

# KENYA MARINE AND FISHERIES RESEARCH INSTITUTE



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2010/2011 SCIENTIFIC ANNUAL REPORT

# **Table of Contents**

PREAMBLE	. V
SCIENTISTS IN THE MARINE AND COASTAL DIVISION	VI

# 

Programme overview	8
PROJECT 1: MALINDI-UNGWANA-BAY; STATUS OF THE FISHERY	9
PROJECT 2: ARTISANAL FISHERIES CATCH ASSESSMENT ALONG THE KENYA COAST	11
Project 3: Incorporating reef fish spawning aggregations into optimal designs for no- fishery reserves: Strengthening fisheries management and coral reef resilience in Western Indian Ocean	-take 1 the 13
PROJECT 4: REPRODUCTIVE BIOLOGY OF SIGANUS SUTOR IN KENYA (WP1 MASMA PROJECT)	15
PROJECT 5: NATURAL GEOGRAPHY OF INSHORE AREAS, NAGISA	16
PROJECT 6: THE MARINE ORNAMENTAL AND CURIO TRADES IN THE WESTERN INDIAN OCEAN – BE OR THREAT?	NEFIT
PROJECT 7: ORNAMENTAL CORAL CULTURE PROJECT	21

# 

PROGRAMME OVERVIEW
PROJECT 1: DEVELOPMENT OF A CATFISH AND TILAPIA SEED PRODUCTION CAPACITY AT THE MOMBASA STATION TO SUPPLY FINGERLINGS TO THE COASTAL FARMERS
PROJECT 2: POPULATION DYNAMICS AND SMALL-SCALE AQUACULTURE OF MUD CRAB (SCYLLA SERRATA) IN EAST AFRICA
PROJECT 3: OPTIMIZATION OF MILKFISH GROWTH TRIALS AT MAKONGENI-GAZI BAY AND MAJAONI- MTWAPA CREEK
PROJECT 4: SILVOFISHERIES TRAINING FOR GAZI BAY COMMUNITIES
PROJECT 5 : EXTENSION SERVICES
PROJECT 6: ENHANCING FOOD SECURITY AMONG COASTAL FISHER COMMUNITIES: PROMOTING SMALL SCALE MARICULTURE TECHNOLOGIES ALONG THE KILIFI CREEK
PROJECT 7: FEED PRODUCTION
PROJECT 8: DEVELOPMENT OF A SEAWEED NURSERY FOR KAPPAPHYCUS ALVAREZI (COTTONII) AND EUCHEUMA DENTICULATUM (SPINOSUM) IN THE SOUTH COAST OF KENYA

PROJECT 9: ORNAMENTAL FISH PRODUCTION
PROJECT 10: EVALUATION OF SHRIMP FARMING AT NGOMENI AND MARICULTURE ACTIVITIES IN SHIMONI KMFRI PLOT
PROJECT 11: DEVELOPMENT OF "AN IDENTIFICATION MANUAL OF FISH LARVAE OFF THE KENYAN COAST"
PROJECT 12: A MOLECULAR CONSIDERATION OF WESTERN INDIAN OCEAN MARINE FISH CONNECTIVITY AND REGIONAL DIFFERENTIATION AT MULTIPLE SPATIAL AND TEMPORAL SCALES AND ITS IMPLICATIONS FOR CONSERVATION AND RESOURCE MANAGEMENT
PROJECT 13: IMPROVEMENT OF THE LIVING STANDARD OF RURAL COMMUNITIES IN KENYA THROUGH ARTEMIA PRODUCTION IN COASTAL SALTWORKS"

### WORK PACKAGE 3: DEVELOPING TECHNIQUES FOR REDUCING POST-HARVEST LOSSES

PROGRAMME OVERVIEW
PROJECT 1: COMMUNITY INVOLVEMENT IN PRODUCTION AND MARKETING OF VALUE ADDED FISH PRODUCTS
PROJECT 2: "REDUCING POST HARVEST LOSSES BY 10%: PREDICTIVE MODEL FOR POST-HARVEST LOSSES EVALUATION
PROJECT 3: SOLAR DRYING TECHNOLOGY FOR FISH DRYING IN THE TANA DELTA REGION
PROJECT 4: A HYBRID SOLAR-WINDMILL DRYER FOR FISH DRYING IN KIPINI

PROGRAMME OVERVIEW
PROJECT 1: SMALL-SCALE, COMMUNITY-BASED, GROW-OUT AQUACULTURES OF MUD CRABS <i>SCYLLA</i> SERRATA AS A SUSTAINABLE LIVELIHOOD IN EAST AFRICA
PROJECT 2: GLOBAL MARKETS AND THE LIVELIHOODS OF COASTAL COMMUNITIES IN THE WIO COUNTRIES: IMPLICATIONS FOR SUSTAINABLE COASTAL MANAGEMENT
PROJECT 3: THE PROBLEM OF SHORELINE CHANGES IN KENYA, THEIR SOCIOECONOMIC IMPACTS AND MITIGATION OPTIONS
PROJECT 4: AN ASSESSMENT OF THE SOCIOECONOMIC IMPACTS OF ENVIRONMENTAL DEGRADATION RELATED TO CLIMATE CHANGE IN FAZA ISLAND, LAMU DISTRICT – KENYA70
PROJECT 5: THE SOCIAL AND ECONOMIC DIMENSIONS OF THE MALINDI UNGWANA BAY FISHERY74

# WORK PACKAGE 5: UNDERTAKE BIOPHYSICAL STUDIES IN RELATION TO FISHERIES ...76

PROGRAMME OVERVIEW
PROJECT 1: THE KENYA COASTAL DEVELOPMENT PROJECT
PROJECT 2: RECEPTOR BINDING ASSAY FOR HARMFUL ALGAL TOXINS
PROJECT 3: BIOCHEMICAL EFFECTS OF SEWAGE, A STORY FROM THE FISH SIDE
PROJECT 4: THE ROLE OF WATER RESERVOIRS IN CARBON CYCLING AND BIOGEOCHEMICAL FUNCTIONING OF TROPICAL RIVERS: CASE STUDY OF RIVER TANA, KENYA
PROJECT 5: DISTRIBUTION OF PATHOGENIC VIBRIO CHOLERAE STRAINS IN AQUATIC ENVIRONMENTS IN COASTAL AREAS OF EAST AFRICA: IMPLICATION TO CHOLERA OUTBREAKS AND CONTROL
PROJECT 6: DEVELOPMENT OF MANAGEMENT PLAN FOR BAMBURI-SHANZU BEACHES WITH SPECIAL FOCUS ON JOMO KENYATTA PUBLIC BEACH
PROJECT 7: ENHANCING REGIONAL CAPABILITY FOR THE ASSESSMENT OF CONTAMINANTS IN THE MARINE ENVIRONMENT. (RAF/7/008)
PROJECT 8: SEA-LEVEL MONITORING PROGRAM IN KENYA
PROJECT 9: AFRICAN MONITORING OF ENVIRONMENT FOR SUSTAINABLE DEVELOPMENT (AMESD) PROJECT
PROJECT 10: ENHANCING SUSTAINABLE MANAGEMENT OF MANGROVE RESOURCES IN KENYA THROUGH PARTICIPATORY APPROACH
PROJECT 11: SWAHILI SEAS - MIKOKO PAMOJA: BRINGING MANGROVE-REDD INNOVATIONS TO LOCAL COMMUNITY
PROJECT 12: MAPPING AND ASSESSMENT OF CORAL REEFS IN SHIMONI-VANGA
PROJECT 13: CORAL BLEACHING AND CLIMATE CHANGE: A CASE STUDY IN SHIMONI-VANGA, SOUTHCOAST KENYA
PROJECT 14: BENTHIC HABITAT MAPPING FOR THE KENYAN COASTAL SHALLOW AREAS
PROJECT 15: PATTERNS OF GENETIC DIVERSITY AND CONNECTIVITY IN A WIDESPREAD CORAL ACROPORA TENUIS ON REEFS IN KENYA
PROJECT 16: SOUTH COAST MULTI-DISCIPLINARY PROJECT
PROJECT 17: RESILIENCE AND ADAPTATION OF MANGROVES AND DEPENDENT COMMUNITIES IN THE WIO REGION TO THE IMPACTS OF CLIMATE CHANGE

Annex 1: Workshops/conferences attended	107
Annex 2: Training	113
Annex 3: Publications	115
Annex 4: Manuscripts under preparation	122
Annex 5: Technical Reports	122
Annex 6: Conference proceedings	124

Annex 7: Professional contributions	125
Annex 8: Funded Proposals	129
Annex 9: Submitted Proposals for Funding	129
Annex 10: Workshop Coordination	132
Annex 11: Student Supervision	132
Annex 12: Other deliverables	133
Annex 13: KMFRI research publications trends	134

# PREAMBLE

KMFRI undertakes a multidisciplinary Programme approach in research that is based on six research Programmes namely, Fisheries, Aquaculture research and development, environment and ecology, natural products and post harvest technology, socio-economics and information and data management. Two of these Programmes namely fisheries and aquaculture are core Programmes of the institute. Due to the government's drive to promote fish farming under the Economic Stimulus Programme (ESP) as an economic enterprise in the country, Aquaculture has been elevated to a national programme currently being co-ordinated from Sagana Station as the national aquaculture center. Each Programme is headed by a coordinator (PC), while the Division is headed by a Deputy Director. An Assistant Director is responsible for the day to day running and coordination of all research activities at the Division, while the Center Director manages the operations of the Center.

Dr Renison Ruwa

Mr. Patrick Gwada

**Dr Jared Bosire** 

Deputy Director: Assistant Director: Center Director:

Research Programme

- 1. Fisheries
- 2. Aquaculture
- 3. Natural Products & Post. Harv. Tech
- 4. Socio-economics
- 5. Information and Data Management
- 6. Marine Ecology and Environment

### **Programme Coordinator**

Dr Edward Kimani Dr Betty Nyonje Mr. Peter Odotte Mr Jacob Ochiewo Mr Harrison Onganda Dr Charles Magori

This Annual report for the various programmes' activities covers the 2010/11 FY i.e. from July 2010 – June 2011. The report covers all the research activities undertaken in the Division during the period under review. The mode of presentation of the various research activities follows the format captured in the performance contract where various research activities are captured under respective thematic areas herein referred to as work packages.

# SCIENTISTS IN THE MARINE AND COASTAL DIVISION

Deputy Director:Dr Renison K. RuwaAssistant Director:Dr Jared BosireCenter Director:Mr. Patrick Gwada

### \* Scientists on study leave on MSc Programs; + Scientists on PhD Programs

PROGRAM	NO	NAME OF OFFICER	POSITION
FISHERIES	1	Dr Edward Kimani	PC/PRO
	2	Gladys Okemwa +	RO I
	3	Nicholas Gichuru*	RO II
	5	Nina Wambiji+	ROII
	6	Esther Fondo	ROI
	7	Patrick Loki*	ROII
	8	Cosmas Munga+	ROII
	9	Aura Christopher+	ROII
	10	Jane Nyamora	ARO
AQUACULTURE	11	Dr. Betty Nyonje	PC/SRO
	12	Dr. James Mwaluma	RO I
	13	Shabaan Mwachireya+	ROI
	14	Dr. Robinson Mugo	ROI
	15	Elisha Mrabu	ROII
	16	Fulanda Benard+	ROII
	17	David Mirera+	ROII
	18	Maurine Mukami+	ROII
	20	Miriam Wainaina	ROII
MARINE ECOLOGY &	21	Dr. Charles Magori	PC/ROI
ENVIRONMENT	22	Dr. Michael Nguli	PC S.CoastProject/SRO
	23	Dr. James Kairo	PRO
	24	Julius Okondo	RO II
	25	Dr. Jacqueline Uku	SRO
	26	Stephen Mwangi	ROI
	27	Joseph Kamau+	ROII
	28	Eric Okuku+	ROII
	29	Boaz Ohowa	ROI
	30	Ben Mwashote +	ROI
	31	Lillian Daudi+	ROII
	32	Pamela Abuodha +	ROI
	33	Jelvas Mwaura	ROII

	34	Juliet Karisa	ROII
	35	Amina Hamza	ARO
	36	Amon Kimeli	ARO
	37	Levy Otwoma+	ARO
	38	Dr Bernard Kirui	ROI
NATURAL PRODUCTS	39	Peter Odote	PC/SRO
	40	Cyprian Odoli	ROII
	41	Stanley Onyango	ARO
SOCIO- ECONOMICS	42	Jacob Ochiewo	PC/RO I
	43	Edward Waiyaki	RO II
	44	Fridah Munyi+	ARO
INFORMATION & DATA	45	Harisson Ong'anda	PC/SRO
MANAGEMENT	46	Jane Ndung'u+	RO II

# WORK PACKAGE 1: Undertake stock assessment surveys for new and existing fishing grounds for the marine and fresh water bodies

# Programme overview

This report covers the half year activities of Fishery Research Program in the Coastal and Marine Research Division during the 2010-2011 Government Contracting year. The Fisheries Research Program conducts fisheries and multidisciplinary research in coastal, inshore and marine fisheries in Kenya through corroborations with other research programs at KMFRI, other government agencies, and projects initiated by CBOs and NGOs as well as the fishery industry. During the July 2010 to June 2011 period, the program prepared the technical report for the activities conducted in 2010-2011 contracting year and planned the activities of the 2010-2011 contracting year. The activities include the SWIOFP prawn trawl protocol and the Malindi-Ungwana bay artisanal fishery survey plan and budget among others. Activities within the Malindi-Ungwana bay project included two shallow water prawn survey, one in January-February 2011 and the second in May-June 2011. A field excursion for the artisanal fishery assessment was also done in September 2010 while the preparation of a review manuscript on for the fishery was prepared for publication. Activities in the south coast fisheries project continued with contribution to the South Coast Management document prepared by KMFRI. From the Catch Assessment data two papers was presented during the ARK II meeting held in Naivasha in November 2010. Twelve peer reviewed publications, and six technical reports co-authored by members of the program and were finalized by during the period. In addition, seven manuscripts that have been prepared by members of the program have been submitted.

Fishery Program continued enjoying support from regional and national donor funded projects during the period. The main ones include:

- The South West Indian Ocean Fisheries Project (SWIOFP) Fisheries project;
- The ornamental coral culture project funded National Council of Science (NCST);
- The regional ornamental fishery project funded by MASMA.
- The Kenya Coast Development Project
- KMFRI seed project

On training, four members of the Fishery Program (Gladys Okemwa, Cosmus Munga, Nima Wambiji, Simon Agembe) are registered for PhDs in different Universities, while two members (Patrick Loki and Nichorus Gichuru) are registered for MScs.

The projects details of each research project are provided below.

# Project 1: Malindi-Ungwana-bay; Status of the Fishery

Participating Institutions: KMFRI, FD Scientific Team Members: Edward Kimani, C. Munga, Source of Funds: GoK Duration: 2007-2012

### **Research Problem**

The Malindi Ungwana bay fishery has been characterized by conflicts between the trawlers on one hand, the small scale artisanal fishers and conservation agencies on the other hand. The main issues surround the contravention of the Fisheries Act, which limits trawling only beyond 5 nm offshore, destruction of artisanal fishing gears by the trawlers, wastage of fish by-catch and killing of non-target species especially the turtles. Trawling has been going on using until August 2006 when the Fishery Department (FD) enforced the Fishery Act and trawlers were removed from within the 5nm offshore limit. Consequently, KMFRI initiated a program to monitor to the artisanal fishery. Landing and effort data and biological information has been collected at Malindi, Ngomeni and Kipini approximately every 3 months from June 2007 to date to assess the status of the fishery.

### Objectives

- to assess the variation of CPUE,
- to determine the species composition and
- to determine the population structure of the main commercial fish and prawn species

### Activities

- Conducted one field work survey March 2011
- Conducted one shallow water prawn trawl survey under SWIOFP
- Data analysis and report preparation.

### Main findings and conclusion

The Malindi-Ungwana bay is important in the marine fishery production in Kenya due to the shallow bathymetric formation and the freshwater, nutrients input by Rivers Tana and Sabaki. The two river deltas are the only parts of the Kenya coast that can be trawled. Four semi-industrial trawlers have been landing between 300 and 600 tons of prawns between 1998 and 2002. Analysis of the existing shrimp and fish landings data from the Kenya Fisheries Department indicate that artisanal landings were consistently higher than the semi-industrial trawl landings until six years before its closure. However, two years before this closure, artisanal landings declined from a mean peak of 1,600 mt in 2004 to 1,000 mt in 2006. Reduced trawler retained fish by-catch landing is also observed within the last year of trawling with a steady reduction of shrimp landings from 2001 to 2003 when landings stabilized at a mean low of about 200 mt annually for the rest of the period from a high of about 600 mt in 2001. It was only in the year 2001 when retained fish by-catch landings were above the shrimp landings as trawlers discarded more by-catch in preference to the target catch. The rest of the period, shrimp landings remained lower due to more retained by-catch at a shrimp to by-catch ratio of 1:1.5 lower than the average ratio of between 1:3 and 1:15 that has been experienced in the tropics. Information available on the artisanal fishery so far, from Fishery Department statistics landing, landings records of several fishers in Malindi, as well as data collected during KMFRI field expeditions at landing beaches between June 2007 and June 2009 are examined to provide insights into the status of the fishery. Fishery Department statistics for Malindi, Ngomeni and Kipini show no remarkable change in prawn landings after removal of the trawlers in 2006.

Field data collection on fish identified over 240 species in 84 families, dominated by siganidae, scombridae, lutjanidae, lethrinidae, clupeidae and mugilidae. Among the common fishing gears, troll lines and hook & lines selected larger fish, over 60cm mean size, *jerife* basket traps selected medium size fish with mean 40-60cm, whereas gillnets, monofilament seine nets and beach seines caught fish with mean size of about 20cm. Daily fish landing were approximately 10Kg for canoes using gillnets as well as hook & lines, and 40-50Kgs for *ngalawa* and *mashua* using gillnets as well as hook & line. Monitoring of fish landings, fishing effort and gear use, as well as examination of biological data from trawl catches as well as artisanal catches to monitors changes in the resource, provide production estimates and evaluate changes in the fishery is recommended.

Preliminary trawling survey results for the first cruise during the NEM season show significant difference in bathymetric distribution of mean prawn catch rates. The highest catch rate was recorded in zone 1 (0 – 10m) with 788.8 ± 351.5Kg/h compared to zone 2 (10 – 20m) with 51.2 ± 37.5Kg/h, and zone 3 (20 – 50m) with 5.2 ± 4.6Kg/h with no prawn catches recorded in zone 4 (50 -100m). Comparison of prawn sizes from this survey and even those of artisanal prawn catches indicate prominent size segregation between the sexes with the females exhibiting a wider range and a larger carapace length. Results of Two-Way ANOVA indicate no significant difference in sizes among the prawn species (*P. indicus, P. monodon, P. japonicus, P. semisulcatus* and *M. monoceros*) and sizes between the trawl and artisanal catches (p < 0.05). The overall sex ratio (males/females) for the trawl prawn catches was 1:0.06 in favor of males compared to an overall sex ratio of 1:1.2 in favor of females for the artisanal prawn catches. Most of prawns landed in the artisanal fishery were juveniles and were smaller during the SEM than during the NEM.

The mean catch rates for the fish by-catch during this survey were significantly higher compared to the target catch (prawns). Zone 1 recorded the highest prawn biomass of 12, 220 Kg/Nm<sup>2</sup> followed by zone 3 with 3, 962.7 Kg/Nm<sup>2</sup> with zones 2 and 4 recording lower mean catch rates of 1,082.6 Kg/Nm<sup>2</sup> and 510.5 Kg/Nm<sup>2</sup> respectively. In zone 1, the most abundant fish species was *Otolithes ruber* (35%) while *Leiognathus lineolatus Pellona ditchela* and *Upeneus taeniopterus* constituted 17% 51% and 26% of the fish in zones 2, 3 and 4 respectively.

# Challenges

- Funding to undertake artisanal fishery assessment fieldwork was available for one sampling campaign.
- The anticipated SWIOFP prawn trawl sampling was conducted during the NEM and SEM seasons with preliminary findings available for the NEM survey only.

# **Project 2: Artisanal Fisheries Catch Assessment along the Kenya Coast**

Participating Institutions: KMFRI Scientific Team Members: Gladys Okemwa, E. Fondo, E. Kimani, Source of Funds: GOK Duration: 5 years

# **Research Problem**

It has been claimed that artisanal fisheries yield have been seriously declining during the last decades. However, empirical evidence to support this claim is often not available. KMFRI initiated a catch assessment monitoring programme in September 2001 to assess trends in fish landings. The aim of the program was initiated to provide direct and assessment of the status and utilization of fisheries resources in order to provide a basis for effective fisheries management.

# Objectives

The main aim of the project is to monitor artisanal fish landings to determine the status of the fishery and variability of gear use and productivity based on catch per unit effort at selected landing beaches.

# Activities

During the year, main activities involved:

- Collection of data by KMFRI data enumerators at landing beaches,
- Data entry and analysis at KMFRI,
- Preparation of draft manuscript for ARK II conference.

• Preparation of south coast management document

### Brief site description and methodology

The Catch Assessment project is based on daily fish landing data collected by KMFRI enumerators at landing beaches. This report provides an overview of Kenya's coastal artisanal fisheries based on catch assessment surveys conducted by the Kenya Marine and Fisheries Research Institute's enumerators in selected landing sites in Vanga, Shimoni, Msambweni, Gazi, Diani and Lamu from 2001 to 2008. The enumerators randomly interview fishermen and data collection designated beaches. During the interview, a data sheet is completed for each individual fishing trip where information on the fishing activity is collected. This includes type of gears used, nominal catches (kgs), number of crew, fishing grounds visited, composition of species groups and fish sizes. The information is captured I a data sheet designed for the purpose and processed onto a database for further analysis. The landing data is used to characterize annual and seasonal variations in the selected fisheries by focusing analyses on estimation of gear variations in catch (kg vessel <sup>-1</sup> trip<sup>-1</sup>) and catch per unit effort (kg fisherman<sup>-1</sup>, day<sup>-1</sup>).

### Main findings and conclusion

Within the Funzi-Shimoni-Vanga area, eleven types of fishing gears (hook&line, basket trap, ring nets, beach seines, gillnets, 'ndowano', scoop nets, spear guns, shark nets (*jarife*), harpoons, troll lines) and four fishing vessels (canoe, dau, outriggers and mashua in addition to foot fishers) were identified during the surveys. The ring net contributed the bulk of the fish landed in Vanga, the beach seine dominating in Majoreni and hook&line in Shimoni and Msambweni. Fishing activities vary spatially and temporally with notable higher fisher concentrations around Mpunguti and Mwambamkuu fishing grounds with ring net fishers often fishing around Sii Island. Aquarium fish collection was found to be concentrate around the Nyuli, and the shallow reefs within Wasini channel. Gear use varied with season, with hook&line (37.8%), basket traps (29.5%) and hooks (15.4%) dominating during the southeast monsoon season, whereas hook&line (61.1%), basket traps (23.0%), are more common during the northeast monsoon season. Hook & line and basket traps collectively contribute 80% of the total weight landed in Shimoni, whereas in Vanga, ringnets are the dominant gear contributing 77% of the total landed weight. Generally higher fish landings in the area are associated with the northeast monsoon season compared to the southeast monsoon season. Mean catch per fisher were highest for ring nets (>11Kg), followed by gill nets, reef seines, hook&line (4-6Kg) and lowest for beach seines, spear guns and basket traps (<3Kg). The catch per unit effort data for most gears during the period between 2001 and 2008 generally show increasing catches. However, several concerns regarding the impacts of fishing gear were identified by the study. The catches of the ring nets, introduced in the area to target nearshore pelagic species, were found to largely overlap with other gears suggesting potential resource use conflict. Illegal gears

including spear guns and beach seines were particularly prevalent in Msambweni and Majoreni areas respectively. Serious concerns on the impacts of seine nets regarding the size and maturity of the bulk of catches attributed to their landings. The ring net fishery, the aquarium fishery, the beach seine fishery have significant economic value and social implications and need to be evaluated with aim of setting clear guidelines or regulations. Research on fisheries that are venerable to local overexploitation such as sea cucumbers, groupers and other aggregating species need studies to provide guidelines for sustainable exploitation. In addition, education, increased awareness and involvement of fishers in research and data collection, and feedback on the implications of the findings are recommended.

### Challenges

# Administration and Staffing

• The number of staff working for the project drastically reduced from 18 to 5 enumerators since with some sites only having one enumerator. The reduced capacity in enumerators has drastically affected the data quality and coverage resulting in data gaps.

# Project 3: Incorporating reef fish spawning aggregations into optimal designs for no-take fishery reserves: Strengthening fisheries management and coral reef resilience in the Western Indian Ocean

Participating Institutions: KMFRI, CORDIO, SFA, IMS Scientific Team Members: Robinson, J., Samoilys, M., Agembe, S. and Jiddawi, N. Source of Funds: WIOMSA MASMA PROJECT Duration: Ongoing

### **Research Problem**

Some 30 million people live in the coastal region of the Western Indian Ocean (WIO), many highly dependent on the region's marine resources. Overfishing and destructive fishing techniques are of increasing concern. Fisheries management in the WIO is still poorly developed, with gear restrictions often the only measure in place, while small scale fisheries largely operate within open access regimes (van der Elst et al. 2004). Despite slow advances in fisheries management, Marine Protected Areas (MPAs) have been declared throughout the WIO, with over 70 now established, some dating back to the 1960s (IUCN 2004). In national reports to the South West Indian Ocean Fisheries Commission (SWIOFC), MPAs are often cited as fisheries management tools. However, as is the case elsewhere, the benefits to fisheries are poorly known or demonstrated.

# Objectives

- 1. To define the spatio-temporal dynamics of spawning behaviour for aggregating species and to identify and determine the importance of aggregation fisheries.
- 2. To determine management requirements for spawning aggregations with a focus on optimal designs for no-take fishery reserves and assessment of the role of existing MPAs in protecting aggregating species.
- 3. To raise awareness and develop policy advice relating to the management of reef fish spawning aggregations at national, regional and global levels.

# Activities

Biological and fisheries sampling, the creel and fisher knowledge surveys, installation of aquatic arrays, verification of *S. sutor* spawning aggregation sites in Kenya, histological and data analyses.

# Brief site description and methodology

Based at sites in Kenya (KEN), Seychelles (SEY) and Zanzibar (ZAN), the project comprises three inter-linking Work Programmes (WP).

WP1: Biological and Fisheries Studies WP2: Fishery Reserve Design and MPA Assessment WP3: Policy/awareness

# Main findings and conclusion

The project has been successful in verifying *S. sutor* spawning aggregations in Kenya and providing further verification of sites for *E. fuscoguttatus*. UVC monitoring programmes have now been established which, over time, will provide knowledge of the spatial and temporal dynamics of aggregations as well as their status.

Imminent spawning indicated by the presence of females with running ripe (hydrated) oocytes was recorded in all months except April and August for *S. sutor*. Preliminary analysis of size at first maturity gave an estimate of 24 cm TL. This concurs with what de Souza (1988) found.

Since our results from the different aspects of this project suggest *E. fuscoguttatus* populations in the south coast area are depleted, the decision to only use the non-invasive method of UVC was considered a sound precautionary approach for the conservation of this species.

# **Constraints/problems encountered**

The main problems encountered since the last progress report are:

We were unable to continue acoustic studies on *E. fuscoguttatus* in Kenya, as detailed below.

With regard to reproductive studies of *E. fuscoguttatus*, we have had to consider the ethics of putting further pressure on a species that is probably over-fished in Kenya, as amply illustrated by the lack of specimens appearing in the monthly creel surveys, and the low abundance of this species seen in UVC surveys. We therefore tried only one month of sampling elsewhere (Mtwapa, north coast) on the basis of anecdotal reports of "healthy" populations. However, none were captured. We have therefore abandoned any efforts to capture this species and greatly increased our UVC surveys instead to obtain as much *in situ* information on spawning periodicity and behaviour in the Diani/Tiwi area.

# Project 4: Reproductive biology of *Siganus sutor* in Kenya (WP1 MASMA Project)

Participating Institutions: KMFRI, CORDIO Scientific Team Members: Agembe, S. and Samoilys, M.A. Source of Funds: WIOMSA MASMA Duration: Ongoing

# **Research Problem**

Siganids (family Siganidae) are widely distributed in the Indo-Pacific region As siganids constitute one of the most important fish stocks in Kenyan coastal waters (de Souza 1988), knowledge of their reproductive biology is necessary to provide management of the fishery.

# Objectives

This study determined the seasonal and lunar spawning periodicity of *S. sutor* in southern Kenya

### Methods and study area

Artisanal fishery catches were sampled at the Msambweni landing site, southern Kenya 5 days /month during the likely reproductive season and 3 days/month for the remainder of the year. Fish were sampled for length and weight, and gonads removed, weighed, and sexed and staged macroscopically based on the external appearance of the ovary, and the appearance of the oocytes within it, viewed with the naked eye. Gonads were sampled and preserved in formalin solution for histological preparations

and microscopic staging based on standard techniques (e.g. Samoilys & Roelofs, 2000). Spawning periodicity was derived from trends in GSI and patterns in gonad maturation from the macro-staging results.

### **Findings and conclusions**

GSI and gonad macro-staging provided evidence that *S. sutor* was reproductively active for broad periods of time on the south coast of Kenya. Peaks in spawning were apparent in the Jan-Feb and Nov periods. Interestingly, although *S. sutor* are largely caught by basket trap, there was a small portion of landed catch from handline fishers. Catches from these fishers tended to be larger sized *S. sutor*, and were ripe during July and August. Spawning months for *S. Sutor* were found to November – February and non-spawning months are July-September

The histology work is now in progress and will identify the reproductive seasons and lunar phases of *S. sutor* more precisely.

# Project 5: Natural Geography of Inshore Areas, NaGISA.

**Collaborating Institutions:** Institute of Marine Science (Tanzania) and University of Eduardo Mondale (Mozambique). **Execution period**: 2000-2010

#### **Research Problem**

Natural Geography In Shore Areas (NaGISA) is a Census of Marine Life field project with 8 regional offices and currently over 240 sampling sites along the shores of over 28 countries. Using global standards to answer local questions NaGISA members (researchers, managers and students) are producing the world's first near shore habitatspecific global census. This is possible because simple, cost-efficient intentionally lowtech sampling protocols allow NaGISA to draw on the participation of international researchers and community groups. NaGISA is set to complete a habitat-specific, qualitative and quantitative survey of the world's ocean shores. The protocols used are simple, cost efficient and low-tech so that they can be adopted by research groups around the world. NaGISA's primary goal is a series of globally-distributed standard transects from the high intertidal zone to a depth of 20m, which can be repeated over a 50-year or greater time frame. The Indian Ocean is one of the geographic regions of NaGISA with a regional office at KMFRI.

### Objective

The specific scientific goals are to elucidate the scale(s) of variability while creating the first quantitative global baseline of coastal biodiversity while the Long-term aspirations

are to increase coastal community marine awareness and improve the state of benthic taxonomy.

The objectives are:

- To determine latitudinal trends in inshore biodiversity
- To create the first global baseline of coastal biodiversity in rocky shores and seagrass beds
- To elucidate the scales of variability (temporal and spatial) in nearshore habitats
- To increase coastal community marine awareness and improve the state of benthic taxonomy
- To assess the interactive effects of multiple drivers, including human activities, on spatial patterns of biodiversity in marine coastal communities at the global scale

# Methodology

The Indian Ocean NaGISA has conducted sampling surveys in Kenya one seagrass site and one rocky shore sites in Kenya, two site in Zanzibar tow site in Mozambique and two sites in Egypt. The sites were assessed using a standard protocol of the Census of Marine Life NaGISA project (<u>www.nagisa.coml.org</u>, Rigby et al. (2007). The protocol is a stratified random sampling design, which typically takes five replicate random samples along a 50 m transect line set at the high, mid, and low intertidal strata and 1 m, 5 m, 10 m, 15 and 20 m below maximum spring tide low water level wherever possible. The location of each replicate is taken by hand held GPS position and a photo taken for future reference.

