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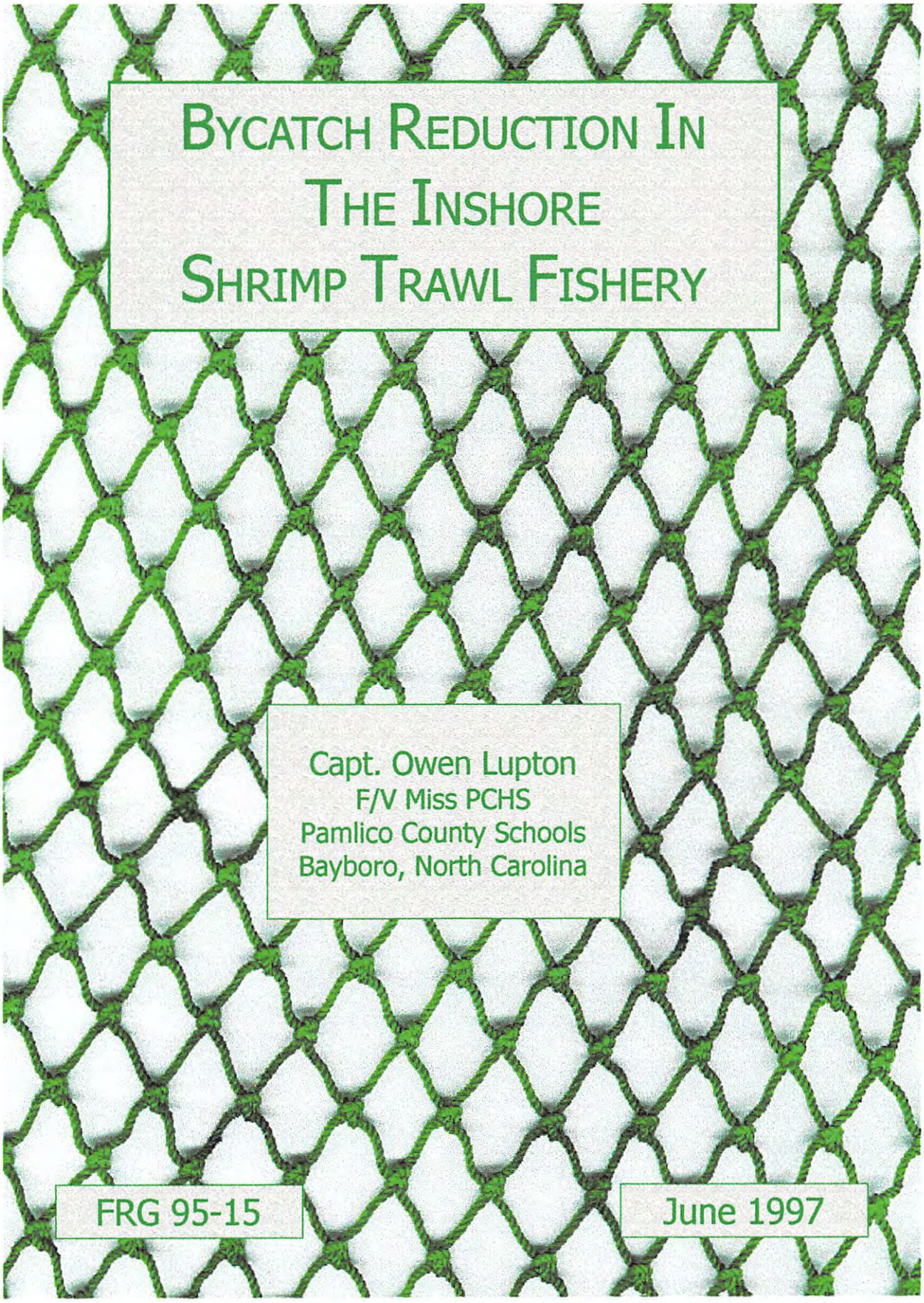
Bycatch Reduction In The Inshore Shrimp Trawl Fishery



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FRG 95-15

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BYCATCH REDUCTION
IN THE INSHORE SHRIMP TRAWL FISHERY

By

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EXECUTIVE SUMMARY

The purpose of Marine Resources Grant FRG 95-15 awarded to Pamlico County Schools was to study the effectiveness of bycatch reduction devices in the inshore shrimp trawl fishery. One of the primary objectives was to determine the percentage of finfish reduction while using each bycatch reduction device. Bycatch reduction devices can possibly create a substantial reduction in the bycatch of all finfish and particularly weakfish without causing estuarine shrimp trawling to become economically impossible. Another primary objective was to ascertain the percentage of shrimp loss while using each bycatch reduction device. A third part of our research was to make enough tows and gather enough data to see whether the bycatch reduction devices would remain consistent over many tows. Paired towing was the method used for the research. Each of three bycatch reduction devices received a minimum of 10 experimental tows

When all tows for the control net were combined there was a total finfish catch of 2,800 kg. When all tows using bycatch reduction devices were combined there was a total finfish catch of 1,279 kg for an overall finfish reduction of 1,521 kg or 3,346 pounds of finfish released. The overall percentage of finfish reduction for all tows was 54.3% with the bycatch reduction devices. Spot made up 58% of the finfish catch in the control and 60% in the bycatch reduction devices. Croaker made up 33% of the catch in the control and 30% of the catch in the bycatch reduction devices. Weakfish made up 5% of the catch in the control and 6% of the catch in the bycatch reduction devices. Miscellaneous fish mostly made up of sublegal southern flounder comprised the remaining 5 to 6% of finfish catch.

When all tows for the control net were combined there was a total catch of all species of 5420 kg. The total combined catch for all bycatch reduction devices was 3,752 kg.

The control net had a combined shrimp catch of 408 kg. for all tows. The experimental bycatch reduction devices had a combined shrimp catch of 370 kg for a reduction of 38 kg or 84 pounds of shrimp. The overall percentage of shrimp loss was 9.3% for all bycatch reduction devices.

Bycatch reduction is a major concern in every fishery and especially for inshore shrimp trawling. Since inshore shrimp trawling takes place in a very fragile ecosystem adjacent to primary and secondary nursery areas, most of the finfish being caught are young of the year or juveniles that are non-marketable and therefore wasted other than as cull scrap returned to the water to feed larger predatory fish, crabs, scavengers, seagulls, and pelicans. The inshore shrimp trawl industry is working in areas that are already severely stressed because of human waste, animal waste, agricultural/urban run-off, and industrial pollution being sent down our rivers and into the sounds by the millions of tons. The commercial fishing industry must do everything within its power to preserve the limited reproductive and growing capacities of our rivers and sounds. In addition the shrimp industry can benefit from reducing the volume of the catch which must be culled every few hours. Less volume in the catch translates into more profit and less work for the shrimpers.

TABLE OF CONTENTS

INTRODUCTION

What results can we expect from the newly available bycatch reduction devices in the inshore shrimp trawl fishery? Our research gathered data for three of the most promising bycatch reduction devices (BRD's) currently under development by North Carolina fishermen. Reduction of finfish in the shrimp trawl fishery is an ever-increasing necessity both from a conservation/economic standpoint and from public perception of shrimp trawling. In addition, the ASMFC has mandated that North Carolina must reduce the bycatch of weakfish, *gray trout*, by 50%. North Carolina's shrimp trawl fishery can benefit greatly by having cleaner tows, longer tow times, more towing time per week, and less culling for the crews by the reduction of unwanted finfish. The research determined the type of finfish caught, reduction of those finfish, and loss of shrimp with each bycatch reduction device. Henceforth in this report bycatch reduction devices will be referred to as BRD's.

The research for the grant was conducted between June 15, 1996 and June 3, 1997. Three 90-minute tows calibrated the trawls to within 10% of each other prior to testing. At intervals of two weeks, we conducted a recalibration tow to assure that both trawls were still fishing within 10%. Tow times were for 90 minutes during the summer and 60 minutes during the fall and spring unless otherwise noted. After 5 tows, the BRD was switched to the opposite side of the vessel to minimize any difference in the trawls. The completed summer research yielded 70 usable tows. The completed fall and spring research yielded 20 usable tows. All fouled tows were disregarded as part of the research.

The two hurricanes that hit North Carolina during the summer of 1996 created unexpected problems. Four days were lost as a result of hurricane Bertha during the best of the shrimp season. Hurricane Fran completely eliminated any shrimping for us during all of September and most of October. The fall fishery for white and pink shrimp never occurred on the western side of Pamlico Sound during the fall of 1996 and no pink shrimp were found during the 1997 spring research. It continues to be difficult to make clear tows because of crab pots and debris washed into the rivers and sounds almost a year after these storms. As a result many tows had to be discarded for collection of data.

GEAR SPECIFICATIONS

The shrimp trawls were 32 foot (headrope) two-seam nets built by Harris Net Shop at Atlantic with 1.5 inch stretch mesh bodies cut on a 4/1 taper and constructed of #12 nylon webbing. Hanging was on 5/16-inch combination cable and the leg lines were 6 ft. The footrope rope had 1/4 inch galvanized chain. The wings had seven loops of chain (*16 links per loop*) and the belly had three loops. Three additional loops of chain were located between the wings and belly at the jib corners. The 3/16-inch tickler chain was two feet shorter than the footrope. The trawl doors were 5 and 1/2 feet long by 28 inches high and had 4 inch by 3/8-inch shoes on the bottom. The towing bridles

were 3/8-inch diameter by 150 feet long. Both trawls were equipped with 120 mesh mini super-shooter TED's with bottom exit and accelerator funnels of stretch poly. The 1.5 inch stretch mesh tailbags were constructed of #36 nylon webbing, 120 meshes around, and 120 meshes long with tie-off up 15 meshes from the bottom. All tailbags had elephant ears attached in place of choke straps to avoid the normal clogging that occurs with choke straps. Both trawls had YKK zippers 10 feet in circumference sewn in between the TED and tailbag. The zippers worked flawlessly and never came apart or unzipped. Tailbag changes took less than 10 minutes.

The first BRD tested was built by Bill Hickman from Winnabow. This BRD was constructed from eight inch PVC pipe and featured a unique trap door designed to close when retrieving the nets to prevent shrimp loss. The Hickman BRD received 48 tows or 53% of the research work.

The second BRD was a large mesh excluder with an accelerator funnel constructed by Medford Daniels Net Shop at Pamlico Beach. The Daniels excluder was made from 7 meshes deep by 34 meshes around of 4.5 inch stretch #120 braided nylon with a 1.5 inch stretch #36 nylon accelerator. The accelerator was 100 meshes at the top by 30 meshes long cut on a 2/1 taper and had a 40 mesh opening at the bottom. Two pieces of bungee cord kept the funnel stretched out at the top and bottom. The Daniels BRD received 10 tows or 11% of the research work.

The third BRD was also a large mesh excluder built by Virgil Potter Seafood of Bayboro. This excluder was 5 meshes deep by 25 meshes around of 8 inch stretch braided 5 mil polyethylene web with 1.5 inch heat set and depth stretched #30 polyethylene webbing for the accelerator funnel. The accelerator was 100 meshes at the top by 30 meshes long and was also cut on a 2/1 taper. The bottom opening was 42 meshes and was held in place by bungee cord at the top and bottom. The Potter BRD received 32 tows or 36% of the research work. Both large mesh fish excluders used half-inch combination cable to make a circular hanging frame.

The research vessel was the F/V Miss PCHS. The Miss PCHS is 38 feet long, powered by a CAT 3208 diesel with a 2:1 gear, and double rigged. The paired tow method was used with one net using a BRD and the other control net without a BRD. All tows were at a vessel ground speed of 2.5 kts as measured by GPS and Loran. Additional information for each tow included the date of tow, time of tow, starting and stopping coordinates for the tow. Other recorded information was water temperature, water depth, moon phase, wind direction and velocity, and tow number. As much as possible, all tows were in a straight line to prevent one net from covering more bottom than the other covered. When turns were required, then two turns were incorporated with one to port and the other to starboard to equalize the bottom covered.

