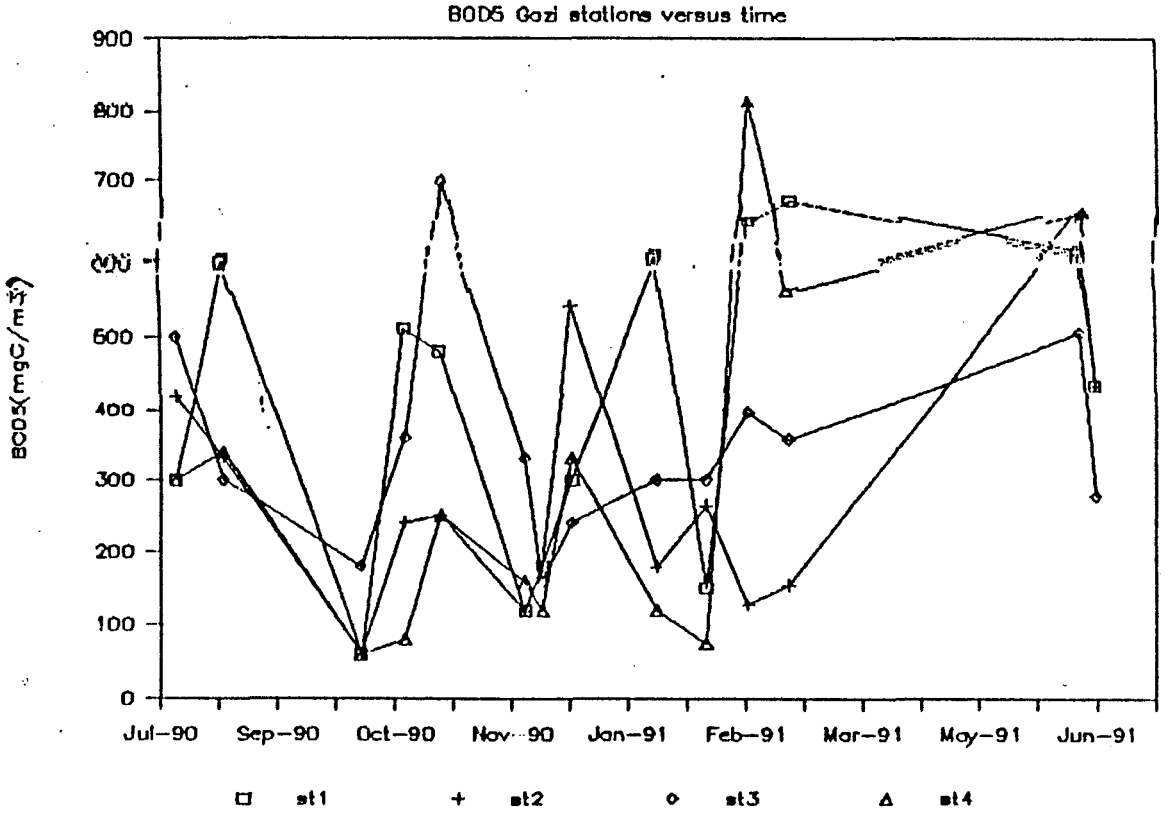
□ BOD5 + oxygen ◇ biomass marine bact

GAZI STATION 4

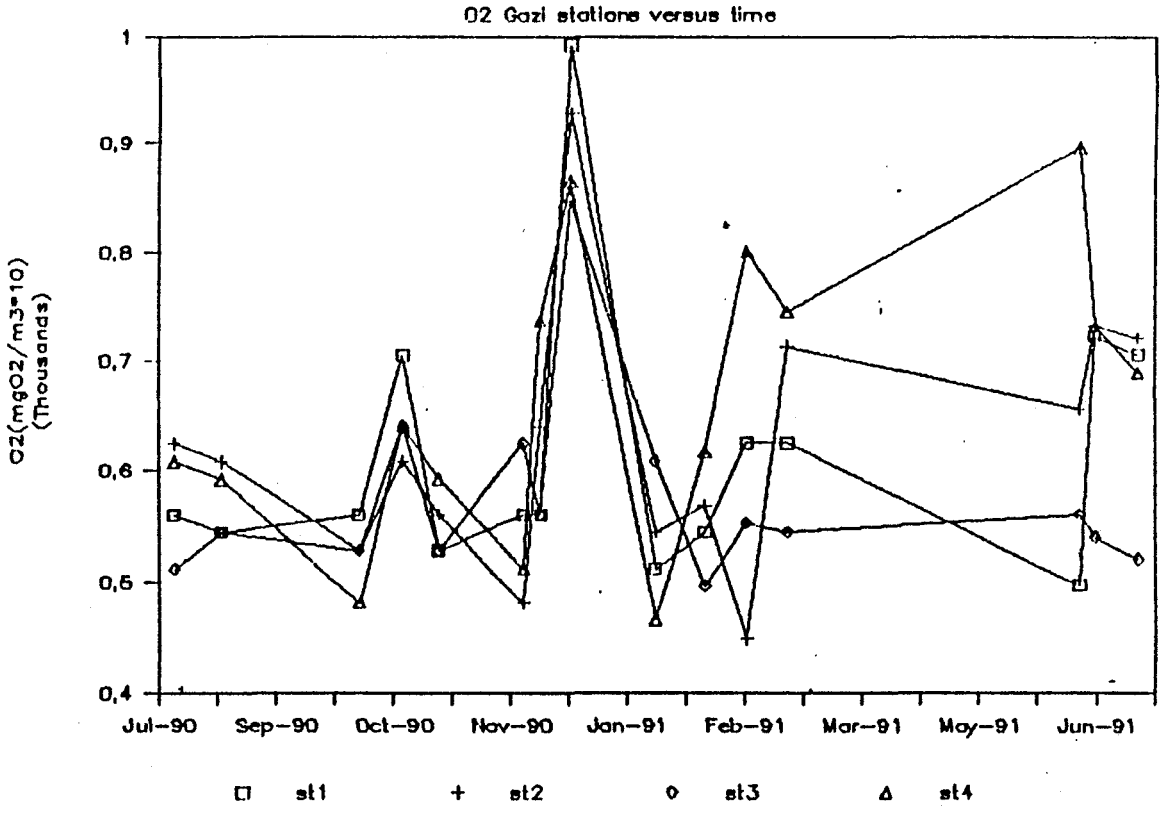


□ BOD5 + O2

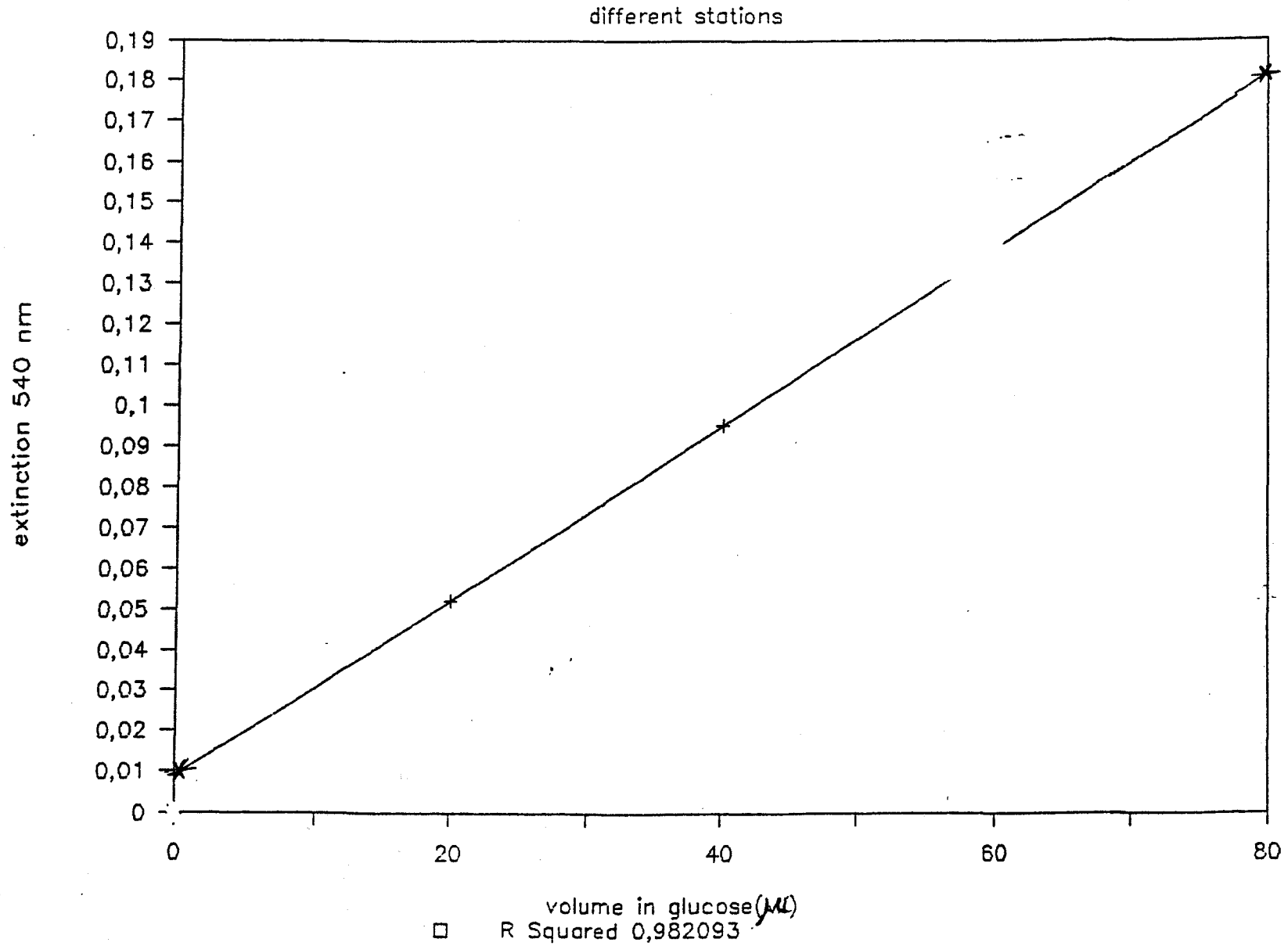
GAZI STATION 1,2,3,4



GAZI STATION 1,2,3,4



EXAMPLE OF A STANDARD FOR CARBOHYDRATES



4.1.7. The Fish community in a mangrove ecosystem

4.1.7.1. Fish Community and Fisheries studies of Gazi Creeks

By E.O. Wakwabi, in collaboration with M.Ntiba, B.Okoth, G.Mwatha and E.Kimani.

SUMMARY

The fish community of Gazi creek is studied by beach seining method.

A sieve net, about 50 m long, 1 cm mesh size and 2 m deep is used in the shallow shoreline water of the creek during low tide. Most samples are limited to low spring tides with isolated samples during neap tides. Low tides are preferred to high tides as they have enhanced catch rates, and offer larger operational ground a long the beaches.

Much interest is cast on the fish species composition, size composition, and the nature of food and feeding habits of a selected species. The occupance of young fish whose adult population is hardly met within the creek is noted with interest. Especially for Caranx ignobilis whose adults are usually associated with open (oceanic) waters.

Note: This report covers only the months of May and June 1990. The rest of 1990 was not adequately sampled and the part of 1991 is reported in Mwatha, G. K. and Kimani, E.

INTRODUCTION

Gazi creek experiences strong tidal fluxes especially during the spring tides. The abiotic and biotic environment in the creek is therefore subject to oceanic influence. During low tide, most of the creek water is fluxed out of the creek. On high (flood) tide, oceanic waters flow into the creek in a more or less stream like manner. Norconsult (1975) used floating drogues to show that tidal currents contribute to the overall distribution of floatable into and out of the Mombasa creeks. This mechanism has been shown to play a vital role in the transportation of fish and crustacean eggs and Larvae between the offshore marine waters and the inshore creek waters, and hence important in serving nursery grounds (Garcia & Le Reste, 1981; Motoh, 1981; Staples, 1985; Subrahimanyam, 1965; and Wakwabi, 1988).

Many species of mangrove fish move into mangrove areas at a particular stage in their life history (usually as larvae, post larvae, juveniles or spawners) and only associate with these areas during the stage. Others move in and out periodically (periodicity of tide etc) to feed. Such that, the success of many tropical fisheries depend on the health of the mangrove

swamps which mostly serve as nursery grounds and hiding (protection) grounds from predation e.g. Snappers, Jacks, Mullets, Sardines etc.

To understand the ways in which human activities affect mangrove swamps, one must understand the influence man has on the environment. Man affects mangrove environment through e.g. fishery collections, mangrove harvesting, mangrove clearing for mariculture or agriculture purposes, indiscriminate discharge of untreated sewage, agro-chemicals etc.

The studies on Gazi Creek will provide data and information on the utility of this creek by different fish species during any stage in their life history. Such information, together with the basic Oceanographic, Hydrographic, and Biological data may help in formulating management strategies relevant to the creeks ecosystem and useful for the establishment of overall management strategies for many more other ecosystems that share the same environmental, biological and fishery tenets.

RESULTS

As shown in the appended list, (Table 1) a total of 23 families of fish represented by 31 species was recorded. 18 of these species were represented by less than 10 specimens (got them represented by only 1 specimen). Goves oyena was the most prevalent, making up to over 46% of the total (748) number caught.

Studies on the food and feeding habits are going on. Initial analysis show evidence that most of the fish caught during this sampling are juveniles whose adults are landed by the local fishermen fishing on the reef far out towards the open sea. The diets of those fishes varied a lot though it was clear that most of the species are feeding on the epibenthic fauna, some on Zooplankton and only the siganids were found to feed solely on plant material mostly seaweeds (Table 2).

DISCUSSION

The data displayed is very small and only represented in four samples dates. It's therefore not conclusive but may be seen as indicative of what the outcome of this study will provide.

TABLE 1
FISHES OF GAZI CREEK

	FAMILY	SPECIES	NO.	SIZE RANGE TLcm
1.	APOGONIDAE	Apogon sp.	12	2.5 - 7.4
	(Cardinal fish)	Archama lineolata	21	3.1 - 8.4
2.	BELONIDAE	Tylosurus leiurus	4	36.5 - 45.5
	(Carfish)			
3.	BLENIDAE	Petroscirtes mitratus	6	3.6 - 5.7
	(Belennies)	Omabranchus straitus	1	6.1
4.	CARANDIDAE	Caranx ignobilis	22	6.2 - 9.7
	(Jacks)	C. sexfassciatus	7	6.8 - 10.7
5.	CLUPEIDAE	Hirklothychthis quadrimaculatus	2	5.7 - 2.6
6.	FISTULARIIDAE	Fistularia petimba	2	15.5 - 17.2
7.	GERREIDAE	Gerres Oyena	348	1.7 - 10.5
8.	GOBIIDAE	Gobius nebulosus	6	4.4 - 7.5
		Gobius spp.	64	2.5 - 6.5
9.	HEMERHAMPHIDAE	Heemirhampus far	5	5.7 - 35.5
10.	LETHRINIDAE	Lethrinus spp.	45	1.7 - 5.7
11.	LUTJANIDAE	Lutjanus fulviflamma		2.4 - 8.4
		L. johni	34	2.5 - 7.7
12.	MONACANTHIDAE	Paramonacanthus barnardi	1	5.7
13.	MUGILIDAE	Pleromugil diadema	1	14.3
14.	MULLIDAE	Upeneus bensasi	1	7.9
		Upeneus sp.	1	8.9
15.	PLATACIDAE	Platax pinnatus	1	4.6
16.	PLATICEPHALIDAE	Platiaphalus grandidiers	1	6.4
17.	SCARIDAE	?	1	5.8
18.	SIGANIDAE	Siganus canaliculatus	26	3.1 - 6.6
		S. sutor	1	2.3
19.	SCORPAENIDAE	Scorpaena mossambica	23	3.7 - 7.3
20.	SHYREANIDAE	Shyraena jello	15	6.8 - 29.5
21.	SYNGNATHIDAE	Syngnathoides biaculeatus	7	7.1 - 11.0
22.	SYNODONTIDAE	Saurida undosquamis	4	5.9 -17.5
23.	TERAPONIDAE	Terapon jarbua	39	2.7 - 13.5
		T. theraps	33	3.3 - 7.0

Table 2: Food and Feeding habits of selected fish spp.

	Species	Family	Sample Size	Size range TL cm	Stomach condition (Freq.)			Digestion level (Freq.)		
					Full	Partial	Empty	Raw	Partial	Advanced
1	Siganus canaliculatus	SIGANIDAE	16	3.1 - 6.5	13	3	0	8	6	2
2	Terapon jarbua	TERAPONIDAE	19	2.8 - 13.5	7	6	6	1	3	15
3	T. theraps	TERAPONIDAE	35	3.3 - 7.0	19	15	1	2	25	8
4	Gerres Oyena	GERRAIDAE	36	3.0 - 10.5	6	17	13	0	10	26
5	Lutianus fulviflammus	LUTJANIDAE	28	3.0 - 7.7	26	2	0	0	20	8
6	Caranx ianobilis	CARANGIDAE	22	6.2 - 9.7	13	5	4	0	12	10
7	Sphyraena jello	SPHYRAENIDAE	3	10.2 - 29.5	0	1	2	0	0	3

Table 2: Food and Feeding habits of selected fish spp.

Species	Family	Sample Size	TL cm Size range	Stomach contents	Freq.	% Freq.	Counts
1 Siganus canaliculatus	SIGANIDAE	16	3.1 - 6.5	1. Macrophytes (Sea weeds + others)	15	93.75	-
				2. Microphytes (Filamentous algae)	15	93.75	Numeral
				3. Copepods	15	93.75	2-47
				4. Trichodesmium	9	56.25	Numeral
				5. Ostracods	5	31.25	1-2
				6. Beyond recognition	8	50.00	-
2 Terapon jarbua	TERAPONIDAE	19	2.3 - 13.5	1. Shrimps (and Mysids)	13	64.42	
				2. Teleoist larvae	2	10.52	
				3. Mollusc shells	2	10.52	
				4. Copepods	1	5.27	
				5. Beyond recognition	8	42.11	
				6. Crops	1	5.27	
				7. Insects	1	5.27	
3 T. theraps	TERAPONIDAE	35	3.3 - 7.0	1. Hyperia Copepods	30	63.89	3-102
				2. Shrimps & Mysids and Acetes	23	65.71	8-64
				3. Teleoist larvae	9	25.71	3-20
				4. Doliolum	6	17.14	1-5
				5. Macrophytes (Sea weeds)	5	14.29	-
				6. Nemotodes (Parasites?)	5	14.29	1
				7. Other Copepods	4	11.43	1-10
				8. Undinula	3	8.57	2-7
				9. Crabs	1	2.86	6
				10. Beyond recognition	15	42.86	
4 Gerras Oyena	GERRAIDAE	36	3.0 - 10.5	1. Copepods	23	63.89	
				2. Nematodes (Parasites?)	14	38.89	
				3. Sand	8	22.22	
				4. Microphytes (Filameutous algae)	6	16.67	
				5. Crustacea	5	13.89	
				6. Mollusc Shells	1	2.78	
				7. Beyond recognition	7	91.67	
5 Lutjanus fulriflammus	LUTJANIDAE	28	3.0 - 7.7	1. Mysids	15	53.57	Numeral
				2. Crabs	6	21.43	1-10
				3. Acetes	5	17.86	1-37
				4. Copepods	4	14.28	2-37
				5. Teleoist larvae	2	7.14	1
				6. Nematodes (Parasites?)	2	7.14	1-2
				7. Beyond recognition	7	25.00	-
6 Caranx janobilis	CARANGIDAE	22	6.2 - 9.7	1. Acetes	17	77.27	1-182
				2. Other Shrimps	9	40.90	1-2
				3. Sand	3	13.64	-
				4. Copepods	2	9.09	2-5
				5. Teleoist larvae	1	4.54	1
				6. Beyond recognition	7	31.32	-
7 Sphyraena	SPHYRAENIDAE	3	10.2 - 29.5	1. Shrimps (Penacid head).	1	33.33	
				2. Sand	1	33.33	
				3. Beyond recognition	3	100.00	

4.1.7.2. The fish community in Gazi Creek

By: N.Ntiba, Wakwabi, Okoth, Kimani, Mwatha

INTRODUCTION

This study is a part of the EEC - VLIR - KMFRI mangrove ecosystem project 1990 - 1993. The major aims of this study include

1) Study of the fish assemblage and the residence status of each species and for those fish that migrate from coral reefs, try to find when the migration occurs.

2) To study the feeding habits of these fish to elucidate food chain relationships within the mangrove ecosystem.

3) To study the importance of these creeks as a nursery habitat especially for economically important fishes.

4) To study the physiological adaptations of these mangrove fauna.

MATERIALS AND METHODS

Beach seining has been done at ebbing tide, flooding and low tide to obtain samples for analysis. This has been done continuously from November 1990 to date.

The fish is collected in polythene bags and labeled indicating date and location of sampling along the creek. The sample is preserved for further analysis is the lab where it is weighed, sorted according to species. For large catches a representative sample is taken using the Dutch-Shuffle-method. Individual body weight, total length, standard length are recorded. The fish is then opened up for food analysis and gonad examination.

RESULTS

During this study forty-six species of fish belonging to 28 families have been encountered (Table 1).

Table 1. List of species and families of fish. Gazi Creek November 1990 to April 1991.

	Family	Species
1	Gerridae	Gerres oyena
		G. punctatus
2	Sphyraenidae	Sphyraena jello
3	Tylosuridae	Tylosulus acus
4	Mullidae	Parupeneus barberinus
		Paru peneus macronema
5	Carangidae	Caranx ignobilis
6	Clupeidae	Sadinella sp.
		Sadinella sidensis
		Herklotsichthys punctatus
7	Siganidae	Siganus oramin
		Siganus sutor
		Siganus stellatus
8	Scaridae	Leptoscarus vaigiensis
		Scarus japanesis
		Scarus persicus
9	Cephalocanthidae	Dactylopena orientalis
10	Lethrinidae	Lethrinus harak
		Lethrinus nebulosa
		Lethrinus semicinctus
11	Ostraciontidae	Lactoria cornuta
		Paramonacanthus baranardi
12	Synodontidae	Saurida tumbil
		Saurida gracilis
13	Anthrimidae	Preresus pinguis
14	Chaetodontidae	Heniochus acuminatus
15	Tetraodontidae	Chelonodon laticeps
16	Fistularidae	Fistulania petimba
17	Acanthuridae	Acanthurus lineolatus
		Ctenochaetus stigosus
18	Monodactyndae	Monodactylus argenteus
19	Bothidae	Bothus mancus
20	Gobidae	Gibius keiensis
		Taenoides jacussoni
21	Apogonidae	Apogonichys sulvensis
22	Apogonidae	Apogon hyalosoma
23	Lutjanidae	Lutjanus fluviflamma
24	Pomacentridae sp.	
25	Anguillidae sp.	
26	Engraulidae sp.	
28	Sillaginidae	Sillago sihama
28	Theraponidae	Therapon jarbua
		Therapon therops

Table 2. List of fish species caught between November 1990 and April 1991 in Gazi Creek. Showing the size ranges.

Month	Family	Species	No.	Size range(cm)
November 1990	Apogonidae	Apogonichys sulvensis	1	
	Sillagidae	Sillago Sihama	13	6.2 - 14.5
	Callyodontidae	Cryptotomus Spinidens	5	4.1 - 8.0
	Theraponidae	Therapon jarbua	1	
	Gobidae	Taenoides jacusssoni	5	3.4 - 5.1
December 1990	Lutjanidae	Lutjanus fluviflamma	19	4.2 - 9.1
	Lethrinidae	Lethrinus harak	9	3.2 - 7.4
	Theraponidae	Therapon therops	22	2.8 - 4.4
	Sphyraenidae	Sphyraena jello	21	5.3 - 12.8
	Siganidae	Siganus oranin	10	2.1 - 6.2
	Siganidae	Siganus rivulatus	1	
January 1991	Sphyraemidae	Sphyreana jello	6	7.3 - 16.8
	Lutjanidae	Lutjanus fluviflamma	7	4.5 - 9.8
	Lethrinidae	Lethrinus harak	4	2.6 - 5.5
February 1991	Siganidae	Siganus oramin	11	3.7 - 7.4
	Siganidae	Siganus Stellatus	6	3.4 - 5.6
	Lethridae	Lethrinus harak	15	4.7 - 8.9
		Lethrinus Semicinctus	5	5.2 - 6.8
	Gereidae	Geres Oyena	24	5.4 - 10.8
	Apogonidae	Apogon hylosoma	5	7.6 - 8.7
	Lutjanidae	Lutjanus fluviflamma	11	4.5 - 8.3
	Sphyraenidae	Sphyraena jello	24	5.8 - 19.0
	Pomacentridae		1	5.5
	Engraulidae		5	6.6 - 7.9
	Angruillidae		1	24.8
	Clupeidae	Sadinella Sp.	4	5.0 - 5.7
	Scaridae	Scarus japanensis	2	5.4
	Scaridae	Saurida tumbil	2	5.4 - 5.7
	Gobidae	Gobius Sp.	1	8.2
	Sillaginidae	Sillago Sihama	1	14.6
	Chaetodontidae	Heniocus acumaninatus	2	7.0
March 1991	Ger. eidae	Geres Oyena	204	9.7 - 17.1
	Sphyraenidae	Sphyraena jello	11	9.8 - 32.5
	Tylosuridae	Tylosurus acus	7	28 - 43.3
	Carrangidae	Caranx Sidensis	13	5.6 - 13.0
	Clupeidae	Sadinella Sidensis	23	8.1 - 11.9
	Clupeidae	Herklotsichthys punctatus	5	4.5 - 5.8
	Siganidae	Siganus oramin	15	3.8 - 33.9
	Scaridae	Leptoscarus vaigiensis	5	6.0 - 10.0
	Scaridae	Scarus japanensis	2	10.0 - 10.5
	Cephalacanthidae	Dactylopena orietalis	1	24.0
	Lutjanidae	Lutjanus fluviflamma	24	7.4 - 16.2

Month	Family	Species	No.	Size range(cm)
	Lethrinidae	Lethrinus harak	10	3.7 - 9.0
	Lethrinidae	Lethrinus nebulosus	8	6.0 - 8.6
	Mullidae	Parupeneus macronema	1	7.3
	Mullidae	Parupeneus barberinus	3	17.4
	Ostraciotidae	Lactoria cornuta	1	7.1 - 20.5
	Synodontidae	Saurida tumbil	1	11.5
	Anthrinidae	Preresus penguis	120	7.4 - 12.9
	Ostraciotidae	Paramonacanthus baranardi	1	3.6
	Chaetodontidae	Chelonodon laticeps	1	
	Fistularidae	Fistularia petimba	1	37.1
	Siganidae	Siganus sutor	5	4.3 - 5.8
	Acanthuridae	Acanthulus lineolatus	1	5.9
	Monodactylidae	Monodaectylus argentus	5	7.4 - 12.4
APRIL 1991	Siganidae	Siganus sutor	6	5.0 - 32.0
	Siganidae	Siganus stellatus	5	5.4 - 13.3
	Lethrinidae	Lethrinus harak	36	5.7 - 11.8
	Lethrinidae	Lethrinus semicinctus	18	5.7
	Tylosuridae	Tylosurus acus	12	17.3 - 44.1
	Sphyraenidae	Sphyraena jello	12	10.8 - 29.4
	Gerreidae	Geres Oyena	359	5.8 - 16.6
	Gerreidae	Geres punctatus	2	14.6 - 16.8
	Acanthuridae	Ctenochaetus strigosus	4	4.6 - 7.4
	Lutjanidae	Lutjanus fluviflamma	4	6.7 - 17.0
	Theraponidae	Therapon jarbua	8	4.8 - 9.4
		Therapon therops	2	7.3
	Synodontidae	Saurida gracilis	1	11.6
	Scaridae	Liptoscanis vaigienis	1	6.8
	Bothidae	Bothus maneus	2	14.6
	Gobidae	Gobius Keiensis	1	5.6

DISCUSSION

The fish community in Gazi creek is diverse dominated by members of a few families including the Gerridae, Theraponidae, Lutjanidae, Sphyraenidae, Siganidae, Lethrinidae, Scaridae and Mullidae. Occationally, migratory fish like the Anthrinidae and the Clupeidae School to breed or feed and dominated the catch. (Table 1).

