# FINAL REPORT

**GRANT NUMBER:** **COOPERATIVE AGREEMENT NA87FM0221/YRII/Amend #78**

**PROJECT TITLE:** **CONTINUATION OF A PROGRAM TO IMPROVE DOCUMENTATION OF FISHING EFFORT IN THE SOUTHEASTERN U.S. SHRIMP FISHERY AND TO BETTER DEFINE BIOLOGICAL PARAMETERS FOR THE RED SNAPPER STOCK ASSESSMENT MODELS**

**AMOUNT OF GRANT:** **Federal $350,000 Match 0 Total $350,000**

**AWARD PERIOD:** **From: May 01, 2001 To: August 31, 2002**

**GRANTEE:** **Gulf and South Atlantic Fisheries Foundation, Inc.**

The Cooperative Agreement, Amendment 3,designated effective 1 May 2001 was signed and forwarded by NOAA Grants Management. The agreement was signed and executed by the Foundation Executive Director on June 25, 2001 with an effective date of May 1, 2001 to February 28, 2002. On February 14, 2002, a 6-month no cost extension was solicited extending the termination date to August 31, 2002.

## EXECUTIVE SUMMARY


Among U.S. fisheries, shrimp traditionally ranks first or second in value and in the top ten in volume, with the majority of production coming from the southeast (South Atlantic and Gulf of Mexico) coastal states (DOC, Fish. Stat. U.S., 1988-1994). In 2001, shrimp consumption reached a record high of 1.4 billion pounds (shell-on, headless weight basis). The fishing gear widely used in this economically important fishery is the otter trawl, a non-selective gear that also captures substantial incidental harvests (bycatch). This incidental fishing mortality is thought to impact the health of several recreationally and commercially important finfish stocks. Earlier studies have shown the range of bycatch to be between 1:3 to 1:4 for the South Atlantic and Gulf of Mexico respectively. Therefore, reduction of bycatch and associated finfish mortality is desirable from both an ecological and economic perspective.

This project addresses some of the key issues and recommendations of the **Joint Shrimp Effort and the Red Snapper Working Group**[1] for Year II of Cooperative Agreement NA87FM0221. Specifically, the Shrimp Effort Working Group recommended that the Foundation *" Conduct Bycatch Reduction Device (BRD) efficacy evaluation and continue development of more effective BRDs."* The Red Snapper Working Group also recommended that the Foundation *"Develop and conduct regional fishery observer-based data collection procedures that would directly measure key finfish incidental Bycatch and mortality attributable to both the shrimp and recreational-for-hire fishery."*

Strengthening the technology subcomponent of current BRD programs is the critical first step in the development of any reasonable Bycatch Reduction Program. The project's main priority was to get additional BRDs certified by capitalizing on the high level of trust afforded by the shrimp industry to the Foundation. A second goal was to conduct fishery dependant (observer-based) pilot studies in the commercial rock shrimp fishery to characterize the catch and bycatch in the rock shrimp fishery.

Five of twelve promising BRD candidates were tested following the official NMFS (Gulf of Mexico and South Atlantic Fishery Management Council) BRD Certification Testing Protocol. Foundation contracted (NMFS certified) fishery observers collected field data on BRD certification tests, collecting shrimp effort, catch, and corresponding rates of red snapper bycatch data on commercial shrimp trawlers in the Gulf of Mexico (GM). The BRDs that were tested and their designers/proponents are:

1) **Double-Opposed Fisheye BRD**- Timothy Adams, Alabama- Gulf of Mexico
2) **Kiffe**- C.J. Kiffe, Louisiana- Gulf of Mexico
3) **Wheeler BRD**- Gregory Atwood/Jack d'Antignac, Georgia- South Atlantic

4) **Hickman Sea Eagle II**- Bill Hickman, North Carolina- Gulf of Mexico
5) **Coulon TED**- Dennis Coulon, Louisiana- Gulf of Mexico

[1] Summary report of the Joint Shrimp Effort and Red Snapper Workshop, March 23-30, 2000. Gulf and south Atlantic Fisheries Foundation, Inc., Tampa,

A summary table of these BRDs showing the total number of tows, good tows, and those with the required snapper in the net follows:

| **BRD Tested** | **Total # of tows sampled** | **Good tows (#)** | **Tows with required Red Snapper in net** | **Remarks** |
|---|---|---|---|---|
| Dbl Opp Fisheye | 86 | 27 | 5 | Five qualifying snapper tows, 0% snapper reduction |
| Kiffe | 2 | 0 | 0 | Broke on 2nd tow, switched to Sea Eagle- see below |
| Wheeler BRD | 20 | 0 | 0 | No tows available for statistical analysis |
| Sea Eagle II | 201 | 48 | 3 | Lowest shrimp loss, best Total Biomass reduction |
| Coulon TED | 166 | 26 | 0 | No snapper qualifying tows recorded |
| **TOTAL** | 475 | 114 | 8 | |

Problems encountered included entanglement with crab traps, snags, and mixing of the catch. One candidate, the CJ Kiffe, broke on the 2nd tow, forcing a switch to the Sea Eagle II. Trips SB 192 and SB 193 were the only two trips we were able to arrange for the South Atlantic region, but with none of the resulting 20 total tows able to be used for statistical purposes, we effectively had no results for the Wheeler BRD. Overall, a total of 254 sea-days leading to 475 tows were accomplished, but only 8 tows had the required number of snapper to qualify the tows. This paucity of snapper to qualify the tows has happened before, but not to the extent we saw here. Of the qualifying tows, at 30% the Sea Eagle II in the 10' position had the greatest reduction in total biomass, with a 5% shrimp loss. At 3.4% shrimp loss, the other qualifying candidate- the Double Opposed Fisheye, seemed better in that category, but only reached a 16.4% reduction in total biomass.

The second goal was to conduct fishery dependant (observer-based) pilot studies in the commercial rock shrimp fishery to characterize the catch and bycatch in the rock shrimp fishery. Unfortunately, a combination of boat breakdowns and bad weather in the South Atlantic prohibited us from completing this portion of the project. Once the weather cleared, the available boats had moved into other areas to fish. An extension was requested and granted, and this allowed us to continue testing promising BRD candidates through the month of August 2002 instead of waiting another year to complete this goal. Results for the additional tows are combined for statistical purposes.

Despite the above noted problems, there were some promising results in terms of potential shrimp retention and bycatch reduction capabilities of the candidate BRDs. It is recommended that further testing of these devices be conducted to reach the required number of 30 tows as set forth in the BRD Certification Testing Protocol.

# CONTINUATION OF A PROGRAM TO IMPROVE DOCUMENTATION OF FISHING EFFORT IN THE SOUTHEASTERN U.S. SHRIMP FISHERY AND TO BETTER DEFINE BIOLOGICAL PARAMETERS FOR THE RED SNAPPER STOCK ASSESSMENT MODELS

## I. INTRODUCTION

### *Background*

Among U.S. fisheries, shrimp traditionally ranks first or second in value and in the top ten in volume, with the majority of production coming from the southeast (South Atlantic and Gulf of Mexico) coastal states (DOC, Fish. Stat. U.S., 1988-1994). In 2001, shrimp consumption reached a record high of 1.4 billion pounds (shell-on, headless weight basis). At the Gulf of Mexico (GOM) ex-vessel level though, annual average prices declined 13.6% between 1997 and 2001 for 21-25 count tails, while 31-40 count tails have declined from $5.21/lb in 1997 to $4.07 in 2001. This problem mainly arises from the importation of cheaper foreign farm-raised shrimp. The southeast region has annually landed >250 million pounds of shrimp valued at >$450 million, accounting for >80% of landings and >90% of value of the entire U.S. shrimp industry. In contrast, Thailand alone exported 418 million pounds to the USA in 2000. This was nearly 200 million pounds more than the entire domestic shrimp production from the Gulf and Southeast Atlantic. Additionally, the domestic shrimp fishery provides substantial direct (harvesting, processing, distribution, retail) and indirect (boat building and maintenance, fishing gear/fuel suppliers) economic opportunities, and the influence of this fishery is felt throughout the U.S. because of widespread demand for this delicacy.

The twin or quad-rigged shrimp trawl is widely used for harvesting this economically important fishery. Trawls are, however, relatively non-selective gear resulting in large incidental harvests (bycatch). Earlier studies have identified over 450 taxa from the Southeast U.S. A generalization of a 10:1 bycatch ratio is often misquoted when in fact, studies have shown the seasonal range of bycatch to be between 1:2.35 to 1:4.25 for the South Atlantic and Gulf of Mexico respectively. Unfortunately, most of this catch is discarded due to limited demand, incentives, or lack of market. Therefore, reduction of bycatch and associated finfish mortality is desirable from both an ecological and economic perspective.