# Findings and Conclusions

Latitudinal gradients in species abundance and diversity have been postulated for nearshore taxa but few analyses have been done over sufficiently broad geographic scales incorporating various nearshore depth strata to empirically test these gradients. Typically, gradients are based on literature reviews and species lists and have focused on alpha diversity across the entire nearshore zone. The data collected by NaGISA has been analysed to determine the diversity, biomass and abundance of macroalgae, echinoderms, polycheates, decapods and seagrasses. So far, the data on macroalgae, echinoderms and decapods have been done. The macroalgae data, pooled for all strata sampled indicated no overall correlations between either estimates of species density or biomass with latitude, although the highest numbers of both were found at midlatitudes. However, when strata were examined separately, significant positive correlations were found for both species numbers and biomass at the intertidal zone. Latitudinal trends in macroalgal species density and biomass do exist for some strata, with more taxa and biomass at higher latitudes.

The data on echinoderms was examined to determine large-scale distribution patterns with specific emphasis on identifying latitudinal trends and large regional hotspots. Echinoderms assemblages sampled from 76 globally distributed sites within 12 ecoregions. Sample-based species richness was overall low (1–5 species per site), with a total of 32 asteroid, 18 echinoid, 21 ophiuroid, and 15 holothuroid species. Abundance and species richness in intertidal assemblages sampled with visual methods (organisms .2 cm in 1  $m^2$  quadrats) was highest in the Caribbean ecoregions and echinoids dominated these assemblages with an average of 5 individuals m<sup>2</sup>. In contrast, intertidal echinoderm assemblages collected from clearings of 0.0625 m<sup>2</sup> guadrats had the highest abundance and richness in the Northeast Pacific ecoregions where asteroids and holothurians dominated with an average of 14 individuals 0.0625 m<sup>2</sup>. Distinct latitudinal trends existed for abundance and richness in intertidal assemblages with declines from peaks at high northern latitudes. No latitudinal trends were found for subtidal echinoderm assemblages. We also tested a set of 14 environmental variables (six natural and eight anthropogenic) as potential drivers of echinoderm assemblages by ecoregions. The natural variables of salinity, sea-surface temperature, chlorophyll a, and primary productivity were strongly correlated with echinoderm assemblages; the anthropogenic variables of inorganic pollution and nutrient contamination also contributed to correlations. Our results indicate that nearshore echinoderm assemblages appear to be shaped by a network of environmental and ecological processes, and by the differing responses of various echinoderm taxa, making generalizations about the patterns of nearshore rocky habitat echinoderm assemblages difficult.

Relationships of diversity, distribution and abundance of benthic decapods in intertidal and shallow subtidal waters to 10 m depth are explored based on data obtained using a standardized protocol of globally-distributed samples. Results indicate that decapod species richness overall is low within the nearshore, typically ranging from one to six taxa per site (mean = 4.5). Regionally the Gulf of Alaska decapod crustacean community structure was distinguishable by depth, multivariate analysis indicating increasing change with depth, where assemblages of the high and mid tide, low tide and 1 m, and 5 and 10 m strata formed three distinct groups. Univariate analysis showed species richness increasing from the high intertidal zone to 1 m subtidally, with distinct depth preferences among the 23 species. A similar depth trend but with peak richness at 5 m was observed when all global data were combined. Analysis of latitudinal trends, confined by data limitations, was equivocal on a global scale. While significant latitudinal differences existed in community structure among ecoregions, a semi-linear trend in changing community structure from the Arctic to lower latitudes did not hold when including tropical results. Among boreal regions the Canadian Atlantic was

relatively species poor compared to the Gulf of Alaska, whereas the Caribbean and Sea of Japan appeared to be species hot spots. While species poor, samples from the Canadian Atlantic were the most diverse at the higher infraordinal level. Linking 11 environmental variables available for all sites to the best fit family-based biotic pattern showed a significant relationship, with the single best explanatory variable being the level of organic pollution and the best combination overall being organic pollution and primary productivity. While data limitations restrict conclusions in a global context, results are seen as a first-cut contribution useful in generating discussion and more indepth work in the still poorly understood field of biodiversity distribution.

Further analysis to elucidate global as well as regional biodiversity trends are going on.

# Project 6: The Marine Ornamental and Curio trades in the Western Indian Ocean – benefit or threat?

Participating Institutions: KMFRI, Fisheries Department
Participating Countries: KENYA, TANZANIA, MOZAMBIQUE, MAURITIUS, MADAGASCAR
Source of Funds: WIOMSA - MASMA
Duration: 1 Year (Dec 2009 to Dec 2010)
National Research Teams: Ecological Surveys: G. Okemwa (Project Leader), E. Kimani,
M. Zamu, E. Waiyaki, C. Muthama, B. Ogutu, J. Muturi

### **Research Problem**

The main concern about Kenya's marine aquarium fishery are the potential impacts of collecting high numbers of juvenile fish leading to population deplections particularly of species that may be vulnerable in addition to damage to the reef habitat. Resource use conflicts have also been rampant particularly with the dive tourism industry and environmentalists who are concerned that the most beautiful fish are disappearing, thereby affecting the aesthetic value of fished grounds.

To mitigate the conflicts there are efforts to develop a management plan. This project assesses ecological and socioeconomic benefits of the fishery as well as potential threats using both primary and secondary approaches. The overall aim of the study is to improve the current knowledge base on the marine ornamental fishery by building on the available information to facilitate better decision-making.

#### **Research Objectives**

1. Assess trends in exploitation trends: cpue, fishing effort, species composition: Methodology: catch monitoring and export trends: (logbook data, fisheries department returns, catch monitoring (Shimoni)

- 2. Assess impacts in fishing grounds: density and abundance of target species in fished and unfished sites. Methodology: underwater visual census surveys in Shimoni
- 3. Determine the socioeconomic characteristics of collectors and perceptions on resource status: Methodology: questionnaire survey

### **Research Findings**

Findings on aquarium catch trends indicate that the total number of fish and invertebrates exported has doubled over the last decade from an estimated 150,000 in 2000 to 250,000 in 2009. This is attributed to increased fishing effort (number of fish species caught per fisher) as well as the diversity of species collected. Fish are collected from 22 sites along the Kenya coast, however 80% of the catches are collected from 7 sites namely (Kilifi, Shimoni, Shelly beach, Kanamai, Nyali, Diani and Kikambala. Fishing effort has increased since 2005 (175% for snorkelers and 67% for divers). Catch per unit effort has however decreased for snorkelers from 20 fish/man/day to 13 fish/man/day; while divers catch has remained stable at 31fish/man/day. This indicates that the shallow water species collected by snorkelers may be experiencing higher fishing pressure due to their ease of accessibility and site fixity.

The abundance of species in catches varies spatially across the coastline which is a reflection of the natural distribution as influenced by the availability of suitable habitats and accessibility of the sites to fishers. For instance, the angelfish *Centropyge acanthops* was most abundantly collected in Shimoni (60%), the angelfish *Pomacanthus chrysurus* in Malindi (35%) and Lamu (30%) and the angelfish Pomacanthus maculosus in Kilifi (27%) and Lamu (32%). These findings have implications on the management strategy which will have to take into account the distribution and abundance of species that are found to be vulnerable to over-collection.

A total of 61 ornamental fish species were identified in underwater census surveys in Shimoni, with the most abundant in all sites being the damselfish, *Chromis dimiata* and *Chromis viridis*. The anemonefishes *Amphiprion allardi* and *Amphiprion akallopisos* were more abundant in the Kisite Marine Park and Mpunguti Researve. Butterflyfish species which are a favourite in the trade were also notably more abundant in the marine park and reserve compared to the fished sites (Nyuli and Sii Island).

The fisher surveys indicated four species to have declined over time (*Paracanthurus hepatus, Pomacanthus chrysurus, Pomacanthus maculos*us and the clownfishes *Amphiprion allardii* and *Amphiprion akallopisos*. Damselfish and anthiases were reported by the fishers to be stable with high recovery rates. In terms of benefits, ornamental fish collectors have a higher income security compared to artisanal food fishers. They however do experience income insecurity during low season (June to August). The fishers felt that diver safety is a major threat to their health as most divers are not formally trained or certified. Food fishers indicated existing animosity to

aquarium fishers, as they viewed them to be destructive to the reef habitats as well as in reducing aesthetics of fishing grounds by over collecting beautiful fish. Overall, the industry supports some management strategies including seasonal or rotational area closures, prohibition of vulnerable species if confirmed through research, development and mainstreaming of minimum standards in holding facilities to reduce mortality, and capacity building of fish collectors to improve dive safety.

### Way Forward

Detailed analysis of project findings is ongoing. It is recommended that site specific management strategies such as spatial and seasonal closures be employed to protect vulnerable species from localized depletions and enhance biodiversity. Towards this, further species specific studies should be conducted to better understand the population dynamics and biology of highly targeted species.

### Project 7: Ornamental coral culture project

Participating Institutions: KMFRI, KWS, Tropical Sea Life Source of Funds: National Council of Science and Technology (NCST) Duration: 1 Year (20010 to Dec 2011) National Research Teams: Edward Kimani, G. Okemwa, Masudi Zamu

### **Research Problem**

Live coral are one of the most important marine ornamental invertebrates traded internationally involving a high diversity of species. They are harvested to supply markets with souvenirs and curios, substrates for home and public aquaria, jewelry, carvings, human bone replacement and traditional medicines and for biomedical purposes. Aquaculture is increasingly cited as a priority solution for reducing harvest pressures on coral reefs associated with the marine ornamental trade, especially in developing indo-pacific countries. As a result, farming of corals for home and public reef aquaria is now strongly being encouraged as a sustainable alternative to harvesting from natural reefs which are increasingly threatened by a myriad of threats that include destructive fishing methods, tourism, coastal developments, and climate change. Culturing of aquarium corals has been shown to be technologically possible and economically viable in the Pacific (e.g. in Fiji, Solomon Islands). Investors in Kenya's marine aquarium industry have shown keen interest in diversifying their trade by exporting corals cultured by local communities to meet a fast growing market demand. However, scientific information and data, as well as practical experience on the biology of cultured corals in the West Indian Ocean region are very limited.

The aim of this study is to conduct a comparative assessment of the performance of two coral species, *Acropora* and *Pocillopora* as potential culture species for the aquarium

market. Information on survival and growth rates of the two species which are among the most preferred species will be collected based on transplant experiments of coral fragments. The major outcomes of the project include biological information determining the viability of the species for culture and an established mother colony for use as source seed. In the long term, culturing coral has the possibilities of immensely expanding the value of aquarium export business and providing alternative sustainable maritime economic activity to local fishing communities.

### Objectives

The aim of the study was to assess the culture suitability and performance of a selection of coral species through a comparative assessment of growth rates and survival by answering the following specific objectives:

- 1. Determine the influence of environmental factors on the growth and survival rates of transplanted *Acropora* and *Pocillopora*
- 2. determine the influence of initial fragment size on the survival and growth rate of the two species

### **Research Activities**

During the period between July and December 2010 the research activities undertaken during the reporting period include:

- 1. Monitoring of growth and survival of coral transplants deployed at the Mombasa Marine Protected Area in June May and June 2010.
- 2. Monitoring the environmental variables including SST, salinity and suspended matter within the study area.

### **Preliminary Findings**

An experiment was carried out for 12 months from April 2010 to April 2011 to assess the viability of culturing ornamental scleractinian corals as a potential livelihood source for local communities involved in ecotourism activities as well as for the ornamental aquarium trade. The transplant technology was tested at the Mombasa Marine Park where 6 species: *Pocillopora darmicornis, P verrucosa, P eydouxi, Acropora humilis, A. selago* and *A. verwei* were transplanted from the adjacent Nyali reserve and monitored for growth and survival. Fragments of these species were cut within a narrow size range from the tips of donor colonies and attached to cement disks using epoxy glue. 600 cement disks were attached to wire mesh using fishing twine on fabricated tables (200 per table) and deployed using SCUBA within the study area in shallow depths of a maximum of 3meters during low tide. For every surviving fragment, growth rate was measured as the change in apical height of the main and tallest branch and its width was measured with vernier callipers (0.01 mm error margin) during each sampling interval. Environmental factors were also monitored simultaneously and included water temperature, salinity, light intensity, and sedimentation. *Acropora humilis, A selago, Pocillopora darmicornis* and *P eydouxi* exhibited the highest survival rates of above 60%. The lowest survival rates were observed for *Pocillopora verrucosa* (37%), *Porites rus* (20%). *Acropora humilis, A selago* and *A. verwei* also exhibited the highest growth rates. The recovery of the inflicted scars from donor colonies was also monitored and 80% fully recovered within three months. Overall, the transplant technology was found to be viable and can be adopted as a method for culturing ornamental corals.

# **WORK PACKAGE 2:** Assess the potential and develop adaptive aquaculture technology

### **Programme overview**

Aquaculture is popularized as a booster to the livelihoods of coastal communities in Kenya. Small-scale coastal aquaculture has successfully been introduced throughout Asia and has the potential to be developed also in Kenya. Aquaculture research that was focused during this financial year aimed at providing catfish (*Clarias gariepinus*) fingerlings for the economic stimulus ponds constructed in Tana River and Taita Taveta in addition to helping the coastal people to culture mud crab (*Scylla serrata*) in the marine waters. Commercial seaweed farming for fisher communities at the south coast has also been introduced as one of the livelihood enhancing avenues under this program. All this is aimed at developing viable aquaculture activities by considering how different species and culture methods depend on resources out-from a wider perspective, and to find out how they fit within existing social structures.

# Project 1: Development of a catfish and tilapia seed production capacity at the Mombasa Station to supply fingerlings to the coastal farmers

#### Participating Institutions: KMFRI

**Scientific Team Members:** Miriam Wainaina, David Mirera, Betty Nyonje, Maurine Mukami James Mwaluma

Technologists: Dan Odiwuor, Johnson Nyamari, Mwendwa Mbaluka, Joseph Wakili Attachement Students: Charles Kalerwa – Mombasa Technical Training Institute (Internship), Emilly Wafula- Makerere University (Internship) Source of Funds: GoK, Seed Grant Duration: 1 fiscal year (July 2010-July 2011)

#### **Research Problem**

The coastal region has developed interest to fresh water fish farming over the current decade. However supply of quality seed stock to the farmers is a big challenge at the moment and hence hindering adoption for the freshwater farming in the region. The inability to supply seed stock is mainly due to limited technological know how among the practitioners and support institutions. Thus the current research was aimed at coming up with enough seed stock to supply to the farmers and consequently help the farmers to understand how to take care of freshwater fish fingerlings as a way of preparing them for their own productions. In addition, the research was aimed at perfecting the technology of seed production within the KMFRI staff for effect dissemination of the same to the farmers. The produced seed stock was destined to both the individuals supporting themselves and those under the ESP support.

### **Specific Objectives**

- To produce quality seed (fingerlings) for Catfish & Tilapia and supply to the farmers at the coast
- To conduct experimental trials to assess survival of catfish fingerlings using hapa nets in tanks

### Methodology

In the current fiscal year, the production of catfish fingerlings has not been to maximum as expected due to very high mortality rate of the catfish fry and limited spawning facilities for Tilapia. In total eleven catfish inducements, have been done in the current fiscal year. However, the losses of hatched fry have been high due to poor management (handling stress, tank leakage & cannibalism). Some of the obtained fingerlings were sold to farmers at prices of Ksh. 3 per piece for catfish and Ksh. 7 for tilapia.

Mature female broodstock are selected and injected with catfish pituitary hormone to induce spawning. They are then stripped to obtain the eggs the following day and eggs are put in a hatchery system to hatch into fry at controlled temperature. The hatched fry are feed with artemia nauphlii that has been shown to enhance survival and growth (Mirera et al., 2010). The one month old catfish fingerlings were transferred into concrete tanks and put into two hapa nets at a stocking density of 325 per meter square to assess growth and survival. The fish are being fed on feeds prepared at the lab in addition to the phytoplanktons available in the ponds. Tilapia brooders are paired in the ratio of 3:1 male:female in the concrete tanks for a period of 28days.Tilapia fry are then harvested and transferred to another concrete tank, any eggs collected during harvesting from the mouth brooders are further incubated to induce hatching.

### Main findings and conclusion

In total, 13,865 catfish fingerlings have been sold to farmers from different places (Emali, Ukunda, Mtwapa and Tanariver) giving a revenue of Kshs. 41,625. Tilapia which was introduced in the 4<sup>th</sup> quarter seem to have a demand and with increased production it can add to the revenue generated by the program. For the catfish production, it has been observed that, more than 90% of the catfish hatchings per inducement die before attaining fingerling stage which indicates a big concern that the program need to address more carefully to avoid this high mortality in catfish production. It had been hoped that by the introduction of tilapia propagation, this would bring in more revenue; however, the plastic tanks behind the canteen could not be put into use due to lack of a predator net (to stop monitor lizard and birds) which has not been purchased. Therefore, the main challenge in tilapia production is limited space

for spawning, which has so far relied on only two small concrete tanks. Preliminary assessment has shown that culture of juveniles in the hapa nets in ponds may help improve survival and growth rate of the fry catfish. However, this was not assessed and established due to high mortalities of the catfish that was produced.

# Project 2: Population dynamics and small-scale aquaculture of mud crab (Scylla serrata) in East Africa

**Participating Institutions:** Kenya Marine and Fisheries Research Institute (KMFRI) **Scientific Team Members:** David Oersted Mirera

Technologists: Johnson Nyamari, Mwendwa Mbaluka, Justus Wakili

**Students:** Hildah Nyaboke – Moi University (Internship), Emily Wafula-Makerere (Internship)

**Community Members:** Daniel Charo, Juma Mwarandani, Dickson Mwamure, Hezron Ngoge

Source of Funds: IFS

Duration: 2 year (2009-2011)

# **Research Problem**

Mud crabs have been cultured in pens, drive-in and floating cages over the last one deacde in Kenya. However survival has not been good. Also the methods have mainly focused on the culture of semi-adult crabs which are not the focus in the current study. The current study looked at the culture of juvenile mud crabs to market size in earthen ponds. The method also compared survival of juvenile mud crabs in pens and ponds over a 3 months period.

# Objectives

- To determine the growth rate of mud crabs in ponds and pens
- To compare survival of juvenile mud crabs in pens and ponds.
- To compare growth and survival of juveniles of different sizes stocked together and those of similar sizes stocked together.
- Compare variations in growth and survival of mud crabs culture in ponds in different sites (Makongeni and Majaoni)

# Brief site description and methodology

The mud crab research was done at Mtwapa creek in ponds and pens. Juvenile crabs were stocked in 50m<sup>2</sup> pens at stocking desnity of 0.5 crabs/m<sup>2</sup> and in ponds of 450m<sup>2</sup> at same stocking density. The crabs were fed on fish oval once in a day at 10% body weight. Similar size class crabs of 20-40mm cw were used in this experiments. The crab experiments were later introduced for testing at the community ponds at majaoni and

Makongeni. The crabs were stocked at density of 2  $crabs/m^2$  and in two separate size combinations (20-35 mm and 20-50 mm, ICW).

### Main findings and conclusion

Preliminary analysis indicated that juvenile mud crabs have higher survival and growth in ponds compared to ponds. The results showered that juvenile crabs reared in ponds may require 8-10 months to reach market size. It was easier to get crabs from ponds and pens using traps, however, for pens it needs one to wait for the high tide before crab capture can be done. Hence, implying that harvesting in pens is tide dependent while in ponds it can be done at any time.

Juvenile mud crabs of average 35g were observed to attain an average weight of 120g over a three months period when stocked at the rate of 2 crabs/m<sup>2</sup>. However varied growth rates were recorded from the two community sites where culture was obtained though not significantly different from each other. Majaoni site at Mtwapa creek recorded relatively high growth rate possibly due to their proximity to the main mangrove channel for water exchange while Makongeni site at Gazi bay had lower values possibly due to the delayed water exchange since the intertidal flats are far from the main mangrove channel leading to delayed tidal water exchange.

# Project 3: Optimization of milkfish growth trials at Makongeni-Gazi bay and Majaoni-Mtwapa creek

 Participating Institutions: Kenya Marine and Fisheries Research Institute (KMFRI), Majaoni Youth Development Group, Makongeni Baraka Conservation Group
 Scientific Team Members: David Oersted Mirera
 Source Of Funds: Community initiative
 Duration: Continuous

### **Research problem**

Milkfish farming has been the focus of most communities for the last two decades in Kenya though with less success in terms of quality productions. Thus the aim of the participatory research is to make an assessment of the possible options that may improve milkfish harvest in community ponds.

### Objectives

- Evaluate the impact of stocking density on growth of milkfish in ponds
- Train the communities on better pond management options to improve milkfish production

# **Brief description of methods**

Milkfish fingerlings were collected from the wild by fishers and community group members in mangrove channels to stock ponds. Fish were corralled for 24 hours in a *hapa* (mosquito) net staked in the pond to enable their measurement (weight, standard and total length) before stocking. The fish were weighed using a balance and their length with a ruler. Size of fingerlings stocked varied between 2-8 cm in total length. The fish were stocked at 2 fish/m<sup>2</sup>.

# Main findings

Milkfish grew from an average stocking weight of 5 g to an average of 115.4 g within 3 months during the wet season but their growth was double in the dry season. The dry season yielded a significantly higher growth rate for both milkfish (1.21g/day) compared to the wet season.

# Project 4: Silvofisheries Training for Gazi bay communities

Participating Institutions: Kenya Marine and Fisheries Research Institute (KMFRI), Gazi fishermen group, Makongeni's Baraka conservation group
Scientific Team Members: David Oersted Mirera
Technologists: Johnson Nyamari
Source of Funds: WWFEFN
Duration: 6 months (2010)

# **Research Problem**

The long time research done at Gazi bay on mangrove conservation and management has seen the need developing livelihood options for the communities in the bay as an incentive to mangrove management. Thus, this training project was designed to help equip the communities at Gazi and Makongeni on the best approaches towards utilizing the mangroves for silvofisheries activities.

# Objectives

- Assess the understanding of the communities in silvofisheries.
- To train the communities on livelihood alternatives
- Build up site-based trials on silvofisheries through contruction and rennovation of existing ponds

# Brief site description and methodology

In the current fiscal year, the Makongeni community was assisted to rennovate their three fishponds and lyned them with nets in preparation for mud crab stocking. One

pond was stocked with 100 sub-adult crabs while the other two are under preparation for stocking. Also Gazi community was assited technically to rennovate two ponds for milkfish farming.

### Main findings and conclusion

The communities need support to stock the ponds prepared since the training programme is concluded.

Good follow-up and close monitoring will help the communities in stocking and culturing the silvofisheries candidate species to market size.

# **Project 5 : Extension Services**

Participating Institutions: Kenya Marine and Fisheries Research Institute (KMFRI)
Scientific Team Members: David Oersted Mirera
Source Of Funds: Mr. Chakera (Farm owner)
Duration: Upon request (2010)

### **Research Problem**

Communities are realizing the need for fish farming along the coast of Kenya. Irrespective of the limited technology, they still opt to initiate fish farming on their own. This when problems of stunted growth and over production occurs from fish like tilapia; farmers tend to seek for answers and hence technical support. This formed the basis for a visit to the Chakera farm at Mtwapa.

### Objectives

- To advice the farmer on how best to improve growth of his tilapia fish
- Advice the farmer on management and feeding regimes for the fish

### Brief site description and methodology

Mr. Chakera cultures his fish in concrete tanks. The fish were sampled and the sorted with respect to size. The collect feeding rate was calculated and water quality measurements analyzed to assess suitability for culture.

### Main findings and conclusion

The fish in the tanks had stunted due to limited feeds given to them. The farmer was advised to give fish the right quantity and if possible assess the possibility of getting the recommended feeds. The stocking density was high and the farmer was advised to help control the population through introduction of catfish.

# Project 6: Enhancing Food Security among Coastal Fisher Communities: Promoting Small Scale Mariculture Technologies along the Kilifi Creek

**Participating Institutions:** Kenya Marine and Fisheries Research Institute (KMFRI), Pwani University, Coastal Oceans Marine Research Development (COMRED), Fisheries department (Kilifi District)

**Scientific Team Members:** David Oersted Mirera, Dr. Christom Mlewa, William Nyaga, David Bett, Joseph Tunje, Dr. Mwakumanya Maarifa

Source of Funds: National Council for Science and Technology (NCST) Duration: 3 Years

# **Research Problem**

An ever increasing population and lack of alternative livelihoods means more people in fishing villages along the Kenya coast venturing into fishing resulting in overexploitation of marine fisheries resources and destruction of marine habitats; which has subsequently undermined food security and contributed to high poverty level. Adoption of small scale mariculture has been shown to enable fisher communities meet their food needs and earn income to raise their standards of living.

# Objectives

- Build capacity of the local fisher communities on various aspects of small scale mariculture
- Facilitate the community to construct, stock and manage cultured organisms in ponds

# Brief site description and methodology

Capacity will be built through trainings, on-site demonstration and participation of community members. The trainings will be structured to transfer knowledge and skills in various aspects of small scale mariculture. The training on small mariculture techniques will focus on construction of production units, stocking, routine fish pond management activities including feeding.

# Main findings and conclusion

The project has been initiated and 15 members of the community given a formal training on basic principles of mariculture. Onsite activities have lead to development of one fish pond and the second one is in its initial stages.

# **Project 7: Feed production**

Participating Institutions: KMFRI Scientific Team Members: Dr. Betty Nyonje, Ms. Miriam Wainaina, Ms. Morine Mukami ,Mr. Joseph Omondo, Mrs. Matunga Source of Funds: GoK, seed fund Duration: One year

# **Research Problem**

Feed requires over 50% of the operating costs of aquaculture production systems. Our work at the programme has focused upon the use of readily available and cheap diets. Formulated fish diets are expensive and not readily available to small-scale farmers, in contrast to commercial livestock feeds. On the other hand the feeds can also be used for human consumption hence there is competition amongst the fish and human beings. The diets that we are currently using are *Caridina niloticus*, wheat bran and maize bran which are quite expensive for fish farmers to obtain. Research into appropriate and low cost feeds or feeding regimes is therefore paramount for aquaculture development. Another issue in respect of availability of affordable feed is the inadequacy of both human and infrastructural capacity to conduct research as well as to mass produce feeds needed for aquaculture development. It is on this note that we are finding means of using the locally available cheap feeds for fish farming.

# Objectives

- Establish nutritional content of locally available and cheap feed ingredients through proximate analysis
- Formulate feed for target species using cheap local ingredients
- Conduct experimental testing of feeds

# Activities

- Proper feed formulation, drying and storing them.
- Proximate analysis of the available local ingredients
- Experimental set-ups of the formulated feeds

# Site description and methodology

The project focuses on locally available by-products particularly agricultural wastes. Feed formulation process involves quantification of the amounts of ingredients needed to form a single uniform diet in a proportion necessary to provide the organism with proper amount of nutrients. The feed formula is based on the target protein level required by a particular species. Protein levels are determined by the standard micro-Kjedahl Nitrogen methods or by extraction in a Soxhlet extractor. Grow-out diet consisting of 30% protein and a starter diet of 35% protein have been formulated from *Caridina niloticus,* rice bran and maize bran. The Pearson's Square method was used for calculating the quantities of different ingredients. For the starter diets the feed ingredients were sieved using fine mesh while for grow-out diets the particles sizes were relatively large. The ingredients were weighed according to the quantified amounts and mixed to get a uniform feed. This was then either fed to the fish directly or pelletized and dried.

### Main findings and conclusion

The formulated diets are used to feed catfish grow grow out size while consumed by goldfish grow and tilapia from fingerling stage at Mombasa aquaculture programme. The pelletized and dried feeds are more convenient to use and store than the originally used agricultural by-products. It is also cheaper than buying or procuring feeds from shops. Feed test experiments carried out so far have proved that cotton seed cake restricts growth of fish. This feed ingredient has therefore been eliminated from the diets formulated. The main challenges faced here are:-

- 1. The drying method of the formulated feeds is a challenge since they are either blown away by wind or rained on. This is because there are no effective drying mechanisms in place. There is need to have drying ovens and racks to solve this problem.
- 2. Lack of proper storage facilities has led to low production of formulated feeds
- 3. The equipment for proximate analysis is not working hence the need to have the equipment repaired.
- 4. The pelletizer is manually run hence there is less production of feeds hence need to have a mortar-run pelletizer.
- 5. Need to add a small pelletizer so as to produce small sized pellets for tilapia fingerlings.
- 6. Establishment of a mariculture research station to be able to establish laboratories and have enough pond and tank space for different food experimental set-ups
- 7. The Caridina is sourced from Kisumu which is far from Mombasa and therefore there is need for more funding in order to test more feeds locally available in the coastal region.
- 8. Need to make our fish feeds as per the KEBS quality standards if we are to sell the feeds to farmers.

Once all these challenges are tackled the feed formulations project will run on well with enough feeds for the experimental set-ups and spare some for selling to farmers.

# Project 8: Development of a Seaweed Nursery for Kappaphycus alvarezi (cottonii) and Eucheuma denticulatum (spinosum) in the South Coast of Kenya

Participating Institutions: KMFRI, Pactkenya, Fisheries, BMU's
Scientific Team Members: Elisha M'rabu Jenoh, Dr. Betty Mindraa Nyonje.
Technical Team: Norah Magangi, Anthony Kiema, Alex Kimanthi, Antony Nzioka.
Source of Funds: Seed GOK and Reco Map Kenya
Duration: July 2010-June 2011

### **Research Problem**

Seaweed farming is often depicted as a sustainable form of alternative livelihood, contributing to poverty reduction and financial revenues in producer countries. Since the market of carrageenan (the extracts of dried seaweed) continues to grow and that current sources of cultivated eucheumatoids seem incapable of meeting demand, at least in quality, price and volume for the requirements of the processing industry. This venture has the potential to change the social economic status of any hard working poor coastal communities, offer employment and substantial foreign exchange to the countries involved at the commercial level of farming owing to availability of the ready market. Extracts of dried seaweed (carrageenan) are highly demanded for their use as thickeners, in food and in pharmaceutical and cosmetic industries. Thus seaweed farming initiative has frequently been suggested as both a means to improve social economic conditions and a means to reduce pressure on capture fisheries.

Kenya, through a collaboration between KMFRI (government parastatol), PactKenya (NGO) and TDCM (BMU) have spear headed the development of commercial seaweed farming. This venture was initiated through the government seed funds and through a project funded by ReCoMap. In this endeavor, KMFRI is involved in the technical aspect of the seaweed development, handling the scientific experiments for the purpose of growth comparison on the three different growing methods namely: Off bottom, Net method and Broadcasting method and on the two seaweed strains. Observations and the results from these experiments are to be used for proper guidance of the seaweed farmers in Kibuyuni in the immediate future but also to guide policy in general for the development of the seaweed industry in Kenya. On the other hand, PactKenya and TDCM were tasked to oversee the commercialization aspect of the seaweed farming in the country.

To develop profitable commercial seaweed farming in Kenya, KMFRI was also tasked to introduce and research on the growth possibility of *Kappaphycus alvarezii* a seaweed species commonly referred to as Cottonnii. *Kappaphycus alvarezii* (Doty) Doty ex Silva is economically important red tropical seaweed highly demanded for its cell wall

polysaccharide, being the most important source of n-carrageenan in the world (Bixler, 1996). It therefore fetches a higher market price than the *E. denticulatum* (spinosum) making it an economically attractive species to grow for commercial purpose. However it is a more delicate species to farm compared to spinosum.

