Framework 25 Appendices

I. Description of Economic Model used in FW25 analyses

II. Methods and Analyses Used by the Scallop PDT for Development of Windowpane AMs

III. 2012 Scallop RSA Final Report, *Testing of Scallop Dredge Bag Design for Flatfish Bycatch Reduction*, Coonamessett Farm Foundation, October 2013.

IV. FY 2014 Scallop Access Area Lottery for Full-time Vessels

1.1 APPENDIX I – ECONOMIC MODEL

1.1.1 ESTIMATION OF PRICES, COSTS, PROFITS AND NATIONAL BENEFITS

The economic model includes an ex-vessel price equation, a cost function and a set of equations describing the consumer and producer surpluses. The ex-vessel price equation is used in the simulation of the ex-vessel prices, revenues, and consumer surplus along with the landings and average meat count from biological projections. The cost function is used for projecting harvest costs and thereby for estimating the producer benefits as measured by the producer surplus. The set of equations also includes the definition of the consumer surplus, producer surplus, profits to vessels, and total economic benefits.

1.1.2 Estimation of annual ex-vessel prices

Fish prices constitute one of the important channels through which fishery management actions affect fishing revenues, vessel profits, consumer surplus, and net economic benefits for the nation. The degree of change in ex-vessel price in response to a change in variables affected by management, i.e., scallop landings and meat count, is estimated by a price model, which also takes into account other important determinants of price, such as disposable income of consumers and price of imports.

Given that there could be many variables that could affect the price of scallops, it is important to identify the objectives in price model selection for the purposes of cost-benefit analyses. These objectives (in addition to developing a price model with sound statistical properties) are as follows:

- To develop a price model that uses inputs of the biological model and available data. Since the biological model projects annual (rather than monthly) landings, the corresponding price model should be estimated in terms of annual values.
- To select a price model that will predict prices within a reasonable range without depending on too many assumptions about the exogenous variables. For example, the import price of scallops from Japan could impact domestic prices differently than the price of Chinese imports, but making this separation in a price model would require prediction about the future import prices from these countries. This in turn would complicate the model and increase the uncertainty regarding the future estimates of domestic scallop prices.

In addition to the changes in size composition and landings of scallops, other determinants of ex-vessel price include level of imports, import price of scallops, disposable income of seafood consumers, and the demand for U.S. scallops by other countries. The main substitutes of sea scallops are the imports from Canada, which are almost identical to the domestic product, and imports from other countries, which are generally smaller in size and less expensive than the domestic scallops. An exception is the Japanese imports, which have a price close to the Canadian imports and could be a close substitute for the domestic scallops as well.

The ex-vessel price model estimated below includes the price, rather than the quantity of imports as an explanatory variable, based on the assumption that the prices of imports are, in general, determined exogenously to the changes in domestic supply. This is equivalent to assuming that the U.S. market conditions have little impact on the import prices. An alternative model would estimate the price of imports according to world supply and demand for scallops, separating the impacts of Canadian and Japanese imports from other imports since U.S. and Canadian markets for scallops, being in proximity, are highly connected and Japanese scallops tend to be larger and closer in quality to the domestic scallops. The usefulness of such a simultaneous equation model is limited for our present purposes, however, since it would be almost impossible to predict how the landings, market demand, and other factors such as fishing costs or regulations in Canada or Japan and in other exporting countries to the U.S. would change in future years.

Since the average import price is equivalent to a weighted average of import prices from all countries weighted by their respective quantities, the import price variable takes into account the change in composition of imports from Canadian scallops to less expensive smaller scallops imported from other countries. This specification also prevents the problem of multi-colinearity among the explanatory variables, i.e., prices of imports from individual countries and domestic landings. In terms of prediction of future ex-vessel prices, this model only requires assignment of a value for the average price of imports, without assuming anything about the composition of imports, or the prices and the level of imports from individual countries. The economic impact analyses of the fishery management actions usually evaluate the impact on ex-vessel prices by holding the average price of imports constant. The sensitivity of the results affected by declining or increasing import prices could also be examined, however, using the price model presented in this section.

The price model presented below estimates annual average scallop ex-vessel price by market category (PEXMRKT) as a function of

- Meat count (MCOUNT)
- Average price of all scallop imports (PIMPORT)
- Per capita personal disposable income (PCDPI)
- Total annual landings of scallop minus exports (SCLAND-SCEXP)
- Percent share of landings by market category in total landings (PCTLAND)
- A dummy variable as a proxy for price premium for Under 10 count scallops (DU10).
- Dummy variables for 2005 and 2010 to take into account the problems with the Japanese aquaculture in those years that reduced the supply of large scallops from this country and increased the demand for US sea scallops.
- A dummy variable for 2010 as a proxy

Because the data on scallop landings and revenue by meat count categories were mainly collected since 1998 through the dealers' database, this analysis included the 1999-2012 period. All the price variables were corrected for inflation and expressed in 2012 prices by deflating current levels by the consumer price index (CPI). The ex-vessel prices are estimated in semi-log form to restrict the estimated price to positive values only as follows:

Log (PEXMRKT) = f(MCOUNT, PIMPORT, PCDPI, SCLAND-SCEXP, PCTLAND, DU10, D2005, D2010)

The coefficients of this model are shown in Table 1. Adjusted R2 indicates that changes in meat count, composition of landings by size of scallops, domestic landings net of exports, average price of all imports, disposable income, and price premium on under 10 count scallops and 2005 and 2010 dummy variables explain over 81 percent of the variation in ex-vessel prices by market category.

Table 1. Regression results for price model

Regression Statistics	
R Square	0.8294
Adjusted R Square	0.8127
Observations	90

Table 2. Coefficients of the Price Model

Variables	Coefficients	Standard Error	t Stat
INTERCEPT	0.73308	0.38656	1.9
MCOUNT	-0.00493	0.00105	-4.7
PIMPORT	0.08477	0.03317	2.56
PCDPI	0.03257	0.00854	3.81
SCLAND-SCEXP	-0.009	0.00235	-3.83
DU10	0.06163	0.04197	1.47
PCTLAND	-0.17398	0.07751	-2.24
d05	0.23794	0.04571	5.21
d10	0.18476	0.04614	4

These numerical results should be interpreted with caution, however, since the analysis covers only 12 years of annual data from a period during which the scallop fishery underwent major changes in management policy including area closures, controlled access, and rotational area management.

1.1.3 Estimation of trip costs

1.1.4 Trip Costs

Data for variable costs, i.e., trip expenses include food, fuel, oil, ice, water and supplies.
The trip costs per day-at-sea (ffiwospda) is postulated to be a function of vessel crew size (CREW), vessel size in gross tons (GRT), vessel length (LEN) fuel prices (FUELP), and dummy variables for limited access general category (LGC) and small dredge (SMD) vessels. This cost equation was assumed to take a double-logarithm form and estimated with data obtained from

observer database. The empirical equation presented in Table 3 estimated more than 52% of the variation in trip costs and has proper statistical properties using the observer data from 1991 to 2012 for the limited access and limited access general category vessels.

Table 3. Estimation of total trip costs per DAS used for the limited access and limited access general category vessels

Number of Observations Used 922

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	92.52095	15.42016	170.10	<.0001
Error	915	82.94714	0.09065		
Corrected Total	921	175.46809			

Root MSE	0.30109	R-Square	0.5273
Dependent Mean	7.60870	Adj R-Sq	0.5242
Coeff Var	3.95712		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.35505	0.43567	7.70	<.0001
lngrt	1	0.17412	0.04209	4.14	<.0001
lnlen	1	0.46272	0.11760	3.93	<.0001
lncrew	1	0.20396	0.09783	2.08	0.0374
lnfuelpr	1	0.83778	0.07341	11.41	<.0001
SMD	1	-0.29295	0.04042	-7.25	<.0001
lgc	1	-0.62941	0.10317	-6.10	<.0001

1.1.5 Estimation of fixed costs

The fixed costs include those expenses that are not usually related to the level of fishing activity or output. These are insurance, maintenance, license, repairs, office expenses, professional fees, dues, taxes, utility, interest, communication costs, association fees and dock expenses. According to the observer data on fixed costs for the period 2001 to 2007, the fixed costs including maintenance, repairs, engine and gear replacement and hull and liability insurance averaged $162,000 per full-time vessel (Table 4). Table 5 shows that fixed costs of the vessels varies by the ton class and larger vessels have higher fixed costs than the smaller boats. Fixed costs for years after 2007 will be updated using the NMFS 2012 Cost Survey.

Table 4. Annual fixed costs for full-time limited access scallop vessels by year (in 2006 inflation-adjusted prices and includes only those observations for insurance cost was available)

Data	2001	2002	2003	2004	2005	2006	2007	2001-2007
Number of vessels	7	20	36	50	40	24	39	216
Maintenance ($)	96,659	52,308	79,108	49,953	69,048	91,045	38,717	63,452
Repairs and replacement ($)	86,912	65,400	81,452	73,349	44,287	38,714	33,414	58,283
Insurance ($)	40,980	35,127	60,501	57,117	61,933	65,896	62,129	57,941
Total fixed costs ($)	224,552	141,719	206,304	155,711	159,542	171,252	122,631	161,819
GRT	148	156	157	156	156	144	150	153
HP	876	799	832	825	813	792	840	822

Table 5. Annual fixed costs of full-time limited access scallop vessels by ton class (2006 inflation adjusted prices, including only those observations for which insurance data were available)

Data	51-100 GRT	101-150 GRT	>150	Average (2001-07)
Number of vessels	18	75	123	216
GRT	75	129	180	153
HP	461	690	957	822
Maintenance ($)	32,657	60,145	70,585	63,452
Repairs ($)	26,152	47,860	70,255	58,283
Insurance ($)	46,784	48,615	65,295	57,941
Total fixed cost ($)	100,780	142,482	182,652	161,819
Ratio of fixed costs to the average for the fleet	0.62	0.88	1.13	1.0

The 2006 and 2007 fixed cost survey data included other cost items such as office, accounting, and interest payments in addition to the repairs, maintenance and insurance.

The model shown in Table 6 is based on the fixed cost survey data and estimates fixed costs as a function of length, year built, horse power and a dummy variable for boats that have multispecies permit. The data included 196 observations and the fixed costs are estimated by using the 97 observations for vessels with dredge and trawl gear. Because the data on communications costs and association fees were missing for most observations, these costs were not included in the estimation but their average values for the scallop vessels were deducted from the gross stock when estimating net boat and crew shares (Table 7).

Table 6. Estimation of basic fixed costs

```
                                GMM with HCCME=1                                  235

                              The MODEL Procedure

                    Nonlinear GMM Summary of Residual Errors

                 DF      DF                                                Adj    Durbin
 Equation      Model   Error        SSE        MSE   Root MSE  R-Square     R-Sq    Watson

 lnfcbasic         5      92    15.8206     0.1720     0.4147    0.7283   0.7165    2.2736


                        Nonlinear GMM Parameter Estimates
```

```
                              Approx                  Approx
Parameter       Estimate     Std Err    t Value     Pr > |t|

intc            -242.988     65.7063      -3.70       0.0004
lenco           1.588635      0.1986       8.00       <.0001
bltco           32.51993      8.6562       3.76       0.0003
d10co           -0.51566      0.1039      -4.96       <.0001
hpco            0.168211      0.1174       1.43       0.1554


     Number of Observations     Statistics for System

     Used               97    Objective        2.3E-18
```

Table 7. Average association fee and communication costs by vessel size

	Average annual association fee	Average annual Communication Costs
All Vessels	1610	3446
Large (>=80 feet)	1895	3939
Medium (<80 feet)	1459	3185

Using the survey cost data, total fixed costs are estimated to be $176,516 per full-time vessel in 2006 constant dollars and $188,343 in 2008 dollars (Table 8). These estimates exclude vessel improvement costs (other than repairs and maintenance) which could be considered as discretionary investment and could be postponed when there is a temporary shortfall in cash earnings. Using this survey data information for the estimated value for fixed costs for 2011, i.e., $191,167 and assuming a vessel share for 48% of gross revenue, it could be estimated that in order to cover the fixed costs in full, a vessel has to earn a gross revenue of $398,264 (break-even revenue) any amount above that would generate profits. If instead average fixed costs were equal to the averages values ($161,819, Table 4), estimated from the observer data for 2001-2007, then adjusting this value for 2011 would result in a total fixed cost of $180,424 and a break-even revenue of $376,313.

Table 8. Estimated fixed costs per full-time vessel

Data	2007	In 2011 Inflation adjusted prices
Estimated basic fixed costs	$176,516	$191,167
Improvement Costs (Difference)	$50,023	$54,175

1.1.6 Profits and crew incomes

As it is well known, the net income and profits could be calculated in various ways depending on the accounting conventions applied to gross receipts and costs. The gross profit estimates used in the economic analyses in the FSEIS simply show the difference of gross revenue over variable (including the crew shares) and fixed expenses rather than corresponding to a specific accounting procedure. It is in some ways similar to the net income estimated from cash-flow statements since depreciation charges are not subtracted from income because they are not out-of-pocket expenses.

Gross profits per vessel are estimated as the boat share (after paying crew shares) minus the fixed expenses such as maintenance, repairs and insurance (hull and liability). Based on the input from the scallop industry members and Dan Georgianna on the lay system, the profits and crew incomes are estimated as follows:

- The association fees, communication costs and a captain bonus of 5% are deducted from the gross stock to obtain the net stock.
- Boat share is assumed to be 48% and the crew share is assumed to be 52% of the net stocks.
- Profits are estimated by deducting fixed costs from the boat share.
- Net crew income is estimated by deducting the trip costs from the crew shares.

1.1.7 Consumer surplus

Consumer surplus measures the area below the demand curve and above the equilibrium price. For simplicity, consumer surplus is estimated here by approximating the demand curve between the intercept and the estimated price with a linear line as follows:

CS= (PINT*SCLAN-EXPR*SCLAN)/2

$$PVCS = \sum_{t=2000}^{t=2008} (CS_t /(1+r)^t)$$

Where: r=Discount rate.

CS_t= Consumer surplus at year "t" in 1996 dollars.

PVCS= Present value of the consumer surplus in 1996 dollars.

EXPR= Ex-vessel price corresponding to landings for each policy option.
PINT=Price intercept i.e., estimated price when domestic landings are zero.
SCLAN= Sea scallop landings for each policy option.

Although this method may overestimate consumer surplus slightly, it does not affect the ranking of alternatives in terms of highest consumer benefits or net economic benefits.

1.1.8 Producer surplus

The producer surplus (PS) is defined as the area above the supply curve and the below the price line of the corresponding firm and industry (Just, Hueth & Schmitz (JHS)-1982). The supply curve in the short-run coincides with the short-run MC above the minimum average variable cost (for a competitive industry). This area between price and the supply curve can then be approximated by various methods depending on the shapes of the MC and AVC cost curves. The economic analysis presented in this section used the most straightforward approximation and estimated PS as the excess of total revenue (TR) over the total variable costs (TVC). It was assumed that the number of vessels and the fixed inputs would stay constant over the time period of analysis. In other words, the fixed costs were not deducted from the producer surplus since the producer surplus is equal to profits plus the rent to the fixed inputs. Here fixed costs include various costs associated with a vessel such as depreciation, interest, insurance, half of the repairs (other half was included in the variable costs), office expenses and so on. It is assumed that these costs will not change from one scenario to another.

PS=EXPR*SCLAN- ΣOPC
ΣOPC = Sum of operating costs for the fleet.

$$PVPS = \sum_{t=2000}^{t=2008}(PS_t /(1+r)^t)$$

Where: r=Discount rate.

PS_t= Producer surplus at year "t" in 1996 dollars.
PVPS= Present value of the producer surplus in 1996 dollars.
SCALN= Sea scallop landings for each policy option.
EXPR= Price of scallops at the ex-vessel level corresponding to landings for each policy option in 1996 dollars.

Producer Surplus also equals to sum of rent to vessels and rent to labor. Therefore, rent to vessels can be estimated as:

RENTVES=PS – CREWSH

Rentves= Quasi rent to vessels
Crewsh= Crew Shares

1.1.9 Total economic benefits

Total economic benefits (TOTBEN) is estimated as a sum of producer and consumer surpluses and its value net of status quo is employed to measure the impact of the management alternatives on the national economy.

TOTBEN=PS+CS

Present value of the total benefits= PVTOTBEN= PVPS+PVCS

1.1.10 Ownership and affiliations in the Scallop Fishery

According to the ownership data for the scallop fishery, several individuals have ownership interest in one single vessel or multiple vessels. In other words, every vessel has multiple owners and some owners of a particular vessel have ownership interest in other vessels with different individuals. Therefore, it necessary to develop a method that would take into account these affiliations in order to derive distinct business entities and assign an entity number to each group of vessels connected by common ownership for the purposes of RFA and other analyses.

The vessel affiliations and the corresponding business entities in the scallop fishery is derived using a method based on 'maximum ownership' criteria. This method follows SBA's criteria for affiliation to the extent possible, which is based on the principle of control that "may arise through ownership, management, or other relationships or interactions between the parties" including foreign affiliations even when the control is not exercised (CFR 121.103 in its Small Business Size Regulations). However, due to the lack of data on those relationships other than ownership of vessels, the business entities are identified based on the the ownership interest only. This approach is also consistent with the way ownership is defined for the purposes of 5% ownership cap provision in the scallop limited access fishery.

The maximum ownership criteria is basically a tool used in assigning all the vessels owned by an individual into the same entity and including the co-owners in the same pool of affiliation. A major proportion of vessels in the scallop fishery is owned by more than two individuals and sometimes as much as 20 or more people making it very time consuming identify the common owners for each vessel. For this reason, a SAS program is developed that identifies the main owner and then the business entities in several steps:

1. In the first step, the program calculates total number of vessels owned by each individual listed as an owner for each scallop vessel (i.e. vessels with scallop permits) as the following examples show.

Table 9. Owners of scallop vessels

Owner	Person-id	Number of vessels owned
Mrs.B	100	7
Mr. A	120	5
Mr. C	130	2
Mrs. D	175	6
Mr. E	125	6

Table 10. Vessels and Affiliations

Vessel	Owner 1	Owner 2	Main owner	Affiliation id
1	Mrs. B	Mr.A	Mrs. B	100
2	Mrs. B	Mr.A	Mrs. B	100
3	Mrs. B	Mr.A	Mrs. B	100
4	Mrs. B	Mr.A	Mrs. B	100
5	Mrs. B	Mr.A	Mrs. B	100
6	Mrs. B	Mr.C	Mrs. B	100
7	Mrs. B	Mr.C	Mrs. B	100
8	Mrs. D	Mr. E	Mrs. D	175
9	Mrs. D	Mr. E	Mrs. D	175
10	Mrs. D	Mr. E	Mrs. D	175
11	Mrs. D	Mr. E	Mrs. D	175
12	Mrs. D	Mr. E	Mrs. D	175
13	Mrs. D		Mrs. D	175
14		Mr. E	Mr. E	125

2. The information in Table 9 is then combined with each vessel entry and the “main owner” for each vessel is identified as that owner who owns the largest number of vessels in
3. Table 10. For example, if Mr. A and Mrs. B were listed as the joint owners of the same 5 vessels and Mrs. B and Mr. C were listed as the joint owners of additional two vessels, Mrs. B has been assigned as the primary owner of these 7 vessels. Consequently, those 7 vessels were considered as one business entity (one affiliation) because they all have one common owner, Mrs.B with control on all these vessels through ownership. The SAS program is then used the person-id for Mrs.B is as the affiliation number for that particular group of vessels.

4. In cases where a vessel has multiple owners that own same number of vessels, a simple method assigns the person with the maximum person-id as the main person of that vessel. For example, if Mr. E and Mrs. D were listed as the joint owners of the same 5 vessels and each also owned another vessel separately, and if Mr.A’s person-id is 125 and Mrs.D’s person-id is 75, then Mr.E is identified as the main owner of those jointly owned five vessels, and Mr.E is identified as the sole owner of vessel 14. Only issue with this approach is that it is not clear if the revenues earned from vessel 14 by Mr.E is used as investment purposes for the operation of vessels 8 to 12 he jointly owns with Mrs.D. If he did, all the vessels in the group (vessel 8 to 14) would have been considered as one business entity.

5. Using the above method resulted in 3 affiliated business entities in the scallop fishery; Entity 100, entity 175 and entity 125. In the second example, instead of selecting the owner based on the highest person-id, we could have selected the person with minimum person-id or maximum revenue or by some random index as the main owner without affecting the number of entities.

It must be pointed out that the concentration of ownership could be even more than estimated with the above method because not all family relationships could be taken into account in identifying the entities. For example, son or a daughter of an owner has the sole ownership of a vessel, that vessel is considered as a separate business entity with the above method.

REFERENCES

Daniel Georgianna and Debra Shrader (2005); “Employment, Income and Working Conditions in New Bedford’s Offshore Fisheries”. Final Report for Contract No. NA03NMF4270265, Saltonstall-Kennedy Program, NMFS, June 22, 2005.

Daniel Georgianna, A.Caas and P.Amaral (1999); The Cost of Fishing for Sea Scallops in the Northeastern United States. University of Massachusetts Dartmouth, Cooperative Marine Education and Research Program, NMFS, Contract Number NA67FE0420. December 16, 1999.

Steve Edwards. 2005. Accounting for Rents in the U.S. Atlantic Sea Scallop FisheryMarine Resource Economics, Volume 20, pp. 61–76

Table of Contents

1.0 METHODS USED TO DELINEATE WP AM AREAS

The approach used to identify the Windowpane AM areas used observer data to model d/k ratios and VMS data to model fleet effort. The development of different AMs occurred in four phases:

1. Model spatial and temporal variations in windowpane and scallop catch rates and resulting d/k ratios.
2. Iteratively close portions of the study domain and reallocate displaced effort until targeted decreases in windowpane catch are accomplished.
3. Use the output from (2) to design spatial and temporal closure scenarios.
4. Test the closure scenarios to determine the predicted impact on windowpane catches and displacement of fishing effort.

1.1 MODEL SPATIAL AND TEMPORAL VARIATIONS IN WINDOWPANE D/K RATIOS

Observer data for windowpane and sea scallop catch rates (catch per haul) from 2006 – 2012 were extracted from the NEFSC OBDBS database and aggregated by gear type, year, month, and ten-minute squares (hereafter TMS). The geographic extent of the analysis was then visually cropped to the area that had sufficient density for analysis. Generalized Additive Models (GAMs) for windowpane and scallop catch rates were developed independently and different GAM model structures were compared based on AIC values. Final model structures were:

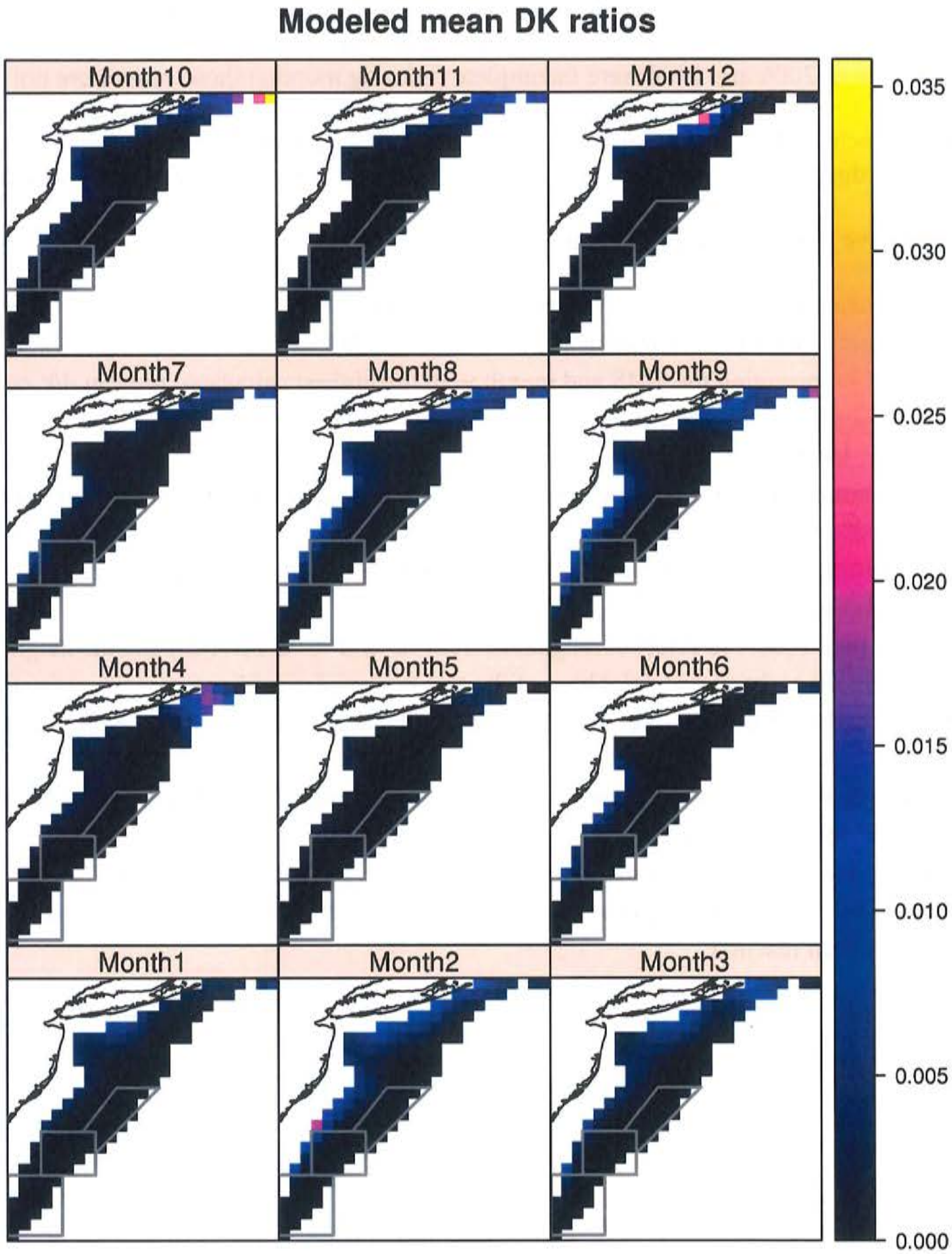
Windowpane catch rates:
sqrt(WPcpue)~s(Month, Latitude, Longitude) + factor(Year) + factor(Gear), weights=ObsEffort

Sea Scallops catch rates:
sqrt(SScpue)~s(Time, Latitude, Longitude) + factor(Gear) , weights=ObsEffort

where Month is the numeric month of the year, Year is the year observed, Time is decimal years based on the combination of Month and year, Latitude and Longitude are the coordinates of the centroid of the TMS, Gear is the gear type (dredge vs. trawl) and ObsEffort is the number of hauls observed in the TMS in a given year and month. Thus, windowpane catch rates are modeled as a consistent and repeating spatial and temporal pattern within a year with offsets for different years and gear types. Conversely, sea scallop catch rates are modeled as a spatial patterns that changes continuously throughout the time series. The PDT then used each model to predict the catch rates for all TMS in all months and years and combined model predictions to obtain spatially- and temporally-explicit d/k ratios. The PDT then calculated the median d/k ratio for each TMS and each month across all years (Figure 1).

The primary outputs for this step are summarized in Figure 1, and additional plots are in Section 2.0.

Figure 1 – Median d/k ratio for each TMS and each month across all year



1.2 ITERATIVE CLOSURE OF THE STUDY DOMAIN

The model-based windowpane and scallop catch rates were combined with total fleet effort for each TMS to estimate total catches. Fleet effort for each TMS was estimated using scallop fleet VMS data from 2006 – 2012. Because VMS data from 2006 and 2008 were incomplete (missing months) these years were not used to model the reallocation of effort. Effort for each TMS and months within years were calculated as the total number of pings (records) for each TMS and time period, given an average velocity of less than 5 knots. This process was only done for the dredge fleet as there was insufficient data to re-distribute effort for the trawl gear type.

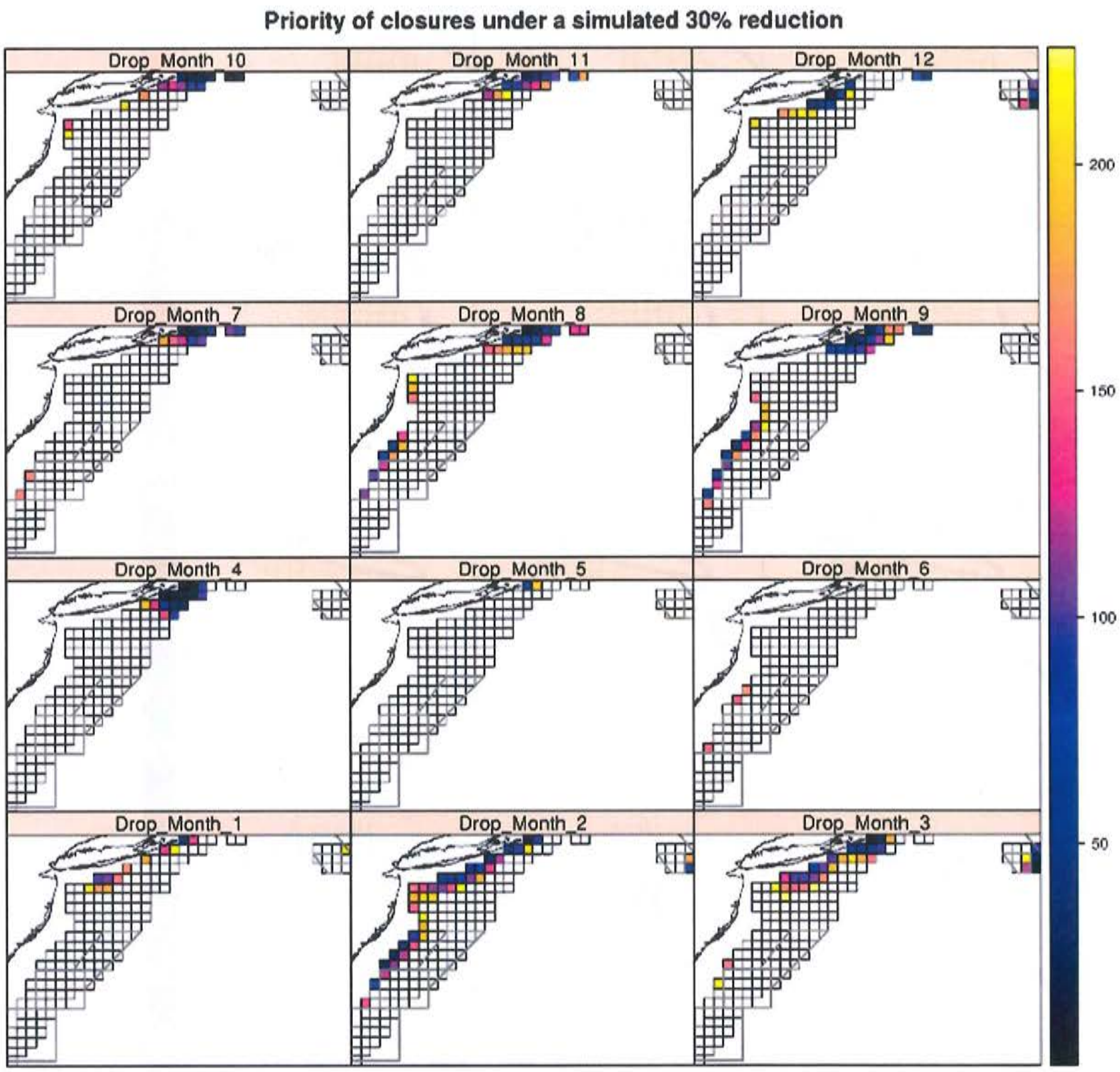
The following iterative process was then invoked:

1. Calculate a base-case total catch of windowpane across all years.
2. Declare a target reduction of windowpane catch (i.e. 10% below base-case)
3. Close the cell representing the TMS and month with the highest calculated median d/k ratio and calculate the scallop catch for that cell.
4. For each year, locate the cells adjacent to the newly closed cell.
    a. Determine which of the eight spatially adjacent cells are within the study domain and are currently open (spatial neighbors).
    b. Determine if the cells in the month prior-to or following the closed cell are open (temporal neighbors).
    c. If the total observed effort of neighbors from 'a' and 'b' is zero, expand the neighborhood to include the eight spatial neighbors of the two temporal neighbors.
5. Pro-rate the scallop catch from the closed cell across the neighbors based on the observed effort in the neighbors.
6. Based on the new scallop catches and the scallop and windowpane CPUE estimates, estimate new total catches of WP for the neighbors.
7. Estimate the total catch of WP assuming the closures and re-distribution of effort.
8. Repeat steps 3-7, drawing from the remaining open cells with the highest d/k ratios, until the target reduction has been reached.

1.2.1 Primary results related to this step

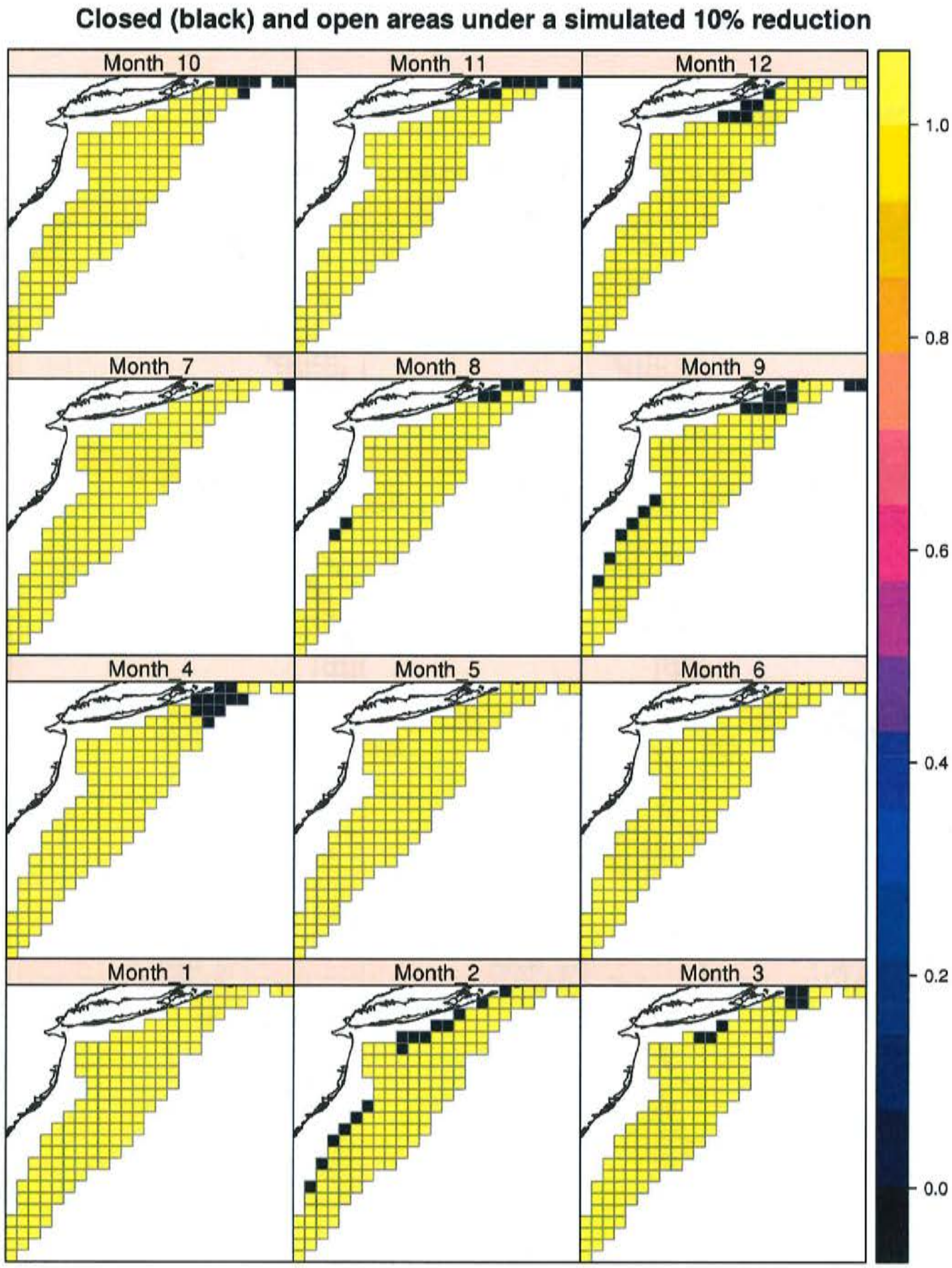
The following figures are the output of the second step of this process. The model identifies "priority" TMS with higher d/k ratios by month. The darker colors are the TMS that would have the highest d/k ratios and would be recommended for closure first. The PDT evaluated several different target reduction plots, but the highest (30% reduction) is shown below as an example. The units are in terms of TMS cells needed to attain the target reduction; for example, about 200 TMS cells would be needed to attain an overall 30% reduction for the year.

Figure 2 – Priority TMS for a target reduction of 30%

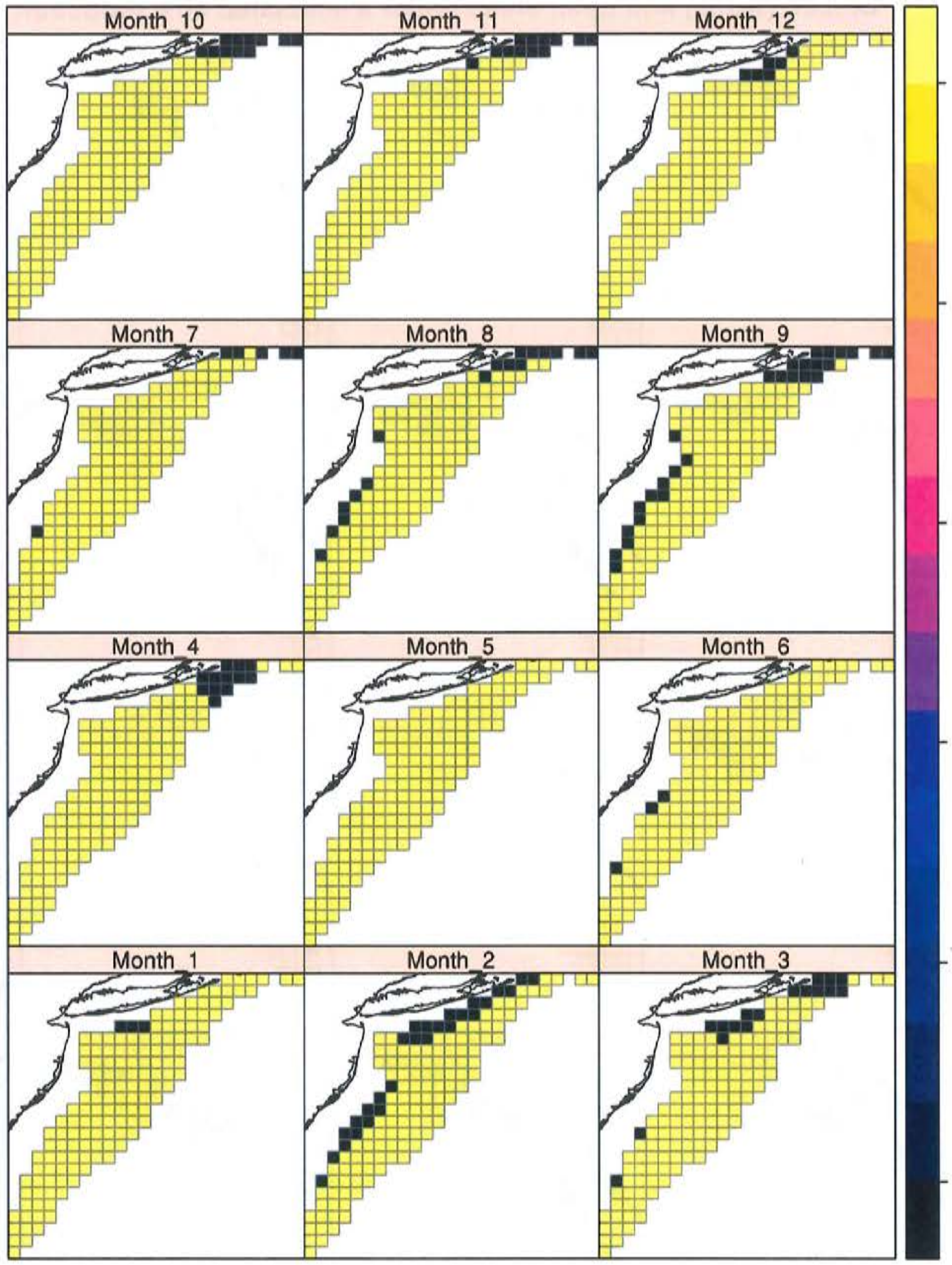


The following figures are the next step within the second phase of this process. The model identified certain TMS to close in order to attain a target reduction of WP catch (10%, 20% and 30%). The PDT used these outputs and further modified them in the section below.

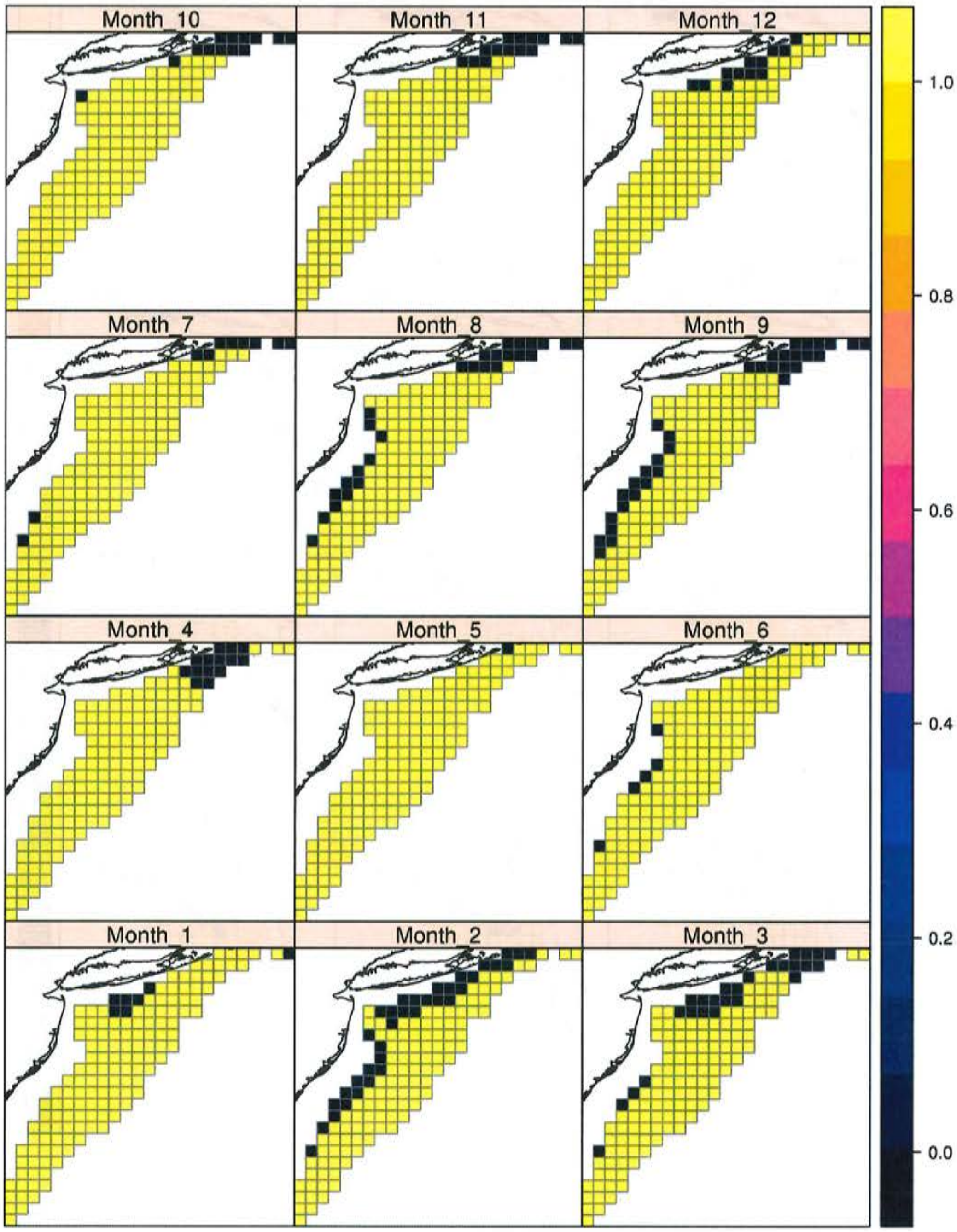
Figure 3 – Model generated closures to attain a target reduction of WP catch



Closed (black) and open areas under a simulated 20% reduction



Closed (black) and open areas under a simulated 30% reduction



1.3 USE OF THE ITERATION MODEL OUTPUT TO DESIGN SPATIAL AND TEMPORAL CLOSURE SCENARIOS.

The PDT modified the closures identified by the iteration model to produce spatial and temporal closure scenarios. The raw model output consists of collections of cells that are often scattered spatially or temporally and thus, are not viable for implementation or enforcement. The PDT modified both the spatial extent and temporal extent of the closures to produce spatially-and temporally-contiguous closed areas and offset the impacts of the closures across the fleet.

