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# Evaluation of Gear Modifications to Reduce the Bycatch of Summer Flounder (*Paralichthys dentatus*) in Sea Scallop Dredges

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## Abstract

Sixty-six pairs of scallop dredge tows were made in the Hudson Canyon Closed Area to test gear modifications to reduce the bycatch of summer flounder (fluke). The project was funded by a scallop TAC set aside. Although the results were marred by the apparently inferior scallop fishing power of the dredge used to test the various modifications, the abilities of the fish sweep and excluder rings to substantially reduce groundfish bycatches were again demonstrated. Significantly, these bycatch reductions are in addition to the reduction achieved by the use of the 10-in twine top.

## Introduction

Sea scallop dredge vessels operating along the US Atlantic coast between Maine and North Carolina primarily fish in depths of 40-100 meters. The scallop fishery overlaps the range of summer flounder (*Paralichthys dentatus*) both spatially and temporally. During certain months, between November and April, when the summer flounder are offshore overwintering, the overlap can be significant.

Scallop vessels do not target summer flounder but do take the species as bycatch. Any mortality is of particular concern because summer flounder is a highly regulated species managed by strict coast wide quotas. Quota controls can require all summer flounder caught to be discarded when trip limits are low or nonexistent.

Gear modifications represent one means to reduce flatfish bycatch. However, any gear modification made with the intent of reducing bycatch can only be acceptable if there is not a significant loss of the target species. Gear modifications can be made with the intent of either preventing the bycatch species from entering the gear, or by allowing escapement after the animal has entered. Both of these approaches are currently being explored with regard to scallop dredge gear and flatfish species.

Several dredge modifications have been field tested to determine their impact on catches of finfish and scallops. Initial measures included modifications of the twine tops to facilitate finfish escapement. Results indicate that a 8-inch diamond mesh twine top, when compared to the traditional 6-inch mesh, can reduce the capture of flatfish without detrimentally affecting the capture of commercial size scallops; at least when scallop densities are low. When the twine top was increased to ten inch mesh, the capture of finfish was reduced even further, however scallop losses were also increased. Eight-inch mesh twine tops are currently mandated resource wide and 10-inch twine tops are required when accessing special areas. Due to the significant losses of scallops with the 10-inch mesh twine top it is not viewed as an adequate solution by scallop fishermen. As a result, further dredge modifications are under development.

Current efforts have focused on gear modifications that prevent flatfish from entering the dredge. A roller sweep and excluder panel configuration was recently tested on Georges Bank (Smolowitz et al, 2003). This modification attempts to divert finfish

bycatch from the mouth of the dredge. The roller sweep is placed under the bale of the dredge in front of the cutting bar to direct fish up off the bottom. The excluder panel blocks the redirected fish from entering the dredge through the opening in the frame (Figure 1). Results from the experimental trips demonstrated a statistically significant reduction in the bycatch of both yellowtail and blackback flounder. Additionally, there was no statistically significant reduction in scallops retained. The purpose of the experiment reported here was to test this design on summer flounder found on the Mid-Atlantic scallop grounds.

## Methods

During 26-29 March 2003 the F/V Defiant conducted a research trip to the area west of Hudson Canyon bounded by 38.6-39.6 N lat and 73.0-74.0 W long (Figure 2). The basic control and experimental dredges were standard for the fishery and fitted with 10-inch twine tops hung with a hanging ratio of one. Both experimental and control dredges were fished without wheels on the bale. The experimental dredges were compared to the control dredges with: (1) the addition of excluder rings only; (2) a fish sweep only; (3) excluder rings plus a fish sweep; (4) excluder rings plus a chain fish sweep; (5) no additional modifications. These modifications were tested against control dredges at 65 localities. At one additional station a video camera was attached to the experimental dredge to monitor the performance of the fish sweep (catch results were not recorded).

Standard commercial scallop fishing techniques were practiced during the trials which were conducted under conditions typical of the fishery. The weather ranged from calm conditions to fairly rough seas (6-foot waves and winds of 35 knots), there were straight tows and turnaround tows, and tidal currents ranged from slack to more than 2 knots.

Duration of the on-bottom fishing time was recorded to the nearest minute; average tow speed was recorded to the nearest 0.1 knot. After a tow, the catch from each dredge was separated by species category and counted (scallop catches were recorded as bushels [bu = 35.2 liters]). A one bushel sub-sample of scallops was measured from most tows. The species categories are: fluke (summer flounder; *Paralichthys dentatus*), sea scallop (*Placopecten magellanicus*), skates (Rajidae, spp undet.), monkfish (*Lophius americanus*), and other flatfishes (variously mixed catches of the genera *Scophthalmus*, *Limanda*, *Liopsetta*, *Pseudopluronectes*, *Glyptocephalus*, and *Paralichthys*). Undersized scallops and most fish were returned to the sea (except for the allowed retention of multispecies and monkfish).

**Data Analyses**

For analysis, the catch counts were transformed to catch rates, expressed as numbers (or bushels of scallops) per hectare. Hectares fished for each tow were calculated with the formula: Area sampled (hectares) by one 15-foot wide (4.572-meter) scallop dredge = Tow time (minutes) x Tow speed (knots) x 0.01411. The constant was calculated from the theoretical area sampled by a dredge in one minute of fishing at one knot (kn; one nautical mile (1852m)/hour) and dividing by 10000. Overall mean catches as numbers/30-min tow are also provided.

We used the one-sided probability obtained from the matched-pairs Student's *t*-test to statistically judge if the mean catch difference (mean D) between control and experimental dredge was equal to zero in the ± direction indicated by the observed D (a null hypothesis of D = 0, no alternative hypothesis). The nonparametric Wilcoxon signed-ranks test was also run for comparative purposes.

Another measure of comparative dredge performance is the mean (average) percent bycatch reduction effected by the experimental dredge relative to the control dredge (the catch rate of experimental dredge subtracted from that of the control dredge, divided by control catch rate and multiplied by 100). This results in a positive percentage when the experimental dredge catch is less than that of the control (much of the time). When the catch rate of the experimental dredge exceeds that of the control dredge (an increased bycatch, or catch in the cases of scallops and monkfish, by the experimental dredge), a negative percent reduction results. Thus, the percent reduction for a trial (or for a series of cumulative trials for a trip such as given in this report) could range as high as 100% (zero catch(es) for the experimental dredge(s)), or so low as to approach negative infinity (or be undefined for zero catch(es) in the control dredge(s)).

Beginning with the second tow, cumulative paired t-tests were run for each species for the remaining tows of the trip. In addition to the cumulative mean catch for control and experimental dredges and the cumulative mean difference, cumulative values for standard deviation, standard error, ±90% confidence intervals, and t-values for mean D were obtained.

An easy way to gain a general understanding of the overall outcome of a test comparison is by plotting, by tow, of all differences (D) between control and experimental dredge catches for each species category. Positive differences result when fewer animals are taken in the experimental dredge (a bycatch/catch reduction); negative differences result when more animals are taken in the experimental dredge (a bycatch/catch increase). These plots permit a quick assessment for an overall result; an estimation of the average difference between dredges; appraisal of consistency in dredge performance; and general examination of catch distribution for possible outliers.

It should be recognized that these differences between control and experimental dredges also reflect the generality that absolute D is related to the magnitude of the

control dredge catch when there is a real (fixed) treatment effect of the experimental dredge. This was confirmed by running first and second degree regressions for all of the data sets for fishes and scallops with D as the dependent variable and the control dredge catch rate as the independent variable. Studentized deleted residuals of these regressions were also run to identify outliers. Matched-pairs tests, correlations and multiple regression analyses were run with and without outliers and extreme values, as determined by residual analyses and normal probability plots.

## Results

***General***. During 4 tows one of the dredges was deployed incorrectly (backjobs), resulting in a total of 61 tows for which comparative scallop catch data are available. Catch data are unavailable for various tows for the other species groups, resulting in the following total sample numbers for each group; fluke (42), skates (45), monkfish (53), mixed flatfishes (57). The geographical distribution of the 61 tows is shown in Fig.2. The depth range sampled was 24-35 fathoms (fm) and averaged 28.3 fm (Fig 3). Towing speed range was 4.0-4.5 kn and averaged 4.2 kn (Fig. 4).

The experiment to test the excluder rings only setup comprised tows 1-15 in the southwestern portion of the sampling area in depths of 24-29 fm (Fig.2 and for all other experiments). The experiment to test the excluder rings plus fish sweep comprised tows 16-34 in the northeastern portion of the sampling area in depths of 27-35 fm. The experiment to test the fish sweep only comprised tows 35-50 in the southwestern portion of the sampling area in depths of 25-35 fm. The experiment to test identical dredges comprised tows 51-55 and 64-66 centered at about 39.0° N and 73.6° W in depths 25-27 fm. The experiment to test the excluder rings plus a chain fish sweep comprised tows 56-63, also centered at about 39.0° N and 73.6° W in depths 25-28 fm.

***Dredge comparisons***. The overall paired t -test and signed-ranks test probabilities, percent reduction, and some associated statistics are given in Table 1. The cumulative percent reduction and 90% CI for each successive tow, as well as the "D-plots", for all species categories and tow series are shown in Fig. 5-9. A summary of results is given in Table 2.

*Fluke*: There was very strong evidence for a 53% decrease in fluke catch with the chain fish sweep and excluder rings combination. There was moderately strong evidence for a 40% reduction in fluke catches with only excluder rings installed, and a 43% reduction with the standard fish sweep and excluder rings combination. There was no evidence for an increase or decrease in fluke catches when the standard fish sweep was fished alone and when the control and experimental dredges were identical.

*Scallops*: There was very strong evidence for decreased scallop catches for three dredge modifications: a 20% reduction when only the excluder rings were used; a 45% reduction when both the standard fish sweep and excluder rings were used; and a 32%

reduction when the chain sweep and excluder rings combination was used. There was moderately strong evidence for a 25% reduction in scallop catches when only the standard fish sweep was used. There was some weak evidence for a 14% reduction when the control and experimental dredges were identical; this is discussed below.

*Skates*: There was very strong evidence for decreased skate catches for all dredge modifications; the reductions ranged from 18% for the excluder rings only to 41% for the standard fish sweep/excluder rings combination. There was no evidence for an increase and decrease in skate catches when identical dredges were compared.

