Enhancing Proof-of-Concept Procedures of Potential Bycatch Reduction Devices in the Southeastern Shrimp Fishery

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Abstract

This study investigated potential finfish reduction devices (BRDs) for shrimp trawls. The major objective was to perform proof-of-concept studies of selected bycatch reduction devices and determine if any would be candidates for future in-depth evaluations for federal certification. Prototypes of new BRDs were obtained from shrimp fishermen, NOAA Fisheries staff, foreign assessments and university scientists. These concepts were subjected to evaluations aboard a commercial shrimp trawler operating under actual fishing conditions. Utilizing federal BRD testing protocols, the experimental gears were towed simultaneously in nets and compared with trawls not equipped with fish excluders. Data obtained from the comparative tows consisted of total catch, total shrimp, and differences in major bycatch species. Analysis of catch parameters were performed using prescribed formulas adopted by NOAA Fisheries. Statistical analyses were performed to provide input for proof of concept. The four prototypes tested exhibited potential reduction effectiveness for important bycatch species in the northern Gulf of Mexico and/or reduced shrimp loss, indicating they may be candidates for further investigations and modifications to move forward in the BRD certification process.

Introduction

The Southeastern shrimp fishery remains one of the most important commercial fisheries in the United States. This industry has produced in excess of $350 million in dockside value over each of the past several years. The fishery is uniquely sustainable because of the annual life cycle and high fecundity associated with Penaeid shrimp. In spite of the healthy stocks of this fishery, incidental bycatch of unwanted species is an ongoing concern. The primary harvesting gear used in the shrimp fishery is the otter trawl. This gear has been used since the early 1900s and remains the most effective means of harvesting shrimp. Although the otter trawl has contributed substantially to the success of the southern shrimp fishery, it is non-selective with respect to catch. Recent offshore bycatch estimates for the Southeastern shrimp fishery indicate that for approximately 213.5 million pounds of shrimp landed annually, 681 million pounds of bycatch are incidentally harvested (U.S. National Bycatch Report, 2011). These figures reflect a bycatch ratio of 0.76. Although trawling has declined in this fishery, finfish bycatch continues to be both an important and contentious issue with recent research attributing a 57% fish bycatch to shrimp trawling in the Gulf of Mexico (Scott-Denton et. al., 2012).

In attempts to reduce the finfish bycatch ratio in the Southeastern shrimp fishery, NOAA Fisheries has implemented bycatch reduction device (BRD) regulations in the Gulf of Mexico and the South Atlantic EEZ (Federal Register, 1997; 1998; 2004; 2008; 2012). As a result of these regulations, vessels are required to utilize designated BRDs in the fishery. To date, the most commonly used exclusion device is the fisheye BRD, which is the simplest and least expensive to use

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and maintain. When installed at 9 feet forward of the bag tie-off rings, this device effectively eliminates 30 percent or more of the fish from the catch, but it also contributes to a shrimp loss of more than 10 percent (Helies and Jamison, 2009). Other federally certified devices are allowable in the fishery, but often fishermen are intimidated by the perceived complexity of the gear and greater cost of most devices compared to the fisheye BRD. Furthermore, various types of BRDs do not perform the same across different areas of the shrimp harvesting region. As a result, more choices of BRDs are needed in the fishery – especially gears that are inexpensive and simple in construction.

Efforts to certify more BRDs for the shrimp fishery continue. Ideas originating from the fishing industry, NOAA Fisheries, and other sources are evaluated at sea aboard commercial fishing vessels utilizing trained, NOAA-certified fishery observers. Data are collected under actual fishing conditions utilizing a defined protocol established by NOAA. In order for a BRD to meet criteria for federal certification, it must demonstrate an ability to reduce finfish by at least 30 percent (Federal Register, 2008). Gears that are tested often arise from fishermen, and it is not known if some of these concepts are viable until they can be taken offshore and formally evaluated. This can often be an expensive and recondite task as the protocol requires that data be collected and analyzed from a minimum of 30 problem-free tows before the gear can be considered for certification. If a device does not meet the minimum of 30 percent finfish bycatch reduction, the at-sea work is often done in vain. Costs of observers, vessel compensation for shrimp loss, insurance and other expenses make this an expensive endeavor. A tremendous amount of effort is wasted through evaluations associated with a BRD that does not meet the federal criteria for certification.

