WIOMSA

MASMA Programme

Grantees Meeting 25-27 November 2020

Programme and Abstracts

Members of the MASMA Programme Committee

Prof. Kassim Kulindwa	Chairperson-University of Dar es Salaam.
Dr. Jorge Santos	Norwegian College of Fisheries Science, University of Tromsø and Arctic University of Norway.
Dr. Jan Robinson	Project Manager, SWIOFish3, Seychelles.
Dr. Adriano Macia	University of Eduardo Mondlane.
Dr. Pascale Chabanet	Institute of Research for Development-La Reunion
Dr. Håkan Berg	Stockholm University.
Dr. Max Troell	Beijer Institute, Stockholm Resilience Center and Swedish International Biodiversity Programme
Prof Moenieba Isaacs	Institute for Poverty, Land and Agrarian Studies, University of Western Cape.
Prof. Ian Bryceson	Department for International Environment and Development Studies at the Norwegian University of Life Sciences.
Dr. Jesper Vasell	Director, KTH Global Development Hub.

Meeting Programme: Starting time 1400-1730 HRS EAT

Day 1, 25 November 2020: MASMA 2020 Projects		
OPENING SESSION		
1400-1405	Welcoming remarks & announcements	WIOMSA
1405-1410	Opening remarks	MASMA Chairperson
1410-1415	Introduction	All
PROJECTS PRESENTATIONS		
MASMA-2020		
1415-1425	Blue Growth Initiative through Farming of Silver Pompano (Trachinotus blochii) and Rabbit Fish (Siganus sutor) for Food Security and Improved Livelihood in East Africa (BLUEGRASI)	PI
1425-1435	Remarks & Discussion	PC
1435-1445	Optimizing Artemia Production Technology for Sustainable Aquaculture Development (APTSAD), Food Security and Economic Growth for the East African Coastal Communities	PI
1445-1455	Remarks & Discussion	PC
1455-1500	Short Break	

Day 1, 25 November 2020: MASMA 2019 Projects		
1500-1510	Billfish Interactions, Livelihoods, and Linkages for Fisheries sustainability in the Western Indian Ocean (BILLFISH - WIO)	PI
1510-1520	Remarks & Discussion	
1520-1530	Slippery resource in peril: Ecology of Western Indian Ocean Anguillid eels and their contribution to sustainable fisheries and livelihood along the East Coast of Africa	PI
1530-1540	Remarks & Discussion	
1540-1550	WIO-BENTH - Identification, characterization and vulnerability assessment of benthic ecosystems in the WIO	PI
1550-1600	Remark and Discussion	PC
1600-1605	Short Break	

Day 1, 25 November 2020: MASMA 2018 Projects		
1605-1615	Larval fish production and dispersal in critical habitats of coastal East Africa" (FLAPSEA project)	PI
1615-1625	Remarks & Discussion	
1625-1635	Assessment of the Ecological Aspects of Microplastic Pollution in Dar Es Salaam, Zanzibar and Mombasa Coastal Marine Environments (MICROMARE)	PI
1635-1645	Remarks & Discussion	
1645-1655	Enabling Sustainable Exploitation of the Coastal Tuna Species (Kawakawa and Skipjack) in the Western Indian Ocean	PI

1655-1705	Remarks and Discussion	
1705-1715	Ecosystem based protection of the coastal zone: the effectiveness of seagrass meadows in coastal erosion management	PI
1715-1725	Remarks and Discussion	
	End of Day 1	PC

Day 2	**PC Meeting 26 November 2020**	
1400-1700	PC Meeting and deliberations	PC

Day 3	**Feedback to Grantees 27 November 2020**	
1400-1700	Feedback to individual Projects, the order of the feedback shall depend on the PC decision.	PC
	End of the meeting	

Projects Funded in 2020

Blue Growth Initiative through Farming of Silver Pompano (*Trachinotus blochii*) and Rabbit

Fish (*Siganus sutor*) for Food Security and Improved Livelihood in East Africa (BLUEGRASI)

Investigators

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Other investigators

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6. **Ms. Esther M. Wairimu**: Research Scientist, KMFRI, Box 81651-80100, Mombasa-Kenya, nimmss2003@yahoo.com/ewairimu@kmfri.co.ke
7. **Mr. Brendan Muli**: Project Coordinator Mariculture**,** Kwetu Training Centre, P. O. Box 685,80109, Mtwapa, Kenya, brendanmutuamuli@gmail.com
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12. **Prof. Mwita Chacha**, Professor of Fish Pathology, University of Dar es Salaam, P. O. Box 60091, Dar es Salaam, Tanzania, Department of Aquatic Science and Fisheries Technology, mwitachacha@yahoo.com
13. **Geofrey Rucho,** Aquaculture Association of Tanzania, ruchogeofrey@gmail.com

Abstract

Background:
Food, especially protein insecurity in Tanzania and Kenya requires a sustainable and multi-faceted approach rather than dependency on freshwater systems (where most of the aquaculture is currently practiced), wild fish capture, fish imports and terrestrial agriculture, all of which are impacted by climate change. Therefore, improvement of fish food security in East Africa needs a utilization of the expansive ocean space for mariculture development and hence the focus of the current research project.

Aim:

The project aims to increase fish production through farming of silver pompano and rabbit fish in Tanzania and Kenya marine waters. Specifically, the project seeks to:

i. Breed and produce seeds for silver pompano and rabbit fish under hatchery conditions.
ii. Examine growth performance of silver pompano and rabbit fish fed on different diets and stocked at different stocking densities.
iii. Evaluate the cost effectiveness of farming silver pompano and rabbit fish in comparison with other cultured species and its impact on community livelihoods.

Methods:

The study will employ different methodologies to achieve the anticipated objectives as detailed below:

i. Collection of broodstock

The initial sub-adult broodstock for silver pompano will be collected from different selected locations in Zanzibar. Sub-adult rabbit fish will be obtained from ongoing experimental cage culture farms in the south coast of Kenya. A total of two hundred brooders will be targeted for each species. Collected fish will be treated with formalin for two minutes and quarantined for 72 hours before being stocked in broodstock rearing tanks. Each specimen will be tagged with Passive Integrated Transponder (PIT) tags to help monitor individual growth and reproductive performances.

ii. Broodstock management, spawning and hatching

a. Silver pompano in Tanzania

The fish will be stocked in circular broodstock rearing tanks with capacity of 10,000 L at the Korea – Zanzibar Marine Centre's hatchery. Brooders will be fed twice at 3% of their body weight per day or to visual satiation, using commercial broodstock diets (40% crude protein), supplemented with fresh fish or squid once a week to stimulate growth and maturation. The broodstock will be reared to between 1000 g to 1500 g. At breeding, three silver pompanos (2 females and 1 male)

will be selected based on the gonadal maturation and transferred to spawning tanks of approximately 10,000 L mounted with photoperiod control facility (14 light:10 dark hours) for pre-conditioning to induce spawning. A Compact Fluorescent Lamp (CFL) of 85 W will be used to provide light intensity of 2000 lux at 1.20 m.

Periodic cannulation of the female brooders will be carried out to assess the progress of maturity of the fish by checking egg development stages. During cannulation, the brooders will be anesthetized and sex separated. When the intra-ovarian egg diameter reaches above 500 µ, the female and male fish will be induced to spawn by intra-muscular injection with ovaprim below the dorsal fin, at a dose of 350 IU per kg body weight. Spawned eggs will be collected from breeding tanks and hatched in circular fiberglass tanks supplied with mild aeration and flow through water system to attain hatching in about 36 hours. Breeding variables including the time to spawning, number of eggs spawned, percentage fertilized eggs and hatching rate will be examined.

b. Rabbit fish production in Kenya

Sub adult rabbit fish from ongoing experimental cage culture farms in the south coast of Kenya will be transported to the hatchery. Before breeding, fish will be reared to sexual maturity in concrete tanks at a density of 3 fish/m^3 and part of the collected brooders will be reared in a RAS in rectangular and circular tanks with a depth of 1.2 m. The brooders will be fed on available formulated diets for rabbit fish at KMFRI. Feeding will be done twice a day using fish pellets at 3% body weight or fed to apparent visual satiation.