*Monkfish*: There was no evidence for an increase and decrease in monkfish catches for 3 of the 4 dredge modifications as well as when identical dredges were compared. There was very weak evidence for a 17% increase in monkfish catches when only the standard fish sweep was used.

*Other flatfishes*: There was very strong evidence for decreased mixed flatfish catches of 49% for the standard fish sweep/excluder rings combination. There was moderately strong evidence of a 35% reduction when only the excluder rings were installed. There was some weak evidence of a 54% reduction in mixed flatfish catches when the chain fish sweep/excluder rings combination was tested. There was no evidence for an increase and decrease in mixed flatfish catches when only the standard fish sweep was installed and when both dredges were identical.

*Gear modifications*: Overall, the standard fish sweep/excluder rings and chain fish sweep/excluder rings combinations were the most effective rigs for reducing incidental finfish bycatches. These combinations also resulted in scallop catch reductions of 45% and 32%.

When only the excluder rings were installed on the experimental dredge, strong and moderately strong evidence demonstrated meaningful reductions in finfish (except monkfish) and scallop catches.

When only the standard fish sweep was installed, the various species of skates was the only finfish group for which catches were affected (a 37% reduction); this modification also resulted in an overall reduction of 25% in scallop catches.

***Distribution and abundance***. The overall distribution and abundance for the five species groups as indicated by control dredge catches is shown in Fig. 9. The abundance of fluke, scallops, skates, and mixed flatfishes were all positively correlated (Table 3). Monkfish catches were positively correlated only with scallop catches. No meaningful negative correlations were observed.

Multiple regression analyses were run to determine the value of the variables latitude, longitude, depth, and tow speed as predictors of control dredge catches for the 5 species groups. With the exception of skates, catch rates showed a tendency to

increase with increased tow speeds; however, none of these results were at a meaningful probability. This is not surprising considering the limited range of the majority of sampling speeds (4.2-4.3 kn).

Depth was not a meaningful predictor for any species group except skates ($P$ = 0.030, r-sq = 11%); latitude and longitude together were not significant predictors for skate catches ($P$ = 0.77, adjusted r-sq = 3.6%), but all three predictors together exhibited an adjusted r-sq value of 13.7% ($P$ = 0.033). This indicates that larger skate catches were experienced in the deeper sampling depths in the northeastern portion of the sampling area.

Latitude and longitude are significant predictors of scallop and monkfish catches, indicating that these species were more abundant in the southwestern portion of the sampling area. Fluke and mixed flatfishes also showed weak, but not meaningful, tendencies to be more abundant in the southwestern area.

## Discussion

The first series of tows (tows 1-15) consisted of testing the starboard dredge rigged with the excluder rings only. In this tow series the starboard dredge caught 20% fewer scallops, 40% fewer summer flounder (fluke), 18% fewer skates, and 35% fewer mixed flatfishes (Appendix Tables 1 and 2). There was no reduction or increase in monkfish catches. Because of results from previous trials, expected reductions in scallop catches by excluder rings alone were from about 0% to perhaps as much as 7-10%; a 20% reduction was an unexpectedly high result.

The next series of tows (16-34) was with a fish sweep added to the starboard dredge. The combination of fish sweep and excluder rings resulted in reduced catches of fluke (43%), scallops (45%), slates (40%), and mixed flatfishes (49%). There was no reduction or increase in monkfish catches. These results were even more surprising than those from the previous tow series because a number of trials with fish sweeps alone had produced *increased* scallop catches of 11-22% while reducing groundfish bycatches on the same scale as observed here. At this time we began to suspect that the starboard (experimental) dredge was not fishing as well as the port (control) dredge.

The above suspicions were verified during the next series of tows (35-50) when the excluder rings were removed and only the fish sweep was tested. Instead of the anticipated increased scallop catches (or at the least, no difference between dredges), a decrease of 25% was observed. This was accompanied by the expected decreases in fluke (32%) and skate (37%) catches. There was some evidence for a meaningful increase of 17% in monkfish catches, but no evidence for an increase or decrease in mixed flatfishes catches. At this time we examined the catch logs of the vessel and found that dredge had also performed poorly on the vessel's previous trip.

As an attempt to verify the inferior scallop fishing power of the starboard dredge, a disjunct series of three and four tows (51-55, 64-66) were made with both control and experimental (starboard) dredges identically rigged. The observed 15% scallop catch reduction was weakly significant (sample size =7, $P = 0.061$) and provided evidence that our suspicion of the reduced fishing power of the starboard dredge was justified. There were too few observations to make any conclusions regarding groundfish bycatch reductions although the tendency was towards increased catches of these species in the starboard dredge.

During tow 39 we had put a video camera on the dredge and found that the standard fish sweep was not making good contact with the bottom most of the time. The chain sweep/excluder ring combination was our last chance attempt during this trip to configure a rig that would produce the anticipated results. By substituting 3/8" chain, hung by 4 links of drop chain, we were confident the chain would be sweeping the bottom at least lightly. However, during the-eight tow series (51-63) we still observed the poor scallop catching ability of the starboard dredge, the catches being reduced by 32%. However, the anticipated reductions in fluke, skates and mixed flatfish catches did occur.

Although the results of these tow series were marred by the apparent poor scallop fishing power of the starboard dredge, the ability of the fish sweep and excluder rings to substantially reduce groundfish bycatches was again demonstrated. Significantly, this bycatch reduction is in addition to the reduction achieved by the use of the 10-in twine top.

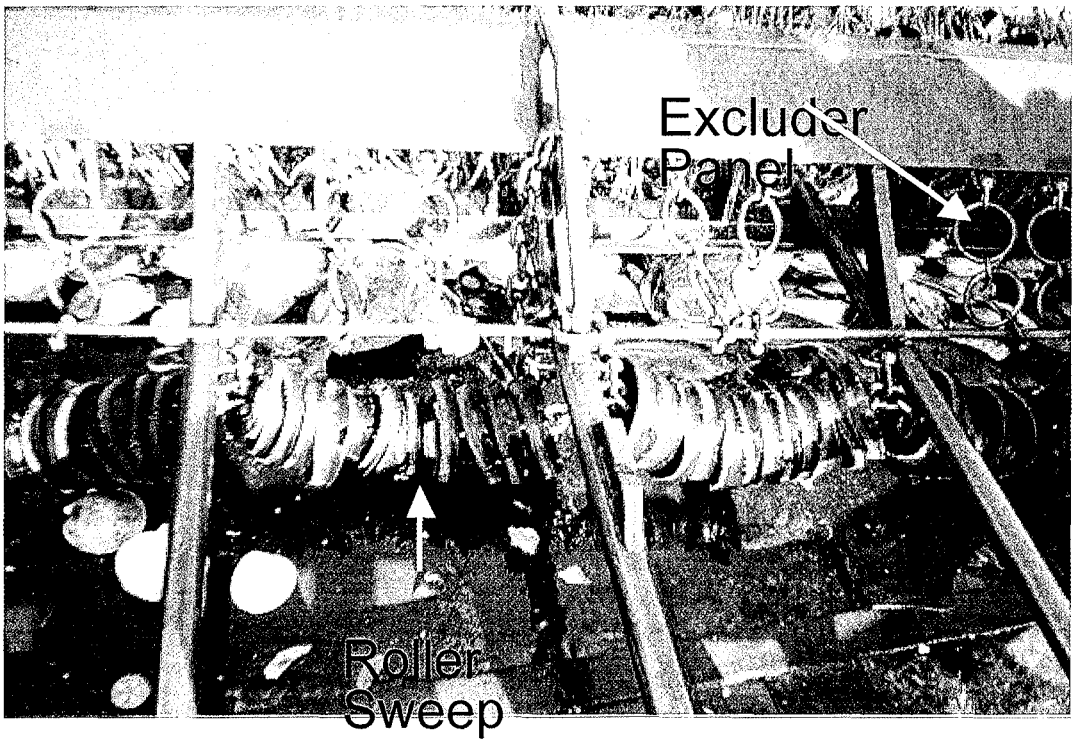



Figure 1. Photo of roller sweep/excluder panel on modified New Bedford style sea scallop dredge.