# Objectives

Overall objective was to compare the three seaweed growing methods namely: Off bottom, Net/lag method and Broadcasting method in Kibuyuni.

# Specific objectives are:

- To determine seaweed growth rates using the three growing methods.
- To determine the growth rate of the two strains of *Euchema denticulatum* (spinosum) species
- To Assess effect of shocks to system during 12 months natural cycle;
  - Pest species
  - o Herbivorous fish
- To establish a cottonii nursery in Kibuyuni.
- To undertake a joint monitoring with KEPHIS on the cottonii nursery.

# Activities

- Collect data on monthly experiment on the seaweed growth rate
- Record all the shocks to system during 12 months natural cycle.
- Establishment of Kappaphycus alvarezii nursery in Kibuyuni.
- Conduct a joint monitoring with KEPHIS on the cottonii nursery

# Site description & Methodology

The main study area is shimoni-Kibuyuni village. In this village both Seaweed experimental plots and commercial were established. Sites for the three planting method were chosen in considering to their suitability since every method is favoured by different factors. After setting the farms, planting of seaweed crop was done at the same time (day) during spring low tide for all the three methods. For each method seedlings of 50g to 100g were used for planting the farms. The farms were monitored every spring tide (two week intervals). Data on growth in grams was recorded three times at two weeks interval using a portable electronic weighing balance and/or normal spring balance. The condition of the harvested seaweed was also recorded and both seawater temperature and salinity was recorded. Herbivory, sedimentation, pest seaweed and ice-ice infestation was also observed and recorded. Salinit , temperature and condition of the harvested seaweed were recorded.

### Quarantine

Imported Kappaphycus alvarezii from Pemba was taken to the lab and washed with water from the ocean and placed in five different aquariums for quarantine as is required by the government for every imported organism. Seawater was pumped directly into the aquarium three times a day for 12 days. Temperature was maintained at 24-26°C (by use of ice in plastic bottles) using a laboratory thermometer. Every tank was subjected to aeration and husbandry in order to maintain its health. Quarantine is on going.

#### Main findings and conclusion

Generally the project went as planned, having taken data for the growth rate as planned. The quarantine went on as well followed by successful introduction of the cottonii the acquiring of the permit to import the seaweed species from Pemba was also a mile stone. Data collection fully went on as planned. We were able to do a joint monitoring with KEPHIS for the cottonii nursery. Preliminary findings indicate that the green species had in average more production in weight than that of the green strain of the E. denticulatum. The months of January to aprill and June to July 2010 showed better growth rates compared to the other months. Result from both years indicate that the method that show better growth rate in terms of weight in grams is the Net/lag method. Temperature and sedimentation were the incidences that highly impacted on the growth of the seaweed. These incidences were reported for both years. In 2010 the presence of high sedimentation caused the drop in production and an increase of ice ice condition on the seaweed during the months of September –December.

### **Project 9: Ornamental fish production**

Participating Institutions: KMFRI

Scientific Team Members: James Mwaluma, Dr. Betty Mindraa Nyonje Technical Team: Mwendwa Mbaluka , Daniel O diwuor Source of Funds: Seed GOK Duration: August 2010-June 2010

#### **Research Problem**

Ornamental fish farming is a way of revenue generation that has been widely used. In Kenya this venture has not been fully appreciated as a way of revenue generation. Today, there are a number of ornamental fish dealers who mainly target the European and the American market. However a few ornamental fish dealers who mainly target both the local and regional market have come up recently. Kenya marine and fisheries research institute endeavored to produce ornamental fish en mass for revenue
generation. During the production process emphasis was put to production of different ornamental fish species. In order to enhance revenue generation, we aimed to make aquaria prototypes so as to market ornamental fishes as a complete package.

### Objectives

- To breed and sell the goldfish for income generation
- To induce and produce different species of goldfish.

### Activities

- Produce at least 500 ornamental fish per month.
- Generate revenue from sell of Ornamental fish
- Make aquaria prototypes and market as complete package

### Brief site description and methodology

### Site description

The ornamental fish were spawned in 4 concrete tanks each measuring 2x1x1 m in Mombasa wet lab center. Mombasa being a tourist town there is high demand of ornamental fishes. For a start we targeted the ornamental fish dealers and walk in clients as our market.

### **Breeding methodology**

Goldfish breed naturally and we did not need to induce them with hormones or pituitary gland solution. Broodstock goldfish were induced to spawn in concrete tanks by temperature control. Water in the breeding tanks was lowered and left for about 4 hours to allow the water to heat and then gradually increased back to the original level. The difference in temperature induced the goldfish to spawn. Goldfish fry were then removed and placed in aquarium tanks where they were fed with live artemia until they attained 10mm after which they were placed in outdoor tanks.

### **Current status and recommendation**

Goldfish sold to dealers and individual buyers generated total revenue of Ksh 8160 this financial year with a production of about 500fry/month. It is envisioned that in the next financial year 2011-12 this amount will be surpassed after renovation of the wet lab and increase in broodstock has been accomplished.

## Project 10: Evaluation of shrimp farming at Ngomeni and mariculture activities in Shimoni KMFRI plot

### Participating Institutions: KMFRI

Scientific Team Members: Dr James Mwaluma, Dr Betty Nyonje, Miriam Wainaina, Dr Robinson Mugo , Maureeen Mukami, Dr Charo, Dr Munguti,
 Duration: 18<sup>th</sup> and 19<sup>th</sup> April 2011

### Introduction

The Ngomeni shrimp farming trials were carried out by Fisheries Department and FAO, Fisheries department, Rome between 1984 and 1986. The project achieved very good results with the production of *Penaeus indicus* with potential of expanding to culture of *P. monodon* (FAO 1985). The two local species grew perfectly over 25 – 35 °C, which were the average temperatures recorded in the ponds during previous cultures. Temperatures in the ponds could reach 42 °C with no adverse effects (FAO, 1985). Results further indicated that *P. indicus* could be cultured in Kenya without sophisticated technology and also due to the fact that that fry were readily available in the area within the mangrove pools. However, in order to play a role in research, development and demonstration, the farm management needed to be seriously modernized (FAO 1985). Further to this, a demonstration of the economics needed to be done taking into account the specificity of the Kenyan condition (FAO 1985).

The Ngomeni aquafarm was found to be a correct tool that needed to be improved to permit easier management, ensure proper farming procedures in order to give reliable repetitive experiments (FAO 1985).

### Objectives

This report is a result of a site visit by KMFRI Aquaculture experts on 18<sup>th</sup> and 19<sup>th</sup> April 2011 whose primary objective was to;

- Assess the previously developed Ngomeni shrimp farm with the intention of reviving the culture.
- To survey the KMFRI Shimoni plot (South coast) with the aim of proposing possible mariculture activities.

### Brief site description and methodology

In Ngomeni, the assessment included a tour around the entire ponds (12.97 ha) on 18<sup>th</sup> and 19<sup>th</sup> April taking stock of the condition/status of the dykes, pond gates, with the intention of identifying ponds which could be immediately revived for culture. A similar

assessment was made for the office infrastructure and sorting out area opposite the grow out

In Shimoni, the assessment involved a visit to the plot site on 20<sup>th</sup> April in order to assessing and to recommend possible mariculture activities.

### **Current status and recommendation**

### Ngomeni

From the tour around all ponds it was observed that shrimp farming was still feasible at Ngomeni, as flooding of the sea water was observed to occur in all ponds and be able to drain completely drain during low tides..

Currently the basis for development of the shrimp farm in Ngomeni is to renovate the existing ponds with emphasis on engineering works and deployment of competent staff at the site. The existing ponds are perfectly adapted for future research and development programme as well as for training. However a lot of improvements should be done in order to stimulate production. It is proposed that trials be carried out on initially three plots (P7, P8 and P9) located near the main inflow gate. However a lot of renovations would be necessary (see full report) Competent staff will also be needed for the day to day activities in the pond. It is recommended that and 4 other locals from Ngomeni be employed to be fully involved in the culture exercise. During culture fencing of the plot will be necessary to deter poachers

### Shimoni KMFRI plot

A tour of Shimoni was made on 20<sup>th</sup> April 2011. The land under survey measures 15 acres and is located 2<sup>nd</sup> row from the sea making it highly suited for mariculture activities. Access to the plot was made from two directions in order to observe the landward extent of the plot. The following observations were made;

- The plot is thick with bushes and shrub
- The plot is underlaid by rock making it easy for construction of buildings and ponds

### Recommendations put forward are;

- As an initial step money should be made available to clear the entire plot of the bush
- Proposal should be written to start development of the plot for mariculture. Suitable target species would be sea cucumbers, grouper culture, ornamental fish

## Project 11: Development of "An identification manual of fish larvae off the Kenyan coast"

Participating Institutions: KMFRI MOI UNIVERSITY Scientific Team Members: Dr James Mwaluma, Professor Boaz Kaunda-Arara Technical Team: Dickson Odongo Source of Funds: Masma (WIOMSA) Duration: February 2011-November 2011

### **Research Problem**

This was an offshoot of the previously funded MASMA project entitled Larval settlement rates and reef recruitment dynamics in coastal Kenya: Implications for fisheries management and Conservation in Eastern Africa" (WIOMSA/MASMA/AG/2004/03).We set out the purpose of production of a marine photographic fish larvae identification manual after realizing the lack of a proper guide for identifying larval fish in the WIO.

This would interest:

- Scientists interested in the identification of larval pools from the WIO
- Students interested in Marine fish larval studies
- Conservation and monitoring initiatives on fish larvae.

### Objectives

Collection and identification of fish larvae from the lowest taxonomical level possible along the coast of Kenya

### Photography and description of fish larvae collected

### Activities

Fish larvae samples were collected from Shimoni, Nyali lagoon Mombasa, English point, Vipingo (Kuruwitu), Kilifi, Watamu and Malindi. Additional fish larvae samples were added from the Ungwana bay project. So far larvae have been identified to the lowest taxonomical level and are awaiting to be transferred to Nelson Mandela Metropolitan University in South Africa where photography and further identification of the species will be done. This will be from August 15- 20<sup>th</sup> August 2011

### Brief site description and methodology

At each site, 7-14 replicate tows were made by towing a  $500\mu$ m plankton net for about 20 minutes behind a boat. Collected samples were labelled and preserved with 5% formalin for laboratory analysis. In the lab, samples were identified to lowest

taxonomical level and preserved with 70% ethanol in individual vials awaiting photography.

### **Current status and recommendation**

Samples have been identified and labelled awaiting photography and further description in South Africa in August 2011.

Project 12: A molecular consideration of Western Indian Ocean marine fish connectivity and regional differentiation at multiple spatial and temporal scales and its implications for conservation and resource management

Participating Institutions: KMFRI, SOKOINE UNIVERSITY, SAIAB & IFREMER
Scientific Team Members: Dr James Mwaluma, Dr Monica Mwale, Dr Augustine Mwandya, Dr Garvin Gouws, Dr Jerome Bourjea, Dr Delphine Muths
Technical Team: Daniel Ocharo (Shimoni), Kenneth (Shimoni)
Source Of Funds: Masma (WIOMSA)
Duration: May 2009- November 2011

### **Research Problem**

This projects aims at studying genetic connectivity and regional intraspecific differentiation in a number of WIO marine fish species. These include *Myripristis* bernerdii, Abudefuf sexfaciatus, and Lutjanus kasmira among others.

### Objective

In so doing, part of the activities envisioned was to sample fish for genetic analysis at different spatial scales including Kenya, Tanzania and South Africa, Seychelles, Comoros, Madagascar and Mozambique.

### Brief site description and methodology

Samples for DNA have been collected in Kenya (Shimoni), Tanzania (Dar es salam, South Africa, Madagascar, Seychelles, Maldives and Mozambique. Tissues samples of muscle, fin or gill were clipped from samples collected by fishermen at fish landing sites and placed in individual vials containing 70% ethanol. These samples were later on transferred to South African Institute for Aquatic Biodiversity (SAIAB) for detailed DNA analysis. Data collected was compared using relevant multivariate (analysis) softwares.

### Current status and recommendation

Genetic differentiation of *Myripristis bernerdi*, and *Lutjanus kasmira* have been described and compared for this species in the Western and SWIO region and the papers have been submitted to MEPS for publication.

## Project 13: Improvement of the Living Standard of Rural Communities in Kenya through Artemia Production in Coastal Saltworks"

### **Participating Institutions:**

- 1. Kenya Marine and Fisheries Research Institute
- 2. Laboratory for Aquaculture and Artemia Reference Center, Department of Animal Science, Ghent University, Belgium
- 3. Can Tho University, Department for fisheries and Aquaculture, Vietnam
- 4. Kensalt, Malindi-Kenya
- 5. Private (Artisana) Salt Farmer, Malindi-Kenya

Scientific Team Members: Dr. Betty Nyonje, Ms. Morine Mukami, Mr. Joseph Omondo, Mr. Dan Ochuodho

**Source of Funds:** Flemish Interuniversity Council – VLIR-UOS **Duration:** Four years

### Duration. Four years

### **Research Problem**

This project intends to upgrade the living conditions of rural communities in Kenya by the pond production of Artemia cysts and biomass in locally available salt production systems, and by application of Artemia cysts and biomass in emerging larviculture initiatives. The benefits of integrated production of salt and Artemia will be demonstrated in a pilot unit: apart from improved salt quantity and quality, an additional source of income is generated through production of Artemia cysts and biomass. These are crucial for the optimal local development of shrimp and fish larviculture. Local community development centres, which have already developed in the past very extensive aquaculture initiatives for the benefit of rural communities, will be the target of demonstration of project activities throughout the project lifetime. The creation of a critical mass of practical and theoretical expertise at the partner institute will be realized through a multi-faceted training programme, including short term trainings on the field, at the Flemish partner institute and at Can Tho University, Vietnam, and by 1 Master of Science in Aquaculture and 1 sandwich PhD study at the Flemish partner institute.

### Objectives

- To explore local Artemia production in order to fulfill the Kenyan requirements for Artemia cysts and biomass and eventually to enter the international market
- To develop routine technologies in view of harvesting, processing, packaging, storing and transportation of locally produced Artemia.

- To improve the use of Artemia cysts and biomass as a source of live food in local aquaculture operations
- To improve the living conditions of coastal rural communities in Kenya by creation of employment opportunities through *Artemia* production and application

### Activities

- Purchase of necessary equipment
- Pond construction
- Inoculation of artemia ponds with artemia
- Proper management of the artemia ponds
- Harvesting of cysts and biomass
- Laboratory tests

### Brief site description and methodology

The project site is located in Kadzuhoni village in Gongoni location in Malindi District. The land on which the project is being carried out is of a salt artisanal farmer, Mr. Swaleh, who is very supportive of this whole initiative. The project first began with construction of ponds for the artemia-salt production. This was later followed by pond preparation i.e. filling the pond with high concentrated water, manuring and raking of ponds. After pond preparation inoculation of artemia and daily pond management followed. The daily pond management involves pumping water in the ponds daily in the already inoculated ponds, raking, manuring and fertilizing, observing the biotic and abiotic parameters and lastly harvesting cysts immediately they are produced.

### Main findings and conclusion

The project has progressed on well since its inception. Twenty one ponds have already been constructed. There are so far two reservoir ponds of  $1000m^2$ , two crystallization ponds of  $300m^2$  and lastly seventeen experimental ponds. Two of the experimental ponds have an area of  $1,000m^2$  each while the other fifteen ponds have an area of  $300m^2$ .

Artemia fransiscana cysts from Vietnam were first inoculated on 1<sup>st</sup> November, 2010. After the first and second inoculation of the ponds took place there was high survival rate of artemia and production of cysts as well. However this was later affected by drastic changes in temperature in the onset of the short rains in December, 2010. However, there was great improvement in the third and fourth quarters of the year since there were no drastic temperature changes experienced. In the fourth quarter about 600g dry weight cysts were collected. Noting that this was the first year of the project where much of the time was used in construction of the ponds and experimental trials it is expected that much will be achieved in the second year.

Two experimental set-ups were carried out on culturing *Artemia* in managed and unmanaged ponds during the third and fourth quarter. It was realized that there was more production of cysts in the managed ponds unlike the unmanaged ponds. The *Artemia* in both experiments grew almost at the same rate up to day 14 and later there were significant disparities in growth observed. This therefore shows that it is better to fully manage artemia ponds to achieve a higher production.

There have been challenges of building brine to the expected salinities and invasion of predators but solutions to these challenges have been found. It is therefore expected that there will be a smooth flow of the project in the second year.

## WORK PACKAGE 3: Developing techniques for reducing post-harvest losses

### Programme overview

The programme focused on work involving post harvest technology and value addition. Value added dried fish products by marination were tried on Siganids (Taffi) in Shimoni. The products were acceptable to the consumers who tasted them. Work on "reducing post harvest losses by 10%" using the predictive model on post harvest losses evaluation was carried out by comparing losses due to traditional handling and processing with losses due to handling and processing by improved drying methods like rack dryers and dome tent dryers. The improved methods resulted in less post harvest losses. . A total of 2 Solar tunnel dryers and a solar tunnel –windmill system were constructed. The dryers were constructed and installed in Shimoni, Moa and Kipini. Some of the dryers faced challenges which are still being addressed. On subsequent testing of the dryer in Shimoni, it was realized that the glass cover for the collector plates kept cracking. Efforts were made and are still being made by our collaborators to establish the root cause of the cracks. The cracks are sometimes large ending up in broken glass. The dryer in Moa was however yet to be tested fully as it was ready in the month of June Drying trials using the hybrid solar-windmill system were carried out. Early in the month of May, strong winds never experienced in Kipini before caused several damages. The windmill system of our dryer was broken in the process. This was more or less a *force majeure* (act of God). Efforts are still being made to see if the windmill system can be restored.

### **Research Scientists**

- 1. Peter Oduor-Odote-Programme coordinator
- 2. Cyprian Odoli-ROII
- 3. Stanley Onyango-ARO

## Project 1: Community involvement in production and marketing of value added fish products

Participating institution: KMFRI Scientific team members: Peter M. Oduor-Odote Source of funds: Lighthouse foundation

### **Overall Objective**

The objective of this study was to produce solar dried value added Taffi products

### Scientific Objectives

- 1. To evaluate organoleptic quality of solar dried Taffi in soy, teriyaki, and brine.
- 2. To evaluate drying characteristics of the value added Taffi products
- 3. Undertake post harvest analysis to establish shelf life

### The problem

Whereas studies that have included technology transfer have been adopted well by the two community groups in Gazi and Shimoni on fish smoking and drying, the full potential of utilization of the valued added smoked or dried products from such value added production systems is still to be realized. This is because currently the communities in the areas where these improved fish products are processed and their trading counterparts at inter-community level cannot afford the real price of the better quality products. This has been brought about by levels of poverty in the regions compounded by the adverse effects of drought and the global financial meltdown. The situation has led to the need of looking at the market beyond the initial target local community areas into the national markets. Such new markets, expanded to reach the national level also come with their challenges which are to be addressed.

### Methods and study area

The study area was in Shimoni where community members belonging to the fisherfolk group were trained on value addition before solar drying of Taffi.

The fish were purchased fresh at Shimoni and gutted then filleted. The fish were washed thoroughly in fresh water, and drained.

The marinades for value addition for 5kg fish were prepared and labeled as follows:

### Soy marinade

1 litre of soy was poured in a clean plastic container, juice of 4 to 5 lemons were added, then 50g salt and 100g sugar added. Ground ginger and garlic was also added. The ingredients were mixed together.

### Teriyaki marinade

400 g of Teriyaki paste was mixed with 15g of garlic powder then 350 mls water added and then mixed thoroughly

### Brine marinade

210g of salt per litre of water was used. The salt was dissolved in water in a clean container and fish placed inside

### Unbrined or untreated control

No additive was used

Each marinade was separately poured at the bottom of a clean container. A layer of fish fillet followed then marinade and fish layer. This stacking continued until all the fish was covered with marinade. The lids of the containers were replaced and the mixture allowed to stand for 2 hours. The marinated fish were removed and drained. The fish were then transferred to the solar tunnel dryer and dried

### Project findings

The high organoleptic scores obtained in this study indicate that the value that was added by marination to the Taffi fillet was appreciated and hence introduction of such products in the market could yield good returns. Teriyaki is good in drying but not as much in taste while soy and brine are good in taste but not so in drying

## Project 2: "Reducing post harvest losses by 10%: Predictive model for post-harvest losses evaluation

**Reducing post harvest losses by 10%:** Predictive model for post-harvest losses evaluation

Participating institution: KMFRI Scientific team members: Cyprian Odoli, Stanley Onyango and Peter M. Oduor-Odote Source of funds: GoK Status: Continuing from previous year

### **Objectives:**

- To come up with an appropriate and efficient loss assessment methodology applicable in our fishery
- To compare losses due to traditional and the developed rack and solar dryers

### **Overall Objective**

To determine the qualitative and quantitative loss incurred in the distribution chain of two main types of fish landed at south coast by comparing post harvest losses and performance of the traditional and improved fish sun drying methods

### Scientific Objectives

I. To come up with an appropriate and efficient loss assessment methodology applicable in our fishery

II. To compare losses due to traditional and the developed rack and solar dryers

### The problem

As the Kenyan population grows, increasing food supply becomes an ever more urgent priority. One vital aspect is the reduction of food loss after harvesting. For fish and seafood, being perishable, the situation is more crucial and the reduction in quantity and/or quality is enormous and difficult to estimate. In Jasini area of Vanga, the sardines that are landed in large quantities are laid on the ground to dry. This leads to contamination. To avoid this, rack dryers and solar tent dryers have been introduced on a small scale to determine whether their use shall result in fish of better quality devoid of sand particles and other forms of contamination

### Methods and study area

The area of study was Jasini area of Vanga (South coast). The methodology used to generate information for Predictive model for post harvest losses evaluation was direct observation and semi-structured interviews.

Three different drying systems were tried out on purchased fish namely sea basin (traditional), rack (improved) and dome dryer (improved). Drying characteristics of the fish were determined after every two hours until constant weight was attained (two days). The following measurements were recorded; Start weight as the weight of the quantity of fish that enters the chain or processed, weight lost (the weight of fish physically lost during processing), Percentage left after drying and weight at low price (fish sold for a reduced price).

Weights and price for products processed by each method were recorded and a market survey carried out at three major market centres to establish marketing channel and product acceptability.

### **Project findings**

The findings showed that major post harvest losses occur during processing on the sea basin (sand) and transportation to markets (retail).

Improved rack drying system produced better quality fish than dome system which was attributed to free air circulation in open rack drying than enclosed dome drying. The improved processing systems contribute to the better utilisation of fish resources by reducing the losses by 10.9% on applying the predictive model.

The retailers and consumers preferred fish dried on sea basin based on appearance whereas improved processed fish scored highly on sensory evaluation of cooked samples in the laboratory

### Project 3: Solar drying technology for fish drying in the Tana delta region

Participating institutions: KMFRI and JKUAT
Scientific team members: Peter M. Oduor-Odote, Cyprian Odoli, Stanley Onyango, Douglas Shitanda
Source of funds: GoK
Status: Continuing from previous year

### Objective

• To develop and test a functional solar tunnel dryer for drying fish in Moa in the Tana delta region,

### The problem

Moa in the Tana delta region is known for traditionally processed fish by smoking and sun drying. Sun drying is done by laying the fish on roofs of the grass thatched houses or hanging them on strings outside or just laying then on the ground. This is a slow drying process and the fish are exposed to contamination by birds, attack by rodents and infestation by insects. Drying in an enclosed cabinet of the solar tunnel dryer helps reduce the risks of contamination

### Methods and Study area:

A solar tunnel dryer was installed in Moa in June. The fabricated glass panel solar powered tunnel dryer was composed of a collector, a drying chamber, exhaust chamber and the power source. There was an inlet chute, a heat collector made up of a collector panel, insulating board and a collector wall. There is a drying chamber made up of drying chamber walls and drying trays. There is an exhaust chute made up both lower and upper end chutes. The power source is supplied by a 100W solar panel and is stored in 100Ah accumulator. The charging of the accumulator is controlled by a 15A charger controller.

### **Project findings**

It is still difficult to ascertain the efficiency of this dryer because drying was carried out during very unstable weather conditions. In the first 2 days of drying, the weather was very cloudy and slightly windy and wet. On the 3<sup>rd</sup> day there was sunshine and a huge drop in weight was observed for the fish drying in the solar tunnel dryer. This study is yet to continue.

### Project 4: A hybrid solar-windmill dryer for fish drying in Kipini

### Participating Institutions: KMFRI

Scientific Team Members: Peter M. Oduor-Odote and Prof. Douglas Shitanda (JKUAT) Source of Funds: National Council of Science and Technology

### **Technological and Scientific Objectives**

- Construct an integrated solar tunnel dryer-windmill system
- Compare performance of the integrated system with the solar tent dryer and drying racks commonly used

Study area: Kipini Status: Continuing from previous year

### The problem:

Kipini is one of the leading fish landing sites in the North coast. Fish drying is commonly practiced. Fish drying however takes place on sand or on rocks as well as on roof tops. These result in unhygienically dried fish. Attempts were made to introduce a hybrid-solar windmill system that could dry the fish hygienically and also dry the fish during dump weather conditions.

### Methods and study area

The study was carried out in Kipini in the North coast of Kenya. In this study, three drying facilities were constructed namely a drying rack, a dome tent dryer and a hybrid solar tunnel dryer and windmill system. The dryers were used to dry fish and a farm produce: pepper. The solar tunnel windmill system was also used to generate electricity for use by a neighbouring homestead. The hybrid solar windmill dryer consisted of a solar collector, hot air chamber, a drying chamber, a hot water heating system made up of copper coil tubes and an insulated water tank, an air inlet and outlet chamber, an airflow system, a wind generator, batteries, inverters and charge controller. The rack dryer consisted of mangrove poles and a nylon attached to the mangrove poles in form of a raised drying table and the dome tent dryer consisted of UV stabilized polyethylene mounted on wooden frames forming a dome structure. At the top was placed an echo vent for air extraction.

### **Project findings**

The fish in the solar windmill system dried fish to a moisture content of 0.208 kg/kg dry basis (db) (17.2% wet basis (wb) from 3.9 Kg/Kg db (79.8% wb). The drying rack dried the fish to a moisture content of 0.228kg/kg (18.54% wb) from 3.9 Kg/Kg db (79.8% wb) while the dome tent dryer dried the fish to a moisture content of 0.532 kg/kg db from 3.9 Kg/Kg db (79.8% wb) over a 4 day drying period. The drying rate constant was 0.06 for the fish in the solar tunnel windmill system and 0.05 in the drying rack and dome

tent dryer. The farm produce that was dried (pepper) lost 80% of weight during the drying period of 4 days and the final product was ground into chilli powder ready for other applications. The hybrid solar-wind mill system dried fish at a faster rate than the drying rack and dome dryer. It also dried the fish to a lower moisture content suitable for storage. Some adjustments were made on the original design of the solar-tunnel windmill system. A hot water system was installed to provide heat during the dump conditions. This is because there were no heating coils that would take direct current (DC) in the market. The windmill system also generated electricity which one house hold was using.

# WORK PACKAGE 4: Investigate the demographic and cultural characteristics of the fisher families in order to understand the relationship between the aquatic resources and the rising human induced pressures

### Programme overview

Socio-economics research programme deals with the studies on social and economic issues that affect the coastal communities and impact on the use and management of marine and coastal resources. Socio-economic assessments and monitoring were conducted on the performance of fisheries and aquaculture, and the relationship between marine and coastal resources and the rising human induced pressures. Specifically, in 2010-2011 performance period, the programme focussed on

- Investigating the demographic and cultural characteristics of the fisher families in order to understand the relationship between the aquatic resources and the rising human induced pressures.
- Study alternative fisheries management systems focusing on the participation of communities on sustainable management of aquatic resources.
- Study the constraints, challenges and opportunities in aquaculture development and those presented by global markets, migrant fishers and shoreline changes.
- Study community vulnerability to emerging issues such as climate change and their capacity to cope and adapt to these issues
- Study the causes and impacts of high poverty levels in fisher communities.

### Personnel

### **Research Officers in-post in the programme:**

- 1. Jacob Ochiewo Research Officer I (Programme Coordinator)
- 2. Edward Waiyaki Research Officer II
- 3. Fridah Munyi Assistant Research Officer (Out of the country for Masters Training on Social Policy Analysis)

One officer, Mrs. Fridah Munyi-Leshan is on training in Belgium and is expected to return before the end of the year.

### **Optimal staffing requirements by 2015:**

Position	Number required
Chief Research Officer	1
Principal Research Officer	2

Senior Research Officer	2
Research Officer I	2
Research Officer II	2
Assistant Research Officer	3
Total	12

The programme has a deficit of 9 scientists. It is important to consider bridging the deficit gradually and eventually eliminating it completely.

### Technical staff working in the programme:

- 1. Charles Muthama: Laboratory Technologist Research Assistant (On Bachelors Training at Moi University, Eldoret)
- 2. Richard Angwenyi: Laboratory technician Research Assistant
- 3. Faith K. Kimanga: Research Assistant

### Volunteers

- 1. Tabitha Muriuki Volunteer Research Assistant
- 2. Horace Owiti Volunteer Research Assistant up to December 2010

### Project 1: Small-scale, community-based, grow-out aquacultures of mud crabs *Scylla serrata* as a sustainable livelihood in East Africa

### Participating Institutions: KMFRI

Scientific Team Members: Jacob Ochiewo, Edward Waiyaki, Fridah Munyi, Tabitha Muriuki and Horace Owiti

Source of Funds: WIOMSA-MASMA

Duration: 2 Years

### **Research Problem**

The most pressing issues for achieving sustainable development of mud crab farming in East Africa are: 1) avoiding potential overexploitation and unsustainable harvesting of large subadults for crab-fatting, and 2) to find sustainable supply of feed resources. Today's crab farming is unfortunately not more sustainable than the traditional fishing of adults, and will not increase the total production of crabs in an area. This is because the average mortality of harvested sub-adults in crab-fattening farms (10% month<sup>-1</sup>; ASCI-VOCA 2005) is higher than their estimated natural mortality in the wild (2% month<sup>-1</sup>; Mahika et al. 2005). Thus, there is a need to find a more sustainable way to obtain seed-crabs for aquaculture. Larval hatcheries have been suggested as a long-term solution to meet an increasing demand for seed-crabs in Tanzania (ASCI-VOCA 2005). Unfortunately, despite indications of success at laboratory scale, large-scale commercial hatchery development for *Scylla serrata* has been very slow due to series of problems (Allan & Fielder 2004, Ut et al. 2007). It is therefore not yet realistic to expect high technology hatcheries to provide a dependent and low priced supply of seedcrabs to local farmers in East Africa.

The seed-fishery would be more sustainable if juvenile crabs were caught at a very young age, i.e. soon after settlement. In many crab species, predation mortality in early juvenile stages is very high (>99% per month) and often density-dependent, but decreases exponentially as the crab grows and obtains a size-refuge from predation. If seed-crabs were fished before such a predation-bottleneck, negative impacts on local populations would be minimized. Moreover, in most crab species, post larvae and small juveniles actively select structurally complex habitats that provide shelter from predation, where they accumulate in high numbers (Moksnes 2002, Moksnes & Heck 2006). If these habitats are identified, high number of small juvenile crabs could potentially be collected with little effort, and before most natural mortality has occurred. The nursery habitat for *S. serrata* is presently not known.

To find acceptable and sustainable sources of supplementary feed to both juvenile and adult crabs, there is a need for systematic inventories of available feed resources on local and regional scales out-from a food security perspective.

