Testing of a Sea Scallop Dredge Dual Mesh Size Twine Top For Bycatch Reduction

Final Progress Report
Prepared for the 2009
Sea Scallop Research Set-Aside

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Project Summary

This project set out to test a dual mesh twine top design to further decrease fish and skate bycatch. The initial twine top design had three rows of 6-inch mesh at the aft end where scallop losses have been shown to occur in standard New Bedford dredges. The remaining forward section of the twine top, where fish attempt escape, was 12-inch mesh. The twine top was hung with a low hanging ratio of one 12-inch mesh to each 4-inch skirt ring. The design changes were tested on the Cfarm excluder dredge frame. The primary testing took place on Georges Bank, in areas of high yellowtail bycatch, and the mid-Atlantic, in areas of high summer flounder bycatch. Six trips were made comparing two identical turtle excluder dredge frames; one with a standard bag and twine top and the other with an experimental twine top and/or other modifications. Additional design changes, not originally in the work plan, were tested when it became apparent that the dual mesh twine top may not significantly reduce fish bycatch when rigged on the Cfarm excluder dredge frame. Tests were also conducted on the influence of turtle chains on fish bycatch rates for the new excluder dredge. This is a progress report; analysis has not been completed on much of the data. Conclusions are preliminary.

Financial Summary

Date:	Description:	Amount:	Scallops
			pounds
9/3/2009	F/V Westport	$35,314.98	18738
9/23/2009	F/V Westport	$31,791.25	13885
10/2/2009	F/V Kathy Ann	$39,724.29	19456
10/8/2009	Nice Glide Fishing, LLC	$32,357.00	
10/23/2009	F/V Tradition	$42,688.93	21966
10/26/2009	Nice Glide Fishing, LLC	$42,372.41	22697
10/29/2009	F/V Celtic	$37,012.01	22491
1/18/2010	F/V Celtic	$33,745.01	13868
	Total:	$295,005.88	133101

Introduction

Bycatch of yellowtail flounder in the scallop fishery is governed by a hard TAC when fishing occurs in the scallop special access areas on Georges Bank. On a number of occasions the bycatch TAC has been taken before the scallop TAC and the areas have been closed resulting in the loss of tens of millions of dollars in revenue to the fishery. As more fisheries are managed with hard TACs similar problems will arise with summer flounder, winter flounder, and skates throughout the range of the fishery.

Coonamessett Farm research efforts to date have demonstrated that the use of a 10-inch mesh twine top can reduce the catch of flatfish, on average, by about 50-60% compared to the historical standard 6-inch twine top (Smolowitz et al, 2001, 2002, 2004). This reduction can be accompanied by a 10-20% reduction in scallop catch. The loss of scallop catch results in the need for increased bottom time which mitigates some of the bycatch reduction benefits and other benefits possibly associated with decreases in bottom time. The loss of scallop catch and bycatch through the 4-inch rings and 10-inch twine top is related to weather conditions as well as the length frequency distribution of the catch. Past video work has shown loss of scallops occurs through the aft end of the twine top just forward of the sweep during tows and haulback.

Background

SER Enterprises of New Bedford, with Coonamessett Farm and MIT Sea Grant, received an S-K Grant in 1994 to develop and demonstrate techniques to eliminate or reduce the by-catch of fish in the New Bedford style scallop dredge. Several dredge modifications were field tested to determine their impact on scallop and fish catch. This initial work demonstrated that an 8-inch square mesh twine top can significantly reduce the catch of flatfish and cod without reducing the catch of commercial size scallops when catch rates are low. Ten inch mesh twine tops were shown to reduce the bycatch further but with a loss of scallop catch (Henriksen et al, 1997).

Coonamessett Farm, and its industry and academic partners, have continued research into means to further reduce bycatch. These projects lead to the development of a new scallop dredge frame design concept that allows for a sweep to be located across the entire width of the dredge in front of the cutting bar. Preliminary trials on the F/V Generation and F/V Westport indicated the new dredge caught between ten and twenty percent more scallops. When rigged with a fish sweep the catch has thirty to forty percent less flatfish and skates than a conventional dredge rigged with a 10-inch twine top, but scallop catches were also reduced. This dredge design works by forcing the fish up off the bottom in front of the frame. The reductions have occurred because some of these fish then swim over the dredge. One major problem was that the fish sweep testing showed highly variable results.

Modifications to the scallop dredge twine top were tested during the 1998 industry survey of the Georges Bank CAII (Dupaul et al 1999). The results of the experiments indicated that there were no differences in finfish bycatch when 8 inch diamond and 8 inch square mesh twine tops were compared. However, there were significant differences in finfish bycatch when a 12 inch square mesh was used but the loss of scallops greater than 70 mm (23 %) was considered unacceptable.

During July and August 2002 the F/V Westport and F/V Nordic Pride conducted four research trips to closed and opened areas of Georges Bank. A total of 311 paired tows were made to test the new scallop dredge frame, 10-inch twine tops, and the use of fish sweeps and excluder rings. The project demonstrated that 10-inch twine tops, when compared to 6-inch twine tops, reduced yellowtail flounder bycatches by 34-84% with an overall weighted average of 59%. The largest reductions of bycatch were also accompanied by a 51% loss of scallop catch. The tests also demonstrated that the fish sweep was effective in reducing bycatch by about 42%. The impacts of the various reduction strategies (twine top mesh size, dredge frame design, fish sweep, excluder rings) have proven not to be cumulative but are in fact interactive. Again, results were highly variable.

What became apparent by the end of the tests is that the most important twine top parameters are associated with mesh size and how the twine top is hung. Changing the width and length of the twine top alters both scallop and flatfish retention. When the number of meshes in the width of the twine top was decreased (lower hanging ratio) more scallops and fish escaped. However, regardless of the number of meshes, if the twine top is installed so that it is under high tension, resulting from too many meshes being removed, escapement does not occur. The length of the twine top is also very important for scallop retention; key factors being the twine top location relative to the sweep chain and the tension in the meshes. Fishermen rig their gear so that the twine top ends just above the center of the sweep. The belief is that a twine top that ends further aft, behind the sweep, allows more scallops to be lost through the meshes. Twine tops ending forward of the sweep, reduce the bag opening (due to weight of the apron rings), forcing scallops under the sweep reducing catch as well.

A review of all our experimental data collected through 2002 indicated high variability in the results due to many factors beyond dredge rigging. These factors include area fished, scallop and bycatch length frequency, scallop and bycatch density, tow direction, and weather. Weather is extremely complicating because it alters in multiple ways how the gear is handled. Rough weather conditions cause more fish and scallops to wash out of the dredge but at rates that are different depending on which side of the vessel the dredge is being fished. The weather dictates the tow direction and prohibits switching the dredges between sides hence risking an experimental bias.

During October 2003, the F/V Westport and F/V Kathy Marie completed 253 tow pairs to the same areas as in 2002 described previously. The primary objective was to understand the factors that were causing the variability in the previous test results by holding as many parameters as possible constant. Briefly, the two vessels participating in the experiment used the same dredge frame on both sides, used identical 10-inch twine tops rigged identically on the experimental side, had the same rigging for the control dredge, fished the same test areas as the previous year, and kept towing speed constant (though each vessel towed at a different speed). The effects of scallop length frequency distribution and weather were apparent and were statistically analyzed. In an area with very large scallops, there was no scallop loss between a 6-inch and a 10-inch twine top while flatfish catches were reduced by about 50%. In areas of smaller scallops there was about a 20% loss of scallops with about a 70% loss of flatfish. A test of blocking the last few rows of the 10-inch twine top found that the scallop loss was reduced substantially but there was still considerable escapement of fish. This, in combination with past video work, indicates that a dual mesh twine top may be very advantageous to achieving the goal of scallop retention and fish escapement.

In 2005 Coonamessett Farm received RSA funds to develop a new turtle excluder dredge incorporating improvements to the design that in all likelihood will reduce sea turtle injury and mortality. In 2006 an RSA proposal was approved to continue to design and test this new dredge frame concept that would reduce the capture and retention of sea turtles, skates and flatfish species. The 2006 RSA project utilized tow tank testing for cutting bar hydrodynamics and computer modeling for frame component design. Besides reducing bycatch of yellowtail (50% reduction) and summer flounder (30% reduction), the new turtle excluder dredge has been shown to reduce threat of injury to sea turtles, maintain scallop catches and hold up to the rigors of fishing (Smolowitz and Weeks, 2008; Milliken et al, 2007)). A 2007 RSA project continued the field testing of this dredge. Preliminary results from these recent field tests indicate that larger twine top meshes may further reduce the bycatch rates of skates and summer flounder if we can also reduce the loss of scallops. This project started out by testing a dual mesh size twine top design for the Cfarm turtle excluder dredge.

A recent study on the effect of scallop dredge twine top hanging ratios (Milleville 2008) found a significant reduction of finfish bycatch when a 60 mesh twine top was compared to a 90 mesh twine top (1.76 vs 2.64 hanging ratio). The reduction in finfish bycatch remained positive when considering varying degrees of scallop catches but this may not be the case when bycatch species are more abundant and scallops are less abundant. The results of this study indicate that standardizing the hanging ratio of the twine top at 2 could be an effective counter to hanging ratios of 3 or higher for the reduction of finfish bycatch. However, there are many ways a fisherman can alter his gear to negate the impacts of various hanging ratios. In the same series of experiments, it was found that short twine tops (5.5 meshes long and an apron of 13 rings) where the sweep chain was located aft of the bottom meshes of the twine top had a significantly greater catch of finfish as opposed to larger twine tops (8.5 meshes long with an apron of 7 rings) where the sweep was located forward the bottom meshes..

Concurrent with this research project, comparison fishing data between standard New Bedford dredge frames and experimental excluder dredge designs were being analyzed. Overall the experimental dredge design concept (cutting bar forward of depressor plate, 45° cutting bar and strut angle at, reduced number of bale bars) increased the catch of scallops while decreasing the retention of important bycatch species. Of the 1,632 observed tows analyzed relative to the standard New Bedford dredge, the experimental dredges increased scallop catch by 3% ($P_t = 0.0000$) while having significant decreases in summer flounder(-11%, $P_t = 0.003$), yellowtail flounder (-46%,

P_t=0.0000), winter flounder (-69%, P_t=0.0000), barndoor skate (-18%, P_t= 0.0000), winter skate (-20%, P_t = 0.005), sand dab (-47%, P_t=0.0000), and fourspot flounder (-20%, P_t=0.0000). Interestingly there were no significant difference in the catch of little skate (-0.3%, P_t = 0.404), and monkfish (1%, P_t = 0.309) along with a significant increase in one species, the American plaice (+14%, P_t = 0.0000). The final dredge frame design that evolved from this process is referred to as the Cfarm excluder dredge.

Methods

There were three types of trips during this project; directed bycatch research with no retained catch, combined bycatch research/compensation, and straight compensation trips collecting data on turtle interactions. The testing occurred over a 6 month period onboard 12 trips, using 5 vessels (Table 1). Six of the trips were compensation trips that compared a standard dredge to the Cfarm excluder dredge, both rigged without turtle chain mats, in the Mid-Atlantic during turtle season. These trips were not analyzed as a part of this project however the results of the comparison are attached to this report as Addendum A. . Two trips were compensation trips into CAII and data was also collected on the twine top comparisons. Four trips were dedicated research trips that compared two turtle dredges; one as a control and one modified. Comparative fishing occurred under typical commercial operations and a variety of weather conditions. Tow times averaged between thirty and sixty minutes depending on location and tow speed ranged between 4.5 and 5 knots. All experimental and control dredges measured 4.6 m wide and on each vessel were fished with identically configured chain bags except where noted. Every dredge used during the testing conformed to existing fishing regulations with the exception of twine top size. Gear was switched between the vessel's sides approximately half way through each trip, or in the middle of a lengthy tow series, in order to mitigate potential bias resulting from being fished on one particular side.

Both the control dredges and experimental dredges were deployed, towed, and retrieved simultaneously while using identical scope. Tows parameter data was collected on tow location, speed, scope, heading, weather, and sea conditions for each tow. One or two trained fisheries observers onboard the vessel collected actual counts and size measurements of both targeted and non targeted catch. After a tow, the catch from each dredge was separated by species category (Table 2) and individually counted; scallop catches were recorded as bushels (bu = 35.2 liters). A one bushel subsample of scallops was measured in 5 mm increments from most tows. When the fisheries observer(s) were off watch, the vessel's crew was responsible for recording tow parameter data as well as bushel counts of kept scallops.

Testing was conducted in many different locations and fishing grounds. The Georges Bank Scallop Access Area CAII is primarily a flat sand substrate, low currents, and with large concentrations of larger sized scallops and yellowtail flounder. Georges Bank Scallop Access Area CAI is a more complex substrate with dense patches of scallops, few yellowtail, but larger populations of winter flounder. In the Mid-Atlantic, the Elephant Trunk Access Area (ETAA) and the Delmarva Access Area (DAA) are primarily flat sand bottom with dense scallop concentrations, few fish, and dense patches of benthic organisms such as sand dollars. Skates are common in all areas.

Analysis

Data were analyzed to determine differences in catch rates between dredges of target and non-target species. Both parametric and nonparametric matched pairs tests were used to assess the results of all observed tows conducted by each dredge modification. A paired Student t-test at the alpha=0.05 level was used to test for significance in catches between the control and experimental gear. This assumes that the catches are normally distributed which may not be the case where total counts of individual species were low (below 100 observations). In addition to the paired t-test, a Wilcoxon matched pairs test was performed to avoid assumptions such as homogeneous distribution of the resource. Catch ratios for each dredge were calculated in order to compare the total count of each bycatch species per a kept scallop bushel. Multivariate problems will inevitably exist due to weather and geographic variability but the experimental design of this study limited the variance between gears by pairing tows and using newly constructed gear.

