Evaluation of the Large Mesh Belly Panel in Small Mesh Fisheries as a Method to Reduce Yellowtail Flounder Bycatch on Cultivator Shoals

A Report to the Northeast Cooperative Research Program

FINAL REPORT

(Updated as per NEFMC Research Steering Committee Request and Incorporating Peer Review Comments)

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ABSTRACT

This project was developed by the Northeast Cooperative Research Program funded Squid Trawl Network to address yellowtail flounder and windowpane flounder bycatch concerns on Georges Bank by evaluating the effectiveness of a standard net modified with a large mesh belly panel to reduce the bycatch of both of these flounder species. The project was proposed by Georges Bank small mesh fishermen as a means to pursue gear certification to be used for yellowtail and windowpane bycatch avoidance in Georges Bank small mesh fisheries when Accountability Measures (AM) are triggered. The Georges Bank yellowtail and windowpane flounder stocks are currently considered overfished and overfishing is occurring. The evaluation of a large mesh belly panel net in deep water while targeting squid and whiting was recommended as a bycatch avoidance solution and was conducted through this project. In response to the NEFMC's action developing Accountability Measures and sub-Annual Catch Limits for windowpane flounder as well as yellowtail flounder, quantifying windowpane bycatch reduction concurrent with yellowtail bycatch reduction was conducted during this project.

Data analysis was conducted to determine if a statistically significant difference existed in yellowtail flounder and windowpane flounder catches in the experimental net with the large mesh belly panel compared to the control net. The difference in catch of target species (squid and whiting) between the experimental net and the control net was also analyzed. Paired t-test results showed a significant difference in catch weights for yellowtail flounder and for windowpane flounder. The large mesh belly panel significantly reduced the bycatch of both flounder species. There was an 80.7 % reduction in yellowtail flounder catch and 59.3% reduction in windowpane flounder catch in the net with the large mesh belly panel compared to the control net. Paired t-test results showed a non-significant result for the catch differences of whiting and squid in the net with the large mesh belly panel compared to the control net. Since the experimental net did not cause significant reduction in the catch of the target species (whiting and squid) but did significantly reduce bycatch of yellowtail flounder and windowpane flounder, the large mesh belly panel shows promise as a possible certified bycatch avoidance net.

INTRODUCTION

Currently, the Georges Bank (GB) yellowtail flounder stock is considered overfished and overfishing is occurring. The GB yellowtail flounder quota has been declining quite dramatically in recent years, and as a result, small-mesh discards of the stock are becoming an increasing proportion of the total U.S. catch. This project was developed to address an immediate fisheries management need and pursue gear certification as an Accountability Measure for yellowtail bycatch in Georges Bank small mesh fisheries.

After considering the unique nature and management of the squid/whiting small mesh fishing in offshore areas, available data about relevant gear research, variability in Georges Bank yellowtail flounder catch rates on small-mesh fishery trips, the requirement to develop effective AMs in Framework Adjustment 51, and forecasts of substantially lower sub-ACLs (annual catch limits) for Georges Bank yellowtail flounder in 2014, the NEFMC Whiting and MAFMC Squid Advisory Panels made the following recommendations for management alternatives that the NEFMC should include and analyze in Framework Adjustment 51:

- Required year round use of a certified bycatch avoidance net when an AM is triggered. AM would be triggered at the end of a fishing year (April 30, 2014 at the earliest), determined a few months after the end of the fishing year, and the industry would have at least six months to procure and begin using a gear listed as an approved bycatch avoidance net at the beginning of the next fishing year (May 1, 2015 at the earliest). This timing would give industry or researchers sufficient time to evaluate experimental trawl performance. Examples of nets to be evaluated in deep water while targeting squid and whiting include a modified Ruhle trawl, a large mesh belly net, and a raised footrope trawl.

Existing research on the above nets are not directly applicable to the offshore squid/whiting fishery on Georges Bank, typically conducted using large vessels. The Ruhle trawl research was conducted using a modified squid rope trawl adapted to work with large mesh (Beutel, et al., 2008). It is not known how this net would work in the squid/whiting fishery when adapted to small mesh currently in use. The large mesh belly net has some promising features, but recent research has focused on reducing winter flounder bycatch in the inshore whiting and squid fisheries (Hasbrouck, et al., 2012, Hasbrouck, et al., 2014). Likewise, the raised footrope trawl research conducted by MADMF was completed in inshore, shallower areas and may not have the same results in deeper water with larger nets towed by larger vessels (McKiernan, et al., 1998).

As a Framework Alternative, the Council would identify a gear-based AM using approved yellowtail flounder bycatch avoidance nets that would be certified by the Regional Administrator based on submitted data and analysis of the above nets. The certification would be based on standards set by the Council in Framework Adjustment 51. If the Georges Bank yellowtail flounder AM is triggered, vessels using small-mesh trawls could only use certified yellowtail flounder bycatch avoidance nets throughout the year (NEFMC, 2013a).

Due to concerns for the declining quota, and increasing significance of small-mesh discards of GB yellowtail flounder, Framework 48 to the Northeast Multispecies Fishery Management Plan adopted a GB yellowtail flounder sub-annual catch limit (sub-ACL) for the small-mesh fisheries (NMFS, 2013). A sub-Annual Catch Limit (ACL) currently regulates small mesh fishing on Georges Bank (GB). For the purposes of this sub-ACL, small-mesh bottom trawl fisheries are defined as those vessels that use a bottom otter trawl with a cod-end mesh size of less than 5 inches. Typical target species for vessels using this gear on GB are whiting and squid. Catches of GB yellowtail flounder by the small-mesh fisheries have generally been less than 100 mt in recent years (NEFMC, 2013b).

Just prior to this project was being proposed, the NEFMC council passed the following motion relative to accountability measures for small mesh fisheries on Georges Bank, to be included in Framework Adjustment 51: “To add an option as a possible Accountability Measure or as a Technical measure, any gear modifications in the small mesh fishery Georges Bank area.”

The GB yellowtail flounder quota has been declining quite dramatically in recent years and as a result, small-mesh discards of the stock are becoming an increasing proportion of the total U.S. catch. If the U.S. quota for GB yellowtail flounder is exceeded, then the U.S. quota for the following fishing year must be reduced by the amount of the overage. The pound-for-pound reduction is applied to the sub-ACL of the fishery component that caused the overage. For example, if the small-mesh fisheries caused an overage of the U.S. quota in Year 1, the small-mesh fisheries sub-ACL would be reduced by the amount of the overage in the next fishing year (Year 2). However, the small-mesh fisheries are currently required to discard all GB yellowtail flounder caught. Thus, a pound-for-pound reduction of the quota, without corresponding measures to help reduce catches of GB yellowtail flounder, would not appropriately mitigate an overage, or prevent future overages from occurring, for the small-mesh fisheries (NMFS, 2014).

Small mesh trawl nets can be made more selective in terms of size and species they retain with the use of bycatch reduction devices. Many factors influence fish capture rates including morphological and behavioral characteristics of fish as well as differences in trawl net design and construction. Successful bycatch mitigation should focus primarily on changes to the trawl design that result in applicable fishing techniques and management tools. There is an urgent need for proven methods that will work within the Georges Bank small mesh fisheries to reduce yellowtail and windowpane flounder bycatch.

The most direct option available for significant yellowtail flounder bycatch reduction in the small mesh whiting and squid fisheries is through conservation engineering and gear technological improvements. Integral to the success of any solutions that strive toward the goal of gear selectivity, is a corresponding improvement in the adoption of these methods by fishermen. This is best achieved by involving fishermen in all program aspects, from idea conception to final results. Success is also dependent on the gear modification not reducing the catch of target species (whiting and squid).

This project was developed by the Northeast Cooperative Research Program funded Squid Trawl Network (STN) to address an immediate fisheries management need and pursue gear certification for a large mesh belly panel net to be used for bycatch reduction as an Accountability Measure for yellowtail and windowpane bycatch in Georges Bank small mesh fisheries. Discussions at the NEFMC Whiting Advisory Panel meeting in September 2013 laid the groundwork for developing gear-based AMs for Georges Bank yellowtail flounder in the small mesh fisheries. A need for proven gear concepts seeking additional consideration for small mesh trawls under this AM was the premise of this research conducted by Cornell Cooperative Extension Marine Program (CCE) and the STN. The STN is a collaborative industry/science effort to form a comprehensive network to identify and address the challenges of bycatch and selectivity in the longfin squid fishery through innovative research. The STN was created in order to establish a collaborative industry, science and management network approach to solving the bycatch challenges of the squid fishery occurring in the Northeast. A STN Program Advisory Committee (PAC) provides guidance and direction to the STN on research efforts. The STN PAC includes commercial fishing industry members, gear designers, fisheries scientists and fisheries managers. The STN PAC decided that the Squid Trawl Network would focus on an immediate response to address the yellowtail bycatch concerns on Georges Bank by evaluating the effectiveness of the large mesh belly panel on Georges Bank based on previous successful research performed by CCE in SNE/MA small mesh fisheries. Results of this previous large mesh belly panel study showed that the use of this modification resulted in an 88% reduction in winter flounder and an 83% reduction in combined demersal species (all flounders, skates, dogfish, and sea robins) (Hasbrouck, et al., 2012). These reductions were statistically significant. In addition, it should be noted that these high percentages of bycatch reduction were achieved while showing no statistically significant loss of the target species, longfin squid (Hasbrouck, et al., 2012). Similar results were proven by Milliken and DeAlteris (2004) in a project aimed at reducing flatfish bycatch in small mesh bottom trawls targeting whiting. In that project large mesh panels in the lower belly of a typical small mesh whiting net were evaluated. Their results showed large mesh belly panels proved to be effective in reducing flatfish bycatch while not reducing the catch of silver hake. Another concept considered by the STN PAC was the 12” drop chain sweep, which also showed promise in reducing winter flounder bycatch. The 12” drop chain sweep resulted in a statistically significant 78% reduction in winter flounder bycatch and a statistically significant 76% reduction in combined demersal species without a significant loss of squid (Hasbrouck, et al., 2013).

CCE maintains an excellent working relationship with fishermen from the Northeast and continually engages the commercial fishing industry, specifically the small mesh fleet, in reference to gear modifications that may be appropriate or effective in addressing bycatch of species of concern such as yellowtail and windowpane flounder. Both the 12” drop chain sweep and the large mesh belly panel modifications were designed with the collaboration of fishermen and net builders. Ultimately, it was agreed upon by the STN PAC that the large mesh belly panel modification had proven to be more effective and was to be selected for further study on Georges Bank.

THE STN PAC also decided that the change in windowpane bycatch that occurred with as a result of the yellowtail bycatch measured should also be quantified. This is in response to the

NEFMC's action developing Accountability Measures and sub-Annual Catch Limits for windowpane flounder in addition to yellowtail flounder. Additionally, this project will extend the knowledge developed to the Georges Bank small mesh fishery and regional fisheries management councils to facilitate the transition of the application of research projects to implementation, to ensure such practices and technologies are available to managers.

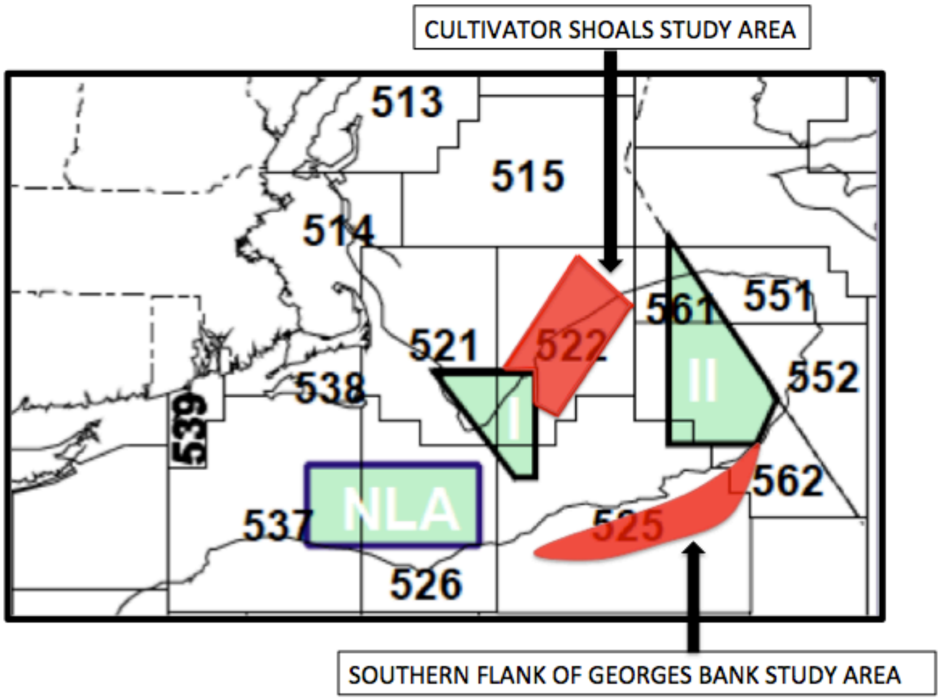
Through this project, the STN aims to help resource managers and fishermen work together to sustainably use, protect, maintain and rebuild marine fisheries. More specifically, this project will develop and evaluate a conservation gear technology approach to address the issue of Georges Bank yellowtail and windowpane flounder bycatch in the small mesh fishery with the use of a large mesh belly panel net and ultimately certify this gear for approved use when AMs for small mesh fisheries are triggered. These goals will be accomplished by comparing the bycatch rates of GB yellowtail flounder and windowpane flounder for the experimental (large mesh belly panel) net and the control net as well as comparing the catch rates of the target species (whiting/squid) for each net and determining the effectiveness of the large mesh belly panel net as a successful bycatch reduction device. By definition and net design these results would also be applicable to the use of a large mesh rope trawl.

METHODS

Study Area

Two study areas have been selected for this overall project (Figure 1). The project has thus been divided into two phases to quantify gear performance in each individual area. The first is an area designated as the southern flank of Georges Bank. The second is a northern area designated as Cultivator Shoals. Observer data, NEFMC and small mesh fishermen have identified these areas as small mesh fishing areas most likely to interact with yellowtail flounder. The southern flank of Georges is a productive area fished by small mesh fishermen for squid and whiting from January – March. A final report has been submitted for the completion of phase one of this project. The northern area on Cultivator Shoals is an area fished by small mesh fishermen targeting whiting. Experimental fishing for phase two in the Cultivator Shoals study area took place in mid-August 2014 and is the basis of this report.

Figure 1. Map of Project Study Areas (in red) on Cultivator Shoals and the Southern Flank of Georges Bank. Green shaded areas have been closed to fishing year-round since 1994, with exceptions.



Research Design

The experimental design was intended to test the large mesh belly panel in the commercial small mesh squid and whiting fishery using existing gear and typical fishing practices. We tested for differences in both the target species catch and flounder species of concern, specifically yellowtail and windowpane flounder. We tested across appropriate identified strata of time, depth, area, and fishing practices. A single commercial twin trawl fishing vessel (F/V Karen Elizabeth) was used in this study to conduct paired replicate tows comparing a control trawl to a large mesh belly panel altered trawl (experimental trawl). This was accomplished by towing both the control and experimental nets at the same time over the same ground. A twin trawl vessel is rigged to tow two nets simultaneously in a twin-rig fashion. The study protocol used the same control/experimental trawls throughout the trip to evaluate the effectiveness of the experimental large mesh belly panel against the study objectives. The participating captain, Captain Chris Roebuck, has extensive experience fishing for squid and whiting in the project areas.

