KENYA MARINE FISHERIES SOCIO-ECONOMIC PROJECT

COMPONENT 1

ENHANCED GOVERNANCE OF MARINE FISHERIES AND BLUE ECONOMY

Research Strategy

Demersal Fishery Stock Assessment

APRIL 2022

Table of Contents

1.0 DEMERSAL FISHERY

1.1 Background

Demersal fishes are a major source of proteins and trade and form a large proportion of the marine harvest globally. They live near the bottom of the sea and concentrate on the continental shelf up to a depth of 500 m (Khedkar et al., 2003). Demersal fisheries are considered to be coastal as they are those that occur on or near the continental shelf and target those fish dwelling at the bottom (benthic fish) or at the lower water column (benthopelagic fish). A number of gears are used to harvest the resources in these habitats. These then influence the diversity of the fish caught and the fishing activity to be engaged in. These fisheries thus provide a great source of nutrition to the coastal communities.

This strategy will highlight two gears, namely gillnets and basket traps in the selectivity studies. Gillnet fishery is the most common in the marine sector in Kenya. A gillnet is a wall of netting that hangs in the water column, typically made of monofilament or multifilament nylon. Mesh sizes are designed to allow fish to get only their head through the netting, but not their body. The fish's gills then get caught in the mesh as the fish tries to back out of the net. Gillnets are widely used in the small-scale and semi-industrial fishery as active and passive fishing gears. The active gill nets are actively operated by pounding or splashing water by the fishers forcing fish to encounter the set net. The passive ones include the drift (Nyavu ya Kuogelesha) gill net, a large sheet of jointed gillnets set in the open waters and left to drift as it catches fish. It is set without anchors and suspended in the water column unattended, and the stationary (Nyavu ya kutega/ Malasha) gill nets which are set or anchored at one station throughout the fishing operation. Most gillnets are large mesh-sized nets commonly referred to as shark nets (*jarife*) and mainly target sharks. Gillnets can be operated either actively (active gill net), stationary (set gill net) or allowed to move (drift gill net). They are made of multifilament nylon strings of varying thickness and mesh sizes of 2-5 inches (5-12cm) for offshore gill nets and 1-4 inches (2.5-11 cm) for inshore gill nets (Samoilys et al., 2011). Gill nets are the most used gear on the Kenyan coast, especially in Lamu, Tana River and Kilifi counties (Frame Survey, 2012, 2014, 2016). The gill net fishery relies mostly on set gill nets accounting for (58%; n = 2,399) while gillnets drift nets (35%; n = 1,465) and very few are actively used (7%; n = 304). The number has increased from 1,131 recorded in 2012 to 1,503 in 2014 and 3835 in 2016, with the sizes ranging from >‘2.5’ to ‘10’ targeting different species.

Gill nets catch a wide range of species depending on the mesh size and size of the net. A diversity of fish species are targeted by the bottom-set gill net fishery along the coast of Kenya. The target catches include demersal reef fishes from families such as Siganidae, Mugilidae, Lutjanidae, and Serranidae, making up 47%. Pelagic fish such as Istiophoridae and Scombridae make 24%, and sharks and rays make 19% (McClanahan and Mangi, 2004). Update with current data. Other studies show that a broad range of benthic and demersal species are captured, including rabbitfish, goatfish, parrotfish, snappers, status kingfish (*Scomberomorous commerson*), emperors, rays (Myliobatiformes), tuna (Scombridae), sharks (Carcharinidae), halfbeaks (Hemiramphidae), needlefish (Belonidae) and lobsters (Panulirus spp) (McClanahan and Mangi, 2004, Samoilys et al. 2011). Drifting gill nets land species such as tuna (Scombojpridae), kingfish (*Scomberomorous commerson*), shark (Carcharhinidae), and monofilament gillnets land halfbeaks (Hemiramphidae) and mullets (Mugilidae) (Samoilys *et al.,* 2011). The fishery yields some low-value by-catch, including *Tachysurus feliceps, Diodon liturosus* and *Pelagicus portunus. Tachysurus feliceps* is mostly deprecated.

Non-targeted (by-catch) species include dolphin species, sea turtles, sharks, other marine mammals and seabirds (Samoilys *et al.,* 2011). The bottom set gill nets also harvest juveniles, especially in the nearshore waters (McClanahan and Mangi, 2004, Kawaka *et al.,* 2015). A total of 59 species of large marine vertebrates were identified as by-catch and by-product species in the SWIO region. Drift, bottom-set gillnets and beach seines caught sea turtles (5 species), marine mammals (8 species) and elasmobranches (46 species) (Kiszka, 2012). By-catch levels were higher in multifilament than in monofilament drift gillnets and less detrimental in bottom set gillnets except for a few species (Kiszka, 2012). Since driftnets generally operate near the air-surface interface, they are likely to catch air-breathing animals, and some of these species, such as mammals, are long-lived, slow-growing and vulnerable to population depletion through relatively low levels of removal. It has been suggested that high seas driftnet fisheries may also threaten the oceanic pelagic ecosystem, which is relatively species-poor (Northridge, 1991) in some cases driftnets may end up ‘ghost fishing for an unknown period (http://www.fao.org/docrep/003/t0502e/t0502e01.htm). Looking into the vulnerability of marine megafauna in Kenya, Zanzibar and Madagascar, it was noted that the primary gear threats to the investigated taxa were bottom-set gillnets (marine mammals, sea turtles and batoids), drift gillnets (marine mammals, batoids and sharks) and longlines (sharks) (Temple et al., 2019).

Stationary gill nets are deployed from a canoe or a boat and are set at the bottom, mid water or at the surface depending on the target species. Bottom gill nets are anchored to the sea bed with large boulders marked with floats and left to fish overnight. The smaller nets are 1.5 x 30 m and are used in shallow lagoon waters of less than 5m depth while large gill nets are of 20 to 50 m dimension. The stationary nets target demersal fishes including emperor, rabbitfish (Siganidae), rays (Myliobatiformes), sharks, kingfish (Scomberomorus commerson), tuna (Scombridae), flounder, needlefish (Belonidae), halfbeak (Hemiramphidae) and lobster (Panulirus spp) with the inshore small nets catching mainly Lethrinus lentjan and siganus sutor ((Samoilys et al., 2011). About 49% of the catches landed from bottom set nets are juveniles.

Drifting gill nets have mesh sizes of 4-8 inches (10-46 cm) and are suspended by floats and held vertically in the water column with lead or stone weights. Fish are entangled by their operculum as they cross through the net. Drift nets are set at the surface in offshore waters from boats or canoes and left to drift with current for some hours before it is hauled. The drift nets are 90 m long and about 8 m width. The drift nets target shark (carcharhinidae), tuna (Scombridae) and kingfish (Scomberomorus commerson). Both the drifting nets and stationary nets also catch turtles, sharks, dolphins and other marine mammals as by-catch (Samoilys et al., 2011).

Basket traps

Basket traps are among the oldest forms of fishing gears known and are globally used in freshwater and marine fisheries. In Kenya, basket traps are considered a traditional fishing gear and are common along the coast, where they contribute close to 40% of the total reef fish landing by weight (Gomes *et al.*, 2013). Locally referred to as lema, basket traps are very simple fishing gears woven with locally available materials into hexagonal mesh-shaped structures and consist of one or more funnel openings, which fish enter and get entrapped. They are commonly used by foot fishers or dugout canoe users and are a preferred fishing gear by the elderly fishers because of their ease of use and little energy investments (Mangi *et al*., 2007).