From an economic perspective there is also a need to assess the cost-return of the activity and to investigate present and future market potential, as well as infrastructure and government policies for mud crab farming. Finally, when introducing a new livelihood in a community/ region, it is important to assess potential social and cultural issues/obstacles for the activity. This is best done by early involvements of the community and by taking advantages of local and traditional practices and knowledge.

### Objectives

The objective of this project is to evaluate the potential for grow-out aquacultures of mud crabs in a socio-economic context. This will be achieved by identifying: (1) social, cultural, economic, attitude and resource related obstacles for crab farming, (2) groups in the community interested in the income generating activity and learn their opinion (special attention will be given to the women), and (3) market, infrastructure and government constraints, opportunities and risks.

### Activities

This project is nearing completion. An extension was granted to enable the research team exhaust data collection and to give the aquaculture component enough time to run some pond experiments to test the viability of pond farming in the region. The pond experiments in Kenya are being run by Mr. David Mirera. In this component, three activities were carried out during the year namely:

- 1. Data collection
- 2. Preliminary data analysis and reporting
- 3. Submission of the project financial report to WIOMSA-MASMA.

### Brief site description and methodology

### Site description

The study is being conducted around Mida creek in Malindi District. This is an area where mud crab (*Scylla serrata*) fattening is being undertaken especially by a community group at Dabasso. The crab fattening activity has benefitted from the research activities that KMFRI has undertaken jointly with Moi University. Pond experiments are being carried out by Mr. David Mirera under the aquaculture component at Majaoni along Mtwapa creek.

### Methodology

A socio-economic assessment was carried out with particular focus on the social, cultural and economic possibilities/obstacles for the mud crab mariculture. Four coastal communities in around Watamu Marine Park and Reserve in Kenya (Dabasso, Dongo Kundu, Mida and Uyombo) were selected for the socio-economic study. These villages represent a range of different previous experience of mud crab fattening. Representatives from the villages; leaders, fishermen and crab farmers in the communities were informed about the project, how and when it could affect the village, and about the socio-economic interviews planned for the fall. Discussions were initiated to establish the previous experience that each village had regarding crab farming; it's success and problems. The project's goals regarding sustainability of crab farming were also discussed with the community members. Based on these discussions, a joint questionnaire and checklists were developed and pretested for structured interviews, key-informant interviews, focus group discussions, and economic assessments, which later began in the month of September 2009. A total of 221 respondents were interviewed between September 2009 and August 2010. In addition, six focus group discussions were conducted with groups of 8-10 people who were either mud crab collectors/farmers or traders.

### Main findings and conclusion

Out of the 221 respondents that were interviewed, 53% were men while 47% were women.

### The social, cultural, economic characteristics

Out of the four villages at Mida creek, only one (Dabaso village) has an active mud crab fattening project. Observation and semi-structured interviews revealed that artisanal fishing and peasant agriculture are the main livelihood activities at Mida creek. Tourism is also an important activity with Watamu being one of the important tourist destination in Kenya. It was established that tourism provide employment opportunities and market for locally produced products including mud crabs.

Mida creek is inhabited by two ethnic groups namely the Giriama community which is dominant and the Watha community which is a minority tribe. The Giriama community culturally depended on agriculture while the Watha community traditionally depended on hunting and gathering for livelihoods. With time, the Watha community is also engaged in peasant farming and other activities that they did not practice culturally.

Focus group discussions showed that presently, mud crab fishing is more popular among the Watha community while the Giriama community is more involved in peasant agriculture and finfish fishing. Consequently, the Watha community is renowned for having unique skills in mud crab fishing.

The villages at Mida creek have norms and values that guide how they conduct their activities. It was however noted that some of the norms and values are disappearing because they are being diluted by the social and religious interactions. It was noted that very few people still maintain the traditional norms and values. The norms however did not seem to act as barriers to community participation in crab fattening projects.

Results from focus group discussions indicated that mariculture is considered a viable alternative livelihood option to fishing households since the fishing households are experiencing declining catch from their traditional fishing grounds. Crab farming according to the majority of the participants came as a new way of maximizing the value of crabs in the market. The community presently considers mud crab farming a normal activity since it complements fishing that they already engage in.

### Social, attitude and resource related obstacles for crab farming at Watamu

Interviews with the Dabasso creek conservation group which has a mud crab fattening project along Mida Creek revealed that a section of the local community had negative attitudes towards the establishment of mud crab farming in the area. This negative attitude constituted a major obstacle to the project especially at its initial stage. This resulted into conflicts that had negative impacts on the project.

Theft was another major problem at Mida creek when crab fattening activity first began. It was reported that all crabs that were first stocked by the Dabasso creek

conservation group were stolen after 2 days and the group had to obtain new seed. This discouraged many members of the group. Handling theft cases was very challenging since those involved were members of the community and whenever they were arrested by police, it caused social instability and mistrust.

Education and awareness is low among many members of the Dabasso creek conservation group and the community in general. The study has shown that 33% of the respondents have no formal education, 53% have reached various levels in primary school, 13% have reached different levels of secondary school and only 1% have diploma. The respondents in Dongo Kundu village have attended school for more years (it is leading in terms of the number and percentage of the population that have completed 8 years of primary school as well as those that have completed 4 years of secondary education) than those from Uyombo, Mida-Majaoni and Dabasso villages. Uyombo village is trailing with about 38% of the respondents having no education.

### Groups in the community interested in mud crab farming

Only one community group, the Dabasso Creek Conservation Group, is actively engaged in mud crab fattening at Mida creek. This group has 30 registered members. It started mud crab fattening on small-scale in 2004 and expanded in 2008. It has 10 floating cages and 20 bottom cages with each cage having 10 compartments. The group also practices fish farming and ecotourism. A part from this group, two other groups namely the Viriko

Vimoyoni Mangrove Conservation Group at Mida-Majaoni village and the Jipe Moyo

Conservation Group at Dongo-Kundu village, are interested in mud crab farming as an alternative livelihood. These groups consist of both men and women who share a common vision.

### Market, infrastructure and government constraints, opportunities and risks

Crabs have higher market price compared to fish. In Watamu, crabs are sold at KShs.300-500 per kg while fish is sold at between KShs.100 and KShs.120 per kg. The high price of mud crabs provides a strong incentive for mud crab fishing and mariculture. Demand for mud crabs is currently high in the tourist hotels e.g. in Watamu, the Dabasso group entered into an agreement with the tourist hotels at Watamu to supply the hotels with mud crabs but it was not easy for them to meet the target at all times thus the crab fattening project became necessary.

Mud crab fattening at Mida creek has experienced a number of constraints. These constraints include the social set up of the area, inadequate financial resources and inadequate seed for stocking. These constraints have affected mud crab farming at

Watamu as follows:

- The lack of project management skills was identified to be one of the constraints to the running of the crab fattening project when it began. The Dabasso creek conservation group has relied on crab fattening experience that they acquired through their interactions with the scientists from KMFRI, Moi University and Kwetu Training Centre who chose to conduct their research on mud crab fattening at this site. So far they have not obtained any specialized training on project management to enable them build their management capacity.
- The Dabasso creek conservation group lacked financial resources to start up at an economically meaningful scale. The group relied on the members monthly contributions to start the project on a small scale. The members' monthly contributions were largely inadequate considering that the members' incomes are low. Operating the project on small-scale has prevented the project from realizing economies of scale. It is important to note that adequate financial resources are required for successful implementation of a mud crab fattening project.
- Reliance on collection of mud crab seed from the wild for the crab fattening project is another constraint to the expansion of the crab fattening project to meet the demand for mud crabs. Obtaining juvenile crabs from the wild is difficult and makes expansion of mud crab farming projects difficult.

## Project 2: Global Markets and the Livelihoods of Coastal Communities in the WIO countries: Implications for Sustainable Coastal management

**Participating Institutions:** KMFRI, KESCOM, Department of Sociology and Anthropology, University of Dar es Salaam

Scientific Team Members: Jacob Ochiewo, Fridah Munyi, Tabitha Muriuki and Horace Owiti

### Source of Funds: WIOMSA-MASMA

**Duration:** The project began in 2009 and is ending in the first quarter of 2011-2012 period.

### **Research Problem**

The implementation of Structural Adjustment Programmes (SAPs) in 1990s and the subsequent neo-liberal policies in Tanzania and other countries in the WIO region significantly changed the structures and processes of coastal resource use and management. Furthermore, the liberalization of coastal resource use which went side by side with the SAPs has resulted into varied impacts on the livelihoods of the poor majority in the coastal areas. For instance, the growing constructions of tourist hotels along the coast lead to enclosure of some of the landing stations and fishing grounds for

the local fishers. But the emergence of large scale marine exploitation projects and the operations of private individuals from outside diminish local user's access to resources both through political manipulation and by virtue of superior extractive technologies (Sigalla 2001; Chachage2003).

The above not with standing, little is known about the magnitude and implications of the impacts of global markets on the livelihoods of individuals and communities that directly depend on the coastal resources in the WIO region. This study therefore examines the impacts that various aspects of global market have on the national and local systems of coastal management. It also explores the manner in which different coastal resource users and managers have been responding to the impacts of global markets. Importantly the study discloses the vulnerability context emanating from the global markets and the ways in which such context affect the livelihoods of the coastal people. The study argues that sustainable management and utilization of coastal resources in the WIO region requires among other things, an understanding and taking into account the implications of the impacts of global markets on the status of coastal resources and the livelihood of the poor majority in the coastal areas. In most cases this is highly ignored in the short term because of the implementation of neo-liberal policies and their privatizing effects. This is despite the fact that the importance of sustainable management of natural resources, in terms of sustaining coastal people's livelihood, is stipulated in the National Integrated Coastal Environment Management Strategies of the WIO countries, National Strategies for Economic Growth and Poverty Reduction, and the UN Convention on Biological Diversity among others (Torrell et al 2004; UN 1992).

The study offers a multidisciplinary understanding of the complexities embedded in the structures and processes of coastal resource use and management in the context of globalization in the WIO region. The study has the potential to inform a range of stakeholders in the efforts towards sustainable coastal management such as policy makers, project planners as well as the managers of coastal resources. Significantly, the proposed study will unveil areas for further multidisciplinary studies on the linkages between globalization, changing forms of interaction between the users and managers of coastal resources and their implications on management.

### Aims & Objectives:

The overall purpose of this study is to understand and document the changing structures and processes of coastal resource use and management as a result of global markets in the WIO region and their implications on the livelihoods of coastal communities. Specifically the project has the following four objectives;

 To examine the demands that the global market exerts on the coastal resources, users and managers of the resources and their implications on sustainable coastal management

- 2. To document the ways in which the aspects of global markets have been impacting the coastal area, its people and their livelihood
- 3. To explore the manner in which different coastal resource users and managers have been grappling with the impacts of global markets
- 4. To assess the vulnerability context of the poor majority in the coastal communities in terms of their livelihood, as a result of the impact of global market.

### Activities

Four main activities have been carried out during this year in order to address the project objectives as follows:

- 1. Collection of quantitative data was completed during this period.
- 2. Data analysis has been completed and results interpreted.
- 3. A project team meeting was held in Dar-es-Salaam in February 2011 to integrate the national reports into a regional report.
- 4. Draft technical report has been written and is being proof-read

### Brief site description and methodology

### Site description

In order to capture the dynamics of global market and how they impact on local fishing communities, study sites were selected on the basis of the following criteria; the presence of fish export activities; the presence of artisanal and or commercial fishing, fish processing and tourism activities. In total five sites were chosen; Kipini, Malindi, Mombasa (Bamburi), Shimoni and Vanga. Within each site, stakeholders were interviewed based on their experience and or knowledge about the five target species. Therefore the respondents came from both rural and urban settings.

### Methodology

A combination of techniques of data collection was employed in this study to collect data during the entire project period. In the first year, the research process began with pilot testing of the research instruments. The pre-testing was done to establish the suitability and consistency of the instruments. Qualitative data collection was then carried out in the first year using livelihood trajectories, in depth interviews and focus group discussions. During the reporting period (2010-2011), quantitative data was collected through surveys. The social survey was informed by qualitative data that was gathered in the first year. The survey was conducted to establish the magnitude and implications of the changes associated with global markets and its impacts on livelihoods of the coastal communities. A structured questionnaire was used to collect

data in this regard. The sample size for the quantitative surveys was determined based on the number of fishers. A total of 164 questionnaires were administered. Data analysis was done using SPSS and MS Excel

### Main findings and conclusion

Global markets exert enormous demand on the coastal and marine resources and communities in Kenya. These ranges from increased effort on marine fisheries and aquaculture to supply both local and export markets, changing consumption patterns and emerging conservation and management policies, regulations and legislative framework with conflicting discourses. The manifestation of global market and the demands it creates have been concentrating in the sectors of fishery, tourism and energy. These demands are linked between these sectors for example, increase of tourism activities creates demand for fishery products.

### Marine products with high demand in the global market

Marine products are harvested to meet the demand in the local and global markets. The global markets for these products include the export market as well as the domestic tourism industry. The marine products whose production has been influenced by demand in the global markets include fishery products such as sea cucumber, octopus, prawns, kingfish, and lobster (figure 1). Other species whose production depends mainly on demand in the tourism industry are kingfish, red snapper, white snapper, black snapper and squid (figure 2). Based on these species, the influence of global markets on fisheries activities has been felt more heavily at Shimoni, Malindi and Kipini with limited impact realized at Vanga.

Most respondents reported that the main marine products that feed into the global markets are declining due to over-harvesting. The reported decline is based on perceived trends in fish catch per person. At both Vanga and Shimoni, sea cucumber was identified by most respondents to be declining. The high commercial value species of sea cucumbers have been over-exploited and their stocks have declined making them very scarce despite increase in their prices in the global market. Lobster and kingfish were also reported to be declining. In Mombasa, the snappers were identified by most respondents to be declining while, in Malindi, the squid was identified by most respondents followed by octopus and red snapper respectively. At Kipini, it was the mackerel that was identified by most respondents to be declining followed by octopus and kingfish respectively. It is evident from these reported declines in marine resources that fishing pressure has increased in order to satisfy the increasing demand in the global markets and the local people have become increasingly conscious that these resources are over-exploited. This raises concern regarding the sustainability of the

livelihoods of the local communities. It further points towards the impacts of global markets on marine resources and the livelihoods of the local communities that depend on these marine resources.



Figure 1. Production and export trends for five marine fishery products

The last panel of figure 1 above shows clearly that the export of fishery products started increasing in 1986. This concides with the time when Kenya started implementing the

Structural Adjustment Policies that were advocated by the Breeton woods institutions. This was therefore the time when global markets effectively penetrated into Kenya and created more demand for fish export.





### **Positive impacts**

Globalization has impacted coastal communities both positively and negatively. The positive impacts that were identified by the respondents included improvement in communication and information exchange, improvement in fishing technology and ways of preservation, increased business opportunities, employment in hotels, increased demand for fish as well as improvement of incomes as a result of expanded markets and better prices of fish (especially high value fish products).

### Negative impacts

Results from qualitative data have shown that globalization has also led to over fishing, overexploitation, and increase in migrant fishers. In order to meet the market demand, fishers were reportedly forced to fish deeper into the sea and sometimes sell all their catch. Globalization has also led to increase in competition in fisheries and prime land near the ocean which has in many places led to loss of beach access routes by fishers. Globalization has also witnessed an increase in school drop outs as school children join fishing or tourism related activities. In some areas, women had joined fishing and other income generating activities to supplement incomes. Changes in social cultural ways of life, for instance changes in dressing codes especially among the youth, was also mentioned. Others were increase in prostitution and drug abuse as a result of influence

from other cultures. These factors have contributed to increase in family breakups, for example in Kipini, which therefore are associated with globalization.

Globalization was also mentioned to have led to increase in conflicts over resources and resource use especially between local users and outsiders. This has partly been due to increased number of resource users and application of different fishing technologies.

Results from the social survey have also shown that local communities have appreciated the negative impacts of globalization on their livelihoods. The negative impacts include inflation, restriction of beach access in areas where tourist hotels have been developed, increase in crime and drug abuse, increase in prostitution and instability in marriages, spread of sexually transmitted diseases (such as HIV/AIDS, gonorrhea and syphilis) and sale of property (land) at unfair prices (Figure 3). These negative impacts were cited at Shimoni, Mombasa, Malindi and Kipini. It was only at Vanga that some of the negative impacts such as crime and drug abuse, spread of sexually transmitted diseases, increase in prostitution and instability in marriages and sale of property (land) at unfair price were not reported.



Figure 3. Perceived negative impacts of globalization at the coast of Kenya

### **Fishing gears used**

The study established that globalization has caused changes in the type of fishing gears and size of effort used to harvest the species that feed into the global markets. 25% of the respondents stated that they use ring net, 24% stated that they use beach seine, 14% stated that they use spear gun while others use hook, fish trap, scuba and spear (harpoon) (Figure 4). These results are interesting since the ring net which is used by 25% of the respondents is a relatively new fishing gear in Kenya and its use has generated conflicts since it is relatively more efficient compared to the gears used by other artisanal fishers. The actual number of ring nets that are already being used at the coast of Kenya may be lower than the number of other fishing gears, but one ring net employs between 30 and 50 fishers. This makes it employ more fishers than other fishers. The high demand from the global markets also led to an increase in the use of destructive fishing gears such as beach seine but its use has been banned by the Kenyan Fisheries Department. The use of spear gun which has emerged number 3 has also generated controversies among the artisanal fishers.

It was noted that the distribution of these gears varied from site to site. At Vanga, ring net was the most popular fishing gear cited by 84% of the respondents followed by the other types of nets. At Shimoni, spear gun was more popular and was cited by 41% of the respondents, followed by scuba that was cited by 27%, nets and traps cited by 13% each, and beach seine cited by 6% of the respondents. At Malindi, fish trap was cited by 30% of the respondents, followed by spear at 23%, beach seine at 20%, scuba at 15%, ring net 7% and other nets 5%. At Mombasa, hook was cited by 61% of the respondents, followed by spear at 31% and other nets 8%. At Kipini, beach seine was the most popular cited by 50% of the respondents, followed by other nets at 34% and ring net at 16%. Overall, figure 2 presents the types of fishing gears used along the coast of Kenya.





Figure 4. Fishing gears used in the coast of Kenya

### **Fishing vessels**

35% of the respondents stated that they use sail boat, 28% stated that they use wooden planked boat, 21% stated that they use motorized fibre-boat while 16% use dug out canoe (Figure 5). It is interesting that while overall the dug out canoe came last after sail boat, wooden planked boat and motorized fibre boat, it was cited by majority of the respondents at Vanga. The distribution of these fishing vessels therefore varies from site to site. At Vanga, dug out canoe was the most common cited by 45% of the respondents followed by wooden planked boat (35%), sail boat (14%), and motorized fibre boat (6%). At Shimoni, motorized fibre boat was cited by 26% of the respondents, followed by outrigger canoe (25%), dug out canoe (19%), wooden planked boat (16%), and sail boat (14%). At Kipini, outrigger canoe was the most common cited by 32% followed by wooden planked boat (23%), sail boat (23%), dug out canoe (16%) and motorized fibre boat (6%). At Mombasa, wooden planked canoe was the most common cited by 44% followed by dug out canoe 38% and sail boat 18. At Malindi, motorized fibre boat was the most common cited by 36% followed by sail boat 33%, outrigger canoe 24% and wooden planked boat 7%.

It was established that the number of fishing vessels has also been continuously increasing as more fishers are recruited into fishing. This trend was also captured by the fisheries frame survey of 2008 which reported that the number of fishing crafts increased by 13 % between 2006 and 2008 (Fisheries Department 2009). The overall trends of the number of fishing crafts indicated an increase over the same period of time. The predominant mode of propulsion for the fishing crafts for the entire marine and coastal fishery was sails (46%), paddles (38%), outboard engines (8%), inboard engines (4%) and pole propulsion (8%). However, in 2008, there was an increasing trend towards the use of motorized crafts compared to previous frame surveys. For instance, crafts with outboard engines increased with a margin of 220 % between 2004 and 2008. Fishing crafts with inboard engines also increased by 48% during the same period.

### **Fishing vessels**



Figure 5. Distribution of fishing vessels in the coast of Kenya

### Conflicts

Globalization has increased pressure on the marine and coastal resources that are increasingly getting over-exploited. This has consequently resulted in conflicts. The main sources of conflicts that were identified by respondents include conflicts between: artisanal fishers and conservation agencies, local people and investors, local fishers themselves, and fishers residing in neighboring villages. These sources of conflicts vary across villages as shown in figure 6.

### **Sources of conflicts**



Figure 6. Types of conflicts across the study sites

### Impacts of globalization on livelihoods

Regarding livelihoods, the results have shown that globalization has led to increased employment of youth and women (Figure 7). In addition, globalization has caused the youth to shift from agriculture to tourism and it has also led to increase in commodity prices including prices of marine products. These impacts have however been realized differently at each of sites.



Figure 7. Perceived impacts of globalization on livelihoods

### Recommendations

The implications of global markets on the status of coastal resources and the livelihoods of the poor section of the coastal communities should be taken into account in coastal and marine resources management decisions in order to achieve sustainable management and utilization of these resources in Kenya. In most cases this has been overlooked and the communities that depend on these resources have continued exploiting them in ways that are not sustainable as they respond to demand created by the global markets. The inshore coral reef fisheries for instance, are under intense pressure from fishing in order to respond to the demand created by global markets in the tourism industry and export market. As a result, there are indications that catches of some high value marine products such as sea cucumbers and lobsters are declining. It is therefore prudent to empower local fishers with the right technology and training to enable them venture into deep sea fisheries to diversify products that can enter the global markets and ease pressure on the coral reef fisheries. This will ensure increased and sustainable production from the marine fisheries and increased incomes to the fishers. Both freshwater aquaculture and mariculture production also needs to be enhanced to reduce pressure on capture fisheries.

Realization of sustainable management of coastal resources has been challenged by the pressure arising from the demand caused by global markets. Consequently, there has been a tendency of actors blaming each other, whereby the coastal communities are blamed for the increased degradation of coastal and marine environments and depletion of the respective resources and managers are blamed for ineffective management approaches. It is important to strengthen the co-management and the use of economic instruments to address the problems and challenges of coastal and marine resources management.

Management of coastal and marine resources have become more complex and challenging in the context of global markets. The coastal communities are increasingly exploring ways of maximizing production from the coastal and marine resources in order to meet the global market demand. It is pertinent to consider the interest of these communities in the efforts towards sustainable management of coastal and marine resources in the eve of global markets. Coastal management priorities have also been shifting towards maximizing returns from the resources. In that respect, the interests of local people are undermined by the interest of the state and the markets. Current management systems need restructuring and transformation in line with coastal communities' interests and benefits.

## Project 3: The problem of shoreline changes in Kenya, their socioeconomic impacts and mitigation options.

Participating Institutions: KMFRI and CDA

Scientific Team Members: Jacob Ochiewo, Dr. Charles Magori, Charles Muthama, Fridah Munyi, Richard Angwenyi Source of Funds: WIOMSA-MASMA Duration: 2 Years

### Objectives

The objectives of this project include:

- Establish the rate and pattern of shoreline changes and the most important natural and anthropogenic causes of shoreline changes
- Establish the relationship between shoreline changes and tourism
- Determine the relationship between shoreline changes and coastal community's livelihood patterns.
- Examine the existing institutional framework (policies and legal mechanisms) in relation to their effectiveness in shore management and recommend appropriate options.
- Examine the existing mitigation measures in relation to their effectiveness (functional and cost) and efficiency and recommend appropriate options

### Activities

Two manuscripts and a manual on shoreline change management were written and submitted to WIOMSA for publication in the WIO Journal of Marine Sciences. During this year, the research team have revised the manuscripts and the manual based on reviewers comments.

### Brief site description and methodology

### Site description

The study was conducted at the Nyali-Bamburi-Shanzu site in Mombasa. This area experiences coastal erosion that threatens coastal investments and community livelihoods.

### Methodology

Socio-economic assessments especially data collection and analysis were completed in 2009-2010 performance period. In total 67 respondents were interviewed between December 2007 and June 2009. This was followed by data analysis and preparation of scientific manuscripts and a manual for publication.

### Main findings

- The results of this study have shown that 23 out 28 Beach Hotels at the Bamburi site are highly vulnerable to shoreline change especially coastal erosion. The costs of shoreline protection at Bamburi site varied from US\$ 3,000 for simple structures to US\$ 86,000 for robust structures, with an average of Ksh.500,000 (US\$6,665). Furthermore, most of the shoreline protection structures were put up without proper technical advice resulting in high maintenance or reconstruction costs. It was established that the sea walls that were constructed without expert advice have collapsed after every 3 years thus making it expensive in the long run.
- At the Bamburi site, stakeholder anecdotal evidence of beach change showed that 60% of respondents considered shoreline erosion to have increased over the last 20 years, resulting in significant loss of beach land. Based on this evidence, a shoreline regression of 20–200m was mapped at Bamburi and 50% of the respondents have relocated their temporary business premises or fish landing banda due to shoreline changes.
- In terms of social costs, community livelihood and security have been destabilized. For example, over 100 fishermen in Nyali have lost part of their fish landing sites due to coastal squeeze, and if displaced by further shoreline regression, they have nowhere else to go. In addition, curio vendors have lost open spaces and shelter that they used to display their wares and now have to operate from beach sands and relocate during high tide. It was also reported that exposure to strong winds and rain have lead to pneumonia and related health problems.

### **Conclusion:**

These results have guided the preparation of a manual for shoreline change which is under review. In addition, two scientific manuscripts have been written and have been positively reviewed for publication in the WIO Journal. One of the manuscripts addresses the sources of sand supply to the coastal beaches in Kenya and Tanzania while the other manuscript addresses the role of monsoonal forcing on sand supply to the beaches at Bamburi in Kenya and Kunduchi in Tanzania.

## Project 4: An Assessment of the Socioeconomic Impacts of Environmental Degradation related to Climate Change in Faza Island, Lamu district – Kenya.

Participating Institutions: KMFRI, Fisheries Department

Scientific Team Members: Edward Waiyaki, Tabitha Muriuki and Richard Angwenyi Source Of Funds: Organization for Social Science Research in Eastern and Southern Africa (OSSREA)

### Duration: 1 year

### Aims & Objectives:

- 1. To Determine the socio-economic impacts of environmental degradation related to climate change on the community living on Faza island
- 2. To investigate the impact of Climate Change on Fishing activity in Faza island
- 3. To examine any methods of mitigating the effects of Climate Change, and the forms of adaptation practiced by the local communities

### Activities

This project is nearing completion. The main activities that have been undertaken during this period include:

- 1. Data collection at Faza and from the Meteorological offices in Nairobi
- 2. Data analysis
- 3. Compilation of technical report that began during this period and is scheduled to be completed at the beginning of the next half of the year.

### Brief site description and methodology

### Site description

The study has been carried out at Faza Island which is located approximately 36 kilometres north-east of the Lamu Island. On geographical scale, Faza Island is located on Latitude 2.067 ° and Longitude 41.106° and is the biggest settlement on Pate Island and has an area of 74.8 km<sup>2</sup>, with an estimated population of 9,500 people. Its population density is 116.3 persons per square kilometer. The island is inhabited primarily by the Bajuni community, who are mainly fishermen.

### Methodology

Questionnaires were prepared and administered up to the end of the first quarter of 2009-2010. Data was compiled in MS Excel and analyzed.

### Main findings and conclusion

The island of Faza is a typical fishing community where fishing activity is the backbone of all other economic activity on the island. Most of the money spent on the island is derived from the fishing sector, either directly through the fishermen or indirectly, through fishery-related activities like fish processing, transport, trading, net-making and boat building or repair. With the coming of the Climate Change phenomenon, during the rainy '*Kusi*'(South-East monsoon which occurs between April to July) season however, sea temperatures have become exceedingly cold and Faza's poorly equipped
artisanal fishermen cannot stay in the waters for long periods. This has limited the levels of their catches. An important social impact of the fishermen's reduced earnings has been that many of them are unable to pay school fees for their children (son). As a result school drop-out rates have increased significantly, and these same young men have been forced to enter the very same over-fished and increasingly over-populated fishery or seek menial jobs at landing sites or boat- building yards. With the adverse effects Climate Change is having on Faza'a fishery this vicious cycle is being perpetuated. Villagers in Faza had been affected by reduced fish catches, firstly because with today's high cost of living the fishermen's reduced earnings (on average they earn between 150-200 Ksh per day) meant that they were unable to meet the domestic needs of their families. The loss of fishing livelihoods had meant an increase in the number of unemployed and idle in Faza – particularly the youth. A negative social impact of this has been the proliferation and increased use of illegal narcotics on the island of Faza in recent years.

The general levels of income there however are very low. From the onset of this study it became apparent that even though most respondents did not clearly grasp the concept of Climate Change, over 90% claimed to have experienced some sort of climatic change over the past ten years. This clearly showed the need to create awareness about Climate Change amongst the population of Faza.

According to respondents in the study increased temperatures, prolonged spells of drought, erratic and intense episodes of rain, reduced fish catch and ever-rising food prices were the major consequences of Climate Change. Environmental Degradation though not clearly visible at the island's shopping centre was present. Deforestation was mentioned by those interviewed as one form of this degradation. One obvious cause of this was the fact that firewood was the primary source of domestic cooking fuel for in the community (89% of respondents stated this). In addition, many houses on the island were constructed using Mangrove poles.

Beach erosion was another form of degradation mentioned. This was evident particularly in the areas where the recently constructed sea-wall did not reach, especially near the primary school. Of the 63% of respondents who mentioned drought as a form of Environmental degradation, more than half claimed that the frequency of the occurrence of drought was between one and two years. The socio-economic impact of this drought included increased cases of starvation, difficulty in accessing water for drinking and death of livestock. Increased food prices, purchasing of water for drinking and cooking and losing livestock due to lack of pasture had put severe financial strain on the resources of an already poor community.

Almost one-third of the respondents in this study mentioned that they did not take any measures to adapt to the effects of Climate Change simply because they lacked the resources to do so – evidence of the poverty within the community. A third of

respondents had resorted to changing the crops they planted as a form of adaptation. Other forms of adaptation included sinking personal boreholes, sourcing water from Magogoni (a center on the west mainland where there exists a Kenya Navy base), changing diets (to include vegetables) and for some it involved starting up an entirely new occupation (such as a small scale business). Over half of the respondents stated that sea levels at Faza had been rising over the last ten years, causing loss of property, disrupting fish activity (especially causing damage and loss to fishing nets), and increasing the levels of coastal erosion in Faza. However, it was widely indicated by respondents that the erection of the sea wall (through the use of the constituency's development fund) had been very useful in stopping this problem. One extreme-weather event experienced by the island's residents over the past ten years had been episodes of erratic but intense rainfall.

Fresh water is a critical problem in Faza island. The island does not have any piped water. The residents rely totally on rain water for their domestic needs. 93% of respondents stated that over the past ten years the level of rainfall had decreased. When it rains this water is usually collected and drained into concrete storage tanks, *"Djabias"*. This water is then sold commercially at between Ksh 15-30 per 20 litre container, depending on the state of availability. The *"Djabia"s* in Faza are owned by Women Self-Help groups, the County Council and by private individuals. The elderly citizens in Faza suffer greatly if they have no one to fetch water for them. Residents are sometimes forced to travel long distances to fetch water (sometimes even as far as Lamu by boat to purchase water and ferry it back to Faza - which is an additional burden on their limited finances). Skin rash too was mentioned as an ailment that commonly occurs.

