KENYA MARINE FISHERIES SOCIOECONOMIC PROJECT

COMPONENT 1

ENHANCED GOVERNANCE OF MARINE FISHERIES AND BLUE ECONOMY

Research Strategy

Shallow Water Prawn Fishery Stock Assessment


JUNE 2022

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1.0 SHALLOW WATER PRAWN FISHERY

1.1 BACKGROUND

In Kenya, shallow water prawn fishery occurs mainly in the estuaries and mangrove creeks in the Malindi-Ungwana bay (MUB) in Northern Kenya. This area presents the richest shrimp semi-industrial shallow water prawn trawling in Kenya since the 1970s following the exploratory fishing surveys, which identified the prawn stocks (Iversen, 1984). The Sabaki and Tana rivers, the largest rivers in Kenya, discharge their waters into the Bay, providing an estuarine condition ideal for three migratory prawn species: *Penaeus monodon Penaeus indicus* and *Penaeus semisulcatus*.

According to Kimani et al. (2018), approximately 900 small-scale fishers target prawns along the entire Kenyan coastline in the inshore areas deploying about 300 prawn seine nets. These fishers mainly use monofilament or multifilament material and cast-nets. This number is considered conservative, given that there are fishers who operate illegally. Over the past four decades, semi-industrial prawn fisheries have developed alongside small-scale fishers, targeting the same resource. This has caused unresolved conflicts and resulted in the banning of prawn trawling in 2006 and the development of the prawn fisheries management plan adopted in 2010 (Munga et al.,201).

The issue of bycatch in prawn trawling is of concern globally. The high bycatch to retained catch ratio has emerged as a major issue in the MUB fishery, with local communities complaining about the high rates of discarded bycatch. Between 2016 and 2019, the prawn to bycatch ratio ranged from 1:3 to 1:9, respectively (KMFRI, 2020). On average, 16% of the catch consisted of the target, 59% retained, and 25% discarded from the semi-industrial fishery. A comparison of the catches from small-scale fishers and bottom trawl catches by Munga et al. (2014) revealed that the diversity of fish and proportion of smaller sized fish was more prominent in trawl than artisanal catches. This brings into sharp focus the effectiveness of the existing management plan in safeguarding a biologically, social, and economically sustainable prawn fishery and the protection of the prawn fishery and habitat over the long term.

Over the years, several studies have been conducted on prawn fishery in MUB to assess different fishery components and the associated impacts (Nzioka, 1979; Mutagyera, 1984; Fennessy et al., 2004). These include studies on the distribution and population structure of prawns (Wakwabi,1999), on the seasonality of the prawns in MUB (Munga, 2013; Kaka, 2019) and studies on conflicts between artisanal fishers and industrial trawlers (Ochiewo, 2004; Mwatha, 2005; Fulanda et al., 2011; Munga et al., 2012; Muriuki 2014; Ndoro 2014). Most of these studies were triggered by the ban on prawn trawling in 2006 and are seen as an attempt to provide scientific evidence for sustainably managing the fishery taking into account the ecological, economic and social aspects (Munga et al., 2012).

For the rational exploitation of the fishery, there is a need to define a biological reference point, which can be scientifically monitored and considered an indicator of stock. The reference point will serve as a red flag, which, if exceeded, will prompt immediate action, such as a substantial reduction in fishing effort/mortality, or in the extreme case, closure of the fishery for a while. Based on scientific recommendations and stakeholders' participation, the Prawn Fishery Management Plan established in 2010 demarcated zoning for trawling activities and estimated a maximum effort of 4.7 trawlers. This was a precautionary measure to avoid pushing the fishery beyond maximum sustainable yield (MSY), estimated at 433 tons/year (Mwatha, 2002). Fulanda et al. (2011) provided a much conservative estimate for the MSY of between 352 – 391 tons and 499 – 602 tons for prawns and fish, respectively (Fulanda et al., 2011).