DATA ANALYSIS AND COLLECTION

The catch from each tailbag was examined in the following manner. All finfish were picked up and separated by species and weighed in kg. This determined what types of finfish were being caught and the bycatch percentages of each. With weakfish,

the numbers were counted in each tailbag and a random subsample of up to 30 individuals was taken. The subsample yielded an average length to the nearest millimeter, total length (TL), and an average weight to the nearest gram. The percentage difference in total catch weight between the control and test BRD used the formula [(control-test)/control*100]. The paired t-test method compared mean catches between the gear. A significance level of $P \leq 0.05$ was used for all tests. All data was recorded and calculated on Microsoft Excel 97.

All shrimp were weighed in kg and then a sample of 3 pounds yielded a count per pound with heads on. A percentage of loss was calculated with each BRD.

All invertebrates other than shrimp were weighed in kg. and a percentage of reduction calculated.

The weight of jellyfish was recorded for each tailbag and reduction calculated. Miscellaneous organisms (shell, tunicates, detritus) were separated and weighed for each tailbag and reduction calculated. Anything found forward of the elephant ear was excluded from the sample. Each net was cleaned by shaking before every tow began.

RESULTS

Bill Hickman Excluder

The initial testing of the Hickman excluder was with the BRD installed by Mr. Hickman at 50 meshes above the tailbag tie-off in the 12 o'clock position. Fourteen tows were completed with the BRD in this location from June 24 to July 2.

Results with the BRD installed in this position and location were disappointing. There was a 14% weight reduction in spot, 13% weight reduction in croaker, and a 20% weight increase in weakfish (Figure 1). Total number of weakfish was 56 in the control and 69 in the BRD for an increase of 23% by number. The average length of weakfish in the control was 186 mm (TL) and the average weight was 135 grams. The average length of weakfish in the BRD was 184 mm (TL) and the average weight was 152 grams. Total finfish catch was 243 kg in the control and 211 kg in the BRD giving an overall reduction of 13.3%. Spot made up 65% of the finfish catch in the control and 64% in the BRD. Croaker made up 16% of the finfish catch in the control and 17% in the BRD. Weakfish made up 4% of the finfish catch in the control and 5% in the BRD. The remaining 15% of finfish in the control was made up of sublegal southern flounder, pinfish, silver perch, and assorted miscellaneous fish. The remaining 14% of finfish in the BRD was made up of the same species as the control. Total catch was 978 kg for the control and 960 kg for the BRD. The loss of shrimp was 2.9%, and jellyfish were reduced 18.7% (Table 1).

Upon consulting with Division of Marine Fisheries biologist Sean McKenna, we decided to move the BRD to the 3 o'clock position still up 50 meshes to ascertain if a different position might help. The results were even more disappointing at this position. The BRD showed a weight increase of 1.5% with spot, 3.7% with croaker, and

48% with weakfish (Figure 2). Total number of weakfish in the control was 28, and the BRD caught 25 for an 11% reduction by number in the BRD. The weakfish in the control had an average length of 211-mm (TL) and an average weight of 96 grams. The weakfish in the BRD had an average length of 231-mm (TL) and an average weight of 160 grams. Total finfish catch was 59 kg for the control and 62 kg for the BRD giving an increase of 5%. Spot made up 61% of the finfish catch in the control and 59% in the BRD. Croaker made up 31% of the finfish catch in the control and 30% in the BRD. Weakfish made up 5% of the finfish catch in the control and 6% in the BRD. The remaining 3% of finfish in the control was composed of menhaden, sublegal southern flounder, and silver perch. The remaining 5% of finfish in the BRD was composed of menhaden and sublegal southern flounder. Total catch was 174 kg for the control and 184 kg for the BRD. Shrimp catch in the BRD was 2.2% greater than in the control (Table 2). Only two tows, both on July 4 were made with the BRD in this position because of the poor results. Mudding in the tailbag was also a problem.

Mr. Hickman requested that his BRD be moved to 35 meshes above the tie-off at the 12 o'clock position. Good finfish reduction took place with the BRD in this location and position. Spot reduction was 40% by weight, croaker reduction was 63% by weight, and weakfish reduction was 71.8% by weight (Figure 3). Total number of weakfish in the control was 56 and the BRD caught 14 for a reduction of 75% by number in the BRD. The average length of weakfish in the control was 140 mm (TL) and the average weight was 71 grams. The average length of weakfish in the BRD was 139 mm (TL) and the average weight was 74 grams. Total finfish catch was 132 kg for the control and 52 kg for the BRD giving a reduction of 61% in the BRD. Spot made up 58% of the finfish catch in the control and 55% in the BRD. Croaker made up 34% of the catch in the control and 38% in the BRD. Weakfish made up 4% of the catch in the control and 2% in the BRD. The remaining 4% of finfish catch in the control was composed of sublegal southern flounder, pinfish, and silver perch. The remaining 5% of finfish catch in the BRD was also composed of sublegal southern flounder, pinfish, and silver perch. Total catch was 443 kg for the control and 355 kg for the BRD. The BRD in this location also reduced the shrimp catch by almost 22% (Table 3). Six tows were made with the BRD in this location and position from July 7 to July 10.

The Hickman BRD was next moved to 40 meshes above the tie-off at the 12 o'clock position. The device functioned well at this position with a 46% weight reduction in spot, 50.5% weight reduction in croaker, and 52.7% weight reduction in weakfish (Figure 4). Total number of weakfish in the control was 240 and the BRD caught 116 for a reduction of 52% by number in the BRD. The average length of weakfish in the control was 157 mm (TL), and the average weight was 82 grams. The average length of weakfish in the BRD was 148 mm (TL), and the average weight was 71 grams. The total finfish catch was 411 kg for the control and 219 kg for the BRD giving a reduction of 47% in the BRD. Spot made up 77% of the finfish in the control and 78% in the BRD. Croaker made up 17% of the finfish catch in the control and 16% in the BRD. Weakfish made up 4% of the finfish catch in the control and 4% in the BRD. The remaining 2% of finfish in the control and BRD was composed of miscellaneous fish. Total catch was 1,062 kg for the control and 857 kg for the BRD. Shrimp loss was 1% for the BRD in this position (Table 4). Ten tows were made with the BRD in this position from July 16 through July 19.

The Hickman BRD was next moved to the 1:30 o'clock position or 15 meshes off center and still up 40 meshes from the tie-off. Weight reduction of spot was 52.9%, croaker 49.4%, and weakfish 35.8% (Figure 5). Total number of weakfish was 262 in the control and 146 in the BRD for a 44% reduction by number. The average length of weakfish in the control was 179 mm (TL) and the average weight was 90 grams. The average length of weakfish in the BRD was 170 mm (TL) and the average weight was 89 grams. Total finfish catch was 370 kg for the control and 187 kg for the BRD giving a reduction of 49%. Spot made up 49% of the finfish catch in the control and 45% in the BRD. Croaker made up 43% of the finfish catch in the control and 43% in the BRD. Weakfish made up 6% of the finfish catch in the control and 8% in the BRD. The remaining 2% of finfish in the control was mostly sublegal southern flounder. The remaining 6% of finfish in the BRD was mostly sublegal southern flounder. Total catch was 616 kg for the control, and 429 kg for the BRD. There was a loss of 9.4% in shrimp weight (Table 5). Ten tows were completed at this position from July 22 to July 25.

We then decided to see whether the shrimp loss would remain constant with tows longer than 90 minutes with the BRD in the same position. The thought was that with the BRD located so close to the lower end of the tailbag, more shrimp might begin to escape as the tailbags filled up. Six tows of 3 hours each were completed from July 26 to July 30. In this portion of the research a subsample of the fish was taken. Each tailbag was dumped in the cull tray and thoroughly mixed. A shrimp basket full was then shoveled up and used for the fish subsample from each section of the cull tray. All shrimp were culled as usual. The subsample of finfish showed a weight reduction of 49.6% of spot, 47.2% of croaker, and 78.9% of weakfish (Figure 6). The number of weakfish in the control subsample was 133 and the BRD subsample caught 42 for a reduction of 68% by number. The average length of weakfish in the control was 142 mm (TL) and the average weight was 43 grams. The average length of weakfish in the BRD was 128 mm (TL) and the average weight was 31 grams. The subsample finfish total was 79 kg for the control and 39 kg for the BRD. The loss of shrimp jumped from 9.4% to 23.3% (Table 6).

The Hickman BRD was given most of the research time because DMF needed to determine whether this BRD gave sufficient reduction of finfish to be approved for use by the public.

Medford Daniels- Large Mesh Excluder

The Daniels BRD was installed at his net shop at 95 meshes above the tie-off or just behind the elephant ear. Weight reduction of spot was 48%, reduction of croaker was 69%, and weakfish was 53.4% (Figure 7). The number of weakfish in the control was 257, and the BRD caught 120 for a reduction of 53% by number. The average length of weakfish in the control was 152 mm (TL) and the average weight was 69 grams. The average length of weakfish in the BRD was 154 mm (TL) and the average weight was 66 grams. Total finfish catch was 350 kg for the control and 158 kg for the BRD giving a reduction of 55%. Spot made up 55% of the finfish catch in the control and 64% in the BRD. Croaker made up 35% of the finfish in the control and 23% in the BRD. Weakfish made up 5% of the finfish catch in the control and 5% in the BRD. The remaining 5% of finfish in the control was mostly sublegal southern flounder and other miscellaneous fish. The remaining 8% of finfish for the BRD was sublegal southern

flounder and other miscellaneous species. Total catch was 564 kg for the control and 372 kg for the BRD. Ten tows were made with the Daniels BRD in this same location from July 31 to August 6. Shrimp loss was 17.5% (Table 7).

Virgil Potter- Large Mesh Excluder

The Potter BRD was installed at 85 meshes above the tie-off and behind the elephant ear. Weight reduction of spot was 72%, reduction of croaker was 75%, and reduction of weakfish was 62% (Figure 8). The number of weakfish in the control was 754 and the number in the BRD was 381 for a reduction of 50% by number. The average length of finfish in the control was 167 mm (TL) and the average weight was 73 grams. The average length of weakfish in the BRD was 155 mm (TL) and the average weight was 52 grams. Total finfish catch was 600 kg for the control and 180 kg for the BRD giving a reduction of 70%. Spot made up 52% of the finfish catch in the control and 48% in the BRD. Croaker made up 34% of the finfish in the control and 28% in the BRD. Weakfish made up 8% of the finfish catch in the control and 11% in the BRD. Sublegal southern flounder and other miscellaneous fish made up the remaining 6% of the finfish catch in the control. Sublegal southern flounder and other miscellaneous fish also made up the remaining 13% of finfish in the BRD. Total catch was 782 kg for the control and 209 kg for the BRD. Twelve tows were made with the Potter BRD in this same location from August 6 to August 9.. Shrimp loss was 19% (Table 8).

The Potter BRD was moved and reinstalled at 9 meshes behind the TED to see whether moving the device further away from the cod end of the tailbag would reduce the shrimp loss without adverse effects on finfish reduction. Ten tows were made with the Potter BRD in this position during the fall from October 21 to November 5, 1996, and ten more tows were made with the BRD in the same location from May 21 to June 3, 1997. Results were encouraging with the BRD actually showing a 5% increase in shrimp over the control tailbag. Unfortunately not many shrimp were caught with a total of only 4.57 kg in the control and 4.79 kg in the BRD. More testing is needed to see whether the shrimp loss will really be eliminated when large amounts of shrimp are present. Weight reduction of spot was 68%, reduction of croaker was 71%, and reduction of weakfish was 58% (Figure 9). The number of weakfish in the control was 143 and the number in the BRD was 58 for a reduction of 59% by number. The average length of weakfish in the control was 167 mm (TL) and the average weight was 223 grams. The average length of weakfish in the BRD was 162 mm (TL) and the average weight was 259 grams. Total finfish catch was 558 kg for the control and 173 kg for the BRD giving a reduction of 69%. Spot made up 56% of the finfish catch in the control and 57% in the BRD. Croaker made up 40% of the finfish catch in the control and 38% in the BRD. Weakfish made up 3% of the catch in the control and 4% in the BRD. Total catch was 623 kg for the control and 238 kg for the BRD (Table 9).

