KENYA MARINE FISHERIES SOCIOECONOMIC PROJECT

COMPONENT 1

ENHANCED GOVERNANCE OF MARINE FISHERIES
AND BLUE ECONOMY

Research Strategy

Stock Assessment of the Small and Medium Pelagic Fishery

MAY 2022

1. BACKGROUND

The fisheries sector plays a significant role in contributing to Kenya's economic development in terms of employment, income generation, foreign exchange and food and nutrition security, among others. The artisanal sector supports thousands of coastal communities along the Kenya coast. Approximately 13,000 fishers are involved in supplying 80% of marine fishery production. Pelagic species in Kenya account for about 25% of the 25,000 mt of fish landed annually. However, the potential annual fishery production for the small and medium pelagic fishery is about 35,200 MT (Maina, 2012.) The fishery operates most effectively during the North East Monsoon (NEM), when non-powered boats can venture into the open waters.

There is an increasing demand for fish in Kenya due to human population growth, which is compounded by declining inshore fisheries. There is a growing dependence on small and medium pelagics due to the schooling behavior, which results in high volumes of low-value catches. The contribution of the small and medium pelagic fishery in landings is variable in terms of gear and location. Commonly harvested fish include sardines, mackerels, barracuda, mullets and milkfish. Various fishing techniques are used to exploit these species, including gill nets (set and drift), fence traps ("Uzio"), cast nets, seine nets (reef seine, beach seines) and handlines. Longlines, trolling lines and ring nets (or small purse seines) are usually operated further offshore.

Medium pelagic species include carangids, seerfish, dolphinfish, barracuda, cobia, while small pelagics include mackerels, scads, sardines, needlefish, halfbeaks and anchovies. The contribution of ring nets (small-scale purse seines) to landings fo small and medium pelagic species along the Kenya coast is remarkable (Thoya et al., 2020). The marine artisanal fisheries frame survey report indicates an increase in ring nets from 1 in 2004 to 38 in 2016. Several studies have attempted to shed more light on the ringnet fishery providing information on catch and effort dynamics (Bett, 2018; Okemwa et al., 2019), spatial-temporal distribution of fishing effort and ecosystem impacts (Thoya et al., 2020), and stock status of selected species (Munga et al 2015). However, there is a need for updated information on the status of exploited species.

This research strategy summarizes the objectives and activities that will be implemented to support revision of the draft small and medium pelagics management plan and the small-scale purse seine management plan. The information generated will also fill research gaps

identified in the action plan for the small and medium pelagic fishery during the annual benchmarking tracking (BMT) process conducted in March 2022.

2. AIM and OBJECTIVES

The aim of this study is to evaluate the small and medium pelagic fishery and provide biological reference points and other pertinent information required to improve management.

The following specific objectives will be addressed:

1. Collate available existing data to provide temporal trends in catch, catch per unit effort and species composition) for small and medium pelagic species
2. Conduct a risk assessment to identify species vulnerable to fishing gears used to capture small and medium pelagic species
3. Conduct catch assessment surveys to evaluate spatial and temporal variations in the species composition, size structure, maturity and catch rates of target and primary species
4. Determine stock characteristics of target and primary species and establish reference points for future stock assessment
5. Develop a robust harvest strategy for target species with control rules based on updated stock assessment
6. Map fishing grounds for the small and medium pelagic fishery to inform marine spatial planning initiatives

3. MATERIALS AND METHODS

3.1. Study sites and species

Fisheries-dependent data will be collected at five landing sites Vanga, Gazi, Kilifi Central, Watamu and Mayungu (Figure 1) along the Kenya coast. The list of target and major primary species prioritized for assessment is presented in Table 1. The target species prioritized for stock assessment are: *Rastrelliger kanagurta, Sphyraena obtusata, Sphyraena flavicauda, Sardinella gibbosa* and *Spratelloides gracillis*.

Table 1. Priority species selected for assessment during the annual BMT process

Target species (> 5%)	Primary species (Major: <5%>2%)
Medium pelagics	*Scomberomorous commersoni*
Sphyraena flavicauda	*Sphyraena jello*
Sphyraena obtusata	*Caranx ignobilis*
Rastrelliger kanagurta	*Carangoides ferdau*
Small Pelagics	*Carangoides ymnosthetus*
Sardinella gibbosa	*Carangoides Bajad*
Spratelloides gracillis	*Caranx sexfasciatus*
Stollephorus commersonii	*Hemiramphus far*