The vessel has two net reels and twin stern ramps. Both nets were set and hauled together. The vessel used one set of doors to spread the two nets (a door on each outside towing cable). The vessel used a 3-wire system with a middle winch. A “clump” (weighted sled) attached to the middle wire was towed between the two nets. Ground cables and bridles go from the clump to the inside wing of each trawl. This vessel normally tows two nets in this fashion during its normal offshore fishing operations. Most vessels of this nature are equipped with electronic instrumentation systems that include sensors on both doors and 2 sensors on the “clump”. This allowed both nets to be fished square to the vessel, the same distance behind the vessel, and with the same wing spread. Door spread was recorded to the nearest fathom at the beginning and end of each tow. During the trip we switched the port/starboard location of the control and experimental trawls twice in order to help normalize any port/starboard effect. We had an equal number of paired tows with the gear on different sides.

The control net used aboard the F/V Karen Elizabeth was an unaltered trawl net typical of the small mesh nets used in the squid and whiting fishery on Georges Bank along the southeastern area and Cultivator Shoals, and is the net that this vessel normally uses on a commercial squid or whiting trip. The control net was a 420 x 16 cm 3-bridle 4-seam box trawl with a sweep length of 40 m (131 ft), a headrope length of 32 m (105 ft), 2 cm (8") mesh (full mesh) webbing in the wings and jibs, and 15 ¼ cm (6”) mesh in the bunts and in the 1st bottom belly. The net had 8 cm (3.15”) webbing in the square, side squares, 1st top belly, 1st side bellies and the 2nd bellies. The last bellies were 6 cm (2.36”) mesh. See Fig. 27 – Net Diagram.

The experimental net was constructed the same as the control net with the addition of a large mesh belly panel. The large mesh panel is made of 80 cm (32”) mesh 6 mm poly webbing, 2 meshes deep X 16 meshes wide sewn into the standard 16 cm (6”) mesh of the belly. With the ‘saw-toothing’ of the 16 cm mesh, this yielded an effective opening of 3 full meshes deep, a total of about 2.4 m (8 ft) of large mesh. The panel was attached five 16 cm meshes (approximately 2.5 ft) behind the footrope and goes from gore to gore (22 meshes wide or approximately 30 ft). See Fig. 28 – Diagram of Large Mesh Belly Panel. See also the narrative following Fig. 28 for an explanation of how to scale and describe the large mesh belly panel to fit in any net.

Tow procedure had the vessel essentially fish as it would in a standard commercial fishing trip, with the exception that tows started at 30 minutes in length and were shortened to 15 minutes due to extremely large catches.

Number of trips and tows

This phase of the project was conducted during August 2014 in the Northern Area of Georges Bank on Cultivator Shoals. During this phase we conducted a total of 42 paired tows, all completed in one 5 day trip. Tow times for this phase of the project started at 30 minutes and were decreased to 15 minutes during the first day due to extremely large catches. Tows occurred during both the day and night but most were conducted during the day.

On Board Catch Processing

Both nets are set and hauled together. Upon haul-back the catch from each net was kept separated on deck during the entire tow work-up procedure. The catch from each net was processed separately.

We sampled yellowtail and windowpane flounder as well as the targeted squid and whiting using standard NMFS survey methods (NEFMC 1988). The goal was to quantify the differences in the catches of these four species between the control and experimental nets. As such, total catch of each species for each tow of both nets was accurately weighed. These four species were also sampled for length frequency. The goal was minimally 100 random length measurements per tow. When fewer individuals were caught, all were measured. We also quantified the catch of yellowtail and windowpane flounder in terms of numbers. This was accomplished by actually counting the fish (if the catch was small) or by utilizing the number of individuals in our length frequency and the weight of that sample extrapolated over the entire yellowtail or windowpane flounder catch. The total catch weight of all species in each tow was obtained either by direct weighing or by catch estimations. Catch estimations were based on basket or tote counts. An average weight was determined by weighing a minimum of 5 baskets or totes. Next, a count of the number of baskets or totes was made for the particular species and this number was multiplied by the average weight. This number was then recorded as the estimated total catch weight. This procedure for catch estimations, based on basket or tote counts, follows the NMFS At Sea Monitoring Program and the Observer Program Biological Sampling protocols as outlined in the NEFSC 2010 sampling manuals.

DATA ANALYSIS AND RESULTS

Below is a quantitative evaluation and summary of the data analysis. Data were analyzed primarily to determine if a significant statistical difference exists in the catch of two flounder species (yellowtail flounder and windowpane flounder) and the target species (squid and whiting) between the control and experimental nets, and to further quantify what the difference was. Since only one vessel was used there was no vessel effect in the analysis relative to the catch between tows or nets. Also, since both the control and experimental nets were constructed the same (with the exception of the belly panel) and fished the same, the gear effect is only related to the belly panel installation.

Statistical tests are based on pairing of the data. For each paired tow the control catch is compared to the experimental. The twin trawl design of the experiment lends itself well to pairing and a pair-based analysis is the best approach. Both parametric and nonparametric statistics are used. All statistics are at the $\alpha = .05$ level. Box plots and plots of control/experimental catches by species show the distributions of each component separately (unpaired). Catch data for four key species and the catch differences between the control net and the experimental net for each tow are shown in Table 3 at the end of this report.

Unfortunately as is the case with many of these species interaction studies, it can be difficult to find commercial quantities of both target and bycatch species at the same time in the same area despite what the NMFS observer data indicates. This was the case in this study and we opted to concentrate on larger catches of yellowtail and windowpane flounder at the expense of smaller and more variable catches of whiting and squid in order to determine the effectiveness of the large mesh belly panel at reducing bycatch of the flounder species. At the time research fishing was taking place on Cultivator Shoals, the whiting fleet was not in the same area as where we found good concentrations of yellowtail and windowpane flounder. The whiting fleet was fishing in deeper water (70 – 90 fathoms) in order to avoid all bycatch. We knew if we fished in that area there would be minimal catch of yellowtail or windowpane flounder.

Catch Comparisons

Yellowtail Flounder

First we looked at the difference in yellowtail flounder catch between the control net and the experimental net with the large mesh belly panel (Figures 2 and 3). Statistical analysis of the data was conducted to determine if the large mesh belly panel experimental net significantly affected retention of yellowtail flounder relative to the standard control net.

T- test results showed a significant difference in the catch weight between the control and experimental net ($t = 7.9043$, $df = 41$, **p-value <0.0001**, mean of x =21.09524). The experimental net significantly reduced the catch of yellowtail flounder compared to the control net. The Wilcoxon test yielded similar results.

Figure 2. Boxplot Distribution of Yellowtail Flounder Catch Weight in the Control and Experimental Net

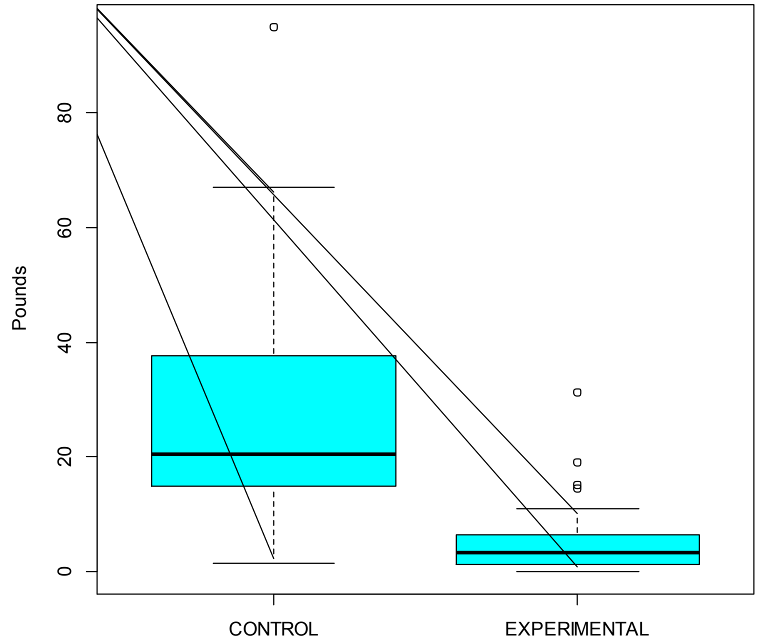
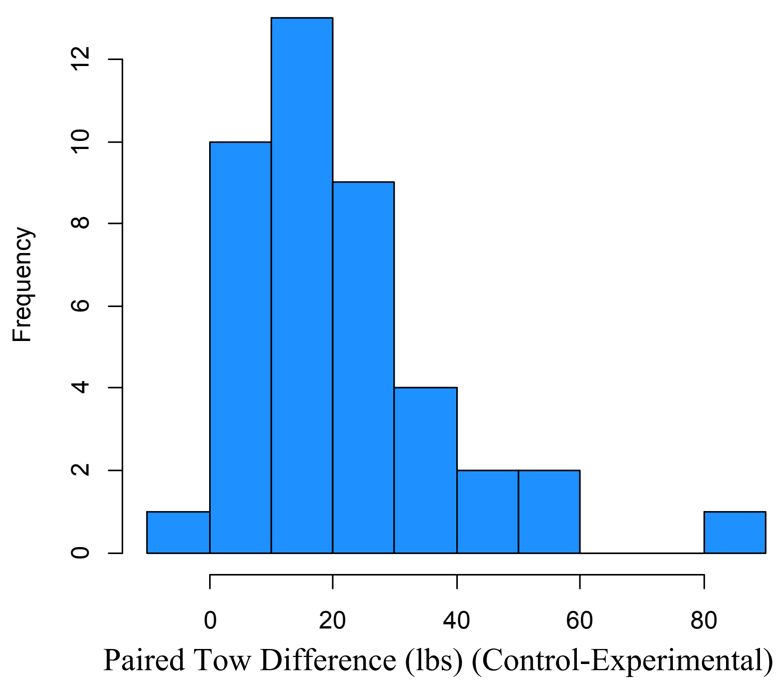
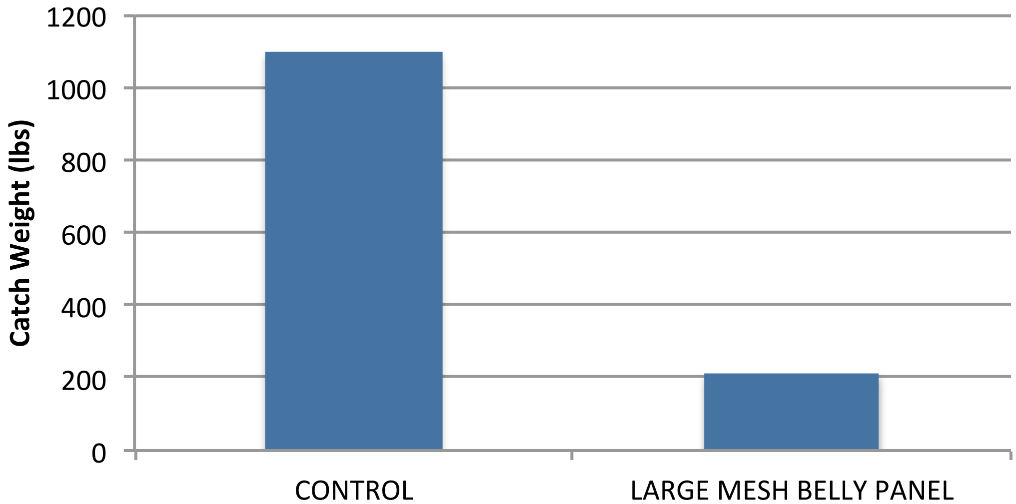


Figure 3. Distribution of Paired Tow Differences for Yellowtail Flounder



In Figure 4 below, the total weight of yellowtail flounder caught by the experimental net and by the control net for all research tows combined are compared.

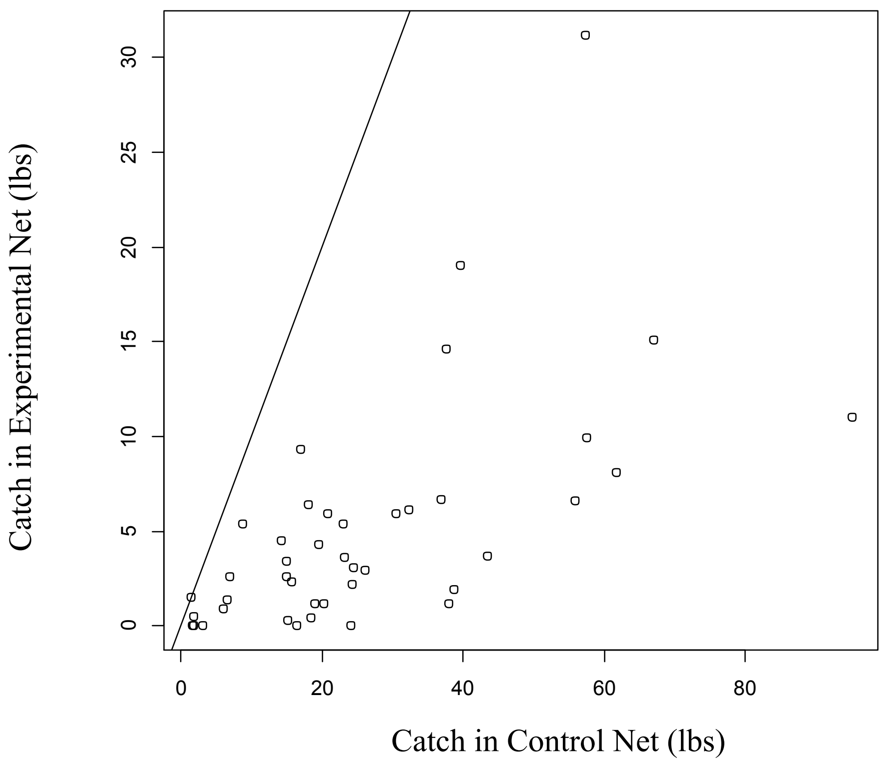
Figure 4. Total Catch Weight of Yellowtail Flounder (lbs) in the Experimental and Control Net for All Trips Combined



The overall reduction in yellowtail flounder catch due to the large mesh belly panel treatment was 80.67% compared to the control net.

Figure 5 below shows the catches of yellowtail flounder in the control net vs. experimental net. This figure clearly shows the relationship and the differences between the pairs of tows.

Figure 5. Catches of Yellowtail Flounder in the Control Vs. Experimental Net



Windowpane Flounder

Next we looked at the difference in windowpane flounder catch between the control net and the experimental net with the large mesh belly panel (Figures 6 and 7). For windowpane flounder, the t- test results showed a significant difference in the catch weight between the control and experimental net (t = 3.2584, df = 41, **p-value = 0.002255,** mean of x =1.514286). The experimental net caught significantly less windowpane flounder. The Wilcoxon test yielded similar results.