Mortality in Faza was attributed by residents mainly to Malaria, Bilharzia, Diaorrhea and Typhoid. 67% of respondents reported that over the past ten years there had been an increase in the occurrence of these diseases. Generally warmer temperatures might explain the increase in cases of Malaria, as the mosquitoes have ideal conditions to breed. Contamination of stored water could account for increased incidences of water-borne diseases such as Typhoid, Bilharzia and Diaorrhea. In an interview, Festus Mboti, the Clinical Officer-in-Charge Faza Sub-District Hospital, stated that the most common weather-related disease he witnesses in Faza is Diaorrheal disease, during the wet rainy season between April and June. From July to September the weather alters and becomes very sunny and windy and these conditions predispose Faza residents to upper-airway infections, which lead to running noses, Coughs and even Pneumonia (which at the time of this study was the highest occurring disease in Faza).

#### Sea Level Rise

In Faza, 62% of respondents claimed to have experienced a rise in the sea level at Faza. The respondents who stated that the sea level had not risen indicated that construction

of the Faza Sea wall was the reason why sea-level rises have not affected residents. Flooding and Destruction of houses (and loss of property), disruption of fishing activity (loss of boats and fishing nets), loss of farmland through inundation and increased coastal erosion were mentioned as some of the observed effects of rising sea levels. Research however, clearly indicates (see table above) that sea levels in Lamu district have been rising over the past decade. Most respondents recalled the Tsunami event six years ago, during which the sea levels in Faza rose significantly causing destruction of homes and other property, fishing boats and nets. Research shows that sea levels in Lamu district over the past fifteen years have risen by about half a centimeter. While this may not seem significant now the long-term implications of this trend are certainly worth very serious consideration.

# Project 5: The Social and Economic Dimensions of the Malindi Ungwana bay fishery

Participating Institution: KMFRI

Scientific Team Members: Jacob Ochiewo, Edward Waiyaki, Richard Angwenyi, Faith Kimanga Source of Funds: Gok Duration: 10 YEARS

# Objectives

The objectives of this project are to:

- 1. Establish the perceptions of the local community on the trends in the artisanal fishers' income
- 2. Assess how benefits are shared along the fish value chain
- 3. Generate socio-economics data to establish the social and economic status of the artisanal fishers four years after the suspension of prawn trawling and inform management decisions.

#### Activities

Data was collected in February 2011and data has been analysed. A techical report is being prepared and to be presented as part of the deliverables for the institutional performance contract.

#### Brief site description and methodology

#### Site description

The study is being conducted at Kipini village in the Tana Delta District, Ngomeni village and Malindi town in Malindi District. These are sites that have experienced conflicts between prawn trawlers and artisanal fishers and KMFRI had been called upon to carry out research that could help resolve the conflicts. KMFRI's is required to conduct multidisciplinary research with Fisheries and Socioeconomics investigations being the core.

#### Methodology

Socio-economic assessments were conducted at Malindi, Ngomeni and Kipini. A combination of observation and questionnaires were used to collect data from the fisher communities. Using direct observation the researchers watched and recorded events in the surroundings. This provided first hand information about complex activities in this area. Data was compiled and analysis began during the data collection period. At the end of each day, the research team sat together to discuss peculiar expressions by the respondents.

#### Main findings and conclusion

Technical report is under preparation. Once completed, the results will be made available to fill this sub-estion.

#### Challenges

There is shortage of personnel since one research officer is currently out of the country for training. The funds that were allocated for the entire Malindi-Ungwana bay project was inadequate and therefore only one field trip was made.

# WORK PACKAGE 5: Undertake biophysical studies in relation to fisheries

# Programme overview

This program is responsible for research on sustainable use and protection of aquatic resources in marine and coastal waters. It therefore monitors and documents the physical (including geological) and chemical characteristics of the various aquatic ecosystems to discern natural and/or human induced changes. The program also undertakes studies on the interrelationships between the biota and their aquatic environment in relation to fisheries, aquaculture and conservation of biodiversity. MEEP, therefore is a critical support pillar for the twin core programs (fisheries and aquaculture), as well as in addressing other coastal ecosystem integrity issues (pollution, habitat degradation/restoration, habitat conversion, biodiversity) and emerging issues such as climate change and invasive species .

Research activities in MEEP in the period under review were under three main thematic units:

- 1. **Critical habitats**: The critical habitats cover mangroves and tidal flats, seagrass beds, coral reefs, and benthic ecology. Various research teams under this unit investigate the status of these ecosystems and inventorize biodiversity, ecosystems threats and provide recommendations for their rational use and improved management.
- 2. Water, sediment quality and aquatic productivity: this comprises environmental chemistry, microbiology and plankton studies. This unit studies the quality of water and sediments both for human needs, biodiversity conservation and pollution, and recommendations for improved management.
- 3. **Oceanography and Meteorology**: This unit investigates bathymetry and hydrodynamics, monitors sea level dynamics, and climate change related issues.

During the half year under review, the following 17 projects were being conducted under MEEP.

# Project 1: The Kenya Coastal Development Project

#### Institutional representation

- 1. Kenya Marine Fisheries Research Institute, Ministry of Fisheries Development
- 2. Fisheries Department, Ministry of Fisheries Development
- 3. Kenya Wildlife Service, Ministry of Forestry and Wildlife
- 4. Kenya Forest Research Institute, Ministry of Forestry and Wildlife
- 5. Coast Development Authority, Ministry of Regional Development Authorities

6. National Environment Management Agency, Ministry of Environment and Mineral Resources

7. Department of Physical Planning, Ministry of Lands Source of Funds: WORLD BANK AND GEF Duration: 2011 - 2016

#### **Development Issues**

The major role of the KCDP is to target those residents of the coast that directly and indirectly use the natural resources, by helping them find livelihood activities that are more profitable and environmentally and socially sustainable. The overall vision of the project is:

**TO:** Achieve social and economic well being, improve standard of living, and create wealth for and by coastal zone communities; **BY:** Diversifying the coastal economy, creating viable jobs, and empowering youth and women; and **THROUGH:** Environmentally and socially sustainable utilization of coastal and marine natural resources.

The KCDP is in line with the government's Vision 2030, which aims to transform Kenya into a middle income country within two decades. The Vision is based on three pillars: economic, social and political. The economic pillar aims to improve economic development to achieve a GDP growth rate of 10 per cent per annum. The social pillar seeks to build a just and cohesive society with social equity. The political pillar aims to put in place a democratic political system founded on issue-based politics that respects the rule of law and protects the rights and freedoms of every individual. The KCDP focuses on one of the poorest regions, supports institutional strengthening in key sectors, and promotes MSMEs and a business environment that leverage growth.

The initial 6 years of the project provides finances for investment needed to build management capacity and an understanding of rural, natural resource-based, development potential in the Coast Province that enables local institutions to effectively utilize the expected significant increase in future Government and donor development investment.

The project follows the accepted multi-sectoral approach to ICZM implemented by governments and agencies around the world and has therefore been developed in partnership with several agencies.

#### Objectives

The following were the objectives of the different components of the KCDP:

The objectives of Component 1 (Sustainable Management of Fisheries Resources) are as follows:

- To enhance governance and management of offshore and coastal fisheries resources;
- To undertake research on coastal and nearshore fish stocks and technologies;
- To enhance market chains for fisheries resources;
- To increase fish production through sustainable aquaculture development.

The objectives of Component 2 (Sound Management of Natural Resources) are as follows:

- To develop a coastal biodiversity information system;
- To enhance Capacity in natural resource management;
- To undertake research and extension;
- To enhance tourism by identifying biodiversity products and markets that will help promote eco-tourism and associated spin-off industries.

The objectives of Component 3 (Support for Alternative Livelihoods) are as follows:

- To undertake integrated spatial planning and development of land capability plans;
- To enhance environmental governance;
- To enhance microenterprise development and private public partnerships.

The objectives of Component 4 (Capacity building, M & E, Project Management, Communication and Coastal Village Fund Sustainable Management of Fisheries Resources) are as follows:

- To undertake capacity building of the project coordination and implementation teams;
- To develop dialogue amongst national partners and regional stakeholders;
- To undertake communication and outreach;
- To administer the Community Village Fund.

#### Project sites

The project sites are yet to be selected and the aim of the agencies is to consolidate their efforts and work together in common sites so that there is cohesion in the delivery of the project objectives.

#### **Project Status**

The financing agreements of the project were signed in November 2010. Currently work is being undertaken to develop the Project Implementation Manual, the Subsidiary agreements, establishment of the Project Coordination Unit and staffing as well as financial arrangements.

#### **PROJECT DETAILS**

A major role of the KCDP Project is to forge coastal development by working with stakeholders within the development process, provide the capacity building needed by all stakeholders (government, non-government, civil society, the private sector, etc.) so that each can play an appropriate role in the achievement of an understanding of the coastal natural resources and the threats that reduce resource values. KCDP is aimed at promoting sustainable use of coastal resources. Additionally, KCDP will target those residents of the coastal area that directly and indirectly use the natural resources, by helping them explore livelihood activities that are more profitable and environmentally and socially sustainable.

The activities of the Project Preparation Phase which lasted from 2008 – 2010 were designed to provide information from scientific studies; engage stakeholders to determine their needs, and determine institutional capacity requirements for the first phase of the KCDP. The following project components were defined for the project in the Project Appraisal Document that was send to the World Bank in March 2010:

Component 1: Sustainable Management of Fisheries Resources

Component 2: Sound Management of Natural Resources

Component 3: Support for alternative Livelihoods

Component 4: Capacity Building, M&E, Project Management, Communication and Community Village Fund (CVF)

The table below provides a breakdown of activities coordinated under the KCDP between July 2010 – June 2011

DATE	<b>AIM OF MEETING &amp; PARTICIPANTS</b>	VENUE
1 <sup>st</sup> – 5 <sup>th</sup> November 2010	World Bank Mission with the Task	KMFRI, Mombasa
	Team Leader, Ann Jeanette Glauber	
28 <sup>th</sup> March – 1 <sup>st</sup> April 2011	World Bank Effectiveness Support	KMFRI, Mombasa
	Mission	
15 <sup>th</sup> June – 22 <sup>nd</sup> June 2011	World Bank Launch Mission	KMFRI, Mombasa

The project was approved by the World Bank Board in July 2010. There were several effectiveness conditions set by the Bank which required to be completed by the different agencies in order for the project to be declared effective. These additional deliverables are documented below.

Deliverables for the KCDP Project effectiveness

- 1. The Project Implementation Manual (PIM)
- 2. Subsidiary Agreements between the Ministry of Fisheries Development and the other implementing agencies

- 3. Designation and appointment of staff for the Project Coordination Unit, and procurement and accounts staff for the implementing agencies
- 4. Computerization of accounting functions within KMFRI

These conditions are in the process of being fulfilled.

KCDP project has been declared effective by the World Bank on 30 June 2011

# Project 2: Receptor binding assay for harmful algal toxins

Participating Institutions: AFRA member states Scientific Team Members: Okuku, Mwangi Source of Funds: IAEA and GoK Duration: 3 years

#### **Research Problem**

One of the more serious and visible problems facing coastal waters and the local economies relying on them relates to the phenomena commonly known as "red tides" or "harmful algal blooms" (HABs). These events are caused by the growth and accumulation of microscopic algae in marine or brackish waters that can cause massive fish kills, contaminate seafood with potentially lethal toxins, and alter ecosystems or coastal aesthetics in many ways. HABs constitute a public health problem because of their unpredictability and the rapidity with which concentrations of toxins may develop.

#### Objectives

- To assess algal toxin dynamics as a function of physicochemical changes in the water column and develop predictive models for bloom toxicity
- To monitor algal toxins in seafood products to ensure they meet the recommended limits
- To monitor water toxin levels thereby providing an early warning to avoid possibilities of aquatic contamination and related ecosystem effects

#### Activities

- Receiving consignments from the IAEA
- Samples collection and analysis
- Hosting of regional coordination meeting
- Hosting of regional training course
- Setting up of the radioisotopes laboratory
- Capacity building

#### Brief site description and methodology (one paragraph)

The study/ monitoring sites were selected to cover the whole Kenyan Coast. The stations include the estuarine stations in Rivers Umba, Ramisi, Mwena, Tan and Sabaki. Oceanic stations of Shimoni, Malindi, Tudor, Mtwapa and Makupa creeks are also included in the study. Phytoplankton samples were collected through filtration of 20l of water through 25µm net for taxonomic water while additional Phytoplankton samples (were collected through filtration on 47mm GF filters) and shellfish samples were collected for biotoxins quantification.

#### Main findings and conclusion (1/2 page)

The results of taxonomic work has indicated steady rise in the species richness and abundances of potentially toxic algae. As compared to UNESCO report of 2001 that only reports 20 species of HABs, the current study reported an increased number of 39 species. Samples for toxin profiles were also collected and are awaiting analysis. Detailed results can be found in a publication that is already in press.

#### **Project 3:** Biochemical effects of sewage, a story from the fish side.

Participating Institutions: KMFRI Scientific Team Members: Okuku Eric Source of Funds: WIOMSA Duration: 1 year

#### **Research Problem**

Discharge of untreated wastewater is a major source of marine pollution, and perhaps the most serious problem within the framework of the GPA. Globally, in spite of action, the problem is growing worse, mainly because of growth in population and rapid urbanization. One method frequently used to assess the ecological effects of pollution in aquatic systems is the abundance and species composition of fauna that is usually complemented with the concept of sensitive and tolerant taxa. However, these higher levels are usually less sensitive and the effects are only evident after irreversible effects have already occurred. *There is an urgent need to develop sensitive, reliable and broadly applicable indicators of ocean health* inorder to effectively safeguard these sensitive ecosystems from land-based pollution activities.

#### Objectives

- To determine the levels of pollutants in water (nutrients and heavy metals) and fish (heavy metals) in the polluted area along a pollution gradient and compare it with the results from relatively pristine area.
- To determine the biochemical effects of contaminants (nutrients and heavy metals) on different species of fish.

• To develop a simple model that can be used to attribute the observed pollutants effects on biota to the measured exposure in the water compartment.

#### Activities

- Field exposure and sampling
- Laboratory analysis

#### Brief site description and methodology

When a fish is residing in a polluted area, part of its energy in spent in homeostasis, this energy could have otherwise been used for growth or accumulated as energy reserves. Living in polluted waters therefore results into tissue wastage. The study approach involves collection of live samples of fish from the opening of Tudor creek and exposing them in the laboratory at sewage concentration of 0, 5, 7.5, 10, 15, 30, 40 and 44%. The fish were then sacrified without anesthesia, whole fresh homogenized and Lipids, proteins and glycogen levels determined.

#### Main findings and conclusion

Percentage energy reserve levels declined at different rates (in response to increasing concentration of sewage) for each species of fish but the reduction was typically between 52.5-5.7%, 0.03-0.0% and 0.26-0.05% for proteins, lipids and glycogen respectively. It was clear from the present study that glycogen, lipid and protein content decreased when exposed to increasing levels of sewage. The decline could be attributed to utilization of energy reserves to meet the rising energy requirement during the increasing stress caused by different levels of sewage in the exposure experiment.

# Project 4: The role of water reservoirs in Carbon cycling and biogeochemical functioning of tropical rivers: Case study of river Tana, Kenya

Participating Institutions: University of Leuven, KMFRI Scientific Team Members: Okuku Eric Source of Funds: VLIR Duration: 4 years

#### **Research Problem**

River damming causes a number of environmental problems such as blocking the transport of sediments downstream, leading to increased sediment build-up in the reservoir whilst causing downstream erosion of former depositional environments. Increased erosion downstream threatens shoreline ecosystems, deepening the riverbed

and narrowing the river over time. This situation leads to reduced water levels, homogenization of river flow and thus reduced ecosystem variability and reduced support for wildlife. Reservoirs also retain nutrients and this further affects downstream ecosystems by altering their community structure and biodiversity as well as reducing their general ecosystem functioning.

### Objectives

- Determine the diurnal, seasonal and spatial variation (including depth profiles) of carbon, nutrients, sediments and carbon isotope characteristics of major river reservoirs;
- Derive first-order estimates of annual sediment, carbon and nutrient retention for the three reservoirs, and the net exchange of CO2 and CH4 across the water-atmosphere interface;
- Identify and quantify the main biogeochemical processes and conditions that maybe of primary importance in controlling variability in cycling and fate of carbon in the reservoirs;
- Explore possible environmental and ecological impacts of damming on the downstream and coastal ecosystems.

#### Activities

- Field sampling
- Laboratory analysis

# Brief site description and methodology

Samples are being collected monthly from before and after stations and within Kamburu, Kindaruma and Gitaru reservoirs. We have also carried out one extensive sampling which involved the collectionmof samples from all the monthly stations as well collection of samples along a transect in the reservoirs. The samples collected include those for  $\partial^{13}C_{DIC}$ ,  $\partial^{13}C_{DOC}$ , POC, PN, and  $\partial^{13}C_{POC}$ , CH<sub>4</sub>, Alkalinity, TSS, ChI a, and physicochemical parameters. Basic water quality and primary production analysis are currently underway in KMFRI while isotopic, CH<sub>4</sub> and carbon analysis will be carried out in Belgium– University of Leuven.

#### Main findings and conclusion

Analysis ongoing.

# Project 5: Distribution of pathogenic Vibrio cholerae strains in aquatic environments in coastal areas of East Africa: Implication to cholera outbreaks and control

Participating Institutions: University of Dar es Salaam, Muhimbili University of Health and Allied Sciences, TANZANIA.
Scientific Team Members: Stephen Mwangi, Jacob Ochiewo,
Source of Funds: WIOMSA (MASMA)
Duration: 2 years (2009/2011)

#### **Research Problem:**

To investigate the link between different environmental factors (biotic and abiotic) and socio-economic factors with cholera epidemicity in the coastal region for improved disease control.

#### Objectives

To identify and characterize both isolated and uncultured *V. cholerae* O1 and O139 from selected aquatic environments along the coastal region of Tanzania and Kenya

- To compare V. cholera isolated from aquatic environments with clinical isolates
- To determine environmental factors and faecal bacterial contamination indicators associated with V. cholerae prevalence in aquatic environments

#### Activities.

- Sampling in marine environment, estuarine environment and groundwater to determine the various ecological and microbiological parameters.
- Socioeconomic assessments in Shimoni-Vanga area using a combination of participatory assessment techniques.
- Participation in Brainstorming meeting among regional participants
- Presentation of results to WIOMSA during 'The Ninth Meeting of the Marine Science for Management (MASMA) Grantees: Monitoring the Performance of the Approved Projects: 29-31 October, 2010 Mombasa, Kenya

#### Brief site description and methodology

Sampling is carrying out in three study areas (Lindi, Dar es Salaam and Tanga) in Tanzania and Shimoni-Vanga in Kenya as representative of the coastal regions of East Africa. In each study area, three sampling stations were established; the first one in the marine environment, the second in an estuarine environment and the third station in a fresh water reservoir. At each station, triplicate samples are collected once a month for one year to determine the various ecological and microbiological parameters. Socioeconomic assessments are carried out in the identified coastal region of Tanzania and Kenya using a combination of participatory assessment techniques. The approach in this methodological section is by objectives where by methods are described to achieve the different objectives and lead by different members from the team.

#### Main findings and conclusion

The results from the study so far indicate high riverine system and groundwater dissolved inorganic nutrients in the Shimoni-Vanga area. Strong link established between landbased activities, groundwater and seawater quality and public health. Remote sensing data now being analysed for spatial and temporal trends using large datasets.

#### Outputs

- Progress report submitted to the PC
- Powerpoint presentation shared among MASMA Grantees meeting

# Project 6: Development of Management Plan for Bamburi-Shanzu beaches with special focus on Jomo Kenyatta Public Beach

Participating Institutions: KWS, Ministry of Lands, CDA, FiD, NEMA Scientific Team Members: Stephen Mwangi, Jacob Ochiewo, Dr. Benard Kirui, Gladys Okemwa Source of Funds: ReCOMAP Duration: 1 year (2010/11)

#### **Research Problem:**

Challenge of unplanned beaches that are unsafe and environmentally impacted with multiple conflicts.

#### Objectives

• Improve public beaches so as to make them safer, cleaner, accessible and enjoyable with reduced user conflict as first steps towards international Blue Flag standard.

#### Activities.

- Multi-institutional Working group meetings on management Plan for Jomo Kenyatta Public Beach
- On ground surveys in the study area.
- Mapping of uses and users of Jomo Kenyatta Public Beach in the Nyali-bamburi-Shanzu area
- Collection of data on resources, water quality, waste water and solid waste management

#### Brief site description and methodology

Jomo Kenyatta public beach is the most heavily used public beach in Kenya and is situated along the Nyali-Bamburi-Shanzu area. JKPB is the most popular recreational resort in Mombasa that is accessible to the public for free and the only facility where Kenyans and foreigners alike can interact, swim and enjoy recreational activities. However, the number, type and level of awareness of beach users pose a serious challenge in the use and management of this beach.

The Management plan aims to legitimize and mainstream the activities undertaken by the public, beach operators, investors and other stakeholders as a way of identifying actions to further improve the beaches and act as first steps towards international Blue Flag standard. It has to be appreciated that Nyali-Bamburi-Shanzu area is an Integrated Coastal Area Management (ICAM) demonstration site for both short and long term activities geared towards sustainable exploitation and use of coastal resources.

#### Main findings and conclusion

Various working group meetings and surveys have been undertaken and reports written. Stakeholders have been identified and stakeholder meeting is scheduled to take place by end of January 2011.

#### Outputs

Discussion paper and quarterly report

# Project 7: Enhancing Regional Capability for the Assessment of Contaminants in the Marine Environment. (RAF/7/008)

**Participating Institutions**: This is a regional programme covering some African countries such as Egypt, Tunisia, Tanzania, Morocco, Ghana, and local participating Institutions include the University of Nairobi (Chemistry Department and the Nuclear Centre), Jomo Kenyatta University of Agriculture and Technology, and other national stakeholder institutions.

Scientific Team Members: Eric Okuku, Stephen Mwangi, Boaz Ohowa, Charles Mitto.

**Source of Funds:** The project is funded in part by the International Atomic Energy Agency (IAEA), being responsible for the purchase of equipment and comsumables (laboratory reagents), and in part by the Government of Kenya through KMFRI SEED funds for field work facilitation.

Duration of the project: 2008-2011.

#### **Research problem**

Marine contamination defies international boundaries. Consequently, there is need to adopt a regional approach to address contamination issues in places like the African region which is almost entirely surrounded by oceans and seas.

#### Objectives

The strategic objectives of the project are to strengthen technical and managerial capabilities of member states, e.g., in the use of nuclear techniques for assessment of contamination of the marine environment, with a view to:

- Determination of inorganic and organic pollutants in the coastal waters of Kenya
- Introduction of pollution monitoring programme in Kenya
- Incorporate the use of nuclear technology in contaminants monitoring
- promoting the conservation and sustainable management of the marine environment.
- addressing food safety and trans-boundary pollution issues.
- introducing pollution monitoring programme along the Kenyan coast.

#### Activities

- Establishment and equipping of KMRI radioisotopes laboratory 2
- Samples collection and analysis
- Hotspot areas identification
- Development of sedimentology maps
- Capacity building
- Development of project database

#### Brief site description and methodology

The study/ monitoring sites were selected to cover the whole Kenyan Coast. The stations include the estuarine stations in Rivers Umba, Ramisi, Mwena, Tan and Sabaki. Oceanic stations of Shimoni, Malindi, Tudor, Mtwapa and Makupa creeks are also included in the study. Water and sediments samples were collected for determination of

nutrints, heavy metals, oraginics, radionuclides and microbial contaminants. For reconstruction of pollutants history, sediments cores were taken. Appropriate approved methods were used to analyse the various samples.

#### Main findings and conclusions

In summary, the results of nutrients contaminations has shown that Mombasa creeks are basically polluted in comparison to refence site Gazi. Rivers Sabaki and Tana were also found to contribute a substantive amount of nutrients to the costal waters. Sewage was found to be the major contributor of nutrients in Mombasa creeks. Interms of the varuious eutrophication classes, Tudor creek was found to be eutrophic (mainly due to various inputs of sewage) where as Makupa and Mtwapa creeks were found to be in the upper limits of mesotrophy. A study of metals enrichment in the Kenya estuaries reported relatively low levels of metals as compared to the other estuaries across the world. Detailed results can be found in three publications (two in press, one under review)

#### Project 8: Sea-Level Monitoring program in Kenya

Participating Institutions: KMFRI, IOC, UHSLC Scientific Team Members: Dr. Charles Magori Source of Funds: IOC/UNESCO Duration: July 2010 - December 2010

#### **Research Problem**

There is a worrying trend of sea level rise around the globe as a result of climate change. If the current trend continues, most low-lying coastal areas will be flooded during high water spring tide. Kenya is not an exception. There is need for a monitoring program of sea-level trends in order to keep coastal and island states in a state of preparedness from the effects of flooding and other extreme oceanic events such as tsunamis, tropical cyclones and storm surges.

#### Objectives

The aim of this project is to:

- Monitor short- and long-term trends of sea level variations along the Kenyan coastline.
- Build up a database of sea level for our own use on the national level (e.g. to produce tide predictions for the ports of Mombasa and Lamu) and for contribution to the global sea level database at the University of Hawaii Sea Level Centre (UHSLC).

• Input data from both stations as part of early warning in case an extreme oceanic event takes place in the Indian Ocean region.

#### Activities

- Measurements of sea-level at high frequency (one minute interval) by means of tide gauges at Mombasa and Lamu stations
- Transmission of data in near real-time status to global sea level data centres
- Maintenance of Mombasa and Lamu tide stations
- Generation of harmonic constituents of sea level variations
- Production of tide tables
- Maintaining and updating of sea level database and website

#### Brief site description and methodology

- Mombasa tide station is located at Liwatoni Jetty in Kilindini harbour
- Lamu gauge is situated at the port of Lamu
- Both stations are installed in jetties and are principal stations on the Global Sea Level Observing System (GLOSS) network and also dedicated components of the Indian Ocean Tsunami Warning System (IOTWS).

#### Main findings and conclusion

Data from Mombasa station (1986-2010) is indicating a trend of rise in the mean sealevel of about 2mm/year, which is in agreement with the global trend and IPCC projections. 68 harmonic constituents generated and tide tables for Mombasa and Lamu for year 2011 produced.

# **Project 9: African Monitoring of Environment for Sustainable Development (AMESD) Project**

Participating Institutions: KMFRI, MOI, ESA Scientific Team Members: Dr. M. Nguli, Dr. B. Kirui, Dr. C. Magori Source of Funds: EU Duration: 3 Years

#### Introduction

In this biannual report highlight is given to AMESD Project, however, it is should be noted that the South Coast Seed Project is ongoing as the Coral Research aspects is yet to be carried out as soon as seed funds are availed. This will be done together with the preparation of the South Coast Resource Management Document. AMESD-Project is a project of African Union Commission (AUC) coordinated from Addis Ababa, Ethiopia with a budget of €21 million funded by European Union Commission (EUC) for the purpose of developing pan-Africa geo-information services.

#### Objective

The overall objective of the AMESD is to enhance monitoring, preparedness and adaptation to environmental change, including sustainable management of the environment thereby contributing to poverty alleviation.

#### Aim

The program aims to attain this broad objective by increasing the information management capacity of African national and regional institutions in support of decision makers at different levels and to facilitate sustainable access to Africa-wide environmental information derived from Earth Observation technologies.

#### Beneficiaries

KMFRI has benefited from the initial AMESD aim which is to ensure that African users have improved access to existing sources of basic Earth Information, field and ancillary data. Other associated countries benefiting from this project are Mauritius, Madagascar, Seychelles, Comoros, La Reunion, Mozambique and Tanzania. Under this arrangement, KMFRI is one of the four institutions in Kenya selected as one of the 47 AMESD thematic satellite receiving stations. KMFRI is under marine and coastal management thema which is under the Regional implementation Center (RIC) coordinated by the Mauritius Oceanography Institute (MOI). The others Kenyan beneficiaries are the Department of Resource Survey and Remote Sensing (DRSRS), Kenya Meteorological Department (KMD) and IGAD Climate Prediction and Application Center (ICPAC) and which land degradation and natural habitats with regard to land cover change dynamics.

#### Equipment

Under the project KMFRI has received satellite equipment to be installed at KMFRI premise as the AMESD-Mombasa, Station. The station consists of;

- One 2,4 C-Band receiving antennae
- Three personal computers and monitors for acquisition and processing of satellite data, including adhoc software
- One Un-interruptible Power Supply (UPS)
- One network switch and associated cables

#### Focal Point & Training accomplishment

Dr Michael M. Nguli is the Focal Point of the Project and Advisory to the Director-KMFRI.

Mr S. Ngete is the proposed AMESD-Mombasa, Station computer system operator. KMFRI scientist (Drs. M. Nguli, B. Kirui and Miss J. Ndungu, Mr Mbaru trainee in SWIOFP-Project) received training under the program Marine and Coastal Management Thema.

Accomplished Training courses were:

- 1. AMESD-MESOBIO Training Coursed to be held on 11-18<sup>th</sup> July 2010 in the La Reunion. Four Kenyans are to participate (Three from KMFRI and one from Fishery Department).
- 2. AMESD-IMTR System Administrators Training Course to be held, for 1 week, in August 2010 at KMD, Dagoretti, Nairobi.

#### Data/Results/Products

KMFRI will use the AMESD-Station for receiving satellite oceanography and fish resource data, products and for training of selected staff to carry out the work. More specifically the data and products include ocean color, sea surface temperature, sea level, currents (numerical models), fish resources, waves and climatologic parameters for the purpose of studying ocean currents, sea surface structure, thermal fronts and productivity (chlorophyll-a) of coastal waters off Kenya and the rest of eastern Africa coast. These studies are crucial to fishery resource management and sustainable fishery especially Tuna fishery in the South Western Indian Ocean region.

#### Way forward/Funding

KMFRI is to come up with own National Project, funded within the AMESD-Project, and make use of AMESD-Mombasa Station, to develop satellite based products for research and management.

# Project 10: Enhancing Sustainable Management of Mangrove Resources in Kenya through Participatory Approach

Participating Institutions: KMFRI, Kenya Forest Services, Ministry Of Livestock Development, Fisheries Department Msambweni.
 Scientific Team Members: Amina Juma, Dr. J. Kairo, Dr. J. Bosire, Dr. B. Kirui
 Source of Funds: UNDP-GEF/SGP
 Duration: 2 Years

**Research Problem** 

Despite the recognized socio-economic and ecological values of mangroves worldwide, they are threatened in Kenya by natural and human induced stresses ranging from overexploitation of wood and non-wood resources, conversion of mangrove areas for other land uses such as prawn culture and salt mining and pollution (Spalding et al., 1997).

# Objectives

- 1. Demonstrating multiple approaches and technologies to restore degraded mangrove areas
- Reducing pressure on mangrove forests and inshore fisheries through: Provision
  of alternative sources of building poles and energy by establishing woodlots of *Casuarina spp* (and other suitable species) by communities adjacent to the
  mangroves. Establishment of alternative sources of livelihood, such as;
  apiculture (bee keeping), aquaculture, and promotion of eco-tourism.
- 3. Capacity building on sustainable management of mangroves among local communities, NGOs, policy makers and relevant management agencies

# Activities

- Quantification of degraded mangrove areas for rehabilitation.
- Establishment of nurseries of mangrove species identified
- Site preparations.
- Mangrove replanting in demonstration site.
- Monitoring performance of replanted mangroves.
- Consultative meetings with the community and agree on the need and nature of alternative livelihoods, and sources of energy and building materials.
- Identification of sites where these activities will be implemented.
- Implementation of these alternatives livelihoods including; extension of mangrove boardwalk, apiculture, aquaculture, and establishment of woodlots of *Casuarina* and other species for firewood and building materials.
- Evaluation of performance of these alternatives.
- Organize with KMFRI and IOI, stakeholder's meetings to raise awareness on the importance, threats and rational management of mangroves
- Production of mangrove awareness materials
- Dissemination of awareness materials.
- Enhanced marketing of the mangrove walkboard

# Brief site description and methodology

The project site is Gazi bay, located in Msambweni district in the south coast of Kenya (4°25'S and 39°50'E). The Government of Kenya identifies the seascape between Chale Island and Gazi as a marine protected area. The dense human population in Msambweni district has caused the degradation of mangroves and associated terrestrial and marine ecosystems; and Gazi bay is one of the most affected areas. Current estimates indicate that 70% of the mangroves in Gazi have been degraded, particularly through excessive removal of wood products (Dahdouh-Guebas et al., 2004).The current the project **demonstrates** the feasibility of reducing pressure on the mangrove forests through promotion of alternative sources of energy and building materials and through promotion of alternative livelihood activities other than conversions of mangrove areas for other land uses.

