ASSESSMENT OF DESIGN AND CONFIGURATION OF TRAWL NETS AND TRAWLERS USED IN NIGERIAN TRAWL FISHERY

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Abstract

Trawlers and trawl net used in Nigeria have undergone some modifications as observed the world over. Direct measurement was carried on the trawl nets to establish the current design and configuration. Trawlers used average 24.12m LOA and power by 608bhp. 99% of all the trawlers are above 18m and 250bhpconsisting of medium size industrial trawler with 125 gross tonnage. Trawl net with total length of 24.15m and mono design of BRD, Square Mesh Window (SMW) is used in all the trawl nets with varying mesh sizes 35mm and 44mm. Codend extension are fitted with TED grid with top escape opening and double flap cover. 61% of the grid are installed at angle 40° - 45° while 32%, 35° - 40° and 7% are less than 35°. Three sizes of TED grid used and dominated by 34" x 34" 59%, 36" x 40" 33% and 42" x 50" 8%. Modifications allow for easy escape of sea turtle from the trawl net, maintenance of TED grid at the best angle of 45° to avoid loss of catches and larger grid size are encouraged, 35mm as BRD are illegal and urgent monitoring at sea is needed to ensure compliance with the regulation.

Keywords: Trawlers, Trawl Net, Codend Extension, Bycatch Reduction Device (BRD) and Turtle Excluder Device (TED)

Introduction

The world trawl fishery has undergone series of modification and development over the years in different areas ranging from the craft/vessel, trawl nets and fishing methods. Fishing fleets are trawl in all oceans, in many areas where there is little knowledge of the habitat (Swartz *et al.*, 2010). Bottom trawling now extends to depths of 2,200 meters (Morato *et al.*, 2006; Rogers and Gianni, 2010, Weaver *et al.*, 2011). An alternative approach to managing selectivity and efficiency of fishing is 'balanced fishing' in which fishery resources are harvested in proportion to their availability and productivity (Garcia *et al.*,2012; Jacobsen *et al.*,2014, He *et al.*,2016, Cadrin*et al.*, 2016). However, even a balanced fishing approach is expected to remain somewhat selective (Garcia *et al.*, 2012). Fassler*et al.*,2016 reported that sustainable management of marine resources and services is increasingly being based on an ecosystem approach (Levin *et al.*,2009).

In Nigeria, flagged registered fishing trawlers/vessels have increased since the outset of inshore trawl fishery in the country (Solarin*et al.*, 2010, 2011; Ambrose and Akanse 2016; Ambrose and Obienu 2016). The trawlers are characteristics by their Length Over All (LOA) and 100 – 150 Gross Tonnage (GRT) which imply that the industry is dominated by small- to medium-sized trawlers (13.0 – 25.0m LOA) owners of which are mainly foreigners (Ganapathiraju and Pitcher, 2006, Solarin *et al.*,2011,Giorgio 2012,Etim *et al.*,2015, Olaniyan 2015, Ambrose and Obienu 2016). The trawlers used double rigged/out-triggers to tow 4 trawl nets simultaneously at speed of 2 knots (1 $m.s^{-1}$) to 6 knots (3 $m.s^{-1}$) for 3 hours when trawling for finfish or shrimps depending on the license permit issued by FDF for about 50 - 55 days (Solarin*et al.*2011). The trawl fishery has been reported to be overcapitalized (200 to 300 additional vessels are licensed annually), and existing vessels are slow to adapt to new fishing practices and gear innovations, thereby reducing fleet efficiency (Banks and Macfadyen 2011; Giorgio 2012; Belhabib *et al.*2015 and 2016). Additional factors were reported to affect the efficiency of the vessels which is return on investment (earnings). This is attributed to low performance of the vessel due to quantity of fish landed and this was accessed through analysis of the catch sales or market price of the quantity (Effiong *et al.*, 2015; Effiong and Eke 2016). The industry has witness reduction in the number of registered operational vessels and declining profitability which was attributed to the prohibitive cost of fuel (Automotive Gas Oil) which constitutes the highest proportion of operational cost (Effiong *et al.*, 2016).