According to the biannual marine frame survey, approximately 3,324 basket traps are operational along the Kenyan coast. However, there has been a consistent general decline since 2014 (MoAFL, 2016). The decline in the use of basket traps has been observed along the entire Kenyan coast and could be attributed to its lack of appeal to the younger new entrants into the fishery due to the off-water time investment required to build and maintain basket traps (Mangi *et al*., 2007).

Basket traps are considered benign compared to other fishing gears and cause low physical direct damage to coral reefs (Mangi and Roberts, 2006). Moreover, basket traps are highly non-selective, capturing a wide range of species but are primarily synonymous with the capture of the Siganidae. Other fish families associated with the basket traps include the commercially important fish families such as goatfish (Mullidae), emperors (Lethrinidae), snappers (Lutjanidae) and groupers (Serranidae). Other non-commercial but ecologically important herbivores such as surgeonfish (Acanthuridae), Moorish idol (Zanclidae), parrotfish (Scaridae), and butterflyfish (Chaetodontidae) are also captured by the basket traps depending on the location of the traps and the baits used.

Previous studies of basket trap fishery in Kenya have revealed that basket traps can retain most fish that enter the traps leading to by-catch of non-target species and juveniles, which could lead to the overexploitation of reef fish populations (Hardt, 2008). Preliminary investigations with gated traps have shown that escape gates can reduce the capture of low-value fish (juveniles and narrow-bodied coral reef species) and lead to complimentary benefits such as an increase in catch of high- and medium-value fish leading to higher incomes among fishers. However, the lack of incentives among fishers to take up the gated traps and the propensity of fishers to remain attached to the traditional basket traps have thwarted the efforts to expand the use of these modified gears.

Overall, relatively little information exists to determine the environmental impacts of the traditional basket trap fishery on target species and the associated ecosystem. Further, no specific management plan regulates the fishery in terms of effort or mesh sizes, which are fundamental to fisheries management. Regulating fishing effort and mesh size of the basket traps can substantially reduce the mortality of juvenile fish (Gomes *et al*., 2013). However, the current fisheries data collection framework in Kenya does not allow for a detailed assessment of these parameters and hence lacks the information necessary for supporting appropriate harvest strategies and harvest control rules (HCRs) for the fishery. Traditional stock-based approaches have largely been ineffective, with management measures often not taking other important aspects of the fisheries into account. As many fisheries have declined over the years, the need for more effective and equitable management is increasingly evident. Based on the basket trap fishery pre-assessment (Fulanda, 2018), a management strategy for the fishery is a key priority. The management strategy should consider the impacts of the fishery on both the primary and secondary species and the associated impacts on the habitat. Here, we perform a retrospective analysis of the existing fisheries data on basket trap fishery in Kenya to compile information and identify potential gaps that need to be filled to develop a management plan for the basket trap fishery in Kenya. Specifically, we focus on the selectivity of basket traps for catch composition and size distribution of the small-scale coastal fishery in Kenya.

1.2 Aim and objectives

The principal aim of the research strategy is to assess the existing data on demersal fishery to provide the assessment necessary to improve the fishery to operate sustainably with minimal deleterious effect on both target and non-target species and the associated habitats. This will be pursued through the following objectives:

1. To review the current state of the basket trap and gillnet fishery at the Kenyan coast, providing an overview of its use and assessment of the target and non-target species;

   Activities:

   1.1. Review and analyze existing data basket trap and gillnet fishery, identifying the data gaps, management measures in place and recommendations suggested for the fishery

   1.2. Identification and analysis of species composition and size structure of target species and non-target species

   1.3. Estimate the catch and effort indices of the artisanal fishing gears

2. To determine the ecological impacts of the basket trap and gillnet fishery on the primary target species and the associated species which are not retained for commercial use.

   Activities:

   2.1. Determine the stock status of the target species using length based indicators (maturity)

   2.2. Assess changes in fish CPUE and species composition over time and the community structure of the target species

   - species composition and size structure
   - target and primary (main), primary (minor), secondary major (incidental catch) and secondary minor and bycatch (ETP species) species
   - population biomass (length-weight, landings)
   - from catch data from all gears
   - maturity from length frequency data

   2.3. Estimate vital selectivity parameters from the basket trap, hook and line, and gill nets that would provide input to correct for selectivity in stock assessment models by examining the effect of varying mesh sizes and funnel sizes for target and non-target species

   - Length frequency data by species and gear (mesh size)
   - Maturity estimates of selected species

3. Determine the type of bait used for all gears and time spent in bait collection
4. To develop a fishery specific management strategy for the basket trap and gillnet fishery

5. To develop harvest control rules for the gill net and basket trap fishery.

2.0 METHODS

2.1 Study Area

Kenya has a coastline of about 640 km, stretching from 1º 30'S at the Somali border to 5º 25'S at the Tanzanian border (Maina, 2012). Although the Exclusive Economic Zone (EEZ) covers 200 nautical miles from the coastline (FAO, 2009), the coastal artisanal fishery largely operates within a narrow continental shelf confined to a small strip of 2.5 to 3.0 nautical miles (McClanahan and Mangi, 2004; Samoilys *et al*., 2011). This region is largely dominated by fringing coral reefs, which occur within 12 nautical miles of the coast (Fondo, 2004). Some of the rich inshore grounds within this strip include the Funzi-Shirazi bay, the Diani-Chale area, Malindi-Ungwana Bay, the North Kenya Bank and the Lamu Archipelago (Maina, 2012).

Artisanal fishers along the Kenya coast use a wide range of fishing gears with basket traps, gillnets, handlines, ringnets and spearguns used as the major gears. The basket traps and gillnet gear are dominantly used in Kwale County, where they contribute 31 % of the catches (Wambiji *et al*., 2018; Ontomwa *et al*., 2021). Traps are deployed from canoes or sailboats that carry 4-6 traps, each with an average of 2 fishers. The traps are lowered into the water by 2 ropes as they are set at the sea bed then the ropes are attached to floats and surface markers. The traps are left overnight and retrieved the following day to remove the catch (Saimoilys, 2011).

The study will be conducted in Shimoni, Gazi, Watamu and Majaoni, where there is high distribution of basket traps (Ontomwa *et al*., 2021) and gillnets in Lamu, Kilifi and Mombasa counties.