Trip Details

The first research trip departing August 6, 2009, Celtic 2009-2, conducted tows in both CAI and CAII on Georges Bank. The control dredge was outfitted with a nominal 10-inch mesh twine top hung 60 meshes across (2:1) and was 8 meshes long attaching to a 3-ring skirt at the frame and to an 8-ring apron attached to the clubstick. The experimental dredge utilized a dual mesh twine top with 5 rows of 12-inch mesh hung 40 meshes across at the frame and 3 rows of 6-inch mesh hung 80 meshes across attached to the apron.. After 30 tows it was determined that the larger mesh twine top was not functioning as expected. A check of the nominal 10-inch twine top found that in fact it was 11.5-inches (stretched mesh); not very different from the 12-inch. The remainder of the trip was then dedicated to short tests of different options to identify other promising option for future testing.

The second trip was Westport 2009-2 departing on September 15, 2009 for CAII; this was a combined compensation and research trip. A total of 85 tows were conducted towing both day and night. Scallop catches were recorded from all tows; complete catch sampling was obtained from 42 tows. The research purpose of this trip was to compare an excluder dredge rigged with a turtle chain mat against a 3 x 3 chain mat.

Trips three and four, Tradition 2009-1 and Celtic 2009-3, were conducted together departing on September 30, 2009 for CAI and CAII. The two vessels fished in close proximity to each other but seldom paired with each other. Both vessels began fishing in CAI comparing the dual mesh (12 and 6) twine top against the standard 10-inch twine top as in the first trip (Celtic 2009-2). Both vessels fished identical rock chains on all dredges. Both vessels were then re-rigged to test turtle chains versus a standard 3 x 3 chain mat and using the 10-inch twine top in CAII.

Trip five, Kathy Ann 2009-8, sailed on November 7, 2009 out of Barnegat Light, NJ and conducted a total of 52 tows during 3 days at sea (cut short due to weather). The goal of the trip was to test two different bag and twine top configurations on the Cfarm excluder dredges in hope of gaining insight on possible mechanisms to reduce the bycatch of summer flounder in the mid Atlantic during late fall. The 40 minute tows were conducted at depths and in fishing grounds outside the scallop access areas along NY and NJ where the captain had recently heard of fluke being caught or had witnessed fluke bycatch in the past. The crew and 2 observers completely sorted and sampled each tow. Since this was not a commercial trip, all catch was immediately returned to the sea.

The experimental dredge on Kathy Ann 2009-8 received a series of iterative concept modifications during the trip starting with tow 33. Each test was a considered a proof of concept test. Due to the limited amount of time for the sea trails, each modification could not be tested extensively enough to be statistically robust. However, modifications that seemed to have potential for shedding light on how the dredge captures bycatch or showed a decrease in bycatch levels, were allocated more tow time. The concepts tested were developed in a collaborative effort between the scientific crew and fishermen on the Kathy Ann.

The last trip, Celtic-2010-1, sailed for a 14,000 compensation/research trip to Closed Area II on January 8, 2010 out of New Bedford, MA. The vessel conducted a total of 116 tows during 10 days at sea; 46 tows were fully sampled. The primary research goal of the trip was to test a dual mesh twine top for effectiveness in reducing yellowtail flounder bycatch. A secondary project undertaken during this trip included the testing of a newly developed dredge mounted camera system. The camera system was to be deployed on the dredge during regular commercial operations in order to observe fish behavior and gear characteristics during a typical commercial fishing effort.

A single treatment was tested during this entire trip. The experimental dredge was rigged with a dual mesh twine top, 16-inch and 8-inch, which was compared to a 10-inch twine top. Both dredge frames were identical Cfarm excluder dredges and each chain bag had the same configuration. The dredge equipped with the duel mesh twine top was designated the experimental dredge while the 10" twine tip dredge considered the control. Figures 1 and 2 show the dredges used in the comparison and Figure 3 gives a detailed view of the experimental dual mesh twine top used.

Results

Celtic 2009-2

Data collected on Celtic 2009-2 (**Table 3)** shows that the two dredges, with different twine tops, fished about the same on scallops. For scallops under the size of 100mm the starboard dual mesh twine top caught 211 scallops versus 297 for the control nominal 10-inch twine top. This may indicate a slight tendency to scallop size selection. **Table 4** shows that when the twine tops were switched between dredges that the scallop catch remained the same between the gears. We assume from this that both dredge frames were fishing the same.

Table 5 is the scallop catch in bushels for tows 2-34 combined comparing the dual mesh twine top hung 40 wide by 3 long (6-inch) x 5 long (12-inch) versus the 10-inch twine top (hung 60 x 8). Again, the scallop bushels in the experimental were slightly higher possibly indicating larger scallops being caught. There is an indication that the dual mesh twine top retained more winter skate, barndoor skate and YT while releasing more fluke under the conditions of this test.

A fish sweep of 5/8” diameter chain was placed in front of the dredge frame to raise fish up before the cutting bar. **Table 6** shows that the fish sweep may be effective in reducing the catch of skates but may also increase the catch of YT and possibly scallops. This test starts to raise the supposition that the more ticklers/sweeps added the higher the catch of YT. Turtle chains consist of 7 ticklers and thus may impact YT catch.

To understand the impact of placing a sweep in front of the cutting bar, the space between the cutting bar and depressor plate was blocked. **Table 7** is the catch results of the experimental gear, with the fish sweeps, having the space between the cutting bar and depressor blocked with twine mesh. The mesh openings in the twine were not uniform and could easily allow small scallops, skates and flats to pass through. Even so, the results indicate that when using a sweep in front of the cutting bar, scallops and bycatch species are “kicked” up and fewer pass into the dredge below the cutting bar. We had to discontinue the use of the twine mesh as a blocking material because it was too flexible thus there was no control of the size opening.

Table 8 represents the catch after the twine blocking was removed and the opening between the cutting bar and depressor was blocked by welded 4-inch rings. The fish sweep was removed. The metal rings were more effective than the twine in blocking the opening. The experimental dredge with blocking may have seen a reduction in scallops and YT but not as much when compared to when a fish sweep is present.

At this point it was noted that both a forward fish sweep and blocking on the dredge frame could impact scallop and yellowtail catch and would be good candidates for future research. However, the dual mesh twine top was still the focus of concern; the issue being the mesh size was too small. To gain some insight, holes (windows) were cut into the dual mesh twine top. **Table 9** presents the catch data when two windows were added to the experimental dredge; one on each side cut out of the 6-inch mesh 3 meshes by 3 meshes. The resulting impact on catch was limited; however there may have been a reduction in little skate.

Table 10 represents the catch when an additional three windows were cut in the 6-inch twine to make a total of 5 windows. There was a large reduction in skate and YT accompanied by a loss of scallops. We then replaced the twine top with the windows with a new 12 inch twine top from skirt to apron 40 meshes across vs 10-inch hung 60 meshes across. We left the three rows of 6-inch mesh hanging free. The twelve inch twine top resulted in a loss of scallops, little skates, and YT (**Table 11**).

We then folded the 6-inch mesh back over the 12-inch mesh and laced it down to form three pockets. The 6-inch mesh cut the loss of scallops and may still have allowed for a reduction in skates and YT (**Table 12**). While the pockets clearly demonstrated scallops were being lost at this location, they were not a good operational solution. The next test involved placing escape holes in the side pieces by removing a section of rings on each side (3 x 4 rings). Opening the side panels seemed to allow more fish and skates to escape without a corresponding loss of scallops (**Table 13**).
At this point we removed the ring blocking between the cutting bar and depressor plate. There was no clear indication of any changes other than possible increase in little skates (**Table 14**).

Next we laced the 6-inch mesh down tight on the 12-inch twine top and cut two windows in the 12-inch mesh just above the 6-inch mesh. Generally we are seeing a reduction of fish with this combined treatment with a possible slight loss in scallops (**Table 15**). Testing was cut short due to vessel problems and we had to terminate the trip and return to port before we could conduct replicates of the most promising modifications.

<u>Westport 2009-2</u>

Table 16 presents the data from Westport 2009-2, a combined research and compensation trip; there were 42 fully sampled tows. The turtle chain equipped dredge caught 14.5% fewer scallops and about the same amount of yellowtail flounder; this resulted in a higher yellowtail catch rate per bushel of scallops. Table 17 examines day/night differences in catch. The ratio of yellowtail to scallops seems to be higher during the day than at night.

<u>Tradition 2009-1 and Celtic 2009-3</u>

Table 18 presents the results of the dual mesh comparison trials for Tradition 2009-1 and Celtic 2009-3. There were few yellowtails in CAI but some of the Tradition's tows were made in CAII which provided some yellowtail catch. Table 19 presents the combined dual mesh trials from CAII with the higher yellowtail catches. Results were similar to the first test of the dual mesh with the addition of the potential reduction of scallop catch.

Both vessels were re-rigged to test turtle chains versus a standard 3 x 3 chain mat and using the 10-inch twine top in CAII. Table 20 presents the results of the Celtic tows. The chain mats were switched between dredges after tow 52. Indications are the turtle chains may increase the catch of yellowtail similar to the Westport results. On the other hand, Table 21, has the results of 19 tows from Tradition 2009-1 (chains switched between dredges after 10 tows) showing a decrease in yellowtail catch rates compared to the 3 x 3 chains. The Tradition 2009-1 conducted nine tows comparing the rock chain matt used in CAI against the 3 x 3 chain mat used in CAII; the test was in CAII (Table 22). The results indicate that the rock chains increased the efficiency of the dredge on scallops and yellowtail but the yellowtail per bushel of scallops decreased. To test the impact of tickler chains thirty tows were conducted on the Tradition comparing a dredge with just the three up and down chains (no ticklers) against a turtle chain mat. The results shown in Table 23 indicate that the removal of the ticklers reduced the catch of scallops and yellowtail but kept the ratio the same.

Kathy Ann 2009-8

The primary treatment (Treatment 1) tested during Kathy Ann 2009-8 was a comparison of an excluder dredge frame rigged with a 7 ring apron and 60 meshes across twine top fishing alongside a identical excluder dredge frame with a 9 ring deep apron with 80 meshes across twine top (Figures 4 and 5). Other than the apron and twine top, all other bag and dredge frame configurations were identical. Neither dredge was fished with rock, tickler, nor turtle chains. The 7 ring apron bag was designated the control dredge and the bag with 9 rings in the apron considered the experimental dredge. A total of 6 different integral “proof of concept” tests were conducted during theses sea trials. Treatments 1 thru 5 were made to the experimental dredge, with Treatment 6 the sole change to the original configuration to the control dredge.

Treatment 1, paired tows 1 – 32, was conducted over two days with no changes to the original treatment to the experimental dredge. These tows were conducted in a variety of depths and areas between New Jersey and New York while in search of areas of a concentration of fluke. After the first two days is was apparent that the experimental dredge was catching significantly more scallops as well as little skates. Although there was a decrease in the bycatch of summer flounder during these tows, the catch rate per a tow was not large enough to determine if the decrease was significant. Results from tows with Treatment 1 are provided in Table 24.

Treatment 2, the next modification to the experimental dredge, was a dramatic change from any previously conducted test, with the goal of discovering a modification that dramatically reduces bycatch while maintaining scallop catch levels. Treatment 2 entailed removing the entire twine top and replacing it with a regulatory complying turtle chain mat. Figure 6 shows photos of this “chain top” modification. The control dredge remained unchanged. The intention of this drastic change was to determine how effectively the twine top functioned in retaining scallops and releasing bycatch. The turtle chains were intended to function as an integrated feature to the chain bag by supplying the support need to allow the bag to retain the proper shape need to fish correctly.

The hypothesis was that the catch of both scallops and bycatch would be significantly reduced relative to the control dredge because of the 14" square spaces now in place where the twine top had been. This hypothesis was proven true with the resulting 75% decrease in both the catch of little skate as well as scallops. These poor catch rates likely resulted from the bag not opening up properly because of the weight of the chain top and/or the catch being lost through the large 14" square spaces in the top of the bag. Complete results from Treatment 2 are available in Table 25. It was also noted that the amount of bottom debris brought up in the catch was noticeably more in the control dredge than in the experimental dredge. The experimental dredge came up much cleaner than the control. With this expected extreme drop in catch rates obvious after 2 tows, the testing of Treatment 2 was promptly halted.

Treatment 3 was then implemented starting with tow 35. This third treatment retained the chain top from the previous trial with addition of 2x60 10" meshes from the old twine top attached from the forward part of the apron and to the second cross chain on the chain top. Figure 4 shows the meshes in place on the experimental dredge. The results from Treatment 3 were much better than expected. The modified dredge caught 11% more scallops over the course of 7 tows, and consistently caught more or equal number of scallops during each tow compared to the control dredge. This is a surprising increase compared to the decreased catch rates observed during the previous treatment with a similar design. However with this increase in scallop catch came a 6% increase in little skate bycatch. When the catch ratio of little skate catch per bushel of scallops is taken into account the bycatch rate was -5% relative to the control dredge. This Treatment 3, known as the "Mat Kite Top" was developed to test the theory that much of the scallop catch loss from Treatment 2 occurred around the area immediately forward of the apron. This treatment was also created with the goal of the twine meshes aiding in opening the bag up by catching the water and functioning as a kite, thus opening the back of the bag up and keeping it from collapsing.