Given the inconsistency in the estimation of the target reference point (MSY) and the need to revise the existing management plan, it is expedient that current efforts should be geared towards the reassessment and definition of an appropriate reference point that can be consistently monitored. Currently, four semi-industrial trawlers are operating in the area, landing about 73 tons of prawns and 429 tons of finfish (2021 Data). The high bycatch levels consisting of a high proportion of finfish and non-finfish bycatch is a cause for concern, which further necessitates the need to assess the ecosystem impact of prawn trawling on the non-target, low-economic value species, which may include some protected, endangered and threatened species such as turtles, sharks and rays (Sources: KMFRI KCDP Stock Assessment data). This requires the identification of appropriate sustainability reference points that management can use at an operational level to assess the status of the fishery while at the same time monitoring the effectiveness of the current management plan.

Given the complexity of the MUB ecosystem and the existing interrelationships between the ecological and social components of the system, a single species-based assessment approach, which assesses species of interest in isolation, is not suited for this fishery. A more holistic approach that assesses impacts on the ecosystem and social system would be ideal to understand the different levels of complexities in the fishery. Earlier attempts were made using the holistic approach to the MUB (Mueni, 2006). However, given the data and labour-intensive nature of the model, it was not possible to validate the model, and as such, the recommendations were not taken up by management.

In this present study, we propose an ecosystem-based approach to evaluate the sustainability of the prawn fishery in Malindi Ungwana bay Prawn Fishery. This is based on the need to review the current fisheries management plan and the recommendations provided in the baseline report (Fulanda, 2018). This proposes that the current focus on the fishery should be geared towards

- Considering the ecosystems and habitats supporting the fishery,
- Emphasizing assessing the stocks' sustainability
- Putting an effective governance and management strategy in place

Fishing and operational indicators

Data type	Some potential variables	Collection scale	Data collection strategy
Catch	Catch CPUE	MUB	Logbooks Observers (Data sources – KMFRI, SWIOFP (2011/12), KCDP, Mueni (2006), Munga (2013)

Effort	No. of vessels; No. of hours	MUB	Logbooks (2011 – 2020) Munga (2013)
Biological	Size (length, length frequencies, weight) Sex/Maturity/	MUB	Observers (Kaka et al.,2019, KMFRI, 2020)
Bycatch (selected species)	Length frequency, growth parameters, mortality, exploitation ratios, recruitment patterns, probability of capture, stock assessment (Y/R)	MUB	Nyamora et al., 2020 (*Upenues vittatus*); Ontomwa et al., 2020 (*Pellona ditchela*); Mzingirwa et al., 2020 (*Otolithes ruber*); Mkare et al., 2019 (*Lobotes surinamensis*)

1.2 AIM AND OBJECTIVES

Aim

This strategy aims to assess the sustainability of the prawn fishery in the Malindi-Ungwana Bay ecosystem by determining the stock status of both target and non-target species based on a holistic ecosystem approach to guide the revision of the Prawn fishery management plan.

Objectives

1. To better understand the prawn fishery (based on existing fisheries data) to ensure that the fishery is operating sustainably.

   Activities:

   I. Assess and compile existing information on the current data status of the prawn fishery to identify the data gaps to guide methodologies and protocols (for additional data collection) and recommendations proposed for intervention.

   II. Assessing the status of the target and non-target species using traditional data-limited quantitative single-species approaches to provide management advice for the prawn fishery

2. Implement an ecosystem-based fisheries management plan for the Malindi Ungwana prawn fishery in line with key policy objectives

Activities:

I. Construct a food web model of the Malindi Ungwana Bay that evaluates the prawn fishery under the current management representing the fishery and the ecosystem components supporting the fishery
II. Using the EwE base model, determine the biological (long-term) carrying capacity for the prawn fishery
III. Run the policy simulation routine in EwE to explore different management scenarios, which maximizes the economics, social, and ecosystem attributes

IV. Conduct an alternative ecological risk assessment approach to all species to provide an understanding of the effects of fishing on non-target species

Outputs

The Key Outputs of this research strategy will include:

a) Annual reports summarizing key research findings and recommendations for interventions
b) At least three peer-review scientific papers published in internationally recognized journals
c) A revised version of the Prawn Fishery Management Plan based on scientific information generated from the re-analysis of available datasets
d) An improved sampling regime for the collection of robust datasets from the fishery

Expected outcomes

a) A reduction of the finfish bycatch in the fishery
b) Successful implementation of the ecosystem-based approach to resource management in the fishery

Expected Impacts

A sustainably managed prawn fishery with minimal resource user conflicts in the Malindi-Ungwana Bay.