After attaining maturity of about 300 g, rabbit fish brooders will be cannulated to assess the readiness to spawn (maturity and size of eggs). The cannulated eggs will be measured using an Image Analysis System (Nikon Labophot 2 attached to a computer with an Image ProPlus Software). Fish will be induced to spawn by using ovaprim at 500 IU/fish or 2 IU/g bodyweight using established protocols. Mature fish will be paired (1 male to 1 female) in 250-L tanks and moderate aeration provided for 48 hours. White plates will be placed at the bottom of every tank for random collection of the eggs. Spawned and fertilized eggs will be collected from breeding tanks and hatched in fiber glass tanks supplied with mild aeration to attain hatching in about 30 hours. Breeding variables to be investigated will include time taken for spawning, number of eggs spawned, percentage of fertilized eggs, hatching and survival rates.

iii. Rearing of larvae of silver pompano and rabbit fish

Larvae will be reared in circular conical shaped bottom tanks of 2 m diameter and 1.5 m depth with continuous aeration and a drain pipe installed at the center. The larvae will be fed on live feeds such as phytoplankton and zooplankton i.e. rotifers (*Brachionus* spp.) and *Artemia* depending on availability and developmental stages for the two species. After two months, the resulting fry will be fed on formulated feeds. Their growth and survival rates at different stocking densities will be investigated. Water quality will be monitored daily throughout the larval phase.

iv. Growth performance and optimum stocking density in ponds and cages

Studies will be conducted to examine the survival and growth rate of the wild and hatchery produced fingerlings stocked at different densities in intertidal ponds using two cost effective locally formulated feeds in Tanzania and Kenya for each species. Preliminary experiments have been undertaken to develop a feed for silver pompano in Tanzania and rabbit fish in Kenya. The

intertidal ponds used will be obtained from current mariculture farmers culturing milkfish, marine tilapia or prawns. The ponds will be renovated to ensure suitability. Fingerlings collected from the wild or bred for each species will be stocked at 3, 4 and 5 fish/m^2 in triplicates and reared for at least twelve weeks while feeding on the formulated innovative diets. The growth performance (final body weight, weight gain, specific growth rate), percentage survival, condition factor, body composition (protein, lipid, ash, dry matter), feed efficiency (feed conversion ratio, feed conversion efficiency, protein efficiency ratio), organ indices (hepatosomatic index, visceral somatic index), yield (net annual yield, gross yield) will be determined.

The cages that are under experimentation at Shimoni will be refined and used in the cage trials. The model cages are of two types (2 x 2 x 2.5 meters (experimental) and 5 x 5 x 2.5 meters (commercial). One empty cage will be reserved to provide holding space in cases of net tearing or need for major repairs. This technology will be shared for use in Tanzania. Prior to cage deployment, site suitability assessments will be done on current speeds and directions, water depth, water quality and substrate type. Three stocking densities of 50, 75 and 100 fish/m^3will be assessed for both silver pompano and rabbit fish with three replications. Similar growth parameters will be analyzed as done on ponds above.

v. Cost analysis of farming the two species and impact on community livelihoods

To achieve this objective, the tidal ponds and the commercial cages will be selected from existing fish farmers culturing milkfish, marine tilapia or prawns. A partial enterprise budget will be used to assess the cost effectiveness of farming the two species in comparison with other farmed marine finfish species in the two countries and elsewhere. At the end of the culture period, fish will be sold at the prevailing market prices and a cash flow budget will be generated. Indices of economic analysis will be evaluated such as income, net return, break-even time, yield and price. To assess change in livelihoods of the communities, initial survey will be conducted before starting the farming and after harvesting, using structured questionnaires to establish the household income from fish farming, fish consumption frequencies and preferences, and employment provided by fish farming. A questionnaire survey will also be administered to different stakeholders at the end of the project in the two countries to understand the public perception on marketing and value chain analysis of farmed silver pompano and rabbit fish in comparison with other farmed marine fish species.

Findings/Results

Objective 1: Two hatcheries in place producing silver pompano and rabbit fish fingerlings (the first of its kind for the two species in the WIO) and at least two MSc students trained in mariculture hatchery techniques

Objective 2: Optimum stocking density for the two species in cages and ponds established and at least two demonstration farms developed in cage and ponds in each country.

Objective 3: Economics of establishing and operating cages and ponds for the two species in place and viability of farming the two species vis-vis other species established.

Implications/Application

Objective 1: Increased mariculture production from farming of the two species in the WIO region. Increased knowledge in marine fish breeding and production of fingerlings.

Objective 2: Quality feed available and affordable leading to increased mariculture production from farming of the two species and improved community livelihoods.
Objective 3: Adoption of cage and pond farming technologies of the two species for the first time in the WIO region, increased production of high value marine species, improved community livelihoods and informed decisions on fish farming.

Optimizing *Artemia* Production Technology for Sustainable Aquaculture Development (APTSAD), Food Security and Economic Growth for the East African Coastal Communities

Countries covered	Kenya and Tanzania
Partner institutions	• Maseno University, Kenya • Kenya Marine and Fisheries Research Institute (KMFRI), Kenya • Tanzania Fisheries Research Institute (TAFIRI), Tanzania • University of Gothenburg, Sweden
Collaborators	• Kadzuhoni Self Help Group, Kenya (community development group) • Kensalt Ltd, Kenya (Private salt producing company) • MWEVUPI salt farmers (Community development group) and Omary salt works (Private salt producing company), Tanga, Tanzania.
Lead institution	Maseno University, P.O. Box Private Bag, Maseno, Kenya
Principal Investigator (PI)	Erick Ochieng Ogello (Ph.D.), Department of Fisheries and Natural Resources, Maseno University, Kenya, P.O. Box Private Bag, Maseno, Kenya, Email: eogello@maseno.co.ke Tel: +254708842832, Alternative Email: erick.ogello@gmail.com
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Project period	2 years
Budget requested	**USD 328,549**
Matching Fund	**USD 161,910 (45% of the requested budget)**

Abstract

Artemia are small crustaceans found in saline habitats such as salt lakes, coastal lagoons and evaporation saltworks. It is the excellent nutrition profile of *Artemia* that makes them suitable for aquaculture, especially as food for larval fish. The fish feed disparity is more critical at larval fish stages. *Artemia* has been used globally (as food for 'baby fish') to improve fish larviculture production in hatcheries and ensure high production of quality larval fish seeds. *Artemia* can as well be used as a protein source to formulate aqua-feed for grow-out fish. Currently, *Artemia* cysts are only used by few hatcheries in East Africa and are expensive since they are imported from Asia, America or Europe. Fortunately, *Artemia* culture has been established on the Kenyan and Tanzanian coast for more than three decades, thanks to the Kenya-Belgium Project (KBP),

implemented by Kenya Marine and Fisheries Research Institute (KMFRI) and University of Ghent (UGent), Belgium that introduced *Artemia fransciscana* to coastal Kenya. However, there is limited scientific information on 1); identity and adaptability of *Artemia* to the local conditions along the Kenyan and Tanzanian coastline, 2); reproductive traits of the East African *Artemia*; and 3; application of local *Artemia* strains in aquaculture initiatives.

The general objective of this project is to improve the livelihood of coastal communities in Kenya and Tanzania through establishment of innovative *Artemia* Value Chain (AVC) linkages that involves production of *Artemia* biomass / cysts, and applications in the emerging larviculture initiatives. Specifically, the project will 1) characterize the local *Artemia* biotopes in coastal Kenyan and Tanzanian using molecular techniques to determine the genetic adaptation of the Artemia biotopes along the East African coastline. 2), apply innovative biofloc technology for mass production of *Artemia* biomass, 3) promote utilization of *Artemia* biomass in emerging local aquaculture initiatives i.e. larviculture, and aqua-feed production.

Description of research methods

Objective 1: *To characterize local Artemia biotopes using molecular techniques:* This project will characterize local *Artemia* strain(s) and cysts in terms of genetic divergence, nutritive capacity, reproductive performance, and determine their suitability for aquaculture. Molecular identification techniques will be done at the University of Gothenburg, Sweden. Artemia samples will be obtained from Kenya and Tanzania during a baseline survey and transported to Sweden for lab analysis. Growth and reproduction laboratory tests with local *Artemia* strain(s) will be performed in Kenya and Tanzania. Parameters will include hatching, growth, and reproduction in abiotic and biotic (phytoplankton) conditions. As prevailing in coastal saltworks, assessment of *Artemia* suitability for pond production will be done using standard methodologies. Similar studies will also be done using original *Artemia* cysts from San Francisco Bay (SFB) sourced from KMFRI-*Artemia* cyst bank, for comparison.

Objective 2: *To apply innovative biofloc technology for mass culture of Artemia cysts and biomass*

Live culture production protocols for other live food resources (i.e. rotifers, copepods and cladocerans) using BFT already exist (Ogello 2017; Ogello *et al*. 2018, 2019). This project will apply these protocols for mass production of *Artemia* biomass in the existing demonstrational units. The technology will be called *Artemia* Biofloc Production Technology (ABPT). New protocols / manuals will be developed and shared with local communities. The *Artemia* biofloc experiments will be carried out at KMFRI's Malindi *Artemia* research field station in Kenya and in the Tanzanian salt works in Tanga. Green Water (GW) technology supplemented with chicken manure, molasses and other environmental wastes will be used at elevated carbon nitrogen ratios (C/N). As developed elsewhere in the world, the project will foresee a dissemination platform of project findings and *Artemia* production protocols for local rural communities. The project will promote adoption of *Artemia* production techniques (biofloc) by commercial salt producers,

artisanal salt farmers and local communities. The activities will include purchasing of equipment and consumables needed for ABFT *Artemia* pond production e.g. molasses, nets, chicken manure extracts etc., enriching water supply, supplementary feeding, raking in culture ponds, water exchange and renewal, biomass harvesting. The physico-chemical conditions will be monitored and phytoplankton analysis will be done using a light microscope on a weekly basis. Data will be collected for *Artemia* population growth parameters.

