Sea Evaluation of Flapper Bycatch Reduction Device in Stow Net Shrimp Fishery

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Abstract: Comparative fishing trials with conventional and modified stow net bunts were carried out in nearshore Atlantic Ocean. The bunt was modified by incorporating flapper bycatch reduction device at 75% bunt length from tip. The stow nets were anchored in a gang of 30 sets; 15 conventional and 15 modified nets. Simultaneous setting and hauling operations of both category of stow net bunts showed that the flapper bunt significantly reduced the bycatch of juvenile fishes up to 54.4% (T-test, P<0.01) with no significant reduction (5%) in the quantity of the target shrimps, *Nematopalaemon hastatus* (T-test, P>0.01). Fusiform shaped and small sized fishes with total length range of 3-10cm were highly reduced in the flapper but while larger bycatch species (11-20cm TL) with morphometric body projections were retained for bycatch livelihood trade. The difference in the behavior of shrimps and fin fishes in relation to tidal current in the bunt which allowed the separation process is discussed.

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Introduction

White shrimps, *Nematopalaemon hastatus* fishery is artisanal and open access enterprise. It is exploited by over 3000 fishers residing in Atlantic coastline of Nigeria, near river mouths. The fishing gear employed is stow net described by Nedelec (1982) and is operated by three different methods based on the habitat (Udolisaet al.1994). In the estuary, it is passively operated by staking with its mouth opened against the direction of tidal current. In near shore sea, it is operated actively by towing as an improvised beam trawling (Ambrose and Williams 2003) and by anchoring in a 'gang' of 25 to 40 nets with mouth opening against the direction of tidal flow for catch retention (Ambrose 2009). Anchored stow net fishing for white shrimps occurs throughout the year and involves securing the net in nearshore sea with depth ranging between 10-20cm at low tide.

As expected anchored and towed stow net catches more shrimps and at the same time catch and retain large quantities of non-target andmultiple species of individuals organisms collectively called 'bycatch' (Saila1983), which consist of several commercially important species of fin and shell fishes. It is estimated that nearly seven million tons of fish bycatch is discarded globally by commercial fishermen every year, in which tropical shrimp fisheries account for a lion share of about 27% global total (Kelleher 2005).

Incidental catching of juvenile fishes from nearshore sea which is ecologicallya fragile habitat, being the spawning ground for gravid adult and nursery ground for young fishes by actively operated stow net is considered to be unsustainable and environmentally harmful. This has a potential of impacting on the future yield and stock recruitment into the fishery of other inshore and offshore fisheries in Nigeria targeting mature stock of bycatch with otter trawl and gill nets.

As a prerequisite to gear modification to reduce the bycatch, an observer programme which involved both fisheries dependent and independent surveys was conducted for one year. The results obtained from this survey studies elucidated that; (I) the bycatch species consist of twenty species from 16 families with a total length range of 3cm to 20cm; (II) the fishery is all year round enterprise, dry season recorded the highest yield of target shrimps and less bycatch and vice versa in wet season, (III) more bycatch and less shrimps are caught during high tide than during low tide (Ambrose 2009).

It is likely that increase of mesh size of stow net bunt from the present 10mm stretched, to 20-50mm to reduce the 20 juveniles of bycatch species incidentally caught and killed would as well result to the loss of large quantity of targeted shrimps. To avoid the economic loss of market shrimps, other options of mitigating the bycatch problem was sought. Reducing the bycatch of unwanted species from actively operated fishing gear such as stow net, beach seine and trawl net in recent years is achieved through physical modification to conventional bunt by incorporating bycatch reduction device (BRD) to improve selectivity (Broadhurst 2000). Sea evaluation of BRD's such as square mesh, and fish eye which employed behavioral differences between shrimps and bycatch species have been conducted by many researchers (Broadhurstet al. 1996; Thorsteinsson 1992; Ambrose 2005). Flapper or 'fish escape cut' belongs to this category of BRD, its utility in bycatch reduction and target shrimp retention have not been done despite the fact that it is the simplest among all the modifications to shrimps bunt (Eayrs 2005).