The primary sources of information used to develop the final range of candidate AM areas are:

1) the "priority" TMS areas with the highest d/k rates (Figure 2);

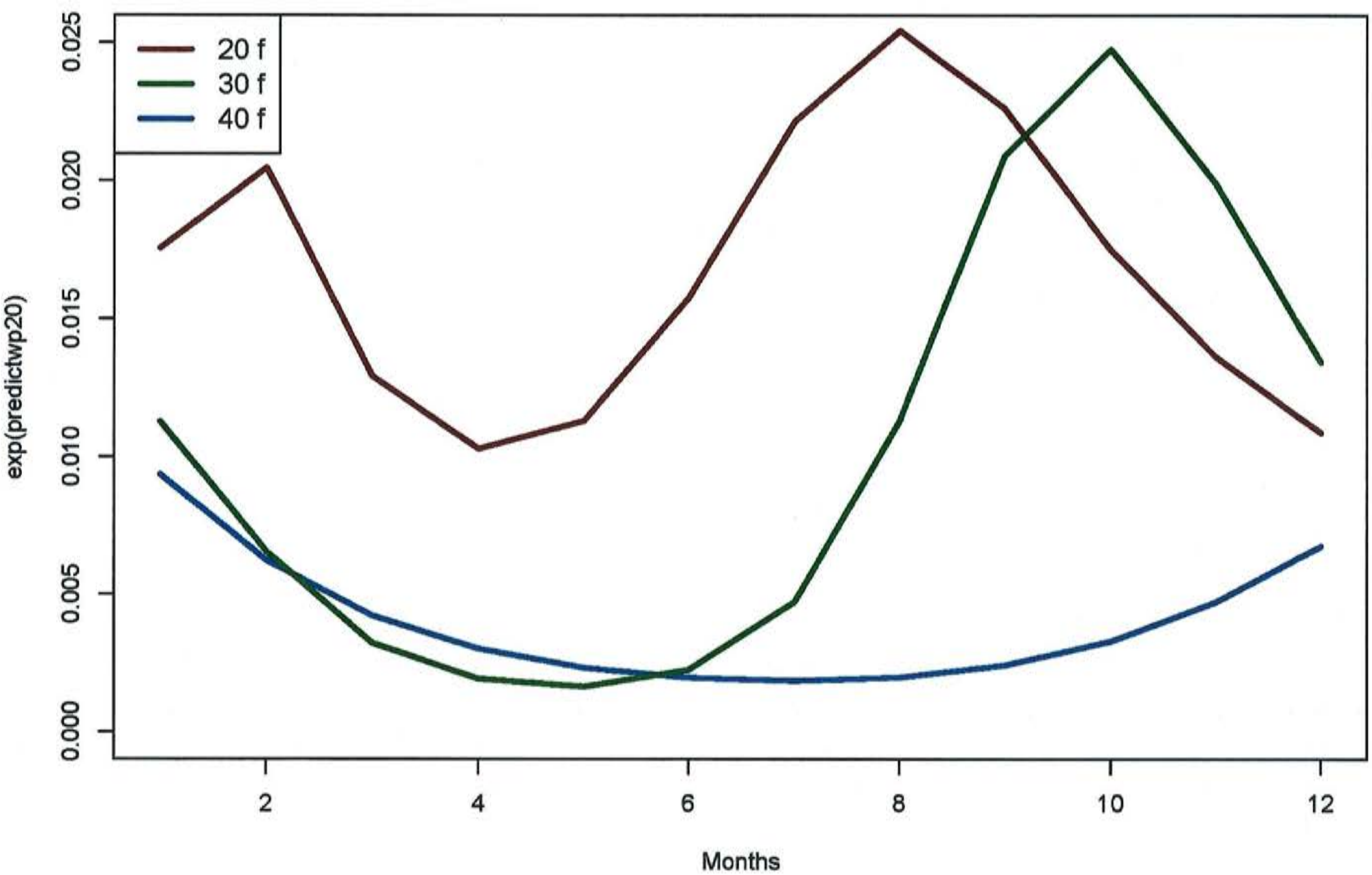
2) the model generated closure TMS scenarios (Figure 3);

3) a separate GAM model that was developed that predicts bycatch by month and depth to identify the appropriate seasons (described below **Figure 4**); and

4) VTR effort location for LA and LAGC vessels (described below **Figure 5**).

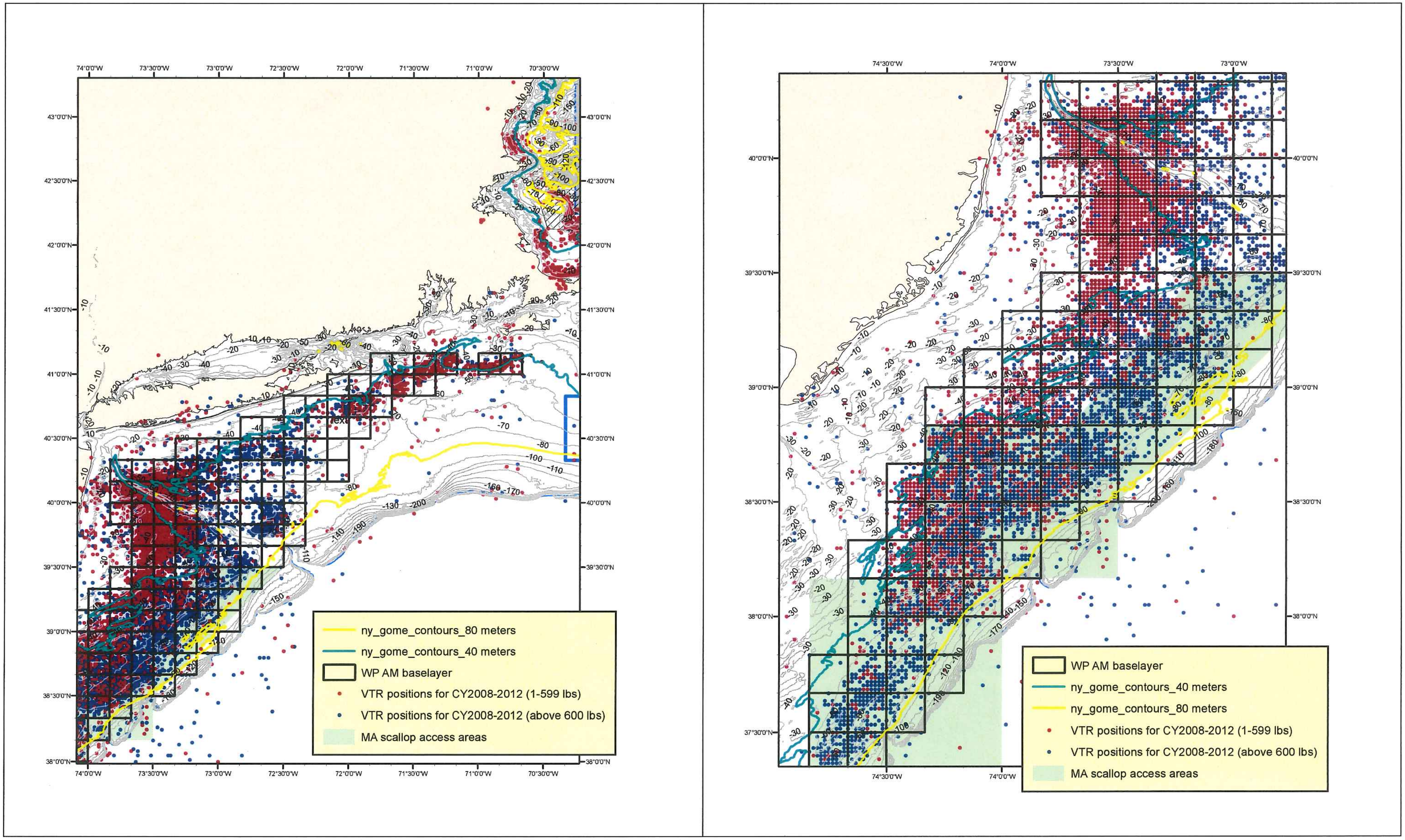
A separate GAM model was developed that predicts bycatch by month and depth using all observed scallop trips from 1999-2011. Analyses were broken out by depth as well as month. During most months, bycatch is highest at 20 fathoms (**Figure 4**). However, during the fall, bycatch seems to be higher at 30 fathoms. Based on these results the PDT supports potential adoption of a season for either an area closure of gear restricted AM for windowpane, in late summer/fall. Therefore, the PDT used this information as well as the outputs in **Figure 4** to identify the seasons associated with the various AM areas developed.

Figure 4 – Predicted WP d/k ratios by month and depth (GAM model results from 1999-2011 scallop fishery observer data)



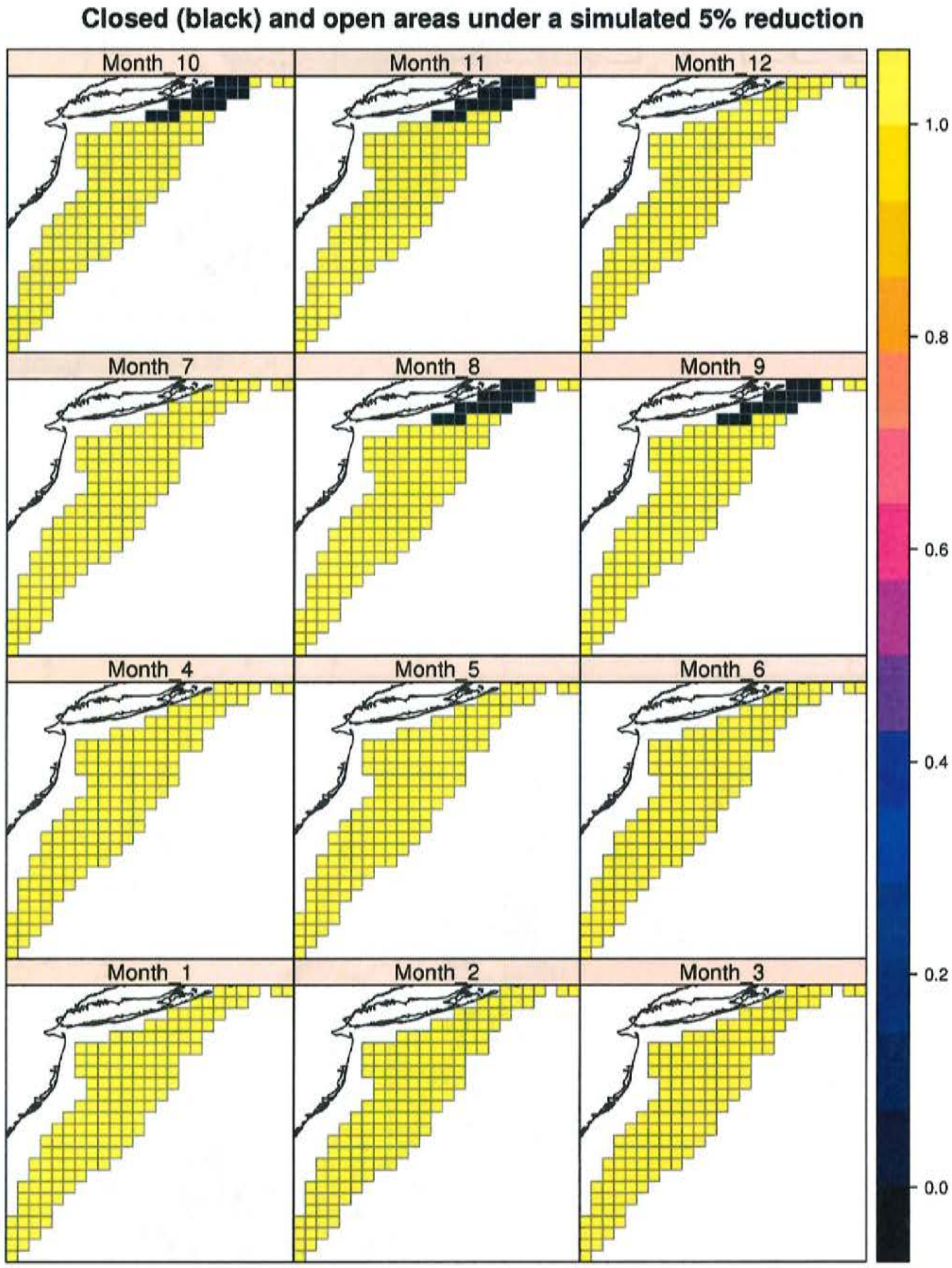
Finally, the PDT did use VTR fishing location information to further refine AM areas. Areas with higher concentrations of effort were avoided. In the end, several areas were developed that encompassed as many of the higher WP bycatch cells, constrained by seasons with higher bycatch rates, and avoiding as many primary fishing locations as possible.

Figure 5 – Scallop fishing effort location based on VTR data 2008-2012 (trips under 600 pounds are in red and trips over 600 pounds in blue)

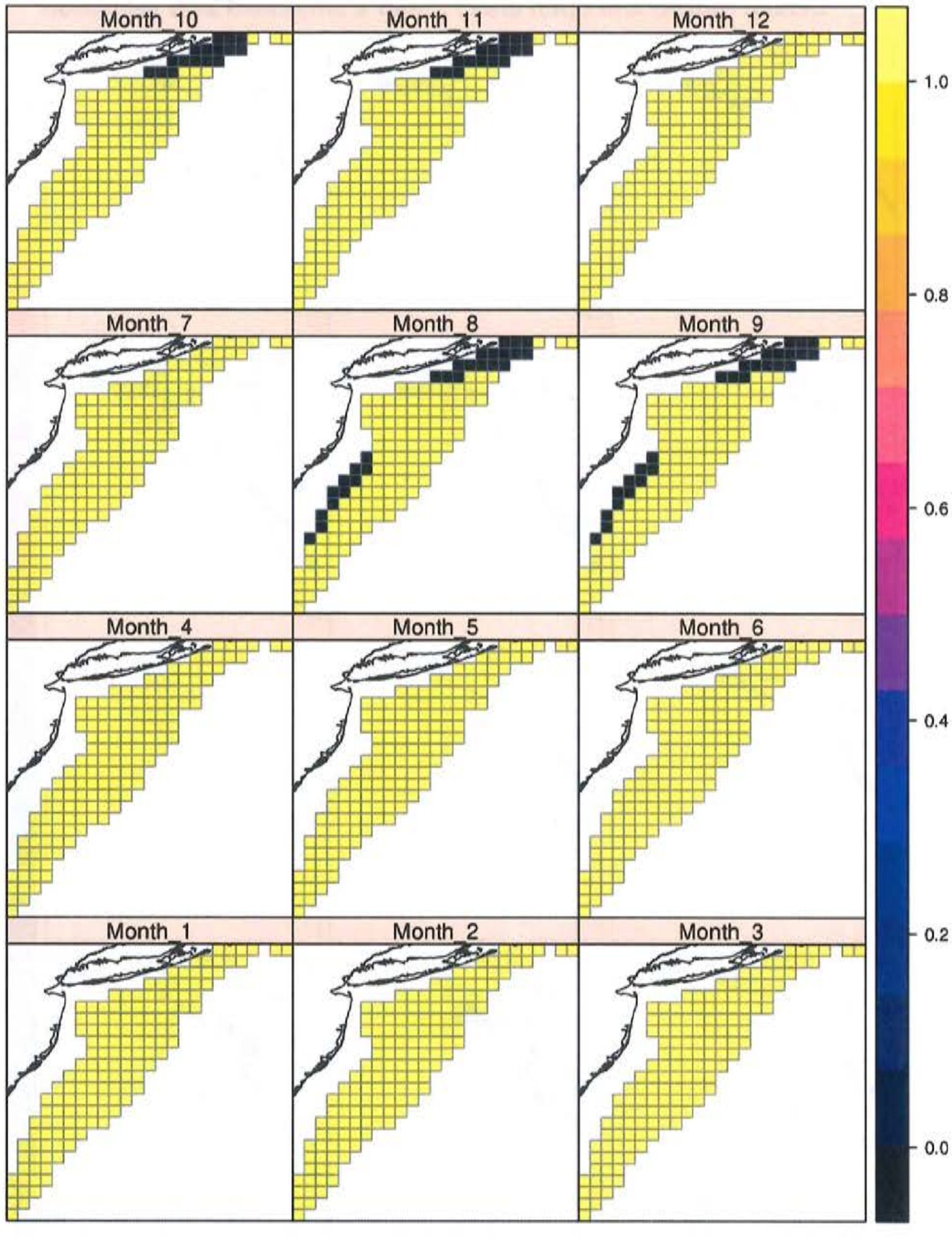


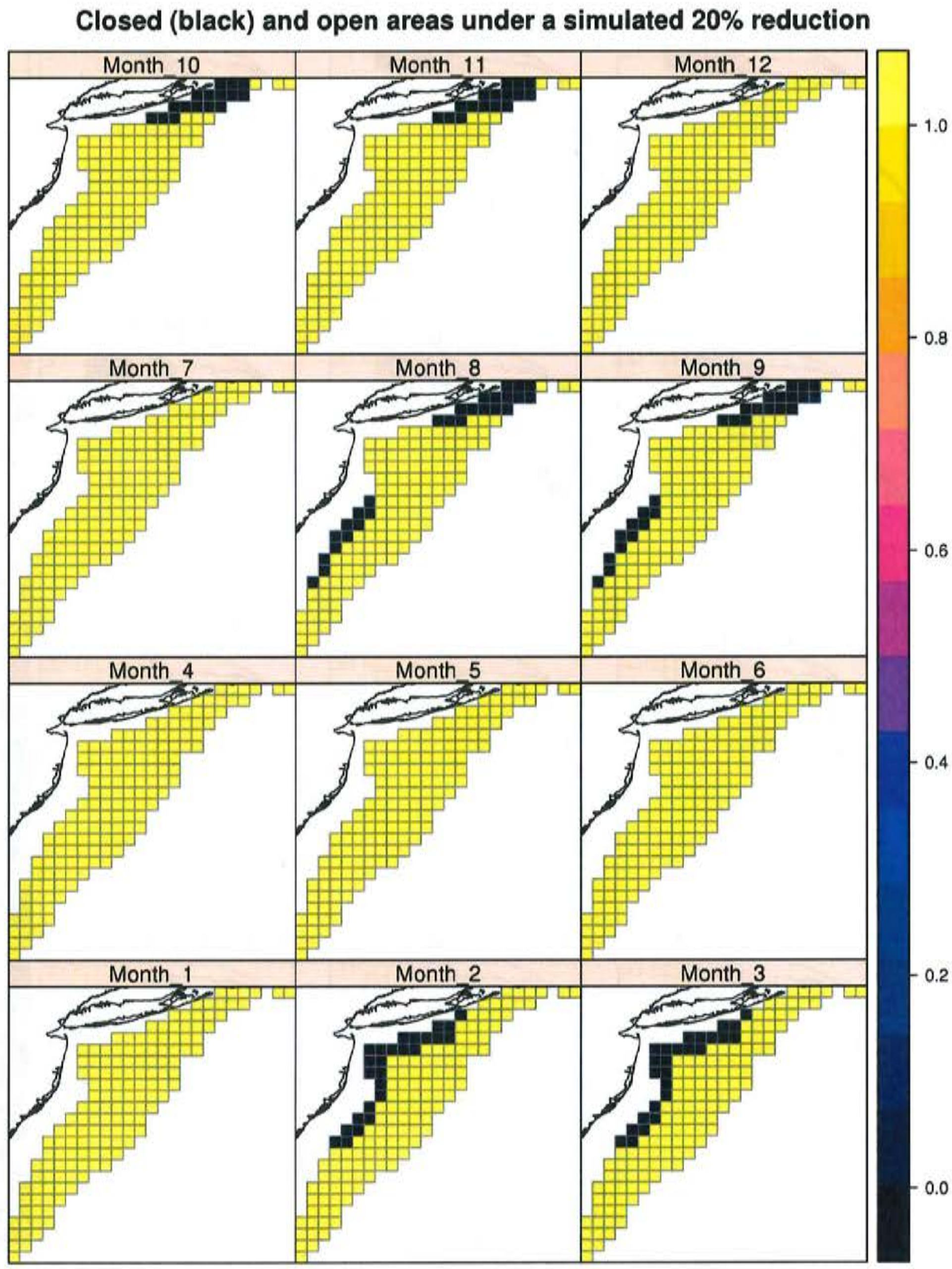
First the PDT used the TMS grids to delineate the boundaries of the AM areas. The figures below represent areas that would generate 5%, 10% and over 20% reductions (Figure 6). The PDT had a conference call on January 6 and decided to turn these areas into more regularly shaped polygons (Figure 7).

Figure 6 – Initial scenarios for 5%, 10% and 20%



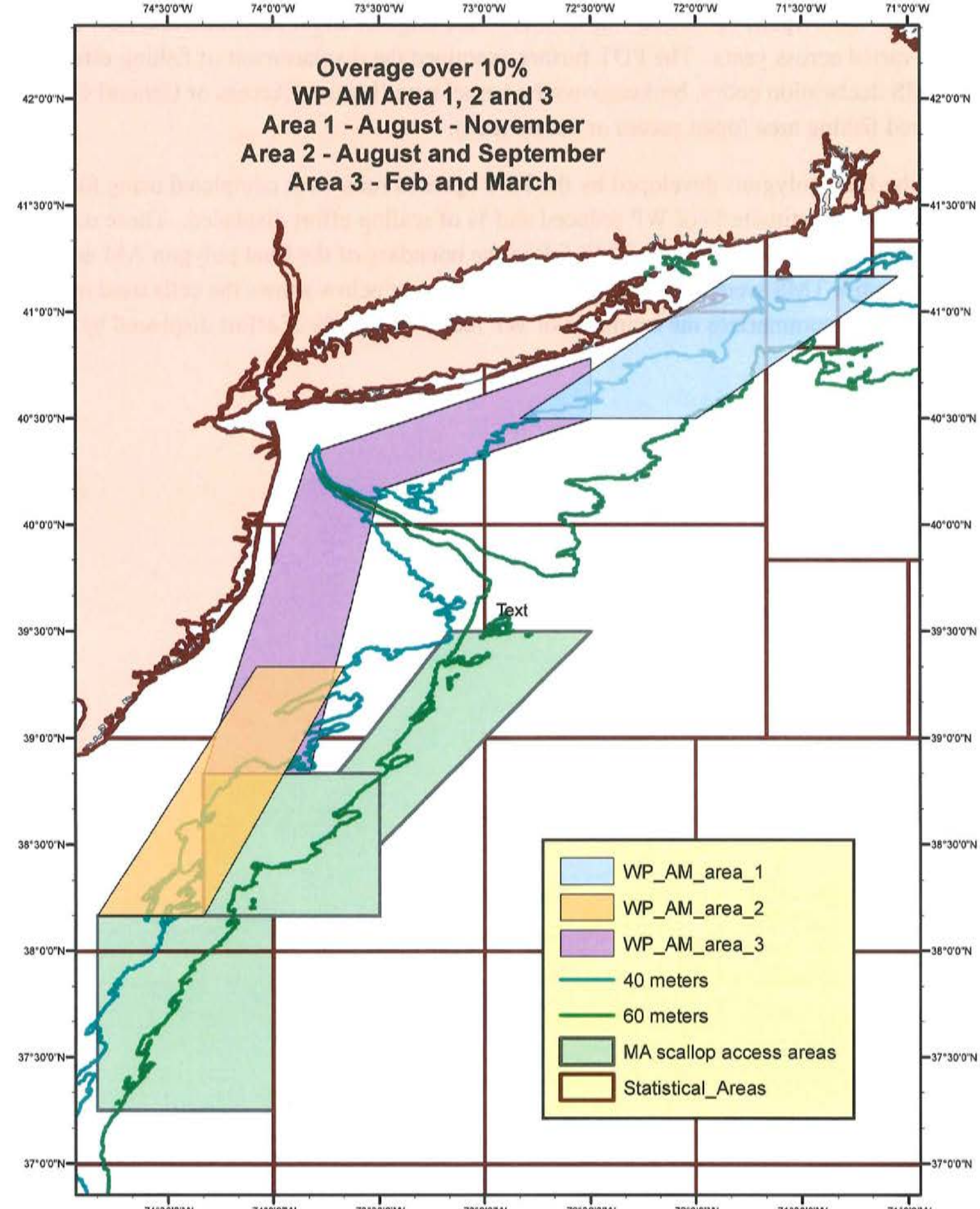
Closed (black) and open areas under a simulated 10% reduction





Closed (black) and open areas under a simulated 20% reduction
Month_10
Month_11
Month_12
Month_7
Month_8
Month_9
Month_4
Month_5
Month_6
Month_1
Month_2
Month_3
1.0
0.8
0.6
0.4
0.2
0.0

Figure 7 – WP AM area alternatives

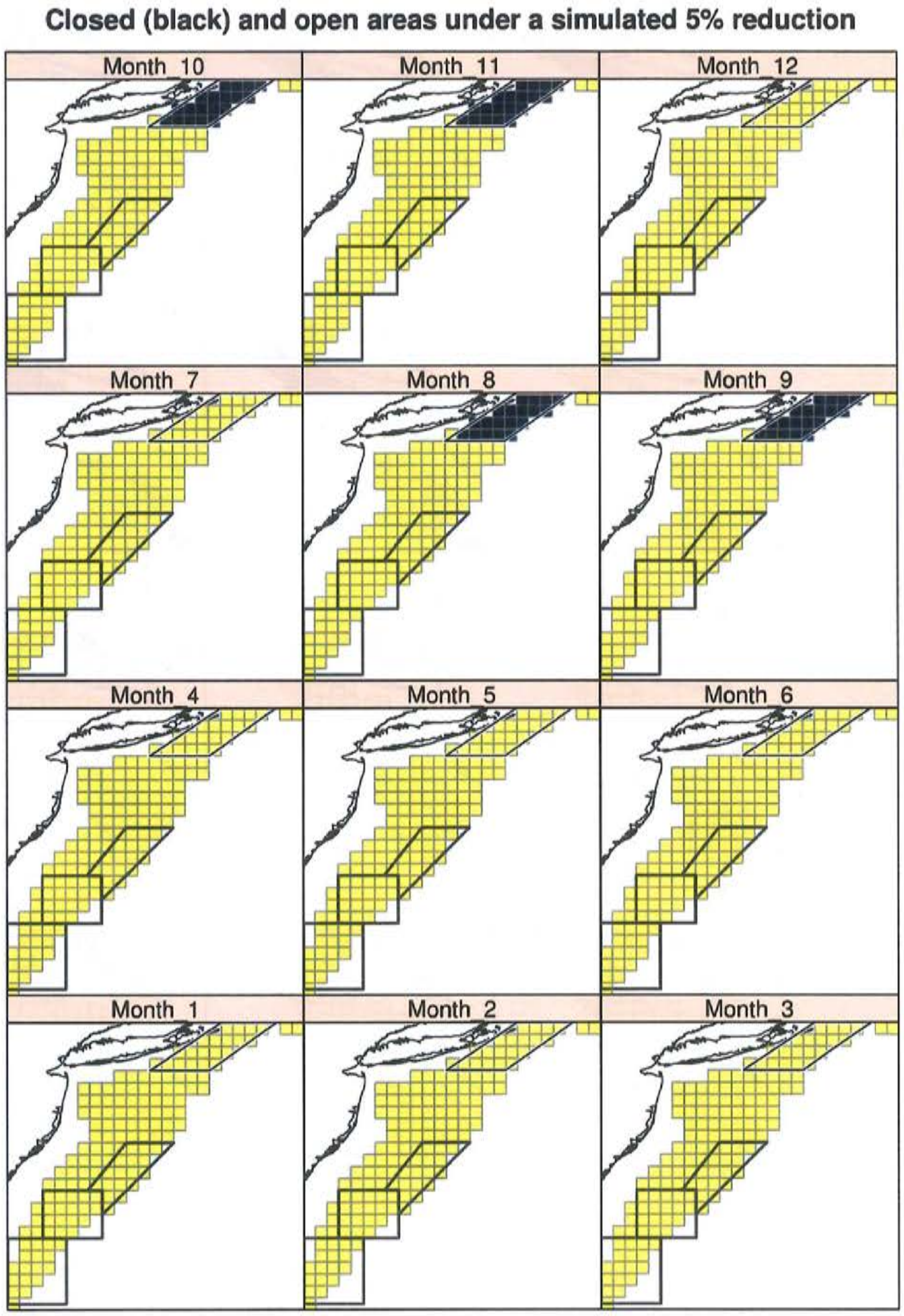


1.4 TEST THE MODIFIED CLOSURE SCENARIOS

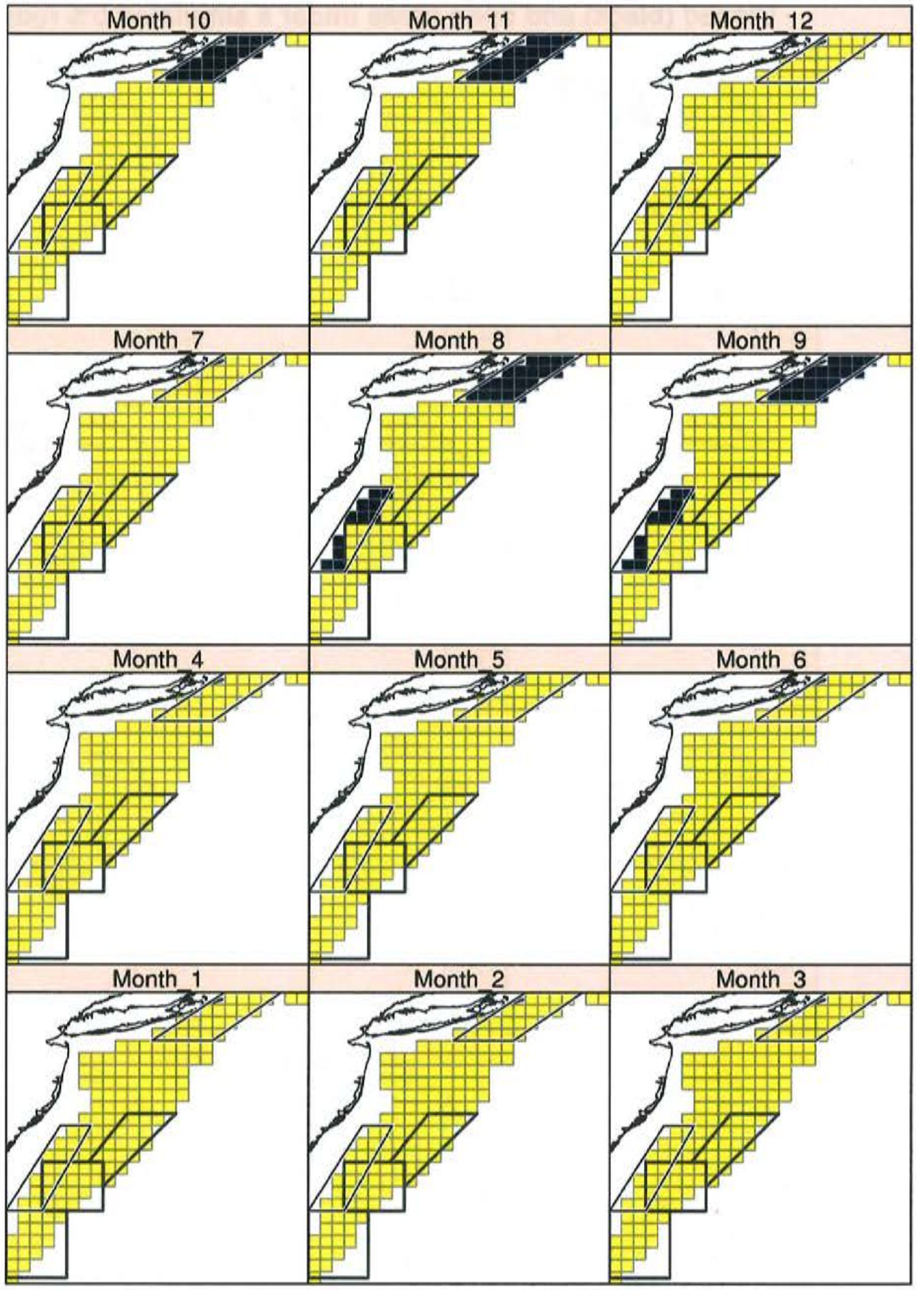
Finally, the PDT tested each closure scenario by feeding the spatial- and temporal-extent of the closure back into the iterative model and closing individual cells, in order of highest median d/k ratios, until all the cells for the closure had been implemented. The PDT then examined if the model-based windowpane reduction was similar to the original target reduction and how the reduction varied across years. The PDT further examined the displacement of fishing effort based on the VMS declaration codes, broken down by vessel type (Limited Access or General Category) and declared fishing area (open access or access area).

Based on the final polygons developed by the PDT updated runs were completed using the final area boundaries to estimate % of WP reduced and % of scallop effort displaced. These data are binned by TMS, so if the center of a TMS fell in the boundary of the final polygon AM areas, the data for the entire TMS were included in the results. Figure below shows the cells used in the results and Table summarizes the estimates of WP reduction and % of effort displaced by the various scenarios.

Figure 8 – TMS cells associated with the final polygon layers for each of the AM scenarios



Closed (black) and open areas under a simulated 10% reduction



Closed (black) and open areas under a simulated 20% reduction

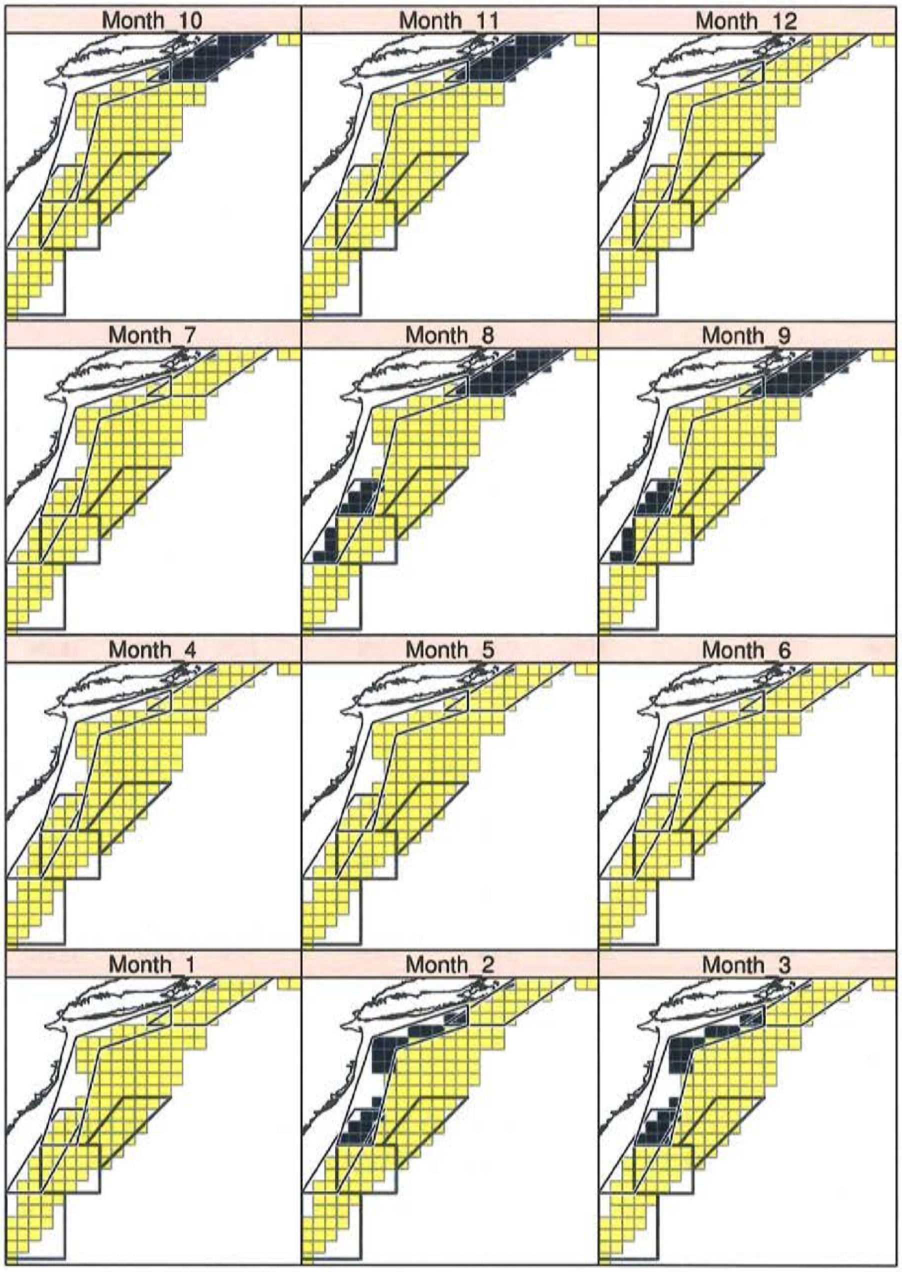


Table 1 – Summary of estimated WP reduction and % of scallop fishery effort displaced by the three AM alternative areas

5% Scenario	WP Catch	Effort displacement							
Year	Reduction	LA_Open	LAGC_AA	LAGC_Open	LAGC_UnClass	RSA_AA	RSA_Open	RSA_UnClass	SAA_AA
2007	1.6%	4.0%	0.3%	0.0%	6.4%	0.0%	0.0%	0.0%	0.0%
2008	0.1%	0.6%	0.0%	6.5%	0.0%	1.7%	0.1%	0.0%	0.7%
2009	1.1%	0.6%	0.0%	2.2%	0.0%	0.3%	0.0%	0.0%	0.0%
2010	19.9%	4.7%	0.0%	7.7%	0.0%	0.0%	30.3%	0.0%	0.0%
2011	3.1%	1.0%	0.0%	11.7%	0.0%	0.0%	47.0%	0.0%	0.0%
2012	1.6%	2.0%	0.0%	4.1%	0.0%	12.5%	35.7%	0.0%	0.1%
mean	4.6%	2.1%	0.1%	5.4%	1.1%	2.4%	18.9%	0.0%	0.1%

10% Scenario									
Year	Reduction	LA_Open	LAGC_AA	LAGC_Open	LAGC_UnClass	RSA_AA	RSA_Open	RSA_UnClass	SAA_AA
2007	27.4%	5.6%	0.6%	0.0%	12.5%	0.0%	0.0%	0.0%	0.0%
2008	3.3%	1.6%	0.0%	14.3%	0.0%	1.7%	0.1%	0.0%	0.7%
2009	8.1%	2.8%	0.0%	4.0%	0.0%	0.3%	0.0%	0.0%	0.0%
2010	20.1%	5.0%	0.0%	10.5%	0.0%	1.0%	30.3%	0.0%	0.0%
2011	3.1%	1.0%	0.2%	12.1%	0.0%	0.0%	47.0%	0.0%	0.0%
2012	1.7%	2.1%	0.0%	5.6%	0.0%	12.5%	35.7%	0.0%	0.1%
mean	10.6%	3.0%	0.1%	7.8%	2.1%	2.6%	18.9%	0.0%	0.2%

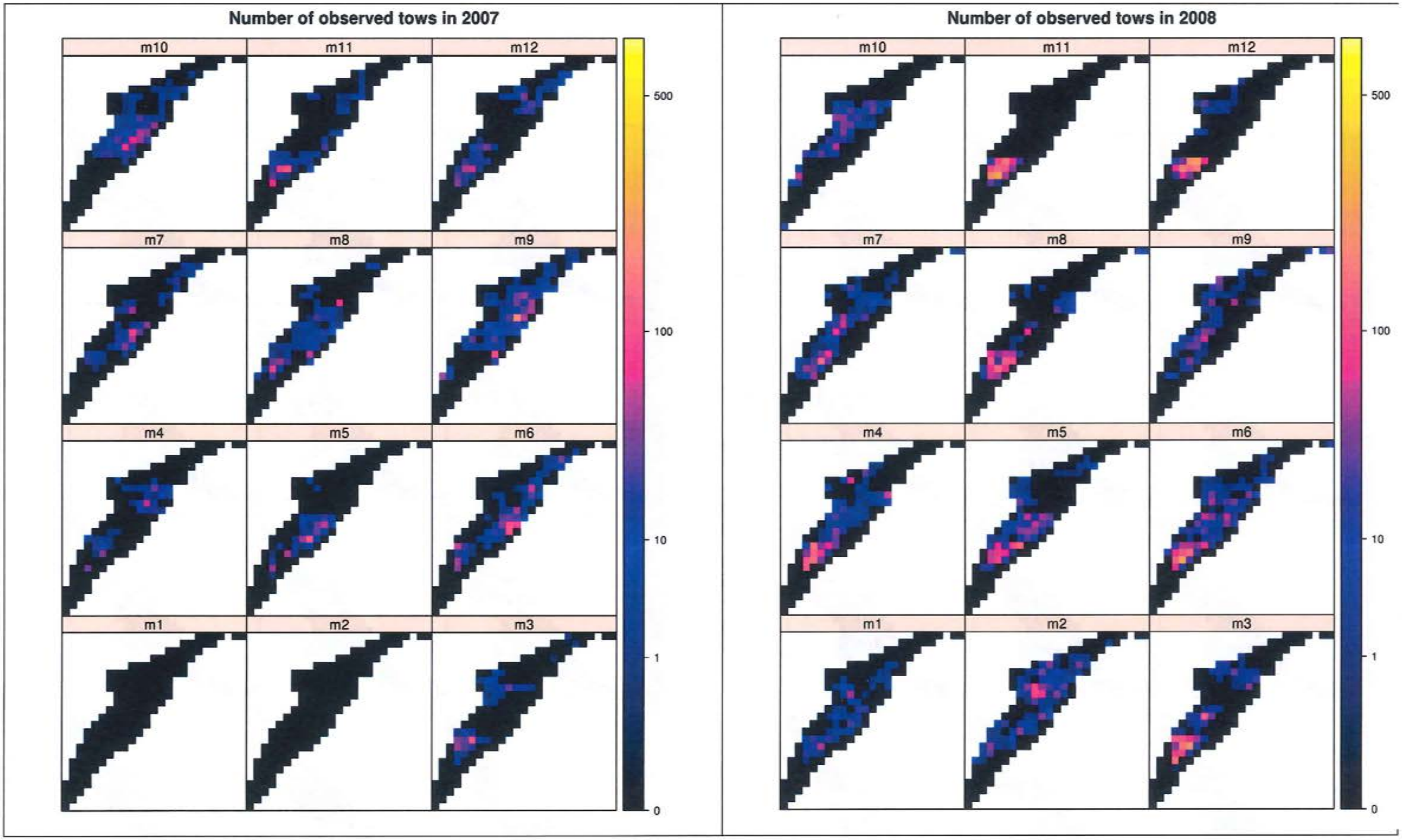
20% Scenario									
Year	Reduction	LA_Open	LAGC_AA	LAGC_Open	LAGC_UnClass	RSA_AA	RSA_Open	RSA_UnClass	SAA_AA
2007	28.2%	6.1%	2.1%	0.0%	14.9%	0.0%	0.0%	0.0%	0.0%
2008	6.1%	5.7%	1.7%	14.3%	8.4%	1.7%	0.9%	0.0%	0.7%
2009	14.0%	4.4%	0.4%	5.4%	0.0%	0.3%	0.0%	0.0%	0.1%
2010	31.8%	6.8%	0.0%	11.0%	0.0%	1.0%	30.3%	0.0%	0.0%
2011	9.1%	6.0%	0.3%	17.3%	0.0%	0.0%	47.0%	0.0%	0.1%
2012	7.8%	4.3%	0.1%	7.9%	0.0%	12.5%	36.4%	0.0%	0.1%
mean	16.2%	5.6%	0.8%	9.3%	3.9%	2.6%	19.1%	0.0%	0.2%

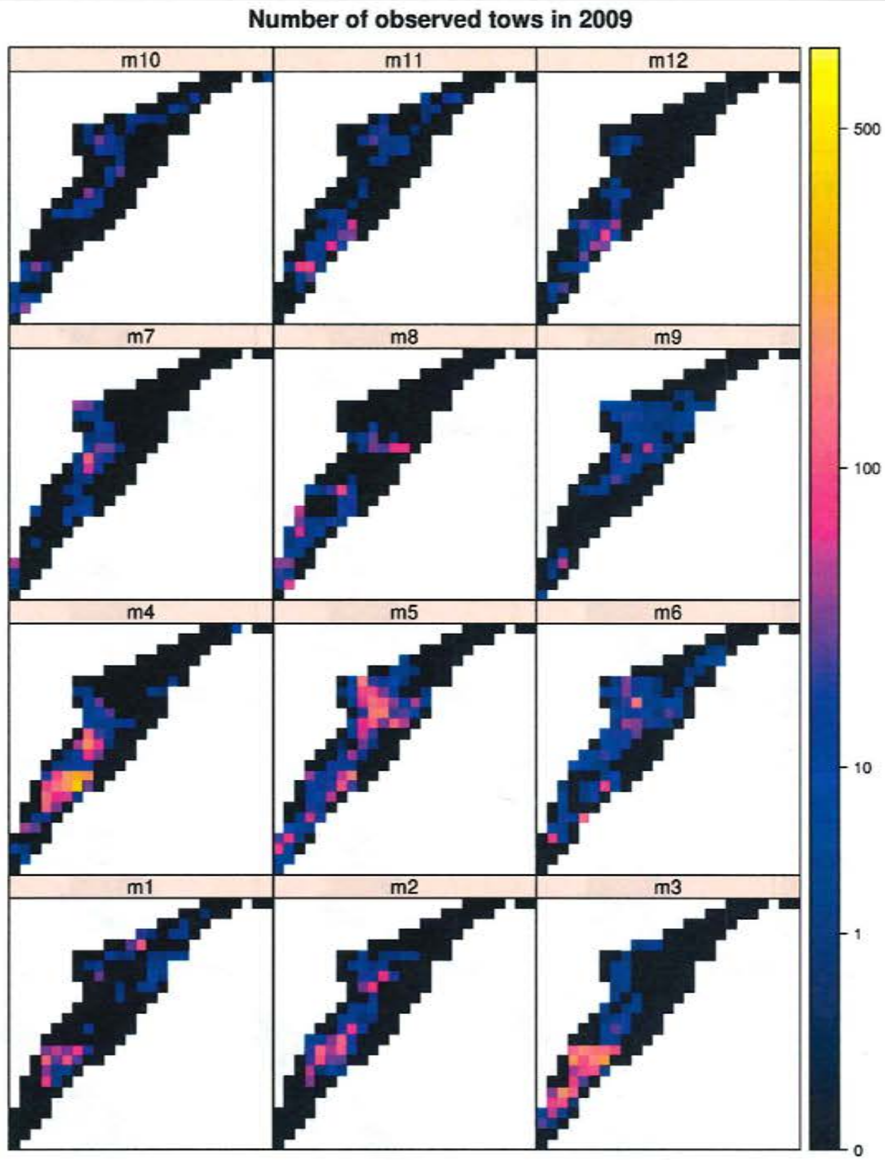
2.0 DETAILED RESULTS RELATED TO THE MODEL FOR SPATIAL AND TEMPORAL VARIATIONS IN WINDOWPANE D/K RATIOS

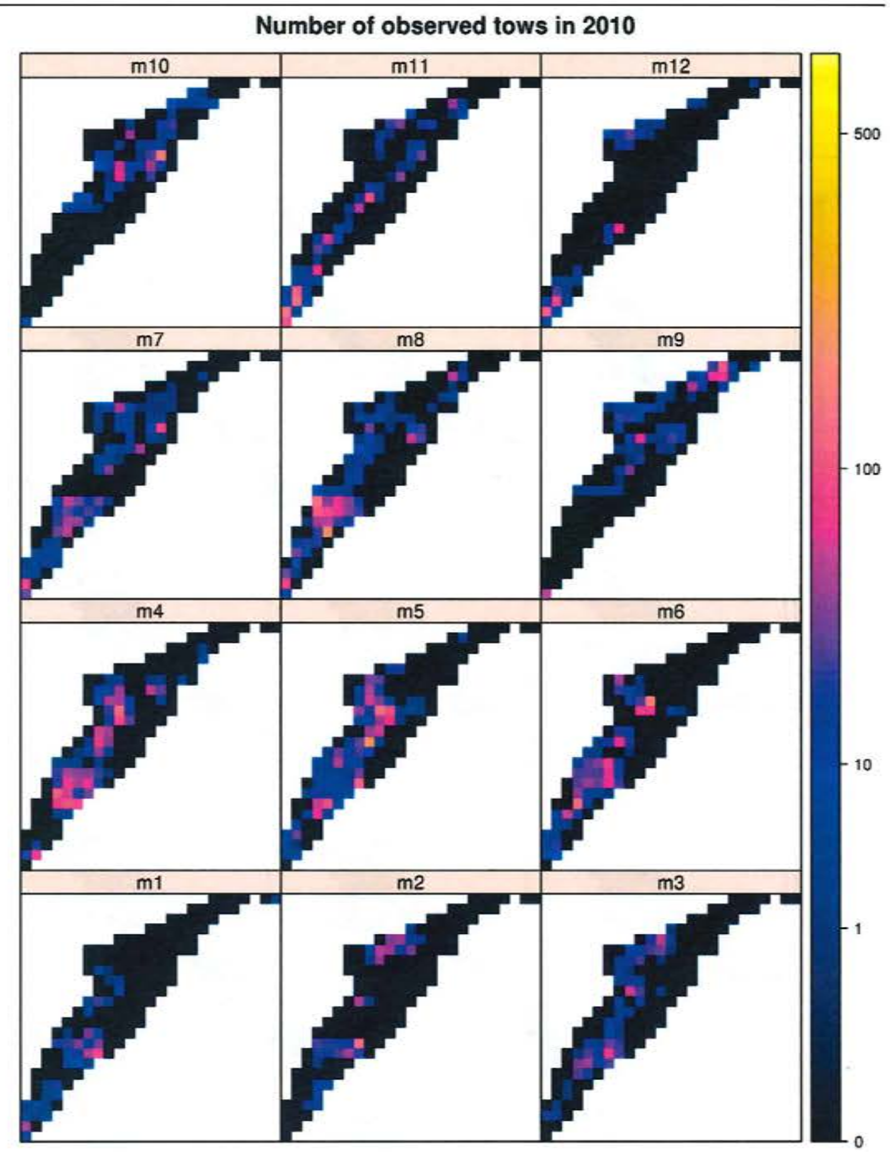
This section includes the plots for the phases involved in the first step of this process: modelling spatial and temporal variations in WP d/k ratios. The final product from this step is a mean d/k ratio per TMS (Figure 1). In order to get to that step there is a number of analyses that were completed and this section includes the outputs for the major stages. Specifically, the number of observed tows per TMS, modeled WP and sea scallop catch rates per TMS, and the resulting modeled d/k ratios. In addition, an overall histogram of all d/k ratios from the observer database were plotted (Figure 14). The vast majority of d/k ratios per tow is less than 0.001.