Figure 6. Boxplot Distribution of Windowpane Flounder Catch Weight in the Control and Experimental Net

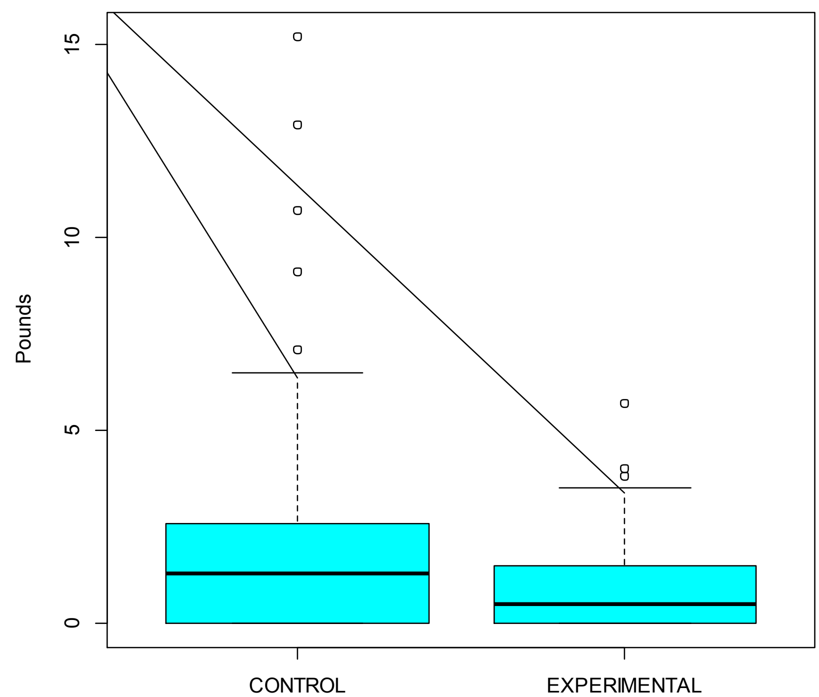
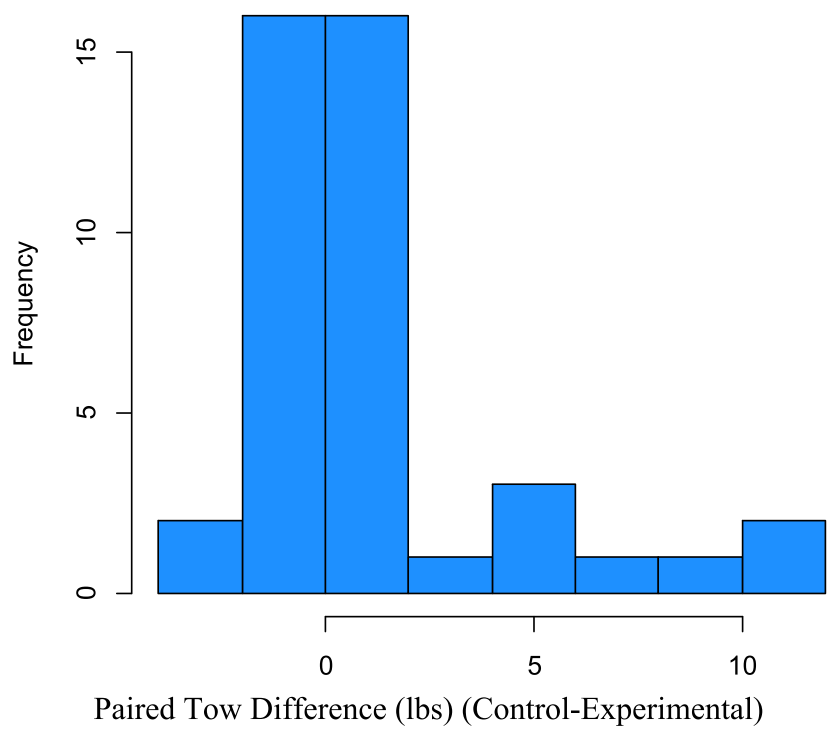
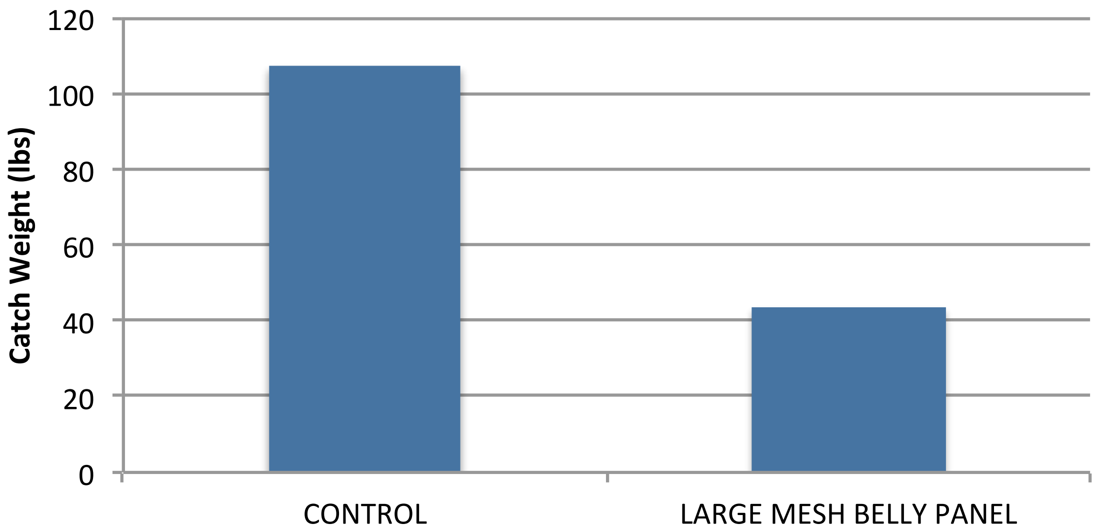


Figure 7. Distribution of Paired Tow Differences for Windowpane Flounder



In Figure 8 below, the total weight of windowpane flounder caught by the experimental net and by the control net for all research tows combined are compared.

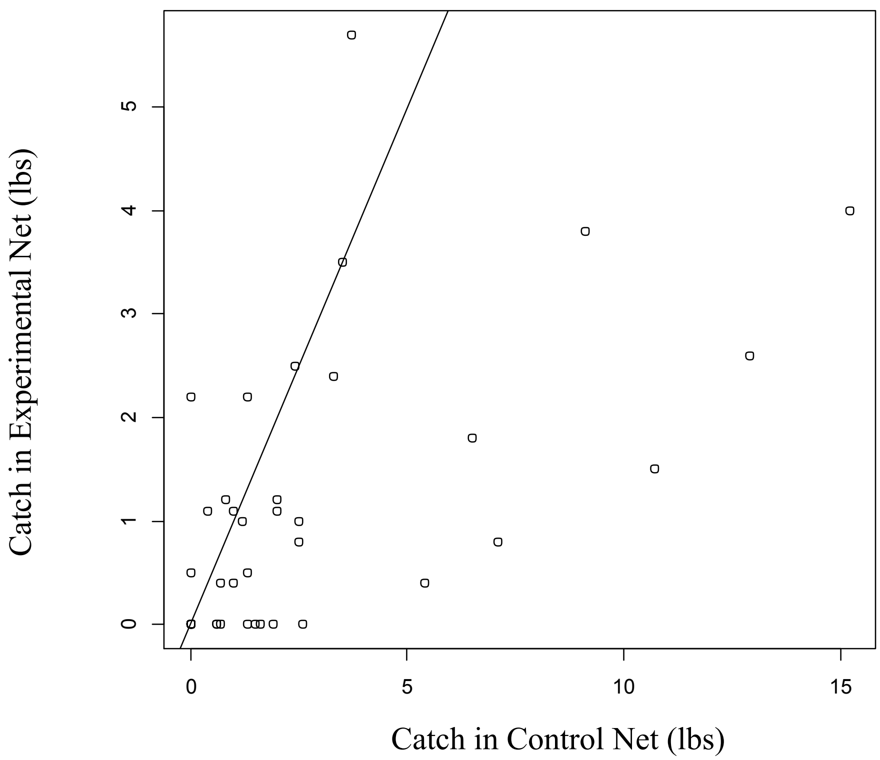
Figure 8. Total Catch Weight of Windowpane Flounder (lbs) in the Experimental and Control Nets for All Trips Combined



The overall reduction in windowpane flounder catch due to the large mesh belly panel treatment was 59.27% compared to the control net.

Figure 9 below shows the catches of windowpane flounder in the control net vs. experimental net. This figure clearly shows the relationship and the differences between the pairs of tows.

Figure 9. Catches of Windowpane Flounder in the Control Vs. Experimental Net



<u>Whiting</u>

Next, the data was analyzed to determine if a significant statistical difference exists in the catch of whiting between the control and experimental nets (Figures 10 and 11). For whiting, t- test results showed no significant difference in the catch weight between the control and experimental net (t = 1.3684, df = 41, **p-value = 0.1787**, mean of x = 155.2476). The experimental net did not affect retention of whiting compared to the control net according to the t-test. The Wilcoxon test however did return a significant result (**p=0.008652**). In order to resolve the difference between the two tests we also ran a non-parametric bootstrap analysis which returned a non-significant result (**p-value = 0.1424**). We consider the large mesh belly panel to not significantly affect the catch of whiting.

Figure 10. Boxplot Distribution of Whiting Catch Weight in the Control and Experimental Net

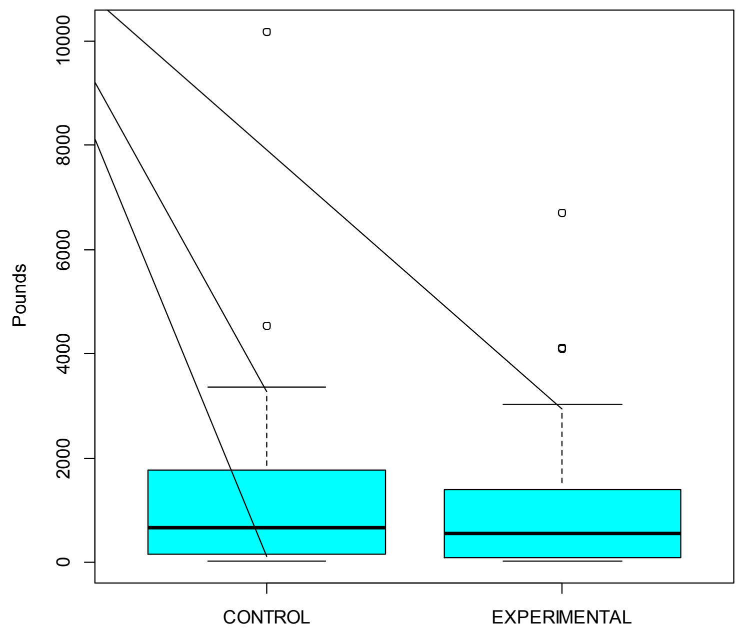
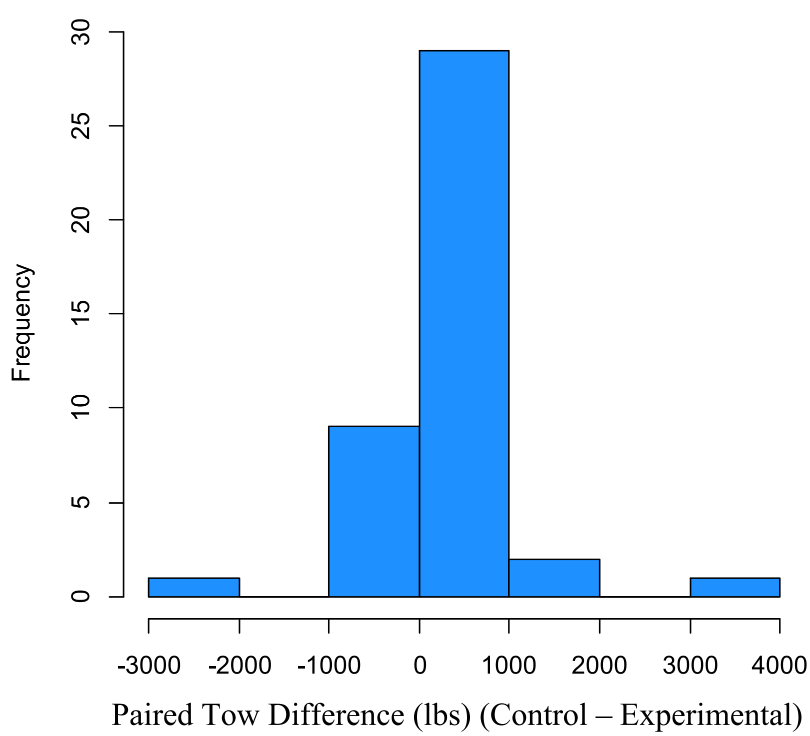
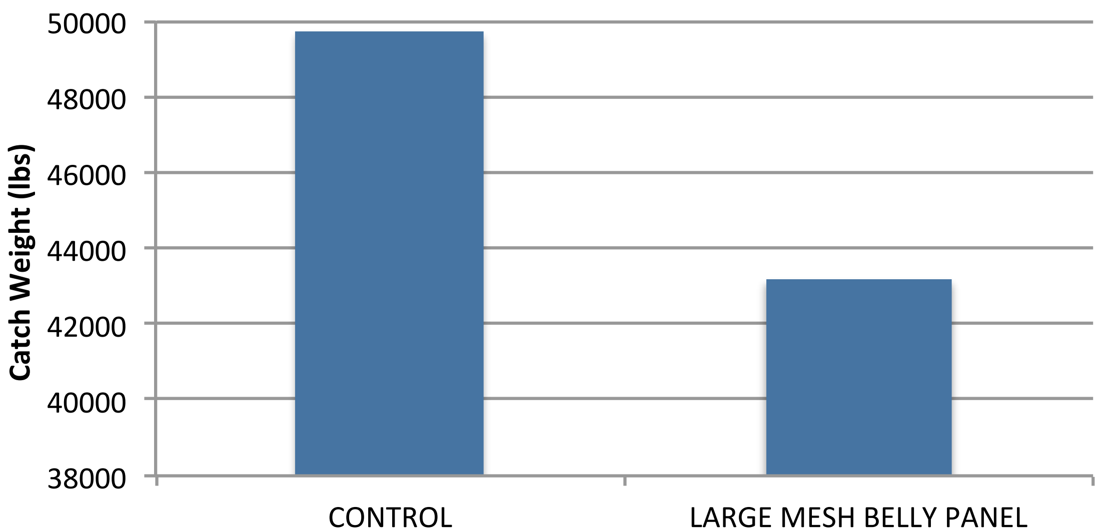


Figure 11. Distribution of Paired Tow Differences for Whiting



In Figure 12 below, the total weight of whiting caught by the experimental net and by the control net for all research tows combined are compared.

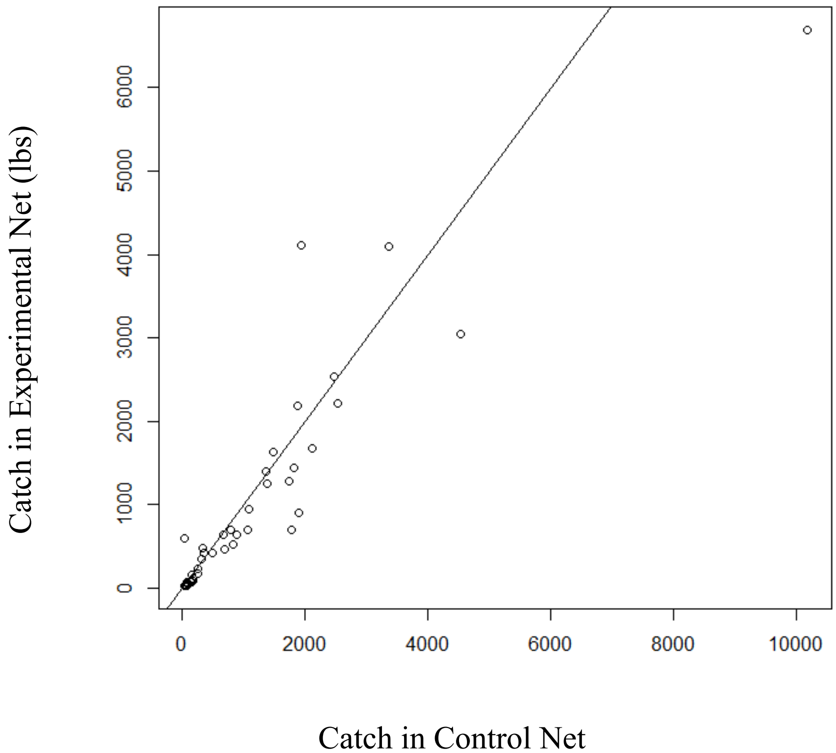
Figure 12. Total Catch Weight of Whiting (lbs) in the Experimental and Control Nets for All Trips Combined



There was no significant reduction in whiting catch due to the large mesh belly panel treatment compared to the control net.

