Framework Adjustment 50

to the

Northeast Multispecies FMP

Appendix II

Analytic Techniques: Derivation of Accountability Measure Areas

Development of Accountability Measure (AM) Areas

This action proposes to adopt area-based AMs for SNE/MA winter flounder for common pool vessels. This section describes the analyses used to identify and define the areas. Much of the information in this section summarizes Groundfish Plan Development Team (PDT) reports documenting this work. This appendix includes information for areas for other stocks so that the analytic approach can be understood in its overall context and application.

The approach used to identify the AM areas uses a combination of observer data and fishery-dependent data. To simplify analyses and make them consistent with data sources used in assessments, the fishery dependent catch data was queried from the "AA" tables created by the Northeast Fisheries Science Center (NEFSC). These tables assign a catch location to catch weights as reported to dealers by matching VTR records to dealer records. Not all trips can be matched and so some dealer records do not have position information; these were not included in the analyses. The analyses were performed for the major groundfish gear: otter trawl, longline, and sink gillnet. Note that these gears are used in other fisheries in addition to the groundfish fishery, particularly in the area south of New England. No attempt was made to assign each trip to a particular fishery, which introduces uncertainty into evaluating the impacts of the AM measures because as proposed they would only limit groundfish fishing trips.

Observer Data Analysis

The first step in the analysis was to query the observer database and extract observed tows for the three primary gears used in the groundfish fishery: large mesh otter trawl, large and extra-large mesh sink gillnets, and longlines. The following discussion will describe the steps used in the analysis for trawl gear catches of windowpane flounder and ocean pout, but similar approaches were used for the other two gears.

Data analyzed were from calendar years 2008 – 2010; all data were pooled. Pooling was done to get a greater geographic coverage of the observed tows and to increase the number of observed tows in the data set. This approach is problematic in that discard rates can differ from year to year and pooling the data glosses over those differences. On the other hand, the management system is unlikely to change the areas annually and so this approach gives a blended picture of discard rates over a recent time period.

The observed tow information on total kept catch and on the discards of windowpane flounder and ocean pout[1] were plotted in Arcview© GIS. The plotted tows were binned into ten-minute squares. This provided an illustration of the range of observer coverage as well as an indication of the squares where most observed discards were documented (see Figure 1 and Figure 2 for an example). The magnitude of observed discards in a square is related to the number of observed trips in a square so these data alone do not necessarily

[1] Since almost all windowpane flounder and ocean pout has been discarded in recent years, the analysis for these species focused on discards. For wolffish and halibut the analysis included kept catch.

indicate the correct areas for AMs. The second step was to calculate a simple ratio of observed species discards to total kept catch (d/kall) in each ten-minute square. This identifies areas with higher discard rates but still does not account for the number of observed tows – there is no measure of variability in this plot, and a square with one observed tow cannot be differentiated from a square with hundreds of observed tows (see Figure 3 for an example).

The discards from a ten-minute square are a function not only of the d/kall ratio but of the total fishing effort in the area. Conceptually the discard ratio can be expanded to an estimate of total discards from the area by multiplying it by the total kept catch in the same area. There is a concern with doing this type of analysis at small spatial scales because of the uncertainty over reported fishing locations. Groundfish fishermen are required to report one fishing location for every statistical area fished that represents the general area of fishing activity. Several studies have shown that while the information is reliable for assigning catch at the stock area level, it becomes less accurate as the spatial scale gets smaller (see, for example, Palmer and Wigley 2009). Nevertheless, the information is often used at small scales. Analyses for the future habitat actions bin the data into 10-km squares; protected species catch estimates bin the data at various depth profiles (Murray 2007); and the impacts of closed areas have been evaluated using the data binned into ten minute squares (Murawski et al. 2005). So for this analysis the data was binned at ten-minute squares. The data limitations must be kept in mind while evaluating these analyses and a criticism of this approach is that it places a heavy reliance on the accuracy of self-reported fishing locations that are known to be inaccurate. A assumption is that by pooling data over a three-year period it is likely the data are a fair representation of fishing activity even if an individual trip is misreported. Another consideration was the desire to make the AM areas as small as can be justified to minimize interference with other groundfish fishing activities. Binning the data at larger scales would make it difficult to identify smaller areas. A sensitivity analysis was performed with the data binned at 30 minute squares in the case of windowpane flounder and trawl gear to see how the analyses would change if binned at a larger scale.

With both observed d/kall and catch data binned into the same ten-minute squares the discards from each square can be estimated by multiplying the observed ratio by the reported kept all. The resulting value can be plotted - or, as is the case in Figure XXX, the log of the value can be plotted because the data are highly skewed. This gives an illustration of the distribution of discards. Note that discards are only estimated in a ten-minute square with both observed trips and reported kept catch. This is more of an issue with sink gillnet gear than trawl gear, as the distribution of observed hauls does not cover the range of reported kept catches (see Figure 20).

The estimated discards by ten-minute square were further analyzed to identify statistically-significant “hotspots” – areas with higher or lower discards than the region as a whole. ArcGis© includes an analytic tool which calculates these areas. As described by the software “This tool identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots).” The tool uses a spatial statistic called the Getis - Ord G* statistic. It does not identify isolated features with a high or low value; it identifies features that have a high (or low) value that are surrounded by other features with a high (or low) value. These areas reflect a statistically significant departure from complete spatial randomness. These areas generally match areas with high d/kall ratios.

The use of the statistic requires the user to define the appropriate neighborhood for the analysis, and results can be sensitive to the choice of the neighborhood. For this analysis the neighborhood was defined with a fixed distance of 25,000 meters, or roughly the eight squares surrounding each ten-minute square. This neighborhood scale was selected primarily because of a desire to use a scale that would allow for designing AM areas that were as small as possible. In addition, only ten minute squares with more than 10 or more observed tows were used in order to minimize effects of isolated observed tows. A sensitivity analysis was run using all squares for windowpane flounder and trawl gear; the results were not noticeably different than when all squares were included.

For wolffish and halibut a similar approach was followed. Because a larger proportion of the catches of these species were retained in recent years the approach was modified to use a catch/kall ratio for the observer data and kept catches of the species were combined with the estimated discards in each ten-minute square.

Once the hot-spot areas were plotted the AM areas were identified by drawing boundaries around a group of ten-minute squares that accounted for a desired reduction in catches. Because of data limitations with respect to the accuracy of reported fishing locations and the expectation that the areas would not be completely effective, they areas were drawn larger than would be expected if the data were completely accurate and compliance was 100 percent. The area boundaries may be adjusted in the future as experience is gained on the effectiveness of the AM system. For SNE/MA winter flounder, AM areas were selected in several locations in order to spread the effects of the AM areas across the region.

The figures following this discussion are the output from the analyses.

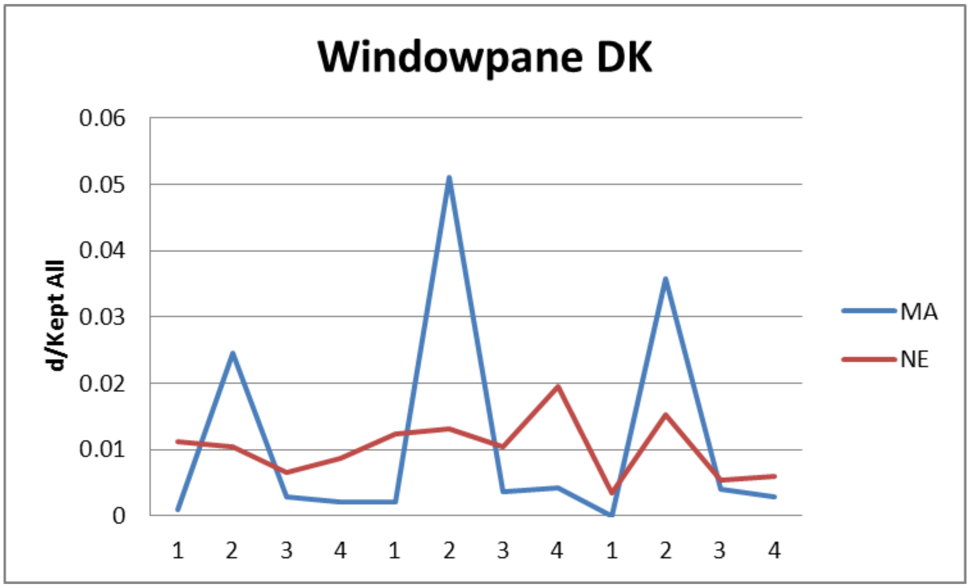
Additional Analyses

The preceding section describes the method used to identify the AM areas. A second approach applied regression trees to windowpane flounder during development of the areas. The results from this approach were consistent and are documented in PDT reports, while not as detailed as the GIS analyses.

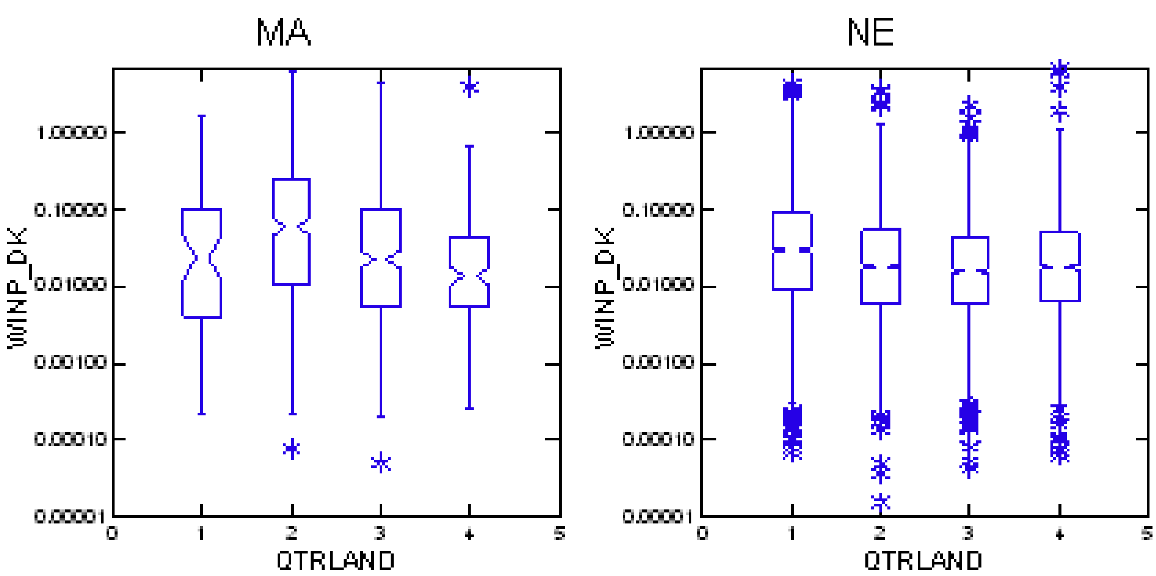
As noted, the analyses used pooled data. Since discard rates may change seasonally within a year, the observer data were analyzed to see if there were different discard rates in each quarter.

The following plot shows the simple windowpane observed sum discards/sum kept all ratio, by quarter, for large mesh otter trawls from 2008 – 2010. The two lines represent trips departing from NE ports and from MA ports (not area fished).

Note there seems to be a clear pattern for trips from MA ports with the ratio peaking in the second quarter. But there does not seem to be as obvious a pattern for trips leaving from NE ports.



The same l data were used for these box plots but were analyzed differently. These charts summarize the discard/kept all ratios on **individual tows** for tows that discarded windowpane flounder (note log scale). There still seems to be an increase in the second quarter for trips departing from MA ports. For NE ports, there might be a suggestion of a higher rate in the first quarter but it is not as pronounced as for the MA ports. The distributions overlap quite a bit, though.



Charts were plotted (not included here) that show the d/Kall ratios by ten minute square and quarter for large mesh otter trawls (050). All data are pooled for the years 2008 – 2010. The data include some tows coded as gear 050 but using an excluder device such as a separator. The ratio is a simple sum of discards divided by the sum of the total kept on observed tows in each ten-minute square. With windowpane flounder on GB there do not appear to be large differences in the observed discard ratios over the four quarters. In the GOM, however, ratios seem higher in the first quarter in the inshore area. There are few squares in SNE that have more than nine tows, making it difficult to draw conclusions

For ocean pout, ratios on GB appear higher in the second and possibly the third quarters, and lower in the first and fourth quarters. The inshore GOM seems to follow an opposite pattern. Again, the lack of observations in SNE makes it difficult to draw conclusions.

