Evaluation of Demersal Longline Gear off South Carolina and Puerto Rico With Emphasis on Deep-water Reef Fish Stocks

G. MICHAEL RUSSELL, ELMER J. GUTHERZ, and CHARLES A. BARANS

Introduction

There are no definitive studies testing the efficiency of bottom longlines and other line fishing gears applicable to commercial reef fish assessment. Stock assessment techniques for reef fish in the western central Atlantic, Gulf of Mexico and Caribbean Sea have been presented by several authors (Barans, 1982; Cody et al., 1981; Gutherz, 1982; and Nelson and Carpenter, 1968). Target species included groupers (*Epinephelus* spp. and *Mycteroperca* spp.), porgies (*Calamus* spp. and *Pagrus* spp.), snappers (*Etelis oculatus*, *Pristipomoides macrophthalmus*, *P. aquilonaris*, and *Lutjanus* spp.), and sharks. Kawaguchi (1974) concluded in his studies of the Caribbean snapper fishery that bottom longlines were inefficient compared with hand reels, possibly due to the clumped distribution of target species. However, bottom longlines were found to be twice as effective as snapper reels for tilefish, *Lopholatilus chamaeleonticeps*, on mud bottoms off South Carolina (Low et al., 1983). Matlock et al. (In press) has begun studies to define longline gear efficiency for yellowedge grouper and tilefish off Texas.

Fishery independent catch-per-unit-of-effort (CPUE) data are essential to accurately assess abundance of reef fish resources. Objectives of this study were to: 1) Describe standard longline sampling techniques for deepwater reef fish, 2) clarify apparent advantages and disadvantages of both bottom and offbottom longlines, and 3) compare species compositions and catch rates obtained with the two types of longlines.

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Methods

Study Areas

Comparative gear trials were conducted during three cruises in two geographical areas. These studies were conducted aboard the South Carolina Wildlife and Marine Resources Department (SCWMRD) Ship *Oregon*, cruise OE-82-04, 7/29-8/13/82; the NOAA Ship *Oregon II*, Caribbean cruise 129, 8/26-9/30/82; and NOAA Ship *Delaware II*, Caribbean cruise 83-06, 5/25-7/2/83[1]. The *Oregon* sampled in 183-199 m (100-110 fm) east of Charleston, S.C. (lat. 32°44′N, long. 78°06′W.) in a 0.8km^2 area (referred to as the "Charleston Lumps" in this paper). The site consisted of rock habitat with 40°-50° slopes and 12-26 m of relief. Flattened boulders up to 2 m wide were located near the ridge tops. These boulders appeared to move downslope after becoming undermined and breaking off. Steep ridges were separated by gullies and/or interspersed among rubble slopes. Gullies were composed of compressed foraminifera and shell hash with the appearance of sand. Often the "sand"/shell hash was in dune-like formations.

The Caribbean study area sampled by the NOAA Ships *Oregon II* and *Delaware II* included the west and north coast of Puerto Rico and the north coasts of Culebra and St. Thomas Islands. Fishing depths were between 69 and 589 m (38-324 fm); however, the majority of effort occurred between 183 and 457 m (100-259 fm). Bottom type consisted of mud, rock, coral and shell. The area was characterized by steep walls with precipitous drops to deeper waters. The upper shelf areas generally consisted of ridge tops along limestone walls.

Sampling Procedures

Bottom and offbottom (Kali poles—Anonymous, 1982) longlines were fished, either joined together or separately, but adjacent to one another. Kali pole hooks on the offbottom longlines were numbered consecutively from top to bottom. Catch data included a tally of hooks with bait, hooks without bait, fish caught, and the hook position on the offbottom longlines where fish were caught.

Specimens lost over the side as well as those brought aboard were recorded by species. Massive tangles often prevented accurate recording of species and numbers caught by hook (Fig. 1). These conditions caused some variation between the published cruise report and the data in this paper.