Generally the fish size is small ranging between 5 to 10cm in length (Table 2). This is a clear indication that the creek fish community is dominated by juvenile fish since mature fish of the same species are hardly caught in the creek.

From the work done to date it can be observed that the number of teleost fish species is considerably less compared to other creeks in Kenya. Reay et al (1987) got a total of eighty three species while working in Tudor Creek. However work is still at the initial stages and no scientific conclusions can be made yet.

For our future work the sampling procedure has been altered. Thus from June 1990 sampling will be done in three definite stations (ie end of creek, mid-creek and creek month near the open sea) during spring low tide for three days every month. This alteration has been found necessary in order to a consistent and comparative set of data in order to achieve the objective set for this project.

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4.1.8. SUBSTRATE INFLUENCE ON THE PHYSICAL AND CHEMICAL PROPERTIES OF MANGROVE SOILS

By: K.K.Kairu

INTRODUCTION

The mangrove ecology is influenced by many aspects which includes among others, the tidal cycle, seepage and altitude in relation to sea level. In non Mangrove areas, strong evidence of influence of soil salinity by soil type and water table have been documented. It is therefore of interest to investigate how the soil type influences salinity in mangrove areas, especially in regard to vegetation structure. To achieve this, areas with known different soil types were selected for the study.

The Gazi mangrove environment occupies a raised beach terrace ontop of which an alternating layer of sand and peat is observed. In Port Reitz, the creek cuts through Jurassic shales which have weathered to a thick clay horizon intercalated with peat in some areas adjacent to the channel.

METHODOLOGY

In each of the study areas fig.1, transects were selected perpendicular to the main creek. Using a hollow plastic tube soil samples were collected, on the surface and a depth of 0.3-0.5m at low tide.

In the laboratory, the water retention capacity was determined by drying to constant weight, samples of known weight. The clorinity was then determined by mixing equal weight of each sample with 20 ML of distilled water and centrifuging. This procedure was repeated twice. To determine how the levels of chlorinity in pore waters or films in the soil samples vary, it was assumed that the chlorinity recorded in the samples was available in the liquid or solid phase in the wet sample.

SUBSTRATE CLASSIFICATION

The collected soil samples were classified of the basis of their texture and mineralogy into clays sandy clays sand or peat.

OBSERVATIONS

Their is a strong relationship between, the substrate, water retention, clorinity and Mangrove structure (fig.2). Larger fluctuations are observed in the Gazi area. The clay and peat content appears to reduce clorinity extremes in both areas their is therefore an indication that their must be a significant relationship between the vegetation structure and the nature of substrate.

The study is in progress and at the end of the rain season, it will be Interesting to investigate how precipitation affects the clorinity levels in the different areas.

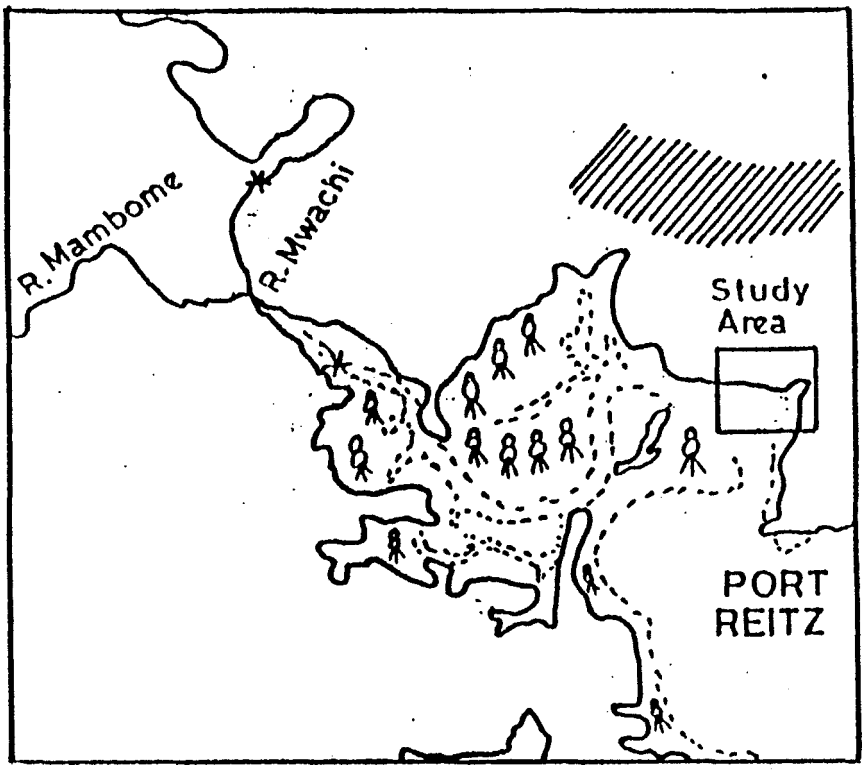


Figure 1 Study Area Port Reitz Area.

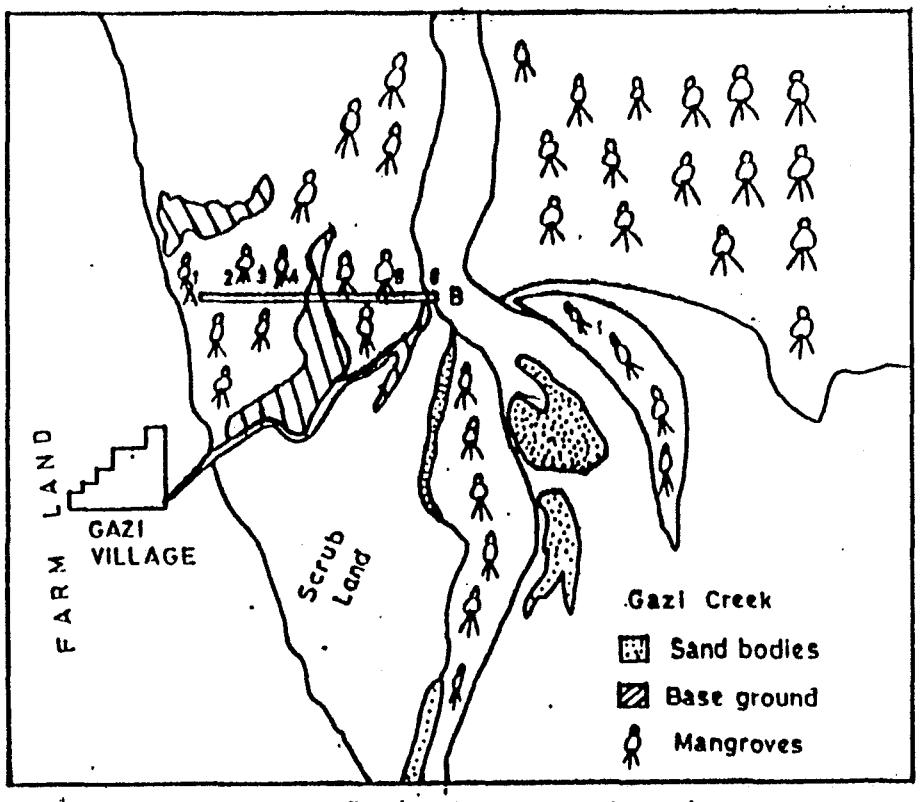
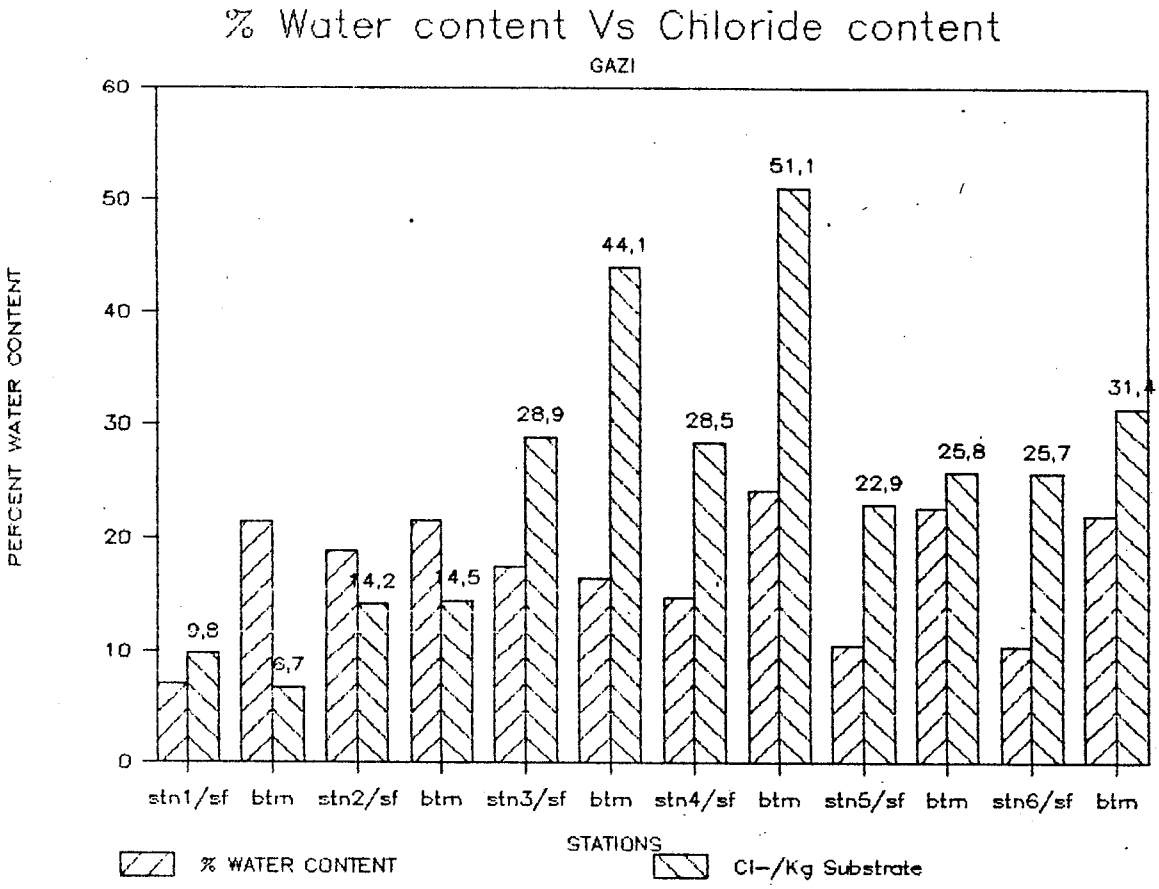
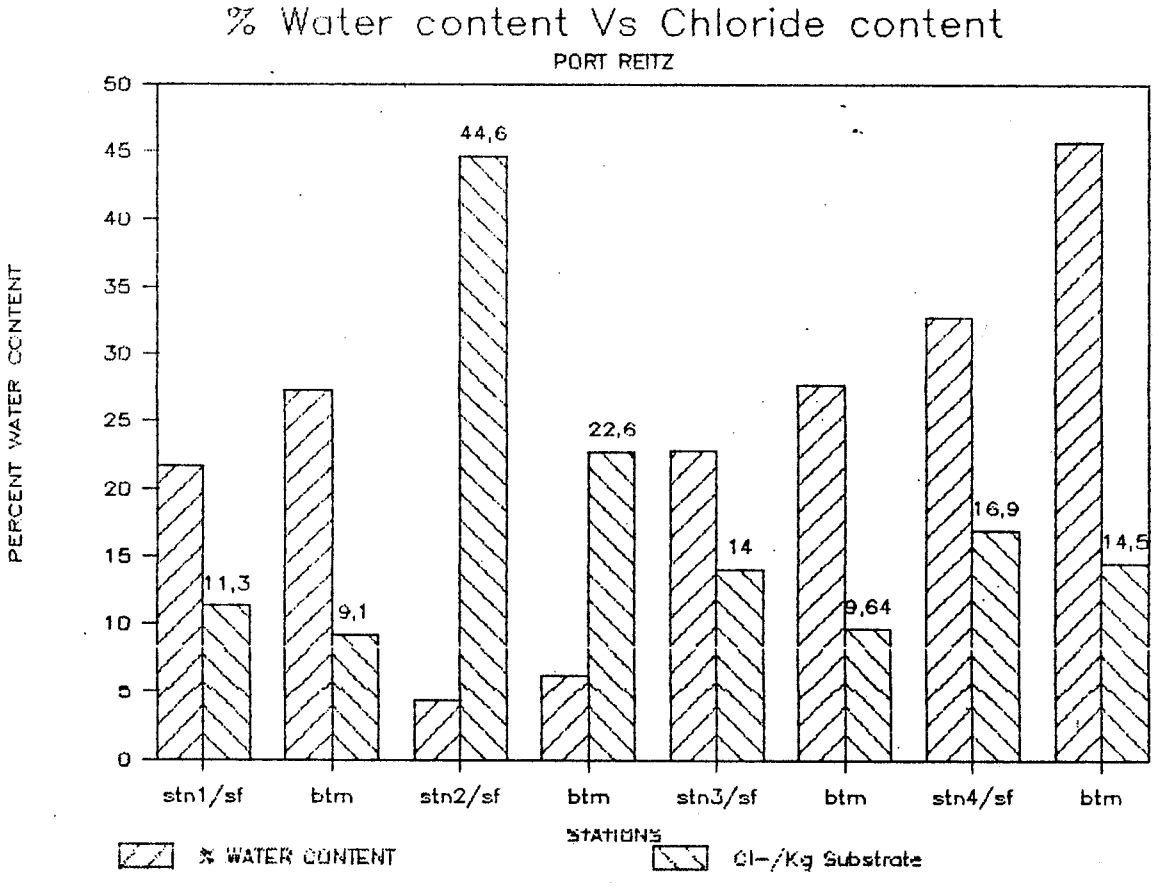


Fig. Ib Study Area: Gazi.


% Water content Vs Chloride content
GAZI
PERCENT WATER CONTENT
60
50
40
30
20
10
0
9,8
6,7
14,2
14,5
28,9
44,1
28,5
51,1
22,9
25,8
25,7
31,4
stn1/sf
btm
stn2/sf
btm
stn3/sf
btm
stn4/sf
btm
stn5/sf
btm
stn6/sf
btm
STATIONS
% WATER CONTENT
Cl-/Kg Substrate


% Water content Vs Chloride content
PORT REITZ
PERCENT WATER CONTENT
50
45
40
35
30
25
20
15
10
5
0
11,3
9,1
44,6
22,6
14
9,64
16,9
14,5
stn1/sf
btm
stn2/sf
btm
stn3/sf
btm
stn4/sf
btm
STATIONS
% WATER CONTENT
Cl-/Kg Substrate

4.2. RESEARCH IN THE FRAME OF THE VLIR PROJECT

4.2.1. The distribution, growth and economic importance of the Agarophyte, Gracilaria (Gigartinale) on the kenya coast.

By: H.A. Oyieke

INTRODUCTION

As stated in the last report this work is part of my Ph.D Thesis to be submitted to the University of Nairobi as soon as the work is completed. This study was divided into three major sections:

(i) The Ecology and Taxonomy of the genus

(ii) Seasonality and growth studies

(iii) Agar Extraction and Analysis

RESULTS AND DISCUSSION

i. The Ecology and Taxonomy

This section has more or less been completed though the voucher specimens of the species studied still need to be compared with those of other herbariums. Arrangements are underway to send them to Dr. Coppejans of the University of Ghent for confirmation of their identities. The ecology of the seven Gracilaria species, i.e. G. edulis, G. corticata, G. crassa, G. fergusoni, G. millardetii and G. verrucosa is now known. Different species were recorded growing in different habitats such as rocky pools, sandy pools, lagoons, muddy shores, rocky platforms, sandy channels and reef edges. The surveys revealed that there are no large expanses of Gracilaria beds at any one of the stations sampled that could be compared to those of the temperate regions. Most of the populations were found in discrete patches while some occurred as isolated thallus.

Of the seven Gracilaria species reported only G. millardetii and G. edulis are strictly eulittoral whereas G. verrucosa is the only strictly sublittoral species. The rest of the species had some percentage of growth recorded in the eulittoral and partly in the sublittoral. Though greater percentage of G. crassa was observed in the eulittoral zone it would be in order to note that they were observed in pools under hidden crevices at reef edges thus indicating that they are exposed to direct insolation at any one time of the day. The temperatures in these pools were generally cooler than in the surrounding pools that were exposed at low tides. The fact that G. crassa pools were mostly situated at reef edges means that they were never exposed for long hours during low tides. Likewise G. corticata species that were observed in the eulittoral zone were found growing near the edge of the reef in pools that were never exposed for long hours

during low tides. In addition to this they were growing as epiphytes on lower parts of Thalassodendron ciliata thus being sheltered from direct insolation. The rest of the species were observed in the eulittoral zone where they were quite exposed to direct insolation during low tide. However, it was noted that the sublittoral population of G. salicornia had more robust growth than the eulittoral population.

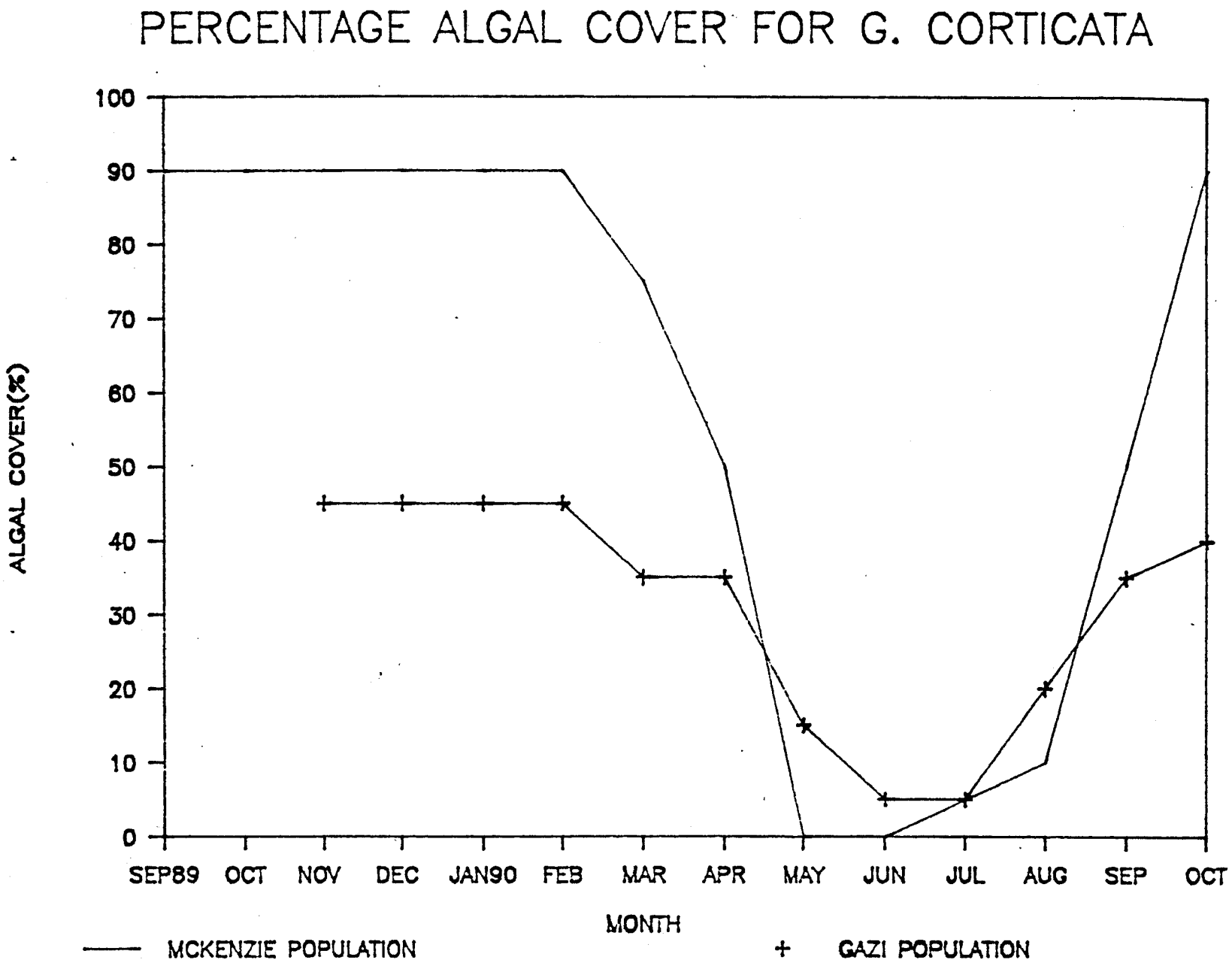
ii. Seasonality and Growth Studies

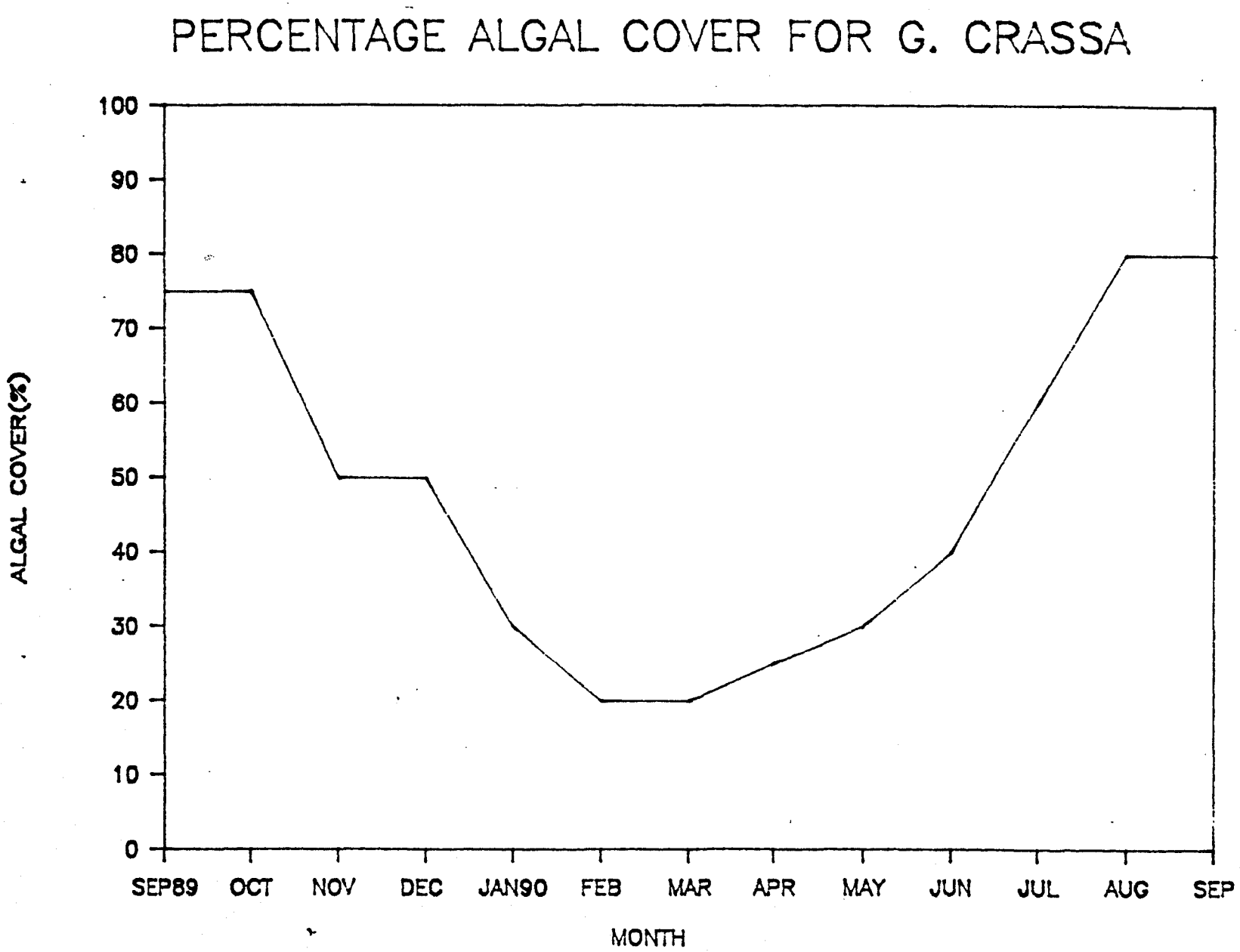
The results obtained in this study clearly show that the algal cover for both the G. corticata population at Gazi and at McKenzie was at maximum during the period covering September to March, while that for G. salicornia ranged from August to January. The maximum cover period for G. millardetii was July to January while that for G. crassa was July to December. The general trend in this study therefore, shows the period for maximum Gracilaria cover as that period covering the end of the South-East Monsoon season and the first half of the North-East Monsoon season.

Figures 1-4 show the seasonality phenomenon observed in this study.

iii. Agar extraction has been done on five different species namely G. corticata, G. crassa, G. fergusoni, G. salicornia and G. millardetii. These were the only species found in quantities large enough for extraction. In addition to that the harvesting for extraction was only possible during those months when they were in season.

From the extractions done it is evident that G. corticata had the highest agar yield followed by G. crassa, G. millardetii, G. fergusonii and G. salicornia in that order. The results indicated a marked seasonality in the agar yield. At the moment arrangements are underway to carry out physical and chemical analysis of the extracts before any report is given on the quality of the agar extracts.