Wolffish discard ratios appear to be lowest in the first quarter. In the inshore GOM the ratios appear higher in the third quarter, but there does not seem to be much difference between the second through fourth quarters. It is difficult to detect much seasonality in the discard ratios for halibut. For sink gillnet gear, wolffish were not observed in sink gillnet tows at all in the first quarter. The second and third quarter seemed to have the highest catch/ kept all ratios.

Literature Cited:

Murawski, S. A., Wigley, S. E., Fogarty, M. J., Rago, P. J., and Mountain, D. G. 2005. Effort distribution and catch patterns adjacent to temperate MPAs. ICES Journal of Marine Science, 62: 1150-1167.

Murray KT. 2007. Estimated bycatch of loggerhead sea turtles (*Caretta caretta*) in U.S. Mid-Atlantic scallop trawl gear, 2004-2005, and in sea scallop dredge gear, 2005. US Dep Commer, Northeast Fish Sci Cent Ref Doc 07-04; 30 p.

Palmer, Michael C. and Wigley, Susan E. 2009. Using Positional Data from Vessel Monitoring Systems to Validate the Logbook-Reported Area Fished and the Stock Allocation of Commercial Fisheries Landings. North American Journal of Fisheries Management, Vol. 29, Issue 4, 2009.

Figure 1 – Number of observed large mesh otter trawl tows, by ten-minute square, 2008 and later

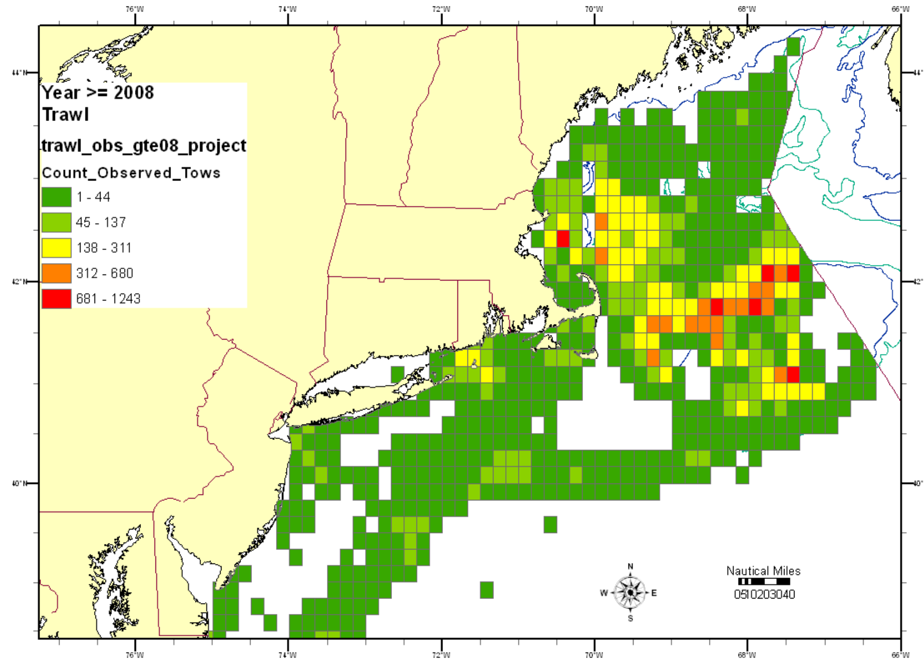


Figure 2 – Large mesh otter trawl expanded discards of ocean pout, 2008 - 2010

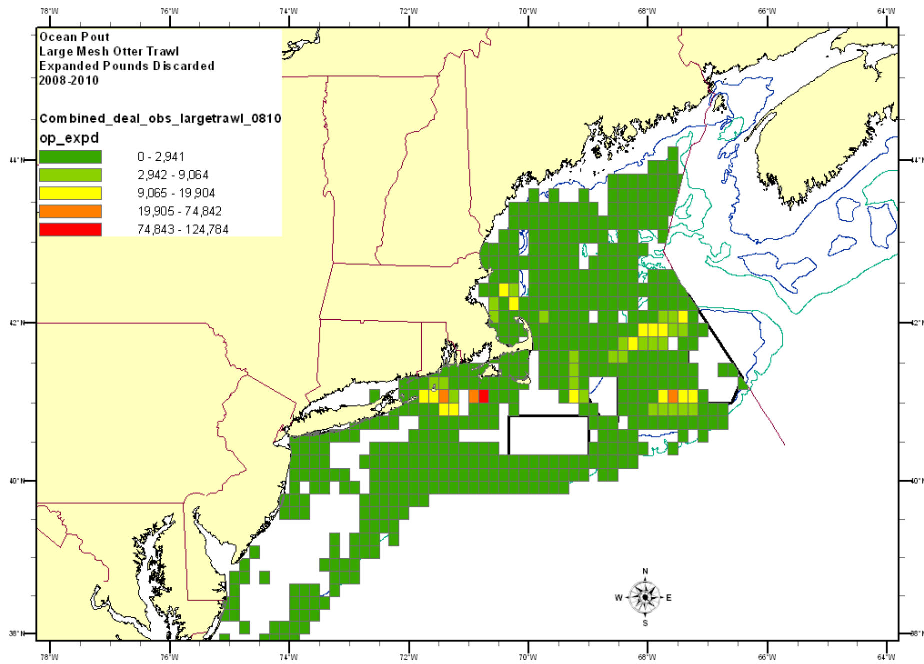


Figure 3 – Large mesh otter trawl expanded discards of ocean pout (log scale), 2008 - 2010

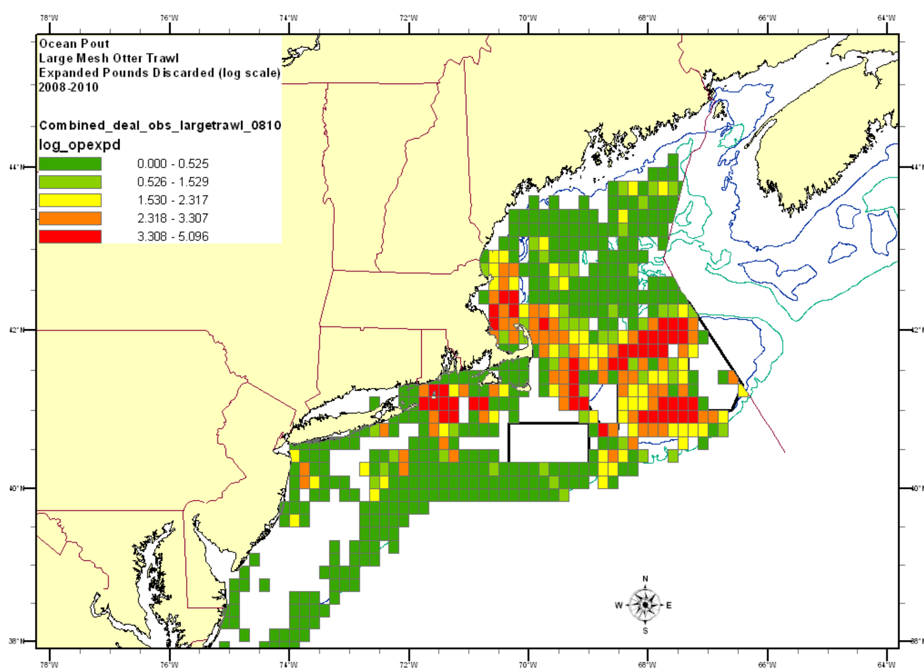


Figure 4 - – Getis Gi* hotspots for large mesh otter trawl expanded discards of ocean pout, all observed tows.

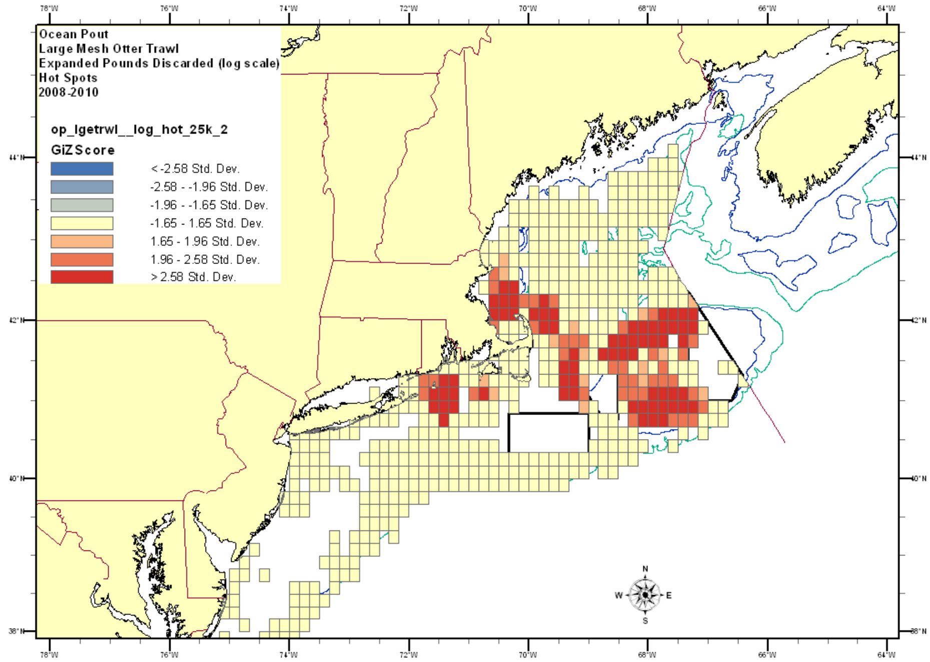


Figure 5 - Getis Gi* hotspots for large mesh otter trawl expanded discards of ocean pout, 10 or more observed tows in each ten-minute square

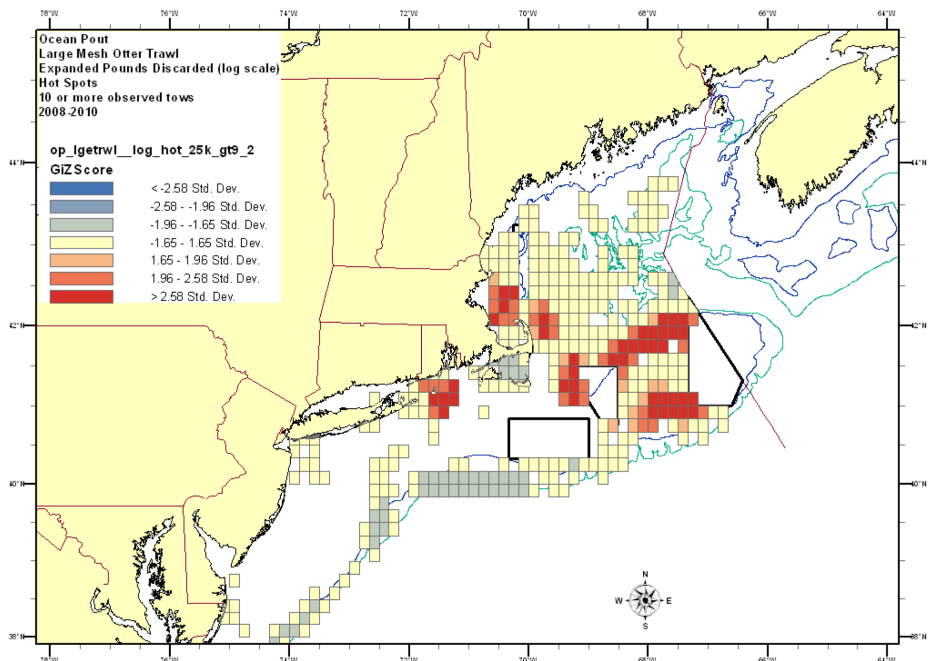


Figure 6 – Large mesh otter trawl catches of Atlantic halibut (reported kept catch plus expanded discards)