Fishing Methods and Gear

Bottom longlines consisted of a buoy (Fig. 2) and mainline section (Fig. 3) Buoy lines were constructed with 1.27

[1]Cruise reports are available through G. Michael Russell, NMFS Pascagoula Laboratory, P. O. Box 1207, Pascagoula, MS 39568.

cm twisted nylon in 183 m sections. Connections were made with 1.27 cm brummel hooks except where weights were tied to the buoyline with lighter line. This allowed tangled weights to break free (Fig. 2). Buoy poles were counter weighted with a 7 kg weight attached by a "D" ring. The counter weight was attached to a 4.76 cm stainless steel cable 0.3 m long with a quick release snap for easy attachment and removal (Fig. 2).

A 183 m mainline, constructed of 0.97 cm braided nylon with 50 gangions, was used for each set. A gangion consisted of an "AK" snap, a 70 cm length of 91 kg test monofilament, and a #7 circle tuna hook. Gangions were spaced 2 m apart.

Offbottom longlines consisted of a floating mainline (0.97 cm polypropylene rope) with attached Kali poles. These poles (schedule 80 PVC pipe) were 2.44 m in length with reinforcing rod inserted into the lower end and a 10 cm diameter deepwater float wired to the upper end. This maintained the pole's vertical position during fishing operations. Poles were attached by beckets at 7.26 m intervals (Fig. 3). Each pole was equipped with five or six alternating, but equally spaced, gangions.

Figure 1.—An offbottom longline Kali pole tangle; clearing these are time consuming and may be dangerous to crew members.

Submersible

Cooperative cruises were conducted by the National Marine Fisheries Service (NMFS), South Carolina Wildlife and Marine Resources Division (SCWMRD), and Harbor Branch Foundation, Inc. to supplement fishery-independent catch data and to assess fish stocks. These cruises utilized the submersible *Johnson Sea-link II* for in situ observations of bottom and offbottom longlines. Fishing attitude and position of the gear relative to the bottom was observed along with species caught. Bottom topography and its effect on longline deployment and retrieval was noted.

Analytical Methods

Prior to comparison of catches between offbottom and bottom longline gear, the data were standardized to number of fish caught per 100 hooks. For comparison of catches by gear the data were log $(X + 1)$ transformed (Elliott, 1977). Three categories were then compared: 1) Total fish between geographical areas; 2) Caribbean shark species, two species of wenchmen, *Pristipomoides aquilonaris* and *P. macrophthalmus*, and all other snappers; and 3) South Carolina blackbelly rosefish, *Helicolenus dactylopterus*, and two species of tilefish (tilefish and blueline tilefish, *Caulolatilus microps*). Transformed and untransformed mean catches and variances of fish per 100 hooks recovered by set were compared by Student's "t" tests and "F" (alpha = 0.05) F-tests (Sokal and Rohlf, 1969). Differences in mean catch between two Kali pole positions (top three hooks vs. bottom two or three hooks, depending on whether it was a five- or six-hook set) on the offbottom longlines were compared by chi-square analysis.

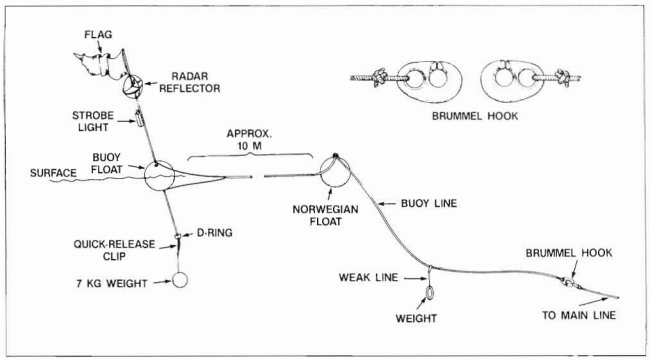

Figure 2.—Diagrammatic representation of buoy system with appropriate connections, lights, and radar reflectors to assist locating the gear.

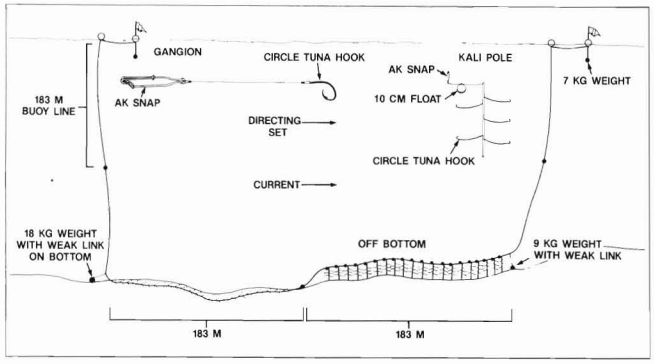

Figure 3.—Diagrammatic representation of a longline set including bottom and offbottom lines and buoy system.