As current fisheries management thinking seems to be heading toward the more holistic approach of ecosystem management, concerns about the species composition, discards, and finfish incidental mortality may arise from various perceptual, ecological, and economic factors. This same incidental mortality may contribute to allocation issues and problems of overfishing for commercially and recreationally important finfish stocks (e.g. Red Snapper *Lutjanus campechanus*, Weakfish *Cynoscion regalis*, or Spanish mackerel *Scomboromorus maculates*). These general concerns about bycatch in the shrimp fishery prompted amendments to the 1990 Magnuson Fishery Conservation and Management act. This amendment mandated the Secretary of Commerce establish a program (Incidental Harvest Research Program) under the jurisdiction of the Gulf of Mexico and South Atlantic Fishery Management Councils, to assess impacts of incidental harvest by the shrimp trawl fishery on the region's fishery resources.

The Foundation, involved since the program's outset, coordinated the development of a strategic document- "**A Research Plan Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries**". The plan was completed under the auspices of a Bycatch Steering Committee composed of representatives from commercial and recreational fishing interests, National Marine Fisheries Service (NMFS), universities, state fishery management agencies, regional marine fisheries commissions, federal fishery management councils, and public environmental organizations. The long-term goal of the plan was to provide reliable information leading to adequate management strategies for the fishery

resources of the southeastern United States. A series of specific objectives were designed to meet the
Congressional mandate for reducing finfish bycatch in the shrimp trawl fishery.
Two general types of bycatch reduction devices (BRDs) have been tested extensively and certified for their ability to reduce finfish bycatch. The *fisheye*, a simple metal frame shaped almost like an oval ice cream cone, provides a permanent opening for fish to escape. With proper installation and sufficient size, this BRD can reduce finfish catch by 15-30% with about a 5% shrimp loss. The second, *expanded mesh-extended funnel,* containing at least 3 bars of large mesh surrounding a modified accelerator funnel located behind the TED (Turtle Excluder Device) has about 20-25% finfish reduction with no shrimp loss. The gear reduces about 25% of the snapper and 30% of the weakfish. Based of these results, regulations concerning bycatch reduction were or are being implemented throughout the southeast. Although achieving consistency for which BRD to use is a goal between the states, there remain differences in various state regulations. Even after extensive testing, a very limited number of BRDs have been found that meet or exceed minimum criteria for acceptance. Partially this is due to indeterminate species composition in some areas or BRDs tested on a limited basis in some areas.

The involvement and cooperation of industry and other target users in the development and certification testing of industry-derived BRD prototypes has been recognized as a win-win situation, facilitating the much needed trust and cooperation between commercial industry and government fishery agencies. The Foundation has always sought to involve fishermen as sources of new BRD design ideas and full partners in BRD research.

## II. PURPOSE

This project is a continuation of the Foundation's commitment toward addressing bycatch issues in the southeastern shrimp trawl fishery. Working cooperatively with shrimp trawlers, the Foundation hopes to enhance their contribution in the development, evaluation, and modification of new BRDs. More specifically, the long-term objective is to identify, make design improvements, and conduct certification tests on as many industry-derived BRDs as possible. The specific goals of this project were:

a) Solicit and pre-screen as many industry, NMFS, State, or internationally developed BRDs that show potential for use in the Gulf of Mexico and South Atlantic shrimp fishery;
b) Conduct operational tests on approximately seven (7) promising BRDs following the official NMFS (Gulf of Mexico and South Atlantic Fishery Management Council) BRD Certification Testing Protocol;
c) Collect field data on BRD certification tests using Foundation contracted (NMFS certified) fishery observers;
d) Analyze and disseminate the results of tests to the commercial fishing industry, federal and state fishery management agencies, and Sea Grant/Marine Extension Service;
e) Collect shrimp fishing effort, catch and corresponding rates of red snapper bycatch among commercial shrimp trawlers in the Gulf of Mexico;
f) Determine the red snapper bycatch and estimated fishing mortality (F) reduction potential of various experimental BRDs; and
g) Conduct fishery dependant (observer-based) pilot studies in the commercial rock shrimp fishery to characterize the catch and bycatch in the rock shrimp fishery.

## III. APPROACH

**Statement of Work**

This section defines the activities conducted (objectives a-g) and included within the budget period May 01, 2001 to August 31, 2002. In this period, the Foundation sought to provide support for the field certification testing and further development of twelve industry-generated BRDs or BRD/TED combinations originally proposed for this project.
Those twelve gears considered were:

1 Super Shooter TED as TED/BRD combination
2 Modified Jones-Davis w/ double hoops & modified funnels
3 Dennis Coulon TED/BRD combination
4 Australian TED/BRD combination
5 NMFS modified box BRD design prototype
6 NMFS modified TED/BRD design
7 Kelly-Girourard Grid
8 Fish Slot II
9 Hickman's Sea Eagle II
10 Wheeler TED/BRD combination
11 Deiyo's TED/BRD
12 Modified Web Panel BRD

Of the twelve designs originally submitted, some were quite complex in design and Foundation efforts to incorporate them with industry cooperative evaluations were futile. Several had received testing in previous Foundation evaluations and were considered to be promising candidates for certification. The potential of the others was unknown and was subjected to proof of concept investigations by NMFS off Panama City, FL. During those efforts, Foundation Observer Coordinator Russell O'Brien joined the NMFS Harvesting Branch and collaborated with investigations of these prototype gears. Divers and video provided underwater viewing of the excluders. Additionally, the NMFS project provided insight into gears that might be problematic. Through this effort, the Foundation was able to cull several devices from the list of potential gear, thus saving much costly offshore evaluations. The five selected based on their past performance, hydrodynamic flow characteristics, and modifications were:

1. **Modified Double Opposed Fisheye** (Industry proponent- Timothy Adams, Gulf of Mexico)
   This BRD is a modification of the standard fisheye BRD but unlike the standard fisheye, the double opposed fisheye has an elongated escape 'tunnel'. Underwater video observations of fisheye performance show fish, especially red snapper, easily going in and out of the escape hole and the tunnel aids in preventing backwash of bycatch during haulback. (FIGURE A)

2. **Kiffe BRD** (Industry proponent- C.J. Kiffe, Gulf of Mexico)
   C.J. Kiffe, a veteran Louisiana net maker and fishing gear designer developed this BRD design. The gear aims to reduce shrimp loss while increasing bycatch reduction. With super shooter TEDs, a 'dead zone' of reduced velocity water is created alongside the shooter funnel. Connected to the frame of the hard TED is an accelerator funnel with a 4:1 taper. Constricted water flow through the tunnel creates a 'jet' of fast moving water to carry shrimp far back into the cod end, while also creating another dead zone where fish can escape through the 8" square mesh webbing panel. Finally, a second funnel aft directs water flow and shrimp into the cod end and helps prevent shrimp escape. (FIGURE B)

3. **Wheeler BRD** (Industry Proponents- Gregory Atwood/Jack d'Antignac, South Atlantic)
   This BRD was designed by Fred Wheeler, a veteran gear designer who has been fabricating TED grids for years. The Wheeler BRD is a TED/BRD combination where an irregular-shaped hole is welded on the top section of the standard hard TED. A 23x11.5 mesh hole is cut on the netting material immediately behind the TED/BRD hole. A cover the same size as the hole is sewn on the BRD hole and TED opening.

Therefore, fish passing through the TED could swim forward and out through the exit hole made by the irregularly shaped hole on top of the TED. (FIGURE C)

4. **Hickman Sea Eagle II** (Industry proponent- Bill Hickman, Gulf of Mexico)
Popular among South Atlantic fishermen, the Hickman Sea Eagle II BRD is a successful design by William Hickman. This particular BRD is also one of three BRDs certified by the state of Texas for use as a fish excluder in its waters. Earlier underwater observations had shown that most observed shrimp loss occurred during the haul-back phase of the trawling operation. The Sea Eagle II BRD is constructed of stainless steel bars with a pressure sensitive trap door that opens during regular towing but closes at haul back. This design seems to have the potential to lower shrimp loss while reducing bycatch compared to standard fisheye BRDs. (FIGURE D)

5. **Coulon TED/BRD** (Industry proponent- Dennis Coulon, Gulf of Mexico)
Popular among the shallow, inshore shrimp trawlers of Louisiana, Dennis Coulon's design has been recommended for testing in the deeper shrimp fishing grounds of the Gulf of Mexico. This is a top-shooting TED with a 3" wide spoiler plate attached to a rigid frame mounted on the forward side. The spoiler creates an area of vortices and low water flow that allows fish to swim out and escape. Because of the large exit hole, shrimp loss due to backwash is a potential problem. This is overcome by the use of choker straps, which also help to eliminate side-bias and maintain balance. (FIGURE E)

Generally, the Foundation made funds available that covered or offset the costs of material, labor, and vessel costs directly associated with the development and evaluation of experimental BRD design prototypes. The cooperating fishing vessels were provided with token compensation based on a daily flat rate. This compensation was an incentive due to the estimated shrimp loss incurred while testing experimental gear and to pay for the observer's food and accommodations. Costs associated with BRD construction and related gear modifications were also reimbursed by the Foundation. In turn, cooperators donated some of their time spent in BRD construction, gear testing, and bycatch sorting as industry match to this research project. Foundation involvement also included arranging for any special permits required and providing trained observers to record the results of the tests. Additionally, the Foundation arranged for vessel liability insurance (Protection and Indemnity) associated with the observer's presence on the trawler and the cost of data entry and analysis.