In an attempt to ameliorate the risk of directing time consuming and expensive work toward certification of a gear that might not be successful, efforts were focused on evaluating different BRD candidates through proof-of-concept.

Objectives

The goals of this project were to perform proof-of-concept testing of various prototype BRDs to determine candidates for future in-depth federal certification trials. Tasks included:

1. Solicit new BRD designs from NOAA Fisheries, industry and international sources so that devices can be subjected to proof of concept.
2. Construct and perform modifications on certain BRDs and construction of additional gears for offshore evaluations.
3. Observe potential effectiveness of BRDs/ modifications aboard commercial trawlers and determine which are most likely to meet federal criteria for certification.
4. Provide recommendations and insight to entities testing new gears for federal BRD certification.

Methods

Solicitation of new BRD Designs

Members of the shrimp industry were contacted regarding ideas in developing BRD candidates. Through these discussions, two devices were used in our study – Kiel BRD and the Burbank TED/BRD Combination. Several ideas were obtained from NOAA Fisheries Harvesting Branch in Pascagoula. Two of the gear technicians asked that one of the devices that they had constructed, L&J TED/BRD Combination, be evaluated. Another idea, Hummer Line, was also obtained from them. During these discussions, it was also learned that a previously tested device, Modified Cylinder BRD, had been modified in design in hopes of making it less bulky and potentially more acceptable to the shrimp industry. Although NOAA Fisheries had already obtained some initial, very favorable data from this gear, we agreed to utilize it in our studies to see how the fishermen aboard the vessel would respond to its rather different and sophisticated design. Finally, we determined that an Australian BRD prototype, Witches Hat (Gerner and Maynard, 2010) might be a viable candidate for evaluation.

Construction and Modifications of Gear

Some gear, such as the Kiel BRD, was not complicated to construct. With the necessary components, we were able to easily build and install it aboard the vessel. The Burbank TED/BRD Combination was purchased from

Burbank Trawl Company and delivered to Texas. Two other gear designs, L&J TED/BRD Combination and Hummer Line, were constructed and provided to us by the NOAA Fisheries Harvesting Branch in Pascagoula, Mississippi. Additionally, we acquired the Nested Cylinder from the Pascagoula Laboratory for evaluation. Materials were purchased to construct the Witches Hat aboard the vessel.

Observe Potential Effectiveness of BRDs Aboard Commercial Trawlers and Determine Which Are Most Likely To Meet Federal Criteria for Certification

A suitable trawler, the F/V *Miss Madeline*, was recruited for these evaluations. The 80’, 550 h.p. vessel towed 4-50’ trawls. The first effort aboard the trawler proved somewhat difficult as trawl damage from obstructions and bogging in soft substrate hindered our ability to easily tune trawls and perform BRD evaluations. We returned to port after two weeks and the vessel owner re-equipped the boat with new trawls. We then completed a 34-day trip in which the majority of our data were collected.

Data were acquired using established protocols and methods outlined in the 2008 NMFS Bycatch Reduction Manual. Importantly, after tuning tows were performed to assure that comparative trawls were fishing similarly, the experimental BRD was installed in one of the outside trawls and compared to the other outside trawl with no BRD. TEDs were used in all trawls. As much as possible, tests were conducted with an equal number of tows with the BRD in each outside net to prevent potential bias from a trawl. Data were recorded on OMB approved data sheets to allow for consistent data collection. Overall catch, total shrimp weight and total finfish for each of the experimental and control trawls were recorded on the Station Sheet BRD Evaluation Form. Following the federal protocol, a bushel basket of catch was removed from each of the control and experiment trawl piles after overall weight of catch has been obtained. From each sample basket, the primary species of fish were separated, weighed and counted.

The main difference between the established NMFS protocols and this study is that the minimum series of thirty acceptable tows for formal BRD certification were not conducted. It should be noted that often it takes 50 sea days to perform a formal BRD certification process on one device (Frank Helies, personal communication). To provide more solid statistical foundation to the BRD certification process, more than 30 tows are often performed. Instead of this lengthy process, prototype BRDs were subjected to tows over several nights fishing and preliminary data acquired as to their potential effectiveness. Through this process, a number of BRDs could be observed and data collected.

