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# FISHING GEARS CHARACTERISTICS AND FISHING EFFORT IN ARTISANAL FISHERIES OF FERGUSON'S GULF IN LAKE TURKANA, KENYA

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## ABSTRACT

Lake Turkana fisheries is characterized by widespread use of artisanal gears. Despite the use of artisanal fishing gears in Ferguson's gulf, the characteristics and fishing effort is not known yet there is reported decline in fish yield. We investigated fishing gears characteristics and fishing effort by sampling 162 fishing gears. This study used descriptive longitudinal research design. Differences in fishing gears characteristics and fishing effort was determined by one way ANOVA and post hoc mean separation by Duncan's Multiple Range Test (DMRT) significant at $\alpha = 0.05$. The mean number of nets in beach seine gears (11.39±5.82) was significantly higher than purse seine (7.29±5.55) and gill net gears (4.11±2.83); ANOVA, $\alpha = 0.05$, $F_{(2,159)} = 29.642$, $p = 0.0001$. Higher mean mesh sizes were recorded in gill net gears (3.37±0.65 inches); ANOVA, $\alpha = 0.05$, $F_{(2, 159)} = 12.273$, $p = 0.0001$. Purse seine gears recorded the highest mean number of hauls per day (22.8±1.64) while gill net gears recorded the lowest mean number of hauls (1.39±0.49); ANOVA, $\alpha = 0.05$ $F_{(2, 159)} = 4139.39$, $p = 0.0001$). The longest mean time between hauls in minutes was recorded in gill net gears (934.44±635.04); ANOVA, $\alpha = 0.05$ $F_{(2, 159)} = 111.594$, $p = 0.0001$. The differences in fishing effort and characteristics implied lack of uniformity and varied selectivity. The highest mean number of nets and shortest time between hauls recorded in purse seine gears implied high fishing effort. Knowledge of characteristics of fishing gear and fishing effort is critical for management of Lake Turkana fisheries.

**Keywords:** Fishing gears; Artisanal fisheries; Fishing effort, Ferguson's Gulf, Lake Turkana

# 1 INTRODUCTION

## 1.1 Characteristics of artisanal fishing gears

Gill nets are efficient, relatively inexpensive and capable of catching higher amount of economically valuable fish than other artisanal gears [1]. Fishermen attach two nets vertically or horizontally to form long panels, with mesh sizes in order to increase the surface area in gill net gears [2]. According to [1] gill nets are placed early in the evening and removed early the next morning and hauling is done daily to prevent catch spoilage. While these studies indicate efficiency and affordability of gill net gears, pointing to significantly potential high use intensities, their characteristics and fishing effort need to be determined and compared to those of other gears used in inland artisanal fisheries.

Beach seine have been used several thousands of years ago and on every continent, including Africa, North America and elsewhere [3]. They consist of robust nets made of multifilament nylon with variable but small mesh sizes [4, 5, 6, 7]. Beach seine gears are hauled out of the water on to the beach manually or by means of a tractor, vehicle or winch [8]. These studies provided insights into widespread use, characteristics and operation of beach seine gears. However, they did not determine the characteristics and fishing effort of beach seine gears.

Purse seine is one of the most advanced types of fishing gears and it has been used for more than 200 years while the modified purse seine started to evolve only 100 years ago [9]. Purse seine is still widely used by fishers in almost every part of the world although with various modifications. They are strong nets made of multifilament nylon with variable but small mesh size created by joining six or more small mesh nets [10]. The purse seine is set and hauling is done within 4 to 8 minutes using motor boat and for large purse seines hauling may take around 15 to 20 minutes [11]. However, these studies did not establish the mean number of nets attached together, mesh sizes and number of hauls by purse seine gears.