Results

Underwater Observations

Over rough bottom, Kali poles remained upright and free of bottom obstructions appearing as a "picket fence". This upright orientation with the bottom, along with several hooked fish, can be seen in Figure 4. Regardless of longline type, fish captures were habitat specific with few fish caught on bottom with little or no relief. Observations of bottom longlines indicated that difficulty might be expected during retrieval when the lay of the line was among rocks and bottom projections; however, few retrieval difficulties were experienced.

Species Composition

Species diversity from bottom and offbottom longlines was almost identical between similar areas (Table 1). Both longline types caught shark, snapper, and grouper in the Caribbean (*Oregon II*-129 and *Delaware II*-83-06), while blackbelly rosefish, tilefish, and grouper were the most abundant species captured on the Charleston Lumps (*Oregon* OE 82-04).

Pole Position

Fish caught were not evenly distributed among the vertical array of hooks (Fig. 5). This was evident in both Charleston Lumps and Caribbean species groups (Fig. 5). Although the lower group of hooks consistently caught more fish (except grouper and blueline tilefish, *Oregon* 82-04), there were few significant differences in catch rates between upper and lower hook positions (Table 2). Both the total catch and catch of blackbelly rosefish off the Charleston Lumps were significantly greater at the lower hook positions, perhaps indicating a greater abundance of blackbelly rosefish or a close association to the bottom. Small sample sizes for individual species groups, other than blackbelly rosefish, did not allow an analysis of catch trends.

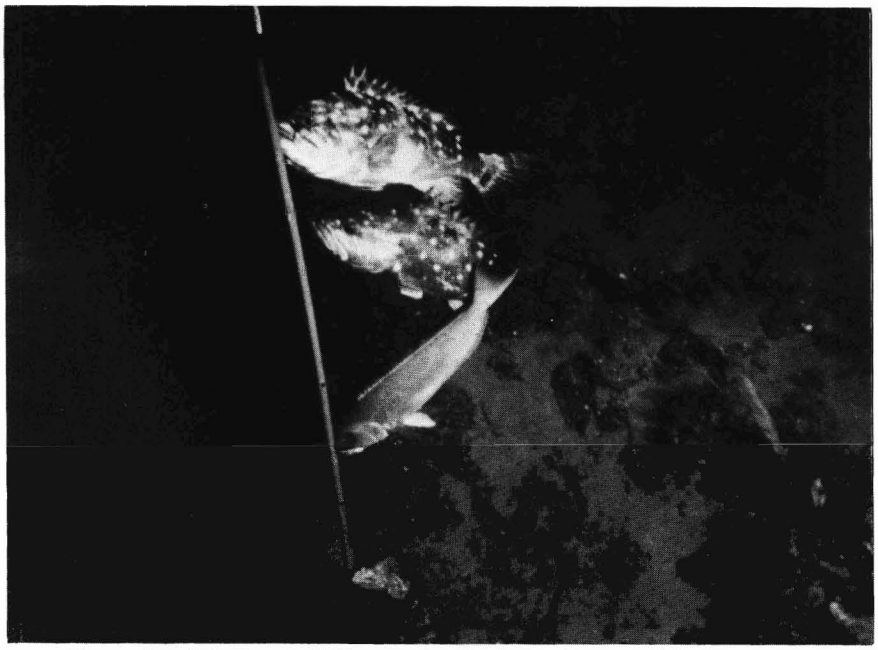

Figure 4.—A Kali pole fishing on the Charleston Lumps with, from top to bottom, snowy grouper, blueline tilefish, and blackbelly rosefish.