**Figure 2. F/V Defiant Mar 2003.** Locations for all tows (top left) and five series of gear comparisons. See text.

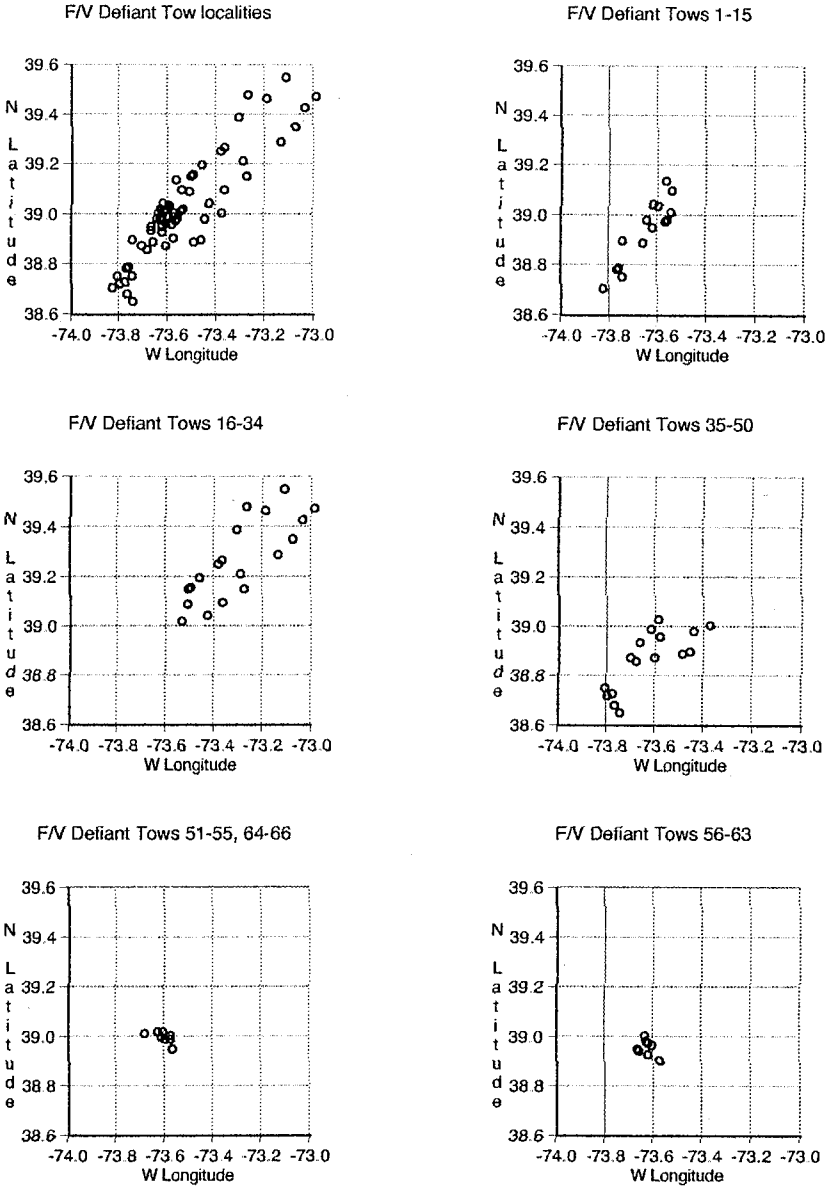
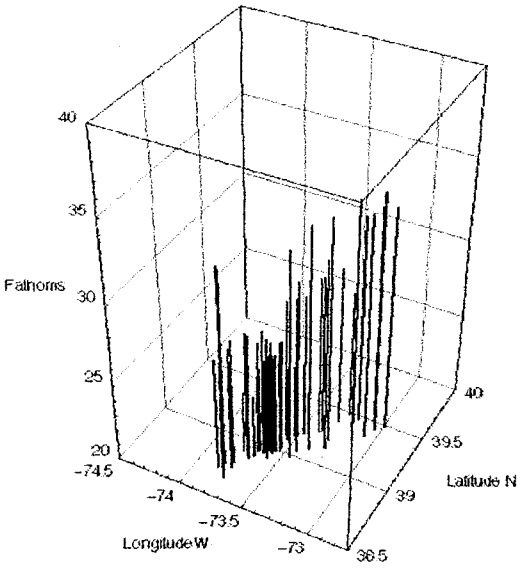
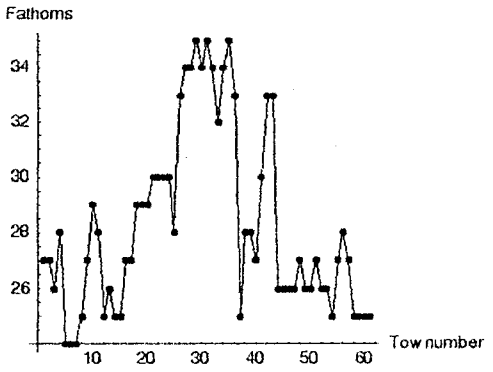


**Fig 3.** Tow depths for **F/V Defiant Mar 2003**. Below: depth by tow locale; lower left: depth by tow number; lower-right: frequencies of sampled depths. Mean depth = 28.3, median speed = 27.0, variance = 10.84.



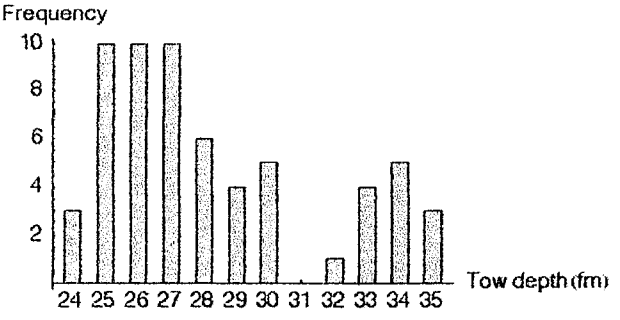



**Fig 4.** Tow speeds for **F/V Defiant Mar 2003**. Mean speed = 4.23, median speed = 4.23, variance = 0.011.

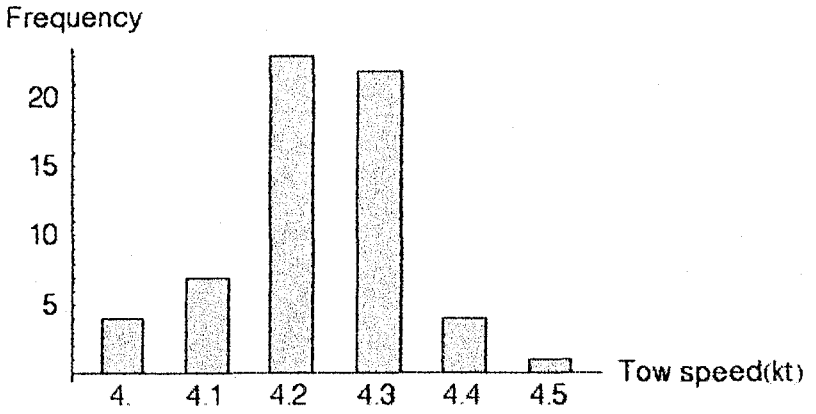
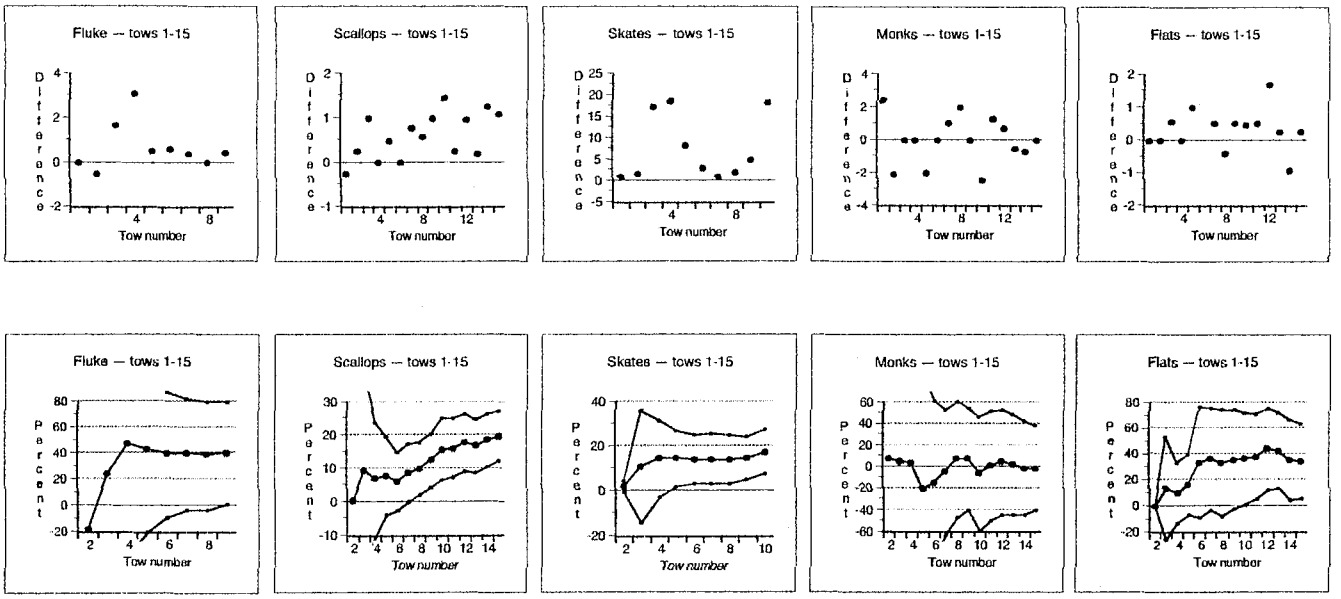
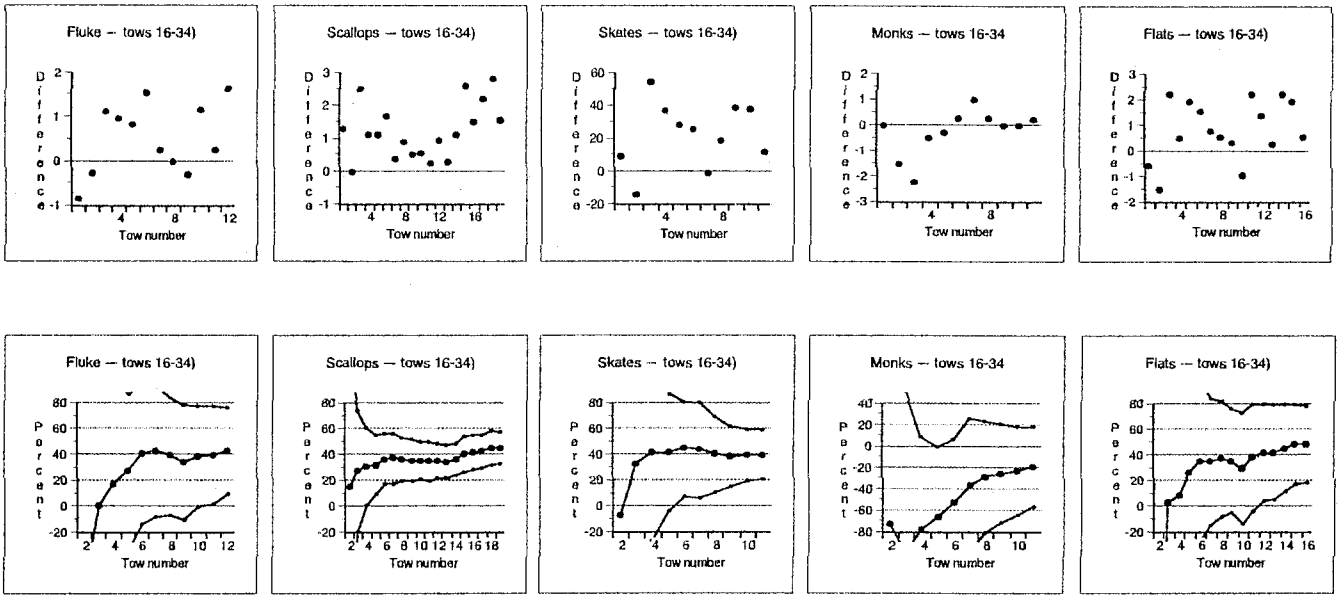


**Figure 5. Defiant Trip Mar 2003, Tows 1-15.** Plots of differences (D) between dredge catches (control dredge minus experimental dredge as numbers of fishes or bushels of scallops per hectare) and cumulative mean percent difference between control and experimental dredges, bounded by the ±90% confidence interval, by tow, for five species categories. Positive differences result when fewer animals are taken in the experimental dredge (a bycatch/catch reduction); negative differences result when more animals are taken in the experimental dredge (a bycatch/catch increase). Also refer to Table 1.