## Project Management

Personnel and Responsibilities

*Principal Investigators:*

Ms. Judy L. Jamison Executive Director, overall administrative supervision
Mr. Geoffrey C. LaneProgram Director, technical supervision, data interpretation

*Foundation Staff:*

Ms. Gwen Hughes Program Specialist
Ms. Charlotte Irsch Grants/ Contract Specialist

*Regional & Fishery Observer Coordinators*

Mr. Gary Graham Gulf of Mexico- Texas A&M University Sea Grant
Mr. Lindsey Parker South Atlantic- University of Georgia Marine Extension
Service
Mr. Russell O'Brien Fishery Observer/Vessel Coordinator

*Data Management: and Analysis*

Mr. Phil Diller Data Manager, data proofing and remote database entry.

Mr. Tyson Hatton Data Analyst, data reduction and statistical analysis

*Observers* (GM= Gulf of Mexico, SA= South Atlantic)

6 Each has successfully completed training on the BRD Certification Testing Protocols and Sea Turtle Handling Protocols provided by scientists at the NMFS-Galveston Lab

The Gulf and South Atlantic Fisheries Foundation, Inc. was responsible for the project's overall administration and coordination through its Tampa Florida office. The Foundation Executive Director, Ms. Judy Jamison, has the ultimate responsibility for all administrative Foundation activities, with oversight by the Foundation's Board of Trustees. She ensured timely progress of activities to meet project objectives and confirmed compliance of all activities with NOAA/NMFS guidelines. Additionally, she prepared operational reports concerning project performance. Under her direct supervision, administrative assistants Gwen Hughes and Charlotte Irsch monitored the progress of observer activities, provided guidance on cost control, processed requests for reimbursement, generated supporting documentation, and assisted auditors during their reviews. The Program Director, Mr. Geof Lane, has overall responsibility of the technical aspects of the project, including the coordination of personnel activities at satellite locations. At the outset of this project, Dr. Thomas Jamir was the Program Director, but Mr. Lane succeeded him, and coordinated all analytical efforts.

The two Regional Coordinators and Fishery Observer Coordinator have direct day-to-day responsibility for the activities of field observers and Data Manager, and coordinated these activities through continual communication with Foundation staff. In their capacity, the Coordinators a) acted as liaisons between observers and cooperating vessels, b) reviewed, with the Data Manager, incoming data for completeness and accuracy, and c) monitored personnel performance. Also, Captain Lindsey Parker succeeded Dave Harrington as South Atlantic Coordinator during this project.

The Foundation has contracted with specific qualified data collection and management personnel to perform various tasks throughout its involvement in the Bycatch Program. Observers were responsible for collecting accurate field data according to established protocols. Data management personnel transferred the raw data into a manageable computer database format for analysis and inclusion in the programmatic pooled data set archived at NMFS Galveston.

## IV. DATA PROTOCOLS

The Foundation worked cooperatively with commercial shrimp trawlers to ensure all tests were conducted according to the NMFS revised protocols and guidelines outlined in the following documents:

1) "**Shrimp Trawl Bycatch Research Requirements**" document published by U.S. DOC NOAA NMFS Southeast Fisheries Science Center {Miami} and Southeast Regional Office {St. Petersburg} [November 1991];

2) "**A Research Plan Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries**" document published by the Gulf and South Atlantic Fisheries Development Foundation, Inc. with support of NOAA/NMFS under Cooperative Agreements NA17FF0233-01 and NA17FD0103-01 [August 1992];

3) "**Shrimp Trawl Bycatch Characterization Sampling Protocol Manual for Data Collection**" produced by U.S. DOC/NOAA/NMFS Southeast Fisheries Science Center {Galveston} [September 14, 1992];

4) "**Evaluation of Bycatch Reduction Devices Sampling Protocol Manual for Data Collection**" produced by U.S. DOC/NOAA/NMFS Southeast Fisheries Science Center {Galveston} [September 14, 1992];

5) "**Bycatch Reduction Device Testing Protocol Manual**" published by the South Atlantic Fishery Management Council [1997 and 2000 draft revisions]; and

6) "**Gulf of Mexico Bycatch Reduction Device Protocol Manual**" published by the Gulf of Mexico Fishery Management Council [1999 and 2000 draft revisions].

All BRDs were subjected to a 4-step testing process as indicated below. However, this project was only concerned with step (3), operational testing phase-

*1) Prototype development - developer designs a BRD and makes initial limited field tests denoting bycatch reductions and shrimp retention.*

*2) Proof of concept - the prototype is installed on a research or commercial vessel and the standard sampling protocols are followed to collect data on bycatch reductions and shrimp retention for a minimum of 20 tows.*

*3) **Operational testing -** the BRD is installed in nets aboard commercial fishing vessels throughout the southeast U.S. The BRD is evaluated under normal working conditions with an observer collecting data on bycatch reduction and shrimp retention according to standard sampling protocols. The observer also documents any comments and suggestions of the captain concerning the gear's efficiency and/or necessary modifications.*

*4) Industry evaluation - the BRD is distributed to selected commercial fishing vessels throughout the southeast U.S. to be deployed during normal fishing activities. The captain is required to collect data concerning bycatch reduction and shrimp retention, and is requested to provide comments and suggestions concerning its acceptability and/or necessary modifications.*

## V. DATA COLLECTION AND PROCESSING

1) **Data collection**- Data collection was accomplished through the use of NMFS certified observers that collected the data aboard voluntarily participating commercial shrimp trawlers. All sampling was fishery-dependent, with data collected under normal working conditions. For each tow sampled, detailed information concerning gear configuration, location, time, and catch was recorded. Total catches of the sample nets were weighed, and a basket (@ 30 kg. or 70-80 lbs.) sample from both a 'control' (no BRD) and 'experimental' (with BRD) net was collected. This type of paired net sampling for BRD evaluations allows direct comparisons of the catch between two nets on a single trawl effort. To offset any possibility of the nets fishing with dissimilar efficiency, the BRD was moved to the 'control' net for half the samples and the old 'experimental' net became the control. This is to eliminate any biases associated with a specific net to more accurately reflect the BRD's effectiveness.

Species within each sample were identified, enumerated, weighed as a species lot, and individuals of select 'key' species were measured. All Red Snapper caught in both the control and experimental nets were collected with lengths and aggregate weights documented and recorded in the Select section of the station sheet for each net. The total number of tows per trip depended on the fishing activity of each vessel and the logistical time restraints imposed from need to complete one sampling effort (i.e. one sampling effort may not have been completed before the next tow was brought aboard, thus the next tow was not sampled.)

2) **Data processing**- Data collection and management procedures were designed to ensure minimal data entry errors. The data sheets were proofed for accuracy and completeness at the end of each trip by the observers, and the data was then given to the Observer Coordinator to ensure accuracy before the data was forwarded to the Data Manager for computerization. Irregularities or any questionable/ confusing entries on the data sheets were noted by the data entry personnel who referred to the observer for confirmation of corrections, as necessary. The Observer Coordinator then proofed data once more. Once computerized, a printout of the data was crosschecked against the original data sheets for input errors, corrections were made to the computer file, and the edited version checked against the previous version. After being verified as accurate, the data were archived in a pooled, multi-organizational data set at NMFS Galveston Lab, and an additional set of the data was given to Foundation personnel.

3) **Data analysis**- The species number and weight for the entire tow of each designated sample net were extrapolated using the ratio of the sample weight (or number) vs. the total weight:

**Equation 1** $$\frac{\text{Sample Species wt. (no.) X Total Net Wt.}}{\text{Total Sample Wt.}} = \text{Extrapolated species wt. (no.) in net}$$

(Certain species are designated as "select" and every individual of that species is collected from the catch of the net {not just the sample}. If "select" species are taken, then the weight of that {those} species is subtracted from the Total Net Weight, and the weight of that {those} species contained in the sample is subtracted from the Total Sample Weight before extrapolating the data for the other species in question.)

These extrapolated values were then converted to a catch-per-unit-effort (CPUE) based on the hours towed:

**Equation 2** **Extrapolated Sp. Wt. (No.) ÷ Hr towed = Catch per hr**

Mean (+/- SE) catch rates for the trip (or other unit of time) were then calculated based on the summation of these CPUE values for all successful tows sampled during a particular trip or time period.