The PDT also include maps of fishing effort, based on VMS coverage, that were used for reallocating effort in the second phase of the process (Section 1.2).

Figure 9 – Number of observed tows per TMS with WP catch by month and year




Number of observed tows in 2009
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
500
100
10
1
0


Number of observed tows in 2010
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
500
100
10
1
0

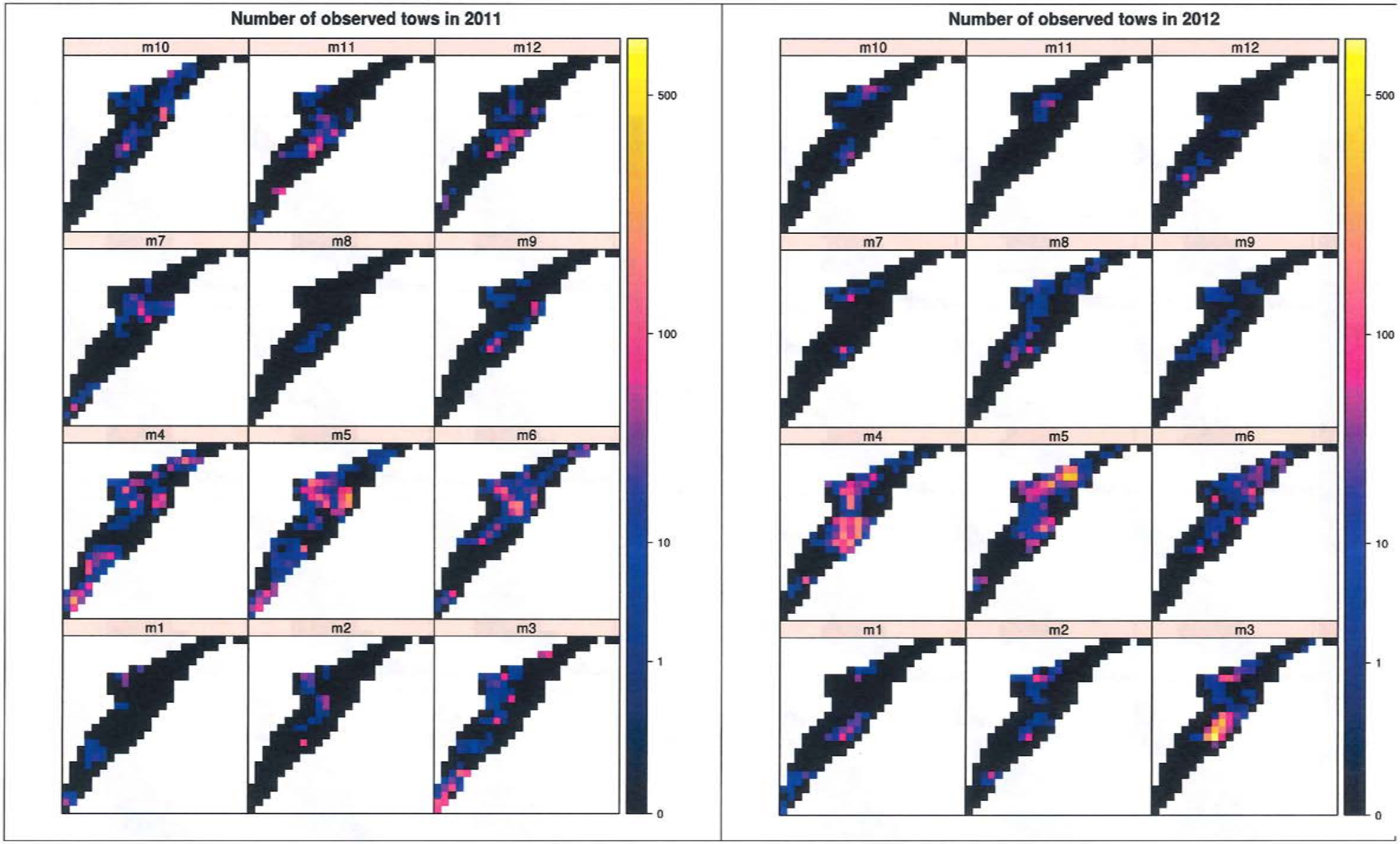
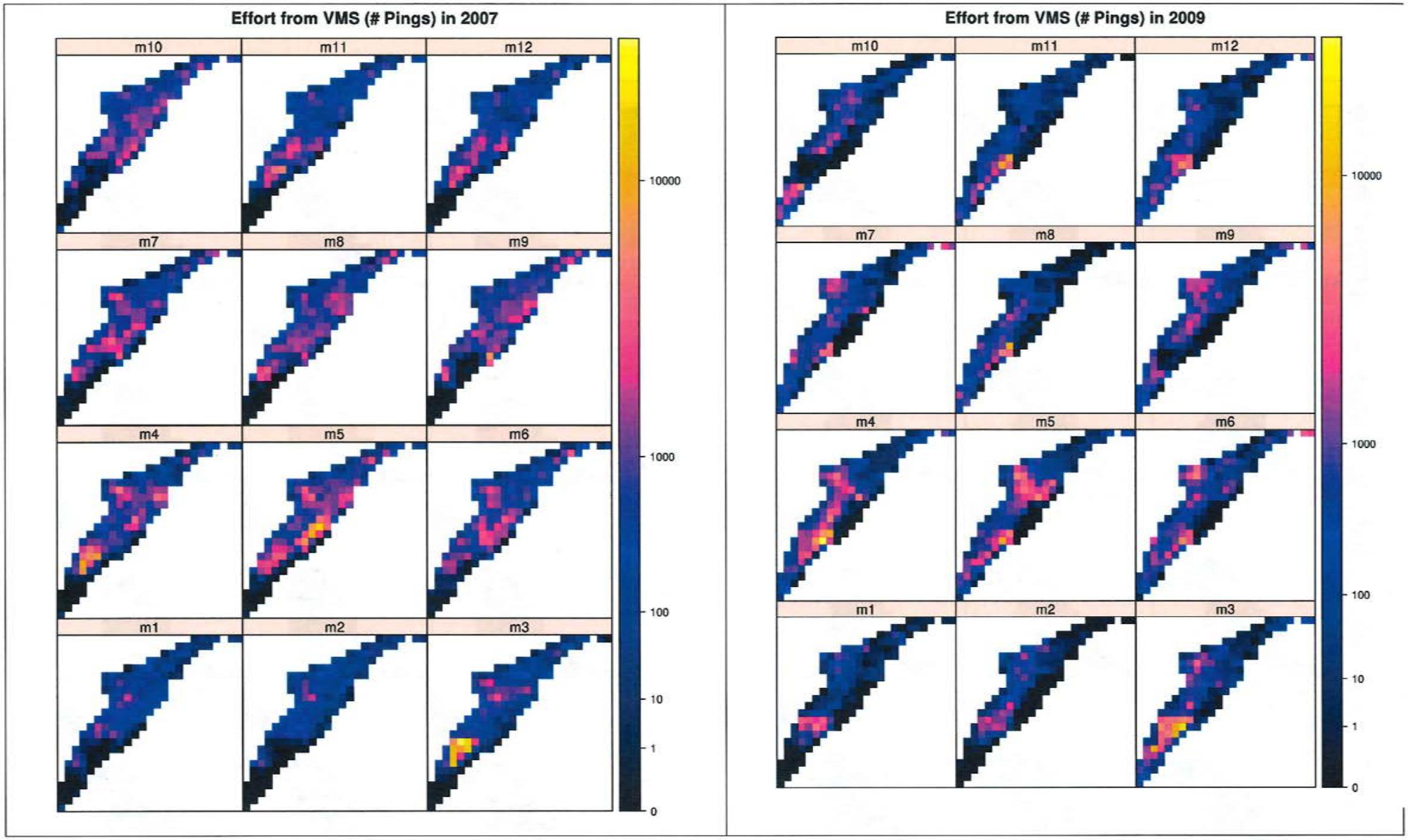
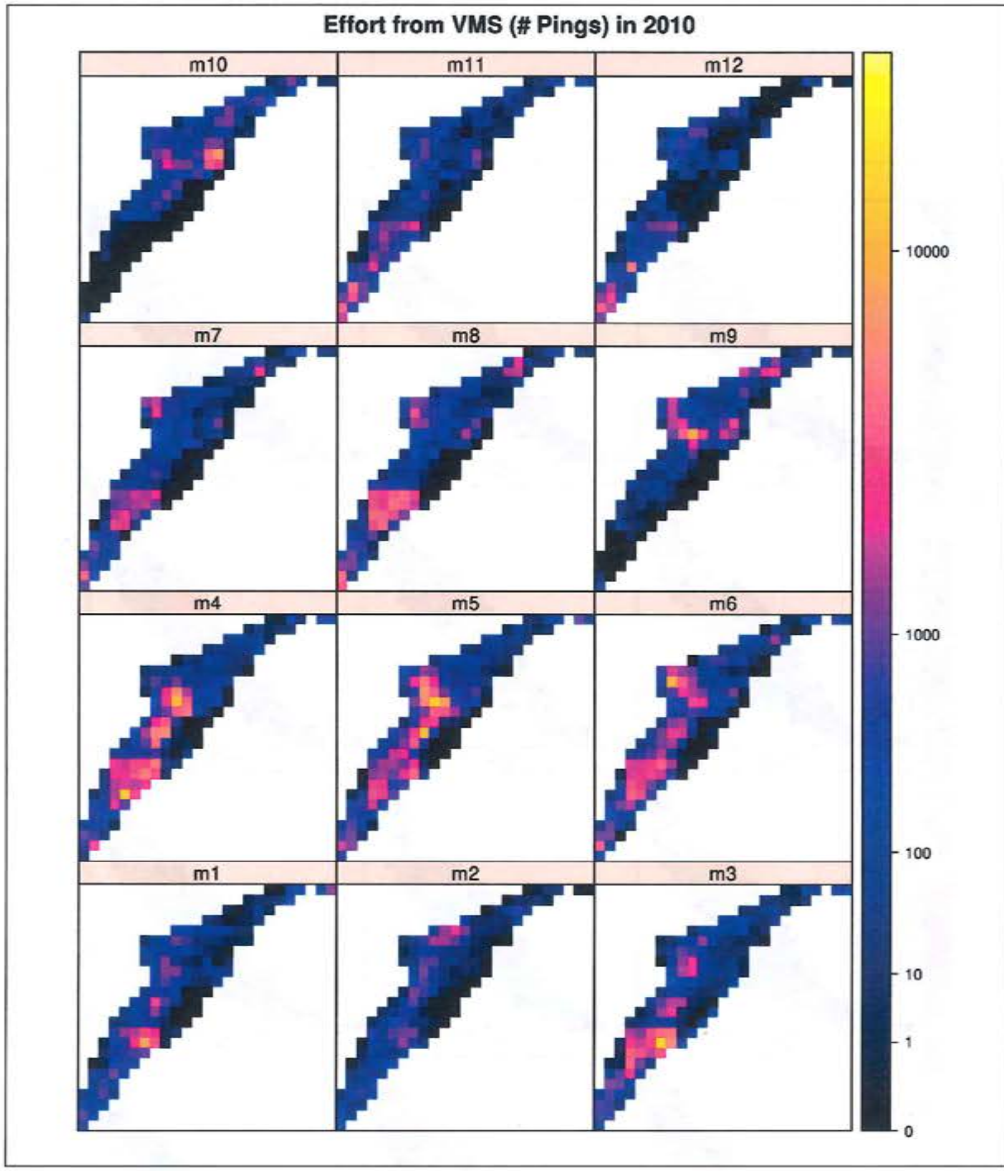
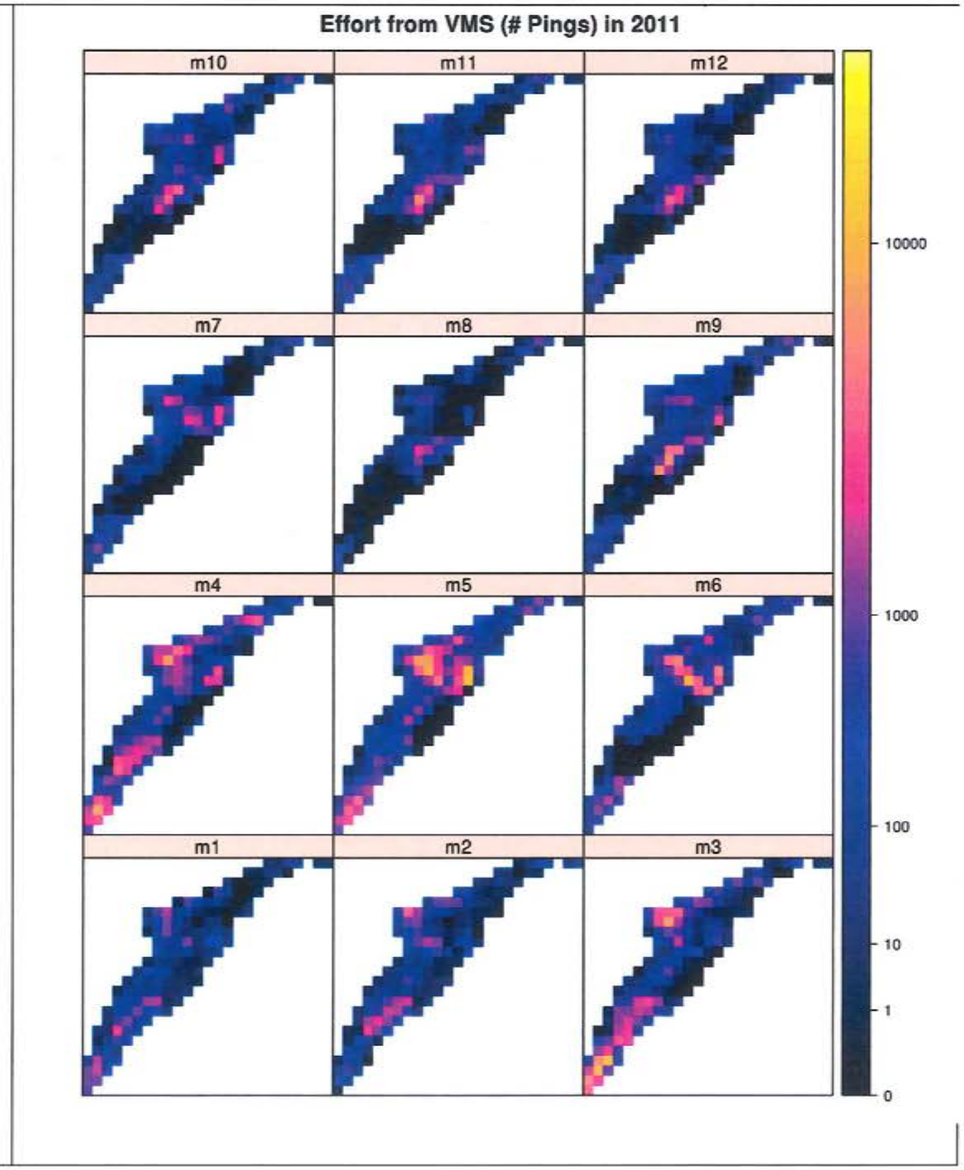

Number of observed tows in 2011
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
500
100
10
1
0
Number of observed tows in 2012
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
500
100
10
1
0

Figure 10 – Number of VMS pings per TMS by month and year (note that VMS plots for 2006 and 2008 are not available for the full year, so not included)




Effort from VMS (# Pings) in 2010
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
10000
1000
100
10
1
0


Effort from VMS (# Pings) in 2011
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
10000
1000
100
10
1
0

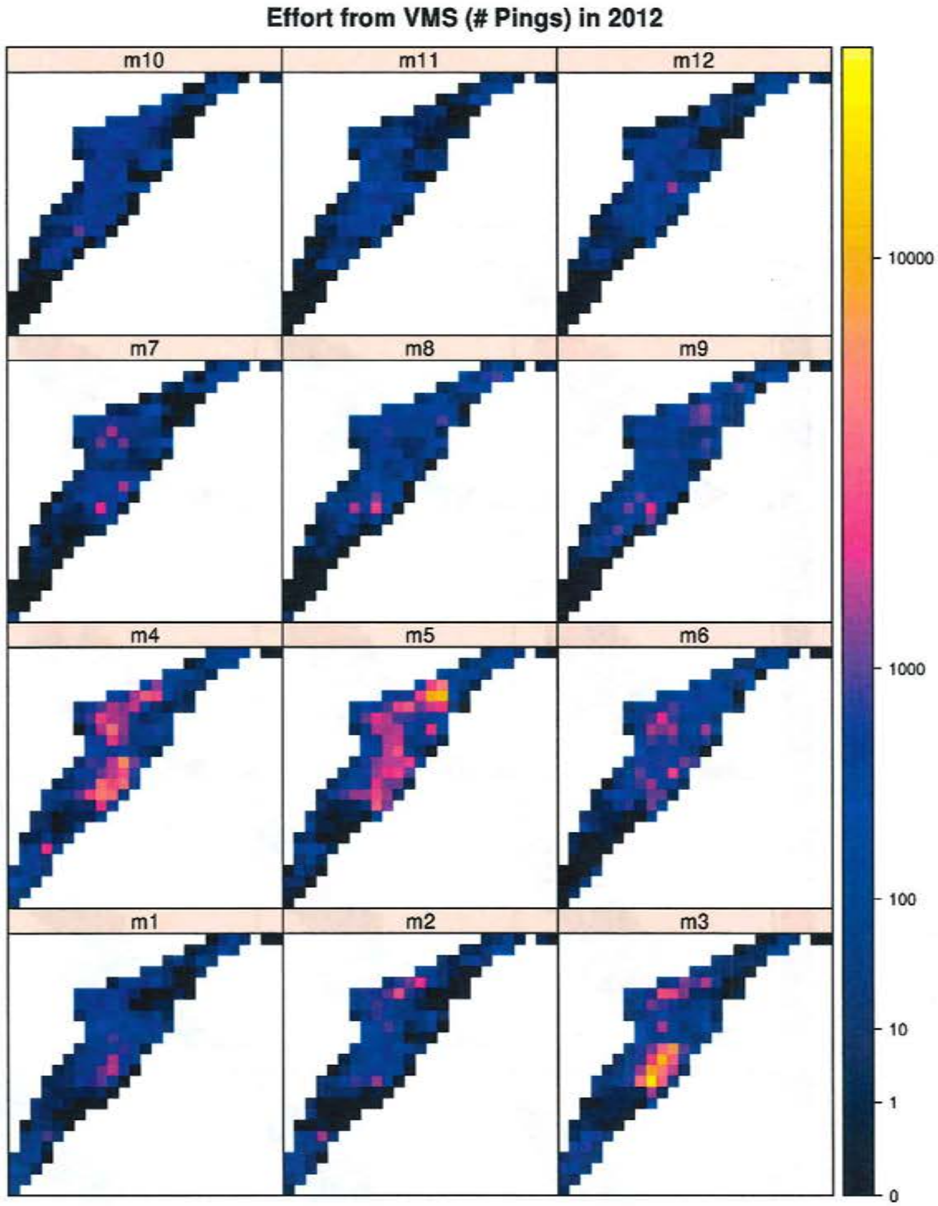
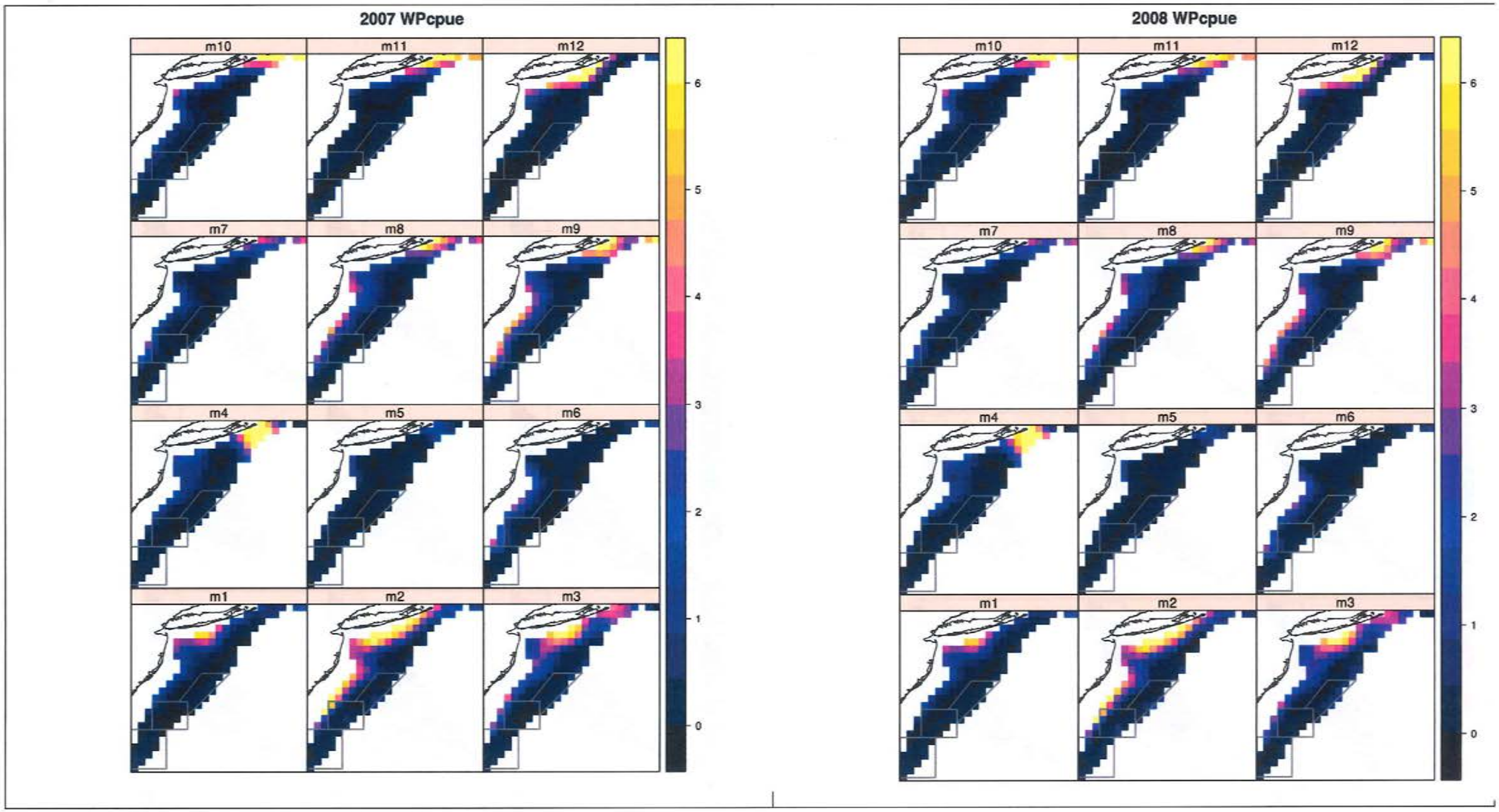
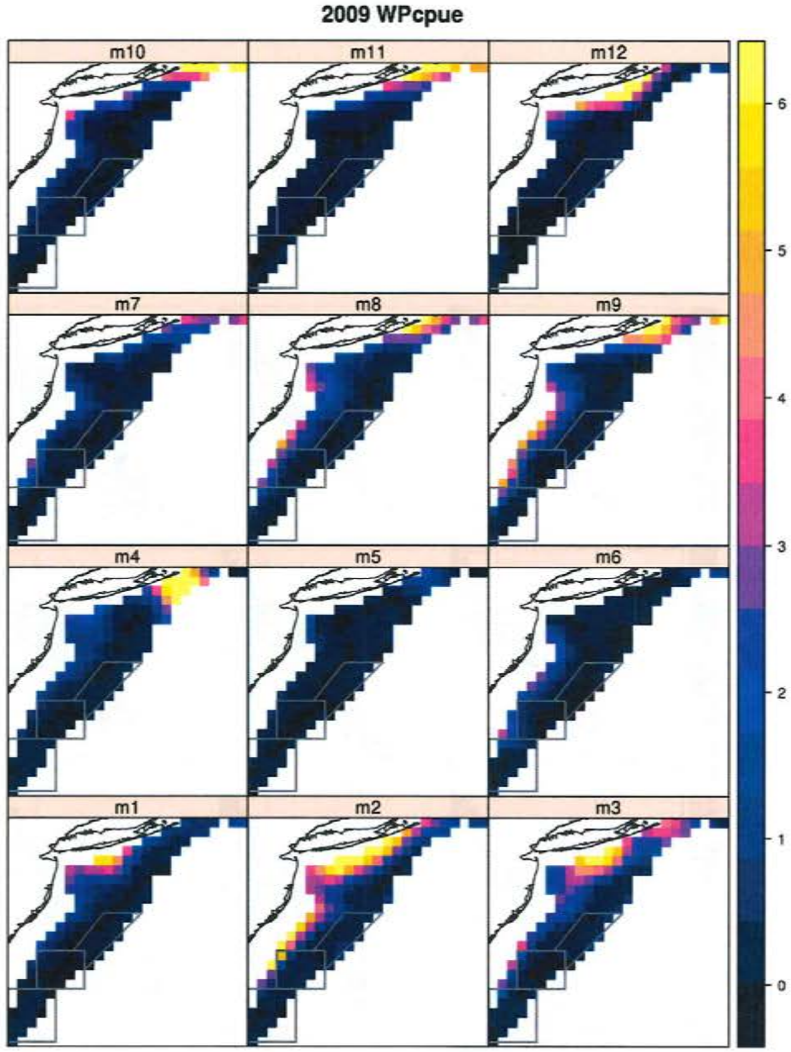
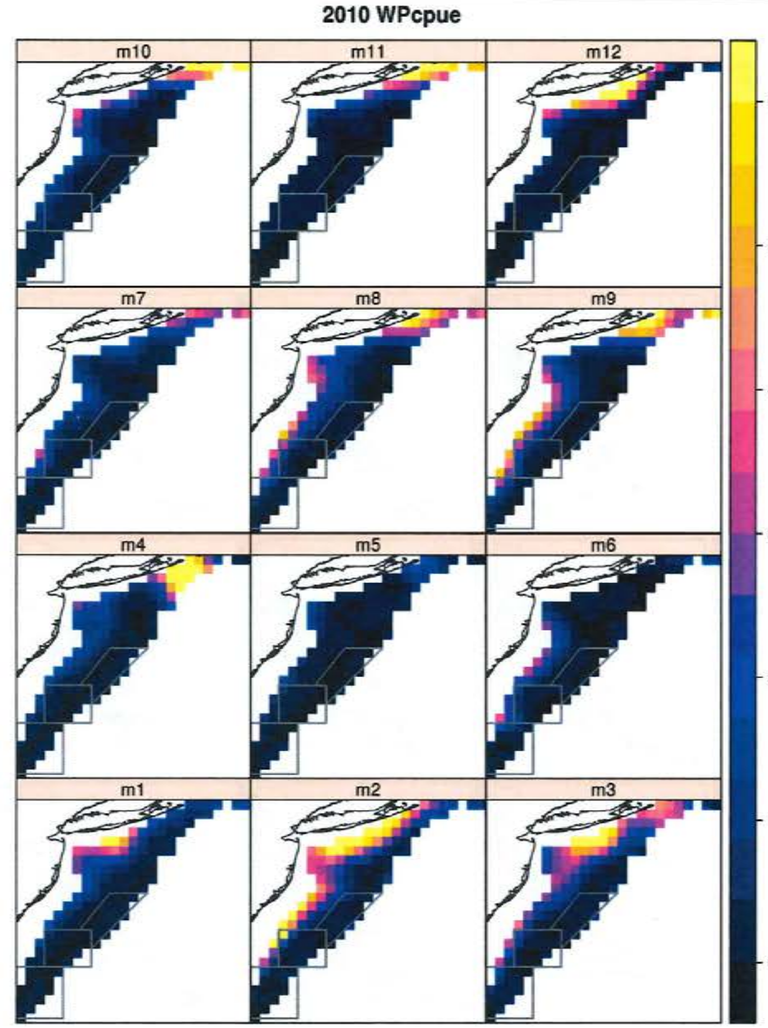
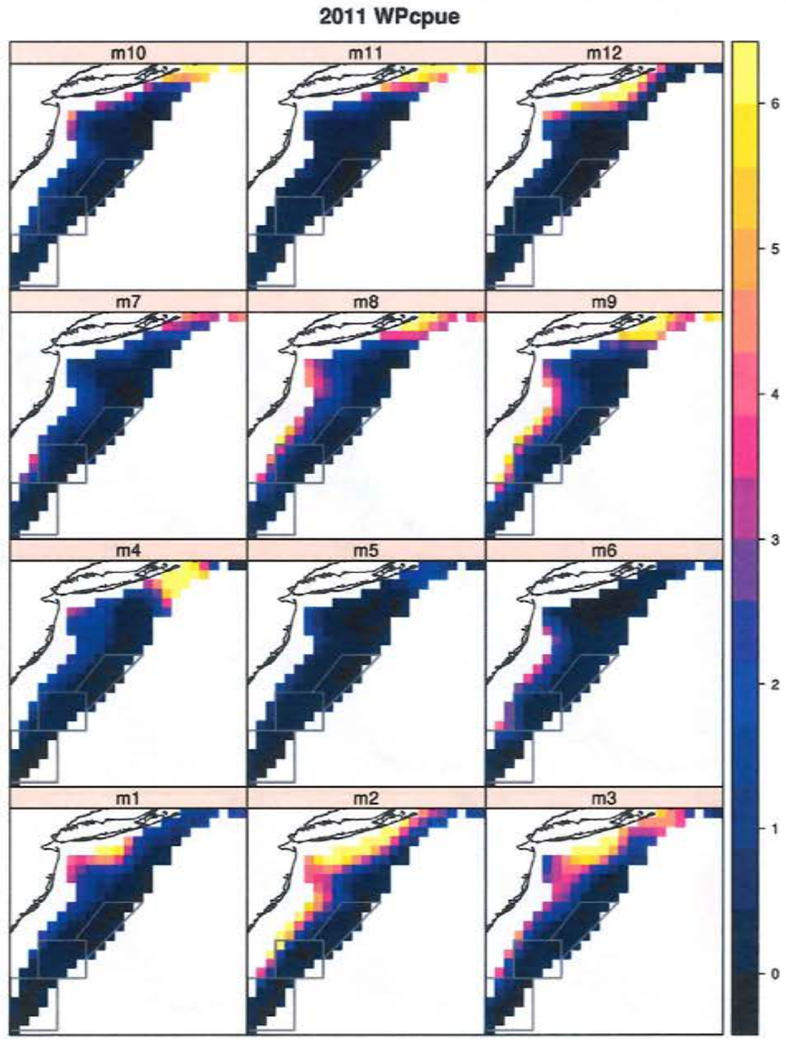

Effort from VMS (# Pings) in 2012
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
10000
1000
100
10
1
0

Figure 11 – Model predicted WP catch by month and year




2009 WPcpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
6
5
4
3
2
1
0


2010 WPcpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
6
5
4
3
2
1
0


2011 WPcpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
6
5
4
3
2
1
0

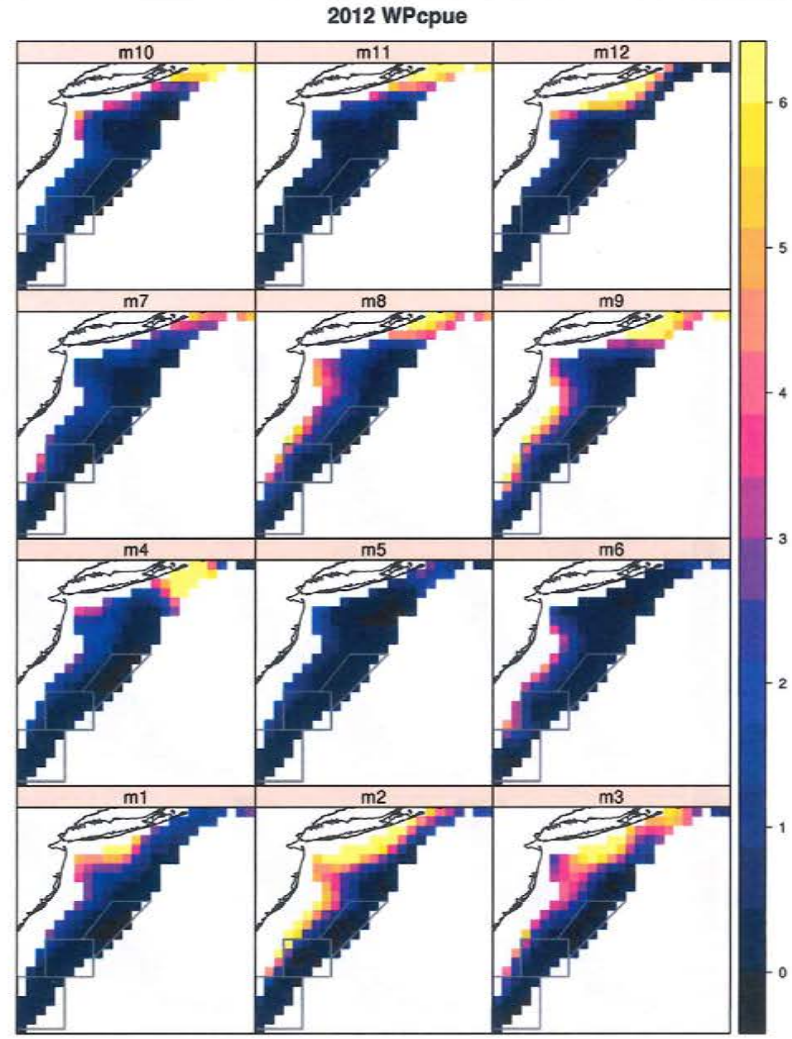
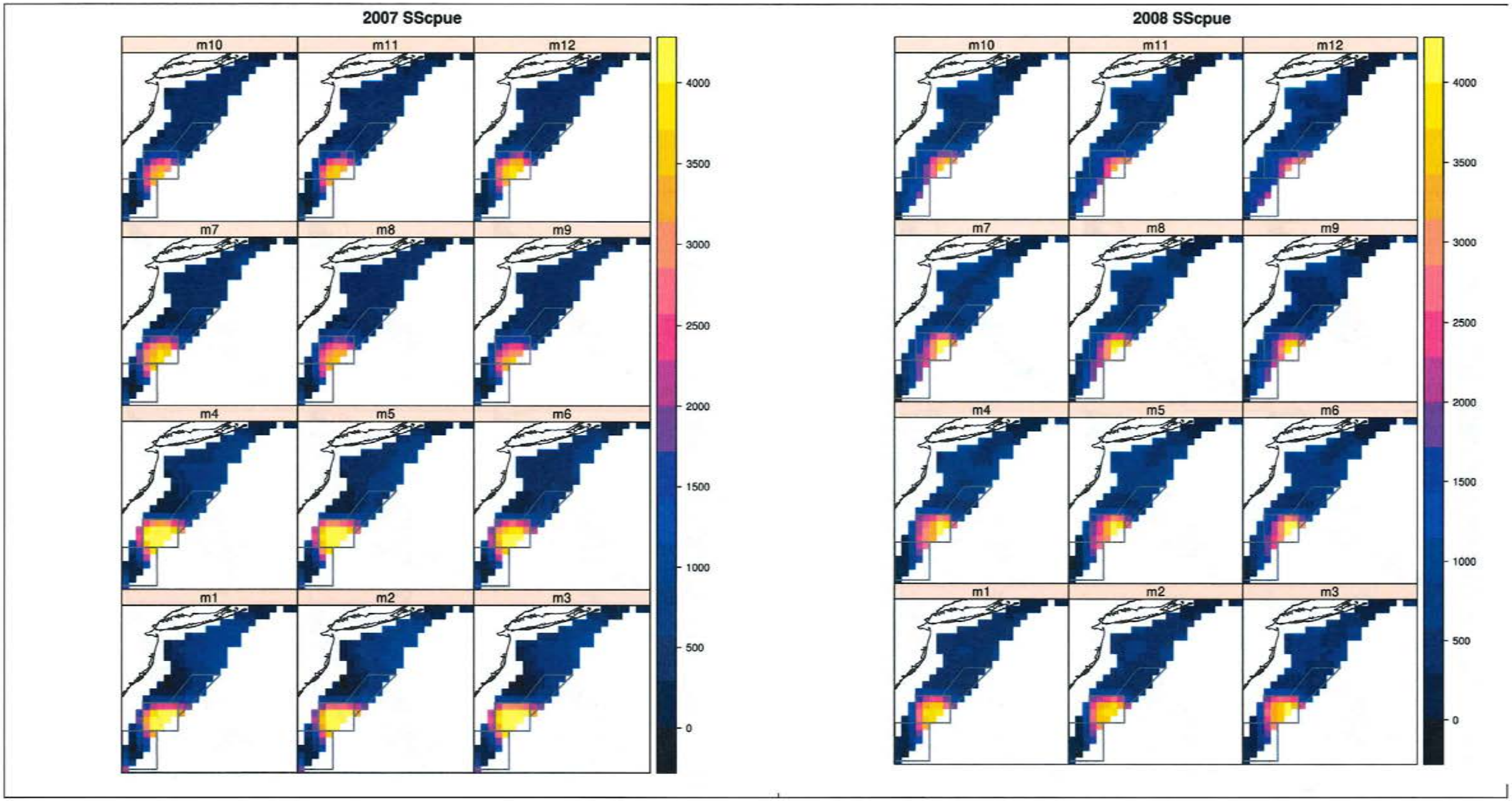
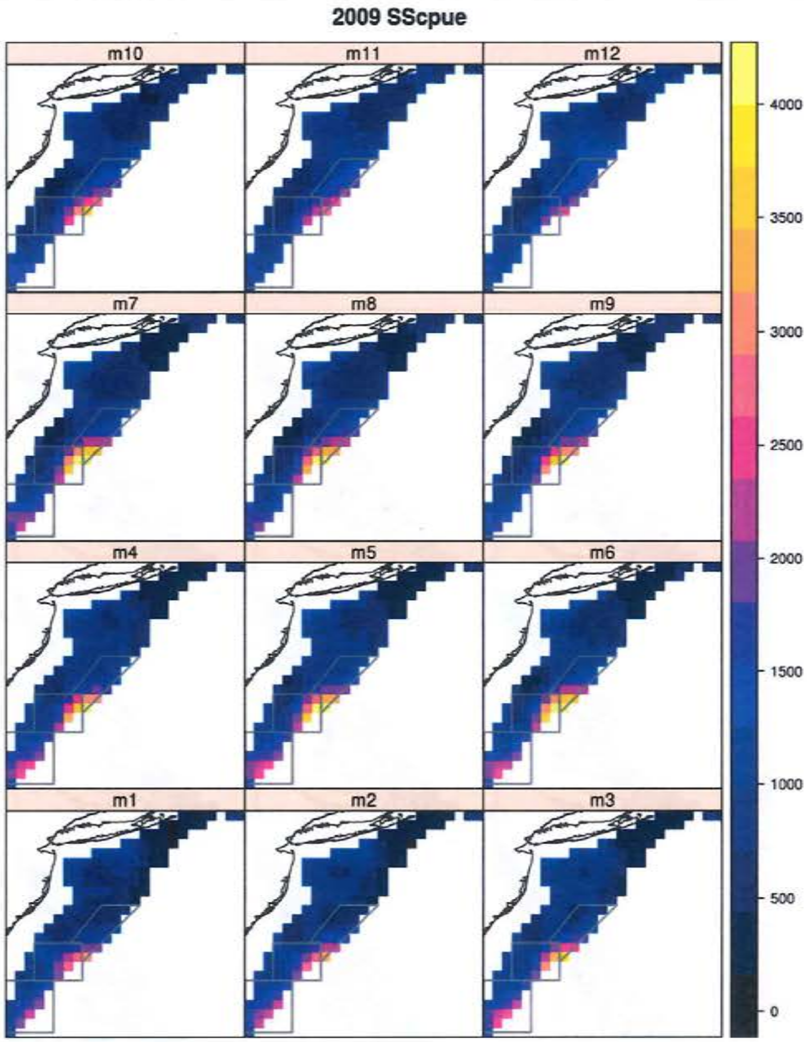
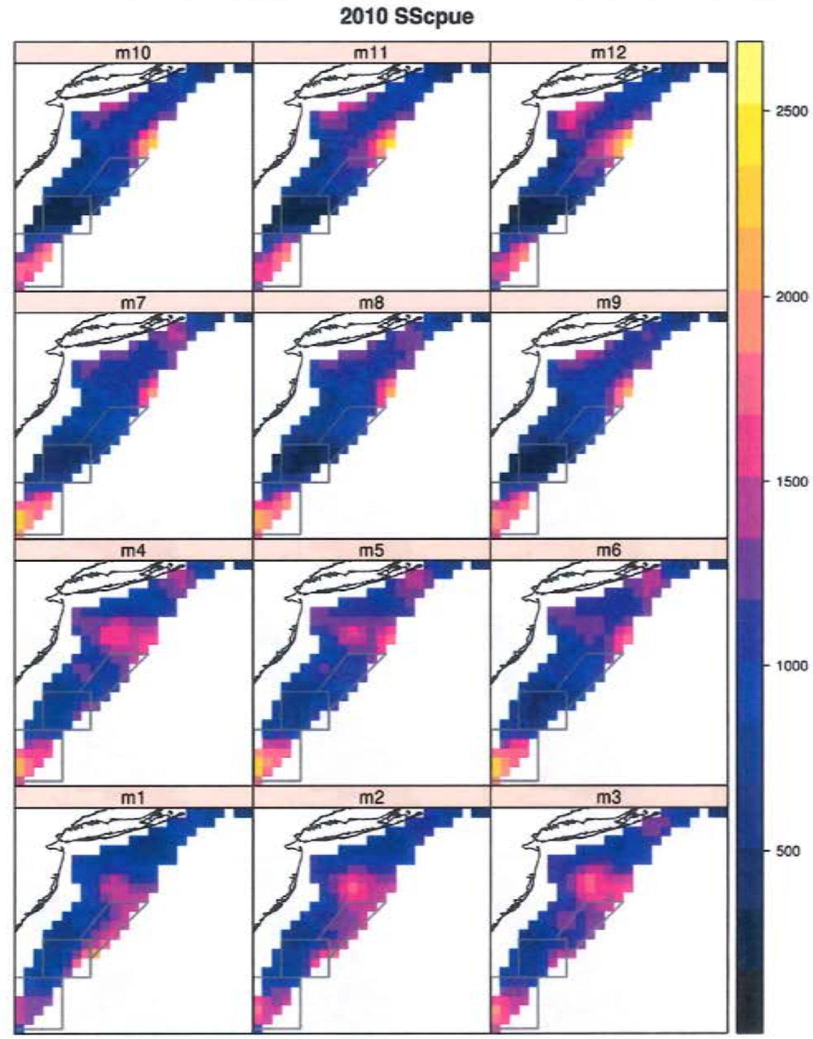
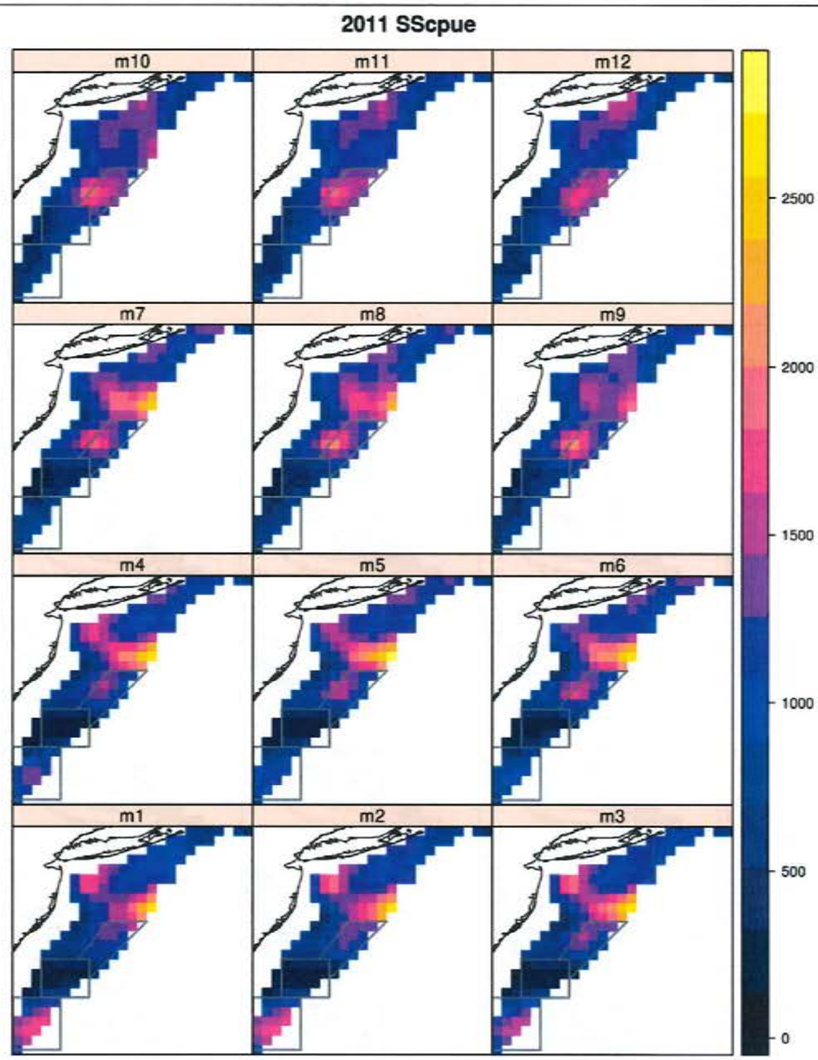