Comparison of Catch

The number of fish caught per 100 hooks recovered was consistently greater for bottom longlines than offbottom longlines (Fig. 6, Table 3). Significant differences existed between mean numbers of fish caught for all sharks, blackbelly rosefish, and snapper (1982 data)

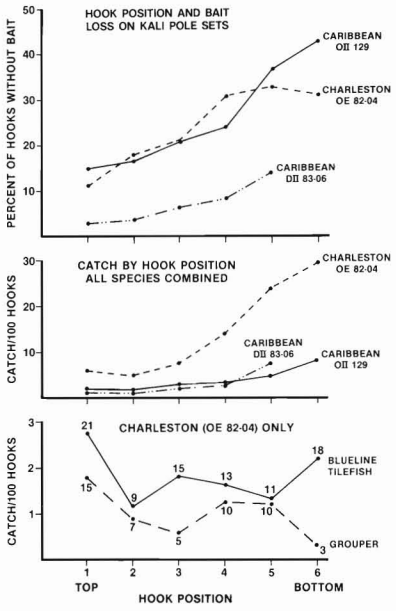

Figure 5.—Bait loss and catch rates by hook positions for Kali poles on offbottom longlines during two comparative cruises in the Caribbean and one off the Charleston Lumps.

Table 1.—Catch composition for three cruises by gear type with numbers of each species caught.

Species	Bottom longline no.			Offbottom longline no.		
	OII 129	DII 83-06	OE-82-04	OII 129	DII 83-06	OE-82-04
	Number of specimens					
Snappers						
Etelis oculatus	17	14	0	8	9	0
Lutjanus buccanella	4	2	0	4	0	0
Lutjanus vivanus	9	6	0	13	8	0
Pristipomoides aquilonaris	23	0	0	18	3	0
Pristipomoides macrophthalmus	69	21	0	53	20	0
Rhomboplites aurorubens	6	0	0	5	2	0
Groupers						
Epinephelus flavolimbatus	3	9	5	4	6	0
Epinephelus guttatus	1	1	0	1	0	0
Epinephelus mystacinus	13	16	0	7	12	0
Epinephelus niveatus	2	1	36	2	1	51
Sharks						
Carcharhinidae	2	0	0	5	0	0
Carcharhinus plumbeus	0	9	0	0	5	0
Centrophorous granulosus	111	0	0	138	0	0
Centrophorous sp.	0	68	0	0	66	0
Dalatias licha	0	1	0	1	0	0
Etmopterus hillianus	0	0	0	2	0	0
Etmopterus virens	0	0	0	0	3	0
Galeus arae	0	0	0	1	0	0
Heptranchias perlo	2	0	0	8	0	0
Hexanchus vitulus	13	9	0	10	7	0
Mustelus canis	49	91	0	42	63	0
Scyliorhinus retifer	1	0	1	0	1	2
Scyliorhinus torrei	0	0	0	1	0	0
Scymnodon sp.	2	0	0	1	0	0
Squalus asper	1	0	0	0	0	0
Squalus cubensis	162	110	0	176	172	0
Tilefish						
Caulolatilus microps	0	0	51	0	0	82
Lopholatilus chamaeleonticeps	0	0	12	0	0	15
Other species						
Caranx lugubris	0	0	0	1	0	0
Chimaera cubana	0	1	0	1	0	0
Conger oceanicus	0	0	0	0	0	1
Conger triporiceps	0	0	0	0	1	0
Gymnothorax moringa	11	5	0	5	7	0
Gymnothorax sp.	1	1	0	0	3	0
Haemulon album	0	1	0	0	0	0
Helicolenus dactylopterus	0	0	415	0	0	531
Hildebrandia flava	1	0	0	1	0	0
Hildebrandia gracilior	0	0	0	3	0	0
Hyperoglype sp.	0	0	0	0	0	2
Ophichthus sp.	9	6	0	1	0	0
Ophichthus gomesii	0	3	0	0	0	0
Polymixia sp.	0	0	0	2	0	0
Pomadasys crocro	0	0	0	1	0	0
Pontinus longispinis	0	0	1	0	0	0
Pontinus rathbuni	0	0	1	0	0	0
Ruvettus pretiosus	0	0	0	1	0	0
Saurida sp.	0	2	0	0	1	0
Seriola dumerili	3	1	2	0	0	0
Seriola rivoliana	2	0	0	0	0	0
Sphyraena barracuda	0	0	0	0	1	0
Urophycis floridanus	0	0	15	0	0	14
Urophycis earlli	0	0	1	0	0	0

Table 2.—Comparison of mean catch rates per 100 hooks recovered by hook position on offbottom longline poles. (NS = nonsignificant, X^2 = chi-square, ** = significant at 0.01 level).