CONCLUSIONS

The Hickman BRD is a unique concept. It is relatively easy to install and change because it uses plastic wiring ties for installation rather than sewing webbing. The BRD gave no problem as far as tearing up or damage to itself. Construction is from regular PVC pipe and should be cheap to produce. Mr. Hickman supplied two sizes of the

BRD. One of these was the eight-inch diameter model with which we did all testing. The other BRD was a smaller six-inch diameter model. Both BRD's were alike in design and both had a wire grate to regulate the size of the fish allowed to escape. We did not use the wire grate because we were trying to get the maximum reduction. There was some concern that using the grate in inside waters might encourage fishermen to target fish that could otherwise escape. This might be a violation since it could be a directed fishery at certain times. We did not test the six-inch design because we felt the eight-inch would give the maximum reduction. One observation about the eight-inch design was that it was green PVC pipe, which was painted black. Some testing by English researchers has indicated that fish escape better through a white opening above because it appears to be invisible from inside the tailbag. Testing with the six inch white PVC design could prove to allow just as many fish to escape. The smaller model could work better and be less likely to catch on something and rip the tailbag.

Some care must be taken when hoisting the tailbag equipped with the Hickman BRD. The best location at 40 meshes above the tie-off places the BRD in a position to catch against the bumper railings or cap rails. This could tear the tailbag or cause the BRD to rip from the tailbag. The greatest drawback to this BRD seems to be that it must be in exactly the right place to work efficiently. We found the best position to be 40 meshes above the tie-off at the 12 o'clock position. The BRD qualified at this position for the ASMFC required reduction of over 50% of weakfish. This BRD seems to work best during short tows. Long tows could cause the loss of shrimp to increase as the tailbag fills toward the opening of the BRD. Larger boats which tend to retrieve their nets with more speed and power could also negate the effect of the closing trap door. Small vessels or hand retrieval operations will probably benefit by the trap door design. Mr. Hickman is in the process of having his BRD model patented; however, it will be very difficult to keep anyone from copying or modifying the design for his or her own use.

The Daniels BRD did a good job of reducing the finfish catch as installed by him at 95 meshes above the tie-off. This BRD was above the required 50% reduction of weakfish mandated by ASMFC. We found the shrimp loss to be unacceptably high at 17.5% in this location. We relocated the BRD to 9 meshes behind the TED and ahead of the elephant ear. No data collection occurred due to a lack of time, but we feel that results similar to the Potter BRD should occur at this location. Three observations about the BRD that we received from Mr. Daniels are noted. The first is that the large braided nylon used for the BRD is strong, but makes the BRD heavy. There may be a need for the heavy nylon when the BRD installation is between the elephant ear and tie-off to prevent tearing the tailbag apart when large catches occur. It is not necessary when installed behind the TED as there is little pressure exerted forward of the elephant ear during haul-back. The second observation is that the accelerator funnel should be stretch mesh poly rather than nylon. The nylon causes gilling of small spot and croaker and is difficult to clean. The third observation is that the combination cable used to make a frame does not really hold the BRD in the circular fashion as intended. This is worse when the BRD installation is behind the elephant ear and squashes against the vessel's sides during haul-up. A stiffer ring of the type being made by Steve Parish at Shallotte would perhaps work better when installed behind the TED.

The Potter BRD installation was at 85 meshes above the tie-off. This was to give some comparison to the Daniels BRD located at 95 meshes above the tie-off. Reduction of finfish was greater with the Potter BRD and weakfish reduction was well above the 50% ASMFC requirement at 62%. Shrimp loss was higher than the Daniels BRD and was 19%. Upon relocation of the Potter BRD at 9 meshes behind the TED, fish reduction remained about the same and shrimp loss did not occur. Installation in this location requires the removal of about 18 meshes of web from the back of the TED. As already stated, more testing with greater concentrations of shrimp needs to occur to determine if the shrimp percentages will remain constant. Vessels equipped with the large mesh type BRD's need to retrieve the nets at a higher engine rpm and be going to windward or against the current. This will help keep more pressure on the shrimp so they cannot move forward and go out the BRD during haul-back. This design will work better with power winches rather than hand retrieval operations. The Potter BRD was light and easy to handle. Strength of the braided poly could be a problem if installed behind the elephant ear, but not be when installed behind the TED. The stretch mesh poly accelerator funnel worked well and gilling of small fish was not a problem. The Potter BRD was easy to clean. The Potter BRD also used combination cable for the circular frame and had similar problems to the Daniels design. Again the stiffer frame being marketed by Steve Parish would probably enhance the performance of this BRD. This BRD will work best if installed without being dipped in netcote. The netcote defeats the efficiency of the stretch mesh poly accelerator. This BRD worked the best in my opinion and would be my preference at this time if installed at 9 meshes behind the TED. If the low shrimp loss remains consistent during more tests, this BRD can truly be a bonus for larger vessels.

RECOMMENDATIONS

The Hickman BRD received approval by DMF as a result of the research conducted by their vessel and ourselves. This excluder requires installation no more than 40 meshes above the tie-off rings to be effective in finfish reduction. The grate should not be allowed in internal waters to avoid any chance of a directed finfish fishery during some seasons.

The Daniels BRD can improve if it incorporates the suggestions made in the conclusion's section. The shrimp loss needs improvement for this BRD to gain widespread acceptance among commercial fishermen. The installation of this BRD at 9 meshes behind the TED should greatly lower the shrimp loss.

The Potter BRD and the Daniels BRD are basically the same except for the types of material used to build them. The Potter BRD is easier to work with because of the lighter poly webbing. If shrimp loss continues to remain under 5% with the Potter BRD installed at 9 meshes behind the TED, then this BRD will become very attractive to fishermen and conservationists alike.

We can estimate the average working time per week is 100 hours per vessel. If reduction of finfish is 50%, then each trawler will either be able to tow twice as long per tow or have half the volume for the same tow time. We can estimate the average tow time at 2 hours per vessel and the average haul-back time at 15 to 20 minutes. This

means 12% to 16% of the workweek is hauling-back and setting-out. The result is 12 to 16 hours of possible tow time with trawls out of the water. The vessel is actually towing only 84 to 88 hours. If the BRD's allow the average tow times to double to 4 hours, then vessels can gain 6 to 8 hours per week in towing time. The results could mean an average increase of 8% of shrimp catches per vessel.

No matter what lengths of normal tow times' vessels use, a reduction of 50% of finfish will allow doubling the length of the tow. Of course the percentages of tow time savings would be less with 3-hour tows extended to 6 hours for example. At 3 hour tow times with haul-back still at 15 to 20 minutes, then an 8% to 11% tow time savings occurs if tows double to 6 hours. Longer tow times should offset a 5% to 10% shrimp loss from a BRD. Another factor in a 50% bycatch reduction is that trawls should catch at optimum levels for longer portions of each tow. The tailbag will not fill up as quickly and thereby tend to close up the spread or pull the footrope off the bottom. Some fuel savings will occur since the trawls will be easier to pull for longer periods of time. In addition, crews can get more opportunity to rest or sleep and spend about half as much time culling the catch. This should translate into a safer vessel with crews being more rested and having less haul-back time where most injuries occur. These are real advantages for the commercial shrimpers, but the saving of 50% of the finfish is important for all North Carolinians, and possibly helps the entire East Coast of the United States.

We feel that North Carolina's fishing community needs commending for the strong effort to come up with beneficial designs to significantly reduce bycatch. We believe these design models with accurate research data will find ways to continue to further reduce bycatch in the shrimp trawl fishery. We applaud The North Carolina Legislature and the Division of Marine Fisheries for successfully coupling industry and research in a unique process to benefit our marine resources and all the people of North Carolina.

TABLE 1. Total catch weights and reduction with the Hickman BRD at the 12 o'clock position up 50 meshes above the tie-off rings, testing in western Pamlico Sound, North Carolina, Summer 1996.

	Total Weight (kg)			
n=14*	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	54.3	52.7	-2.9%	6.83E-1
Summer Shrimp	54.3	52.7	-2.9%	
White Shrimp	0	0	0.0%	
Pink Shrimp	0	0	0.0%	
SOUTHERN FLOUNDER	0	0	0.0%	
legal--over 330 mm	0	0	0.0%	
sublegal--und 330 mm	6.5	6.32	-2.8%	
SPOT	158.34	136.14	-14.0%	3.82E-1
ATLANTIC CROAKER	66.4	57.7	-13.1%	1.46E-1
WEAKFISH	8.74	10.51	20.3%	3.30E-1
SOUTHERN KINGFISH	0	0	0.0%	
ATLANTIC MENHADEN	1.5	1.5	0.0%	
BLUEFISH	0.3	0	-100.0%	
SEA ROBIN	0	0	0.0%	
HOGCHOKER	0.4	0.45	12.5%	
OYSTER TOADFISH	0	0	0.0%	
PINFISH	3.15	2.02	-35.9%	
PIGFISH	0	0	0.0%	
SUMMER FLOUNDER	0	0	0.0%	
FRINGED FLOUNDER	0	0	0.0%	
NORTHERN PUFFER	0	0	0.0%	
WINDOWPANE	0	0	0.0%	
HARVESTFISH	0	0	0.0%	
STRIPED BURRFISH	0	0	0.0%	
INSHORE LIZARDFISH	0.45	0	-100.0%	
PLAINHEAD FILEFISH	0	0	0.0%	
ATLANTIC SPADEFISH	0	0	0.0%	
GIZZARD SHAD	0	0	0.0%	
ORANGE FILEFISH	0	0	0.0%	
BAY WHIFF	0	0	0.0%	
ATL. THREAD HERRING	0	0	0.0%	
GREY SNAPPER	0	0	0.0%	
SHEEPSHEAD	0	0	0.0%	
SPOTTED SEATROUT	0	0	0.0%	
BLACK DRUM	0	0	0.0%	
SPOTTED HAKE	0	0	0.0%	
SOUTHERN STINGRAY	0	0	0.0%	
COWNOSE RAY	0	0	0.0%	
CRABS & OTHER INVERTEBRATES	523.74	566.72	8.2%	2.17E-1
SQUID	0	0	0.0%	
JELLYFISH	155.3	126.2	-18.7%	
MISCELLANEOUS	1.75	3.9	122.9%	
SILVER PERCH	3.4	2.2	-35.3%	
MISCELLANEOUS FISH	0	0	0.0%	
Total finfish	242.68	210.52	-13.3%	
Total catch	977.77	960.04	-1.8%	

*all tows conducted during the daytime

TABLE 2. Total catch weights for the Hickman 8 inch BRD at the 3 o'clock position up 50 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

	Total Weight (kg)			
*n=2	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	9.30	9.50	2.2%	9.37E-1
Brown Shrimp	9.30	9.50	2.2%	
White Shrimp	0.00	0.00	0.0%	
Pink Shrimp	0.00	0.00	0.0%	
SOUTHERN FLOUNDER	0.15	0.72	380.0%	
FLOUNDER-Legal	0.00	0.00	0.0%	
FLOUNDER-Sublegal	0.15	0.72	380.0%	
SPOT	35.82	36.37	1.5%	9.75E-1
ATLANTIC CROAKER	18.18	18.86	3.7%	8.74E-1
WEAKFISH	2.70	4.00	48.1%	5.45E-1
SOUTHERN KINGFISH	0.00	0.00	0.0%	
ATLANTIC MENHADEN	2.00	2.10	5.0%	
BLUEFISH	0.00	0.00	0.0%	
SEA ROBIN	0.00	0.00	0.0%	
HOGCHOKER	0.00	0.00	0.0%	
OYSTER TOADFISH	0.00	0.00	0.0%	
PINFISH	0.00	0.00	0.0%	
PIGFISH	0.00	0.00	0.0%	
SUMMER FLOUNDER	0.00	0.00	0.0%	
FRINGED FLOUNDER	0.00	0.00	0.0%	
NORTHERN PUFFER	0.00	0.00	0.0%	
HARVESTFISH	0.00	0.00	0.0%	
STRIPED BURRFISH	0.00	0.00	0.0%	
INSHORE LIZZARD FISH	0.00	0.00	0.0%	
ATLANTIC SPADEFISH	0.00	0.00	0.0%	
GIZZARD SHAD	0.00	0.00	0.0%	
GULF PIPEFISH	0.00	0.00	0.0%	
ATL. THREAD HERRING	0.00	0.00	0.0%	
SHEEPSHEAD	0.00	0.00	0.0%	
SPOTTED SEATROUT	0.00	0.00	0.0%	
DIAMONDBACK TERRAPIN	0.00	0.00	0.0%	
SPANISH MACKERAL	0.00	0.00	0.0%	
BLACK DRUM	0.00	0.00	0.0%	
SPIDER CRAB	0.00	0.00	0.0%	
SOUTHERN STINGRAY	0.00	0.00	0.0%	
COWNOSE RAY	0.00	0.00	0.0%	
CRABS & OTHER INVERTEBRATE	114.50	122.29	6.8%	3.18E-2
SQUID	0.00	0.00	0.0%	
JELLYFISH	0.00	0.00	0.0%	
MISCELLANEOUS	0.00	0.00	0.0%	
SILVER PERCH	0.23	0	-100.0%	
MISCELLANEOUS FISH	0.00	0.00	0.0%	
Total Finfish	59.08	62.05	5.0%	
Total Catch	183.11	193.84	-0.86	