Objective 3*:* T*o promote utilization of Artemia cysts and biomass in emerging local aquaculture activities for better growth performance, feed utilization and survival of fish and improving local livelihoods*

a) Fish larviculture initiatives: Protocols for co-feeding larval fish using *Artemia* nauplii, other live diets (rotifers, copepods and cladocerans) and commercial inert diets will be produced. This study will be carried out at Maseno, KMFRI and TAFIRI. Culture trials of marine fishes i.e. *Chanos chanos* and crabs or shrimps will be done at KMFRI and Khadzuhoni SHG. Studies of using *Artemia* in comparison with other live and dry feeds will be carried out consecutively. Growth rate and survival studies will be carried out to determine the effectiveness of *Artemia* as compared to the other live and dry starter fish feeds. *Artemia* biomass or cysts will also be supplied to specific hatcheries owned by local communities in Kenya and Tanzania in order to improve larviculture in those hatcheries. University students (undergraduate, masters) undertaking aquaculture studies will be encouraged to run larviculture tests at Maseno University, TAFIRI and KMFRI laboratories using different fish species.

b) Aqua-feed production for grow-out fish: *Artemia* biomass produced in objective 2 above will be harvested using existing techniques and processed as protein source ingredient for fish feed production. We will use the proximate analysis in objective 1 to determine best formulation for *Artemia* aqua-feed. The formulation will be shared among community interest groups so that they can apply this knowledge to develop a cottage feed industry. The project team will also approach commercial fish feed producers for capacity building wherein we will train staff on the potential of *Artemia* as a protein ingredient in aqua-feed production. The commercial companies will be given information about using *Artemia* production as a source of fish meal for aqua-feed production, with a similar approach involving other livestock feed producers in the long run once trials have been shown to be successful. Growth performance, feed utilization and survival of the fish will be analyzed/calculated based on formulated *Artemia*-diets. Local cottage industries will be encouraged to produce more *Artemia*-based fish feeds for sale in local markets.

c) Socio-economic studies on AVC: The study will assess the economic practicability of the venture to uncover strengths and weaknesses. Specific farmers will be identified and briefed on how to apply these tools to assess the economic feasibility of *Artemia* production for applications in aquaculture.

This project will produce a catalogue of the biogeography of existing *Artemia* biotopes in East Africa region, and scientific information, which will put the East African *Artemia* biotopes in the global map for promotion of trade and aquaculture initiatives in the local cities within WIO region. This will improve the livelihoods of the local communities through AVC

Artisanal integrated *Artemia*-salt production ponds in Malindi, Kenya

Omary salt works (Private salt-producing company) in Tanga Tanzania

Projects Funded in 2019

Billfish Interactions, Livelihoods, and Linkages for Fisheries Sustainability in the Western Indian Ocean (BILLFISH-WIO)

Website: https://billfishwio.com; twitter: @billfishwio

Investigators: Dr. Nelly Isigi Kadagi, (African Billfish Foundation (ABF)); Dr. Nina Wambiji, (Kenya Marine and Fisheries Research Institute (KMFRI)); Dr. Lydia Kanyairita (University of Dar es Salaam); Dr. Emmanuel Andrew Sweke (Deep Sea Fishing Authority); Mwaka Barabara Said (Kenya Fisheries Services); Dr. Sean Fennessy & Dr. Bruce Mann (Oceanographic Research Institute (ORI)); Raseta Saverio (Madagscar); José Halafo (Instituto Nacional de Investigação Pesqueira (IIP)): Dr. Joseph Maina Mbui (Macquire University); Prof. Ussif Rashid Sumaila, (University of British Colombia); Dr. Julian Pepperrell, (Pepperell Research & Consulting); Dr. Sam Williams, (University of Queensland); Dr. Robert Ahrens, (NOAA Pacific Islands Fisheries Science Center, USA); Dr. Sarah Glaser, (Secure Fisheries), Dr. Andrew Wamukota, (Pwani University); Dr. Salum Hamed, (University of Dodoma); Dr. Denham Parker, (Department of Agriculture, Forestry and Fisheries, SA), Dr. Melckzedeck Osore, (Kenya Marine and Fisheries Research Institute (KMFRI)).

Countries covered: Somalia, Kenya, Tanzania (including Zanzibar), Mozambique, Madagascar, South Africa

Implementing institutions: African Billfish Foundation (ABF), Kenya Marine and Fisheries Research Institute (KMFRI), University of Dar es Salaam (UDSM), One Earth Future – Secure Fisheries, Oceanographic Research Institute (ORI), Tanzania Deep Sea Fisheries Authority (DSFA), Fisheries Research Institute of Mozambique (IIP)

Extended Abstract Reporting period: September 2019 – September 2020

Prepared by: Dr. Nelly Isigi Kadagi and Dr. Nina Wambiji – Project PIs

Abstract

The Western Indian Ocean (WIO) region has been known as a 'hot-spot' for the targeting of billfish by sport and recreational fisheries. Billfish species are also caught in artisanal and industrial fishing gears providing socio-economic benefits. Despite their importance, limited information exists on their catch dynamics, ecological and socio-economic aspects, and genetic stock structure in the WIO. The lack of information on billfish species coupled with inadequate capacity in skills and knowledge were the main drivers for the WIOMSA-MASMA funded BILLFISH-WIO project. Broadly, the lack of data on billfish and related fisheries has implications on on-going efforts to achieve the transboundary national priorities and key Sustainable Development Goals (SDGs) such as (i) improving food security and nutrition, (ii) promoting wellbeing of communities through equal resource allocation, and (iii) sustainably utilizing and conserving ocean resources. Further, many countries in the WIO are interested in harnessing the potential of their Blue Economy. Therefore, knowledge on billfish is critical in developing sustainable fisheries and ensuring the socio-economic security of fisheries-dependent communities.

Research objectives and methods

This first-ever comprehensive regional study on billfish spans across six countries (Somalia, Kenya, Tanzania (including Zanzibar), Mozambique, Madagascar, and South Africa) aimed to (i) evaluate the historical and present status of billfish species; (ii) explore the socio-economic contribution and governance of billfish; (iii) assess the genetic structure of key species; and (iv) determine the spatial and temporal distribution of billfish species.
To address the objectives, the project deployed various methods as follows:

Objective 1: Evaluate the historical and present status of billfish species
The project team reviewed and assessed historical and current billfish landings and catch rates. In Kenya, fish catch data has been collected from 8 fish landing sites – Ngomeni, Malindi, Watamu, Kilifi, Gazi, Msambweni, Shimoni and Vanga. In Ngomeni, we are working with the fishers directly where they collect the data and are compensated. In Tanzania, historical data was received from Tanzania Deep Sea Fisheries Authority (for both Tanzania and Zanzibar), Ministry of Livestock and Fisheries as well as Tanzania Marine Parks and Reserves Unit. In Mozambique, historical billfish tagging, catch and release dating back to 1958 was obtained from the sport fishing community. In Zanzibar, two enumerators collect data at each site using harmonized data collection methods. CPUE data is collected on intervals of 8 days monthly using standard fisheries assessment survey forms and identification done using the FAO-IOTC guide for tuna and tuna like species. Regionally, the project received over 30 years of recreational data from two leading tagging programmes – the Oceanographic Research Institute (ORI) and African Billfish Foundation (ABF)

Objective 2: Determine the spatial and temporal distribution of billfish species
Mr Pascal Thoya, our Ph.D. researcher (Macquarie University, Australia) obtained billfish data from the Indian Ocean Tuna Commission and OBIS databases. The data were used to examine billfish niche partitioning and implications on environmental variables on billfish niche selection.

The analysis also simulated the relationship between longline fishing effort and billfish co-occurrence.

Objective 3: Assess the genetic structure of critical species

An optimization protocol has been developed by our BSc student Pascah Beti (Pwani University, Kenya), who compared the integrity of DNA collected from samples stored in Ethanol versus Ethylene diamine tetra acetic acid (EDTA) solutions. Several billfish species have been analyzed. In Mozambique, more than 50 tissues of black marlin and sailfish are already collected. In Kenya, over 150 billfish genetic samples have been collected from a commercial long liner and artisanal fishers specifically from Watamu and Kilifi**.**

Objective 4: Explore the socio-economic contribution and governance of billfish

A socio-economic questionnaire was developed and translated in French, Swahili and Somali. Over the last 6 months, more than 50 Somali fishers have been interviewed. Specifically, socio-economic data collection has been obtained mostly from Lido beach off Mogadishu. The Kenyan team visited the study sites in the North coast (Malindi, Ngomeni, Watamu and Kilifi Central BMUs) and South coast (Shimoni, Gazi and Vanga BMUs). A total of 126 respondents so far interviewed. 60 respondents in Nungwi, Mkokotoni and Kizimkazi provided information on catch variability, species composition, gears, marketing, seasonality, and management status.

Findings, outputs and outcomes

Between September 2019 and September 2020, the BILLFISH-WIO project has brought together over 20 collaborators and 9 students (3 Ph.D., 4 MSc and 2 BSc students).

Some of the findings specific to each of the objectives are as follows:

- The review of billfish fisheries in the Western Indian Ocean region (Objective 1-) indicated major data gaps across all fisheries targeting billfish. Specifically, countries such as Somalia and Comoros had no official historical records of billfish species.
- Our results for objective 2, showed that billfish species exhibit niche partitioning and overlaps especially in the Northern and Western Indian Ocean region. Blue marlin and sailfish depicted high overlaps in their niche selection, whereas swordfish and black marlin had low overlaps in their niche partitioning. In addition, environmental controls such as sea surface temperature, salinity, and oxygen. Our study also showed that occurrence of billfish species was highly associated with longline fishing effort distribution.
- For objective 3 (genetic analysis), our protocol for billfish DNA extraction and optimization indicated that the quality of DNA that was extracted was retained when both ethanol and EDTA solutions were used at specific concentrations. However, EDTA was found to be inexpensive in cases where ethanol was unavailable.