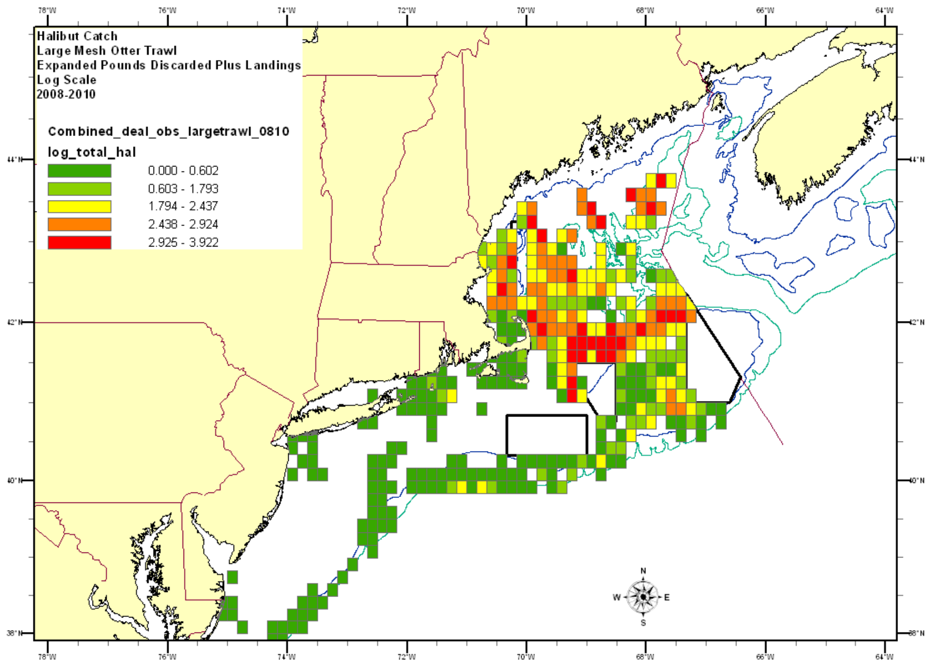


Figure 7 - – Large mesh otter trawl catches of Atlantic halibut (reported kept catch plus expanded discards), log scale

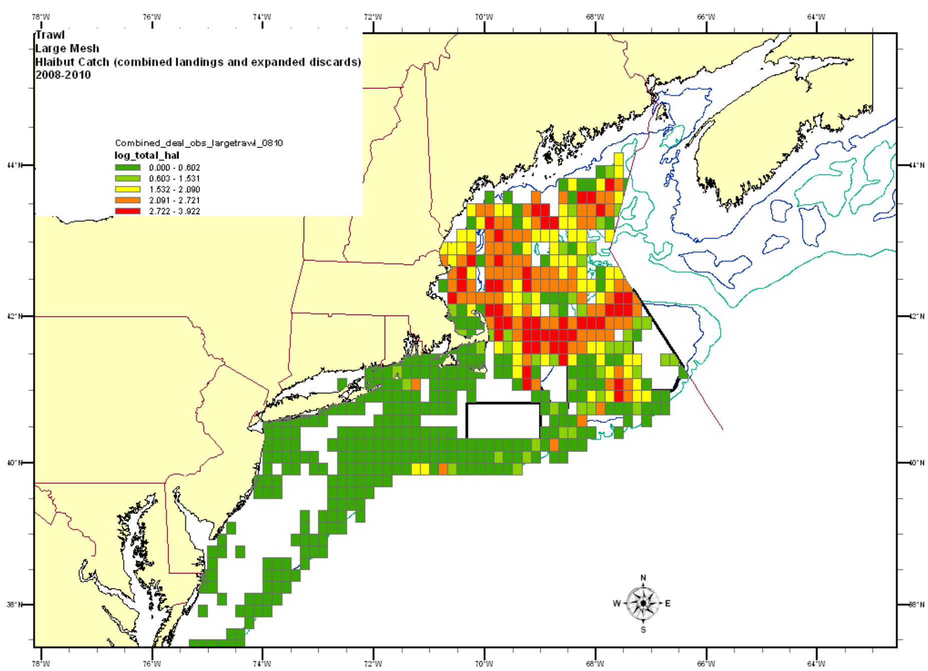


Figure 8 - Getis Gi* hotspots for large mesh otter trawl catch of halibut, all observed tows

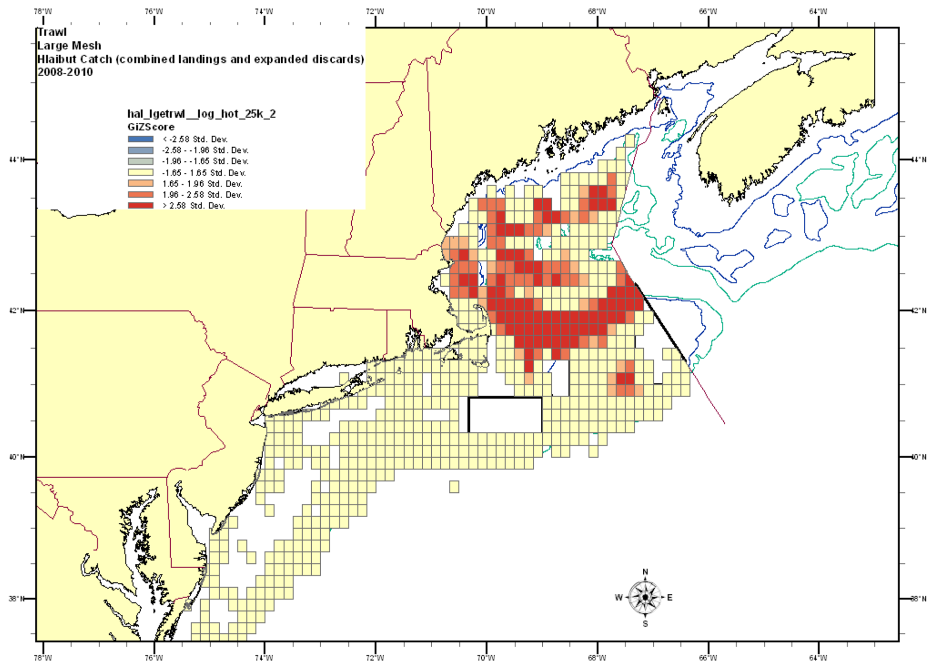


Figure 9 - Getis Gi* hotspots for large mesh otter trawl catch of halibut, 10 or more observed tows in each ten-minute square

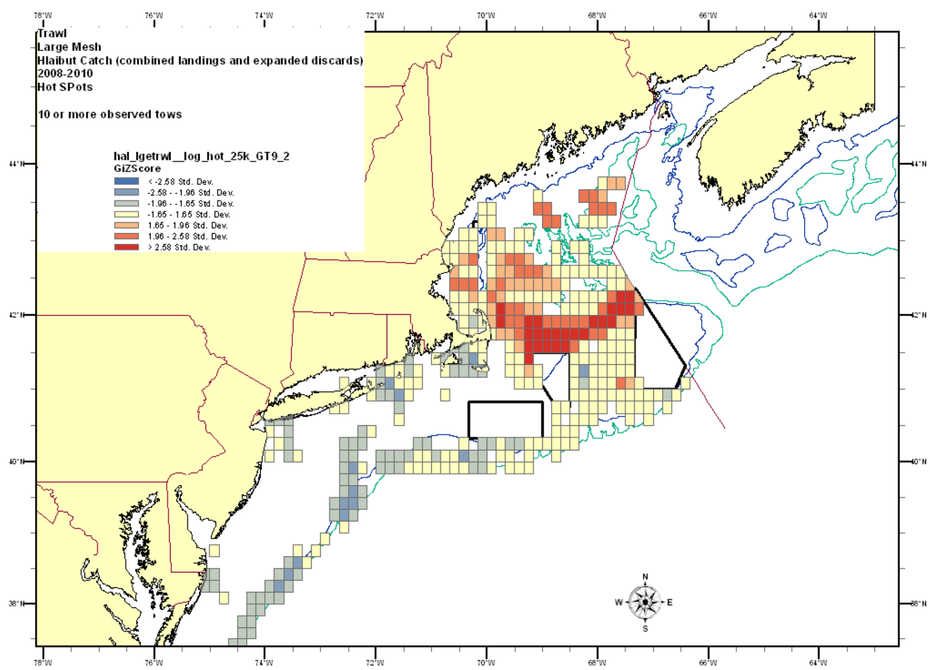


Figure 10 – Large mesh otter trawl Atlantic wolffish catch (landings plus expanded discards)

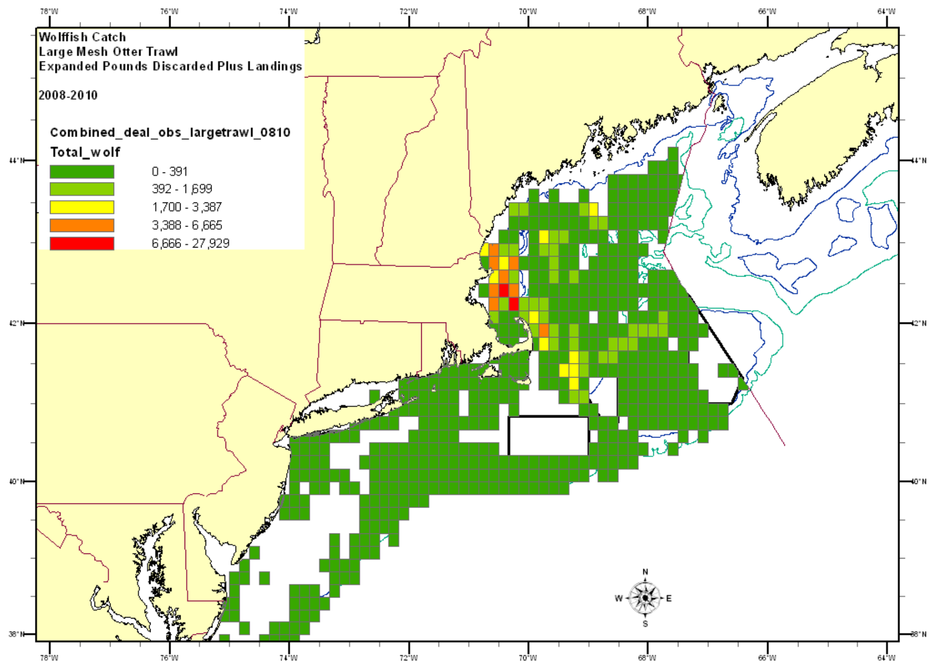


Figure 11 – Large mesh otter trawl Atlantic wolffish catch (landings plus expanded discards), log scale

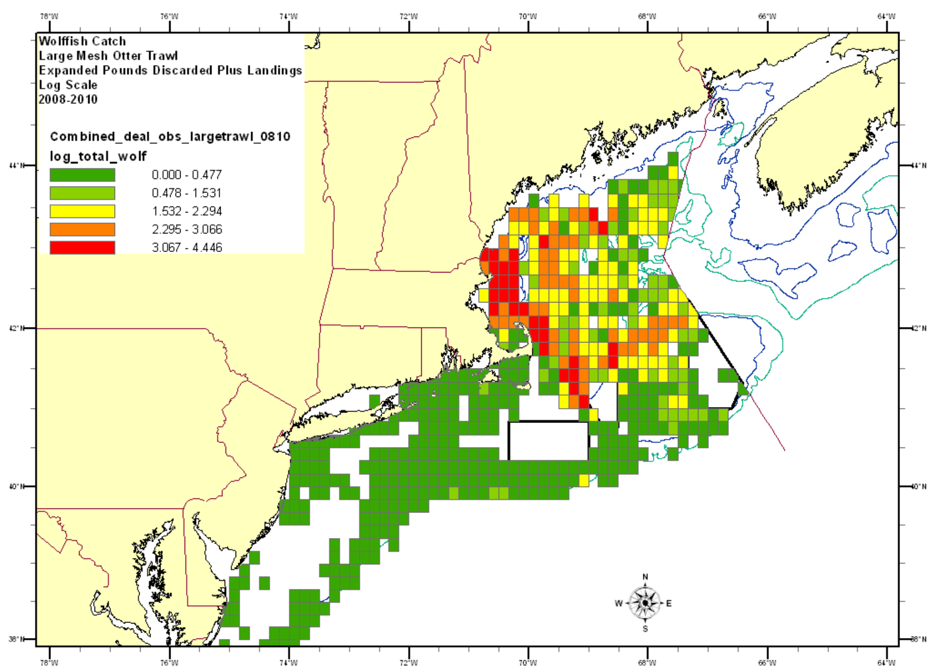


Figure 12 - - Getis Gi* hotspots for large mesh otter trawl expanded catch of wolffish, all observed tows