2012 WPcpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
6
5
4
3
2
1
0

Figure 12 – Model predicted Scallop catch by month and year




2009 SScpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
4000
3500
3000
2500
2000
1500
1000
500
0


2010 SScpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
2500
2000
1500
1000
500


2011 SScpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
2500
2000
1500
1000
500
0

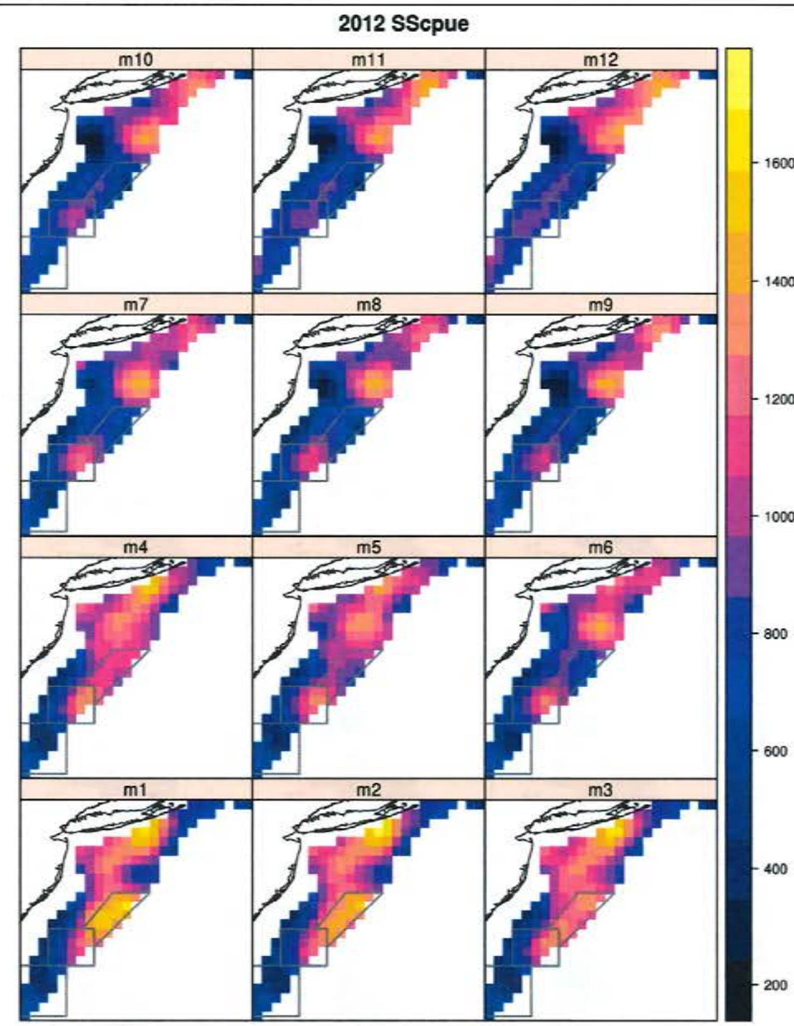
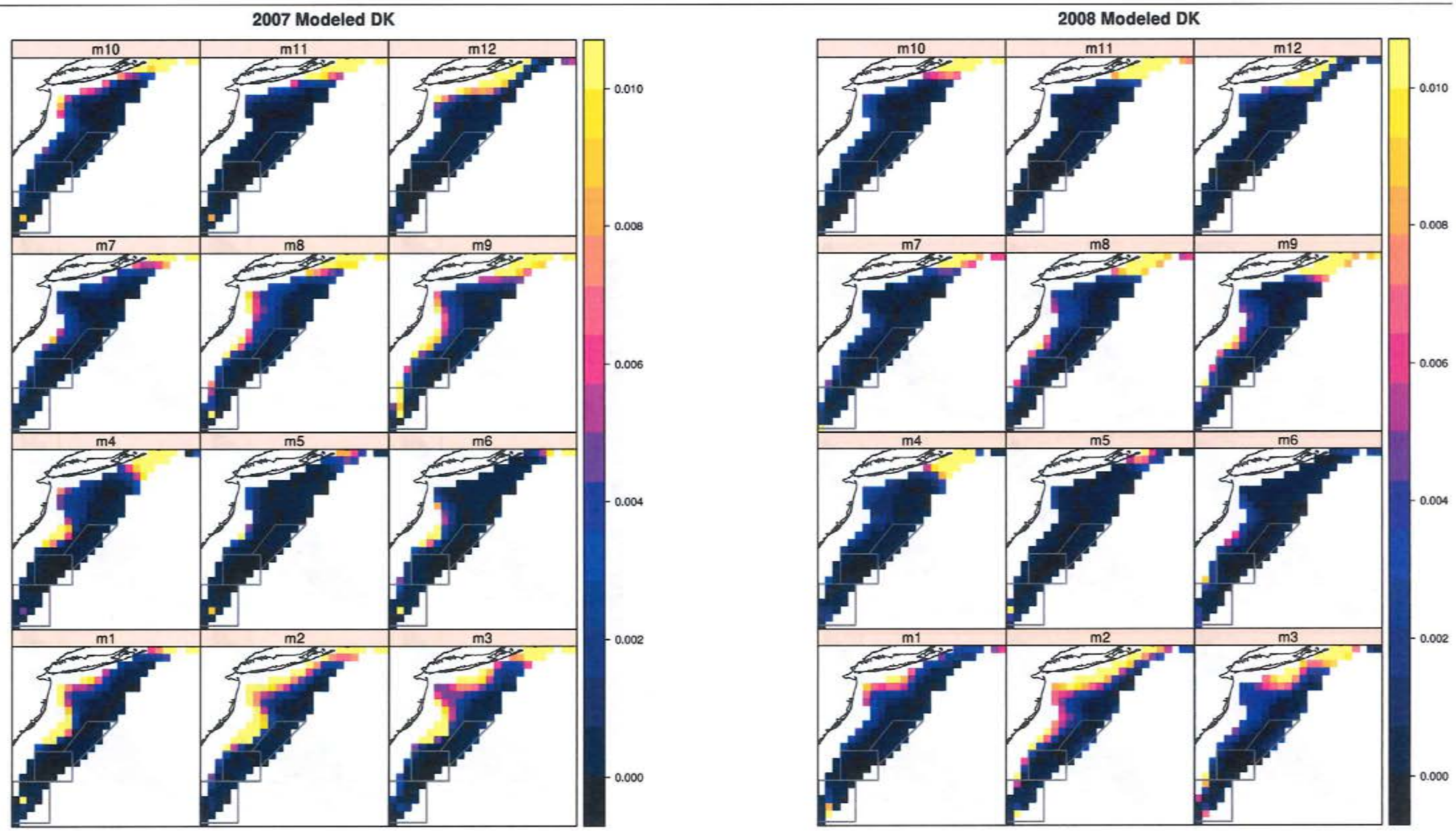
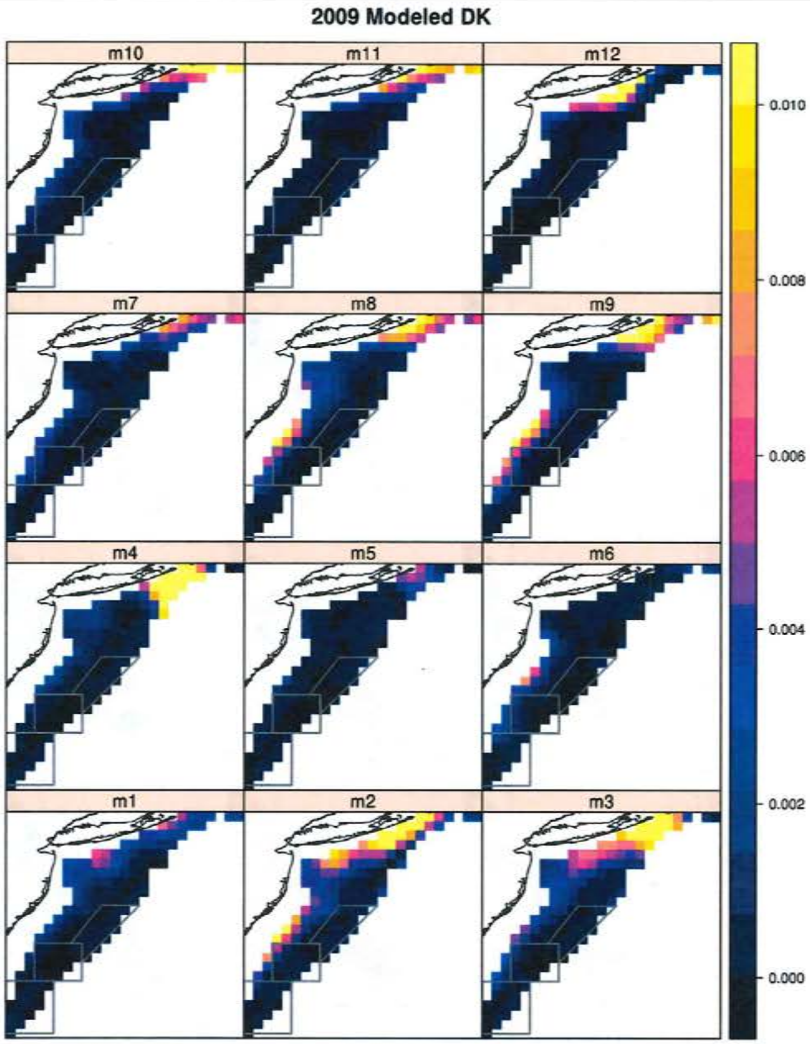
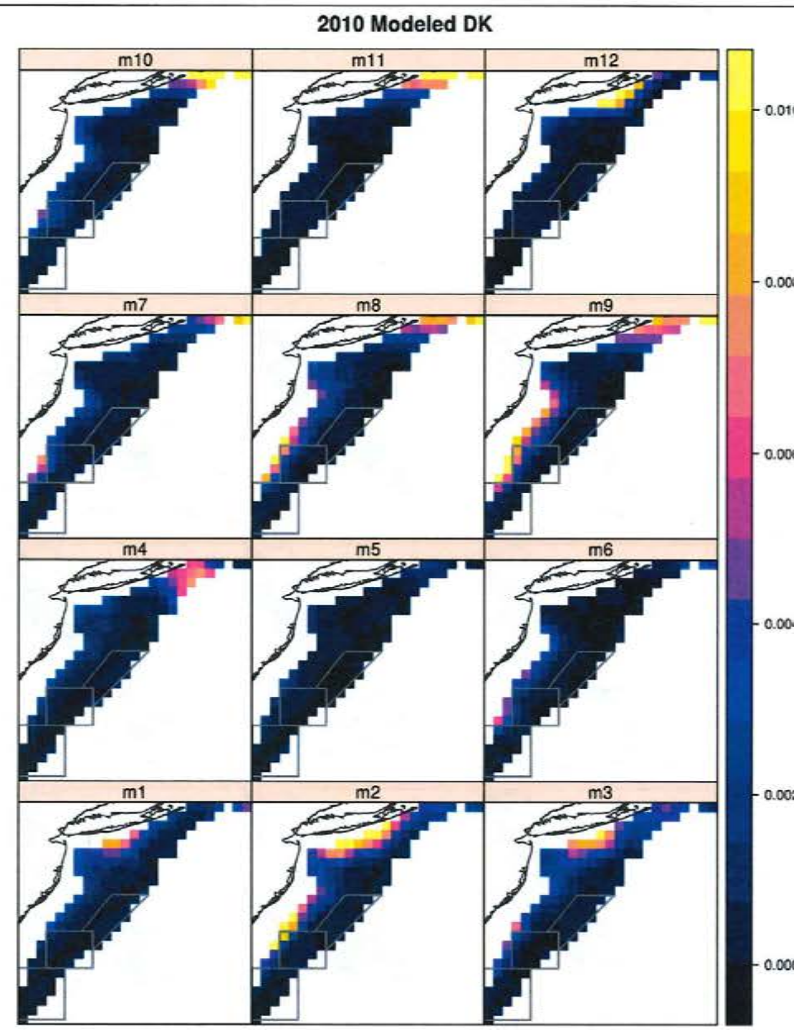
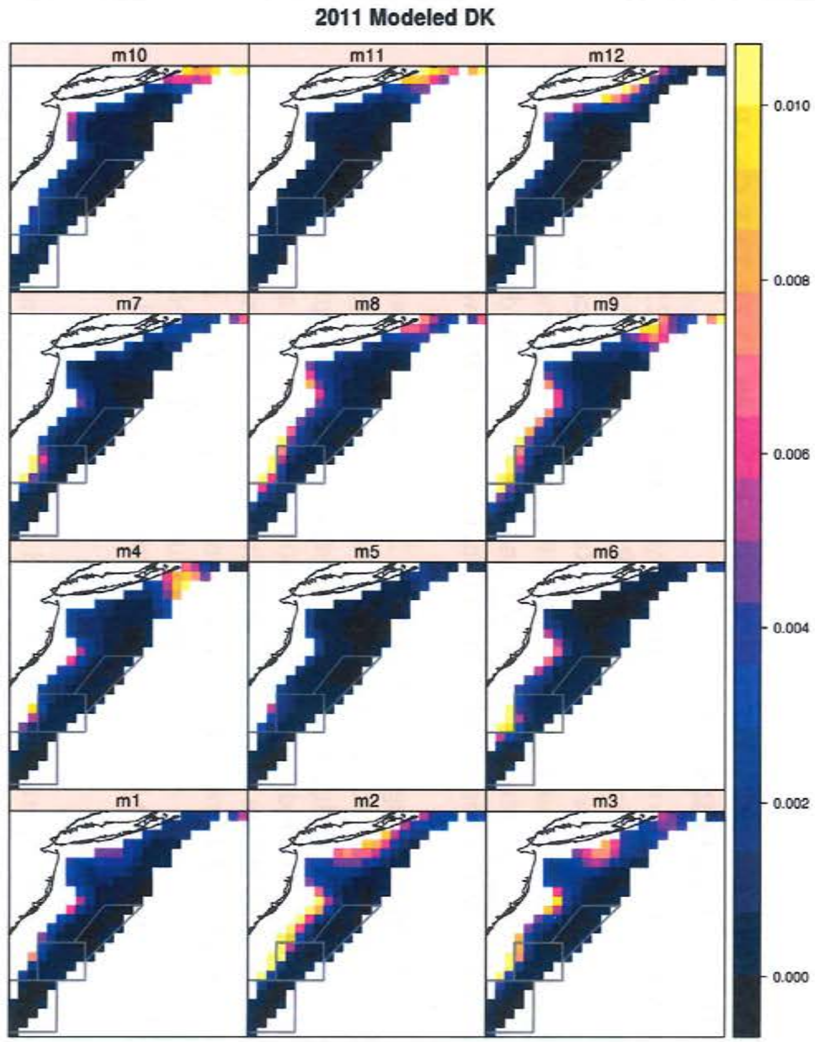

2012 SScpue
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
1600
1400
1200
1000
800
600
400
200

Figure 13 – Model predicted WP discards / scallop kept ratio per TMS by month and year




2009 Modeled DK
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
0.010
0.008
0.006
0.004
0.002
0.000


2010 Modeled DK
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
0.010
0.008
0.006
0.004
0.002
0.000


2011 Modeled DK
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
0.010
0.008
0.006
0.004
0.002
0.000

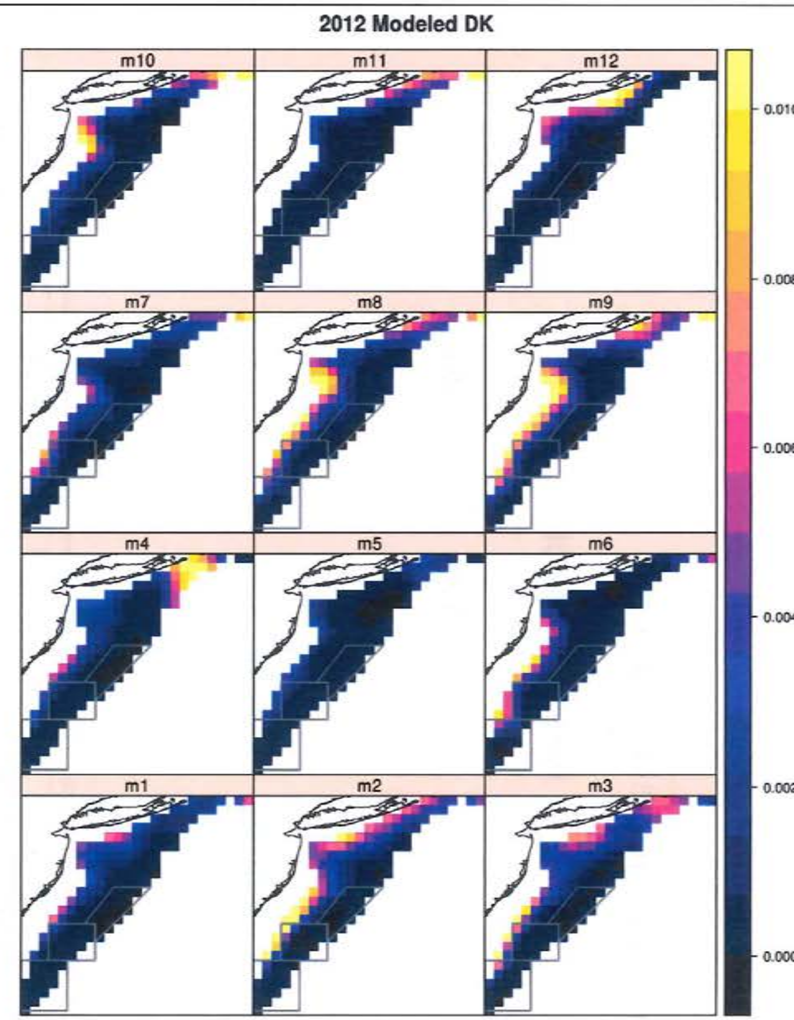
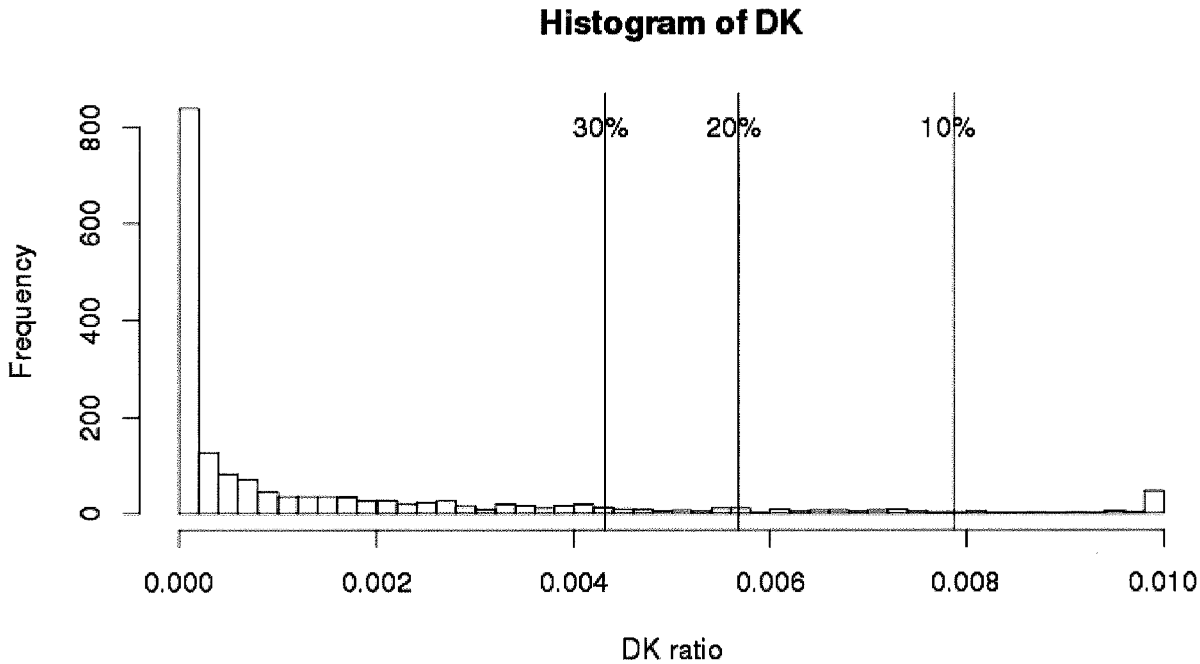

2012 Modeled DK
m10
m11
m12
m7
m8
m9
m4
m5
m6
m1
m2
m3
0.010
0.008
0.006
0.004
0.002
0.000

Figure 14 – Histogram of d/k ratio from all observed hauls



3.0 METHODS AND RESULTS USED TO DEVELOP AND ANLAYZE THE GEAR MODIFICATION AM ALTERNATIVES

The Scallop PDT also explored the use of gear modifications as an AM in FW25. The primary source of information the PDT used is results from a 2012 RSA project titled, "Testing of Scallop Dredge Bag Design Changes for Flatfish Bycatch Reduction" (See Appendix II for the Final Report). This project included four separate research trips on different scallop dredge vessels testing the standard turtle deflector dredge (TDD) and an experimental dredge with two primary gear modifications: a shorter apron and reduced hanging ratio for the twine top.

The four cruises took place between August 2012 and May 2013. A total of about 300 paired tows were completed on four different commercial vessels, about 80 paired tows on each vessel (F/V Concordia, F/V Freedom, F/V Diligence, and F/V Westport). All four trips tested the same two gear modifications (5 ring apron and 1.5:1 hanging ratio for the twine top) and all other aspects of the gear were the same except two vessels used the standard TDD dredge frame configuration, and two vessels used a low profile dredge configuration (LPD). The specific gear specifications are described in Table 2. All trips were conducted on GB and SNE. General tow locations were selected based on known areas with high abundances of fish and scallops (Figure 15).

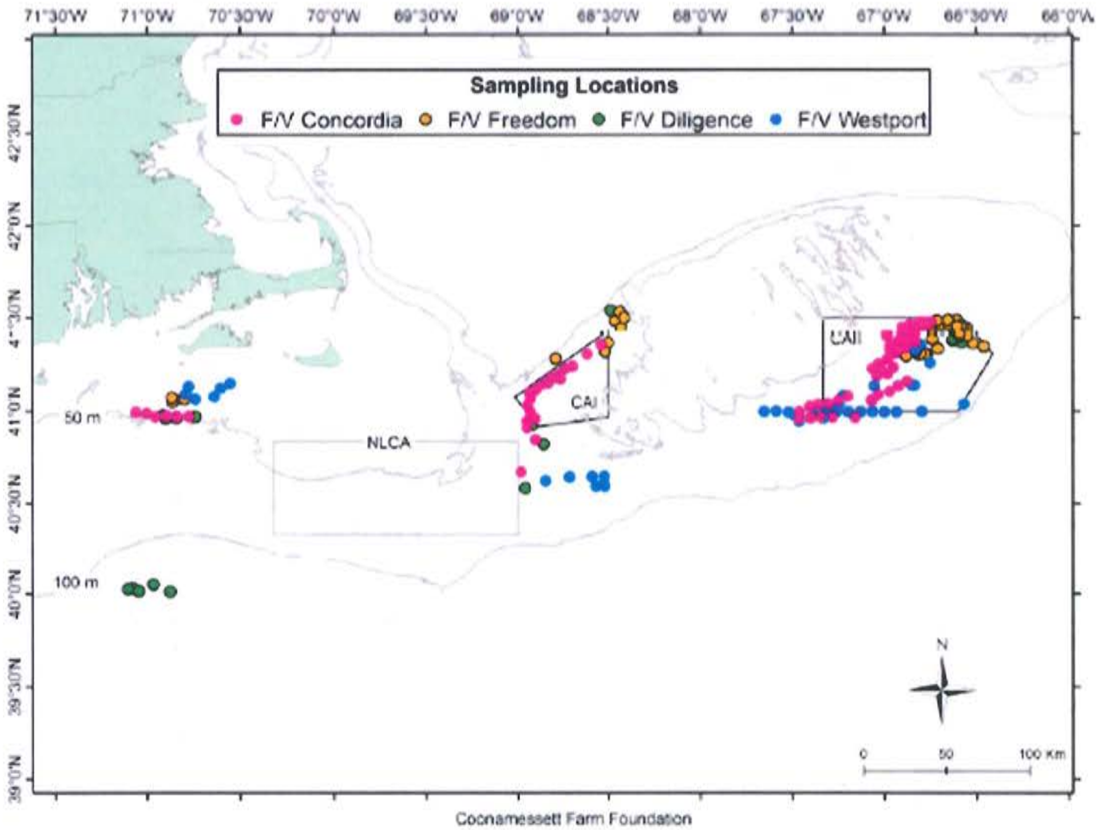
For each paired tow, the catch was separated by species and counted. Scallop catch was recorded in bushels, and at each station scallop length frequencies were recorded for each subsampled bushel. The size frequency of the entire catch was estimated by expanding the catch at each shell height of the subsample by the total number of baskets sampled. All fish were measured to the nearest centimeter, but only counts of winter and little skates.

Catch weights and bycatch rates of both gears were compared for each trip and tested for a significant difference using SigmaPlot. In addition, a Generalized Linear Mixed Model (GLMM) was used to analyze the paired catch data and test for differences in both the pooled length catch data as well as test for differences in the length composition of the catch. The model accounted for multiple vessels used in this experiment and slight variations in gear handing and design.

Table 2 – Gear specifications of the Experimental and control dredges

Dredge Designation	Control	Experimental
Frame	CFTDD	CFTDD and LPD
Type of Chain for Turtle Mat	3/8" Grade 70	3/8" Grade 70
Up and Downs	13	13
Tickler Chain	9	9
Type of Chain for Sweep	Long Link Grade 80	Long Link Grade 80
Number of Links in Sweep	121 long links	121 long links
Chain Sweep Hanging	(6,4,4,2,4...every two links in the bag), 12 link dog chain for the first diamond, 9 link dog chain for the remainder of the rings in the diamond, 11 link dog chain in corners	(6,4,4,2,4...every two links in the bag), 12 link dog chain for the first diamond, 9 link dog chain for the remainder of the rings in the diamond, 11 link dog chain in corners
Twine Top	2:1 with two in the sides (60 Meshes)	1.5:1 with two in the sides (45 Meshes)
Diamonds	14	14
Skirt	2X28 or 2X40	2X28 or 2X40
Sides	6X18 or 6X20	6X18 or 6X20
Apron	8 X 40	5 X 40
Bag	10 X 40	10 X 40
Chaffing Gear	Sewn in three rows down from the sweep for the bag and on the diamonds	Sewn in three rows down from the sweep for the bag and on the diamonds
Club Stick	20 link dog chains	20 link dog chains

Figure 15 – Tow locations for all four RSA trips



3.1 RESULTS

Preliminary results were presented to the PDT in May 2013 and several follow-up conference calls over the summer. Overall the combined gear modifications reduce flatfish bycatch substantially. For the raw catch weights and bycatch rate results the PDT focused on just the results from the two trips that compared the control dredge and the experimental dredge, not the low-profile dredge and the dredge with the escape window. In terms of catch volume, fish represented a greater proportion of the total catch for the control dredge vs. the experimental (5% vs. 3% of the total catch). Overall, there was a significant difference in catch weight between dredges (control vs. experiment) for YT flounder (33% reduction), winter (40%) and windowpane (46%). The differences in scallop and summer flounder catch weights did not test significant (10% and 19% decreases respectively). (Table 3 - Table 5)

Table 3 - Total catch of YT, winter, windowpane, summer flounder, sea scallops and benthos in experimental vs. control dredge (scallop and benthos in bushels and fish in lbs.)

	Benthos (bu)	Yellowtail	Winter	Windowpane	Summer	Scallops (bu)
Experimental (5R)	278	1061	149	314	75	769
Control	374	1621	223	570	135	822
Difference	-96	-560	-74	-256	-60	-53
% Difference	-25.67%	-34.55%	-33.18%	-44.91%	-44.44%	-6.45%
N	148	110	100	75	45	145

Table 4 – Mean weight (lbs.) of fish per tow and standard deviation for the experimental dredge and control dredge with P values

	Yellowtail (SD)	Winter (SD)	Windowpane (SD)	Summer (SD)	Sea Scallops (SD)
Experimental (5R)	10.73 (17.27)	2.13 (2.73)	1.95 (2.22)	6.39 (7.19)	39.56 (42.13)
Control	15.99 (23.56)	3.55 (4.00)	3.58 (3.92)	7.90 (9.56)	44.12 (44.98)
Difference of Means	-5.26	-1.42	-1.63	-1.50	-4.56
% Difference	-32.89%	-40.05%	-45.57%	-19.05%	-10.34%
N	110	100	75	45	145
U Statistic	5018	3692	2100	935	9279
P-Value	0.029*	0.001*	.007*	0.526	0.084

* Denotes significiant difference ($p < 0.05$)

Table 5 – Total YT, winter, windowpane, and scallop weights (lbs) and bycatch rates for the experimental and control dredges

Gear Type		Yellowtail	Winter	Windowpane	Summer	Scallops
Experimental	Fish Weight (lbs)	1169.3	212.90	6.43	287.65	5735.84
(5R)	Bycatch Rate	0.20	0.04	0.001	0.05	
Control	Fish Weight (lbs)	1751.85	355.05	11.70	355.30	6397.05
	Bycatch Rate	0.27	0.06	0.002	0.06	

The final report also evaluated if there were differences in the catch numbers using a GLMM, which combined the results from all survey tows, except the ones with the window escapement panel. The analyses attempted to develop a model that would predict the relative efficiency of the experimental dredge relative to the control dredge based on a variety of covariates, or variables that impact the results. It was found that fish length was not a significant predictor of relative efficiency, except for sea scallops and summer flounder. In addition, it was determined that dredge frame was not a significant predictor, except for sea scallops. Therefore, the model used pooled data for most fish species since neither length or dredge type were significant, or unpooled data for sea scallops and summer flounder since length, and dredge frame for scallops, was a significant variable for those species.

The experimental dredge reduced the catch of YT, winter, and windowpane flounder compared to the control dredge. The average percent change in the catch of the experimental dredge to the control was between 37% and 46% for these three flounder species (Table 6 and Figure 16). In addition, there was an overall reduction in relative efficiency for the experimental dredge versus the control dredge for monkfish, barndoor, and unclassified skates. Average percent change for monkfish was about 12%, 8% for barndoor, and 25% for unclassified skates (Table 7 and Figure 17).

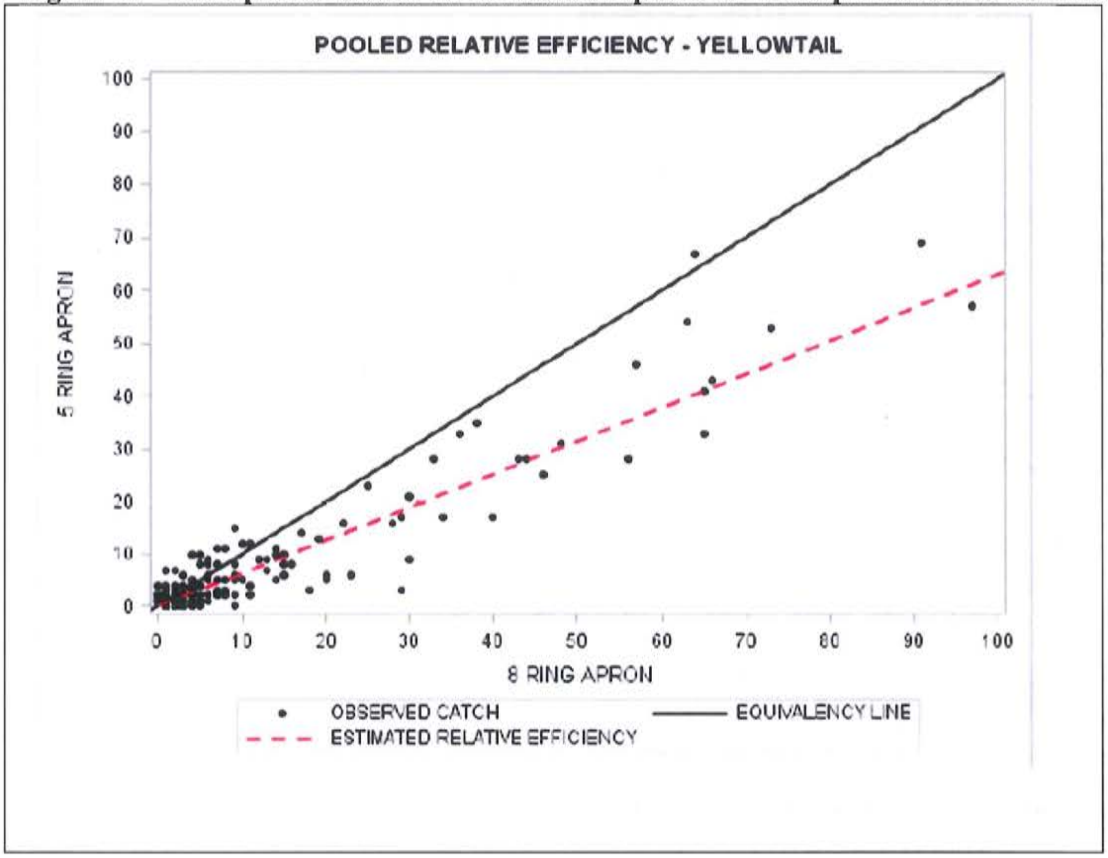
Table 6 – Mixed effects model using pooled catch data from best fit (intercept only) for several fish species. Percent change is the average percent change in catch of experimental versus control dredge

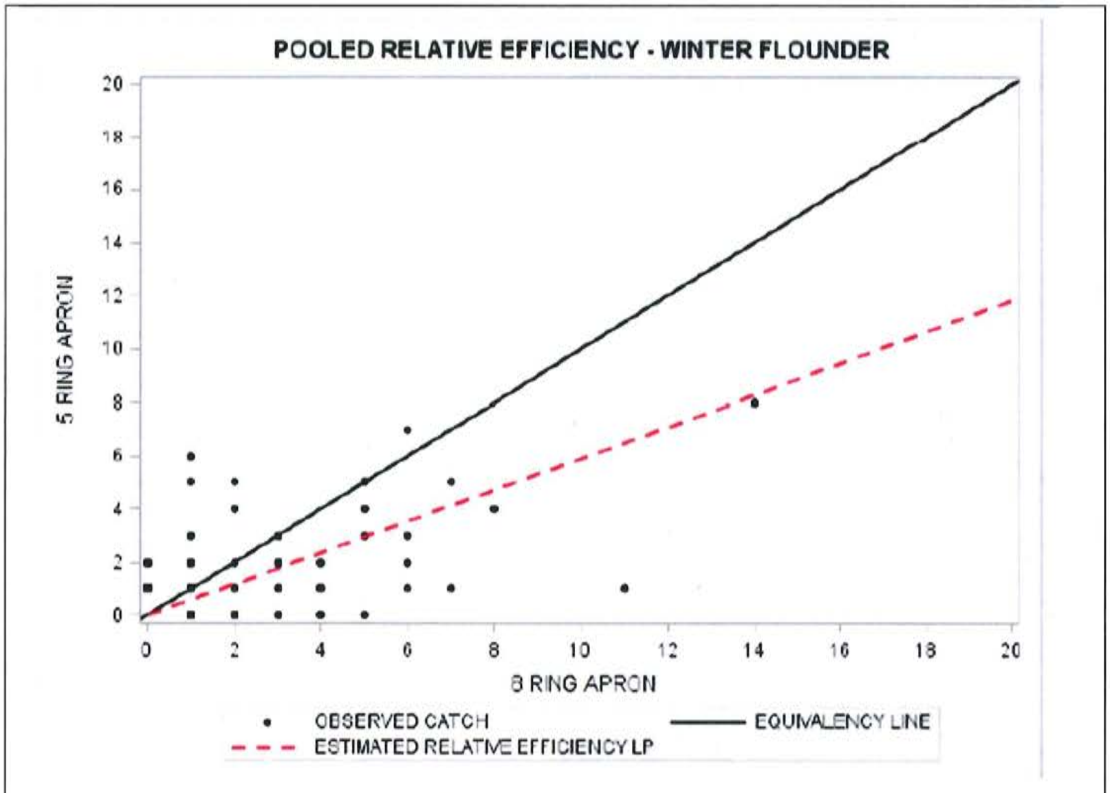
Species	Effect	Estimate	SE	DF	t-value	p-value	LCI	UCI	Exp(Est)	% Change
Yellowtail Flounder	Intercept	-0.463	0.051	189	-9.147	<0.0001	-0.563	-0.363	0.629	-37.1%
Winter Flounder	Intercept	-0.526	0.107	132	-4.932	<0.0001	-0.737	-0.315	0.591	-40.9%
Windowpane Flounder	Intercept	-0.610	0.066	201	-9.259	<0.0001	-0.740	-0.480	0.543	-45.7%
Monkfish	Intercept	-0.131	0.047	228	-2.755	0.0063	-0.224	-0.037	0.877	-12.3%

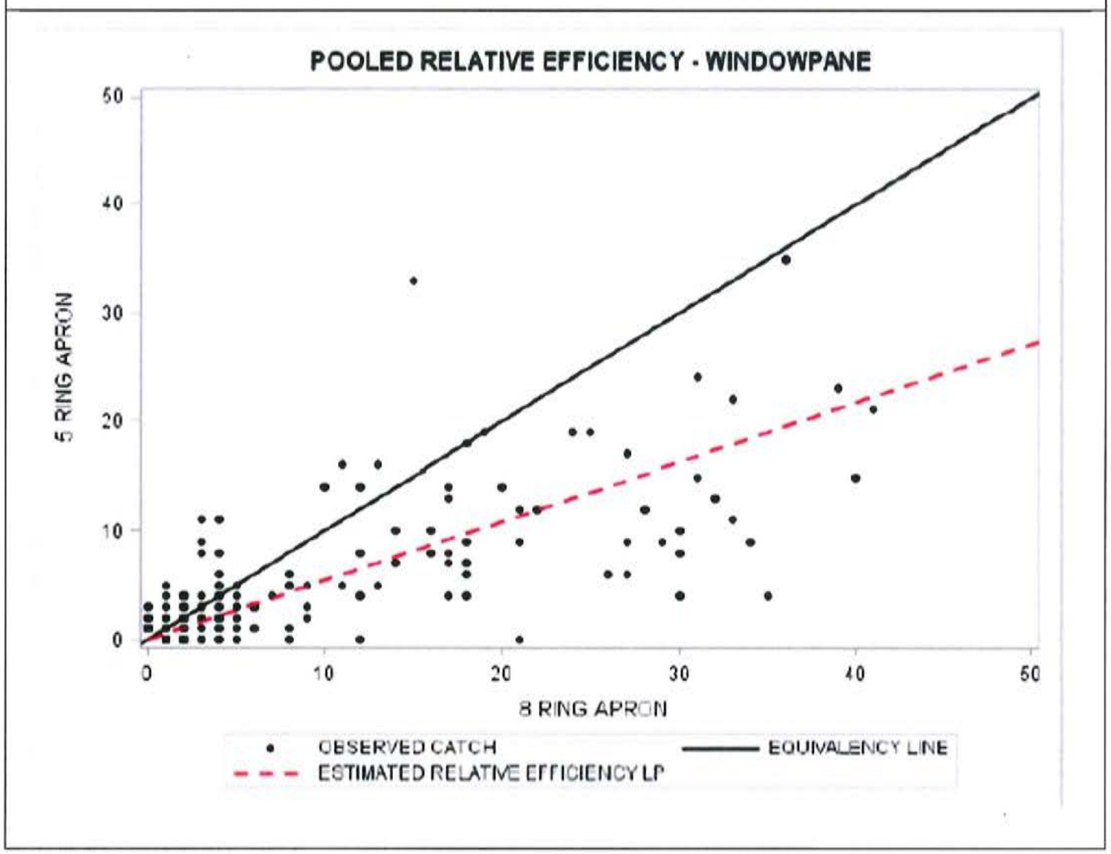
Table 7 – Mixed effects model using pooled catch data from best fit (intercept only) for barndoor and unclassified skates. Percent change is the average percent change in catch of experimental versus control dredge

