Effect of Hanging Ratio on the Catch of Red Sole (*Cynoglossus senegalensis*), Black Sole (*Synaptura cadenati*) and Catfish (*Arius spp*) in The Gambian Bottom Set Gillnet Fishery

By: Gambia-Senegal Sustainable Fisheries Project (USAID/Ba Nafaa)

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Cover Photo: Gillnets deployed by firsherman (Left photo); Used Gillnets in a fishers village (Center photo); Catfish gilled in experimental net (Right photo).

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Acknowledgements

There is little doubt that involving stakeholders as partners in developing management plans will assist in the progress towards improved management of the fishery resources. Local fishermen contributed greatly to this study on gillnet performance. We wish to thank the fishermen of the Gambia who participated in this project. This information dramatically improved the data poor scenario and allowed very specific questions to be formulated and investigated.

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Introduction: Background

Gillnets are one of the oldest types of fishing gears and are widely used to harvest diverse marine species (Sainsbury, 1975). They are considered to be passive gear that interrupts the natural movement of fish and captures them by wedging or gilling the fish in the individual meshes. The vertical orientation of the nets is maintained by flotation on the upper line and a weighted ground-line (Figure 1). Demersal gillnets are constructed so that the sinking force of the weighted ground line exceeds the buoyancy of the flotation on the upper line. This combined with anchors along the length of the gillnet keep it in place along the bottom where the demersal fish species are found. Gillnets can be very selective fishing gear when designed and fished properly. They are simple, easy to mend, require little in terms of on board equipment and relatively cheap to purchase.

Gillnets are considered to be one of the most selective gears available. Selectivity refers to the ability of the gear to sample only a specific proportion of the population. The selectivity of a gillnet is controlled by the size of the meshes, the hanging ratio (HR) and overall dimensions of the net. Baranov's principle of geometric similarity predicts that the catch process of gillnets is a function of fish size and mesh size only. The size of the mesh will be directly correlated with the size of the species that is being targeted (Figure 2).

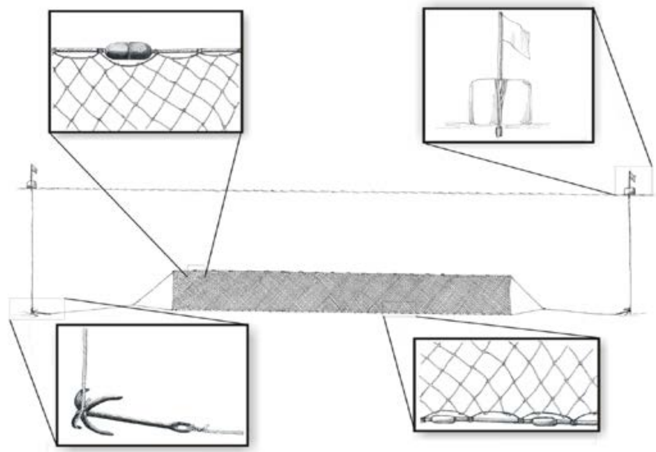


Figure 1. Bottom gillnet illustrating the headrope and footrope configuration (Courtesy of Juan Chuy Sociedad de Historia Natural, Niparaja, 2007)

Figure 2. The size of the mesh determines the size of fish captured by gilling

However, the shape of the meshes is controlled by the hanging ratio (HR) (Cullenberg, 1987; Holst et al., 1994) (Figure 3). HR goes on a scale of 0 to 1, with 0 being a mesh that has no width and 1 being a mesh that has no height. Typical hanging ratios used in commercial fishing range from 0.3 to 0.7. The body shape of the fish will help determine the necessary HR used to capture a particular species. Narrow bodied fish will require a smaller HR, whereas a wide bodied fish will require a larger HR. Knowing the behavior and morphometric characteristics of the target species is also crucial in the design and type of gillnet chosen.