Cruise	Position	Catch per 100 hooks									
		Sharks	Expected	Grouper	Expected	Wenchmen	Expected	Snapper	Expected	Total	Expected
OII 129	Top 3	1.65	2.99	0.09	0.11	0.24	0.42	0.33	0.38	2.33	4.02
	Bottom 3	4.34		0.12		0.59		0.42		5.70	
	X^2	1.21NS		0.01NS		0.10NS		0.01NS		1.41NS	
DII 83-06	Top 3	1.41	2.84	0.12	0.16	0.04	0.19	0.08	0.11	1.72	3.51
	Bottom 2	4.28		0.20		0.34		0.14		5.30	
	X^2	1.45NS		0.02NS		0.24NS		0.02NS		1.82NS	
OE 82-04	Top 3	2.86	11.16	1.53	1.24	1.87	1.82	0.12	0.16	6.26	14.58
	Bottom 3	19.45		0.96		1.76		0.21		22.90	
	X^2	12.33**		0.13NS		0.01NS		0.03NS		9.49**	

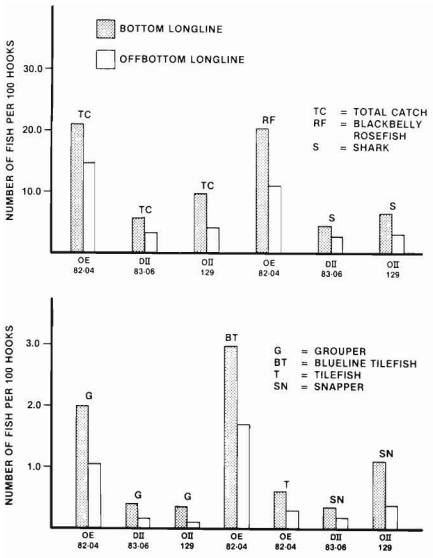

Figure 6.—Catches of grouper, snapper, shark (see Table 1 for species), blueline tilefish, tilefish, blackbelly rosefish, and total catch for bottom and offbottom longlines.

Table 3.—Comparison of means and variances of numbers of fish caught per 100 hooks recovered by bottom longlines (BL) and offbottom longlines (OBL) on three cruises. T = calculated "t" value; F = calculated "F" value; * = significant at 0.05 level; ** = significant at 0.01 level; value in ( ) = df.

		Total fish					Sharks				Snappers			
Cruise and item	Gear	N	$\bar{X}$	S^2	T	F	$\bar{X}$	S^2	T	F	$\bar{X}$	S^2	T	F
Caribbean 1982 (OII 129)														
Untransformed	BL	110	9.8	75.7	6.0**	3.2**	6.4	75.2	3.5**	3.2**	2.4	12.0	4.5**	5.5**
	OBL	110	4.1	23.7	(218)	(109)	3.1	23.5	(218)	(109)	0.8	2.2	(218)	(109)
Transformed	BL	110	0.9	0.2	6.3**	1.3	0.6	0.3	3.0**	1.6**	0.3	0.1	4.1**	2.5**
	OBL	110	0.6	0.1	(218)	(109)	0.4	0.2	(218)	(109)	0.2	0.1	(218)	(109)
Caribbean 1983 (DII 83-06)														
Untransformed	BL	139	5.5	37.9	4.6**	3.8**	4.2	32.1	3.5**	3.2**	0.7	3.6	1.8	3.6**
	OBL	139	2.8	9.9	(276)	(138)	2.3	9.9	(276)	(138)	0.3	1.0	(276)	(138)
Transformed	BL	139	0.6	0.2	3.7**	1.6**	0.5	0.2	3.0**	1.5**	0.1	0.1	1.5	2.1**
	OBL	139	0.4	0.1	(276)	(138)	0.4	0.1	(276)	(138)	0.1	0.0	(276)	(138)