Studies by [10, 7, 6] have established difference in characteristics and fishing effort of beach seine, purse seine and gill net fishing gears. [10] Observed that beach seine, purse seine and gill net gears used in artisanal fishery of the Kenya Coast were supported with lines of floats at the top with a weighted leaded rope at the bottom with significant difference in mesh sizes. They consist of either panels of mono-filament or multi-filament nets ranging from 3 to 5 inches 25 m long and 1.5 m high, while beach seine and purse seine were strong nets made of multifilament nylon with variable but small mesh size of 1 inch measuring 100-200 m long 3-4 m deep in beach seine and mesh nets of 0.5-3 inches measuring 30 by 300 m in purse seine [4, 5, 6, 7]. Beach seine and purse seine gears dominantly consist of long strong and high nets with small mesh sizes while gill net gears consist of large mesh sizes and short nets.

However, [5, 6] pointed out that the length of fishing gears depended on the number of nets joined together. However, these studies on mesh sizes and number of nets of beach seine, gill net and purse seine gears were conducted in coastal artisanal fishery. The characteristics of freshwater artisanal fishing gears, therefore, remain unknown. It is imperative that mesh sizes of nets of beach seine, purse seine and gill net gears used in artisanal fishery be determined for effective fisheries management since they determine the size and biomass of fish species captured as well as bycatch and discard.

Several studies have established that beach seine, gill net and purse seine gears consist of nets attached together so as to increase the total surface area for fish capture [10, 2, 7]. In gill net gears, fishermen attach two nets vertically or horizontally to form gill net panels of 50 or 60 m long, with mesh sizes ranging from 11 to 40 cm, depending on the targeted species [2, 7]. In addition, purse seine and beach seine gears are created by joining six or more small mesh (2.5 cm) nets, each 25 m long and 3–4 m deep [10]. However, these studies were undertaken in coastal artisanal fisheries which differ from inland artisanal fisheries in terms of target fish species and extent of target area, thus the length of these fishing gears could be significantly affected by these factors and therefore cannot be generalized thus necessitating this study.

## 1.2 Fishing effort and use of artisanal fishing gears

Notable difference in fishing effort, has been reported in beach seine, gill net and purse seine gears. Research by [1] conducted at Kainji Lake Lower Basin, pointed that gill nets were placed early in the evening and removed early the next morning and hauling was done daily to prevent catch spoilage. The average time taken to haul gill nets was estimated at 12 hours translating to a minimum of one and a maximum of two fish hauls per day. However, in coastal fisheries of Kenya, as reported by [6] fishers stayed with the set net for up to 4 hours and then hauled the catch towards the moving boat.

However, in artisanal fishery of Panama, [4] observed that the nets were set in the evening between 4 and 6 pm, and then collected after darkness between 8 and 11 pm or set between 11 pm and midnight, and collected in the early morning after

sunrise, from 6:30am to 10 am translating to 4-6 haul hours. The process of setting and hauling the nets could vary in duration depending on the number of nets, environment, and the working force and therefore could vary in different artisanal fisheries. Moreover, this study was undertaken in gill net fishery where motorized fishing vessels were used for casting and hauling the set nets resulting into relatively higher fishing effort in contrast with this study determined the haul time using non-motorized vessels.

Furthermore, beach seines are set in water and manually pulled or dragged with the aid of the towing rope attached to each of the wings [8]. In the process the cod end is gradually drawn close to the shore and finally hauled out of the water on to the beach. The hauling may be done either manually or by means of a tractor, vehicle or winch. The long hauling ropes and the wings of the seine nets herd fish into the centre part of the seine body [12]. However, these studies were undertaken in the industrial fisheries instead of artisanal fisheries which is the focus of this study.

Purse seines are set in the water at the surface and extend down the water column; a fishing vessel is used to encircle an aggregation of schooling fish at maximum speed and hauling is done within 4 to 8 minutes using motorized fishing vessel [6, 7]. Conversely, [11] reported that for large purse seines hauling time may take around 15 to 20 minutes using motor boat. However, the time taken to haul the purse seine gears using non-motorized means is unknown. Moreover, most of the studies have focused on purse seine gears with a bag (purse) at the center than the equivalent consisting of a large wall of netting without a bag in the centre which was prevalent at the study area. Therefore, the study aimed at determining the time taken per haul by purse seine gears without bags and hauling time by non-motorized fishing vessels.