#### Main findings and conclusion

The project has contributed to an increased awareness of the destructive practices and to promotion of sustainable approaches to mangrove management in Gazi bay, which if applied countrywide would result in an improvement of the *supporting* and *regulatory* services of the mangroves. This would in turn result in an increased availability of mangrove resources and in the maintenance of biodiversity, and ultimately, would contribute to the well-being of the coastal communities. In addition, the project has enhance mangrove conservation capacity among the community as well as establish demonstration plots for reforestation and aquaculture. All these will lead to enhanced livelihood and empowerment, particularly among women and youth. This is in addition to reduced pressure on fishery, increased house hold income, and improved food security.

# Project 11: Swahili Seas - Mikoko Pamoja: Bringing mangrove-REDD Innovations to local community

**Participating Institutions: KMFRI;** Ednibrugh Napier, Bangor, Birmingham, and Edinbrugh Universities; Ecometrica UK; and Plan Vivo Foundation

Scientific Team Members: Dr. James Kairo, Dr. Jared Bosire, Jacob Ochiewo, Amina Juma

**Source of Funds:** Natural Environment Research Council **Duration:** 2 years

#### **Research Problem**

Mangroves throughout Kenya and at Gazi have been degraded and removed. The main current pressure on the forests comes from collection of wood for timber and firewood, although past clear felling for industrial uses has left large areas denuded of trees. The past and current degradation has led to shortage of firewood, increased shoreline erosion, reduction in fishery and other biodiversity, loss of carbon, and possibly reduced value as nursery habitats for fish and other wildlife.

#### Objectives

- 1. To preserve the current quality and extent of the mangrove forests of Gazi Bay and of the services they provide to local communities
- 2. To restore degraded areas of mangrove forest in Gazi Bay
- 3. To raise income from forest resources, including carbon credits, for community benefit
- 4. To establish alternative sources of timber and firewood in the Gazi area
- 5. To establish a pilot project demonstrating sustainable mangrove management that will influence mangrove management nationally in Kenya
- 6. To work with the Kenya Forest Service and other government agencies to determine policy about engaging communities in land management, particularly through the provision of ecosystem services through international carbon offset markets

#### **Project activities**

Delineation and mapping of protected areas and monitoring and evaluating their development

- 1. Reforestation of degraded areas and maintenance of nurseries
- 2. Determine carbon storage capacity of the Gazi mangroves using remote sensing, GIS technology and intensive ground-truthing
- 3. Planting of *Cassuarina* plantations and other fast growing trees to subsidize mangrove wood
- 4. Payments for Ecosystem Services, through expansion of community fund for financing community projects (such as new school buildings, installation of electricity in the school, scholarships for poor children attending high school, repair of wind pumps, agricultural diversification etc).

#### Brief site description and methodology

Gazi Bay, in the Kwale district of Kenya, is located 55 kilometers (34 miles) south of Mombasa. The Bay is bordered by 6.2 square kilometers (2.4 square miles) of mangrove forests, which are heavily used by local people as a fishing ground and source of wood for building and fuel. The mangroves have been extensively used and degraded – with large areas clear-felled in the 1970s, commercial logging involving selective removal operating over many years and still continuing in some stands and continuing forest degradation through poaching and cutting for firewood. This has resulted in shortages of building poles and firewood, decreased fishery resources and increased coastal

erosion. The methodology involve protecting initially 107 ha of the current forest from further degradation, leading to forest recovery and carbon accretion. It will also expand reforestation efforts, aiming initially to replant 1 ha yr-1.

#### Main findings and conclusion

The project is in its initial stages. The community is not informed on the emerging opportunities of payment for ecosystem services. There is need of coming up with best ways in which information can be passed to the local for their understanding.

The communities living adjacent the bay are highly dependent on the mangrove resources i.e for poles and firewood and hence coming up with alternative sources of the same is important to prevent leakage and ensuring sustainable mangrove management.

#### Project 12: Mapping and Assessment of Coral Reefs in Shimoni-Vanga

Participating institutions: Kenya Wildlife Services (KWS), Fisheries department (FiD), and Beach Management Units (BMUs)
Scientific team members: Jelvas M. Mwaura and Juliet Furaha Karisa
Source of funds: GOK seed Funds
Duration: 2010 (I year)

#### **Research Problem**

The coral reefs in the south coast of Kenya are among the most diverse and spectacular marine ecological systems, supporting a wide range of economically and culturally activities such as artisanal and a growing commercial fishery as well as tourism industries. Despite their ecological and economic importance, to thousand of coastal population and entire national economy, the reefs are increasingly under various threats likely to undermine their productivity and sustainability and potentially lowering their potential goods and services provisions. The reef fisheries are an extremely, locallly important, natural resources and evidence suggest that fisheries productivity is on decline. There is paucity of biophysical information on which to base future management initiatives for the south coast area. Currently, marine resources monitoring and management is limited to protected and partially managed areas and ignored exploited or near shore-fishing areas. In collaboration with local stakeholders including KWS and Fisheries department, KMFRI is collecting biophysical information to detail current knowledge of the status of the reefs that can be used to facilitate effective adaptation of management initiatives for the southern coast of Kenya.

#### Objectives

Overall the project aims at provisions of detailed information on status of reefs in terms of the abundances and diversity of key reef functional taxa such as hard corals, fish and macro-invertebrates species and ultimately contributes to biodiversity conservation and sustainable utilsation of reef-based resources.

#### **Specific objectives**

- To determine the quality of benthic habitats of specific reef sites subjected to different management practises and exploitation rates.
- To determine the abundance of coral reef fish within specific reef sites subjected to different management practises and exploitation rates.
- To determine the abundance and in cases, the size frequency distribution, of economically or ecologically important invertebrate species at specific reef sites subjected to different management practises and exploitation rates.

#### Activities

- Collection of reef benthic cover, fin-fish and macro-invertebrate data
- Data entry and manipulation, i.e. statistical analysis
- Interpret findings and refine for management recommendations, publications of reports and scientic paper

#### Brief site description and methodology

The main study area is Shimoni-Vanga zone (Mos Bay) that includes Kisite-Mpunguti parka nd reserves areas, Sii island and Mwamba mkuu. A combination of survey methods was adopted similar to those used widely for coral reef assemnt and monitoring (English *et al.*, 1997) to characterize and establish current status of reefs as determined by underwater visual census of reef fish and macro- invertebrates, and benthic habitat's composition. The team also incorporated a few fishermen in reef surveys with a view of involving them in research activities and building up their capacity on reef associated biodiversity and current management issues. Reef survey protocols included: 1). Line transect to record benthic cover (4 replicate 10m transects), 2). Belt transects to using underwater vinsul census (UVC) to assess the abundance of fish groups (4 replicate 50m by belt transect counts, and 3) belt transect to assess the abundance of key macro-invertebrates (4 replicate 50 m by 5m wide belt transects).

#### Main findings and conclusion

The results demonstrate a range of reef conditions from healthy (high coral cover, high fish and invertebrates abundances) to degraded condition (low coral cover, low abundance of targeted fish family). The reefs in core protected and partially protected, remain healthier than reefs in open access, supporting relatively high coral cover and

fish abundance , Macro algae and coral rubble are highest in fished reefs. In protected areas, where coral cover and diversity was highest, coral dependent reef fish (e.g; Chaetodontidae) had higher abundance than in unmanaged areas. For fish that are targeted by local fisheries, both carnivorous (e.g. snappers, carangids, goatfish, groupers) and herbivorous (e.g. parrot fish) were in greater abundance in protected areas but surprisingly surgeonfish and sweetlips were in low abundance . Fish communities were very low abundance particularly exploited species such serranids (groupers), lutjanids (snappers), lethrinids (emperors) and scaridae ( parrotfish) which is evidently due to over fishing . Sea urchins (Diadema spp. and Echinometra mathaei) were in high densities in fished areas and almost completely absent in core protected area.

The composition and distribution of the benthic and fish communities found in southern coast coral reefs reflects the influence of management practices with MPAs showing progress in terms of retaining high coral cover, high fish abundance than fished or openaccess reefs. The lower coral cover and high rubbles in open-access fished reefs implies that provision of physical habitat that potentially provide structure, shelter and food for reef-specific fish such as acanthurids (surgeonfish) is reduced. Commercially important fish species such as snappers, groupers and emperors are in low abundance in fished reefs suggesting overexploitation. In absence of flexible and dynamic intergrated coastal zone management plan for the area, intensive artisanal fishing and habitat degradation by climate change may affect ecological balance and results to further dwidling of reef-associated fisheries and tourism.

# Project 13: Coral Bleaching and Climate Change: A Case Study in Shimoni-Vanga, Southcoast Kenya.

**Collaborators:** Kenya Wildlife Services (KWS), Fisheries department (FiD), and Beach Management Units (BMUs) **Scientific team members:** Mwaura, J.M.; Furaha, J.K. and Otwoma, L.M. **Source of Funds:** GOK Seed Funds **Duration:** one year-2010

#### **Research Problem**

Reef corals are increasingly experiencing coral bleaching and mortality events that are precipitated by global warming and Elnino that results to unusuall warm water of elevated sea surface temperature to cause "whitening" of corals. The aim of this research is to assess and document the coral bleaching extent and impact on coral reefs in terms of coral diversity and community structure as a case study in south coast area, Kenya. Reef deterioration is well documented in the East African reefs and coral bleaching is a ubiquitous concern in the region. The last and most severe global bleaching event was on 1998 where water surface temperature reached levels of up 2.8°c above normal and lasted for a month. In April 2010, coral reefs were subjected to unusually warm water anomaly that resulted to widespread coral bleaching in most reefs.

#### Objectives

The overall objective was to ascertain the impacts of the bleaching event. Specific objective included;

- Compare coral community structure before, during and after bleaching event
- Determine bleaching intensity and severity on coral community

#### Activities

- Collect pre-bleaching and post-bleaching data
- Preliminary analysis
- Analyse data, interpret and refne results for publications of reports and scientific papers.

#### Brief site descriptions and study methodology

To evaluate the intesity and severity of the bleachng episodes, the research team surveyed 9 reef-dominated sites located within 3 different management levels; Kisite ; no-extraction zone (2 sites), Mpunguti reserve (3) and open-access reefs (4 sites). Surveys were conducted using globally standardized reef check survey methods. At each site survey contained 2-3 replicates of a 25\*1 meter band transect within which coral bleaching percentage; genera and size-class were recorded. Bleaching percent estimates were classified into four categories (Normal, pale, partial bleaching and whole bleached).

#### Main findings and conclusions

Coral colonies affected by bleaching event were observed at all nine sites surveyed in April 2010, however, there was a reduction in the severity of bleaching and number of colonies affected compared to 1997-1998. The most severely affected sites were in the park evidently due to higher coverage and dominance of sensitive coral species such as *Acropora, Pocillopora* and *Stylophora*. The post-bleaching survey showed that reefs exposed to high water flow or adjacent to reef depressions were hardest hit than ones in sheltered lagoons

Coral bleaching and mortality is complex and mainly depends on interactions between corals and its physically evironments. Site-specific factors (water flow), colony size and morphology as well as genotypes have been shown to influence bleaching and mortality extents.

# **Project 14: Benthic Habitat Mapping for the Kenyan Coastal Shallow Areas**

Participating institutions: Kenya Wildlife Services (KWS), Wildlife Conservation Society (WCS)
Scientific team members: Jelvas M. Mwaura and Juliet Furaha Karisa
Source of funds: Masma and WCS funded
Duration: 2010 (1 year)

#### **Research Problem**

The project intend to produce detailed benthic habitat maps (1.8 m resolution) for the entire Kenya shallow coastal areas. In order to produce the maps, spectral or reflectance analysis of recent remotely sensed images mostly from 2010 (WorldView2 and QuickBird, 1.8m resolution) will be undertaken through a supervised classification and for validation of the habitat categories. This requires conducting extensive field sampling. The project envision these maps being of considerable use to environmental, fisheries, conservation, management and government agencies in Kenya.

#### Objectives

Conduct quadrat-based benthic habitat mapping and produce ensusing maps

#### Activities

- 1. Conduct quadrat-based benthic habitat mapping
- 2. Conduct spectral analysis of sattelite imagery using suprvised classification scheme.

#### Brief site descriptions and study methodology

The habitat mapping will include Shelly beach, Tiwi, Chale, Gazi, Funzi, Shimoni, Nyali (coral garden), Mombasa (Kenyatta), Kuruwitu, Takaungu, Mida, Watamu, Mayungu, Malindi, and Diani (mwoana). At each site, 10 points should be collected within each making 100 points per site and 1500 points for the entire coastline.

#### Main findings and conclusions

The project has just started on June 2010.

# Project 15: Patterns of genetic diversity and connectivity in a widespread coral *Acropora tenuis* on reefs in Kenya

Participating Institutions: KMFRI and Vrije University, Brussels Scientific Team Members: Jelvas M. Mwaura and Marc Kochzius (Vrije University) Source of Funds: VLIR Funded Duration: 2010 (I year)

#### **Research Problem**

Reef corals and the ecosystems they support have experienced multiple anthropogenic disturbances, including bleaching from global climate change, that operates at local and global scales. However, there are currently limited understanding and information on how and why coral reefs continue to persist through major environmental changes and consequently how they will respond to predicted warming trends in future. The ability of reef corals to not only recover from, but also to adapt to environmental disturbance is highly dependent upon the pattern and strength of connections among populations via dispersal larvae-the mechanism and consequences that vary over geographic scale. Studies of population genetic structure may provide an indication of direction and magnitude of connectivity among reefs and hence an important component in the assessment of the ability of reefs to recovery from major disturbances.

Our study therefore aims at assessing the genetic diversity of the species and consequently to infer its patterns and strength of connectivity among and between reef systems in the southern and northern reefs of Kenya.

#### Specific objectives:

- Determine genetic and genotypic diversity within the reef systems both in the south and northern Kenya ,
- Determine genetic and genotypic diversity between southern and northern reef systems in Kenya,
- From the above, assess the level of the specie's scale of dispersal, direction and strength of connectivity among coral populations.

#### Activities

1. Undertake coral fragments sampling at 5 main stations along the Kenyan Coast **Brief site descriptions and study methodology** 

Our study established 5 sampling locations (Kisite-mpunguti, Diani, Mombasa, Malindi and Lamu) along the Kenyan coast. At least 20 fragments of *A. tenuis* approx. 2 cm in length were taken at each sampling site from haphazardly selected colonies that were at least 3 m apart in order to avoid sampling clones. All fragments were placed in sea water-filled container in the field and later preserved in 95% ethanol in a small plastic container for future processing in advanced laboratory in Vrije university, Belgium.

#### Main findings and conclusions

It is an on-going project.

# **Project 16: South Coast Multi-Disciplinary Project**

(Baraza) Management Document Development 2011.

Participating Institutions: KMFRI, Fisheries Department
 Scientific team members: MEEP, Fishery Project, Natural Product, Socio-economics and Aquaculture Project
 Source of Funds: KMFRI Seed Funds
 Duration: (1) Field & Technical Reporting 2009-2010, (2) Stakeholders Symposium

Preamble

The title for this year's report: Status of South Coast Multi-disciplinary Project is in parallel with a report on the Status of MEEP in the last three years. It is an effort to review the research objectives and activities as well as to capture the latter development regarding the Stakeholders Symposium and finalization of the Management Document for the project through a Retreat Workshop that took place in June 2011.

The project started in earnest in 2008 in Msambweni-Vanga area, the last phase of field work ceased in 2010 following survey on corals by newly employed scientist to fill the gap on corals not taken up at the projects onset.

The goal was to bring out basic information on status of fishery and environmental resources to form basis for management development, and also basis for developing project for external funding.

#### **Research problems**

Research main problems were identified along issues such as overfishing, degradation of fish habitats and water quality

#### Objectives

The above issues lead KMFRI scientist to formulate overriding objectives which included investigating:

- The status of fishery covering catch, gear and fish mapping
- The status of the critical habitats including mangroves, sea grass (biodiversity) and coral reefs
- Water quality including nutrients, turbidity, micro-bio, and environmental drivers-currents, temperature, and water circulation and productivity (plankton distribution).

However the project scope also included:

- Introduction of post-harvest techniques
- Introduction of mari-culture e.g. sea weed farming
- Socio-economic issues of the community.

### Methodology

Research was carried out by way of making 5-day field excursions and cruise to different research sites. First Funzi bay was studies including Shirazi creek and Ramisi creek into which Ramisi River enters the bay. 2<sup>nd</sup> Shimoni-Vanga area was studies. Key stations and transects in which water quality and oceanographic parameters were measured during flood and ebb tides and at the water surface, mid-depth and near the bottom. Parameters included nutrients, salinity, temperature and plankton, sediments samples were occasionally obtained for various sites. In addition currents and sea level measurements were carried out especially within the Wasin Channel. River estuaries of Umba, Mwena in Majoreni, and Ramisi were also sampled during the 5-day excursions.

For critical habitats observations on mangroves extended from Bondo area to Shirazi and later to Vanga area. Benthic community especially sea grass and biodiversity was carried out for water around Shimoni area. Fishery mapping activities catch and gear status was done for mostly in Shimoni- Vanga area.

# Main Activities 1

Field activities were undertaken by team of scientists from each key research project at KMFRI and methodologies relevant to each investigation used. There were no scientists to effectively study the coral reefs. New scientists were employed in 2010 and were given responsibility of carrying out research in coral reefs.

Planning meetings were held regularly chaired by the Coordinator and key briefing seminars (discussant Meetings) with presentations made with members of the various research groups as discussants were held occasionally. During such discussant plus presentation power point were used and minutes taken.

# Main Activity 2

Following various field activities and analysis a Technical Report (Corporate) was prepared. The report contains various technical (multi-authored articles) from scientist in charge of each project component as well as individual scientists. Copy available in KMFRI-Library

# Main Activity 3

In 2010/2011 it becomes apparent that there was need to develop a management document for the larger South Coast Project that includes the emerging issues such as the introduction of aquaculture and eco-tourism. This activity was started in the December 2010, and was in earnest to be executed in 2011 with the help of KMFRI seed funds. A draft document was prepared and discussed in several meetings and the themes of the planned document manned so that each involved scientist was to make his contribution of 6-10 pages in order to have a sample draft document for further discussion. A Kiswahili document was also prepared with a view to dissemination the scientific findings to the stakeholders in a Stakeholder symposium or Baraza.

#### Main Activity 4

Activity 4 is a major one as it involves disseminating the Projects findings in an international scientific meeting, that is ARK II Conference held by KMFRI at Naivasha, in 2010(see ARK II Book of Abstracts). Scientists have been urged to publish their findings in journals and will probably do so in the upcoming 7<sup>th</sup> WIOMSA Conference to be held this year (2011).

#### **Scientific findings**

Research findings from the multi-disciplinary project briefly indicated the following:

#### 1. Fishery status

Inconclusive information on fishery decline; however, conclusive information on fishing grounds, fishermen, and type of gear. It suggests over fishing in the near shore where the large number canoe and boats are being operated. This further suggests deleterious impact on the near shore fishery.

#### 2. (i) Critical habitat(mangroves & sea grass)

Findings established over cropping of mangroves in certain areas, as well as degraded fishery habitats-sea grass and corals. Since observations are reported in the inshore fishing grounds rather than offshore ones it is indicative of impact of canoes and gear being used pointing into need to limit the carrying capacity of some areas of the fishing ground. Further findings indicate degradation due to turbidity inhibition light penetration in some area close to River Umba, where also corals have been bleached.

#### (ii) Critical habitats (Corals)

(There was a gap in the investigation of corals during the first part of the project. Towards the end of the project however KMFRI employed two experts and were assigned to fill the gap). Investigations have revealed impacts due to human influence such as overfishing and bleaching and death due to climate effect and sedimentation. In the south coast concern is on the marginal low value in coral cover, high macroalgae, coral rubble and depleted reef fish abundance. Overall results indicate relatively healthier ecosystems and fish populations within Kisite marine and reserve, however, it is evident that the reserve is not functioning as effectively as it could in preserving fish population numbers and benthic habitats. Gear-based management may be a viable tool for coral reef fisheries management but can be difficult to implement in areas with high dependence on reef fishery and loose management enforcement such as south coasts area. An integration of protected area may be a positive next move that can achieve multiple purposes of sustainable reef fisheries, enhancing fish populations and protection of coral reefs.

#### 3. Water quality, water circulation and productivity

Nutrient concentrations are variable both in time and space- highest near the mangroves and estuarine areas; however, patches were reported further offshore and attributed to water circulation dynamics. Although tidal circulation dominates, there is evidence that secondary circulation is important in some parts of the estuary and the main tidal channel. Environmental data further suggest seasonal fluctuations however, the mechanism, affecting fish catches is not at all clear. These observations suggest fish catch variability is largely seasonal depended i.e. due to low frequency fluctuation on main coastal currents and also as well as due to fresh water discharge.

#### Stakeholder Symposium and Retreat Workshop (2011)

After several delays due to unavoidable circumstances the Stakeholder Symposium (Baraza) and Retreat Workshop aimed at finalizing the Project's management document the Baraza and the Workshop were finally held from 23 to 27<sup>th</sup> June 2011 at KWS-Hall and Millennium Resort in south coast. The Baraza was the 2<sup>nd</sup> following a smaller one held in 2009 at the same venue.

#### Conclusion

The final management document has been discussed and agreed upon by various contributing scientists and is due for final publication in July 2011.

# Project 17: Resilience and Adaptation of Mangroves and Dependent Communities in the Wio Region to the Impacts of Climate Change

Participating Institutions: KMFRI, Eduardo Mondlaine University (Mozambique) Scientific Team Members: Dr. J. Bosire, Dr. J.G. Kairo, Dr. C. Magori, Dr. B. Kirui, Mr. J. Ochiewo, Ms. J. Ndungu, Mr. A. Kimeli Source of Funds: WIOMSA - MASMA Duration: August 2010 – August 2012

#### **Research Problem**

Mangroves are an important coastal resource providing diverse ecosystem goods and services significantly depended on by millions of people in the tropics worldwide. The global mangrove cover ranges from 165,000 – 200,000 sq km with the WIO mangroves being about 5% comprising of nine species. However, regional mangroves are threatened by many factors including conversion, overexploitation, pollution, and more recently by climate change effects. While sea level rise is a major threat on mangrove ecosystems in the long-term, immediate indirect threats namely flooding and sedimentation pose a reasonable challenge already compromising the integrity of mangrove forests and dependent livelihoods. A 115-year coral record from Kenya has been found to preserve the history of rainfall anomalies in East Africa in relation to global warming-induced Indian Ocean Dipole (IOD) variability. The project aims to investigate the resilience of mangroves in Kenya and Mozambique to flooding and sedimentation, which are strongly influenced by the IOD using satellite imagery and validated with intensive ground truthing; conduct vulnerability assessments of WIO mangroves to sea level rise (SLR) under different scenarios; investigate the socioeconomic impacts of climate change impacts to communities in the study sites including their adaptive capacity to the vagaries of climate change; undertake pilot mangrove restoration using "climate smart species" in areas which suffered mangrove die-back due to the IOD related sedimentation/flooding and eventually review legislation/policies relevant to mangrove and determine their effectiveness in responding to climate change. Major outputs of the project will include among others: resource maps indicating and data on mangrove resilience to CC and also providing information for improved forest management; information on adaptive capacity of local communities to climate change related impacts; demonstrated mangrove plantations using "climate smart species" and increased awareness on CC impacts on mangroves in the WIO region.

#### Objectives

- 1. Assess impact of climate change on mangroves and dependent communities;
- 2. Conduct vulnerability assessments of study sites to sea level rise;
- 3. Assess land use changes in the study sites and their real or perceived indirect impacts on mangroves;
- 4. Conduct ecosystem restoration using 'smart" species

#### Activities

Review available data on Kenyan continental shelf and document them

#### Brief site description and methodology (one paragraph)

Mwache Creek (403.01' S & 39.06038.06'E) is located 20 km Northwest of Mombasa city in Coast Province. The total area of the wetland is approximately 1,500 ha with about 70% of the surface area being covered with mangroves. Tudor creek bounds Mombasa island on the northwest and extends some 10 km inland. The creek has two main seasonal rivers, Kombeni and Tsalu.

The proposed project is multi-disciplinary in nature and addresses issues and gaps identified in the current call including (but not limited to): assessment of ENSO and IOD impacts; increased understanding of current relationship between climate and biodiversity; evaluation of current mangrove forestry management regimes and determination of their effectiveness for adapting to climate change impacts and providing ecosystem services; assessment of adaptive capacity of marine species and influences on species composition, biodiversity, resistance and resilience to disturbance, and regeneration potential; evaluation of restoration potential of marine ecosystems that are threatened or have been impacted by climate impacts; evaluation of marine ecosystems and adaptation strategies of communities whose resources are threatened or have been impacted by climate change.

#### Main findings and conclusion

On going project.

# Annex 1: Workshops/conferences attended

- 1. MASMA grantees meeting in October 29<sup>th</sup> to 31<sup>st</sup> 2010 in Mombasa Kenya, to review research progress (Gladys Okemwa)
- KMFRI Aquatic Resources of Kenya (ARK II) Conference in Naivasha, Kenya in November 16<sup>th</sup> to 19<sup>th</sup> 2010 (Edward Kimani, Gladys Okemwa, Christopher Aura, Esther Fondo, Simon Agembe)
- 3. KCDP Fisheries Component Development and Planning Meetings (Gladys Okemwa, Edward Kimani)
- 4. SWIOFP Scientific committee meeting, Mauritius 8<sup>th</sup> to 12<sup>th</sup> October 2010 (Edward Kimani)
- 5. SWIOFP crustacean component 2011 budget meeting, 9-11 August 2010, South Africa.
- 6. First ODINAFRICA IV Project National Coordination meeting. 22<sup>nd</sup> July 2010, KMFRI Conference Hall, Mombasa.
- 7. Simon Agembe attended a Workshop to Plan for Publication of Project Results held at Sun n Sand Hotel on 1-7<sup>th</sup> October 2010
- 8. The "Census of Marine Life 2010: A Decade of Discovery" events to share the results of the Census' ten years of collaborative scientific research between 4-6 October 2010 in London (Edward Kimani)
- 9. SWIOFP Component 2 (crustaceans) Survey Protocol Meeting. 14<sup>th</sup>-15<sup>th</sup> July 2000, Mombasa
- 10. WIOFish Project Meeting. 21-25 March 2011. SWIOFP Boardroom, KMFRI, Mombasa
- 11. Stakeholder Consultative Meeting for Lobser Fishery Improvement Plan/Assessment in Kenya (2<sup>nd</sup> June 2011). Royal Court Hotel Mombasa. (Gladys Okemwa).
- 12. Ringnet Management Plan- Drafting Meeting, held at Kilifi from 26<sup>th</sup> to 28<sup>th</sup> May 2011.
- 13. International Conference on Aquatic Resources of Kenya (Ark-II) Aquatic Research for Development, (16th -19th November, 2010) held at the Kenya Wildlife Training Institute, Naivasha Kenya.
- 14. Artemia Mission for planning the inception of the KMFRI-VLIR Artemia Project from 22<sup>nd</sup> 30<sup>th</sup> August, 2010. KMFRI Headquarters; Mombasa. (Morine, Dr Betty)
- 15. KAPAP Research Call Workshop 14<sup>th</sup> 18<sup>th</sup> September 2010 EAST College Embu.
- 16. Workshop for Setting specifications for fish farm inputs 20<sup>th</sup> 23<sup>rd</sup> September 2010; Merica Hotel Nakuru.
- 17. Curriculum Development for fish farming workshop: KMFRI Business Wing, 10<sup>th</sup> 14<sup>th</sup> October 2010.
- 18. KCDP Project Implementation Manual preparation workshop; 12-18<sup>th</sup> October 2010.
- 19. ESP Seed Component Induction meeting; Banana Leaf Hotel; Nyeri 2<sup>nd</sup> 4<sup>th</sup> November 2010.
- 20. Workshop for Development of Standard Operating Systems for Fish Seed; 24<sup>th</sup> 26<sup>th</sup> November 2010. Gossip Hotel; Mlolongo.
- 21. Finalization of silvofisheries Training through rennovation of mud crab ponds at makongeni (21<sup>st</sup> -28<sup>th</sup> November 2010)
- 22. Project Implementation committee meeting for the Gazi UNDP Project 1<sup>st</sup> December 2010
- 23. Attended the 9th Masma grantees meeting 29-31st October 2010 at Whitesands Beach Hotel
- 24. Attended the 14th South African Marine Science Symposium 4-7th April 2011, Rhodes University Grahamstown, South Africa (Dr. Mwaluma)
- 25. Research Extension workshop organized by the Ministries of Agriculture and Livestock, Kenyatta University Mombasa Campus 18th May 2011. Presented a paper on "Aquaculture research at KMFRI Mombasa" (Dr. Mwaluma)
- 26. Induction and planning workshop on implementation of seed component activities 2010-2011 at Banana leaf Hotel Nyeri, 3<sup>rd</sup> Nov, 2010 (Dr. Betty, Miriam)
- 27. Regional Training in Biodiversity Informatics at KCCT-Nairobi 20<sup>th</sup>-30<sup>th</sup> September, 2010 (Miriam)
- 28. KCDP effectiveness support mission held at KMFRI conference hall from 28<sup>th</sup> March to 1<sup>st</sup> April, 2011. (Morine, Dr. Betty, Mirera)
- 29. Finalization of silvofisheries Training through rennovation of mud crab ponds at makongeni 21<sup>st</sup> -28<sup>th</sup> November 2010 (Mirera)
- 30. Project Implementation committee meeting for the Gazi UNDP Project 1<sup>st</sup> December 2010 (Mirera)
- 31. Aquaculture working group meeting held to formulate the National Aquaculture Policy held in Nakuru from 21<sup>st</sup> -26<sup>th</sup> March 2011(Mirera)
- 32. Final stakeholders workshop for the Gazi Community project funded by UNDP on 24<sup>th</sup> February 2011-03-30 (Mirera)