With the unexpected success of Treatment 3's ability to retain scallops at an acceptable level, attention was turned to reducing the bycatch of little skate while maintaining the Mat Kite Top concept. Using the limited time and materials available onboard, it was decided that an iterative test of the placement of a single ticker chain should be conducted starting with Treatment 4. A 5/8" sweep chain was used was used as the tickler chain, which is much heavier than that typically applied for ticklers. The first position of this "tickler sweep" was aft of the frame attached to the back of the shoes as tight as possible.

A dramatic loss of 59% of the scallop catch and 41% of the skate bycatch was observed in the experimental dredge using Treatment 4. After 2 tows of unacceptable levels scallop catch rates in the experimental dredge, Treatment 4 was abandoned and a new position of the tickler sweep was employed.

Treatment 5 followed the iterative trial/error test concept, the ticker sweep was moved forward on the dredge, so that it was forward of the frame. The chain was hung in 2 bites, with one end of each bite connected 6" forward of the extension on the outer bail and the other end attached at the same distance to the frame on the center bail. The tickler sweep had enough links so that it hung just forward of the cutting bar. A large increase of 61% more scallop catch in the experimental dredge relative to the control resulted from the application of Treatment 5. The experimental dredge caught more scallop during all 4 tows with Treatment 5. However, once again this gain in scallop catch was paired with an increase of 13% more skate bycatch. Again, when compared in terms of catch ratios, the experimental dredge caught 30% less skate per bushel of scallops.

With the success of treatment 5 and worsening weather conditions, one last quick test was conducted during Treatment 6, this time to the control dredge. The crew's shock that Treatment 5 was leading to increased catch of scallops, lead them to want to make the next modification in the iterative proof of concept testing of the tickler sweep placement on the control dredge. Another sweep tickler, identical to the one on the experimental dredge was placed on the bail of the control dredge. The placement on the bail was forward 1' relative to the sweep tickler placement on the experimental dredge to which it was compared.

Interestingly, both tows conducted with the sweep tickler place forward on the bail of the control dredge resulted in a 120% increase in scallop catch relative to the experimental dredge. As with previous tests, there was also an increase in the catch of little skate, although the level of increase was not consistent between the two tows.

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Catch results from this trip, using the 16-inch/8-inch dual mesh twine top, are available in Table 26. No operational difficulties were incurred from the use of the experimental twine top. In total there was no significant change in scallop catch, with experimental dredge catching 1,325 bushels and the control 1,289 (2.7% difference, p=0.079) during all good tows and 522 and 515 respectively during observed tows (-1% difference, p =0.269). There was however a significant increase in bycatch of several species, including: little skate (10%, p =0.000), winter skate (5%, p =0.192), and sand dab (7%, p= 0.0379). There was no significant difference observed in the catch of yellowtail flounder. Other species caught during the trip, but not in large enough numbers to determine a detectable difference, include fourspot flounder, summer flounder, winter flounder, sea raven, barndoor skate, and monkfish.

The camera system was tested during 3 tows towards the end of the trip during days with relatively fair weather. A robust camera system housing and dredge mounting system was constructed by the crew prior to sailing. Photos of the dredge mounted camera system are provided in Figures 5. The entire system worked extremely well and over 3 hours of good quality footage was obtained of the experimental dredge fishing at

35 fathoms. Two different camera angles were used, one with the camera mounted on top of the dredge frame at the port corner looking aft across the twine top. The second was with the camera placed on top and in the middle of the dredge frame, facing down and forward at an angle that allowed fish being overtaken by the bail and cutting bar to be viewed. The first camera angle with the view of the twine top, showed no fish escaping through the large meshes and most of the dust cloud starting around the back section of the twine top. The forward looking view showed several different fish behaviors. In several instances the fish did not move or attempt to escape from the dredge's path. Some attempted to escape, only to swim the wrong direction right into the dredge. Others attempted to swim to the sides only to be overtaken by the fast moving dredge. The few that managed to avoid catch only did so because they happened to be toward the outside of the dredge's path and facing the right direction away from the dredge. A number of fish were observed attempting to evade capture by swimming up into the water column and over the dredge frame (Figure 6). The speed of the dredge makes speciation of individual fish recorded on the camera difficult.

Discussion

The project set out to test a dual mesh twine top concept based on observations from previous testing using a standard New Bedford style dredge frame. In this project the twine tops were tested on Cfarm excluder dredge frames. The testing of the dual mesh twine tops on the Cfarm excluder dredge was not as successful in reducing bycatch as we hoped. Analysis that was underway on another project comparing the standard New Bedford dredge to the new Cfarm excluder dredge was finding a significant reduction in fish bycatch with the excluder dredge which may be attributed to the forward cutting bar design. In past tests we found fish bycatch reductions resulting from forward positioned fish sweeps were not cumulative with reductions engendered by larger twine tops. This may in fact be what was occurring here with the Cfarm excluder dredge.

Underwater video taken with the dredge mounted camera during Celtic-2010-1 captured numerous yellowtail flounder reacting to the Cfarm excluder dredge's forward positioned cutting bar. A number of fish swam upward when contacting the bar and either went into or over the dredge frame. In the standard dredge, if the same behavior occurs when contacting the cutting bar, it is highly unlikely the fish would go over the dredge frame as the depressor plate blocks this exit. However, the fish would be in a good position to attempt an escape through the twine top. However, a significant amount of yellowtail went under the cutting bar.

The first set of comparisons had one dredge with a standard 10-inch twine top hung with 60 meshes across and one with the dual mesh twine top hung 40 meshes across. On the first trip, after a series of 34 tows, it became clear that the dual mesh twine top was not reducing the bycatch of fish or retaining more scallops as anticipated. Upon measuring the standard 10-inch twine top we found that it actually measured 11.5-inches; only 0.5 inches smaller than our large mesh of the dual mesh twine top. In effect, the two twine tops had virtually the same large mesh size. The key differences were that the dual mesh was hung tighter and had smaller mesh just in front of the apron. The dual mesh may retain 5% more scallops, retain more YT, and release fluke. Given the poor results of the dual mesh in the preliminary trials we decided to test a variety of options in combination with each other to see what combinations may be worth testing under amore rigorous approach.

When we used a 14-inch turtle chain mat in place of the twine top we had significant loss of scallop catch. When we covered the chain mat openings closest to the apron with mesh catch increased. When the 16-inch dual mesh twine top was tested there was virtually no change in scallop or yellowtail catch. Again, fluke seem to be able to get out through the larger mesh twine tops. All this information combined may indicate that the increased tension in the meshes that occurs when going to larger mesh sizes, due to fewer meshes taking the load, makes it difficult for the weaker yellowtail to escape.

When we cut windows in the twine top forward of the sweep this result in loss of both scallops and yellowtail without significantly changing the ratio of catch to bycatch. Inversely, blocking the area in front of the sweep with smaller meshes retains more scallops and fish maintaining the same catch ratio. It may be worthwhile to attempt reducing the tension in the twine top mesh by running some up and down chains between the apron and skirt. Using a longer apron or dual mesh twine top with this configuration should retain more scallops but the impact on yellowtail would still be questionable. Opening up holes in the ring bag side pieces seemed to show promise in reducing yellowtail catch without significant loss of scallops. This is an area that can use more study.

The use of chain sweeps forward of the cutting bar impacts catch in significant ways. Most of the catch of scallops and fish enter the dredge under the cutting bar. A sweep forward of this position kicks up scallops and fish increasing the percentage that enter the dredge above the cutting bar; some go over the dredge entirely. So far we have not found a consistent way to use this knowledge to increase or maintain scallop catch while reducing fish bycatch. More studies are needed to test the sensitivity and effectiveness of different placements of the tickler sweep on the bail. Experimental trials during this study seem to indicate that the further forward the sweep tickler is, the better the catch of scallops.

The use of turtle chain mats, and other chain configurations, in the bag have mixed results. There is an indication that turtle chains can result in higher yellowtail counts per bushel of scallop catch. There is a need for additional testing in areas of high yellowtail bycatch.

This is a final progress report for this project but additional analysis is planned and there is still a large amount of video to be viewed. A scientific report, utilizing the results of this study and other studies, will be written in the near future.

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Table 1: Research trips undertaken

Vessel Trip ID	Trip Type	Gear Comparison	Departure Date	OPS Area	Scallop Catch (lbs)	Tow #
F/V Celtic 2009-2	Research	Twine Top	8/6/09	CAI/CAII	0	66
F/V Westport 2009-1	Compensation	Dredge	8/24/09	ETAA	18738	122
F/V Westport 2009-2	Compensation	Twine Top	9/15/09	CAII	13885	85
F/V Kathy Ann 2009-7	Compensation	Dredge	9/18/09	ETAA	19348	239
F/V Tradition 2009-1	Research	Twine Top	9/29/09	CAI/CAII	0	86
F/V Celtic 2009-3	Research	Twine Top	9/29/09	CAI/CAII	0	80
F/V Diligence 2009-3	Compensation	Dredge	9/30/09	ETAA	18722	127
F/V Tradition 2009-2	Compensation	Dredge	10/9/09	Delmarva	21966	159
F/V Celtic 2009-4	Compensation	Dredge	10/13/09	Delmarva	22491	118
F/V Diligence 2009-4	Compensation	Dredge	10/13/09	Delmarva	22697	152
F/V Kathy Ann 2009-8	Research	Twine Top	11/1/09	Mid-Atlantic	0	52
F/V Celtic 2010-1	Compensation	Twine Top	1/9/10	CAII	13868	116

Table 2. Common and Scientific names of species caught

Common Name	Species Name
Yellowtail flounder	*Limanda ferruginea*
Sea scallop	*Placopecten magellanicus*
Monkfish	*Lophius americanus*
Summer flounder	*Paralichthys dentatus*
Fourspot flounder	*Paralichthys oblongus*
Little skate	*Raja erinacea*
Barndoor skate	*Raja laevis*
Winter skate	*Raja ocellata*
American plaice	*Hippoglossoides platessoides*
Witch flounder	*Glyptocephalus cynoglossus*
Winter flounder	*Pseudopleuronectes americanus*
Sand dab	*Lophopsetta maculate*

Table 3: Celtic 2009-2 Length frequency distribution of scallops Tows 1-29; Experimental dual mesh on starboard side.

Tow	Experimental																											SUM
Shell Ht	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
45-50										1													1						2
50-55					1					1													2						4
55-60					1					2													2						5
60-65					4					1																			5
65-70				1	1					2						1													5
70-75					0					0																			0
75-80					0					0																			0
80-85					0					0	1	1										1				1			4
85-90	1				0					1	0	0			1				1			0	1					2	7
90-95	1	2	2	4	1		1			7	0	3	2	1	0	3	1			1		2	3	4	1		2	1	42
95-100	0	1	5	15	23	1	0	5	1	8	2	10	0	0	6	6	1			2	12	3	6	14	4	3	4	5	137
100-105	2	2	4	6	35	6	9	8	5	12	9	14	1	1	6	24	20			5	11	11	10	19	12	5	11	9	257
105-110	0	7	4	10	38	9	11	5	8	14	12	12	0	4	14	19	24	2	5	9	10	13	5	16	10	3	9	14	287
110-115	1	9	12	11	15	6	13	7	7	15	13	19	4	9	13	12	9	3	3	4	8	10	10	5	9	15	10	9	261
115-120	3	6	10	14	9	7	10	1	14	5	17	15	5	5	20	7	14	4	12	7	13	15	16	13	14	16	19	4	295
120-125	2	3	7	17	4	5	8	8	15	9	20	7	1	5	12	9	11	19	17	8	6	13	16	6	12	19	19	14	292
125-130	3	3	4	13	7	11	7	6	11	7	13	2	1	5	5	6	3	6	9	11	3	14	6	7	11	9	11	10	204
10-135	4	4	1	6	1	11	9	9	11	3	7	2	5	1	2	2	3	8	4	3	5	2	6	1	6	7	7	7	137
135-140	12	4	5	6	0	10	9	12	2	12	6	6	3	0	4	3	4	12	10	2	6	5	8	4	2	5	5	1	158
140-145	6	9	4	4	5	13	6	13	7	10	3	4	11	5	5	4	5	8	7	5	7	8	5	5	6	5	4	5	179
145-150	7	7	8	4	3	5	6	6	0	1	4	4	8	5	6	7	4	4	10	14	8	3	3	3	6	4	7	6	153
150-155	5	12	11	2		4	1	1	2	1	2	6	14	12	6	5	1	3	2	6	7	7	4	9	5	7	4	7	146
155-160	8	5	3	1		1			1			5	9	12	2	2			3	8	2	3	4	1	3			5	78
160-165	6	2	3										1	3	2	0			1	2	1	1		1	0				23
165-170	4	0											1			1								1	1				8
170-175	0	1																											1
SUM:	65	77	83	114	148	89	90	81	84	112	109	110	66	68	104	111	100	69	84	87	99	111	108	109	102	99	112	99	2690