Species	Effect	Frame	Estimate	SE	DF	t-value	p-value	LCI	UCI	Exp(Est)	% Change
Barndoor Skate	Intercept		-0.078	0.084	167	-0.925	0.356	-0.245	0.089		
	Frame	LPD	-0.557	0.135	167	-4.112	<0.001	-0.825	-0.290	0.530	-47.0%
	Frame	CFTDD	0.000							0.925	-7.5%
Unclassified Skate	Intercept		-0.290	0.039	301	-7.38	<0.001	-0.368	-0.213		
	Frame	LPD	-0.183	0.057	301	-3.17	0.001	-0.296	-0.069	0.623	-37.7%
	Frame	CFTDD	0.000							0.749	-25.1%

Figure 16 – Total pooled catches for several fish species for the experimental vs control dredge




POOLED RELATIVE EFFICIENCY - WINTER FLOUNDER
5 RING APRON
8 RING APRON
0
2
4
6
8
10
12
14
16
18
20
OBSERVED CATCH
EQUIVALENCY LINE
ESTIMATED RELATIVE EFFICIENCY LP


POOLED RELATIVE EFFICIENCY - WINDOWPANE
5 RING APRON
8 RING APRON
0
10
20
30
40
50
OBSERVED CATCH
EQUIVALENCY LINE
ESTIMATED RELATIVE EFFICIENCY LP

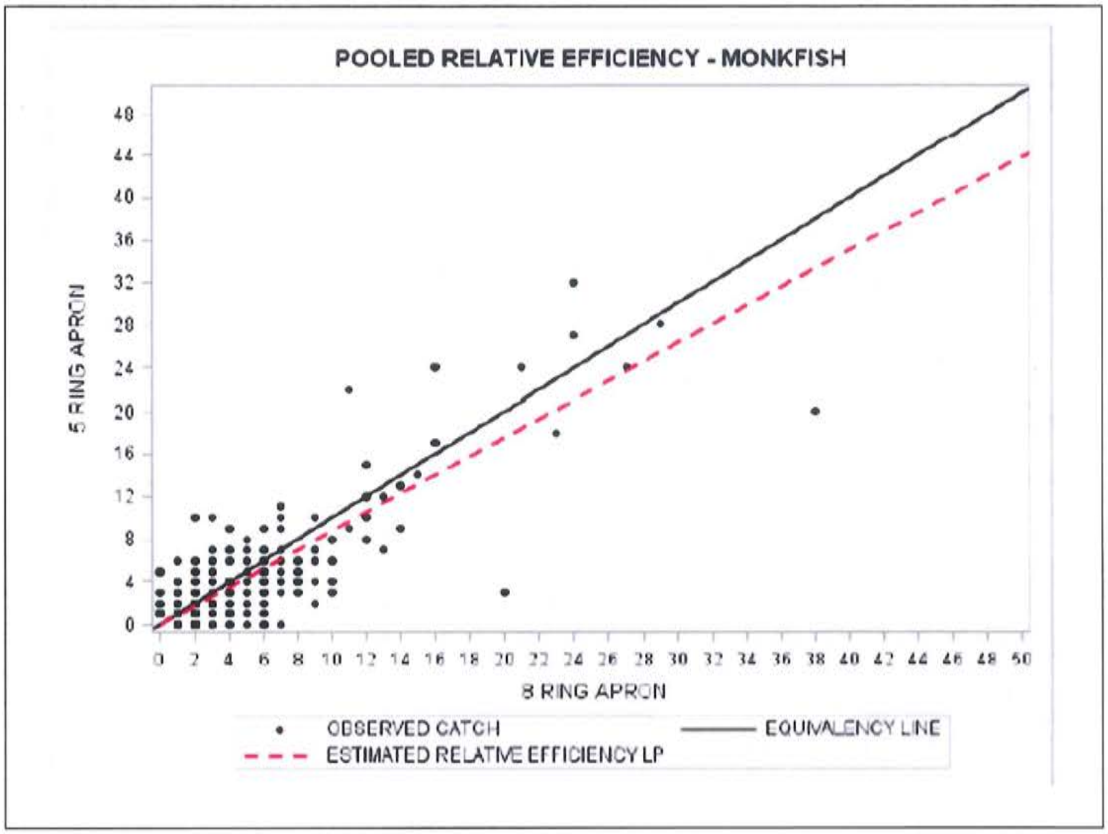
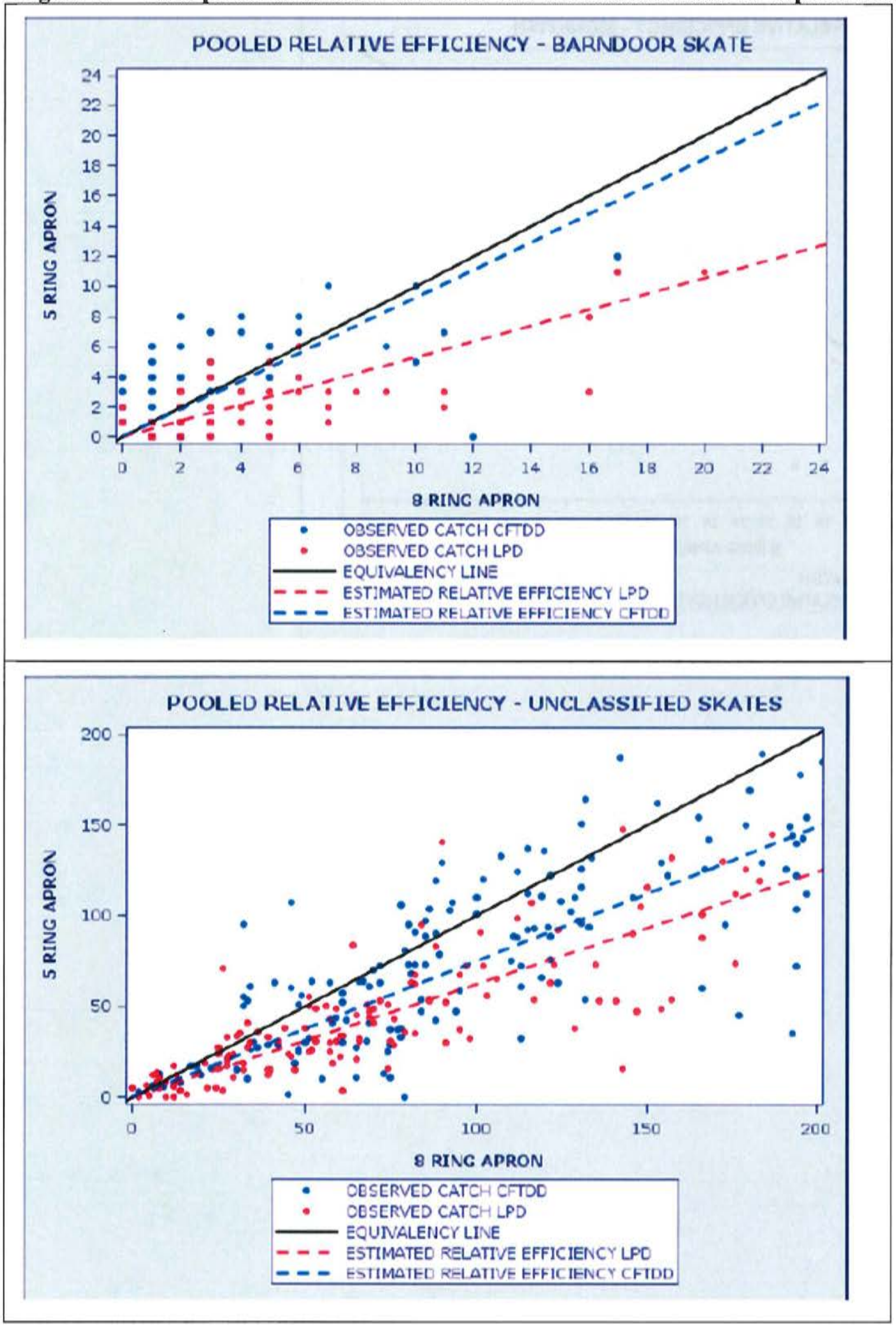

POOLED RELATIVE EFFICIENCY - MONKFISH
5 RING APRON
8 RING APRON
OBSERVED CATCH
EQUIVALENCY LINE
ESTIMATED RELATIVE EFFICIENCY LP

Figure 17 – Total pooled catches for barndoor and unclassified skates for experimental vs control dredge.

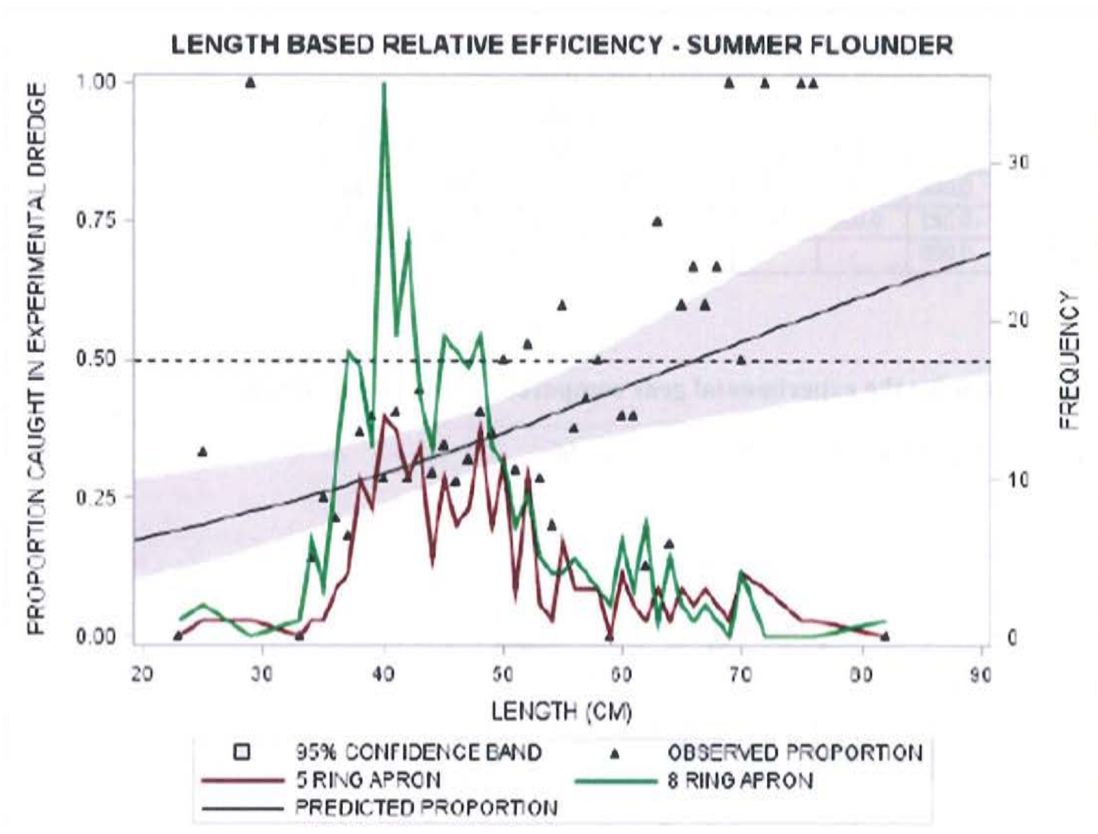


Summer flounder is the only fish species that demonstrated a significant length based effect; lower efficiency in experimental dredge versus the control and efficiency increased with length (Table 8 and Figure 7).

Table 8 – Mixed effects model for summer flounder catch using unpooled catch data

Species	Effect	Estimate	SE	DF	t-value	p-value	LCI	UCI
Summer Flounder	Intercept	-2.205	0.520	411	-4.241	<0.001	-3.227	-1.183
	Length	0.033	0.011	411	3.148	0.002	0.013	0.054

Figure 18 – Relative summer flounder catch for experimental and control dredge



3.1.1 Sea scallops

Overall, there was a reduction in relative scallop catch efficiency using the experimental gear compared to the control. The overall reduction in terms of catch weights is estimated to be about 10% for the experimental dredge (Table 4). Furthermore, the experimental dredge was less efficient at catching smaller scallops than the control (Table 5). This has important impacts on the scallop resource because discard mortality is reduced if fewer small scallops are caught in the gear.

Results from catch weight analysis indicated that there was no significant difference in scallop meat weight between the experimental and the control dredges, whereas GLMM analysis yielded a difference in numbers of scallops. This can be explained by greater size selectivity of the experimental dredge that caught fewer, but larger scallops on average, resulting in a difference in numbers of scallops but no difference in meat weight between dredges.

Table 9 - Mixed effects model for sea scallops using unpooled catch data

Species	Effect	Frame	Estimate	SE	DF	t-value	p-value	LCI	UCI
Sea Scallop	Intercept		-0.770	0.105	3662	-7.326	<0.001	-0.976	-0.564
	Size		0.004	0.001	3662	6.133	<0.001	0.003	0.006
	Frame	LPD	-0.285	0.058	3662	-4.921	<0.001	-0.399	-0.172
	Frame	CFTDD	0.000						

Figure 19 – Relative sea scallop catch for the experimental gear compared to the control dredge

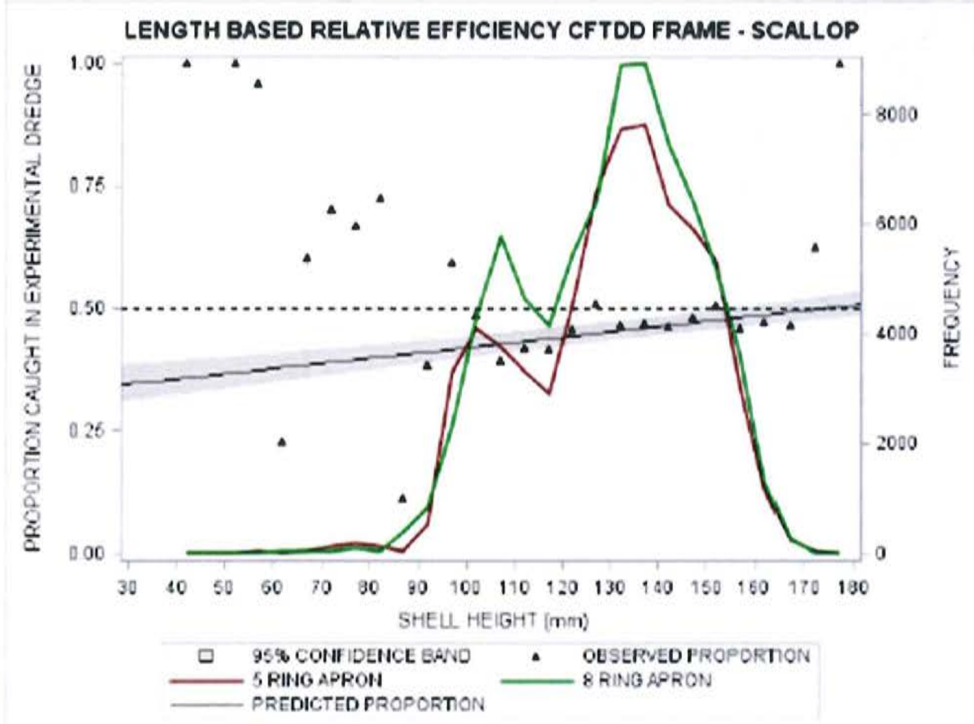


Figure 20 - Size frequency distribution of scallops in the experimental and control dredges. Mean number of scallop per tow with standard error bars

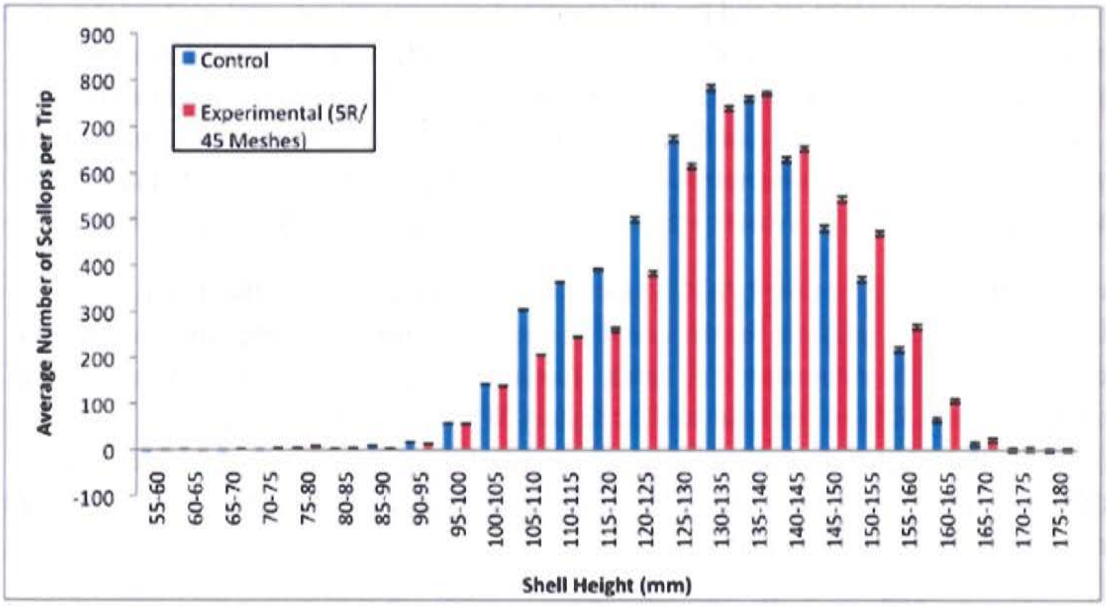


Table 10 – Estimated and percent difference in scallop catch weights at various cull points in commercial size selectivity for the experimental compared to control dredge

Cull Point	Class	5R CFTDD (lbs)	Control (lbs)	Difference	% Difference	P-Value
< 90 mm	Discard	9.53	13.53	-4.00	-29.58%	0.544
> 90 mm	Retain	5726.31	6383.52	-657.21	-10.30%	0.602
< 100 mm	Discard	143.73	120.42	23.31	19.35%	0.643
> 100 mm	Retain	5592.11	6276.63	-684.52	-10.91%	0.534
< 110 mm	Discard	489.77	571.04	-81.27	-14.23%	0.782
> 110 mm	Retain	5246.07	5826.01	-579.94	-9.95%	0.629
< 120 mm	Discard	847.33	1065.83	-218.50	-20.50%	0.94
> 120 mm	Retain	4888.50	5331.22	-442.715	-8.30%	0.707

4.0 BACKGROUND INFO RELATED TO SCALLOP FISHERY CATCH OF SNE/MA WP

When GF FW48 considered a sub-ACL for the scallop fishery for SNE/MA WP the historical estimates of catch by scallop permit type were evaluated. GARM III and the 2012 updated assessment only included catches from LA vessels, which was estimated to be about 32% of the total SNE/MA WP catch. Before 2004, there was limited observer coverage of LAGC vessels. Therefore, for FW48 the GF PDT estimated the total catch of SNE/MA WP by LAGC vessels (dredge and trawl combined) so it could be combined with the estimate of catch for LA vessels. Using the same discard estimation methodology that was used for the 2012 GARM and 2004-2010 observer data, the average catch of LAGC vessels was 21.85mt for dredge and trawl gears combined.

FW48 used the average catch estimate of 22 mt for LAGC vessels and combined that with the data for LA vessels for 2001-2010. In some years the estimate for the LAGC fishery is a substantial proportion of the total scallop fishery catch, even higher than the estimate of LA catch. Assuming the 22 mt estimate is accurate, the LAGC fishery WP catch may be about 30% of the total scallop fishery WP catch. This may not be unreasonable since WP is more concentrated in shallow waters for most of the year. There are several years when LA catches are higher than other years (2005 and 2010). This is likely due to LA vessels fishing in more shallow areas than normal, where WP are more abundant.

The sub-ACL adopted is based on the 90th percentile of scallop fishery catches (LA and LAGC combined as a percentage of the total WP catch) for the time period 2001-2010. That is equivalent to 36% of the total ACL.

Table 11 - Limited access scallop fishery discards of SNE/MAB windowpane flounder, 2001-2010. Landings were less than 1 metric ton in all years.

Calendar Year	Catch	Limited Access Scallop Dredge/Trawl Discards	Limited Access Scallop Fishery Catches as Percent of Total	General Category (Trawl/Dredge) Scallop Fishery Catch Assumption	Total Scallop Fishery Catch As Percent of Total
2001	184	7	3.8%	22	14.1%
2002	339	50	14.7%	22	19.9%
2003	522	73	14.0%	22	17.5%
2004	400	44	11.0%	22	15.6%
2005	330	103	31.2%	22	35.5%
2006	431	63	14.6%	22	18.8%
2007	349	41	11.7%	22	17.0%
2008	321	53	16.5%	22	21.9%
2009	463	55	11.9%	22	15.9%
2010	490	187	38.2%	22	40.8%
		Average, 2001-2010	16.8%		21.7%
		90th percentile, 2001-2010	31.9%		36.0%

Table 12 – Estimate of LA and LAGC scallop fishery WP catch

Calendar Year	Est of LA Discards	Assumption of LAGC Discards	Total scallop fishery catch	% LAGC
2001	7	22	29	75.9%
2002	50	22	72	30.6%
2003	73	22	95	23.2%
2004	44	22	66	33.3%
2005	103	22	125	17.6%
2006	63	22	85	25.9%
2007	41	22	63	34.9%
2008	53	22	75	29.3%
2009	55	22	77	28.6%
2010	187	22	209	10.5%

Note: LAGC estimate is based on the average WP catch from observed trips in 2004-2010 and applied for all years

The current estimate of SNE/MA WP catch by the scallop fishery is provided below. To date, the estimate of catch is about 200,000 pounds or 91 mt, about 50% of the sub-ACL. In 2013 the LAGC fishery current estimate of SNE WP catch is about 20% of the total scallop fishery catch (5% for LAGC trawl fishery and 15% for LAGC dredge)

Windowpane Flounder Sub-ACL for the Directed Scallop Fishery
Southern New England/Mid-Atlantic Stock Area

Report run on:	December 26, 2013
For data reported	December 24, 2013
Quota period:	2013
Quota period dates:	03/01/13 to 02/28/14

	Limited Access Fleet*						Limited Access General Category IFQ Fleet								
	Nantucket Lightship		Southern New England		Mid-Atlantic		Nantucket Lightship		Southern New England		Mid-Atlantic				
Date	Kept (lb)	Discards (lb)	Kept (lb)	Discards (lb)	Kept (lb)	Discards (lb)	Dredge discards (lb)	Trawl discards (lb)	Dredge discards (lb)	Trawl discards (lb)	Dredge discards (lb)	Trawl discards (lb)	Monthly total catch (lb)	Cumulative catch (lb)	Percent of sub-ACL (403,446 lb)
March-13	-	-	-	3,582	-	3,217	-	-	616	336	2,915	-	10,667	10,667	2.6
April-13	-	-	-	14,792	-	6,729	-	-	1,118	907	4,372	77	27,995	38,662	9.6
May-13	-	2,005	-	21,856	-	4,156	-	-	1,803	1,119	3,402		34,341	73,003	18.1
June-13	-	9,236	-	8,474	-	995	60	-	1,151	1,551	3,401	25	24,892	97,894	24.3
July-13	-	8,605	-	11,745	-	1,295		-	1,261	1,517	3,712		28,135	126,030	31.2
August-13	-	6,027	-	12,840	-	1,593	26	-	1,447	489	3,292	-	25,713	151,743	37.6
September-13	-	3,836	-	12,480	-	1,835		-	1,000	655	3,125	34	22,966	174,709	43.3
October-13	-	2,683	-	5,428	-	961		-	1,090	794	2,178		13,135	187,844	46.6
November-13	-	2,704	-	697	-	324	-	-	420	234	823		5,202	193,046	47.8
December-13	-	756	-	995	-	279	-	-	199	26	472	-	2,727	195,773	48.5
Total	0	35,851	0	92,889	0	21,384	85	0	10,106	7,629	27,693	137	195,773		

*The limited access fleet is not split into dredge and trawl components because there is insufficient observer coverage for such a stratification.

In order to comply with data confidentiality requirements, discards for areas and/or gear types that only have 1 - 2 vessels in a month will be aggregated with discards from preceding month(s) until the 3 vessel minimum is met.

NOTE: This report uses audited observer data (May - October 2011; March 2012; June 2012 - July 2012) for limited access general category IFQ trawl trips in Mid-Atlantic; and the most recent 12 months of audited observer data (September 2012 - August 2013) for both fleets in Southern New England, Mid-Atlantic and Nantucket Lightship.

NOAA FISHERIES

These data are the best available to NOAA's National Marine Fishery Service (NMFS) when this report was compiled. Data for this report are supplied to NMFS from vessels via Vessel Trip Reporting and the Vessel Monitoring System, and dealers via Dealer Electronic Reporting. Data may be preliminary. Discrepancies with previous reports are due to corrections made to the database.

5.0 BACKGROUND ON LAGC EFFORT IN SNE/MA (FROM FW24)

This section has been included from FW24 because it has information about LAGC catch by area and month that is useful when considering the potential impacts of the WP AM measures. These analyses will be updated to reflect the areas currently under consideration for FW25, but many are the same as FW24.

5.1 LAGC TRAWL

A substantial proportion (67.1%) of the scallop landings by these vessels took place in areas 612 and 613 in years 2010-2011 (**Table 14**). As Table 13 shows, the seasonal distribution of scallop landings by OTF+OTC vessels varied, but in 2010 and 2011 the majority of landings occurred from May-July.

Table 13. Percentage composition of Scallop Landings by Trawls (OTF+OTC) by month from areas 612 and 613 (VTR data for 2010-2011 calendar years, vessels with LAGC-IFQ permits)

MONTH	612	613	Grand Total
1	0.71%	4.94%	5.65%
2	2.31%	1.18%	3.50%
3	0.61%	3.33%	3.94%
4	0.66%	6.66%	7.32%
5	9.05%	4.03%	13.08%
6	16.16%	4.47%	20.63%
7	9.96%	2.14%	12.10%
8	5.34%	4.12%	9.46%
9	4.73%	2.37%	7.10%
10	3.81%	3.76%	7.57%
11	0.67%	3.37%	4.04%
12	0.43%	5.18%	5.61%
Grand Total	54.45%	45.55%	100.00%

Note: The trips with more than 1200lb. of scallop landings are excluded.

Table 14. The 2010-2011 landings in closed periods for SNE/MA AM schedule (3 Digit Areas 612+613, LAGC-IFQ vessels using trawl gear, i.e., OTF+OTC)

Schedule for Closure					
Overage	**LAGC Trawl Closure**	**Sum of scallop landings for 2010+2011 in 612+613**	**Sum of scallop landings from all areas**	**Landings in 612+613 as % of scallop landings from all areas during the closure period**	**Landings in 612+613 in the closure period as a % of all scallop landings from all areas during the whole year**
2% or less	Mar-Apr	71,977	125,075	57.5%	11.3%
2.1-3%	Mar-Apr, and Feb	94,329	150,168	62.8%	14.8%
3.1-7%	Mar-May, and Feb	177,957	280,472	63.4%	27.8%
7.1-9%	Mar-May, and Jan-Feb	214,064	331,588	64.6%	33.5%
9.1-12%	Mar-May, and Dec-Feb	249,921	377,580	66.2%	39.1%
12.1-15%	Mar-June, and Dec-Feb	381,760	580,169	65.8%	59.7%
Open Period	July to November	257,388	372,522	69.1%	40.3%
	All Year	639,148	952,691	67.1%	100.0%

Although, the impacts on the overall LAGC fishery may be small at the low overage rates, there could be some distributional impacts on vessels from different states and ports. The closures will impact vessels home ported in New York and New Jersey most. LAGC vessels that are home-ported in those states landed majority of scallops in 612 and 613 (Table 15).

Table 15. Number of OTF+OTC vessels and Scallop landings by homeport and area (VTR data for 2010-2011, vessels with LAGC-IFQ permits, all trips including the ones>1200)

			Home state			
year	Area	Data	MA+RI	NY+NJ	Oth.MidAt	Grand Total
2010	612	Number of vessels		21	6	27
		Scallop lb.		33,133	74,396	107,529
	613	Number of vessels		11	NA	13
		Scallop lb.		114,695	NA	NA
	other	Number of vessels	NA	6	20	35
		Scallop lb.	NA	>15000	179,436	>185,000
Total Scallop lb.			NA	165,886	254,632	421,943
2011	612	Number of vessels		14	15	29
		Scallop lb.		20,580	212,019	232,599
	613	Number of vessels	NA	11	NA	NA
		Scallop lb.	NA	174,829	NA	175,629
	other	Number of vessels	12	10	14	36
		Scallop lb.	NA	>25000	73,379	108,557
Total Scallop lb.			4,170	226,417	286,198	516,785

5.2 LAGC DREDGE

Table 16 – SNE/MA YT AM schedule for LAGC dredge vessels if scallop fishery AM is triggered and LAGC dredge catch is more than 3% of total catch

	AM closure area and duration		
Overage	539	537	613
2% or less	Mar-Apr	Mar-Apr	Mar-Apr
2.1% - 7%	Mar-May, Feb	Mar-May, Feb	Mar-May, Feb
7.1% - 12%	Mar-May, Dec-Feb	Mar-May, Dec-Feb	Mar-May, Feb
12.1% - 16%	Mar-Jun, Nov-Feb	Mar-Jun, Nov-Feb	Mar-May, Feb
16.1% or greater	All year	Mar-Jun, Nov-Feb	Mar-May, Feb

Table 17. Percentage composition of Scallop landings by scallop dredge vessels (DRS) by month and area (VTR data for 2010-2011, vessels with LAGC-IFQ permits)

Monthlanded	537	539	612	613	Other	Grand Total
1	0.3%	0.3%	0.6%	0.1%	6.6%	7.8%
2	0.1%	0.1%	0.7%	0.1%	2.1%	3.2%
3	0.3%	0.2%	0.8%	0.2%	4.2%	5.7%
4	0.3%	0.4%	0.8%	0.2%	6.1%	7.8%
5	0.6%	0.5%	1.7%	0.4%	7.6%	10.7%
6	0.4%	0.7%	1.9%	0.2%	7.7%	11.0%
7	0.3%	0.7%	2.1%	0.3%	8.6%	11.9%
8	0.3%	0.6%	1.3%	0.4%	8.7%	11.3%
9	0.2%	0.8%	1.3%	0.3%	6.9%	9.4%
10	0.1%	0.5%	0.9%	0.2%	6.4%	8.0%
11	0.1%	0.4%	0.5%	0.1%	5.1%	6.2%
12	0.1%	0.3%	1.4%	0.0%	5.0%	6.8%
Grand Total	3.0%	5.4%	14.0%	2.5%	75.2%	100.0%

Note: The trips with more than 1200lb. of scallop landings are excluded.

Table 18. Scallop landings by LAGC-IFQ vessels by gear code and permit as a % of total landings in areas 537+539+613 (VTR data, including trips (all trips).

LAGC category	GEAR	LA Permit	LAGC Permit	2010	2011	Grand Total
IFQ	DRC			0.1%	0.0%	0.07%
	DRS	YES	YES	2.7%	5.0%	3.97%
		NO	YES	5.0%	7.4%	6.35%
	DRS Total			7.8%	12.4%	10.31%
	DSC			0.0%	0.6%	0.36%
	OTC			0.0%	0.1%	0.07%
	OTF			3.5%	4.2%	3.85%
IFQ Total				11.4%	17.3%	14.66%
NGOM				9.2%	13.1%	11.35%
INCIDENTAL				28.4%	13.8%	20.31%
LA Permit only				51.0%	55.8%	53.68%
Grand Total				100.0%	100.0%	100.00%

6.0 WP AM FOR GF FMP (SECTION 4.2.5.2 AND APPENDIX 4 OF FW47)

This section has been included as background information

The groundfish fishery AM for windowpane flounder will be implemented if the total ACL (as opposed to the groundfish sub-ACL) is exceeded. Should a sub-ACL be allocated to another fishery and AMs developed for that fishery, the AMs for both fisheries will be implemented only if the total ACL for the stock is exceeded.

If the AM is implemented trawl vessels would be required to use approved selective trawl gear that reduces the catch of demersal species. Approved gears include the separator trawl, Ruhle trawl, mini-Ruhle trawl, rope trawl, and other gear authorized by the Council in a management action or approved for use consistent with the process defined in 50 CFR 648.85 (b)(6). There would be no restrictions on longline or gillnet gear.

Areas: The applicable areas where gear restrictions would apply are shown in Figure 2. The areas are designed to be stock specific – the areas on GB are implemented only if the ACL for northern windowpane flounder is exceeded; the areas in SNE are implemented only if the southern windowpane flounder ACL is exceeded. Both areas would be implemented if the ACL for ocean pout is exceeded. The size of the areas for the restrictions is based on the amount of the overage. In each case the smaller area is implemented for ACL overages that are between the management uncertainty buffer and up to 20 percent; both the smaller and larger areas area implemented for overages of more than 20 percent.

Figure 2 - AM areas (small) for Northern and Southern Windowpane and Ocean Pout

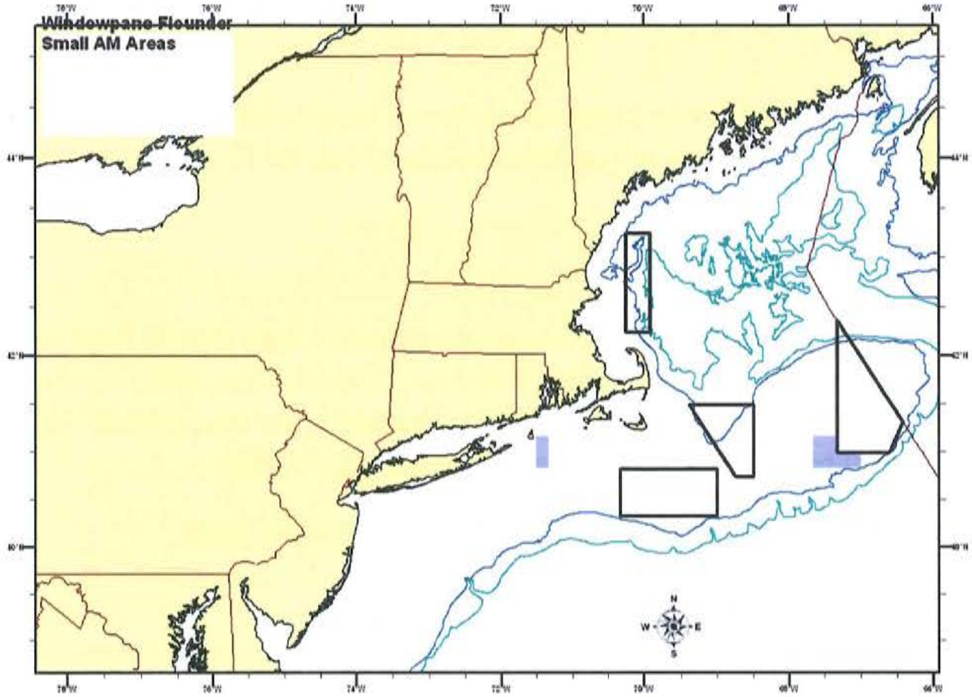
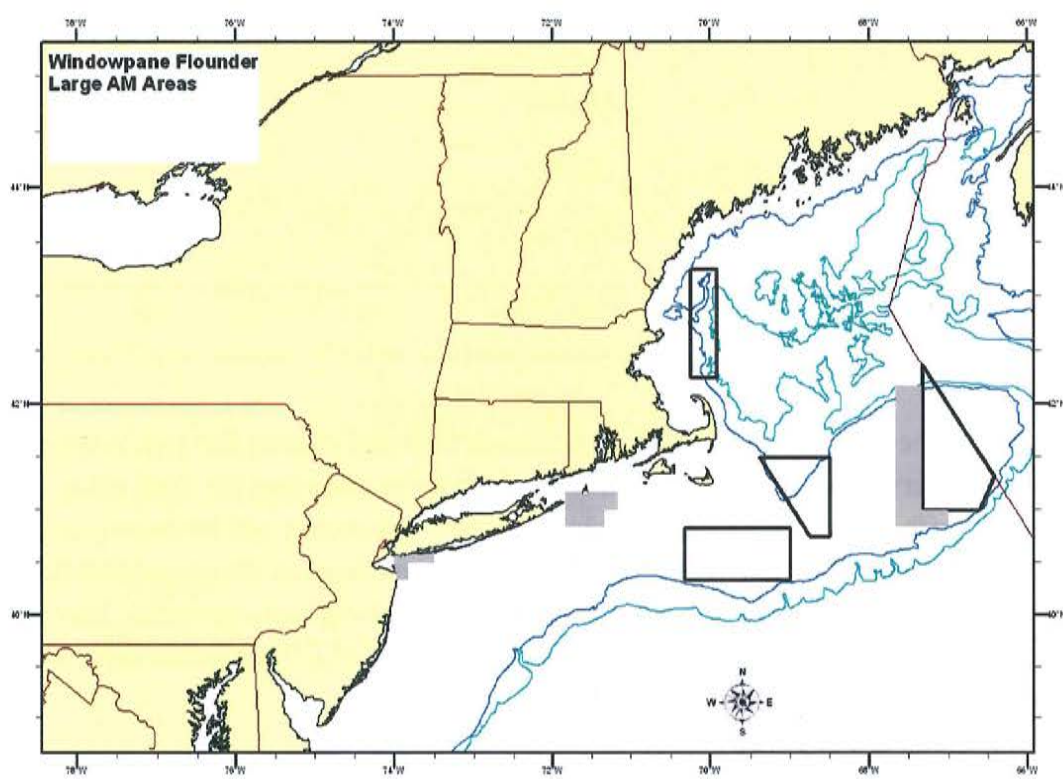


Figure 3 – AM area (large) for windowpane flounder and ocean pout



Potential Economic Impacts of Windowpane flounder AMs described in FW47

If adopted, this option would implement trawl gear restrictions in certain areas during either year 2 or year 3 based on ACL overages that occurred in year 1.

If this option were triggered, both common pool and sector-based vessels would have the choice of either using an approved selective gear or not fishing in the area. Two sub-options are considered, the first with smaller areas and the second with larger areas.

Sub-option 1: Smaller areas

Nearly $7 million dollars of total revenues by groundfish fishing vessels are estimated from trips in these areas. The majority of these revenues (93%) were reported on trips hailing from New Bedford, MA (Table 75). Note also that $6 million dollars in gross revenue from vessels hailing from New Bedford is not insignificant—it is nearly 10% of the $65 million landed in that port by permitted groundfish vessels in FY 2010.

Table 76 – Gross revenues from VTR trips reported inside Sub-option 1 (smaller areas) during FY 2010

PORT	GROSS REVENUE	
Boston, MA	$	169,802
Gloucester, MA	$	82,521
New Bedford, MA	$	6,136,129
Nantucket, MA	$	357
Montauk, NY	$	138,882
Newport, RI	$	13,887
Pt Judith, RI	$	410,124
Grand Total	$	6,951,702

Only a portion of these revenues will be affected by this option, as vessels may still elect to fish inside these areas with selective gear. Selective gears have not been used extensively in these areas thus far, indicating that it is generally more profitable to fish with traditional gears than selective gears. Whether it will be more profitable to fish in other areas or to continue fishing inside these areas with selective gears depends on the profitability of other fishing options. Given the relatively small size of these areas, the additional trip costs (steaming time, etc.) are likely negligible. The true cost will be the difference between the profitability of fishing inside these areas and the profitability of making those trips in the next best outside area.

The use of selective gear does substantially change the composition of the catch inside the windowpane and ocean pout (small) areas. Both VTR reported and observer data collected from tows inside the areas show a much higher proportion of haddock and lower proportion of flatfish relative to traditional trawl gears.

Table 77 – Proportion of kept catch on observed and VTR-reported trips using selective (separator, Rhule) and traditional (otter) trawl gears inside the small windowpane AM option areas

	Observer				VTR			
	selective		**traditional**		**selective**		**traditional**	
cod	$ 23,194	4.1%	$ 155,022	13.5%	$ -	0.00%	$ 525,406	7.6%
haddock	$ 510,581	91.1%	$ 656,658	57.3%	$ 64,553	100.00%	$ 3,128,320	45.4%
flats	$ 24,012	4.3%	$ 259,142	22.6%	$ -	0.00%	$ 1,624,265	23.6%
pollock	$ 117	0.0%	$ 9	0.0%	$ -	0.00%	$ 3,522	0.1%
white hake	$ -	0.0%	$ 6	0.0%	$ -	0.00%	$ 5,591	0.1%
skates	$ 1,688	0.3%	$ 32,881	2.9%	$ -	0.00%	$ 1,377,939	20.0%
other	$ 783	0.1%	$ 36,106	3.2%	$ -	0.00%	$ 10,601	3.1%
squids	$ -	0.0%	$ 5,255	0.5%	$ -	0.00%	$ 211,506	0.2%
Grand Total	$ 560,376		$ 1,145,079		$ 64,553		$ 6,887,148	

Average revenues per tow for the selective gears in these areas were approximately 31% higher than per-tow revenues using traditional gears on observed trips, though fewer tows were observed. Whether or not fisherman will chose to use the selective gear in these areas remains to be seen, but while this option appears to affect $7 million in revenues it appears that nearly all of that revenue can be made up for at relatively low cost by using the approved selective gears or moving to a different fishing location.

Table 78 – Revenue per tow by two types of trawl gears from tows observed inside windowpane small areas

Trawl net	**Revenue per tow**	**number tows**
selective	$ 2,536	223
traditional	$ 1,918	597

Sub-option 2: Larger areas

Approximately $15 million in estimated gross revenues is estimated to have come from these areas, with 75% of these revenues coming from New Bedford, MA. Pt. Judith is the next-most affected port, with almost $1.7 million in estimated gross revenues coming from these areas.

Table 79 - Gross revenues from VTR trips reported inside Sub-option 2 (larger areas) during FY 2010

Port	Gross revenue
Stonington, CT	$ 42,178
Boston, MA	$ 299,027
Gloucester, MA	$ 256,697
New Bedford, MA	$ 11,717,014
Nantucket, MA	$ 26,708
Pt Pleasant, NJ	$ 44,777
Cape May, NJ	$ 11,698
Monmouth, NJ	$ 15,571
Belford, NJ	$ 517,276
Belmar, NJ	$ 5,630
Freeport, NY	$ 139,899
Greenport, NY	$ 20,750
Montauk, NY	$ 605,159
Point Lookout, NY	$ 242,128
Newport, RI	$ 59,075
Pt Judith, RI	$ 1,670,090
Grand Total	$ 15,685,911

Selective gears again substantially change the composition of the catch inside the windowpane and ocean pout large areas. Both VTR reported and observer data collected from tows inside the areas show a much higher proportion of haddock and lower proportion of flatfish relative to traditional trawl gears.

As with the small windowpane areas, catch rates per observed tow were about 33% higher with the selective gears than with traditional gear for observed tows in the large areas. As with the smaller areas, it is not clear that all revenues from these areas will be lost if the AMs are triggered, as vessel operators may choose to use selective gear, or may fish in other areas.

Table 80 - Proportion of kept catch on observed trips using selective (separator, Ruhle) and traditional (otter) trawl gears inside the large windowpane AM option areas

	Observer				VTR			
	selective		**traditional**		**selective**		**traditional**	
cod	$ 75,181	7.4%	$ 294,954	12.5%	$ 59,338	11.80%	$ 984,926	6.5%
haddock	$ 818,668	80.6%	$ 880,722	37.3%	$ 347,798	69.00%	$ 4,970,878	32.7%
flats	$ 48,349	4.8%	$ 581,598	24.6%	$ 66,019	13.10%	$ 4,373,327	28.8%
pollock	$ 56,472	5.6%	$ 4,783	0.2%	$ 2,925	0.60%	$ 35,403	0.2%
white hake	$ 38	0.0%	$ 2,054	0.1%	$ -	0.00%	$ 61,362	0.4%
skates	$ 4,450	0.4%	$ 266,161	11.3%	$ 1,217	0.20%	$ 2,615,678	17.2%
other	$ 11,972	1.2%	$ 229,621	9.7%	$ -	5.30%	$ 519,877	10.7%
squids	$ -	0.0%	$ 101,112	4.3%	$ 26,745	0.00%	$ 1,620,419	3.4%
Grand Total	$ 1,015,131		$ 2,361,006		$ 504,042		$ 15,181,869	

Table 81 - Revenue per tow by two types of trawl gears from tows observed inside windowpane large areas

Trawl net	**Revenue per tow**	**number tows**
selective	$ 2,452	417
traditional	$ 1,804	1309

In summary, implementing the small windowpane flounder and ocean pout AM area could affect $7 million in groundfish revenue; while the larger area could affect $15 million in revenue. Not all of these revenues are likely to be foregone, as fishermen can choose to fish in the areas with selective gear or could fish in other areas. The delay in implementation of the restriction will give fishermen some time to plan their operations to mitigate the economic impacts of the measure. This AM will have negative economic impacts compared to the Option 1/No Action AMs for these stocks because it will actually affect fishing behavior and the AM applies to all groundfish fishing vessels, not just common pool vessels. At a minimum, fishermen will have to alter their behavior which may impose additional costs; while at a maximum, it could reduce revenues by $15 million if the larger areas are implemented simultaneously. This option cannot be compared to Options 3, 4 or 5 because they address different stocks.