PERCENTAGE ALGAL COVER FOR G. CORTICATA
ALGAL COVER(%)
100
90
80
70
60
50
40
30
20
10
0
SEP89
OCT
NOV
DEC
JAN90
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
MONTH
MCKENZIE POPULATION
GAZI POPULATION


PERCENTAGE ALGAL COVER FOR G. CRASSA
ALGAL COVER(%)
100
90
80
70
60
50
40
30
20
10
0
SEP89
OCT
NOV
DEC
JAN90
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
MONTH

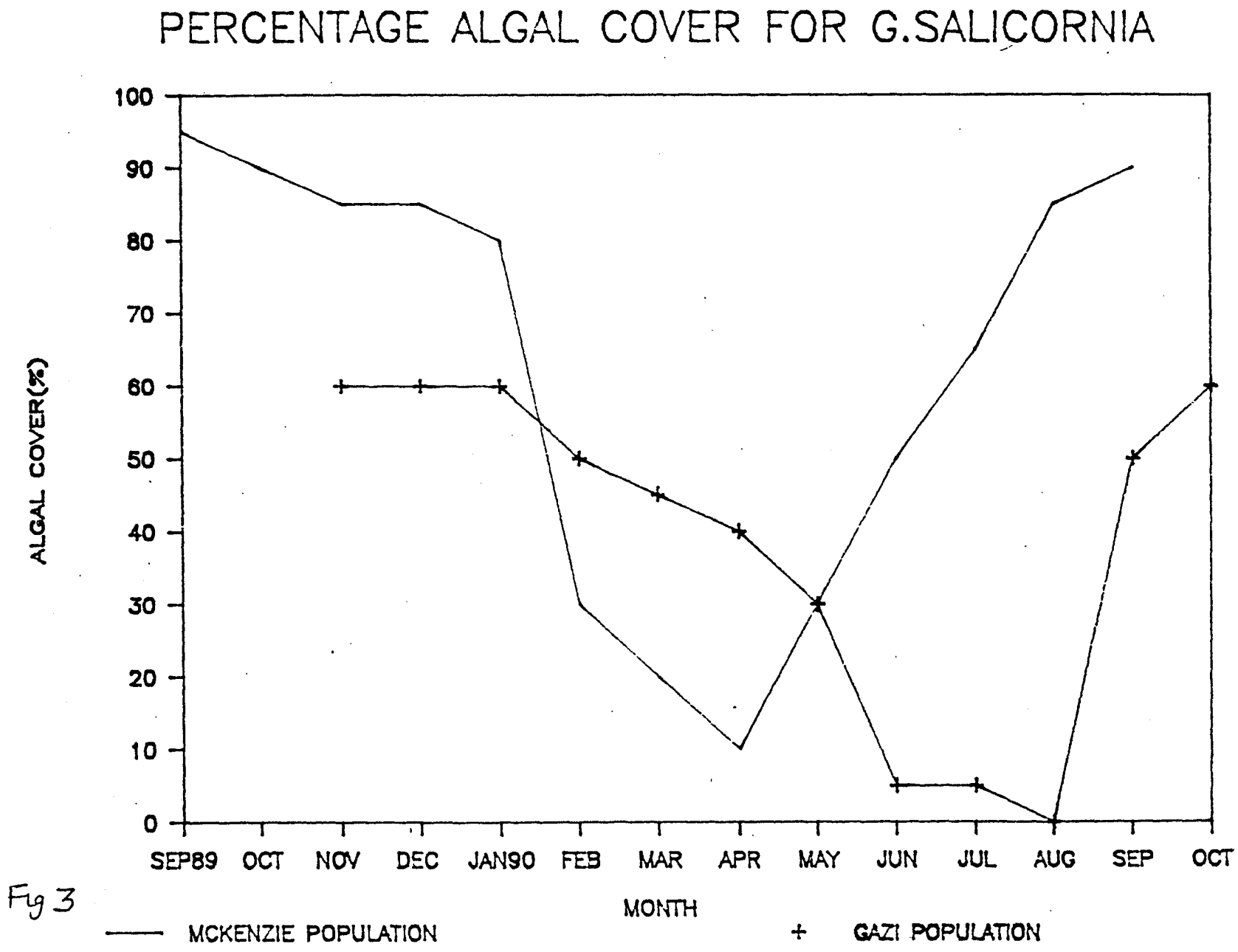
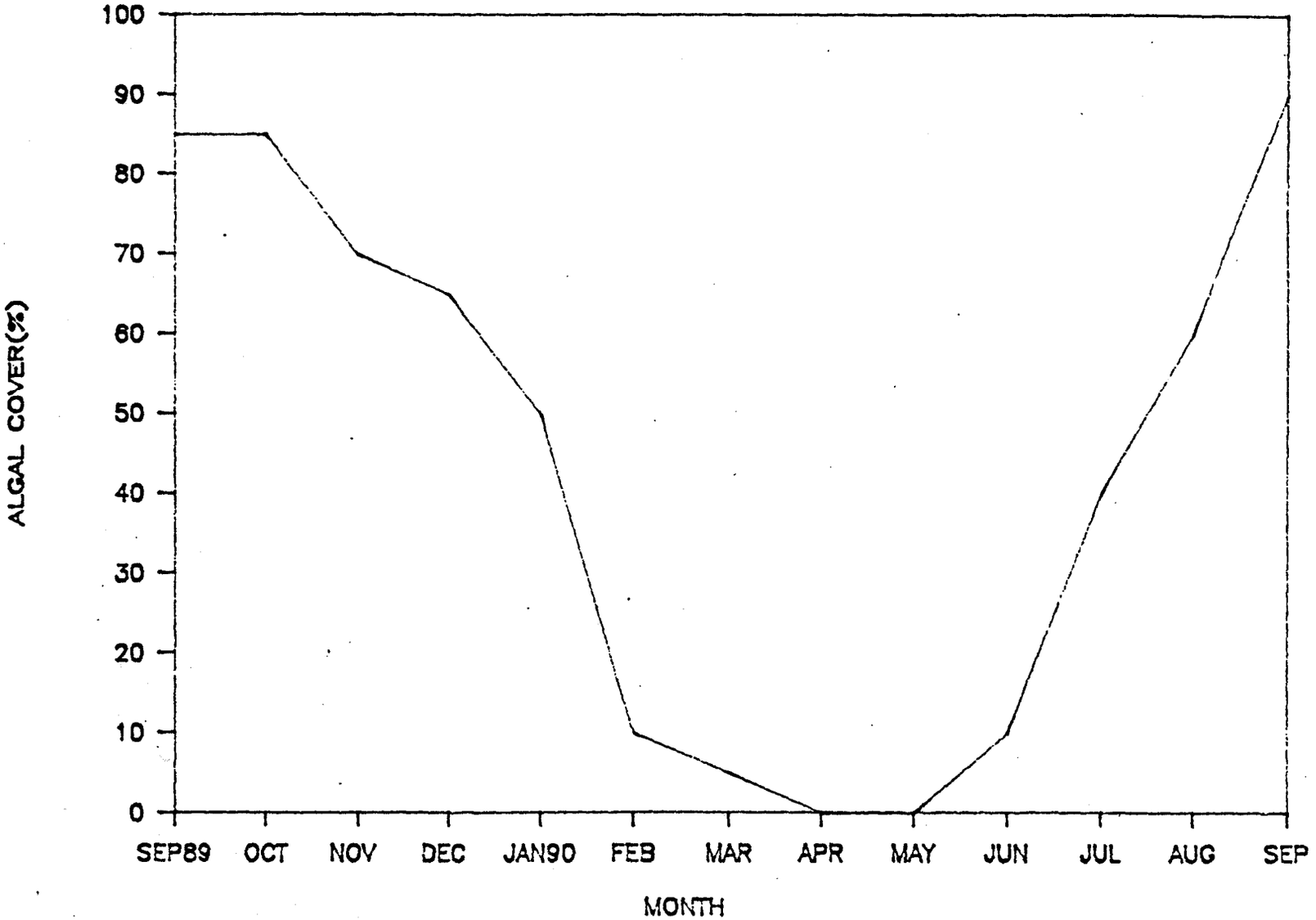

PERCENTAGE ALGAL COVER FOR G.SALICORNIA
ALGAL COVER(%)
100
90
80
70
60
50
40
30
20
10
0
SEP89
OCT
NOV
DEC
JAN90
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
MONTH
MCKENZIE POPULATION
GAZI POPULATION

Fig 3

PERCENTAGE ALGAL COVER FOR G.MILLARDETII



4.2.2. Seaweeds of Kenya; a general survey of their economic potential along the Coa

By: J.G.Wakibia

INTRODUCTION

Seaweeds are of direct importance to man as dietary supplement,food additives source of industrial feedstock and as a base of synthesis of a wide range of chemical products.Indirectly they are contributors to the natural food chain and habitats.

Kenya requires phytocolloids in the food industries,medicinal industries and agricultural practices.Kenya coast has a wealth of algae but meets its seaweed product demands through direct importation.These products era extracted from seaweeds,some of which are found on the kenyan coast.The lack of seaweed exploitation may be probably due to lack of information on the seaweeds of economic importance,their distribution and quantitative ecology.This study would try to give some quantitative and qualitative information on those seaweeds of high economic importance in kenya by studying their standing crop and front height.This information would be applicable for possible exploitation of the seaweeds by assessing and evaluating the present status of the stocks of economically important species of seaweeds.It could also be used as a basis for formulation of resource management scheme to maintain and enhance the production of algae resources in kenya.

OBJECTIVES

To identify seaweeds of economic importance,measure their standing crop,percentage cover and front heights and documentation on their current uses in kenya.

METHOD.

Thirteen(13) stations are used to represent the whole kenya coast.Abundance will be measured using the transect-quadrant method.A 50 by 50cm quadrant will be used for measuring the standing crops and percentage cover of the species of economic importance.The seaweeds harvested from each belt will be sorted,weighed to give wet weight and dried to in an oven for three days(3) at 105°C to give dry weight.

SUMMARY

Preliminary surveys have to be conducted in Shimoni,Likoni,English Point,Kanamai,Vipingo, and Nyali. The positioning of permanent line transect is being carried out.Most of the common seaweeds in these stations have been collected, identified and herbaria prepared.The following observations have been made:Kanamai,Vipingo and Nyali are very rich in marine angiosperm vegetation notably Thalassia hemprichii,being dominant in the lagoons and Thalassodedron ciliatum near the reef edge.Others include Halodule wrightii and Halodule universi.Seaweeds especially the brown and red ones are partially distributed with Sargassum spp. and Turbinaria spp. within the coral region.and some Ulva spp. near the platform.

English point and Shimoni regions are rich in seaweed diversity and abundance.The most abundant species are Sargasssum spp.,Ulva spp.,Gracilaria Cystoseira Myrica,Laurencia pappilosa.Within the establishment of permanent line transect the quantitative survey will start using the permanent quadrant method.

4.2.3. A comparative Study of growth and recruitment of selected coral species along the Kenya Coast.

By : J. Mutere

INTRODUCTION

This project is being carried out at three study sites namely Malindi Marine Park, Vipingo and Kanamai. Malindi represents coral reefs that are protected whereas Vipingo and Kanamai represent unprotected reefs. Percent cover of living and dead coral studies at the study sites were carried out to determine the coral population structure. This is to form the baseline information from which recruitment and growth studies can be made.

METHODS

Studies of the percentage living and dead coral done using the line transect method. This was done during the low neap and spring tides and transect of 25m length were laid parallel to the beach. Data collected was represented by graphs (Appendices 1,2, and 3). Corals were collected for the institute reference collection, for from each study site. This was done by random swimming and collecting the corals by use of hammer and chisel, as each new species was encountered. Corals collected were bleached in a solution of fresh water and household bleach and then sun-dried and packed in labelled polythene bags for storage.

RESULTS

The Malindi study site has the highest percent cover of living coral followed by Vipingo then Kanamai. At Malindi percent living coral cover ranges from 8.6% to 58.86%: at Vipingo, 6% to 24.2%% and at Kanamai, 2.86% to 16.4%. For percent dead standing coral cover, it ranges from 18.46% to 79.86%% at Malindi, 14% to 55.9% at Vipingo and 3% to 17.4% at Kanamai.

The highest to lowest coral species diversity at each site was in the same order as for percent cover of living coral. Acropora sp appears to be the dominant genus at Malindi study site, Whereas Palauastrea sp is the dominant genus at Vipingo and Porites sp at Kanamai.

Several coral genera are common to all the three sites namely Favia, Galaxea, Pocillopore, and Porites. However, the Malindi and Vipingo study areas appear to have more genera in common than with Kanamai, namely Acropora, Echinopora Favia, Fungia, Galaxea, Goniastre, Hydnophora, Leptoria, Pocillopora, Porites and Montipora.

DISCUSSION

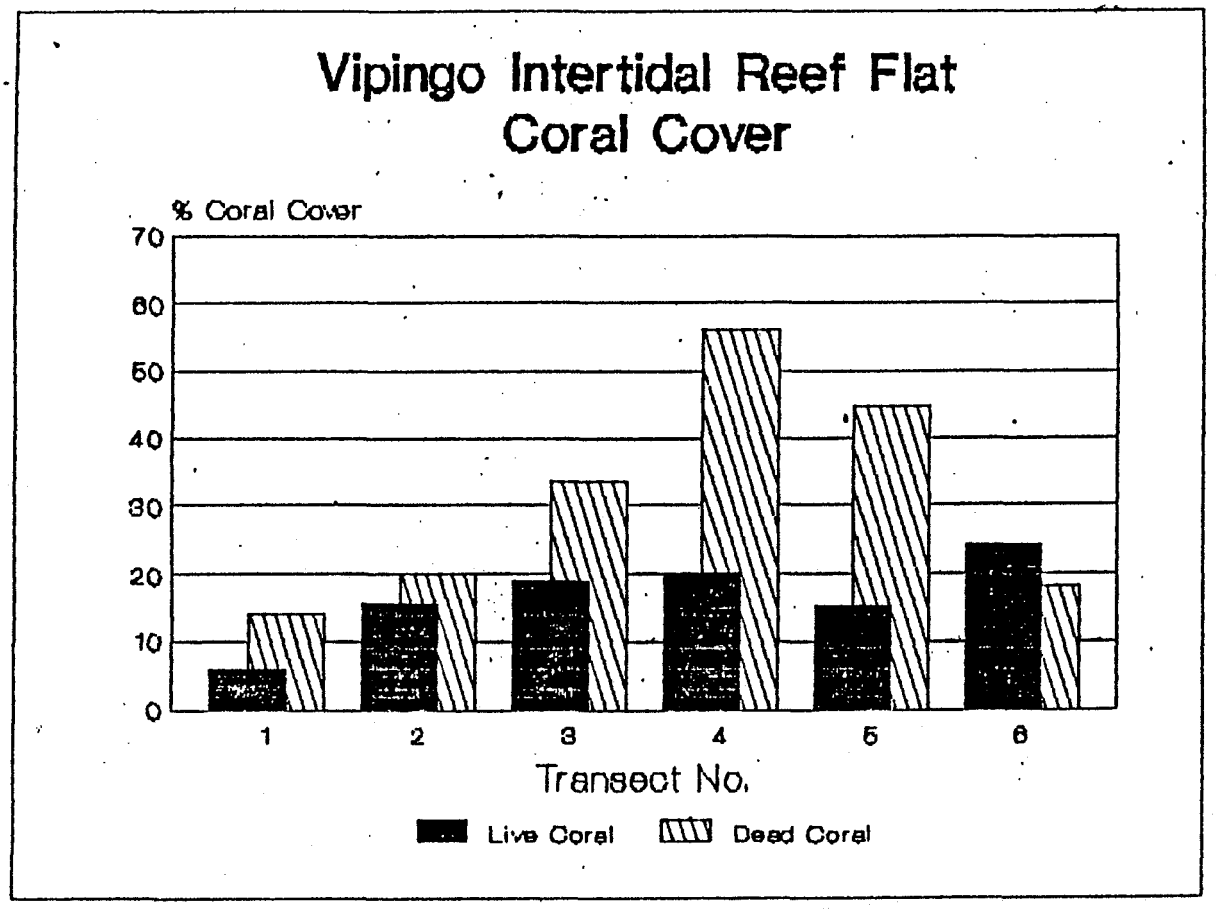
The variation seen at the three study sites in terms of species diversity and percent living and dead standing coral cover may be due to certain factors. One such factor is the differences in reef structures whereby at Malindi, the area under study is a patch reef but that of Vipingo and Kanamai sites are fringing reefs. The differences in wave energy and local currents are also other factors to be considered. The depths and differences in levels of exposure at low tide are also important in determining the community structure.

The levels of human exploitation at the three sites varies in that Malindi is in protected marine waters and therefore not exploited for fishing and coral collection as the other two sites.

All the aforementioned are factors that should be investigated more closely to give a better idea as to the factors governing coral community structure on the reef flats and lagoons of the Kenyan reefs.

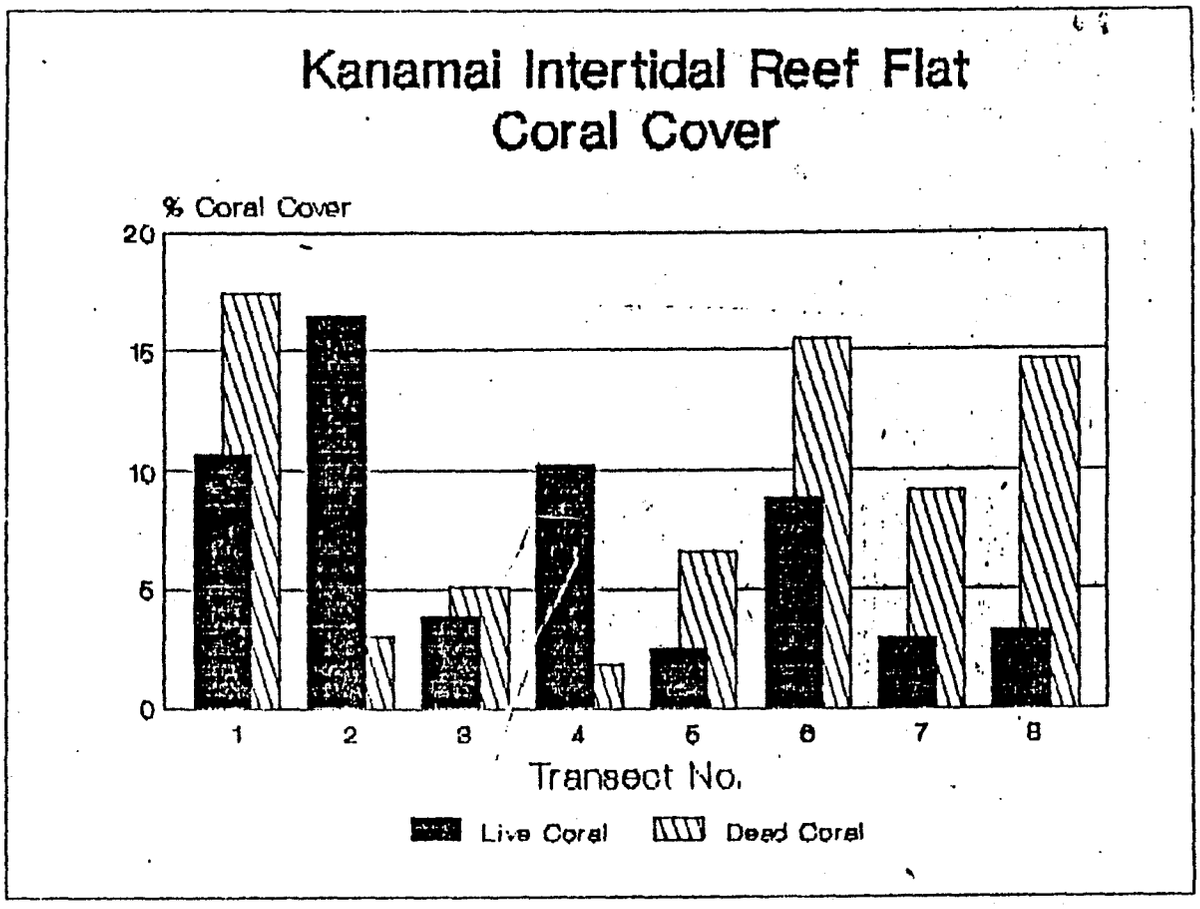
GENUS LIST

GENUS	Malindi	Vipingo	Kanamai
Acropora	+	+	
Astreopora		+	
Coscinarea			
Cyphastrea			
Echinopora	+	+	
Favia	+	+	+
Favites		+	
Fungia	+	+	
Galaxea	+	+	+
Goniastrea	+	+	
Hydnophora	+	+	
Leptoria	+	+	
Leptoseris		+	
Lobophyllia			
Oxypora			
Pavona		+	+
Pocillopora	+	+	+
Porites	+	+	+
Psammocora			
Montipora	+	+	
*Tubipora		+	+
Platygyra		+	
Seriatopora		+	+
Goniopora		+	
Stylophora			
Herpolitha			



Vipingo Reef(7-7-89)

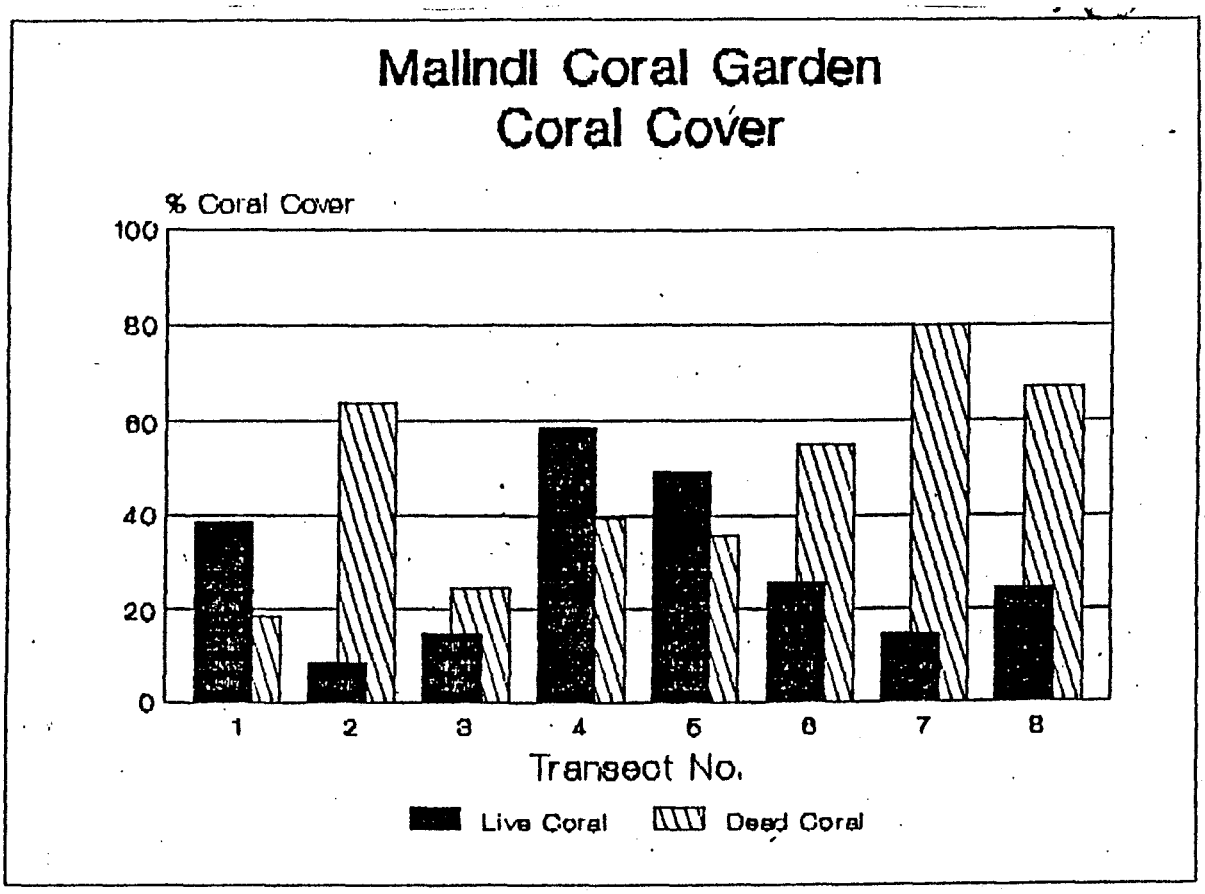
Transect No.	% Live Coral	% Dead Coral
1	6	14
2	15.7	20
3	19	33.7
4	20.1	55.9
5	15.3	44.8
6	24:2	18.2



Kanamai Intertidal Reef Flat Coral Cover

Kanamai Reef

Transect No.	% Live Coral	% Dead Coral
1	10.66	17.4
2	16.4	3
3	3.86	6.06
4	10.2	1
5	2.4	6
6	8.86	15.
7	2.86	9
8	3.13	14



M ndi Reef

Transect No.	% Live Coral	% Dead Coral
1	38.33	18.46
2	8.6	64.2
3	14.53	24.66
4	58.86	39.46
	48.73	35.86
	25.46	54.73
	15	79.86
	24.66	67

4.2.4. Assessment of pollution in the coastal and marine environment around Mombasa

4.2.4.1. Theoretical Assessment of the pollution sources and loads of the Creeks around Mombasa

By: J.Munga, K.Delbeke, S.Tsalwa, S.Mwaguni and J.Wijnant

INTRODUCTION

As very little information is available on the state of the Marine environment of Kenya a research programme "Assessment and control of pollution in the Kenyan Coastal and marine environment " was started. The programme is conducted as a collaboration between KMFRI, Kenya Government Chemist and KBP. It consists of different subprojects:-

1. Theoretical assessment of the pollution sources and loads.
2. Monitoring of pollution levels in the coastal and estuaries environments.
3. Assessment of the importance of pollution on the mangrove oyster, crassostrea cucullata.

For the theoretical assessment useful

RESULTS

1.Domestic Sewage Disposal

The Mombasa municipality has separate sewerage systems for domestic sewage and storm drainage (fig. 2). The sewerage system for domestic sewage serves about 11% of the population of Mombasa. There are two treatment plants, for sewage disposal, located in the island at Kizingo and the west mainland at Kipevu. The Kizingo plant is capable of carrying out primary treatment of sewage before discharge into the Tudor creek, and covers about 20% of the island. The Kipevu plant was designed for sewage treatment to the secondary stage, and discharges into the Kilindini creek. An estimated 72% of the population use pit latrines, and the rest (17%) use septic tanks and soakage pits for sewage and waste water disposal. Sludge from septic tanks is usually disposed off at the Kibarani dumpsite in the vicinity of the Makupa creek.

Data on the sewage strength at the outfalls from the treatment plants (GOK, 1974) and information on average sewage strength from septic tanks and pit latrines (Iwugo, 1990) was used to estimate the daily organic and inorganic pollution loads due to domestic sewage disposal, into the creeks around Mombasa (table 1).

TABLE 1: Waste from domestic sources

Disposal System	Pop. (10^3p)	WV $m^3/_{cd}$	WV $10^3 m^3/_d$	BOD_5 g/cd	BOD_5 tn/d	SS g/cd	SS tn/d	N g/cd	N tn/d	P g/dc	P tn/d
Sewerage											
(a) Island	42	0.07	3.11	44.0	1.85	280	11.76	40	1.68	10	0.42
(b) West Mainland	13	0.13	1.70	47.7	0.62	90	1.17	20	0.26	10	0.10
Pit Latrines	376.32	-	-	20	7.53	-	-		-		-
Septic tanks/ soakage pits	89.54	-	-	30	2.69		-		-		-

Pop = population WV = waste volume SS = suspended solids N = nitrogen compounds P = phosphorus compounds Units p = persons, tn = tonnes, cd = capita day (-) = no data available.

Although the sewage treatment works serve only about 11% of the population, the effluent from the treatment plants has a considerable contribution to the pollution load. The level of treatment of the sewage thus needs to be seriously reviewed and appropriate improvements incorporated.

2. Storm Water Runoff

There are 3 storm water drains discharging into the Tudor creek, and 3 other drains discharging into the Kilindini creek from the island and west mainland areas (fig. 3). The rest of the Mombasa area provides non-point sources of storm water into the creeks. For the purpose of estimating the contribution of storm water runoff to the pollution load, a runoff coefficient of 0.75 was assumed (table 2). The total surface area and mean rainfall were, 210 m2 and 1038 mm/year, respectively.

Table 2: Contribution of storm water runoff to pollution loads

Runoff Volume		BOD_5		SS		N		P	
$10^3 m^3/km^2 d$	$10^3 m^3/d$	$g/m^3 d$	$10^3 kg/d$	$g/m^3 d$	kg/d	$g/m^3 d$	kg/d	$g/m^3 d$	kg/d
2.13	447.3	140	62.62	450	201.3	5	2.24	3	1.34

The storm water runoff thus contributes significantly to the pollution load of the study area.

3. Industrial Wastes

All Mombasa industries are considered as potential sources of pollution. The types of pollutants produced are organic degradable materials, suspended solids, nutrients, oils, heavy metals, detergent, etc.