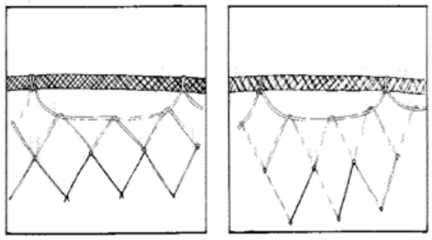
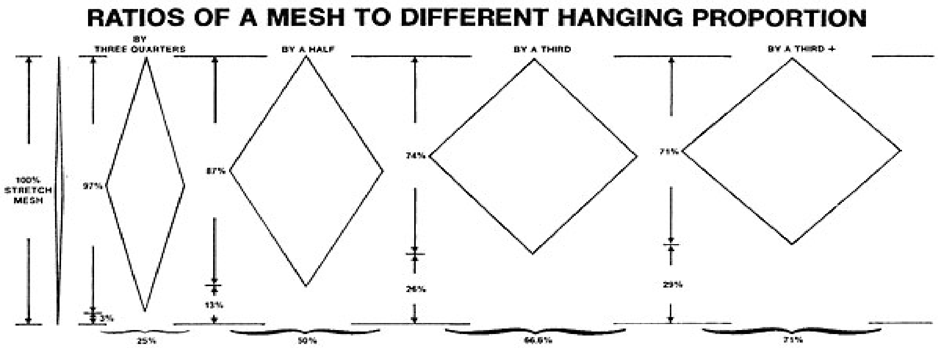
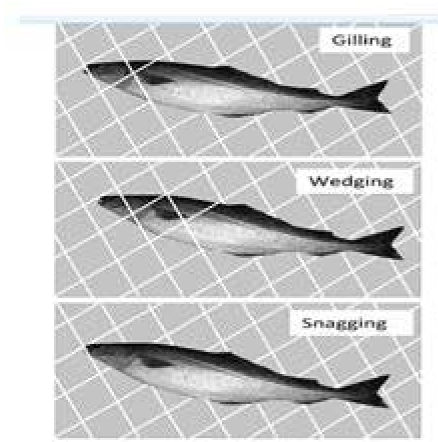


Figure 3. Examples of different hanging ratios and their effect on the mesh shape.



In addition to gilling which is the preferred capture mechanism, fish can be caught by wedging, snagging and entanglement (Figure 4). A looser hung mesh will allow for more entanglement.



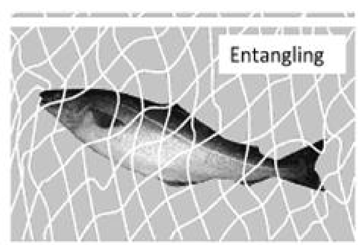


Figure 4. Various methods of capture for a fish in a gillnet.

In 2011, field observations were made in The Gambia to characterize the sole bottom set gillnet fishery (Gabis et al., 2011). The webbing was not tied to the head or foot rope and a vertical up and down line was not used. Instead, the webbing was allowed to hang loosely on the headrope and footrope giving the nets a HR of 0 (Figure 5).

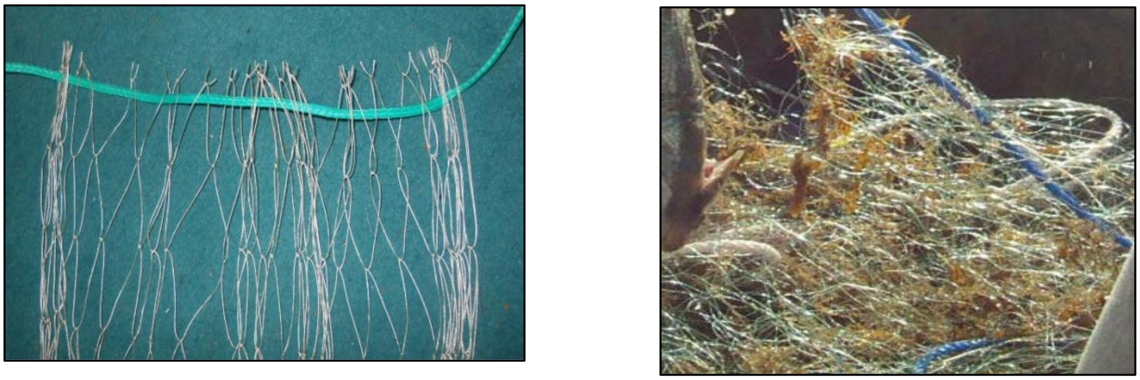


Figure 5. Gillnets for sole in the Gambia are principally used without a hanging ratio (HR). Netting is not attached to the headrope or footrope with twine but is woven loosely through the meshes. Left picture (a) illustrates the technique; picture at right (b) is the actual Gambian sole net.