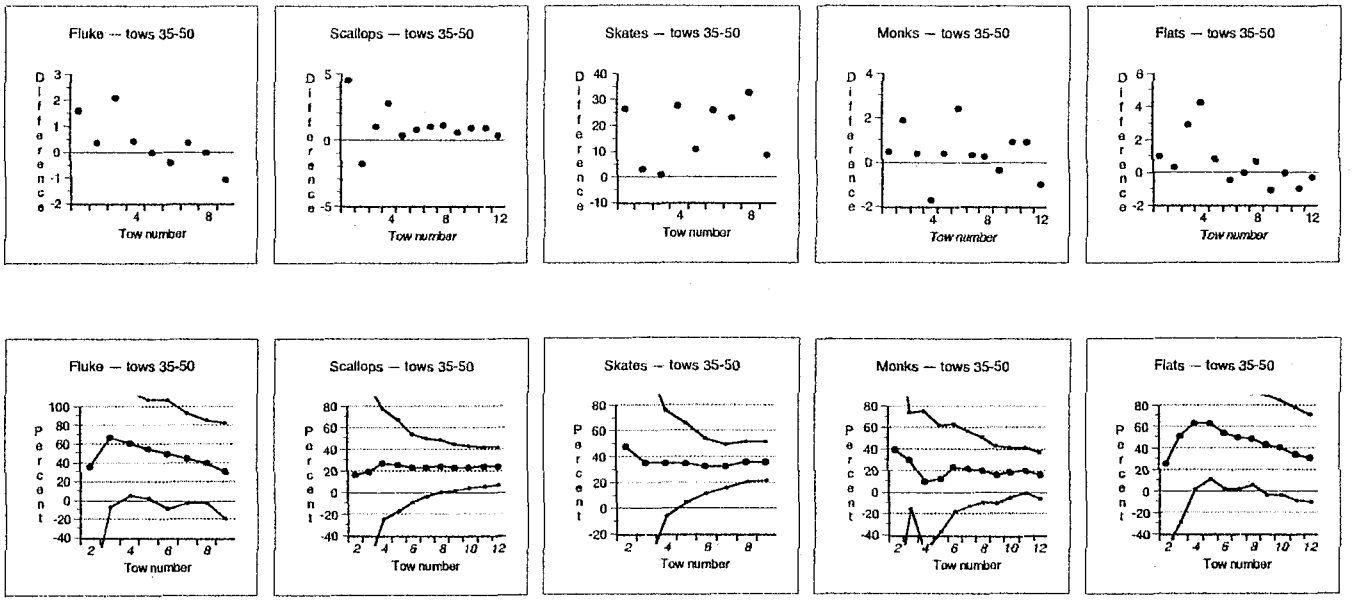

*Experimental dredge with excluder rings only*

**Figure 6. Defiant Trip Mar 2003, Tows 16-34.** Plots of differences (D) between dredge catches (control dredge minus experimental dredge as numbers of fishes or bushels of scallops per hectare) and *cumulative mean percent difference between control and experimental dredges, bounded by the ±90%* confidence interval, by tow, for five species categories. Positive differences result when fewer animals are taken in the experimental dredge (a bycatch/catch reduction); negative differences result when more animals are taken in the experimental dredge (a bycatch/catch increase). Also refer to Table 1.



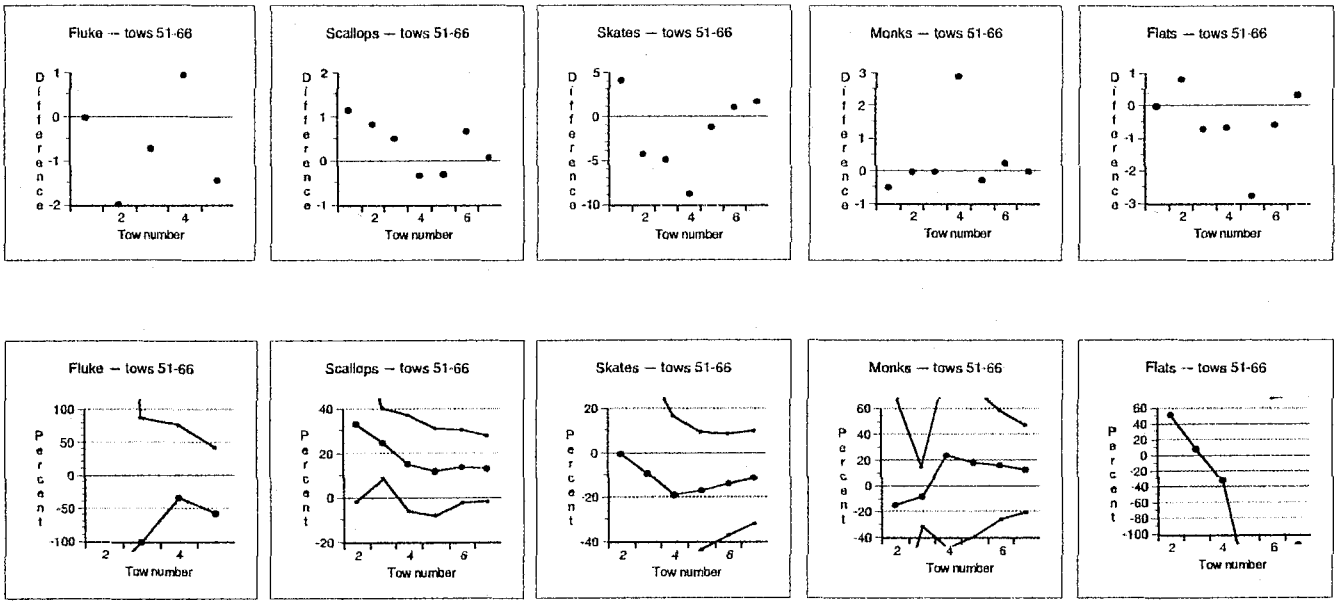

*Experimental dredge with fish sweep and excluder rings*

**Figure 7. Defiant Trip Mar 2003, Tows 35-50.** Plots of differences (D) between dredge catches (control dredge minus experimental dredge as numbers of fishes or bushels of scallops per hectare) and cumulative mean percent difference between control and experimental dredges, bounded by the ±90% confidence interval, by tow, for five species categories. Positive differences result when fewer animals are taken in the experimental dredge (a bycatch/catch reduction); negative differences result when more animals are taken in the experimental dredge (a bycatch/catch increase). Also refer to Table 1.



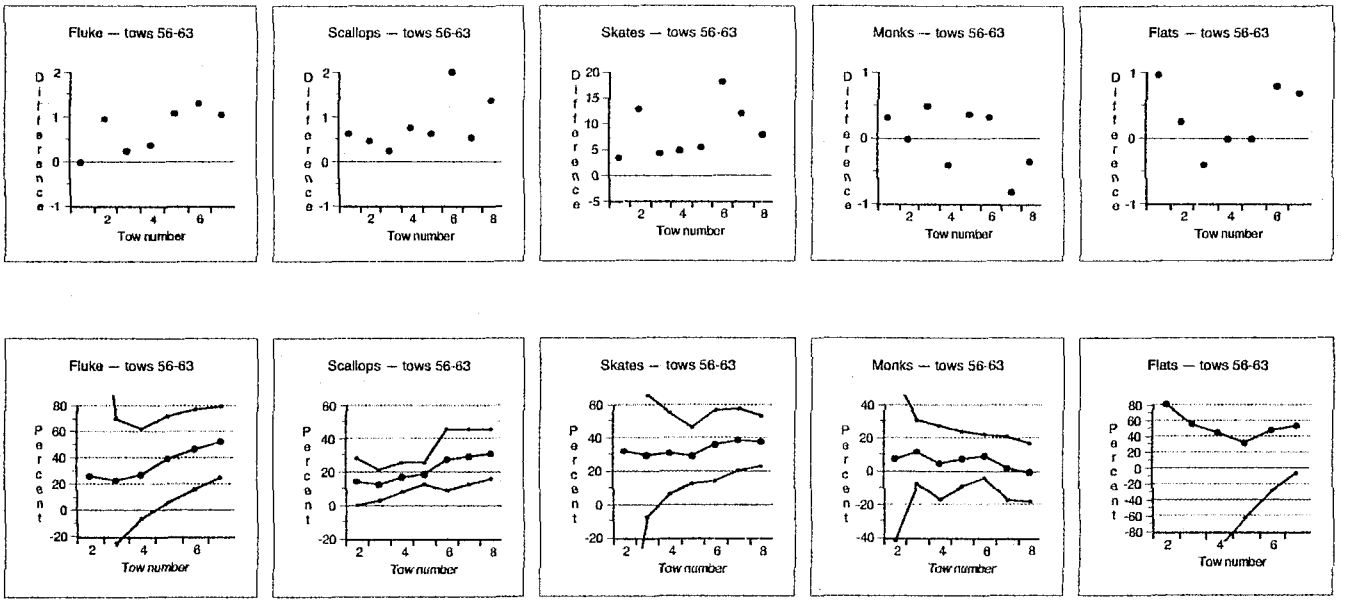

*Experimental dredge with fish sweep only*

**Figure 8. Defiant Trip Mar 2003, Tows 51-55, 64-66.** Plots of differences (D) between dredge catches (control dredge minus experimental dredge as numbers of fishes or bushels of scallops per hectare) and cumulative mean percent difference between control and experimental dredges, bounded by the ±90% confidence interval, by tow, for five species categories. Positive differences result when fewer animals are taken in the experimental dredge (a bycatch/catch reduction); negative differences result when more animals are taken in the experimental dredge (a bycatch/catch increase). Also refer to Table 1.