Figure 13 below shows the catches of whiting in the control net vs. experimental net. This figure clearly shows the relationship and the differences between the pairs of tows.

Figure 13. Catches of Whiting in the Control Vs. Experimental Net



Squid

Next, the data was analyzed to determine if a significant statistical difference exists in the catch of squid between the control and experimental nets (Figures 14 and 15). For squid, t- test results showed no significant difference in the catch weight between the control and experimental net (t = -1.5294, df = 41, **p-value = 0.1339**, mean of x = -0.08095238). The Wilcoxon test yielded similar results (p=0.1624). The bootstrap analysis also yielded results similar to the t-test and Wilcoxon test (p=0.196).

Figure 14. Boxplot Distribution of Squid Catch Weight in the Control and Experimental Net

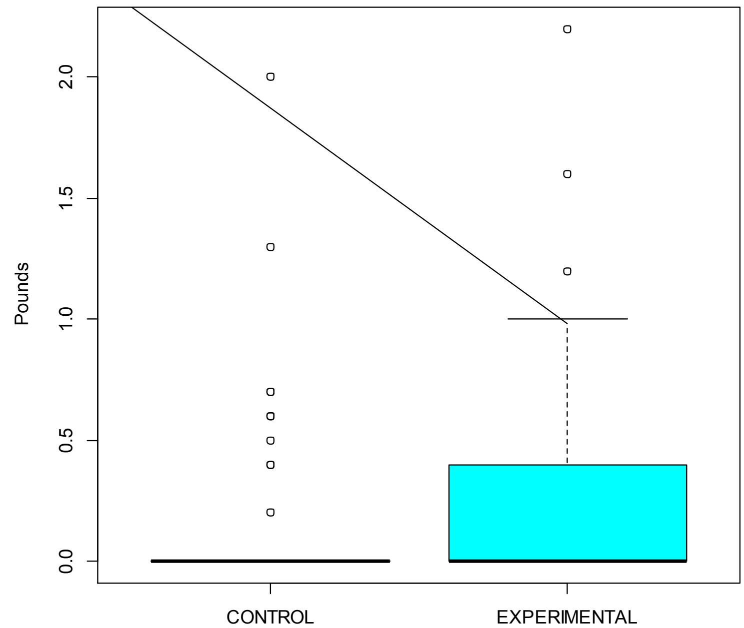
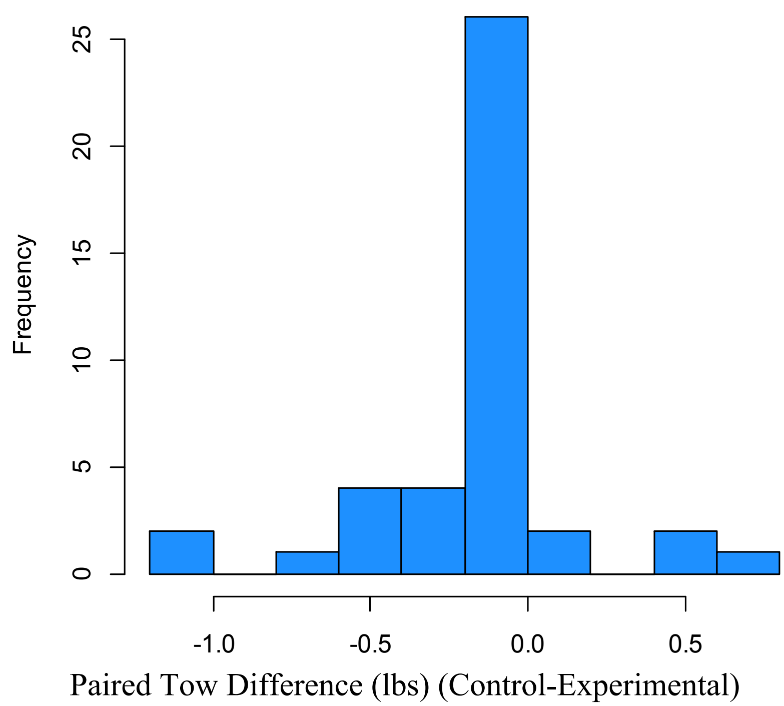
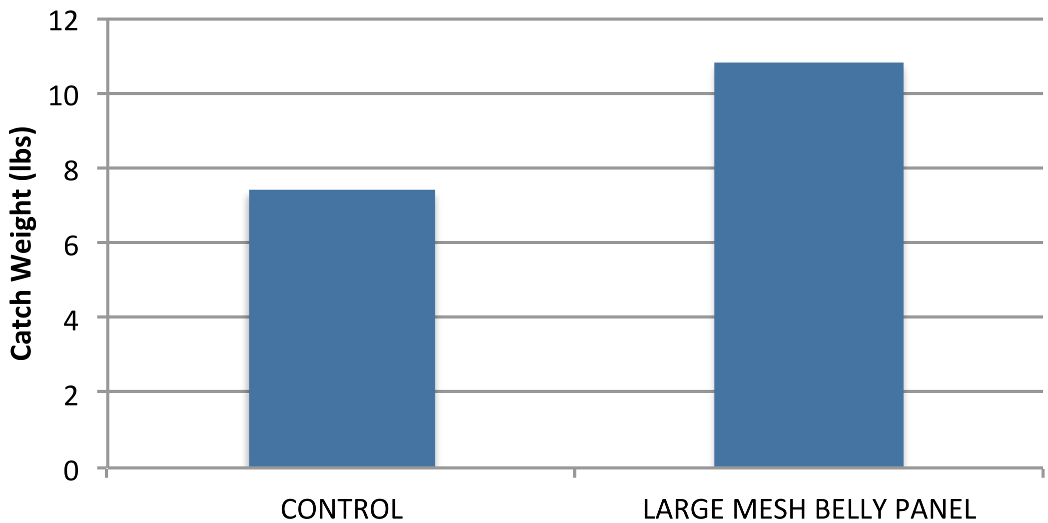


Figure 15. Distribution of Paired Tow Differences for Squid



In Figure 16 below, the total weight of squid caught by the experimental net and by the control net for all research tows combined are compared.

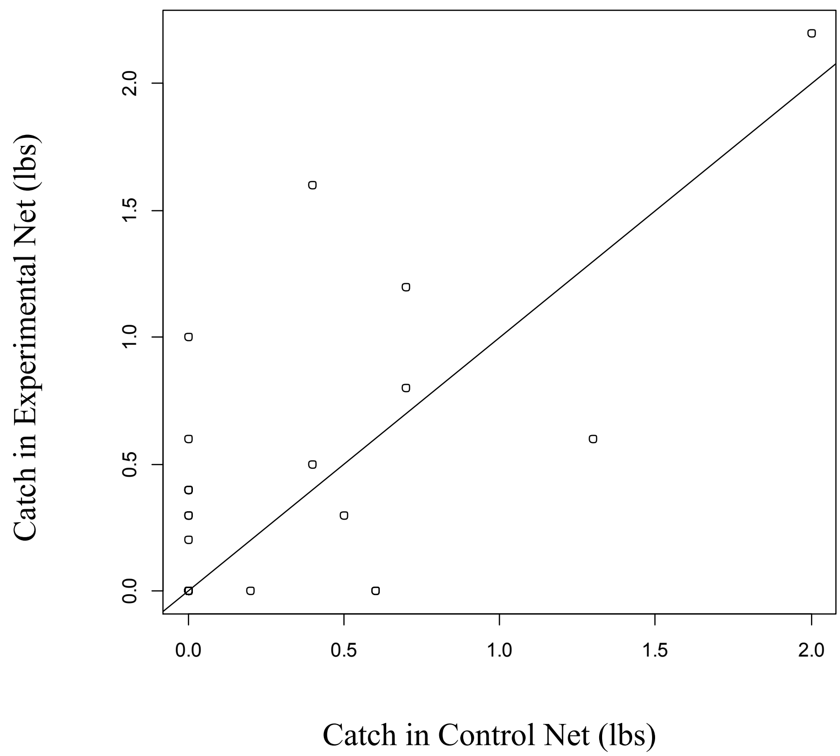
Figure 16. Total Catch Weight of Squid (lbs) in the Experimental and Control Nets for All Trips Combined



Compared to the control net, the experimental net with large mesh belly panel does not significantly affect squid catch. It is important to note that squid catches were extrememly low and often zero for most tows. The maximum weight of squid caught per tow was 2.7 lbs.

Figure 17 below shows the catches of squid in the control net vs. experimental net. This figure clearly shows the relationship and the differences between the pairs of tows.

Figure 17. Catches of Squid in the Control Vs. Experimental Net



Catch Summary

In summary, statistical analysis indicates that there was a significant difference in catch of both yellowtail flounder and windowpane flounder in the control net compared to the experimental net with the large mesh belly panel. The experimental net reduced the quantity of yellowtail and windowpane flounder bycatch. The overall reduction in yellowtail flounder catch due to the large mesh belly panel treatment was 80.7% compared to the control net. The overall reduction in windowpane flounder catch due to the large mesh belly panel treatment was 59.3% compared to the control net. There was no significant difference in whiting or squid catch between the control and the experimental nets. The large mesh belly panel did not affect retention of these target species.

The catches of the target species we encountered were extremely variable for commercial catches. Whiting catches ranges from 19 lbs to over 10,000 lbs. Squid catches were extremely low, reaching a maximum of 2.7 lbs during one tow, and were often zero. This density level of fish is the situation that we experienced during the study. Unfortunately, as is the case in many species interaction studies, it was difficult to find commercial quantities of both target and bycatch species at the same time in the same area. We opted to concentrate on larger size catches of yellowtail and windowpane flounder at the expense of whiting and squid catch, as estimating the bycatch reduction of these species was the focus of this study. The sample size (number of paired tows) proved sufficient to detect a catch differences between the two nets for the four species we examined.

Length Frequency

Data analysis of yellowtail flounder, windowpane flounder, whiting and squid lengths was also performed to look for differences in length selectivity between the nets. The mean lengths for each tow and net were calculated for these four species. The paired differences in mean length were then compared in the control and experimental nets. Mean lengths are shown in Table 1.

Table 1. Mean Lengths (cm) of Four Species in the Control and Experimental Nets

	CONTROL	EXPERIMENTAL
Yellowtail Flounder	29.61	30.83
Windowpane Flounder	24.74	26.34
Whiting	27.15	27.11
Squid	16.41	16.78

Next we conducted a series of t-tests. The t- test was performed for each species to look for significant differences in length by treatment. Results are shown in Table 2 and are described below.

Table 2. T-Test Results for Length Frequency Difference Between Nets

	p-value
Yellowtail Flounder	<0.0001 Significant
Windowpane Flounder	0.000223 Significant
Whiting	0.6041 Not Significant
Squid	0.621 Not Significant

According to Table 2, there were significant differences in the lengths of yellowtail and windowpane flounder in the control net compared to the experimental net. The length frequency distributions of whiting and squid were not significantly affected by the use of the large mesh belly panel.

The effect of the large mesh belly panel on the lengths of each species is further examined below.

Yellowtail

Figure 18 compares the mean lengths of yellowtail flounder between the two nets.

Figure 18. Boxplot of Mean Lengths of Yellowtail Flounder in the Control and Experimental Nets

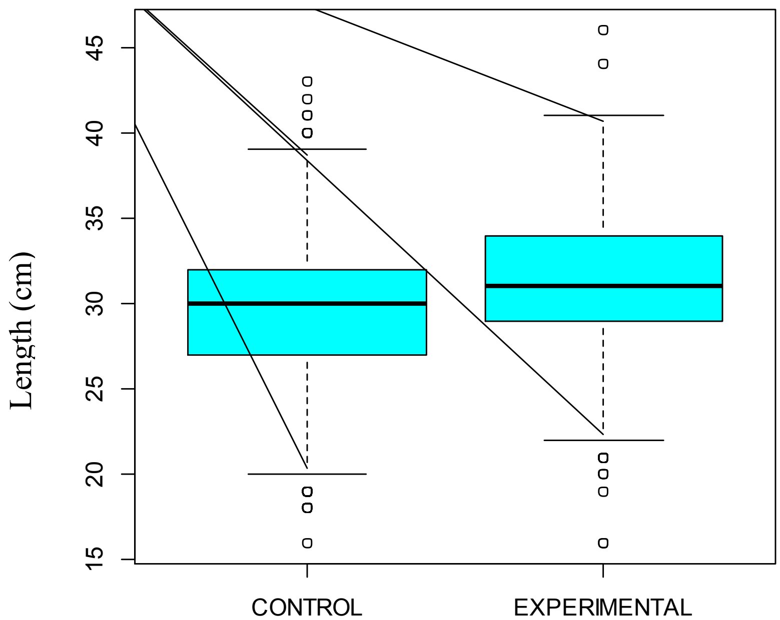
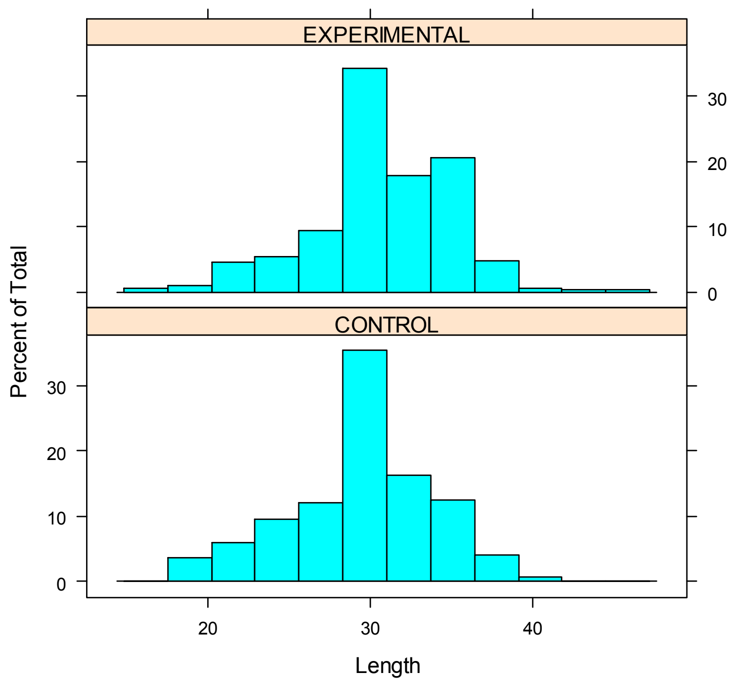


Figure 19 below compares the length frequency distribution for yellowtail flounder between the two nets.