Head ropes were rigged with minimal floatation. Given the range of species captured, it appeared that the net was sometimes laying on the bottom (catching invertebrates) and at times catching a wide range of sizes of pelagic and demersal fish. Therefore, the net selectivity was compromised by the lack of an HR and the lack of flotation on the headrope.

Sole and catfish species are the principal catches of the sole gillnet. The sole are red sole (*Cynoglossus senegalensis*) and the black sole (*Synaptura cadenati*). Catfish species include up to 6 species (identified by the fishermen) dominated by the smoothhead catfish (*Arius heudelot*) and the rough head sea catfish (*Arius latiscutatus*). If the net is used to target sole, there is a large bycatch of catfish species which have been identified as vulnerable species for overfishing (Gabis, et al., 2012). In order to improve the selection potential of the net for catfish, this study examined the catches of three different HRs: 0.25, 0.5 and 0.75. The objective of this research was to characterize the catch of these predominant species in the gillnet with alternative hanging ratios and make suggestions on how to reduce the catch of vulnerable species.

The null hypotheses were:

The catch of sole species (fish size and total catch) will not be affected by the hanging ratio
The catch of catfish species (fish size and total catch) will not be affected by the hanging ratio.

Materials and Methods

Description of Fishing Area

The fishing trials were conducted off the coast of Brufut village on the Atlantic coast of The Gambia (Lat 16.48.807-16.26.595 and Long 13.26.032-13.26.032). This area is characterized by exposed open coastal beaches composed of mostly sand bottom with some rocky reef areas.

Figure 6. The Gambia is located around the Gambia River surrounded by Senegal. Coastal sites are characterized by sandy open beaches. Star indicates Brufut fishing site.

Fishing trials were conducted from April 13-17, 2012; June 11-24, 2012 and July 19-24, 2012. There were a total of 21 net hauls.

Gillnet Characteristics

Control (Normal Fishing Net): This net is representing the current net style used in the fisheries. The monofilament gillnet was 84mm stretched mesh length of 0.4 mm diameter. There were nine 40 meter sections, no up and down lines were used to restrict height (fishermen stated their nets fished 1.5 meters off the bottom). The panel of webbing used was 24 meshes deep, which was determined to be the most common depth used by many of the beach fishermen. Leads were spaced every 1.5 meters and floats were added every 7 meters using traditional materials (Figure 7).

Experimental: The experimental monofilament gillnet was constructed of nine sections; three 0.25 HR sections, three 0.5 HR sections, and three 0.75 HR sections. All sections were 40 meters in length. Up and down lines were used to maintain a height of 1.5 meters. The mesh size used was 84 mm stretched mesh length. The upper line was constructed of Polyethylene (PE) and lower line was constructed of polyamide (PA). Leads were placed every 0.75 meters on the lower line and floats were placed every 2 meters on the upper line. The following guidelines indicated how the nets were to be constructed (Table 1):

Table 1. Net section characteristics.

0.25 Hanging Ratio Gillnet (3 Sections)	0.5 Hanging Ratio Gillnet (3 Sections)	0.75 Hanging Ratio Gillnet (3 Sections)
- 18 meshes deep - 4 meshes per tie - Tie length 8.4 cm	- 21 meshes deep - 4 meshes per tie - Tie length 16.8 cm	- 27 meshes deep - 4 meshes per tie - Tie length 25.2 cm

The nine 40 meter sections of the control net were attached in one gillnet in alternating sections. This allowed for each HR group to be spread out evenly and fish similar bottom types. The order of the HR went as follows: Section #1-HR 0.25, Section #2-HR 0.5, Section #3-HR 0.75, Section #4-HR 0.25, Section #5-HR 0.5, Section #6-HR 0.75, Section #7-HR 0.25, Section #8-HR 0.5, Section #9-HR 0.75 for a total n = 3 for each hanging ratio. All sections were numbered in order to identify the section as it was being hauled aboard.

For both nets, anchors were used at the beginning, along the length and at the end of the set to keep it in place during the fishing period. Up and down lines with marker flags were used to mark the beginning and end of the set to aid in identification and retrieval of the gear.

Figure 7. Construction of the nets was supervised by active fishermen to ensure an accurate representation of the fishing gear currently in use.