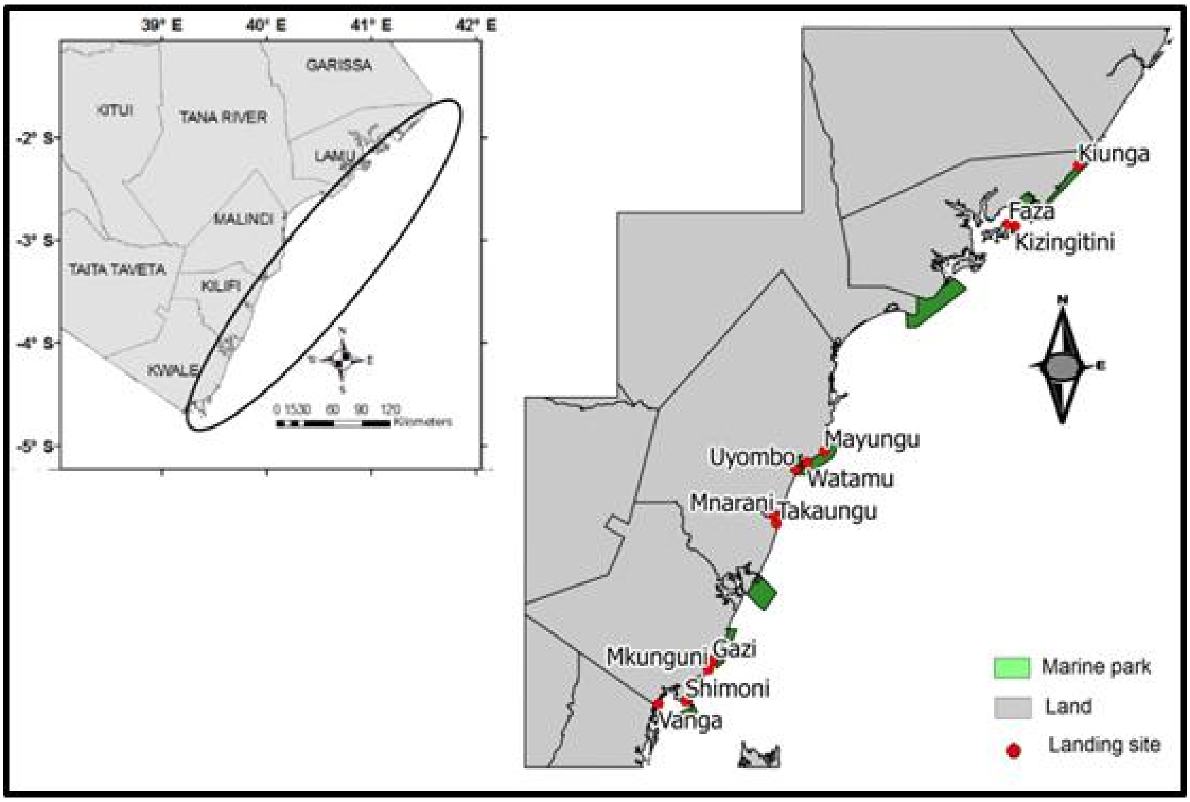

Figure 1: Map showing the potential sampling sites

2.2 Study species

Data will be collected on all fish landing sites covering Kwale, Mombasa, Kilifi, Tana River and Lamu counties. The study will focus on all gears deployed along the entire coastline that catch *Siganus sutor* and *Leptoscarus vaigiensis, Scarus ghobban* and *Lutjanus fulviflamma* as the target species (Ontomwa *et al*., 2021). Stock assessment for the major and minor primary species forming < 5 % -2 % and < 2% of the total catches, respectively, will also be conducted. The impact of the basket trap fishery on other species (major and minor secondary species) will be assessed. The categorized species for the basket trap fishery stock assessment is shown in Table 1.

Table 1: Target, primary and secondary (main and major) species for basket trap fishery stock assessment. Source: KMFRI, 2021 Catch assessment technical report.

Target species > 5 %	Primary (Main) <5 % ->2 %	Primary (Minor) <2 %	Secondary major (incidental catch)	Secondary minor

Siganus sutor (43.44 %)	*Scarus ghobban* (4.79 %)	*Parupeneus barberinus* (1.70 %)	*Chaetodon spp*	*Diodon holocanthus*
Leptoscarus vaigiensis (9.91 %)	*Lutjanus fulviflamma* (4.44 %)	*Scolopsis bimaculatus* (1.42 %)	*Pomacanthus spp*	*Diodon hystrix*
	Lethrinus lentjan (4.21 %)	*Lethrinus harak (1.39 %)*	*Abudefduf spp*	*Sagercentron tieroides*
	L. mahsena (2.21 %)		*Arothron spp,*	*Platax teira*
	L borbonicus (2.89 %)		*Holocanthus spp*	

2.3 Sampling Methods

Assessment levels based on sample size and representation of the data namely:-

- Size based (maturity)
- For species with less than 100 samples x analysis not conducted
- More advanced analysis- LBSPR, CMSY

Several methods shall be used to understand the demersal reef fisheries, including:

1. Conduct a review/gap analysis of the existing demersal fisheries data collection protocols to refine the data collection protocols for the artisanal fisheries and minimum data requirements for stock assessments

2. Collate existing data and conduct desktop research

To understand the stock status of reef demersal fisheries, existing literature will be collated and desktop research will be conducted to identify information gaps in the data collection and stock assessment for the reef demersal basket trap and gillnet fishery. The review will cover marine fisheries frame surveys (2004, 2006, 2012, 2014, 2016 and 2018), catch assessment survey reports, existing management measures, National and County regulations and policies, SDF statistics reports, KMFRI reports, including various publications on demersal species to identify the methods used so far and results found.

The review shall then be used to assess trends of available proxy indicators (catch rates), size structure of the target, and primary and secondary species covering all the different gears that capture the target species from marine fisheries frame surveys (2004, 2006, 2012, 2014, 2016 and 2018), catch assessment survey reports, existing management measures, National and County regulations and policies, SDF statistics reports, KMFRI reports including various publications on basket trap fishery (Hicks and MacClanahan, 2012; Mbaru and McClanahan, 2013; Gomes *et al*., 2013; Condy *et al*., 2014; Wambiiji *et al*., 2018; Tuda *et al*., 2016; Mrombo *et al*., 2018; Mbaru, 2018; Mbaru *et al*., 2020) will be jointly reviewed to identify information gaps to be addressed in the data collection and stock assessment for the reef demersal basket trap fishery. A risk-based framework shall be conducted thereafter for primary species (main and minor) to derive information on the current status of the stock through stakeholder engagements through meetings.

The reviewers will comprise Kenya Fisheries Service (KeFs) Directors, County Fisheries Directors, and KMFRI scientists.

3. Fieldwork

Before the onset of data collection, all enumerators will be trained on appropriate data collection protocols that have previously been used to train Observers and BMU's, including recording, storage and archival of data. All data collection methods will be standardized for the reef fish fishery within the Kenyan waters by having the same data form used and collecting data on specific days of the month to capture the lunar cycle.

Data of length and weights and gonads will be collected to provide information on catch dynamics and population biology of primary and secondary species caught by the different gears will be collected monthly.

All gears that capture the target and non-target species will be sampled. Landed fish will be sorted and target species will be identified to species level using relevant field guides (Smith and Heemstra, 1986; Lieske and Myers, 1994; Anam and Mostarda, 2012). Individual fish total lengths will be measured to the nearest centimetre (cm) using measuring boards or tape measures. The individual fish weights will be recorded to the nearest 0.01gm using hand-held portable electronic balances. Parameters such as the total weight of the catch, mesh-sizes used in selectivity studies or fishers identified who are using specific mesh sizes , length and width, vessel length, vessel type, gear type, effort, fishing ground and the number of fishermen per vessel will also be recorded. Biological samples of all the species represented in the landed catches will also be recorded. Sampling will involve fisheries research scientists and technologists from Kenya Marine and Fisheries Research Institute (KMFRI) in collaboration with Counties, fisheries officers from Kenya Fisheries Service (KeFS) and personnel from the beach management units (BMUs).

The sampling will run for 12 months, beginning in April 2022 and ending in April 2023. Data collectors will record data simultaneously across all sampling dates at all sites. Sampling dates will be based strictly on the lunar cycle, which influences fishing effort and likely species distribution. Sampling will be carried out over 10 to 12 days within each lunar cycle: 3 days at full moon, 3 days at the new moon, and 3 days at each first and third quarter. Sampling will be carried out regardless of weather or effort, thus providing defensible and representative data. Sampling days are as shown in the Appendix from a calendar generated for the project. Information on the type of bait used for all gears and time spent in bait collection will also be gathered.