Figure 19. Yellowtail Flounder Lengths as a Percent of the Total in the Control and Experimental Nets



T-test results showed that yellowtail flounder were significantly larger in the experimental net (p=<0.0001). The mean length of yellowtail flounder in the experimental net was 1.21 cm larger than the mean length in the control net. The mean length of yellowtail flounder in the control net was 29.61 cm. The mean length of yellowtail flounder in the experimental net was 30.83 cm. Although the difference is statistically significant, the result may not be biologically significant.

Windowpane

Figure 20 below compares the mean lengths of windowpane flounder between the two nets.

Figure 20. Boxplot of Mean Lengths of Windowpane Flounder in the Control and Experimental Nets

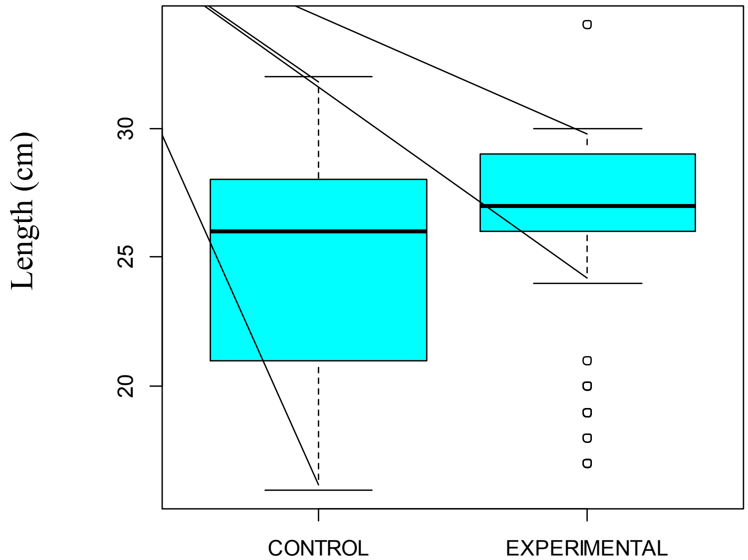
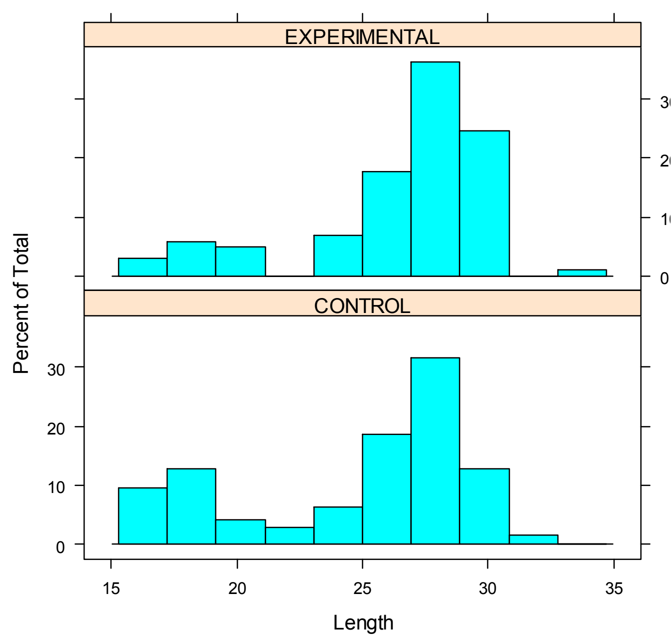


Figure 21 below compares the length frequency distribution for windowpane flounder between the two nets.

Figure 21. Windowpane Flounder Lengths as a Percent of the Total in the Control and Experimental Nets



T-test results show that there is a statistically significant size difference in the mean length of windowpane flounder between the control and experimental nets (p=0.000223). The mean length of windowpane flounder in the control net was 24.74 cm. The mean length of windowpane flounder in the experimental net was 26.34 cm. This is a difference of 1.60 cm. Although the difference is statistically significant, the result may not be biologically significant.

Whiting

Figure 22 below compares the mean lengths of whiting between the two nets.

Figure 22. Boxplot of Mean Lengths of Whiting in the Control and Experimental Nets

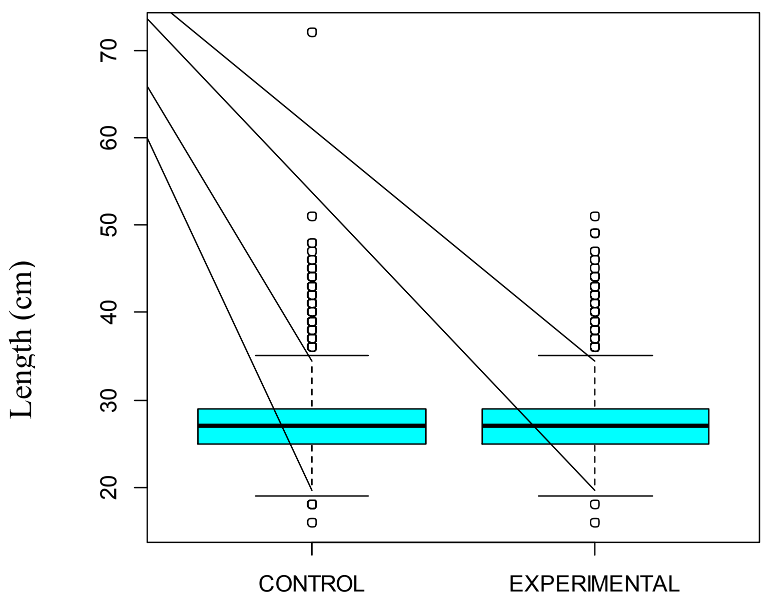
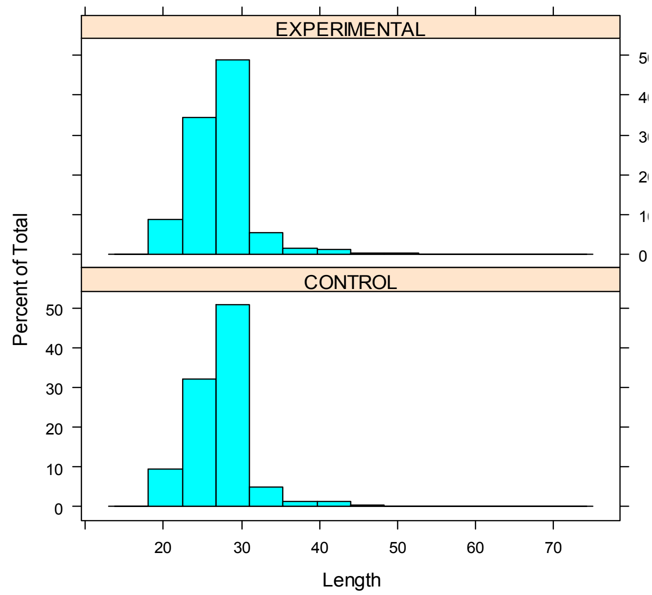


Figure 23 below compares the length frequency distribution for whiting between the two nets.

Figure 23. Whiting Lengths as a Percent of the Total in the Control and Experimental Nets



T-test results show no significant size difference in whiting between experimental and control nets (p=0.6041). The difference in mean length of whiting in the control net compared to the experimental net was 0.04 cm.

Squid

Figure 24 below compares the mean lengths of squid between the two nets.

Figure 24. Boxplot of Mean Lengths of Squid in the Control and Experimental Nets

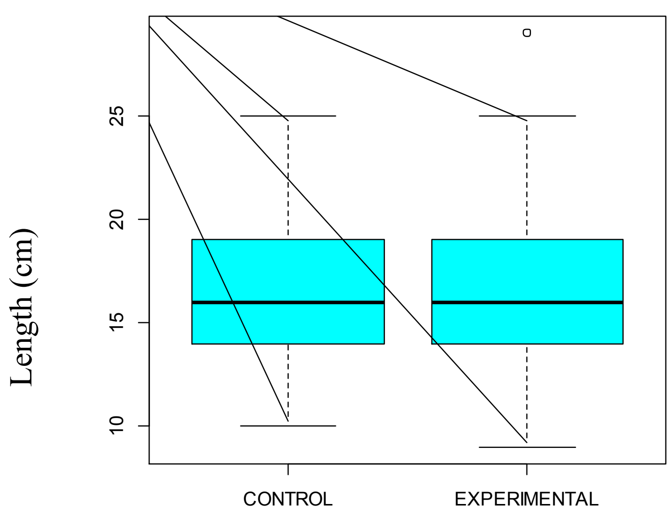
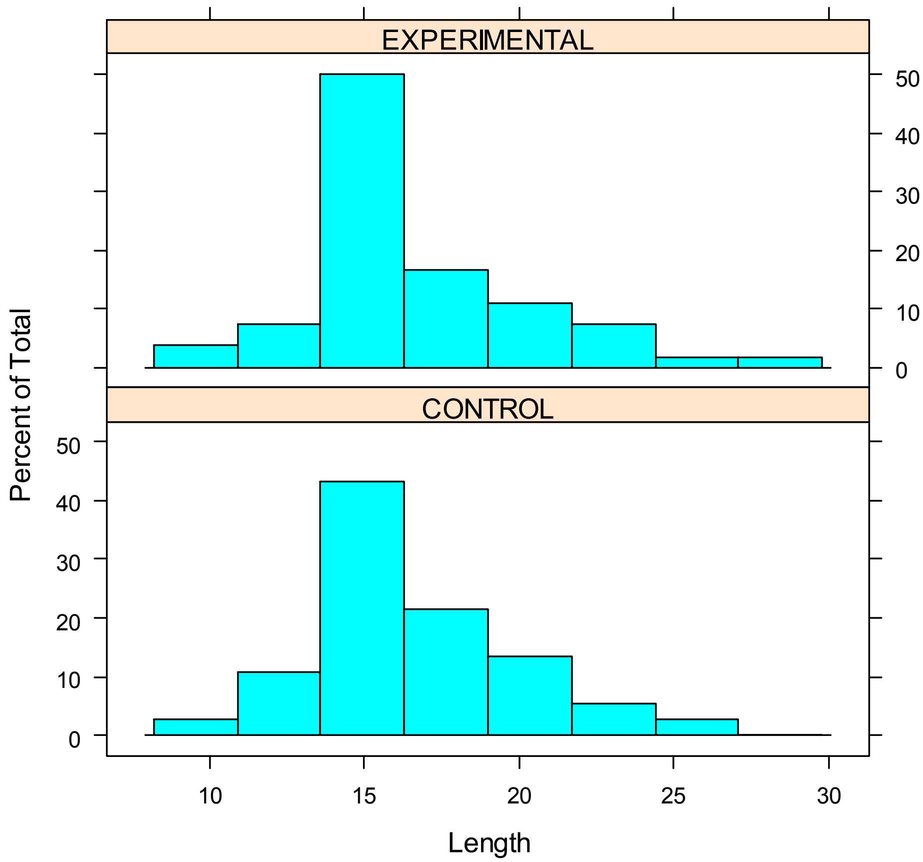


Figure 25 compares the length frequency distribution for squid between the two nets.

Figure 25. Squid Length Frequency Distribution as a Percent of the Total in the Control and Experimental Nets



T-test results showed no significant size difference in squid between experimental and control nets (p=0.621). The mean length of squid in the experimental net was 0.37cm larger than in the control net.

Length Frequency Summary

For yellowtail and windowpane flounder, the size differences are significant yet they are relatively small. These statistical differences may or may not be biologically significant.
The mean length of yellowtail flounder in the experimental net was 1.21 cm larger than the mean length in the control net. The mean length of windowpane flounder in the experimental net was 1.6 cm larger than the mean length in the control net.

Other Effects

Day Vs. Night

Experimental fishing occurred both day and night. Although the experiment was not designed to specifically test for day/night differences, the data were analyzed to test for differences between day/night catches since escapement through the large mesh belly panel may have been influenced by light. The day and night paired tow differences are analyzed below (Figures 26-29).

Figure 26. Paired Tow Differences for Yellowtail Flounder Catch During Day Tows

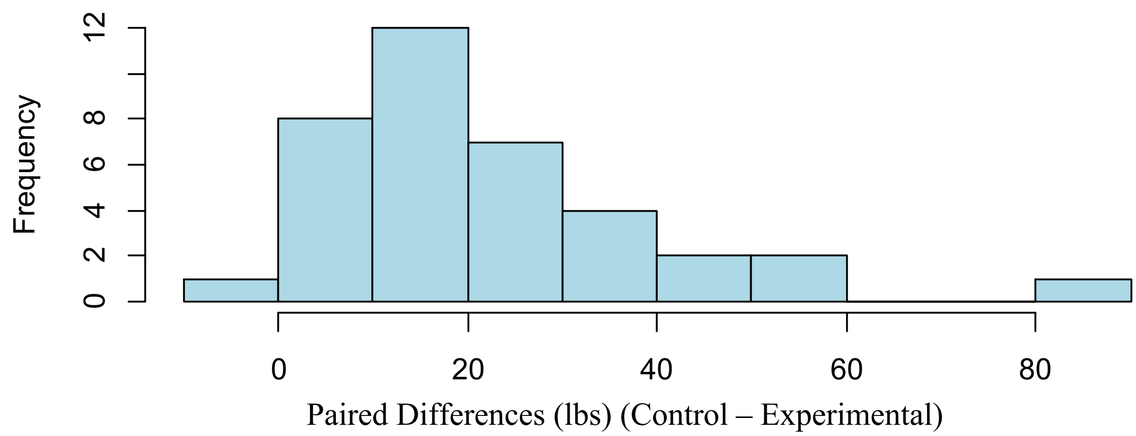
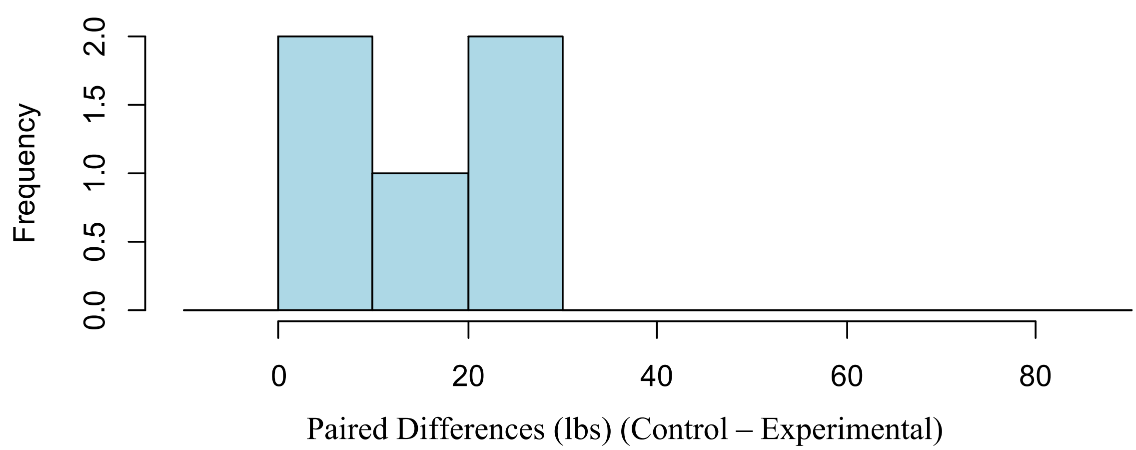


Figure 27. Paired Tow Differences for Yellowtail Flounder Catch During Night Tows



For yellowtail flounder, t- test results showed a significant difference in the catch weight between the control and experimental net during day tows ($t = 7.4864$, $df = 36$, **p-value <0.0001**, mean of x = 22.11622) and a significant difference during night tows ($t = 3.4042$, $df = 4$, **p-**

value = 0.02717, mean of x = 13.54). Non-parametric bootstrap analysis provided similar results.