Most industries also use septic tanks and soakage pits for disposal of domestic sewage and industrial sullage. Likewise, sludge from septic tanks is disposed off at the Kibarani dumpsite. Industrial liquid waste, that is most probable contaminated with toxic chemical is often allowed to discharge into the storm water drain and eventually into the creeks; for example, the Kenya oil Refinery. Some industrial establishments are however allowed to discharge waste into vertical drains that end on the water table. During flood tide, however, the drains sometimes overflow with unpleasant effects. Vertical drains are a potential source of toxic wastes which may seep unneutralized into the marine environment.

Pollution loads from some major industries have, so far, been considered. (table 3). The nature, quality and quantity of contribution to the pollution load varies according to the industrial processes carried out. The more extensive investigation of the pollution loads from all industries is being shore and data will be available soon.

Table 3: Contribution of industrial activities to pollution loads

Industry	Unit	Inp/d	Prod/d	BOD_5		SS		Oil		Phenols		N & P		S		HM	
				kg/unit d	kg/d	kg/unit d	kg/d	kg/unit d	kg/d	kg/unit d	kg/d	kg/unit d	kg/d	kg/unit d	kg/d	kg/unit d	k
KMC	tnLWK	78.8	-	6.0	472.8	5.6	441.3	-		-		-		-		-	
KBL	m^3beer	-	123.4	18.8	2,319.9	7.3	900.8	-		-		-		-			
Steel Tubes	tn	-	23.3	2.2	51.2	2.32	54.1	-		-		P:0.02	0.47	-		Zn:0.007 Fe:0.19 Cr:0.015	
Cabro-works	tn	-	1.0	8.0	8.0	40.0	40.0	-		-		-		-		-	
KOR*	10^3tn	5.48	-	0.65	3.56	0.67	3.67	0.15	0.82	0.1	0.55	-		1.0	5.48	Cr:0.49	

Inp/d = Input/day, Prod/d = production/day, HM = heavy metals, LWK = live weight of animals killed,
KMC = Kenya Meat Commission slaughter-house, KBL = Kenya Breweries Ltd. beer manufactures, KOR = Kenya Oil Refineries.
* Data from KOR to be reviewed.

4. Beach Hotels

Tourist beach hotels use septic tank - soakage pit systems for sewage and sullage disposal, which are often allowed to overflow into the sea. The sludge from septic tanks is usually, removed by private companies and dumped at the Kibarani disposal site. Some beach hotels dispose water from their swimming pools, containing chlorine and copper sulphate (CuSO4), directly into the sea.

There are 17 beach hotels that were considered for the estimation of the contribution of tourist resorts to marine pollution (table 12). The mean bed occupancy for the period 1978 - 1988 is 61.1%, with a total bed capacity of beach hotels in the Mombasa district of 4.692 (GOK 1988).

Table 4: Waste from tourist beach hotels

Bed Occup.*	BOD_5		SS		N		P	
No./d	g/cd	kg/d	g/10^3 pers.d	kg/d	g/10^3 pers.d	kg/d	g/10^3 pers.d	g/d
2,867	30	86.01	43.84	45.87	9.04	9.46	1.1	1.15

* Bed occupancy

Source of per capita values: WHO (1989) and Iwugo (1990).

The contribution of beach hotels to the total degradable organic matter, thus amounts to, approximately, 0.03%. The disposal of the toxic constituents swimming pools, chlorine and CuSO4, might pose a greater threat to the marine environment.

5. Solid Wastes

Municipal solid wastes or refuse is invariably disposed off by dumping at the Kibarani landfill site. The estimated quantity of refuse dumped at the Kibarani site is 54.750 tonnes annually. Dumped sludge from public places and public conveniences was estimated at 18 - 20,000 m3 annually. Whereas, waste from private latrines septic tanks and soakage pits was also estimated at 18 - 20,000 m3 annually. The total refuse production for the period 1968 - 1974 was estimated at a mean of 100,000 tonnes/year. Domestic refuse contributes appreciably to the BOD load, apart from other contaminants, through leachate into the creek waters (table 5). Considerable industrial solid waste is also haphazardly dumped, normally by private contract, at Kibarani. The industrial waste is of unknown composition or quantity. However, it may include waste from soap manufacturing industries, which may be contaminated with Zinc, and textile wastes contaminated with chromium. The petroleum refineries produce considerable quantities of hazardous sludges, contaminated with oil, marcaptans, tetraethyl lead (TEL), and rust, which are however disposed off on agricultural land near

the establishment, where they undergo degradation and also fertilize the land.

In addition, condemned human and animal food shipped in through the Kenya Ports Authority (KPA) is often disposed off on another site near the Kibarani municipal dumpsite. For instance, between February and November 1990, more than 647 tonnes of condemned foodstuffs were disposed off by the KPA Public Health Officer, which were additional sources of BOD stress to the creek waters.

Table 5: Leachate from solid waste

	Unit	Quantities Unit/d	BOD_5 kg/unit,d	kg/d
Municipal refuse	tn	150	17.56	2,634
Sludges	m^3	110	7.0	770

6. Estimated Total Pollution Loads

In the estimation of the total pollution loads into the Kilindini/Port Reitz and Tudor creeks, total dispersion of the introduced contaminants in the creek waters was assumed.

CONCLUSION

Calculations of the total pollution loads into the 2 creeks show, that the degradable organic pollution (BOD) load is mainly due to domestic sewage.

The results indicate that the area can be considered to be, relatively, unpolluted compared to international standards. BOD concentrations are however expected to be higher at the sewage and storm water outfalls. The results also indicate a higher contamination by degradable materials in the Tudor creek, while the Kilindini creek receives, comparatively, more industrial effluents. The significance of the contribution of industrial effluents to pollution of the area can only be ascertained by a more comprehensive study.

Table 6: Total pollution loads discharged into the Kilindini/Port Reitz creek

Source	WV $10^3 m^3/d$	BOD_5 tn/d	SS tn/d	Oil kg/d	N kg/d	P kg/d	S kg/d	Ph kg/d	HM kg/d
Domestic sewered	1.7	0.62	1.17	-	260	100	-	-	-
unsewered	-	5.55	-	-	-	-	-	-	-
Storm water runoff	223.7	31.31	0.10	-	1.0	1.0	-	-	-
KBL	-	2.32	0.9	-	-	-	-	-	-
Steel Tubes	-	0.05	0.05	-	-	-	-	-	-
Cabroworks	-	0.01	0.04	-	-	-	-	-	Zn: 0.06 Fe: 4.43 Cr: 0.35
KOR	5.48	0.04	0.04	0.8	-	-	5.5	0.6	Cr: 2.69
Refuse & sludges	-	3.40	-	-	-	-	-	-	-
Totals		43.3	2.3	0.8	261	101	5.5	0.6	Zn: 0.06 Fe: 4.43 Cr: 3.04
Concentrations (ppb) at Mean Sea Level		181	10	0.0	1.1	0.4	0.3	0.0	-
at Neap Tide		773	40	0.0	4.7	1.8	1.0	0.0	Fe: 0.1 Cr: 0.1

* Phenols

Table 7: Total pollution loads discharged into the Tudor creek

Source	WV $10^3 m^3/d$	BOD_5 tn/d	SS tn/d	Oils kg/d	N kg/d	P kg/d
Domestic						
sewered	25.92	3.11	11.76	-	1.680	420
unsewered	-	5.55	-	-	-	-
Storm water runoff	223.7	31.31	0.1	-	1.0	1.0
KMC slaughter house	-	0.47	0.44	170	-	-
Totals		39.18	12.3	170	1.681	421
Concentrations (ppb)						
at Mean Sea Level		455	140	2.0	19.5	4.9
at Neap Tide		1633	510	7.1	70.0	17.5

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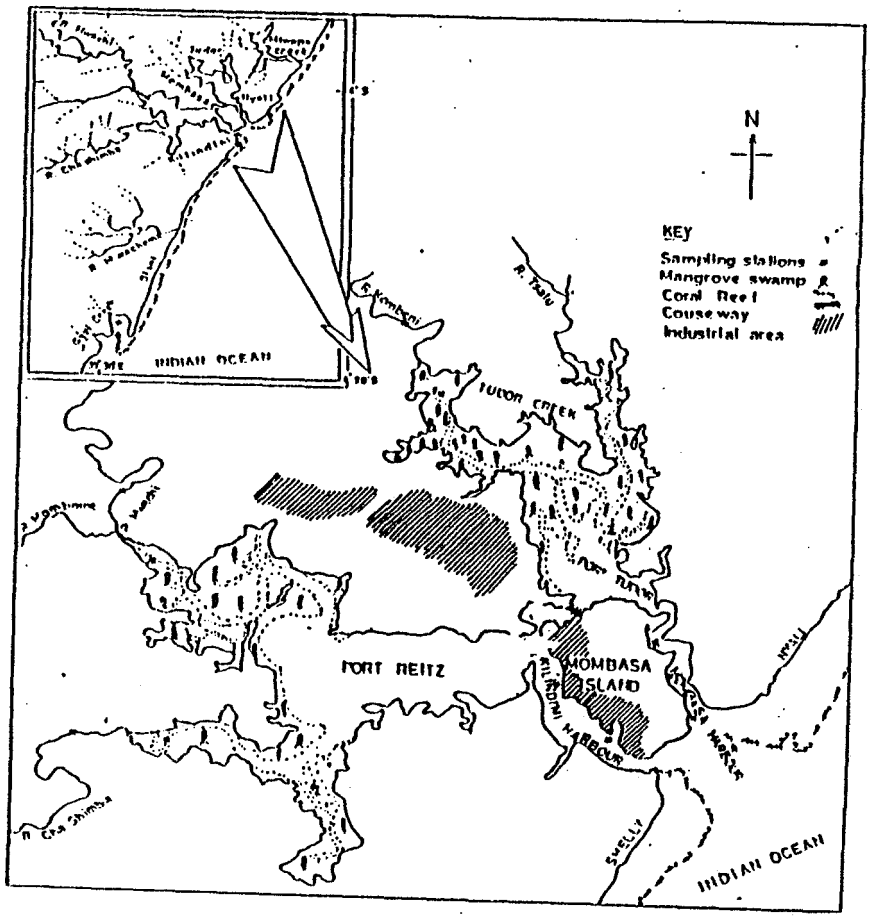


Figure 1: Map of the study area, showing sampling stations

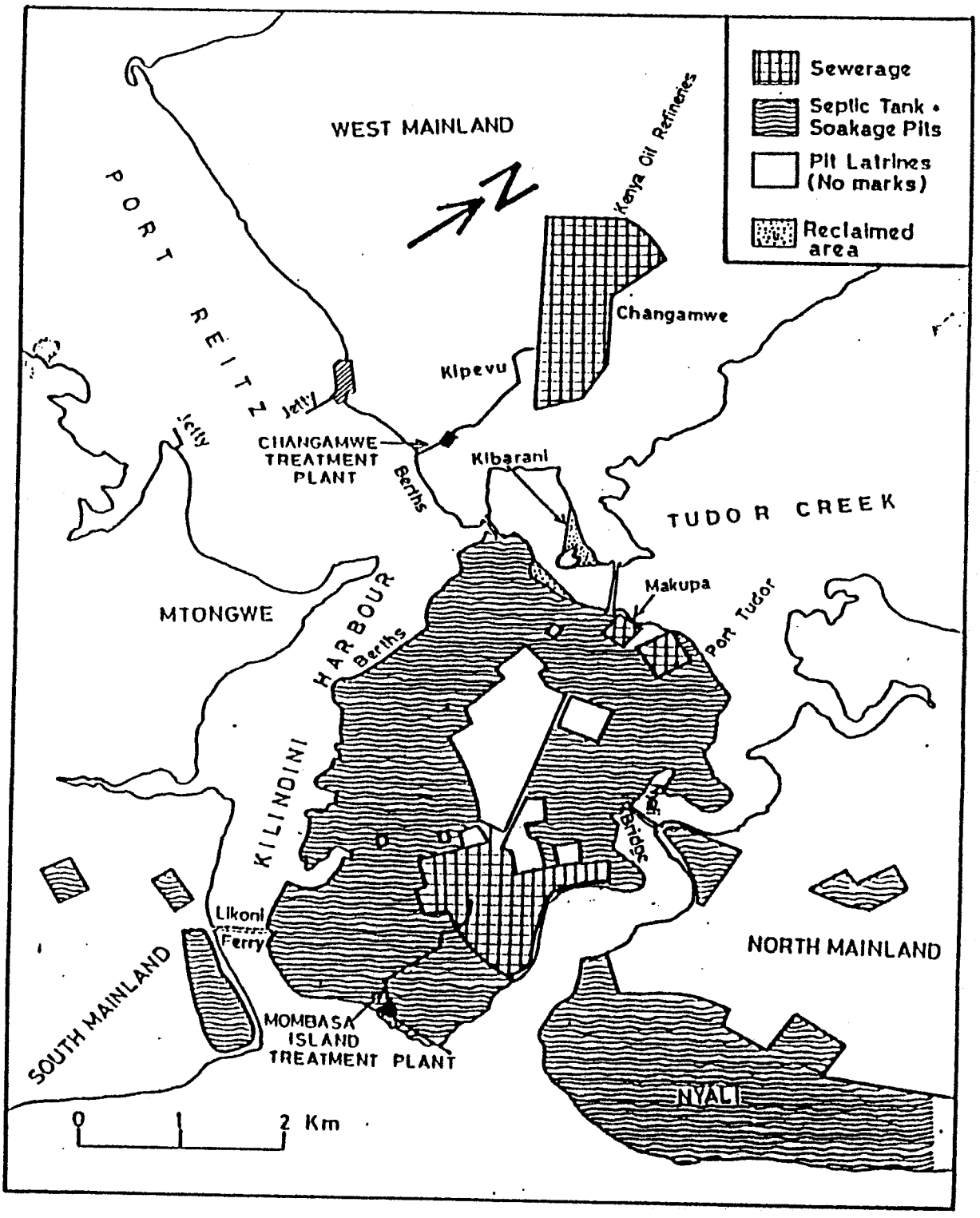


Figure 2: Sewage disposal systems

source: GOK (1974)

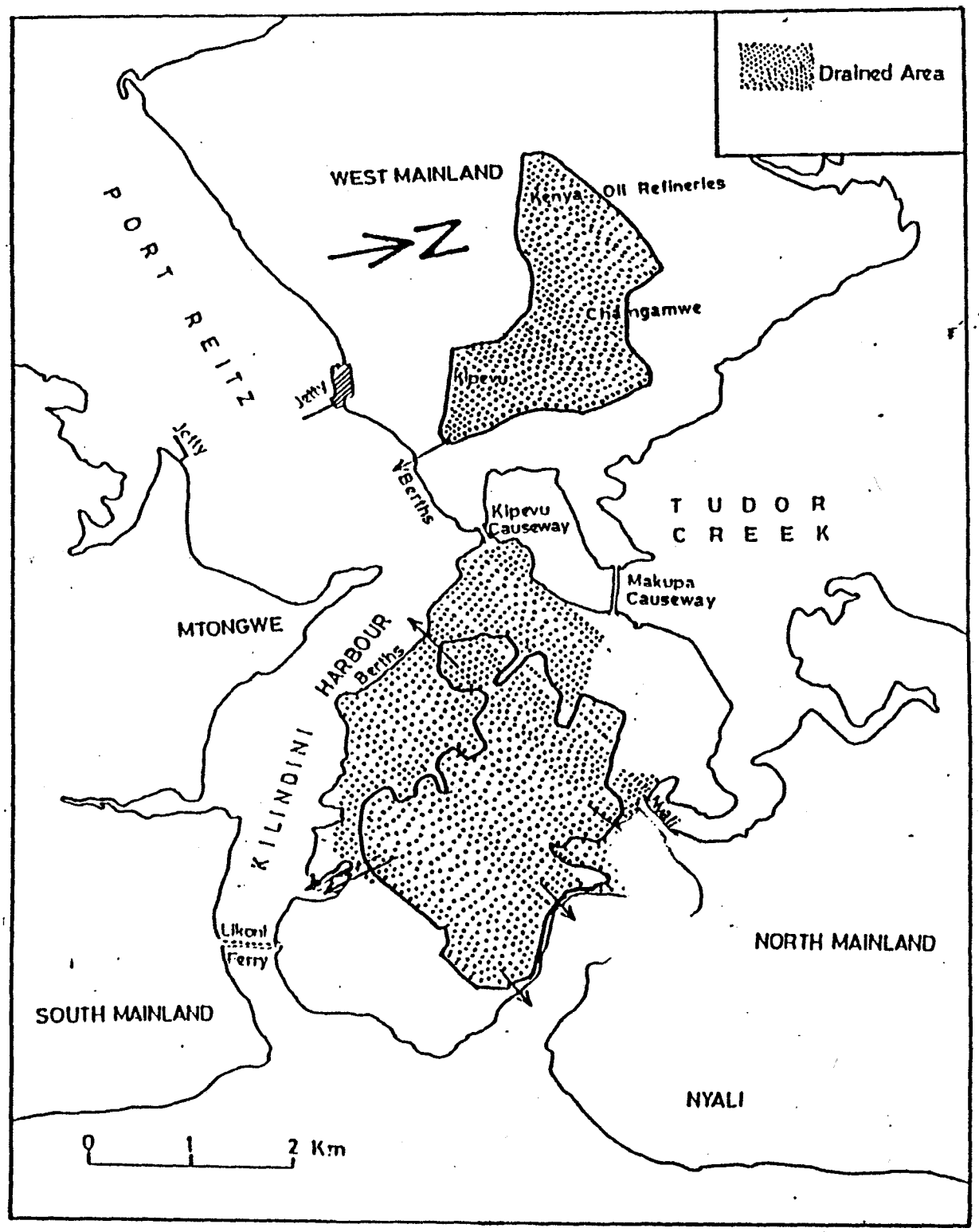


Figure 3: Existing storm er drainage drainage areas

source: GOK (19)

4.2.4.2. Monitoring of Pollution levels in the coastal and estuarine environment around Mombasa

By : J.Wijnant, K.Delbeke, J.Munga, S.Mwangi, M.Owili.
With technical assistance of M.Umani,J.Othoto,
N.Marocco and P. Mathendu

INTRODUCTION

The study is done in collaboration with the Kenyan Government Chemistry Department and is supported by UNEP, in the frame of the EAF/6 program "Assessment and Control of pollution of the Kenyan Marine environment".
The theoretical investigation of the pollution loads in the creeks around Mombasa (see previous chapter) indicated that Tudor Creek receives essentially biodegradable organic pollutants from municipal sewage and
stormwater drain outfalls. Kilindini/Port Reitz creeks receives less pollution from municipal sewage but is also polluted, to an unknown extent, by industrial pollution and leakage from the Municipal dumpsite.
The pollution monitoring part of the program will allow one to obtain a set of baseline data to be compared with the obtained results from the theoretical investigation and to be used as a reference for further pollution monitoring.
At present, basic environmental parameters are being investigated :Salinity, Temperature, PH, Dissolved oxygen, Nutrients, Particulate organic carbon, BOD_5 , petroleum hydrocarbons, heterotroph and pathogenic bacterial counts and phytoplankton biomasslevels. The data will allow us to have a first general evaluation of the state of the marine environment. In a later stage, environmentally toxic and stable pollutants such as organochlorine residues and heavy metals, will be investigated. This report deals with the first set of data obtained in the Mombasa Creeks.

MATERIALS AND METHODS

Water (surface and bottom) and sediment samples were taken on board of the RV Maumba with respectively Niskin bottles and a Van Veen grab sampler. The samples were collected at different stations in Kilindini/Port Reitz Creek, Tudor Creek and Gazi (reference site)(Fig.1) between 10th April and 17.th May 1991. At the connection between Makupa end Kilindini (oilspill and municipal dumpsite) and at Mbaraki (stormwater drainage outfall) samples were taken at different time intervals during one tidal cycle.
Salinity, temperature, PH and water depth were measured immediately, using the respective meters. Water (1 liter) was filtered immediately on board for measurements of chlorophyll and POC. The filters were preserved through freezing before analyses on a spectrophotometer, according to Parson and Strickland. Nu-

trients are preserved with chloroform before freezing and analyzed with a nutrient analyzing system. Petroleum hydrocarbons were extracted on board and analyzed with a UV spectrophotometer. Oxygen and BOD_5 values are obtained using the Winkler Method. The method used for heterotrophic and pathogenic bacterial counts are described in Wijnant et. al., 1991. All samples are taken in duplicate, except for bacterial countings, BOD measurements and oxygen levels, which are taken in triplicate or more.

RESULTS AND DISCUSSION

Table 1 gives an overview of the results obtained sofar. The data on POC, nutrients and petroleum hydrocarbons are being processed and will be available soon.
The differences noted in temperature between the different station are a reflection of the onset of the rainy season during the sampling period. No clear differences in water temperature were noted between the different station within one transect, nor within one tidal cycle (for Makupa and Mbaraki sites).
PH values range usually range between 7.7 and 8.5 between. The lowest value was recorded in Gazi (7.3), the highest pH in Makupa(9.4). Surface sea water has a characteristic pH range between 8 and 8.3. A change in pH due to photosynthetic uptake of carbondioxide by phytoplankton to 9.5 and a decrease to 7.3 at night are still to be considered as normal for biological active Marine tropical waters. The pH values therefore do not seem to cause any hazard to the marine environment.
Low oxygen values are sometimes note. Oxygen values range between 4.5 and 9 mg/l. Values below 5mg/l were recorded for the deeper water layer during outgoing tide for the Makupa site and for the whole water column, at the Kenyan meat factory .
Relatively high BOD_5 ,heterotrophic biomass and Ecoli numbers are recorded for the Makupa area and Tudor Creek (Coast General). When considering the WHO (1967) guidelines of 1000/100ml for total coliform group and the EEC guidelines (1975) of 500 total coliform and/or 100 faecal coliform/100ml, than one can note that all levels are under the guidelines.

When considering the data on oxygen, BOD_5, bacterial numbers and chlorophyll levels in some more details (Fig 2 - 4), one observes for the surface water in Kilindini Creek a decrease in oxygen and an increase in chlorophyll levels and BOD_5 levels going inward in the creek, (fig 2). A decrease in oxygen level and an increase in chlorophyll, BOD_5 levels and heterotrophic bacterial numbers was observed with outgoing tide, compared to incoming tide, for the surface waters of the makupa site (fig 3). One must therefore consider Makupa creek as an important source of organic pollution for Kilindini creek, due to the Kibarani dumpsite and the remains of the oilspill.
The deeper water samples from Kilindini Creek show a similar decrease in oxygen levels as surface waters, however with sometimes lower BOD levels and heterotrophic bacterial numbers in

the Makupa area (fig. 2). The bottom water samples from Makupa show lower levels of oxygen, BOD_5 and heterotrophic bacterial numbers at outgoing tide, compared to incoming tide (fig 3). The decrease in oxygen as well as in heterotrophic bacterial numbers and biomass levels for the bottom samples compared to the surface water samples in the Makupa area should be investigated more deeply.

The samples taken at Mbaraki only show small changes in oxygen, BOD5 and heterotrophic bacterial numbers over one tidal cycle (fig 3). Mbaraki is therefore, at present, not considered as a major pollution site for Kilindini Creek.

In Tudor Creek, a lower oxygen and higher BOD5, chlorophyll and bacterial levels are observed for the inner creek, at the Kenyan meat factory compared to the open sea station (fig 4). The samples from the hospital are contradictory, showing either normal or elevated levels for BOD_5 and heterotrophic bacteria (fig 4) as well as for E coli (table 1).

When comparing the data with the ones obtained for Gazi, similar environmental data are observed. The measured BOD_5 values are however much higher then predicted from the preliminary theoretical investigation (Table 2) . More replicas are however needed and a remeasurement of the contamination levels (data from 1975) at the sewage and water drainage outfalls seems necessary and is being undertaken .

CONCLUSION

The monitoring of pollution levels in the creeks around Mombasa has started, the first data are available. The first results, although preliminary, are higher than the ones obtained in the theoretical investigation. The area shows a minor pollution by organic degradable compounds. The area around Makupa is probably to be considered as the most important pollution source for the area. The area around the Coast general hospital also surely needs further investigations. Further data collections will allow one to obtain a reliable database, including variations due to tidal water movements and seasons. The results on other basic parameters and on important toxic compounds will allow us to make real conclusions.