Publications produced or in preparation

- Kadagi, N.I, Wambiji, N., Belhabib, D., & Ahrens, R. (2020). Characterizing competitive interactions between recreational and artisanal billfish fisheries in Kenya. *Ocean and Coastal Management* (*in print*).
- Kadagi, N.I, Wambiji, N., Fennessy, S, D., Allen, M.S., & Ahrens, R. (2020). Challenges and Opportunities for Sustainable Development and Management of Marine Recreational and Sport Fisheries in the Western Indian Ocean. *Marine Policy* (*in print*).
- Kadagi. N.I., Wambiji, N., Mann, B., Parker, D., Daly, R, Rato, D.A.M., Halafo, J., Gaspare, L., Sweke, E.A., Ahmed, S., Saverio, R., Maina, J., Glaser, S., Sumaila, U.R.

(Submitted). Status, Challenges and Recommendations for Sustainable Billfish Fisheries in the Western Indian Ocean. *Review in Fish Biology and Fisheries* (under review).

- Thoya, P, Kadagi, N.I, Wambiji, N., Williams, M.S., Pepperell, J.G, Mollmann, C., Schielle, K, Maina, J., (in Prep). Environmental controls of billfish species in the Indian Ocean and implications for their management and conservation.

Some project partnerships

- Discussions are underway on analysis of genetic samples through DArT Sequencing with our collaborators Dr. Sam Williams and Dr. Julian Pepperell (University of Queensland, Australia) and the Commonwealth Scientific and Industrial Research Organization (CSRIO) in Australia.
- In Somalia, BILLFISH-WIO has partnered with Project Kalluun, which connects 4 universities (City University- Mogadishu, East Africa University- Bosaso, Berbera Maritime and Fisheries Academy, Kismayo University) and provides video lectures and training for students in data collection, on billfish species and genetic tissue sampling. Through the collaboration with Secure Fisheries in Somalia, the BILLFISH-WIO is in the process of negotiating access to nation-wide catch data from the government fisheries officers.
- Through funding from Pew Charitable Trusts to Dr. Nina Wambiji, BILLFISH-WIO is working with the National Fisheries Research Institution, Institut National De Recherche Pour L'agriculture, La Pêche Et L'environnement-Comoros to promote collaboration on billfish data collection and reporting.
- The project has pursued collaboration with Institut Halieutique et des Sciences Marines (IH.SM) and the Centre National de Recherches Océanographiques (CNRO) in Madagascar.
- The project has collaborated with Dr. Maina Mbui of Macquarie University, Australia, to address objective two.
- In December 2019, Dr. Isigi Kadagi visited Mozambique and met with the Director of National Fisheries Research Institute, members of the sport fishing community, and local leaders.

Two key outcomes are worth mentioning: First, BILLFISH-WIO has developed collaborative work with stakeholders in Somalia. Second, The Pew Marine Fellowship awarded to Dr. Nina Wambiji has made it possible for BILLFISH-WIO to expand its work to additional countries making it a total of 10 countries covered in this research. Given the trans-national nature of billfish species, the possibility of collecting data in 10 countries will provide pertinent information and contribute to the process of developing regional management actions.

Implications

BILLFISH-WIO provides a much-needed first-time region-wide survey of billfish fisheries. The data and information, particularly on catch dynamics, habitat preferences and interactions with fisheries is critical for national and regional management of billfish species given their highly migratory nature. While the pandemic resulted in some data gaps and limited field work, considerable measures such as strengthening citizen science have been put in place to address these setbacks. Beyond the project findings, we envisage the involvement of Somalia in various activities of the BILLFISH-WIO as the beginning of Somalia's active participation in the WIOMSA community, of which it is an integral member yet with minimal visibility.

SLIPPERY RESOURCE IN PERIL: ECOLOGY OF WESTERN INDIAN OCEAN ANGUILLID EELS AND THEIR CONTRIBUTION TO SUSTAINABLE FISHERIES AND LIVELIHOOD ALONG THE EAST COAST OF AFRICA

Fig. The subject of the study; a large eel collected by team member Celine Hanzen during her Ph.D. in South Africa.

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Abstract

The Western Indian Ocean Marine Sciences Association (WIOMSA) has appointed the University of Mpumalanga (UMP), Egerton University (EU), Kenya Marine and Fisheries Research Institute (KMFRI), and University of KwaZulu-Natal (UKZN) to undertake the research project aimed to characterize the risk of multiple stressors to the largely unknown life cycle ecology of our local eels and their contribution to subsistence fisheries in the region. In addition to the existing team a new collaborative link has been made with the Eduardo Mondlane (EM) University in Mozambique who will have one student registered and based in Mozambique on the study.

The study has been initiated in October 2019 with the signing of the contract for the WIOMSA Grant No: MASMA/OP/2018/04 and UMP. This extended abstract presents the tasks initial results and progress on the study achieved during 2020. The study has been structured around seven objectives established to achieve the aim that will be unpacked into a series of research projects being undertaken by specialist scientists and post-graduate students from our collaborating institutions.

The following objectives are proposed:

1. Undertake a literature review of the known diversity, distributions, biology, ecology and socio-ecological importance of WIO Anguillids. This review will be undertaken in the context of socio-ecological value of global Anguillids.
2. Establish hypotheses of the biology and ecology of WIO Anguillids, and their use as a targeted fisheries species from existing literature and specialist solicitations from fisheries managers/scientists and ecologists in the WIO region. Surveys will be undertaken to the Tana and Ramisi systems (Kenya), Limpopo (Shingwedzi and Olifants tributaries) system and the Inkomati Estuary (Mozambique/South Africa) and Thukela Estuary (South Africa).
3. Characterise the timing and prevalence of the recruitment of Anguillid eels into the Tana and Ramisi Estuaries (Kenya), and the Inkomati Estuary (Mozambique/South Africa) and Thukela Estuary (South Africa), and threats to these migrations.
4. Characterise the timing and prevalence of the escapement of Anguillid silver eels from rivers back into the sea, including some initial preliminary marine migration routes and behavioral ecology information (Tana, Inkomati and Thukela Estuaries). This will include the evaluation of threats to this escapement migrations.
5. Evaluate the contribution that WIO Anguillid eel fisheries make to local community livelihoods and any commercial fisheries opportunities. Socio-ecological and economic etc.
6. Undertake a regional scale ecological risk assessment of multiple stressors to the wellbeing of Anguillid eel populations throughout the WIO.
7. Review water resource use, protection and fisheries regulations in the region and make recommendations to address ecological, social and economic management of Anguillid eels and associated river connectivity and fish migrations.

Methodology

Following the objectives established for the study the methodology is presented for each of the objectives of the study have been incorporated into three phases of the study.

Phase I includes the project inception and literature review (*objective 1*) phase included the identification of research tasks for the project team and their appointment of post-graduate students

onto the study. Dr. Celine Hanzen who is a project member and represents UKZN is also a Post-Doctoral Fellow and will contribute to the human capacity development of the study. Ms. Catherine Kariuki (Ph.D., Cand.) and Ms. Lena M. Gitonga (M.Sc., Cand.) have been registered at EU and Justice B. Baya (M.Sc., Cand.) has been registered at Pwani University but will work on the project with EU and KMFRI. Ms. Annalize van der Merwe (M.Sc., Cand.) has registered at UMP and Álvaro A. Vetina (M.Sc., Cand.) will register in 2021 but has already been appointed to the project. He is based at EM and will support the UMP team in Mozambique. Finally, Leawin Africa (M.Sc., Cand.) has registered at UKZN and will work on the UKZN part of the study.

The literature review part of the study has been initiated by the whole team and some noticeable achievements include the availability of the 2020 publication and use of the Distribution, ecology and status of anguillid eels in East Africa and the Western Indian Ocean authored by Hanzen et al. and complementary work from Celine's Ph.D. This data is being enhanced with evaluations of Anguillid distributions, fisheries and livelihood evaluations and multiple stressor evaluations including establishment of causal risk pathways between stressors and Anguillid populations and the human communities who depend on these eels (Figure 1).