Figure 28. Paired Tow Differences for Windowpane Flounder Catch During Day Tows

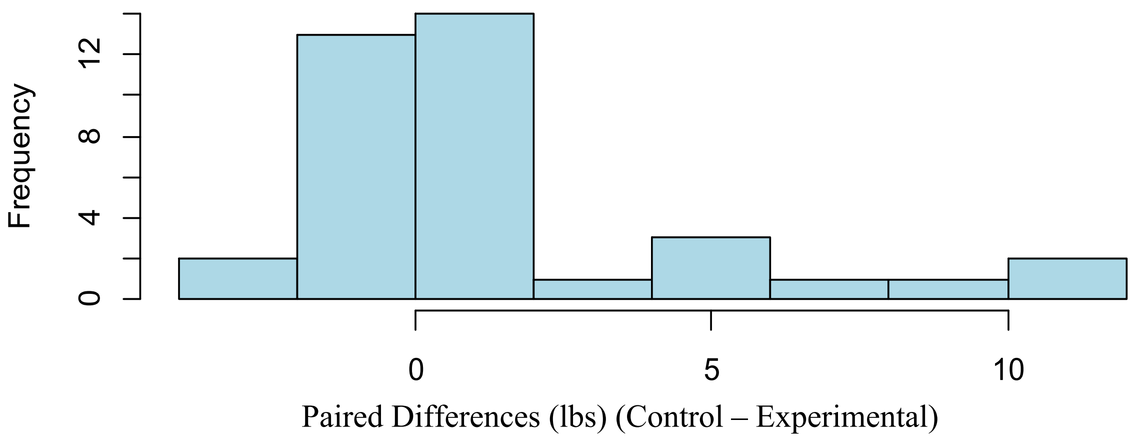
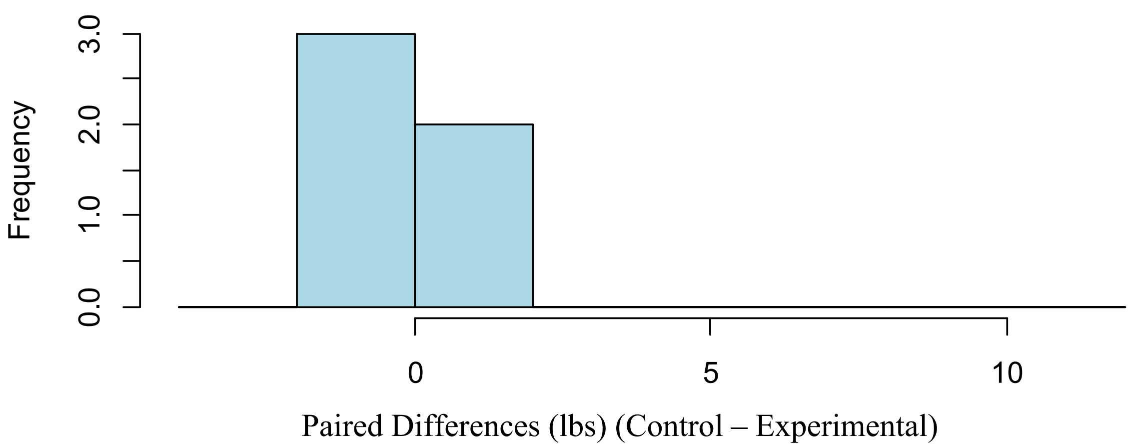


Figure 29. Paired Tow Differences for Windowpane Flounder Catch During Night Tows



For windowpane flounder, t- test results showed a significant difference in the catch weight between the control and experimental net during day tows (t = 3.1439, df = 36, **p-value =0.0033**, mean of x = 1.643243). There was no significant difference in the catch weight between the control and experimental net during the night tows (t = 1.483, df = 4, **p-value = 0.2122**, mean of x = 0.56). Non-parametric bootstrap analysis provided similar results.

Day/Night Summary

In summary, there was a statistically significant difference in the mean catches between the control and experimental nets during the day for both windowpane and yellowtail flounder and during the night for yellowtail flounder only. There was no significant difference for windowpane flounder at night. However, we need to take precaution in interpreting the statistical results for night tows particularly for windowpane flounder. As was stated above, the experiment was not designed to test for day/night differences. For this experiment, we had a total of only 5 tows that occurred at night. For yellowtail flounder all 5 tows caught yellowtail flounder. For windowpane flounder only 2 of the night tows caught windowpane flounder. Nighttime results on their own are therefore lacking statistical strength. As was suggested by the peer review, day/night results lack statistical strength and should not be included in the report. However, we are reporting these results to comply with the request of the Research Steering Committee.

Side (Port Vs. Starboard)

We looked at yellowtail and windowpane flounder catches on each side of the vessel separately to see if the results were different based on which side of the vessel the control or experimental net was fished on (Figures 30-33). We performed this test to explore if there might be a difference in catchability depending on which side of the boat the net was towed on. Since the experimental and control nets were switched twice during the experiment in order to randomize for side, we did not expect there to be a side effect. We performed t-tests and non-parametric bootstrap analysis on the paired tow differences in catch for side.

Figure 30. Paired Tow Differences for Yellowtail Flounder Catch With the Control Net on the Port Side

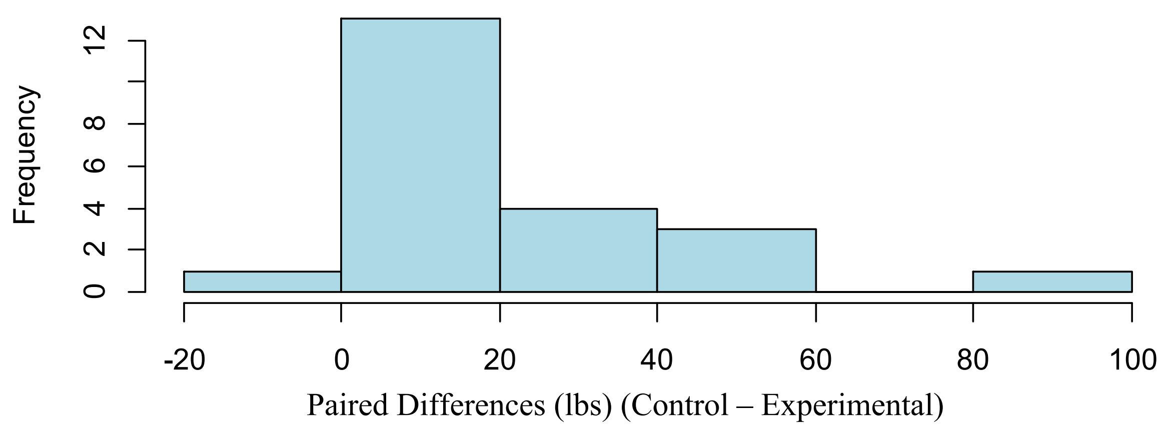
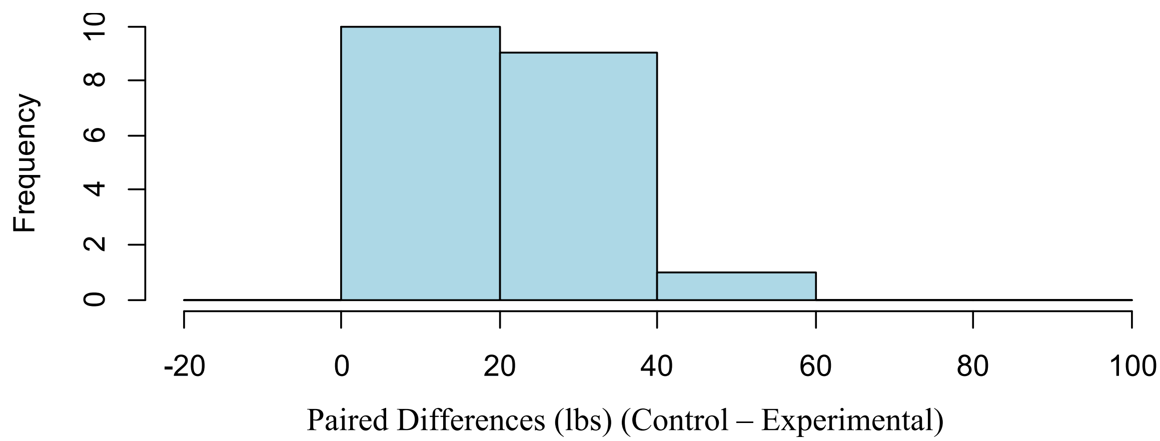


Figure 31. Paired Tow Differences for Yellowtail Flounder Catch With the Control Net on the Starboard Side



For yellowtail flounder, t- test results showed a significant difference in the catch weight between the control and experimental nets when the control net was on the port side (t = 4.2392, df = 21, **p-value =0.00036**, mean of x = 19.959) and a significant difference when the control net was on the starboard side (t = 9.8288, df = 19, **p-value <0.0001**, mean of x = 22.345). Non-parametric bootstrap analysis provided similar results.

Figure 32. Paired Tow Differences for Windowpane Flounder Catch With the Control Net on the Port Side

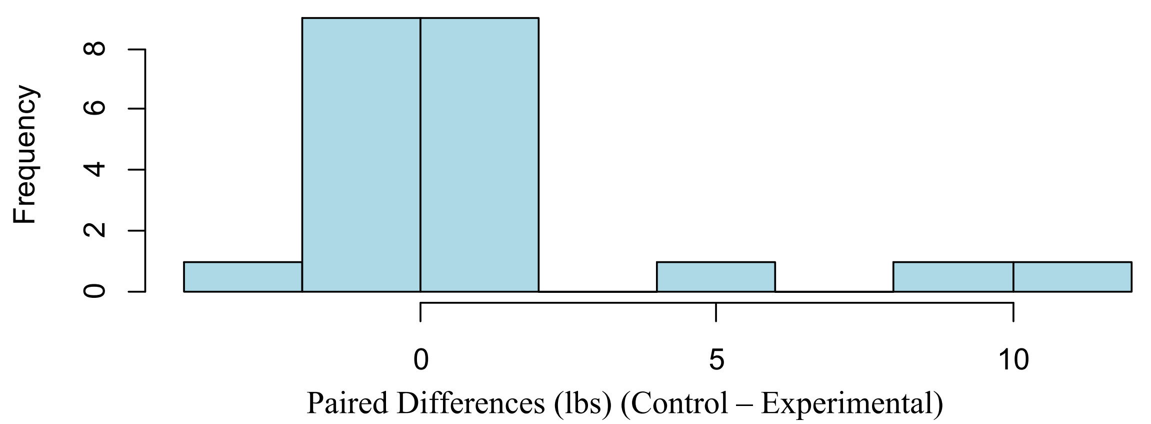
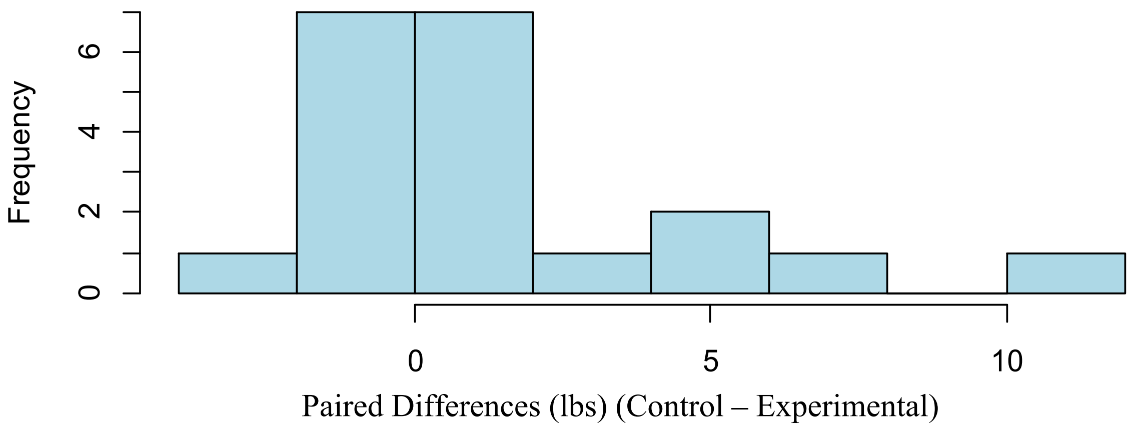


Figure 33. Paired Tow Differences for Windowpane Flounder Catch With the Control Net on the Starboard Side



For windowpane flounder, t-test results showed a nearly significant difference in the catch weights between the control and experimental nets when the control net was on the port side (t = 1.9796, df = 21, **p-value =0.061**, mean of x = 1.340909). However, bootstrap analysis of the same data yielded a significant result **(p-value = 0.012**). We ran a Shapiro-Wilk test for normality (W=0.6805, p-value <0.0001) which indicated that the data is not Gaussian. Therefore, the bootstrap is the more appropriate test and the catch difference is significant. There was a significant difference in the catch weights between the control and experimental nets when the control net was on the starboard side (t = 2.6396, df = 19, **p-value =0.01616**, mean of x = 1.705). Non-parametric bootstrap analysis provided similar results. Therefore there was a significant difference in the catch weights of windowpane flounder between the control and experimental nets regardless of which side of boat the net was on.

<u>Side Summary</u>

For both yellowtail and windowpane flounder the difference in catch between the control and experimental nets is significantly different regardless of which side of the boat the nets are on. There is no side effect.

<u>Door Spread</u>

We tested for door spread to see if there was a statistically significant difference in door spread between the control and experimental nets. First we tested for differences in door spread at the start of each tow. T-test results showed no significant difference in door spread at the start of the tow (**p-value = 0.07014**). Next we tested for differences in door spread at the end of each tow. There was no significant difference in door spread at the end of the tow (**p-value = 0.0897**).

Door Spread Summary

For most tows, the door spread was the same for both the control and experimental nets. The majority of tows had a door spread of 31 fathoms (See Table 3). In the few instances where there was a difference, the difference was generally only 1 fathom. Since there appears to be no statistically significant difference in door spread for the two nets, catch as a function of door spread was not analyzed.

DISCUSSION

The main focus of this project was to examine the differences in yellowtail flounder and windowpane flounder catches in the experimental net with the large mesh belly panel and the control net. We also examined the catch differences in target species (squid and whiting) between the two nets. Paired t-test results showed a significant difference in catch weights for yellowtail flounder and for windowpane flounder. The large mesh belly panel significantly reduced the bycatch of both flounder species. There was an 80.67% reduction in yellowtail flounder catch and 59.27% reduction in windowpane flounder catch in the net with the large mesh belly panel compared to the control net. T-test results showed a non-significant result for the catch difference of whiting and of squid in the net with the large mesh belly panel compared to the control net. Since the experimental net did not cause significant reduction in the catch of the target species of whiting and squid but did significantly reduce bycatch of yellowtail flounder and windowpane flounder, the large mesh belly panel shows promise as a possible certified bycatch avoidance net. The results of this study show that the large mesh belly panel should be forwarded to the NEFMC for further consideration in management as an additional gear type in the small mesh fishery to reduce yellowtail and windowpane flounder bycatch.