1.3 METHODS

1.3.1 Study Area

The semi-industrial prawn fishery takes place in Malindi-Ungwana Bay, from Malindi in the south to Ras-Shaka in the north (and lies between latitudes 2°30′-3°30′ S & longitudes 40°00′-41°00′ E). The Bay has a shallow continental shelf that ranges from 15- 60 km offshore; Sabaki and Tana rivers, discharge their waters into the Bay.

Small-scale prawn fishery takes place in shallow areas in mangrove creeks and bays in sites such as: Mijikenda and Kipini open inshore areas, Gongoni and Kurawa in the salt works; spatial expanse of the inshore mangrove areas from Vanga to Kiunga is also prime fishing areas for the small-scale prawn fisheries. Smaller stocks occur within smaller river deltas and estuaries of Lamu (Mkokoni), Kwale (Majoreni) and Mombasa Counties (Mwache and Tudor creeks), some areas in Shimoni (Mwazaro/Kiwambale). Study areas selected for the assessment of prawn fishery (Figure 1) are the North Coast and South Coast. The north coast areas include **Kipini**, Ngomeni, **Mijikenda** (Malindi) and **Kibokoni** (Kilifi). The south coast areas include **Kiwambale/Mwazaro** and **Majoreni** areas in Shimoni. These areas have established prawn fisheries, with the south coast sites of Shimoni lacking data.

Priority study sites: Kipini, Mijikenda, Kibokoni, Kiwambale, Majoreni

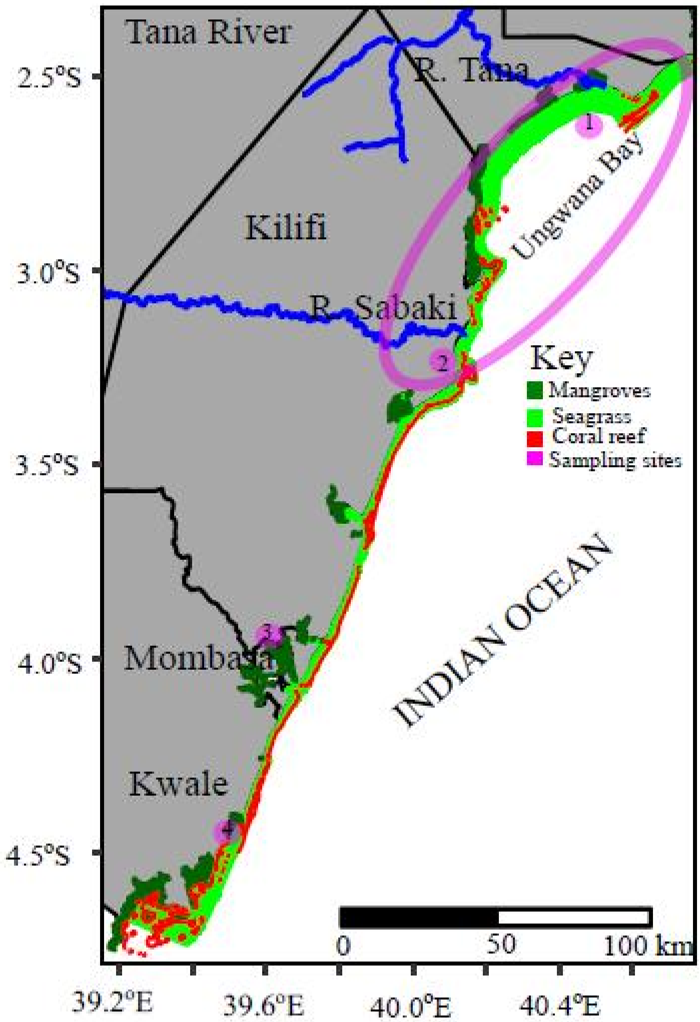

Figure 1. Map showing the coast of Kenya and the main study site in Malind-Ungwana Bay. Other study sites include Kibokoni in Kilifi and Mwazaro and Majoreni in the south coast.