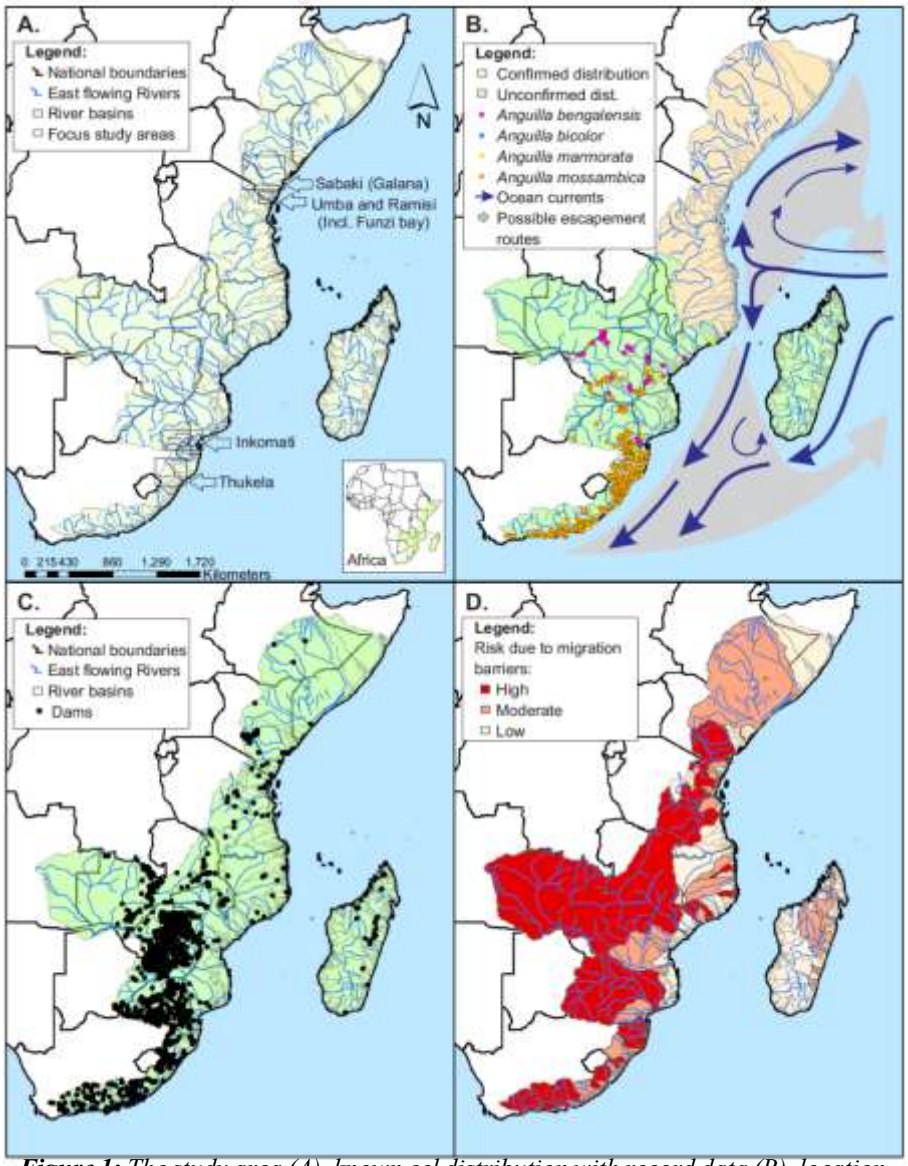

Figure 1: *The study area (A), known eel distribution with record data (B), location of dams in the region (C) and an example of a preliminary low confidence risk evaluation of barrier formation to the eels in the region associated with dams (D).*

Phase II includes the data collection (*objectives 2-5*) with the initiation of field surveys to elucidate the biology and ecology of yellow and silver eels within the east-flowing rivers. This research has been initiated within the four focus study areas (Figure 1(A)). In addition, the characterization of the recruitment fisheries surveys has been initiated in 2020

although there have been major delays due to the COVID-19 pandemic and procurement of equipment for the field surveys. Research on the escapement of eels has not been initiated as yet but is expected to be prioritized in 2021.

Phase III includes the regional scale ecological risk assessment of multiple stressors to the wellbeing of Anguillid eel populations (*Objective 6*) and the contribution of the study to regional water resource use, protection and fisheries regulations (*Objective 7*). These objectives are dependent on data from phases I and II and will only be initiated during 2021 when data becomes available. The risk assessment approach for this study is based on extensive African case studies undertaken by O'Brien et al and will result in a spatial distribution of risk to the wellbeing of eels and their contribution to the livelihoods of vulnerable human communities (Figure 1(D)).

Results

Preliminary results all pertain to the ongoing literature reviews and initial collection of eel distribution data and the commencement of post-graduate studies initially concerned with the biology and ecology of yellow and silver eels. And some initial new information on the recruitment of eels into the Thukela Estuary in South Africa. Important new information includes the expansion of the known Anguillid distributions from southern Africa into east Africa with new specimens collected by the Kenyan team in this study (Figure 1(B)). We have also started to improve our understanding of the life cycles and requirements of Anguillid eels and multiple stressors affecting their wellbeing and use in the region.

Implications and applications

We have experienced some delays in 2020 primarily due to survey and travel restrictions and procurement of equipment due to COVID-19 restrictions. With the easing of these restrictions we have observed a rapid increase in sampling efforts for objectives 2-5 and procurement of equipment recently which will all contribute to a positive start in 2021. We are presently approximately six months behind our initial work plan but may be able to catch up in 2021. We have had many successes in 2020 and hope to align efforts and improve research efforts in 2021. Short terms plans include hosting a survey training workshop in South Africa for all post-graduates and initiation of an overlapping 12-month recruitment survey in the estuaries of the Sabaki and Ramisi (Funzi Bay) Estuaries in Kenya and Inkomati Estuary in Mozambique and align this to ongoing work on the Thukela Estuary. In 2021 we will continue inland research on the yellow and silver eels and initiate an escapement project with support from Robert Schabetsberger from the University of Salzburg. In 2021 we will also initiate training on regional scale ecological risk assessments and the use of the risk outcomes to contribute to fisheries regulations in the region and the ecological, social and economic management of Anguillid eels and their use in the region.

Our team is working well together and we expect to produce a range of publications and outputs associated with post-graduate students. Thank you again for the opportunity to undertake this valuable research that will contribute to the wellbeing of our region and the people who we care about.

WIO-Benth: Identification, characterization and vulnerability assessment of benthic ecosystems in the WIO

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Bernadine Everett - Oceanographic Research Institute

Fiona MacKay - Oceanographic Research Institute

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Errol Wiles – South African Institute for Aquatic Biodiversity

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Reporting period

1 September 2019 – 31 October 2020

Countries

Kenya, Madagascar, Mozambique, South Africa, Tanzania, Norway

Abstract

We aim, on a coarse scale, to describe, model and map continental shelf and upper slope seabed habitats and their benthic communities in the western part of the Western Indian Ocean (WIO), in order to assist with regional marine spatial planning (MSP).

Specific objectives

- Develop a coarse-scale seabed classification scheme for continental shelf and upper slope habitats in the WIO
- In terms of this classification scheme, characterize and determine the extent of seabed habitat types of the continental shelf and upper slope in the western part of the WIO
- Characterize and determine the spatial extent of benthic communities of the continental shelf and upper slope in the western part of the WIO

- Create the first benthic biotope descriptions for the continental shelf and upper slope of the western part of the WIO using information on seabed habitat types and benthic communities
- Identify the location and determine extent of potentially vulnerable offshore marine habitats in the western part of the WIO

Method

General

This project is making use of existing ship survey data, particularly from the Dr Fridtjof Nansen research vessel. This required letters of permission from the participating countries in which Nansen surveys occurred and a Memorandum of Understanding between FAO (the Executing Agency of the EAF-Nansen Programme) and WIOMSA (funders of the MASMA WIO-BENTH project) to address data copyright and dissemination issues, to provide due recognition of the EAF-Nansen Programme, and to ensure that data usage is aligned with the Programme's objectives. Participating country representatives were asked to prepare and submit inventories of soft-sediment benthic survey data from other (non-Nansen) vessels, so their suitability for the project could be assessed. A series of data cleaning and analysis workshops are planned to process and analyze with the data.

Methods towards meeting Objectives:

- Develop a coarse-scale seabed classification scheme…

This is an iterative process, and the scheme is being developed as the nature, extent and suitability of the various data sources become apparent. At the finest level, high- resolution seabed information can be retrieved from analysis and interpretation of sediment samples obtained from benthic grab sampling; then, increasingly lower resolution levels of seabed information can be obtained from: acoustic back-scatter generated from scientific multi-beam echo-sounders; remotely-sensed satellite data; digitized electronic charts; and by inference from the habitat preferences of benthic communities caught in bottom trawls.

- Characterize and determine the extent of seabed habitat types…

Closely linked to outputs of the first objective, seabed habitat types inferred from single/multibeam echo sounding, ship and satellite bathymetry and its derived parameters, and biotic habitat associations, will be mapped and modelled using GIS; also included will be layers reflecting the physico-chemical characteristics of the water column in close proximity to the seabed.

- Characterize and determine spatial extent of benthic communities…

Patterns in the benthic communities sampled by bottom trawl and benthic grab on past research surveys will be examined using multivariate analysis, and mapped in layers using GIS.

- Create the first benthic biotope descriptions…

The mapping of seabed habitat types and benthic community patterns will enable the description and characterization of biotopes across the study region.

- Identify the location and determine extent of potentially vulnerable offshore marine habitats….

The characteristics of the biotopes will determine their potential vulnerability to threats.