Data and information will be recorded in generic data sheets customized to other artisanal fisheries activity. A back to office report will be made after each sampling trip. Laboratory analysis will be done and a report will be made. Determination of stock status of the target species using length based indicators (maturity) will ensue based on appropriate methodologies as highlighted in the step wise analysis workflow. Fish identification key will be produced based on the species found in the Kenyan waters. Quarterly reports and presentations will be made on the progress of the activity.

Gonad study

The sex of the fish will be determined after dissection. Maturity stages will be determined on a sub-sample as described by Ntiba and Jacarrini (1990) as Stages I and IIa -immature, stage IIb-recovering, stage III-active, stage IV-ripe, stage V-fully ripe and lastly stage VI-spent. Gonad lobes will be removed weighed (±.0001 g), fat trimmed from their edges dissected and put in maturity categories. They will be stored in perforated plastic bags with 10% formaldehyde fixative for at least 14 days then later transferred to 70% ethanol until histological work is performed. The overall sex ratio will be calculated using reference formula:

$\chi 2= \Sigma (f – F) 2 /F$

Where f = observed weight of the gonads, and F = expected weight of the gonads.

2.4 Determination of selectivity focusing on basket traps and gillnets

Estimation of vital selectivity parameters from the basket trap and gill nets that would provide input to correct for selectivity in stock assessment models by examining the effect of varying mesh sizes and funnel sizes for target and non-target species

Both gillnets and basket traps of different mesh sizes will be used for sampling and their catches recorded separately. From the specimen collected, the total length of the species, as well as their total weights, will be recorded to the nearest 0.1cm and 0.1g, respectively. Each fish specimen will be dissected to examine their gonad development and maturity stages based distinct maturity stages.

Gillnet selectivity studies will take into consideration the size and shape of the fish, mesh size, twine characteristics (material, construction, thickness, colour, and flexibility), hanging of net, and method of fishing. Gang and net dimensions, Hanging ratio, Vertical slack, floatation and weight, soaking time and arrangement of nets in the fleet - sequence and joining between nets; interaction between nets (the number of panels in each gillnet will be recorded both vertically and horizontally and assigned codes).

For basket traps, the entrance sizes for different traps will be measured and the individual total length including the maximum girth of the fish caught by the traps will be measured to the nearest 0.1 cm. Holt’s (1957) model will be used to determine mesh selectivity of the traps.

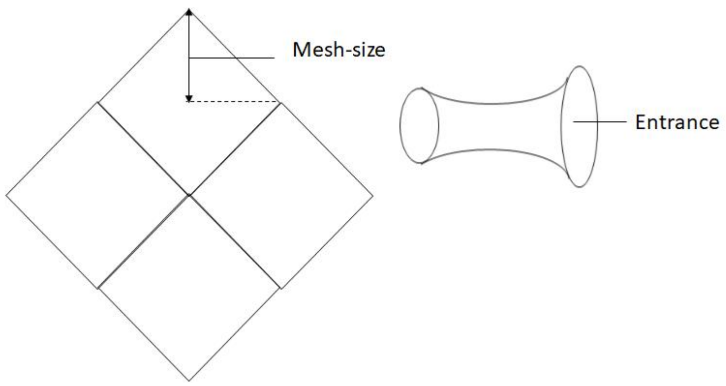

Figure 2: Basket trap mesh and entrance dimensions

Habitat studies

The stock status of the secondary target species (ETPs) harvested by all artisanal gears will be assessed in line with the target species by applying the appropriate models for analysis. Therefore, the results will be used to develop management measures to maintain the maximum sustainable yield (MSY) of the species and their conservation.

In order to develop management measures/strategies to manage ETP species, an Ecosystem Approach to Fisheries Management will be applied to offer a greater chance of developing realistic, equitable and management plans. This will involve the collection of target and bycatch data, understanding the habitats in which the species reside, the fishery impacts on the ecosystem, the threats to the fishery from external factors, good governance by incorporating BMUS is the work and documenting the socio-economic benefits. Some of these targets touching on the human impacts will be tackled by the Socio-economists. Bench marking toolkit will be used to access different fisheries and species. This approach pursues sustainability by balancing ecological and human well-being through good governance. Effective fisheries management has always been a challenge, especially in complex multispecies, multi-gear fisheries.

2.5 Data Analysis

The basket trap and gillnet fisheries suffer from a number of challenges such as inconsistent data collection, data collected not representative of the lunar cycle thus the reproduction patterns and growth unknown for many species, lack of all size classes collected, detailed characteristics of the gears notably documents to understand the impact on the fisheries. Thus, several analyses will be conducted to address the different objectives. These analysis will include:-

i) Selectivity analysis for the basket traps and gillnet gears

To determine the selectivity of the basket traps and gill nets we will adopt Holt's (1957) method which has been widely used in selectivity studies (Olsen, 1958; Olsen and Tjemsland, 1961, Koura and Shaheen, 1967). Holt's (1957) method assumes that for two gill nets/basket traps A and B, where mesh sizes differ slightly, the shape of their selection curves is the same and the mean selection lengths are proportional to mesh size as shown from the formula $L_m = K \theta$ where L_m is the mean selection length, θ is the mesh size and K is constant.

The selectivity constant (K) for target species will be determined from the regression equation of log ratios of the number of fish of certain size groups caught by two appropriate meshes (B/A or C/B or C/A) and the total length of the fish. The data regarding the number of fish of each size group caught by gill nets/basket traps of different mesh sizes will be adjusted for differences in effort (number of gill nets/basket traps deployed during the study period) according to El-Zarka et al., 1970.

Maturity

Length based indicator (LBI)

Length-Based Indicators (LBI) in Microsoft excel will assess the maturity and calculate reference points of species caught by all gears using the length frequency data and life history parameters (ICES 2015; Froese et al., 2016). Status indicators will be calculated from length-frequency distributions and compared to Reference Points (RP) derived from life-history parameters and ecological theory or empirical observation, providing a snapshot of status under steady-state assumptions. This approach will be used to classify stocks according to the conservation of large and small individuals, maximum sustainability status, and yield optimization (ICES, 2015). A traffic light approach will be used to compare ratios of indicators and reference points to expected values where conservation, yield or MSY properties will be achieved. This suite of LBI outputs will provide an overall perception of stock status.

LBI method will consider the following indicators related to:

(i) conservation of large individuals: $L_{max5\%}$, which is the mean length of the largest 5% of the fish, and P_{mega}, which is the proportion of large fish in the catch (“mega-spawners”), that is fish of a size larger than the optimum length (L_{opt}=3L_{∞}/(3+M/K)) plus 10%. $L_{max5\%}$ indicator is compared to the reference point L_{∞} defining the corresponding indicator ratio $L_{max5\%}/L_{\infty}$, which provides information about the degree of truncation of the population length structure that may be caused by fishing and whose expected value in healthy stocks is above 0.8 (Miethe and Dobby, 2015). P_{mega} follows the idea summarized by Froese (2004) as “Let the mega-spawners live” and in healthy stocks P_{mega} must be above 0.3 (Froese, 2004 and ICES, 2015).

(ii) Conservation of immatures individuals will be: Lc, the length at first catch, and $L_{25\%}$, which is the 25th Percentile of length distribution. Both indicators will be compared with the reference point L_{mat} defining the indicator ratios $L_{25\%}/L_{mat}$ and L_c/L_{mat} that follow the principle “Let them spawn” (Froese, 2004) and will be expected to be higher than 1 in healthy stocks.