1.3.2 Study Species

There are five main species of prawns that are targeted in the prawn fishery. For the assessment, three primary species have been selected based on the dominance in the semi-industrial and artisanal catches (see Table 1 and 2): Indian white prawn (*Penaeus indicus*); giant tiger prawn (*Penaeus monodon*) and Speckled shrimp (*Metapenaeus monoceros*). Three secondary species selected for this study include: Japanese tiger prawn *Penaeus japonicus*, Green tiger prawn (*Penaeus semisulcatus*) and peregrine shrimp (*Metapenaeus stebbingi*). The bycatch species which are dominant in the prawn fishery include: *Otolithes ruber*, *Upenues vittatus*, *Pellona ditchela*, *Sphyraena flauvicauda*, *Arius africanus* and *Lobotes surinamensis*. These are the dominant bycatch species caught in the semi-industrial fishery (Table 3).

Priority species:

Target: *P. indicus, P. monodon, M. monoceros, P. japonicas, P. semisulcatus, M. stebbingi*

Bycatch: *Otolithes ruber*, *Upenues vittatus*, *Pellona ditchela*, *Pomadasys maculatus*, *Arius africanus*, *Lobotes surinamensis*.

Table 1. Abundance of penaeid prawns species landed in small scale fisheries of the Malindi-Ungwana Bay

Species	**% biomass**
Penaeus monodon	34.85%
Penaeus indicus	34.55%
Macrobrachium rude	21.07%
Metapenaeus monoceros	6.01%
Macrobrachium rosenbergi	2.49%
Metapenaeus stebbingi	0.55%
Penaeus semisulcatus	0.47%
Marsupenaeus japonicus	0.01%

Semi-industrial prawn fishery

Data collection on semi-industrial prawn trawling will be collected through the National Observer Program. The data for 2016 to 2019 show that the dominant target species is *P. indicus*. The observers will sample and collect data on catch (total sampled, retained and discarded), catch composition to species level and biological data for selected species following sampling protocols adopted from the Southwest Indian Ocean Fisheries Project (SWIOFP) Observer Program Data Collection Guide, 2012.

Table 2. Species composition of prawn species sampled from semi-industrial shallow water prawn fishery

Penaeidae species	2016	2017	2018	2019	% Total
Fenneropenaeus indicus	47.14%	59.15%	45.07%	33.48%	45.78%
Metapenaeus monoceros	25.70%	13.76%	24.85%	18.80%	21.05%
Penaeus monodon	20.11%	9.11%	17.04%	29.81%	20.02%
Penaeus semisulcatus	5.79%	13.59%	4.73%	5.14%	7.22%
Penaeus japonicus	1.14%	2.59%	1.27%	5.67%	2.73%
Penaeus canaliculatus	0.00%	1.18%	5.82%	0.68%	1.10%
Penaeus latisulcatus	0.01%	0.00%	0.00%	3.72%	1.04%
Penaeus marginatus	0.00%	0.00%	0.00%	1.41%	0.39%
Metapenaeus stebbingi	0.08%	0.06%	0.06%	0.57%	0.21%
Parapenaeus fissurus	0.00%	0.00%	0.00%	0.71%	0.20%
Trachysalambria curvirostris	0.02%	0.51%	0.01%	0.00%	0.12%
Penaeopsis balssi	0.00%	0.00%	0.55%	0.00%	0.06%

Penaeus maculatus	0.00%	0.00%	0.39%	0.00%	0.04%
Marsupenaeus japonicus	0.00%	0.00%	0.12%	0.00%	0.01%
Penaeus taeniopterus	0.00%	0.06%	0.00%	0.00%	0.01%
Batepenaeopsis acclivirostris	0.00%	0.00%	0.09%	0.00%	0.01%

Prawn trawling produces large amounts of bycatch. In MUB, bycatch species consist of finfish, crabs, octopus, sharks, rays etc. The bulk of the bycatch however is finfish. According to the reports and data collected, several species have been selected for the assessment. These species comprise 60% of the catches. The species are shown in Table 3.