## 2 MATERIALS AND METHODS

### 2.1 Study Area

Ferguson's Gulf of Lake Turkana where the present study was conducted is located about mid-way along the western shore of Lake Turkana stretching from 0328.28 North and 03550.50 East [13]. It is 4 km from Kalokol and the most accessible part of Lake Turkana. It is fringed with doum palms, and grass with the *Prosopis juliflora* colonizing the western side. Presently, the Gulf has high number of artisanal fishers with increased fishing activity and rapidly developing fish processing and marketing.




**Figure 1: Map of Kenya (left Inset) showing location of Lake Turkana and Ferguson's Gulf**

Source: Adopted from Opalo (2013)

### 2.2 Research design and sampling procedure

This study used descriptive longitudinal research design where the data was collected for a period of 6 months. A sampling frame consisting of a population of 208 fishermen was obtained from Longech and Natirae Beach Management Units. Stratified sampling was used to categorize the fishermen into those using beach seine (64), gill net (66) and purse seine gears (78). For analysis of data using One-way ANOVA, a minimum sample size of 156 or approximately 52 per group was needed [15]. This study used a sample size of 162 fishing gears or 54 gears per group. Simple random sampling was used to obtain respective sample sizes for beach seine, purse seine and gill net gears.

### 2.2.1 Data collection and processing

The number of hauls per day (from 6am to 6pm) and time per haul, taken as the time between when the fishing gear has been fully cast into water and when wholly removed from the water, in minutes was estimated based on observation by the researcher. The number of nets was estimated by counting the number of nets joined together while mesh size was measured using tape measure to obtain the full mesh distance between the centres of the two opposite knots of a stretched mesh according to [16] procedure.

### 2.3 Data analysis

One-Way ANOVA at $\alpha = 0.05$ was used to test for significant differences in characteristics and fishing effort of artisanal fishing gears. For differences that were found significant at $\alpha = 0.05$, post hoc separation of means was done by Duncan Multiple Range Test. Descriptive statistics was used to summarize the data presented as means, percentages and standard deviations. The qualitative data was analyzed by thematic analysis and coding.

## 3 RESULTS

### 3.1 Characteristics and Fishing Effort of Artisanal Fishing Gears

**Table 1: Mean number of nets and mesh sizes of gill net, purse seine and beach seine fishing gears**

| Fishing gears | Characteristics (Mean±SD) | |
|---|---|---|
| | Number of nets | Mesh size (inches) |
| Gill net | $4.11\pm2.83^{A}$ | $3.37\pm0.65^{B}$ |
| Purse seine | $7.29\pm5.55^{B}$ | $2.89\pm0.48^{A}$ |
| Beach seine | $11.39\pm5.82^{C}$ | $2.85\pm0.66^{A}$ |

Means with different superscripts in the same column are significantly different at $\alpha = 0.05$ (Means separated by DMRT)

Considering the number of nets per fishing gear of fishing gears separately, majority (38.9%) of gill net gears consisted of 2 nets followed by 3 nets (11.1%), 4 nets (11.1%), 5 nets (11.1%) and 10 nets (11%). The least proportion consisted of 1 net (5.6%) and 9 nets (9%). However, in purse seine gears, the highest (24%) proportion of gears consisted of 4 nets, followed closely by 22.2% made up of 3 nets, the lowest proportion (1.9%) comprised of 15 nets and 18 nets per fishing gear. Others included 5 nets (11.1%), 6 nets (11.1%), 20 nets (11%), 7 nets (5.6%), 10 nets (5.6%) and 12 nets (5.6%). A relatively high (16.7%) proportion of beach seine gears was made up of 18 nets followed by 12 nets (16.7%), 17 nets (11%), 6 nets (11%), 3 nets (11%), 16 nets (5.6%), 8 nets (5.6%), 4 nets (5.6%), 20 nets (5.6%), 5 nets (5.6%) and using 10 nets (5.6%) per fishing gear of beach seine gears.