Our specific goals in this research were to complete a series of sea experiment under normal commercial fishing conditions to assess the shrimps retention and by-catch exclusion characteristics of a flapper BRD inserted in the anterior bunt of stow net that operates in Nigerian neashore Atlantic.

Materials and Methods

Study site and fishing unit

Fishing trials with the flapper bunt and conventional bunt were conducted by a 4-man fishing crew using a wooden fishing craft of length overall 9.5m, powered by 25HP outboard engine. Near shore Atlantic ocean with depth ranging from 10m to 20m off the mouth of Cross River, South East Nigerian coast (Latitude $4^{o}30^{1}$ to 5^{0}' N and Longitude 8^{o} 10' to 8^{o} 30' E) was fished with anchored stow net in 2014. The stow net employed for the research was conical in shape and made of six panels joined with a take up ratio of 1:2 (Fig.1). The mouth of the net was salvaged with a thicker netting panel (R380 tex) and the mesh size was larger (20mm) than other segments to withstand pulling tension from tidal and ocean currents.

The stow net bunt used in the study measured 252 meshes from anterior to posterior tip, 204 meshes in circumferences and were constructed from 10mm mesh size, knotless and braided netting. The lift and spread of the mouth was respectively 2.5m and 2.8m and was achieved by a wooden stake and beam of diameter 4cm.

Modifications of bunts

The flapper was designed simply as a 'hole' and was located in the top of the bunt through which fish can voluntarily swim out from the stow net. It was constructed according to the method outlined by Eayrs (2005). Two 10 bar cuts were made to form a triangular flap of netting in the anterior and upper panel of bunt. The flapper was located at 75% position from bunt tip (Fig.2). The edges of the flapper was reinforced with twine to prevent damage to the netting. The flap was fold back and attached to the apex of the triangular flap to the bunt five meshes ahead of the escape opening.

Evaluation of bunts

The nets were anchored in a 'gang' of 30 sets. Each net carries a plastic buoy to show setting spot. In the gang of 30 set nets, 15 bunts were modified to incorporate flapper BRD, while 15 were conventional bunts without flapper. They were set and hauled at the same. Soaked period lasted for 4-6 hours.

Two hauls were made per trip at high and low tides. At low tide, nets were set with the mouth facing north pole and at high tide, it was set with its mouth facing south pole for catches to be filtered and maintained by tidal current. The modified bunts were compared against the conventional bunts in an independent paired fishing trial using simultaneous soak and hauls method on an established shrimping ground (Pettovello 1999; Thorsteinson, 1992). Over one year, a total of 30 replicate landings were completed.

Data collected

After each haul, the bunts were emptied into plastic buckets labeled A and B for modified bunts and conventional bunts respectively.

On board sorting of fishes from shrimps started toward shore and was completed upon landing at shore. The fishes were identified with the aid of available key (Scheider, 1990). All organisms were sorted into species and higher taxa. The following data were collected from each landing: (a) the total weight of bycatch species in kilogram (b) the total weight of shrimps in kilogram (c) the weight number and sized of commercially important fin and shell fish species (Broadhurstet al. 1996; 1999).

Analysis of catch data

Catch data from all the 30 replicate landings, for each of the treatment in the paired comparison were pooled for analysis. The weight of bycatch species and target shrimps from both the conventional bunts and flapper bunts were compared.

The null hypothesis that the weights of landings (shrimps, total bycatch species and commercially important bycatch species) from conventional and flapper bunts do not differ was tested using two-tailed paired T-test.

Results

The mean catch of bycatch species was significantly less in the flapper bunt ($P<0.01$, Table 1) than in conventional bunt. The modified flapper bunt reduced 5% and 54.4% of target shrimps, *Nematoplaemon hastatus* and bycatch species respectively (Table 1). Large and flattened fishes, and fishes with morphometric body projection have high probability of retention by the flapper bunt, example *Cynoclossus senegalensis* ($P>0.01$), *Callinectes* *amnicola* (P<0.05), *Dasyatis margarita* (P<0.05; 0.01) *Drepane Africa na* (P<0.05) and *Sepia elegans* (P>0.01, Table 2). Fusiform shaped and small sized fishes with total length range of 3-10cm were highly reduced in the flapper bunt e.g. *Epinephelus aenus* (P<0.01), *Trichiurus lepturus* (P<0.01), *Pomadasys jubelini* (P<0.01), and *Chloroscombrus chrysurus* (P<0.01, Table 2).