Table 3: Bycatch species that comprise 60% of catches by prawn trawlers

Species	**2016**	**2017**	**2018**	**2019**	**Total**
Otolithes ruber	14.97%	6.71%	10.07%	9.08%	9.28%
Pellona ditchela	5.30%	0.00%	6.46%	3.19%	5.30%
Pomadasys maculatus	5.34%	3.36%	4.30%	3.99%	4.02%
Upeneus vittatus	0.78%	3.31%	7.29%	4.50%	4.02%
Secutor insidiator	2.69%	4.62%	3.94%	3.60%	3.86%
Johnius amblycephalus	7.90%	4.52%	1.88%	1.38%	3.43%
Leiognathus equulus	3.33%	2.92%	5.26%	3.01%	3.38%
Sphyraena flavicauda	0.00%	3.92%	1.73%	3.87%	3.00%
Trichiurus lepturus	5.35%	4.17%	2.10%	0.76%	2.76%
Upeneus sulphureus	3.48%	3.95%	1.71%	1.17%	2.51%
Pomadasys multimaculatus	2.29%	1.02%	2.49%	3.00%	2.16%

Galeichthys feliceps	7.39%	2.96%	0.00%	0.00%	2.04%
Polydactylus sextarius	1.97%	2.23%	2.74%	1.57%	2.03%
Lobotes surinamensis	3.72%	1.43%	1.81%	1.85%	1.97%
Upeneus taeniopterus	0.16%	1.85%	1.29%	2.48%	1.75%
Sphyraena jello	0.00%	1.96%	2.84%	1.56%	1.67%
Leiognathus bindus	0.00%	4.85%	0.00%	0.00%	1.62%
Rastrelliger kanagurta	0.65%	1.11%	0.61%	2.43%	1.45%
Gazza minuta	0.47%	2.53%	1.64%	0.73%	1.44%
Psettodes erumei	0.98%	1.87%	0.84%	1.38%	1.40%
Saurida undosquamis	0.88%	1.48%	1.88%	0.96%	1.27%
Arius africanus	0.00%	0.00%	1.36%	2.17%	1.01%

1.3.3 Sampling Methods

Retrieval and compilation of existing fisheries dependent and independent datasets

Before collecting new data, the team will gather as much as possible all the existing fisheries dependent data, including data from small scale catch assessment surveys (CAS), frame surveys, and fisheries observer programmes (i.e., Malindi-Ungwana Bay trawl observer data), catch report data (Kenya Fisheries Service; KeFs), and frame surveys (KeFs). Before analysis, the datasets will be inspected manually to determine the variables they contain and edited to remove typing errors and inconsistencies, especially for units of measurement.

Retrospective analysis of existing data to identify information gaps to inform the areas of focus of the Research Strategy

The quality of the compiled and edited datasets, for this, datasets from prawn fishery observer programme, CAS, and prawn annual catch landing data will be inspected so as to allocate appropriate analytical methods to each data category. At a species level, regardless of whether target or bycatch species, species with more datasets on length frequencies will best be analyzed using relatively advanced data-poor methods, including the ELEFAN approach implemented in TropFishR. Species with relatively small sample sizes on length frequencies will be analyzed using Length Based Indicator (LBI; Cope and Punt, 2009), Length-Based Spawning Potential Ratio (LBSPR; Hordyk et al., 2015), Length-Based Indicator (traffic lights approach; Caddy, 1998). During the stock assessment training workshop, preliminary retrospective analyses of the datasets were conducted. Preliminary results of the available data based on the above analyses have indicated that;

i) available data on prawns from the artisanal fishery (CAS) was not consistently collected in months and years,

ii) fisheries observer data seems to be biased in months and size of targeted prawns, iii) sample sizes were variable, and

iii) some variables/indicators (i.e., maturity, sex) were not consistently captured. This gave unrealistic preliminary results that can partially gauge the status of the exploited stocks.