The goal of the Bycatch Research Program was to reduce shrimp trawl incidental mortality by 50%, based on stock assessments for the two key finfish species, Red Snapper in the Gulf of Mexico and Weakfish in the South Atlantic. The South Atlantic additionally has an interest in achieving similar reductions for Spanish mackerel. The goal is to reduce mortality on the Age 0 and Age I age classes, the dominant ages taken by trawlers. In the South Atlantic, two target options have been defined for the weakfish and mackerel: a 50% fishing mortality reduction *or* a 40% reduction in the numbers of fish taken per net-hour, but the 50% mortality reduction is still the only criterion for evaluating red snapper reductions in the Gulf of Mexico. Calculating such a reduction in fishing mortality requires examining the reductions for specific length classes within each year class. Then the length-specific reductions must be incorporated into the survivorship calculations for each length group within these year classes.

Of course, for all tests and evaluations, it was equally important to consider the changes in shrimp catch attributable to the various BRD designs. The initial Bycatch Research Plan specifically identified that a researcher's goal should be to produce a BRD that addresses finfish reduction while also retaining at least 95% of the shrimp. This has been a benchmark for achievement, not an identified criterion for acceptance or rejection of a particular BRD. In any event, for any BRD recommended (or certified) for use, it was imperative that shrimp retention data be available to the shrimp fishermen. Obviously, it would be to their benefit to select a

BRD that had the least shrimp loss, but if a shrimp fisherman preferred to use a BRD that met finfish requirements but retained less shrimp, that would be their prerogative. All analyses included comparisons of the shrimp retention, total biomass reduction, and specific finfish reductions for the various BRD designs.

To calculate the reduction attributable to a specific BRD, total biomass reduction for a particular tow was calculated as:

**Equation 3{(BRD net weight ÷ Control net weight) - 1} X 100 = % reduction**

For the various species, reductions were calculated by:

- extrapolating, using Equation 1, the total weight (or number) of a species taken in both the Control and BRD net based on the weight (or number) of that species present in the sample for each tow,
- generating a CPUE per tow using Equation 2,
- generating a grand mean and associated appropriate statistics of these CPUE values over the trip (or other unit of measure) for both the Control and BRD net, and
- calculating an overall percent reduction in the BRD net based on these means using the format of Equation 3.

Only tows which have representatives of a species in one or both nets are used for these calculations. Total absence of a species from both nets does not provide information on reduction-gear efficiency. Additionally, if a species was considered "select", then the extrapolations were unnecessary.

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

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

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

Under the current protocol, the statistical hypothesis assumes the BRD candidate does not meet the bycatch reduction criterion. The draft 2000 BRD Certification Testing Protocol requires the use of “ratio analysis” which, according to Dr. Arvind Shah, provides a simpler way to calculate reductions while providing additional options for analysis (e.g. error estimates). Under the draft 2000 modified protocol, the null hypothesis assumes the candidate meets the bycatch reduction criteria. Details of this procedure are included in Appendix A. Dr. Shah’s SAS program was used to calculate shrimp loss, total biomass reduction, and the gear reduction rates for red snapper in the Gulf of Mexico and weakfish/Spanish mackerel in the South Atlantic as both approach results in comparable BRD reduction estimates. If accepted, the proposed revisions limit certification of BRD candidates to their ability to reduce the catch of juvenile red snapper in the Gulf of Mexico and weakfish in the South Atlantic.

## VI. RESULTS AND DISCUSSION

The following are the results of tests conducted on various experimental industry Bycatch Reduction Devices. ‘IS’ means insufficient numbers of snappers were present to for statistical analysis. Only two series of tows (FB190 and FB195) had sufficient numbers of snapper present to qualify the tows for red snapper reduction. The results for the paired tow tests are summarized in the matrices below with positive numbers indicating a higher reduction rate for the control net. Each matrix shows the results for the paired tows.

1) **Double-Opposed Fisheye BRD**- Timothy Adams, Gulf of Mexico

| | **Reduction Rate at various distances from cod end tie-off** | | |
|---|---|---|---|
| **N= 40** | **Trip 190 (8’4”)** | **Trip 198 (12’6”)** | **^Trip200 (12’6”)** |

| | | | |
|---|---|---|---|
| **Total Biomass** | -22.2% | -3.4% | -4% |
| **Red Snapper** | -33.3% | IS | -20% |
| **Shrimp Loss** | 2% | 10% | 0% |

For Trip FB190, 30 tows were completed. Of the 13 paired tows worked up to completion, 5 tows fit the standard tow time of 6.5 hrs (+/- 10%) and also contained sufficient red snapper for qualifying reduction rates. For Trip FB198, 37 tows were completed with 15 tows meeting the standard tow times and 11 tows fit within the standard tow time of 7.5hrs (+/- 10%). For Trip FB 200, 19^ tows were completed with 11 meeting the standard tow time but none having the requisite amount of snapper present for qualifying red snapper reduction. These results are for the port side only as a shortened trip forced discontinued testing of the BRD on the Starboard side.

**2) Kiffe**- C.J. Kiffe, Gulf of Mexico

* Unfortunately, this candidate broke on the 2nd tow, forcing the discontinued testing of the BRD. The CJ Kiffe went basically untested, but further testing may be warranted based on past performance of this candidate.

**3) Wheeler BRD**- Gregory Atwood/Jack d'Antignac, South Atlantic

There were 13 tows completed for this BRD on Trip SB192 and 7 tows for Trip SB193. However, none of the tows could be statistically analyzed.

**4) Hickman Sea Eagle II**- Bill Hickman, Gulf of Mexico

| | **Reduction Rate at various distances from cod end tie-off** | | |
|---|---|---|---|
| **N= 48** | **Trip 191 (4')** | **Trip 195 (10')** | **Trip 196 (10')** |
| **Total Biomass** | -16% | -32.2% | -20.2% |
| **Red Snapper** | IS | -10.5% | IS |
| **Shrimp Loss** | 8.7% | 0% | 30%* |

There were 48 total tows from Trip FB191, the first 2 of which were unusable due to the breakage of the Kiffe BRD. Of the remaining 46 tows, 19 were acceptable for doing statistical analysis, but only 9 fit into the standard tow time of 6 hours (+/- 10%), and none of those had sufficient red snapper present to qualify the tows. Trip 194 had 17 tows completed. None were worked up to completion due to the improper protocol being used. Trip FB195 had a total of 73 tows, 19 of which were acceptable for statistical analysis. 12 of the 19 paired tows fit into the standard tow time of 6.5 hours (+/- 10%) and of those, only 3 contained sufficient numbers of snapper to qualify the results. Trip FB196 had no qualifying snapper tows, but there were 65 tows completed with 10 paired-tows for analysis. *If the one large catch in the experimental net is ignored, the remaining 9 paired tows increase the experimental net shrimp loss to 9.1%, but for the 8 standard-time tows, there was a 36.4% average shrimp loss for the control net due to that large shrimp catch in the experimental net. If that sample is ignored, the remaining 7 tows cause the loss rate of the experimental net to drop to 0%.

**5) Coulon TED/BRD**- Dennis Coulon, Gulf of Mexico

| | **Reduction Rate at various distances from cod end tie-off** | |
|---|---|---|
| **N= 26** | **Trip 201** | **Trip 209** |
| **Total Biomass** | -29.3% | +1.8% |
| **Red Snapper** | IS | IS |
| **Shrimp Loss** | 5.7% | -6.3% |

For Trip FB201, no tows had the required number of red snapper present, but a total of 146 tows were completed resulting in 19 paired tows sufficient for statistical analysis.

There were 11 tows that fit within the standard tow time of 7 hrs (+/- 10%) resulting in an average 10% shrimp loss. Additionally, nearly continuous fouling of the nets by abandoned crab traps plagued trip 201. For Trip FB209, 20 tows were completed with 7 paired tows available for statistical analysis. 5 tows fit within the standard tow time of 4 hours (+/- 10%). No tows contained sufficient red snapper to qualify the tows, and the average shrimp loss reached 7.9%

## Individual Cruise Summaries of BRD Results

**FB190**- There was 30 tows completed. The paired tows tallied 13. From the paired tows, 5 fit into the standard tow time of 6.5 hours (+/- 10%). (Double Opposed Fisheye BRD, 8'4" position)

Biological reductions were observed for the 13-paired tows.

- Shrimp Loss: The average of these tows indicated the control net had a 2% shrimp loss compared to the experimental net. Paired tow n=13.
- Snapper Number Reduction: Experimental net reduction of snapper by 33.3% when compared to the control net. Paired tow n= 13.
- Finned Fish Reduction: Experimental net reduction of finned fish by 31.0% when compared to the control net. Paired tow n=13.
- Total Biomass Reduction: Experimental net reduction of total biomass by 22.2% when compared to the control net. Paired tow n=13.