- Consultative workshop for the Ecosystem Services for Poverty Alleviation (ESPA) project (Whole Decision Network Analysis for Coastal Ecosystems (WD-NACE) at Diani 10<sup>th</sup> February 2011 (Mirera)
- Integrated Coastal Zone Management Plan (ICZMP) stakeholders consultative meeting at Kenyatta University, Mombasa and Pwani University College, Kilifi 11<sup>th</sup> -14<sup>th</sup> January 2011 (Mirera)
- 35. Aquaculture working group meeting held to formulate the National Aquaculture Policy held at Nakuru from 3<sup>rd</sup> 6<sup>th</sup> May 2011 (Mirera).
- 36. National Aquaculture Policy stakeholder consultative meeting at Charonyi Guest house, Voi 4<sup>th</sup> -5<sup>th</sup> April 2011 (Mirera)
- 37. National Aquaculture Policy final stakeholders consultative meeting at Lukenya Guest house, Machakos from 15<sup>th</sup> 20<sup>th</sup> May 2011 (Mirera)
- 38. ISO 9001:2008 QUALITY MANAGEMENT SYSTEM. Re launch of ISO document and progress workshop. 26<sup>th</sup> to 28<sup>th</sup> April 2011. (BM Nyonje)
- Strategic Planning Workshop for Kwetu Training Centre at Lambda Holiday Resort, Mtwapa, Mombasa from 20<sup>th</sup> – 22<sup>nd</sup> June 2011 (Mirera)
- 40. KMFRI Monitoring and Evaluation task force meeting at Pwani University, Kilifi from 22<sup>nd</sup> 24<sup>th</sup> May 2011. (Miriam, Mirera)
- 41. Finalization of the Report on the Management of Fishery and Environmental Resources of Kenyan South Coast 25th 27th June 2011(Elisha, Miriam)
- 42. Fish feeds and seeds standards workshop. Merica Hotel Nakuru; 21<sup>st</sup> to 24<sup>th</sup> June 2011. (BM Nyonje)
- 43. Workshop for the harmonization of the regional report for the MASMA funded Global Markets project, Dar-es-Salaam, Tanzania, 09<sup>th</sup> 13<sup>th</sup> February 2011.
- 44. Workshop for the mangroves and climate change project, Maputo-Govuro, Mozambique, 23<sup>rd</sup> 28<sup>th</sup> January 2011.
- 45. IFS-WIOMSA Science Outreach Workshop, Zanzibar, 5<sup>th</sup>-11<sup>th</sup> December 2010.
- 46. International Conference on Aquatic Resources of Kenya (ARK II) Aquatic research for Development, Naivasha, Kenya, 16<sup>th</sup> 19<sup>th</sup> November 2010.
- Ninth Meeting of the Marine Science for Management (MASMA) Grantees: Monitoring the Performance of the Approved Projects, Mombasa, 29<sup>th</sup> – 31<sup>st</sup> October 2010.
- 48. World Bank/ Ministry of Finance hosted Financial Training workshop; 10 11th September 2010, KCB, Karen, Nairobi (Dr. Uku, Dr. Bosire, Mwangi)

- 49. PIM 33. International Conference on Oceans, Climate Change and Sustainable Development: Challenges to Oceans and Coastal Cities. 2-4 September 2010, Beijing, China (Dr. Kairo).
- 50. Meeting of the Ecology Expert Working Group to develop a Management Plan for the Kisite-Mpunguti Conservation Area 22nd 23rd September 2010, Sapphire Hotel, Mombasa. (Dr. Uku)
- 51. Training on sediments dating, 03-12 July 2010, Morocco (Okuku)
- 52. RAF 7008 Regional Coordination meeting 25-28 August 2010 (Okuku)
- 53. 1st National Coordination meeting on Ocean Data and Information Network for Africa (ODINAFRICA-IV) Project. 22 July 2010, Mombasa, Kenya (Dr. Magori, Okondo, Mwaura)
- 54. National stakeholder workshop on climate variability, adaptation and coastal processes, 22-24 September 2010, Mombasa, Kenya. (Dr. Magori, Dr. Osore)
- 55. Taskforce meeting on pollution prevention and control guideline development, Mombasa Beach Hotel 23-24th September 2010 (Okuku)
- 56. Regional AMESD-MESOBIO training course on: "Environment, living resources, remote sensing & fisheries in the South West Indian Ocean", 12-17 July 2010 La Réunion, France (Dr. Nguli, Dr. Kirui)
- 57. First ODINAFRICA-IV Training Course on Coastal and Marine Atlas, 26 July 6 August 2010, Mombasa, Kenya (Dr. Kirui, Kimeli)
- 58. Introduction to Marine Data for Young Scientists (6-10 September, 2010) in Oostende Belgium (Kimeli).
- 59. MASMA-Cholera Project Brainstorming meeting, Tanga, Tanzania, 28th 30th September 2010 (Mwangi)
- 60. KWS management planning of the Kilifi Marine Conservation Area Ecology Programme hosted by KWS on 27-29 September, 2010 (Mwaura)
- 61. WWF meeting on programme strategising including priotising marine research and monitoring (Mwaura)
- 62. SWIOFP Biodiversity component Turtle Training Workshop, 30 August to 2 September 2010 in Reunion Island, at the KELONIA Marine Turtle Observatory. (Karisa)
- 63. Coral population structure: An assessment of Kenyan coral reefs' health using sizefrequency distribution, KMFRI Internal Seminar, 7 July 2010, KMFRI Mombasa conference hall. (Karisa)

- 64. The KMFRI Annual Conference, ARK II, Naivasha, 16th 19th November 2010 (Dr. Uku, Dr. Bosire, Dr. Kairo, Dr. Kirui, Dr. Magori, Dr. Nguli, Dr. Osore, Mwangi, Gwada, Amina, Kimeli, Mwaura, Karisa, Ndung'u).
- 65. Working group meeting to develop publications for NaGISA 19th 22nd December 2010 (Dr. Uku)
- 66. Working group meeting to develop the ARK II Conference report 15th 18th December 2010 (Dr. Uku, Dr. Bosire, Dr. Osore, Gwada)
- 67. IOC-UNESCO-Workshop on implementing adaptation to climate change in east and west Africa, Nairobi, Kenya, 3-5 November 2010 (Dr. Kirui)
- 68. Marine and Coastal Atlas Development Workshop, 22-26 Nov 2010 in Oostende Belgium (Kimeli)
- 69. Marine and coastal Katoomba Group Meeting private event. November 1- 4, 2010, La Paz Mexico (Dr. Kairo)
- 70. WIOMSA.MASMA Grantee Meeting, Nov. 29-31, 2010, Mombasa, Kenya. (Dr. Bosire, Dr. Kairo, Dr. Magori)
- 71. Global Environment Facility (GEF) West Indian Ocean Marine Highway Project Workshop on Environment Sensitivity Atlas (ESA) mapping component 2nd consultant mission 21-24 February 2011 in Malindi, Kenya (Kimeli)
- 72. The final stakeholder's workshop of the project "Enhancing sustainable Management of mangrove Resources in Gazi Bay, through participatory approach" on 24th February 2011, at Diani Forest Investment Ltd. Ukunda. Presented the two years project overview (Amina).
- 73. Participatory Natural Resource Management (PNRM) course at Kenya Forestry Research Institute (KEFRI) Muguga from 31st January to 11th February 2011. (Amina)
- Initiation Workshop for the Mangroves and Climate Change Project between Kenya and Mozambique. Maputo, Mozambique, 24 – 27 January 2011. (Dr. Bosire, Dr. Kairo, Dr. Magori)
- 75. Workshop on Ecosystem Approach to Fisheries (EAF) Implementation in the South West Indian Ocean Fisheries Commission (SWIOFC) Area, Pretoria, South Africa, 21-24 February 2011. (Dr. Magori)
- 76. Training on AAS, QC and QA in analytical chemistry, International Atomic Energy Agency (IAEA) Monaco laboratory, 10th January to 10th March 2011. (Okuku)
- 77. South West Indian Ocean Fisheries Project (SWIOFP) Mid Term Review Workshop, Male the Maldives 08 – 12 March, 2011. (Dr. Osore)

- 78. International training course on Climate Change Adaptation in Agriculture and Natural Resources Management: Policy Making and Programming for Sustainable Development, 28 February to 11 March 2011, Kampala, Uganda. (Karisa)
- 79. Meeting of the World Bank Project Coordinators, Treasury, Nairobi 3rd March 2011 (Dr. Uku)
- 80. Meeting with Nagasaki University, KMFRI 11th March 2011 (Dr. Uku, Dr. Bosire, Dr. Magori, Gwada)
- 81. Evaluation meeting with the team from the East African Community 25th March 2011 (Dr. Uku, Dr. Osore, Dr. Magori, Dr. Nguli, Gwada)
- 82. World Bank Effectiveness Support Mission, KMFRI, Mombasa 28th March 1st April 2011 (Dr. Uku, Dr. Kairo, Dr. Bosire, Dr. Osore, Gwada)
- 83. National Stakeholders Workshop on Inputting and Validation of Draft Coastal zone Pollution, Prevention & Control Guidelines", Mombasa Beach Hotel, 30th March to 1st April 2011 (Kimeli)
- 84. IOC/UNESCO Blue Carbon Working Group meeting at the UNESCO Headquarters, 7 Place de Fontenoy 75352 Paris, France, 15 – 17th Feb 2011 (Dr. Kairo)
- Terminal project workshop "Enhancing sustainable Management of mangrove Resources in Gazi Bay, through participatory approach. Diani Forest Investment Ltd. Ukunda. I served as technical advisor for the project, 24th Feb. 2011 (Dr. Kairo)
- Regional Conference on climate change adaptations in the coastal areas of WIO, Balaclava Fort, Mauritius. I organized a special session on REDD+ Innovations in WIO, 21-23 March 2011 (Dr. Kairo)
- 87. Visiting fellow at United States Geological Survey (USGS)- National Wetlands Research Centre Lafayette. USA, 24th January - 14th February 2011 (Dr. Kirui)
- 88. Global Environment Facility (GEF) National Prioritization Exercise for Kenya. Great Rift Valley Lodge, Naivasha, Kenya, 22nd-25th March 2011 (Dr. Kirui)
- 89. Coral Reef Task Force meeting, Nairobi: 8th 9th April 2011 (Dr. Uku)
- 90. NEMA ICZM meeting, Mombasa: 25th May 2011 (Dr. Uku)
- 91. South Coast Stakeholders Workshop, Shimoni.24th June 2011. Presented on Integrated mangrove management, A case study of Gazi Bay (Amina)
- IOC-WMO Second In-Region Capacity Building Workshop of the Data Buoy Cooperation Panel for countries of the Western Indian Ocean, Mauritius, 2- 6 May 2011 (Dr. Magori, Kimeli)
- 93. Ocean Teacher Academy Marine GIS Training Course UNESCO/IOC Project Office for IODE, Oostende, Belgium, 16 20 May 2011 (Kimeli)

- 94. AMESD E-training workshop in Mauritius 7-13 May 2011 (Dr. Nguli)
- 95. SERVIR Africa workshop: Africa Coral Bleaching Modelling Workshop 20th June to 1st July 2011, Nairobi, Kenya (Karisa)
- 96. Msambweni-Vanga Resource assessment Stakeholder workshop on 24th. June 2011. (Dr. Bosire, Dr. Nguli, Dr. Kairo, Dr. Magori, Dr. Kirui, Gwada, Mwaura, Mwangi, Okuku, Amina)
- 97. Msambweni-Vanga Resource assessment Stakeholder workshop on 24th. June 2011. (Mwaura)
- Retreat for final write up of Kenya Aquatic a management oriented document for for Shimoni-Vanga area fisheries (Dr. Nguli, Dr. Kairo, Dr. Magori, Dr. Kirui, Gwada, Mwaura, Mwangi, Okuku).
- 99. Kisite-Mpunguti Marine Reserve Plan stakeholder workshop on 21st. June 2011 at reef lodge hotel Shimoni south coast (Mwaura)
- 100. Malindi-Watamu Marine Reserve Plan stakeholder workshop on 23st. June 2011 at Mnarani club hotel in Kilifi (Mwaura)
- 101. Launch of the State of the Coast Report and Integrated Coastal Zone Management (ICZM) Action Plan, Mombasa Beach Hotel, 30 June 2011 (Dr. Kairo, Dr. Magori, Okuku)
- 102. Fellowship on organic contaminants for Veronica Wanjeri within the framework of the project, France May-July 2011 (Okuku)
- 103. RAF 7007 Regional coordination meeting 31-2nd April 2011 (Okuku)
- 104. RAF 7007 Regional Training course on RBA of ASP toxins, 3-9th April 2011 (Okuku).
- 105. IAEA coordinators workshop, 20-21 April 2011 (Okuku)
- 106. Project meeting and launching of field work in Govuro, Mozambique; under the Masma Project 'Resilience of mangroves and dependent communities in the WIO region to the impacts of climate change.' - Maputo, Mozambique. 3 – 14 May 2011 (Dr. Kairo)
- 107. EPZ investment/linkages opportunities workshop for coast region. Kwale County Hall. 3 May 2011 (Dr. Kairo)

#### Annex 2: Training

- 1. Mr. Thomas Mkare continued his Master of Science in Zoology (Genetics) in the University of Stellenbosch, South Africa.
- 2. Emanuel Mbaru continued Master of Philosophy in Ichthyology and Fisheries Science course at the Rhodes University, South Africa.

- Ms Gladys Okemwa joined Moi University for a PhD degree course in Fisheries and Aquatic Resource Management at Moi University supported partially by a WWF Russell E Train grant.
- 4. Mr. Christopher Aura obtained a Japanese Government scholarship for PhD to commence in 2011.
- 5. Mr. Simon Agembe joined Moi University for PhD in Fisheries and Aquatic Sciences Moi University.
- Training workshop on Seed Production and Fish Hatchery Management Course at the National Research and Development and Training Centre (NARDT) 16<sup>th</sup> -21<sup>st</sup> Jan 2011 (Miriam Wainaina, Emily Wafula, Charles Kalerwa, Johnson Nyamari)
- Training in commercial seaweed development and farming techniques. Organised by RecoMap. Conducted by Mr. Bong. Held at KMFRI office Gazi station 10th -11th December 2010 (Elisha M'rabo)
- 8. Training seminar on tilapia management for the FEEPP phase II at (NARDT) 28<sup>th</sup> March to 2<sup>nd</sup> April 2011 (Mirera, Justsu Wakili, Mwendwa Mbaluka)
- 9. Training on Artemia pond culture and cyst quality control at Can Tho University, Vietnam. 15<sup>th</sup> March to 30<sup>th</sup> May 2011 (Dan Odiwuor).
- 10. Sandwitch PhD program Linnaeus University, Sweden (Mirera)
- 11. Sandwitch PhD program Ghent University, Belgium (Morine Mukami)
- 12. Ms. Fridah Munyi-Leshan is going on with her one-year Master of Social Policy Analysis studies offered by Luxembourg, Katholieke Universeit Leuven, Belgium. This course began on 1<sup>st</sup> September 2010 and runs up to Mid July 2011.
- 13. Edward Waiyaki went for a short training course on market access for sustainable development, November 2010, Wageningen University, Netherlands.
- 14. A volunteer, Miss Tabitha Muriuki, went for a 2 month training course on Socioeconomic assessments and project management, January-March 2011, United Kingdom
- 15. IOC's Science Fellowship Programme: Young African Leaders For Long-Term Adaptation To Climate Change on Ocean and Coastal Zones of Africa (Dr. Kirui
- 16. Wageningen fellowship: Training on climate change adaptation in agriculture and natural resources management (Karisa)
- 17. Fellowship on Climate change and women scientists: Training and networking on climate change assessment, information dissemination and policy advocacy, still under review (Karisa)
- 18. Application for the ALA Fellowships on Coral reefs and Ocean Acidification. In progress (Karisa)

19. Application for the 54th UNEP/UNESCO/BMU International short course on Climate change adaptation for developing and emerging countries. In progress (Karisa)

# **Annex 3: Publications**

- 1. Fondo, E. N., E. N. Kimani and D. O. Odongo. 2010. The status of mangrove mud crab fishery in Kenya. East Africa. *International Journal of Fisheries and Aquaculture Vol. 2(3), pp. 79-86, July 2010.*
- Brenda Konar1, Katrin Iken1, Juan Jose' Cruz-Motta2, Lisandro Benedetti-Cecchi, Ann Knowlton1, Gerhard Pohle, Patricia Miloslavich, Matt Edwards, Thomas Trott6, Edward Kimani, Rafael Riosmena-Rodriguez, Melisa Wong, Stuart Jenkins, Angelica Silva, Isabel Sousa Pinto, Yoshihisa Shirayama. 2010. Current Patterns of Macroalgal Diversity and Biomass in Northern Hemisphere Rocky Shores. PloS One. Published.
- Simon Agembe, Chrisestom M. Mlewa and Boaz Kaunda-Arara. 2010. Catch Composition, Abundance and Length-Weight Relationships of Groupers (Pisces: Serranidae) from Inshore Waters of Kenya. Western Indian Ocean J. Mar. Sci. Vol. 9, No. 1, pp. 91 - 102, 2010.
- Katrin Iken1, Brenda Konar, Lisandro Benedetti-Cecchi, Juan Jose' Cruz-Motta, Ann Knowlton, Gerhard Pohle, Angela Mead, Patricia Miloslavich, Melisa Wong, Thomas Trott, Nova Mieszkowska, Rafael Riosmena-Rodriguez, Laura Airoldi, Edward Kimani, Yoshihisa Shirayama, Simonetta, Fraschetti, Manuel Ortiz-Touzet, Angelica Silva .2010. Large-Scale Spatial Distribution Patterns of Echinoderms in Nearshore Rocky Habitats. PLoS ONE 5(11): e13845. doi:10.1371/journal.pone.0013845
- Thomas K. Mkare, Julius O. Manyala, Christopher A. Mulanda and Emmanuel K. Mbaru1 2010. Relation between phytoplankton composition and abundance and physicochemical characteristics of Chepkanga Dam, Eldoret, Kenya. Lakes & Reservoirs: Research and Management 2010 15: 111–118.
- 6. Mugo R., S. Sei-Ichi, A. Hihira and T. Kuroyama. 2010. Habitat characteristics of skipjack tuna (*Katsuwonus pelamis*) in the western North Pacific: remote sensing perspective. *Fisheries Oceanography*, 19(5): 382-396.
- Saitoh S, Robinson Mugo1, I Nyoman Radiarta1, Shinsuke Asaga1, Fumihiro Takahashi2,Toru Hirawake1, Yoichi Ishikawa3, Toshiyuki Awaji3, Teiji In4, and Shigeki Shima. 2011. Some operational uses of satellite remote sensing and marine GIS for sustainable fisheries and aquaculture. *ICES Journal of Marine Science*; doi:10.1093/icesjms/fsq190.

- 8. Wambiji Nina, Yong-Ju Park, Ji-Gweon Park, Se-Jae Kim, Sung-Pyo Hur, Yuki Takeuchi, Akihiro Takemura. 2010. Expression patterns of type II and III iodothyronine deiodinase genes in the liver of the goldlined spinefoot, *Siganus guttatus*. Fisheries Science Ms. No. FISC-D-10-00224R1.
- Penha-Lopes, G., S. Xavier1, J. Okondo, S. Cannicci, E. Fondo, S. Ferreira, C. Macamo, A. Macia, S. Mwangi and J. Paula.2010. Effects of Urban Wastewater Loading on Macro- and Meio-infauna Assemblages in Subtropical and Equatorial East African Mangroves. Western Indian Ocean J. Mar. Sci. Vol. 9, No. 2, pp. 195-212.
- 10. Fulanda, B., Ohtomi, J., Mueni, E. and E. Kimani. Fishery Trends, Resource-use and Management System in the Ungwana Bay Fishery Kenya. *Ocean & Coastal Management.*
- 11. Mirera, O. D., Kairo, J. G., Kimani, E, N and Waweru, F. K. (2010). A comparison in fish assemblages in mangrove forests and on intertidal flats at Ungwana bay, Kenya. *African Journal of Aqautic Science*, 35 (2): 165-171.
- 12. Mwaluma, J.M, B Kaunda-Arara, J. Rasowo, M.K Osore and V. Oresland (2010) Seasonality in fish larval assemblage structure within marine reef National Parks in coastal Kenya. *Environ Biol Fish* DOI: 10.1007/s10641-010-9749-z
- 13. Mwaluma J.M, B. Kaunda-Arara and J. Rasowo (2010) Alongshore distribution and abundance of fish larvae off the coast of Kenya. *African Journal of Marine Science*. DOI: 10 2989/1814232x.2010.538154
- 14. Aquaculture Development in Kenya (2011). Nyonje, B.M, Charo Karisa, H, Macharia, S. K, Mbugua, M. SAM NO. 7 2011.
- 15. Grimsditch, G., Mwaura J.M., Kilonzo, J. and Amiyo, N. (2010) The Effects of Habitat on Coral Bleaching Responses in kenya. *Ambio*.Vol.39:295-304pp.
- 16. Kairo J. Decomposition of mangrove roots: effects of location, nutrients, species identity and mix in a Kenyan forest. Estuarine, Coastal and Shelf Science (2010). 88:135-142
- 17. E.K. Mbaru, E.N. Kimani, L.M. Otwoma, A. Kimeli and T.K. Mkare (2011): Abundance, Length-Weight Relationship and Condition Factor in Selected Reef Fishes of the Kenyan Marine Artisanal Fishery. Advance Journal of Food Science & Technology 2011 (Vol. 3 Issue: 1)
- M.D.-d. Alba, M.D. Galindo-Riano, M.J. Casanueva-Marenco, M. Garcia-Vargas, C.M. Kosore, (2010), Assessment of the metal pollution, potential toxicity and speciation of sediment from Algeciras Bay (South of Spain) using chemometric tools, Journal of Hazardous Materials, doi:10.1016/j.jhazmat.2011.03.020

- Gil Penha-Lopes, Susana Xavier, Julius Okondo, Stefano Cannicci, Esther Fondo, Susana Ferreira, Célia Macamo, Adriano Macia, Stephen Mwangi and José Paula1. Effects of Urban Wastewater Loading on Macro- and Meio-infauna Assemblages in Subtropical and Equatorial East African Mangroves. Western Indian Ocean J. Mar. Sci. Vol. 9, No. 2, pp. 195-212, 2010
- M.D.-d. Alba, M.D. Galindo-Riano, M.J. Casanueva-Marenco, M. Garcia-Vargas, C.M. Kosore, 2011, Assessment of the metal pollution, potential toxicity and speciation of sediment from Algeciras Bay (South of Spain) using chemometric tools, Journal of Hazardous Materials, 190, 177 – 187
- 21. Okuku, E.O, Mubiana V.K, Hagos, K.G, Kokwenda, P and Blust, R. (2010). Bioavailability of sediments bound heavy metals: A comparative study of selected locations along the Eastern African coast, Western Indian Ocean J. Mar. Sci. 9,(1) 325-334.
- 22. Mirera, O. D., Kairo, J. G., Kimani, E, N and Waweru, F. K. (2010). A comparison in fish assemblages in mangrove forests and on intertidal flats at Ungwana bay, Kenya. *African Journal of Aqautic Science*, 35 (2): 165-171.
- 23. Mwaluma J.M., Kaunda-Arara B., Rasowo J., Osore M. K and Øresland V. (2011) Seasonality in fish larval assemblage structure within marine reef National Parks in coastal Kenya. Environ Biol Fish 90: 393-404.

#### **Book Chapters**

- 1. Musa, S., Aura M. C. and Ngugi, C. C. (2010). The Effect of Three Different Feed Types on Growth Performance and Survival of African Catfish Fry (*Clarias gariepinus*) Reared in the Moi University Hatchery, Kenya. Submitted to Samaki news Magazine for 2010-2011.
- 2. G. Okemwa and E. Wood (2011) The Aquarium Fishery: A sustainable option or not? Swara (Special Issue on Marine Conservation).

#### Manuscripts Submitted/under review/in rpint

- Hura, S., Y. Takeuchi, Y. Esaka, N. Wambiji, Y. Park, H. Kang, H. Bok Jeong, Y. Lee S. A. Takemura. Diurnal expression patterns of neuralhypophysial hormone in the brain of the threespot wrasse *Halichoeres trimaculatus*. *Comparative Biochemistry and Physiology* (submitted).
  - 2. Mbaru E.K., C.M. Mlewa, E.N.Kimani. 2010. Length–weight relationship of 39 selected reef fishes in the Kenyan coastal artisanal fishery. (Short communication). *Fisheries Research* (Accepted).

- 3. Munga C. Z., M. O. Said, D. Obura, A. Vanreusel and D. Quebas. Resourse user perceptions on continued existence of the Mombasa Marine Park and Reserve, Kenya. *J. of West. Indian Ocean Mar. Science*. (Accepted).
- 4. Mbaru E.K. and E.N. Kimani. Abundance, Length-Weight Relationship and Condition Factor in Selected Reef Fishes of the Kenyan Marine Artisanal Fishery. *Advance Journal of Food Science and Technology* (Accepted).
- Kiteresi, L. I., Okuku, E. O., Mwangi, S. N., Ohowa, B., Wanjeri, V. O., Okumu, S. and Mkonu, M. (2011). Assessment of the Influence of land based activities on the phytoplankton communities of Shimoni-Vanga system, Kenya. (In press, Accepted Manuscript). International Journal of Environmental Research.
- Eric O. Okuku; Stephen N. Mwangi; Daniel Munga; Boaz Ohowa; Linet Kiteresi; Veronica W. Wanjeri; Stucky Okumu; Joseph Kilonzi. (2011). Sewage Pollution in the Coastal Waters of Mombasa City, Kenya: A norm rather than exception. (In press: Accepted manuscript) International Journal of Environmental Research.
- Okuku, E.O., Ohowa, B., Munga D., Mwangi, S.N., Kiteresi L. I., Wanjeri, V.O., Okumu, S., and Kilonzo J. (2011). Sewage pollution in the coastal waters of Mombasa City, Kenya: A norm rather than an exception (Article in Press)
- 8. Okuku E.O and Peter, H.K (2011) Choice of heavy metals Bioindicator: a critique of the method that uses Total heavy metals (In press, International Journal of Environmental Research)
- 9. Wambiji Nina<sup>a</sup>, Yong-Ju Park<sup>c</sup>, Ji-Gweon Park<sup>b</sup>, Se-Jae Kim<sup>b</sup>, Sung-Pyo Hur<sup>a</sup>, Yuki Takeuchi<sup>a</sup>, Akihiro Takemura<sup>a.</sup> Effect of possible environments on type II iodothyronine deiodinase gene expression in the brain of a tropical fish, *Siganus guttatus. Comparative Biochemistry and Physiology*.
- 10. Aura, M. C., Munga, C. N., Kimani, E. N., Manyala, J. O. and Musa, S. (2010). Length-Weight Relationships for 14 Deep Sea Species off the Kenyan Coast. Submitted to Panam JAS.
- Aura, M.C., Anam, R.O., Musa, S. and Kimani, E.N. (2010). Preliminary Investigations of Length-Weight Relationship and Condition Factor of the Sparidae (*Dentex Marocannus*, Valenciennes 1830) of Malindi, Kenya. Submitted to WIOMSA Journal.
- 12. Aura, M.C., Kimani, E. N., Manyala, J.O., Ndoro, C.K., Munga N.Z., Musa, S. and Orembo, O.B. (2010). Deep-sea Fish Assemblages of the Kenyan Indian Ocean: A case Study of Malindi-Ungwana Bay Trawl Fishery. Submitted to WIOMSA Journal.
- 13. Musa, S., Aura, C. M. and Ngugi, C. C. (2010). Evaluation of Stocking Density on the Growth and Survival of Nile Tilapia (*Oreochromis niloticus* Linn, 1758) Fry in Low and High Altitude Regions. Submitted to Journal of African Zoology.

- 14. C. Taquet; S. Planes; J. Bourjea; S. Lapegue; S. Ciccione; C. Muir, G. Okemwa, J. Mortimer; R. Nel; H. Grizel (2011). First records of a hybrid zone between Atlantic-Mediterranean and Indo-Pacific green turtle (Chelonia mydas) populations and a mtDNA cline in the Mozambique Channel (Indian Ocean). Submitted to Journal of Molecular Biology.
- 15. Mirera. H. O. D. (2010). Experimental polyculture of milkfish *(Chanos chanos)* and mullet *(Mugil cephalus)* using earthen ponds in Kenya. WIO J. Marine Science.
- 16. Mirera. H. O. D, Kairo. J. G. and Kimani. N. K. (2010). Abundance and distribution of juvenile shrimp in the forests and beach flats of mangrove ecosystems in Ungwana bay and semi-industrial trawling implications. WIO J. Marine Science.
- 17. Mirera. O. D and Moksnes. P. (2011). Cannibalistic interactions of juvenile mud crabs (*Scylla serrata-* Forsskal-1775): The effect of habitat and crab size (Aquaculture research).
- 18. Mirera. O. D. (2011). Trends in exploitation, development and management of artisanal mud crab (*Scylla serrata*-Forsskal -1775) fishery and small-scale culture in Kenya: An overview (Ocean and coastal management).
- 19. Christopher Mulanda Aura, Safina Musa, Eric Ogello Ochieng, Levy Michael Otwoma, Wainaina Miriam and Rodrick Kundu (2010 . Methane Emissions from Riverine and Swampy Coastal Wetlands: Influence of Open and Macrophyte Infested Areas".) journal of Lakes & Reservoirs
- 20. Muths D1, Tessier E2, Gouws G3, Mwale M3, Mwaluma J4, Mwandya A4, Bourjea J1 (2011) Important genetic connectivity for the reef fish Lutjanus kasmira in the West Indian Ocean. Mar.Eco.Prog.Ser
- 21. Wainaina M, Kaunda B, Njiru J. (2011) Seasonality in fish assemblage structure of a Mangrove Creek, Tudor, Kenya. WIOJMS
- 22. Muths D, Tessier E, Craig M, Gouws G, Mwale M, Mwaluma J, Mwandya A, Bourjea J (2011) Restricted dispersion of the reef fish Myripristis berndti at the scale of the South-West Indian Ocean compared to the known transoceanic species connectivity Mar.Eco.Prog.Ser
- 23. Mirera. H. O. D. (2010). Experimental polyculture of milkfish (*Chanos chanos*) and mullet (*Mugil cephalus*) using earthen ponds in Kenya. WIO J. Marine Science.
- 24. Mirera. H. O. D, Kairo. J. G. and Kimani. N. K. (2010). Abundance and distribution of juvenile shrimp in the forests and beach flats of mangrove ecosystems in Ungwana bay and semi-industrial trawling implications. WIO J. Marine Science
- 25. Odoli, C. O., B. Ohowa and S. Tunje. Evaluation of fish handling techniques employed by artisanal fishers and quality status at landing time of the main fish

genera along the Kenyan coast. WIO Journal of Marine Science (Response to Reviewers' comments sent back for consideration).

- 26. Daudi L. N. Restoration of Kenyan seagrass beds: an experimental study of the associated meiofauna using artificial seagrass mimics. Submitted to Restoration ecology Journal (Under review)
- 27. Sand Supplies to Eastern African Beaches: The Cases of Bamburi, Kenya and Kunduchi, Tanzania (In preparation – revised after reviewers comments).Y.W. Shaghude, J.W. Mburu, J. Uku, N. Nyandwi, C. Magori, J.Ochiewo, I. Sanga, and R.S. Arthurton
- Longitudinal and Latitudinal Abundance of Common Seagrass Species in Inshore Areas (Prepared for submission). Edward N. Kimani, Christopher M. Aura, Jacqueline Uku
- 29. Mwaura, J.M. Mwachui, A.A and Furaha, J.K. (2010) Assessing coral communities and their bleaching susceptibility in two reserves in Kenya(in review)
- 30. Mwaura, J.M., Juliet Karisa, and Obura, D.O. (2010). Assessing fishing impacts on resilience of coral reefs to climate change (in review)
- 31. Okuku, E. O., Mwangi, S. N., Munga, D., Ohowa, B., Kiteresi, L. I., Wanjeri, V. O., Okumu, S., and Kilonzo, J. Sewage Pollution in the Coastal Waters of Mombasa City: A norm rather than an exception. (Manuscript submitted to International Journal of Environmental Research).
- 32. Kairo. J., Judy Okello, Tree dispersion, abundance and regeneration of a sediment impacted mangrove forest: Case Mtwapa Creek Kenya.; targeting: *Forest Ecology and Management Journal*
- 33. Kairo J., Joseph Langat; Species mixing boosts the below-ground root production of mangrove trees; Targeting: Journal of Ecology.
- 34. Boaz Ohowa; Eric Okuku; Linet Kiteresi; Stephen Mwangi, Daniel Munga; Joseph Kamau; Veronica Wayayi, Joel Gatagwu; Joseph Kilonzo; Paul Okumu; Mary Mkonu. Nutrient dynamics and plankton biomass in Funzi Bay Shimoni Vanga area, Southern coast of Kenya. Manuscript submitted to the International Journal of Environmental Research. (Verdict: REJECTED, not a priority area for the journal).
- 35. Okuku Eric. Choice of heavy metals Bioindicator: a critique of the method that uses Total heavy metals (submitted to IJES)
- 36. Okuku Eric. Nutrients dynamics and cycling in three tropical rivers draining into the Indian Ocean- Submitted to WIOMSA journal of marine sciences
- 37. Biases in vegetation sampling methods another uncertainty in implementing REDD - submitted to Journal Science, together with Renske Hijbeek, Nico Koedam, Johan Schoukens and, Farid Dahdouh-Guebas.