Conduct hands-on training of observers and newly recruited staff (KeFS, County, BMUs) on species identification to improve the collection of species disaggregated data

Before embarking on fieldwork, a three-day hands-on training on sampling and species identification will be conducted using the Southwest Indian Ocean Fisheries Project (SWIOFP) Observer Program Data Collection Guide, 2012. The training will enable data collectors to undertake unbiased sampling and identify species correctly to avoid biased sampling and species misidentification problems. This three-day training will be done on board a commercial vessel with theory at the Catholic Training Institute in Malindi.and will cover the following subjects: Sampling, species identification, taking catch, effort and biological information and data, data entry forms, data entry and reporting. The training will be offered by KMFRI Scientists; and in the end, the trainees will be equipped with the skills to sample, data collection, data enrty and reporting.

Stock status relative to PRI: Conduct a biological study on the target species to determine the stages of maturity and assess if there have been changes in their breeding cycle. This will then be used as a proxy to assess if the current closed season regulation is still valid

A random subsample of 30% of the total catch will be collected from which variables consistent with the data collection form will be recorded. Biological data (i.e., length, weight, maturity, sex) will be collected from four stations representing the distribution range of the target species. Kipini and Mijikenda were selected to represent Malindi-Ungwana Bay fishery, Kibokoni to represent Kilifi, while Kiwambale and Majoreni to represent stocks from the southern part of the country. Data will be recorded in the datasheets developed for sampling (see Annex)

In each sampling station, sampling will be done twice a month for one year, with each survey targeting different tidal cycles (i.e., neap tide & spring tide). This is important for species exhibiting different movement behaviours. This approach will allow the capture of individuals from different life stages.
Only prawn fishers will be targeted during sampling, including fishers strictly using prawn targeting gears or mixed gears. An observer will sample and collect prawn data onboard industrial vessels

Conduct a fisheries independent study to determine species abundance and distribution in the non-fished areas (i.e intermediate area between where small-scale fishing occurs and industrial - 1.5 to 2nm)

A chattered small scale prawn fishing vessel will be deployed to fish within the intermediate zone twice a year, once during the Northeast monsoon season and the other in the Southeast monsoon season. The two independent surveys will be conducted in 2022 and 2023, with each survey conducted for 15 days. These surveys will capture the prawn population in the two seasons within the intermediate area, stratified by depth. Different mesh sizes are to be used to capture the various sizes of prawns. Biological data, including; species composition, size-frequency and maturity stages of the individual species, will be collected.

1.4 DATA ANALYSIS

Data to be analyzed will include unpublished long-term catch effort and biological data for semi-industrial prawn fishery data (2011 and newly collected data on catch-effort and biological data from the artisanal fishery. Length frequency catch data of the three target species and selected bycatch species will be done to estimate growth and mortality parameters. Both contemporary and long-term trends in reference points and MSY will be estimated from the data to provide the status of the stocks. The distribution maps of target species will also be developed. The carrying capacity of MUB, exploration of the closed/open seasons and the fishery impacts will be analyzed using an ecosystem model in Ecopath with Ecosim, using the existing model of Ungwana Bay (Mueni, 2006) as a baseline.

1.5.4. References

Caddy, J. 1998. A Short Review of Precautionary Reference Points and Some Proposals for their Use in Data-Poor Situations, 379, Food and Agriculture Organisation, Rome.

Cope JM & Punt AE. 2009. Length-Based Reference Points for Data-Limited Situations: Applications and Restrictions, Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 1:1, 169-186, DOI: 10.1577/C08-025.1

Fulanda B, Ohtomi J, Mueni E, Kimani E. 2011. Fishery trends, resource-use and management system in the Ungwana bay fishery Kenya. Ocean and Coastal Management. 54: 401—414.

GoK (Government of Kenya) 1991. Fisheries Act Cap 378 – Laws of Kenya. Government Press.

Hordyk, A., Ono, K., Valencia, S., Loneragan, N., and Prince, J. 2015. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES Journal of Marine Science, 72: 217–231.