Tow	Control																											
Shell Ht	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
45-50																													0
50-55																													0
55-60					3		1			2	1						1												8
60-65					4		1			6		1			3					1									16
65-70					4					1																			5
70-75					0					0																			0
75-80					0					0																			0
80-85					1					2		4			1	1				1									10
85-90	0			4	2	1				2	1	5			2	1					1		1						20
90-95	0			5	3	2	1	1	4	10	5	2			7	6				1	1	3	8	8	3	3	1		74
95-100	0			6	22	1	1	6	1	19	13	7	1	1	10	13	8			7	11	1	7	15	7	4	2	1	164
100-105	2	1	2	6	36	8	12	6	2	11	19	13	0	0	18	20	8		1	13	9	1	21	27	1	7	5	3	252
105-110	1	2	6	7	29	2	11	7	10	14	18	24	3	7	12	19	8	2	1	6	5	10	28	19	12	6	8	2	279
110-115	3	4	19	13	18	6	10	4	15	13	10	21	4	10	11	9	9	4	2	3	3	21	21	8	7	13	19	9	289
115-120	0	3	14	10	12	4	6	7	11	9	16	15	2	9	12	10	12	4	3	9	8	13	13	8	19	19	16	12	276
120-125	1	6	17	18	12	3	3	5	5	12	22	8	4	4	14	6	13	3	11	9	8	10	7	11	17	19	25	19	292
125-130	4	3	8	8	0	7	8	3	6	6	9	10	7	6	6	8	9	6	5	2	3	5	2	7	7	5	12	7	169
10-135	4	1	1	9	4	11	16	9	7	9	1	4	4	4	6	3	2	4	4	3	3	9	4	3	3	6	10	4	148
135-140	5	3	5	6	1	17	10	12	12	5	3	2	14	5	5	3	2	3	5	4	4	6	5	3	4	3	8	7	162
140-145	9	4	2	12	3	13	5	13	8	3	4	1	14	3	2	4	5	6	20	5	4	2	5	6	5	3	3	6	170
145-150	11	7	11	6	2	4	2	3	13	3	2	5	9	7	6	6	1	14	8	9	6	5	4	6	3	4	4	8	169
150-155	8	15	7			3	1	4			1	2	6	12	2	5	3	5	8	9	9	4	1	6	7	3	7	3	131
155-160	9	12	1								1	4	0	8	3		3	1	6	4	7	5	1	3	2	2	2	3	77
160-165	1	3	1										1	4					1	2		3		0		1			17
165-170	2	1											2											1					6
170-175	0	0													1							3							4
SUM:	60	65	94	110	156	82	88	80	94	127	126	128	71	80	121	114	84	52	75	88	82	101	128	131	97	98	122	84	2738

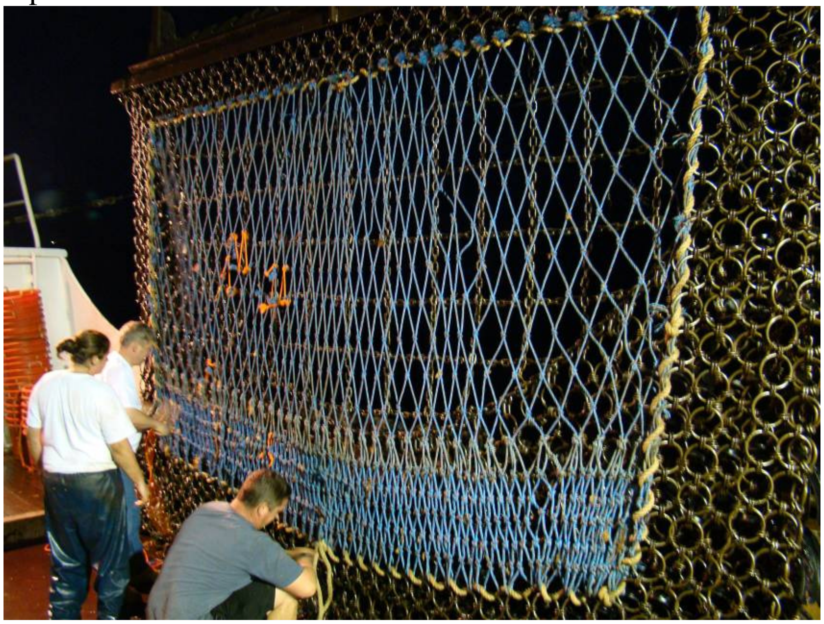
Dredge Frames: I-be Bags: Skirt 2 x30; Sides: 6 x 17; Apron: 8 x 40; Diamonds: 14; Sweep: 133 links Turtle Chains: 13 x 7
Conti Twine Top 10-inch 60 x 8
Experimental: Twine Top 40 x 3 (6") x 5 (12")
Tows 2-29 Experimental on Starboard side
Tows 30-34: Twine tops swapped sides

Table 4: Celtic 2009-2 Scallop length frequency distribution tows 30-34 with experimental twine top on port side dredge.

Tow	Experimental					SUM
Shell Ht	30	31	32	33	34	
45-50						0
50-55						0
55-60						0
60-65						0
65-70						0
70-75						0
75-80						0
80-85						0
85-90						0
90-95						0
95-100					1	1
100-105				2	2	4
105-110		1	3	3	2	9
110-115	2	0	2	0	0	4
115-120	2	0	0	1	0	3
120-125	9	4	8	3	3	27
125-130	8	5	7	8	1	29
10-135	6	7	1	4	1	19
135-140	4	7	4	0	2	17
140-145	7	4	5	9	9	34
145-150	14	11	14	15	20	74
150-155	11	15	19	15	10	70
155-160	6	5	3	5	8	27
160-165	2	5	2	1	1	11
165-170	1		1			2
170-175						0
SUM:	72	64	69	66	60	331

Tow	Control					
Shell Ht	30	31	32	33	34	
45-50						0
50-55						0
55-60						0
60-65						0
65-70						0
70-75						0
75-80						0
80-85						0
85-90						0
90-95						0
95-100			1			1
100-105	3	1	3			7
105-110	1	0	2	2	2	7
110-115	1	3	1	0	0	5
115-120	7	2	2	2	1	14
120-125	7	3	0	5	3	18
125-130	6	9	3	1	2	21
10-135	4	3	4	4	4	19
135-140	1	1	4	2	3	11
140-145	10	7	5	6	7	35
145-150	13	17	20	15	16	81
150-155	8	11	15	15	15	64
155-160	11	10	7	9	8	45
160-165	2	3	3	4	4	16
165-170					1	1
170-175						0
SUM:	74	70	70	65	66	345

Table 5: Celtic 2009-2 Catch data analysis from tows 2-34 comparing dual mesh twine top to the 10-inch control.



Celtic 2009-2
Dual Mesh vs Control

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
2	58	56	80	78	0	2	16	4	2	6	6	11	1	2	1	2		
3	18.5	17.25	101	70	5	8	14	8	1	9	10	10	6	19	9	11		1
4	11	8.5	65	59	1	2	11	9	0	1	5	6	10	1	4	1		
5	28.5	29.5	116	197	4	2	10	4	4	0	2	6	7	11	13	19	1	0
6	19	16	155	135	1		5	5			2		5	11	1	1	1	2
7	8	9.5	88	99		1	1				3		6	4	2	0	5	3
8	5	5.5	80	67		1	3	0	2	0		1	2	4	1	1		2
9	23	18	122	118		1	4	5				1	8	6		1		5
10	14	13	112	159	2		3	6			1		3	5	3		5	9
11	16.5	17.25	66		3	3	1	6	1		1	1	23	24	1	2		
12	19	19.5	64	53		3	2		4		4		6	4	15	9	1	
13	22	19.5	85	77	2	4	15	11			8	8	10	5	3	4		
14	12	12	68	60			20	19	1		12	14			2	4		
15	11	10.25	42	48			9	12	7		3	4	1		7	5		
16	21.75	21	76	68	2	1	10	9	4	1	5	1	2	4	15	6		
17	20	19	67	75	1	4	9	8			3	2	10	11	12	1		1
18	20	16.75	122	147	4	8	4	10	2	0	4	3	20	17	8	11	0	1
19	1	0.75	48	54	1	1	6	6	1	0	6	1	2	2	1	0		2
20	2.5	2.5	73	73	3	1	9	14			1	2	5	6	2	0		1
21	15	17	98	145	4	6	8	8			5	2	7	8	8	9		
22	19	15	99	97	4	1	6	15	2		8	10	8	13	2	4		
23	13.75	12.75	67	78		1	8	5	1	2	1	6	5	2	3	2		
24	24.75	22.25	113	89	4		10	7	1	1	8	7	3	1	10	4		1
25	17	17.75	85	103	5	3	9	8			4	1	11	19	3	7	2	
26	14.5	14	108	72	2	7	3	9	1	1	1	4	12	8	1	1	0	2
27	17.5	17	72	51	2	1	2	6	1		3	0	3	3	8	1		
28	23	20.5	66	52	2		1	5			2	3	3	4	3	3		
29	9	10.5	83	74	1	1	3	3			2	2	3	3	1	1	5	5
30	6.25	6	44	24	1	2		2	1		2	5			255	254		
31	6	5.75	34	35	8	2	1	1	2	2	2		1		297	243		
32	6.75	7	23	25	6	7	2	5	2		4				181	172		
33	6	5	20	20	6	6	2	3	2	1		1			169	116		
34	7	6	21	11	1	5	2	1	6	3	1	3			213	131		
Totals																		
Exp	516.25	488.25	2563	2513	75	84	209	214	48	27	119	115	183	197	1254	1026	20	35
Difference	28		50		-9		-5		21		4		-14		228		-15	
	105.7%		102.0%		89.3%		97.7%		177.8%		103.5%		92.9%		122.2%		57.1%	

Table 6: Catch with a fish sweep of 5/8-inch chain added in front of the cutting bar.

Celtic 2009-2

Added Fish Sweep

Tow #	Scallop (bu) Exp	Control	Skate Exp	Cont	Fourspot Exp	Cont	Monk Exp	Cont	Winter Skate Exp	Cont	Barndoor Exp	Cont	Winter Flounder Exp	Cont	YT Exp	Cont	Fluke Exp	Cont
35	8.75	8	54	51	5	3	1	4		3	5	9			204	190		
36	8.5	9	32	61	1	4	1	2			1	4			265	239		
37	6	6	26	27	1		3	1	3	6	1	2			130	118		
Totals																		
Exp	23.25	23	112	139	7	7	5	7	3	9	7	15	0	0	599	547	0	0
Difference	0.25		-27		0		-2		-6		-8		0		52		0	
	101.1%		80.6%		100.0%		71.4%		33.3%		46.7%				109.5%			

Table 7: Tows with a mesh cover closing the space between the cutting bar and depressor.

Celtic 2009-2

Added Twine Blocking

Tow#	Scallop (bu) Exp	Control	Skate Exp	Cont	Fourspot Exp	Cont	Monk Exp	Cont	Winter Skate Exp	Cont	Barndoor Exp	Cont	Winter Flounder Exp	Cont	YT Exp	Cont	Fluke Exp	Cont
38	7	7	33	51	3		1	2	2	4		3			145	252		
39	1.25	7	1	57		2	1			1	1	2		1	57	229		
Totals																		
Exp	8.25	14	34	108	3	2	2	2	2	5	1	5	0	1	202	481	0	0
Difference	-5.75		-74		1		0		-3		-4		-1		-279		0	
	58.9%		31.5%		150.0%		100.0%		40.0%		20.0%		0.0%		42.0%			

Table 8: Tows with ring blocking and no fish sweep.

Celtic 2009-2

Added Ring Blocking-Removed Fish Sweeps

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
40	5.75	6	24	21	2	7	1	2	1	3	1	1			212	250		
41	7.25	8.25	42	47	3	3	2	2	1	1	2	1			201	224		
42	5	5.75	24	21	3		1	4	2	2					136	139		
Totals																		
Exp	18	20	90	89	8	10	4	8	4	6	3	2	0	0	549	613	0	0
Difference	-2		1		-2		-4		-2		1		0		-64		0	
	90.0%		101.1%		80.0%		50.0%		66.7%		150.0%				89.6%			

Table 9: Two windows added to the twine top.

Celtic 2009-2

Cut 2 windows in 6" mesh

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
43	7	6	39	44	2	8	3	3	1	1	3	1			250	263		
44	5.25	5	18	16	2		1			1	1	1			115	115		
Totals																		
Exp	12.25	11	57	60	4	8	4	3	1	2	4	2	0	0	365	378	0	0
Difference	1.25		-3		-4		1		-1		2		0		-13		0	
	111.4%		95.0%		50.0%		133.3%		50.0%		200.0%				96.6%			

Table 10: Three more windows cut in twine top.

Celtic 2009-2

Cut 3 more windows

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
45	4	6.5	7	56	1	1	2	3		1	1	8			20	124		
46	4	4.75	8	75	2	3	2	3	1		1	4			40	130		
Totals																		
Exp	8	11.25	15	131	3	4	4	6	1	1	2	12	0	0	60	254	0	0
Difference	-3.25		-116		-1		-2		0		-10		0		-194		0	
	71.1%		11.5%		75.0%		66.7%		100.0%		16.7%				23.6%			

Table 11: Twelve inch twine top from skirt to apron 40 meshes across vs 10-inch hung 60 meshes across.

Celtic 2009-2

New Dual Mesh w/12" to apron; 6' hanging loose; no windows; still ring blocking

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
47	3.5	6	5	50		3	2	5		1	4	3			42	145		
48	5	5.5	28	40	2	3			1		6	1			148	164		
49	2	4	8	41		1		2		1	3	1			43	132		
50	6	6.75	28	39	7	5	1	6	1		1			1	188	258		
51	3.5	6.5	8	30		1	2	1		2	1				35	206		
52	4.75	5.75	15	47	3	2		1	1	3	1	1			131	240		
53	4	6.75	12	38	2	3	4	2	1	1	1				88	187		
Totals																		
Exp	28.75	41.25	104	285	14	18	9	17	4	8	17	6	0	1	675	1332	0	0
Difference	-12.5		-181		-4		-8		-4		11		-1		-657		0	
	69.7%		36.5%		77.8%		52.9%		50.0%		283.3%		0.0%		50.7%			

Table 12: Added three pockets using the 6-inch mesh over the 12-inch mesh.