The difference in the number of nets joined together across the fishing gears implied the complex nature of multi-gear artisanal fisheries interms of characteristics of fishing gears and potential catch yields. The high number of nets joined together in beach seine gears, was attributed to the need to maximize the biomass of fish per haul as it was labour intensive since it was operated manually. However, the least number of nets in gill net gears was attributed to the fact that gill net gears concentrate on catch yield interms of size than the number of fish captured as opposed to beach seine and purse seine gears. The findings on difference in number of nets in gill net, purse seine and beach seine gears were consistent with [7]. [17, 18, 10] that found out that beach seine, purse seine and gill net gears used by artisanal fishers consisted of varying number of nets joined together so as to increase the surface area for fish capture resulting into high fish biomass. [18] established that non-selective fishing gears such as beach seines and purse seines recorded the highest number of nets so as maximize the number of fish captured in the artisanal fisheries of the Kenya's South Coast. Further, the hand gill nets mostly used by artisanal fishermen consisted of the lowest number of nets due to the fact that the fishermen use only number of gill nets of a chosen mesh size; concurrent to the findings of this study.

Gill net gears had larger (3.37±0.65 inches) mean mesh sizes than purse seine (2.89±0.48 inches) and beach seine gears (2.85±0.66 inches). There was significant difference in mesh sizes among fishing gears (One-way ANOVA, $\alpha = 0.05$ ($F_{(2,159)} = 12.273$, $p = 0.0001$). DMRT further confirmed that mean mesh sizes of beach seine gears differed significantly from mean mesh sizes of gill net gears but not from mean mesh sizes of purse seine gears. Gill net gears had the larger (3.37±0.65 inches) mean mesh sizes than purse seine (2.9±0.47 inches) and beach seine (2.9±0.67 inches) gears.

The study also revealed that the 3'' mesh size nets were dominant in gill net (n = 54) and purse seine gears (n =54) accounting for 55.9% and 42.6% respectively. Nonetheless, 2.5'' mesh size nets were dominant in beach seine gears representing 44% of the total (N = 54). This was followed by 3.5'' (16.1%) in gill net, 2.5'' (36.9%) in purse seine and 3'' (18%) in beach seine gears. The largest 5'' mesh size nets were only found in gill net gears but missing in purse seine and beach seine gears as illustrated in Figure 3 below.

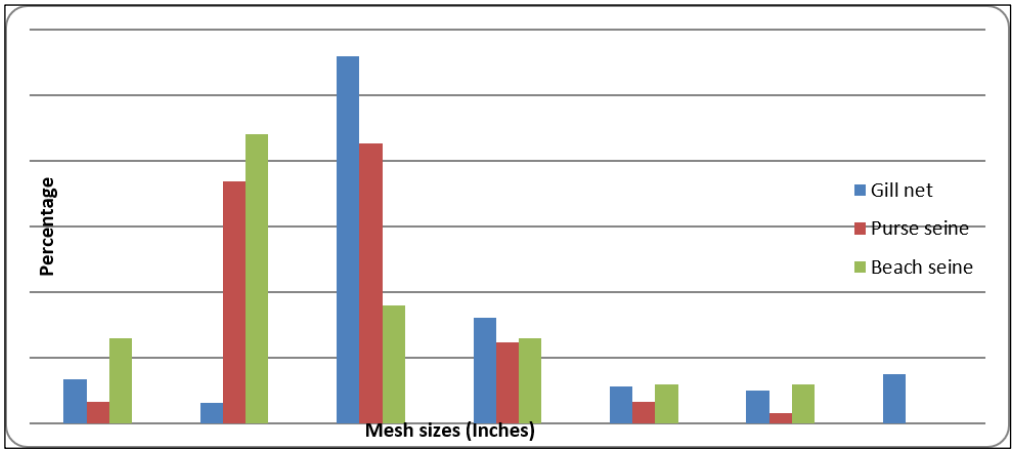



**Figure 2: Mesh sizes of fishing gears used in Ferguson's Gulf. The 3'' mesh size nets dominated the gill net (55.9%) and purse seine gears (42.6%), while the 2.5'' (44%) mesh size nets dominated the beach seine gears.**