Biological reduction observations for the 5 paired tows, which fit the standard tow times.

- Shrimp Loss: The experimental net had a shrimp loss of 3.4% when compared to the control net. Paired tow n=5.
- Snapper Reduction: Experimental net reduction of 0% compared to the control n=0.
- Finned Fish Reduction: Experimental reduction rate of 27.3% when compared to the control net. Paired tow n=5.
- Total Biomass Reduction: Experimental reduction of 16.4% when compared to the control net. Paired tow n=5.

**FB191**- There was 48 tows completed. The paired tows tallied 19. From the paired tows, 9 fit into the standard tow time of 6 hours (+/- 10%). (Hickman Sea Eagle II, 4' position)

Biological reductions were observed for the 19-paired tows.

- Shrimp Loss: The average of these tows indicated the control net had an 8.7% shrimp loss compared to the experimental net. Paired tow n=18.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental net reduction of finned fish by 21.3% when compared to the control net. Paired tow n=19.
- Total Biomass Reduction: Experimental net reduction of total biomass by 16% when compared to the control net. Paired tow n=19.

Biological reduction observations for the 9 paired tows, which fit the standard tow times.

- Shrimp Loss: The experimental net had a shrimp loss of 8.3% compared to the control net. Paired tow n=8.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental reduction rate of 21.7% when compared to the control net. Paired tow n=9.
- Total Biomass Reduction: Experimental reduction of 13.8% when compared to the control net. Paired tow n=9.

**SB192**- There was 13 tows completed. The paired tows tallied 0. (Wheeler BRD)

**SB193**- There was 7tows completed. The paired tows tallied 0. (Wheeler BRD)

**FB194**- There was 17 tows completed. The paired tows tallied 0. (Hickman Sea Eagle II)

**FB195**- There was 73 tows completed. The paired tows tallied 19. From the paired tows, 12 fit into the standard tow time of 6.5 hours (+/- 10%). (Hickman Sea Eagle II, 10' position)

Biological reductions were observed for the 19-paired tows.

- Shrimp Loss: The average of these tows indicated the experimental net had a 0% shrimp loss compared to the control net. Paired tow n=19
- Snapper Number Reduction: Experimental net reduction of snapper by 10.5% when compared to the control net. Paired tow n= 7.
- Finned Fish Reduction: Experimental net reduction of finned fish by 32.6% when compared to the control net. Paired tow n=17.
- Total Biomass Reduction: Experimental net reduction of total biomass by 32.2% when compared to the control net. Paired tow n=17.

Biological reduction observations for the 12 paired tows, which fit the standard tow time.

- Shrimp Loss: The experimental net had a shrimp loss of 5.0% compared to the control net. Paired tow n=12.
- Snapper Number Reduction: Experimental net reduction of snapper by 18.8% when compared to the control net. Paired tow n= 3.
- Finned Fish Reduction: Experimental reduction rate of 35.7% when compared to the control net. Paired tow n=12
- Total Biomass Reduction: Experimental reduction of 30% when compared to the control net. Paired tow n=12.

**FB196**- There was 65 tows completed. The paired tows tallied 10. From the paired tows, 8 fit into the standard tow time of 6.5 hours (+/- 10%). (Hickman Sea Eagle II, 10' position)

Biological reductions were observed for the 10-paired tows.

- Shrimp Loss: One large shrimp catch in the experimental net boosted the average percentage of loss for the control to 30% when compared to the experimental average. If the heavy sample for the experimental net is ignored, then the remaining 9 samples cause the average loss rate of the experimental net to go up to 9.1%. Paired tow n=10.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental net reduction of finned fish by 22.2%. Paired tow n=9.
- Total Biomass Reduction: Experimental net reduction of total biomass by 20.2%. Paired tow n=9.

Biological reduction observations for the 8 paired tows, which fit the standard tow times.

- Shrimp Loss: One large shrimp catch in the experimental net boosted the average percentage of loss for the control to 36.4% when compared to the experimental average. If the heavy sample for the experimental net is ignored, then the remaining 7 samples cause the average loss rate of the experimental net to go up to 0%. Paired tow n=8.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental reduction rate of 22.4% when compared to the control net. Paired tow n=8.
- Total Biomass Reduction: Experimental reduction of 17.9% when compared to the control net. Paired tow n=8.

**FB198**- There was 37 tows completed. The paired tows tallied 15. From the paired tows, 11 fit into the standard tow time of 7.5 hours (+/- 10%). (Double Opposed Fisheye, 12'6" position)

Biological reductions were observed for the 15-paired tows.

- Shrimp Loss: The average of these tows indicated the control net had a 10% shrimp loss compared to the experimental net. Paired tow n=15.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental net reduction of finned fish by 4.7% when compared to the control net. Paired tow n=12.
- Total Biomass Reduction: Experimental net reduction of total biomass by 3.4% when compared to the control net. Paired tow n=15.

Biological reduction observations for the 11 paired tows, which fit the standard tow times.

- Shrimp Loss: The average of these tows indicated the control net had a 16.7% shrimp loss when compared to the experimental net. Paired tow n=11.
- Snapper Reductions: No qualifying snapper tows. Paired tow n=0.
- Finned Fish Reduction: Experimental reduction rate of 6.6% when compared to the control net. Paired tow n=10.
- Total Biomass Reduction: Experimental reduction of 5.1% when compared to the control net. Paired tow n=11.

**FB200**- There was 19 tows completed. The paired tows tallied 12. From the paired tows, 11 fit into the standard tow time of 6.5 hours (+/- 10%). (Double Opposed Fisheye, port side only due to shortened trip)

Biological reductions were observed for the 12-paired tows.

- Shrimp Loss: The average of these tows indicated the experimental net had a 0% shrimp loss compared to the control net. Paired tow n=12
- Snapper Reduction: Experimental net reduction of 20% compared to the control with the one qualifying tow. n=1
- Finned Fish Reduction: Experimental net reduction of finned fish by 18.8% when compared to the control net. Paired tow n=11.
- Total Biomass Reduction: Experimental net reduction of total biomass by 4% when compared to the control net. Paired tow n=12.

Biological reduction observations for the 11 paired tows, which fit the standard tow times.

- Shrimp Loss: The average of these tows indicated the experimental net had a 6.7% shrimp loss when compared to the control net. Paired tow n=11.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental reduction rate of 20.7% when compared to the control net. Paired tow n=10.
- Total Biomass Reduction: Experimental reduction of 7.7% when compared to the control net. Paired tow n=11.

**FB201**- There was 146 tows completed. The paired tows tallied 19. From the paired tows, 11 fit into the standard tow time of 7 hours (+/- 10%). (Coulon TED/BRD)

Biological reductions were observed for the 19-paired tows.

- Shrimp Loss: The average of these tows indicated the control net had a 5.7% shrimp loss compared to the experimental net. Paired tow n=19.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental net reduction of finned fish by 7% when compared to the control net. Paired tow n=19.
- Total Biomass Reduction: Experimental net reduction of total biomass by 29.3% when compared to the control net. Paired tow n=19.

Biological reduction observations for the 11 paired tows, which fit the standard tow times.

- Shrimp Loss: The average of these tows indicated the control net had a 10% shrimp loss compared to the experimental net. Paired tow n=11.

- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental reduction rate of 0% when compared to the control net. Paired tow n=11.
- Total Biomass Reduction: Experimental reduction of 28.8% when compared to the control net. Paired tow n=11.

**FB209**- There was 20 tows completed. The paired tows tallied 7. From the paired tows, 5 fit into the standard tow time of 4 hours (+/- 10%). (Coulon TED/BRD)

Biological reductions were observed for the 7-paired tows.

- Shrimp Loss: The average of these tows indicated the experimental net had a 6.3% shrimp loss compared to the control net. Paired tow n=7.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental net reduction of finned fish by 8.4% when compared to the control net. Paired tow n=7.
- Total Biomass Reduction: An average control net reduction of total biomass by 1.8% when compared to the experimental net. Paired tow n=7.

Biological reduction observations for the 5 paired tows, which fit the standard tow times.

- Shrimp Loss: The average of these tows indicated the control net had a 7.9% shrimp loss compared to the experimental net. Paired tow n=5.
- Snapper Reductions: No qualifying snapper tows. n=0
- Finned Fish Reduction: Experimental reduction rate of 14% when compared to the control net. Paired tow n=5.
- Total Biomass Reduction: Control reduction of 7.5% when compared to the experimental net. Paired tow n=5.