		Total fish					Blackbelly rosefish				Tilefish (all species)			
S. Carolina 1982 (OE 82-04)														
Untransformed	BL	34	28.1	192.4	4.2**	2.2**	21.2	114.1	4.2**	2.3**	3.7	13.8	1.8	2.1**
	OBL	34	16.0	85.4	(66)	(33)	12.0	50.0	(66)	(33)	2.3	6.8	(66)	(33)
Transformed	BL	34	1.4	0.1	4.2**	1.2	1.3	0.1	4.1**	1.0	0.5	0.1	1.5	1.4**
	OBL	34	1.2	0.1	(66)	(33)	1.0	0.1	(66)	(33)	0.4	0.1	(66)	(33)

Table 4.—Comparison of means and variances of numbers of fish caught per set (not standardized to catch per 100 hooks recovered) by bottom longlines (BL) and offbottom longlines (OBL) on three cruises. T = calculated "t" value; F = calculated "F" value; * = significant at 0.01 level; value in ( ) = df.

		Total fish					Sharks				Snappers			
Cruise and item	Gear	N	$\bar{X}$	S^2	T	F	$\bar{X}$	S^2	T	F	$\bar{X}$	S^2	T	F
Caribbean 1982 (OII 129)														
Untransformed	BL	110	4.7	16.3	0.2	1.7*	3.0	16.6	−0.6	1.6*	1.2	2.7	1.2	1.0
	OBL	110	4.6	27.3	(218)	(109)	3.4	27.3	(218)	(109)	0.9	2.6	(218)	(109)
Transformed	BL	110	0.6	0.1	1.2	1.3	0.4	0.1	−0.1	1.2	0.2	0.1	1.6	1.1
	OBL	110	0.6	0.1	(218)	(109)	0.4	0.2	(218)	(109)	0.2	0.1	(218)	(109)
Caribbean 1983 (DII 83-06)														
Untransformed	BL	139	2.7	9.2	−0.2	1.0	2.0	7.8	−0.5	1.2	0.3	0.8	0.0	1.0
	OBL	139	2.8	9.6	(276)	(138)	2.2	9.7	(276)	(138)	0.3	0.9	(276)	(138)
Transformed	BL	139	0.4	0.1	−0.1	1.0	0.3	0.1	−0.1	1.2	0.1	0.0	0.0	1.0
	OBL	139	0.4	0.1	(276)	(138)	0.3	0.1	(276)	(138)	0.1	0.0	(276)	(138)

		Total fish					Blackbelly rosefish				Tilefish (all species)			
S. Carolina 1982 (OE 82-04)														
Untransformed	BL	34	16.3	84.3	−1.8	1.4	12.5	57.9	−1.7	1.3	1.9	2.9	−1.6	2.8*
	OBL	34	20.6	122.1	(66)	(33)	15.8	72.8	(66)	(33)	2.8	8.0	(66)	(33)
Transformed	BL	34	1.2	0.1	−1.9	1.3	1.1	0.1	−1.8	1.3	0.4	0.1	−1.0	1.5
	OBL	34	1.3	0.0	(66)	(33)	1.2	0.1	(66)	(33)	0.5	0.1	(66)	(33)

and the total finfish catch for each of the three cruises. Mean catches were significantly different among transformed and untransformed data. Mean numbers of snapper (1983 data) and tilefish caught by bottom and offbottom longlines were not significantly different (Table 3).

Comparisons of means and variances for all untransformed numbers of fish caught by bottom and offbottom longlines indicated that catches of all species groups and total catches were significantly different (Table 3). Catches of two total fish groups (cruises *Oregon II*-129 and *Oregon* OE 82-04) and blackbelly rosefish by the two gear types were not significantly different when transformed values were compared.

Catches were similar between bottom and offbottom longlines when the unit of effort compared was a "set" (not standardized to catch per 100 hooks returned (Table 4)) but offbottom longlines were always fished with at least twice as many hooks over the same general distance as the bottom longline. There were no significant differences in the mean numbers of fish caught by the two gears for any species group during any cruise when tested with either untransformed or transformed data (Table 4).