The three species of mostabundance and prioritized bycatch species of croakers, *Pseudotolithus species* were highly reduced in flapper bunt (P<0.01, Table 2). Most of fish bycatch species retained by modified bunt (46.40%) were larger size species (11-20cm, TL) that could not pass through the escape hole of the flapper.

Table 1: Weights (kg) of target shrimps and total bycatch species from 30 replicate hauls each from conventional bunt (O) and flopper bunt (F) used in T-test comparison (F against O ; N = 30; xp< 0.05 xxp< 0.01).

No. of hauls	Conventional bunt (O)		Flapper bunt (F)	
	Target shrimps	Total bycatch Species	Target shrimps	Total bycatch species
1	6.8	1.2	7.1	0.8
2	14.1	1.8	8.5	0.3
3	5	0.9	6	1.1
4	10.2	1.5	9.5	0.2
5	20.6	2.1	12.6	1.1
6	13	1.3	15.6	1.1
7	15.1	2.1	15.7	0.8
8	22.7	3.2	18.1	1.0
9	14.2	1.9	12.5	0.6
10	15	2.2	16.1	1.6
11	16.3	3.1	11.2	0.6
12	14.2	2.3	15.5	0.5
13	17.1	2.1	10.1	0.2
14	15.2	2.8	10.9	0.9
15	10.5	0.9	12.8	1.1
16	12.1	1.2	8.1	0.1
17	8.9	0.8	12.2	1.1
18	11.1	1.2	13.8	0.7
19	9.1	1.1	9.2	0.5
20	5.2	0.4	11.6	0.3
21	10.8	0.5	8.0	0.5
22	4.1	0.2	6.1	0.5
23	2.3	0.5	7.5	0.3
24	4.4	1.1	2.8	0.2
25	3.2	0.9	2.6	0.3
26	2.1	0.4	3.1	0.5
27	3	0.6	4.2	0.2
28	2.1	0.2	2.1	0.2
29	3.8	1.0	3.3	0.4
30	2.4	0.8	2.8	0.6
Total	194.6	40.0	279.6	18.3
Mean	9.82	1.34	9.32x	0.61x,xx
% Reduction			5.0	54.4

Table 2: Average weights (kg) of commercially important bycatch species from 30 replicate tows (N) from conventional bunt (O) and flapper bunt (F) used for t-tests comparison (F Versus O).

Names of species	Family	O	F	Percentage reduction in F[(mean in O – mean in F)/mean in O] x 100	Statistical inference xp<0.05 xxp<0.01 yp>0.05 yyp>0.01
Lutjanusdentatus	*Lutjanidae*	2.5	0.8	68.0	**x, xx**
Dasyatis margarita	*Dasyatidae*	1.5	1.61	-7.3	**Xyy**
Pomadasysjubelini	*Pomadasyidae*	2.1	1.1	47.6	**x, xx**
Chloroscombruschrysurus	*Carangidae*	1.3	0.5	61.5	**x,xx**
Selene dorsalis	*Carangidae*	1.28	0.79	38.2	**X**
Sepia elegans	*Sepiidae*	1.3	1.71	-31.5	**y,yy**
Callinectesamnicola	*Portunidae*	2.1	2.0	4.7	**y**
Galeoidesdecadactylus	*Polynemidae*	3.78	1.6	57.6	**x**
Pentanemusquinquarius	*Polynemidae*	2.2	0.38	82.7	**x,xx**
Drepaneafricana	*Drepanidae*	1.63	1.48	9.9	**y**
Cynoglossussenegalensus	*Cynoglossidae*	1.5	2.1	-40	**y,yy**
Pseudotolithuselongatus	*Sciaenidae*	4.22	1.8	57.3	**x**
Pseudotolithussenegalensis	*Sciaenidae*	3.5	2.0	42.8	**x**
Pseudotolithustypus	*Sciaenidae*	2.0	0.63	68.5	**x,xx**
Ilishaafricana	*Clupeidae*	2.1	1.1	47.6	**x**
Trichiuruslepturus	*Trichiuridae*	7.1	2.8	60.6	**x,xx**
Epinephelusaenus	*Serranidae*	1.8	0.5	72.2	**x,xx**