(iii) Mean length of individuals above L_{mean} which will be compared to individuals above L_c and with the reference points L_{opt} and L_{F}=M= (1-a) Lc+aL_{∞}, a=1/ (2(M/K) +1), which is a length-based proxy for MSY, defining the indicator ratios, L_{mean}/L_{opt} and L_{mean}/L_{F}=M, for optimal yield and MSY considerations, respectively. Their values in healthy stocks are expected to be approximately 1, for L_{mean}/L_{opt}, and equal or larger than 1, for L_{mean}/L_{F}=M. The indicator ratio L_{mean}/L_{opt} follows the principle “Let them grow” (Froese, 2004).

LBI indicators will require the length frequency data from catches/landings and the life-history parameters (L_{mat}) obtained from existing literature or from Fishbase. The results derived from the application of the LBI method will be analyzed and interpreted taking into account that it assumes equilibrium conditions (constant total mortality and recruitment along the entire data time series), logistic selectivity, and that the catch length distribution is representative of the population length distribution (Froese, 2004)

ii) Reference points

In order to understand the stock status of the primary and secondary target species and any by-catch, stock assessments will be undertaken once reference points are determined using several methods are shown below:

Stock status of the species

a) Biomass

i) Spawning biomass

Length-Based Spawning Potential Ratio (LBSPR) http://barefootecologist.com.au/lbspr will be used to calculate the effect of basket trap and gill net fisheries on the spawning biomass per recruit for the target species (Hordyk et al. 2015). Length-Based Spawning Potential Ratio (LBSPR) is based on the concept that without fishing, the population can reach 100% of its natural spawning potential, but that fishing reduces the population's SBPR. The SPR index ranges between 0 and 1, with a value of 1 representing an unexploited stock (Goodyear, 1993). It is frequently assumed that stocks with a SPR range between 0.35-0.4 could be considered exploited at MSY level (Legault and Brooks, 2013). Stocks with a SPR below 0.1-0.15 are considered close to collapse (such limits have been fixed on basis on Goodyear, 1993), who pointed out that for SPR values below 0.2 the risk of collapse increases considerably.

The LB-SPR method requires length composition data of the catch and life history parameter. The model will estimate the selectivity-at-length and the ratio F/M, which in turn will be used to calculate the SPR. All simulation modelling will be done using the open-source statistical software (R-shiny app). The life history information will be sought from previous studies in the WIO region including published and unpublished results or from FishBase.

iii) Maximum sustainable yield (MSY)

Catch_MSY will be used to estimate biomass of demersal reef fish species. The method will use a time series of total catch data, and resilience of the species to estimate biomass, exploitation rate (E), MSY, intrinsic growth rate (*r*), and carrying capacity (*k*). CMSY works by randomly selecting combinations of two parameters (*r*, and *k*, and maximum stock size) with the assumption that stock doesn't collapse and stock remain below *k*) according to Schaefer's (1954) model which will be used to calculate annual biomasses for a given set of r and k parameters. We will use resilience estimates from FishBase, which are based on Musick (1999) as modified by Froese et al. (2000), to assign default values to the allowed range for the random samples of the maximum intrinsic rate of population increase r.

b) Growth and mortality parameters

Length frequency catch data (LFCD) of demersal fish species such as *Siganus sutor, Leptoscarus vaigiensis, Scarus ghobban, Lutjanus fulviflamma,* will be analyzed using the electronic length frequency analysis (ELEFAN; Pauly and David 1981; Pauly et al. 1982; Pauly, 1987; Schwamborn *et al*., 2019) in ShinyTropFish (version 0.9.1) based on the TropFishR package (version 1.7.0; Milden-berger *et al*., 2017) to assess the status of the species by estimating the growth and mortality parameters from modal progression and catch curve analysis.

i) Estimation of Growth Parameters

The Von Bertalanffy's growth parameters (VBGP, von Bertalanffy, 1938), that is, asymptotic length (L_∞) and growth constant (K), will be estimated using the LFCD by applying the seasonalised von Ber-talanffy's growth function (VBGF) to the LFCD (Somers, 1988). The LFCD will be grouped into bins using the following formula;

Optimum bin size (OBS) = $0.23 * L_{max}^{0.6}$

Where L_{max} is the maximum length of each species caught

An initial value of L_∞ will be estimated based on the mean of the 1% of the largest observed individual in the sample (L_{max}) following Pauly's (1984) formula:

where $L_\infty = L_{max} / 0.95$

The growth performance index (Φ') (Pauly, 1984), will be used to compare growth parameters.

The estimated potential longevity t_{max} of the species will be computed from the formula (Pauly, 1980; Taylor, 1958):

$t_{max} = 3/K$

ii) Mortality Parameters

The instantaneous total mortality rate (Z) will be com-puted from the LFCD based on the linearized length-converted catch curve (LCC) (Pauly, 1983). Natural mortality will be calculated from the empirical formulae of Pauly 1980 by using a mean sea surface temperature of the fishing area, that equal to 25^{0}C mortality (F) will be expressed as F= Z - M and the exploitation rate (E) will be estimated as F/Z according to (Gulland, 1971). The fishery resource status will be assessed according to Patterson fishing (1992) by the comparability of the current fishing mortality rate with the optimum or the target (F_{opt}) and limit (F_{limit}) biological reference points (BRP) which will be delineated as: F_{opt} = 0.5 M and F_{limit}=2/3 M.

c) Probability of capture

The probability of capture will be estimated based on the ascending left arm of the length-converted catch curve (Pauly and Munro, 1984). Primarily, the method entails the backward extrapolation of the right, descending left arm of the catch curve in each length class. The probability of capture will be obtained by dividing, for each length-class, the numbers caught (N) by the numbers available (N/P), resulting in a curve from which the length at first capture Lc will be estimated (Pauly, 1987).

d) Yield per recruit (YPR)

The length-based yield per recruit model (YPR) by Thompson and Bell (1934) will be used to evaluate the exploitation levels of the selected fish species, which would result in optimum yield. With the growth parameters as the input, the reference levels F_{max} (the fishing mortality, which produces the highest yield per recruit), $F_{0.5}$ (the fishing mortality that results in a 50 % reduction of the biomass compared to the unexploited population), and F 0.1 (the fishing mortality that corresponds to 10 % of the slope of the yield per recruit curve at the origin) will be estimated. The impacts of varying fishing mor-tality and selectivity (Lc/ L∞) will be assessed using the yield isopleths diagrams.

e) Catch-Per-Unit-Effort (CPUE)

Catch-per-unit effort (CPUE) will be calculated based on daily catches divided by the number of fishers and number of fishing hours and expressed as kg fisher^{-1} hr^{-1} (Munga et al., 2014), and total fish catches by gear type divided by number of vessels for each day expressed as kg vessel^{-1} hr^{-1}. The daily catches per vessel will be used to determine the total annual fish landings based on the total number of fishing gears and total number of fishing days in a year. Total catches of the most abundant and target fish species will be calculated from totals of all catch assessments for the entire sampling period. Species proportions (relative abundance) will be calculated from fish sub-samples taken during the catch assessment campaigns. These proportions will be used to raise the individual fish species total catches by day, month (maximum of 10 fishing days), and by year (maximum of 10 fishing months). These annual total catches will be used to estimate the spawning stock biomass for determination of stock status of the most abundant and target demersal reef fish species.

iii) Species composition and size structure Janet & Geoffrey_ PRIMER-E/statistica/past

Species composition and size structure of basket trap and gill net fisheries will be determined using MS Excel to give an overview of which are the dominant species in the two fishing gears. Multidimensional Scaling (MDS) in PRIMER will be used to analyze different species encountered by the gears in different fishing grounds.

iv) Management

Management limits for the basket trap and gillnet fisheries species will be determined using the stochastic production model in continuous time (SPiCT, Pedersen and Berg, 2017) which assumes that the catch data should be representative of both landings and by-catch, stock size indices should be in terms of biomass (not numbers) and representative of the part of the stock vulnerable to the commercial fleets, the so called exploitable stock biomass (ESB). However, usually the gear selectivity of the commercial and scientific fleets do not coincide and thus the stock size indices have to be corrected to exclude individuals that are not represented in the commercial fleets. Biomass indices are assumed to be snapshots at given points in time. Therefore, the timing of survey indices has to be given as decimal years reflecting the timing of the survey (e.g. 1995.5 for the middle of the year). The timing of the survey will be matched to the closest model time. Commercial CPUE indices should be associated with the midpoint of the interval of the corresponding catches, i.e. middle of the year if they are based on yearly aggregated catches and effort.