*all tows conducted during the daytime

TABLE 3. Total catch weights for the Hickman 8 inch BRD at the 12 o'clock position up 35 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

	Total Weight (kg)			
*n=6	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	34.40	26.90	-21.8%	1.25E-3
Brown Shrimp	34.40	26.90	-21.8%	
White Shrimp	0.00	0.00	0.0%	
Pink Shrimp	0.00	0.00	0.0%	
SOUTHERN FLOUNDER	2.12	1.27	-40.1%	
FLOUNDER-Legal	0.00	0.00	0.0%	
FLOUNDER-Sublegal	2.12	1.27	-40.1%	
SPOT	76.55	28.20	-63.2%	1.09E-2
ATLANTIC CROAKER	45.20	19.80	-56.2%	1.82E-2
WEAKFISH	4.47	1.26	-71.8%	3.83E-2
SOUTHERN KINGFISH	0.00	0.00	0.0%	
ATLANTIC MENHADEN	0.00	0.00	0.0%	
BLUEFISH	0.00	0.00	0.0%	
SEA ROBIN	0.00	0.00	0.0%	
HOGCHOKER	0.00	0.00	0.0%	
OYSTER TOADFISH	0.00	0.00	0.0%	
PINFISH	1.85	0.66	-64.3%	
PIGFISH	0.00	0.00	0.0%	
SUMMER FLOUNDER	0.00	0.00	0.0%	
FRINGED FLOUNDER	0.00	0.00	0.0%	
NORTHERN PUFFER	0.00	0.00	0.0%	
HARVESTFISH	0.00	0.00	0.0%	
STRIPED BURRFISH	0.00	0.00	0.0%	
INSHORE LIZZARD FISH	0.00	0.00	0.0%	
ATLANTIC SPADEFISH	0.00	0.00	0.0%	
GIZZARD SHAD	0.00	0.00	0.0%	
GULF PIPEFISH	0.00	0.00	0.0%	
ATL. THREAD HERRING	0.00	0.00	0.0%	
SHEEPSHEAD	0.00	0.00	0.0%	
SPOTTED SEATROUT	0.00	0.00	0.0%	
DIAMONDBACK TERRAPIN	0.00	0.00	0.0%	
SPANISH MACKERAL	0.00	0.00	0.0%	
BLACK DRUM	0.00	0.00	0.0%	
SPIDER CRAB	0.00	0.00	0.0%	
SOUTHERN STINGRAY	0.00	0.00	0.0%	
COWNOSE RAY	0.00	0.00	0.0%	
CRABS & OTHER INVERTEBRATE	278.15	267.70	-3.8%	1.00E-1
SQUID	0.00	0.00	0.0%	
JELLYFISH	33.18	35.64	7.4%	
MISCELLANEOUS	0.00	0.00	0.0%	
SILVER PERCH	1.8	0.45	-75.0%	
MISCELLANEOUS FISH	0.00	0.00	0.0%	
Total Finfish	131.99	51.64	-60.9%	
Total Catch	477.72	381.88	-20.1%	

*all tows conducted during the daytime

TABLE 4. Total catch weights with the Hickman 8 inch PVC BRD at the 12 o'clock position up 40 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

	Total Weight (kg)			
*n=10	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	140.8	139.38	-1.0%	5.63E-1
Summer Shrimp	140.8	139.38	-1.0%	
White Shrimp	0	0	0.0%	
Pink Shrimp	0	0	0.0%	
SOUTHERN FLOUNDER	5.02	4.46	-11.2%	
legal--over 330 mm	1	0	100.0%	
sublegal--und 330 mm	4.02	4.46	10.9%	
SPOT	315.32	169.57	-46.2%	4.00E-3
ATLANTIC CROAKER	71.46	35.37	-50.5%	2.36E-3
WEAKFISH	17.49	8.28	-52.7%	9.17E-3
SOUTHERN KINGFISH	0	0	0.0%	
ATLANTIC MENHADEN	0	0	0.0%	
BLUEFISH	0	0	0.0%	
SEA ROBIN	0	0	0.0%	
HOGCHOKER	0	0	0.0%	
OYSTER TOADFISH	0	0	0.0%	
PINFISH	0.45	0	-100.0%	
PIGFISH	0	0	0.0%	
SUMMER FLOUNDER	0	0	0.0%	
FRINGED FLOUNDER	0	0	0.0%	
NORTHERN PUFFER	0	0	0.0%	
WINDOWPANE	0	0	0.0%	
HARVESTFISH	0	0	0.0%	
STRIPED BURRFISH	0	0	0.0%	
INSHORE LIZARDFISH	0	0	0.0%	
PLAINHEAD FILEFISH	0	0	0.0%	
ATLANTIC SPADEFISH	0	0	0.0%	
GIZZARD SHAD	0	0	0.0%	
ORANGE FILEFISH	0	0	0.0%	
BAY WHIFF	0	0	0.0%	
ATL. THREAD HERRING	0	0	0.0%	
GREY SNAPPER	0	0	0.0%	
SHEEPSHEAD	0	0	0.0%	
SPOTTED SEATROUT	0	0	0.0%	
BLACK DRUM	0	0	0.0%	
SPOTTED HAKE	0	0	0.0%	
SOUTHERN STINGRAY	0	0	0.0%	
COWNOSE RAY	0	0	0.0%	
CRABS & OTHER INVERTEBRATES	494.9	482.1	-2.6%	2.68E-1
SQUID	0	0	0.0%	
JELLYFISH	9	9.5	5.6%	
MISCELLANEOUS	7	7	0.0%	
SILVER PERCH	0.75	0.25	-66.7%	
MISCELLANEOUS FISH	0.3	0.75	150.0%	
Total Finfish	410.79	218.68	-46.8%	
Total Catch	1062.49	856.66	-19.4%	

*all tows conducted during the daytime

TABLE 5. Total catch weights with the Hickman 8 inch BRD at the 1:30 o'clock position up 40 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

	Total Weight (kg)			
*n=10	CONTROL	EXPERIMENTAL	PERCENT DIFFERENCE	P(T<=t)
SHRIMP	44.65	40.45	-9.4%	2.23E-1
Summer Shrimp	44.65	40.45	-9.4%	
White Shrimp	0	0	0.0%	
Pink Shrimp	0	0	0.0%	
SOUTHERN FLOUNDER	5.75	4.52	-21.4%	
legal--over 330 mm	0	0	0.0%	
sublegal--und 330 mm	5.75	4.52	-21.4%	
SPOT	179.75	84.72	-52.9%	2.29E-5
ATLANTIC CROAKER	160.02	80.91	-49.4%	8.49E-4
WEAKFISH	23.85	15.3	-35.8%	3.20E-2
SOUTHERN KINGFISH	0	0	0.0%	
ATLANTIC MENHADEN	0.5	0.11	-78.0%	
BLUEFISH	0	0.33	100.0%	
SEA ROBIN	0	0	0.0%	
HOGCHOKER	0	0.3	100.0%	
OYSTER TOADFISH	0	0	0.0%	
PINFISH	0.4	0	-100.0%	
PIGFISH	0	0.35	100.0%	
SUMMER FLOUNDER	0	0	0.0%	
FRINGED FLOUNDER	0	0	0.0%	
NORTHERN PUFFER	0	0	0.0%	
WINDOWPANE	0	0	0.0%	
HARVESTFISH	0	0	0.0%	
STRIPED BURRFISH	0	0	0.0%	
INSHORE LIZARDFISH	0.07	0.74	957.1%	
PLAINHEAD FILEFISH	0	0	0.0%	
ATLANTIC SPADEFISH	0	0	0.0%	
GIZZARD SHAD	0	0	0.0%	
ORANGE FILEFISH	0	0	0.0%	
BAY WHIFF	0	0	0.0%	
ATL. THREAD HERRING	0	0	0.0%	
GREY SNAPPER	0	0	0.0%	
SHEEPSHEAD	0	0	0.0%	
SPOTTED SEATROUT	0	0	0.0%	
BLACK DRUM	0	0	0.0%	
SPOTTED HAKE	0	0	0.0%	
SOUTHERN STINGRAY	0	0	0.0%	
COWNOSE RAY	0	0	0.0%	
CRABS & OTHER INVERTEBRATES	179.85	182.2	1.3%	7.45E-1
SQUID	0	0	0.0%	
JELLYFISH	12	11.5	-4.2%	
MISCELLANEOUS	9	8	-11.1%	
SILVER PERCH	0	0	0.0%	
MISCELLANEOUS FISH	0	0	0.0%	
Total finfish	370.34	187.28	-49.4%	
Total catch	615.84	429.43	-30.3%	

*all tows conducted during the daytime

TABLE 6. Total catch weights the Hickman 8 inch BRD at the 1:30 o'clock position up 40 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

	Total weight (kg)			
n=6*	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	39.00	29.90	-23.3%	2.28E-2
Summer Shrimp	39.00	29.90	-23.3%	
White Shrimp	0.00	0.00	0.0%	
Pink Shrimp	0.00	0.00	0.0%	
SOUTHERN FLOUNDER	1.06	0.63	-40.6%	
legal--over 330 mm	0.00	0.00	0.0%	
sublegal--und 330 mm	1.06	0.63	-40.6%	
SPOT	46.65	23.50	-49.6%	4.04E-2
ATLANTIC CROAKER	25.10	13.25	-47.2%	8.90E-2
WEAKFISH	6.21	1.31	-78.9%	4.11E-2
SOUTHERN KINGFISH	0.00	0.00	0.0%	
ATLANTIC MENHADEN	0.00	0.00	0.0%	
BLUEFISH	0.00	0.00	0.0%	
SEA ROBIN	0.00	0.00	0.0%	
HOGCHOKER	0.00	0.00	0.0%	
OYSTER TOADFISH	0.00	0.00	0.0%	
PINFISH	0.00	0.00	0.0%	
PIGFISH	0.00	0.00	0.0%	
SUMMER FLOUNDER	0.00	0.00	0.0%	
FRINGED FLOUNDER	0.00	0.00	0.0%	
NORTHERN PUFFER	0.00	0.00	0.0%	
WINDOWPANE	0.00	0.00	0.0%	
HARVESTFISH	0.00	0.00	0.0%	
STRIPED BURRFISH	0.00	0.00	0.0%	
INSHORE LIZARDFISH	0.00	0.00	0.0%	
PLAINHEAD FILEFISH	0.00	0.00	0.0%	
ATLANTIC SPADEFISH	0.00	0.00	0.0%	
GIZZARD SHAD	0.00	0.00	0.0%	
ORANGE FILEFISH	0.00	0.00	0.0%	
BAY WHIFF	0.00	0.00	0.0%	
ATL. THREAD HERRING	0.00	0.00	0.0%	
GREY SNAPPER	0.00	0.00	0.0%	
SHEEPSHEAD	0.00	0.00	0.0%	
SPOTTED SEATROUT	0.00	0.00	0.0%	
BLACK DRUM	0.00	0.00	0.0%	
SPOTTED HAKE	0.00	0.00	0.0%	
SOUTHERN STINGRAY	0.00	0.00	0.0%	
COWNOSE RAY	0.00	0.00	0.0%	
CRABS & OTHER INVERTEBRATES	50.33	70.67	40.4%	6.93E-2
SQUID	0.00	0.00	0.0%	
JELLYFISH	8.00	8.50	6.3%	
MISCELLANEOUS	0.00	0.00	0.0%	
SILVER PERCH	0.00	0.00	0.0%	
MISCELLANEOUS FISH	0.00	0.00	0.0%	
Total Finfish	79.02	38.69	-51.0%	
Total Catch	176.35	147.76	-16.2%	

*all tows conducted during the daytime

TABLE 7. Total catch weights and reduction for the Medford Daniels Large Mesh Fish Excluder, nets tested in western Pamlico Sound, Summer 1996.