Appendix III

Testing of Scallop Dredge Bag Design for Flatfish Bycatch Reduction

Final Report

Prepared for the 2012

Sea Scallop Research Set-Aside

October 2013

Submitted By

Farrell Davis, Katherine Thompson- Coonamessett Farm Foundation, Inc

In Collaboration with

David Rudders- Virginia Institute of Marine Science

Coonamessett Farm Foundation, Inc
277 Hatchville Road
East Falmouth, MA 02536
508-356-3501 FAX 508-356-3503
contact@cfarm.org
www.coonamessettfarmfoundation.org

NOAA Grant Number: NA12NMF4540041

A. Grantee: Coonamessett Farm Foundation, Inc

B. Project Title: **Testing of Scallop Dredge Bag Design for Flatfish Bycatch Reduction**

C. Amount of Grant: $242,360

D. Award Period: 3/01/2012-2/28/2014

E. Reporting Period: 5/01/2012-5/31/2013

Project Summary

Throughout the duration of this project, from March 1, 2012 through May 31, 2013, four separate research trips were completed. The Coonamessett Farm Turtle Deflector Dredge (CFTDD) rigged with a control bag (8 ring apron and 60 mesh twine top) was compared to the CFTDD experimental bag (5 ring apron, 45 mesh twine top), the Low Profile Dredge (LPD) rigged with an experimental bag and a CFTDD experimental bag with windows for catch comparisons. The summary of the four trips can be seen below.

Vessel	Start Date	End Date	Number of Tows	Experimental Dredge Frame
Concordia	8/26/2012	8/31/2012	106	CFTDD
Freedom	10/19/2012	10/23/2012	80	CFTDD
Diligence	2/25/2013	3/1/2013	80	LPD
Westport	5/14/2013	5/18/2013	76	LPD

Introduction

The Georges Bank sea scallop (*Placopecten magellanicus*) fishery is well managed and economically productive. This is due in part to the involvement and cooperation of the commercial scallop fishing industry in mitigating groundfish bycatch and ultimately creating a more sustainable fishery. With consumer demand for more sustainably harvested seafood increasing, there is an overwhelming need to change fishing habits to avoid excessive bycatch. The severity of current bycatch management tools, like fishing ground closures, has resulted in the loss of millions of dollars in revenue in the past. Gear modifications in conjunction with gear restricted zones represent a new economically viable tool for the fishery management toolkit.

The rigorous testing of the Coonamessett Farm Turtle Deflector Dredge (CFTDD) has shown it to be successful in reducing the bycatch of loggerhead sea turtles (*Carretta carreta*) without any loss in scallop catch efficiency. The dredge frame was designed to smoothly guide turtles over the top of the dredge by moving the cutting bar forward and eliminating most of the bale bars so not to impede escape (Smolowitz et al. 2010; Smolowitz et al. 2012). During the 2011 RSA Seasonal Bycatch Survey, a CFTDD was simultaneously fished alongside New Bedford dredges supplied by the participating vessels (NA11NMF4540027). It was observed that the difference between the bycatch rates of yellowtail flounder (*Limanda ferruginea*) for New Bedford dredges with an apron greater than 8 rings and a higher twine top hanging ratio and the CFTDD was greater than the difference between New Bedford dredges with an apron less than or equal to 8 rings and a lower twine top hanging ratio (Tables 1 and 2). The scallop fleet typically fishes dredge bags with twine tops 80-90 meshes across (3:1 hanging ratio) and aprons between 7-13 rings long (Tables 1 and 2). Since 2011, CFF has been using a control dredge bag with a twine top 60 meshes across and an 8 ring apron that typically has lower bycatch than commercial gear.

Building on this observation, a proposal was drafted to determine if a shorter apron and a lower twine top hanging ratio than the control dredge would reduce the bycatch rate. Twine top and apron length are two gear characteristics that depend upon one another and are therefore tested together in this project. We hypothesized that a reduced apron size reduces flatfish bycatch by increasing the area through which flatfish can escape and that a lower twine top hanging ratio further increases the probability for flatfish escapement by creating larger openings. This bag design was tested on both a CFTDD and a Low Profile Dredge (LPD).

The LPD frame was tested to determine if a modified frame further reduces bycatch as compared with the CFTDD frame. We hypothesized that a lower angled depressor plate which reduces head bail height off the seafloor would enable fish to swim over the dredge and avoid capture.

In past projects, CFF has also tested the effectiveness of windows (openings cut in the twine top or ring bag) in allowing fish to escape without adversely influencing scallop catch. We further tested the use of windows cut into the sides of the dredge bag in a separate experiment associated with this project.

Methods

We compared catch data from four trips: two testing the CFTDD frame and two testing the LPD frame. All of the trips were conducted on Georges Bank (in open and closed areas) and in Southern New England (SNE) open areas. Tow locations were chosen for their high abundance of fish as well as scallops (Figure 1).

On the first two trips, each vessel was outfitted with two 4.57 m (15 ft) wide CFTDDs: an experimental and a control dredge. The control dredge was rigged with an eight row apron (8R) and a twine top with a hanging ratio of 2 meshes to a ring (Table 3, Figure 2). We chose to use this frame and bag design as a control because this control dredge was used on past projects as well as the current 2013 RSA Bycatch Survey (NA13NMF4540011). The experimental dredge was rigged with a five row apron and a twine top with a hanging ratio of 1.5 meshes to a ring (Table 3, Figure 2). On the last two trips, the vessels were outfitted with the control dredge and a low profile dredge (LPD) rigged with a 5 row apron and a twine top hung with a 1.5:1 hanging ratio as the experimental dredge (Table 3).

In an additional experiment, two by six ring windows in the sides of the experimental bag were tested on the last 30 tows of the first trip of the project. Windows were not tested on subsequent trips in an effort to standardize the gear, maximize sample size, and limit the number of changes. We decided to focus specifically on assessing the effects of a short apron and low twine top hanging ratio on the relative catches of sea scallops and important bycatch species.

While at sea, the dredges were towed at a vessel speed of 4.6-4.8 knots using 3:1 wire scope. The tows were 30 minutes in duration unless lengthened to one hour in bad weather and rough seas. All tow parameters were recorded including start and end positions, depth, and sea conditions. Tows where one or both of the dredges experienced a technical failure (e.g. twine top fouled in tail chain hook) were declared invalid and eliminated from the analysis.

For each paired tow, the catch from each dredge was separated by species and individually counted. The entire scallop catch was recorded as bushels (bu=35.2 liters). A one bushel subsample of scallops from each dredge was picked at random from each tow. These subsamples were measured in 5 millimeter incremental groups to estimate the length frequency of the entire catch. The size frequency of the entire catch was estimated by expanding the catch at each shell height of the subsample by the total number of baskets sampled. All of the commercially important finfish species and barndoor skates were measured to the nearest centimeter and counts were taken of winter and little skates (Table 4).

Gear Comparisons

The objective of the analysis was to determine if the experimental and control dredges performed differently and how those differences might affect catch rates and size selection of both scallops and the major finfish bycatch species. For a particular species our analysis only focused on tows where that species was caught in at least one of the dredges.

Catch weights and bycatch rates of the experimental and control dredges were compared for each trip. Finfish species weights were calculated using NEFSC length-weight relationships (Wigley et al. 2003). Scallop weight was calculated using shell height meat weight projections for Georges Bank and Southern New England provided by VIMS using data collected on the 2013 RSA Seasonal Bycatch Survey (NA13NMF4540011). Bycatch rate was calculated for each of the major flatfish species as the ratio of pounds of flatfish divided by the pounds of scallop meats. We tested for a significant difference in catch weights between the control and experimental dredge bag designs using either a Student's t-test for normally distributed data (Shapiro-Wilk test, $p > 0.05$) or a Mann-Whitney Rank Sum Test for nonparametric data (Shapiro-Wilk test, $p < 0.05$). All statistical analysis was done using SigmaPlot® v. 12.5.

During a dredge tow the bag fills up with benthos, scallops, fish and skates. To determine if bag fullness influenced fish and scallop catch in the experimental and control dredges, we examined the 145 tows from the first two trips with the CFTDD frame in which scallops were caught. Total volume in bushels was calculated by adding the bushels of benthos, scallops, skates, and flatfish together. The number of fish per bushel was estimated for this analysis as 85 skates, 80 yellowtail, 75 winter, 200 windowpane, and 10 summer flounder based on observations made during the four research cruises. We then calculated the proportion of benthos, scallops, skates, and flatfish to the total catch for the 30 largest tows and the 30 smallest tows.

In addition, a Generalized Linear Mixed Model (GLMM) was used to analyze the paired catch data and test for differences in both the pooled length catch data as well as test for differences in the length composition of the catch. The GLMM was used to analyze catch as numbers of animals. Within this modeling framework, the random effects acknowledge the potential for differences that may have occurred at both the trip and individual tow levels. The GLMM groups all the data and gives an overall perspective on how the two gears compare.

This approach has the advantage of mirroring the actual biotic and abiotic conditions under which the dredge will operate. Multiple vessels and slight variations in gear handling and design were included in the experimental design and, while this variability exists, the GLMM modeling approach detailed in the next section accounts for the variability and allows for a more broad inference (relative to vessels) to be made.

Statistical Models – GLMM

Catch data from the paired tows provided the information to estimate differences in the relative efficiency for the gear combinations tested. In addition we tested the influence of frame design on the relative efficiencies of catching various species as a fixed effect. This analysis is based on the analytical approach in Cadigan et al. 2006.

Assume that each gear combination tested in this experiment has a unique catchability. Let q_r equal the catchability of the experimental dredge (5R apron) and q_f equal the catchability of the control dredge (8R apron) used in the study. The efficiency of the experimental relative to the control will be equivalent to the ratio of the two catchabilities:

$$\rho_l = \frac{q_r}{q_f} \qquad (1)$$

The catchabilities of each gear are not measured directly. However, within the context of the paired design, assuming that spatial heterogeneity in scallop/fish and fish density is minimized, observed differences in scallop/fish catch for each vessel will reflect differences in the catchabilities of the gear combinations tested.

Let C_{iv} represent the scallop/fish catch at tow location i by dredge v, where v=r denotes the experimental dredge and v=f denotes the control dredge. Let λ_{ir} represent the scallop/fish density for the i^{th} tow by the experimental dredge and λ_{if} the scallop/fish density encountered by the control dredge. We assume that due to random, small scale variability in animal density as well as the vagaries of gear performance at tow i, the densities encountered by the two gears may vary as a result of small-scale spatial heterogeneity as reflected by the relationship between scallop/fish patch size and coverage by a paired tow. The probability that a scallop/fish is captured during a standardized tow is given as q_r and q_f. These probabilities can be different for each vessel, but are expected to be constant across tows. Assuming that capture is a Poisson process with mean equal to variance, then the expected catch by the experimental dredge is given by:

$$E(C_{if}) = q_f \lambda_{if} = \mu_i \qquad (2)$$

The catch by the control dredge is also a Poisson random variable with:

$$E(C_{ir}) = q_r \lambda_{ir} = \rho \mu_i \exp(\delta_i) \qquad (3)$$

where δ_i =log ($\lambda_{ir}/\lambda_{if}$). For each tow, if the standardized density of scallops /fish encountered by both dredges is the same, then δ_i=0.

If the dredges encounter the same scallop/fish density for a given tow, (i.e. $\lambda_{ir}=\lambda_{if}$), then ρ can be estimated via a Poisson generalized linear model (GLM). This approach, however, can be complicated especially if there are large numbers of tows and scallop/fish lengths (Cadigan et al. 2006). The preferred approach is to use the conditional distribution of the catch by the CFTDD at tow i, given the total non-zero catch of both vessels at that tow. Let c_i represent the observed value of the total catch. The conditional distribution of C_{ir} given C_i=c_i is binomial with:

$$\Pr(C_{ic} = x | C_i = c_i) = \binom{c_i}{x} p^x (1-p)^{r_i - x} \qquad (4)$$

where p=ρ/(1+ρ) is the probability that a scallop/fish captured by the experimental dredge. In this approach, the only unknown parameter is ρ and the requirement to estimate μ for each tow is eliminated as would be required in the direct GLM approach (equations 2 & 3). For the binomial distribution $E(C_{ir})$=$c_i p$ and $Var(C_i r)$=$c_i p/(1-p)$. Therefore:

$$\log\left(\frac{p}{1-p}\right) = \log(\rho) = \beta \qquad (5)$$

The model in equation 5, however, does not account for spatial heterogeneity in the densities encountered by the two gears for a given tow. If such heterogeneity does exist then the model becomes:

$$\log\left(\frac{p}{1-p}\right) = \beta + \delta_i \tag{6}$$

where δ_i is a random effect assumed to be normally distributed with a mean=0 and variance=σ^2. This model is the formulation used to estimate the gear effect $exp(\beta_0)$ when catch per tow is pooled over lengths.

Often, gear modifications can result in changes to the length based relative efficiency of the two gears. In those instances, the potential exists for the catchability at length (l) to vary. Models to describe length effects are extensions of the models in the previous section to describe the total scallop catch per tow. Again, assuming that between-pair differences in standardized animal density exist, a binomial logistic regression GLMM for a range of length groups would be:

$$\log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \delta_i + \beta_1 l, \delta_i \sim N(0,\sigma^2), i = 1,\ldots,n. \tag{7}$$

In this model, the intercept (β_0) is allowed to vary randomly with respect to tow.
The potential exists, however, that there will be variability in both the number as well as the length distributions of scallops/fish encountered within a tow pair. In this situation, a random effects model that again allows the intercept to vary randomly between tows is appropriate (Cadigan and Dowden 2009). This model is given below:

$$\log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \delta_{i0} + \beta_1 * l, \delta_{ij} \sim N(0,\sigma_j^2), i = 1,\ldots,n, j = 0,1. \tag{8}$$

Adjustments for sub-sampling of the catch

Additional adjustments to the models were required to account for sub-sampling of the catch. In most instances, due to high scallop catch volume, particular tows were sub-sampled. This is accomplished by randomly selecting a one bushel sample for length frequency analysis. Finfish were always sampled without subsampling. One approach to accounting for this practice is to use the expanded catches. For example, if half of the total catch was measured for length frequency, multiplying the observed catch by two would result in an estimate of the total catch at length for the tow. This approach would overinflate the sample size resulting in an underestimate of the variance, increasing the chances of spurious statistical inference (Millar et al. 2004; Holst and Revill 2009). In our experiment, the proportion sub-sampled was not consistent between tows as only a one bushel sub-sample was taken regardless of catch size. This difference must be accounted for in the analysis to ensure that common units of effort are compared.

Let q_{ir} equal the sub-sampling fraction at tow i for the vessel r. This adjustment results in a modification to the logistic regression model:

$$\log\left(\frac{p_i}{1+p_i}\right) = \beta_0 + \delta_i + (\beta_1 * l_i) + \log\left(\frac{q_{ir}}{q_{if}}\right), \delta_{ij} \sim N(0,\sigma_j^2), i = 1,...,n. \quad (9)$$

The last term in the model represents an offset in the logistic regression (Littell et al. 2006).

Our analysis of the efficiency of the experimental dredge relative to the control dredge consisted of multiple levels of examination. For all species, the full model consisted of unpooled (by length) catch data, including a categorical variable to denote dredge frame (i.e. CFTDD, LPD):

$$\log\left(\frac{p_i}{1+p_i}\right) = \beta_0 + \delta_i + (\beta_1 * l_i) + (\beta_2 * f_{ij}) + \log\left(\frac{q_{ir}}{q_{if}}\right), \delta_{ij} \sim N(0,\sigma_j^2), i = 1..n,\ j = 0,1\ldots(10)$$

The symbol f_{ij} equals the categorical variable denoting dredge frame configuration. Model fit was assessed by AIC. If AIC and factor significance indicated that length was not a significant factor in predicting relative efficiency, the data was pooled over length. The random intercept model, including f_{ij} was evaluated to asses relative differences in total catch (see equation 6).

We used SAS/STAT® PROC GLIMMIX v. 9.2 to fit the generalized linear mixed effects models.

Results

Catch Weight and Bycatch Rate

Total catch in numbers of fish and bushels of whole scallops is presented in Table 5. In terms of catch volume, fish represent a greater proportion of the catch (4.96% in the control and 2.99% in the Experimental CFTDD) in the low volume tows as compared with the high volume tows (1.04% in the Control and 0.83% in the Experimental dredges) (Table 6). Skate catch comprised a higher proportion of the catch for low volume tows compared to high volume tows, which had more scallops and benthos (Table 6).

A total of 148 valid tows were conducted to compare catch weights of the experimental (CFTDD with the 5R apron/ 45 mesh twine top and no windows) and control dredges. Tables 7, 9 and 11 only present analysis of tow pairs where species of interest were caught. There was a 10% reduction in scallop catch and a 19% decrease in summer flounder in the experimental (5R, 45 mesh twine top) dredge as compared with the control that did not test significant (Table 7). Yellowtail, winter, and windowpane flounder catches were reduced by 33%, 40% and 46% respectively and there was a significant difference between dredges (Table 7). Bycatch rate of all flatfish species was lower in the experimental dredge, especially yellowtail flounder (Table 8).

For the LPD, 150 tows were used for comparison. Catch of all four species of flatflish and scallops was reduced by 40%-68%, however scallop catch was also significantly reduced by 31%

(Table 9). Bycatch rates for all species were lower for the experimental dredge than the control dredge with a more pronounced difference for windowpane and summer flounder (Table 10).

Out of the 30 tows with the two by six windows in the sides of the experimental dredge, 28 of the tows were analyzed as valid tows. There was no significant difference in catch weight of yellowtail, summer flounder, or sea scallops (40%, 19%, and 6% reductions, respectively) between dredges for these tows (Table 11). For winter and windowpane flounder (47% and 88% reduction, respectively), there was significantly less catch in the experimental dredge with windows (Table 11). There was a reduction in bycatch rate for all species in the experimental dredge (Table 12).

GLMM Results

Catch data

The data from the four research trips were treated as a single data set for the purposes of this analysis. The two apron configurations influenced twine top length and hanging ratio, therefore these two characteristics were treated as a combined effect. An additional difference between the experimental gears was dredge frame configuration. On two of the trips a CFTDD frame was used, while on the other two cruises the experimental dredge consisted of a LPD frame. The control dredge configuration was consistent on all cruises.

Overall, this data set consisted of 298 valid tow pairs that were examined in the analysis. A number of tows (30 tows) in which windows were cut into the experimental dredge bag were excluded from the analysis.

Statistical models

This analysis attempted to construct a model that would predict the relative efficiency of the experimental (5R) dredge relative to the control dredge based on a variety of covariates. In some instances, especially since gear modifications may alter the relative size composition of the catch, it was informative to analyze relative catch at length to determine length-based relative efficiency. Length was not a significant predictor of relative efficiency for most species, in which case pooled catch data were analyzed. The effect of dredge frame was also examined for its impact on the relative efficiency of the experimental dredge relative to the control dredge.

Model Results

For some species, there was simply not enough data to provide meaningful results from the model. Most cases involved a small number of tow pairs where there were non-zero observations and the model failed to converge. Table 13 shows the best model fit as determined by AIC for the various species in the analysis. Parameter estimates associated with the best model fit are shown in Tables 14-17. Graphical representations of the observed catches (either pooled or unpooled depending upon best model fit) and predicted relative efficiencies derived from the model output are shown in Figures 3, 5-10.

Sea scallops were the only species for which the data were best fit by a length-based model that includes dredge frame as a fixed effect. There was an overall reduction in relative scallop catch efficiency using the experimental dredge configuration relative to the control dredge (Table 14, Figure 3). There was also a significant length effect, since the experimental dredge was less efficient at capturing smaller scallops than the control dredge (Table 14, Figure 4). It is important to understand the impact of the observed difference in relative efficiency with respect to expected scallop catch. One important aspect of size selectivity is discards of small scallops during shucking, which is not regulated. Size selectivity during shucking can considerably influence scallop catch depending on cull point (Tables 18 and 19).

Summer flounder were the only other species that demonstrated a significant length-based effect on the estimated relative efficiency. There was a significant reduction in relative summer flounder catch efficiency in the experimental dredge compared to the control dredge (Table 15, Figure 4). Dredge frame was not significant in predicting relative efficiency in this case. Catch efficiency of summer flounder increased with length (Figure 5).

Animal length was not a significant predictor of relative efficiency for the remaining species analyzed and the catch data was pooled over length. For barndoor and unclassified skates, there was an overall reduction of relative efficiency for the experimental dredge relative to the control dredge (Table 16, Figures 6-7). Dredge frame was also significant for these species. The experimental dredge reduced the catch of yellowtail flounder, winter flounder, windowpane flounder and monkfish, relative to the control dredge (Table 17, Figures 8-11). Parameter estimates were negative indicating reduced catch in the experimental dredge (Table 17).

The reduction in relative scallop catch efficiency was greatest between the LPD and control dredge frames (Figure 3). The LPD dredge frame also produced a greater reduction in fish bycatch relative to the control dredge frame.

Discussion

The results indicate that the experimental CFTDD reduced bycatch and trash with a slight reduction in scallop catch, while the LPD had a similar reduction in bycatch but a much larger decrease in scallop catch. There was a reduction of bycatch species in the experimental CFTDD without a significant difference in sea scallops, though scallop catch was slightly (10%) lower. The LPD was not ideal; while bycatch was also reduced, there was a significant (31%) loss in scallop catch. The GLMM analysis indicates that the lower scallop catch in the LPD as compared with the CFTDD was not a function of size selectivity, since there were fewer scallops over all size classes (Figure 2).

Despite the significant loss in scallop catch observed in this study, the LPD still has the potential to be an effective means of reducing bycatch in the scallop fishery. In past studies, the LPD caught less volume of benthos and demonstrated scallop size selectivity (NA11NMF4540021). The 22.5° angle of the depressor plate may be too extreme causing the cutting bar to lift off the seafloor bottom and reducing scallop catch. In future studies we will test the performance of an LPD frame with a higher depressor plate angle.

Tows with zero catches for a given species were excluded from the catch weight analysis. Incorporating the zero catch tows increases the variance of the data. Zero catch tows for a given species are uninformative in gear testing, since there is no way to differentiate between lack of catch due to fish absence and lack of catch due to gear selectivity.

Results from catch weight analysis indicated that there was a significant difference in catch weight for all species except sea scallops and summer flounder between the CFTDD experimental and the control dredges (Table 7). GLMM analysis yielded a difference in numbers of animals between dredges for all species caught, including sea scallops and summer flounder (Tables 14-17). This can be explained by size selectivity, since sea scallops and summer flounder were the only two species for which there was a length-based effect. The experimental dredge was more size selective, catching larger scallops, which compensates for fewer scallops caught. Since the scallops that are caught in the experimental dredge are larger on average, the difference in total scallop meat weight was not significant.

It is beneficial for the fishery to catch larger scallops for both economic and biological reasons. Large scallop meats generally have a higher market value than small meats. Increasing the size of capture would raise the average yield per recruit (DuPaul et al. 1989). Discard mortality is higher for small scallops because they tend to be more susceptible to desiccation and heat on deck (Stokesbury et al. 2011). Therefore, catching fewer small scallops would decrease the discard mortality rate.

The CFTDD experimental dredge catches fewer fish and small scallops than the control dredge, which indicates that it is more selective. By reducing the apron size and twine top hanging ratio, the mechanical sorting ability is increased. The experimental dredge has a higher mechanical sorting ability due to an extended twine top that overhangs the sweep. The 10.5 inch mesh of the twine top with a low hanging ratio sorts the catch more efficiently than the 4 inch steel rings of the bag. Since the short apron does not overhang the sweep, fish and small scallops that are deflected up come into contact with the twine top, permitting the release of fish and small scallops. The dredge is less efficient at catching small scallops because they are less dense and are more susceptible to the mechanical sorting process than large scallops (Bourne 1965).

The 10% loss in scallops in the experimental CFTDD is not due the volume of material in the bag. The difference in scallop catches between the experimental and control CFTDDs in the 30 highest volume tows was minimal (Table 6). Yochum and DuPaul (2008) determined that the volume of trash in the dredge bag did not significantly impact scallop catch. A longer tow time on a commercial tow could influence the volume of material in the bag, but may not impact scallop catch.

Volume of material in the dredge bag appears to influence the efficiency of the gear at catching flatfish. Material accumulates in the bag from clubstick to sweep/twine top. Once the material reaches the twine top the efficiency of the dredge at retaining fish decreases, since the 10.5 inch mesh of the twine top with a low hanging ratio has larger openings than 4 inch steel rings of the bag. When the bag is completely full, the dredge "bulldozes" along the bottom and only the densest of material is retained. Figure 12 illustrates this hypothesis, where fish catch efficiency would be greatest at point A and decrease as material accumulates from point A to C.

In this study it was observed that tows with low volume had a greater proportion of fish in the catch as compared with high volume tows (Table 6). Otter trawl studies have shown that catch volume and the shape of the cod-end influence selectivity (Herrmann 2005). Future experimentation is needed to determine if and to what extent the shape of a scallop dredge bag influences the overall catch efficiency of the dredge.

This hypothesis could be tested by filming fish behavior and dredge bag shape as it fills over the course of a tow. In the 2013 Gear Project, Coonamessett Farm Foundation used GoPro cameras attached to the gooseneck of the dredge to investigate the behavior of fish ahead of the cutting bar and during the hauling back of the dredge. We plan to continue testing camera placement on future trips to observe fish behavior behind the head bail.

Windows in the bags significantly reduced windowpane flounder catch. CFF has tested windows in the dredge bag in past experiments and the side pieces seem to be the most effective location of windows in reducing bycatch. Further testing of windows in this location on the bag under various fishing conditions is needed to determine whether this may be an effective management tool.

In conclusion, the gear modifications reduced bycatch in two ways. The first is that bycatch is prevented from entering the bag. The low profile dredge has a reduced angle of attack and a head bail that is towed lower to the seafloor, thereby enabling fish to swim over the dredge and avoid capture. Secondly, the gear facilitates the escape of non-target species after capture. Reducing the apron size decreases the distance from the sweep to the twine top, thus facilitating fish escapement. Decreasing the twine top hanging ratio may increase the mesh opening and further facilitate escapement. Understanding the abiotic (accumulation of material) and biotic factors (fish behavior) that impact dredges performance will inform more effective gear modifications to reduce bycatch without significantly impacting the target species catch. Gear modifications in conjunction with other management tools, such as gear restricted areas, represent an economically viable solution for reducing bycatch in the scallop fishery.

REFERENCES

Bourne, N. 1965. A comparison of catches by 3- and 4-inch rings on offshore scallop drags. J. Fish. Res. Board Can. 22: 313-333.

Cadigan, N.G., S.J. Walsh, and W. Brodie. 2006. Relative efficiency of the *Wilfred Templeman* and *Alfred Needler* research vessels using a Campelen 1800 shrimp trawl in NAFO Subdivisions 3Ps and divisions 3LN. Can Sci Advis Secret Res Doc 2006/085; 59 pp.

Cadigan, N.G. and J. J. Dowden. 2009. Statistical inference about relative efficiency of a new survey protocol, based on paired-tow survey calibration data. Fish. Bull. 108:15-29.

DuPaul, W.D., E.J. Heist, and J.E. Kirkley. 1989. Comparative Analysis of Sea Scallop Escapement/Retention and Resulting Economic Impacts. VIMS. Technical Report. PB-90-115221/XAB.

Herrmann, B. 2005. Effect of catch size and shape on the selectivity of diamond mesh cod-ends I. Model development. Fish. Res. 71: 1-13.

Holst, R. and A. Revill. 2009. A simple statistical method for catch comparison studies. Fisheries Research. **95**: 254-259.

Littell, R.C., G.A. Milliken, W. Stroup, R. Wolfinger, and W.O. Schabenberger. 2006. SAS for Mixed Models (2nd ed.). Cary, NC. SAS Institute Inc.

Millar, R.B., M.K. Broadhurst, and W.G. Macbeth. 2004. Modeling between-haul variability in the size selectivity of trawls. Fisheries Research. **67**:171-181.

Smolowitz, R., H. Haas, H.O. Milliken, M. Weeks, and E. Matzen. 2010. Using Sea Turtle Carcasses to Assess the Conservation Potential of a Turtle Excluder Dredge. N. Amer. J. Fish. Manage. 30: 993-100.

Smolowitz, R.J., H.O. Milliken, and M. Weeks. 2012. Design, Evolution, and Assessment of a Sea Turtle Deflector Dredge for the U.S. Northwest Atlantic Sea Scallop Fishery: Impacts on Fish Bycatch. N. Amer. J. Fish. Manage. 32: 65–76.

Stokesbury, K.D.E., J.D. Carey, B.P. Harris, and C.E. O’Keefe. 2011. Incidental fishing mortality may be responsible for the death of ten billion juvenile sea scallops in the Mid Atlantic. Mar. Ecol. Prog. Ser. 425:167-173

Wigley, S.E., H.M. McBride, and N.J. McHugh. 2003. Length-weight relationships for 74 fish species collected during NEFSC research vessel bottom trawl surveys, 1992-9. NOAA Tech Memo NMFS NE 171; 26p.

Yochum, N. and W.D. DuPaul. 2008. Size-selectivity of the northwest Atlantic sea scallop (*Placopecten magellanicus*) dredge. J. Shell. Res. 27: 265-271.

TABLES

<u>Table 1</u> Impact of Apron Length on Bycatch Rates from the 2011 RSA Bycatch Survey

			Yellowtail (lbs)		Scallops (lbs)		Bycatch Rate	
All stations	Twine Top Size	Apron Size	Turtle	New Bedford	Turtle	New Bedford	Turtle	New Bedford
Arcturus (Mar)	8.5 x 90	10 x 40	249	477	7360	8495	0.034	0.056
Westport (May)	8.5 x 80	13 x 40	182	260	9798	9757	0.019	0.027
Wisdom (Jan)	11 x 90	10 x 38	334	432	4617	4543	0.072	0.095
Total			765	1170	21775	22796	0.035	0.051
Celtic 2010 (Oct)	7.5 x 60	8 x 40	619	538	7575	6666	0.082	0.081
Celtic 2011 (Apr)	7.5 x 60	8 x 40	224	282	7078	7777	0.032	0.036
Liberty (June)	8.5 x 90	7 x 38	231	215	15517	12087	0.015	0.018
Endeavour (July)	8.5 x 80	8 x 40	222	270	9836	9185	0.023	0.029
Regulus (Aug)	7.5 x 43	8 x 38	544	514	6179	5565	0.088	0.092
Resolution (Sept)	10.5 x 36	8 x 42	637	400	5456	5638	0.117	0.071
Ranger (Oct)	9 x 33	7 x 38	763	372	6085	5491	0.125	0.068
Horizon (Dec)	8 x 96	8 x 44	445	336	4501	4338	0.099	0.077
Venture (Feb)	7.5 x 80	7 x 36	332	201	4288	3102	0.077	0.065
Regulus (March)	7.5 x 43	8 x 38	304	360	4040	4166	0.075	0.086
Endeavour (April)	8.5 x 80	8 x 40	446	366	5205		0.086	
Total			4765	3854	75760	64015	0.063	0.060
Turtle Dredge	8 x 40							

Table 2 Impact of Twine Top Hanging Ratios on Bycatch Rates from the 2011 RSA Bycatch Survey

Selected stations	Twine Top Size	Yellowtail (lbs)		Scallops (lbs)		Bycatch Rate	
		Turtle	New Bedford	Turtle	New Bedford	Turtle	New Bedford
Arcturus (Mar)	8.5 x 90	204	367	4589	5296	0.045	0.069
Westport (May)	8.5 x 80	125	194	7015	6880	0.018	0.028
Liberty (June)	8.5 x 90	141	143	8678	7067	0.016	0.020
Endeavour (July)	8.5 x 80	118	141	5530	5764	0.021	0.024
Horizon (Dec)	8 x 96	250	193	2811	2747	0.089	0.070
Wisdom (Jan)	11 x 90	218	284	2906	2966	0.075	0.096
Venture (Feb)	7.5 x 80	194	146	2314	1933	0.084	0.075
Endeavour (April)	8.5 x 80	264	242	2906		0.091	
Totals		1515	1710	36749	32653	**0.041**	**0.052**
Regulus (Aug)	7.5 x **43**	439	422	3738	3355	0.118	0.126
Resolution (Sept)	10.5 x **36**	459	315	3081	3505	0.149	0.090
Ranger (Oct)	9 x **33**	577	271	3479	3265	0.166	0.083
Regulus (March)	7.5 x **43**	214	249	2525	2717	0.085	0.092
Totals		1689	1258	12823	12843	**0.132**	**0.098**
Turtle Dredge	**8.5 x 60**						

Table 3 Gear Specifications of the Experimental (CFTDD and LPD) and Control Dredges

Dredge Designation	Control	Experimental
Frame	CFTDD	CFTDD and LPD
Type of Chain for Turtle Mat	3/8" Grade 70	3/8" Grade 70
Up and Downs	13	13
Tickler Chain	9	9
Type of Chain for Sweep	Long Link Grade 80	Long Link Grade 80
Number of Links in Sweep	121 long links	121 long links
Chain Sweep Hanging	(6,4,4,2,4...every two links in the bag), 12 link dog chain for the first diamond, 9 link dog chain for the remainder of the rings in the diamond, 11 link dog chain in corners	(6,4,4,2,4...every two links in the bag), 12 link dog chain for the first diamond, 9 link dog chain for the remainder of the rings in the diamond, 11 link dog chain in corners
Twine Top	2:1 with two in the sides (60 Meshes)	1.5:1 with two in the sides (45 Meshes)
Diamonds	14	14
Skirt	2X28 or 2X40	2X28 or 2X40
Sides	6X18 or 6X20	6X18 or 6X20
Apron	8 X 40	5 X 40
Bag	10 X 40	10 X 40
Chaffing Gear	Sewn in three rows down from the sweep for the bag and on the diamonds	Sewn in three rows down from the sweep for the bag and on the diamonds
Club Stick	20 link dog chains	20 link dog chains

Table 4 Species List

Common Name	Scientific Name
Invertebrates	
Sea Scallop	*Placopecten magellanicus*
Flatfish	
Yellowtail Flounder	*Limanda ferruginea*
Winter Flounder	*Pseudopleuronectes americanus*
Windowpane Flounder	*Scophthalmus aquosus*
Summer Flounder (Fluke)	*Paralichthys dentatus*
4-spot Flounder	*Paralichthys oblongus*
American Plaice	*Hippoglossoides platessoides*
Grey Sole	*Glyptocephalus cynoglossus*
Groundfish	
Haddock	*Melanogrammus aeglefinus*
Atlantic Cod	*Gadus morhua*
Monkfish	*Lophius americanus*
Spiny Dogfish	*Squalus acanthias*
Skates	
Barndoor Skates	*Dipturus laevis*
Little Skates	*Leucoraja erinacea*
Winter Skates	*Leucoraja ocellata*

Table 5 Total catch of yellowtail, winter, windowpane, and summer flounders, sea scallops and benthos in the experimental (5R-top, LPD-middle, and 5R with windows-bottom) versus control dredges. Benthos and sea scallops are quantified in bushels and flatfish in pounds (lbs).

	Benthos (bu)	Yellowtail	Winter	Windowpane	Summer	Scallops (bu)
Experimental (5R)	278	1061	149	314	75	769
Control	374	1621	223	570	135	822
Difference	-96	-560	-74	-256	-60	-53
% Difference	-25.67%	-34.55%	-33.18%	-44.91%	-44.44%	-6.45%
N	148	110	100	75	45	145

	Benthos (bu)	Yellowtail	Winter	Windowpane	Summer	Scallops (bu)
Experimental (LPD)	205	271	13	556	112	431
Control	251	388	32	1030	193	622
Difference	-46	-117	-19	-474	-81	-191
% Difference	-18.48%	-30.15%	-59.38%	-46.02%	-41.97%	-30.76%
N	150	80	33	127	53	149

	Benthos (bu)	Yellowtail	Winter	Windowpane	Summer	Scallops (bu)
Experimental (5R w/window)	41	302	23	2	3	126
Control	42	501	42	13	3	130
Difference	-1	-199	-19	-11	0	-4
% Difference	-2.38%	-39.72%	-45.24%	-84.62%	0.00%	-3.08%
N	28	20	25	8	6	28

<u>Table 6</u> Mean and standard deviation scallop, benthos, skate and total fish catch per tow in bushels and proportion of total catch in the experimental CFTDD and Control Dredge in the 30 largest tows (top) and the 30 smallest tows by volume (bottom).

		Scallop	Benthos	Skate	Fish
Experimental	**Mean (SD)**	11.49 (9.28)	3.93 (4.90)	1.11 (0.64)	0.14 (0.16)
	Proportion	68.94%	23.56%	6.67%	0.83%
Control	**Mean (SD)**	11.95 (9.61)	4.38 (3.53)	1.18 (0.67)	0.18 (0.25)
	Proportion	67.54%	24.77%	6.65%	1.04%

		Scallop	Benthos	Skate	Fish
Experimental	**Mean (SD)**	1.93 (0.93)	0.49 (.48)	0.59 (0.52)	0.09 (0.10)
	Proportion	62.18%	15.93%	18.90%	2.99%
Control	**Mean (SD)**	2.61 (1.35)	0.67 (0.82)	0.62 (0.44)	0.20 (0.24)
	Proportion	63.56%	16.29%	15.19%	4.96%

Table 7 Mean weight (lbs) of fish per tow and (standard deviation) for the experimental CFTDD (5R/ 45 meshes) and Control Dredge. P-values were obtained using a Mann-Whitney Rank Sum Test.

	Yellowtail (SD)	Winter (SD)	Windowpane (SD)	Summer (SD)	Sea Scallops (SD)
Experimental (5R)	10.73 (17.27)	2.13 (2.73)	1.95 (2.22)	6.39 (7.19)	39.56 (42.13)
Control	15.99 (23.56)	3.55 (4.00)	3.58 (3.92)	7.90 (9.56)	44.12 (44.98)
Difference of Means	-5.26	-1.42	-1.63	-1.50	-4.56
% Difference	-32.89%	-40.05%	-45.57%	-19.05%	-10.34%
N	110	100	75	45	145
U Statistic	5018	3692	2100	935	9279
P-Value	0.029*	0.001*	.007*	0.526	0.084

* Denotes significiant difference (p < 0.05)

Table 8 Total yellowtail, winter, windowpane flounder and scallop weights (lbs) and bycatch rates for the experimental CFTDD and Control Dredge.

Gear Type		Yellowtail	Winter	Windowpane	Summer	Scallops
Experimental	**Fish Weight (lbs)**	1169.3	212.90	6.43	287.65	5735.84
(5R)	**Bycatch Rate**	1.36	0.25	0.01	0.05	
Control	**Fish Weight (lbs)**	1751.85	355.05	11.70	355.30	6397.05
	Bycatch Rate	1.92	0.39	0.01	0.06	

Table 9 Mean weight (lbs) of fish per tow and (standard deviation) for the Low Profile Dredge and Control Dredge. P-values were obtained using a Mann-Whitney Rank Sum Test.

	Yellowtail (SD)	Winter (SD)	Windowpane (SD)	Summer Flounder (SD)	Sea Scallops (SD)
Experimental (LPD)	3.20 (4.24)	0.61 (0.97)	2.08 (3.42)	5.91 (12.03)	22.28 (20.99)
Control	5.31 (6.36)	1.89 (2.14)	3.83 (5.56)	10.18 (12.68)	32.21 (26.92)
Difference	-2.11	-1.28	-1.75	-4.27	-9.99
% Difference	-39.79%	-67.85%	-45.67%	-41.99%	-31.03%
N	80	33	127	53	149
U Statistic	2368	312	8621	824	8156
P-Value	0.004*	0.002*	0.001*	0.001*	<0.001*

* Denotes significiant difference ($p < 0.05$)

Table 10 Total yellowtail, winter, windowpane flounder and scallop weights (lbs) and bycatch rates for the Low Profile Dredge and Control Dredge.

Gear Type		Yellowtail	Winter	Windowpane	Summer	Scallops
Experimental (LPD)	**Fish Weight (lbs)**	255.7	20	264.35	312.95	3341.31
	Bycatch Rate	0.08	0.01	0.08	0.09	
Control	**Fish Weight (lbs)**	424.60	62.20	486.40	539.50	4843.03
	Bycatch Rate	0.09	0.01	0.10	0.11	

Table 11 Mean weight (lbs) of fish per tow and (standard deviation) for the experimental CFTDD with windows and the Control Dredge. P-values were obtained using a Mann-Whitney Rank Sum Test or a Student's t-test.

	Yellowtail (SD)	Winter (SD)	Windowpane (SD)	Summer (SD)	Scallops (SD)
Experimental (5R window)	16.95 (18.36)	1.35 (1.46)	0.11 (0.215)	2.83 (3.55)	30.61 (13.34)
Control	28.32 (28.16)	2.56 (2.12)	0.93 (0.522)	3.50 (3.97)	32.62 (12.71)
Difference	-11.37	-1.21	-0.81	-0.67	-2.02
% Difference	-40.14%	-47.38%	-87.78%	-19.06%	-6.18%
N	20	25	8	6	28
Test Statistic	3267	207	2	16	-0.6 ”
P-Value	0.151	0.038*	0.001*	0.818	0.282 ”

* Denotes significiant difference ($p < 0.05$)

” P-value obtained from Student's t-test.

Table 12 Total yellowtail, winter and windowpane flounder and sea scallop weights (lbs) and bycatch rates for the experimental CFTDD with windows and the Control Dredge.

Gear Type		Yellowtail	Winter	Windowpane	Summer	Scallops
Experimental (5R window)	**Fish Weight (lbs)**	339.05	33.70	0.90	17.00	856.93
	Bycatch Rate	0.40	0.04	0.00	0.02	
Control	**Fish Weight (lbs)**	566.40	64.05	7.40	21.00	913.40
	Bycatch Rate	0.62	0.07	0.01	0.02	

Table 13 Model building results for each species examined in the analysis. Fixed effects included in the model indicate the specification that resulted in the lowest AIC value for that particular species. Random effects are shown in brackets and were included at the tow level. Species where the model failed to converge are indicated.

Species	**Model Specification**
Barndoor Skate	RE_{5R} ~ intercept +frame+[tow]
Unclassified Skate	RE_{5R} ~ intercept +frame+[tow]
Summer Flounder	RE_{5R} ~ intercept + length + [tow]
Yellowtail Flounder	RE_{5R} ~ intercept +[tow]
Winter Flounder	RE_{5R} ~ intercept +[tow]
Windowpane Flounder	RE_{5R} ~ intercept +[tow]
Monkfish	RE_{5R} ~ intercept +[tow]
Sea Scallops	RE_{5R} ~ intercept + length + frame + [tow]

Table 14 Mixed effects model for sea scallop catch using the unpooled catch data . Results are for from the model that provided the best fit (intercept, length and frame) to the data as supported by model comparison (minimum AIC value). Confidence limits are Wald type confidence intervals. Parameter estimates are on the logit scale.

Species	**Effect**	**Frame**	**Estimate**	**SE**	**DF**	**t-value**	**p-value**	**LCI**	**UCI**
Sea Scallop	Intercept		-0.770	0.105	3662	-7.326	<0.001	-0.976	-0.564
	Size		0.004	0.001	3662	6.133	<0.001	0.003	0.006
	Frame	LPD	-0.285	0.058	3662	-4.921	<0.001	-0.399	-0.172
	Frame	CFTDD	0.000						

Table 15 Mixed effects model for summer flounder catch using the unpooled catch data. Results are for from the model that provided the best fit (intercept and length) to the data as supported by model comparison (minimum AIC value). Confidence limits are Wald type confidence intervals. Parameter estimates are on the logit scale.

Species	**Effect**	**Estimate**	**SE**	**DF**	**t-value**	**p-value**	**LCI**	**UCI**
Summer Flounder	Intercept	-2.205	0.520	411	-4.241	<0.001	-3.227	-1.183
	Length	0.033	0.011	411	3.148	0.002	0.013	0.054

Table 16 Mixed effects model for barndoor and unclassified skates using the pooled catch data. Results are for from the model that provided the best fit (intercept and frame) to the data as supported by model comparison (minimum AIC value). Confidence limits are Wald type confidence intervals. Parameter estimates are on the logit scale and the exp(Estimate) is the estimated relative efficiency on the probability scale. Percent change represents the average percentage change in the catch of the 5 ring apron dredge relative to the 8 ring apron dredge.

Species	**Effect**	**Frame**	**Estimate**	**SE**	**DF**	**t-value**	**p-value**	**LCI**	**UCI**	**Exp(Est)**	**% Change**
Barndoor Skate	Intercept		-0.078	0.084	167	-0.925	0.356	-0.245	0.089		
	Frame	LPD	-0.557	0.135	167	-4.112	<0.001	-0.825	-0.290	0.530	-47.0%
	Frame	CFTDD	0.000							0.925	-7.5%
Unclassified Skate	Intercept		-0.290	0.039	301	-7.38	<0.001	-0.368	-0.213		
	Frame	LPD	-0.183	0.057	301	-3.17	0.001	-0.296	-0.069	0.623	-37.7%
	Frame	CFTDD	0.000							0.749	-25.1%

Table 17 Mixed effects model using the pooled catch data. Results are from the model that provided the best fit (intercept only) to the data as supported by model comparison (minimum AIC value). Confidence limits are Wald type confidence intervals. Parameter estimates are on the logit scale and the exp(Estimate) is the estimated relative efficiency on the probability scale. Percent change represents the average percentage change in the catch of the 5 ring apron dredge relative to the 8 ring apron dredge.