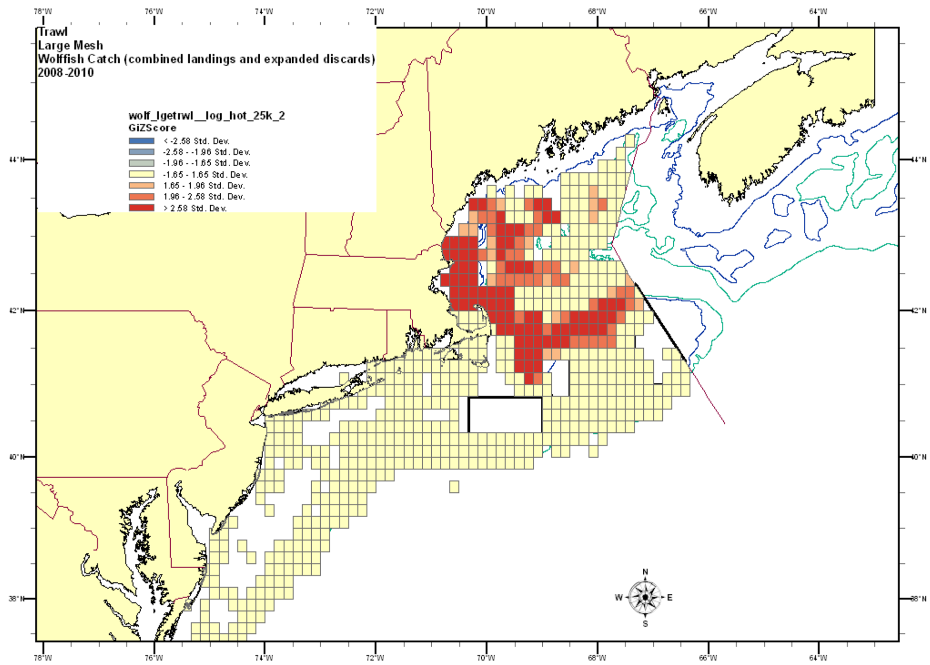


Figure 13 - Getis Gi* hotspots for large mesh otter trawl catch wolffish, 10 or more observed tows in each ten-minute square

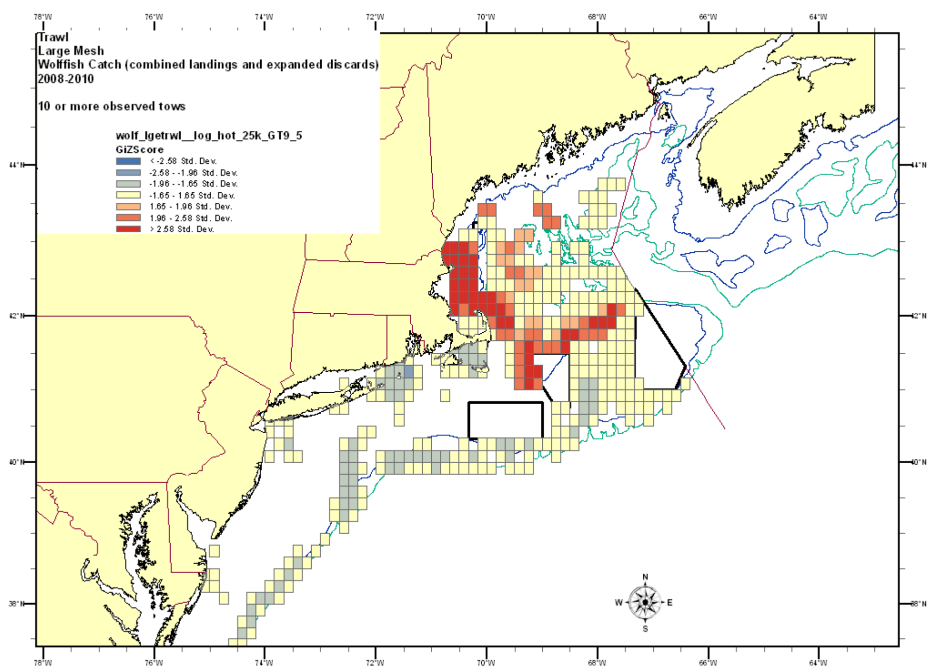


Figure 14 – Observed large and extra-large mesh sink gillnet hauls plotted over sink gillnet reported kept catch by ten-minute square, 2008 - 2010

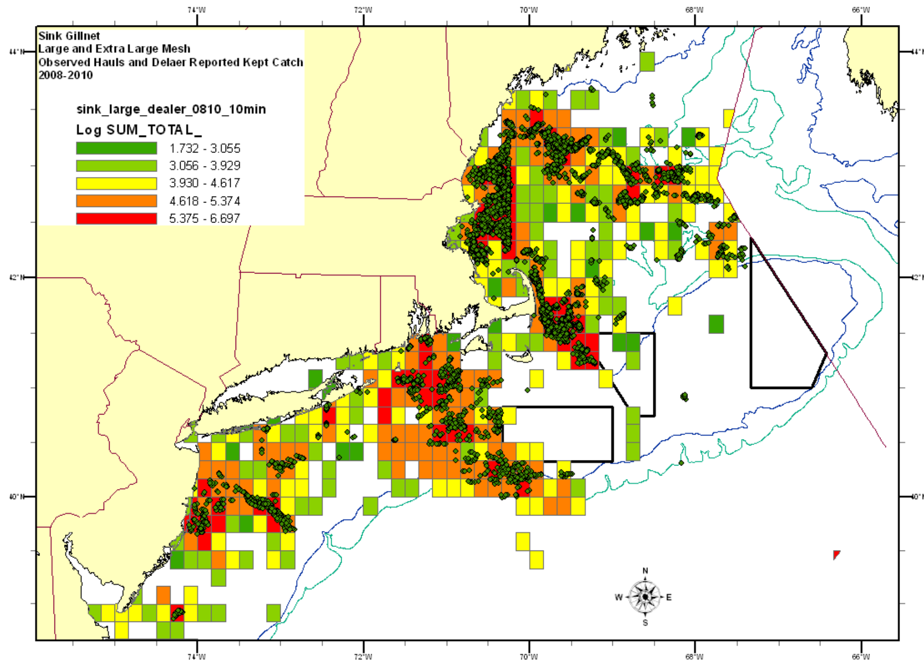


Figure 15 – Sink gillnet catch, areas with 10 or more observed tows, 2008 - 2010

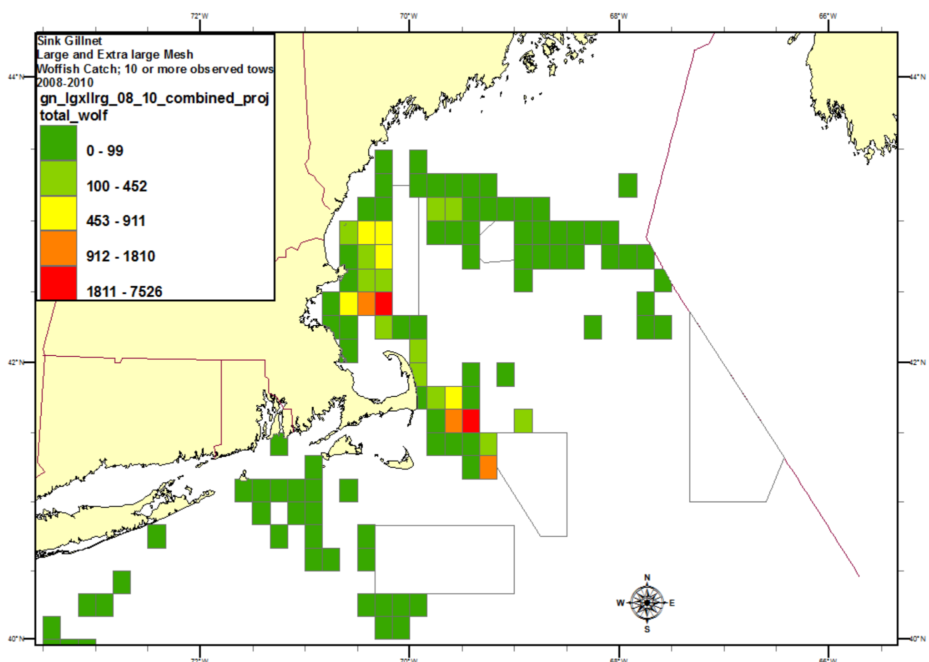


Figure 16 – Sink gillnet catch, areas with 10 or more observed tows, log scale, 2008 - 2010

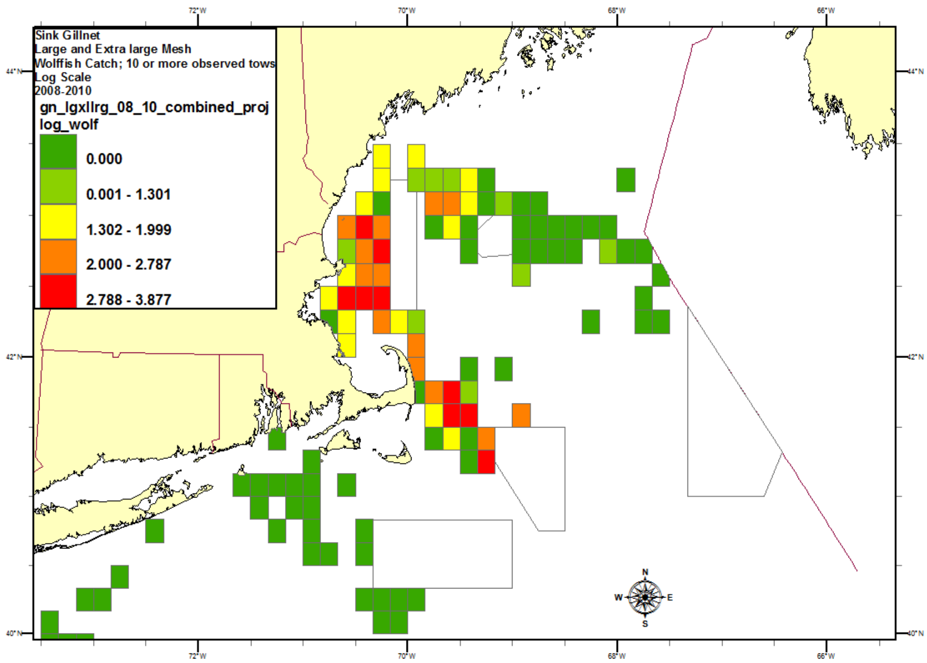


Figure 17 – Sink gillnet wolffish hotspots, areas with ten or more observed tows only, 2008 - 2010

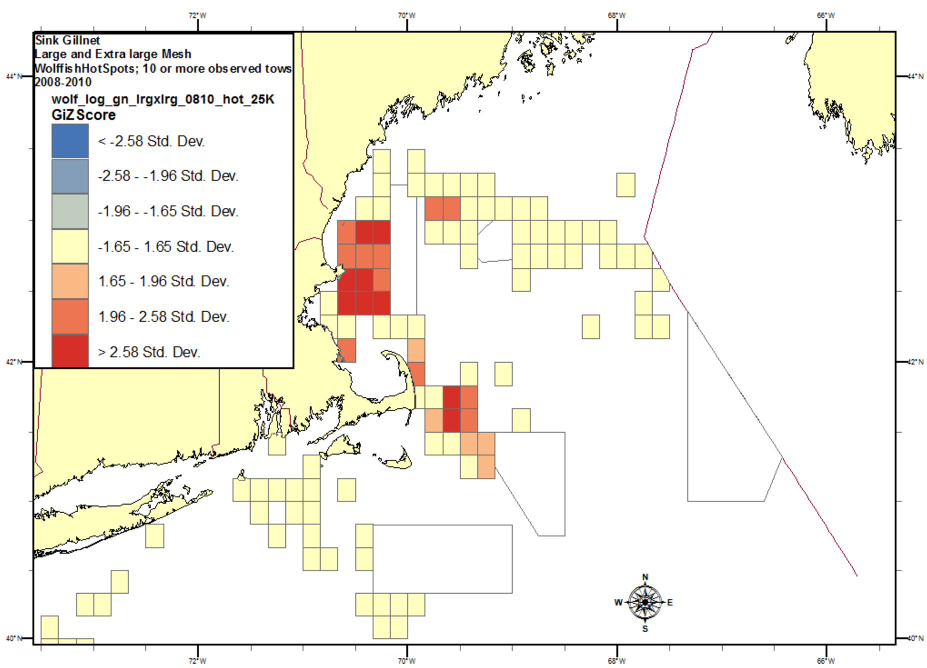


Figure 18 – Sink gillnet halibut catch, areas with ten or more observed tows, 2008 -2010