Many studies have been carried on the statics and dynamics of trawl gear in order to improve its performance and efficiency (warp, otter board and trawl net) using dimensions of net width, net height, warp tension (Engås, 1994, Cho and Go 2000, Hu *et al.*, 2001, Matuda, 2001, Lee *et al.*, 2001, 2005, 2008, Park, 2005 and 2007, Fujimori *et al.*,2005,Juza *et al.*, 2010, Prat *et al.*, 2008, Park, 2014). These modifications include strategies like increasing codend mesh size or using meshes with

square geometry (Fonteyne and M'Rabet 1992, Guijarro and Massutí, 2006, Ordines *et al.,* 2006, Santos *et al.,* 2016). Square mesh geometry facilitates escapement for roundfish species, while the effect on flatfish selectivity is unclear or negative (Guijarro and Massutí, 2006; Fonteyne and M'Rabet1992, Robertson and Stewart, 1988). The size selection of fishing gears is described by selectivity curves, which quantify the probability that a given length class of a given fish species will be caught, assuming that it is available to the gear. Selectivity curves differ between gear types and configurations of gears (Dickson *et al.,* 1995, Wileman *et al.,* 1996,Hovgård and Lassen, 2000,Stepputtisa, 2016)

Trawl nets used in Nigeria have also undergone some modifications as observed the world over. Ogbona 2001 reported technical detail of the trawl net (37.4m) length used in the trawl industrial fishery. Solarin *et al.*2005 reported modification in the technical details of the trawl net used in the industry shrimp fishery. The modification include the inclusion of a codend extension region where TED is installed and thereby increase in the trawl net length (40.4m) (Solarin *et al.,* 2005, 2011). In 1996, TED became a pre-condition and a regulatory requirement for all nations which export shrimps to the United States (Solarin *et al.,* 2005, 2011). This is accordance with the Turtle Conservation Regulations of Fisheries Act of Nigeria (decree) No 71 of September, 1996 (a supplement of the Sea Fisheries Act (decree) No. 71 of 1992. The Nigerian Institute for Oceanography and Marine Research (NIOMR) in collaboration with the FDF developed the locally made TED with super shooter or bent rod weed less grid for adoption by the Industrial fishermen (Solarin*et al.*2005, 2011). Solarin *et al.,* 2011 reported that hard TED grid with minimum size of 81.0cm by 81.0cm, are installed in codend extension made of polythene (PE) synthetic netting material with R1500 tex twine thickness and 45 or 50mm mesh size while Fakoya*et al.,*2015 reported stretch mesh size of 44mm and 76mm for shrimp and fishes respectively. The angle of inclination of the grid is best at 45°. Many of trawl nets are fitted with TED with bottom escape opening (Solarin *et al.,* 2003, 2005 and 2011, Ambrose and Obienu 2016) while Ambrose and Obienu reported one fishing company using the top opening escape for the TED.

This paper surveys the industrial trawl fishery with a focus on the establishing the current trawl net configuration and trawlers operating in Nigerian waters.

Materials and Methods

A total of 196 trawl nets from 49 vessels using 4 trawl nets per vessel were survey inAugust 2013 at ApapaFishing Port terminal, Lagos State. Secondary data of all registered vessels were obtained from Federal Department of Fisheries during the survey period which include the vessel details such as Length Over All (LOA), Brake Horse Power (BHP) and Gross Tonnage. Direct measurement was carried on the trawl nets used in Nigerian Industrial Inshore Fishery in other to establish the current design and configuration according to Udolisa and Solarin (1982). Measurements were carried out using Keson Fiber Glass Meter tape model OTR10M50 and NeikoDigital Vernier Caliper/Micrometer Gauge, Model: JEW95VC150 was usedto the nearest cm and mm respectively. A digital angle meter Pittsburgh Digital Angle Gauge, Model 95998 was used determine angle of TED grid installation. Secondary data was collected from Federal Department of Fishery (FDF) on annual bases of the vessel types and configuration in the industry. The trawlers were classified according to Banks and Macfadyen 2011 which is based on LOA andbrake horse power (BHP).