Celtic 2009-2

Added 3 pockets of 6' mesh; kept ring blocking

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
54	6	6.5	24	24	3	3					4	4			133	133		
55	6	7	40	58	3	4	1	4			1	3			181	227		
56	8	7	50	52	8	3	1	1	1	1	2	2		1	210	237		
Totals																		
Exp	20	20.5	114	134	14	10	2	5	1	1	7	9	0	1	524	597	0	0
Difference	-0.5		-20		4		-3		0		-2		-1		-73		0	
	97.6%		85.1%		140.0%		40.0%		100.0%		77.8%		0.0%		87.8%			

Table 13: Opened holes in the side panels

Celtic 2009-2

Opened Side panels

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
57	6	7	24	33	1		3	5							135	173		
58	7	8	61	86	2	5		3	1		4	9			106	181		
Totals																		
Exp	13	15	85	119	3	5	3	8	1	0	4	9	0	0	241	354	0	0
Difference	-2		-34		-2		-5		1		-5		0		-113		0	
	86.7%		71.4%		60.0%		37.5%				44.4%				68.1%			

Table 14: The welded ring blocking was removed

Celtic 2009-2

Removed ring blocking

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
59	6	6.75	23	33	4	3		4			2	4	1		160	178		
60	4.5	5.5	15			1	2	1				2			115	121		
Totals																		
Exp	10.5	12.25	38	33	4	4	2	5	0	0	2	6	1	0	275	299	0	0
Difference	-1.75		5		0		-3		0		-4		1		-24		0	
	85.7%		115.2%		100.0%		40.0%				33.3%				92.0%			

Table 15: Laced the 6-inch mesh down tight on the 12-inch twine top and cut two windows in the 12-inch mesh just above the 6-inch mesh.

Celtic 2009-2

Laced 6" down; cut 2 windows in 12"

	Scallop (bu)		Skate		Fourspot		Monk		Winter Skate		Barndoor		Winter Flounder		YT		Fluke	
Tow #	Exp	Control	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont
61	7.5	8	32	48	2	5	2	1	1	2					136	174		
62	6	8	31	28	1	1	1	2	2						89	78		
63	6.75	11	64		1		3		2		2	1	4	2	1		2	
64	29	31	104	123	1	1	2	4			1	3	5	3		1		
65	21.25	19	46	104	5	6	4	5	1	5	3	2	11	5	12	6		
66	22	22.5	72	90	4	3	7	10	5	5	6	11	6	8	2	5		
Totals																		
Exp	92.5	99.5	349	393	14	16	19	22	11	12	12	17	26	18	240	264	2	0
Difference	-7		-44		-2		-3		-1		-5		8		-24		2	
	93.0%		88.8%		87.5%		86.4%		91.7%		70.6%		144.4%		90.9%			

Table 16: Westport 2009-2 comparisons of a dredge with turtle chains versus a 3 x 3 chain rig.

	Scallop (bu)	Trash (bu)	Skate	Yellowtail	Monk	Fourspot	Sand dab	Witch	Winter Fl
3 x 3	638	55	4949	1217	159	76	44	1	12
Turtle Mat	545	51	6243	1231	209	76	57	1	18
diff (%)	85.5%	93.1%	126.1%	101.2%	131.4%	100.0%	129.5%	100.0%	150.0%
YT/scal bu	1.91	**3 x 3 chains**							
YT/scal bu	2.26	**Turtle Mat chains**							
	118.4%	**% diff Yt catch ratios**							

Table 17: Westport 2009-2 Day/night comparisons of turtle chains versus 3 x 3 chains.

DAY (46 tows)

	Scallop (bu)	Trash (bu)	Skate	Yellowtail	Monk	Fourspot	Sand dab	Winter Fl
3 x 3	621	23	5253	1182	87	45	29	11
Turtle Mat	583	22	6785	1207	114	51	35	17
diff	94%	99%	129%	102%	131%	113%	121%	155%
YT/scal bu	1.90	3 x 3 chains						
YT/scal bu	2.07	Turtle chain mats						
% diff	1.09	**% diff Yt catch ratios**						

NIGHT (33 tows)

	Scallop (bu)	Trash (bu)	Skate	Yellowtail	Monk	Fourspot	Sand dab	Winter Fl
3 x 3	509	32	2544	517	72	31	15	1
Turtle Mat	448	29	2613	522	95	25	22	1
diff	88%	89%	103%	101%	132%	81%	147%	100%
YT/scal bu	1.02	3 x 3 chains						
YT/scal bu	1.16	Turtle chain mats						
% diff	1.15	**% diff Yt catch ratios**						

Table 18: Tradition 2009-1 and Celtic 2009-3 results of dual mesh twine top comparisons.

			Scallop (bu)	Skate	Fourspot	Monk	Black Back	YT	Fluke	Dab
Combined CAI		**Totals**	**537**	**2367**	**30**	**138**	**130**	**4**	**11**	**98**
	Difference	**from Control**	**-77.6**	**-102**	**-13**	**21**	**-9**	**0**	**1**	**-19**
		% Difference	**-13%**	**-4%**	**-30%**	**18%**	**-6%**	**0%**	**10%**	**-16%**
	Dual	**YT/scalbu**	**0.01**							
	10-inch		**0.01**							
Tradition-2009-1		**Totals**	**350.5**	**1897**	**24**	**138**	**91**	**186**	**5**	**34**
CAI & CAII	**Difference**	**from Control**	**-67**	**-201**	**-11**	**18**	**-9**	**-24**	**-2**	**-35**
		% Difference	**-16%**	**-10%**	**-31%**	**15%**	**-9%**	**-11%**	**-29%**	**-51%**
	Dual	**YT/scalbu**	**0.53**							
	10-inch		**0.50**							
Celtic-2009-3		**Totals**	**210**	**1035**	**14**	**10**	**45**	**3**	**6**	**71**
CAI	**Difference**	**from Control**	**-14.1**	**-23**	**0**	**-1**	**3**	**3**	**2**	**10**
		% Difference	**-6%**	**-2%**	**0%**	**-9%**	**7%**	**0%**	**50%**	**16%**
	Dual	**YT/scalbu**	**0.01**							
	10-inch		**0**							

Table 19: Tradition 2009-1 and Celtic 2009-3 results of dual mesh twine top comparisons.

			Scallop (bu)	Skate	Fourspot	Monk	Black Back	YT	Fluke	Dab
Combined		Totals	155	1483	40	45	12	761	2	29
CAII	Difference from Control		-13.2	-158	15	-14	6	24	-4	-4
		% Difference	-8%	-10%	60%	-24%	100%	3%	-67%	-12%
	Dual	YT/scalbu	4.92							
	10-inch		4.39							
Tradition 2009-1		Totals	23.5	565	8	10	6	185	0	7
CAII	Difference from Control		-3.5	-122	2	-4	3	-21	-1	-6
		% Difference	-13%	-18%	33%	-29%	100%	-10%	-100%	-46%
	Dual	YT/scalbu	7.87							
	10-inch		7.63							
Celtic 2009-3		Totals	131.25	918	32	35	6	576	2	22
CAII		Difference from Cc	-9.7	-36	13	-10	3	45	-3	2
		% Difference	-7%	-4%	68%	-22%	100%	8%	-60%	10%
	Dual	YT/scalbu	4.39							
	10-inch		3.77							

Table 20: Celtic 2009-3 comparison of turtle chains versus 3 x 3 chains.

			Scallop (bu)	Skate	Fourspot	Monk	Black Back	YT	Fluke	Dab
		Totals	484	4018	76	111	21	1943	15	70
Celtic-2009-3	Difference from Control		-2.6	10	1	-25	10	-197	-1	-14
Tows 29-80		% Difference	-1%	0%	1%	-18%	91%	-9%	-6%	-17%
	3 x 3	YT/scalbu	4.02							
	Turtle chns		4.40							
Celtic-2009-3		Totals	270	1476	43	79	7	1090	7	25
Tows 29-52	Difference from Control		-3	-64	-7	-4	6	-168	2	1
		% Difference	-1%	-4%	-14%	-5%	600%	-13%	40%	4%
	3 x 3	YT/scalbu	4.04							
	Turtle chns		4.61							
		Totals	214	2542	33	32	14	853	8	45
Celtic-2009-3	Difference from Control		1	74	8	-21	4	-29	-3	-15
Tows 53-80		% Difference	0%	3%	32%	-40%	40%	-3%	-27%	-25%
	3 x 3	YT/scalbu	3.99							
	Turtle chns		4.14							

Table 21: Tradition 2009-1 comparison of turtle chains versus 3 x 3 chains

		Scallop (bu)	Skate	Fourspot	Monk	Black Back	YT	Fluke	Dab	Winter Skate	Barndoor
	Totals	102.58	3062	28	28	2	775	3	64	186	42
	Difference from Control	14.58	884	12	2	-5	241	-4	22	17	15
	% Difference	17%	41%	75%	8%	-71%	45%	-57%	52%	10%	56%
3 x 3	YT/scalbu	7.56									
Turtle chns		6.07									

Table 22: Tradition 2009-1 comparing a rock chain mat versus 3 x 3 chains.

		Scallop (bu)	Skate	Fourspot	Monk	Black Back	YT	Fluke	Dab	Winter Skate
	Totals	81	198	16	15	0	176	0	6	53
	Difference from Control	24	87	10	-4	0	77	-1	1	-24
	% Difference	42%	78%	167%	-21%	0%	78%	-100%	20%	-31%
3 x 3	YT/scalbu	2.17								
Rock chns		1.74								

Table 23: Tradition 2009-1 comparing a turtle chain mat against 3 up and down chains (no ticklers).

		Scallop (bu)	Skate	Fourspot	Monk	Black Back	YT	Fluke	Dab	Winter Skate	Barndoor
	Totals	209.25	2875	70	43	24	868	7	73	183	64
	Difference from Control	-19.08	78	-1	-28	6	-80	1	17	-2	-18
	% Difference	-8%	3%	-1%	-39%	33%	-8%	17%	30%	-1%	-22%
no ticklers	YT/scalbu	4.15									
turtle chns		4.15									

Table 24: Treatment 1: Kathy Ann 2009-8; Experimental with 9-ring apron versus a control with 7-ring apron

Control Dredge *Experimental Dredge*
Bag with 7 ring apron & 60 mesh twine top vs. Bag with 9 ring apron & 80 mesh twine top

Kathyann-2009-8 Treatment #1

Species	Scallop (bu)	Skate	Fluke	Monk	4 Spot	YT	Sand Dab	Clearnose
Dredge	EXP	EXP	EXP	EXP	EXP	EXP	EXP	EXP
# of Tows	32	32	32	32	32	32	32	32
Total Count	155	2858	77	35	74	5	27	12
Difference in Count	16	1120	-8	21	20	-1	16	6
% Difference in Count	12%	64%	-9%	150%	37%	-17%	145%	100%

Table 25: Treatment 2: Kathy Ann 2009-8

Control Dredge
Bag with 7 ring apron & 60 mesh twine top turtle chain top

vs.

Experimental Dredge
Bag with 9 ring apron &

("Turtle Matt Top")

Kathyann-2009-8 Treatment #2

Species	Scallop (bu)	Skate	Fluke	Monk	4 Spot	YT
Dredge	EXP	EXP	EXP	EXP	EXP	EXP
# of Tows	*2*	*2*	*2*	*2*	*2*	*2*
Total Count	2	35	1	0	0	3
Difference in Count	-7	-106	0	-3	-2	0
% Difference in Count	-76%	-75%	0%	-100%	-100%	0%

Table 26: Treatment 3: Kathy Ann 2009-8

Control Dredge *Experimental Dredge*

Bag with 7 ring apron & 60 mesh twine top vs. Bag with 9 ring apron & turtle chain top with

2x60 meshes added to top

of apron

("Improved Matt Top")

Kathyann-2009-8 Treatment #3

Species	Scallop (bu)	Skate	Fluke	Monk	4 Spot	YT	Clearnose	Winter
Dredge	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**
# of Tows	*7*	*7*	*7*	*7*	*7*	*7*	*7*	*7*
Total Count	50.5	894	9	11	21	8	4	3
Difference in Count	5	251	0	-2	-19	4	3	2
% Difference in Count	11%	39%	0%	-15%	-48%	100%	300%	200%

Table 27: Treatment 4: Kathy Ann 2009-8

Control Dredge		*Experimental Dredge*
Bag with 7 ring apron & 60 mesh twine top turtle chain top with and tickler of apron	vs.	Bag with 9 ring apron & 2x60 meshes added to top added behind cutting bar

Kathyann-2009-8 Treatment #4

Species	Scallop (bu)	Skate	Fluke	Monk	4 Spot
Dredge	EXP	EXP	EXP	EXP	EXP
# of Tows	*2*	*2*	*2*	*2*	*2*
Total Count	7	191	9	2	6
Difference in Count	-10.25	-133	3	-3	-4
% Difference in Count	-59%	-41%	50%	-60%	-40%

Table 28: Treatment 5: Kathy Ann 2009-8

Control Dredge
Bag with 7 ring apron & 60 mesh twine top turtle chain top with and tickler added to top of apron

vs.