Hook Loss

Regardless of gear, hook losses were less than 10 percent. Partial hook loss ranged from 0.6 percent of the hooks deployed (offbottom longlines off the Charleston Lumps) to 7.3 percent (bottom longlines in Caribbean). During each cruise, bottom longlines consistently lost more hooks than did offbottom longlines (Table 5).

Discussion

The nearly identical catch composition between bottom and offbottom longlines within similar geographical areas indicates similar behavioral characteristics to the fishing gear when the same bait and hook sizes are fished. Thus the question of efficiency rests with both the CPUE and ease of deployment and retrieval.

Trends in the vertical distribution of catch on offbottom longlines were evident only among nonpriority species.

Table 5.—Hook loss by cruise and gear type.

Gear	Caribbean OII 129		Caribbean DII 83-06		Charleston OE 82-04	
	No.	%	No.	%	No.	%
Bottom longline						
Total	246	4.5	138	7.3	26	1.2
Partial[1]	196	3.6	138	7.3	26	1.2
Offbottom longline						
Total	654	5.0	277	7.2	29	0.6
Partial[1]	414	3.1	177	4.6	29	0.6

[1]Does not include hooks lost in loss of complete sets.

Catches of priority species were too low for conclusive results which may be an indication of a low population size. Blackbelly rosefish and sharks were caught more frequently at lower hook positions suggesting a high abundance or close association with the bottom. The higher number of grouper and blueline tilefish (*Oregon* 82-04) caught on the upper hooks may indicate a reduced dependency on the bottom or the unavailability of lower hooks due to their utilization by blackbelly rosefish and/or sharks. Species feeding patterns or food preference may also make the lower hooks more attractive.

Significant differences were noted between mean catch rates per 100 hooks of bottom and offbottom longlines (Table 3). This difference is an expression of the higher number of hooks along the bottom on a standard longline and the generally higher catch rate of the lower hooks on offbottom longlines. When comparing catch rates between sets, irrespective of the number of hooks, no significant difference is noted between the two gear types (Table 4). The equality of catch between bottom and offbottom longlines reflects the larger number of hooks fished on offbottom longlines. The similarity in catch and its nonsignificance between gear types when measuring catch per set indicates that a given number of fish in a given habitat will be caught irrespective of the gear type or bait used. Bottom longlines caught more fish per 100 hooks than did offbottom longlines.

Hook loss was an indicator of gear fouling on rough habitats. However, this type habitat is where the highest concentrations of commercially exploitable stocks are found. A larger number of hooks, expressed as percent per set, was lost from bottom longlines as more hooks were in direct contact with the bottom. Although a higher percentage of hooks was lost from bottom longlines, this gear may be a better deep-water reef fish assessment tool as offbottom longlines were more difficult to bait, set, and retrieve. In addition, upon retrieval they were often tangled and difficult to clear with the resultant loss of fishing time and possibly a portion of the catch (Fig. 1). Offbottom longlines were designed to minimize bottom fouling and gear loss on rough bottom habitats, but this advantage was offset by frequent handling difficulties. For population assessment, because of the habitat specificity of the exploitable species, the best gear configuration may be a "short" bottom longline directed at a specific habitat. Retrieving a "short" set straight off the bottom reduces loss of fishing gear by minimizing potential fouling. These conditions influenced SCWMRD to use short habitat specific setlines to investigate deep-water demersal finfish resources off South Carolina and northern Georgia (Low et al., 1983).

Recommendations

Short (30 m) bottom longlines with 20-30 hooks fishing within specific habitats may be a more realistic gear configuration for evaluation of deep-water stocks and their distribution. Insufficient inshore effort has been expended in areas of high relief to evaluate offbottom longlines for inshore populations; however, they may be a useful tool for stock assessment in this habitat. Surveys using offbottom longlines should be conducted from vessels not exceeding 15 m as large vessels tend to pull the mainline to the vessel causing tangles when dragging the mainline and poles across the bottom. Small vessels can more easily maintain position over the mainline allowing the gear to be hauled straight off the bottom.

Acknowledgments

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