Table 2 : BOD_5 values obtained through the theoretical investigation and the monitoring study(mg O_2 /m^3)

Area	BOD_5 calculated		BOD_5 measured	
	Mean	Max	Mean	Max
Kilindini	181	773	1200	1720
Tudor	455	1633	973	1600

Table 1: Range of measured environmental data in the different creeks around Mombasa and in Gazi (Min -Max)

STATION	DEPTH	TEMP.-RANGE	PH	SAL‰.	O2mg/l	BOD5mgC/m3	BIOMASS/ml*100	E.COLI/l	F.S./l
Makupa	S	30,5-31,0	8,0-9,3	29,5-31,5	6,2-6,7	600-1020	150-360	80-1000	nm
	D	30,3-30,8	8,1-9,4	29,5-31,0	4,6-6,4	540-840	200-360	160-400	nm
Mbaraki	S	28,7-29,5	8,1-9,2	30,0-34,0	6,2-6,9	300-480	20-20	0-200	nm
	D	28,8-29,4	8,2-9,2	31,0-34,0	6,1-7,0	300-540	30-30	0-200	nm
Kilindini I	S	29,7-31,5	8,1-8,2	25,0-29,5	5,7-7,8	350-570	60-200	0-140	nm
	D	29,5-31,4	8,1-8,2	24,5-28,5	5,6-7,2	350-660	20-260	0-200	nm
incoming tide LT									
Kilindini II	S	26,2-29,0	8,0-8,2	30,0-35,1	6,5-6,5	276-564	12-410	20-80	800-1380
	D	25,5-27,1	8,0-8,3	31,0-34,9	6,4-6,5	192-612	72-440	20-80	300-1300
Tudor I	S	28,8-29,2	7,9-8,2	32,0-37,0	5,9-7,0	300-600	80-180	0-45	nm
LT	D	28,8-29,0	8,0-8,2	32,90-37,0	5,8-6,0	300-450	66-600	0-40	nm
Tudor II	S	27,9-28,0	7,7-8,4		4,5-7,2	300-540	42-300	40-440	120-340
incoming tide	D	27,8-28,0	7,8-8,5		5,0-6,6	180-360	88-900	0-680	260-620
Gazi	S	27,5-28,8	7,4-8,1	20,0-31,0	5,0-9,0	600-660	260	nm	200-1000

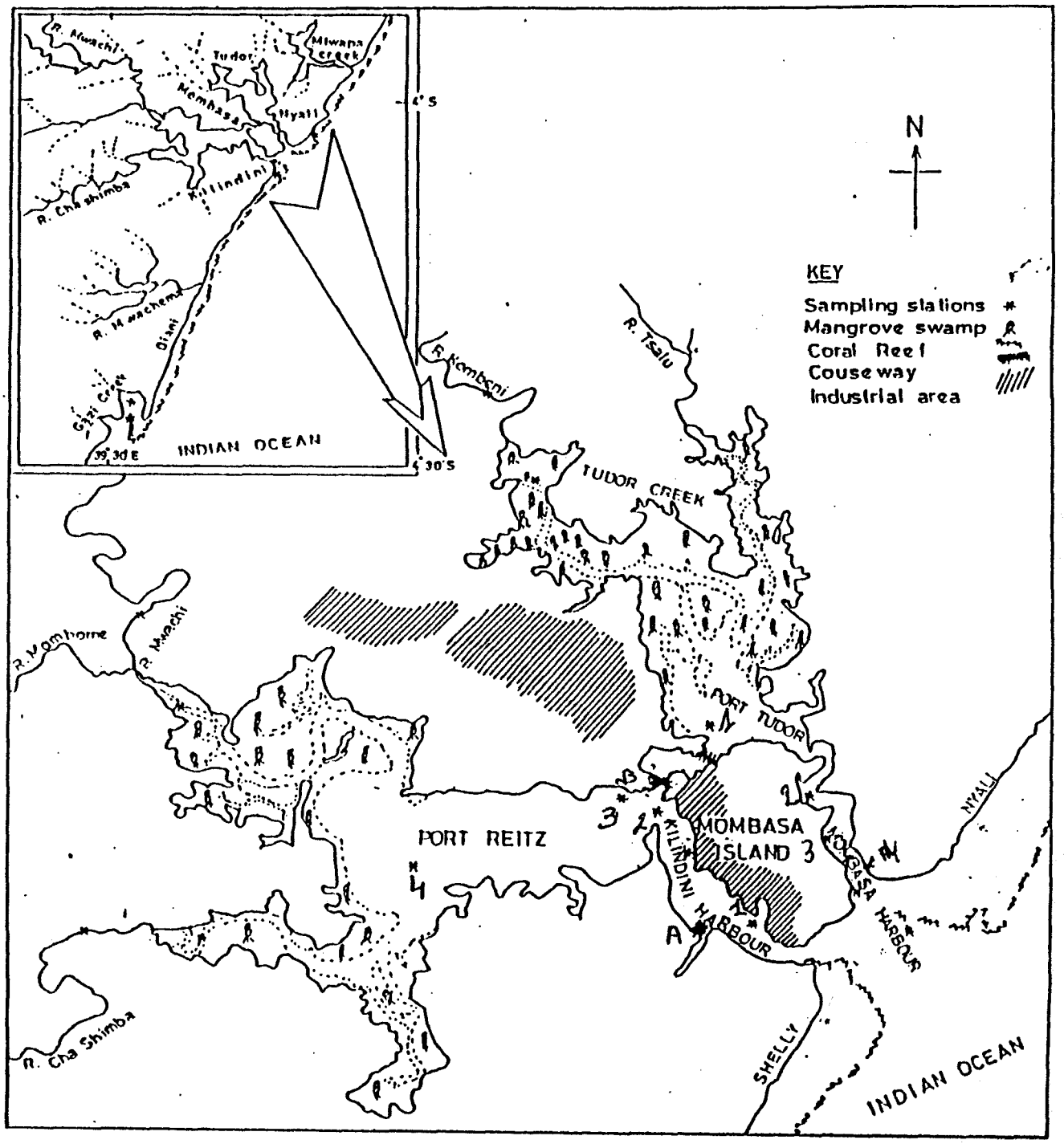
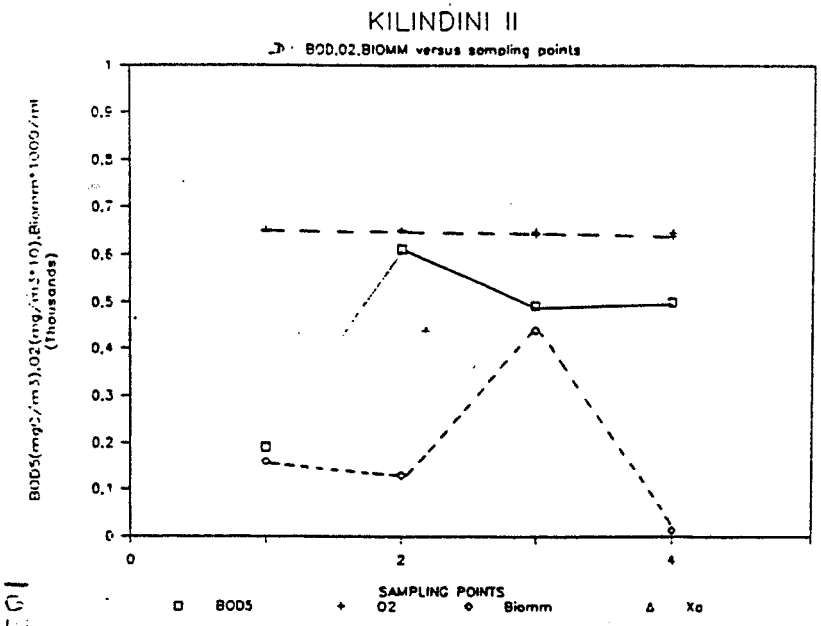
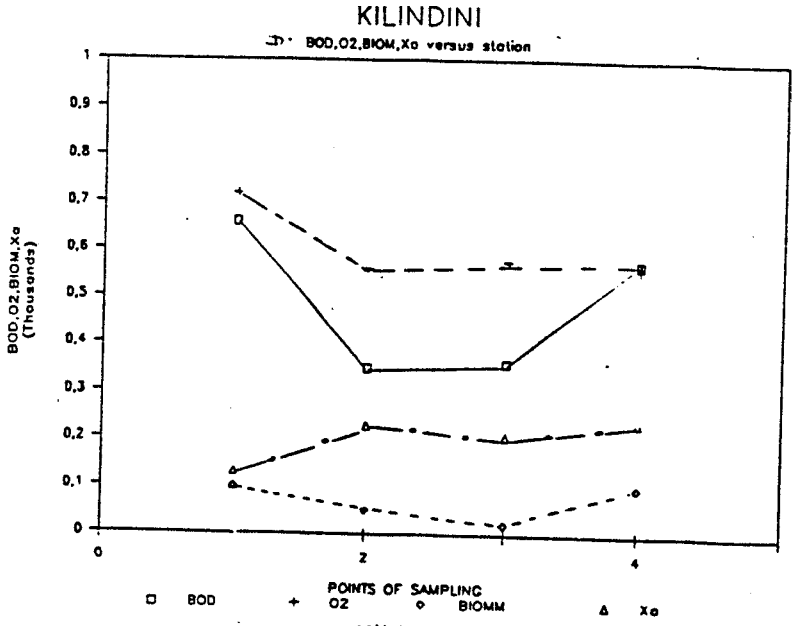
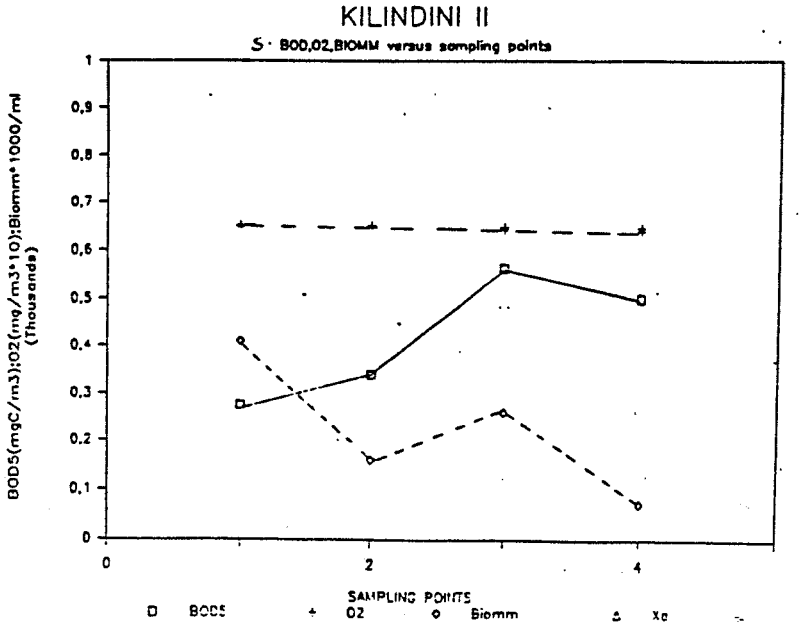


Figure 1: Map of the study area, showing sampling stations







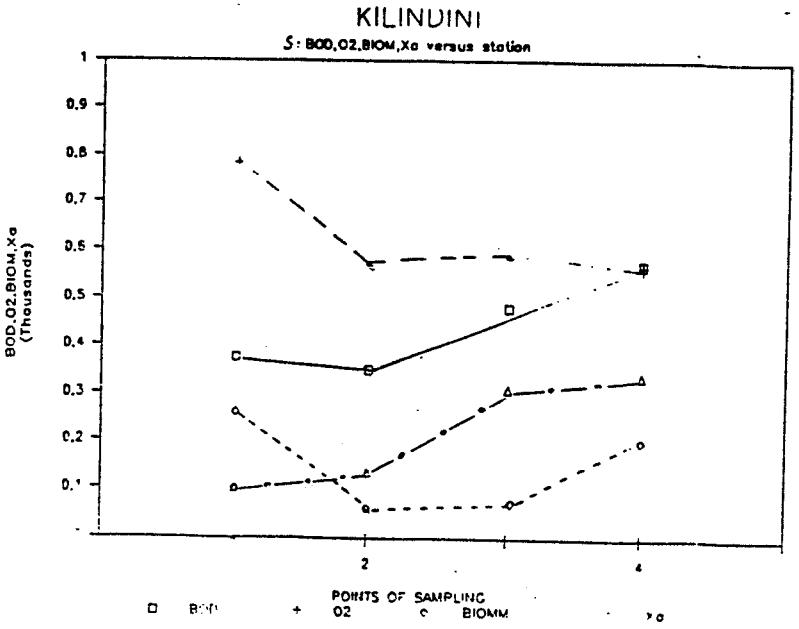


Figure 2: Variations in oxygen levels, BOD 5 levels , chlorophyll a levels and total heterotrophic bacterial numbers at different stations in Kilindini Creek (see Fig 1): Sampling dates : Kilindini I: 16-4-1991, Kilindini II: 16-6-1991

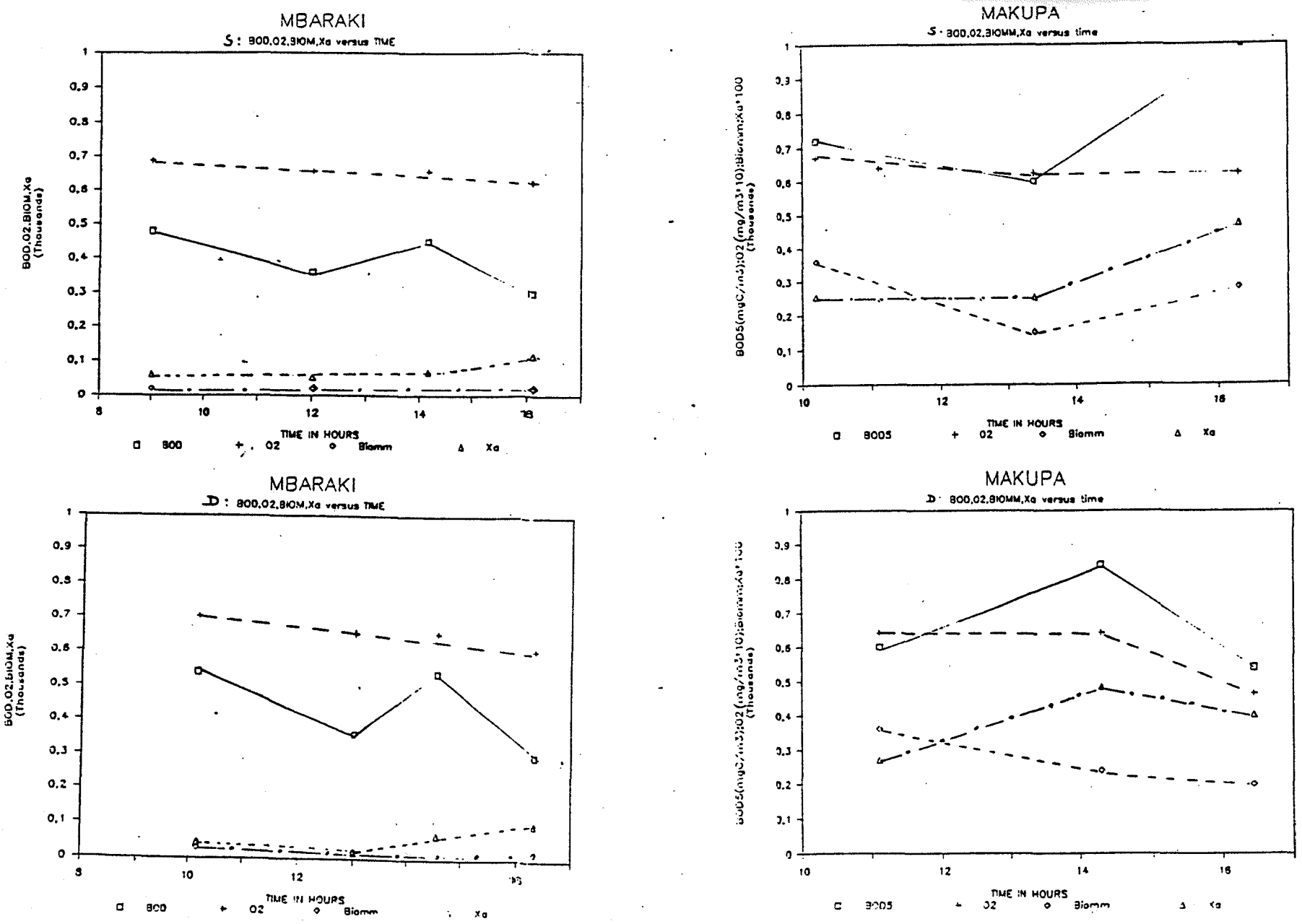
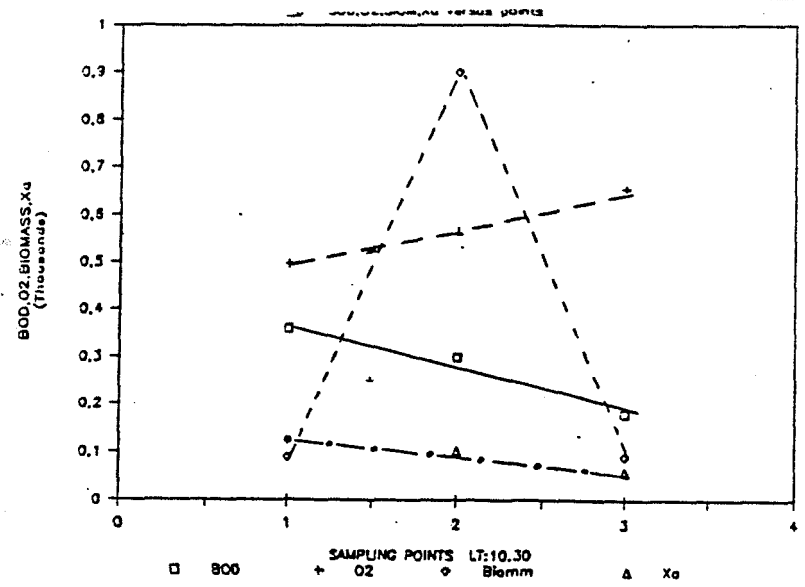
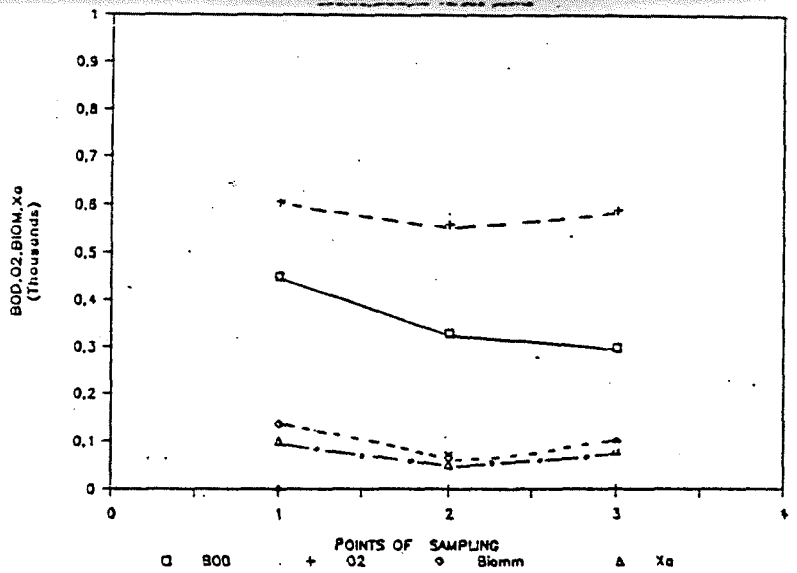
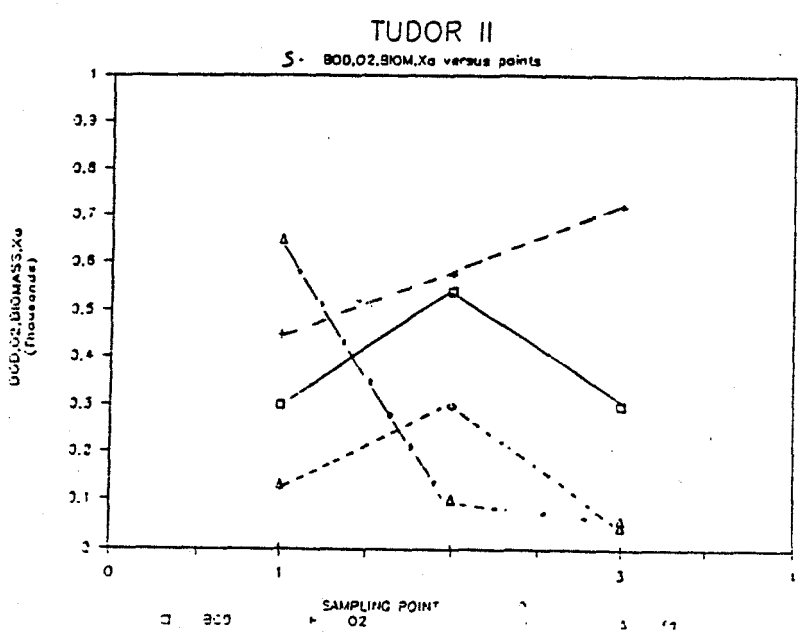


Figure 3: Variations in oxygen levels, BOD 5 levels, chlorophyll a levels and total heterotrophic bacterial numbers within a tidal cycle at Makupa (10-4-1991) and Mbaraki (25-4-1991) (B & A)







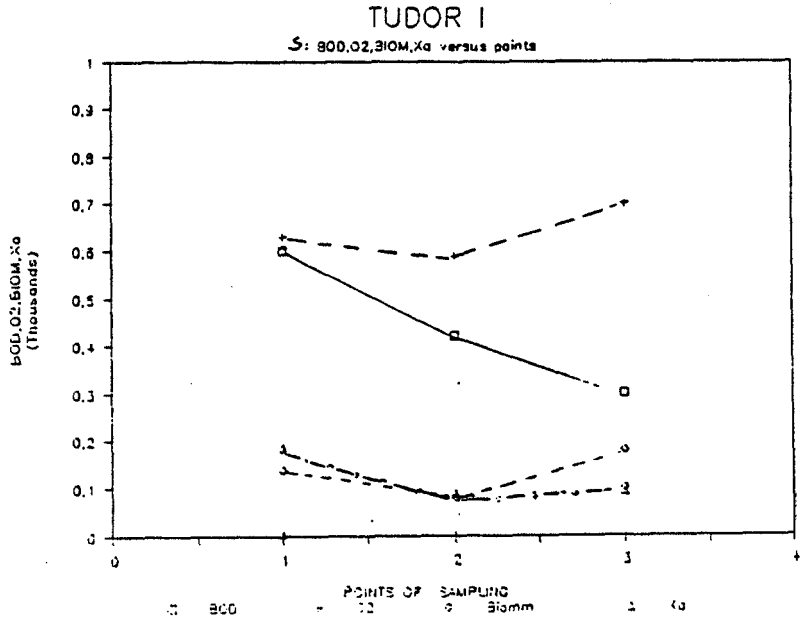


Figure 4: Variations in oxygen,BOD 5 levels, chlorophyll a levels and total heterotrophic bacterial numbers at different stations in Tudor Creek (see Fig1)

4.2.4.3. Assessment of pollution impact on the Mangrove Oyster, ment of the impact of pollution on the Mangrove oyster,Crassostrea cucullata

By: K.Delbeke, O.Omolo, M.Umani & O.Anyango

INTRODUCTION

The pollution impact study is part of a collaboration programme "Assessment and control of pollution in the Kenyan coastal and marine environment". The programme is conducted as a collaboration between KMFRI,Government chemistry and KBP. It consists of different subprojects:
(1) A theoretical investigation of the pollution sources and pollution loads from municipal, industrial and agricultural wastes (see previous chapter).
(2) Monitoring of pollution levels and establishment of baseline contamination levels for the area(see previous chapter).
(3) Assessment of the effects of the pollution on the marine environment(this study).

It is aimed, in the frame of the third subproject, to investigate the biological condition of the Mangrove oyster,Crassostrea cucullata, from the potentially more polluted area (Mombasa), in comparison with an "unpolluted" site (Gazi). The Mangrove oyster,was chosen as indicator organism, due to the known usefulness of bivalves as indicator organisms (e.g.Phillips,1980; Bayne et.al.,1982; MAP,1987;), due to the importance of the oysters for human consumption and due to available knowledge of the oysters' biology and ecology (Ruwa 1984 and 1990; Tack et.al., 1990).

The study consists of three parts:
- study of the basic biological characteristics (size frequency distributions, condition and sexual maturity).
- study of the biochemical characteristics (lipid and protein content, enzyme activities)
- study of the physiological characteristics (metabolic and grazing rates, scope for growth)

This report only deals with the first part of the study.

MATERIALS AND METHODS

Between 20th and 30th March 1990 (pre-spawning and spawning period), oysters were collected respectively in Gazi Creek (40 km south of Mombasa), Mtongwe (Kilindini creek) and Port Reitz (Fig.1). Due to the known impact of the population density on the substrate and of the tidal height of the oysters' site on the growth of the oysters, only individuals being characterized by less than 70% cover on the substrate and situated at a tidal height around 60-95 cm above datum were collected. The collected oysters were immediately transported to the laboratory and frozen alive. The shell sizes, sexual maturity of the females (size of

gonads and ripeness of the ova) and the dry weight of the oysters were recorded.

RESULTS

The results on the oysters' shell size (length and width) and the oysters' dry weight (Table 1 and Figs. 2 & 3) show that the oysters from Gazi are smaller than the oysters from Kilindini (Mtongwe) and Port Reitz. The noted differences for shell length and dry weight measurements are significant (P 0.01 in a students t test).
When comparing the oysters' ratio : dry weight oyster/shell length, being an indication for the oysters' condition, one observes the highest condition index in Mtongwe. The oysters from Gazi have the lowest condition index. The noted differences are statistically significant (P 0.01 in a students t test).
The observed differences in shell sizes, body dry weight and condition index are not to be understood by differences in maturity stages between the 3 populations (table 1) nor by differences in population densities or tidal height (see materials and methods).The comparison of the condition index also excludes possible differences in oysters size due to collection of the oysters (essentially the bigger ones) for human consumption.

DISCUSSION

This first preliminary investigation could not detect any adverse effect of pollution from the Mombasa district on the considered oysters' growth. The area around Mombasa is essentially characterized by pollution by biodegradable organic compounds from municipal discharges and some additional industrial pollution of yet unknown magnitude (see previous chapter). It therefore seems possible that the increased load of organic matter might enhances the oysters' growth, directly (uptake of DOM or POM by oysters) or indirectly (through eutrophication). The results are nevertheless to be interpreted with care. More data on population sizes, and condition index (as internal shell volume) are needed. The study of the biochemical and physiological characteristics of the oysters as well as the analyses of contaminants in the oysters' tissues will allow us to draw conclusions on the oysters condition and its value for human consumption.