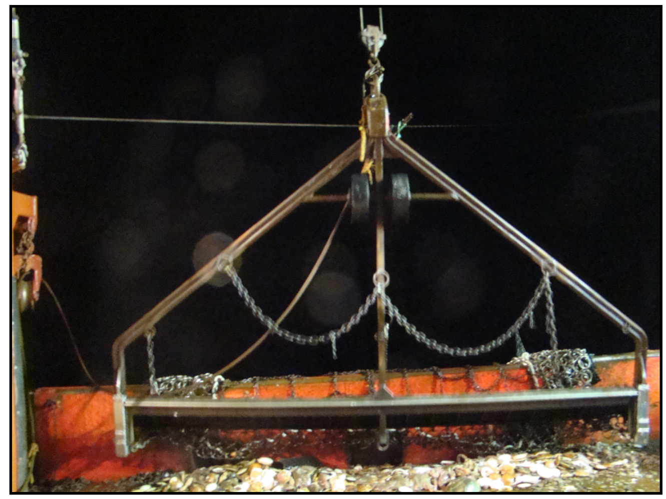
Experimental Dredge
Bag with 9 ring apron & 2x60 meshes in front of cutting bar

Kathyann-2009-8 Treatment #5

Species	Scallop (bu)	Skate	Fluke	Monk	4 Spot	Sand Dab	Winter Skate
Dredge	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**
# of Tows	3	3	3	3	3	3	3
Total Count	9	255	8	2	1	1	0
Difference in Count	-6	-145	3	1	-3	0	-1
% Difference in Count	-40%	-36%	60%	100%	-75%	0%	-100%

Table 29: Treatment 6: Kathy Ann 2009-8

Control Dredge		*Experimental Dredge*
Bag with 7 ring apron & 60 mesh twine top turtle chain top with and tickler added to top of apron	vs.	Bag with 9 ring apron & 2x60 meshes midway on frame

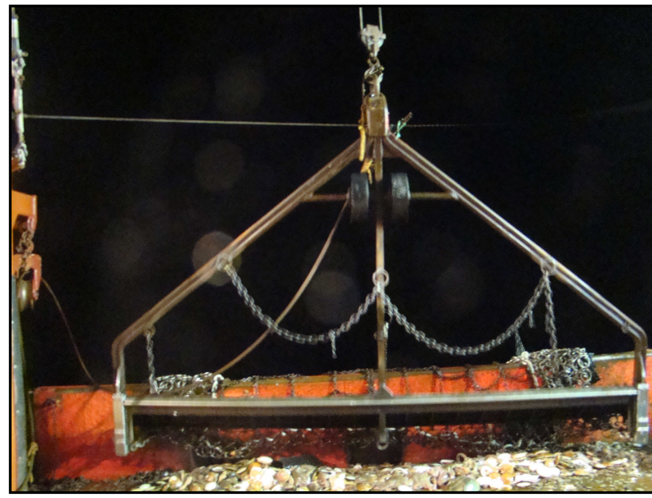


Kathyann-2009-8 Treatment #6

Species	Scallop (bu)	Skate	Fluke	Monk	4 Spot
Dredge	**EXP**	**EXP**	**EXP**	**EXP**	**EXP**
# of Tows	*4*	*4*	*4*	*4*	*4*
Total Count	30.25	301	4	4	2
Difference in Count	12.15	34	-5	2	1
% Difference in Count	67%	13%	-56%	100%	100%

Table 30: Treatment 7: Kathy Ann 2009-8

Experimental Dredge *Experimental Dredge*
Bag with 7 ring apron & 60 mesh twine top vs. Bag with 9 ring apron &
turtle chain top with apron & tickler added midway on frame 2x60 meshes
added to top of apron and
tickler midway on frame



Kathyann-2009-8 Treatment #7

Species	Scallop (bu)	Skate	Fluke
Dredge	CONTROL	CONTROL	CONTROL
# of Tows	*2*	*2*	*2*
Total Count	18	140	2
Difference in Count	9.8	35	0
Difference in Count	120%	33%	0%

Table 31: Celtic 2010-1 16-inch and 8-inch dual mesh twine top vs a standard twine top

Celtic-2010-1

Species	Scallop (bu) all tows		Scallop (bu)observed tows		Skate		Winter Skate		Sand Dab		Yellowtail	
Dredge	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp
Mean	11	12	11	11	97	106	34	35	41	43	52	52
Variance	5	8	10	9	2148	2482	312	455	435	380	224	226
Observations	113	113	46	46	46	46	46	46	46	46	46	46
Hypothesized Difference	0		0		0		0		0		0	
P(T<=t) one-tail	0.080		0.269		0.000		0.192		0.038		0.352	

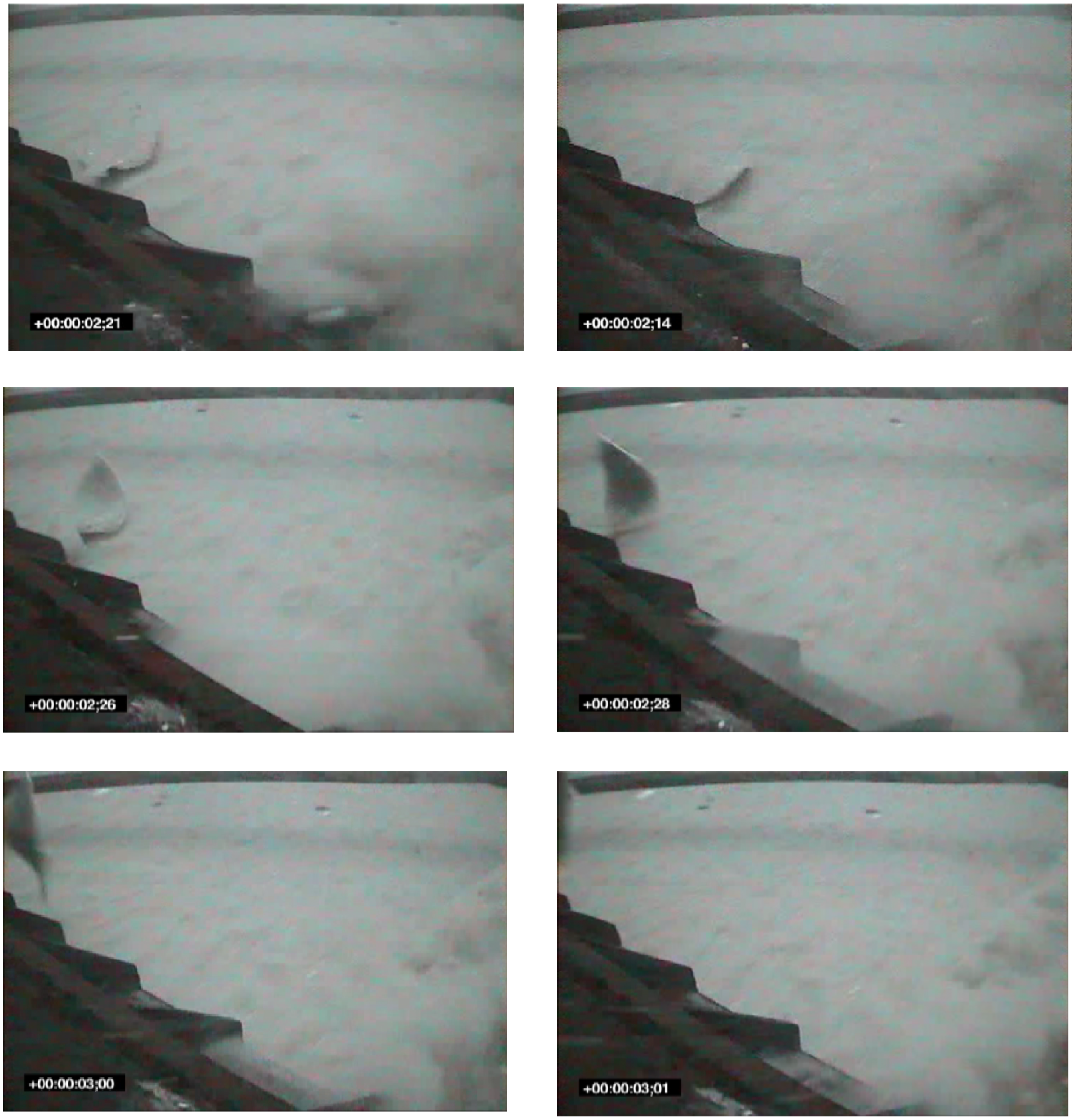
Species	Four Spot		Fluke		Sea Raven		Blackback		Barndoor		Monk	
Dredge	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp
Mean	2	2	1	1	1	1	1	1	1	1	1	1
Variance	4	4	1	1	1	1	2	3	1	1	1	1
Observations	46	46	46	46	46	46	46	46	46	46	46	46
Hypothesized Difference	0		0		0		0		0		0	
P(T<=t) one-tail	0.450		0.336		0.434		0.415		0.330		0.261	

Celtic-2010-1

Species	Scallop (bu)		Skate		Winter Skate		Sand Dab		Yellowtail	
Dredge	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp
SUM	521.5	515	4448	4887	1549	1622	1866	1996	2412	2370
Difference		-6.5		439		73		130		-42
% Difference		-1%		10%		5%		7%		-2%
Catch Ratio			8.5	9.5	3.0	3.1	3.6	3.9	4.6	4.6
% Difference in Ratio				11%		6%		8%		-1%

Species	Four Spot		Fluke		Sea Raven		Black Back		Barndoor		Monk	
Dredge	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp	Control	Exp
SUM	92	94	30	34	25	26	53	51	29	32	42	47
Difference		2		4		1		-2		3		5
% Difference		2%		13%		4%		-4%		10%		12%
Catch Ratio	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
% Difference in Ratio		3%		15%		5%		-3%		12%		13%

Figure 6: Sequence of shots showing a yellowtail escaping up and over a Cfarm excluder dredge.



ADDENDUM A:

Scallop Dredge Comparison Study

Final Report
For
NMFS, Northeast Fisheries Science Center
NFFM7320-8-26515

November 2009

Submitted By

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Executive Summary

The purpose of this contract was to provide trained scientific data collectors who collected catch information during commercial fishing trips. Since June, 2007 under this contract we have sampled sixteen commercial fishing trips that were collecting RSA compensation. The trips compared the turtle excluder dredge designs to the standard New Bedford dredge; both dredge types rigged without turtle chains in areas where turtles were known to be present. These trips entailed 154 days at sea (DAS) and 1675 tow pairs observed for turtles; 841 of which were sampled for catch. During these tows three turtles were considered takes by the turtle excluder dredge and three turtles were taken by the standard dredge. The hypothesis being tested is that fishing with the Cfarm turtle excluder dredge will result in a lower probability of turtle injuries than fishing with a standard dredge. As of the completion of this contract, insufficient data has been collected to test the hypothesis. More trips are needed to understand the ability of this dredge design on reducing injury and mortality possibly resulting from benthic sea turtle interactions and resulting catch.

1. Project Background and Description

During the last decade, fisheries observers have documented turtle interactions with the Atlantic sea scallop dredge fishery. During 2001 and 2002, NEFSC collected observer data from the Hudson Canyon Access Area and the Virginia Beach Access Area and estimated that there were 169 catches of sea turtles in scallop dredge fishery (in these two areas during 2001 and 2002). Observer coverage extended spatially in 2003 and 2004, and NEFSC estimated the number of turtle catches in the Mid-Atlantic region was 749 in 2003 (Murray 2004) and 180 in 2004 (Murray 2005).

In response to the known and estimated turtle interactions with scallop dredge gear, Coonamessett Farm with support from NMFS began investigating gear modifications that could reduce the probability and severity of sea turtle interactions. Coonamessett Farm and VIMS tested a chain mat excluder that was designed to keep turtles from entering the dredge bag and reduce the risk of injury associated with being in the dredge bag or being brought on board. In 2004, the scallop industry proposed that NMFS issue a rule to require the use of the chain mat excluder for all sea scallop dredge vessels fishing south of Long Island and North of Cape Hatteras from May 1 through October 15 each year. The chain mats have sharply reduce the capture of sea turtles in the dredge itself, as well as any ensuing injuries as a result of being caught in the dredge (*e.g.*, drowning, crushing in the dredge bag, crushing on deck, etc.). Although it is possible that the chain mat could also reduce benthic interactions, NMFS is not assuming the chain mat will reduce the number of injurious benthic interactions, such as turtles passing under the cutting bar. The industry and NMFS continue to research ways to further reduce the number and severity of turtle interactions in the scallop dredge fishery. One goal of this project is to determine whether a difference in takes between the two dredge designs can be attributed to the location where turtles may be interacting with the dredges. Analysis of scallop and fish catches was not covered under this project's contract.

2. Hypothesis/Objectives

The hypothesis being tested is that fishing with the Cfarm turtle excluder scallop dredge will result in a lower probability of turtle injuries than fishing with a traditional dredge. The paired testing would evaluate whether the Cfarm dredge reduces the number of sea turtles that are observed taken in the gear. The presumption is made that any differences in turtle catch between the two dredges is due to bottom interactions and that interaction rates during haulback are similar. If the Cfarm dredge has significantly lower catches of turtles then interactions are occurring on the sea floor and injury mitigation is probably occurring.