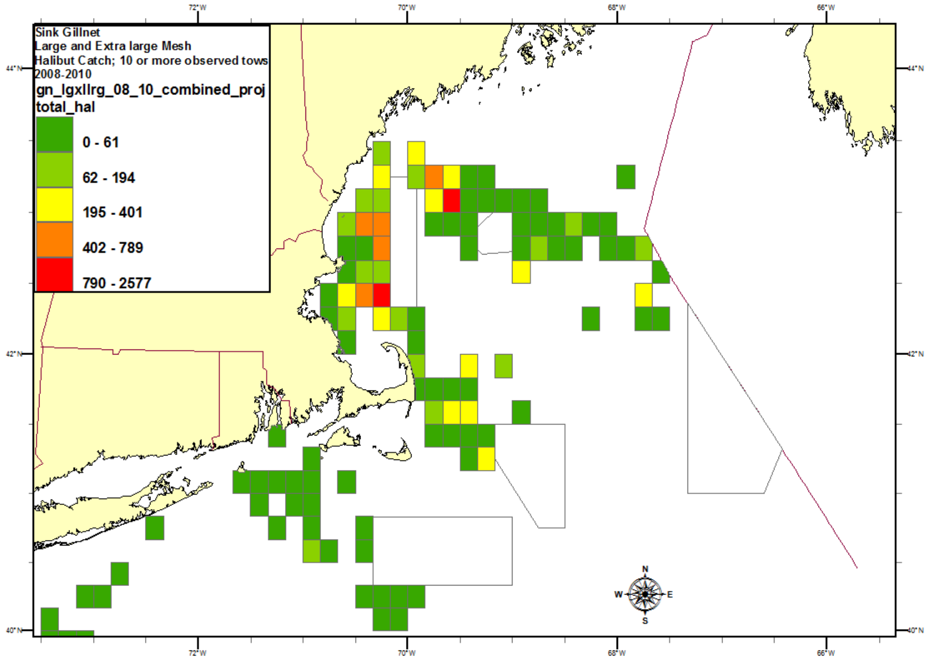


Figure 19 – Sink gillnet halibut catch, log scale, areas with ten or more observed tows, 2008 -2010

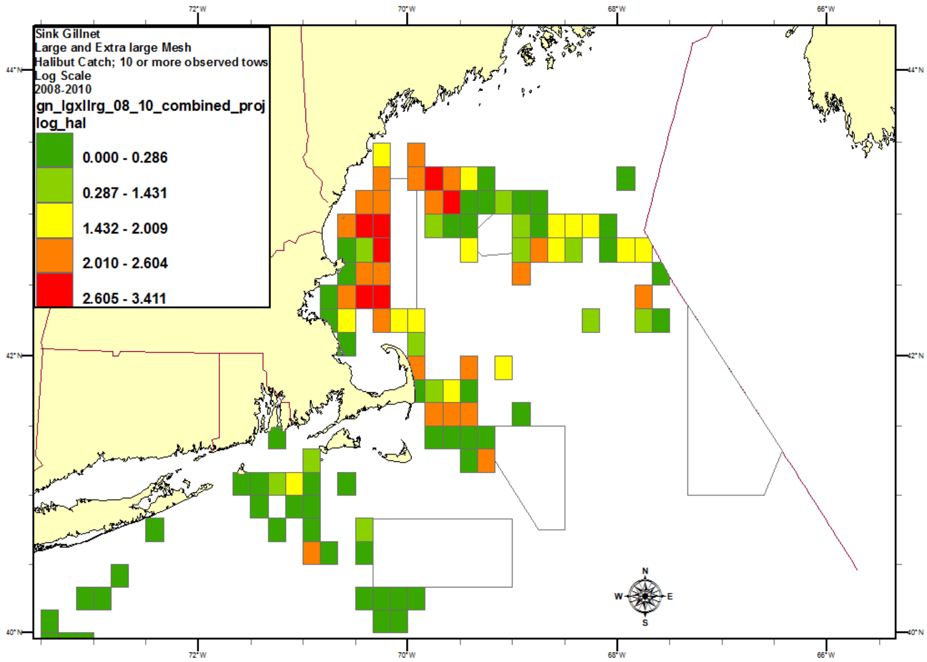


Figure 20 – Sink gillnet halibut hotspots, areas with ten or more observed tows, 2008 - 2010

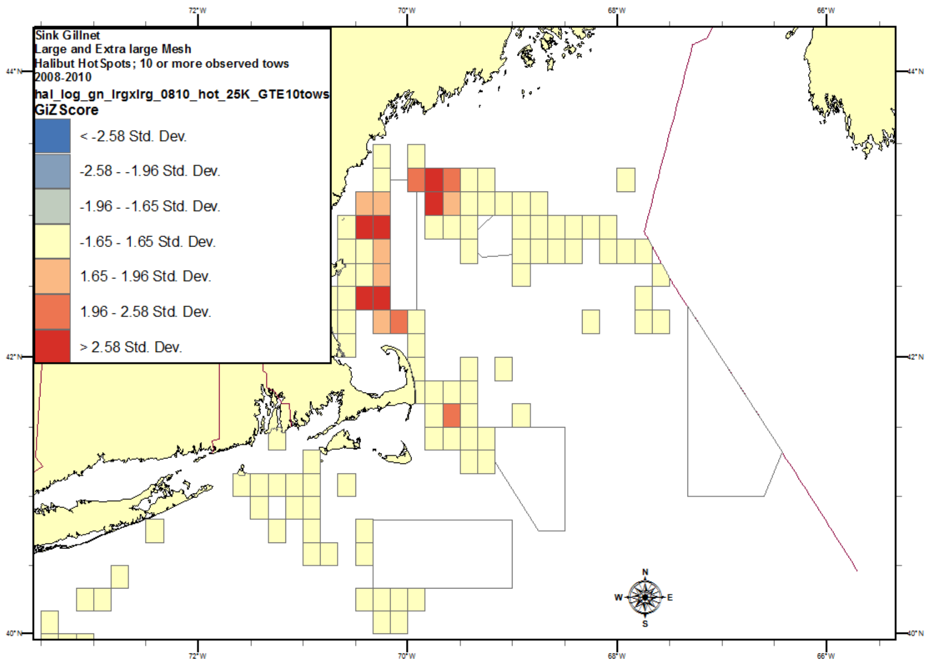


Figure 21 – Large mesh otter trawl observed discards of SNE/MA winter flounder, log scale

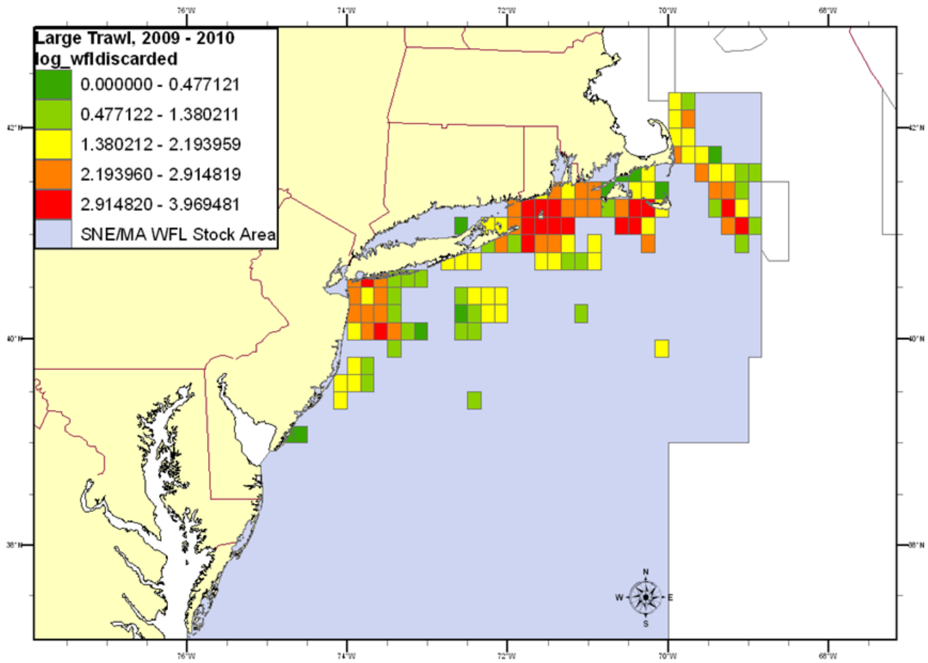


Figure 22 – Large mesh otter trawl observed discard/kept all ratios, SNE/MA winter flounder

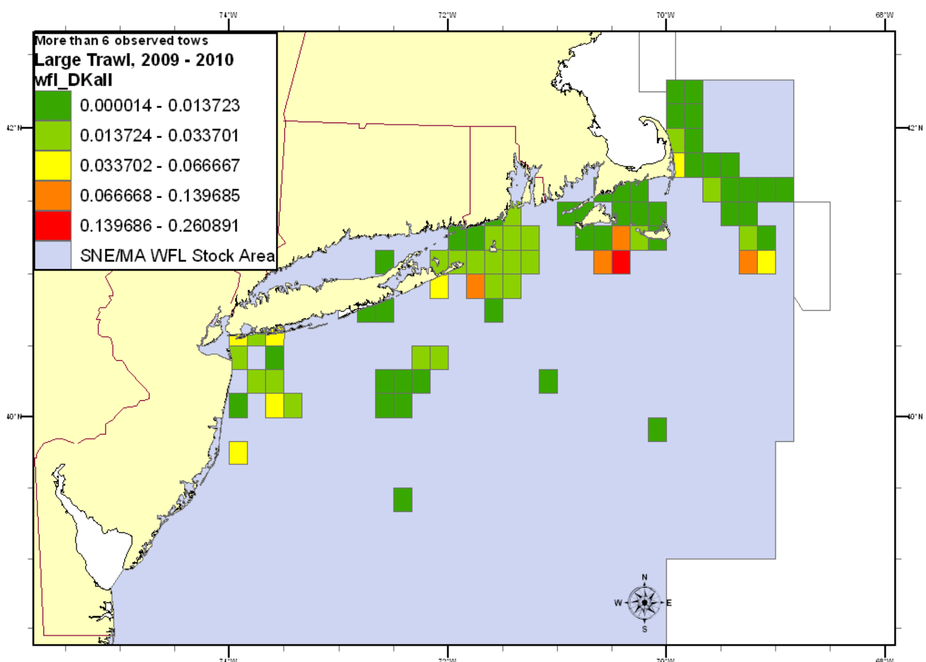


Figure 23 – Large mesh otter trawl expanded discards of SNE/MA winter flounder, log scale