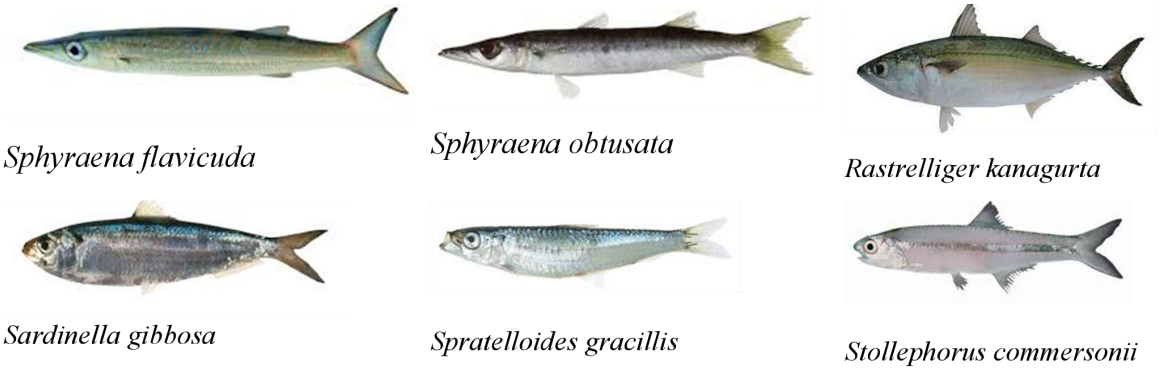

Figure 1. Photos of the selected target species that will be assessed

3.2. Catch surveys and biological sampling

Catch surveys: Shore-based catch assessment surveys will be conducted to document all gears that catch small and medium pelagics. Surveys to collect catch information and biological data for the target species will be conducted over five to seven consecutive days for a period of 1 year between July 2022 and June 2023. During each survey, details on the vessel, gear type, number of fishers, total catch (kg) per trip, and species will be documented. Additional catch data will be obtained from previous projects and ongoing projects/initiatives (Table 2) will be collated and included for a more comprehensive assessment.

Table 2. Inventory of available datasets for small and medium pelagics indicates

Project	**Years**
KCDP CAS	2014 - 2015
KMFRI CAS	2008, 2017 - 2020
KEMFSED CAS	Ongoing (2022 -)

Biological data: For length distribution, the fish will be selected randomly and the fork length will be measured to the nearest 0.1cm. When possible, individual weights will be measured using an electronic weighing scale to the nearest 0.01kgs. The monthly target for length measurements will be 200 fish for each species. A random subsample of at least 50 fish will be obtained each month for examination and extraction of gonads to determine sex and gonad maturity stages. Mean monthly gonadosomatic indices (GSI) will be calculated for each sex by expressing the gonad weight as a proportion ofthe total body weight. The timing and frequency of spawning will then be established by plotting the proportion of fish by maturity stage and gonadosomatic indices against the sample period.

3.3. Risk assessment

The semi-quantitative risk assessment method, Productivity Susceptibility Analysis (PSA) is widely used in assessing the relative sustainability of species impacted by a particular fishery. The method has gained popularity in the assessment of data-poor fisheries. PSA ranks each species being assessed based on a number of attributes relating to productivity which reflect the capacity to recover from overfishing and susceptibility to capture. The attributes are scored from 1 (least susceptible; least productive) to 3 (most susceptible; most productive). The scores for susceptibility and productivity attributes for each species are averaged, and then combined to produce an overall vulnerability score from 0 (least vulnerable) to 3 (most vulnerable). Species with the highest ranks across all attributes are then considered most vulnerable to becoming unsustainable under current levels of fishing. Vulnerability, in an ecological risk assessment context, can be defined as the potential for the productivity of a stock to be diminished beyond expected natural fluctuations by direct and/or indirect fishing impacts. Unlike stock assessment, PSA does not provide quantitative population status estimates or biological reference points. Instead, PSA helps to identify and prioritize species for further assessment or management intervention to mitigate the risk of population decline for vulnerable species. In this context, the PSA will be used to assess the vulnerability of pelagic species caught by the fishery. The outputs will complement the stock assessment study for species that will not be formally assessed under the project.

3.4. Data Analysis

Estimation of growth parameters: The length data for each species will be grouped into appropriate length bins. Growth parameters will then be estimated by fitting the von Bertalanffy growth function (von Bertalanffy, 1960). This will include asymptotic length ($L\infty$) and growth coefficient (K). K-Scan will be conducted to determine a reliable estimate of the K value (Pauly and David, 1981), defined by the equation:

$$Lt = L\infty\ (1\text{-}e\text{-}k\ (t\text{-}t_0)$$

Where Lt = mean length at age t; $L\infty$ = asymptotic length; t=age and t_0=the hypothetical age at which length is zero. The annual instantaneous rate of natural mortality (M) will be estimated using the empirical equation derived by Hoenig (1983). Total mortality coefficient (Z) will be estimated using the length converted catch curve method, and natural mortality rate (M) will be estimated using Pauly's empirical relationship (Pauly, 1980). The ascending left arm of the length-converted catch curve will be used to determine the probability of capture of each length class according to Pauly (1983). The annual instantaneous rate of fishing mortality (F) will then be calculated by subtracting the natural mortality rate (M) from the total mortality rate (Z). The calculation will also be made for the upper and lower 95%confidence intervals for Z in order to derive a range of fishing mortality rate estimates. The exploitation rate (E) will then calculated as the proportion of fishing mortality relative to total mortality (E=F/Z). Parameter estimation will be done using ELEFAN.