The Cfarm dredge is a design that was built and explored in a collaborative effort between Cfarm, VIMS, NERO, NEFSC, and SEFSC. The modification reduced the number of support bars on the bale and changed the geometry of the dredge frame by moving the cutting bar forward. These changes are hypothesized to decrease harmful benthic interactions with sea turtles by allowing the turtles to move up and over the frame rather than forcing them under the cutting bar. Divers videoed this modified dredge coming in contact with turtle carcasses and turtle models during 12 successful trials (Milliken et al, 2007). In a preliminary study (SEFSC, 2005) the carcass came in contact with the modified dredge and was deflected up and over the dredge frame. In another case, the carcass got wedged under the bale bar and was forced under the cutting bar. In order to further increase the probability of turtles going over the dredge frame (rather than being crushed beneath it), this dredge design was further modified by decreasing the number of bale bars. This modified dredge was experimentally fished in 2005 under another research effort to assess its ability to catch scallops, and preliminary results suggest no significant difference in scallop catches was detected. Additional testing in September 2008 in Cape Cod bay using divers and dredge mounted cameras found the latest Cfarm turtle excluder dredge design, referenced in this document as dredge design 5, may be 100% effective in guiding turtles up and over the dredge frame based on nine encounters with turtle carcasses (Smolowitz et al, 2008).

The experimental design under this contract uses two paired dredges, one equipped with a standard dredge and one equipped with the Cfarm turtle excluder dredge. There were five variations of the turtle excluder dredge used during this project. One design change was the testing of various forms of turtle guards; additions added to the cutting bar to possibly aid turtles up and over the cutting bar. For the purpose of this project we grouped all turtle dredge designs together. This paired design is an accepted standard in gear work and is utilized to minimize unaccountable environmental variation. Our planned statistical analysis is to use a paired t-test, which is an appropriate statistical test to use with the paired experimental design.

The number of hauls needed to detect a statistical difference (if one exists) between the traditional and modified dredges depends on how effective the modification is at reducing the number of observed turtle catches. We used a simple power analysis to estimate the number of hauls needed to detect a significant difference (alpha=0.05). In the analysis we used the catch rate documented in the scallop dredge final report (DuPaul et al 2004, traditional dredge = 8 turtles in 3248 hauls), and we assumed that hauls were independent. If the catch rate in the DuPaul study is mirrored in this upcoming study and the dredge reduces the observed turtle bycatch by 25%, then 5278 hauls would be needed to detect a significant difference between the dredges. If the dredge reduces the observed turtle bycatch by 75%, then 2030 hauls would be needed to detect a significant difference between the dredges. The number of sea days required to accomplish 5278 hauls can be approximated by dividing by 10 (9.89 observed hauls per day, based on preliminary September through December 2005 sea scallop observer data). Thus, we were planning for about 528 sea days. Higher scallop catch rates in recent years in the access areas means less tows are accomplished per trip further increasing the amount of effort required to gather the needed data.

3. Justification and Broader Significance

This research has broad significance and the results will be shared with the NMFS Northeast Regional Office (NERO), who is responsible for managing the Atlantic sea scallop dredge fishery. Reducing injuries produced by the scallop dredge fishery could help to reduce as many as 479 serious sea turtle injuries a year (2004 Biological Opinion on Atlantic Sea Scallop Fishery Management Plan – Consultation No. F/NER/2004/01606; the BiOp in effect when this study was initiated). A reduction in serious injuries would support the ESA mandate to recover threatened and endangered species. In addition, this proposal is directly responding to NMFS research priorities including the following bulleted citations:

- The Loggerhead Recovery Plan lists six major actions that are needed to achieve recovery. The fifth action is “minimize mortality from commercial fisheries.” To date, the fishery in the NE region with a high estimated sea turtle bycatch is the scallop dredge fishery (see Murray 2004 for bycatch estimate), and the scallop dredge experiment is designed to eventually reduce sea turtle injuries in the scallop dredge fishery.
- The 2004 Biological Opinion on Atlantic Sea Scallop Fishery lists Reasonable and Prudent Measures and Conservation recommendations related to reducing sea turtle bycatch in the scallop dredge fishery.
- The first of four Reasonable and Prudent Measures is “NOAA Fisheries must reduce the capture of sea turtles in the scallop dredge fishery by requiring modification of scallop dredge gear at times and in areas where sea turtle interactions are likely to occur.” Preliminary testing of the modified scallop dredge (in Panama City, 2004) suggests that the modification of the dredge may reduce the capture of sea turtles. Further testing is needed before this modification could be implemented in the fishery.
- The first of six conservations recommendations is “NOAA Fisheries should work to further cooperation between the industry and NOAA Fisheries regarding the take of protected species in the fishery. Given the high cost of observer coverage in the fishery and the limited number of observers, other methods for obtaining information from the industry, exchanging information with the industry, and collectively seeking solutions to address sea turtle interactions with scallop fishing gear should be sought bearing in

mind the role of the NEFMC as well." As with the previous testing of the scallop dredge chain mat, NEFSC plans to continue to exchange information with the industry and involve the industry in testing this modified gear.

4. Results

Coonamessett Farm arranged and coordinated sixteen trips on commercial scallop vessels and arranged for NMFS trained scientific data collectors to be onboard. A total of 154 DAS, in which 1675 paired tows (Table 1) were conducted and scallop and turtle catch monitored. Scallop and fish catch data was collected from 841 of the observed tows (Table 2). No statistical analyses were conducted under this contract however catch data has been analyzed (Smolowitz et al, 2007; Smolowitz and Weeks, 2008)

Table 1: Trip Summary for trips covered by observers funded by this contract.

Vessel/Trip #	Date Sailed	Date Landed	DAS	Total # of Tows	Dredge with Turtle	Date of Inc. Take	Tow # with Take
Friendship 2007-4	6/5/2007	6/20/2007	16	116			
Friendship 2007-5	8/22/2007	8/29/2007	8	42			
Celtic 2007-6	11/5/2007	11/13/2007	9	109			
Westport 2007-2	11/20/2007	11/29/2007	10	100			
Kathy Ann 2008-2	8/6/2008	8/12/2008	7	107	Cfarm & Standard	8/9 & 8/10	55 & 74
Tradition 2008-1	8/6/2008	8/13/2008	8	92	Cfarm		
Grand Larson 2008-1	8/19/2008	8/22/2008	4	63			
Elizabeth 2008-1	10/31/2008	11/5/2008	6	60			
Araho 2009-1	6/4/2009	6/11/2009	8	111	Standard	6/4/2009	12
Celtic 2009-1	6/11/2009	6/20/2009	10	106	Cfarm	6/12/2009	11
Generation 2009-1	6/17/2009	6/26/2009	10	38			
Kathy Ann 2009-2	6/22/2009	7/2/2009	12	118			
Generation 2009-2	7/8/2009	7/17/2009	10	41			
Kathy Ann 2009-4	7/17/2009	8/4/2009	19	203			
Westport 2009-1	8/25/2009	9/2/2009	7	130			
Kathy Ann 2009-7	9/19/2009	9/28/2009	10	239			
		Total Tows	**154**	**1675**			

Notes: No turtle chains were used on any tows.
Turtle takes recorded for all tows; scallop and fish catch on sampled tows.
Control dredges were all New Bedford (NB) style

Note: A turtle caught in a standard dredge after this contract period (Tradition 2009-2) is counted in the six takes covered by this report.

Table 2: Catch Summaries from trips testing dredge design 5 in the Mid-Atlantic region (Fish catch in numbers).

Trip	Scallop (bu)	Trash (bu)	L. Skate	Fourspot	Monk	Fluke	Scallop (bu)	Trash (bu)	L. Skate	Fourspot	Monk	Fluke
	Experimental						Control					
Kathy Ann 2008-2	185	49	171	17	6		162	47	200	11	7	
Tradition-2008-1	782	178	1982	38	90		832	173	1730	27	76	
ARAHO-2009-1	634		990	63	152		498		722	35	98	
Celtic 2009-1	94	48	127	5	14		93	46	125	7	30	
Kathy Ann 2009-2	417	1064	1812	33	93		436	1037	1366	24	102	
Generation2009-2	812	244	204	3	23		828	260	247	4	21	
Kathy Ann 2009-4	745	2290	1659	51	134		775	2325	1349	55	123	
Westport 2009-1	389	281	1268	44	162		368	287	1279	50	135	
Kathy Ann 2009-7	1271	1877	3252	73	2	60	1145	1847	3021	72	2	70
Diligence-2009-3	487	759	1990	43	40		460	698	1913	50	39	
F/V Tradition 2009-2	838	0	884		1	312	867	0	907		13	353
Celtic-2009-4	1016		483	3	3	58	1171		454	15	2	75
Diligence 2009-4	858	298	1842	17	4	141	811	294	1949	14	2	183
Totals	8527	7087	16664	390	724	571	8442	7013	15262	364	650	681
Percentages	101.00%	101.06%	109.19%	107.14%	111.38%	83.85%						

Blank spaces indicate catch was not recorded.

Dredge Design

Experimental Dredge Frame Design 3, as seen in Figures 1-7, was tested on trips Friendship 2007-4, and Friendship 2007-5. On the remaining trips the dredge was fished without any turtle guards attached to the cutting bar (Design 5).

Figure 1. Experimental dredge design 3 with turtle guards on the cutting bar and a doubled outer bale.

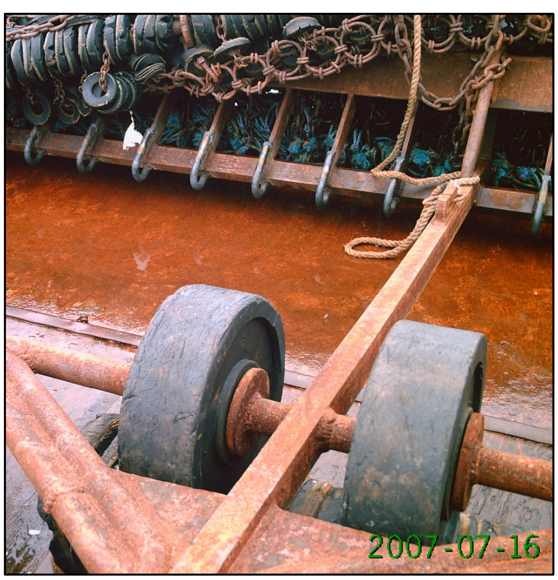

Figure 2. Wheels used on the experimental dredges had two molded 5"x 16" wheels with the axis positions 30" from top of the gooseneck.

Figure 3. Side view of shoe used; the shoe was ½" x 3" spring steel cut 17 1/2" long and attached to 1 1/2" x 3 ½" x 15" long bar stock

Figure 4. Space between struts measured 8 ½"; the spacing between the 8" depressor plate and cutting bar measure 10". The turtle guards were made of 1" hardened steel round stock and placed every 9" along struts

Figure 5. The bale extended forward 9 inches (interior measurement) before tapering to the tow point.

Figure 6. Overall view of dredge

Turtle Take Information:

Vessel/Trip ID: Araho 2009-1 **Date of Take**: 6/4/2009 **Tow #:** 12
Time: 1022 **Gear & Location of Turtle**: Standard dredge; in bag
Condition: Badly injured **Carapace Length**: 77.5 cm **Species:** Loggerhead

Commentary: A loggerhead turtle was observed inside the bag of the port (control) dredge as the captain lifted the bag over the rail of the boat and set the bag of the dredge on deck. The observer and crew removed the turtle from the chain bag. The captain had not set the dredge frame on deck yet; he held the dredge frame up in the air while the crew removed the turtle from the chain bag. The turtle was facing upside down on its carapace in the middle of the chain bag on top of the catch. The turtle was removed from the bag and placed to the side while the gear was dumped. The turtle's carapace was cracked almost its entire length and the front left flipper had quite a bit of fresh blood present. The turtle was alive, moving its head up and down, but appeared to have some pretty bad injuries.

The observer speculated that since the turtle was right on top of the catch with no scallops or bycatch on top of it and the dredge frame had not yet been let down, the turtle might have received the damage to its carapace when the dredge contacted the side of the boat while the dredge was being lifted out of the water or during the tow. The observer did not expect the turtle to survive. He took measurements, noted injuries, took pictures, identified ID characteristics, took a DNA sample, and only placed one inconel tag (#RRH306) since the turtle was likely to be brought ashore dead.

Project Leader Ron Smolowitz was contacted and he informed the vessel to transfer the turtle to the F/V Bay Star VII, that was returning to port, so that the turtle could be sent to rehabilitation. At 1500 hours the F/V Bay Star VII arrived and the turtle was transferred wrapped in a twine top. The turtle was placed carefully over the stern into the water and the other boat pulled the line in and lifted the turtle over the side. The turtle was still alive and trying to swim when pulled aboard the other vessel.

The turtle died at the rehabilitation facility several days later and underwent a necropsy.

Vessel/Trip ID: Tradition 2008-1 **Date of Take**: 08/09/2009 **Tow #:** 32
Time: 0711 **Gear & Location of Turtle**: turtle dredge; not observed
Condition: unknown **Carapace Length**: 100 cm estimated **Species:** Loggerhead

Commentary: Large loggerhead spotted on the port side by crew member during haul back after tow 32. Crew member was on stern after hooking up when he noticed a splash while the dredge was being dumped on deck. The crew member who initially spotted the turtle said he saw it 1 ft away from the boat as the dredge was being brought onboard. He said that it had a fresh 1 ft wound in the middle of the carapace toward the back end. He described the wound as white and seemed to be deep. No bleeding was witnessed.