The larger mean mesh size in gill net gears as shown in Table 1, implied that they are size selective and catches mainly larger sized and mature fish species than beach seine and purse seine and beach seine gears. The fact that gill nets are selective and could be easily controlled for capture of specific fish species and sizes to meet the market and personal preferences accounted for large mean mesh size in gill net gears. This study revealed that, a a negative relationship between mean mesh sizes and the mean number of nets joined together in gill net, purse seine and beach seine gears. Thus, the higher the mean number of nets joined together, the smaller the mean mesh size. This could stem from the difference in the yielding potential of gill net, purse seine and beach seine gears. In gill net gears, the catch yield could be maximized by using larger mesh sizes while increasing the number of nets joined per gear and using small mesh sizes could potentially increase the catch yield in purse seine and beach seine gears.

As established by the study, purse seine and beach seine gears consisted of relatively small mesh size nets compared to gill net gears (Table 1). Therefore, the gill net gears used in Ferguson's Gulf were size selective compared to purse seine and beach seine gears. The small mesh sizes in beach seine and purse seine gears implied potential capture of small-sized fish by these gears which could lead to recruitment overfishing in Ferguson's Gulf in long term.

Concerning the fishing effort; the number of hauls undertaken by beach seine, purse seine and gill net gears in Ferguson's Gulf were recorded per day. The highest (22.8±1.64) mean number of hauls was recorded in purse seine gears while the lowest (1.39±0.49) mean was recorded in gill net gears, with beach seine gears recording mean of 8.3±1.3 hauls per day. There was significant difference in mean number of hauls of fishing gears (One-way ANOVA, $\alpha$ =0.05, $F_{(2,159)}$ = 4136.38, p=0.001), with DMRT showing significant difference in the mean number hauls of purse seine, beach seine and gill net gears (Table 2).

**Table 1: Mean number of hauls and time per haul recorded in fishing gears used in Ferguson's Gulf**

| Fishing gears | Fishing Effort (Mean±SD) | |
|---|---|---|
| | Number of hauls per day | Time between hauls (Minutes) |
| Gill net | $1.39\pm0.49^{A}$ | $934.44\pm635^{A}$ |
| Purse seine | $22.8\pm1.64^{B}$ | $17.65\pm8.10^{B}$ |
| Beach seine | $8.3\pm1.3^{C}$ | $25.11\pm9.49^{C}$ |

Means with different superscripts in the same column are significantly different at $\alpha$=0.05 (Means separated by DMRT)

The proportionate composition of number of hauls per fishing gear indicated that, in purse seine gears, majority consisted of twenty five (27.7%) hauls followed by twenty six (16.7%), twenty three (16.7%), twenty eight (11.1%), twenty seven (5.6%), twenty one (5.6%) and twenty (5.6%). Likewise, in beach seine gears the number of hauls consisted of eight (27.7%), twelve (27.7%), eleven (11.1%), thirteen (11.1%), fourteen (5.6%), ten (5.6%), nine (5.6%) and seven (5.6%). In addition, the number of hauls in gill net gears consisted of one (61%) and two (39%) only (see Figure 3).