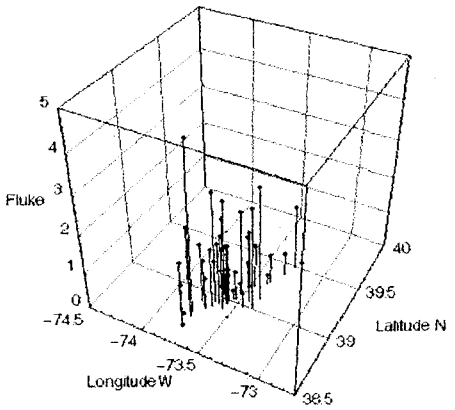

*Experimental dredge identical to control dredge*

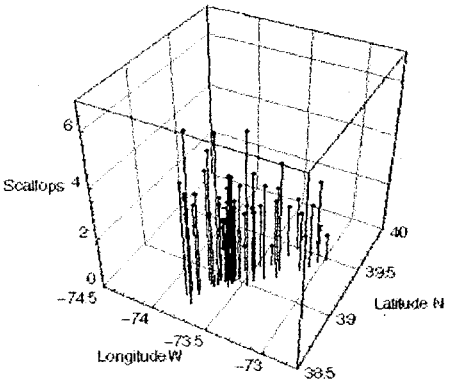
**Figure 9. Defiant Trip Mar 2003, Tows 56-63.** Plots of differences (D) between dredge catches (control dredge minus experimental dredge as numbers of fishes or bushels of scallops per hectare) and cumulative mean percent difference between control and experimental dredges, bounded by the ±90% confidence interval, by tow, for five species categories. Positive differences result when fewer animals are taken in the experimental dredge (a bycatch/catch reduction); negative differences result when more animals are taken in the experimental dredge (a bycatch/catch increase). Also refer to Table 1.

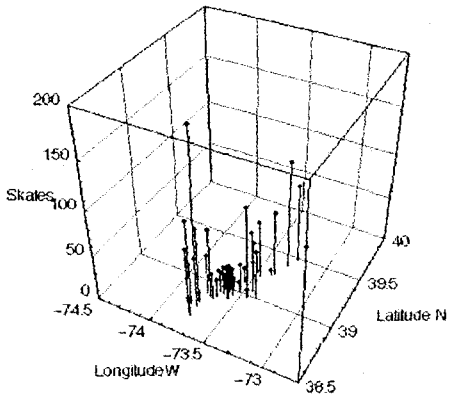


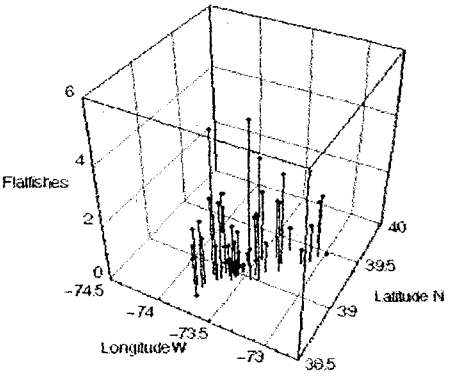

*Experimental dredge with chain sweep and excluder rings*

**Fig 10.** Control dredge catches (nos. or bu per hectare) for **F/V Defiant Mar 2003**. Catches for Defiant tow 1 are not shown for fluke (8.9 /ha), skates (276/ha), monkfish (13.3 /ha), and mixed flatfishes 8.9 /ha). Also not shown is tow 35 for scallops (12.5 bu/ha).



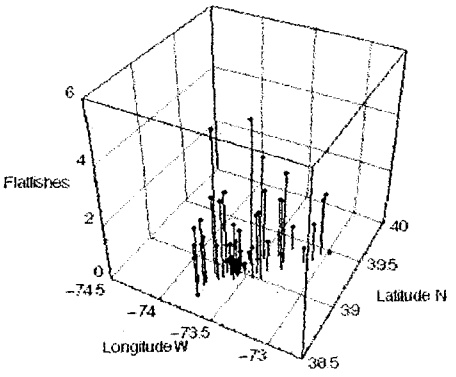



**Table 1.** Matched-pairs *t*-test statistics for control and experimental sea scallop dredge catches obtaine during fishing trip **F/V Defiant Mar 2003** (mean control and experimental catches also given as numbers per 30 minute tow). A negative value for mean D and mean percent reduction results when the mean ca of the experimental dredge exceeds that of the control dredge. Probabilities for the nonparametric Wilcoxon signed-ranks test for differences between dredges are also given. Refer to Table 2, Figs 4-8, and the text for further information. ** = $P < 0.01$.

| Species category, tow series, and *sample size (n)* | Controls: Mean catch: *no. or bu/* hectare and (30-min tow) | Experi-mentals: *Mean catch:* no. or bu/ hectare and (30-min tow) | Mean D ±90% CI | Mean percent reduction ± *90% CI* | Standard error of mean *D* | Student's t-test *probability* (1-sided) | Wilcoxon signed ranks *probability* (1-sided) | F-ratio probability *for variance* of control and experi-mental catches |
|---|---|---|---|---|---|---|---|---|
| **Fluke** | | | | | | | | |
| Tows 1-15 (9) | 1.70 (3.00) | 1.79 (1.01) | 0.69±0.67 | 40.4±39.4 | 0.361 | 0.046 | 0.055 | 0.12 |
| Tows 16-34 (12) | 1.24 (2.20) | 0.70 (1.25) | 0.54±0.41 | 43.3±33.1 | 0.228 | 0.019 | 0.027 | 0.14 |
| Tows 35-50 (9) | 1.18 (2.13) | 0.80 (1.45) | 0.38±0.60 | 32.2±50.8 | 0.321 | 0.14 | 0.19 | ** |
| Tows 51-55, 64-66 (5) | 1.12 (2.05) | 1.75 (3.20) | -0.63±1.11 | -55.9±98.7 | 0.519 | 0.15 | 0.19 | 0.27 |
| Tows 56-63 (7) | 1.37 (2.49) | 0.64 (1.16) | 0.73±0.37 | 53.3±27.2 | 0.191 | 0.004 | 0.016 | 0.34 |
| **Sea scallop** | | | | | | | | |
| Tows 1-15 (15) | 3.06 (5.41) | 2.46 (4.34) | 0.60±0.23 | 19.7±7.63 | 0.133 | 0.00023 | 0.00037 | 0.20 |
| Tows 16-34 (19) | 2.73 (4.87) | 1.50 (2.67) | 1.24±0.33 | 45.3±12.2 | 0.192 | 0.000002 | 0.000004 | 0.17 |
| Tows 35-50 (12) | 4.46 (8.03) | 3.35 (6.03) | 1.11±0.76 | 24.9±17.11 | 0.425 | 0.012 | 0.011 | 0.09 |
| Tows 51-55, 64-66 (7) | 2.85 (5.22) | 2.46 (4.51) | 0.39±0.42 | 13.6±14.8 | 0.217 | 0.061 | 0.078 | 0.37 |
| Tows 56-63 (8) | 2.68 (4.86) | 1.83 (3.32) | 0.85±0.39 | 31.6±14.7 | 0.208 | 0.0024 | 0.0039 | 0.34 |
| **Skates** | | | | | | | | |
| Tows 1-15 (10) | 43.4 (76.1) | 35.8 (62.7) | 7.62±4.38 | 17.6±10.1 | 2.388 | 0.0055 | 0.0098 | 0.46 |
| Tows 16-34 (11) | 56.5 (100.6) | 33.6 (59.8) | 22.9±11.0 | 40.5±19.4 | 6.052 | 0.0018 | 0.0049 | 0.08 |
| Tows 35-50 (9) | 48.6 (88.2) | 30.7 (55.7) | 17.9±7.30 | 36.8±15.0 | 3.925 | 0.0009 | 0.0019 | 0.13 |
| Tows 51-55, 64-66 (7) | 15.7 (28.7) | 17.4 (31.8) | -1.68±3.30 | -10.7±21.0 | 1.699 | 0.18 | 0.23 | 0.08 |
| Tows 56-63 (8) | 22.8 (41.3) | 14.0 (25.4) | 8.79±3.52 | 38.6±15.5 | 1.861 | 0.001 | 0.004 | 0.13 |
| **Monkfish** | | | | | | | | |
| Tows 1-15 (15) | 1.63 (2.88) | 1.65 (2.91) | -0.01±0.64 | -0.8±39.4 | 0.365 | 0.49 | 0.50 | 0.28 |
| Tows 16-34 (11) | 1.32 (2.35) | 1.57 (2.79) | -0.25±0.49 | -18.8±37.4 | 0.273 | 0.19 | 0.23 | ** |
| Tows 35-50 (12) | 2.66 (4.79) | 2.21 (3.98) | 0.45±0.59 | 16.9±22.0 | 0.326 | 0.097 | 0.075 | 0.12 |
| Tows 51-55, 64-66 (7) | 2.51 (4.59) | 2.16 (3.95) | 0.35±0.84 | 13.8±33.7 | 0.435 | 0.23 | 0.56 | 0.12 |
| Tows 56-63 (8) | 1.84 (3.33) | 1.84 (3.33) | 0.0±0.3 | 0.0±17 | 0.165 | 0.50 | 0.41 | 0.19 |
| **Other flatfishes** | | | | | | | | |
| Tows 1-15 (15) | 1.42 (2.50) | 0.93 (1.64) | 0.49±0.41 | 34.7±28.9 | 0.232 | 0.026 | 0.017 | 0.12 |
| Tows 16-34 (16) | 1.72 (3.08) | 0.88 (1.57) | 0.85±0.52 | 49.1±29.9 | 0.294 | 0.0057 | 0.0084 | 0.02 |
| Tows 35-50 (12) | 1.99 (3.59) | 1.37 (2.46) | 063±0.80 | 31.4±40.4 | 0.448 | 0.095 | 0.161 | 0.07 |
| Tows 51-55, 64-66 (7) | 0.44 (0.80) | 0.93 (1.70) | -0.49±0.84 | -112±193 | 0.434 | 0.15 | 0.22 | 0.02 |
| Tows 56-63 (7) | 0.62 (1.12) | 0.29 (0.52) | 0.33±0.37 | 53.8±59.1 | 0.189 | 0.064 | 0.094 | 0.13 |

**Table 2. Defiant Mar 2003.** Summary of experimental scallop dredge performance relative to the control dredge for 5 experimental tow series. Refer to Table 1, Figs 4-8, and the text for further information.