Results

Summary of the configuration of 119 industrial inshore trawlers registered and operating in Nigerian waters during the study period are presented in Table 1. Trawlers used in the industry ranges 13.30 m-25.91 m with an average of 24.12 m LOA and power by 520.61 bhp-617 bhp with an average of 608 bhp. The classification of 119 industrial inshore trawlers registered and operating in Nigerian waters during the study period are presented is presented in Fig. 1 and 2.

Table 1 : Summary of Description of Trawler operating in Nigerian Inshore Trawl Fishery

Description	Minimum	Maximum	Average
Length of All (LOA) (m)	13.30	25.91	24.12
Gross Tonnage (mt)	89.00	150.00	125.16
Brake Horse Power (BHP)	520.61	671.00	608.00

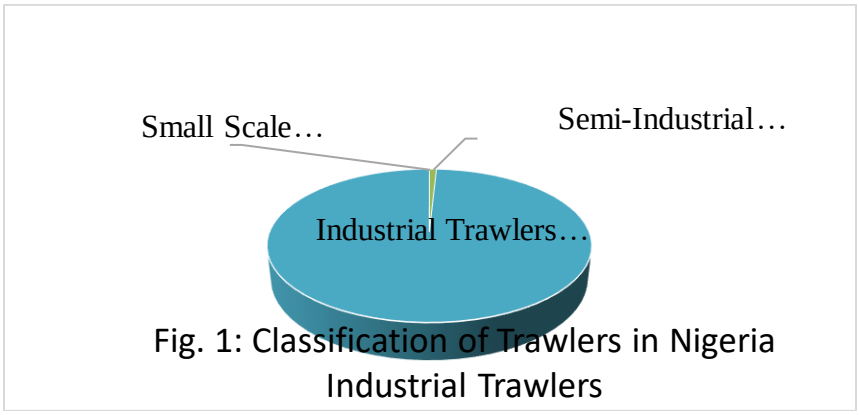

Fig. 1: Classification of Trawlers in Nigeria

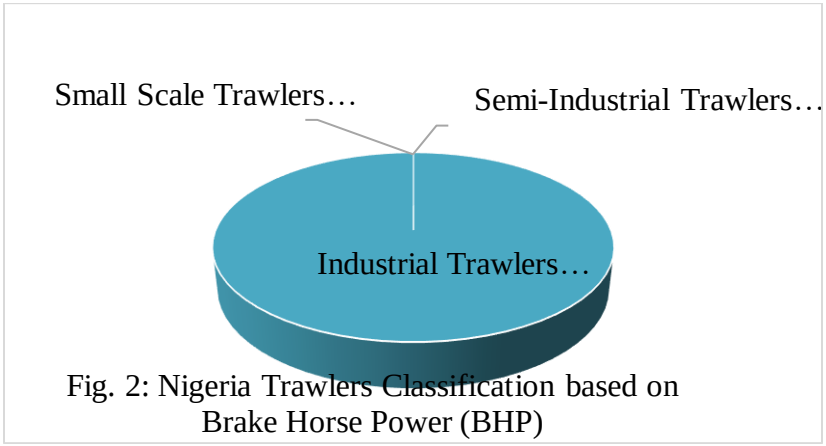

Fig. 2: Nigeria Trawlers Classification based on Brake Horse Power (BHP)

Trawlers with LOA of 19m upward dominated the industry constituting 99% of all trawlers used and are propel by brake horse power greater than 250bhp as indicated in Fig. 1 and 2.

Trawl Net Design

A total of 196 trawl net installed with TEDs were studied and technical configuration and design of the industrial trawl net currently in used is presented in Table 2 and Fig. 3.

Table 2: Configuration of Industrial Trawl Net used in Nigerian Inshore Trawl Fishery

Description	No. of Meshes	Length (m)
Wings (50mm Mesh Size)	100	5
Body (50mm Mesh Size)	235	11.75
Codend Extension (50mm Mesh Size)	60	3
Codend (44mm Mesh Size)	100	4.4
Head Rope		21.34
Foot Rope (Chain 20mm)		24.38
Square Mesh Window (35mm and 44mm Mesh Size)	50 x 50	
Turtle Excluder Device (TED) Opening	60 x 160	

The nets are constructed with 50mm mesh sizes from the wings to the codend extension, while the codend is constructed with 44mm mesh sizes. Square Mesh Window bycatch catch reduction device were constructed from 2 mesh sizes 35mm and 44mm (Table 2).