Statistical Methods

In order to achieve the project’s third objective, to observe the potential effectiveness of BRDs/ modifications aboard commercial trawlers and determine which are most likely to meet federal criteria for certification, we used the statistical protocol adopted by NOAA Fisheries (Helies and Jamison, 2009). This approach employs a “modified” paired t-test, whereby tests are performed after the control values are reduced by an arbitrary percent. We compared BRD values to corresponding control values reduced by 30% and 25% to be consistent with BRD certification criteria (Federal Register, 2008). That is, we estimated the percent chance that the estimated reduction was e” 30% as well as the percent chance it was <25%.

Criteria for selection included but was not limited to:

1) There is at least a 50% probability that the true reduction rate of the BRD candidate meets the bycatch reduction criterion (*i.e.*, the BRD candidate demonstrates a best point estimate [sample mean] that meets the certification criterion); and

2) There is no more than a 10% probability that the true reduction rate of the BRD candidate is more than 5 percentage points less than the bycatch reduction criterion.

To be certified for use in the fishery, the BRD candidate will have to satisfy both criteria. The first condition ensures that the observed reduction rate of the BRD candidate has an acceptable level of certainty that it meets the bycatch reduction criterion. The second condition ensures the BRD candidate demonstrates a reasonable degree of certainty that the observed reduction rate represents the true reduction rate of the BRD candidate.

The traditional approach to these analyses is to extrapolate species number and weight for the entire catch using the ratio of the sample weight (or number) vs. the total trawl weight.

Equation 1:

$$\frac{(Sample\ Species\ Weight) \times (Total\ Trawl\ Weight)}{(Total\ Sample\ Weight)} = Extrapolated\ Species\ Weight$$

These extrapolated values will then be converted into catch-per-unit-effort (CPUE) based on the hours towed:

Equation 2:

$$\frac{(Extrapolated\ Species\ Weight)}{(Tow\ Time\ in\ Hours)} = Catch\ /\ Hour$$

These CPUE values will be compared between the “control” and “experimental” trawl for shrimp retention, total biomass reduction, finfish reductions, and red snapper reduction. Total biomass reduction will be calculated as:

Equation 3:

$$\frac{(BRD\ Net\ Weight\ -\ Control\ Net\ Weight)}{(Control\ Net\ Weight)} x\ 100\% = Percent\ Reduction$$

For the various species, reductions will be calculated by:

1. Extrapolation using Equation 1, the total weight (or number) of species taken in both the control and BRD trawl based on the weight (or number) of that species present in the sample tow;
2. Generating a CPUE using Equation 2;
3. Generating a mean trip CPUE (or other unit of measure) for both the Control and BRD net; and
4. Calculating an overall percent reduction in the BRD net based on these means using Equation 3.

The CPUE means will be tested for significant difference ($p<0.05$) through the use of paired t-tests according to the following hypotheses:

$$H_o: \mu_{control} - \mu_{BRD} = 0$$

$$H_a: \mu_{control} - \mu_{BRD} \neq 0$$

Results

From September 9 to November 1, 2013, a total of 39 tows were attempted. Due to fouling and hangs, only 27 of these tows were useable for analyses. We estimated the reduction in total catch and brown shrimp; however, only three fish species occurred across tows frequently enough to allow analysis of bycatch reduction — longspine porgy (*Stonotomus caprinus*), Atlantic croaker (*Micropogon undulates*), and red snapper (*Lutjanus campechanus*) (Figure 1, Percent Occurrence). Furthermore, the effectiveness of BRDs was estimated as percent reduction relative to the control catch, so only tows without zero catches in the control trawl could be used to prevent division by zero. Sample sizes for testing each BRD type-species combination are reported along with the results in Table 1. Only one tow was available for the nested cylinder, which precluded testing of this design.

For the Keil design, not enough tows were available to test Atlantic croaker and red snapper, but we estimated longspine porgy were reduced by 22% (95% confidence limits = 5%, 38%; Table 1). However, this design exhibited the greatest reduction in brown shrimp catch or shrimp loss (8.5%; -7.2%, 4.1%; Table 2).