Findings/Results

- The MoU between FAO and WIOMSA was finally signed in April 2020, and access to Nansen survey data has been facilitated by the Institute for Marine Research.
- Inventories of non-Nansen survey data from participating countries are still awaited – the delay in producing these is concerning, as numerous requests have been sent; the limited data from these surveys received so far have considerable data quality issues.
- A variety of historical survey data from the study region (some dating back to the first IIOE expedition) have been obtained from a variety of sources, to inform seabed habitat types.
- Literature review is ongoing, and key references have been placed on a dedicated Google Drive project.
- The collaborating IMR chief engineer was allocated time from his institute to process relevant multibeam data from RV Dr Fridtjof Nansen surveys, and is using a combination of Fledermaus and ArcMap / QGis to produce raster files.
- The project geologist has examined electronic chart data for use at the regional scale, although satellite-based information (Shuttle Radar Topography Mission SRTM) is more useful at this scale to generate a regional base layer that displays habitat types at a low resolution.
- Based on the relative proportions of seabed habitat preferences of organisms caught in the available bottom trawl surveys (see below), trawl stations were assigned a habitat type (hard/mixed/soft), and basic habitat maps in ArcGIS were generated using interpolation.
- Two WIO-Benth candidates have been nominated for participation in EAF-Nansen oceanographic data analysis training course, with a view to generating seabed habitat mapping layers based on water column parameters (from CTD) in close proximity to the seabed.
- Nansen bottom trawl data for the period 2007-2018, as well as from some non-Nansen surveys available from previous projects (total ca. 850 trawls) have been cleaned and validated including confirmation of taxa names based on global taxonomic authorities and known distributions; per-taxon information on habitat preferences and life history has been assigned based on literature review and expert input. These validated taxa have been used to generate preliminary seabed habitat maps (see above). Preliminary multivariate analyses of the community composition data have been undertaken – these will be pursued further once additional data sets from non-Nansen surveys become available.
- Data cleaning and analysis workshops, including an EAF-WIO-Benth benthic community analysis workshop, have been postponed owing to COVID-19.

Implications/Applications

Our project plans to develop a regional, area- and ecosystem-based tool (an atlas of seabed habitats and soft sediment benthic communities) to assist with marine spatial planning. The knowledge of the diversity of habitats and their communities will form a spatial layer which will be available to overlay with other spatial layers on extractive activities such as fisheries, oil and gas activities and layers which will map other large-scale factors. Together, these layers will enable marine spatial planning to be better informed for the WIO region. Our project is clearly aligned towards assisting UNEP's Nairobi Convention initiatives aimed at advancing MSP in the region, including providing the platform for contributing to Marine Protected Areas management.

Projects Funded in 2018

Larval fish production and dispersal in critical habitats of coastal East Africa" (FLAPSEA project)

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Reporting period: **June 2019-September 2020**

Countries Covered: **Kenya, Tanzania and Sweden**

Abstract

The "***Larval fish production and dispersal in critical habitats of coastal East Africa***" (FLAPSEA project) is a MASMA funded project by the Western Indian Ocean Marine Science Association (WIOMSA) from 2019-2021 to study fish larvae in seagrass habitats and adjacent zones. The goal of this project is to investigate how food-provisioning services in the form of fish production are threatened by coastal habitat degradation and how production of this natural resource is related to climate change and coastal development in East Africa. The project will ultimately identify sensitive seagrass habitats that need to be protected and threshold values for healthy productive seagrass habitats, and estimate the socio-economic costs of seagrass beds loss to fisheries. Specifically, this will be done by addressing the following objectives including identification of habitat conditions critical for fish recruitment and key drivers for fish larvae production, Identification of dispersal potential of fish larvae from the seagrass habitats to where adult fish spawn, prediction of future economic impacts and the most vulnerable coastal areas, and provision

of scientific information that can lead to improved management and protection strategies in coastal East Africa.

Progress has been made in implementation of activities including, inception meetings, site surveys, stakeholders meeting, sampling and data analysis workshops in both Kenya and Tanzania. Sampling commenced in June 2019 and has extended to September 2020 covering the SEM and NEM season.

Emerging results since inauguration cover research conducted in 2019-2020 during June, July, August 2019 (SEM), November, December, January & February 2019-2020 (NEM) and June, July, August & September 2020 (SEM). FLAPSEA identified sensitive seagrass habitats located at Watamu and Diani in Kenya, and Kigombe and Mwarongo Tanga in Tanzania where sampling has been underway in sites demarcated as healthy and degraded. Useful data and information have been collected that support the need to protect seagrass habitats in these localities. More analyses are underway to determine the productivity of healthy seagrass habitats and to estimate the socio-economic costs of their loss to fisheries production and implication to community livelihoods.

Monthly variation in plankton abundance was apparent, with little difference between healthy and degraded sites. Phytoplankton and zooplankton encountered reflect common genera expected in coastal waters of Kenya and Tanzania. Peak abundance of fish eggs observed in June at healthy seagrass areas is indicative of preferred habitats for fish spawning, possibly with series of spawning events synchronised with the Southeast Monsoon (SEM) season and peak of primary productivity as indicated by presence of Chlorophyll "*a*." This could be strategic to ensure that hatched larvae have a higher chance of survival through food availability. A seasonal pattern is expected after sampling and analysing samples of the Northeast Monsoon (NEM) season. Fish larvae species associated with seagrass areas in Kenya and Tanzania were *Leptoscrus vaigiensis* and *Siganus sutor* - in line with what was expected in the project objectives and therefore justification for selecting this family for planned genetics studies.

FLAPSEA has established research collaboration with two other MASMA funded projects namely "Seagrass Protect" and MICROMARE, as well as SOLSTICE Project affiliated to WIOMSA. Collaborative activities with Seagrass Protect planned for 2020 will involve data sharing and joint field work to map seagrass. FLAPSEA will share with MICROMARE Project expertise in taxonomy and modelling. SOLSTICE Project will collaborate in sharing regional oceanographic data.

Capacity building is a key activity undertaken in the initial year. Eight students, four females and four males, have registered for postgraduate degrees addressing research questions related to FLAPSEA objectives. Four PhD students and one MSc are registered at Stockholm University, two for MSc at Dar-es-Salaam University and one for MSc at Pwani University. Potential papers to be produced are presented, and plans to disseminate project information are discussed.

Assessment of the Ecological Aspects of Microplastic Pollution in Dar Es Salaam, Zanzibar and Mombasa Coastal Marine Environments (MICROMARINE)

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Countries covered: Tanzania (Dar es Salaam and Zanzibar) and Kenya

Period: November 2020 (2020-2021 FY)

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Abstract

The three major aims of MICROMARINE project are: 1) to assess microplastic pollution in sediment, water and biota samples collected from Dar Es Salaam, Zanzibar and Mombasa (Kenya) coastal marine environments; 2) to identify the major polymers, organic polymer additives and organic pollutants present in microplastics in coastal marine environments of the participating member states; and 3) to investigate the interactions of microplastics and Persistent Organic Pollutants (POPs) with marine biota, which are being addressed through the following six specific objectives: 1) to quantify the abundance, distribution and fate of microplastics in coastal marine environments of the participating member states; 2) to identify the major polymers, organic polymer additives and organic pollutants present in microplastics in coastal marine environments of the participating member states; 3) to investigate the potential role of microplastics as vectors of marine pollutants and their trophic transfer in marine food webs; 4) to equip public and private stakeholders with the scientific basis for the development and compliance with general environmental regulations concerning chemicals used in plastic production; 5) to foster the development of a diverse scientifically trained workforce through coastal and ocean education programs; and 6) to raise public awareness of the risks that microplastics pose to marine ecosystems and, eventually, human health.

Methodology

Sampling campaign was conducted in December 2019 to collect surface water microplastics (MPs), sediment MPs (beach and seabed sediments) and fish (*Lethrinus harak*) from the selected sites in Dar es Salaam, Zanzibar and Kenya according to Mu, *et al.,* (2019), Frias *et al.,* (2018) and Mziray and Kimirei, (2016) respectively in order to address objectives 1 and 2. MPs in water were analyzed according to Kovac Virsek, *et al.,* (2016); Gago *et al.*, (2018) and (Gewert, *et al.,* 2017). Beach and seabed sediments were treated according to Cordova, et al., (2018) and Quinn, *et al.,* (2017) then examined and classified based on morphological characteristics according to Frias *et al.,* (2018); Kosore, *et al.,* (2018); Kanhai *et al.* (2017; Maes *et al.* (2017) and Castillo *et al.,* (2016). Microplastic abundance in sediments was expressed as number of particles kg^{-1} of dry sediment (Maes, *et al.* 2017). Fish samples were treated according to Alomar, *et al.,* (2017) then prepared and analyzed according to De-La-Torre, *et al.,* (2019) and Bessa *et al.,* (2019). Objective 1 was effectively addressed, while part of objective 2. (i.e., samples for polymer identification) have been sent for imaging and analysis using optical microscopy and FTIR spectroscopy at the NMD laboratory and the results are expected earliest by the end of 2020 due to lack of access to the laboratory due to the COVID-19 pandemic. Laboratory experiments to address objective 3 have just started. Delay in starting experiments to address objective 3 has been partly due the slow process of procurement of fluorescent microspheres caused by COVID-19 pandemic. Objectives 4 and 5 have not been done mainly due to COVID-19 pandemic. Objective 6 have partly started; some tools have already started being developed and once completed; they will be distributed to stakeholders. We expect to execute objectives 4 and 5 in the coming phase after next financial requisition.