	Total Weight (kg)			
*n=10	CONTROL	EXPERIMENTAL	PERCENT DIFFERENCE	P(T<=t)
SHRIMP	43.35	35.75	-17.5%	9.62E-2
Summer Shrimp	43.35	35.75	-17.5%	
White Shrimp	0	0	0.0%	
Pink Shrimp	0	0	0.0%	
SOUTHERN FLOUNDER	8.1	6.58	-18.8%	
legal--over 330 mm	0	0	0.0%	
sublegal--und 330 mm	8.1	6.58	-18.8%	
SPOT	194.48	101.17	-48.0%	9.40E-5
ATLANTIC CROAKER	118.37	36.6	-69.1%	5.03E-4
WEAKFISH	17.12	7.97	-53.4%	1.77E-2
SOUTHERN KINGFISH	0	0	0.0%	
ATLANTIC MENHADEN	0.95	0.75	-21.1%	
BLUEFISH	0.1	0	-100.0%	
SEA ROBIN	0.1	0	-100.0%	
HOGCHOKER	1.13	0.89	-21.2%	
OYSTER TOADFISH	0.2	0	-21.2%	
PINFISH	1.71	1	-41.5%	
PIGFISH	0.72	0.6	-16.7%	
SUMMER FLOUNDER	0	0	0.0%	
FRINGED FLOUNDER	0	0	0.0%	
NORTHERN PUFFER	0.1	0	-100.0%	
WINDOWPANE	0	0	0.0%	
HARVESTFISH	1.11	0	-100.0%	
STRIPED BURRFISH	0.3	0	-100.0%	
INSHORE LIZARDFISH	2.15	1.79	-16.7%	
PLAINHEAD FILEFISH	0	0	0.0%	
ATLANTIC SPADEFISH	0.3	0.2	-33.3%	
GIZZARD SHAD	0	0	0.0%	
ORANGE FILEFISH	0	0	0.0%	
BAY WHIFF	0	0	0.0%	
ATL. THREAD HERRING	0.15	0	-100.0%	
GREY SNAPPER	0	0	0.0%	
SHEEPSHEAD	0	0	0.0%	
SPOTTED SEATROUT	0.12	0	-100.0%	
BLACK DRUM	0	0	0.0%	
SPOTTED HAKE	0	0	0.0%	
SOUTHERN STINGRAY	0	0	0.0%	
COWNOSE RAY	0	0	0.0%	
CRABS & OTHER INVERTEBRATES	129.3	135	4.4%	5.24E-1
SQUID	0	0	0.0%	
JELLYFISH	34	36	5.9%	
MISCELLANEOUS	8	8	0.0%	
SILVER PERCH	2.33	0	-100.0%	
MISCELLANEOUS FISH	0	0	0.0%	
Total Finfish	349.54	157.55	-54.9%	
Total Catch	564.19	372.3	-34.0%	

*all tows conducted during the daytime

TABLE 8. Total catch weights and reduction for the Virgil Potter BRD at 85 meshes above the tie-off rings, tested in Western Pamlico Sound, North Carolina, Summer 1996.

	Total Weight (kg)			
*n=12	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	37.55	30.25	-19%	1.95E-7
Summer Shrimp	37.55	30.25	-19%	
White Shrimp	0	0	0%	
Pink Shrimp	0	0	0%	
SOUTHERN FLOUNDER	11.65	11.45	-2%	
legal--over 330 mm	0	0	0%	
sublegal--und 330 mm	11.65	11.45	-2%	
SPOT	310.02	85.8	-72%	1.10E-6
ATLANTIC CROAKER	203.15	50.8	-75%	8.23E-8
WEAKFISH	50.4	19.35	-62%	2.15E-6
SOUTHERN KINGFISH	0.7	0	-100%	
ATLANTIC MENHADEN	2.1	1.07	-49%	
BLUEFISH	0.55	0	-100%	
SEA ROBIN	0.34	0.26	-24%	
HOGCHOKER	2.96	2.42	-18%	
OYSTER TOADFISH	0.5	0	-100%	
PINFISH	4.74	2.62	-45%	
PIGFISH	2.28	1.37	-40%	
SUMMER FLOUNDER	0	0	0%	
FRINGED FLOUNDER	0	0	0%	
NORTHERN PUFFER	0	0	0%	
WINDOWPANE	0	0	0%	
HARVESTFISH	2.43	1.35	-44%	
STRIPED BURRFISH	0	0	0%	
INSHORE LIZARDFISH	3.71	1.88	-49%	
PLAINHEAD FILEFISH	0	0	0%	
ATLANTIC SPADEFISH	0.2	0	-100%	
GIZZARD SHAD	0	0	0%	
ORANGE FILEFISH	0	0	0%	
BAY WHIFF	0	0	0%	
ATL. THREAD HERRING	0	0	0%	
GREY SNAPPER	0	0	0%	
SHEEPSHEAD	0	0	0%	
SPOTTED SEATROUT	0	0.25	100%	
BLACK DRUM	0	0	0%	
SPOTTED HAKE	0	0	0%	
SOUTHERN STINGRAY	1	0	-100%	
COWNOSE RAY	0	0	0%	
CRABS & OTHER INVERTEBRATES	120.4	126	5%	3.93E-1
SQUID	0	0	0%	
JELLYFISH	10	9.7	-3%	
MISCELLANEOUS	15	16	7%	
SILVER PERCH	0	0	0%	
MISCELLANEOUS FISH	2.77	1.41	-49%	
Total Finfish	599.5	180.03	-70%	
Total Catch	782.45	208.78	-73%	

*all tows conducted during the daytime

TABLE 9. Total catch weights and reduction for the Virgil Potter BRD at 9 meshes behind the TED, tested in Western Pamlico Sound, Fall 1996/Spring, 1997.

	Total Weight (kg)			
*n=20	CONTROL	EXPERIMENTAL	Percent Difference	P(T<=t)
SHRIMP	4.57	4.79	5%	4.52E-1
Summer Shrimp	0	0	0%	
White Shrimp	0	0	0%	
Pink Shrimp	0	0	0%	
SOUTHERN FLOUNDER				
legal--over 330 mm	1	0.85	0%	
sublegal--und 330 mm	4.1	3.25	-21%	
SPOT	311.62	98.61	-68%	2.60E-3
ATLANTIC CROAKER	224.35	65.51	-71%	1.34E-4
WEAKFISH	16.48	6.89	-58%	4.25E-5
SOUTHERN KINGFISH	0	0	0%	
ATLANTIC MENHADEN	0	0	0%	
BLUEFISH	0	0	0%	
SEA ROBIN	0	0	0%	
HOGCHOKER	0.45	0.3	-33%	
OYSTER TOADFISH	0	0	0%	
PINFISH	0.6	0.34	-43%	
PIGFISH	0	0	0%	
SUMMER FLOUNDER	0	0	0%	
FRINGED FLOUNDER	0	0	0%	
NORTHERN PUFFER	0	0	0%	
WINDOWPANE	0	0	0%	
HARVESTFISH	0	0	0%	
STRIPED BURRFISH	0	0	0%	
INSHORE LIZARDFISH	0.4	0.26	-35%	
PLAINHEAD FILEFISH	0	0	0%	
ATLANTIC SPADEFISH	0	0	0%	
GIZZARD SHAD	0	0	0%	
ORANGE FILEFISH	0	0	0%	
BAY WHIFF	0	0	0%	
ATL. THREAD HERRING	0	0	0%	
GREY SNAPPER	0	0	0%	
SHEEPSHEAD	0	0	0%	
SPOTTED SEATROUT	0	0	100%	
BLACK DRUM	0	0	0%	
SPOTTED HAKE	0	0	0%	
SOUTHERN STINGRAY	1	0	-100%	
COWNOSE RAY	0	0	0%	
CRABS & OTHER INVERTEBRATES	41.3	40.5	-2%	6.15E-1
SQUID	0	0	0%	
JELLYFISH	3.1	2.7	-13%	
MISCELLANEOUS	18.5	17.5	-5%	
SILVER PERCH	0.9	0.7	0%	
MISCELLANEOUS FISH	0	0	0%	
Total Finfish	555.8	172.61	-69%	
Total Catch	623.27	238.1	-62%	

*all tows conducted during the daytime

Figure 1. Total catch weights and reduction for 14 tows with the Hickman BRD at the 12 o'clock position up 50 meshes above the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

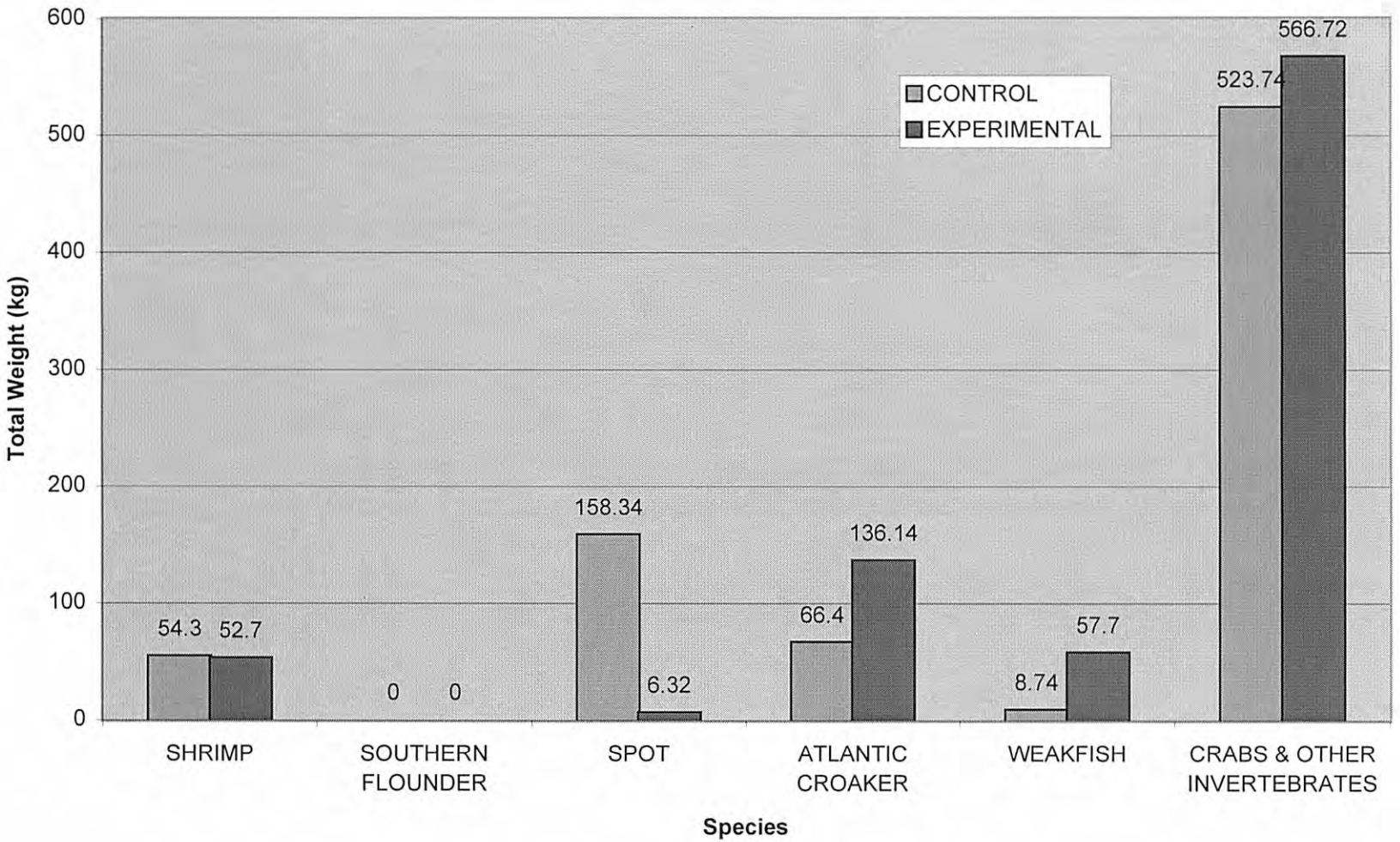


FIGURE 2. Total catch weight comparisons for the Hickman 8 inch BRD at the 3 o'clock position up 50 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