As more members of industry adopt this modification to their current trawl gear it will improve current fishing practices, therefore, providing a reduction in bycatch and bycatch mortality which will allow the stocks of yellowtail and windowpane flounder to rebuild at a faster rate.

SUMMARY OF CONCLUSIONS

- The large mesh belly panel was shown to be effective in reducing the quantity of yellowtail flounder bycatch. We estimated the bycatch reduction for yellowtail flounder to be 80.67% and the reduction in windowpane flounder bycatch to be 59.27%.
- There was no significant difference in whiting catch between the control net and the net modified with the large mesh belly panel. Retention of this target species was maintained using the experimental net.
- There was no significant difference in squid catch between the control net and the net modified with the large mesh belly panel, although catch sizes were small.
- Possible additional effects of day/night, side and door spread do not appear to have an effect on the above results.

Table 3. Tow and Catch Data for Four Key Species

TRIP NUMBER	TOW NUMBER	TOW DATE	TOW START TIME	TOW END TIME	DAY (D)/NIGHT (N)	CONTROL NET: SIDE - PORT (P) OR STARBOARD (S)	CONTROL NET: DOOR SPREAD @ TOW START (FA)	CONTROL NET: DOOR SPREAD @ TOW END (FA)	CONTROL NET: YELLOWTAIL (LBS)	CONTROL NET: WINDOWPANE (LBS)	CONTROL NET: LONGFIN SQUID (LBS)	CONTROL NET: WHITING (LBS)	EXPERIMENTAL NET: SIDE - PORT (P) OR STARBOARD (S)	EXPERIMENTAL NET: DOOR SPREAD @ TOW START (FA)	EXPERIMENTAL NET: DOOR SPREAD @ TOW END (FA)	EXPERIMENTAL NET: YELLOWTAIL (LBS)	EXPERIMENTAL NET: WINDOWPANE (LBS)	EXPERIMENTAL NET: LONGFIN SQUID (LBS)	EXPERIMENTAL NET: WHITING (LBS)	CATCH DIFFERENCES (CONT-EXP: YELLOWTAIL (LBS)	CATCH DIFFERENCES (CONT-EXP: WINDOWPANE (LBS)	CATCH DIFFERENCES (CONT-EXP: LONGFIN SQUID (LBS)	CATCH DIFFERENCES (CONT-EXP: WHITING (LBS)
2	1	08/19/14	2:30	3:00	N	P	31	32	1.7	0	0	1878.1	S	31	32	0	0	0	2189.8	1.7	0	0	-311.
2	2	08/19/14	5:00	5:30	N	P	31	31	39.6	3.3	0	3353	S	31	32	19	2.4	0	4094.9	20.6	0.9	0	-741.
2	3	08/19/14	8:38	9:02	D	P	30	31	57.3	1.3	0	1942.3	S	31	32	31.2	2.2	0	4105.3	26.1	-0.9	0	-216
2	4	08/19/14	11:59	12:29	D	P	30	31	1.9	1.5	2	35.5	S	31	31	0	0	2.2	590.6	1.9	1.5	-0.2	-555.
2	5	08/19/14	12:52	13:22	D	P	31	31	18	0	0.7	887.8	S	31	31	6.4	0	1.2	639.7	11.6	0	-0.5	248.
2	6	08/19/14	15:12	15:42	D	P	31	32	7	0	0	2533.8	S	31	32	2.6	0	0.4	2218.2	4.4	0	-0.4	315.
2	7	08/19/14	17:16	17:46	D	P	32	32	1.4	0.7	0	489.6	S	32	32	1.5	0.4	0	422	-0.1	0.3	0	67.
2	8	08/20/14	7:28	7:43	D	S	31	32	30.5	3.7	0	10176.4	P	31	31	5.9	5.7	0	6700.1	24.6	-2	0	3476.
2	9	08/20/14	10:56	11:11	D	S	30	31	18.4	6.5	0.4	2105.7	P	31	32	0.4	1.8	1.6	1665.4	18	4.7	-1.2	440.
2	10	08/20/14	12:40	12:55	D	S	31	31	55.8	1	0	1820.2	P	31	31	6.6	0.4	0	1435.8	49.2	0.6	0	384.
2	11	08/20/14	14:20	14:35	D	S	30	31	14.9	2	0	1474.7	P	31	32	2.6	1.2	0.2	1628.1	12.3	0.8	-0.2	-153.
2	12	08/20/14	15:21	15:36	D	S	31	31	36.9	0.6	0	4523.8	P	32	32	6.7	0	0	3039.2	30.2	0.6	0	1484.
2	13	8/20/14	17:40	17:55	D	S	31	31	20.7	2.4	0.6	1361	P	31	31	5.9	2.5	0	1389.9	14.8	-0.1	0.6	-28.
2	14	8/20/14	18:26	18:41	D	S	31	31	24.4	9.1	0	1387.9	P	31	31	3.1	3.8	0	1243.5	21.3	5.3	0	144.
2	15	8/20/14	19:00	19:16	D	S	32	32	38	2.6	0	2477.1	P	31	31	1.2	0	1	2530.5	36.8	2.6	-1	-53.
2	16	8/20/14	21:01	21:16	N	S	31	31	15.1	0	0	1772.3	P	31	31	0.3	0	0	697.2	14.8	0	0	1075.
2	17	8/21/14	6:21	6:36	D	S	30	30	43.5	0	0.6	1727.5	P	30	30	3.7	0	0	1277.3	39.8	0	0.6	450.
2	18	8/21/14	7:21	7:36	D	S	31	31	15	0	1.3	1085.7	P	31	31	3.4	0	0.6	937.3	11.6	0	0.7	148.
2	19	8/21/14	8:11	8:26	D	S	31	31	20.3	2.5	0.7	819.6	P	31	31	1.2	0.8	0.8	513	19.1	1.7	-0.1	306.
2	20	8/21/14	9:17	9:32	D	S	33	33	14.2	12.9	0	331.7	P	32	32	4.5	2.6	0	481	9.7	10.3	0	-149.
2	21	8/21/14	9:47	10:02	D	S	32	32	23.2	1.3	0.5	244.1	P	32	32	3.6	0.5	0.3	234.8	19.6	0.8	0.2	9.
2	22	8/21/14	10:26	10:41	D	S	32	32	24	2.5	0	156.8	P	32	32	0	1	0.4	90.4	24	1.5	-0.4	66.
2	23	8/21/14	11:33	11:48	D	S	31	31	26	7.1	0	167.1	P	31	31	2.9	0.8	0	111.1	23.1	6.3	0	5
2	24	8/21/14	12:04	12:19	D	S	31	31	32.3	0	0	131.7	P	31	31	6.1	0.5	0	62.3	26.2	-0.5	0	69.
2	25	8/21/14	12:49	13:06	D	S	31	31	15.6	0	0	1887.1	P	32	32	2.3	0	0.6	905.4	13.3	0	-0.6	981.
2	26	8/21/14	13:24	13:39	D	S	31	31	24.2	1	0.4	141.8	P	31	31	2.2	1.1	0.5	70.5	22	-0.1	-0.1	71.
2	27	8/21/14	14:42	14:57	D	S	31	31	16.5	1.6	0.2	51.8	P	31	31	0	0	0	33.2	16.5	1.6	0.2	18.
2	28	8/23/14	7:46	8:01	D	P	30	30	22.9	0	0	302.9	S	31	31	5.4	0	0	341.5	17.5	0	0	-38.
2	29	8/23/14	8:17	8:32	D	P	31	31	8.7	0.7	0	61.8	S	31	31	5.4	0	0	55.1	3.3	0.7	0	6.
2	30	8/23/14	8:49	9:04	D	P	31	31	19	5.4	0	62.9	S	30	30	1.2	0.4	0	62.2	17.8	5	0	0.
2	31	8/23/14	9:22	9:37	D	P	31	31	1.8	15.2	0	30.2	S	31	32	0.5	4	0	30.1	1.3	11.2	0	0.
2	32	8/23/14	10:08	10:23	D	P	31	31	6.6	3.5	0	73.7	S	31	31	1.4	3.5	0.3	25.4	5.2	0	-0.3	48.
2	33	8/23/14	10:58	11:13	D	P	31	31	38.7	1.3	0	158.9	S	31	31	1.9	0	0	155.1	36.8	1.3	0	3.
2	34	8/23/14	11:33	11:48	D	P	31	31	3.1	10.7	0	25.7	S	31	31	0	1.5	0	19.4	3.1	9.2	0	6.
2	35	8/23/14	12:31	12:46	D	P	31	31	6.1	0.6	0	171.2	S	31	31	0.9	0	0	87.2	5.2	0.6	0	8
2	36	8/23/14	13:02	13:17	D	P	31	31	19.5	0	0	47.9	S	31	31	4.3	2.2	0	27.9	15.2	-2.2	0	2
2	37	8/23/14	13:44	13:59	D	P	31	31	57.4	1.2	0	793.6	S	31	31	9.9	1	0	701.1	47.5	0.2	0	92.
2	38	8/23/14	15:44	15:59	D	P	31	31	95	0.4	0	1070.8	S	31	31	11	1.1	0.3	698.5	84	-0.7	-0.3	372.
2	39	8/23/14	16:49	17:05	D	P	30	30	67	2	0	687.1	S	32	32	15.1	1.1	0.4	460.5	51.9	0.9	-0.4	226.
2	40	8/23/14	17:24	17:39	D	P	30	30	61.6	0.8	0	248.6	S	30	30	8.1	1.2	0	169	53.5	-0.4	0	79.
2	41	8/23/14	19:52	20:01	N	P	30	30	37.6	0	0	662	S	31	31	14.6	0	0	636.4	23	0	0	25.
2	42	8/23/14	20:24	20:39	N	P	30	30	16.9	1.9	0	348.8	S	30	30	9.3	0	0	413.9	7.6	1.9	0	-65.

Figure 34. Diagram of the 420 x 16 cm Trawl Net

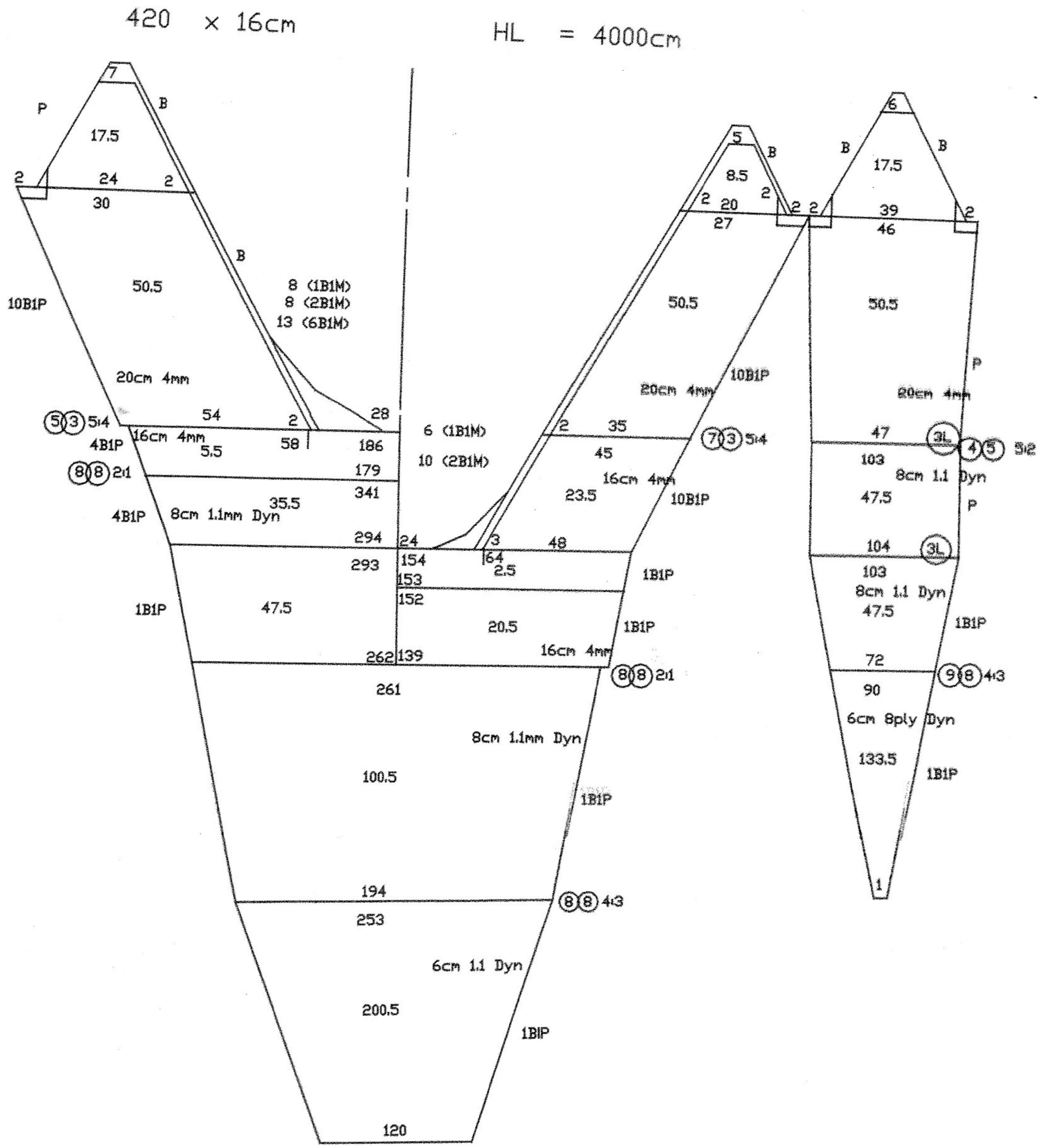
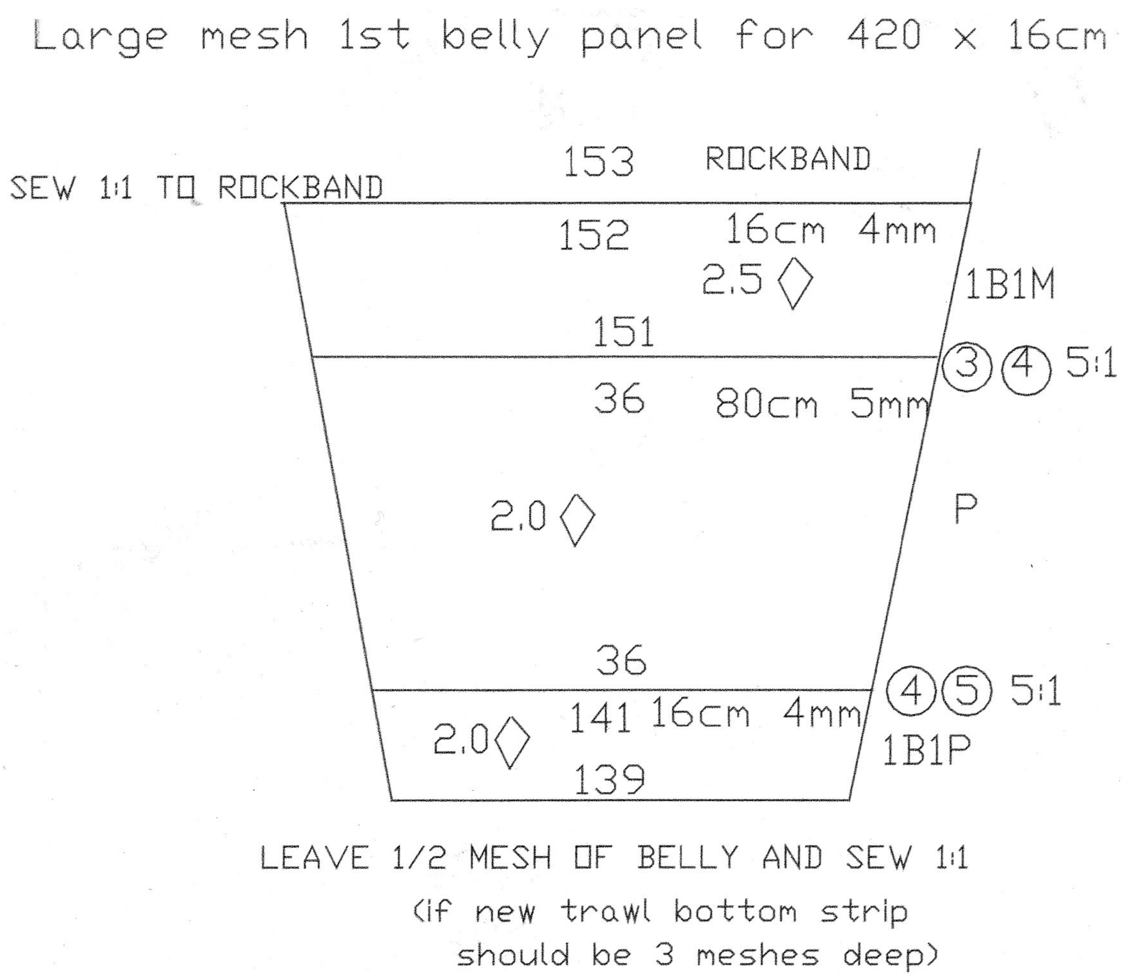