| Tow series | Fluke | Sea scallop | Skates | Monkfish | Other flatfishes |
|---|---|---|---|---|---|
| Experimental dredge with excluder rings only. Tows 1-15. Fig. 4. | Moderately strong evidence for a 40% decrease in fluke catch. | Very strong evidence for a 20% decrease in scallop catch. | Very strong evidence for an 18% decrease in skate catch. | No evidence for a reduction or increase in monkfish catch. | Moderately strong evidence for a 35% decrease in mixed flatfishes catch. |
| Experimental dredge with fish sweep and excluder rings. Tows 16-34. Fig 5. | Moderately strong evidence for a 43% decrease in fluke catch. | Very strong evidence for a 45% decrease in scallop catch. | Very strong evidence for a 41% decrease in skate catch. | No evidence for a reduction or increase in monkfish catch. | Very strong evidence for a 49% decrease in mixed flatfishes catch. |
| Experimental dredge with fish sweep only. Tows 35-50. Fig 6. | No evidence for a reduction or increase in fluke catch. | Moderately strong evidence for a 25% decrease in scallop catch. | Very strong evidence for a 37% decrease in skate catch. | Some weak evidence for a 17% increase in monkfish catch. | No evidence for a reduction or increase in mixed flatfishes catch. |
| Control and experimental dredges identical. Tows 51-55, 64-66. Fig 7. | No evidence for a reduction or increase in fluke catch. | Some weak evidence for a 14% decrease in scallop catch. | No evidence for a reduction or increase in skate catch. | No evidence for a reduction or increase in monkfish catch. | No evidence for a reduction or increase in mixed flatfishes catch. |
| Experimental dredge with chain fish sweep and excluder rings. Tows 56-63. Fig 8. | Very strong evidence for a 53% decrease in fluke catch. | Very strong evidence for a 32% reduction in scallop catch. | Very strong evidence for a 39% decrease in skate catch. | No evidence for a reduction or increase in monkfish catch. | Some weak evidence for a 54% decrease in mixed flatfishes catch. |

**Table 3.** Control dredge catch correlations between species groups during **F/V Defiant Mar 2003**. Sample size, probability of Pearson product-moment correlation, and probability of Spearman's rank correlation for each correlation.

| | Fluke | Scallops | Skates | Monkfish |
|---|---|---|---|---|
| **Scallops** | | | | |
| Sample size | 40 | | | |
| Pearson P | 0.03 | | | |
| Spearman's P | 0.01 | | | |
| **Skates** | | | | |
| Sample size | 37 | 42 | | |
| Pearson P | 0.048 | 0.008 | | |
| Spearman's P | 0.009 | 0.001 | | |
| **Monkfish** | | | | |
| Sample size | 40 | 51 | 43 | |
| Pearson P | 0.25 | 0.014 | 0.46 | |
| Spearman's P | 0.15 | 0.032 | 0.44 | |
| ***Flatfishes*** | | | | |
| Sample size | 36 | 53 | 39 | 48 |
| Pearson P | 0.01 | 0.002 | <0.00001 | 0.18 |
| Spearman's P | 0.007 | 0.008 | 0.00001 | 0.08 |

| Trip: Defiant 2003-1 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time | Tow Time | Start Position | | End Position | | Speed | Depth | Wire out | Vessel | Catch (bu) | | |
| DATE | TOW # | Start | Minutes | Latitude | Longitude | Latitude | Longitude | Knots | Fathoms | Fathoms | Heading | port | stbd | Comments |
| 3/25/2003 | 1 | 1424 | 32 | 38:40:41 | 73:48:32 | 38:42:87 | 73:46:60 | 4.5 | 27.1 | 85 | 052 | 9 | 9.5 | Stbd dredge experimental |
| 3/25/2003 | 2 | 1510 | 31 | 38:42:81 | 73:46:04 | 38:44:61 | 73:44:51 | 4.3 | 27.5 | 85 | 050 | 6.5 | 6 | Wind East @ 10 Knots |
| 3/25/2003 | 3 | 1552 | 30 | 38:45:03 | 73:44:14 | 38:48:51 | 73:42:34 | 4.2 | 26.6 | 85 | 040 | 5 | 3.25 | |
| 3/25/2003 | 4 | 1642 | 32 | 38:47:08 | 73:41:75 | 38:49:41 | 73:40:94 | 4.3 | 28.0 | 85 | 040 | 7.5 | 7.5 | |
| 3/25/2003 | 5 | 1727 | 36 | 38:49:82 | 73:40:82 | 38:51:97 | 73:39:45 | 4.0 | 24.0 | 75 | 040 | 9 | 8 | |
| 3/25/2003 | 6 | 1814 | 30 | 38:52:28 | 73:39:10 | 38:54:30 | 73:38:39 | 4.0 | 24.0 | 75 | 040 | 10 | 10 | |
| 3/25/2003 | 7 | 1909 | 35 | 38:54:82 | 73:38:12 | 38:58:47 | 73:34:08 | 4.0 | 24.0 | 75 | 050 | 3 | 1.5 | |
| 3/25/2003 | 8 | 1950 | 44 | 38:58:79 | 73:33:70 | 38:59:02 | 73:32:35 | 4.1 | 25.0 | 80 | 050 | 6.5 | 5 | |
| 3/25/2003 | 9 | 2044 | 35 | 38:59:33 | 73:32:14 | 39:01:49 | 73:30:71 | 4.0 | 27.0 | 85 | 050 | 4 | 2 | |
| 3/25/2003 | 10 | 2131 | 36 | 39:01:87 | 73:30:47 | 39:04:08 | 73:29:82 | 4.1 | 29.0 | 90 | 052 | 5 | 2 | |
| 3/25/2003 | 11 | 2218 | 65 | 39:03:85 | 73:29:88 | 38:59:85 | 73:31:57 | 4.2 | 28.0 | 85 | 212 | 3.5 | 2.5 | |
| 3/25/2003 | 12 | 2335 | 70 | 38:59:57 | 73:31:83 | 38:57:14 | 73:33:49 | 4.2 | 25.0 | 75 | 050 | 9.5 | 5.5 | |
| 3/26/2003 | 13 | 0057 | 70 | 38:57:03 | 73:33:71 | 38:58:23 | 73:32:43 | 4.2 | 26.0 | 75 | 212 | 12.5 | 11.75 | Wind South @ 30 Knots |
| 3/26/2003 | 14 | 0240 | 74 | 38:58:15 | 73:32:49 | 38:57:27 | 73:33:26 | 4.2 | 25.0 | 75 | 050 | 14.5 | 9 | |
| 3/26/2003 | 15 | 0421 | 70 | 38:57:27 | 73:33:27 | 38:57:66 | 73:32:96 | 4.2 | 25.0 | 75 | 212 | 12.5 | 8 | |
| 3/26/2003 | 16 | 0640 | 60 | 38:57:95 | 73:32:22 | 38:58:11 | 73:33:08 | 4.3 | 27.0 | 85 | 050 | 15.75 | 11 | |
| 3/26/2003 | 17 | 0806 | 67 | 38:58:60 | 73:32:50 | 39:02:65 | 73:29:47 | 4.2 | 27.0 | 85 | 050 | 15 | 15 | |
| 3/26/2003 | 18 | 0943 | 60 | 39:03:39 | 73:29:05 | 39:07:48 | 73:27:11 | 4.2 | 29.0 | 95 | 050 | 10 | 5.5 | |
| 3/26/2003 | 19 | 1057 | 70 | 39:07:36 | 73:27:35 | 39:07:09 | 73:27:42 | 4.2 | 29.0 | 95 | 220 | 10.5 | 5.75 | |
| 3/26/2003 | 20 | 1220 | 60 | 39:06:97 | 73:27:59 | 39:07:04 | 73:27:49 | 4.2 | 29.0 | 95 | 220 | 9 | 5 | |
| 3/26/2003 | 21 | 1343 | 65 | 39:07:44 | 73:27:14 | 39:10:40 | 73:22:69 | 4.2 | 30.0 | 95 | 042 | 9 | 2.5 | Wind SW @ 25 Kn |
| 3/26/2003 | 22 | 1459 | 65 | 39:10:85 | 73:22:47 | 39:14:97 | 73:20:10 | 4.3 | 30.0 | 95 | 042 | 3.25 | 1.75 | |
| 3/26/2003 | 23 | 1617 | 64 | 39:15:23 | 73:19:18 | 39:19:31 | 73:18:70 | 4.2 | 30.0 | 95 | 040 | 10 | 6.5 | |
| 3/26/2003 | 24 | 1734 | 60 | 39:19:72 | 73:18:51 | 39:23:57 | 73:13:20 | 4.1 | 30.0 | 95 | 040 | 7.25 | 5.5 | |
| 3/26/2003 | 25 | 1847 | 60 | 39:23:99 | 73:13:07 | 39:27:74 | 73:10:87 | 4.1 | 28.0 | 90 | 040 | 7.5 | 5.5 | |
| 3/26/2003 | 26 | 1958 | 70 | 39:28:03 | 73:10:54 | 39:28:90 | 73:04:84 | 4.1 | 33.0 | 105 | 120 | 3 | 2 | |
| 3/26/2003 | 27 | 2123 | 53 | 39:28:89 | 73:04:23 | 39:27:78 | 72:59:75 | 4.2 | 34.0 | 105 | 170 | 9 | 6 | |
| 3/26/2003 | 28 | 2238 | 53 | 39:27:27 | 72:59:47 | 39:23:85 | 72:58:59 | 4.2 | 34.0 | 105 | 240 | 3.5 | 2.5 | |
| 3/26/2003 | 29 | 2345 | 60 | 39:23:45 | 72:59:00 | 39:20:66 | 73:02:95 | 4.2 | 35.0 | 105 | 247 | 5.5 | 1.5 | |
| 3/27/2003 | 30 | 0100 | 60 | 39:20:18 | 73:03:57 | 39:17:53 | 73:07:66 | 4.3 | 34.0 | 110 | 243 | 9.5 | 0 | |
| 3/27/2003 | 31 | 0214 | 61 | 39:17:06 | 73:08:29 | 39:13:04 | 73:11:80 | 4.2 | 35.0 | 110 | 243 | 8.75 | 3.25 | |
| 3/27/2003 | 32 | 0330 | 60 | 39:13:01 | 73:12:05 | 39:08:86 | 73:13:54 | 4.3 | 34.0 | 105 | 210 | 16 | 8 | |
| 3/27/2003 | 33 | 0501 | 60 | 39:08:18 | 73:13:90 | 39:05:83 | 73:18:45 | 4.2 | 32.0 | 105 | 250 | 13 | 3 | |