**SUMMARY TABLE OF TESTS ON INDUSTRY BRD PROTOTYPES**
(All figures represent the experimental net unless otherwise noted.)

| Candidate Trip # | PT Shrimp Loss | PT Snpr reduction | PT FinF reduction | PT TBM reduction | ST Shrimp Loss | ST Snpr reduction | ST FinF reduction | ST TBM reduction |
|---|---|---|---|---|---|---|---|---|
| **DOF 8'4" FB 190** | Control - 2% PT n=13 | 33.3% | 31% | 22.2% | 3.4% ST n=5 | *Control* -0% (n=0) | 27.3% | 16.4% |
| **DOF 12'6' FB 198** | Control -10% PT n=15 | IS | 4.7% | 3.4% | 16.7% ST n=11 | IS | 6.6% | 5.1% |
| **DOF12'6" FB 200** | 0% PT n=12 | 20% | 18.8% | 4% | 6.7% ST n=11 | IS | 20.7% | 7.7% |
| **SE II 4' FB 191** | Control -8.7% PT n=19 | IS | 21.3% | 16% | 8.3% ST n=9 | IS | 21.7% | 13.8% |
| **SE II 10' FB 195** | 0% PT n=19 | 10.5% | 32.6% | 32.2% | 5.0% ST n=12 | 18.8% (n=3) | 35.7% | 30.0% |
| **SE II 10' FB 196** | ~*Control* -30% PT n=10 | IS | 22.2% | 20.2% | ˚*Control* -36.4% ST n=8 | IS | 22.4% | 17.9% |
| **COU FB 201** | Control -5.7% PT n=19 | IS | 7% | 29.3% | Control -10.0% ST n=11 | IS | 0.0% | 28.8% |
| **COU FB 209** | 6.3% PT n=7 | IS | 8.4% | 1.8% | 7.9% ST n=5 | IS | 14% | Control -7.5% |

**Key to Abbreviations**

**PT**= paired tow **ST**= standard tow **n**=# of tows

**Snpr**= red snapper **FinF**= finfish **TBM**= Total Biomass

**DOF**= Double Opposed Fisheye BRD **SE II**= Sea Eagle II BRD **COU**= Coulon TED/BRD

~One large shrimp catch in the experimental net boosted the average loss for the control net to 30%. If ignored, the remaining samples cause the average loss for the experimental net to rise to 9.1%.

˚ One large shrimp catch in the experimental net boosted the loss average in the control net to 36.4%. If that catch is ignored, the average percent reduction for the experimental net rises to 0%.

One of the goals in retesting these candidates was to measure their performance at different places within the net to compare the reduction rates and shrimp loss or gain to locate the optimal location for the BRD. In the above matrix, the results of similarly placed BRDs are grouped together to make ready comparisons.

## VII. CONCLUSIONS / RECOMMENDATIONS

A total of twelve BRDs were originally proposed for this project. Five made the final selection. Unfortunately, only two of the five BRDs tested had sufficient numbers of Red Snapper where a comparison could be made for snapper reduction and shrimp loss. The Sea Eagle II in the 10' position, had a 5% shrimp loss and an 18.8% snapper reduction. At 30%, this BRD also had the greatest overall reduction in total biomass. The Double Opposed Fisheye in the 8'4" position had a 3.4% shrimp loss with no snapper reduction. With so few data points to compare, it would be both unfair and problematic to suggest the performance of the other BRD candidates were substandard and warrant no further testing.

The fact that we were limited to a small number of data points made the mathematical analysis difficult for this project. A single point of change has dramatic effects on the final products of the statistical analysis because the data points were so few. Previous tests of these devices (Jamir, T.V. and J.L. Jamison. *Enhancing Industry Contributions Toward Bycatch Reduction in the Shrimp Fishery of the Gulf of Mexico and South Atlantic* NOAA/NMFS #NA87FD0099, Final Report. 2001) have demonstrated the following rates of reduction:

1) The Double Opposed Fisheye had a 4% shrimp loss reduction, 60% red snapper reduction, and an 18% reduction in total biomass.

2) The Sea Eagle II combined a 3% shrimp loss with 11-41% red snapper reduction and 28% reduction in total biomass.

3) Likewise, the Coulon TED/BRD averaged less than 1% shrimp loss while maintaining a 49% red snapper reduction and 11% reduction in total biomass.

The results of this series of tests obviously do not reflect the early successes recorded with these BRD candidates. Likewise, because of a miscommunication between the vessel captain and owner, the data for two trips was completely unusable and had to be thrown out (SB 192 and SB 193). These 2 trips represented nine sea days and twenty tows, the entire effort in the South Atlantic for this project. For Trip FB194, confusion by the observer on the proper protocol resulted in no good tows for analysis of the trip. Steps have been taken by the Foundation's Observer Coordinator to minimize the chance that similar problems would occur again.

Some problems we encountered were difficult to analyze. An example is the complete lack of snapper allowing us to do further statistical analysis of the data. In a perfect world, one could say that the BRD candidates were operating at maximum efficiency, and the lack of snapper is the result of 100% exclusion. Although not impossible and a highly sought after goal, that scenario is highly unlikely, given the past performance of these devices and their performance during this project. We are still left to ponder however, the overall paucity of snapper and lack of tows containing sufficient quantities of snapper for statistical analysis. With no prior knowledge of the devices, one might be inclined to discard them and seek others. Unfortunately for these candidates, their results and analysis suffer due to the lack of snapper encountered by the vessels.

Another problem we encountered was a slight side bias by the nets despite prior tuning. Where this becomes a major setback is when we are addressing the issue of the very small sample size, and any change has a great influence on the overall results. I am sure that these variances are merely an artifact but result in slightly higher overall rates of finfish reduction and shrimp loss. If such a bias had been recorded and only one vessel used in the testing, the problem would be easier to trace. The protocol states that nets used must be calibrated (tuned) to minimize any net/side bias in catch efficiency prior to the start of a test series or after any gear modification or change. Nets fishing on different sides may experience fishing efficiency differences. For this reason, the experimental BRD is moved between the port and starboard nets. The nets were supposedly pre-tuned as per the protocol; we used multiple vessels and fished in various areas over different times of the year, yet even with this much variety and randomization, we still record a slight bias. It is suggested that we conduct further analysis to see if the nets are being properly tuned before BRD evaluations are initiated, as well as attempt to increase the number of acceptable tows to increase our sample size.

Lastly, the hurricane season and events immediately following September 11, 2001 added to our problems, especially for the Rock Shrimp component of this project (objective g). The weather forced many vessels to remain in port due to rough seas. The anthrax scare also played a part, in that an observer refused to go to the East Coast to work. Our problems with finding qualified observers were compounded when two of our three contracted observers left. Since many observers have joined the NMFS observer program, our Observer Coordinator has had to find new applicants and train them. He was able to hire four, three of whom are still active. In the end, we were unable to get observers and vessels scheduled at the same time before the Rock Shrimp season waned and the boats moved back into the shrimp fishery out of Key West, FL.

Aside from the two problems of few data points and lack of red snapper, there were also problems related to the BRD Certification Testing Protocol. The lack of snapper combined with the requirement of an adherence to the +/- 10% tow duration limits the number of ‘good tows’ available for statistical analysis. Over the course of 245 sea days expended in the Gulf resulting in a total of 475 tows, 114 tows were worked up to completion, 72 tows (~15%) fit within the Protocol’s time requirements, but only 8 tows fit within the Protocol’s snapper requirement. The 10% tow time range can be altered, but such deviations must be described in detail and their acceptance toward certification is subject to review by the Regional Administrator. However, even if we increased our average tow time range to 15%, only 3 additional tows could be added to the statistical analysis of candidate devices. It might be better in cases such as these, to look at finfish reduction as a whole, rather than the individual species, then make our analyses from there. This would be more in line with a total biomass bycatch reduction policy, if BRD Certification Testing Protocols were ever amended to account for an ecosystem approach.

As more stringent BRD regulations are implemented, the database on these and other modified BRDs grows. Eventually, we hope to discover a BRD that exceeds the required reduction rate with little or no shrimp loss. As is to be expected, high rates of shrimp loss can lead to higher rates of effort, as a fisherman tries to offset the lower catch rates associated with use of these devices. Unfortunately, two of the candidates gave no results and the results obtained testing the other five devices during the run of this grant resulted in dismal figures. It is recommended that further testing be performed, with the hope that future tests will better or mimic previous testing of these candidates.

## IX. PROJECT IMPACTS

It is very possible that among all the commercial fishing operations in the Gulf of Mexico, the shrimp fishing industry is the most interested in achieving a high level of success for bycatch reduction efforts as they stand to gain the most from the process. A substantial economic benefit and savings is accrued by the successful elimination of non-target species from the shrimp catch. This translates to the elimination of manual labor to separate the shrimp from the catch, lower fuel consumption and operating costs, reduction of wear and tear on the fishing gear, and the ability to return with a higher quality of shrimp.