The nets were set cross tide parallel to each other. Approximately 50 meters was put between the gears in order to prevent tangling and destruction of the gear. The gear was alternated, control net on south side one day then on the north side the next day, in order to account for any directional migration of fish up and down the coast. The gear was fished for 24 hour sets in order to allow for a full tidal cycle to pass. When hauled back all fish were collected and data was recorded for each section. Lengths and weights were taken for each species brought aboard. Subsampling occurred when large volumes of fish were caught and could not be individually sampled.

The study was designed as a paired comparison to allow for maximization of sample size and statistical power. Each section was numbered on the experimental net and was considered a pair to the same number on the control net. The resultant parameter to be analyzed would be the difference between the total catch of each species of each pair (HR section and the control section). A t t-test would be used to distinguish if the difference is significantly different that zero.

Differences in the mean size of fish for each section would be computed and averaged for daily means and compared using a one way ANOVA with hanging ratio as the factor. Lengths of the fish in each section would be combined overall to generate a length frequency analysis and examined with a non-parametric Kolmorgov-Smirnov (KS) test to test for distribution differences between the three hanging ratios and the control net at α=0.05.

Results

The predominant catch for all nets was catfish spp. Total catch of catfish was larger than either black or red sole. The number of fish caught for each species was much larger in the control net than in any experimental net.

Total Catch

Species/HR	0.25	0.50	0.75	Control	Total
Black	20	12	5	89	126
Red	16	8	4	28	56
Catfish	35	21	20	137	213

Table 2. Total catches of the three target species for each hanging ratio.

Figures 8, 9 and 10 show the size frequencies of the fish caught by species. The KS test showed no significant difference for size distribution caught between each HR and the control net (NFN).

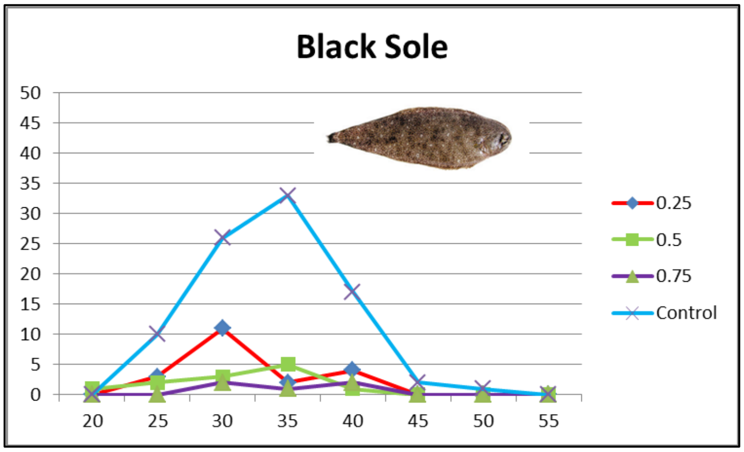


Figure 8.. Size frequency distribution of black sole caught in each hanging ratio.