Head Rope of 21.34m and foot rope of 24.28m are used for trawl nets opening, with body of the net 11.75m long consisting of 50mm mesh size net (Fig. 3).

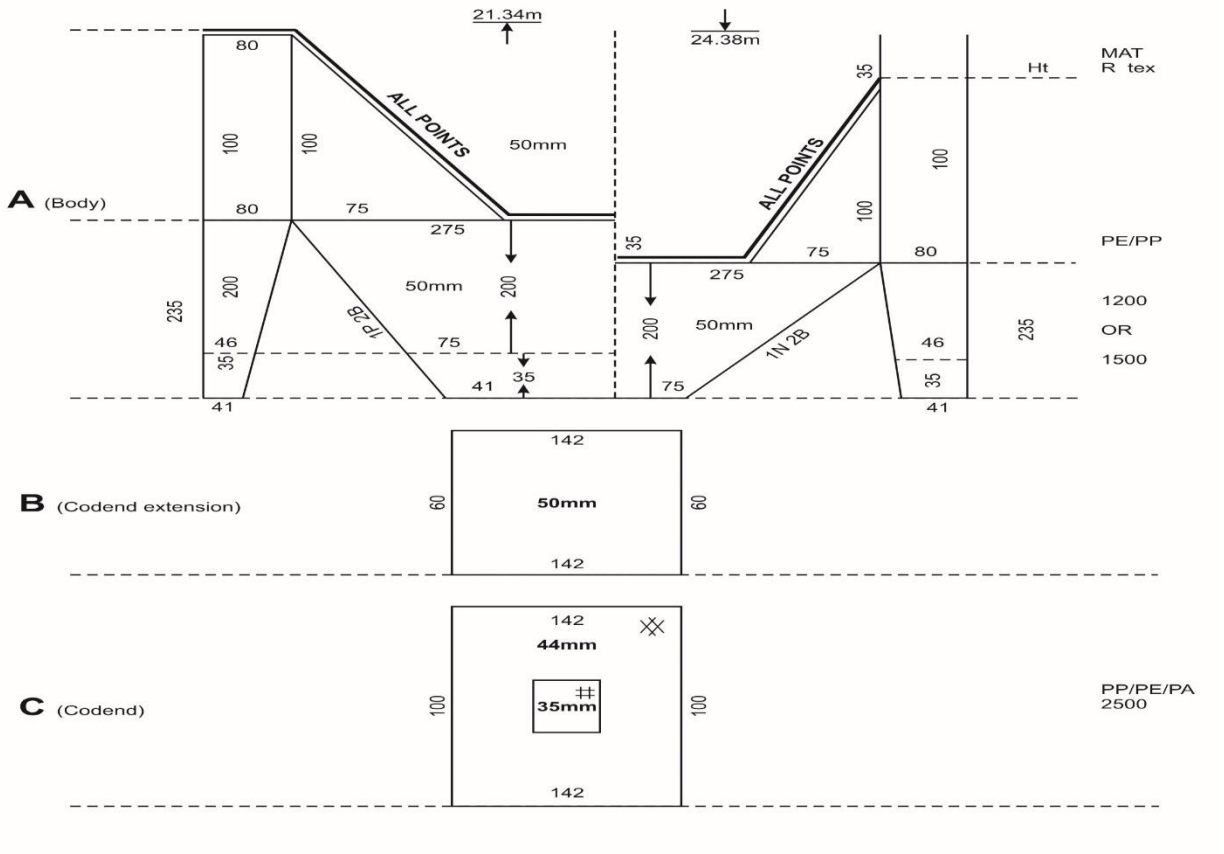

Fig. 3: Technical design of the industrial trawl net used in Nigerian Inshore fishery.

Modified codend extension construction details indicating the double cover escape opening, angle of grid installation and belly rope (Fig. 4).