The Hummer design exhibited reduction rates similar to the Keil for longspine porgy, brown shrimp, and total

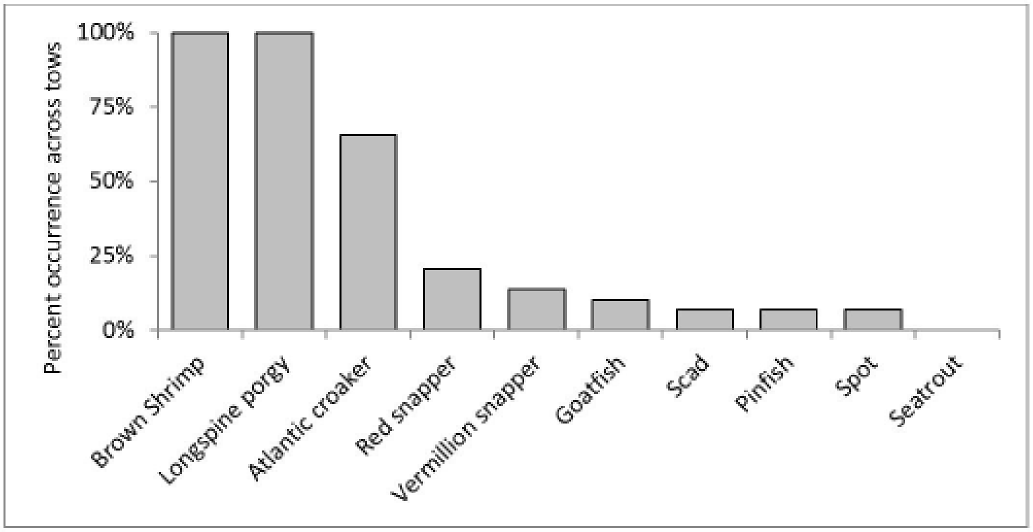

Figure 1. Occurrence. Percent of paired tows for which each species indicated was present in either the trawl fit with a bycatch reduction device (BRD) or the trawl without the BRD (control). Paired tows of all BRD types were combined for a total *n*=27.

Table 1. Bycatch reduction estimated from paired tows of trawls fitted with bycatch reduction devices (BRDs) and trawls without BRDs (controls). Only tows where at least one of the bycatch species was observed in the control were included. Positive values indicate reductions, whereas negative values represent increases. CPUE = catch per one hour of towing, which is reported in pounds.

Parameter	Keil	Hummer	L&J	Burbank
		Porgy		
n (number of paired tows)	8	6	8	5
Mean CPUE for control	6.9	4.8	3.2	5.1
Mean CPUE for BRD	5.5	3.7	3.2	5.1
% Reduction	21.5	23.0	1.2	-1.8
95% CLs for reduction	(4.9, 38.2)	(-12.1, 58.1)	(-29.6, 32)	(-48.8, 45.2)
% chance that reduction was ≥ 30%	14.1	30.9	3.3	5.1
% chance that reduction was <25%	68.7	55.7	94.4	92.4
		Atlantic croaker		
n (number of paired tows)	1	4	8	5
Mean CPUE for control	4.0	2.5	0.8	2.5
Mean CPUE for BRD	2.8	1.0	0.2	1.2
% Reduction	30.9	58.8	70.2	51.2
95% CLs for reduction	-	(-126.6, 244.1)	(-25.9, 166.2)	(7.7, 94.7)
% chance that reduction was ≥ 30%	-	71.1	88.5	94.4
% chance that reduction was <25%	-	26.7	10.2	4.0
		Red snapper		
n (number of paired tows)	0	0	0	5
Mean CPUE for control	-	-	-	1.2
Mean CPUE for BRD	-	-	-	0.9
% Reduction	-	-	-	20.5
95% CLs for reduction	-	-	-	(-43.6, 84.6)
% chance that reduction was ≥ 30%	-	-	-	32.2
% chance that reduction was <25%	-	-	-	58.5

catch. Though not statistically significant, the point estimate for catch of Atlantic croaker showed a 59% reduction (-127%, 244%) when using this BRD.

The L&J BRD showed virtually no reduction in bycatch of longspine porgy, but almost met the certification criteria for Atlantic croaker (89% chance that reduction e"30%; 10% reduction <25%). There was a point estimate increase of brown shrimp catch (-11%; -24%, 2%).

Although this was a pilot study with less than the required sample size of 30 paired tows (n=5), the Burbank BRD was the only design to meet the certification criteria in all other respects for Atlantic croaker. Bycatch reduction of longspine porgy was nominal, but the point estimate reduction for red snapper was 21%. Furthermore, no substantial brown shrimp loss was indicated.