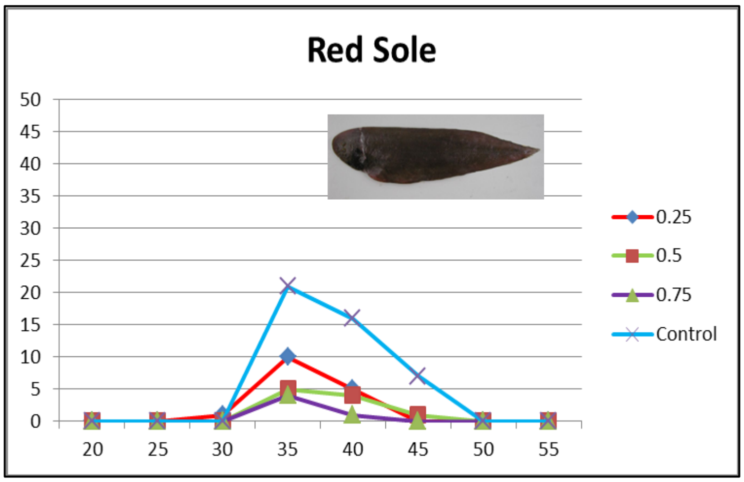


Figure 9. Size frequency distribution of red sole catch in each hanging ratio

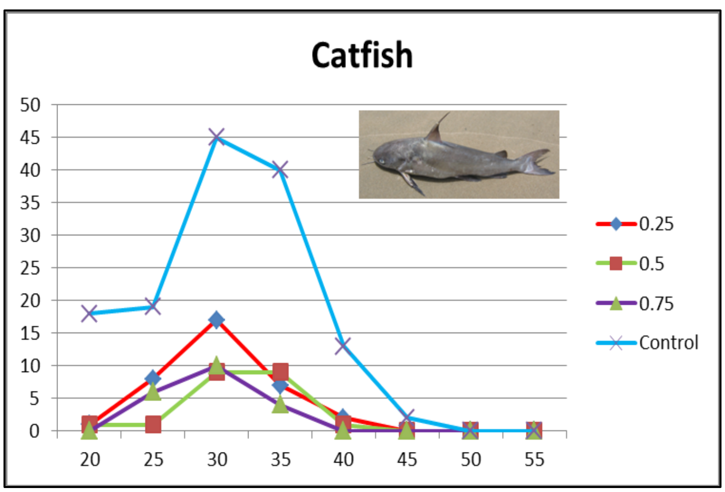


Figure 10. Size frequency distribution of catfish catch in each hanging ratio.

Mean Size

The low catches for the major species in each section prevented the effective use of paired comparisons. All data for each day for each HR were combined and daily means were calculated for the pooled data. Average sizes for each HR was then calculated for the whole study period. A one way ANOVA was performed on the within species data (following the central limit theorem for data normality) (SAS 9.2; α=0.05) (Table 3).

Net Hanging Ratio	Mean (+/- SE)	Mean (+/- SE)	Mean (+/- SE)
	Black Sole	Red Sole	Catfish
NFN (Control)	32.1 (0.54)	36.89 (0.63)	28.8 (0.51)
0.25	30.4 (0.93)	34.94 (0.64)	28.2 (0.68)
0.5	28.92 (1.6)	35.44 (1.07)	29.8 (0.92)
0.75	32.6 (1.64)	34.5 (1.26)	27.3 (0.75)

Table 3. Mean size of fish caught with standard error.

There was no significant difference between mean sizes between any HRs for red sole, black sole or catfish (P=0.23, 0.13, 0.433 respectively).

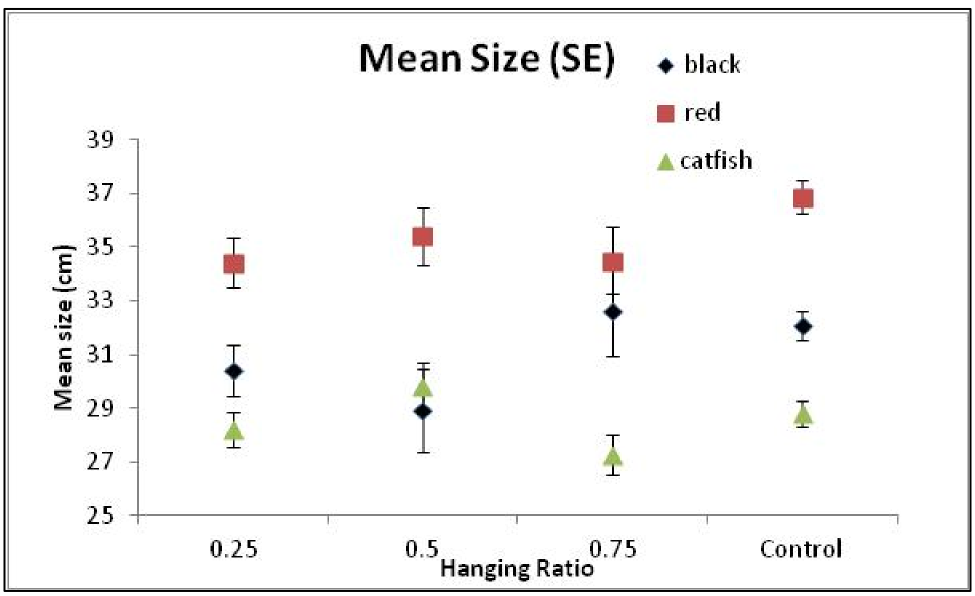
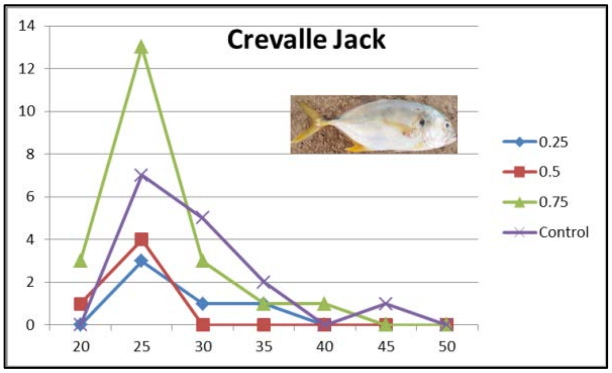