Kaka RM, JO Jung'a, M Badamana, RK Ruwa, and HC Karisa, Morphometric variations among populations of the wild Penaeid shrimps in Malindi–Ungwana Bay along the

Northern Coast of Kenya (2019) Journal of Aquaculture, Fisheries & Fish Sci-ence 2(2) pp: 155-164

Kenya Marine and Fisheries Research Institute (KMFRI) 2020. Current status of the shallow water industrial prawn trawling fishery in Kenya. KMFRI Research Report No. OCS/FIS/2019-2020/C1.4 i & iii. 56 pp.

Kimani EN, Aura MC, Okemwa GM (eds.). 2018. The Status of Kenya Fisheries: Towards the sustainable exploitation of fisheries resources for food security and economic development. Kenya Marine and Fisheries Research Institute (KMFRI), Mombasa. 135 pp

Mkare TK. 2013. Genetic population structure of penaeid prawns Penaeus monodon Fabricius 1798, Fenneropenaeus indicus H. Milne Edwards 1837 and Metapenaeus monoceros Fabricius 1798 in the Malindi–Ungwana bay, Kenya. MSc Thesis. University of Stellenbosch, South Africa.

Mueni EM. 2006. A trophic model for the Ungwana Bay fishery, Kenya: Linking fisheries to ecosystem management. MSc Thesis. UNESCO-IHE Delft. The Netherelands. 127 pp.

Munga C, Ndegwa S, Fulanda B, Manyala J, Kimani E, Ohtomi J, Vanreusel A. 2012. Bottom shrimp trawling impacts on species distribution and fishery dynamics; Ungwana bay fishery Kenya before and after the 2006 trawl ban. Fisheries Science 78: 209-219.

Munga CN, Mwangi S, Ong'anda H, Ruwa R, Manyala J, Groeneveld J, Kimani E. 2014. Fish catch composition of artisanal and bottom trawl fisheries in Malindi-Ungwana bay, Kenya: a cause for conflict? Western Indian Ocean Journal of Marine Science 13(2): 31 – 46

Munga CN. 2013. Ecological and socio-economic assessment of Kenyan coastal fisheries: The case of Malindi-Ungwana bay artisanal fisheries versus semi-industrial bottom trawling. PhD Thesis. Ghent University, Belgium 210 pp.

Mutagyera WB. 1984. Distribution of some deepwater prawns and lobster species in Kenya waters. In The proceedings of the NORAD- Kenya Seminar to review the marine fish stocks in Kenya. Mombasa, 13-15.

Mwatha GK. 2002. Assessment of the prawn fishery, bycatch, resource use conflicts and performance of the turtle excluder device. In Current status of trawl fishery of Malindi-Ungwana bay. KMFR Technical report. 97 pp.

Mwatha GK. 2005. Stock Assessment and Population Dynamics of Penaeid Prawns in the Prawn Trawling Grounds of Malindi-Ungwana bay. The challenges of managing the prawn fishery in Kenya. WIOMSA/MARG-I/2005-06. 21 pp.

Mzingirwa F.A , JM. Nyamora , JO. Omukoto and P Tuda. 2020. Stock assessment of the Tigertooth croaker, Otolithes ruber (Bloch & Schneider, 1801) from the commercial prawn trawl fishery bycatch in coastal Kenya. WIO Journal of Marine Science 19 (2) 149 – 165.

Ndoro CK, Kaunda-Arara B, Munga CN, Ruwa R. 2014. Influence of Seasonality and Bathymetry on Decapod Crustacean Community Structure in Malindi - Ungwana bay, Kenya. Western Indian Ocean Journal of Marine Science 13(1): 31 – 46.

Nyamora J, FA Mzingirwa. 2020. Stock assessment of Upeneus vittatus from commercial trawl by catch in Malindi-Ungwana bay fishery. KMFRI Research Technical Report No. OCS/FIS/2018-2019/ C1.2.i. 15 pp

Nzioka RM. 1979. Observations on the spawning seasons of East African reef fishes. Journal of Fish Biology 14: 329-342.