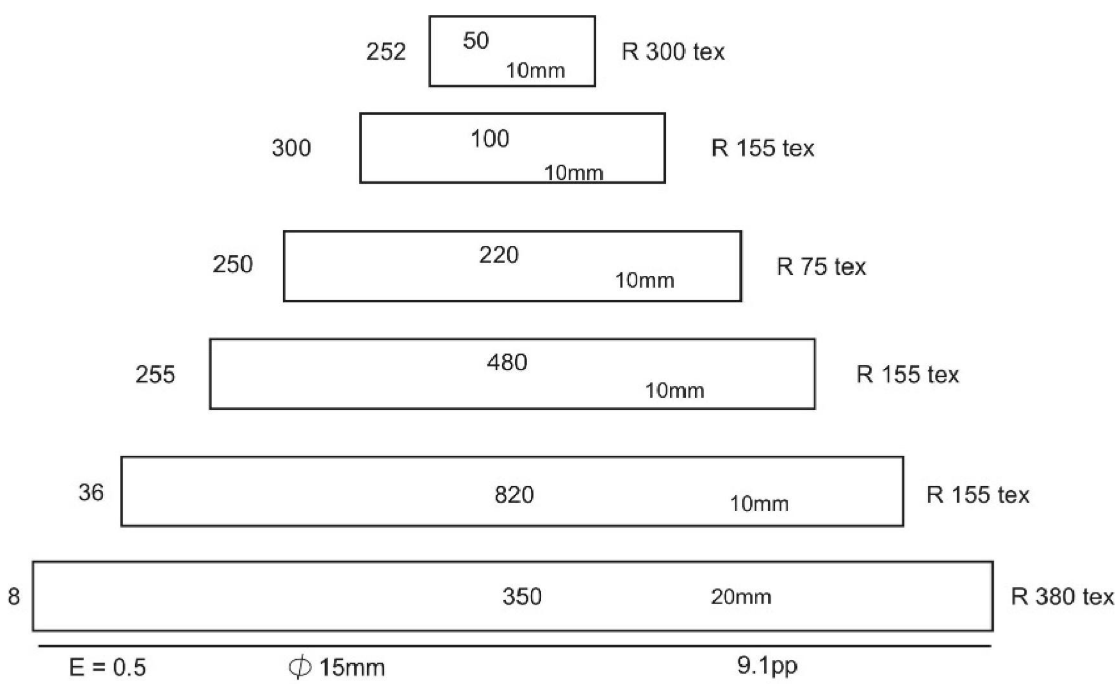

Fig. 1. Design specification of stow net used in the study

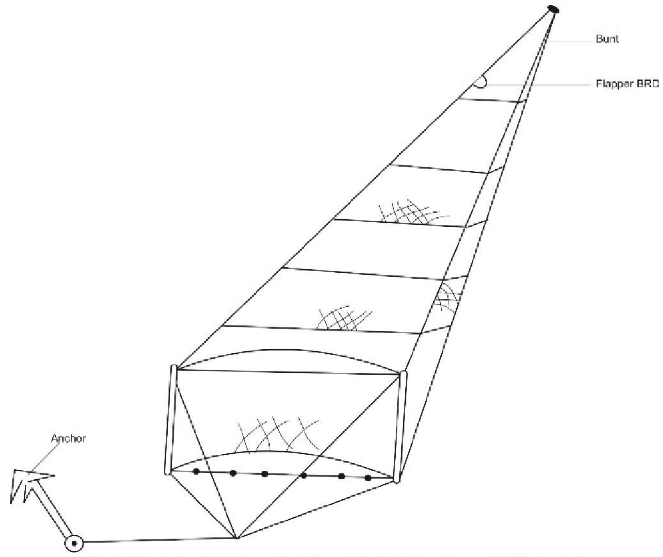

Fig. 2. Diagrammatic representation of anchored stow net with modified flapper bunt