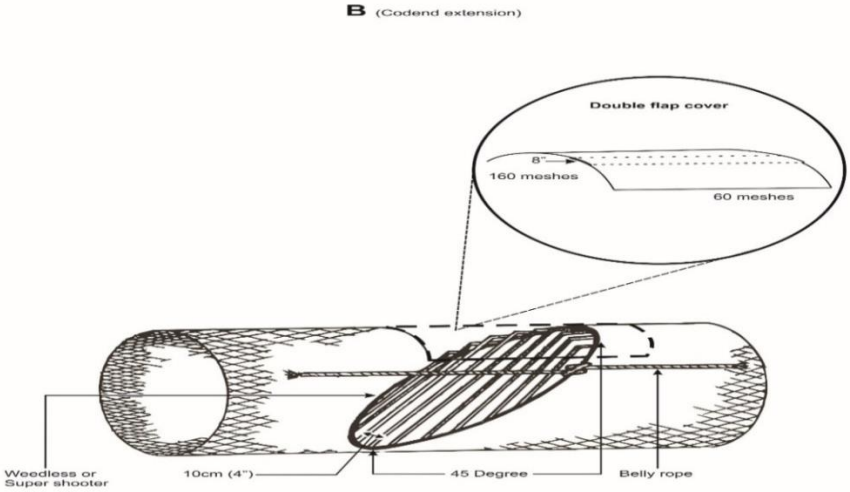

Fig. 4: Codend extension installed with turtle extruder device (TED) at angle 45ºand a double flap cover

Codend extension are fitted with TED with an escaped opening covered with Double flap cover and TED grid is held at angle 45ºwith bell rope (Fig. 4).

Square Mesh Window (SMW) constructed with 35mm mesh size on some codend of trawl net used in the industry (Fig. 5).

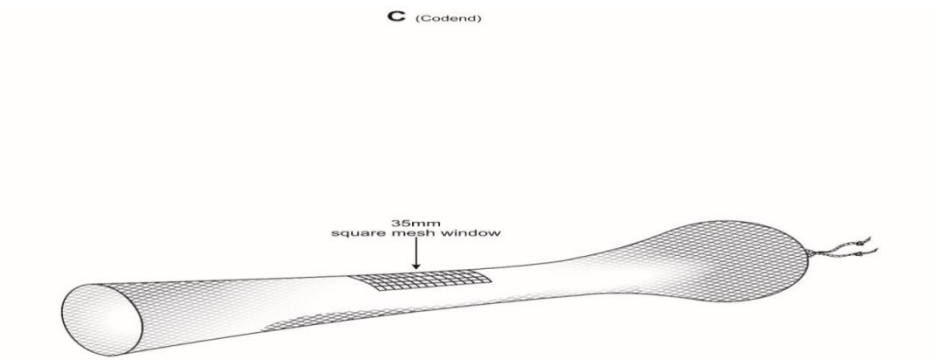

Fig. 5: Codend installed with square mesh window (SMW) Bycatch Reduction Device (BRD).
A mono design of BRD namely Square Mesh Window (SMW) is recorded in all the trawl net (Fig.5).
Each vessel tow 2 pairs of trawl nets (4 nets) attached to outrigger 1 pair on each side of the outrigger. The nets are separated dummy door on each side before attachment to 300kg wooden otter doors (Fig. 6 and 7).

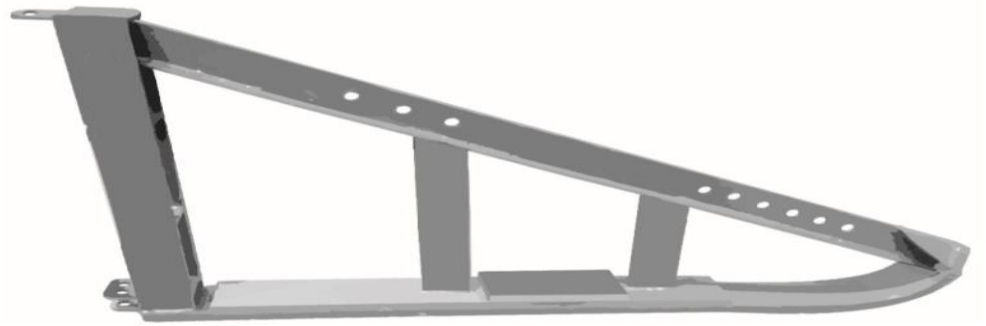

Fig. 6: Dummy door used to separate a pair of trawl net on outrigger during trawling