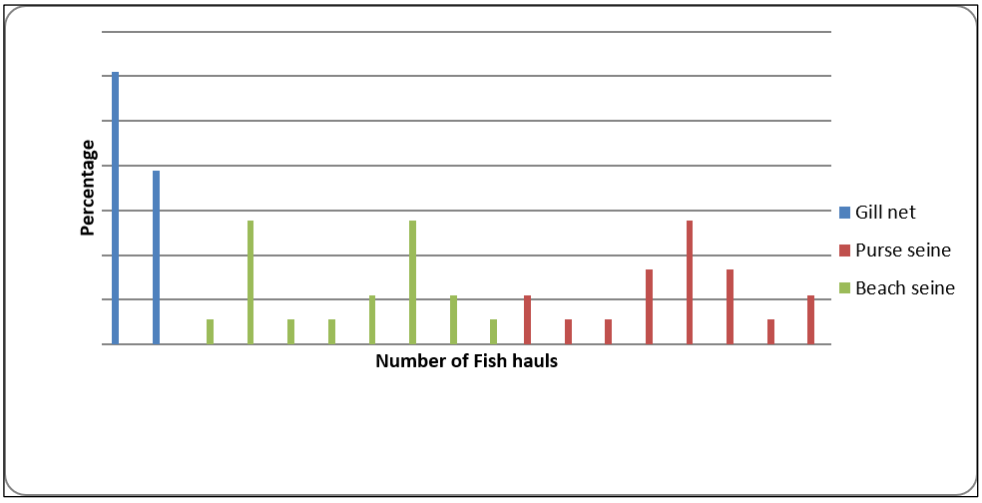



**Figure 3: Number of hauls per day by fishing gears used in Ferguson's Gulf. In gill net and purse seine gears, majority consisted of one (61%) and twenty five (27.7%) hauls respectively. Highest number of hauls consisted of eight (27.7%) and twelve (27.7%) in equal proportions in beach seine gears.**

The time per haul by beach seine, purse seine and gill net fishing gears was established by the study and recorded in minutes as the time interval starting when the fishing gear was cast and ending when completely out of water. The highest mean time (934.44±635.04 minutes) taken per haul was recorded in gill net gears while the lowest mean time (17.65±8.10 minutes) was recorded in purse seine gears and 25.11±9.49 mean time per haul in minutes was recorded in beach seine gears. There was significant difference in mean time per haul of beach seine, purse seine and gill net gears (One-way ANOVA, $F_{(2,159)} = 111.594$, $p=0.0001$). DMRT established significant difference in mean time per haul in all fishing gears. As shown in Table 2 above, the longest (934.44±635 minutes) time taken per haul was recorded in gill net gears while the shortest time (17.65±8.10 minutes) was recorded in purse seine gears. The mean time taken per haul per fishing gears are illustrated in Figure 5 below.

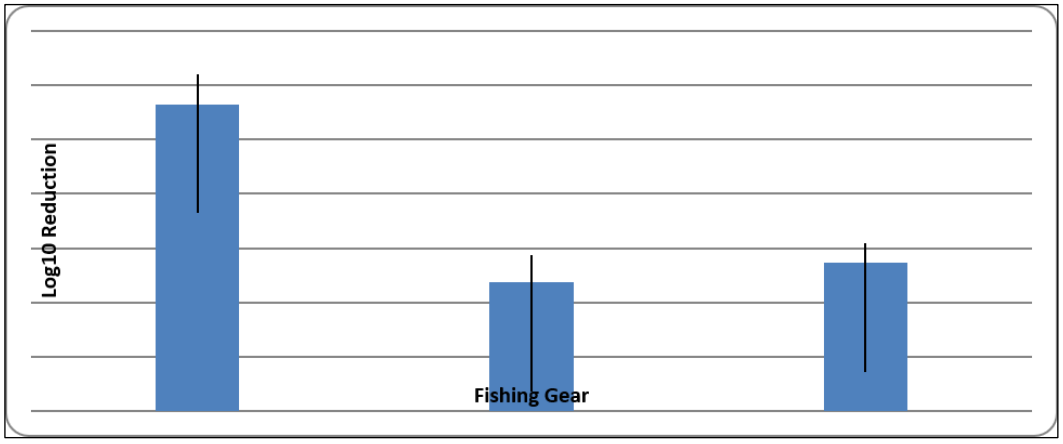



**Figure 4: Mean time taken per haul in the log reductions of minutes by fishing gears used in Ferguson's Gulf. Gill net (n = 54), purse seine (n = 54) and beach seine (n = 54) gears took mean times of 934.44±635 minutes, 17.65±8.10 minutes, 25.11±9.49 minutes respectively.**

The difference in the fishing effort (see Table 2) of the fishing gears indicated the variation in daily fish yields of these gears. The highest mean number of hauls in purse seine gears implied highest fish yields per day, while the lowest number of fish hauls in gill net gears denoted the lowest fish yields interms of biomass. The results of this study revealed that the mean number of hauls in fishing gears could be explained by the mean time taken per haul. Thus, fishing gears such as gill net which recorded longer mean haul time had least mean number of hauls and purse seine gear which recorded the shortest mean haul time had the highest mean number of hauls per day.