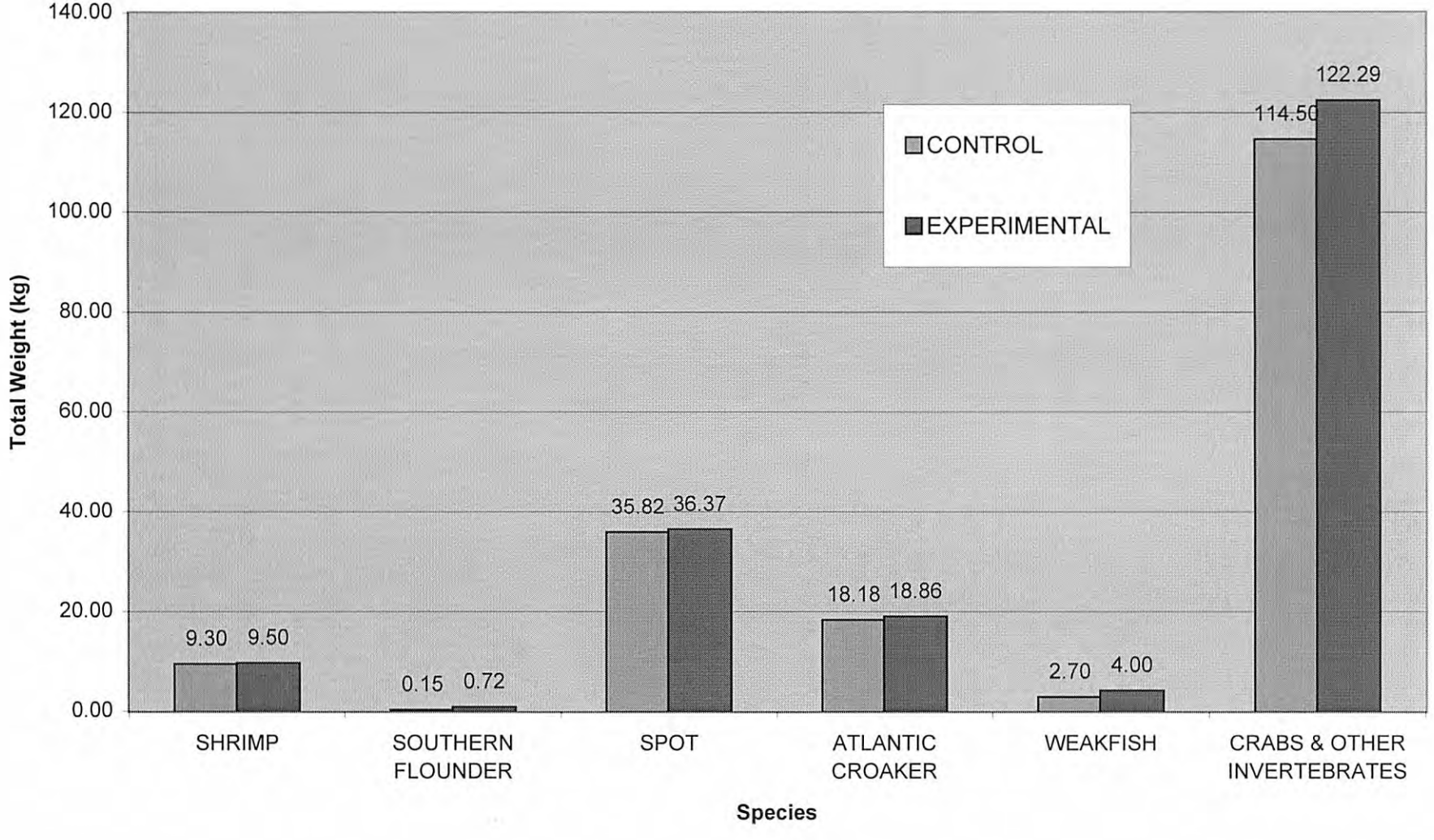


FIGURE 3. Total catch weight comparisons for the Hickman 8 inch BRD at the 12 o'clock position up 30 meshes from the tie-off, tested in western Pamlico Sound, North Carolina, Summer 1996.

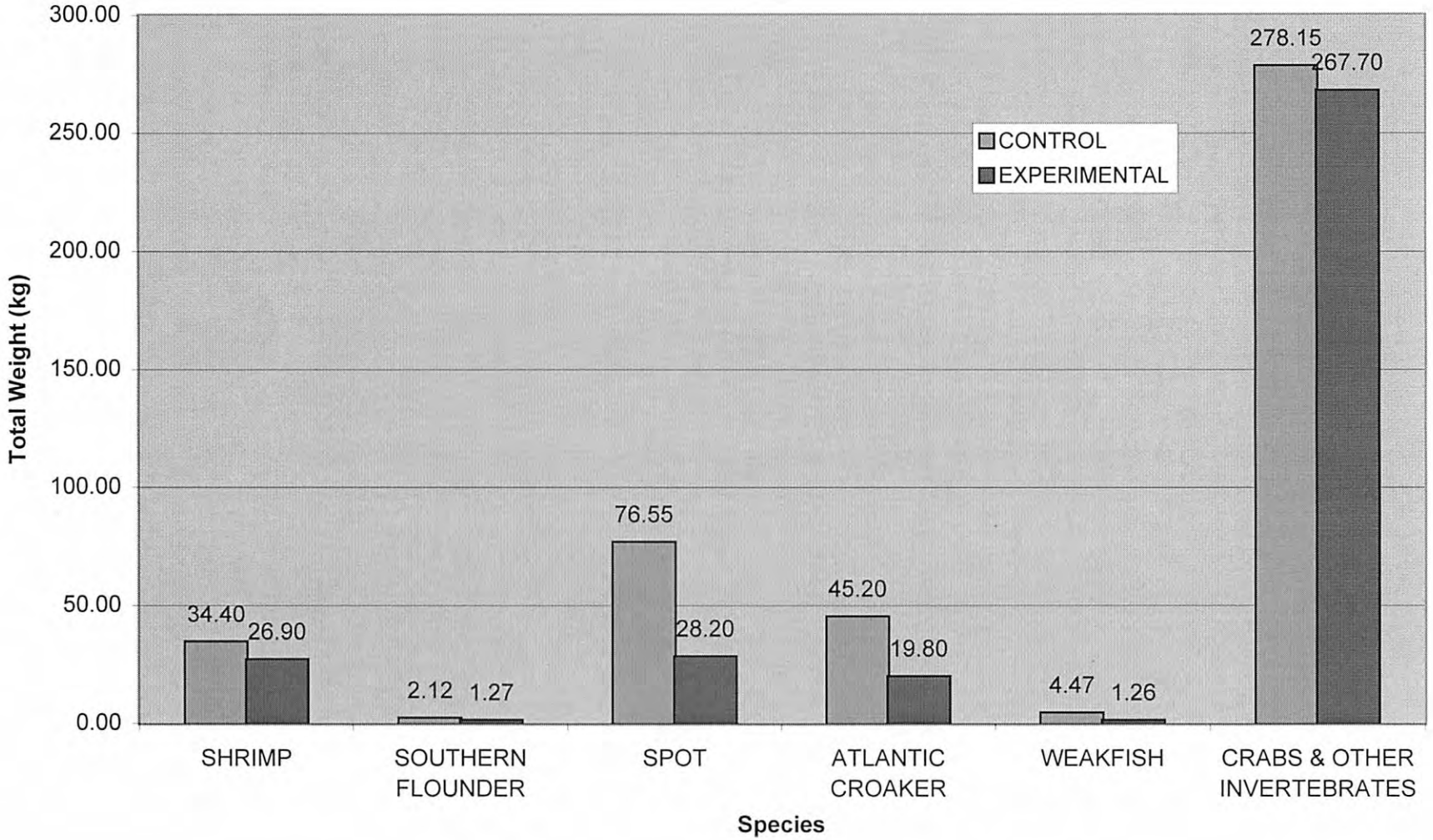


Figure 4. Total catch weights for 6 tows with the Hickman 8 inch BRD at the 1:30 o'clock position up 40 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

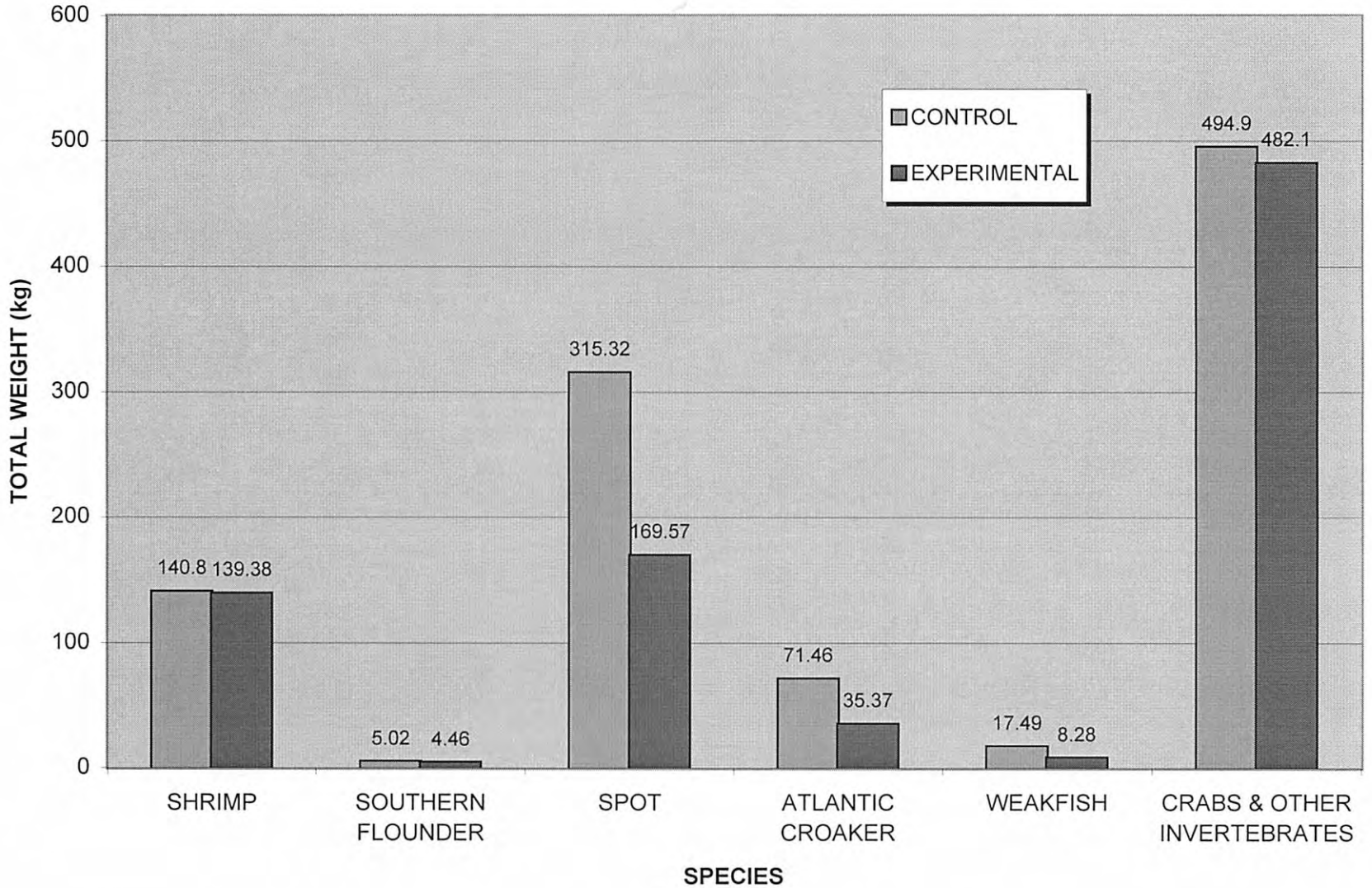


FIGURE 5. Total catch weights for 10 tows with the Hickman 8 inch BRD at the 1:30 o'clock position up 40 meshes from the tie-off rings, tested in western Pamlico Sound, North Carolina, Summer 1996.