Results and conclusion

A total of 2429 particles were confirmed to be microplastics with varying abundances ranging from 0 – 38161.40 MPs m^{-3} and an overall average abundance of 1843.4 ± 25.9 MPs m^{-3}. Of the 2429 confirmed particles, 1473 particles representing 61% of the total; 606 particles (25%); and 350 particles (14%) were found in the surface waters of Kenya, Dar Es Salaam and Zanzibar respectively. High number of particles recorded in Kenya are majorly contributed by the site in Malindi. Seabed sediments recorded an overall mean range of 0 – 187.96 ± 15.36 MPs kg^{-1} DW with an overall mean of 80.05 ± 8.68 MPs kg^{-1} DW. On the other hand, beach sediments had an overall mean of 274.5 ± 13.1 MPs kg^{-1} and a mean range of 11.09 ± 6.40 – 1176.89 MPs kg^{-1} DW. It was observed that there was high MPs abundance in beach sediments compared to those of seabed. Individual pieces of *Lethrinus harak*, 22 – 74 per site in number totaling to 387 individuals were purchased as samples. Out of the 387 individuals, 187 individuals were found to have invested a total 440 MP particles. The range of MPs abundance in *L. harak* was 1.0 – 3.57 MP $individual^{-1}$ with an overall average of 2.09 ± 0.83 MPs $individual^{-1}$.

The preliminary results reveal the presence of MPs in surface water, seabed sediments and *L. harak* in nearshore and territorial marine waters of East Africa. However, some analysis still going on in order to provide reasonable conclusions. Preparation of manuscripts will commence once the final results are complete. A manuscript entitled ***"Microplastic Pollution on the Surface Water Dar es Salaam and Zanzibar Marine Environment"*** is currently in its final state of preparation. Reconstruction of microplastics pollution history in sediments of intertidal areas by radiometric dating technique is currently being carried out albeit it has been delayed by the COVID-19 pandemic. Part of this objective address issues on the examination of the stratigraphic and spatial

trends of microplastics in sediment cores and determination of the sediment geochronology in marine coastal environments, as well as evaluation of the anthropogenic impacts and the associated risks of microplastics on sediments of marine coastal environments.

Experiments on the uptake, tissue distribution, final fate and effects of microplastics in organisms representing pelagic and benthic ecosystems, as well as the investigation on the interactions of microplastics and Persistent Organic Pollutants (POPs) with marine biota have just been started in November 2020. Experiments in this objective will cover: 1) determination of the impacts of microplastics ingestion on survival and reproduction of adult Artemia Spp, 2) effects of ingested waterborne polyethylene microspheres on growth (length, weight and condition index) and survival of *O. urolepis Sepp* Juveniles, 3) influence of microplastics on the reproductive (fecundity) energy deficit in adult *O. urolepis Sepp*, 4) assessment of microplastic transfer from Artemia Spp to *O. urolepis urolepis*, 5) examination of microplastic vector effect on bioavailability of organic pollutants to *O. urolepis urolepis* juveniles through food chain.

Objectives on fostering the development of a diverse scientifically trained workforce through coastal and ocean education programs and raising public awareness of the risks that microplastics pose to marine ecosystems and, eventually, human health will mainly be done in the next phase of this project. Initial steps such as development of tools have already started. This work will be executed in the next phase of the project.

Enabling Sustainable Exploitation of the Coastal Tuna Species (Kawakawa and Skipjack) in the Western Indian Ocean

PROJECT PARTNERS

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REPORTING PERIOD: January–November 2020

COUNTRIES: Tanzania, Kenya, Mozambique, South Africa

Abstract

This project aims to describe the genetic diversity, population structure and connectivity of two commercially important small tuna species, Kawakawa and Skipjack, across the coasts of Tanzania, Kenya, Mozambique and South Africa, and relate this to key economic, biological and environmental information to inform management and development of the fisheries sector. Key objectives include: **1.** Determine genome-wide genetic diversity within populations in the Western Indian Ocean (WIO), and so define biological population (stock) structuring and levels of connectivity (effective migration/gene flow) across the region; **2.** Investigate the influence of oceanographic factors (sea surface temperature and chlorophyll-a) on the distribution, spawning pattern, genetic structure and abundance of Kawakawa and Skipjack in the WIO region; **3.** Conduct economic analysis of Kawakawa and Skipjack tuna fisheries, for aiding resource management and optimizing societal benefit.

Methodology

Methodology comprises genetic analysis of tissue samples preserved in 90% ethanol at -20˚C using Restriction Site Associated DNA Polymorphism (RADSeq), tunable Genotyping by sequencing (tGBS) and Single Nucleotide Polymorphism (SNPs); biological and reproductive data such as fork/total length (FL/TL), body weight, gonad weight, maturity status, size at maturity (L_{50}) and gonad somatic index (Objective 1); environmental variables (e.g. sea surface temperature and chlorophyll-*a*) *to* be extracted from NOAA satellite Aqua MODIS sensor website to determine the seasonal and spatial pattern in relation to the life history (spawning pattern); catch trend data and historical data catch rates (CPUE), modelling and remote sensing outputs will be used to determine

the distribution, spawning pattern and abundance of tuna species in the region (Objective 2), and semi-structured surveys and questionnaires will be applied to obtain socio-economic data including value chain analysis on tuna fisheries (Objective 3).

Progress for the period of January- November 2020;
For Objective 1, tissue samples were collected for Kawakawa and Skipjack tuna in all participating countries (Kenya, Tanzania, Mozambique and South Africa). but not all samples have yet reached the United Kingdom. Once all samples are in place the genetic analysis will be undertaken.

For Objective 2, biological parameters and catch assessment data have commenced and data has been collected for all countries with full data only available for Kenya. Results indicate a total of 129mt of landed fish were caught between September 2019-October 2020 at two study locations (Vanga/Gazi and Watamu/Kilifi) using fixed and drifting gillnets, monofilament gillnets, reef seines, ringnets, handlines, longlines, and trolling lines. Nineteen gear-vessel combinations were recorded dominated by Mashua_(Ringnet) (74%), Mashua_ (Drifting Gillnet) (14%), Dugout canoe, (Reefseine) (6%), Fibre boat_(Trolling) (3%) and Fibre boat_(Handline) (2%). Kenya's artisanal tuna fishery is multispecies, targeting tuna and tuna-like species. Kawakawa was the most frequently landed species (about 57% of the total weight sampled) when compared to Skipjack (about 12%). Four other tuna species were recorded: Big eye *Thunnus obesus*, Frigate tuna *Auxis thazard*, Bullet tuna *Auxis rochei,* and Yellowfin tuna *Thunnus albacares.* Seventy-eight percent of Kawakawa tuna were mature (stage III–VI). Significant differences in fork length is apparent between the sexes. Estimated size at maturity (L_{50}) for males and female was 54.5 cm and 57.07 cm, respectively. Seventy-nine percent of Skipjack tuna were mature, however, with no significant difference between the sexes. Estimated L_{50} size at maturity (L_{50}) for this species was 57.89 cm. Fishing units targeting tuna landed an average of 148.8 ± 13.6 kg daily, with each fisher landing about 12.5 ± 0.7 kg daily. Average catch rates differ significantly between locations. Higher average catch rates are present off the south coast (156 kg kg/vessel/day) compared to the north coast (110 kg/vessel/day), likely influenced by differences in fishing gears and accessibility of fishing grounds. Seasonal variations in catch rates are also observed, with higher catch rates (76% of Kawakawa, 98% of skipjack tuna) during the northeast monsoon (NEM) season (October–March). General peaks in catch rates occur in February and May.

Preliminary data analysis from Tanzania, based on a total of 3500 Kawakawa and 866 Skipjack individuals collected in Tanga and Mtwara were collected. Ringnets, gillnets and handlines are the main fishing gears used. Large catches of Kawakawa and Skipjack tuna are prevalent in the northern part and southern part of Tanzania, respectively. Mean length of Kawakawa for the study period was 53cm FL whereas the minimum and maximum length was 44cm and 83cm FL, respectively. Small-sized Kawakawa are more often observed in August and September. For Tanga the catch of kawa kawa is dominated by mature and ripe and running females, indicating the existence of potential spawning grounds. Additionally, historical data were obtained from DSFA and the government ministries, and primary data on oceanographic parameters have been collected by the SOLSTICE Project-Tanzania component. Analysis is planned for early 2021.

In Mozambique, the majority of individuals of Kawakawa (n= 65) had a similar total length. Individuals tend to school together not far from the coast, and prey on small fishes and squid. Total length for Skipjack tuna (n=51) is also similar. It must be noted however, that the gear comprises

handlines, which are very selective due to the hook sizes used, and target mostly adults. Catch and effort data were collected 3 times a week by beach recorders. Kawakawa and Skipjack do not appear regularly on catches of the artisanal fisheries. Skipjack is most often caught using handlines whilst Kawakawa are caught using seine nets. *Auxis thazard* is also caught by the artisanal fisheries, and in about the same amounts as Kawakawa.

For South Africa in the region of 50 skipjack tuna have been obtained in the western Cape, and biological analysis is underway. An MSc student will be appointed in early 2021, and will be collecting samples from the south and east coasts, as well as undertaking the questionnaire survey. Genetic samples for the south and west coasts have been collected, and will be forwarded to the UK.