Industry input and participation were solicited through all phases of this project. By having the direct participation of fishermen to develop devices and methods to alleviate the bycatch problem, we achieve important benefits. One non-quantifiable benefit is the fact that the fishermen are taking an active role in determining fishery management strategies that have a direct impact on their livelihood. The experience of conducting BRD prototype testing provided cooperators with both insight and perspective about research and fisheries management. Additionally fishermen were given the opportunity to better understand the mission of the government’s bycatch reduction program. Ultimately, this should lead to an easier transition toward any management strategies imposed by the mandatory use of BRDs in shrimp trawls.

## X. ACKNOWLEDGMENTS

The Gulf and South Atlantic Fisheries Foundation, Inc. would like to extend our deepest thanks to members of the Gulf of Mexico and South Atlantic shrimp fishing industry that participated and shared their ideas, time, and vessels to make this project possible. We also extend the same gratitude to industry gear designers and other innovators that provided us with materials to perform this work. Sea Grant and Marine Extension staff, state fishery agencies, NMFS personnel and administrators, and others that lent assistance, technical guidance, and support are also recognized. In so short a space it is not possible to name everyone by name, but please know that without the combination of your help, commitment, and drive, our work would not have been possible.

## XI. SELECTED REFERENCES

Bycatch Reduction Device Testing Protocol Manual, published by the South Atlantic Fishery Management Council [1997 and 2000 draft revisions]

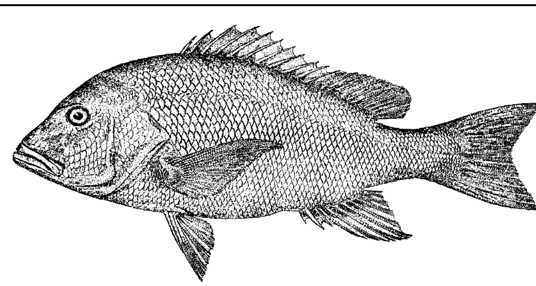
Gulf of Mexico Bycatch Reduction Device Protocol Manual, published by the Gulf of Mexico Fishery Management Council [1999 and 2000 draft revisions]

Engass, A., D. Foster, B. Hathaway, J. Watson, and I. Workman. 1999. The Behavioral Response of Juvenile Red Snapper (*Lutjanus campechanus*) to Shrimp Trawls that Utilize Water Flow Modifications to Induce Escapement. MTS Journal (33) 2:43-50.

Gallaway, B.J. and J.G. Cole. 1999. Reduction of Juvenile Red Snapper Bycatch in U.S. Gulf of Mexico Shrimp Trawl Fishery. North American Journal of Fisheries Management 19:342-355

Jamir, T.V. and J.L. Jamison. 2001. Enhancing Industry Contributions Toward Bycatch Reduction in the Shrimp Fishery of the Gulf of Mexico and South Atlantic: Final Report (NOAA/NMFS #NA87FD0099).

Thomas, J.S., G. D. Johnson, and C. M. Formichella. Objective and Subjective Effects of Bycatch Reduction Devices on Gulf Coast Commercial Shrimp Fishers: A Final Report. Department of Sociology & Anthropology, University of South Alabama (NA77FD0077)



Red Snapper- *Lutjanus campechanus*

# FIGURES A-E
# (Schematics)

Tim Adam's Modified Double-Opposed Fisheye BRD. A. Schematic view showing attachment of device to trawl body and method of fish escapement. B. Schematic showing location of Tim Adam's BRD on the trawl

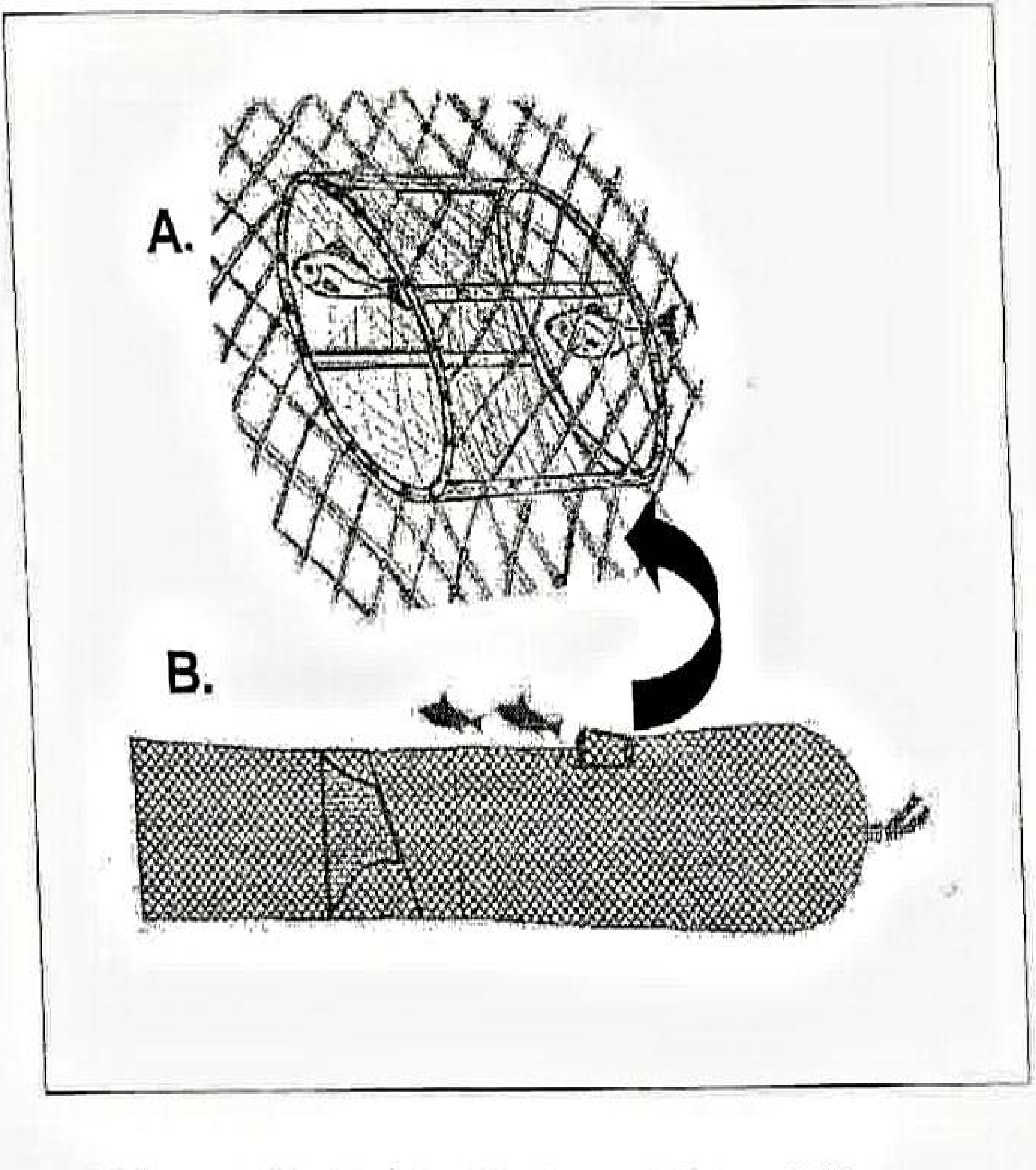
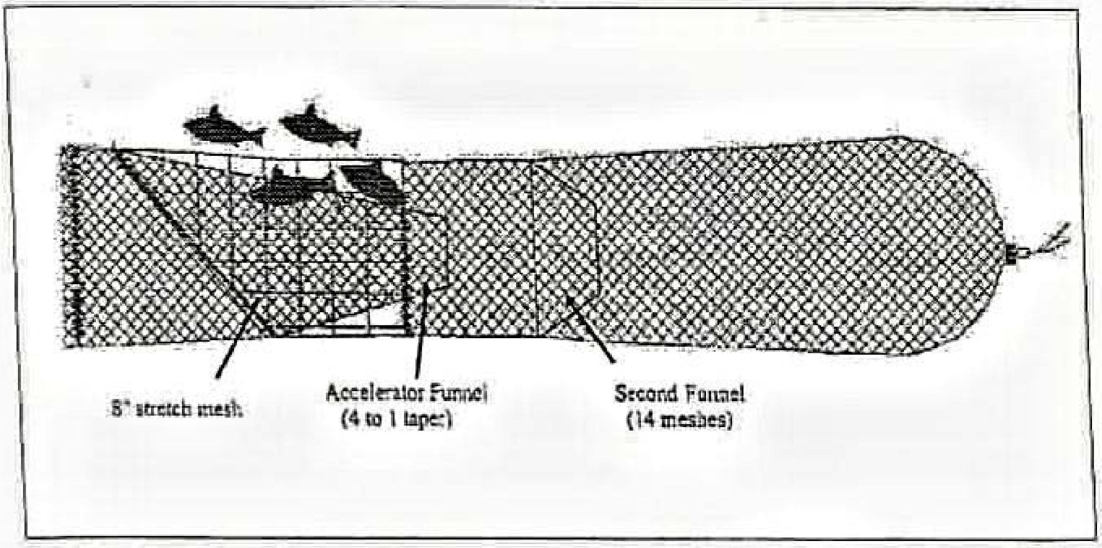