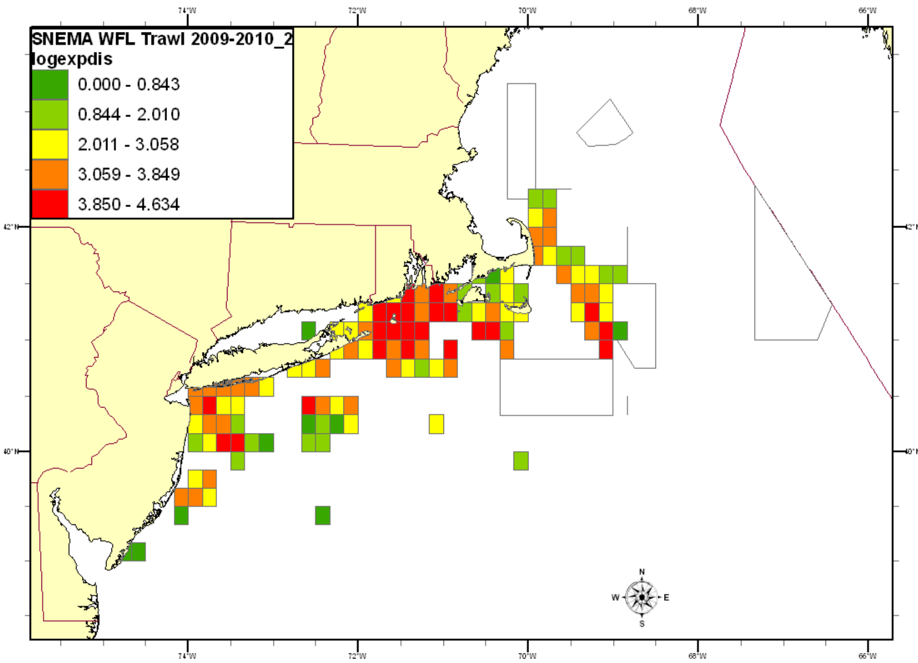
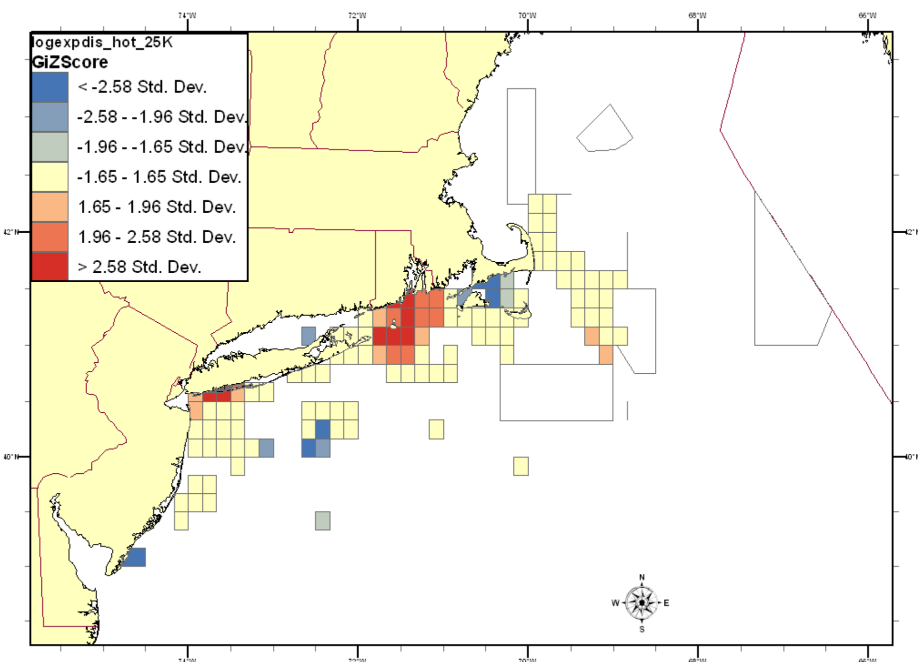


Figure 24 – Large mesh otter trawl Getis-G* hotspots for SNE/MA winter flounder discards



Identifying hotspots of windowpane discard using regression tree analyses on windowpane discards per tow and proportion of tows with windowpane

Developed for the groundfish PDT

by

Steven Correia
Massachusetts Division of Marine Fisheries
July 19, 2011

I used regression trees to identify geographic areas with high and low proportion of tows with windowpane or log10 discards of windowpane per tow. Tom Nies provided a dataset of observed tows. The analysis was based on tow observations. Total discards were estimated by multiplying the discard rate (discard (species)/ (kept all) by the kept hailweight. Tow observations were treated as independent, that is the correlation of tows within trips was ignored. All analyses were completed on at tow level, and the distribution of observed effort or fleet effort was not taken into account in this analysis.

Tree regression proceeds by binary recursive partitioning of the predictor variables in order to minimize the variance within each split and maximize the difference in mean between the two splits. The use of latitude and negative longitude as variables results in the creation of rectangles with homogeneous catches.

Proportion of tows with windowpane.

Tows were coded as having windowpane (1) or no windowpane(0). The overall proportion of tows with windowpane over the entire study area was 0.30. The proportion of tows with windowpane is plotted against latitude and negative longitude (Figure 27 and Figure 28). The plot suggests that the highest proportion of positive tows with windowpane occur between 41 and 42 degrees north latitude and west of 70 degrees longitude and east of 69 degrees longitude.

I used a tree regression of presence/ absence of windowpane in tow with negative longitude and latitude as predictor variables. The full tree was pruned using 10-fold cross-validation and a complexity parameter chosen using the 1 standard deviation rule on the average error from cross-validation. The pruned tree is shown in Figure 28 and explains 29.9% of the deviance. Fitted proportions were derived using gridded area defined by latitude 35.5 to 44.3 in 0.1 degree increments and longitude (-75.7 to -63.6, in 0.1 degree increments. Note that portions of this area do not contain observed trips. The fitted proportion positive tows are shown as level plots in Figure 29. Tow locations are shown in Figure 30. Areas with relatively high proportion of tows with windowpane are western Georges Bank, Southern New England near Long Island and the Nantucket Light ship area and inshore western Gulf of Maine.

Catch of windowpane weight per tow

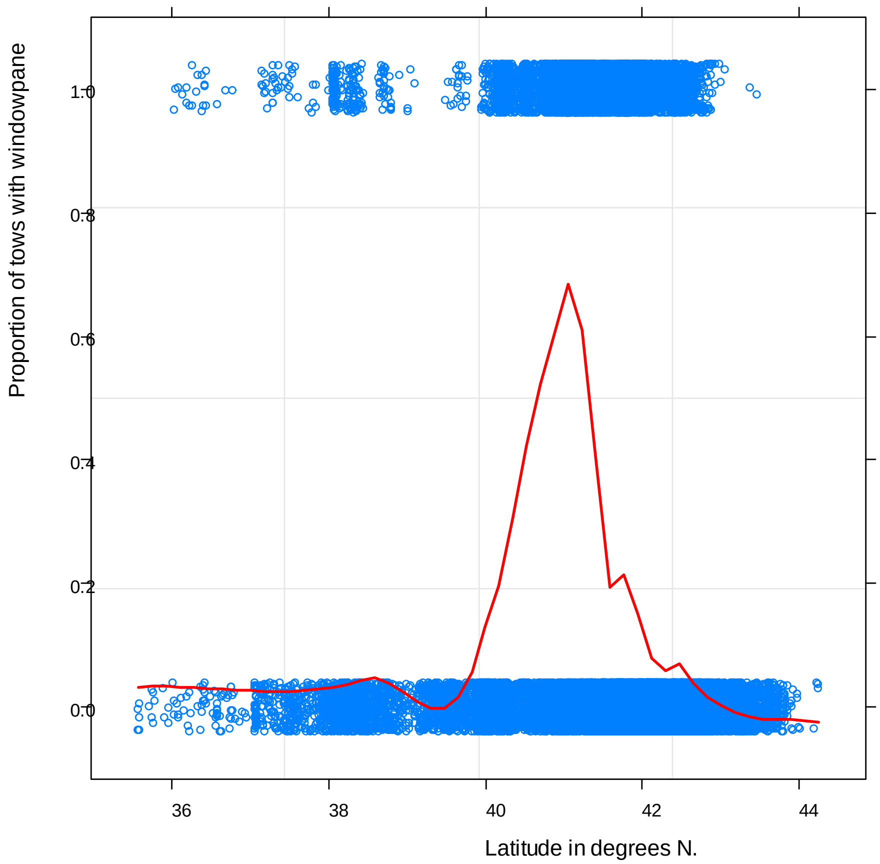
Windowpane are generally caught in small quantities, and 75% of tows with windowpane discards are 38 lb or less. However, the distribution is highly skewed right and tows with large amount of windowpane occur but are relatively rare. For example, the 90th quantile is 94 lb, the 99th quantile is 363, and the 99.9 is 1018 lb. Boxplots of the windowpane catch by bins of latitude and longitude are shown in Figure 31 and Figure 32. The Large contrast in the median or iterquartile range is not apparent in either the bins of latitiude or longitude. Bins with high number of observations do tend to have more observations at the tails than bins with fewer observations.

I used a regression tree to log10 windowpane discards using the same method applied to the proportion of tows. This analysis included tows with zero observations. The pruned tree is shown in Figure 33 and explains 29.9% of the deviance. Fitted proportions were derived using gridded area defined by latitude 35.5 to 44.3 in 0.1 degree increments and longitude (-75.7 to -63.6, in 0.1 degree increments. Note that portions of this area do not contain observed trips. An attempt to fit a regression tree to only tows with windowpane was unsuccessful, likely a result of lack of contrast in the observations.

The fitted proportion positive tows are shown as level plots in Figure 34. Tow locations are shown in Figure 30. Results are similar to areas identified with proportions. Given the lack of contrast in distribution of discards in the positive tows and skewness in the distribution, the proportion of zero tows is having a large influence on the analysis. The fitted values are highest off Long Island (7.0 lb per tow) and Southern Georges (5.6 lb per tow) and Georges Bank (3.7).

Comparison with spatial statistics analysis.
These areas identified as high and low discards generally correspond to area's identified Tom Nies's high-low clustering analysis using Getis-Ord G statistics.

Implications for using area management as an accountability measure.
The regression tree analyses identified areas with high and low proportion of tows with windowpane and also areas with high and low discard per tow. These results would need to be scaled by expected effort in order to be useful for defining areas to use as accountability measure. Additionally, the effects of redistributing effort to non- AM on windowpane discards needs consideration. The lack of contrast in the distribution of discarded windowpane suggests that areas may need to be larger rather than smaller to reduce windowpane discards and may reduce the economic yield from other groundfish species.


Proportion of tows with windowpane
1.0
0.8
0.6
0.4
0.2
0.0
36
38
40
42
44
Latitude in degrees N.

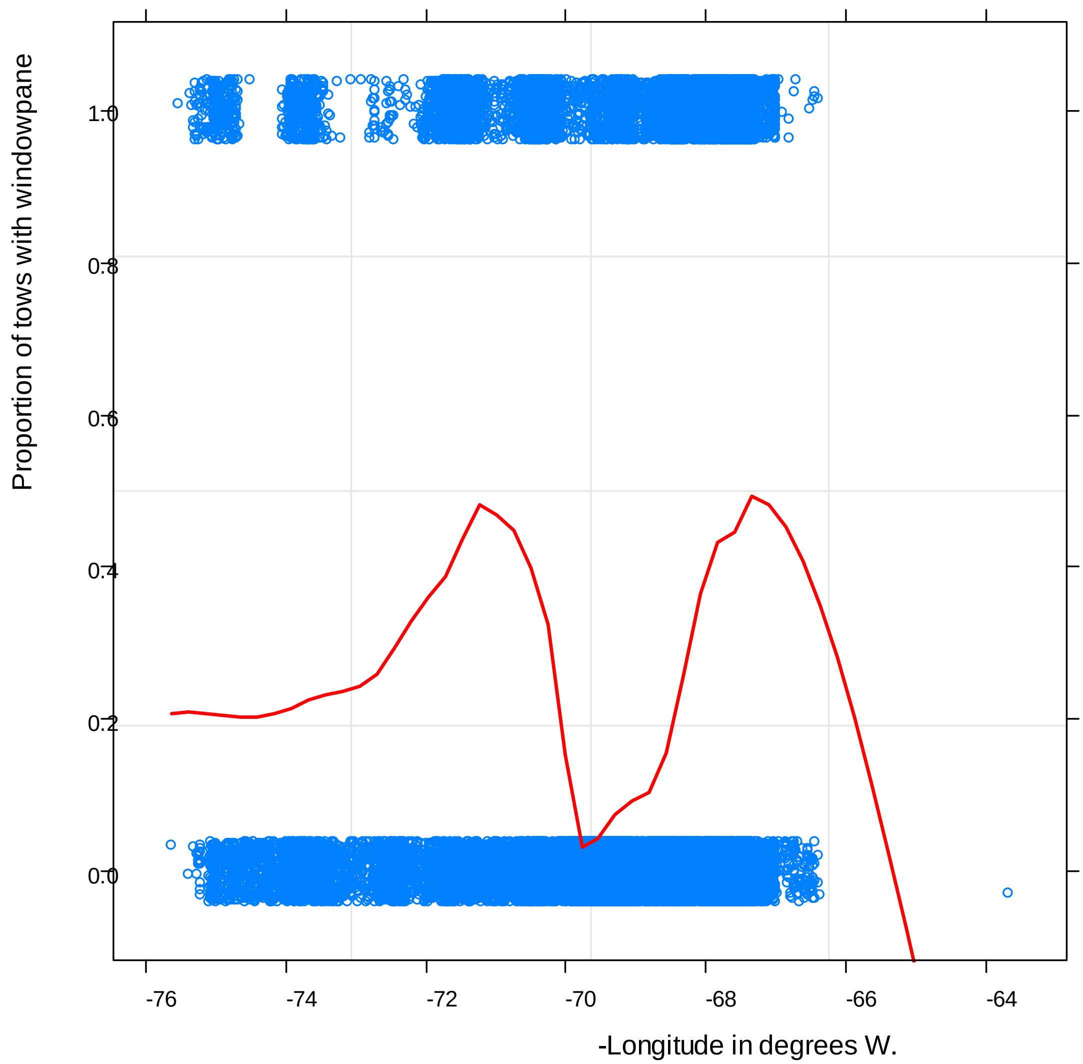


Figure 25. Proportion of tows with windowpane against beginning longitude. Red line is loess with span=0.2 and degree=1 and represents proportion positive tows. Blue dots are jittered presence (1)/ absence (0) of windowpane.