In terms of Objective 3, two questionnaires for value chain analysis were developed and finalized, one targeting the small-scale commercial fisheries and one targeting the recreational fishery in South Africa. The questionnaires will be undertaken early next year.

The research by the PhD student is underway; progress has been made on collection and analysis of biological data collected from Kenya, which is the only complete data set available so far. The Covid-19 outbreak has delayed the project, as the student has not been able to travel to the UK as planned

The Covid-19 outbreak and international lockdown have posed significant challenges to the current project and delayed its activities by about 12 months, with a major gap in data collection between March-August 2020. Collection of biological and oceanographic data as well as catch assessment and socio-economic surveys are pending. Genetic analysis was also impacted as there is a delay in sending the genetic samples from Tanzania, Mozambique and South Africa to Aberystwyth University, UK for sequencing and analysis. Also, the genetic laboratories have been closed for much of this period. As the lockdown restrictions are slowly easing it is expected that the project activities will be back to normal in 2021. These incorporate collection of continuous biological and oceanographic data in all countries, analysis of genetic material, as well as analysis on connectivity through modelling and remote sensing, done in conjunction with scientists in the UK. Furthermore, the questionnaire data should be complete by June 2021.

We are therefore, in order to catch up the project activities, requesting one-year no-cost extension of the current project. To further assist with data collection and analysis, a postdoctoral researcher from Rhodes University has been newly appointed to work alongside with the PhD student, and it is intended to appoint an MSc student in 2021

We are confident that the outcomes will provide (i) a robust knowledge base contributing to the sustainable management of exploited stocks, (ii) genetic resources for cost effective population monitoring by national laboratories, including fish traceability and (iii) information of adaptive diversity to inform predictive models of stock responses to harvesting and climate change.

ECOSYSTEM BASED PROTECTION OF THE COASTAL ZONE: THE EFFECTIVENESS OF SEAGRASS MEADOWS IN COASTAL EROSION MANAGEMENT

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Abstract

AIM: To identify and evaluate ecosystem services provided by seagrass meadows for humans and improved biodiversity in the Western Indian Ocean.

OBJECTIVES:

1) Investigate stakeholder and citizen needs and perceptions of coastal erosion and the ecosystem services provided by seagrass meadows.
2) Inventory of seagrass meadows along the coasts of Tanzania, Zanzibar and Mozambique.
3) Evaluate secondary effects on biodiversity from the interplay between the shallow marine coastal zone and the coastal terrestrial environment.
4) Identify and contrast natural locations with and without seagrass meadows to study how seagrass influence sediment movement and water currents.
5) Build numerical models to simulate the physical impact of ecosystem based coastal protection (seagrass).
6) Investigate best practice for seagrass restorations.
7) Evaluate how seagrass restoration can lead to sustainable coastal management, to inform evidence-based decision making.

METHODOLOGY

WP1: field surveys involving questionnaire survey, Nominal Group Technique, Key Informant Interviews and Participatory Mapping for WP1 comprised six coastal communities in Kinondoni District and Kigamboni District, Tanzania, while in Mozambique interviews was implemented in Maputo Bay and Inhambane Bay.

WP2: compilation of satellite image is ongoing for macroscale seagrass mapping. Micros-scale mapping using drones and underwater camera will follow in 2021. Compilation of seagrass species composition in sites where other WPs have been conducted is underway.

WP3: samples were collected between July and September 2020 representing the SE monsoon season. Terrestrial and adjacent marine habitat data were collected in Kunduchi and Kimbiji representing sites with seagrass, while Buyuni and Mbweni representing sites with no seagrass. In the field, sediment samples for organic matter and carbonate content, inorganic nutrients (nitrate and phosphate), and grain size were collected using sediment corer. In the laboratory, organic matter was analyzed using the loss on ignition (at 550^0C, 6 hrs.) method, while carbonates were analyzed using acidification method. Furthermore, to assess biodiversity, invertebrates such as insects, arachnids, and crustaceans were sampled using i) sweep-nets iii) pitfall traps, and iii) sieving soil/sediment. In addition, we also identified terrestrial plant biodiversity; trees, shrubs and lower plants (grasses, seedlings and herbs) respectively. While most samples have already been analyzed at this point, samples for nutrients and grain size are yet to be analyzed, together with finishing the identification of plants and invertebrates to lower taxonomic levels.

WP4: data for the SE monsoon season were collected between July and September 2020, close to Dar es Salaam including three sites with seagrass (Kunduchi, Kimbiji and Puna) and three without seagrass (Buyuni, Ununio and Mbweni). The sea bottom topography was determined by using a hand-held echo sounder and a hand-held GPS. The beach profile for each site were calculated using a theodolite and a vertical graduated staff. All data was corrected for tides before analyzing. All samples have been analyzed – next these data will be used for the numerical model in WP5.

WP5: will accordingly use data collected in WP4 – together with additional data on wave height, wave period and water level, that will be collected during NE monsoon January 2021 and SE monsoon May 2021.

WP6: in March 2020 seagrass restorations were completed in Inhaca island Mozambique, focusing on *Zostera capensis* and *Cymodocea serrulate* species. In Tanzania, we planted *Syringodium isoetifolium* in October 2020. A number of restoration methods in both countries. Monitoring is conducted monthly.

WP7: stakeholder meeting for dissemination of findings are planned.

RESULTS

WP1: The results demonstrate similar perceptions of the local communities regarding functions, causes for degradation and uses of the seagrass meadows in both countries. Respondents indicated support to fisheries production being the most important function of seagrass meadows, with

shoreline protection ranking third in Tanzania and forth in Mozambique. Destructive fishing practices and climate change were perceived as the leading causes of seagrass degradation in both countries. Causes of shoreline changes were associated mainly with climate change such as storms. The results further indicated that the local communities have a good understanding of socio-economic and ecological values of seagrass. However, they prefer grey infrastructure as the best option regarding curbing coastal erosion and not ecosystem restoration. Therefore, our present analysis is that more effort on seagrass restoration research, demonstrations and awareness campaign on the importance of seagrass in shoreline protection is required. All data for WP1 has been analyzed and manuscript writing is ongoing.

WP2: Mapping information about seagrass abundance and coverage from southern Mozambique and along the coastline of Dar es Salaam is underway.

WP3: We indicate that sediments from sites with seagrass meadows are rich in organic matter content and decreasing seaward from the terrestrial environment. In addition, sediments from areas with no seagrass are rich in carbonate content and increasing seawards from the terrestrial environment. In general, the ratio between organic matter and carbonate was higher (0.512) in areas with seagrass meadow than in areas with no seagrass. However, this value is less compared to the ratio (0.74) globally. According to biodiversity, a total of 774 individual invertebrates belonging to 21 taxonomic groups, based on the 117 samples has so far been identified. The most abundant groups are Hymenoptera, Coleoptera, Orthoptera and Isopoda. A higher number of invertebrates were collected from the terrestrial realm (from the high-water mark moving inland) compare the intertidal zone. According to plants, no clear trend was observed between sites with and without seagrass meadows.

WP4: The sea bottom topography showed marked variation between the northern Dar es Salaam sites and the southern Dar es Salaam sites, regardless of the presence of seagrass meadows. With the exception of the Mbweni site, the other northern Dar es Salaam sites (Kunduchi and Ununio) were characterized by relatively steep sea bottom topography, while the southern Dar es Salaam sites (Buyuni and Puna, with the exception of the Kimbiji site) were characterized by gently sloping sea bottom topography. The results on the beach profiles measurements revealed that all sites had prominent depressions with deepest points lying at more than about 0.5 m below the mean bathymetric level. Kunduchi, Kimbiji and Puna also had prominent sand banks (positive relief features) with highest points lying more than 0.5 m above the mean bathymetric levels, while other Mbweni, Buyuni lacked such positive relief features. Those sites with both prominent positive and negative relief features seemed to be the most highly potential sites for seagrass proliferation. The positive relief features may potentially either protect the seagrasses from wave erosion or enhance the functioning of the seagrasses for shore protection. Preliminary for the Dar es Salaam area indicate the presence of mixed seagrass beds at the intertidal area, with zonation featuring in the subtidal and deeper areas. The mixed seagrass beds are mainly composed of *Halodule uninervis*, *Halophila ovalis*, *Cymodocea rotundata*, *C. serrulata* and *Thalassia hemprichii*. In the upper subtidal area pure stands of *Syringodium isoetifolium*, with *Thalassodendron ciliatum* dominating in the lower subtidal and deep areas. The processing of data for seagrass shoot density and percentage cover is ongoing.

WP6: Several restoration techniques have been tested with *Zostera capensis*, *Cymodocea serrulata* and *Syringodum isoetifolium* with monitoring underway. For an example, over 10,000 modules of *C. serrulata* plants has been planted. Data on survival rate, shoot density and percentage cover is still being processed. In general, the sod method seems to perform better for *C. serrulata*, while other preliminary observation indicates good performance of the plug method over sprig for *S. isoetifolium*. The work in ongoing and more data will be announced later.

Unfortunately, COVID-19 19 has significantly delayed certain objectives within the project.