Ochiewo J. 2006. Harvesting and sustainability of marine fisheries in Malindi-Ungwana bay, northern Kenya coast. Report NO: WIOMSA/MARG-I/2006 – 03. 44pp.

Ontwoma MB, et al., 2020. Some aspects of the Biology of the Indian pellona, Pellona ditchela (Valenciennes, 1847): Case study of Malindi-Ungwana bay prawn trawl fishery of the Kenya marine waters (Submitted manuscript).

Wakwabi, EO; J Mees. 1999. The epibenthos of the backwaters of a tropical mangrove creek (Tudor creek, Mombasa, Kenya). Netherlands Journal of Zoo/ogy 49 (3): 189-20.

1.5.5 Annexes

Survey data sheet for Catch-Effort data

Name of fisher (optional):		Date: _____/_____/______
Age of Fisher:	Resident village:	County:

Boat type:	Propulsion:	Boat length:	
No of fishers in boat	Gear type:	Time Out:	Time In:
Fishing grounds:	Landing site:	No. of Nets	Total length:
Total catch (kg):	BAC (Days fished / week):	Mesh sizes:	

Species	TN(no.)	TW(g)	Price/kg	Species	TN (no.)	TW(g)	Price/kg

Survey data sheet for the Biological prawn catch sampling

Date:	COUNTY:	LANDING SITE:			FISHING GROUND:		
	NAME OF FISHER:	ENUMERATOR:				SHEET NO: ....OF	
Specimen number	Species name:	Carapace length (mm)	TL (mm)	Weight (g)	Sex (M/F)	Maturity stage (1-5)	Remark/gonad sample label

Five maturity stages to be use: Immature (1); maturing (2); mature (3); running (4); spent (5)

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2.0 WORKPLAN

Table 1: Work plan and summary budget

Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Collating existing data (2 weeks with 1 day meeting)														
-catch landings														
-catch-effort														
-biological data														
-published and unpublished reports														
Stock assessment meeting (3 days)														

Stock assessment training workshop (cross-cutting between the various fisheries components) (2 weeks)														
A synthesis and writing workshop (5 days)														
-share and discuss results from the previous analyses														
-identify and conduct additional analyses if any for reanalysis														
-drafting of reports,														
-drafting of policy briefs														
-drafting of manuscripts														
-set timelines for completion of the documents														
Results dissemination workshop (2 days)														
Prawn Fishery Management Plan review workshop (5 days)														
Workshop to discuss the research strategy (methods & protocols)														
A three days hands on training on species identification, data collection and sample preservation measures														

Sensitization meetings to create awareness with communities at landing sites														
CAS surveys to collect catch effort & biological data														
Experimental surveys (depth profiles/larval dispersal)														
Data analyses														
Reporting														
Dissemination workshops														

Tasks and responsibilities

- ➔ Dr. Mkare: work on the by catch data sets
- ➔ Janet: work on biological crustacean data sets
- ➔ Dr. Kimani: work on catch and effort data sets
- ➔ Dr. Fondo: Review of the prawn work done and identify the gaps
- ➔ Dr. Fondo: An ecosystem model of the Malindi Ungwana Bay estimating the carrying capacity.

Table 2: The Fishery Team / Personnel

Participant Name	Responsibility:	Affiliation:
Esther Fondo	Team Leader - Industrial Catch/Effort analysis and model	KMFRI
Edward Kimani	Team member - Stock assessment	KMFRI
Thomas Mkare	Team member - Artisanal Catch/Effort analysis and diets	KMFRI
Janet Mwangata	Team member - Length frequency analysis	KMFRI
Nimrod Ishmael	Team member-intern	KMFRI
Valarie Silali	Team member-intern	KMFRI
Wilfred Gumo	Team member-intern	KMFRI
Birgitta Adhiambo Okoth	Team member-intern	KMFRI
Evans Nyanchoka	Team member -Technical	KMFRI
Kenneth Omondi	Team member - Technical	KMFRI
Sammy Kadhengi	Team member - Technical	KMFRI