3.0 REPORTING

3.1 Expected Outputs

A detailed report on:

1. Baseline status of the fisheries
2. Developed fisheries data collection, analysis and reporting protocols
3. Habitat characteristics of basket trap/gillnet fishing grounds including benthic structure, status of bait, composition (species and size structure) of macro-invertebrates and fish.
4. Fishery characteristics (length-weight composition, species composition, maturity stages etc.
5. The stock status of the target and non- target species and respective management measures.
6. Mapped fishing grounds for basket trap and gillnet fisheries along the Kenyan coast
7. Dissemination (manuscripts, minutes, charts, posters)

3.2 Expected Outcomes

1. Stock status for the major species targeted by basket traps and gillnets - recruitment patterns, and ascertain current fishing intensity on the resource.
2. Data and information to build into Management plans in the regulation of basket trap and gillnets fisheries.
3. Inventorized information from the demersal fisheries.

3.3 Expected Impacts

1. Managed fisheries and reduced resource user conflicts
2. Improved stock monitoring measures for the basket trap and gillnet fisheries
3. Improved livelihoods.

4.0 REFERENCES

Dyck, A., Sumaila, U. (2010). Economic impact of ocean fish populations in the global fishery. J. Bioecon. 12, 227–243

El-Zarka, S., Koura, R., and Shaheen, A. H. (1970). Selectivity of wire basket traps for Tilapia (T. nilotica, T. galilaea and T. zillii). ICES Journal of Marine Science, 33(2), 282-291

Froese, R. (2004). Keep it simple: three indicators to deal with overfishing. Fish and Fisheries, 5 (1), 86-91. 524

Froese, R., Palomares, M.L.D. and Pauly, D. (2000) Estimation of life history key facts. In: FishBase 2000: Concepts, Design and Data Sources. (eds R. Froese and D. Pauly). ICLARM, Los Banos, Laguna, Philippines, pp. 167–175.

Froese. R., Demirel. N., Coro. G., M Kleisner. K. M., & Winker. H. (2017). Estimating fisheries reference points from catch and resilience. Fish and Fisheries, 18, 506–526.

Goodyear, C. P. (1993). Spawning stock biomass per recruit in fisheries management: foundation and current use. Canadian Special Publication of Fisheries and Aquatic Sciences, 67-82.

Hawkins, J. P., and Roberts, C. M. (2004). Effects of artisanal fishing on Caribbean coral reefs. Conservation Biology, 18(1), 215-226.

ICES (2015). Report of the fifth Workshop on the development of quantitative assessment methodologies based on life-history traits, exploitation characteristics and other relevant parameters for data-limited stocks (WKLIFE V). Lisbon, Portugal.

Kawaka JA, Osuka K, Samoilys M (2015) Evaluation of Kenya’s coastal gillnet fishery for policy recommendation. CORDIO/UNDP project.

Khedkar, G. D., Jadhao, B. V., Chavan, N. V., and Khedkar, C. D. (2003). FISH| Demersal Species of Tropical Climates. doi:10.1016/b0-12-227055-x/00472-7

Kiszka J (2012) Bycatch assessment of vulnerable megafauna in coastal artisanal fisheries in the South West Indian Ocean Fisheries Project (SWIOFP) Final report. 77pp

Legault, C. M., & Brooks, E. N. (2013). Can stock–recruitment points determine which spawning potential ratio is the best proxy for maximum sustainable yield reference points? ICES Journal of Marine Science, 70(6), 1075-1080

Mangi, S.C. and Robert, C.M. (2007). Factors influencing fish catch levels on Kenya’s coral reefs Fisheries Management Ecology, 14(4), 245 - 253.

Mangi, S.C., Roberts, C.M. and Rodwell, L.D. (2007). Financial comparisons of fishing gear used in Kenya's coral reef lagoons. Ambio, pp.671-676.

Mbaru, E.K. and T.R. Mcclanahan (2013). Escape gaps in African basket traps reduce by-catch while increasing body sizes and incomes in a heavily fished reef lagoon. Fisheries Research, 148: 90-99. DOI: 10.1016/j.fishres.2013.08.011

McClanahan TR, Mangi SC (2004). Gear-based management of a tropical artisanal fishery based on species selectivity and capture size. Fisheries Management and Ecology 11(1): 51–60

Miethe, T., and Dobby, H. (2015). Selection of length-based indicators for shellfish stocks and fisheries. Working Document, ICES report WKLIFE V 2015 ICES CM 2015/ACOM: 56.

Munga, C.N., Omukoto, J.O., Kimani, E., and Vanreusel, A. (2014). Propulsion-gear-based characterization of artisanal fisheries in the Malindi-Ungwana Bay, Kenya and its use for fisheries management. Ocean & Coastal Management 98: 130 – 139.

Musick, J.A. (1999) Criteria to define extinction risk in marine fishes. Fisheries 24, 6–14.

Ontomwa M. B., Fondo E. N., Okemwa M. G., Wambiji N., Kimani E., Orembo B., Omukoto Johnstone, Mwangata J., Ocharo D., Omondi, K. Nyanchoka E., and Omweri J. (2021). Catch assessment survey report, Kwale County. KMFRI Research Technical Report No. OCS&BE/FIS/2020-2021/C2.i 75 pp

Pauly, D (1980). On the interrelationships between natural mortality, growth parameters, and mean environ-mental temperature in 175 fish stocks. ICES Journal of Marine Science 39: 175-192

Pauly, D (1987). A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic inverte-brates, ICLARM Conference Proceedings. pp 7-34

Pauly, D, David N (1981). ELEFAN I, a BASIC program for the objective extraction of growth parameters from length-frequency data. Meeresforschung 28 (4): 205-211

Pauly, D, Munro J (1984). Once more on the comparison of growth in fish and invertebrates. Fishbyte 2: 1-21

Pedersen, Martin W., and Casper W. Berg. (2017). "A stochastic surplus production model in continuous time." Fish and Fisheries 18 (2): 226–43. https://doi.org/10.1111/faf.12174.

Samoilys, M. A., Maina, G. W., and Osuka, K. (2011). Artisanal fishing gears of the Kenyan coast. Mombasa CORDIO/USAID. 36pp.

Schaefer, M. (1954). Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna

Schwamborn, R, Mildenberger, TK, Taylor, MH (2019). Assessing sources of uncertainty in length-based estimates of body growth in populations of fishes and macroinvertebrates with bootstrapped ELEFAN. Ecological Modelling 393: 37-51

Somers, IF (1988). On a seasonally oscillating growth func-tion. Fishbyte 6: 8-11

Taylor, CC (1958). Cod growth and temperature. ICES Journal of Marine Science 23: 366-370

Taylor, MH, Mildenberger TK (2017). Extending electronic length frequency analysis in R. Fisheries Manage-ment and Ecology 24: 330-338

Teh, L.S., Teh, L.C. and Sumaila, U.R., (2011). Quantifying the overlooked socio-economic contribution of small-scale fisheries in Sabah, Malaysia. Fisheries Research, 110(3), pp.450-458.