Figure 35. Diagram of Large Mesh Belly Panel



Scaling the Large Mesh Belly Panel to Fit Other Nets

The design and construction of a large mesh belly panel to go into an existing small mesh trawl is based on the premise that the large mesh panel will have the same coverage area as the belly that it is replacing. To that end, the first step is to determine the ratio of the mesh sizes involved. The large mesh belly twine is 80cm KKFM (Knot center to Knot center Full Mesh), 2 meshes deep with a 40cm sowing seam on top and bottom. In most cases the existing 1st bottom belly twine sizes are 12cm KKFM and 16cm KKFM yielding ratios of 20:3 and 5:1, respectively. Therefore, to determine the width of large mesh panel, one takes the number of meshes of the existing belly and divides by the ratio. Some number of one to one meshes can be included on the edges to facilitate the lacing of the bottom panel to the top or sides.

In practice, it is beneficial to leave some number of meshes behind the sweep to facilitate installation and in many cases the second bottom belly is smaller mesh therefore leaving at least a half mesh of the narrow end of the 1st bottom belly facilitates installation. Then it is a matter of using ratio to determine the appropriate depth of the large mesh belly panel.

As an example, the 1st bottom belly of a common 420 x 16cm 4 – seam trawl is 154 meshes on the wide end, 139 meshes on the narrow end and is 23.5 meshes deep of 16cm webbing (a very common depth). The large mesh belly panel consists of 2 meshes deep of 80cm webbing with the sowing seam on either end yield 3 deep of 80cm.

80cm x 3meshes = 240cm
240cm / 16cm = 15 - 16cm meshes

Therefore, if 6 meshes are left behind the sweep and 2.5 meshes are left on the narrow end of the belly, the belly will sow in and be the correct depth.

To determine the width of the large mesh panel, take the width of the belly at 6 meshes behind the sweep, 150, and divide by the ratio, 80:16 (5:1) and you get the width of the large mesh belly, 30.

150 meshes of 16cm / 5 = 30 meshes of 80cm

In practice the large mesh panel is made wider so there can be some one to one meshes on the sides of the panel to facilitate goring to the top or sides. For the 420 x 16cm trawl a 36 mesh wide panel was used.

In terms of enforcement, the first thing is the mesh size. 80cm 6mm webbing has a BKFM (Between the Knot Full Mesh) of 30”. Secondly, the width of the panel is that it should go all the way from one bottom gore to the other bottom gore. And lastly, the depth is 3 - 80cm meshes, but it is easier for enforcement if it was said that the depth was at least 90” of 30” BKFM mesh or greater.

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APPENDIX 1

Review of "Evaluation of the Large Mesh Belly Panel in Small Mesh Fisheries as a Method to Reduce Yellowtail Flounder Bycatch on Cultivator Shoals"

Reviewer Comments and Response to Reviewer's Comments

All editorial suggestions have been incorporated into the final report. The following are our responses to the reviewer's technical comments.

Comment A13

The data analysis appears appropriate except that in some of the comparisons (e.g., squid, day/night) the data are very sparse. A power analysis on the data would help provide the reader an understanding of the ability of the analysis to adequately detect a difference.

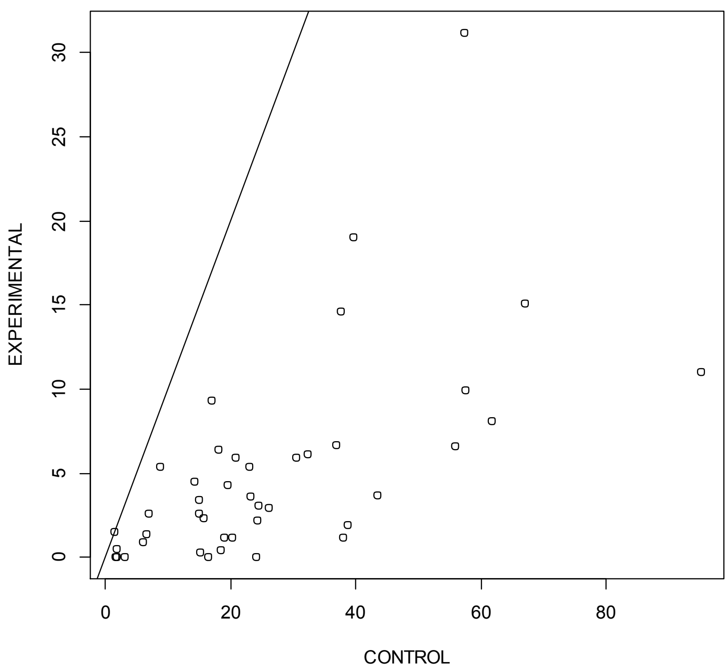
Response: Yes, we are pushing the analysis beyond the limits it was designed for in order to address the continually expanding questions raised in the reviews. For these types of questions an expanded study with more data would be useful. As we have pointed out in the report and at the December 2014 RSC meeting, there are not enough data points at night for any meaningful analysis.

Comment A15

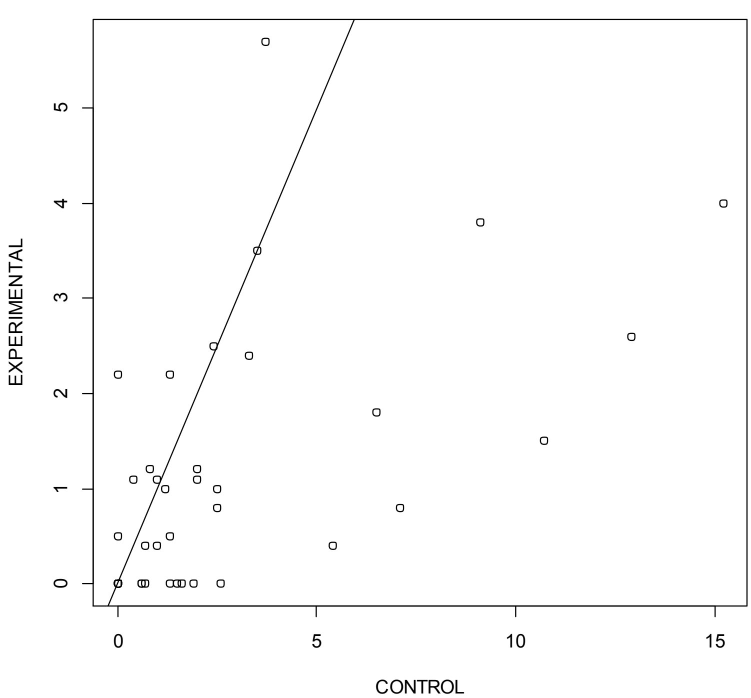
Minor comment: I find it informative to view the catches of the control (Y) versus the experimental (X) for each species. This type of graph clearly shows the relationship and the differences between the pairs of tows.

Response: The hypothesis being tested is the significance of the average paired differences, but I understand how the requested plots can be informative too. The plots are presented below and will be incorporated into the final report.

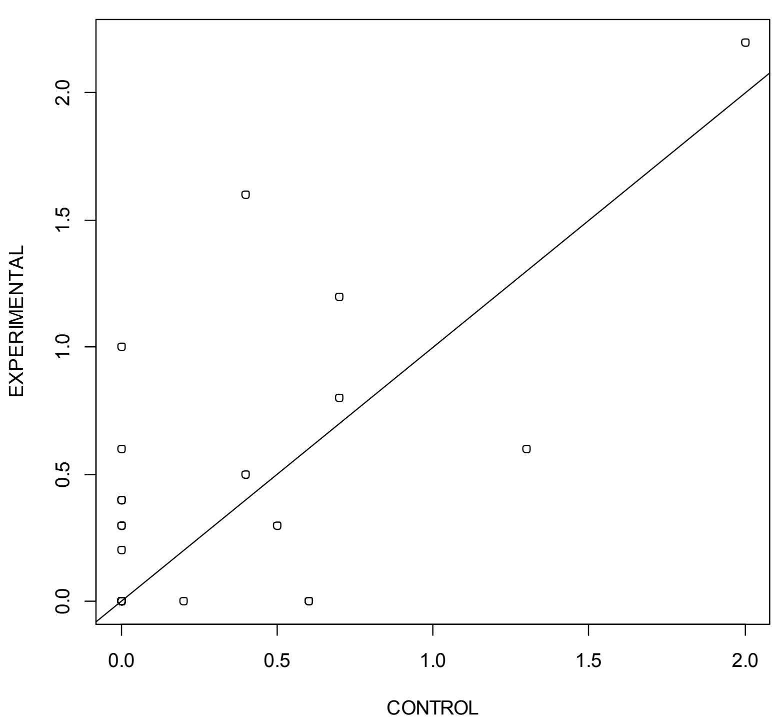
Yellowtail Flounder Pounds Landed



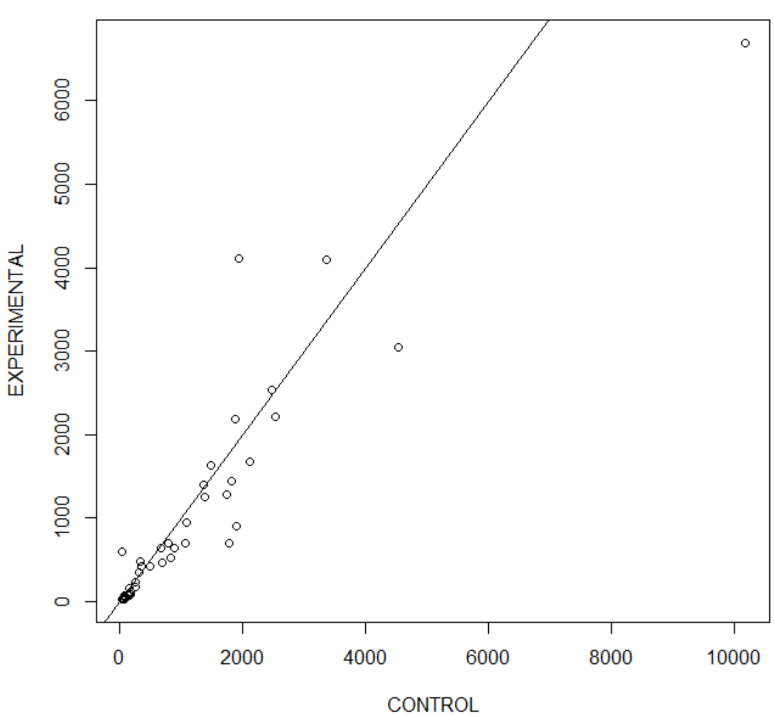
Windowpane Pounds Landed



Squid Landed



Whiting Landed



Comment A17
I'd consider running the bootstrap analysis on these data as well, given the relatively small sample size.

Response: Usually bootstrap doesn't deal with small sample sizes very well either. The results are below:

```
> t.test(brd.diff)

        One Sample t-test

data:  brd.diff
t = -1.5294, df = 41, p-value = 0.1339
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
 -0.18785148  0.02594672
sample estimates:
  mean of x
-0.08095238

> wilcox.test(brd.diff)

        Wilcoxon signed rank test with continuity correction

data:  brd.diff
V = 53, p-value = 0.1624
alternative hypothesis: true location is not equal to 0

Warning messages:
1: In wilcox.test.default(brd.diff) :
  cannot compute exact p-value with ties
2: In wilcox.test.default(brd.diff) :
  cannot compute exact p-value with zeroes

> i=80;boot.diff = sample(brd.diff,size=i,replace=T);t.test(boot.diff)$p.value
[1] 0.1962145
```

The bootstrap analysis agrees with the t-test and Wilcoxon test. The bootstrap analysis results will be incorporated into the final report.

Comment A19

The analysis presented doesn't support this statement. The analysis only tells you that the mean length was different. Do you conclude this from looking at the length frequency data? If so, you should state that here.

Response: The report will be revised as follows: The mean length of yellowtail flounder in the experimental net was 1.21 cm larger than the mean length in the control net. The mean length of windowpane flounder in the experimental net was 1.6 cm larger than the mean length in the control net. This will be incorporated into the final report.

Comment A20

For these analyses, I'd suggest a fixed effects ANOVA to actually estimate the day/night difference directly. This will also help with your sample size problem at night.

Response: We wouldn't do an ANOVA on these as the point of the study is to show that there are or are not differences between control and experimental treatments. An ANOVA here, or more appropriately a two-sample t-test with an unequal variance assumption, would show whether there was a day/night difference, but if there were no difference one wouldn't be able to tell if there were no difference because the data didn't shown differences between control and experimental, or whether the differences between control and experimental showed the same differences. The tests provided confirm the differences seen in the overall study. The small sample sizes for the night tows indicate no likely influence the initial findings. Again, we are parsing out the data too finely in pursuing questions that the experiment wasn't set up to address.

Comment A21

Reporting a result when the power of test is likely very small may mislead some readers. I would suggest that they run a power analysis and report that the power of the test was too low to adequately report the results, or omit the finding and just state that the number of pairs with windowpane flounder were too low to confidently report any results.

Response: We agree. At the December 2014 RSC meeting and in the report, it was highlighted that at night there were only 5 tows that caught yellowtail flounder and only 2 tows that caught windowpane flounder. But, the point of these runs is to satisfy the concern of the RSC that the results will not change as a result of time of day or side of boat. They do not. As this reviewer suggests, we should omit these findings and just state that the number of pairs were too low to confidently report results. We will include this comment in the final report.

Comment A24

Response: See response to A20 above.

Comment A25

This gives the impression that you ran this test only when the results did not meet your expectations. Should consider running this test for all data sets analyzed, although difference data would generally be expected to be normally distributed.

Response: This was the only time this assumption was in question as a result of differences in the resulting p value between tests. So, we should go with the test that does not assume normality. There is no need to explore this question for the other analyses.