## 4 DISCUSSION

### 4.1 Characteristics and Fishing Effort of Artisanal Fishing Gears

As shown in Table 1, the difference in the number of nets joined together across the fishing gears implied the complex nature of multi-gear artisanal fisheries interms of characteristics of fishing gears and potential catch yields. The high number of nets joined together in beach seine gears, was attributed to the need to maximize the biomass of fish per haul as it was labour intensive. However, the least number of nets in gill net gears was attributed to the fact that gill net gears concentrate on catch yield interms of size than the number of fish captured as opposed to beach seine and purse seine gears. The findings on difference in number of nets in gill net, purse seine and beach seine gears were consistent with [7, 7, 18, 10] that found out that beach seine, purse seine and gill net gears used by artisanal fishers consisted of varying number of nets joined together so as to increase the surface area for fish capture resulting into high fish biomass. [18] stablished that non-selective fishing gears such as beach seines and purse seines recorded the highest number of nets so as maximize the number of fish captured in the artisanal fisheries of the Kenya's South Coast. Further, the hand gill nets mostly used by artisanal fishermen consisted of the lowest number of nets due to the fact that the fishermen use only number of gill nets of a chosen mesh size; concurrent to the findings of this study.

The larger mean mesh size in gill net gears as shown in Table 4.1, implied that they are size selective and catches mainly larger sized and mature fish species than beach seine and purse seine and beach seine gears. The fact that gill nets are selective and could be easily controlled for capture of specific fish species and sizes to meet the market and personal preferences accounted for large mean mesh size in gill net gears. This study revealed that, a a negative relationship between mean mesh sizes and the mean number of nets joined together in gill net, purse seine and beach seine gears. Thus, the higher the mean number of nets joined together, the smaller the mean mesh size. This could stem from the difference in the yielding potential of gill net, purse seine and beach seine gears. In gill net gears, the catch yield could be maximized by using larger mesh sizes while increasing the number of nets joined per gear and using small mesh sizes could potentially increase the catch yield in purse seine and beach seine gears.

As established by the study, purse seine and beach seine gears consisted of relatively small mesh size nets compared to gill net gears (Table 4.1). Therefore, the gill net gears used in Ferguson's Gulf were size selective compared to purse seine and beach seine gears. The small mesh sizes in beach seine and purse seine gears implied potential capture of small-sized fish by these gears which could lead to recruitment overfishing in Ferguson's Gulf in long term. These findings concurred with Maina (2012) that reported the use of a wide range of nets with varied mesh sizes in the Kenyan artisanal fishery with small mesh sizes recorded in purse seine and beach seine gears and large mesh sizes recorded in gill nets. Further, [18, 10] also found out that beach seine and purse seine gears consisted of small mesh size nets in artisanal fishery of the Kenyan Coast similar to the findings of this study. Studies by [5, 19] also reported use of small mesh-sized beach seine gears in artisanal fisheries of Lake Victoria and Lamu. Furthermore, the use of large mesh size nets in gill net gears also agreed with the findings of [20, 18, 5, 17] that gill net gears consist of larger mesh sizes.

The small mesh sizes of purse seine and beach seine gears used in artisanal fishery could have implications for management of fish resources in Ferguson's Gulf. During the study it was observed that such gears caught virtually everything that it enclosed and was unselective while the highly selective gill nets caught only the right size of fish which got stuck in the meshes. Therefore to manage the fish resources of Ferguson's Gulf, appropriate minimum mesh sizes should be recommended for beach seine and purse seine gears. The use of larger mesh sizes in gill net gears allowed some of the fish to escape through the larger meshes and have time to grow older and larger resulting into lower catch rates. As pointed out by [21, 22, 23], in long-term, the delayed capture would lead to a useful increase in the stock size, thereby improving the spawning stock and future yields of Ferguson's Gulf.