Species	Effect	Estimate	SE	DF	t-value	p-value	LCI	UCI	Exp(Est)	% Change
Yellowtail Flounder	Intercept	-0.463	0.051	189	-9.147	<0.0001	-0.563	-0.363	0.629	-37.1%
Winter Flounder	Intercept	-0.526	0.107	132	-4.932	<0.0001	-0.737	-0.315	0.591	-40.9%
Windowpane Flounder	Intercept	-0.610	0.066	201	-9.259	<0.0001	-0.740	-0.480	0.543	-45.7%
Monkfish	Intercept	-0.131	0.047	228	-2.755	0.0063	-0.224	-0.037	0.877	-12.3%

Table 18 Estimated and percent difference in scallop catch weight at various cull points in commercial size selectivity for the experimental 5 ring apron (5R/45 mesh) dredge as compared to the control dredge. Values are a function of the underlying scallop length frequency distribution and are relative. P-values were obtained using a Mann-Whitney test.

Cull Point	Class	5R CFTDD (lbs)	Control (lbs)	Difference	% Difference	P-Value
< 90 mm	Discard	9.53	13.53	-4.00	-29.58%	0.544
> 90 mm	Retain	5726.31	6383.52	-657.21	-10.30%	0.602
< 100 mm	Discard	143.73	120.42	23.31	19.35%	0.643
> 100 mm	Retain	5592.11	6276.63	-684.52	-10.91%	0.534
< 110 mm	Discard	489.77	571.04	-81.27	-14.23%	0.782
> 110 mm	Retain	5246.07	5826.01	-579.94	-9.95%	0.629
< 120 mm	Discard	847.33	1065.83	-218.50	-20.50%	0.94
> 120 mm	Retain	4888.50	5331.22	-442.715	-8.30%	0.707

Table 19 Estimated and percent difference in scallop meat weight at various cull points in commercial size selectivity for the experimental low profile dredge (LPD) as compared to the control dredge. Values are a function of the underlying scallop length frequency distribution and are relative. P-values were obtained using a Mann-Whitney test.

Cull Point	Class	LPD (lbs)	Control (lbs)	Difference	% Difference	P-Value
< 90 mm	Discard	2.87	5.54	-2.67	-48.19%	1
> 90 mm	Retain	3338.45	4737.51	-1399.06	-29.53%	0.367
< 100 mm	Discard	11.96	25.96	-14	-53.93%	0.917
> 100 mm	Retain	3329.36	4817.08	-1487.72	-30.88%	0.114
< 110 mm	Discard	115.42	204.27	-88.85	-43.50%	0.9
> 110 mm	Retain	3225.9	4638.78	-1412.88	-30.46%	0.113
< 120 mm	Discard	394.57	736.33	-341.76	-46.41%	0.808
> 120 mm	Retain	2946.75	4106.72	-1159.97	-28.25%	0.159

FIGURES

Figure 1 Map of tow locations in Southern New England (open area), and western and eastern Georges Bank (open and closed areas)

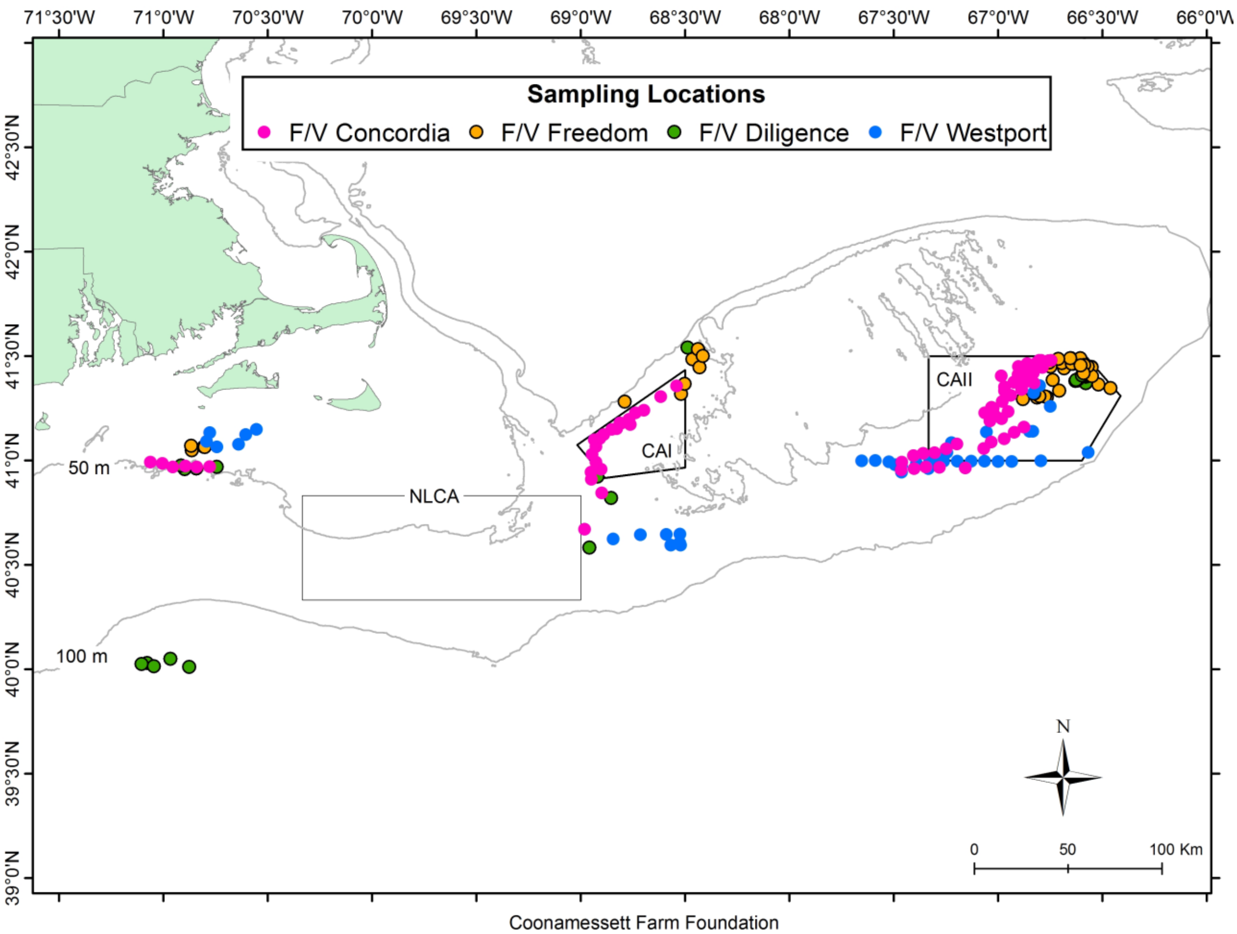


Figure 2 Diagram of the differences between the control and experimental bag design. The control dredge (left) has an 8 row apron and 60 mesh twine (2 meshes: 1 ring) and the experimental dredge (right) has a 5 row apron and a 45 mesh twine top (1.5 meshes: 1 ring).

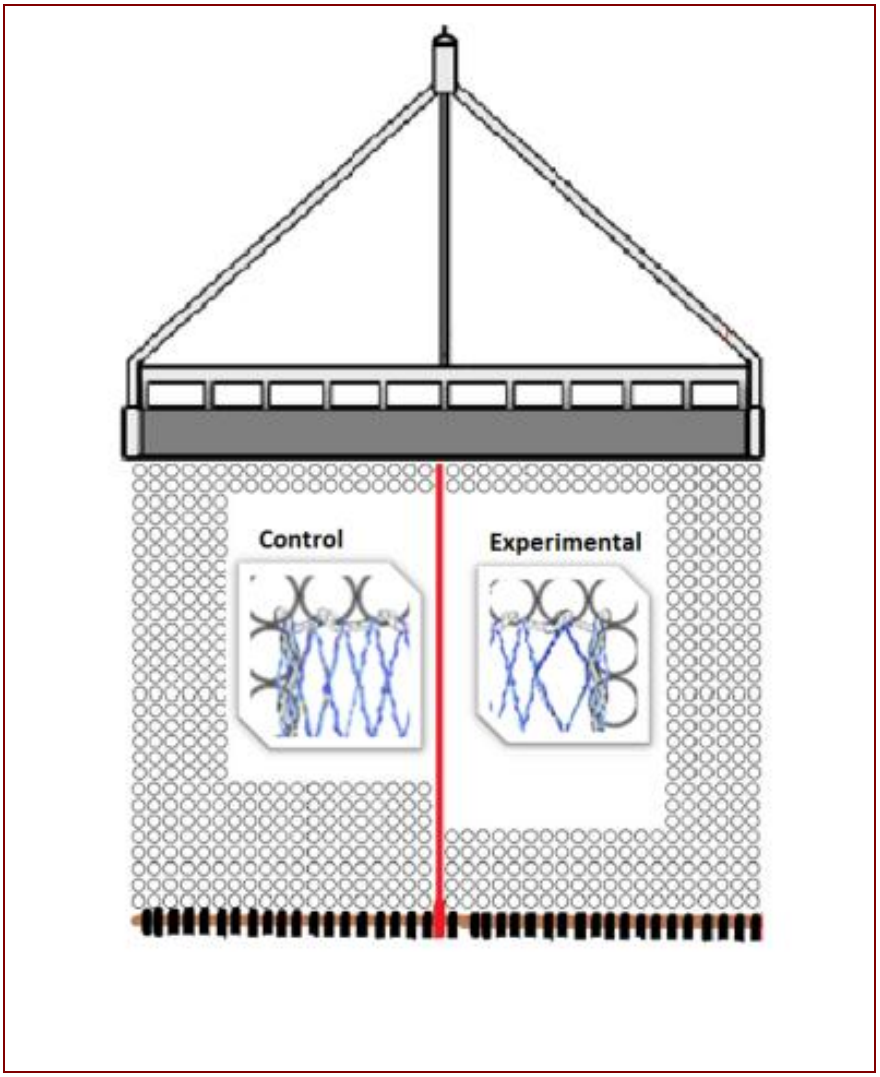


Figure 3 Relative sea scallop catch by the two dredge configurations. The triangles represent the observed proportion at length ($Catch_{5R}/(Catch_{5R} + Catch_{8R})$), with a proportion > 0.5 representing more animals at length captured by the experimental dredge. The grey area represents the 95% confidence band for the modeled proportion (solid black line). The top panel depicts results with respect to the low profile dredge frame and the bottom panel represents the results from the analysis of the CFTDD frame.

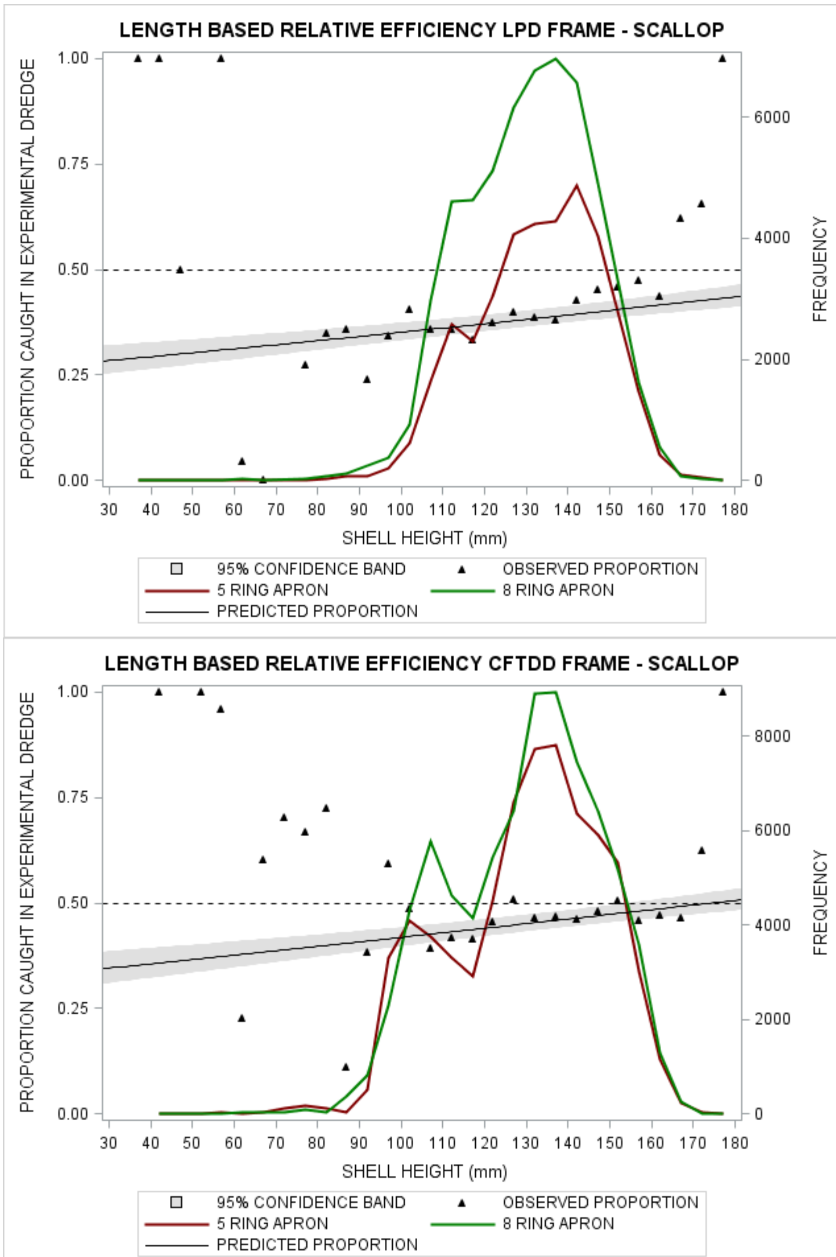


Figure 4 Size frequency distribution of scallops in the experimental CFTDD and Control Dredges. Mean number of scallops per tow with standard errors are show.

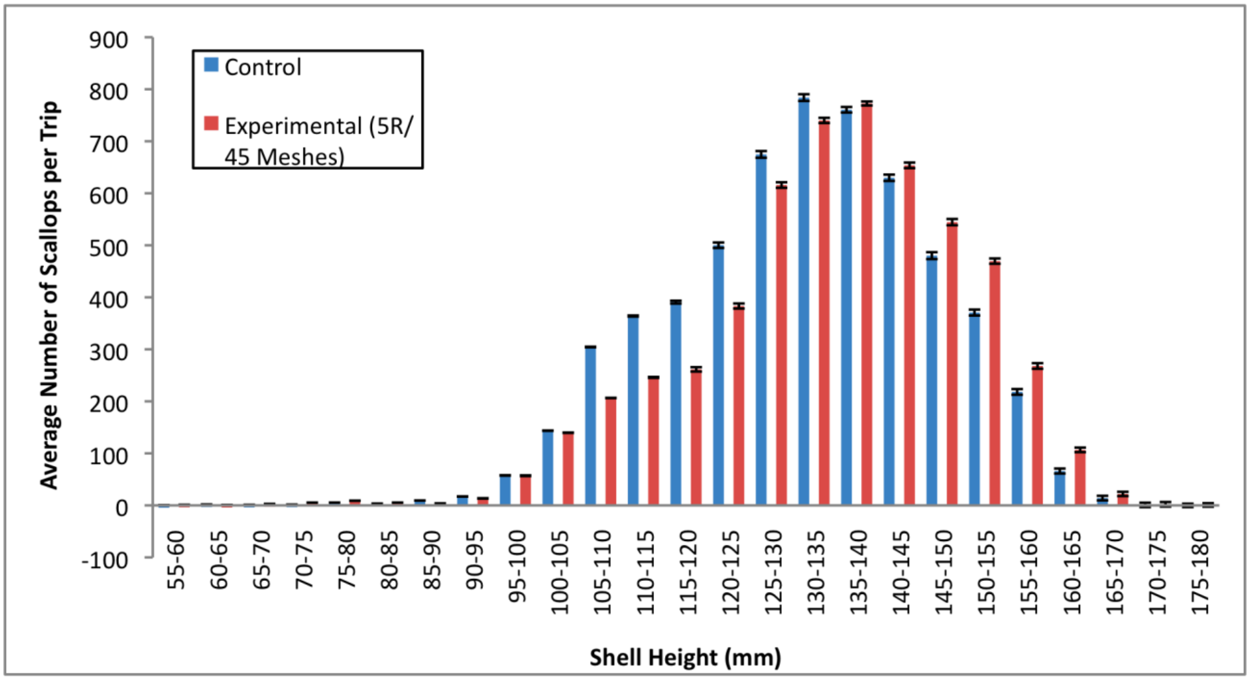


Figure 5 Relative summer flounder catch by the two dredge configurations. The triangles represent the observed proportion at length ($Catch_{5R}/(Catch_{5R} + Catch_{8R})$, with a proportion >0.5 representing more animals at length captured by the experimental dredge. The grey area represents the 95% confidence band for the modeled proportion (solid black line). Model output indicated that dredge frame was not a significant factor and the catch data was grouped to include both frames.

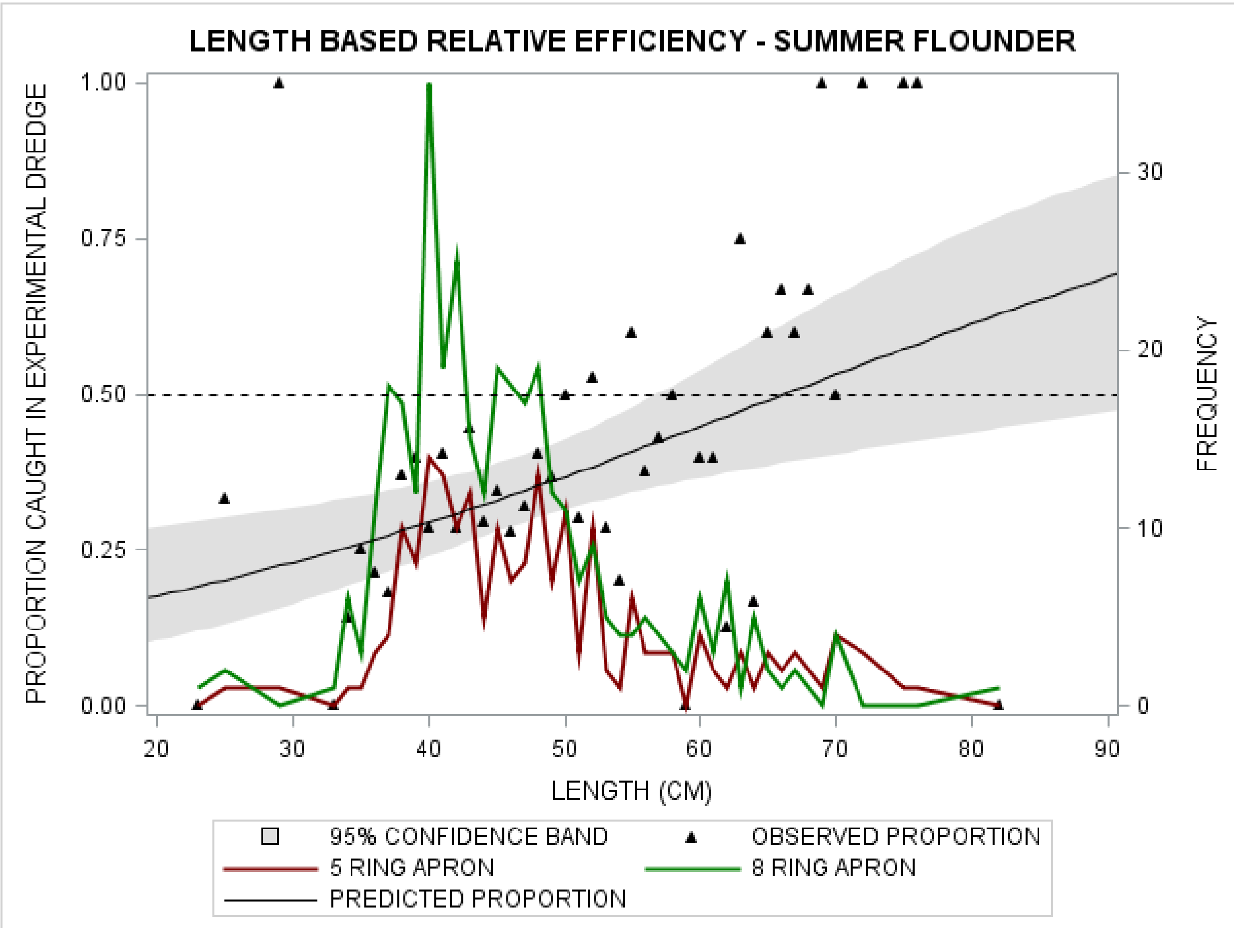
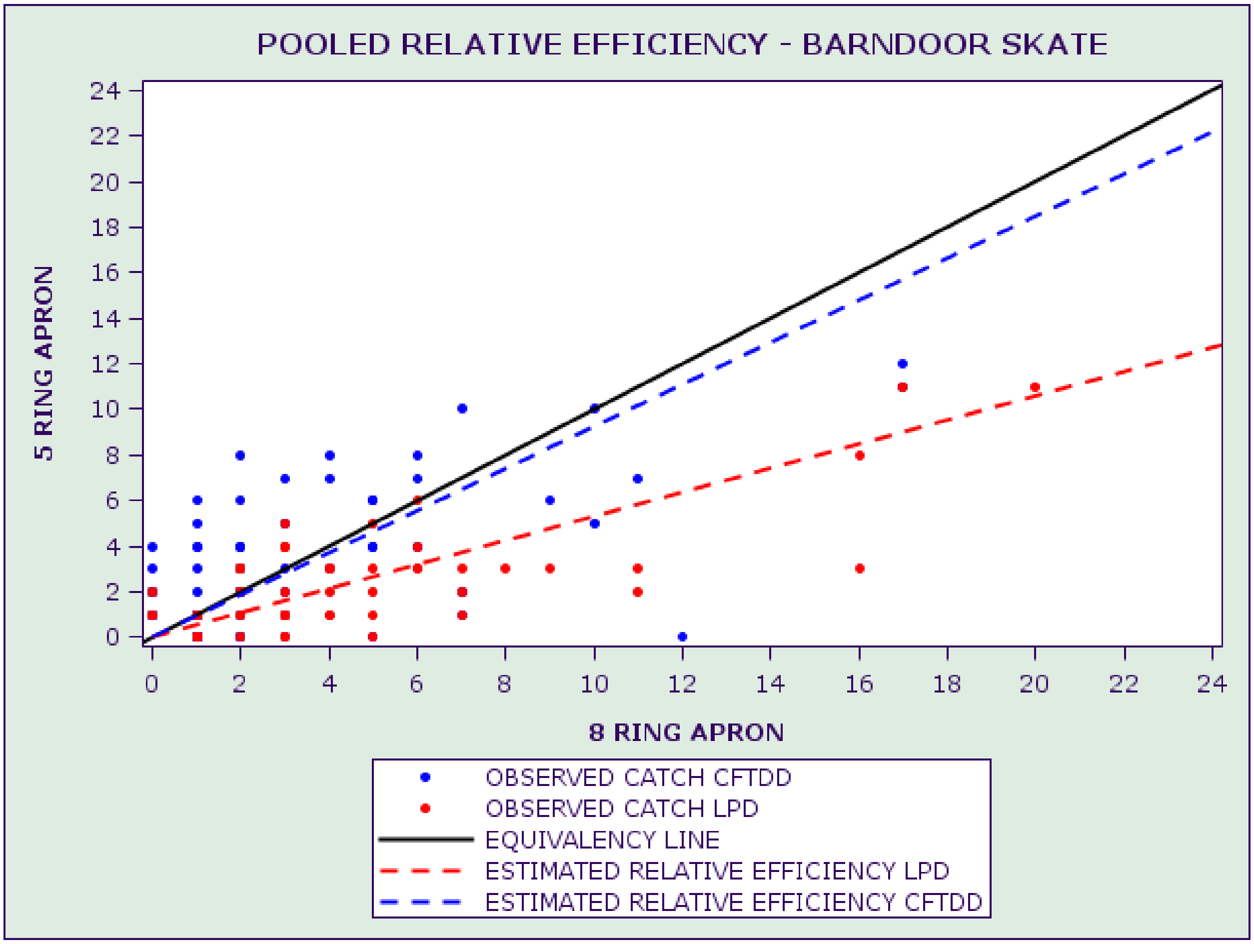


Figure 6 Total pooled catches for barndoor skate for the Experimental Dredge vs. the Control dredge. Model output from the analysis of the pooled data indicated that dredge frame was a significant factor and the two estimated relative efficiencies are show as the red and blue dashed lines. The black line has a slope of one.



<u>Figure 7</u> Total pooled catches for unclassified skate for the Experimental Dredge vs. the Control dredge. Model output from the analysis of the pooled data indicated that dredge frame was a significant factor and the two estimated relative efficiencies are show as the red and blue dashed lines. The black line has a slope of one.

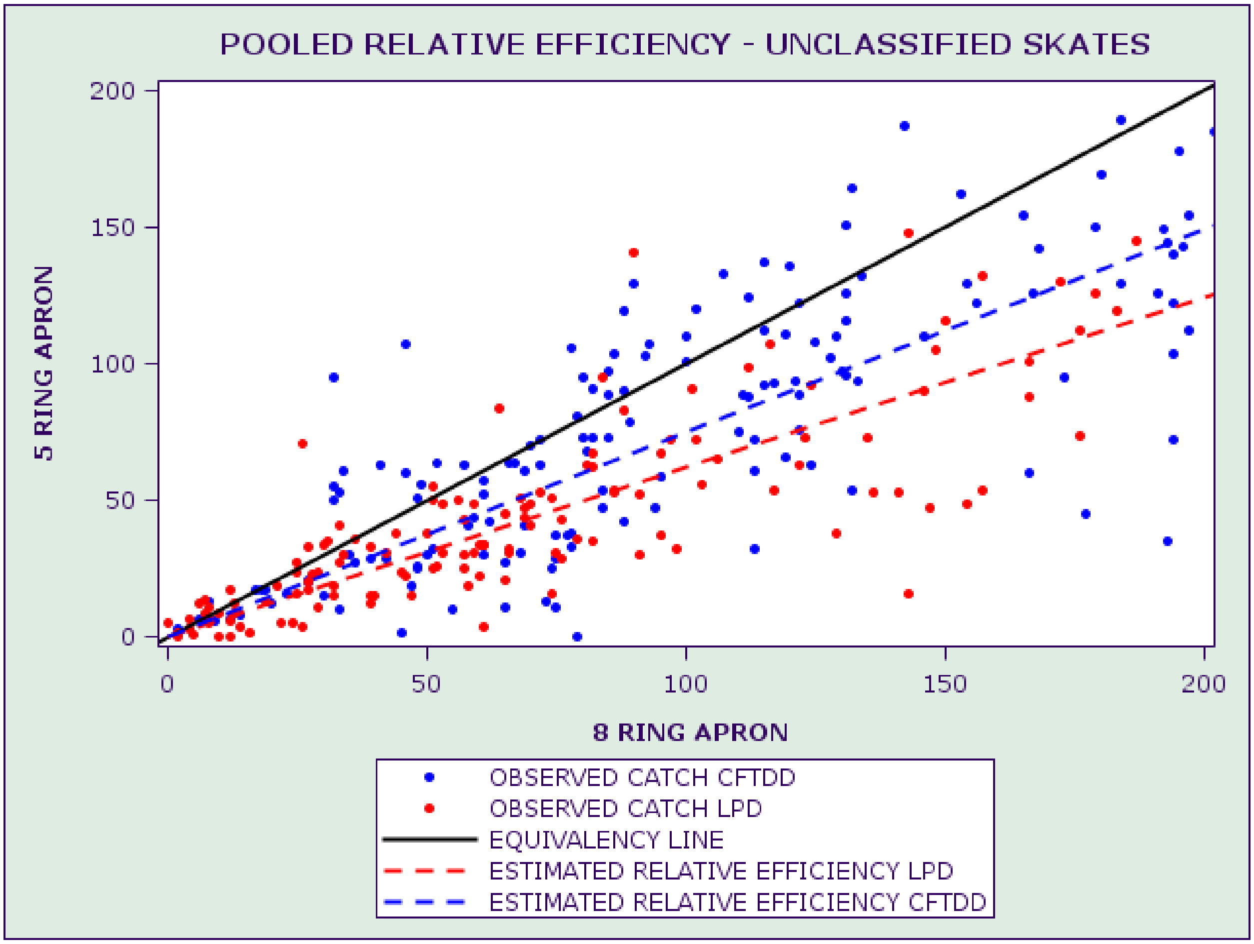


Figure 8 Total pooled catches for yellowtail flounder for the Experimental Dredge vs. the Control dredge. Model output from the analysis of the pooled data indicated that the intercept only model was the most appropriate specification. The estimated relative efficiency is show as the red dashed line. The black line has a slope of one.

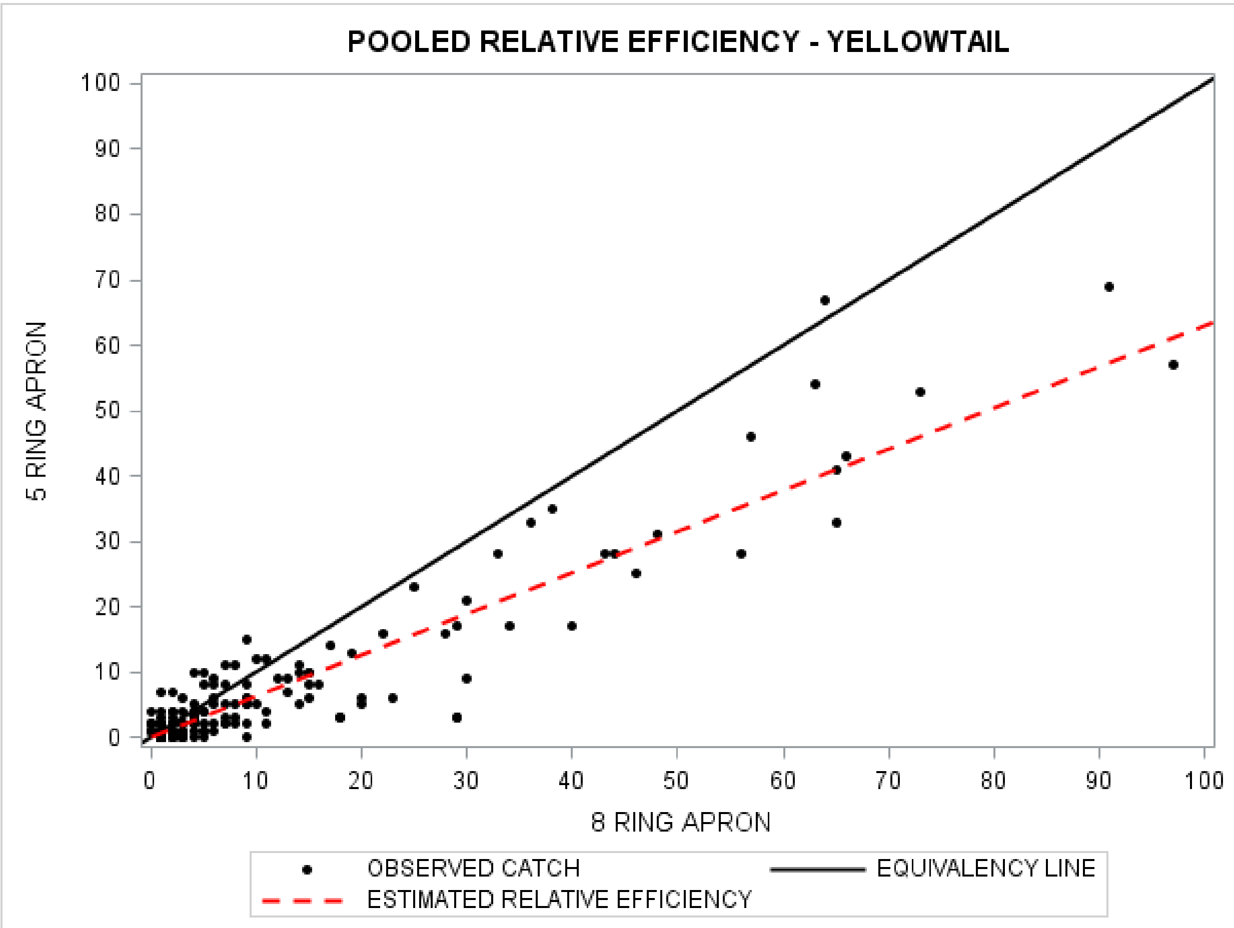


Figure 9 Total pooled catches for winter flounder for the Experimental Dredge vs. the Control dredge. Model output from the analysis of the pooled data indicated that the intercept only model was the most appropriate specification. The estimated relative efficiency is show as the red dashed line. The black line has a slope of one.

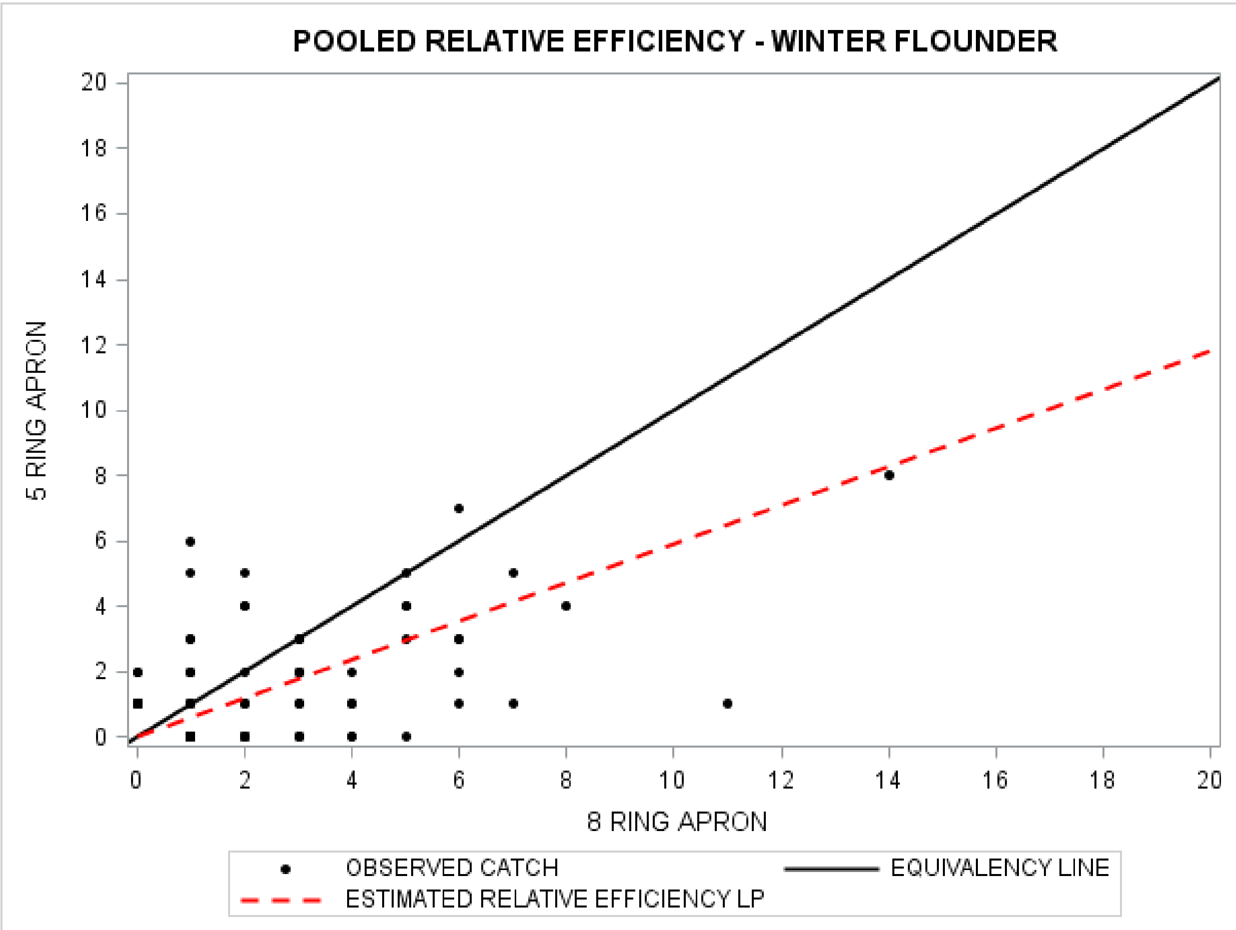
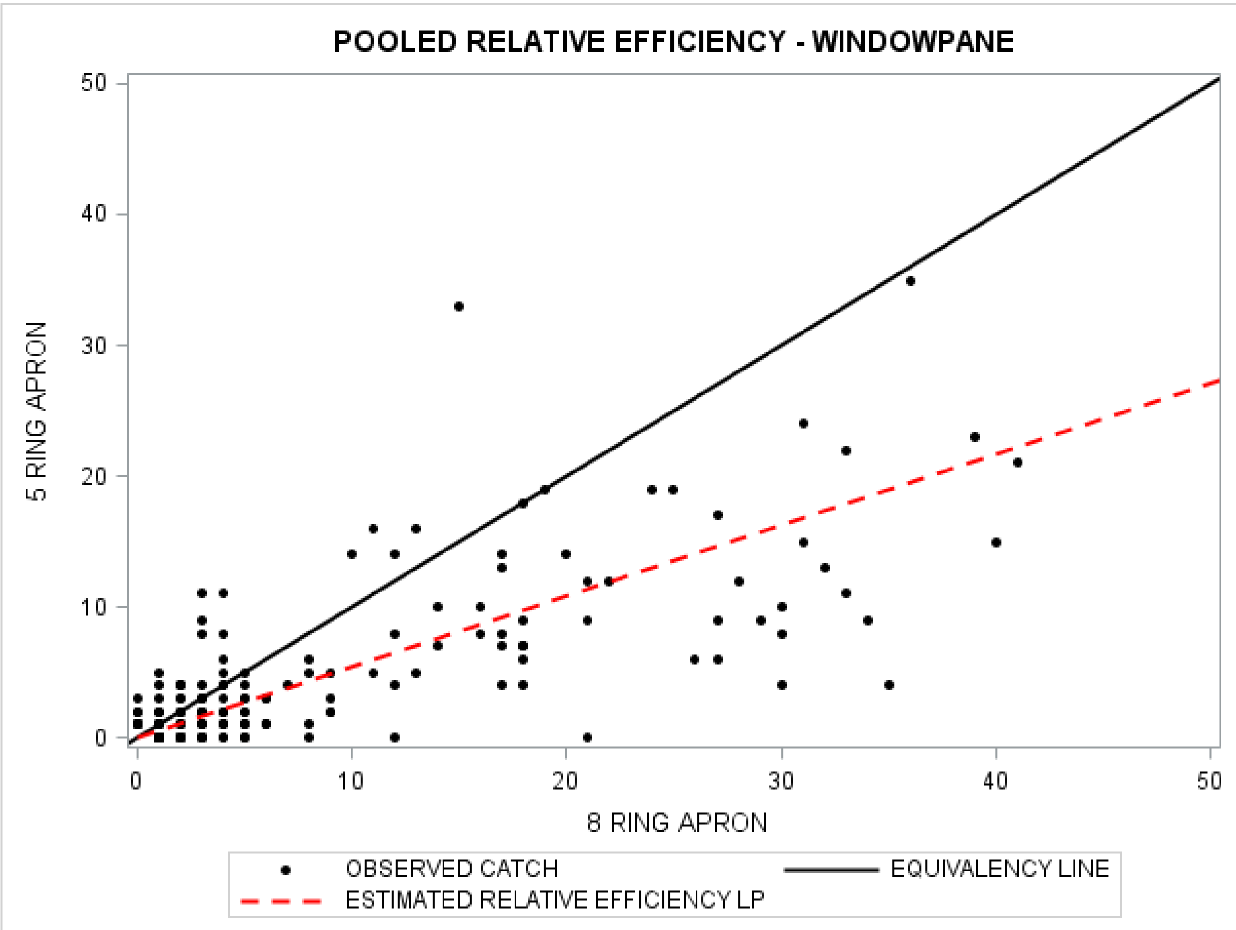


Figure 10 Total pooled catches for windowpane flounder for the Experimental Dredge vs. the Control dredge. Model output from the analysis of the pooled data indicated that the intercept only model was the most appropriate specification. The estimated relative efficiency is show as the red dashed line. The black line has a slope of one.



<u>Figure 11</u> Total pooled catches for monkfish for the Experimental Dredge vs. the Control dredge. Model output from the analysis of the pooled data indicated that the intercept only model was the most appropriate specification. The estimated relative efficiency is show as the red dashed line. The black line has a slope of one.

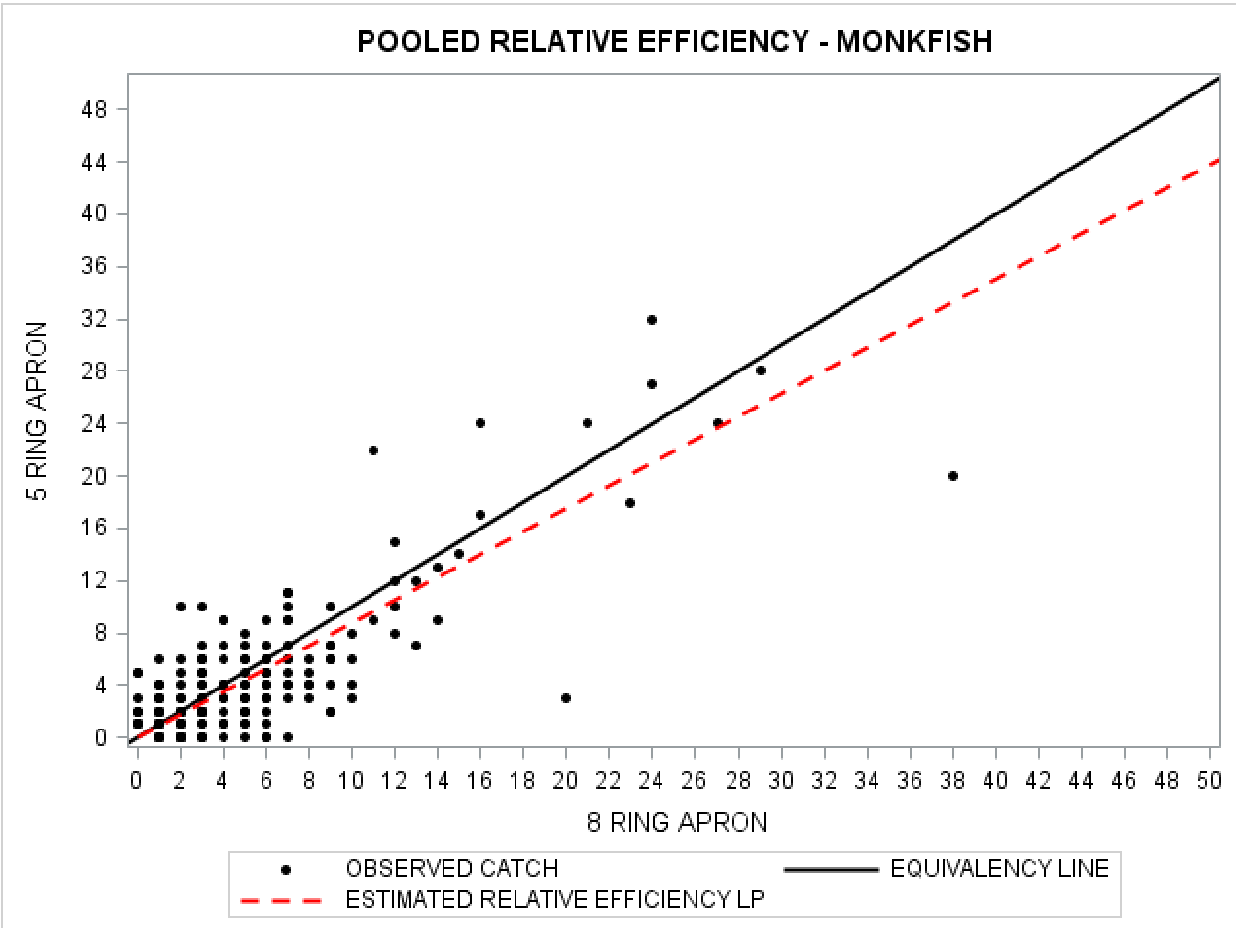
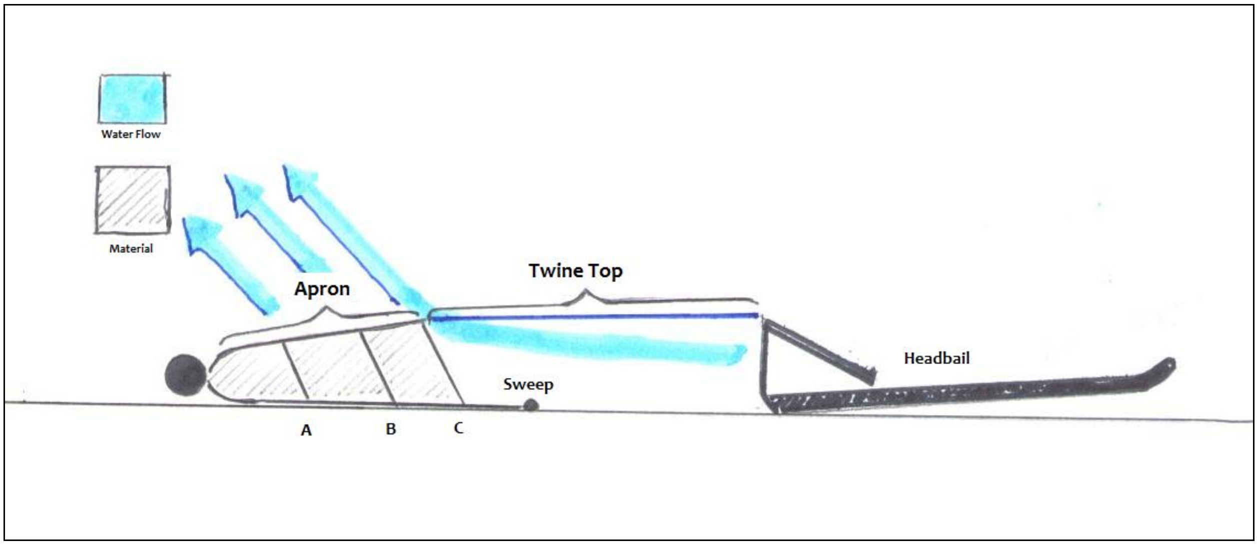
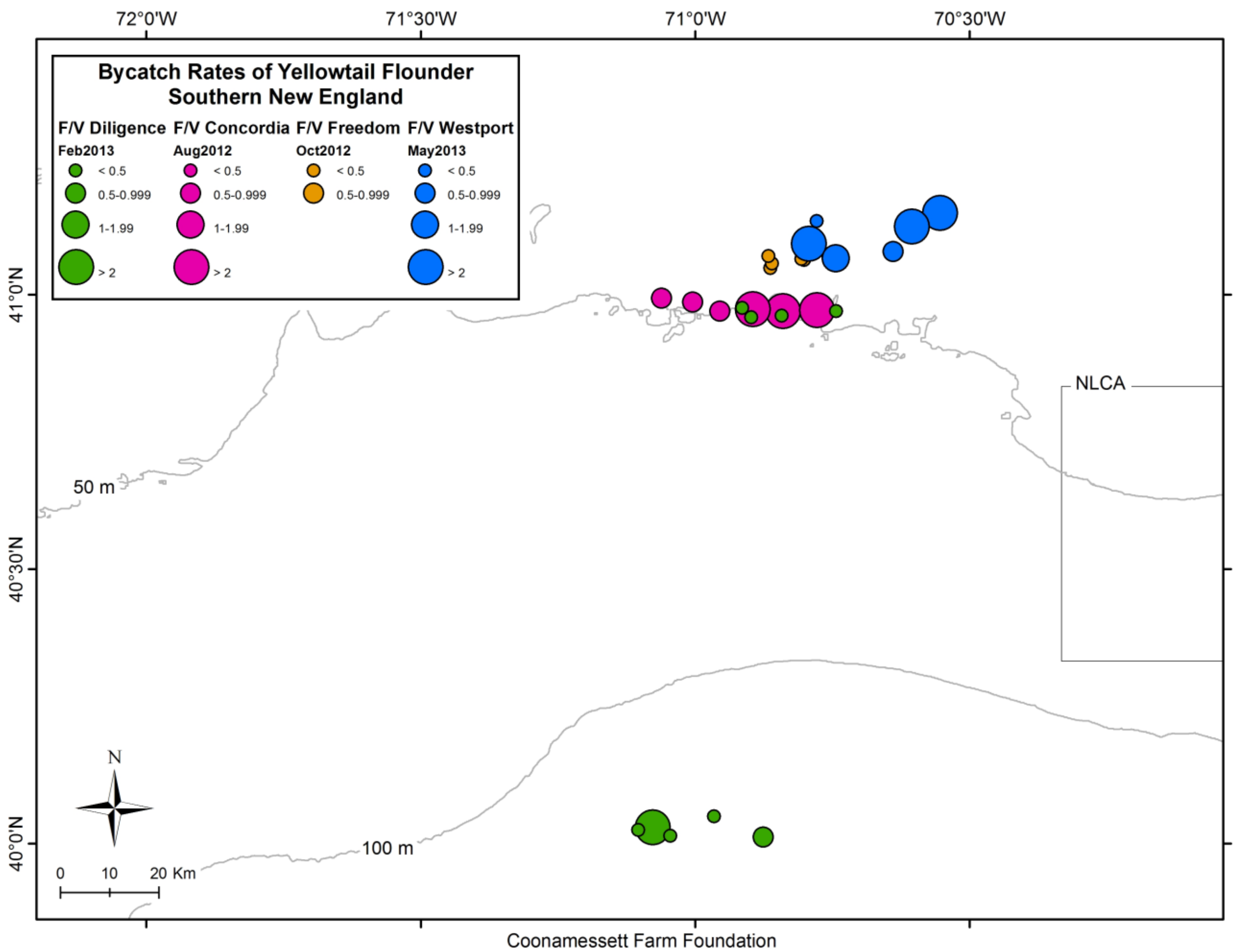


Figure 12 Diagram of change in scallop dredge selectivity as material accumulates in the dredge bag while being towed.