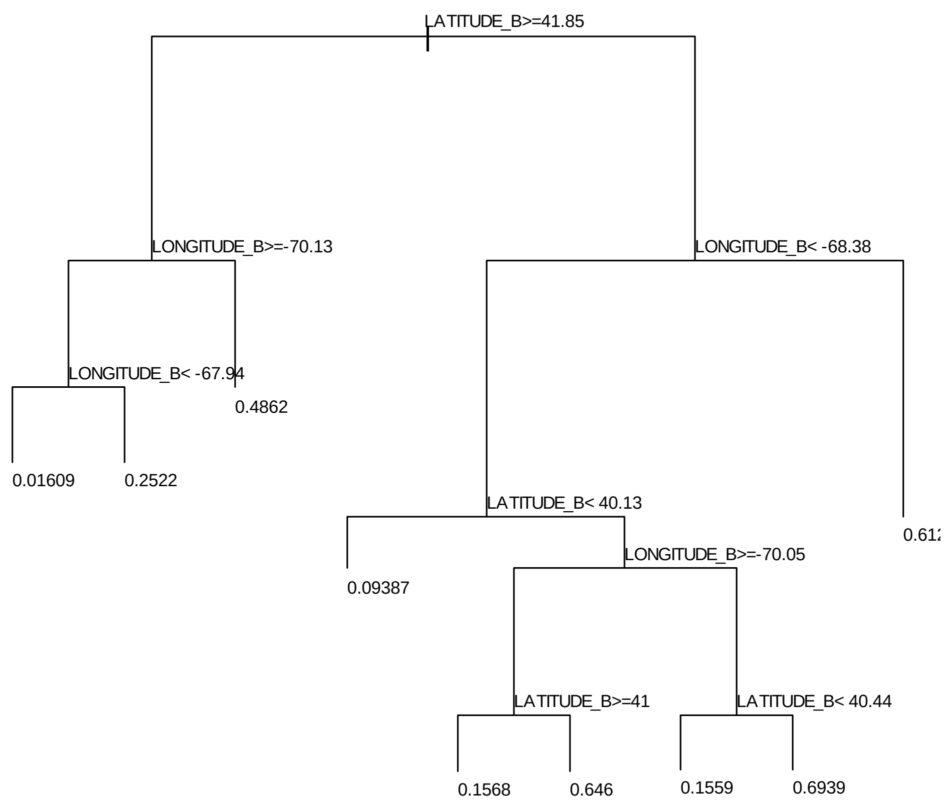


Figure 26. Partition tree for presence/absence (proportion) of windowpane in observed tows. Pruned tree using xerror+1 standard deviation as cut off criterion. Numbers at end of splits are fitted proportion of tows with windowpane.

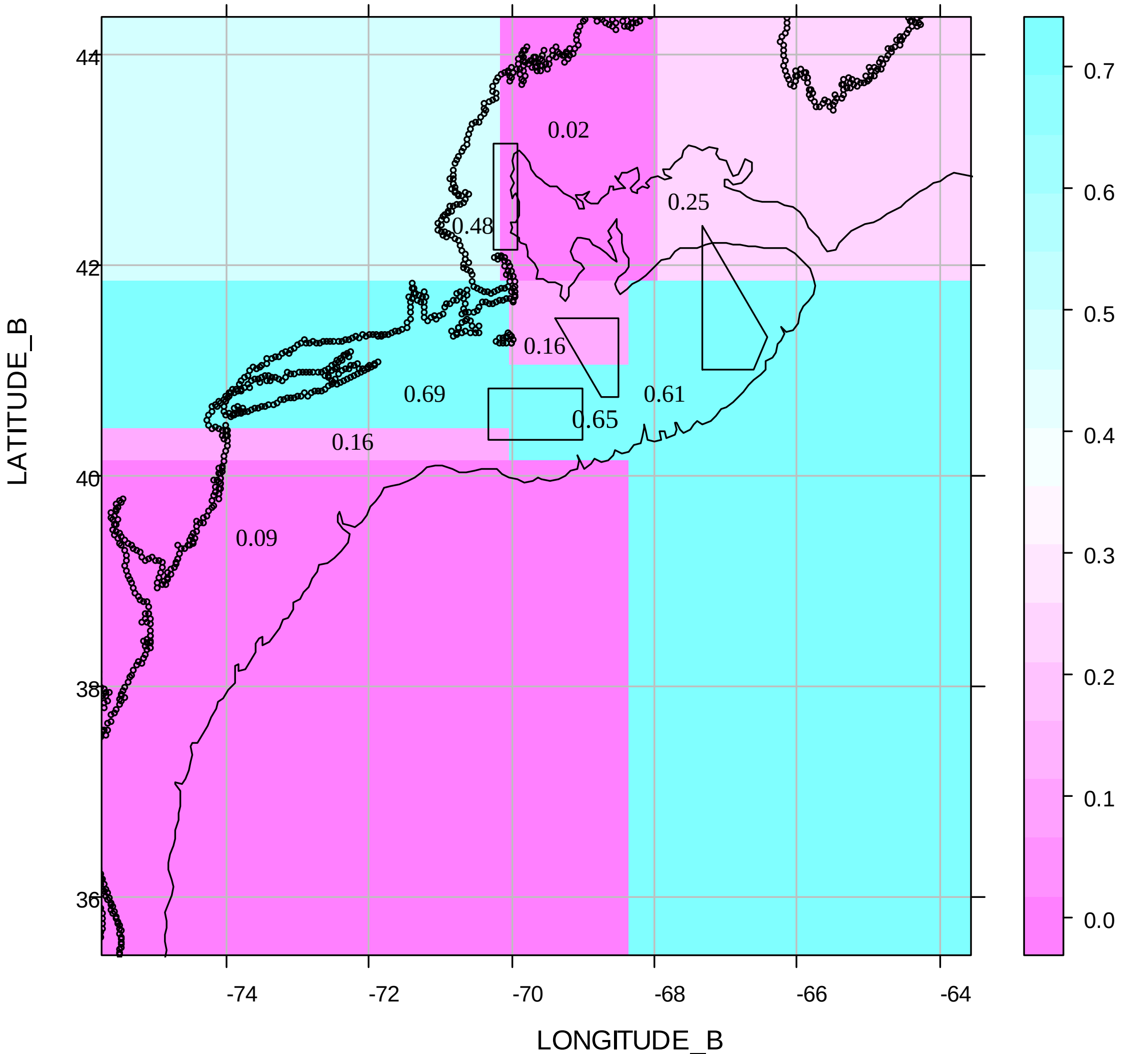


Figure 27. Levelplot of predicted proportion positive tows from tree regression based on latitude and longitude. Number within shaded area is proportion positive tows. Note that predicted values for areas without data should be ignored (see Figure 30 for location of tows) .

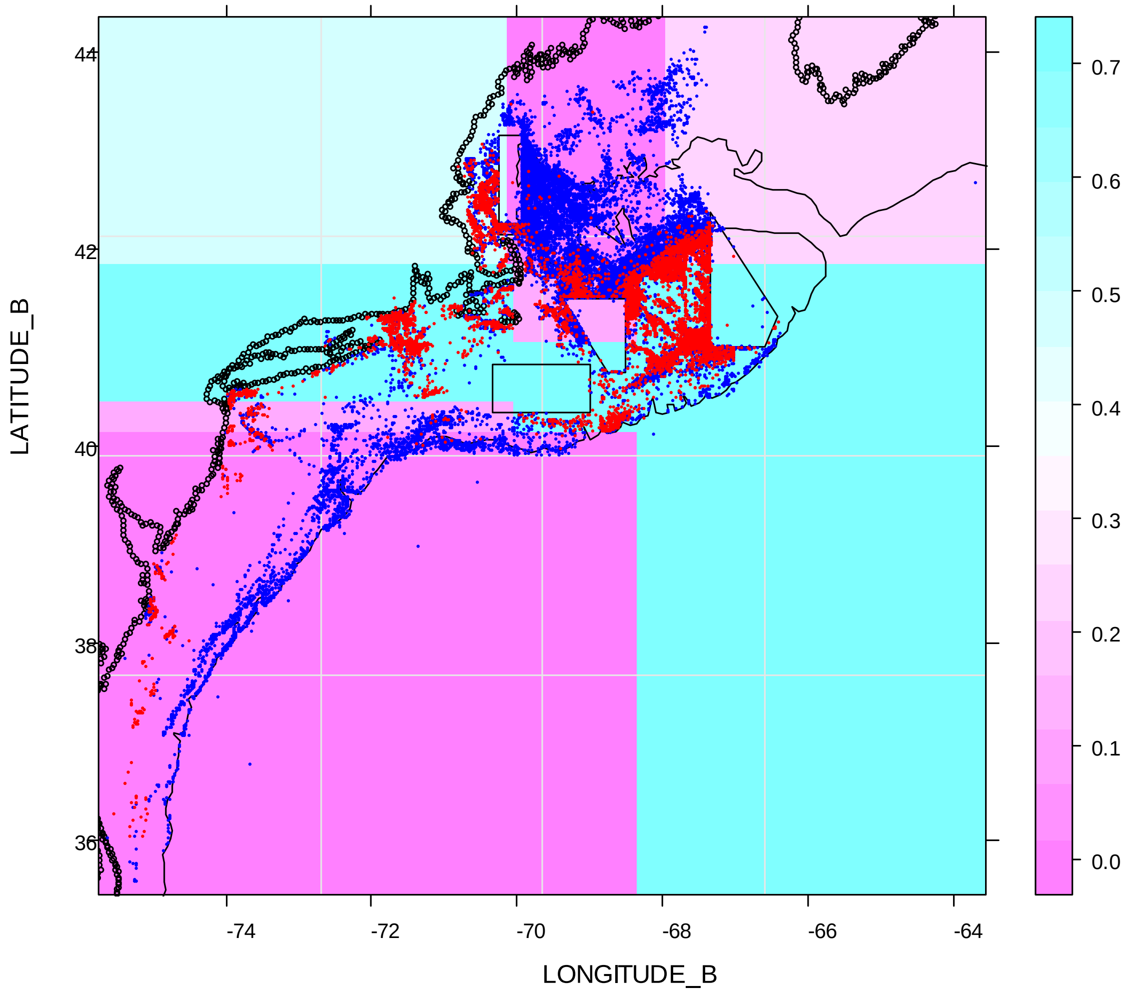


Figure 28. Same as Figure 3 but with observed tows (blue=no windowpane, red=windowpane observed). Colored regions coded to represent proportion of tows with windowpane (see scale on right).

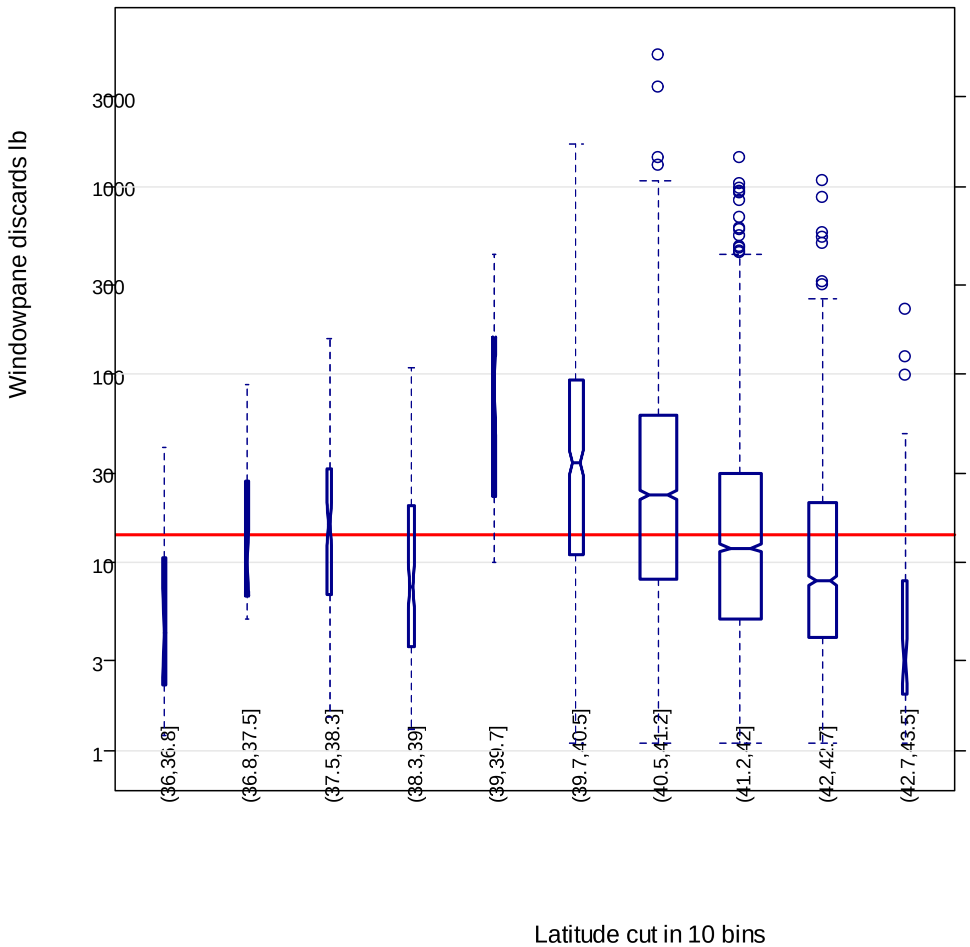


Figure 29. Boxplots of windowpane catch per tow (lb) by 10 bins of latitude. Zero tows not included. Width of box is proportional to square root of the number of observations. Red line is overall median. Note that y axis scale is logarithmic.