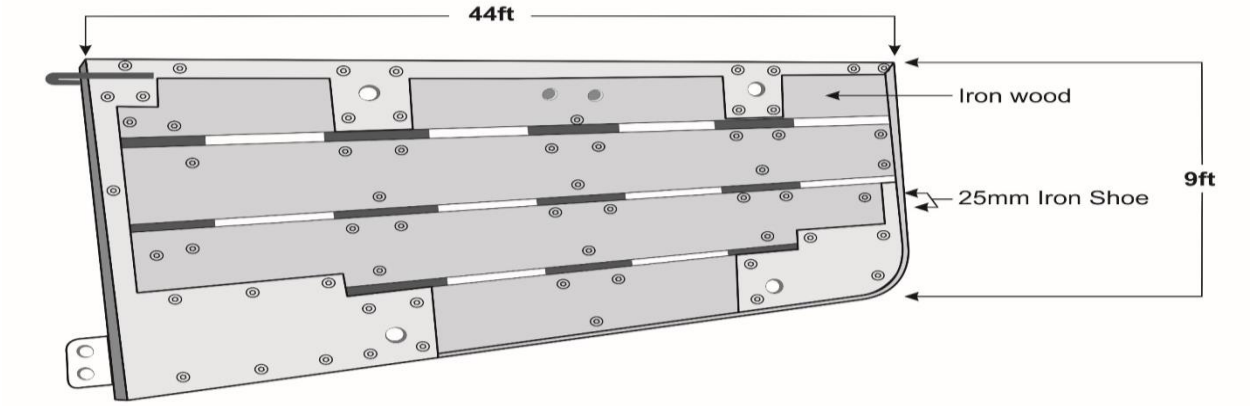

Fig. 7: Wooden otter door used in Nigerian Inshore trawl fishery.
Three sizes of TED grid were recorded on the trawl nets which is dominated by 34" x 34" (86.36cm x 86.36cm) constituting 59%, 36" x 40" (91.44cm x 101.6cm) 33% and 42" x 50" (106.68cm x 127cm) 8% (Fig. 8), installed at three different angles dominated by 40º - 45º 61%, 35º - 40º 32% and less than 35º constitute 7% (Fig. 9) during the study period.

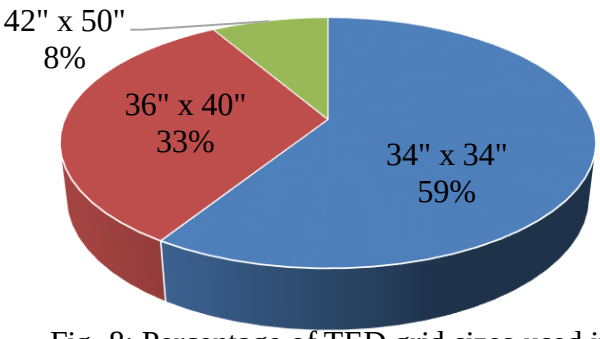

Fig. 8: Percentage of TED grid sizes used in Nigerian Trawl nets.

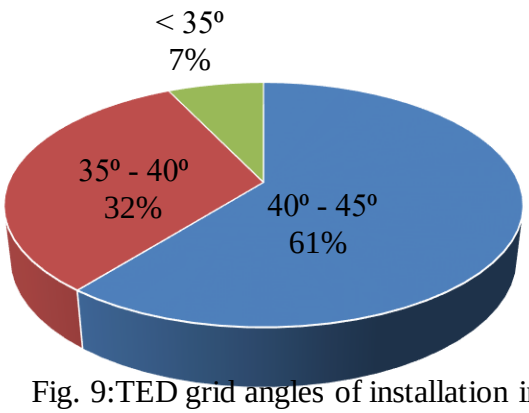

Fig. 9:TED grid angles of installation in Nigerian trawl nets.