- 38. James Kairo, Joseph K. Lang'at Sigi, Bernard Kirui, Martin W. Skov, Maurizio Mencuccini, and Mark Huxham Species mixing boosts the below-ground root production of mangrove trees, submitted to Journal of Ecology.
- 39. James Kairo, Gabriel Grimsditch, Steven Bouillon, Ravi Prabhu and , Max Troell Mangroves, REDD+ and ecosystem services, Submitted to the Coastal Management Journal.
- 40. James Kairo, Judith A. Okello and Nico Koedam Tree dispersion, abundance and regeneration of a sediment impacted mangrove forest: Case Mtwapa Creek Kenya. Manuscript prepared for Journal of Forest Ecology and Management.
- 41. James Kairo, Virginia W. Wang'ondu, Jared Bosire, Jenesio Kinyamario, Francis Mwaura, Farid Dahdouh-Guebas, and Nico Koedam. Litter production in natural and reforested stands of three mangrove species in the South coast of Kenya. Manuscript prepared for Coastal ecology and management journal
- 42. Mwaura, J.M. Mwachui, A.A and Karisa J.F. (2010) Assessing coral communities and their bleaching susceptibility in two reserves in Kenya(in review)
- 43. Mwaura, J.M., Karisa JF, and Obura, D.O. (2010) Assessing fishing impacts on resilience of coral reefs to climate change (in review)
- 44. Jelvas Mwaura, Juliet furaha, Mwachui Ali and Amon Kimweli (2011)The effect of life history traits and thermal history on Bleaching and Mortality patterns in Reefbuilding Corals (submitted to African Journal of Marine Science)
- 45. Mwaura, J. M. And Furaha, J. Coral reef fish and benthic community patterns of Kisite-Mpunguti-Vanga reefs of Kenya.
- 46. Kiteresi L.I., Okuku E.O., Mwangi, S.N., Ohowa B., and Mkono M. (2011). Potentially Harmful Algae along the Kenyan Coast: A Norm or Threat (under review- International Journal of Environmental Research and Technology)
- 47. Ongore, C.O, Okuku, E.O., Ohowa, B., Munga D., Mwangi, S.N., Kiteresi L. I., Wanjeri, V.O., Okumu, S., and Kilonzo J. (2011). Characterization of the Nutrients Enrichment in the Estuarine and Related systems of the Kenya Coastline (International Journal of Environmental Research and Technology)
- 48. Okuku, E.O (2011). Biochemical effects of Sewage discharge in coastal waters of Mombasa: A story from the fish side (WIOMSA MARG 1 report)
- 49. Ochieng, J, Okuku, E.O and Kairo, J.G. 2011. Challenging Poverty in a healthy environment: a case of local communities living along Mtwapa Creek Kenya (Book Contribution) Okuku, E. O., L. Kiteresi, B. O. Ohowa, S. Mwangi, D. Munga, , J. Kamau, V. W. Wayayi, P. Okumu, J. Gatagwu and J. Kilonzo (2011). Nutrients dynamics and cycling in three tropical rivers draining into the Indian Ocean.(Under review)

- 50. Ochieng J, Okuku E.O and Munyau, N. (2011) Advocating for sustainability in mangroves utilisation: a case study of Kilifi Kenya (Book Contribution)
- 51. Litter production in natural and reforested stands of three mangrove species in the South coast of Kenya. Revised and submitted to Wetlands Ecology and Management (WETL) together with Virginia W. Wang'ondu, Jared O. Bosire, Jenesio I. Kinyamario, Francis B. Mwaura, Farid Dahdouh-Guebas, and Nico Koedam.

# Annex 4: Manuscripts under preparation

- Gouws G., Mwale M., Bourjea J., Muths D., Mwaluma J., Mwandya A., and Gon O. (2011) Many fish and many genes: providing insight into Western Indian Ocean connectivity and biogeography
- 2. One manuscript has been prepared and will be submitted to Global Environmental Change for publication.
- 3. One manuscript on the implications of globalization on livelihoods of coastal communities is under preparation.

# **Annex 5: Technical Reports**

- 1. Aura, M.C., Musa, S., Kimani, E. N. and Abila, R. (2010). Seasickness or Lake Sickness: A Phenomenon You Can't Escape! Submitted to KMFRI newsletter for 2010.
- 2. Management of Fishery and Environmental Resources of Kenyan South Coast. A Rich National Heritage. June 2011. 34pp.
- 3. SWIOFP Kenya shallow water prawn trawl survey sailing orders Voyage SWIOFP2011C201a.
- 4. SWIOFP Kenya shallow water prawn trawl survey sailing orders Voyage SWIOFP2011C201a trip report
- Report of SWIOFP Component 2 (crustaceans) survey protocol workshop held at KMFRI on 14<sup>th</sup> – 15<sup>th</sup> July 2010, Mombasa, Kenya.
- 6. Murales, J., V. Stuart, T. Platt and S. Sathyendranath (eds). 2011. IOCCG publication Handbook of Sattellite remote sensing image interpretation. Applications for marine living resources conservation and management. (R. Mugo contributed to the publication).
- Fondo E. N., E. N. Kimani, C. N. Munga, C. M. Aura, G. Okemwa, S. Agembe (2011). A Review of the Marine Fish resources research of Kenya and influence on Management. Fisheries Program. KMFRI Value Use Document.

- Mwaluma J., Mugo R., Wainaina M., Mukami M., Charo M. Munguti and Nyonje B. (2011) Report on the status and development of shrimp farming activity at Ngomeni and development of Shimoni KMFRI plot, 18th-21st April 2011. pp 15.
- ARTEMIA Project. June 2011 'Improvement of the living standards of rural communities in Kenya through Artemia production'. Betty M. Nyonje and Maurine Mukami
- 10. Commercial seaweed farming at the South Coast of Kenya. A report on the scientific monitoring of commercial *Eucheuma denticulatum* farms and *Kappaphycus alvarezi* nurseries. June 2011; Elisah Mrabo and Betty Nyonje
- 11. Mariculture development as a sustainable livelihood option for the Kenyan Coastal fisher communities. June, 2011. David Mirera
- 12. Ensuring provision of quality seeds for the Kenyan fish farmer. A report on Authentication of public and private fish seed producers and hatcheries. Paul Orina, Miriam Wainaina, Safina Musa, Betty M. Nyonje, Harrison Charo.
- 13. Rapid On-site Scoping and Screening for Environmental Assessment Study Requirements: Environmental and Social requirement - ARTEMIA PROJECT. June 2011. P. Gwada, S.N. Mwangi, E. Okuku. J. Ochiewo and B.M. Nyonje.
- 14. Seaweeds EMP report. P. Gwada, S. Mwangi, J. Ochiewo, E. Okuku, B.M. Nyonje
- 15. Technical report on massive fish kills in Galana River (Okuku, Mwangi)
- 16. Preliminary report on Status of corals, fin-fish and macro-invertebrates component for critical habitat and biodiversity survey of the southcoast area (shimoni-mpunguti) (Mwaura, Karisa)
- 17. Coral identification down to genus and species level guide for use in the field (Mwaura, Karisa)
- 18. Preliminary report on Status of corals, fin-fish and macro-invertebrates component for critical habitat and biodiversity survey of the southcoast area (shimoni-mpunguti) (Mwaura, Karisa)
- 19. Coral identification down to genus and species level guide for use in the field (Mwaura, Karisa)
- 20. Final technical report for the project 'Enhancing sustainable management of mangrove resources in Kenya through participatory approach' (Amina, Dr. Kairo)
- 21. Technical report on Status of corals, fin-fish and macro-invertebrates component for critical habitat and biodiversity survey of the southcoast area(shimonimpunguti) (Mwaura, Karisa)

# **Annex 6: Conference proceedings**

- 1. AfricaGIS2009 Workshop held at Kampala Uganda from 25th to 30th October. I presented a paper on "Use of GIS and Remote Sensing in Assessing Aquaculture Sites in Embu District".
- Aura, C.M & Raburu, P.O. 2010. Sustaining the Health River Ecosystems: Is the Index of Biotic Integrity Part of the Solution? *Fisheries & Water Resources* VI: 357-360: *Proceedings of the Moi University 4<sup>th</sup> Annual International Conference*, July 29<sup>th</sup> – 1<sup>st</sup> August, 2008.
- Aura, M.C & Raburu, P.O. 2010. Bioassessment of the Water Quality of River Kipkaren, Nzoia River Basin, Kenya. Fisheries & Water Resources VI: 319-328: Proceedings of the Moi University 4<sup>th</sup> Annual International Conference, July 29<sup>th</sup> – 1<sup>st</sup> August, 2008.
- Coastal aquaculture development in East Africa Challenges and Prospects (Zanzibar, Tanzania; 29th November to 8th December 2009). Paper presented: "An overview of marictulture development in Kenya"
- 5. Eighth Meeting of the Grantees of Marine Science for Management (MASMA) Programme: Monitoring the Performance of the Approved Projects (21st-23rd October 2009, at Whitesands Hotel in Dar es salaam, Tanzania). Paper presented: "Small-scale, community-based, grow-out aquacultures of mud crabs *Scylla serrata* as a sustainable livelihood in East Africa"
- Kundu, R. C. Aura, M. Muchiri, M. Njiru, & J.E. Ojuok. 2010. The Agony of Fishing at Lake Naivasha, Kenya. Is Community Participation in Management the Solution ? *Fisheries & Water Resources* VI: 331-340: *Proceedings of the Moi University 4<sup>th</sup> Annual International Conference*, July 29<sup>th</sup> – 1<sup>st</sup> August, 2008.
- M'rabu E. S. Cannicci, J. Bosire & F. Dahdouh-Guebas. 2010. How can we mitigate impacts of global climate change on mangrove forests in Kenya. International Symposium on the biodiversity associated with mangrove ecosystems in Southeast Asia, held in Hanoi, Vietnam on 17-19 May 2010. Oral presentation.
- Muthumbi, A. N. B.M. Nyonje, J.O. Ochiewo & Wakibia, J.K (2010) Integrated Salt-Artemia production and mariculture in a mangrove wetland at the Kenya coast. Presented at CHE dissemination workshop 20<sup>th</sup> – 24<sup>th</sup> June 2010.
- 9. Odoli C.O. 2010 Value links introductory training by Agri and cooperative training and consultants ltd at sun n sand May 10th to 14<sup>th</sup>
- 10. Odoli, C.O. 2009. Arctic Tilapia Full Colony, Optimal Storage and Transport Conditions for Fillet . Presented in advances in Euro Seafood Technology, Copenhagen, Denmark October 2009. Kenya Coast Development Project (KCDP)

stakeholders workshop (Final Mission); 15th -26th February 2010, at KMFRI-Mombasa

- 11. Odoli, C.O. 2009. Poster presentation: Quality Status of Artisanal Fish Landings along the Kenyan Coast. Presented at WIOMSA Symposium in Reunion, August 2009
- 12. Oduor-Odote, P.M. 2009 IP Workshop for Researchers in R&D Institutions. 3rd to 4th September 2009. Neptune beach, South Coast, Mombasa.KECOBO, KIPI, KEPHIS and funded by KEPLOTRADEII Program-Ministry of Industrialization
- 13. Oduor-Odote, P.M. 2009. Workshop on KMFRI business Wing. Retreat in Mbita. 1st to 5th August in Mbita Safari Hotel. Sponsor-KMFRI
- 14. Oduor-Odote, P.M. 2009. Worksop for FIMACEDP/KCDP PROJECT. World Bank MINI-MISSION 22nd to 30th SEPTEMBER 2009. Held in KMFRI Conference Hall.Sponsor-World Bank
- 15. Oduor-Odote, P.M. 2010. 3rd National Conference on Dissemination of Research Results and Exhibitions of Innovations. KICC (2010) As Innovator
- 16. Oduor-Odote, P.M. 2010. Commission for Higher Education Workshop at Mombasa Beach Hotel 20th to 24th June 2010

### **Annex 7: Professional contributions**

- 1. Simon Agembe is a member of the Management plan for Ksite-Mpunguti marine park preparation team
- 2. Edward Kimani is a member of the technical team for the preparation and implementation of Ungwana-bay Prawn Fishery management plan
- 3. Edward Kimani represents KMFRI in the Lamu lobster fishery Marine Stewardship Council (MSC) certification process
- 4. Cosmas Munga, Simon Agembe, Gladys Okemwa and Esther Fondo represent KMFRI at the Ring Net Technical committee
- 5. Gladys Okemwa is a member of the National Sea Turtle Strategy Implementation committee, member of the Aquarium Fishery Management Plan team and Member of the Ringnet Management Plan drafting team.
- 6. E. Fondo recognition in participation in the Census of Marine Life Program.
- 7. Member and editor of WIO mariculture forum (Mirera)
- 8. Member of KMFRI monitoring and evaluation team (Mirera, Miriam)
- 9. Member of KMFRI EIA evaluation team (Dr. Mwaluma, Mirera)

- 10. Member of the National Aquaculture Policy development working group (Dr. Betty, Mirera)
- 11. Member of SARNISSA (Morine, Mirera, Miriam)
- 12. Member of ESP secretariat (Dr. BM nyonje)
- 13. Component leader, National seed production and dissemination Fish Framing Enterprise Productivity Program (Dr. BM Nyonje)
- 14. Member National Aquaculture Development Working Group (Dr. BM Nyonje)
- 15. Member of KAPAP task force for development of research grants manual (Dr. BM Nyonje)
- 16. Resource person in Training of Hatchery managers (Dr. BM Nyonje)
- 17. Mr. Ochiewo is a member of working group for the preparation of the Prawn Fishery Management Plan for Kenya.
- 18. Mr. Ochiewo is a member of working group for the preparation of the Lobster Fishery Certification and Management Plan for Kenya.
- 19. Mr. Ochiewo is in-charge of KMFRI's Performance Contract Secretariat.
- Mr. Ochiewo served as a Guest Trainer on MPA Social Issues at the WIO-COMPAS Level 1 – Certification Course for Marine Protected Area Professionals, organized by WIOMSA and partners.
- 21. Mr. Ochiewo served as a member of the team of experts for preparation of the National Plan of Action of the ICZM Policy.
- 22. Project Coordination, KCDP Project based at KMFRI (Dr. Uku)
- 23. Country Coordination, WIOMSA (Dr. Uku)
- 24. Member Editorial Board WIOMSA Scientific Journal (Dr. Uku, Dr. Bosire)
- 25. Member of KMFRI ISO certification preparation team (Gwada)
- 26. Member of a team writing a book on Gazi ecosystem (Dr. Kairo, Dr. Bosire, Dr. Kirui)
- 27. Member, working team on the development of Jomo Kenyatta Public Beach funded by RECOMAP (Dr. Kirui, Mwangi)
- 28. Undergraduate student supervision: (Dr. Kirui, Karisa, Mwaura)
- 29. IOI/UNESCO Blue Carbon Working Group Member (Dr. Kairo)
- 30. Input Implementation Manual for Natural Resources and Biodiversity Component of KCDP (Dr. Kairo)

- 31. Supervising PhD Students: Lillian Daudi (University of Ghent) and Austin Hemphries (South Africa) (Dr. Uku)
- 32. Ph.D and MSc. student supervision (Dr. Kairo)
- 33. Technical Support to communities engaged in mangrove conservation activities in Kenya, Tanzania and Somali (Dr. Kairo)
- 34. National PADH Expert: ICZM National Plan of Action through NEMA (Dr. Kairo)
- 35. Chair Task force to prepare 2009/10 annual report for KMFRI (Dr. Kairo)
- 36. Part-time lectureship: Kenyatta University, Mombasa Campus (Dr. Kairo, Dr. Kirui) Mombasa University Polytechnic- (Ohowa)
- 37. KMFRI newsletter committee member and compilation of M&C annual report (Dr. Kirui, Daudi)
- Focal Point for AMESD-Project smooth communication/acquisition of AMEDS-Station equipment and KMFRI-AMSED Project Dissemination Report No. 1 March, 2011 (Value added Product for Stakeholders) (Dr. Nguli)
- 39. Concept note to MOI on AMESD-SEACCE Proposal (Dr. Nguli)
- 40. Consultancy: Draft Report on Potential for Ocean power generation in Kenya (Dr. Nguli)
- 41. Ongoing drafting of oceanography training lectures, and enhancement of registry for the membership of the newly formed Regional Hydrographic Oceanographic Academy revised acronym form ROSA to RHOSA) –idea presented to the Assessment Mission Team (i.e. Dr Dimitri from IOC) and first
- Brochure developed/web-site attempted(Dr. Nguli)
- 43. Member of the Shoreline Change Management Taskforce (Dr. Magori, Kimeli)
- 44. Member of Kenya National Hydrographic and Oceanographic Committee (KNHOC) (Dr. Nguli, Dr. Magori, Gwada)
- 45. Regional Coordinator for Global Sea Level Observing System (GLOSS) (Dr. Magori)
- 46. Development and updating of web site for GLOSS-AFRICA (Dr. Magori)
- 47. National ASCLME Cruise and CBT Coordination for Kenya (Dr. Magori, Gwada)
- 48. Member of committee tasked with reviewing of EIA/EA reports for NEMA on behalf of KMFRI (Ohowa, Karisa)
- 49. KWS coast research division: technical assistance towards the implementation of the adaptive management program for Mombasa Marine National Park and Reserve (Karisa)

- 50. Mapping of marine and coastal habitats and resource use in Kiunga MNR-Lamu archipelagos. Host institution; WWF Kiunga Project (Mwaura)
- 51. Participation in the compilation of the Gazi Environmental Impact Assessment Report and coordinating the Gazi mangrove Project (Amina)
- 52. EIA for the proposed construction of the first three berths and associated infrastructure of Lamu port at Manda bay- ongoing (Dr. Bosire, Dr. Kairo, Gwada, Dr. Magori, Dr. Kirui, Karisa)
- 53. Coordinating the Project Enhancing Sustainable Management of Mangrove Resources through Participatory approach funded by UNDP- GEF/SGP (Amina)
- 54. EIA for the proposed construction of the first three berths and associated infrastructure of Lamu port at Manda bay- ongoing (Karisa)
- 55. Planning meeting for the National training of on-site oil spill responders, on-scene commanders and personel of the national incident command team, 8th October 2010, KMA boardroom, Mombasa. (Karisa)
- 56. Development of proposal on ESPA, 11-15 October 2010, Travellers beach hotel, Mombasa (Karisa)
- 57. Member of a working group spearheaded by the Ministry of environment and natural resources: Development of proposals to be submitted to the United Nations Framework Convention on Climate Change (UNFCCC), adaptation fund (Dr. Kirui)
- 58. Member- GEF Western Indian Ocean Marine Highway Project (Dr. Kirui)
- 59. Participation in a Western Indian Ocean Marine Science Assocoaition project analysis meeting 21st-27th.October 2010, Kilifi. A MASMA Project on "How do protected areas affect fishers? An assessment of fishers' spatial behaviour around protected areas". (Mwaura)
- 60. Participation in a WWF consultative meeting on Lamu atlas development in shimba hills :Hosted by WWF (Mwaura)
- 61. Member of KMFRI sub-committee tasked with reviewing Environmental Impact assessment report for Nema; Reviewed and submitted comment on "Environmental Impact Assessment Project report for the Proposed Mwakirunge Sanitary Landfill in Mombasa Town". (Mwaura)
- 62. Management Document for South Coast Resources, Kenya Aquatica, Volume No. 6 Bulletin of KMFRI (Pre-retreat Working Draft Document) and Stakeholder Value Added Report in Kiswahili: 'Jarida La Kenya Aquatica, Toleo No. 4'. (Dr. Nguli)
- 63. Coordinating the Project Enhancing Sustainable Management of Mangrove Resources through Participatory approach funded by UNDP- GEF/SGP (Amina)

- 64. Member of KMFRI Committee appointed to create process to identify and award the most productive staff (Dr. Osore)
- 65. Composing for articles on news about KMFRI, its programmes and staff and uploading on the Institute website and other regional sites (Dr. Osore)
- 66. Contribution to development and write-up of Kisite and Mpunguti Marine Management Plan (KMMP) for KWS, as an expert on ecological management programme organized at Ukunda, 30 march-2 April 2011. (Mwaura)
- 67. KMFRI Annual report 2009/10, Porini village, 30th March to 1st April 2011 (Dr. Kairo, Karisa).
- 68. Member Editorial Board WIOMSA Scientific Journal (Dr. Uku, Dr. Bosire)
- 69. MSc Student Supervision, Arne Kinds, University of Ghent. (Dr. Uku)
- 70. Member- Kenya National RAMSAR Committee (Dr. Kirui)
- 71. Coordination Mikoko Pamoja project (Amina, Dr. Kairo)
- 72. Facilitator KMFRI/Earthwatch capacity building programme on participatory forest Management (Training manual developed) (Amina)
- 73. Sub-consulted by CORDIO EA under the project: Conservation and Sustainable Management of Kenya's Marine and Coastal Resources in Shimoni - Vanga Area (Karisa)

## **Annex 8: Funded Proposals**

- 1. Population dynamics and small-scale aquaculure of mud crab (Scylla serrata) in East Africa (IFS ) Funded
- 2. Enhancing Food Security among Coastal Fisher Communities: Promoting Small Scale Mariculture Technologies along the Kilifi Creek (Submitted to NCST- (Funded)- Lead Institution –Pwani University
- 3. Artemia Project 'Improvement of living standards of rural communities in Kenya through Artemia production' Funded by VLIR
- 4. KAPAP

## **Annex 9: Submitted Proposals for Funding**

- 1. Ecological economics of mud crab silvofisheries, A strategy for coastal communities to cope with climate change (Concept submitted to IDRC)
- 2. Sustainable environmental and livelihood initiatives submitted to CDTF in partnership with Dzarino Community Based training Organization (Results not yet out)

- 3. Enhancing Food Security among Coastal Fisher Communities: Promoting Small Scale Mariculture Technologies along the Kilifi Creek (Submitted to NCST- Concept accepted and full proposal submitted)- Lead Institution –Pwani University
- 4. Ecological economics of mud crab silvofisheries, A strategy for coastal communities to cope with climate change (Concept submitted to IDRC)
- 5. Implementation of Environmental Management Plan for *Eucheuma denticulatum* (spinosum) farming in the South Coast of Kenya (ReCoMaP)
- Climate Variability and its Impacts on Mangrove Ecosystems in the WIO Region. Submitted to WIOMSA/MASMA program. US\$ 150,000. (FUNDED) (Dr. Bosire, Dr. Kairo, Dr. Kirui, Dr. Magori)
- The feasibility of mangrove REDD projects in the Western Indian Ocean: Linking mangrove conservation and climate change adaptation to the global carbon markets". Submitted together with Blue ventures (Madagascar) to WIOMSA/MASMA program. US\$ 150,000. (FUNDED) (Dr. Kairo *et al.*)
- 8. Mikoko Pamoja. NERC/ESPA Project submitted together with universities of Napier, Bangor and Edinburgh,. Overall budget £250,000 (Dr. Kairo *et al.*)
- 9. Habitat Fragmentation and its Impact on the Ecosystem Functioning of Kenyan Seagrass Beds-PhD Project funded, 2010-2014 (Daudi)
- 10. Using Remote Sensing and Ethno-perceptions to Assess Decadal Mangrove Forest Cover Changes at District levels along the Kenya Coastline. Submitted to Rufford grants – Awaiting outcome (Dr. Kirui)
- 11. Using Satellite observation to describe Semi- Industrial Prawn Fishery and River Plumes front off Malindi-Ungwana Bay Kenya. Submitted to AMESD-Awaiting outcome (Dr. Kirui)
- 12. Resilience and adaptation of mangroves in the WIO region to the impacts of climate change- submitted to MASMA Successful (Dr. Bosire, Dr. Kairo, Dr. Kirui)
- 13. Capacity building on Mangrove conservation for livelihood improvement and climate change preparedness Submitted to Africa Adapt Knowledge Sharing Innovation Fund. Status: Under review (Amina)
- 14. NCST Grant. Assessing the effectiveness of MPAs and other forms of fisheries management to climate change in Kenyan coral reefs. A joint concept between KMFRI, KWS, FiD and Kuruwitu-EAWS project proposal receipt acknowledge and awaiting outcome by November 2010. (Mwaura-project leader )
- 15. PhD proposal write up on coral genomics and ecology Sumitted to VUB and under consideration (Mwaura)

- 16. Assessing the effectiveness of Marine Protected Areas and other forms of fisheries resource management to climate change in Kenyan coral reefs, Submitted to NCST, Still under review (Karisa)
- 17. Informatics component will apply biodiversity information collected for improved management, exploration, presentation and analysis. Submitted to JRS, Still under review (Karisa)
- 18. Genetic Connectivity between Mangrove Forests and Coral Reefs in Kenya: Informed Management of Ecosystems for Improved Fisheries, Submitted to NCST, Still under review (Karisa)
- 19. Empowering the local community in monitoring of Community Conservation Areas (CCA) in South Coast, Kenya. Submitted to RSG, Still under review. (Karisa)
- 20. IFS Grant- Title of the project proposal: Investigating the spatial distribution of greasy grouper Epinephelus tauvina (Serranidae) in relation to habitat differences and protection levels in coastal Kenya. Accepted on June 2010 for further review; accepted after expert second review and waiting final result Feb 2011. (Mwaura)
- 21. Submited a Ph.D Proposal on collaborative project on coral population genetics to Vrije University Brussels, Belgium, Results will be out end May 2011 (Mwaura)
- 22. Alleviating Poverty in Coastal Communities through Ecosystem Services Science the Western Indian Ocean (ACCESS -WIO). A NERC/ESPA proposal submitted together with University of Plymouth, CORDIO\_EA and KMFRI. Under review (Dr. Bosire, Dr. Kairo, Dr. Magori, Karisa)
- 23. Empowering the local community in monitoring of Community Conservation Areas (CCA) in South Coast, Kenya. Submitted to RSG, not successful. (Karisa)
- 24. Quantifying gas-phase losses of carbon from intact and degraded mangrove ecosystems. A NERC/ESPA proposal submitted together with Bangor University, Edinburgh, and KMFRI. Passed 1<sup>st</sup> round (Dr. Kairo)
- 25. Integrated Coastal Zone Management (ICZM): a policy support research and capacity building project. A VLIR Project Submitted together with VUB, KWS and KMFRI. Under review (Dr. Kairo)
- 26. Conservation of Kenya Mangrove Forests and associated ecosystems. A GEF/UNEP PIN submitted to national GEF committee. Passed first round (Dr. Kairo)
- 27. AMESD-IOC-Mini Proposal for KENYA. On Investigation on Oceanographic Changes and distribution of yellow fin tuna in Kenya using Satellite Imagery. Submitted to AMESD. Under review (Dr. Nguli)
- 28. Assessment of Organic Contamination in the Marine and Coastal Environment of Kenya: to be considered for funding under MEEP seed projects in the next FY. Still waiting for the response (Mitto).

29. Alleviating Poverty in Coastal Communities through Ecosystem Services Science - the Western Indian Ocean (ACCESS -WIO). Submitted to ESPA, still under review (Karisa, Dr. Bosire, Dr. Magori)

### **Annex 10: Workshop Coordination**

- 1. WIOMSA Kenya Chapter Meeting KMFRI, Mombasa, 3rd September 2010 (Dr. Uku)
- 2. ARK II meetings in KMFRI on the following dates: 13th July, 27th July, 17th September 2010 (Dr. Uku, Dr. Bosire, Dr. Kairo, Dr. Kirui, Mwangi. Dr. Osore)
- 3. Stakeholder workshop on climate change and coastal processes at KMFRI, Mombasa on 22-24 Sep 2010 (Dr. Magori, Dr. Osore)
- 4. Working group meeting to prepare the Project Implementation Manual (PIM) for the KCDP Project, Kanamai , 12th 18th October 2010 (Dr. Uku)
- 5. Pre-WIOMSA Grantees Meeting to prepare Kenyan Grantees for the WIOMSA meeting 26th October 2010 (Dr. Uku)
- World Bank Mission with the Task Team Leader, KMFRI, Mombasa, 1<sup>st</sup> 5<sup>th</sup> November 2010 (Dr. Uku)
- 7. The KMFRI Annual Conference, ARK II, Naivasha, 16th 19th November 2010 (Dr. Uku, Dr. Bosire, Dr. Kairo, Dr. Osore, Dr. Kirui, Dr. Nguli, Gwada, Mwangi)
- Meeting of the National Project Steering Committee for the KCDP Project Maji, House, Nairobi – 1<sup>st</sup> December 2010 (Dr. Uku)
- 9. Organised Seminar on AMESD-Project and AMESD-Mini Project, KMFRI Conference Hall, Mombasa on 4th Jan 2011. (Dr. Nguli)
- 10. World Bank Effectiveness Support Mission for the Kenya Coastal Development Project (KCDP), KMFRI, Mombasa – 28th March – 1st April 2011 (Dr. Uku, Dr. Bosire, Mwangi)
- 11. World Bank Launch Mission, KMFRI, Mombasa: 15th 22nd June 2011 (Dr. Uku, Mwangi)
- 12. National Project Steering Committee Meeting for KCDP, Maji House, Nairobi: 20th May 2011 (Dr. Uku)

### Annex 11: Student Supervision

- 1. Hildah Nyaboke Moi University (Internship)
- 2. Emilly Wafula Makerere University (Internship)
- 3. Damaris Njeri Egerton University (Attachment)

- 4. Victor Odongo Pwani Unversity (Attachment)
- 5. Prosper Mremi Ghent University (MSc thesis, field work)

# Annex 12: Other deliverables

### 1. Presidential Award

Moran of the Burning Spear (MBS) awarded to Dr. James Kairo by His Excellency the President and Commander in Chief of the Armed Forces of the Republic of Kenya, Hon. Mwai Kibaki.

### 1. Publicity

- Simon Agembe organized world 2010 Mombasa ASK Show and Nairobi trade fair 2010
- Esther Fondo was involves in the preparation of the WIOFish Database Annual Report

### 2. Value added Documents:

- Mirera. O. D. (!!!). Community guidelines on mariculture development (Milkfish, mud crab and prawns)- under development
- Poster on Enemies of our Ocean: a synthesis of the various contaminant (Okuku)
- Facts sheet on Harmful algal Blooms: a public health concern (Okuku)
- Facts sheets on water quality (Okuku, Mwangi)

#### 4. Extension services

Authentication exercise for the fingerling producers between (Dec 2010 to April, 2011). Fish farmers in 5 Counties: Bungoma, Busia, Vihiga, Kakamega, Taveta & Tana River 19 Constituencies were visited 8 fish farmers, were certified to produce and supply fingerlings (Miriam).



**Annex 13: KMFRI research publications trends** 

Figure 1: KMFRI articles from peer reviewed journals for the last 10 years



Figure 2: KMFRI popular Journals for published work and their impact factors for the last 10 years



Figure 3: Top ten individual scientists having published in peer reviewed journals



Figure 4: Top ten individual scientists having published as first authors in peer reviewed journals