The difference in the fishing effort of the fishing gears indicated the variation in daily fish yields of these gears. The highest mean number of hauls in purse seine gears implied highest fish yields per day, while the lowest number of fish hauls in gill net gears denoted the lowest fish yields interms of biomass. The results of this study revealed that the mean number of hauls

in fishing gears could be explained by the mean time taken per haul. Thus, fishing gears such as gill net which recorded longer mean haul time had least mean number of hauls and purse seine gear which recorded the shortest mean haul time had the highest mean number of hauls per day.

The difference in hauling time and number of hauls per day could be explained by the nature and the operation of these gears. In Ferguson's Gulf, purse seines were set at the surface and extended down into the water column and non-motorized fishing vessel was used to encircle an aggregation of fish. Once the cycle is complete, the net was brought a board the vessel by hauling it, thus took a shorter time per haul. Moreover, purse seine gears were set off shore and in relatively deeper waters of Ferguson's Gulf therefore the need to maximize the catch by increasing the number of hauls unlike beach seine and gill net gears. On the other hand, beach seines were most often set from the rafts; one end remained on shore, while the rest of the net was set in a curved path and brought back to the beach within a shorter time. Therefore, given shorter time per haul, the beach seine and purse seine gears recorded relatively higher number of hauls per day in Ferguson's Gulf. The findings in Table 4.2 are supported by [18] that reported high number of hauls and shorter time per haul by beach seine and purse seine gears used in artisanal fishery of Kenya's South Coast.

However, in Ferguson's Gulf, gill nets were passively set at the water surface and remained relatively stationary with the use of weights. The fish were usually caught either when trying to swim through a mesh or when becoming wedged ("gilled") or when becoming entangled in the netting. The period taken to capture the targeted fish species could be longer depending on the fish movement, leading to longer time taken by gill net gears per haul and least hauls recorded per day as established by this study. This concurred with [4, 1] that reported longer haul time and fewer hauls respectively, of gill net gears used in artisanal fisheries of Pedro González in Panama and Kainji Lake Lower Basin, Nigeria, respectively.

In Ferguson's Gulf, beach seine and purse seine gears operated more or less in competition with one another with the main objective of maximizing the catch without limits on the quantity of fish caught and the number of hauls. Therefore the fishermen continued fishing until yields are so low as to be not worth the effort expended. Thus, so long as the number of fish hauls and hauling time is unlimited, in the long term, the spawning fish stock could be reduced to the point where there could be a possibility of the fish stock collapse in Ferguson's Gulf. [23] also associated the high number of hauls by purse seine and beach seine gears with a decline in the catch and an increase in the quantities of small fish of economically important species worldwide. However, the use of large mesh sizes in gill net gears of Ferguson's Gulf, could not only offer increased potential yields, but also reduce the likelihood of stock collapse, and leaves a larger mature stock as a buffer against the periods when the fish stock is low. It is therefore important that the number of hauls by beach seine and purse seine gears predominantly consisting of small mesh sizes and high number of nets should be regulated so as to avert possible fishery collapse.

## 5 CONCLUSION

Beach seine and purse seine gears consisted of small mesh sizes nets while gill net gears consisted of large mesh sizes nets. The highest number of hauls was recorded in purse seine gears which took the shortest time per haul and could lead to change in fish community structure of Ferguson's Gulf at higher fishing effort.

### *RECOMMENDATION*

- The number of fishing hauls and nets of purse seine gears should be limited so as to avoid possible overfishing in Ferguson's Gulf.
- The continued use of beach seine gear, in Ferguson's Gulf, despite the ban by Fisheries Management and Development Act of 2016, points to lack of compliance to this legislation. The fisheries stakeholders should ensure that beach seine gear is not used by artisanal fishing gears in Ferguson's Gulf so as to sustainably manage the fish resources.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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### *Disclosure of conflict of interest*

The authors declare that there are no conflicts of interest regarding the publication of this research.

*Statement of informed consent*

Informed consent was obtained from all individual participants included in the study.

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