Discussion

Gear damage was often experienced during the offshore evaluations, which made acquisition of data very difficult. Instead of a planned 30-day trip, the PIs dedicated 50 days at sea in an effort to collect data.

One part of these investigations was to evaluate the Nested Cylinder BRD for potential acceptability by fishermen. The previous designs had proven to be too bulky to be adopted by the shrimp industry. We towed the modified gear for several nights and observed the crew handling it. Although it was initially intimidating, the crew agreed that it could be a viable choice for a reduction device. Because proof of concept was previously performed by NOAA Fisheries, and safe handling of the gear approved by fishermen aboard our vessel, it will be a recommended candidate for formal BRD certification trials. In fact, it is the next gear to be evaluated by the Gulf and South Atlantic Fisheries Foundation through use of an at-sea observer aboard a commercial vessel. The owner and crew of the F/V *Miss Madeline* have already agreed to participate in the certification process.

When we began construction of the Witches Hat BRD, it became obvious that the gear might be more cumbersome than we had initially expected; hence, we assigned it a lower priority. Had there been sufficient time left in the trip, we would have incorporated it into our studies. Unfortunately, we experienced gear damage on our fiftieth day and returned to port, thus obviating our opportunity for evaluation.

A major factor impacting our investigations was the fact that we encountered lower densities of important bycatch species such as Atlantic croaker, longspine porgy, and juvenile red snapper. This phenomenon probably relates to the deeper depths that the crew was forced to fish in order to acquire economically necessary quantities of shrimp.

Parameter	Keil	Hummer	L&J	Burbank
	Brown shrimp			
n (number of paired tows)	8	6	8	5
Mean CPUE for control	10.3	9.8	7.1	8.6
Mean CPUE for BRD	9.5	9.1	7.8	8.7
% Reduction	8.5	6.5	-10.9	-0.7
95% CL	(-7.2, 24.1)	(-4.9, 18)	(-23.7, 1.9)	(-6.8, 5.4)
	Total catch			
n (number of paired tows)	8	6	8	5
Mean CPUE for control	60.2	53.5	39.2	44.1
Mean CPUE for BRD	55.8	49.2	39.8	45.6
% Reduction	7.3	8.1	-1.3	-3.5
95% CL	(7.1, 7.5)	(8, 8.2)	(-1.7, -0.9)	(-3.9, -3)

Table 2. Reduction in catch estimated from paired tows of trawls fitted with bycatch reduction devices (BRDs) and trawls without BRDs (controls). Positive values indicate reductions, whereas negative values represent increases. CPUE = catch per one hour of towing, which is reported in pounds.

An important consideration in reduction of longspine porgy is that this species is perhaps one of the most difficult to exclude from a trawl. In fact, the highest rate of exclusion obtained from BRDs that are already certified is 22% (NOAA Fisheries Service, 2011).

Future Work

The Gulf and South Atlantic Fisheries Foundation has already agreed to subject the Modified Nested Cylinder BRD to formal certification trials utilizing an at-sea observer in the early summer of 2014. From the evaluations that were performed with the other BRDs in this project, we believe that the Hummer BRD, L&J BRD, and Burbank are candidates for certification, and they will be recommended for such in the future.

Additionally, we plan to recruit collaborators in the shrimp fishery to tow and evaluate the Hummer Line for practicality and effectiveness in the fishery. It is believed that it has the potential to eliminate Atlantic croaker from the catch, and this would be extremely important in the nearshore white shrimp fishery where it is extremely abundant.

Likewise with the Kiel BRD, we will attempt to obtain Letters of Authorization from state and federal agencies to place the gear aboard cooperative trawlers and receive feedback from industry.

We believe Kiel and Witches Hat BRD performance is based on creating areas of reduced water velocity, and modification of position and float size in the Kiel BRD may be warranted. Incorporating an expanded mesh panel in conjunction with the Witches Hat may enhance bycatch reduction, and we plan to conduct proof of concept for this combination in the future.

As a result of this study, the tested BRDs have demonstrated proof of concept and the potential to be candidates for certification in spite of challenges endured due to depth and resulting paucity of important bycatch species. In conclusion these gears will be recommended for further study and necessary modifications to move forward in the BRD certification process.

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