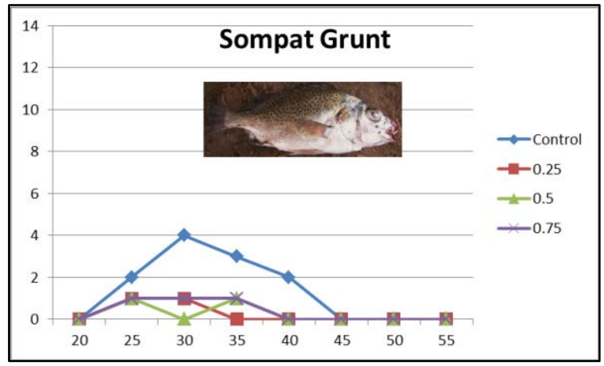
Figure 11. Mean size of each species captured per hanging ratio.

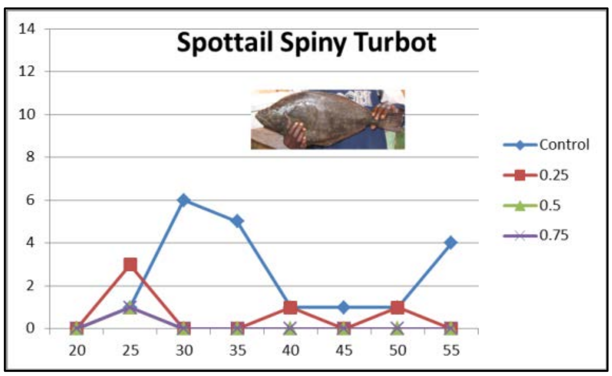
Figure 11 illustrates the mean size of each species captured per hanging ratio. Although there were no significant differences between the hanging ratios for each species, it is interesting to note the range of species caught with their respective mean size. Although data on capture technique (gilling, entangling, wedging) was not recorded, it is probable that the gear interacts with the species in different ways.

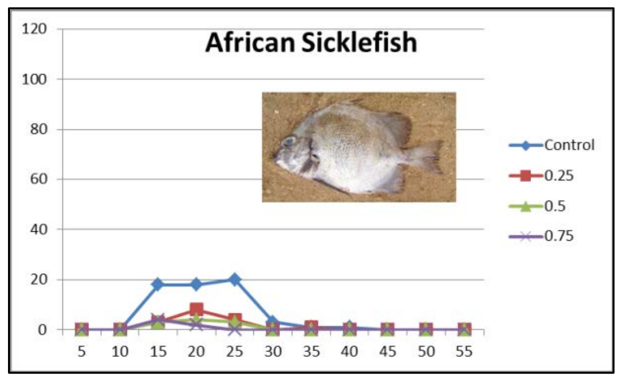
Other Species

There were several other species captured in the gillnet experiment but with numbers too low to be analyzed. These include Crevalle Jack, Sompat Grunt, Spiny Turbot, African Sicklefish and Monroe Doctorfish. The size distributions are shown for illustration only Figures 12 a-e.









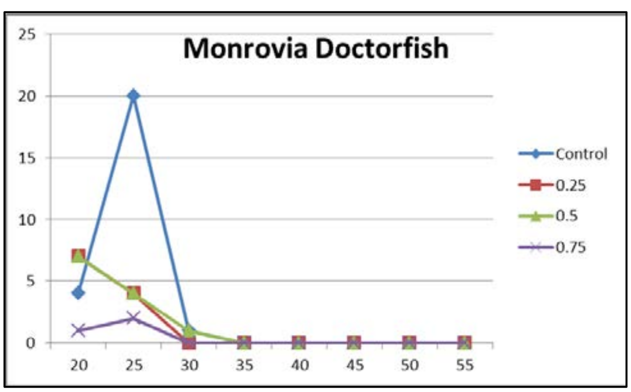
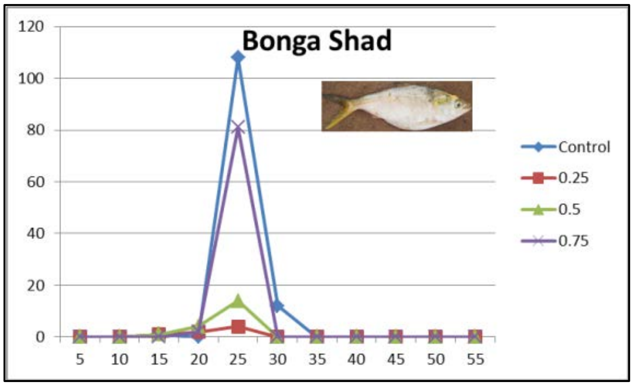