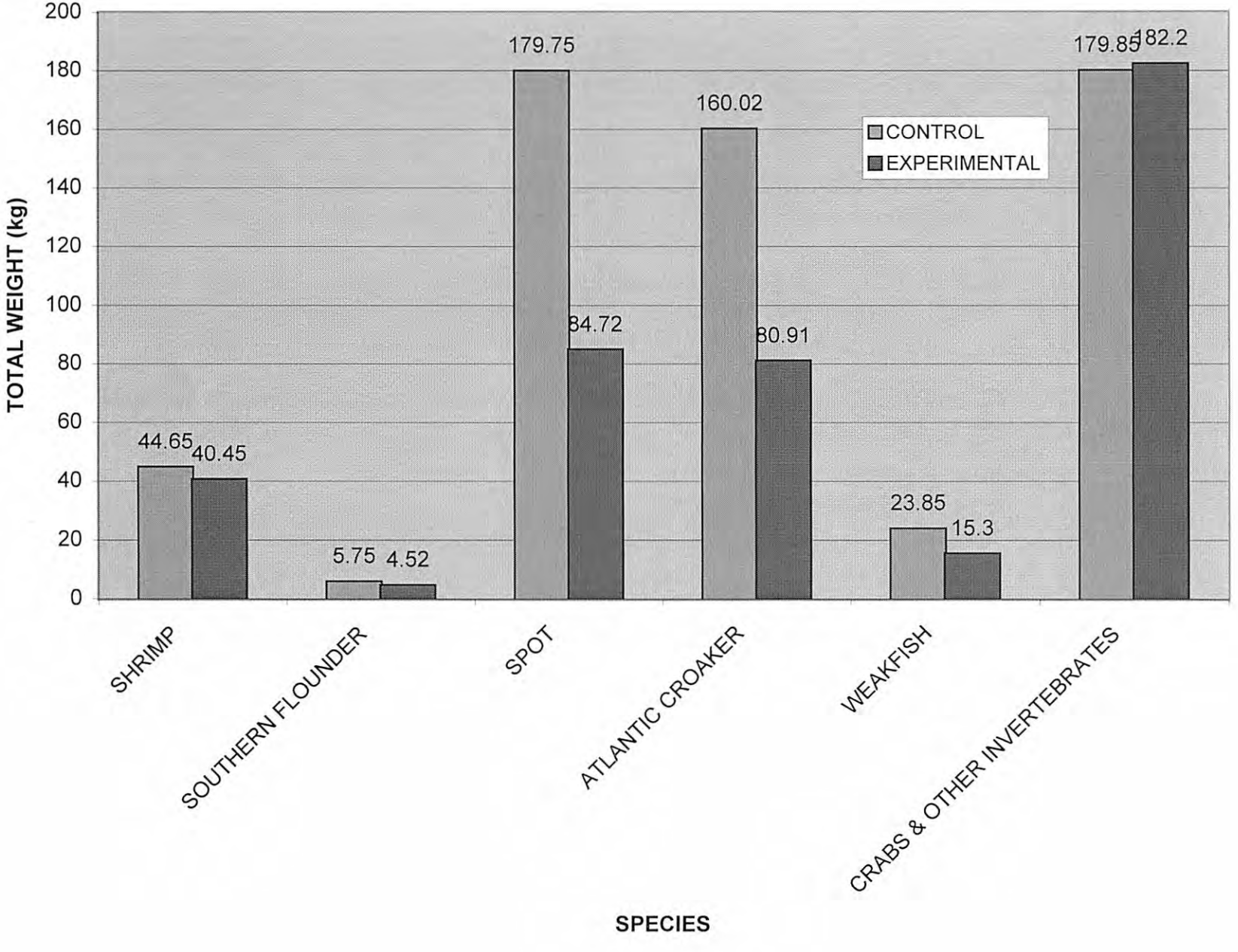


FIGURE 6. Total catch weights for 6 tows with the Hickman 8 inch BRD at the 1:30 o'clock position up 40 meshes from the tie-off rings, tested in Pamlico Sound, North Carolina, Summer 1996.

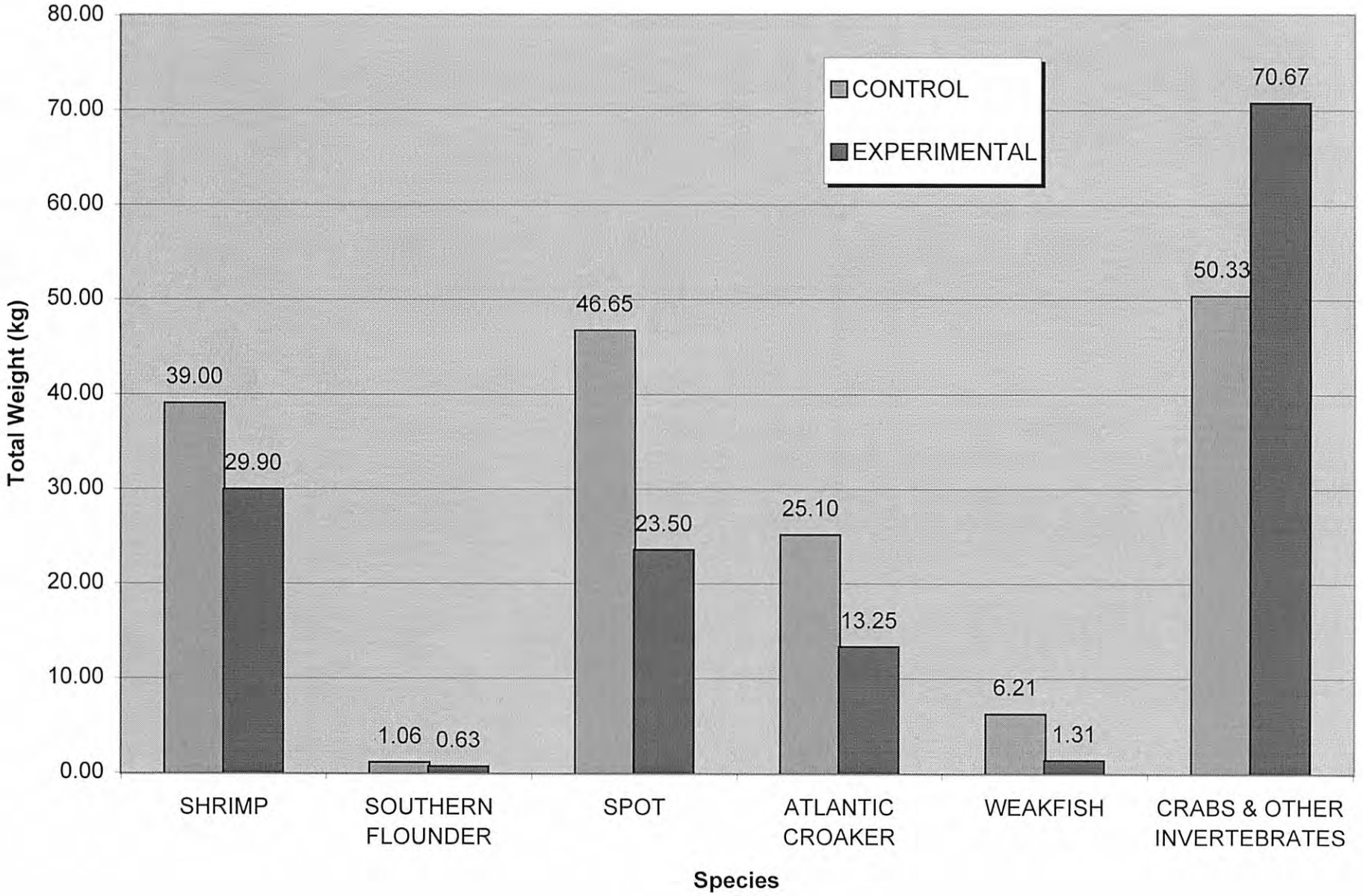


FIGURE 7. Total catch weights for 10 tows for the Medford Daniels Large Mesh Fish Excluder, nets tested in western Pamlico Sound, North Carolina, Summer 1996.

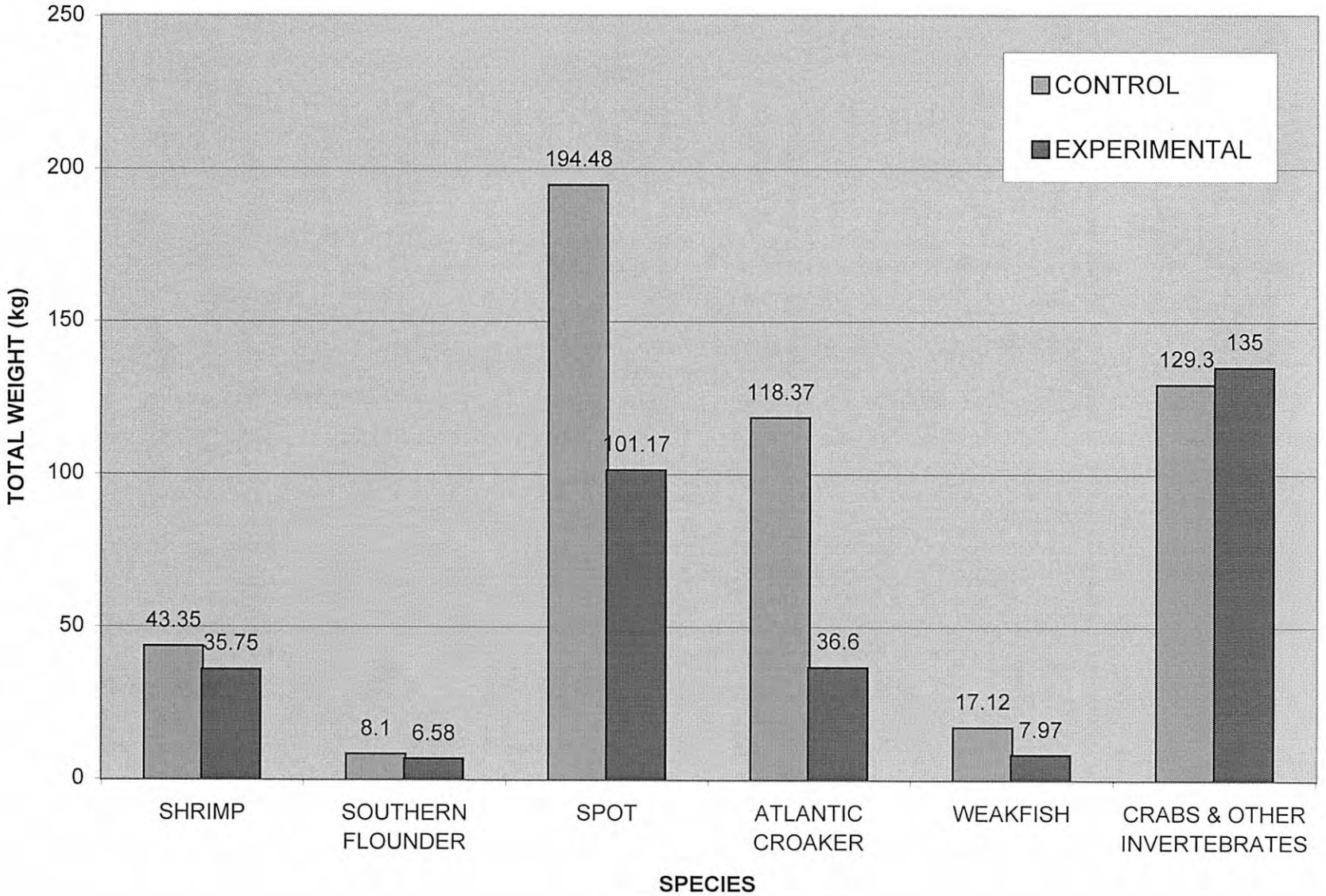


FIGURE 8. Total catch weights comparison for the Virgil Potter BRD at 85 meshes above the tie-off rings, tested in Western Pamlico Sound, North Carolina, Summer 1996.