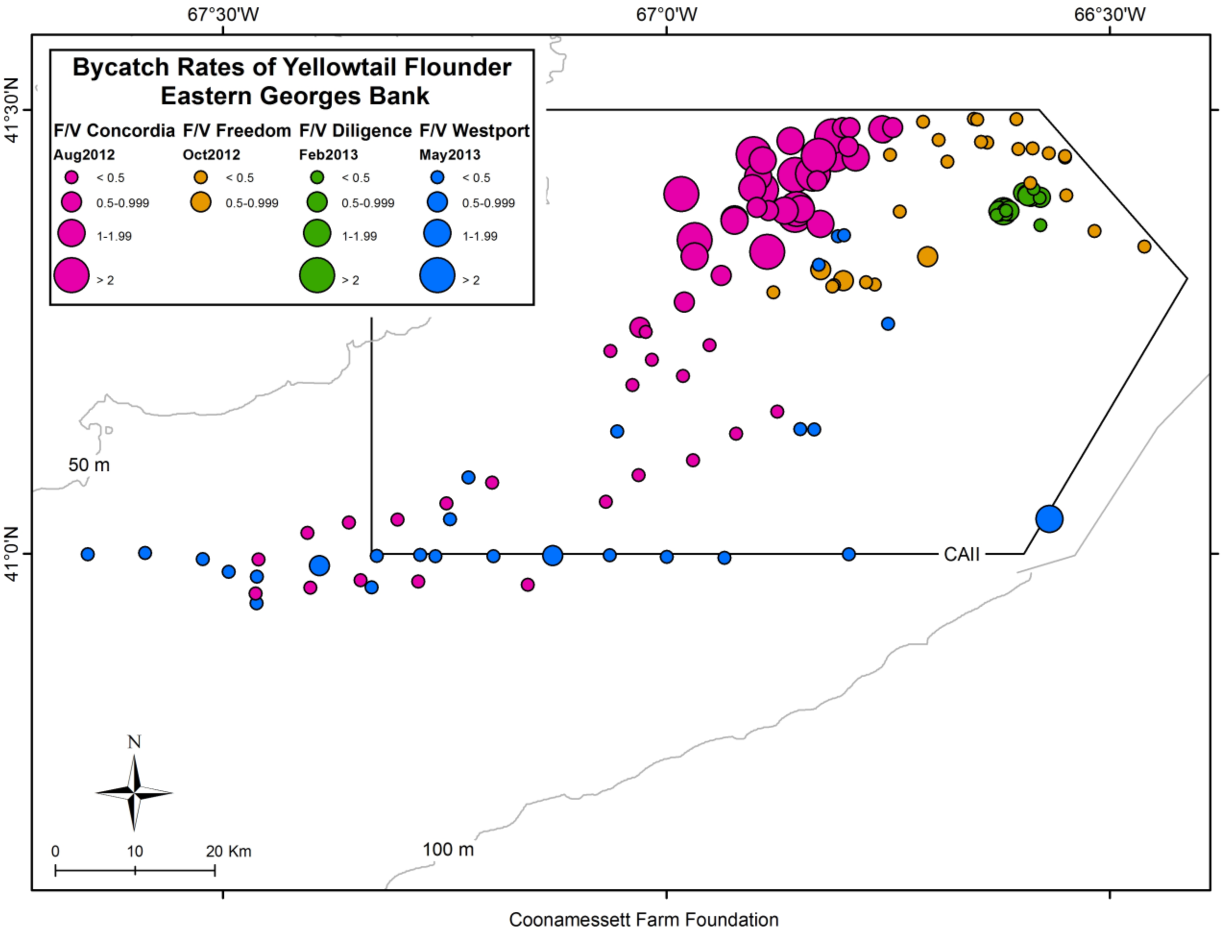


APPENDIX A

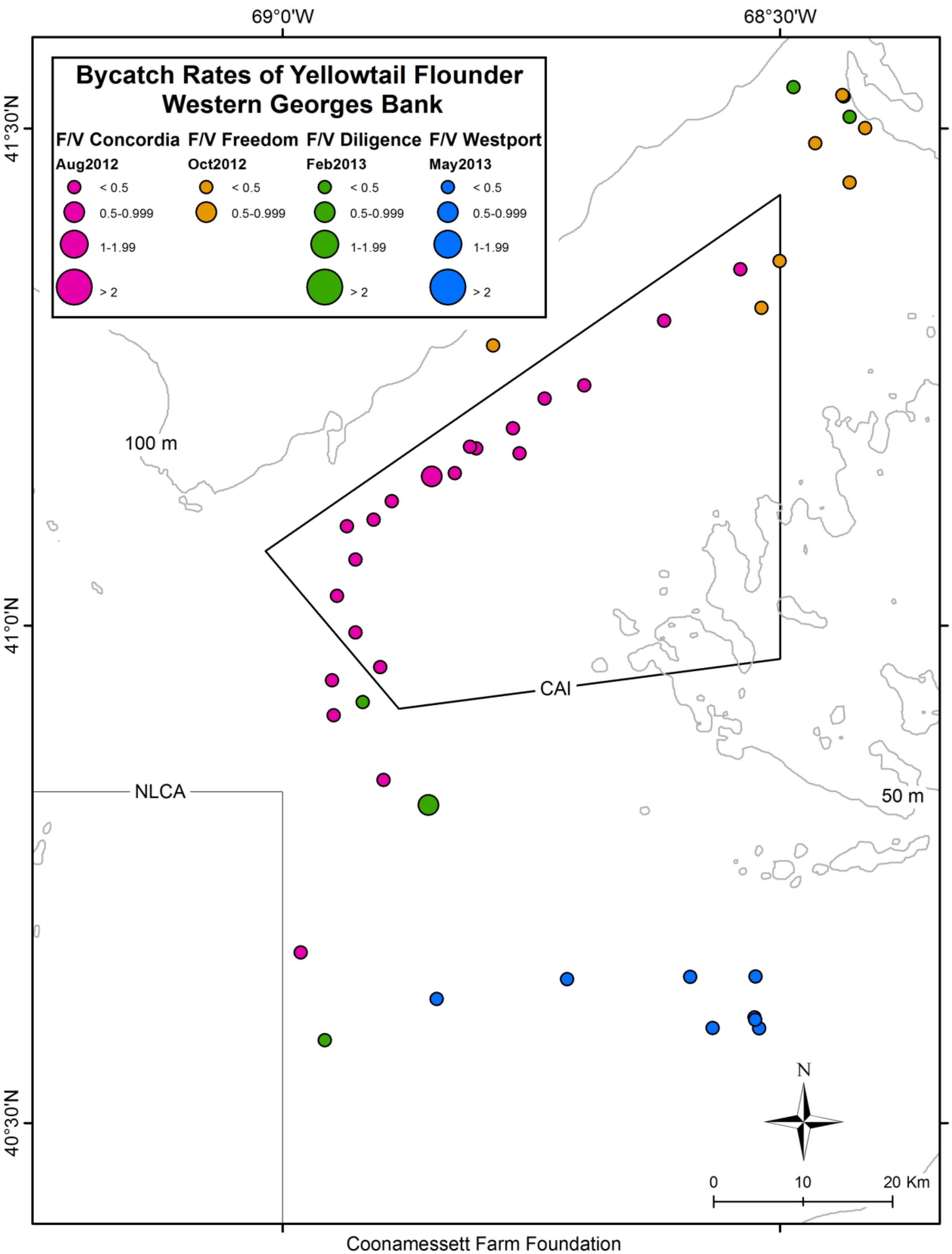
<u>Appendix A Figure 1</u> Bycatch rate map of tows in SNE



Appendix A Figure 2 Bycatch rate map of tows on eastern Georges Bank



<u>Appendix A Figure 3</u> Bycatch rate map of tows on western Georges Bank



APPENDIX B

Appendix B Figure 1: Side by side comparison of a Cfarm turtle deflector dredge (CFTDD) frame with a Low profile dredge (LPD) frame. Note the differences in frame height and shoe length.

Appendix IV

FY 2014 Scallop Access Area Lottery for Full-time Vessels (FRAMEWORK 25)

Note: These proposed trip assignments are based on permit data from January 2014 and are dependent upon permit renewals for the 2014 fishing year. This table only includes access area assignments for Nantucket Lightship and Closed Area 2, and does not reflect any action the Council takes on Delmarva access area trips (all vessels would receive one trip, so no lottery assignments are necessary). Should NMFS approve Framework 25, these allocation assignments will be updated prior to implementation to reflect any vessel replacements or ownership changes that may occur. Any adjustments to this information will be made publically available.

	Permit	Vessel or CPH Name	Access Area	Owner	State	Telephone
1	220886	SUSAN MARIE	NL	SOUTH BAY SEAFOOD INC	NJ	(609) 522-3400
2	250968	ALEXANDRA L	CA2	BLUE BILL FISHERIES INC	NJ	(609) 884-3405
3	251687	BELLA ROSE	NL	CHALLENGE FISHERIES INC	ME	(207) 266-1960
4	251729	NEGOTIATOR	CA2	T & T FISHERIES LLC	NJ	(609) 463-0768
5	251730	SOVEREIGN STAR	CA2	SOVEREIGN STAR FISHING INC	MA	(508) 996-0525
6	310909	JENNA LEE	NL	JENLEE FISHERIES INC	MA	(508) 790-3181
7	310912	INHERITANCE	CA2	MONTREAL FISHING CORP	MA	(508) 994-4264
8	310915	AMANDA ASHLEY	NL	JULIE RENEE INC	NC	(252) 670-1176
9	310918	KARINA	CA2	KARINA LLC	NJ	(609) 374-3465
10	310927	JEFFREY SCOTT	CA2	TRAWLER JEFFREY SCOTT INC	VA	(757) 870-9473
11	310928	COOL CHANGE	CA2	J T B K FISHING CORP	MA	(508) 996-0525
12	310941	COVE	NL	COVE FISHING CORP	MA	(774) 202-4369
13	310945	GRAND LARSON III	CA2	GRAND LARSON INC	NJ	(609) 548-1625
14	310947	MS MANYA	CA2	CAPT JOHN INC	NJ	(609) 494-2094
15	310963	MISS TAYLOR	CA2	B DOCK SEAFOOD LLC	NJ	(856) 297-4927
16	310982	ANDY TWO	CA2	F/V ANDY ONE INC	VA	(804) 379-5717
17	310985	KATHRYN MARIE	NL	KATHRYN MARIE SCALLOPING COMPANY LLC	MA	(508) 996-0525
18	310986	MISS LESLIE	CA2	MASS FISHING CORP	MA	(508) 993-9505
19	310992	STEPHANIE B II	NL	BENAVIDEZ SEAFOOD INC	VA	(757) 898-4307
20	310994	FURIOUS	NL	EMPIRE SCALLOP LLC	CT	(203) 876-8923
21	310998	HELEN LOUISE	CA2	HELEN LOUISE INC	NC	(252) 670-1176
22	320026	F NELSON BLOUNT	CA2	F NELSON BLOUNT INC	NJ	(609) 494-2094
23	320130	OCEAN WAVE	NL	OCEAN WAVE SCALLOP CO INC	NJ	(609) 884-1771
24	320134	ELIZABETH	CA2	THIRTY FATHOM FISH CORP	NJ	(609) 494-2207
25	320306	MISS SUE ANN	CA2	F/V MISS SUE ANN LLC	NJ	(609) 884-3000
26	320394	SHEARWATER	CA2	G L HATCH INC	ME	(207) 596-0185
27	320416	ADRIANNA	NL	F/V ADRIANNA LLC	NJ	(609) 884-3000
28	320422	NORREEN MARIE	CA2	F/V NORREEN MARIE LLC	NJ	(609) 884-3000

29	320571	LINDSAY L	CA2	LINDSAY L INC	NJ	(609) 548-1625
30	320582	ASHLEY GAIL	CA2	ISLAND PRIDE SEAFOOD INC	VA	(757) 880-1919
31	320634	WILLIAM LEE	CA2	CARKEZ FISHERIES INC	MA	(508) 965-0525
32	320655	ATLANTIC WARRIOR	CA2	ATLANTIC WARRIOR INC	NJ	(609) 522-3400
33	320657	TRAVIS & NATALIE	CA2	F/V TRAVIS & NATALIE LLC	NJ	(609) 884-3000
34	320814	MASTER BRAXTON	CA2	TRAWLER MASTER BRAXTON INC	NC	(252) 249-0123
35	320857	GASTON BELL	CA2	CHESAPEAKE ATLANTIC SFD HRVST INC	NC	(252) 249-0123
36	321022	ALEXANDRIA DAWN	CA2	ALEXANDRIA DAWN FISHERIES INC	NY	(631) 834-1878
37	321109	TENACIOUS	CA2	F/V MICHELLE INC	NJ	(609) 884-3000
38	321122	MISS SHAUNA	CA2	MISS SHAUNA LLC	MA	(508) 993-9505
39	321131	PRIDE & JOY	CA2	T & S FISHERIES LLC	NJ	(609) 463-0768
40	321135	ANN M	CA2	ANN M FISHING CORP	MA	(508) 996-0313
41	330103	DISCOVERY	CA2	SECOND CHANCE FISHERIES LLC	MA	(508) 996-0313
42	330126	PREDATOR	CA2	PREDATOR FISHERIES INC	MA	(508) 996-0525
43	330147	OCEAN CAT	CA2	NEW OCEAN LLC	MA	(508) 996-3742
44	330166	GOLDEN NUGGETT	NL	GOLDEN NUGGETT LLC	NJ	(609) 884-7600
45	330215	PEROLA DO CORVO	CA2	SASHA FISHING CORP	MA	(508) 992-3334
46	330258	GODS MERCY	CA2	GOD'S MERCY LLC	NC	(252) 745-7243
47	330269	OCEAN PROWLER	CA2	NEW OCEAN LLC	MA	(508) 996-3742
48	330272	CHALLENGE	CA2	CHALLENGE FISHERIES LLC	MA	(508) 993-6730
49	330285	RELENTLESS	CA2	OAJ INC	NJ	(609) 607-0841
50	330288	JEAN MARIE	CA2	JEAN MARIE INC	NC	(252) 726-8158
51	330292	LILLIE BELLE	CA2	TRAWLER CAPT FUD LLC	NC	(252) 514-7003
52	330301	EXPECTATION	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
53	330308	BARBARA PAULINE	NL	BARBARA PAULINE INC	NJ	(609) 886-6729
54	330311	STACY LEE	CA2	STACY LEE INC	NJ	(609) 884-1771
55	330325	OCEAN BOY	CA2	OCEAN BOY INC	NJ	(609) 884-1771
56	330331	CAPT BOB	NL	EDGAR SEAFOOD PRODUCTS INC	NJ	(609) 884-3000
57	330336	MISS AMANDA	CA2	MISS AMANDA INC	NC	(252) 726-8158
58	330348	OCEAN PURSUIT	CA2	NEW OCEAN LLC	MA	(508) 996-3742
59	330361	LITTLE JESSE	NL	RDM CORPORATION OF SUFFOLK	VA	(757) 869-9386
60	330368	VIRGINIA CLIPPER	CA2	B & C TRAWL INC	VA	(757) 869-4313

61	330378	CAPT PEABODY	CA2	WILLIAM F PEABODY	VA	(757) 245-3022
62	330380	ABRACADABRA	CA2	TRAWLER ABRACADABRA INC	NJ	(609) 886-2575
63	330394	WILLIAM & LAUREN	NL	F/V WILLIAM & LAUREN INC	NJ	(609) 494-0367
64	330396	MOTIVATION	CA2	F/V MOTIVATION LLC	NJ	(609) 425-8983
65	330396	MOTIVATION	NL	F/V DEFENDER LLC	NJ	(609) 425-5319
66	330399	LADY ROSLYN	NL	F/V LADY ROSLYN LLC	NJ	(609) 884-3000
67	330434	INSTIGATOR	CA2	CDK TRAWLERS INC	NJ	(609) 522-1598
68	330449	CAROLINA CAPES	NL	LAS GUERAS INC	VA	(757) 460-2716
69	330461	VIRGINIA LYNN	CA2	VIRGINIA LYNN COMMERICAL FISHING INC	NJ	(609) 335-4828
70	330489	RAELEEN MICHELLE	NL	WHITE FISHERIES INC	MA	(508) 996-0525
71	330491	OCEAN QUEEN	CA2	OCEAN QUEEN INC	NJ	(609) 884-1771
72	330504	LINDA	NL	BOAT SANTA RITA II INC	MA	(617) 650-5436
73	330521	JERSEY CAPE	NL	CAPE TRAWLERS INC	NJ	(609) 884-7600
74	330535	SUSAN MARIE II	NL	F/V SUSAN MARIE INC	NJ	(609) 522-3400
75	330543	MISS WILMA ILENE	CA2	TRAWLER WILLIAM F PEABODY INC	VA	(757) 245-3022
76	330550	MISS MADDY	CA2	MADDY INC	NJ	(609) 494-7392
77	330566	HAWK	NL	HAWK SCALLOP CO INC	NJ	(609) 884-1771
78	330578	MISS VERTIE MAE	NL	TRAWLER MISS VERTIE MAE INC	VA	(757) 245-3022
79	330581	FAIR WIND	NL	BOAT VENTURE INC	MA	(508) 996-0313
80	330586	WARRIOR	NL	WARRIOR FISHING CORP	MA	(508) 996-0525
81	330597	BEACHCOMBER	NL	BEACHCOMBER INC	VA	(800) 561-4168
82	330620	CAPTAIN LYMAN	NL	WWJT INC	VA	(321) 223-7200
83	330622	OCEAN PRINCESS	CA2	OCEAN PRINCESS INC	NJ	(609) 884-1771
84	330626	CAPT JEFF	NL	BHG SCALLOP LLC	VA	(757) 870-9473
85	330629	OCEAN LADY	CA2	OCEAN FISHING LLC	MA	(774) 202-4369
86	330636	NAVIGATOR	CA2	CAROLINA GIRL III INC	VA	(757) 898-8512
87	330654	IAN NIGEL	CA2	IAN NIGEL INC	VA	(321) 223-7200
88	330663	CRYSTAL & REBECCA	NL	TRAWLER CRYSTAL & REBECCA INC	VA	(757) 245-3022
89	330668	CHIEF	NL	CHIEFTAIN SCALLOP COMPANY	CT	(860) 767-2441
90	330683	CHRISTIAN & ALEXA	CA2	TRAWLER DIANNE & MAUREEN INC	NJ	(732) 681-4006
91	330687	SASSY GIRL	NL	FULCHER ENTERPRISES INC	NC	(252) 514-7003
92	330690	STONINGTON JO	CA2	STONINGTON FISH & LOBSTER INC	CT	(860) 535-0882

93	330703	COURAGEOUS	NL	COURAGEOUS FISHING CORPORATION	MA	(508) 996-0525
94	330720	KRIS & AMY	CA2	KRIS & AMY FISHING INC	MA	(508) 992-3334
95	330729	FISHERMANS DREAM	NL	H & T COMMERCIAL FISHING CO	NJ	(609) 465-9919
96	330742	OCEAN PRIDE	CA2	OCEAN PRIDE INC	NJ	(609) 884-1771
97	330749	MY GIRL	CA2	MY GIRL INC	NJ	(609) 465-9919
98	330778	ATLANTIC BOUNTY	NL	F/V ATLANTIC BOUNTY LLC	NJ	(609) 884-3000
99	330780	OCEAN GOLD	CA2	OCEAN GOLD INC	NJ	(609) 884-1771
100	330781	FREEDOM	CA2	NEW FREEDOM FISHING CORP	MA	(774) 202-4369
101	330783	SEA QUEST	CA2	SEA QUEST INC	NJ	(609) 884-3405
102	330784	U-BOYS	CA2	U-BOYS LLC	VA	(757) 728-0600
103	330786	SASSY SARAH	NL	HIWALL INC	VA	(757) 728-0600
104	330788	MIZ ALMA B	CA2	TEJANO CORP	VA	(757) 898-8512
105	330791	GABRIELLE PAIGE	CA2	B&C FISHERIES LLC	VA	(804) 725-6510
106	330793	CAPTAIN BILLY HAVER	CA2	CAPTAIN JUAN INC	VA	(757) 460-2716
107	330796	HEAR NO EVIL	NL	HEAR NO EVIL FISHING CORP	MA	(508) 996-0313
108	330798	PACER	CA2	OCEAN FISHING LLC	MA	(774) 202-4369
109	330799	DEFIANT	CA2	FLAVIAN FISHING CORP	MA	(508) 996-0525
110	330800	CHIEF & CLYDE	NL	CHIEF SCALLOPING CORPORATION	MA	(508) 996-0525
111	330803	OCEAN FOX	NL	NEW OCEAN LLC	MA	(508) 996-3742
112	330806	SUZEE Q	NL	SUZEE Q LLC	VA	(757) 868-7405
113	330807	DICTATOR	NL	DICTATOR INC	ME	(207) 244-5328
114	330811	VANTAGE	NL	NELSON FISHING INC	MA	(508) 479-0729
115	330816	LADY EVELYN	CA2	F/V LADY EVELYN LLC	NJ	(609) 884-3000
116	330817	CHAZS TOY	CA2	DIAMOND SHOAL SEAFOOD INC	NC	(252) 249-0123
117	330818	ADVENTURESS	CA2	F/V ADVENTURESS LLC	NJ	(609) 884-3000
118	330828	COLLIN & WARREN III	CA2	COLLIN & WARREN INC	NJ	(609) 884-1771
119	330829	JANE CAROLYN	CA2	TRAWLER CAPT ALFRED INC	NC	(252) 745-5331
120	330832	CRYSTAL GIRL B	CA2	CRYSTAL GIRL INC	NJ	(609) 465-9919
121	330834	DANIEL JOSEPH	CA2	TRAWLER GARLAND CHRISTOPHER INC	NC	(252) 249-0123
122	330848	FISHERMANS DREAM B	CA2	FISHERMANS DREAM COMM FISHING INC	NJ	(609) 465-9919
123	330852	GASTONS LEGACY	CA2	FULCHER TRAWLING LLC	NC	(252) 637-1552
124	330860	ASHTON MATTHEW	NL	TRAWLER RICHARD HEATH INC	NC	(252) 514-7003

125	330870	TONY TWO	CA2	TONY ONE INC	VA	(757) 593-3463
126	330871	THE CHIEF	CA2	CC SCALLOPING INC	MA	(508) 996-0525
127	330875	CAPT KENNY	CA2	B & C SCALLOP COMPANY INC	VA	(804) 725-3794
128	330877	MIZ-B	CA2	BENAVIDEZ AND SONS INC	VA	(757) 898-8512
129	330884	LUCKY DANNY II	CA2	LUCKY DANNY INC	VA	(804) 379-5717
130	330885	KARAH D	NL	KARAH D INC	NC	(252) 745-4956
131	330886	MEKONG	NL	RUBY S LLC	NJ	(908) 727-5555
132	330891	MISS CROCKETT	CA2	CHINCOTEAGUE BAY SEAFOOD INC	VA	(757) 247-9000
133	330893	KAREN NICOLE	CA2	KAREN NICOLE INC	NJ	(609) 884-1771
134	330895	PURSUIT	CA2	VIRGINIA VENTURE CORP	VA	(757) 898-8512
135	330896	MIRAGE	NL	MIRAGE FISHING LLC	MA	(508) 993-9505
136	330898	MASTER JAMES	CA2	F/V MASTER JAMES INC	NJ	(609) 884-1771
137	330899	CAPT POTTER	NL	SIDDIE GOLDEN INC	NC	(252) 745-5331
138	330900	LADY DEBORAH	NL	F/V LADY DEBORAH LLC	NC	(252) 249-0123
139	330902	RESILIENT	CA2	ONEONTA FISHERIES INC	MA	(508) 996-0525
140	330903	DISCOVERY II	NL	DISCOVERY SEAFOOD INC	NJ	(732) 267-2741
141	330906	OCEAN PROWLER	CA2	OCEAN PROWLER INC	NJ	(609) 884-1771
142	330907	ANDREA A	CA2	ANDREA A LLC	NJ	(609) 884-1771
143	330908	GROWLER	CA2	COVE FISHING CORP	MA	(508) 996-3742
144	330910	CAMERON SCOTT	NL	VENTURE FISHING LLC	VA	(757) 870-9473
145	330911	KIM & JR II	CA2	CAPE MAY BAIT INC	NJ	(609) 884-3405
146	330912	PURSUIT	NL	CAPE MAY FISH CO	NJ	(609) 884-3405
147	330913	KELLY S	NL	FLAVIAN FISHING CORP	MA	(774) 526-1940
148	410019	MICHIGAN	CA2	TAURUS FISHING CORP	MA	(508) 996-0313
149	410045	CHRISTINE & JULIE	CA2	GALLANT FISHERIES INC	MA	(508) 994-4264
150	410068	PATIENCE	NL	PATIENCE FISHERIES LLC	MA	(508) 993-6730
151	410074	DONNY C	CA2	EXPEDITION FISHING CO INC	MA	(508) 996-0313
152	410080	HARVESTER	CA2	HARVESTER FISHERIES LLC	MA	(508) 993-6730
153	410095	NASHIRA	CA2	OHARA CORPORATION	MA	(508) 993-6730
154	410103	ELISE G	CA2	ELISE G LLC	NJ	(609) 884-7600
155	410127	INDEPENDENCE	CA2	T & R FISHING INC	MA	(508) 996-0313
156	410129	CHRISMAR	CA2	CHRISMAR INC	VA	(757) 482-3238

157	410134	LET IT RIDE	NL	LET IT RIDE FISHING CORP	MA	(508) 996-0313
158	410145	KATHY ANN	CA2	KATHRYN ANN FISHING INC	MA	(508) 992-3334
159	410146	CELTIC	CA2	CELTIC FISHERIES LLC	MA	(508) 993-6730
160	410147	BARBARA ANNE	CA2	F/V BARBARA ANNE LLC	NJ	(609) 884-3000
161	410150	TINA LYNN	CA2	HILL ENTERPRISES INC OF NJ	NJ	(609) 884-7262
162	410151	ABIGAIL & MYLES	NL	TRAWLER CRYSTAL & REBECCA INC	VA	(757) 245-3022
163	410153	FRANK & MARIA	NL	TRAWLER DIANE MARIE INC	VA	(757) 728-0600
164	410154	PONTOS	CA2	F/V PONTOS LLC	NJ	(609) 884-3000
165	410156	SANTA BARBARA	CA2	CHRISTINA & SANDRA FISH CORP	MA	(508) 996-0525
166	410157	JANE ELIZABETH	CA2	JOHN AND JANE LLC	MA	(508) 758-6600
167	410161	RESOLUTE	NL	TYLER FISHING LLC	MA	(508) 992-3334
168	410167	PATRIOTS	NL	PATRIOTS CORP	MA	(508) 999-5607
169	410169	VIRGINIA WAVE	CA2	VIRGINIA WAVE INC	VA	(757) 880-1919
170	410173	AMY MARIE	NL	CAPE CLAM INC	NJ	(609) 884-7600
171	410174	EDGARTOWN	CA2	NORDIC INC	MA	(508) 996-0313
172	410175	LUZITANO	NL	THE HOPE II INC	MA	(508) 994-4264
173	410176	VIRGINIA DARE	CA2	HARBOR SEAFOOD	VA	(757) 869-4314
174	410178	SEA RANGER	CA2	BRONCO FISHERIES INC	MA	(508) 996-0313
175	410179	FRANCIS M LEE SR	NL	SEA PRODUCTS INC	NJ	(609) 884-3000
176	410182	VIRGINIA REEL	CA2	GABRIELLE PAIGE CORPORATION	NY	(516) 429-4735
177	410184	PAUL & MICHELLE	CA2	FAIRHAVEN FISHING CORP	MA	(508) 994-4264
178	410185	JULIE G	CA2	W W FISHERIES LIMITED	MA	(508) 994-4264
179	410187	FORTUNE HUNTER	CA2	MISTY SEAS INC	NC	(252) 322-5695
180	410192	ARAHO	CA2	OHARA CORPORATION	MA	(508) 993-6730
181	410193	DEFIANT	CA2	CAROLINA DREAM INC	VA	(757) 898-8512
182	410195	KATHY ROSE	CA2		NC	(252) 745-5338
183	410200	CHIEF & CLYDE II	NL	WARRIOR SCALLOPING CORPORATION	MA	(508) 992-9524
184	410202	JANICE LYNELL	CA2	TRAWLER YVONNE MICHELLE INC	VA	(757) 245-3022
185	410205	DETERMINATION	NL	F/V DETERMINATION INC	NJ	(609) 884-1771
186	410210	TROPICO	CA2	TROPICO FISHING INC	MA	(508) 636-5971
187	410211	STARDUST	NL	S J FISHERIES INC	MA	(508) 996-0525
188	410213	CAPT MALC	CA2	COMPANION OF WANCHESE INC	VA	(757) 728-0600

189	410214	AMBASSADOR	CA2	TONNESSEN FISHERIES INC	MA	(617) 996-0313
190	410215	HUNTRESS	CA2	ISAKSEN FISHING CORPORATION	MA	(617) 996-0313
191	410219	YVONNE MICHELLE	CA2	TRAWLER YVONNE MICHELLE INC	VA	(757) 245-3022
192	410221	JUSTICE	CA2	NORDIC INC	MA	(508) 997-5331
193	410226	ZEUS	NL	STEPHANIE FISHING CORP	MA	(508) 992-3334
194	410228	VIRGINIA QUEEN	CA2	GLOUCESTER SEAFOOD OF VA INC	VA	(757) 880-1919
195	410229	AVENGER	CA2	AVENGER FISHING LLC	MA	(508) 996-0525
196	410232	SUSAN L	CA2	FIVE FATHOMS INC	NJ	(609) 884-3405
197	410235	ELIZABETH & NIKI	CA2	ELIZABETH & NIKI FISHING CORP	MA	(508) 994-4264
198	410236	VILA DO CONDE	NL	VILA DO CONDE INC	NJ	(609) 884-7828
199	410238	STEPHANIE VAUGHN	CA2	C & I FISHING CORP	MA	(508) 992-3334
200	410239	LEADER	CA2	F/V LEADER INC	NJ	(609) 884-1771
201	410247	FRONTIER	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
202	410248	MAELSTROM	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
203	410249	WESTPORT	NL	E & J SCALLOP CORP	MA	(508) 996-0525
204	410251	AMBER NICOLE	NL	AMBER NICOLE INC	NJ	(609) 884-1771
205	410253	SETTLER	CA2	FRONTIER FISHING CORP	MA	(508) 996-0525
206	410254	EXPLORER	NL	L V FISHING INC	MA	(508) 996-3742
207	410255	MISS MAUDE	NL	FAITH EVELYN INC	VA	(757) 728-0600
208	410261	LEGACY	CA2	ADMIRAL INC	MA	(508) 758-3427
209	410266	REFLECTION	NL	NORDIC FISHERIES INC	MA	(508) 993-5300
210	410267	MADISON KATE	CA2	SEA VENTURES LLC	MA	(508) 758-6600
211	410268	GENERATION	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
212	410269	FRIENDSHIP	CA2	OHARA CORPORATION	MA	(508) 993-6730
213	410270	MARGARET ROSE	NL	POOR BOY LLC	NJ	(609) 884-9068
214	410275	APOLLO	NL	APOLLO FISHING LLC	MA	(508) 992-3334
215	410279	NADIA LEE	NL	ATLANTIC SHELLFISH INC	NJ	(609) 884-1771
216	410280	AMBITION	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
217	410281	OCEAN LEADER	CA2	NEW OCEAN LLC	MA	(508) 996-3742
218	410282	KAYLA ROSE	NL	AJ SCALLOPING INC	MA	(508) 996-0525
219	410284	MARY ANNE	CA2	BOAT MARY ANNE INC	MA	(508) 994-4264
220	410285	SILVER SEA	NL	F/V SILVER SEA LLC	NJ	(609) 884-3000

221	410288	HERITAGE	CA2	OHARA CORPORATION	MA	(508) 993-6730
222	410289	JERSEY GIRL	NL	F/V JERSEY GIRL LLC	NJ	(609) 884-3000
223	410290	RELENTLESS	NL	CAROLINA CLIPPER INC	VA	(757) 898-8512
224	410291	LITTLE SAMMIE	CA2		NC	(252) 926-1851
225	410293	FEARLESS	CA2	S & F FISHING INC	MA	(508) 994-4264
226	410309	BOUNTIFUL II	CA2	ISAKSEN FISHING CORPORATION	MA	(508) 996-0313
227	410315	DIVINE MERCY	NL	DIVINE MERCY LLC	NC	(252) 745-7243
228	410323	ENDURANCE	NL	SAI FISHERIES INC	MA	(508) 993-0235
229	410326	KAREN ELIZABETH	CA2	SALT POND FISHERIES INC	RI	(401) 741-1831
230	410337	MISS STEVIE B	CA2	MISS STEVIE B CORP	VA	(757) 898-8512
231	410338	THOR	NL	THOR FISHING CORPORATION	MA	(508) 993-5342
232	410341	FREEDOM	NL	HAAKONSEN LLC	MA	(508) 996-0313
233	410343	EILEEN MARIE	CA2	EILEEN MARIE FISHING INC	MA	(508) 992-3334
234	410346	CORSAIR	CA2	CORSAIR FISHING INC	MA	(508) 509-8100
235	410347	JANICE & JULIE	NL	W G FISHERIES INC	MA	(508) 994-4264
236	410353	OCEAN HUNTER	NL	NEW OCEAN LLC	MA	(508) 996-3742
237	410357	JOAN MARGUERITE	NL	C & S FISHERIES INC	MA	(774) 836-5803
238	410363	LADY OF FATIMA	CA2	CAPT SANTOS FISHING CORPORATION	MA	(508) 992-3334
239	410366	ACT IV	NL	NORPORT INC	MA	(508) 748-2827
240	410371	NANCY ELIZABETH	CA2	NANCY ELIZABETH LLC	NJ	(609) 884-7600
241	410384	THUNDER BAY	CA2	F/V ADRIANNA LLC	NJ	(609) 884-3000
242	410386	INCENTIVE	CA2	INCENTIVE FISHERIES LLC	MA	(508) 993-6730
243	410392	MAJESTIC	NL	MAJESTIC FISHING LLC	MA	(508) 996-0525
244	410393	NORTH QUEEN	NL	NORTH QUEEN FISHING INC	MA	(508) 992-3334
245	410394	CONTENDER	CA2	MICHIGAN FISHING CORP	MA	(508) 996-0313
246	410413	LIBERTY	CA2	NORDIC INC	MA	(508) 996-0313
247	410414	MIZ JUANITA B	CA2	CAPTAIN MARSHALL INC	VA	(757) 898-8512
248	410415	HUNTER	NL	HUNTER SCALLOPING COMPANY LLC	MA	(508) 996-0525
249	410416	NORDIC PRIDE	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
250	410417	ATLANTIC	CA2	KAVANAGH FISHERIES INC	MA	(508) 992-3334
251	410418	CANYON EXPRESS	NL	COVE FISHING CORP	MA	(774) 202-4369
252	410419	BRITTANY ERYN	NL	BLUE SEAS VENTURES LLC	MA	(508) 758-6600

253	410420	DILIGENCE	NL	DILIGENCE INC	MA	(508) 996-0313
254	410422	TRADITION	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
255	410423	CAROLINA QUEEN III	NL	CAROLINA QUEEN II INC	VA	(757) 898-8512
256	410430	SANDRA JANE	NL	J & M FISHING INC	MA	(508) 996-0313
257	410432	ENDEAVOR	CA2	HANSEN SCALLOPING INC	MA	(508) 996-0525
258	410441	CAROLINA BOY	CA2	CAROLINA BOY INC	VA	(757) 898-8512
259	410444	TYLER N NOAH	CA2	VILA NOVA FISHING INC	MA	(508) 992-3334
260	410451	VILA NOVA DO CORVO II	CA2	VILA NOVA DO CORVO II INC	MA	(508) 992-3334
261	410455	PATTY JO	CA2	STONINGTON FISH & LOBSTER INC	CT	(860) 535-0882
262	410456	PAMELA ANN	NL	STAR LLC	MA	(508) 758-6600
263	410459	SANTA MARIA	NL	SANTA MARIA FISHING CORP	MA	(508) 997-2197
264	410463	BETH ANNE	CA2	BETH ANNE FISHING INC	MA	(508) 994-4264
265	410469	ANTICIPATION	CA2	F/V ANTICIPATION LLC	NJ	(609) 884-3000
266	410476	ITALIAN PRINCESS	CA2	ITALIAN PRINCESS INC	VA	(757) 898-8512
267	410489	VENTURE	CA2	NORDIC INC	MA	(508) 996-0313
268	410493	SANTA ISABEL	CA2	SANTA ISABEL FISHING CORP	MA	(508) 997-2197
269	410496	KATHY MARIE	NL	ARNIES FISHERIES INC	MA	(508) 996-0525
270	410499	KATHY & JACKIE	NL	KATHY & JACKIE FISHING CORP	MA	(508) 996-0525
271	410505	KATHY ANN	NL	KATHY ANN CORPORATION	NJ	(609) 548-5020
272	410507	GUIDANCE	CA2	GUIDANCE FISHING CORP	MA	(508) 996-0525
273	410508	LAUREN & MATTHEW	NL	TRAWLER MISS VERTIE MAE INC	VA	(757) 245-3022
274	410514	YANKEE PRIDE	NL	YANKEE PRIDE FISHERIES INC	RI	(401) 741-1831
275	410519	ACORES	CA2	IVONILDE FISHING CORP	MA	(508) 992-3334
276	410541	DIANE MARIE	CA2	DIANE MARIE FISHERY INC	MA	(508) 509-8100
277	410547	REGULUS	NL	EMPIRE FISHERIES LLC	CT	(203) 876-8923
278	410550	FJORD	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
279	410551	RANGER	NL	OHARA CORPORATION	MA	(508) 993-6730
280	410552	RAIDERS	CA2	PATRIOTS CORPORATION	MA	(508) 999-5607
281	410553	RESOLUTION	NL	OHARA CORPORATION	MA	(508) 993-6730
282	410554	K A T E	NL	COMPASS FISHING CORP	MA	(508) 996-0525
283	410556	QUEEN OF PEACE	NL	SANTOS FISHING CORP	MA	(508) 992-3334
284	410558	WEATHERLY	CA2	OHARA CORPORATION	MA	(508) 993-6730

285	410561	K A T E II	CA2	COMPASS FISHING CORP	MA	(508) 996-0525
286	410564	ILHA BRAVA	NL	C & C FISHING CORP	MA	(508) 992-3334
287	410571	REDEMPTION	NL	F/V REDEMPTION LIMITED LIABILITY COMPANY	NJ	(609) 425-8983
288	410572	NESKONE	NL	NORDIC FISHERIES INC	MA	(508) 993-6730
289	410575	INSPIRATION	CA2	AARSHEIM FISHING CORP	MA	(508) 748-2827
290	410578	MISS GEORGIE	NL	MISS GEORGIE INC	NC	(252) 670-1176
291	410579	CAPT GASTON	CA2	LEGACY TRAWLING INC	NC	(252) 637-1552
292	410586	SHARON K	NL	KENPAC FISHING CORP	MA	(508) 994-4264
293	410590	VILA NOVA DO CORVO I	CA2	VILA FISHING CORP	MA	(508) 992-3334
294	410592	ANNIE ELIZABETH	CA2	G & C SCALLOP FISHERIES INC	NC	(252) 249-0123
295	410593	GOOD NEWS II	CA2	DELORES OF WANCHESE INC	VA	(757) 728-0600
296	410595	POLARIS	CA2	OHARA CORPORATION	MA	(508) 993-6730
297	410596	ZIBET	NL	ZIBET INC	MA	(508) 996-0331
298	410597	GEORGES BANKS	CA2	G & J FISHERIES INC	MA	(508) 994-4264
299	410598	CRYSTAL AND KATIE	NL	KATIE & CRYSTAL LLC	VA	(804) 868-7405
300	410599	WISDOM	CA2	NORDIC FISHERIES INC	MA	(508) 993-5300
301	410600	ALASKA	CA2	INVINCIBLE FISHING CORPORATION	MA	(774) 202-4369
302	410601	HORIZON	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
303	410603	ARCTURUS	CA2	OHARA CORPORATION	MA	(508) 993-6730
304	410604	ATHENA	CA2	ATHENA FISHING CORP	MA	(508) 992-3334
305	410607	VANQUISH	CA2	NELSON FISHING INC	MA	(508) 479-0729
306	410608	VAUD J	CA2	VAUD J INC	NJ	(609) 884-3405
307	410610	CONCORDIA	CA2	KVILHAUG LLC	MA	(508) 996-0313
308	410612	HERA II	NL	S & S FISHING LLC	MA	(508) 992-3334
309	410613	GYPSY GIRL	CA2	ORION VENTURE LLC	MA	(508) 992-3334
310	410614	ROST	NL	NORDIC FISHERIES INC	MA	(508) 993-6730
311	410615	PYXIS	NL	OHARA CORPORATION	MA	(508) 993-6730
312	410616	NORSEMAN	CA2	NORDIC FISHERIES INC	MA	(508) 993-6730
313	410617	RELIANCE	CA2	OHARA CORPORATION	MA	(508) 993-6730