| | | Time | Tow Time | Start Position | | End Position | | Speed | Depth | Wire out | Vessel | Catch (bu) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | TOW # | Start | Minutes | Latitude | Longitude | Latitude | Longitude | Knots | Fathoms | Fathoms | Heading | port | stbd | Comments |
| | | | | | | | | | | | | | | |
| 3/27/2003 | 34 | 0614 | 60 | 39:05:15 | 73:18:61 | 39:01:09 | 73:20:40 | 4.3 | 34.0 | 110 | 205 | 13.75 | 8 | |
| 3/27/2003 | 35 | 0750 | 62 | 39:00:08 | 73:20:69 | 38:56:47 | 73:23:39 | 4.3 | 35.0 | 110 | 230 | 47 | 30 | |
| 3/27/2003 | 36 | 0943 | 43 | 38:55:67 | 73:23:44 | 38:52:07 | 73:23:12 | 4.3 | 33.0 | 105 | 280 | 8.5 | 13 | |
| 3/27/2003 | 37 | 1038 | 50 | 38:52:36 | 73:23:65 | 38:52:41 | 73:28:20 | 4.2 | 33.0 | 105 | 280 | | | fouled |
| 3/27/2003 | 38 | 1140 | 50 | 38:52:28 | 73:28:80 | 38:52:00 | 73:33:99 | 4.1 | 32.0 | 100 | 280 | | | fouled |
| 3/27/2003 | 39 | 1301 | 15 | 38:52:12 | 73:35:28 | 38:52:08 | 73:36:72 | 4.2 | 26.0 | 75 | 240 | | | Camera |
| 3/27/2003 | 40 | 1342 | 40 | 38:51:92 | 73:37:27 | 38:50:68 | 73:40:41 | 4.2 | 25.0 | 75 | 240 | 8 | 5.5 | |
| 3/27/2003 | 41 | 1434 | 40 | 38:50:42 | 73:40:50 | 38:48:00 | 73:42:26 | 4.2 | 28.0 | 100 | 212 | 12.5 | 5.75 | Wind calm |
| 3/27/2003 | 42 | 1525 | 40 | 38:47:78 | 73:40:42 | 38:45:36 | 73:44:20 | 4.2 | 28.0 | 100 | 212 | 7 | 6 | |
| 3/27/2003 | 43 | 1620 | 40 | 38:45:01 | 73:44:18 | 38:42:66 | 73:48:44 | 4.3 | 27.0 | 100 | 212 | 15 | 13 | |
| 3/27/2003 | 44 | 1714 | 40 | 38:42:27 | 73:46:75 | 38:39:78 | 73:48:80 | 4.3 | 27.0 | 100 | 210 | | | backjob |
| 3/27/2003 | 45 | 1820 | 45 | 38:39:72 | 73:48:11 | 38:41:25 | 73:45:10 | 4.3 | 30.0 | 105 | 120 | 11 | 8 | |
| 3/27/2003 | 46 | 1918 | 47 | 38:41:00 | 73:45:00 | 38:38:56 | 73:42:88 | 4.4 | 33.0 | 105 | 120 | 10 | 6.5 | |
| 3/27/2003 | 47 | 2018 | 47 | 38:38:23 | 73:42:20 | 38:38:02 | 73:38:73 | 4.3 | 33.0 | 105 | 120 | 12 | 10 | |
| 3/28/2003 | 48 | 0114 | 70 | 38:55:44 | 73:34:44 | 38:57:98 | 73:32:72 | 4.1 | 26.0 | 80 | 220 | 13 | 9 | |
| 3/28/2003 | 49 | 0255 | 70 | 38:57:82 | 73:33:15 | 38:57:69 | 73:30:04 | 4.3 | 26.0 | 80 | 220 | 12 | 8 | |
| 3/28/2003 | 50 | 0430 | 70 | 38:57:45 | 73:33:42 | 38:57:74 | 73:32:98 | 4.2 | 26.0 | 80 | 214 | 9.5 | 7.5 | Wind East @ 25 kn |
| 3/28/2003 | 51 | 0602 | 70 | 38:58:28 | 73:32:75 | 38:55:71 | 73:34:77 | 4.3 | 26.0 | 80 | 049 | 9 | 4 | |
| 3/28/2003 | 52 | 0726 | 60 | 38:55:77 | 73:34:47 | 38:56:74 | 73:34:35 | 4.2 | 27.0 | 80 | 080 | 14 | 11 | |
| 3/28/2003 | 53 | 0900 | 46 | 38:56:87 | 73:34:37 | 38:56:74 | 73:33:64 | 4.4 | 26.0 | 80 | 085 | 11.5 | 10 | stbd sweep turned |
| 3/28/2003 | 54 | 0959 | 46 | 38:56:77 | 73:33:43 | 38:57:01 | 73:33:62 | 4.4 | 26.0 | 80 | 080 | | | stbd back job |
| 3/28/2003 | 55 | 1058 | 50 | 38:56:91 | 73:34:30 | 38:57:35 | 73:32:37 | 4.4 | 26.0 | 80 | 080 | 12.5 | 13.5 | |
| 3/28/2003 | 56 | 1231 | 50 | 38:57:54 | 73:33:66 | 38:57:15 | 73:32:30 | 4.3 | 27.0 | 80 | 080 | 11 | 9 | |
| 3/28/2003 | 57 | 1331 | 51 | 38:57:22 | 73:32:89 | 38:57:01 | 73:32:16 | 4.3 | 26.0 | 80 | 090 | 13 | 11.5 | |
| 3/28/2003 | 58 | 1433 | 65 | 38:57:24 | 73:32:74 | 38:57:14 | 73:32:48 | 4.3 | 26.0 | 80 | 090 | 12.5 | 11.5 | |
| 3/28/2003 | 59 | 1804 | 44 | 38:58:18 | 73:33:92 | 38:55:73 | 73:35:02 | 4.2 | 25.0 | 75 | 210 | 4 | 2 | |
| 3/28/2003 | 60 | 1900 | 45 | 38:55:39 | 73:35:79 | 38:54:20 | 73:34:37 | 4.3 | 27.0 | 85 | 210 | 5.75 | 4 | |
| 3/28/2003 | 61 | 1958 | 50 | 38:54:34 | 73:37:87 | 38:54:04 | 73:31:50 | 4.3 | 28.0 | 85 | 120 | 8 | 1.75 | |
| 3/28/2003 | 62 | 2059 | 60 | 38:54:07 | 73:34:10 | 38:53:45 | 73:34:55 | 4.4 | 27.0 | 85 | 120 | 4 | 2 | |
| 3/28/2003 | 63 | 2212 | 50 | 38:53:63 | 73:35:14 | 38:58:42 | 73:34:55 | 4.1 | 25.0 | 75 | 020 | 9 | 5 | |
| 3/29/2003 | 64 | 0057 | 60 | 38:58:30 | 73:34:80 | 38:57:73 | 73:34:01 | 4.3 | 25.0 | 75 | 220 | 7.5 | 8.5 | |
| 3/29/2003 | 65 | 0323 | 60 | 38:56:83 | 73:35:50 | 38:56:42 | 73:34:69 | 4.3 | 25.0 | 75 | 190 | 8 | 5.5 | |
| 3/29/2003 | 66 | 0553 | 45 | 38:56:23 | 73:34:99 | 38:56:36 | 73:34:87 | 4.4 | 25.0 | 75 | 220 | 4.5 | 4.25 | |

| F/V Defiant Trip 2003-1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tow # | Tow Time (m) | Speed knts | Port | Control w/10-inch twine top | | | | Stbd | Experimental w/Excluder rings only | | | |
| | | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) |
| 1 | 32 | 4.5 | 9 | 4 | 125 | 6 | 4 | 9.5 | 4 | 123 | 1 | 4 |
| 2 | 31 | 4.3 | 6.5 | 2 | 163 | 3 | 2 | 6 | 3 | 160 | 7 | 2 |
| 3 | 30 | 4.2 | 5 | 3 | 70 | 4 | 2 | 3.25 | 0 | 39 | 4 | 1 |
| 4 | 32 | 4.3 | 7.5 | 8 | 150 | 2 | 3 | 7.5 | 2 | 114 | 2 | 3 |
| 5 | 36 | 4.0 | 9 | 4 | 110 | 1 | 7 | 8 | 3 | 93 | 5 | 5 |
| 6 | 30 | 4.0 | 10 | 4 | 52 | 4 | 7 | 10 | 3 | 47 | 4 | 2 |
| 7 | 35 | 4.0 | 3 | 0 | 9 | 7 | 1 | 1.5 | 0 | 7 | 5 | 0 |
| 8 | 44 | 4.1 | 6.5 | 3 | 37 | 5 | 0 | 5 | 2 | 32 | 0 | 1 |
| 9 | 35 | 4.0 | 4 | 1 | 45 | 4 | 1 | 2 | 1 | 35 | 4 | 0 |
| 10 | 36 | 4.1 | 5 | 1 | 88 | 0 | 2 | 2 | 0 | 50 | 5 | 1 |
| 11 | 65 | 4.2 | 3.5 | | | 5 | 3 | 2.5 | | | 0 | 1 |
| 12 | 70 | 4.2 | 9.5 | | | 3 | 7 | 5.5 | | | 0 | 0 |
| 13 | 70 | 4.2 | 12.5 | | | 3 | 5 | 11.75 | | | 5 | 4 |
| 14 | 74 | 4.2 | 14.5 | | | 6 | 5 | 9 | | | 9 | 9 |
| 15 | 70 | 4.2 | 12.5 | | | 9 | 5 | 8 | | | 9 | 4 |
| Average | 46.0 | 4.2 | | | | | | | | | | |
| Totals | | | 118 | 30 | 849 | 62 | 54 | 91.5 | 18 | 700 | 60 | 37 |
| Stbd vs Port dredge | | | | | | | | | | | | |
| Percent retention scallops | | | 78% | | | | | | | | | |
| Percent retention fluke | | | 60% | | | | | | | | | |
| Percent retention skates | | | 82% | | | | | | | | | |
| Percent retention monkfish | | | 97% | | | | | | | | | |
| Percent retention other flatfish | | | 69% | | | | | | | | | |
| Bycatch per bushel of scallops | | | | 0.25 | 7.19 | 0.53 | 0.46 | | 0.20 | 7.65 | 0.66 | 0.40 |