Stock assessment: The derived values of $L\infty$, K, M, F, a (constant) and b (exponent) for each species will be used as inputs in other length-based methods to determine the status of selected priority species. Optimal length Lopt will be calculated from $L\infty$, M and K using the equation of Beverton (1992):

$$L_{opt} = 3L\infty / (3 + M/K)$$

Selectivity curves will be generated by fitting the logistic function to probability of capture and size data which will then be used to derive values of the sizes at capture at probabilities of 0.5 (SL_{50}), 0.75 (SL_{75}), 0.95 (SL_{95}), and the size at which fish are fully recruited to the fishery (L_{100}). The Beverton and Holt (1966) yield per recruit model modified by Pauly and Soriano (1986) will be used to determine the size at which yield per recruit would be maximized (L_{max}). The resource status will then be determined by comparing estimates of fishing mortality rate with target (F_{opt}) and limit (F_{limit}) biological reference points (BRP's) which will be defined as: F_{opt} = 0.5M and F_{limit} = 2/3M, following Patterson (1992).

The length-based indicators by Froese (2004) will be applied to catch length composition data and calculated for each species for comparison among gear types and years (available for the medium pelagic species only). The Length-based spawning potential ratio (LBSPR) , a data-limited length-based stock assessment method will be used to assess the stock status relative to the biological reference points (SPR). The LBSPR method requires as input length composition data of the catch, as well as the three parameters: m/k, $L\infty$ and L_{50}. The model estimates selectivity-at-length and the relative fishing pressure, F/M and the resulting spawning potential ratio (SPR) (Hordyk et al., 2015).

4. Reporting

Data and information will be recorded in a standardized datasheet. All surveys will involve debriefing before each trip. A trip report will be prepared at the end of each sampling survey and made available to all teams. A final workshop will be held to analyze the data recorded from all the surveys and prepare a joint final report to advice the management.

5. Expected Outputs

The following outputs are expected:

i. Hard copies of the data sheets
ii. Soft copies of the data
iii. Trip reports
iv. Annual technical reports on stock status of selected priority species

6. Expected Outcomes

i. Information on the composition of catches targeting small and medium pelagics
ii. Biological information on selected priority species
iii. Improved information on spatial and seasonal trends in catch rates for small and medium pelagic species

7. Expected Impacts

i. Improved governance of the small and medium pelagic fishery
ii. Management plan for the ring net fishery

8. References

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Annex I: Workplan

Table 1: Work plan and summary budget

	2022						2023											
Activity	Q3			Q4			Q1			Q2			Q3			Q4		
Field surveys																		
Data analysis and reporting																		

Annex II. The Fishery Team / Personnel

Participant Name	Responsibility:	Affiliation:
Dr Gladys Okemwa	Senior Research Scientist	KMFRI
Almubarak Athman Abubakar	Research Scientist	KMFRI
Fatuma Mzingiriwa	Research Scientist	KMFRI
Boaz Orembo	Research scientist	KMFRI
JibrilOlunga	Technician	KMFRI
Joshua Omweri	Technician	KMFRI
Evan Nyachoka	Technician	KMFRI
Hafidh Ishmail	Intern	KMFRI
Fred Kurgat	Intern	KMFRI

Annex III. Project Summary

Title:	Kenya Marine Fisheries and Socio-Economic Development Project (KEMFSED)
Project Development Objective (PDO):	To improve management of priority fisheries and mariculture and increase access to complementary livelihood activities in coastal communities.
Project Structure:	The project has three components: **Component 1**: **Governance and Management of Marine Fisheries.** The component will support improvement of management of marine fisheries in Kenyan waters. Fisheries governance related interventions will be promoted through strengthened co-management of nearshore fisheries and infrastructure development in relation to fisheries management at national and county levels. Component 1 has 3 sub-components: (1.1) Enhanced Governance of Marine Fisheries and Blue Economy (1.2) Co-management; and (1.3) Infrastructure development **Component 2**: **Coastal Community Empowerment and Livelihoods.** The component will strengthen livelihoods in coastal communities through a combination of technical and financial support for the implementation of livelihood, social welfare, and environmental subprojects; provision of scholarship grants and complementary capacity-building and mentoring of beneficiaries. **Component 3**: **Project Management**. The component will finance support for project management at both national and county levels to ensure coordinated and timely execution of project activities.

Specific Objectives	Conduct scientific research and training to support stock assessment of priority fisheries
Expected Outputs for Component 1.2	Improved information to support management of priority fisheries
Geographical scope:	Five (5) counties riparian to the Indian Ocean along the Kenyan Coast including Kwale, Mombasa, Kilifi, Tana River and Lamu.
Source of Funding	World Bank (IDA) and Government of Kenya