Teh, L.S.L., Teh, L.C.L., Zeller, D., Cabanban, A., (2009). Historical perspective of Sabah's marine fisheries. In: Zeller, D., Harper, S. (Eds.), Fisheries Catch Reconstructions: Islands Part 1. Fisheries Centre Research Report, vol. 17. University of British Columbia Fisheries Centre, Vancouver, pp. 77–98.

Thompson, W, Bell F (1934). Effect of changes in intensity upon total yield and yield per unit of gear. Report of the International Fisheries Commission 8: 7-49

Von Bertalanffy, L (1938). A quantitative theory of organic growth (inquiries on growth laws. ii). Human Biol-ogy 10: 181-213

Wambiji, N., Ohtomi, J., Fulanda, B., Kimani, E., Kulundu, N. and Hossain, M.Y., 2008. Morphometric relationship and condition factor of *Siganus stellatus*, *S. canaliculatus* and *S. sutor* (Pisces: Siganidae) from the Western Indian Ocean Waters. South Pacific Studies, 29(1), pp.1-15.

Annexes

Annex I: Inventory of selected fish species

Species	Parameter		
S. sutor	L/W relationship	a= 0.0328; b= 2.716	
	Growth	L∞= 36.2 cm SL; K= 0.87, r^2 =0.909; L_{max}=35.2 Common length = 30cm TL	Kenya
	Max. Age	2.5 yrs	
L. vaigiensis	L/W relationship	a=0.0174; b=2.79	
	Growth	L∞ = 29.8 cm TL ; K = 1.65 L_{max} = 35 cm TL	Kenya, Kanamai
	Age	-	
S. ghobban	L/W relationship	A = 0.0229; b = 2.97	
	Growth	L∞ = 27.5 cm FL; K = 0.473 L_{max}= 75 cm TL Common Length = 30 cm TL	Seychelles

	Age	13yrs	
L. fulviflamma	L/W relationship		
	Growth	L_∞=29 cm TL; K= 0.15 L_{max}= 35.0 cm TL Common Length = 30 cm TL	Tanzania
	Max. Age	23 yrs	

2.0 WORKPLAN AND BUDGET ESTIMATE

Table 1: Work plan and summary budget

Activity	**Quarter 4**		**Quarter 1**			**Quarter 2**			**Quarter 3**			**Quarter 4**			
	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Budget/Yr (KES)
Planning meeting and familiarisation of the demersal fisheries strategy	x														
On-site sensitization meeting with communities at selected sampling sites to establish areas of engagements			X												
Stock assessment training		X													
Review and analyze existing data all fisheries, identifying the data gaps, management measures in place and recommendations suggested for the species/fishery/gears															
Identification and analysis of species composition and size structure of target species and non-target															

species (catch effort data, biological data and habitat mapping)															
Determine the stock status of the target species using length based indicators (maturity)															
Estimate vital selectivity parameters from the basket trap and gill nets that would provide input to correct for selectivity in stock assessment models by examining the effect of varying mesh sizes and funnel sizes for target and non-target species															
Data analysis (workshops)															
Reporting (reports, publications)															
Dissemination workshops/meetings															
														TOTAL	

Table 2: Detailed Budget

A	Field work (CAS) 7 sites	No. of months	Person s	Days	Unit cost	Total Year 1	Year 2
	Per diems: Lead Scientist	6	1	10	10,500	630,000	630,000
	Per diems: Scientists	6	3	10	8,400	1,512,000	1,512,000
	Per diems: Technical staff	6	2	10	84,000	1,008,000	1,008,000

	Per diems: Drivers	6	2	10	4,900	588,000	588,000
	Local travel (car/boat fuel)	6	3	2	8,000	288,000	288,000
	Community (BMUs)	6	7	10	500	210,000	210,000
	County Officers	6	7	10	1,000	420,000	420,000
	Fish samples	6	7	1	4,000	168,000	168,000
	Airtime	6	7	1	1,000	42,000	42,000
B	**Data analysis and reporting writing**						
	Per diem Lead scientist	2	5	1	10,500	105,000	105,000
	Per diem scientists and technical staff	2	5	5	8,400	420,000	420,000
	Hall hire and refreshment	2	5	6	2,000	120,000	120,000
	car fuel and lubricants	2	200	1	150	60,000	60,000
	TOTALS					**5,571,000**	**5,571,000**

Equipment and materials

Data forms, fish measuring boards, GPS, thermometer, digital cameras, fish identification keys, stationery, Alcohol 95% (absolute ethanol), Plastic bags (large, medium, small), Gloves industrial, Surgical gloves (1 box of 100), Tracing paper, scalpels, Set of knives, Electronic scale (0.0000) and spring balances (salter) 100kgs, 200 kgs, 20 L plastic bucket/drum with lid to preserve fish samples for ID if needed, Writable

Compact Discs (CDs), Permanent marker pens (0.5 – 1.0mm), Sticker tags (2 x 3 cm), A4 paper, Notebooks/Shorthand, Writing boards, Air time, Venier callipers, formaldehyde, nitric acid, mercuric chloride, Glacial acetic acid, picric acid, tracing paper, haemoxylene eosin, Raincoats, Tape measures, specimen ziplock bag.

Table 3: The Fishery Team / Personnel

Participant Name	Responsibility:	Affiliation:
Nina Wambiji	Lead scientist	KMFRI
Mary Ontomwa	Scientist	KMFRI
Janet Mwangata	Scientist	KMFRI
Jane Nyamora	Scientist	KMFRI
Thomas Mkare	Scientist	KMFRI
Emmanuel Mbaru	Scientist	KMFRI

Annex 2: Sampling schedule from April to June 2022

		HIGH TIDE				LOW TIDE			
APRIL		MORNING		AFTERNOON		MORNING		AFTERNOON	
DAY	DATE	TIME	TIDE	TIME	TIDE	TIME	TIDE	TIME	TIDE
FRI	1	4:18	3.46	16:37	3.72	10:18	0.21	22:40	0.24
SAT	2	4:50	3.44	17:07	3.78	10:47	0.21	23:12	0.24
SUN	3	5:20	3.35	17:34	3.73	11:15	0.26	23:43	0.3
MON	4	5:47	3.22	18:01	3.61	11:42	0.37	--:--	----
TUE	5	6:14	3.06	18:28	3.42	0:12	0.43	12:09	0.52
WED	6	6:40	2.86	18:56	3.2	0:42	0.61	12:36	0.71
THU	7	7:08	2.64	19:27	2.96	1:14	0.82	13:03	0.92
FRI	8	7:40	2.39	20:07	2.71	1:51	1.07	13:33	1.15
SAT	9	8:27	2.15	21:13	2.47	2:43	1.33	14:13	1.4
SUN	10	10:24	1.99	23:25	2.39	4:21	1.51	16:05	1.63
MON	11	--:--	----	12:56	2.15	6:39	1.44	18:43	1.54
TUE	12	1:06	2.54	13:59	2.49	7:43	1.2	19:52	1.27
WED	13	2:03	2.78	14:37	2.86	8:21	0.95	20:36	0.97
THU	14	2:45	3.01	15:09	3.21	8:53	0.72	21:13	0.67
FRI	15	3:22	3.22	15:40	3.51	9:24	0.52	21:47	0.41