The percentage composition of TED grid sizes used in Nigeria trawl net is presented in Fig. 9 and prevailing angle of installation is presented in Fig. 10.

Discussion

Trawlers used in the Nigeria industrial inshore trawl fishery ranges 13.30 m -25.91 m with an average of 24.12m Length Over All (LOA) and power by 520.61 bhp-617 bhpwith an average of 608 bhp. About 99% of all the trawlers are above 19m and are propelled by 250bhp which agrees with Etim *et al.*, 2015, which reported 25m LOA and 150 gross tonnage while Ambrose and Obienu (2016) reported a range of 13m – 25m and 130 gross tonnage. According to Banks and Macfadyen (2011) the industry cannot be said to consist of small-medium trawlers as reported by several authors (Ganapathiraju and Pitcher, 2006; Solarin *et al.*, 2011; Giorgio 2012; Etim *et al.*, 2015; Olaniyan 2015; Ambrose and Obienu 2016) rather the industry consist of medium industrial trawler since 99% are above 19 m LOA powered by 250 bhpand average of 125 gross tonnage although a maximum of 150 gross tonnage is recorded in the industry.

Trawl net used in the industry has undergone further modification as observed in this study, head rope of 21.34m and foot rope of 24.28m were recorded with total body of the net 24.15m which does not agree with Ogbona (2001) who reported technical detail of the trawl net of 37.4m and Solarin *et al.*, 2005 and 2011 reported an increase in the trawl net length to 40.4m.

A mono design of BRD namely Square Mesh Window (SMW) is recorded in all the trawl net with varying mesh sizes between 35mm and 44mm which does not agree with several authors (Ogbona 2001; Ambrose and Obienu 2016; Fakoya *et al.*, 2015, Solarin *et al.*, 2005, 2011 and 2016)that reported between 44mm and 50mm mesh size. The smaller

meshes might have been introduced to reduced escape of juvenile fishes and perceived escape of target species with an intent to increase fish catches, the observed 35mm are illegal meshes as stipulated in the Sea Fisheries Act (decree) No. 71 of 1992.

All the codend extension used in trawl net in the industry are fitted with TED grid with top escape opening and covered with double flap cover which agreed with. Solarin *et al.,* (2016) and a modification over Solarin *et al.,* 2005 and 2011who reported a single flap cover and Ambrose and Obienu 2016 who reported a bottom opening for one of the company.Grid angle of installation of 45° recorded in the study agrees with report of someauthors since 61% of the grid are hanged at angle range of 40° - 45° while 32% are installed between 35° - 40° and 7% are observed to be less than 35°which implies that the industry is losing high volume of its catch since 39% of the grid angle is lower than 45°. The angle of inclination of the grid is best at 45° according to Broadhurst, 2000; Eayrs, 2005 and 2007 which implies that the industry is losing high volume of its catch since 39% of the grid angles are lower than 45° although 61% are installed appropriately. This could be due to inappropriate angle of installation and lack of monitoring on the part of the skippers to maintain the angle at 45° during and after voyage. In order that address the challenge a bell rope has been introduced to hold and minimize shifting of the grid angle during trawling.

Three sizes of TED grid were recorded on the trawl nets which is dominated by 34" x 34" (86.36cm x 86.36cm) constituting 59%, 36" x 40" (91.44cm x 101.6cm) 33% and 42" x 50" (106.68cm x 127cm) 8%, although installed at three different angles recorded during the study period which is slightly different from the observation of Solarin *et al.,* 2005 and 2011 who reported minimum size of 81.0cm by 81.0cm.

Conclusion

Nigeria Industrial trawl fishery and trawl net used have undergone series of modification in trawler size and trawl nets configurations. The reported modifications are improvement over the previous design of trawl net used in the industry in other to allow for easy escape of sea turtle from the trawl net, maintenance of TED grid at the best angle of 45° to avoid loss of catches and larger grid size are encouraged which is currently the list used. However, reported 35mm mesh sizes observed in some trawl net for the BRD is illegal and requires action on the part of the monitoring agent Federal Department of Fishery to put in place mechanism for sea boarding and monitoring of the trawlers to ensure compliance with the regulation at the jetty and sea during fishing period.

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