| Tow # | Tow | Speed | Port | Control w/10-inch twine top | | | | | Stbd | Experimental w/Excluder rings and fish swee | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time (m) | knts | | | | | | | | | | | |
| | | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) |
| 16 | 60 | 4.3 | 15.75 | 4 | 128 | 4 | 2 | | 11 | 7 | 93 | 4 | 4 |
| 17 | 67 | 4.2 | 15 | 3 | 120 | 4 | 1 | | 15 | 4 | 176 | 10 | 7 |
| 18 | 60 | 4.2 | 10 | 4 | 157 | 3 | 9 | | 5.5 | 2 | 59 | 7 | 5 |
| 19 | 70 | 4.2 | 10.5 | 6 | 230 | 7 | 7 | | 5.75 | 2 | 76 | 9 | 5 |
| 20 | 60 | 4.2 | 9 | 4 | 230 | 5 | 9 | | 5 | 1 | 128 | 6 | 2 |
| 21 | 65 | 4.2 | 9 | 6 | 167 | 5 | 7 | | 2.5 | 0 | 65 | 4 | 1 |
| 22 | 65 | 4.3 | 3.25 | 1 | 21 | 4 | 0 | | 1.75 | 0 | 23 | 0 | 0 |
| 23 | 64 | 4.2 | 10 | 3 | 274 | 6 | 8 | | 6.5 | 3 | 202 | 5 | 5 |
| 24 | 60 | 4.1 | 7.25 | 2 | 412 | 4 | 3 | | 5.5 | 3 | 275 | 4 | 1 |
| 25 | 60 | 4.1 | 7.5 | 6 | 301 | 4 | 0 | | 5.5 | 2 | 167 | 4 | 0 |
| 26 | 70 | 4.1 | 3 | 1 | 85 | 6 | 0 | | 2 | 0 | 35 | 5 | 0 |
| 27 | 53 | 4.2 | 9 | | | | 5 | | 6 | | | | 4 |
| 28 | 53 | 4.2 | 3.5 | | | | 0 | | 2.5 | | | | 3 |
| 29 | 60 | 4.2 | 5.5 | | | | 8 | | 1.5 | | | | 0 |
| 30 | 60 | 4.3 | 9.5 | | | | 5 | | 0 | | | | 0 |
| 31 | 61 | 4.2 | 8.75 | | | | 2 | | 3.25 | | | | 1 |
| 32 | 60 | 4.3 | 16 | | | | 12 | | 8 | | | | 4 |
| 33 | 60 | 4.2 | 13 | | | | 9 | | 3 | | | | 2 |
| 34 | 60 | 4.3 | 13.75 | 11 | | | 4 | | 8 | 5 | | | 2 |
| Average | 61.5 | 4.2 | | | | | | | | | | | |
| Totals | | | 179.25 | 51 | 2125 | 52 | 91 | | 98.25 | 29 | 1299 | 58 | 46 |
| Stbd vs Port dredge | | | | | | | | | | | | | |
| Percent retention scallops | | | 55% | | | | | | | | | | |
| Percent retention fluke | | | 57% | | | | | | | | | | |
| Percent retention skates | | | 61% | | | | | | | | | | |
| Percent retention monkfish | | | 112% | | | | | | | | | | |
| Percent retention other flatfish | | | 51% | | | | | | | | | | |
| Bycatch per bushel of scallops | | | | 0.28 | 11.85 | 0.29 | 0.51 | | | 0.30 | 13.22 | 0.59 | 0.47 |

| Tow # | Tow | Speed | Port | Control w/10-inch twine top | | | | | Stbd | Experimental w/ fish sweep only | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time (m) | knts | | | | | | | | | | | |
| | | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) |
| | | | | | | | | | | | | | |
| 35 | 62 | 4.3 | 47 | 10 | 204 | 10 | 16 | | 30 | 4 | 103 | 8 | 12 |
| 36 | 43 | 4.3 | 8.5 | 1 | 24 | 9 | 3 | | 13 | 0 | 15 | 4 | 2 |
| 40 | 40 | 4.2 | 8 | 7 | 60 | 8 | 7 | | 5.5 | 2 | 57 | 7 | 0 |
| 41 | 40 | 4.2 | 12.5 | 3 | 182 | 3 | 12 | | 5.75 | 2 | 116 | 7 | 2 |
| 42 | 40 | 4.2 | 7 | 2 | 71 | 4 | 3 | | 6 | 2 | 45 | 3 | 1 |
| 43 | 40 | 4.3 | 15 | 0 | 228 | 12 | 5 | | 13 | 1 | 164 | 6 | 6 |
| 45 | 45 | 4.3 | 11 | 4 | 179 | 6 | 3 | | 8 | 3 | 116 | 5 | 3 |
| 46 | 47 | 4.4 | 10 | 3 | 180 | 7 | 5 | | 6.5 | 3 | 85 | 6 | 3 |
| 47 | 47 | 4.3 | 12 | 0 | 60 | 9 | 0 | | 10 | 3 | 35 | 10 | 3 |
| 48 | 70 | 4.1 | 13 | | | 11 | 5 | | 9 | | | 7 | 5 |
| 49 | 70 | 4.3 | 12 | | | 10 | 6 | | 8 | | | 6 | 10 |
| 50 | 70 | 4.2 | 9.5 | | | 7 | 7 | | 7.5 | | | 11 | 8 |
| | | | | | | | | | | | | | |
| Average | 51.2 | 4.3 | | | | | | | | | | | |
| Totals | | | 165.5 | 30 | 1188 | 96 | 72 | | 122.25 | 20 | 736 | 80 | 55 |
| | | | | | | | | | | | | | |
| Stbd vs Port dredge | | | | | | | | | | | | | |
| Percent retention scallops | | | 74% | | | | | | | | | | |
| Percent retention fluke | | | 67% | | | | | | | | | | |
| Percent retention skates | | | 62% | | | | | | | | | | |
| Percent retention monkfish | | | 83% | | | | | | | | | | |
| Percent retention other flatfish | | | 76% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Bycatch per bushel of scallops | | | | 0.18 | 7.18 | 0.58 | 0.44 | | | 0.16 | 6.02 | 0.65 | 0.45 |

| Tow # | Tow | Speed | Port | Control w/10-inch twine top | | | | | Stbd | Experimental w/ 10-inch twine top only | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time (m) | knts | | | | | | | | | | | |
| | | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) |
| | | | | | | | | | | | | | |
| 51 | 70 | 4.3 | 9 | 3 | 42 | 6 | 2 | | 4 | 3 | 24 | 8 | 2 |
| 52 | 60 | 4.2 | 14 | 2 | 85 | 7 | 4 | | 11 | 9 | 100 | 7 | 1 |
| 53 | 46 | 4.4 | 11.5 | 4 | 60 | 7 | 0 | | 10 | 6 | 74 | 7 | 2 |
| 55 | 50 | 4.4 | 12.5 | 8 | 56 | 13 | 0 | | 13.5 | 5 | 83 | 4 | 2 |
| 64 | 60 | 4.3 | 7.5 | 0 | 53 | 5 | 1 | | 8.5 | 0 | 57 | 6 | 11 |
| 65 | 60 | 4.3 | 8 | 0 | 44 | 12 | 3 | | 5.5 | 0 | 40 | 11 | 5 |
| 66 | 45 | 4.4 | 4.5 | 1 | 29 | 8 | 1 | | 4.25 | 5 | 24 | 8 | 0 |
| | | | | | | | | | | | | | |
| Average | 55.9 | 4.3 | | | | | | | | | | | |
| Totals | | | 67 | 18 | 369 | 58 | 11 | | 56.75 | 28 | 402 | 51 | 23 |
| | | | | | | | | | | | | | |
| Stbd vs Port dredge | | | | | | | | | | | | | |
| Percent retention scallops | | | 85% | | | | | | | | | | |
| Percent retention fluke | | | 156% | | | | | | | | | | |
| Percent retention skates | | | 109% | | | | | | | | | | |
| Percent retention monkfish | | | 88% | | | | | | | | | | |
| Percent retention other flatfish | | | 209% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Bycatch per bushel of scallops | | | | 0.27 | 5.51 | 0.87 | 0.16 | | | 0.49 | 7.08 | 0.90 | 0.41 |

| Tow # | Tow | Speed | Port | Control w/10-inch twine top | | | | | Stbd | Experimental w/ chain fish sweep and exclud | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time (m) | knts | | | | | | | | | | | |
| | | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) | | Scallops (bu) | Fluke (#) | Skates (#) | Monk (#) | Flats (#) |
| | | | | | | | | | | | | | |
| 56 | 50 | 4.3 | 11 | 4 | 65 | 10 | 0 | | 9 | 4 | 54 | 9 | 0 |
| 57 | 51 | 4.3 | 13 | 7 | 94 | 3 | 3 | | 11.5 | 4 | 54 | 3 | 0 |
| 58 | 65 | 4.3 | 12.5 | 7 | 74 | 10 | 2 | | 11.5 | 6 | 56 | 8 | 1 |
| 59 | 44 | 4.2 | 4 | 1 | 34 | 4 | 0 | | 2 | 0 | 21 | 5 | 1 |
| 60 | 45 | 4.3 | 5.75 | 3 | 61 | 6 | 1 | | 4 | 0 | 46 | 5 | 1 |
| 61 | 50 | 4.3 | 8 | 5 | 98 | 5 | 2 | | 1.75 | 1 | 42 | 4 | 2 |
| 62 | 60 | 4.4 | 4 | 4 | 74 | 3 | 3 | | 2 | 0 | 28 | 6 | 0 |
| 63 | 50 | 4.1 | 9 | 0 | 70 | 5 | 3 | | 5 | 0 | 47 | 6 | 1 |
| | | | | | | | | | | | | | |
| Average | 51.9 | 4.3 | | | | | | | | | | | |
| Totals | | | 67.25 | 31 | 570 | 46 | 14 | | 46.75 | 15 | 348 | 46 | 6 |
| | | | | | | | | | | | | | |
| Stbd vs Port dredge | | | | | | | | | | | | | |
| Percent retention scallops | | | 70% | | | | | | | | | | |
| Percent retention fluke | | | 48% | | | | | | | | | | |
| Percent retention skates | | | 61% | | | | | | | | | | |
| Percent retention monkfish | | | 100% | | | | | | | | | | |
| Percent retention other flatfish | | | 43% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Bycatch per bushel of scallops | | | | 0.46 | 8.48 | 0.68 | 0.21 | | | 0.32 | 7.44 | 0.98 | 0.13 |