Discussion

This research have shown how strategically located escape window in shrimp stow net bunt can reduce the bycatch and at the same time maintain the catches of the target shrimps in a small scale and open access fishery, typical of developing countries. Bycatch from small scale fishery have not attracted public attention, because of inaccessible area of operation, lack of record and the fact that it is significantly low per fisherman, but when bycatch from thousand fishers is pooled, the weight become enormous and call for concern from both nutritional and conservation point of views. Bycatch with length range of 11-20cm account for almost46% of landed bycatch from both bunts and are sorted and consumed locally, while bycatch with length range of 3-10cm TL from modified bunt escape into the water and those from conventional bunt are sorted and discarded ashore. This however, eliminates the problem of protein waste. Beckett (1989) observed that the size range of individual organisms in the catch has implications for year-to-year and total yield from the resource. The quantity of bycatch species (54.4%) reduced by the flapper bunt and the fish size, ranging from 3 to 10cm in total length, where the majority of the fish bycatch species are excluded from the modified flapper bunt are at sustainable level to allow for future recruitment of thejuvenile into the stock and fishery.

Knowledge of the behavioral differences between fin fish bycatch species and the target shrimps is applied in the separation process. When fishes, ecologically nekton and shrimps (mostly larvae), ecologically planktons enters the bunt, their response to stimuli from inflowing tidal water current toward the posterior bunt of stow net is quite different, fin fishes are always directed and pushed by tidal current together at the narrow part of the bunt exhibiting an escape response to the sides and top of the net (Wardle, 1986). The location of the flapper exit opening at anterior bunt makes fishes to escape freely due to their up and down movement in response to tidal water flow current inside the wall of stow net bunt netting. In using flapper BRD that make use of behavioral difference between fish and shrimp in the separation process, a factor that we took into consideration was the relative swimming speed of the fishes to be excluded and the location of the BRD in stow net bunt. In a comparative study of the swimming speed and behavior of over 40 species of fishes, Beamish (1978) observed that not withstanding environmental and biological challenges, majority of fishes, 5 to 15cm were unable to maintain their normal cruising speed for more than 10 minutes. Bycatch species found in the fishery falls within a total length range of 3 to 20cm, and the measured speed of tidal current in the area according to Ibe et al. (1994) is 0.66m/s. Based on the above swimming problem encountered by juvenile fishes in stow net bunt, it was justified that to provide enough chance for fishes to escape during soaking, the BRD should be inserted in an area of the bunt where there is a great reduction in relative water flow, and this is immediately anterior to the bunt (Broadhurst and Kennelly 1997). The response of shrimps to water current in bunt is fair and weak. Several studies have shown that shrimps and other crustacean are not capable of maintaining active escape response against current of water generated by towing or tidal flow (Lockhead 1961; Newland and Chapman 1989). Shrimps are quickly pushed against the mesh and towards the back of the flapper bunt by tidal current where they remain passive throughout the entire soaked duration. Stow net bunt was modified to take advantage of the differences in shrimp and fish behavior by incorporating a flapper on the top of the anterior bunt section only, so that only small sized and fusiform shaped fishes might escape without much reduction in the catches of shrimps or of larger commercially important bycatch species.

Conclusion

The flapper bunt evaluated achieved the biological and socio-economic objectives of this research work by excluding juveniles (3-10cm TL) bycatch species to grow and be recruited into the fishery in future, and by retaining large sizes (11-20cm TL) of bycatch species for the continuation of bycatch livelihood trades as well as the retention of large quantity of target shrimps(95.92%). Fishers on their own endorsed the use of this BRD, which in addition is simple to operate and cheap to construct. With the adoption of this technology by the Nigerian fishers, there is a great potential for shrimps to be produced with the lowest ecological costs, with the least waste and with the least impact on the marine habitat.

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