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Table : Shell size ,dry weight of the meat, condition index (dry weight /shell length) and maturity stage of oysters collected in the creeks around Mombasa: Mtongwe (Kilindini creek) and Miritimi (Port Reitz) and in Gazi. Mean values and standard deviations; n=number of samples (cond.=condition).

place	n	shell length (cm)	Shell width (cm)	Dry weight (gr)	cond. index	%mature females
Mtongwe	111	3.23 ± 0.68	2.34 ± 0.52	0.252 ± 0.330	0.052 ± 0.096	53
Port Reitz	79	3.77 ± 0.75	2.33 ± 0.57	0.138 ± 0.081	0.027 ± 0.043	53
Gazi	128	2.94 ± 0.57	1.88 ± 0.44	0.071 ± 0.049	0.016 ± 0.016	58

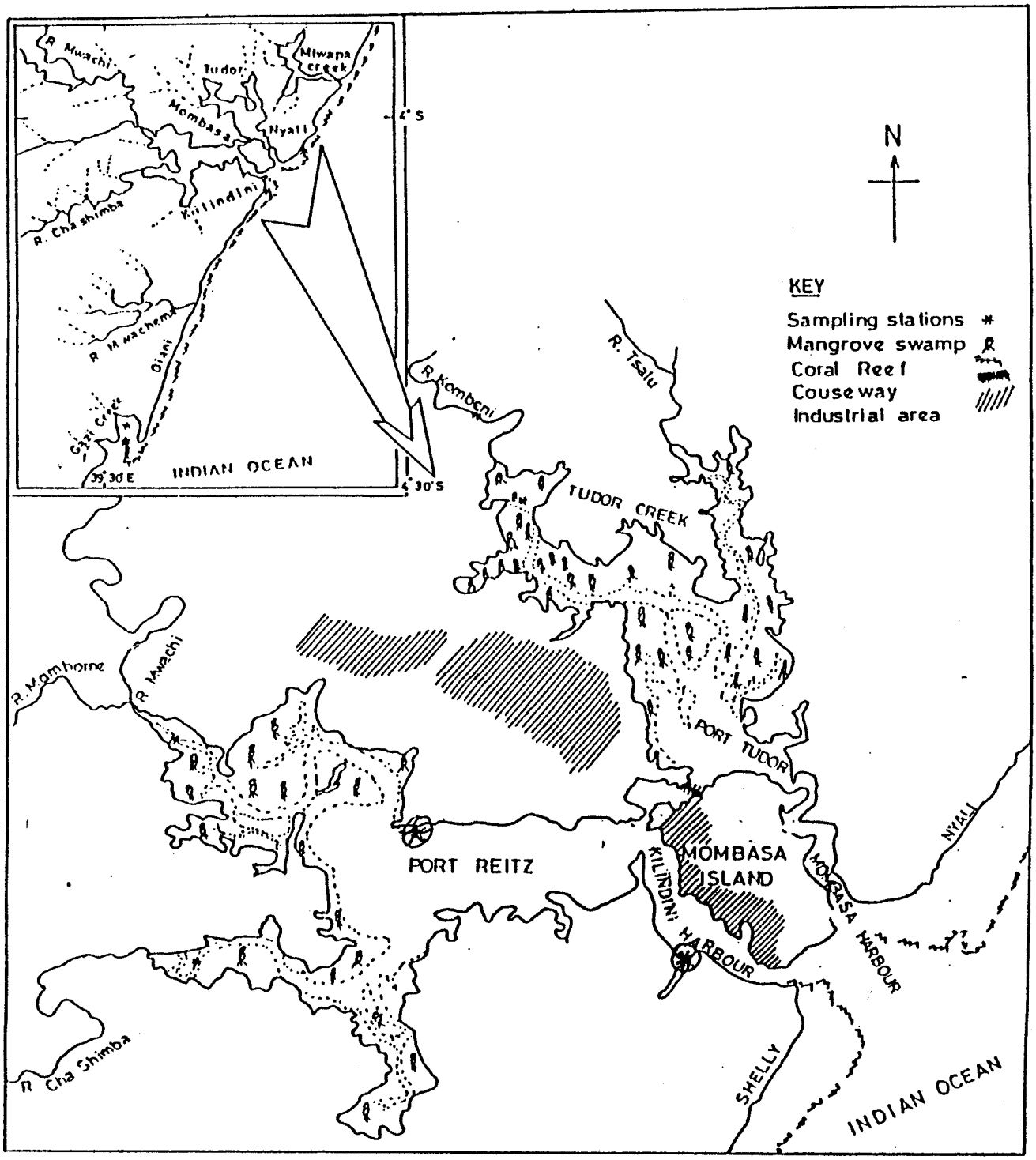

Figure 1: Map of the study area, showing sampling stations

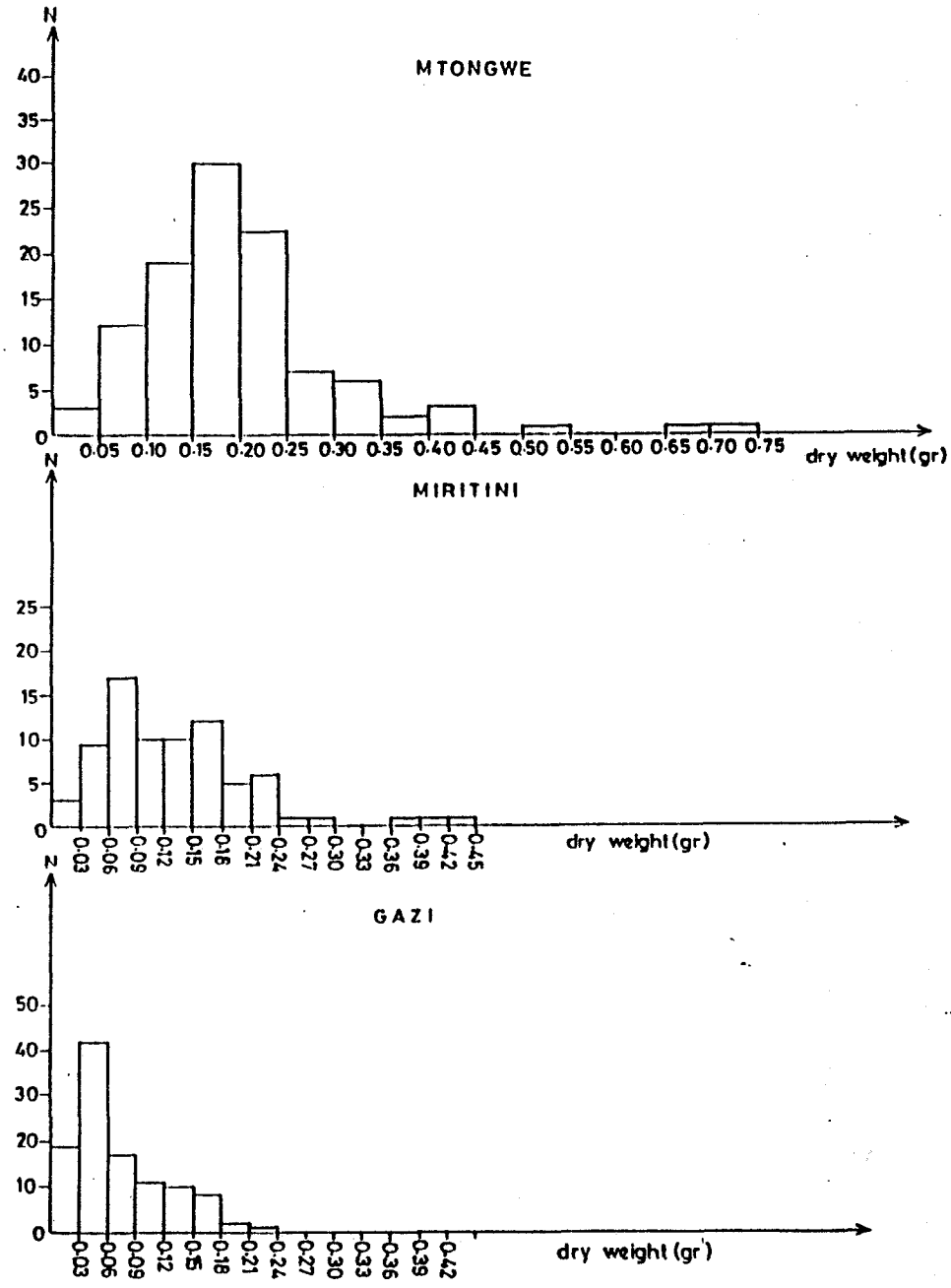

Figure 1: Frequency distribution of the dry weight of oysters collected in respectively Mtongwe, Miritimi and Gazi.

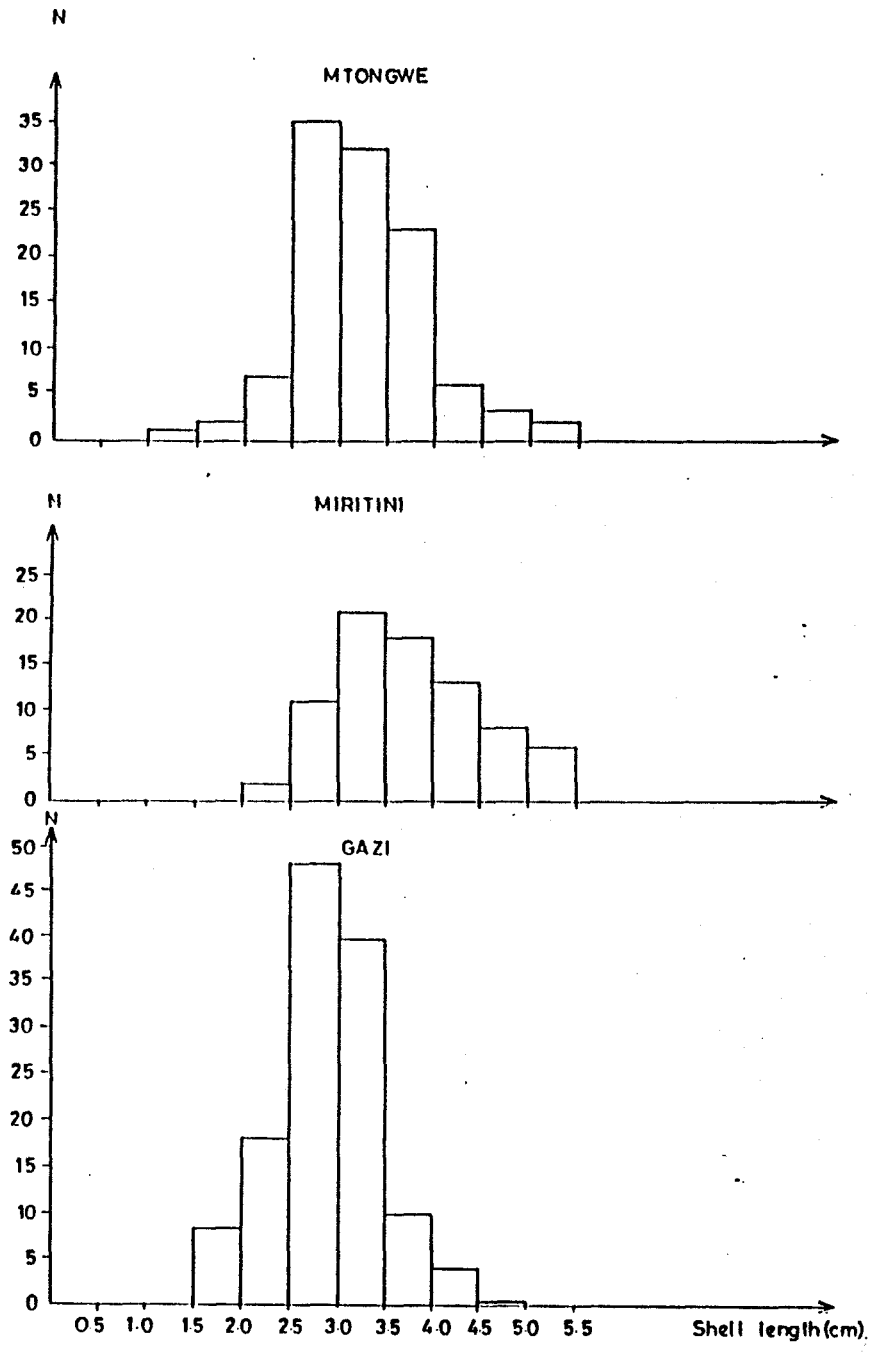

Figure 2: Frequency distribution of the shell length of oysters collected in respectively Mtongwe, Miritimi and Gazi.

4.2.5. A report on the culture of Siganus sutor in tanks.

By: B.Okoth

AIM.

1 The aim of this project is to try different Culture techniques so that these fish can be can be successfully Cultured here in Kenya; as they are very popular and their market value is within the reach of the common man.

2 To try and formulate cheap and adequate diets formulated using local Ingredients growth and good body Composition.

3 To try and Induce these fish to spawn in captivity as the availability of seed is of a major constraint in agriculture. So far no such research is going on in Kenya (for Marine fish) and it is important that it is done so as to promote aquaculture given the vast area of sea that Kenya has.

METHODOLOGY

Fish are normally brought in live from Gazi, where they are caught during low tide by beach Seining. The fish caught are then packet in polythene bags containing little sea water and the bag is then filled with oxygen and lied.

These fish are then transported to the lab where they are kept in 1 ton concrete tanks. In the 1st week the fish are fed on algae collected from the sea and in the second when the fish are used to tank conditions they are trained to eat pellets.

Different types of pellets have been composed so far, and experiments are going on to find the suitability of these proteins. Experiment are also being carried out to find the optimum protein and fat requirement of these fish so as to help in compounding pellets that meet the nutritional requirement of the fish.

This work is still in the early stages.

CONSTRAINT

1 The biggest constraint has been the availability of sea water but this now has been rectified by the acquisition of a new pump.

2 Lack of aquariums is also another problem. These are required for larval rearing we need 20 30L plastic aquariums for stocking larvae. The experiments have to be done under different environmental conditions as well as different feeding regimes.

4.3. RESEARCH DONE BY VISITING SCIENTISTS

Report study trip to Mombasa - Kenya. November 12 - 18, 1990.

Dr. Maya Borel Best
Nat. Mus. Nat. Hist. Leiden
Postbus 9517
2300 RA Leiden, the Netherlands.

Purpose: One week orientation on possibilities of coral reef research projects in Mombasa - Kenya.

Introduction.
As teacher of the coral reef ecology course (FAME) in the VUBrussels, I was asked to supervise the MSc student Amanuel Melles from Asmara-Ethiopia. Coral reefs are worldwide threatened by overexploitation and landerosion. The research proposal of A.Melles is therefor orientated towards "the influence of terrigenous sediments on health and growth of coral reefs off the Kenyan coast".
Because I was not as yet familiar with the coral reefs off Kenya or with the practical circumstances to carry out a project there, I was asked by Prof. P. Polk to do some orientating fieldwork in Kenya with A.Melles in November 1990. One week work with some fieldtrips should be enough for orientation in view of my twenty years experience with coral reef research in the Indo-Pacific (mainly Indonesia) region.

KMFRI = Kenyan Marine Fisheries and Research Institute - Mombasa.
The research station is well situated along the sea side in Mombasa, but has to contend with many reorganisation problems. The director Dr. E. Okemwa was very helpful and hospitable and promised the reef team, consisting of A. Melles, J. Mutere, two Belgium divers (M.Maas and D.Martens) and myself, to supply the transport (jeep and boat) necessary for fieldwork.
The technical services and material of car and boat, as well as available diving equipment were not adequate for this kind of research. The main problems concerned the diving equipment and boat (dingy). For safety reasons a well functioning compressor and regular tested SCUBA-tanks are essential. This was not the case however, so diving with borrowed tanks and bad air was the result. Most work therefor was done by snorkling.
The boat transport was not sufficient either, the motor broke down and the light boat tipped over with a little swell on our way to the reef at Gazi.
In conclusion I can state that the KMFRI equipment for reef research is not adequate as yet . Good reliable diving equipment and a heavier motor boat is necessary for further coastal reef research.

KMFRI Guesthouse. FAME project.
Under the guidance of Prof. P. Polk the KMFRI guesthouse is operating well. Scientists and students are invited to participate in marine and fresh water projects.
As a consequence of the in 1988 started theoretical reefcourse "Coral Reef Ecology" as given in Brussels for FAME students, the plan has risen to start fieldwork possibilities for the students in Mombasa and eventually to give the FAME course also here.

Kenyan reefs.

Coral reefs are complex ecosystems characterized by a state of dynamic equilibrium comprising innumerable invertebrate fauna and flora. Healthy reefs are important for a rich marine life and for protection of the coast. The equilibrium is subjected to the impact of sediment flow. Currents and fresh water imputs from rivers deliver sediments which have an important controlling effect on the reefs. The Kenyan coastline extends over 450 km along East Africa. The continental shelf is narrow and supports fringing reefs and patch reefs which lie o.5 - 2 km offshore.

During the excursions made to reefs north of Mombasa, Malindi and Gazi, the general condition of the reefstructure and the diversity of the coral species (main reef builders) composition, was studied.

In the lagoon and innerreef algae and seagrass beds dominated first to be taken over by low diversity reef patches. Approximately 60 coral species belonging to 22 genera were counted. An inventarisation was made and a reference collection was started.

Striking was the absence of coral species that indicate healthy and rich reef biotopes. Also the large colonies of Porites (up to 4 m diameter) were for a large part dead and showed only living parts at the outsides, the toppart was covered by sediment and dead.

It was my conclusion that these inner reefs along the coast of Kenya are strongly influenced by land erosion (sediment - fresh water), but also by the effects of too heavy touristic pressure.

This will be tested by the work of Amanuel Melles of which the practical part has started in November 1990 and will be worked out during the next six months in the ~~in the~~ Netherlands under my guidance (see Research Project Proposal A. Melles Oktober, 1990)

Conclusions.

To start a coral reef research programme in Mombasa for East Africa the practical infrastructure in the KMFRI has to be installed.

Because the inner reefs along the coast of Kenya are strongly deteriorating a reef programme should be set up, that is orientated towards reef protection. The most important destructing factors (probably sediment, river outlet, tourism) should be studied in order to advise the Kenyan governement of the necessary steps to be taken to save the coastal reefs from complete destruction. Because the reef construction and diversity of the outer reefs are far more solid and rich, the recolonisation of reef building organisms at the inner reef might take place in the future when the destructive factors are reduced as far as possible.

/4690

REPORT OF M.Sc. DATA COLLECTION FIELD WORK ALONG THE KENYAN COAST

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Towards the partial fulfillment of my M.Sc. I did my field work along the Kenyan coast during-November 1990. The field work was carried out at several sites on the Kenyan coast. Preliminary survey of the following sites was made: Kenyatta Beach, Bamburi,

Nyali, Malindi and Gazi. The survey of the latter site ended in failure due to a boat accident. Most of the preliminary surveys were done by snorkeling and covered the first week of November. After the selection of sites, corals were collected for taxonomic, isotopic and radiographic studies. The depth regimes covered during collection ranged from 2m up to 23 m.
Preparation of coral samples for studies (cleaning, labelling, etc.) was done at the KMFRI guest house. For isotopic and radiographic studies coral cores and slabs are needed: in the absence of a corer, every attempt to improvise at the KMFRI's workshop did not bear fruits. Corals slabs were roughly prepared with the help of stone disc cutting machine at a local workshop in Mombasa. Precision cutting will be done in Amsterdam.
Spot X.rays of some coral species were taken.
Apart from coral collection, line transects were laid at Malindi and quadrants at Nyali and Bamburi. By this method coral species coverage was estimated.
In order top aid in the identification and characterization of coral species and bottom topography, slide pictures were taken using a Nikonos underwater camera.
For a possible long term monitoring of coral reef, permanent site was established comprising three depth regimes (12-17m).
During my field work, I was assisted by my advisor Dr. Best. Dirk Martens, Mare Maes and Erik Slim, to whom I am grateful, have joined me during my diving sessions and helped considerably in underwater sampling tasks.

I had encountered some logistic problems and inconveniences. Against all my expectations, cooperation with Ms. J. Mutere proved: difficult, if not impossible. My passport has been withhold for two weeks by the Malindi Wildlife Service Warden because the presumed papers of permission were either delayed of missing.

On Nov. 14 1990, I had an accident while I was out at sea near Chale Island, Gazi Dr. Best, J. Mutere and Erik Slim and the boat skipper were with me. The accident occurred when the engine of

the boat stopped functioning, and moments later we were overturned by big waves. I have lost an NC-11 diving computer, a Nikonos compact camera and a pair of glasses, J. Mutere lost one of her fins. Local fishermen helped in towing us towards the coast. Although such accidents can happen, the KMFRI's boat was not sea-worthy at all, especially in the outer reef.

In accomplishing my task, my work was facilitated by the help of Prof Polk and Dr. K. Delbeke. I extend my thank to both Erik Slim, apart from joining me in the later and deeper dives, had assisted with transportation. My special thank to him whenever possible, I took the opportunity if my stay in Mombasa doing a literature reach through RECOSCIX WIO . Mr. P. Pissierssens was helpful in thin regard.My field work was made possible by the financial assistance provided be Sarec, Roata and VLIR and efforts of FAME. I am grateful to all. KMFRI Cooperation is also acknowledged

My field work was made possible by the financial assistance provided by SAREC, ROSTA and the VLIR project and efforts of F.A.M.E. I am grateful to all KMFRI's cooperation is also acknowledged.

Kenya-Belgium Project in Marine Sciences "Higher Institute for Marine Sciences" KMFRI - VLIR project

Marine phytal Harpacticoida from Kenya
with emphasis on seagrass dwelling species

by Bruno Demeulenaere

Introduction.

In the framework of the Kenya-Belgium project in Marine Sciences and the KMFRI - VLIR project, a preliminary study of the phytal harpacticoids of the Kenyan coast was undertaken.

The aim of this work is, in first instance, to provide an introduction to the species of phytal harpacticoids from the region as well as to present data on abundance and diversity of this particularly interesting component of the meiofauna. The animals were obtained from seagrasses and algae but the emphasis is put on seagrass (Thalassodendron sp.) dwelling species.

To (re)evaluate the hypothesis that harpacticoids can be used as a "fine tool" in pollution monitoring (see also Heip, 1980), the diversity of harpacticoids from two places along the Kenyan coast will be compared among each other and also with the respective nematode/copepod ratio's (further refered to as N/C ratio) of the two sites. The N/C ratio is widely accepted as being a reflection of the condition of a system with regard to pollution stress, although it is designed to be used for sediment dwelling species.

A brief discussion about the usefulness of different diversity indices, by evaluation of the present results and comparison with earlier (and more extensive) studies of this kind is presented.

On the species lists also a TWINSPAN analysis is performed to gain some additional knowledge on the respective assemblages of harpacticoids.

Next to the diversity analysis, harpacticoid abundance will be determined.

A second part of the present work is dedicated to taxonomy. Results are too preliminary to give an account of them in this report.

Material and methods.

The study area

In order to estimate the abundance and diversity of harpacticoids on seagrasses and to evaluate their possible use as a fine tool in pollution monitoring, samples were taken at two locations along the Kenyan coast English point (ref. "pollution") and Gazi (ref. "no pollution").

English point, the site that is considered to be under some environmental stress, is situated at the mouth of Tudor Creek north of Mombasa Island. The samples are in fact not taken at English point itself but in front of the little beach next to the Kenyan Marine and Fisheries Research Institute and very near to the actual point.

Gazi is a small fishing village some 50 km south of Mombasa. The samples that were taken there are considered to be representative for a non-disturbed site.

Material and methods

Only the leaves of the seagrass Thalassodendron sp. were considered. They were collected by gently sliding a transparent plastic core over one or (where possible) more leaves at a time.and then closing the core at both sides. The total content of the core is transfered to a plastic bag. One sample consists of leaves taken from one plant or from plants in the near vicinity.

At English point 2 x 2 replicas were collected at low tide (outgoing, 1 to 1/2 h before lowest tide). At Gazi, 2 replicas were taken in the main tidal channel and 3 in the artificial channel facing the oyster racks (see Fig. C); also at low tide (outgoing, 1 to 1/2 h before lowest tide).

In the field, $MgCl_2$ (10%) was added to the leaves in the plastic bag which was then shaken thoroughly. $MgCl_2$ serves to stun the harpacticoids present on the leaves. In the lab, the content of the plastic bags was poured over a 63 um sieve. Subsequently, the leaves were washed with a 5% formaldehyde solution.

In order to have an idea of the effectiveness of the technique used to remove the animals, 5 leaves were picked out at random to check them under the binocular (Wild). No harpacticoids were found on the rinsed seagrass leaves.

Although some of the leaves showed extensive epiphyte coverage where harpacticoids can attach themselves to, the removal can be considered to be almost 100% effective.

Other samples that were taken, include several red and green algae from the intertidal area at English point. These samples will only be used for taxonomic purposes since sampling was not performed quantitatively. All samples were preserved in a 5% formaldehyde solution.

The dissection of the specimens was done with 0.3 mm tungsten needles that were frequently sharpened electrolytically. Dissections were performed using a Wild stereomicroscope. The dissected animals are mounted on slides in a drop of lactophenol. Coverglasses were sealed with nailpolish or glyceel®.

Determination of the specimens was done using Wells' key (1979), Lang's "Monographie der Harpacticiden" (1948) and several revised keys and original descriptions.

Drawings were made with the aid of a camera lucida (Wild 1.25x) on a Wild microscope (enlargment in most cases 1000 x or 500 x). Some morphological details, like the mouthparts of the smaller species are not drawn because they were damaged during dissection.

Results and discussion

The species lists on which all calculations are based are to be found in the addendum

1. Seagrass samples

Table 1 : dry weight, surface area and their ratio for the different samples

Sample	Dry weight (g)	Surface area (cm^2)	DW/S
G1	0.551	354	0.002
G2	0.342	201	0.002
G3	0.695	375	0.002
EP1	0.565	301	0.002
EP2	0.580	330	0.002
EP3	0.394	240	0.002

The equality of the DW/S ratio for all samples indicates that no big differences in epiphytic coverage occur. Differences in the number of species will most probably not be due to this factor.

2 Abundance and N/C ratio

Table 2 : numbers of Harpacticoida and Nematoda and their ratio

Sample	Harpacticoida (ind./cm2)	Nematoda (ind./cm2)	N/C
G1	1.85	1.75	0.946
G2	2.98	2.38	0.799
G3	0.88	0.92	1.045
EP1	2.62	2.90	1.107
EP2	2.69	2.83	1.052
EP3	2.15	2.65	1.230

The fluctuating values for harpacticoid abundance in the Gazi samples are probably a reflection of differences in microspatial distribution patterns. Some leaves support much more harpacticoids than others. For example sample G2 with a surface area of 201 cm^2 contained 2.98 ind./cm^2 whereas sample G3, where the leaves have a surface area of 375 cm^2 contains 'only' 0.88 ind./cm^2. Note that these figures are nothing but a reflection of the abundance at the time the samples were taken. Abundance can change drastically over short periods of time.

The values for the N/C ratio are a good reflection of the fact that this ratio was designed to be applied on sediment samples (with different organic load) and is not suited for phytal assemblages.

3 Diversity

3.1 The figures

In Gazi Bay, 14 families (and 1 Fam. inc. which is not counted), 29 genera and 42 species are found. English point samples revealed 10 families, 23 genera, and 29 species.

From these data we could conclude that on all taxonomic levels considered, and especially on the species level, the harpacticoid community of Gazi Bay is more diverse than the community of English point.

Table 3 : division among the three taxanomic levels considered

	Gazi	English point
families	14	10
genera	29	23
species	42	29

In total 53 different taxa have been found. Of those, 19 could, with certainty,be determined to species level. Of 5 species some doubt remained and hence they are quoted as "cf.sp."

Table 4 : % of species in common between samples of the same site.

Samples	% in common
EP1-EP2	48.0
EP1-EP3	40.7
EP1-EP4	42.9
EP2-EP3	48.0
EP2-EP4	47.4
EP3-EP4	52.4
G1-G2	39.2
G1-G3	30.0
G2-G3	39.4
G4-G5	53.8

The differences in species composition between samples of the same locality are quite big (Table 4) so one could argue that if more samples would have been analysed, another species richness would have been found. Species richness is an index that is clearly affected by sampling intensity. Kempton (1979) showed that species richness may be biased even if a complete species list is available. This is caused by fluctuations due to reproduction cycle characteristics. In general, Kempton found that the measures best in discriminating between two sites are most sensitive to sample size.

If more samples would have been investigated, the number of species would increase at both sites on an equal basis, thus confirming the observed diversity differences. It is also not excluded that the number of species found in the extra samples would not be greater in Gazi (having in mind the big differences that already exist with this limited number of samples).

Table 5 : Family composition of the sites (% of total species)

	Gazi	English point
Thalestridae	19.0	20.7
Diosaccidae	19.0	17.2
Tisbidae	11.9	6.9
Porcelidiidae	9.5	6.9
Laophontidae	7.1	20.7
Harpacticidae	4.8	6.9
Ectinosomatidae	4.8	6.9
Ameiridae	2.4	3.4
Ambunguipedidae	0.0	6.9
Ancorabolidae	2.4	0.0
Longipediidae	2.4	0.0
Tegastidae	2.4	3.4
Louriniidae	2.4	0.0
Cylindropsillidae	2.4	0.0
Metidae	2.4	0.0

Note : it must be mentioned that *Metis ignea* , although not found in the present samples,has also been reported from Tudor in plankton samples (James Mwaluma KMFRI, pers. comm.)

As can be seen from Table 5, the typical phytal families (as pointed out by Hicks, 1977) are clearly dominant in Gazi whereas in English point this feature is not so pronounced. This could be an indication of 'forced resource partitioning', which diminishes the portion of true phytal species, due to a higher environmental stress posed upon the English point community. This is of coarse all very speculative.

The differences in species richness (Table 3), which point out Gazi Bay as having more species (more diverse?) than English point (Tudor?), together with the fact that pollution in Tudor is not very intensive, could make one conclude that the diversity of Harpacticoida is a good instrument in the monitoring of (beginning or 'subtle') environmental stress. But if one does not consider the raw data (Table 3) but the diversity indices calculated from these data, it will be clear that care has to be taken when drawing firm conclusions. In the following paragraphs, several diversity indices will be evaluated and some of the points where one has to aware of before drawing any conclusions, will be mentioned.

3.2 The indices

3.2.1 Gazi Bay

Samples from the artificial channel (G1, G2 and G3) : physical stress fluctuates more over a certain period than it does in the main tidal channel. Current speed is also higher than for the samples taken in the main channel.

Samples from the main channel (G4 and G5) correspond better with the English point samples as far as physical stress is concerned.

Table 6 : diversity indices for the Gazi samples

	H'	Brillioun	SI	exp H'
G1	3.34	3.08	0.14	10.13
G2	3.90	3.57	0.09	14.89
G3	4.01	3.63	0.09	16.12
G4	3.34	3.06	0.18	10.09
G5	3.95	3.58	0.10	15.45

3.2.2 English point

Table 7 : diversity indices for the English point samples

	H'	Brillioun	SI	exp H'
EP1	3.68	3.42	0.09	12.84
EP2	3.27	3.04	0.14	9.67
EP3	3.98	3.67	0.07	15.81
EP4	3.17	2.91	0.14	8.98

Only by looking at the values of H' for the different samples, one can see that these data fluctuate within the locality and that these fluctuations are comparable to inter-site fluctuation. It is not very usefull to try to find out if differences between the two localities are significant or not on this level. Although H' is widely used, it does not appear to be a good choise here.