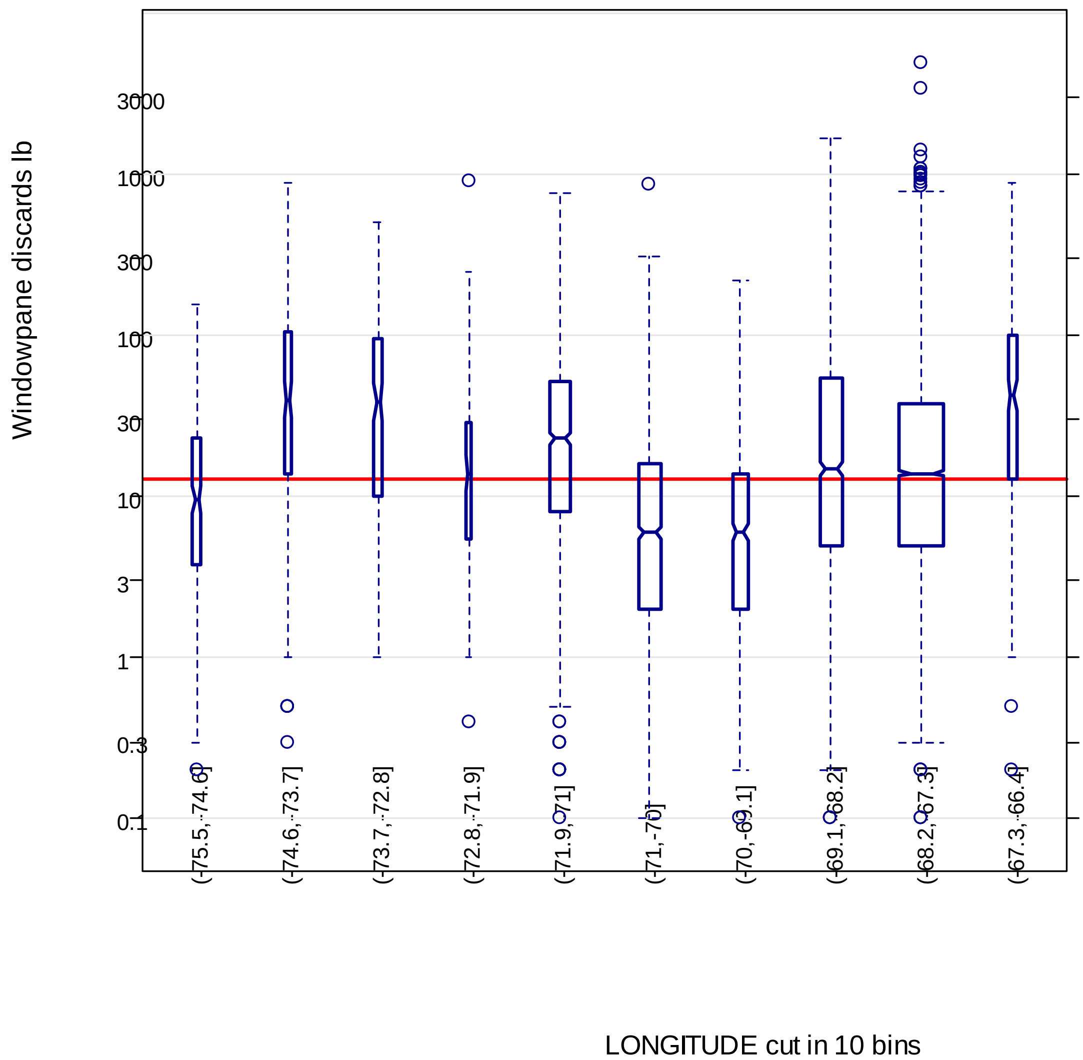


Figure 30. Boxplots of windowpane catch per tow (lb) by 10 bins of negative longitude. Zero tows not included. Width of box is proportional to square root of the number of observations. Red line is overall median. Note that y axis scale is logarithmic.

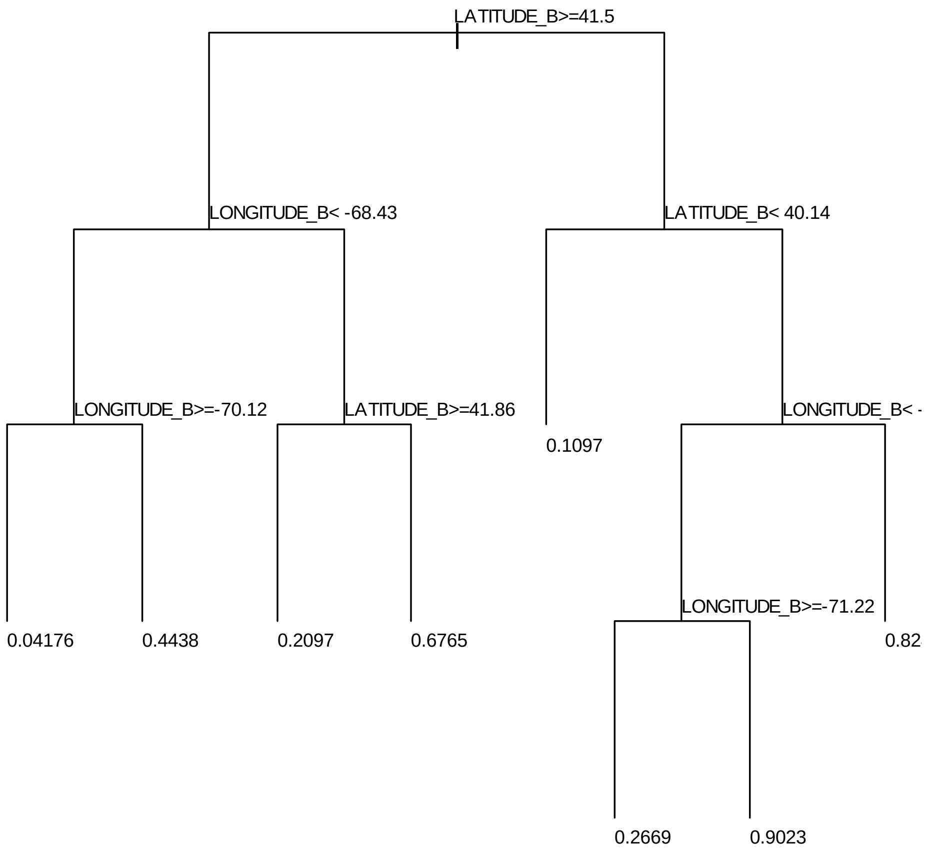


Figure 31. Pruned tree from regressing log10 windowpane discards against negative longitude and latitude. Numbers at end of leaves are log10 windowpane discards in lb.

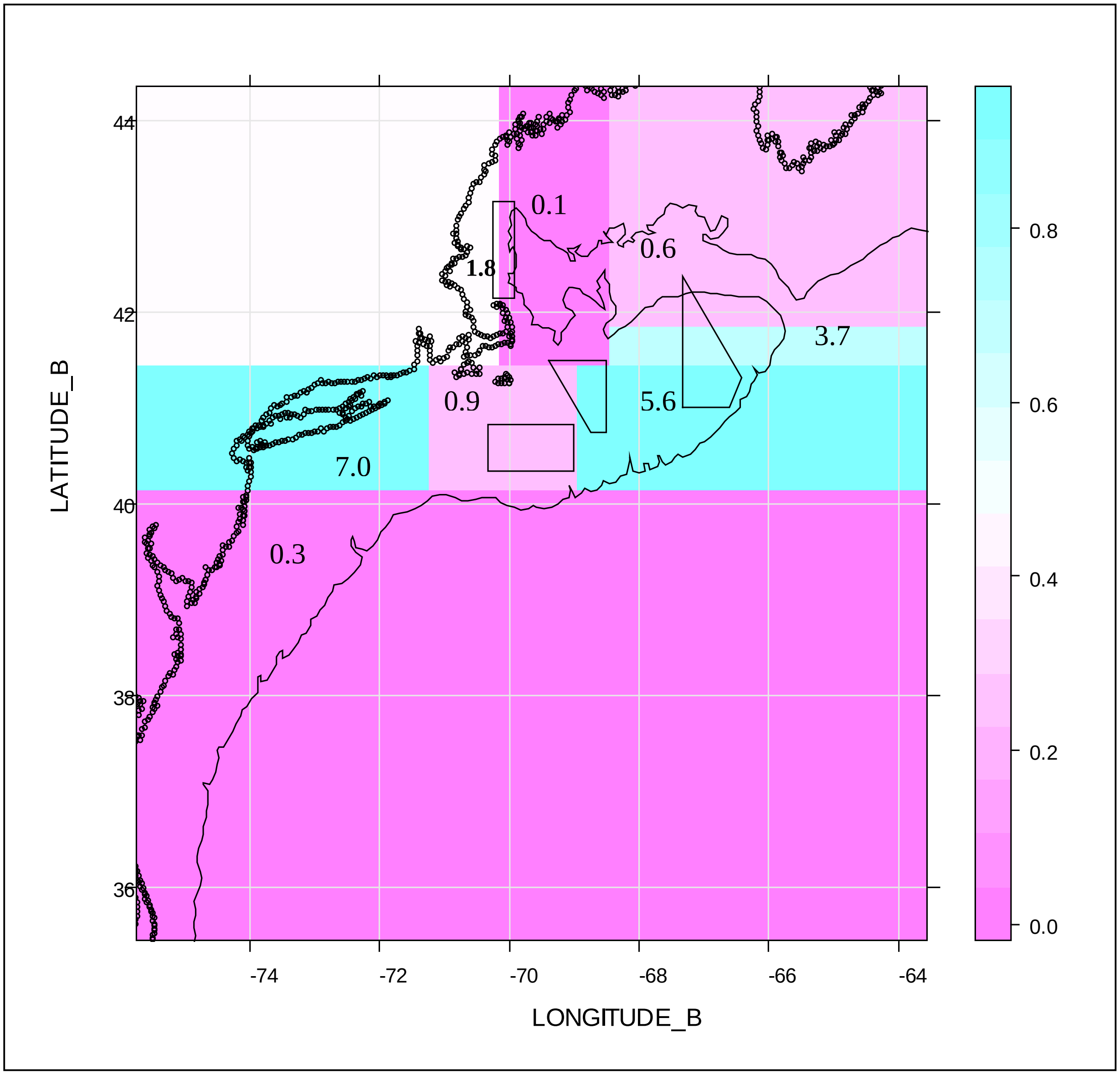

LATITUDE_B
LONGITUDE_B
44
42
40
38
36
-74
-72
-70
-68
-66
-64
0.0
0.2
0.4
0.6
0.8
0.1
1.8
0.6
3.7
0.9
5.6
7.0
0.3

Figure 32. Levelplot of tree regression of log10 windowpane dk* hailwt +1 lb. Numbers within the chart are the back-transformed geometric mean catch (lb). Scale on right bar is in common logs. Note that predicted values for areas without data should be ignored (see Figure 30 for location of tows)