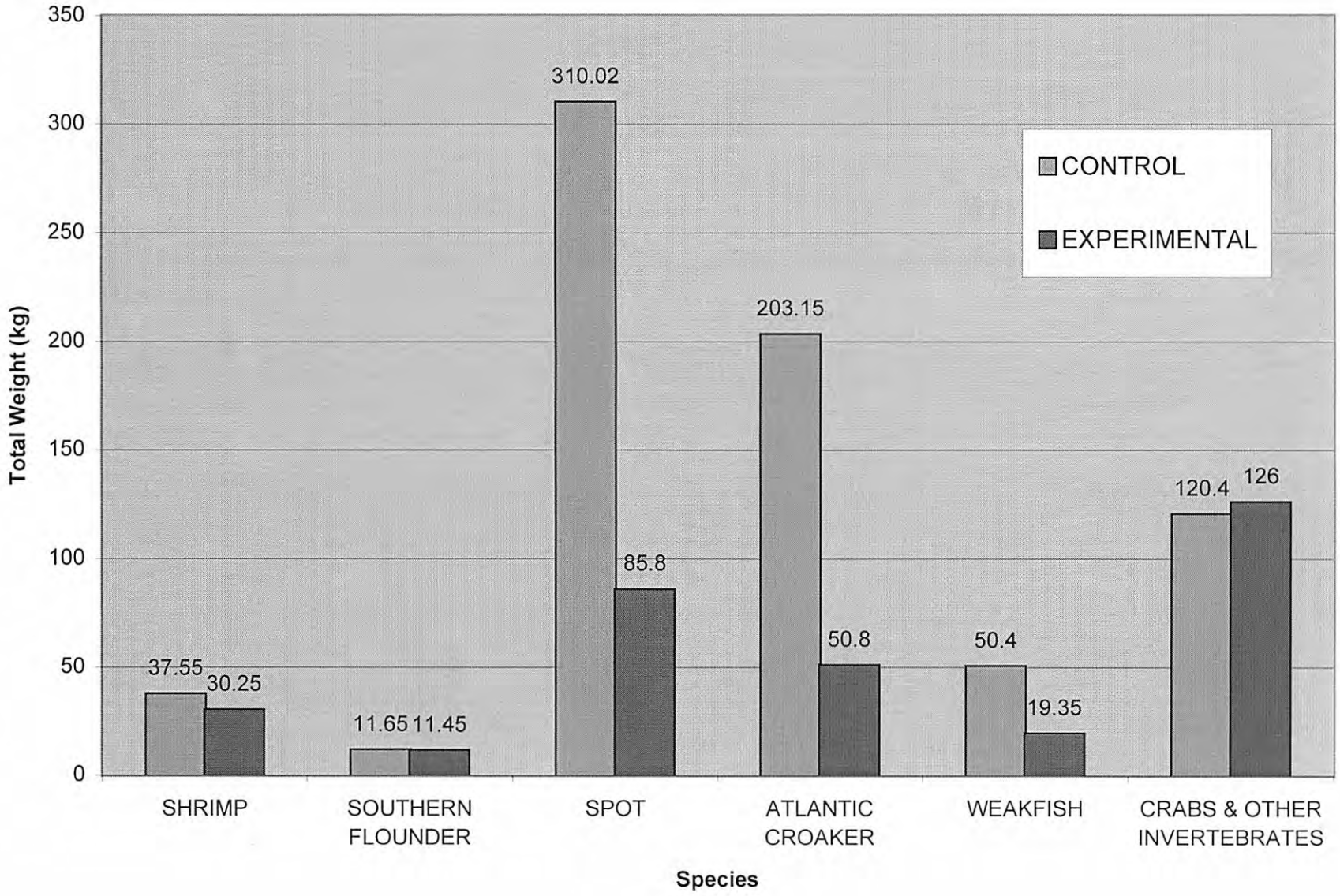
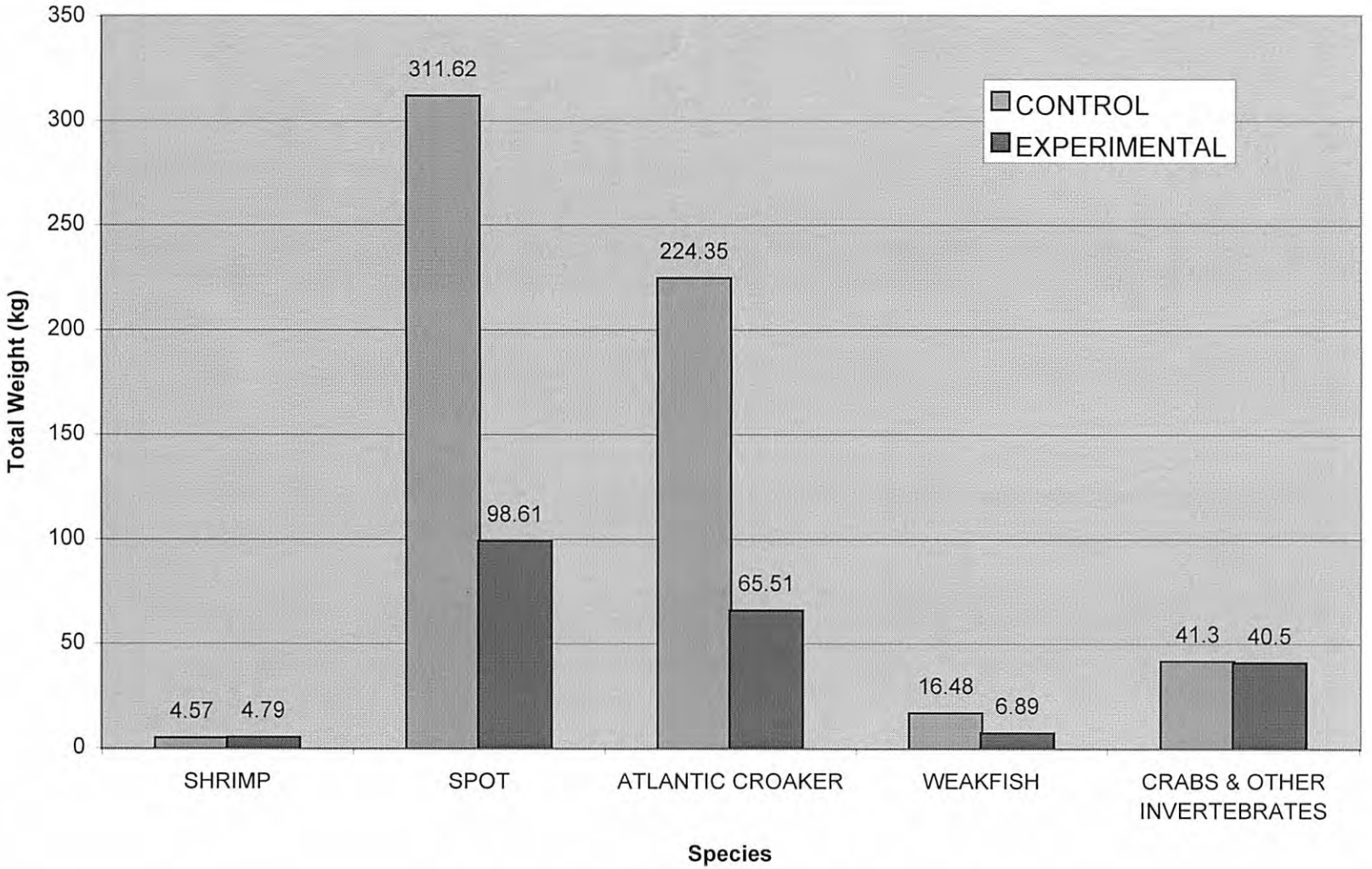
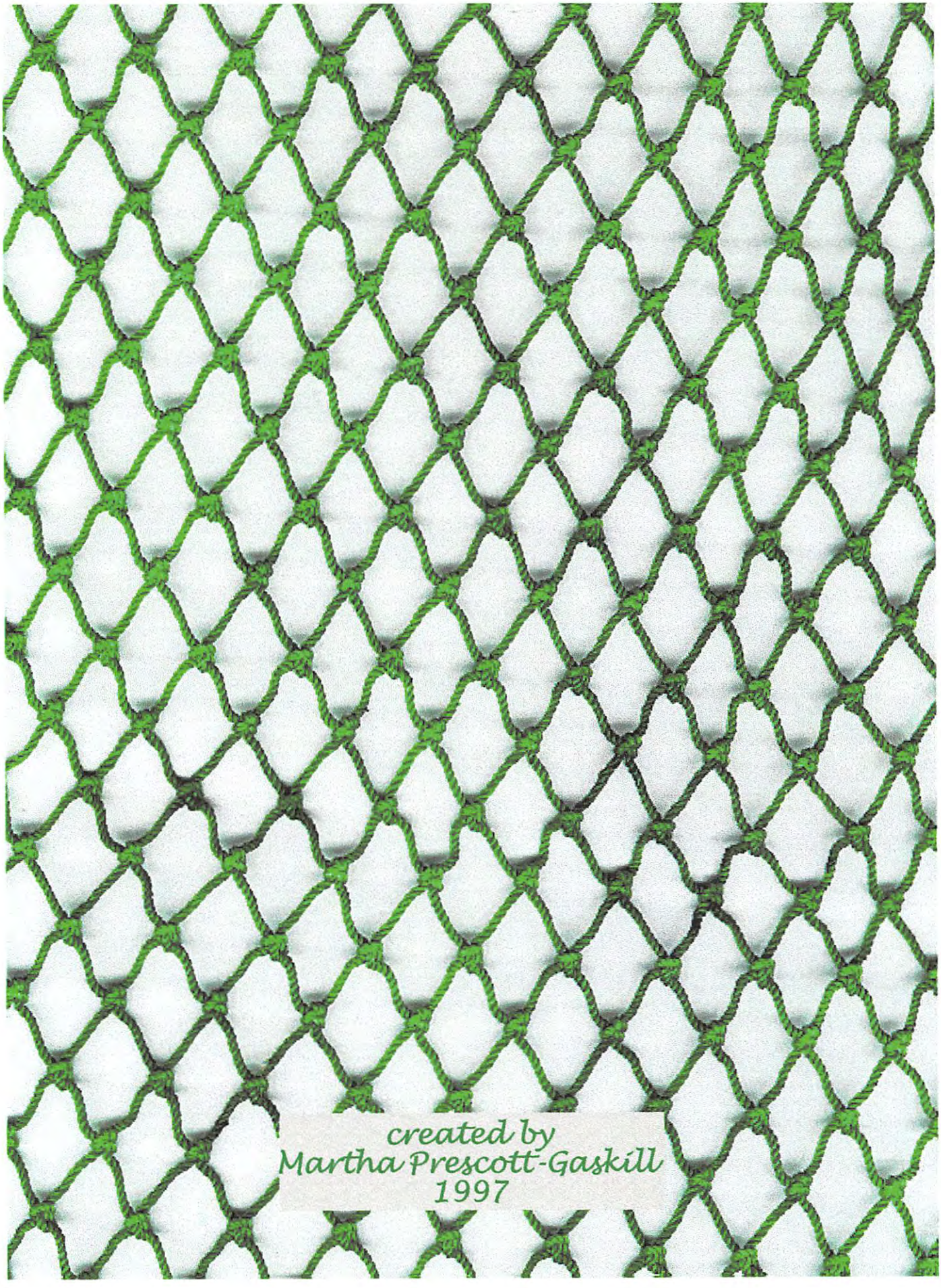


FIGURE 9. Total catch weight comparisons for the Virgil Potter BRD at 9 meshes behind the TED, tested in western Pamlico Sound, North Carolina, Fall/Spring, 1996-97.

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