Bearing in mind the above stated reasoning as well as the richness data of Table 3 . it is obvious that H'. although widely used. is useless as a discriminator in this context.

The fact that H' is not very usefull here can be due to the fact that the species list was not exhaustive, in other words, that the exact number of species occurring on Thalassodendron sp. is not known. Presence of all species is one of the assumptions made when calculating H'.

The calculation of H' is also dependent of for example, reproductive cycles and of "patchiness" (which can also be a consequense of the reproduction cycle of the species in question). This patchy occurrence is frequently encountered in the samples :

For example *Diosaccus cf. hameltoni* is very abundant in G3 (26 individuals out of 151) whereas it is absent from G1 and only two individuals are found in G2. The same can be said of *Dactylopusia tisboides* (33 out of 152 in G5) and especially *Esola hirsuta* (61 out of 156 in G4). A number of other species exhibit minor "patchiness".

In the case of *Esola hirsuta* , the reproductive cycle almost certainly plays an important role.

A clear cut case of how the reproduction cycle could influence the calculation of H' is the one of *Eudactylopus fasciatus* This species has been recorded in some cases and not in others. Samples from the same place, but taken with an interval of six months, showed a marked difference in abundance (no absolute values are known for the July '90 samples but thorough examination of quite large samples revealed very few animals in some while in others the species was not present at all (pers. obs.)).

It can be expected that such is the case for lots of other species as well. The data obtained can be regarded as a reflection of these inherent problems.

The Brillioun index shows the same pattern as the H' values, confirming the findings of Heip et al. (1988) that this index is not suited for meiobenthic assemblages. Though Pielou (1975) states that this index is better than H' for small populations..

For the Simpson index the same thing can be said.

The exp H' is clearly the best discriminator thusfar (this has also been demonstrated by Kempton (1979)). On the family level a difference of 2 units is observed. Although this is not a very spectacular difference, it does confirm the general trend found in the data of Table 3.

For the average values of exp H' on species level of both localities (summation of all species and their respective abundances for Gazi and English point) the following values were found :

$$\exp H'_{\text{Gazi}} = 20.86$$

$$\exp H'_{\text{English point}} = 14.95$$

On the species level the differences in exp H' for both localities are more clear cut than on the family level.

3.2.3 Margalef's index

Comparison of the two sites as evaluted by Margalef's index, an index based (unlike the indices mentioned above) on species richness alone :

$$D_{mg} = (S-1)/\ln N$$

The following values were found for the separate samples :

Table 8 : Margalefs index of diversity

Sample	D_{mg}
G1	3.375
G2	4.143
G3	4.385
G4	3.951
G5	4.379
EP1	3.157
EP2	3.772
EP3	3.823
EP4	2.314

When one considers the total number of species and their abundance per site the following values are found :

$$D_{mg}\ \text{Gazi} = 6.317$$

$$D_{mg}\ \text{English Point} = 4.406$$

These values are also a good reflection of the (evident, see Table 3) difference in species richness. The values for G1 (3.375) and EP4 (2.314) can be regarded as exeptions to the general trend that the values for Gazi Bay are are always higher than those for English Point. This cannot be said of the H' values for both sites.

So, concluding one can say that exp H' is the best discriminator followed by species richness (as expressed by Margalef's index), H', Simpsons index and the Brillioun index are not suited. The fact that exp H' has the best discriminating abilities and not D_{mg} as found by Kempton (1979) can be due to the relative important dependence on sample size of the latter.

The differences in physical stress (which are inevitably present), together with the (not proven) pollution stress may account for the differences in species richness found between English point and Gazi Bay. Tudor Creek and the tidal channel can hardly be called highly polluted sites (although there is no heavy industry since the harbour and associated industry are at the other side of Mombasa Island, there may be influence from the sewage of Mombasa and from the hospital and the meat factory discharges). Concluding that the observed differences are entirely due to human induced stress factors is too rash. Monthly investigations of the composition of the harpacticoid community are necessary to evaluate this problem on a more solid basis.

The differences in species richness on the other hand, are too large to be neglected. One could argue that at least twelve species occur at English point that don't occur at Gazi, but the other way around, twenty eight species are confined to Gazi alone.

Already at the family level, there is a difference of 4 units, and as Herman & Heip (1988) point out, one really doesn't have to perform the time consuming dissections (to arive at the species level) to come to a conclusion in all cases. This is also illustrated by the diversity analysis performed on the family data of Table 5 :

Table 9 : Family level diversity

	Gazi	English point
H'	3.33	3.04
Brillioun index	3.08	2.95
Simpson index	0.13	0.14
exp H'	10.07	8.23

It is clear that exp H' is the best discriminator.

Considering further the N/C ratios, which don't show a very convincing difference when applied to phytal assemblages, the use of the phytal harpacticoid community and the measure of its diversity by means of the simple species richness data, must at least be kept in mind as a cheap and quite practical alternative for other methods.

But without certainty about pollution (is there polution and if so of what kind and to what extend), and without data on the (possible) effects on the macrofauna of this pollution (Raffaëlli & Mason, 1981), this conclusion is a bit premature. It is then of course also the question if ày differences in macrofaunal composition are not caused by other (e.g. physical) factors than pollution. The simplest conclusion, judging from the above mentioned data, is that the phytal harpacticoid "community" of Gazi bay is more diverse (in the literal meaning of the word i.e. having more species than ...) than the English point (Tudor) "community". About the reasons for this difference, be it pollution or intrinsic properties of the ecosystem, nothing firm can be concluded.

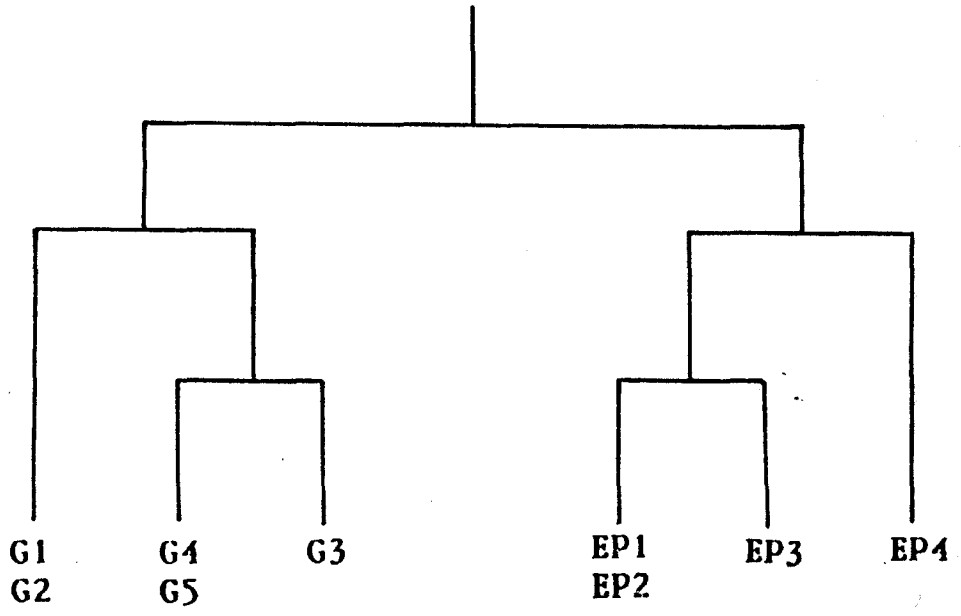
6. Twinspan analysis.

TWINSPAN (TWo-way INdicator SPecies ANalysis) is a FORTRAN program in which species as well as samples are classified. The indicator analysis is not the real basis of the method so the name TWINSPAN can be confusing. A better name is "dichotomized ordination analysis". So the basic method used in this program is the division of ordinations.

This analysis is dealt with separately because in se it has nothing to see with the use of harpacticoid diversity to separate the two locations.

The output (see addendum) contains all information in a very compact manner.

The dendrogram resulting from this analysis and showing graphically the separation of the different samples (stations) looks like this :



The two locations are nicely separated although a few irregularities occur. There are a lot of species with a high 'cut level' (weight for the abundance of a species) that are common to both localities. The species that caused this 'smooth' separation are present in lower numbers when compared to those common species.

Thus, the grouping can be interpreted as being the result of a specific assemblage of species occurring exclusively and with few representatives in one of the two localities.

Esola longicauda , *Bradyellopsis sp*, *Paralaophonte sp*, *Amphiascus cf. parvus* and *Diarthrodes sp. B* are all species with a high cut level for English point and occur in very low numbers or not at all in Gazi Bay.

For Gazi Bay, *Esola hirsuta*, *Diosaccus hamiltoni*, *Eudactylopus andrewi*, *Porcellidium davigerum* and *Metis ignea* are the dominant species. Of those, only *Porcellidium davigerum* is found (at very low numbers) at English point.

The separation of G3 from G1 and G2 (all these samples come from the artificial channel) can be due to the abundance of *Diosaccus hamiltoni* (cut level 5 in G3, 2 in G2 and 0 in G1). *Robertsonia propinqua* , *Tisbintra nanksaurica* and *Scuttelidium sp. B* are species that are present in G3 only (cut level 2). This toghether with the lack of *Metis ignea* in G3 and its abundance in G2 and G1 could be an explanation for the fact that G3 is separated from the samples G4 and G5 from the main channel.

The separation of EP1 and EP2 from the two other samples is a consequence of, like demonstrated above, the inequal species distribution. In this case mostly *Amphiascus cf. parvus* , *Bradyellopsis sp.* and *Paralaophonte sp.* are responsible.

This TWINSPAN analysis confirms the separation of Gazi Bay and English point harpacticoid assemblages as evaluated by means of diversity analysis. All this can thus be seen as a 'confirmation' or a justification of the previously used methods to detect differences in the two species assemblages considered.

Bearing all the above mentioned statements in mind, one could say that, in this context of evaluating the use of Harpacticoida in pollution monitoring through diversity- and TWINSPAN analysis, it can be sufficient to focus on one particular taxonomic group instead of considering the complete meiobenthic spectrum.

All figures, species lists and TWINSPAN printout are to be found in the addendum.

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Addendum

In this addendum you can find the species lists on which all calculations were based toghether with the print-out of the TWINSPAN analysis.

The last column (EP? and Gazi?) of the species lists indicates the precense of that species at the other locality : 1 = present; 0 = absent.

The indications "sp.inc.", "cf.sp *x* " and "gen.inc." mean respectively that the specimen could not be determined up to species level, the specimen is with some doubt determined as *x*. and the specimen could only with certainty be determined up to family level.

	Species name	G1	G2	G3	G4	G5	sum	EP?
1	Eudactylopus fasciatus "SP"	12	11	0	3	7	33	1
2	Eudactylopus andrewi	6	11	7	0	10	34	0
3	Dactylopusia tisboides	4	17	7	7	33	68	1
4	Diarthrodes ponticus	0	0	4	1	8	13	1
5	Diarthrodes sp. A	7	14	8	9	7	45	1
6	Diarthrodes sp. B	0	0	0	0	3	3	0
7	Scuttelidium sp. A	14	11	2	0	5	32	1
8	Scuttelidium sp. B	0	0	3	0	0	3	0
9	Tisbe sp. inc.	2	1	1	4	1	9	0
10	Porcellidium clavigerum	44	6	4	11	0	65	0
11	Porcellidium ovatum	4	4	0	9	6	23	1
12	Porcellidium viride	8	0	1	0	2	11	0
13	Porcellidium sp. D	0	4	5	4	4	17	0
14	Metis ignea	17	28	0	0	0	45	0
15	Diosaccus sp. inc.	3	0	0	2	0	5	0
16	Paramphiascopsis sp. inc.	3	0	2	0	0	5	0
17	Diosaccus hameltoni	0	2	26	0	2	30	0
18	Diosaccus monardi	0	4	7	0	0	11	0
19	Amphiascopsis sp.	0	1	0	0	0	1	1
20	Rynchalagena cf. littoralis	0	7	7	12	8	34	1
21	Diosacopsis sp. inc.	0	2	0	0	0	2	0
22	Robertsonia propinqua	0	0	2	0	0	2	0
23	Ancorabolidae gen. inc.	1	1	0	0	0	2	0
24	Laophonte sp.	0	2	3	1	0	6	1
25	Laophonte sp. B	0	3	0	1	1	5	0
26	Esola hirsuta	0	0	2	61	3	66	0
27	Nitocra affinis	9	5	0	0	4	18	1
28	Syngastes sp.	7	0	4	5	3	19	1
29	Harpacticus cf. obscurus	0	16	17	7	0	40	1
30	Harpacticus sp. B	0	2	0	0	0	2	0
31	Peltidium cf. maldivium	0	0	0	0	6	6	0
32	Paradactylopodia brevicornis	0	0	2	6	2	10	1
33	Paradactylopodia sp. inc.	0	0	0	1	0	1	0
34	Ectinosoma sp. inc.	0	0	5	5	13	23	1
35	Ectinosomatidae gen. inc.	0	0	0	0	4	4	0
36	Longipedia weberi	0	0	0	0	3	3	0
37	Cylindropsillidae gen. inc.	0	0	0	6	1	7	0
38	Tisbintra nankaurica	0	0	2	0	0	2	0
39	Lourinia cf. armata	0	0	0	1	0	1	0
40	Fam. inc.	0	1	0	0	0	1	0
41	Tisbidae gen. inc.	1	0	0	0	0	1	0
42	Peltidium sp. inc. cop.	0	1	9	0	0	10	0

	Species name	EP1	EP2	EP3	EP4	sum	Gazi?
1	Dactylopusia tisboides	21	40	14	7	82	1
2	Diarthrodes sp. A	13	1	0	0	14	1
3	Diarthrodes sp. B	0	7	11	0	18	1
4	Diarthrodes ponticus	16	13	14	3	46	1
5	Paradactylopodia brevicornis	6	19	4	2	31	1
6	Eudactylopus fasciatus "S"	0	1	2	0	3	1
7	Eudactylopus fasciatus "SP"	0	0	3	4	7	1
8	Ambunguipes rufocincta	1	0	0	0	1	0
9	Ambunguipes similis	0	1	0	0	1	0
10	Teissierella sp. inc.	3	6	2	8	19	0
11	Amphiascopsis sp.	9	3	0	0	12	1
12	Rynchotagena cf. littoralis	23	27	22	32	104	1
13	Amphiascus cf. parvus	0	0	12	0	12	0
14	Paraidya sp. inc.	0	2	9	0	11	0
15	Scuttelidium sp. A	4	2	8	4	18	1
16	Laophonte sp.	13	12	6	7	38	1
17	Heterolaophonte strömi	2	0	0	0	2	0
18	Paralaophonte sp. inc.	7	12	0	0	19	0
19	Esola longicauda	0	3	11	5	19	0
20	Esola sp. inc.	0	0	3	0	3	0
21	Laophontidae gen. inc.	0	0	2	0	2	0
22	Porcellidium clavigerum	0	0	1	0	1	1
23	Porcellidium ovatum	1	0	3	0	4	1
24	Syngastes sp.	1	0	0	0	1	1
25	Harpacticella sp. inc.	1	0	0	0	1	0
26	Harpacticus cf. obscurus	15	6	9	12	42	1
27	Nitocra affinis	7	0	9	16	32	1
28	Ectinosoma sp. inc.	16	0	9	0	25	1
29	Bradyellopsis sp. inc.	0	0	0	12	12	0

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                 568971234

18 Para sinc   --1------   000000
31 Pelt mald   ---3-----   000000
34 Ecte ginc   ---2-----   000000
35 Long webe   ---2-----   000000
36 Cyli ginc   --31-----   000000
38 Lour arma   --1------   000000
26 Esol hirs   --522----   000001
13 Porc sped   -2223----   000010
 8 Scut speb   ----2----   000011
16 Dios hame   -2-25----   000011
22 Robe prop   ----2----   000011
37 Tisb nank   ----2----   000011
28 Syng spec   3-3221---   00010
17 Dios mona   -2--3----   00011
41 Pelt sico   -1--3----   00011
 9 Tisb sinc   21211----   001000
15 Dios sinc   2-2------   001001
25 Laop speb   -211-----   001001
 2 Euda andr   34-43----   001010
10 Porc clav   534-2--1-   001010
12 Porc viri   3--21----   001010
14 Meti igne   45-------   001011
21 Dioc sinc   -2-------   001011
23 Anco ginc   11-------   001011
30 Harp speb   -2-------   001011
39 Fami ince   -1-------   001011
40 Tisb ginc   1--------   001011
 5 Diar spea   3433341--   0011
11 Porc ovat   2233-1-2-   0011
 1 Euda fasc   4423--132   010
 7 Scut spea   4423-2232   010
33 Ecti spec   --3434-3-   011
 3 Dact tisb   243535543   1000
27 Nito affi   33-2-3-34   1001
29 Harp obsc   -43-44334   1001
20 Rync lito   -34335555   101
32 Para brev   --3223422   101
 4 Diar pont   --1324442   110
24 Laop spec   -21-24433   110
52 Brad sinc   --------4   11100
44 Teis sinc   -----2323   11101
49 Esol long   ------243   11101
19 Amph spec   -1---32--   111100
42 Ambu simi   ------1--   111100
43 Ambu rufo   -----1---   111100
47 Hete stro   -----2---   111100
48 Parl sinc   -----34--   111100
51 Hart sinc   -----1---   111100
45 Amph parv   -------4-   111101
46 Pard sinc   ------23-   111101
50 Laop ginc   -------2-   111101
53 Esol sinc   -------2-   111101
 6 Diar speb   ---2--34-   11111

                 000001111
                 001110001
                   001001
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Visit to K.M.F.R.I., Mombasa

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Aims: A. Preliminary research "Comparative physiological ecology of the oyster *Crassostrea cucullata* "
B. Commercial Oyster Culture - Kenya: Financial Analysis

A. Preliminary research "Comparative physiological ecology of the oyster *Crassostrea cucullata* "

The oyster *Crassostrea cucullata* is a suspension feeder. Three methods have been commonly used to study particle filtration by bivalves.

The first method involves channeling water into and from shell cavities with devices which collect all water flowing through the gills. This method has been criticized because oysters may not behave normally when subjected to the stress of the collecting device.

The second method involves measurements of rates at which undisturbed bivalves clear particles in standing water. Objections to studies in standing water are that previously filtered material may be resuspended and refiltered (recycled) and also that particle concentrations will change with time.

The third method makes use of chambers of flowing water. This method makes it possible to measure differences in numbers of particles, amounts of Particulate Organic Carbon (P.O.C.), and amounts of chlorophyll

entering and leaving the system. Differences are attributed to filtration by the animals. Water flowed continuously over the oysters under conditions approaching those of the natural environment. This also served to avoid recycling.

In the study "Comparative physiological ecology of the oyster *Crassostrea cucullata* " we will make use of the third method. The main purpose during our visit to Mombasa was testing this method making use of the chambers we were using in a similar study ""Comparative physiological ecology of the oysters *Crassostrea gigas* and *Ostrea edulis* "

The experiments were conducted at the K.M.F.R.I. (Kenya Marine and Fisheries Research Institute) - Mombasa, Kenya. Water for all studies was pumped from a source 0,5 m above the bottom, in the Tudor Creek, to a constantly overflowing overhead trough in the laboratory. Water flow was ± 1 l/min (in each chamber).

Several difficulties arose during the experiments:

- The small amounts of P.O.C. and chlorophyll in the water made it very difficult to measure the differences between the inflow and the outflow of P.O.C. and chlorophyll.
- The silicone used became mouldy after a period of six days.

At the moment we are building new chambers. The new chambers will allow us to measure P.O.C., chlorophyll, and other variables more exactly. These chambers will be finished in the early part of the year 1992.

B. Commercial Oyster Culture - Kenya: Financial Analysis

You can find the results of this study in the annex

COMMERCIAL OYSTER CULTURE - KENYA: FINANCIAL ANALYSIS

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Summary and conclusion

Collecting big oysters of the species *Crassostrea cucullata* at the current rate will lead to the overexploitation of this species in Kenya. Moreover, the method which local gatherers use to collect the oysters results in damage to the mangrove trees.

A commercial oyster culture would solve both problems and financially it seems to be an interesting investment.

There would be an internal rate of return of 22,8% on a yearly basis. The Benefit-Cost ratio is 1,69. This means that costs can rise by 69%. The Net Present Worth is 51,750,000 KES after 25 years (investment: 10,041,000 KES).

A. Introduction

Six years ago the Kenyan Government requested the Belgian Government's collaboration in the field of Marine Sciences. The Free University of Brussels and the Laboratory of Ecology and Systematics under the direction of Prof. Dr. P. Polk in particular, accepted the challenge. After 6 years it has become obvious that this collaboration has borne fruit and continues to generate useful results.

In the past several projects like the Kenyan Belgian Project in Marine Sciences failed because the linkage between research, education and equipment was lacking. What can a specialist do without facilities? What use is equipment without expertise and teaching? The importance of the simultaneous development of these three components cannot be overestimated. The teaming-up of Kenyan and Belgian experts was a guarantee for the scientific value of the work.

Originally the project was a collaboration between the K.M.F.R.I. (Kenyan Marine and Fisheries Research Institute) and the Free University of Brussels. In the meanwhile, experts of the universities of Ghent, Antwerp, Limburg, Leuven and Liège became involved. The Institute for Marine Sciences (IZWO) is collaborating for Scientific Literature Search. Kenyan Scientists got specialized training in different universities and institutes in Belgium. Belgian experts and students carried out research in Kenya. The exchange of information, know-how and experience proved to be very successful.

The EEC Research Project "Dynamics and Assessment of Kenyan Mangrove Ecosystems" has integrated the famous Delta Institute (The Netherlands), the University of Nijmegen (The Netherlands), Kenyatta University (Kenya) and Nairobi University (Kenya) into the existing group.

The Kenyan Belgian Cooperation in Marine Sciences, which started as an agreement between the Kenyan and Belgian Governments, continued to extend its contacts. Donors now include the Belgian National Science Foundation, the Flemish Interuniversity Council, the European Economic Community, IOC-UNESCO and UNEP.

The documentation centre of the project has in the meantime developed into an independent offshoot of the project, known as the IOC-UNESCO-RECOSCIX project (director: P. Pissiersens).

While fundamental research is developing at an accelerated speed, applied research can give practical results immediately and throughout the next decade.

In 1986, the director of the Kenyan Belgian Cooperation in Marine Sciences was asked by the Minister for Development Cooperation to initiate scientific activities which might result in profit; up to then the activities had been purely scientific.

Kenyan officials view commercial oyster culture favourably because the Kenyans are obviously keen to participate in ventures which generate funds and create employment.

A commercial oyster culture would also conserve the mangrove ecosystem in the short term and benefit the whole of the marine ecosystem in the long term.

B. Kenya Today

Government and Economy

President Daniel arap Moi holds executive power assisted by a Vice President and Cabinet chosen from the legislature, the National Assembly. This body consists of 158 members elected by universal suffrage, 12 Presidential nominees, the Speaker and the Attorney-General. The Assembly's term is for five years unless it is dissolved by the President or its own majority "no confidence" vote.

The process of government in Kenya is essentially democratic, but there is only one political party, the Kenya African National Union (KANU).

Kenya is an independent republic, a member of the Organisation of African Unity (OAU), the Commonwealth and the United Nations.

The country's record of stability and sound government, as well as its development performance since Independence in 1963, have placed it among the most prosperous nations in Black Africa. It is a major recipient in Africa of international development aid.

On its own account, Kenya is among the world's leading exporters of quality coffee, teas, and pineapples. Other primary exports are horticultural produce, pyrethrum, sisal and other cash crops. Tourism is an important source of foreign revenue, with further substantial income resulting from Kenya's position as the regional center for communication, insurance and general commerce.

Geography

Kenya is an independent republic with an area of 582,644 sq km, including approximately 13,600 sq km of inland water. It is bounded in the north by the deserts of Somalia, Ethiopia and the Sudan; to the east by Somalia and the Indian Ocean; and to the south and west by Tanzania and Uganda.

The country is roughly bisected by the equator, extending as it dies between latitudes five degrees north and 4.40 degrees south. Mean longitude is 40 degrees east, which is three hours ahead of GMT.

Broadly, the country may be divided into four main physiographic regions:

- *The Rift Valley and Central Highlands:*
  Fertile, mountainous, lake-studded, and the most developed region economically and in terms of human settlement.

- *Western Kenya:*
  Low plateau farmland east of Lake Victoria.

- *Northern and Eastern Kenya:*
  A vast T-shaped expanse of country from west of Lake Turkana (Rudolf) across the north to the Somalia border and to the Tanzania border in the south. This is mainly semi-arid rangeland for nomadic pastoralists and wildlife.

- *The Coastal Belt:*
  480 km of Indian Ocean littoral, including coral reefs, beaches, mangroves, and a narrow fertile strip where sub-tropical agriculture is practiced and which gives way to bush and semi-desert.

Climate

With an altitude that ranges from sea level to 5,200 m, the temperature, rainfall, and humidity variations are extreme.

In relation to the four physiographic zones, the climate and land-types can be characterized as follows:

- *The Rift Valley and Central Highlands:*
  This highland region of Kenya generally experiences invigorating, fairly cool conditions, rather like a Swiss summer. The climate ranges from temperate in the Central Rift Valley to arctic on the Mount Kenya peaks.

The land here is the most productive in Kenya. In the uplands, between 1,500 - 2,000 m, the greater part of Kenya's agricultural output is produced. In the Rift itself, production is mixed - crops, dairy and livestock.
The central massif of Mt. Kenya and the high Aberdares form the country's main water catchment area, with rainfall of up to 3,000 mm per year on the mountains, producing run-offs to the main Rift lakes.

- *Western Kenya:*
  Hot, moist, with the rains spread fairly evenly through the year. Most of the rain falls in the early evening.

- *Northern and Eastern Kenya*
  The land ranges from lava desert around Lake Turkana (Rudolf), where west of the lake rainfall averages below 225 mm per year and temperatures rise to 39°C; through sand desert at the Chalbi in the north, arid bush supporting pastoral activities, vast dry grass and acacia rangeland, down to the soda lake of Magadi in the south, where again temperatures can be as high as 38°C.

- *The Coastal Belt:*
  The coral beaches are hot with about 70° humidity but tempered by breezes. Then comes a narrow coastal plain, suitable for agriculture (fruits, nuts, cotton, dairy) but this soon gives way to thorn scrub and semi-desert.

C. Location of the oyster culture

Geography

480 km of Indian Ocean littoral, including coral reefs, beaches and mangroves, and a narrow fertile strip where sub-tropical agriculture is practiced.

Kenya possesses 22 extensive mangrove creeks, with a total surface area of 52,000 hectares.

Climate

The coral beaches are hot with about 70° humidity but tempered by breezes. Then comes a narrow coastal plain, suitable for agriculture (fruits, nuts, cotton, dairy) but this soon gives way to thorn scrub and semi-desert.

The climate of Mombasa can be considered to be representative:

- Altitude: 17 m
- Rainfall: Average minimum 20 mm (February) to maximum 240 mm (May) average annual 1,000 - 1,250 mm
- Sunshine: Averaging a maximum of nine hours per day in March and a minimum of seven hours in May
- Temperature: Mean annual minimum: 22° C
  Mean annual maximum: 30° C.

Location

The oyster culture will be spread out along the whole length of the Kenyan coast (in different mangrove creeks). Thus we are able to minimize the risks (oil pollution, bacterial pollution, etc...) and the distances between oyster culture and consumer.