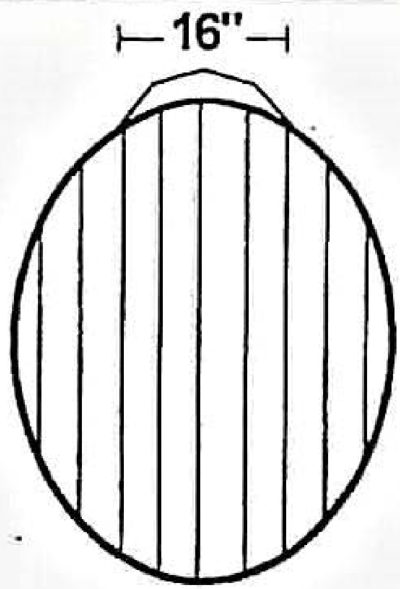

Figure A. Modified Double-Opposed Fisheye BRD

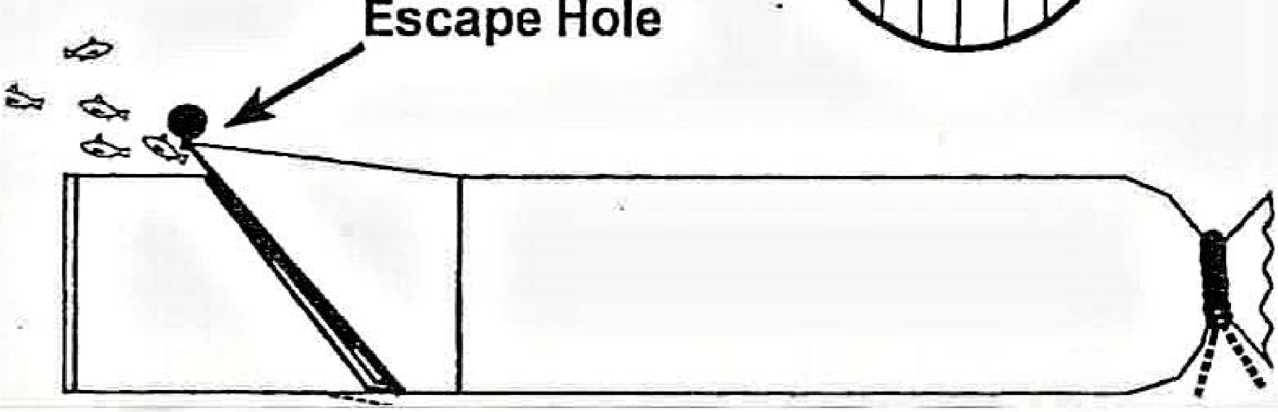
## Figure B. C.J. Kiffe's Double Funneled Extended Mesh

Schematic view showing attachment of devices to trawl body and method of fish escapement.




## Figure C. Wheeler BRD



Hickman's Modified Sea Eagle II BRD. A. Schematic view showing attachment of device to trawl body, method of fish escapement, and door mechanism. B. Schematic showing location of the Modified Sea Eagle II BRD on the trawl.

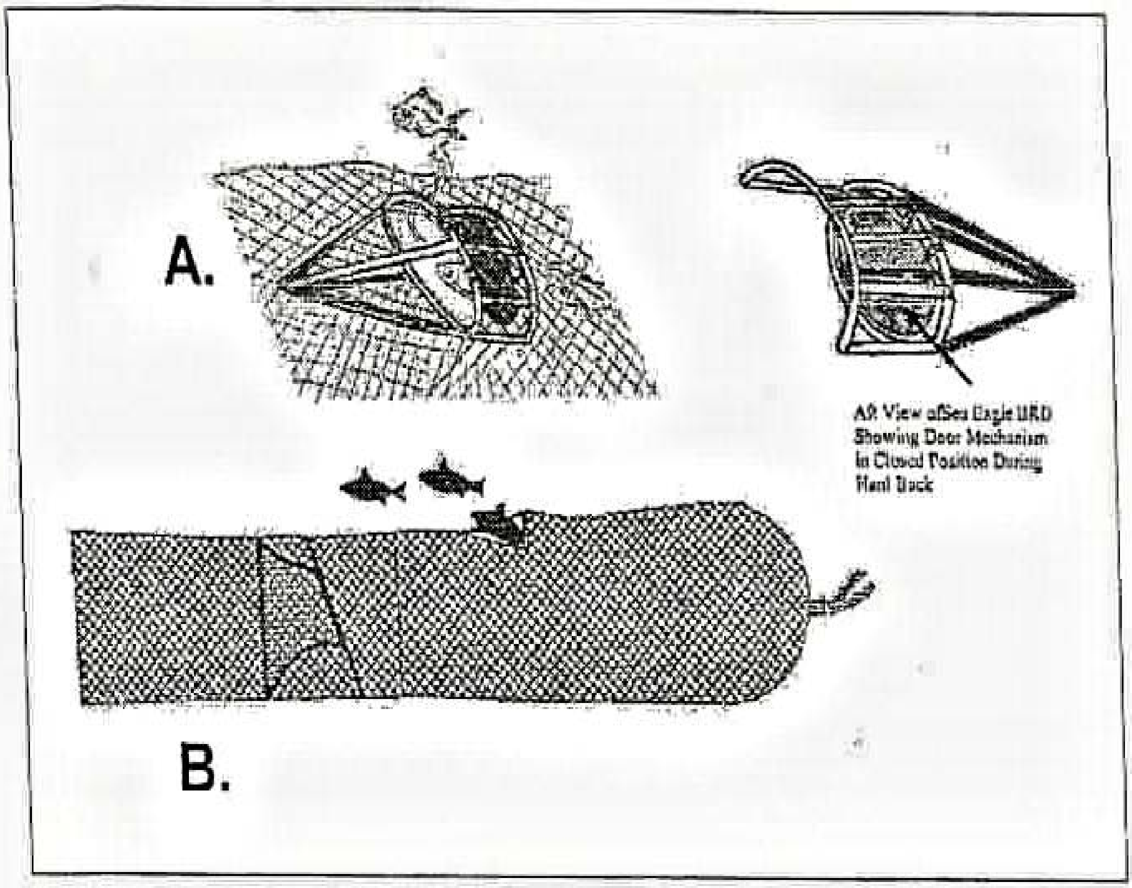



Figure D. Hickman's Modified Sea Eagle II BRD

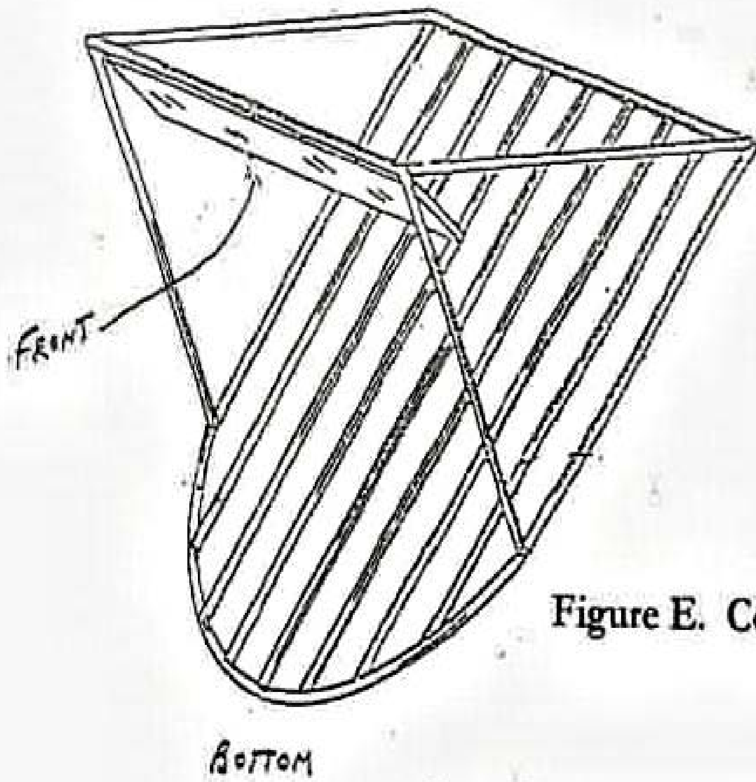



Figure E. Coulon TED/BRD