Dredge was completely onboard and the vessel out of gear when turtle was first noticed. The observer and crew never saw the turtle in contact with dredge or vessel.

Turtle observed by observer from wheelhouse immediately after initial spotting. Observer initially spotted from above in wheel house about 40 feet away from the turtle. Turtle was in the glare of the sun the entire time, so details were difficult to witness. The observer did briefly see a crack in the carapace described in the same way when initially spotting the turtle. Large barnacles were observed on the vertebral scutes. Photos were obtained. Turtle sighted for a total of 2 minutes. Turtle was swimming away from the vessel on the surface, but seemed to have trouble making way. The observer witnessed two breaths taken by the turtle before diving. Vessel turned around to set back out and the turtle dove and not spotted again. Captain, observer, and initial spotted all saw to looked to be a fresh crack in the carapace about 1 ft long running longitudinally along dorsal scutes.

GPS log was being recorded, temperature loggers was deployed on starboard dredge, depth was 28 fathoms, weather was clear and sunny, tide was slack, wind was 10-15 northwest, boat had turned on starboard dredge, average speed was 4.5 knots. Both dredges caught 10 bushels of scallops. Several other turtles had been sighted during this day. A recreational boat was also going fast 500 yards off the vessel's starboard during the spotting. 6 other scallop vessels fishing within 5 miles of sighting.
Position was 38.61, -73.84

Vessel/Trip ID: Celtic 2009-1 **Date of Take**: 6/12/2009 **Tow #:** 11
Time: 0550 **Gear & Location of Turtle**: Turtle dredge; in bag
Condition: minor injuries **Carapace Length**: 83.0 cm **Species:** Loggerhead

Commentary: The loggerhead was caught on the starboard side (Turtle dredge) in the chain bag. The turtle was very active crawling around the deck; very good condition with some superficial injuries (1-inch crack in carapace and two shallow holes in plastron). The observer conducted the required sampling and let the turtle go and watched it dive right away. Two flipper tags were applied (RRT035 and RRT 036).

Vessel/Trip ID: Kathy Ann 2008-2 **Date of Take**: 8/9/2008 **Tow #:** 55
Time: 1345 **Gear & Location of Turtle**: Standard dredge; in bag
Condition: minor injuries **Carapace Length**: 80.0 cm **Species:** Loggerhead

Commentary: PSID 01- Loggerhead turtle; Carapace reddish brown in color, 2 pairs of prefrontal scales; overall body was in good condition; animal was conscious and alert and active on deck. The carapace was cracked (appeared to be new) in two locations; one crack was about an inch and a half long on the left side towards the rear; a little bit of white showing but no blood. The other carapace crack was over the right flipper about four inches long with a little blood possibly to the flesh underneath bright red in color. The observer speculated that the cracks probably occurred when dredge was dumped out. No other fresh wounds or scars. The turtle was caught in the control dredge.

Vessel/Trip ID: Kathy Ann 2008-2 **Date of Take**: 8/10/2008 **Tow #:** 74
Time: 1218 **Gear & Location of Turtle**: Turtle dredge; in bag **Condition**: unharmed
Carapace Length: 35 cm estimated **Species:** Unknown

Commentary: One of the crew members, Jose Guiao, threw the turtle overboard out of habit before the observer was able to identify species or take a photograph. The turtle was caught in the experimental dredge. The plastron did appear to be white from the wheelhouse along with underside of the flippers. (Tow 74 hauled @1218 on 8/10/2008; 38-45.8, 73-59.9). Since there was some confusion regarding this take; further interviews were conducted to ascertain the condition and fate of the turtle.

When the observer was questioned about PSID 02, by Matt Weeks and Ronald Smolowitz, she could not confirm that someone in the crew implied the turtle was dead. In her brief viewing of the turtle from the pilot house she thought it was a loggerhead. It should be noted that scallop crews return everything on deck, other than scallops that they keep, to the sea as fast as possible as they work through the pile of catch.

Jose Guirao was questioned, by the vessel captain and vessel fleet manager, upon landing and described the interaction and his involvement as follows: "A haul back occurred. After the dredges were emptied and put back over the side. I saw a small turtle in the pile. I approached the turtle and noticed he was fine and released him over the side. I just reacted; I did not think. I did what I would do under a normal trip…I just made a mistake with regard to the fact that we had an observer aboard who needed to identify and be the lead with any turtle before release. The boat was not moving yet, it was before we set the gear out again. The turtle appeared to be the same species as the previous turtle we tagged and released. The turtle was approximately 14" x 10" and weighed approximately 5-7 lbs. When the turtle was released I saw it swim away." Our preliminary conclusion from the crew members description was that PSID 02 could be a small loggerhead, approximately 35 cm in length that was uninjured. Due to the unusually small size for a loggerhead and lack of positive identification it may be best to classify the turtle as "nk".

Vessel/Trip ID: Tradition 2009-2 **Date of Take**: 10/20/2009 **Tow #:** 138
Time: 0308 **Gear & Location of Turtle**: Standard dredge; in bag
Condition: unharmed **Carapace Length**: 107.5 cm **Species:** Loggerhead

Commentary: The captain hauled the dredge back and observed a turtle inside the port (control) dredge. The turtle was sitting upright on top of the catch in the center of the bag. The crew took the turtle out of the dredge bag before the frame was set down on deck. The observer photographed, scanned for PIT tags, obtained a biopsy, and measured the turtle. The observer placed two Iconel tags in the rear flippers (#RRH325 in the left; #RRH307 in the right). The turtle was alive and active trying to bite the observer. There appeared to be no damage or blood showing at all on the turtle. Four of the crew lifted the turtle and placed him back in the water. The turtle swam off appearing to be in good physical condition.

Note: All carapace measurements provided above are curved notch to tip.

Table 3: Summary of all turtle dredge research trips.

Vessel/Trip ID	Date Sailed	Date Returned	Area	Total Tows	Oberved Tows	Experimental Frame	Chain Mat?
Celtic 2006-1	5/19/2006	5/21/2006	SNE open	11	11	Dredge Frame 1	No
Celtic 2006-2	5/25/2006	6/11/2006	SE part	218	92	Dredge Frame 1	No
Westport 2006-1	7/31/2006	8/6/2006	CAII	27	9	Dredge Frame 1	No
Celtic 2006-3	10/6/2006	10/18/2006	CAII	114	76	Dredge Frame 2	No
Westport 2006-2	9/14/2006	9/26/2006	CAII	162	75	Dredge Frame 2	No
Resolution 2006-1	11/7/2006		NLSA	25	14	Dredge Frame 4	No
Resolution 2006-2	11/13/2006		CAII	91	30	Dredge Frame 4	No
Resolution 2006-3	12/9/2006		Northern Edge	186	74	Dredge Frame 2	No
Nordic Pride 2007-1	1/6/2007		Northern Edge	252	98	Dredge Frame 2	No
Nordic Pride 2007-2	2/9/2007		Northern Edge	295	76	Dredge Frame 2	No
Westport 2007-1	3/28/2007		ETAA	68	45	Dredge Frame 3	No
Celtic 2007-1	4/10/2007		ETAA	32	16	Dredge Frame 3	No
Freindship 2007-1	5/15/2007	5/29/2007	HCAA	100	53	Dredge Frame 3a	Yes
Freindship 2007-2	6/5/2007	6/20/2007	HCAA	184	89	Dredge Frame 3	Yes
Freindship 2007-3	6/27/2007	7/10/2007	HCAA	161	43	Dredge Frame 3	Yes
Freindship 2007-4	6/5/2007	6/20/2007	HCAA	116	55	Dredge Frame 3	No
Freindship 2007-5	8/22/2007	8/29/2007	ETAA	42	19	Dredge Frame 3	No
Diligence 2007-1	9/20/2007		CAI	88	50	Dredge Frame 3	No
Diligence 2007-2	8/20/2007	8/27/2007	CAI	93	54	Dredge Frame 3	No
Celtic 2007-6	11/5/2007	11/13/2007	ETAA	109	60	Dredge Frame 3	No
Westport 2007-2	11/20/2007	11/29/2007	ETAA	100	60	Dredge Frame 3	No
Kathy Ann 2008-2	8/6/2008	8/12/2008	ETAA	107	12	Dredge Frame 5	No
Tradition 2008-1	8/6/2008	8/13/2008	ETAA	92	57	Dredge Frame 5	No
Grand Larson 2008-1	8/19/2008	8/22/2008	ETAA	63		Dredge Frame 5	No
Elizabeth 2008-1	10/31/2008	11/5/2008	ETAA	60		Dredge Frame 5	No
Araho 2009-1	6/4/2009	6/11/2009	ETAA	111	46	Dredge Frame 5	No
Celtic 2009-1	6/11/2009	6/20/2009	ETAA	106	8	Dredge Frame 5	No
Generation 2009-1	6/17/2009	6/26/2009	ETAA	38	17	Dredge Frame 5	No
Kathy Ann 2009-2	6/22/2009	7/2/2009	ETAA	118	61	Dredge Frame 5	No
Generation 2009-2	7/8/2009	7/17/2009	ETAA	41	23	Dredge Frame 5	No
Kathy Ann 2009-4	7/17/2009	8/4/2009	ETAA	203	106	Dredge Frame 5	No
Westport 2009-1	8/25/2009	9/2/2009	ETAA	130	39	Dredge Frame 5	No
Kathy Ann 2009-7	9/19/2009	9/28/2009	ETAA	239	109	Dredge Frame 5	No
Diligence 2009-3	9/30/2009	10/8/2009	ETAA	127	54	Dredge Frame 5	No
Tradition 2009-2	10/9/2009	10/23/2009	Delmarva	159	82	Dredge Frame 5	No
Celtic 2009-4	10/13/2009	10/26/2009	Delmarva	118	76	Dredge Frame 5	No
Diligence 2009-4	10/13/2009	10/26/2009	Delmarva	152	79	Dredge Frame 5	No
Trip Total: 37			**Tow Total**	**4338**	**1868**		

Table 4: Brief descriptions of turtle dredge modifications used during testing.

Dredge Frame 1	single outer bale, rebar guards, long shoe
Dredge Frame 2	single outer bale, wheel guards, long shoe
Dredge Frame 3	doubled outer bale, hardened guards, short shoe
Dredge Frame 3a	doubled outer bale, wheel guards, short shoe
Dredge Frame 4	Single Bale
Dredge Frame 5	doubled outer bale, short shoe

Notes:

Outer Bale: The bar that runs along the outside of the dredge from the frame to the towing point. Figure 5 shows a double bale bar while figure 6 shows a single bale bar.

Turtle guards: Loops of steel welded to the cutting bar made of rebar initially (dredge design 1) and upgraded to hardened steel in dredge design 3 as shown in the dredge figures. In dredge design 3a the turtle guards were made of rubber wheels.

Dredge shoes: The section of the dredge frame that rides along the sea floor. The short shoe was 40 cm long; the long shoe was 80 cm in length.

Vessel/Trip #	Date Sailed	Date Landed	Area	DAS	Total # of Tows	Dredge with Turtle	Take Date	Tow #	Time	Gear location	Condition	Hypothesis
Friendship 2007-4	6/5/2007	6/20/2007	HCAA	16	116							
Friendship 2007-5	8/22/2007	8/29/2007	ETAA	8	42							
Celtic 2007-6	11/5/2007	11/13/2007		9	109							
Westport 2007-2	11/20/2007	11/29/2007		10	100							
Kathy Ann 2008-2	8/6/2008	8/12/2008	ETAA	7	107	Cfarm	8/9/2009	55	1345	In bag	minor injuries	possibly injured when dredge was dumpe
Kathy Ann 2008-2	"	"	"			Standard	8/10/2009	74	1218	In bag	unharmed	
Tradition 2008-1	8/6/2008	8/13/2008	ETAA	8	92	Cfarm						
Grand Larson 2008-1	8/19/2008	8/22/2008	ETAA	4	63							
Elizabeth 2008-1	10/31/2008	11/5/2008	ETAA	6	60							
Araho 2009-1	6/4/2009	6/11/2009	ETAA	8	111	Standard	6/4/2009	12	1022	In bag	badly injured	Caught on seafloor
Celtic 2009-1	6/11/2009	6/20/2009	ETAA	10	106	Cfarm	6/12/2009	11	0550	In bag	minor injuries	Caught on haulback; injured on deck
Generation 2009-1	6/17/2009	6/26/2009	ETAA	10	38							
Kathy Ann 2009-2	6/22/2009	7/2/2009	ETAA	12	118							
Generation 2009-2	7/8/2009	7/17/2009	ETAA	10	41							
Kathy Ann 2009-4	7/17/2009	8/4/2009	ETAA	19	203							
Westport 2009-1	8/25/2009	9/2/2009	ETAA	7	130							
Kathy Ann 2009-7	9/19/2009	9/28/2009	ETAA	10	239							
Diligence 2009-3	9/30/2009	10/8/2009	ETAA	8	127							
Tradition 2009-2	10/9/2009	10/23/2009	Delmarva	15	159	Standard	10/20/2009	138	0308	In bag	unharmed	Caught on haulback
Celtic 2009-4	10/13/2009	10/26/2009	Delmarva	14	118							
Diligence 2009-4	10/13/2009	10/26/2009	Delmarva	14	152							
		Total Tows		**205**	**2231**							
Notes: No turtle chains were used on any tows.												
Turtle takes recorded for all tows; scallop and fish catch on sampled tows.												
Control dredges were all New Bedford (NB) style												

Table 5: Summary of all trips conducted during the turtle season in turtle areas without turtle chains.

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