SAT	16	3:57	3.36	16:11	3.74	9:54	0.37	22:21	0.21
SUN	17	4:31	3.43	16:43	3.88	10:25	0.27	22:55	0.1
MON	18	5:05	3.4	17:17	3.91	10:57	0.24	23:31	0.1
TUE	19	5:40	3.29	17:52	3.83	11:30	0.28	--:--	----
WED	20	6:15	3.12	18:30	3.65	0:09	0.21	12:06	0.4
THU	21	6:55	2.91	19:13	3.37	0:49	0.41	12:45	0.6
FRI	22	7:42	2.67	20:04	3.06	1:36	0.67	13:32	0.87
SAT	23	8:48	2.45	21:17	2.77	2:34	0.94	14:35	1.17
SUN	24	10:30	2.36	23:02	2.64	3:57	1.15	16:21	1.39
MON	25	--:--	----	12:16	2.51	5:42	1.18	18:15	1.34
TUE	26	0:37	2.73	13:32	2.81	7:04	1.03	19:33	1.13
WED	27	1:45	2.9	14:23	3.12	7:59	0.85	20:27	0.88
THU	28	2:37	3.06	15:04	3.39	8:40	0.7	21:10	0.66
FRI	29	3:20	3.17	15:38	3.59	9:16	0.59	21:47	0.49
SAT	30	3:56	3.21	16:10	3.69	9:48	0.52	22:20	0.38
		HIGH TIDE				LOW TIDE			
MAY		MORNING		AFTERNOON		MORNING		AFTERNOON	
DAY	DATE	TIME	TIDE	TIME	TIDE	TIME	TIDE	TIME	TIDE
SUN	1	4:29	3.19	16:39	3.71	10:18	0.49	22:52	0.34

MON	2	4:58	3.14	17:07	3.64	10:48	0.49	23:22	0.37
TUE	3	5:26	3.05	17:35	3.51	11:17	0.53	23:51	0.45
WED	4	5:53	2.93	18:04	3.34	11:45	0.6	--:--	----
THU	5	6:21	2.78	18:34	3.16	0:22	0.58	12:13	0.72
FRI	6	6:51	2.61	19:08	2.97	0:54	0.75	12:43	0.88
SAT	7	7:28	2.43	19:48	2.78	1:32	0.94	13:16	1.08
SUN	8	8:20	2.27	20:44	2.59	2:20	1.14	14:03	1.31
MON	9	9:45	2.2	22:12	2.46	3:28	1.3	15:32	1.52
TUE	10	11:29	2.32	23:50	2.49	5:02	1.34	17:36	1.51
WED	11	--:--	----	12:48	2.6	6:22	1.24	18:58	1.3
THU	12	1:04	2.65	13:42	2.93	7:17	1.06	19:54	1.02
FRI	13	2:00	2.84	14:25	3.26	8:02	0.87	20:39	0.72
SAT	14	2:46	3.02	15:04	3.54	8:41	0.68	21:19	0.46
SUN	15	3:28	3.15	15:41	3.75	9:19	0.52	21:59	0.25
MON	16	4:08	3.21	16:19	3.87	9:56	0.41	22:38	0.14
TUE	17	4:47	3.22	16:58	3.88	10:35	0.34	23:18	0.13
WED	18	5:26	3.16	17:39	3.8	11:14	0.35	23:59	0.22
THU	19	6:07	3.07	18:22	3.62	11:57	0.44	--:--	----
FRI	20	6:52	2.94	19:10	3.38	0:43	0.39	12:42	0.62

SAT	21	7:45	2.81	20:04	3.12	1:32	0.6	13:35	0.87
SUN	22	8:51	2.7	21:09	2.89	2:29	0.83	14:41	1.14
MON	23	10:11	2.66	22:30	2.74	3:37	1.02	16:09	1.34
TUE	24	11:36	2.75	23:54	2.7	4:56	1.12	17:42	1.37
WED	25	--:--	----	12:51	2.94	6:11	1.13	19:01	1.26
THU	26	1:09	2.76	13:49	3.16	7:13	1.08	20:01	1.07
FRI	27	2:09	2.84	14:34	3.35	8:03	1.01	20:49	0.87
SAT	28	2:57	2.91	15:11	3.49	8:44	0.93	21:28	0.7
SUN	29	3:37	2.95	15:45	3.55	9:21	0.84	22:03	0.57
MON	30	4:11	2.97	16:17	3.55	9:56	0.75	22:36	0.5
TUE	31	4:41	2.95	16:49	3.5	10:28	0.68	23:07	0.49
		HIGH TIDE				LOW TIDE			
JUNE		MORNING		AFTERNOON		MORNING		AFTERNOON	
DAY	DATE	TIME	TIDE	TIME	TIDE	TIME	TIDE	TIME	TIDE
WED	1	5:10	2.9	17:19	3.41	11:00	0.65	23:38	0.52
THU	2	5:39	2.83	17:50	3.3	11:30	0.66	--:--	----
FRI	3	6:10	2.74	18:22	3.18	0:10	0.58	12:00	0.73
SAT	4	6:44	2.65	18:56	3.05	0:43	0.68	12:32	0.85
SUN	5	7:23	2.57	19:34	2.91	1:19	0.8	13:09	1.01

MON	6	8:11	2.52	20:21	2.76	2:00	0.93	13:57	1.19
TUE	7	9:12	2.51	21:23	2.62	2:50	1.06	15:06	1.34
WED	8	10:22	2.58	22:41	2.53	3:51	1.15	16:35	1.39
THU	9	11:36	2.74	--:--	----	5:00	1.18	17:58	1.29
FRI	10	0:01	2.55	12:44	2.96	6:08	1.13	19:07	1.08
SAT	11	1:12	2.64	13:42	3.21	7:08	1	20:06	0.82
SUN	12	2:12	2.76	14:32	3.44	8:01	0.84	20:56	0.57
MON	13	3:04	2.89	15:18	3.63	8:50	0.68	21:42	0.35
TUE	14	3:51	2.99	16:02	3.75	9:36	0.52	22:26	0.22
WED	15	4:35	3.07	16:47	3.8	10:22	0.4	23:09	0.16
THU	16	5:19	3.12	17:32	3.76	11:07	0.36	23:52	0.2
FRI	17	6:03	3.13	18:18	3.64	11:53	0.4	--:--	----
SAT	18	6:49	3.11	19:04	3.47	0:37	0.3	12:40	0.55
SUN	19	7:39	3.06	19:53	3.25	1:23	0.46	13:32	0.78
MON	20	8:35	3	20:45	3.02	2:11	0.66	14:30	1.05
TUE	21	9:37	2.94	21:46	2.8	3:04	0.87	15:39	1.29
WED	22	10:46	2.92	23:01	2.63	4:03	1.08	16:58	1.41
THU	23	--:--	----	12:00	2.96	5:10	1.24	18:19	1.4
FRI	24	0:25	2.56	13:09	3.06	6:21	1.32	19:33	1.27

SAT	25	1:40	2.59	14:04	3.18	7:25	1.3	20:29	1.08
SUN	26	2:37	2.67	14:48	3.29	8:18	1.2	21:14	0.9
MON	27	3:21	2.74	15:28	3.36	9:02	1.06	21:51	0.75
TUE	28	3:57	2.79	16:04	3.4	9:41	0.9	22:25	0.64
WED	29	4:29	2.83	16:37	3.4	10:16	0.76	22:57	0.56
THU	30	4:59	2.85	17:09	3.38	10:49	0.68	23:28	0.52