Figure 12 a-e : Size distributions of Crevalle Jack, Sompat Grunt, Spiny Turbot, African Sicklefish and Monrovia Doctorfish

Bonga shad and Atlantic Bumper were caught in higher quantities (Figure 13 a and b). There was a significant difference in mean size of Bonga shad captured (p=0.001), but not for Atlantic Bumper (p=0.96) (Table 4). Contrary to all other species, the 0.75 hanging ratio captured more numbers of Atlantic Bumper than any other arrangement including the control net.

Table 4. Mean size and standard error for Bonga shad and Atlantic Bumper

Net Hanging Ratio	Mean (+/- SE)	Mean (+/- SE)
	Bonga shad	Atlantic Bumper
NFN (Control)	24.02 (0.12)	21.24 (0.25)
0.25	19.28 (1.57)*	21.08 (0.27)
0.5	21.05 (0.60)*	21.28 (0.29)
0.75	22.35 (0.09)	21.230.15)



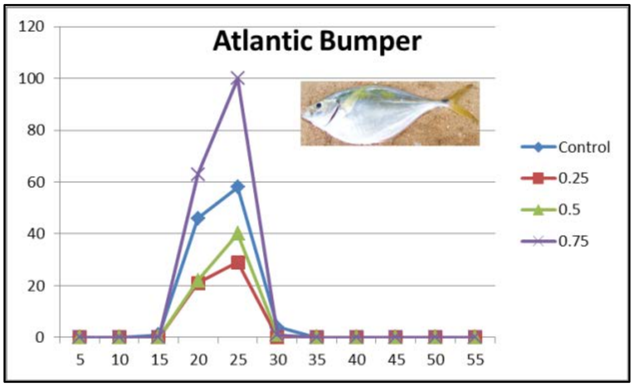


Figure 13: a (Bonga Shad) and b (Atlantic Bumper). Length frequency of fish captured in each hanging ratio.

Discussion

The hanging ratio of the gillnet has the potential to influence the mechanism for fish capture by changing the shape of the mesh size. It is expected that a round fish will be more selectively caught with a mesh shape of 0.5 while a flatter mesh shape such as 0.25 will effectively gill a flatfish. A net hung with slack (HR of 0) would be expected to catch fish primarily through entanglement catching a large range of sizes and shapes. A fish with more hard spines would also be expected to entangle.

The catch comparison information from this study found no difference between mean size of each species caught by different HR sections except for Bonga shad. There was no difference in the shape of the length frequency (KS test) between HR for the species. This result is also similar to that obtained by Ayaz et al (2010) for sea bream where there was no effect on mean size with differing hanging ratios. They attribute this result to the morphology of the fish that lacks spinous processes that could cause entanglement. This same argument could be implied for the sole species but not catfish. Photos taken during fishing trials point to extreme entanglement with the control net. Not only are most fish caught in this manner, but many bottom dwelling species were found near the floatline. Insufficient floatation will allow the net to lay on the bottom during high current situations.

Figure 14. (a) Sole entangled in control net; (b) catfish entangled in the control net and (c) catfish gilled in experimental net.

Hanging ratios are only one factor in determining net selection characteristics. Mesh size, twine type and diameter, the lack of proper floatation, and fish characteristics also play important roles and may overpower the effect of the hanging ratio. The lack of effect from hanging ratio changes may be a product of these factors plus low sample sizes.

Except for Atlantic Bumper, the control net caught greater quantities of fish. It is unlikely that fishermen will eagerly accept the use of nets that improve selection if the decrease in catch is large. Therefore this approach has little possibility of being adopted by the fishermen even if it could be proven to be more size selective. Other methods for improving size selection such as mesh size and gear design should be pursued in future studies, as well as other management tools to reduce fishing mortality of vulnerable species.

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