D. Oyster Culture

The mangrove oyster *Crassostrea cucullata*

The scientific name of the oyster is *Crassostrea cucullata.* This species is extremely abundant in the mangrove creeks present in the Kenyan coastal area, where it grows on the extensive air-roots of the mangrove trees. They live so closely together, however, competing for space and food, that the majority never reach the size necessary for human consumption. In fact, most of these oysters are only 2 to 4 centimeters in size.

As far as taste and appearance are concerned, the Kenyan oyster compares favourably with its European counterpart; a rich creamy yellow color and a stronger flavour are characteristic features.

Present situation

About 40,000 oysters are , presently, being cultured in Gazi, 48 kilometers away from Mombasa.

Gazi is linked to Mombasa by an asphalt road in good condition. There is a river to be crossed by pontoon, however, making it a trip of approximatively one hour by motor vehicle.

The village of Gazi lies next to the road and about two km from the mangrove creek where the experimental oyster plot is located. The path leading to the site necessitates a four-wheel drive vehicle.

The villagers and the village headman are very enthusiastic about the culture; they were hired and paid to collect the wild oysters, erect, clean and maintain the racks, etc... As a consequence, they look after the site to protect their interest in it.

Local and international Market

The local market:

Kenya has a well developed tourist industry; a number of high-class restaurants are found in and around the touristic cities (Nairobi, Mombasa).
Several restaurants in Mombasa and Nairobi presently serve fresh oysters on ice. While still smaller than the European variety, these oysters reach the size that can be attained after two to three years of culturing.
At present, the restaurants buy the oysters from local gatherers who search extensive areas to find such big specimens. The method which local gatherers use to collect the oysters results in damage to the mangrove trees.
Collecting big oysters in the wild is leading to the virtually complete removal of these specimens. This is followed by a substantial increase in price, since more extensive areas will have to be searched. In these conditions, moreover, the restaurants cannot be guaranteed freshness. At the moment restaurant owners pay 1 to 2 KES for each oyster, but this includes a majority of smaller specimens. Moreover, some refuse is always present. Tamarind restaurant (one of the biggest restaurants in Mombasa) is willing to pay 6 KES/oyster (400,000/year ; starting in 1995).
The sale of cultured oysters to Kenyan restaurants will generate local and foreign currency.

The International Market:

Kenyan oysters can be exported to generate foreign currency:

- the price of the Kenyan cultured oysters is far below that of the European ones.
- there exists an excellent transportation network linking Mombasa to the rest of the world.

It is difficult to predict at this stage which countries would be the best targets for export. Many restaurants in Europe are interested to serve Kenyan oysters as a speciality. The sizeable expatriate

communities in other African countries and in the Middle East could also be targeted.

Land Use

90% of the tidal area of the mangroves is property of the Kenyan Government. It would be possible to rent this area for a period of 99 years. Because the project will generate foreign currency while at the same time protecting the mangrove ecosystem, the rent would be a nominal amount.

Social aspects

The implantation of the oyster culture does not affect other activities of the local population.

As far as possible, personnel will be hired and material bought in the villages in the immediate proximity of the oyster culture. As a consequence, the local population will look after the site to protect their interest in it.

Development of the oyster culture

Prior to initiating business operations in Kenya, we need to obtain a number of approvals and registrations, some general and others applying to specific activities only. To expedite the processing of these applications, we will make use of the services of the Investment Facilitation Committee at the Investment Promotion Centre (IPC). The Centre assists investors by helping them to complete an "Investment Proposal Form" that contains nearly all the information required, thus transforming the investment application procedures into a "one-step" process.

We will entrust the development of the oyster culture to a specialized firm for a period of three years. This firm will also be responsible for the education of the local personnel and of a future local manager, the delivery of the necessary know-how and the creation of a national and international distribution network. The advantage of involving a specialized firm is the low cost compared with the wages of several expatriate experts. This firm is called "the expert" in the financial analysis below.

Export Processing Zone Incentives (Kenya)

- duty and VAT exemption on imported machinery, equipment, tools, spare parts and raw materials
- 10 years tax holiday and thereafter a flat tax rate of 25% on profits for the next 10 years
- no withholding tax on dividends
- exemption from exchange control
- operations in foreign currencies permitted
- 100% foreign ownership permitted
- exemption from VAT on locally procured goods
- one single licence for all manufacturing activities
- competitive lease/rental fee
- available infrastructure and utilities at cost

Number of oysters

Two hundred racks will be built every year. Those racks can carry 720,000 oysters.

Financing

The financing of the oyster culture will involve three major groups of investors

1. private investors inside Kenya
2. private investors outside Kenya
3. institutes and organisations inside and outside Kenya

E. Financial analysis

Costs

a) Investments

10 041 000 KES.

Personnel, transportation, material needed for the racks, maintenance, expert, accounting and administration (more detailed figures in the cost-benefit analysis).

b) Operation and maintenance costs

Those costs increase every year (more racks).

Benefits

Every year 200 racks will be built, with a total capacity of 720,000 oysters. The selling price of the oyster is based on prices offered in

1991 for oysters delivered in 1995 (more detailed figures in the cost-benefit analysis).

Cost-benefit analysis

Definitions:

Present worth:

If someone is earning 1,000 $/year for a period of five years, the last 1,000 $ has not the same value as the first 1,000 $.
The process of finding the present worth of a future value is called "discounting". The interest rate assumed for discounting is the "discount rate". The interest rate used for compounding assumes a viewpoint from here to the future, whereas discounting looks backward from the future to the present.
Generally the discount rate is a number between 8% and 12%. We will base our cost-benefit analysis on a figure of 12% (a worst-case assumption).

Benefit-Cost Ratio

This is the ratio obtained when the present worth of the benefit stream is divided by the present worth of the cost stream.
If the benefit-cost ratio is less than 1, then the present worth of the costs at this discount rate exceeds the present worth of the benefits, and we will not recover our initial expenditure plus the return on our investment from the project.
Note that the absolute value of the benefit-cost ratio will vary depending on the interest rate chosen. The higher the interest rate, the lower the resultant benefit-cost ratio, and, if a high enough rate is chosen, the benefit-cost ratio will end up below 1.
One convenient aspect of the benefit-cost ratio is that it can be used directly to find out by how much costs could rise without making the

project economically unattractive. E.g., a Benefit-Cost Ratio = 1.69 means that costs can rise by 69% before the benefit-cost ratio would reach the critical value of 1.
In practice, it is common to compare the present worth of the net benefit with the present worth of the investment cost plus the operation and maintenance costs.

Net Present Worth:

The most straightforward discounted cash flow measure of project worth is the net present worth (often abbreviated as NPW). This is simply the present worth of the incremental net benefit or incremental cash flow stream. The net present worth may also be computed by finding the difference between the present worth of the benefit stream less the present worth of the cost stream.
A project is financially interesting when the NPW is positive.

Internal Rate of Return:

This is the discount rate that makes the net present worth of the incremental net benefit stream or incremental cash flow equal zero. This discount rate is called the internal rate of return. It is the maximum interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even. It is the "rate of return on capital outstanding per period while it is invested in the project".
The internal rate of return is a very useful measure of project worth. It is the measure the World Bank uses for practically all its economic and financial analyses of projects and the measure used by most other international financing agencies.

Cost-Benefit Analysis (x 1,000 KES)

Remark: During the period of investment we increased the costs with 10% on a yearly basis. During the period with a positive cash flow we did not increase the costs. Here the increase of the costs would be followed by an increase of the benefits.

Cost-Benefit analysis (x 1,000 KES)

Year	Total number of racks	Total number of oysters	Total number of personnel	Labour (1)	Material Racks	Transport	Expert
1	400	0	9	230	624	400	2000
2	600	0	6	170	340	100	1760
3	800	0	8	240	373	110	1400
4	1000	720000	10	310	410	121	600
5	1200	720000	12	380	410	121	600
6	1400	1440000	14	450	410	121	600
7	1600	1440000	16	520	410	121	600
8	1800	2160000	18	590	410	121	600
9	2000	2160000	20	660	410	121	600
10	2200	2880000	22	730	410	121	600
11	2400	2880000	24	800	410	121	600
12	2600	3600000	26	870	410	121	600
13	2800	3600000	28	940	410	121	600
14	3000	4320000	30	1010	410	121	600
15	3200	4320000	32	1080	410	121	600
16	3400	5040000	34	1150	410	121	600
17	3600	5040000	36	1220	410	121	600
18	3800	5760000	38	1290	410	121	600
19	4000	5760000	40	1360	410	121	600
20	4200	6480000	42	1430	410	121	600
21	4400	6480000	44	1500	410	121	600
22	4600	7200000	46	1570	410	121	600
23	4800	7200000	48	1640	410	121	600
24	5000	7920000	50	1710	410	121	600
25	5200	7920000	52	1780	410	121	600

(1) 2500 KSh/month gross

Cost-Benefit analysis (x 1,000 KES)

Year	Maintenance	Accounting-administration	Total costs	Total benefits	Cash-flow	Net benefit* (Cash-flow - taxes)
1	0	600	3854	0	- 3854	- 3854
2	0	660	3030	0	- 3030	- 3030
3	308	726	3157	0	- 3157	- 3157
4	462	798	2701	4320	1619	1619
5	616	798	2925	4320	1395	1395
6	770	798	3149	8640	5491	5491
7	924	798	3373	8640	5267	5267
8	1078	798	3597	12960	9363	9363
9	1232	798	3821	12960	9139	9139
10	1386	798	4045	17280	13235	13235
11	1540	798	4269	17280	13011	10409
12	1694	798	4493	21600	17107	13685
13	1848	798	4717	21600	16883	13506
14	2002	798	4941	25920	20979	16783
15	2156	798	5165	25920	20755	16604
16	2310	798	5389	30240	24851	19880
17	2464	798	5613	30240	24627	19701
18	2618	798	5837	34560	28723	22978
19	2772	798	6061	34560	28499	22799
20	2926	798	6285	38880	32595	26076
21	3080	798	6509	38880	32371	25896
22	3234	798	6733	43200	36467	29173
23	3388	798	6957	43200	36243	28994
24	3542	798	7181	47520	40339	32271
25	3696	798	7405	47520	40115	32092
TOTAL			**121207**	**570240**	**449033**	**366315**

* From the tenth year, taxes have to be paid

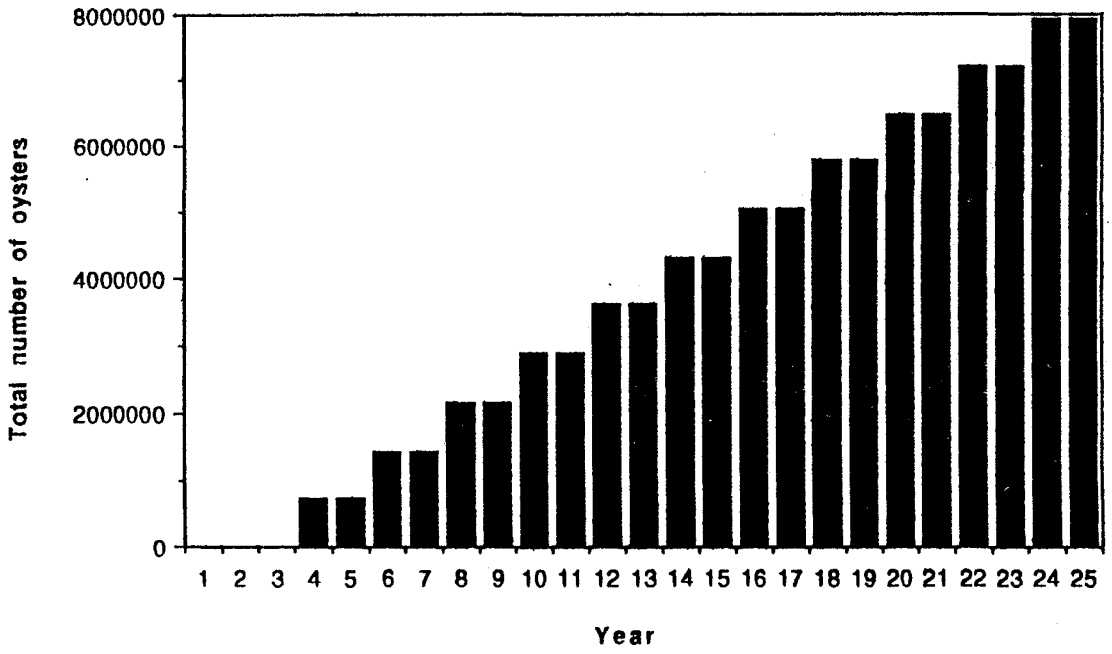
Cost-Benefit analysis (x 1,000 KES)

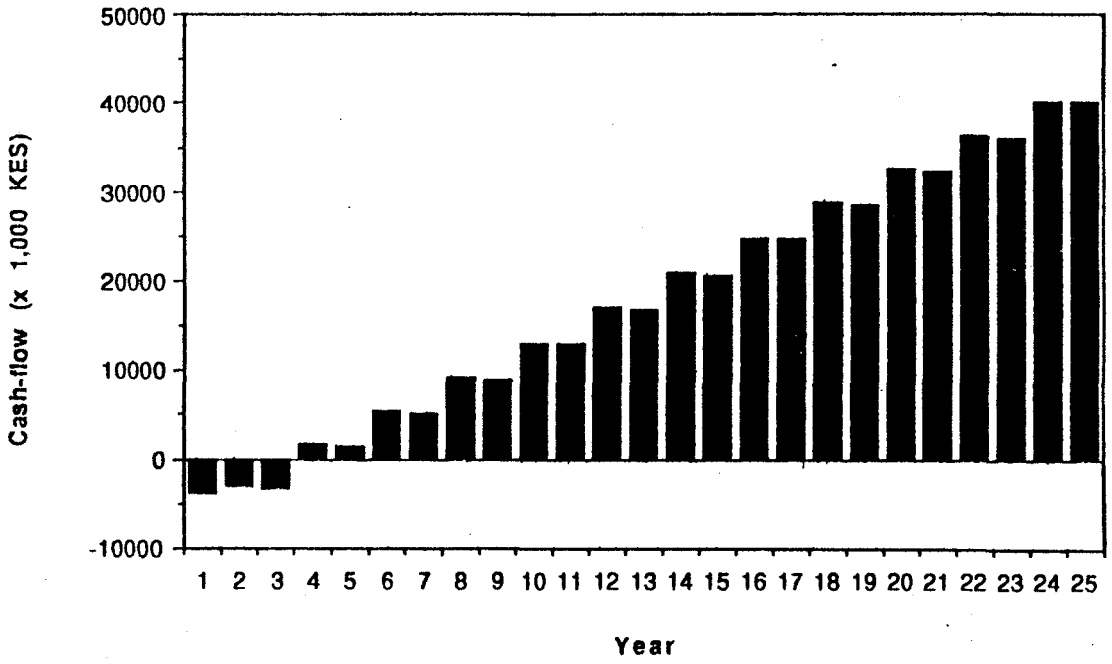
Year	Discount rate (12%)	Cost discounted	Benefits disc.	Cash-flow disc.	Net benefit disc.
1	0.893	3441	0	- 3441	- 3441
2	0.797	2414	0	- 2414	- 2414
3	0.712	2247	0	- 2247	- 2247
4	0.636	1717	2747	1029	1029
5	0.567	1658	2449	790	790
6	0.507	1596	4380	2783	2783
7	0.452	1524	3905	2380	2380
8	0.404	1453	5235	3782	3782
9	0.361	1379	4678	3299	3299
10	0.322	1302	5564	4261	4261
11	0.287	1225	4959	3734	2987
12	0.257	1154	5551	4396	3517
13	0.229	1080	4946	3866	3092
14	0.205	1012	5313	4300	3440
15	0.183	945	4743	3798	3038
16	0.163	878	4929	4050	3240
17	0.146	819	4415	3595	2876
18	0.130	758	4492	3733	2987
19	0.116	703	4008	3305	2644
20	0.104	653	4043	3389	2711
21	0.093	605	3615	3010	2408
22	0.083	558	3585	3026	2421
23	0.074	514	3196	2681	2145
24	0.066	473	3136	2662	2129
25	0.059	436	2803	2366	1893
TOTAL		**30544**	**92692**	**62133**	**51750**

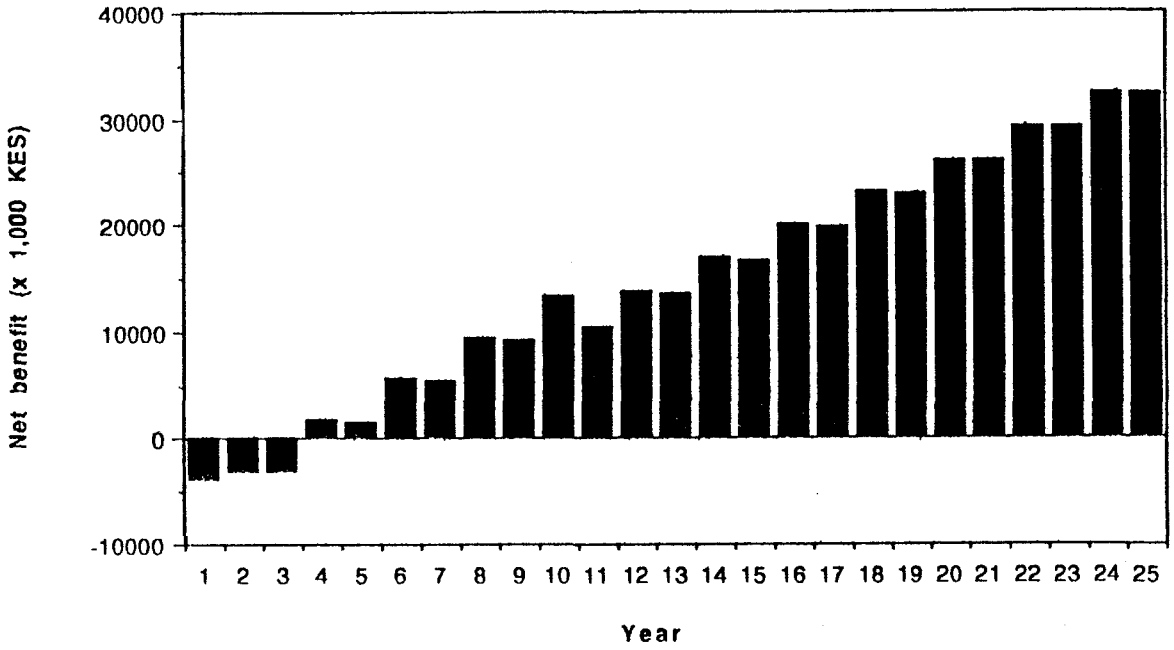
Results Cost-Benefit analysis:

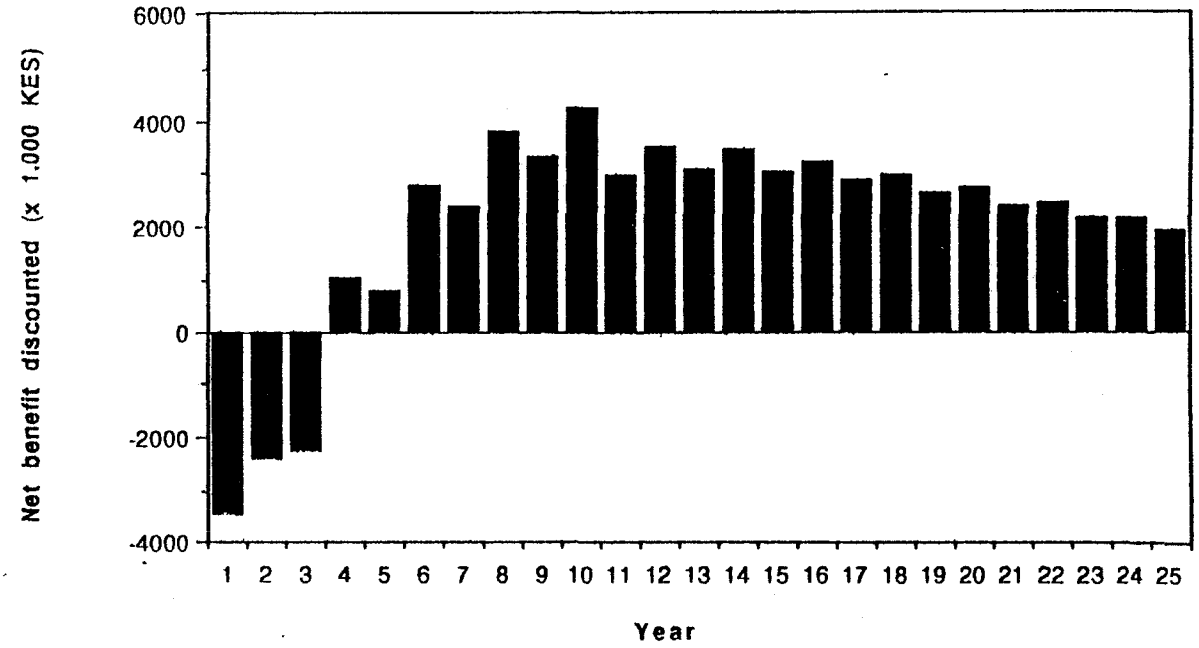
Net Present Worth (NPW): 51 750 000 KES
Internal Rate of Return: 22,8%
Benefit-Cost Ratio: 1,69

Enclosure: Graphs Cost-Benefit analysis






Net benefit (x 1,000 KES)
40000
30000
20000
10000
0
-10000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Year


Net benefit discounted (x 1,000 KES)
6000
4000
2000
0
-2000
-4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Year

PROJECT PROGRESS REPORT

NAME: JOSECK, DAVID MWANIKI

UNIVERSITY OF NAIROBI

CLASS: BSC. III

PROJECT: RELATIONSHIP BETWEEN SHELL LENGTH AND LIVE BIOMASS OF MANGROVE OYSTER, CRASSOSTREA CUCULLATA

From 21st to 27th November,1990, I carried out the preliminary part of the above project which involves determination of the relationship between shell length and live biomass of mangrove oyster Crassostrea cucullata Born (Bivalvia). The project which is being supervised by Dr. E. Vanden Berghe, is a part of my undergratuate Bachelor of Science degree course. Within those seven days in the field, I managed to carry out the following:-

1. Determination of sampling stations in Gazi Bay mangrove forest area which is my data collection area.

2. Determination of the method to use in determining the height above datum level along the sampling stations. I found that the best method to use is the bottle top method which involves fixing bottle tops on a mangrove stem at close heights and recording the time the tide reaches at a particular height. From this, the height above datum can easily be calculated.

3. Determination of mangrove species on which the oysters grow. The biggest oysters generally grow on Rhizophrora mucronata which is the commonest mangrove species on the zone of optimal oyster growth. However, I also managed to identify the other mangrove species.

4. I also familiarised myself with the various aspects of the parameters I intend to measure when I collect the sample. These parameters include:

a) The mangrove species on which the oysters grow

b) The height of oyster growth above ground. Optimum growth of the oysters occur at heights of about 20cm to 80cm above ground.

c) The diameter of the substrate (mangrove stem or branch) on which the oysters are growing.

d) The orientation of the oysters in relation to the direction of wave approach (either parallel or perpedicular).

5. I also collected and tested the first pilot sample. I managed to collect 130 oysters, measured their shell length and wet and dry biomass. However, when I computed the data, there was insignificant relationship between shell length and live biomass. This could have resulted from collecting the oysters at a low height (<20 cm above ground). I intend to rectify this in my second sample. I also intend to measure the weights of shells in my second sample and relate it to the shell length and/or biomass.

TITLE

ASPECTS OF ECOMORPHOLOGY OF THE MANGROVE OYSTER, CRASSOSTREA CUCULLATA, BORN (BIVALVIA)

BY

JOSECK, DAVID MWANIKI

UNIVERSITY OF NAIROBI

ZOOLOGY DEPARTMENT

A dissertation presented in partial fulfilment for an award for the degree of Bachelor of Science (B.Sc.).

MAY 1991

ABSTRACT

The East African oyster, Crassostrea cucullata Born (Bivalvia) is a sedentary mollusc which grows in the wild on trunks, roots and pneumatophores and rocky substrata in brackish water environments that dot the Kenya coast. This oyster is a potential protein source which is generally underexploited. Its protein content is far superior to that of any red meat or even fish (Polk, 1985-86).This work was primarily done in order to determine the relationship between shell length and live biomass of this littoral oyster. However, shell length is also correlated with height above bottom, diameter of substrate on which the oyster is growing, shell weight and orientation of the oyster. The height of the growing oyster above bottom, the diameter of the substrate on which the oyster is growing, and the orientation of the oyster in relation to tidal current direction (either parallel or perpendicular) are regarded as environmental factors. The shell length has a positive correlation with the biomass. The shell length versus diameter of substrate and shell weight also shows a significant positive correlation. No correlation was found between shell length and height above bottom on the one hand or orientation on the other. For the shell length versus biomass the correlation coefficient was 0.26. The correlation between shell length and diameter of substrate was also 0.26.

5. OTHER ACTIVITIES

The project is actively participating in the organization of an International symposium and workshop " Status and future of Large Marine Ecosystems (LME) of the Indian Ocean.

The project has also been further involved in the start, although on a very small scale of a commercial oyster farming at Gazi: different new racks have been build and the oysters are settling naturally on the substrata. It is planned to start a large scale oyster farm in the very near future (see report J.Tack)

The set up of an aquaculture section is aimed. At present fish are being raised in the fish ponds of the Institute (see report on aquaculture). One of the researchers is seriously interested in doing research on prawn culturing.

6. CONCLUSION

The research is proceeding very well. The sampling are being done on a regular basis and the necessary analyzing equipment is available.
When overviewing the research results from the past year, one can note some important achievements.
The results from the research on the Mangrove ecosystem in Gazi allowed one to obtain a better understanding of some important ecological compartments: Mangrove trees, phytoplankton, zooplankton, fish, bacteria and nutrients. Data are available on mangrove biomass levels, biomass increments, litterfall, littercomposition and litterdecomposition. Within the pelagic creek ecosystem, information has been obtained on community composition and species diversity for zooplankton, phytoplankton and fish. Biomass levels and/or activities of the pelagic compartments (phytoplankton, zooplankton, fish, bacteria) were evaluated over a one year cycle and compared to the environmental abiotic factors (temperature, salinity, oxygen, nutrients) simultaneously measured. The benthic community at Gazi was also studied ; data are available on the distribution and cover of benthic algae and on the abundance and diversity of marine Harbacticoids. More results on zoobenthos will be available soon in the frame of a Masters' thesis at the State University of Ghent. Although it is too early for a synthesis of the ecological functioning of the Kenyan Mangrove ecosystem, it seems obvious that at least part of the ecological puzzle is being unravelled.

The results on the diversity and cover of marine algae and corals along the Kenyan coast are very important from a conservation and economic viewpoint. More data on coral species diversity, growth and age will be available soon, in the frame of a Masters' thesis for the FAME course.
The assessment of the pollution impact in the area around Mombasa has started; the first basic data on landbased pollution sources and loads have been compiled. A set of data on degradable organic materials and microbial pollution, is available for Tudor creek, covering a one years cycle. These and other environmental parameters (Temperature, pH, Oxygen, POC, ...) have been, or will be measured soon, in the creeks around Mombasa and in the Mombasa coastal area.
The positive evolution of the projects (VLIR and EEC) is furthermore being reflected in the increasing number of organizations and researchers visiting the projects at the Kenya Marine and Fisheries Research Institute.

7.APPENDIX

List of main addresses :

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Fax : 32/2.641.34.03