

Draft working paper for predissemination peer review only

Working Paper #2
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**Estimating in-season discards from the Northeast United States groundfish fishery:
Discard Estimator Performance Simulation Study (Part I)**

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A working paper in support of the Discard Estimation Methodology Review

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Introduction

A comparison of discard estimator performance was initially accomplished through a simulation study using observer data within Microsoft Excel (MS Excel). This simulation study was developed in preparation for the discard estimation methodology working group meeting on November 18, 2009 at the Falmouth Technology Park. The initial simulation work compared the proposed moving average estimators, a newly developed cumulative estimator, and the estimators (combined ratio, quarter stratified) used in SBRM and the groundfish stock assessments (Wigley et al. 2007). The proposed moving average ratios differed from the ratios used in US Canada quota monitoring by using kept all in the denominator instead of the species kept for the discarded species (Caless and Wang 2004). The working group concluded from the initial simulation study that the moving window estimators produce biased estimates of the discards. In most cases the moving window estimators trend to be biased high. This working paper (Part 1) describes the initial simulation study along with some additional work done after the meeting on testing simulation assumptions and the effects of data trimming on the estimators. Working paper 2 (Part 2) describes additional simulation work done after the working group meeting which focused on the performance of the cumulative and temporal stratified estimators incorporating calculations of the variance on the estimators (Palmer 2010). This final simulation study was recoded in SAS due to computation limitations within excel.

MS Excel Simulation Study

The initial MS Excel simulation study was developed using observer trip data. A dataset constructed from observed data should capture the expected variation associated with discard monitoring. Stock, gear, and mesh specific observer trip data was retrieved to fabricate a years worth of data. The initial MS Excel simulation study assumes that one trip occurs on each day of the year. After the November 18th working group meeting the MS Excel simulation was reconfigured to accept actual observer data collected over time to test the effect of this assumption. In addition, the subsequent SAS simulation (Part 2) did not require an observer trip on each day of the year. After the observed trip data is assembled then the known discards are calculated from the sum of the discards across all trips. Different estimators were compared through random pulls of the trip data using a targeted sampling rate (observer coverage rate). Estimates for each estimator from 5000 random draws were compared relative to the true discards. Results from a range of targeted sampling rates (10%, 20%, 40%, 60% and 95%) were examined. The targeted sampling coverage rate in the MS Excel simulation results in a distribution of the actual coverage rates within the simulation. In the SAS simulation (Part 2) the exact coverage rate was accomplished within each iteration through sampling without replacement.

The estimators examined were a 20, 35 and 50 day discard/kept all moving window, cumulative discard/kept all ratio method, combined ratio estimator, and a quarter stratified discard/kept all estimator. The cumulative and quarter stratified estimators are variants of the separate ratio (Cockran, 1963). The cumulative method is essentially the same as the quarter stratified method with no temporal stratification. The separate and combined ratio estimators are described in Standardized Bycatch Reporting Methodology (SBRM) (Wigley et al. 2007).

Separate Ratio Estimator

Total discarded pounds of species j is defined as:

$$(1) \quad \hat{D}_{1,j} = \sum_{h=1}^L K_h r_{s,jh}$$

where

$$(2) \quad r_{s,jh} = \frac{\sum_{i=1}^{n_h} d_{jih}}{\sum_{i=1}^{n_h} k_{ih}}$$

$\hat{D}_{1,j}$ is the total estimated discarded pounds for species j ;

K_h is the total kept pounds in stratum h ;

$r_{s,jh}$ is the separate ratio for species j in stratum h ;

d_{jih} is discards of species j from observed trip i in stratum h ;

k_{ih} is kept pounds of all species on observed trip i in stratum h ;

L is the number of strata $h=1, \dots, L$

Combined Ratio Estimator

The combined ratio method is based on a ratio estimate pooled over all strata and trips within strata. Total discarded pounds for species j is defined as:

$$(1) \quad \hat{D}_{2,j} = \sum_{h=1}^L K_h r_{c,j}$$

where

$$(2) \quad r_{c,j} = \frac{\sum_{h=1}^L N_h \sum_{i=1}^{n_h} \frac{d_{jih}}{n_h}}{\sum_{h=1}^L N_h \sum_{i=1}^{n_h} \frac{k_{ih}}{n_h}}$$

where

$D_{2,j}$ is total discarded pounds for species j ;
 K_h is total kept pounds in stratum h ;
 $r_{c,j}$ is the combined ratio of species j ;
 d_{jih} is discards of species j from trip i in stratum h ;
 k_{ih} is kept pounds of all species on trip i in stratum h ;
 N_h is the number of total trips in stratum h ;
 n_h is the number of observed trips in stratum h .
 L is the number of strata $h=1, \dots, L$

The moving window ratio estimators are applied to the total kept all for the day $(t+1)$ after the window. The estimated ratio within the initial (startup) window is calculated from all trips in the initial window. The initial window ratio is applied to the kept all for each day within the window. Therefore this information is not available until the day after the initial window has past. In the excel simulations if random sampling does not result in an observer trip within the window then the run drops out of the simulation due to an undefined divide by zero calculation. The number of iterations which drop out of the simulation due to the lack of observed trips was tracked and can be used as an indication of estimator applicability in relation to the sampling. The cumulative method continually updates the estimated discard / kept all ratio using all the data to date and applies this ratio to the cumulative kept all to date. This method does allow for adjustments in the discards as more data becomes available. Although not a common occurrence, a reduction in the estimated discards over time can occur as data becomes available. Functionally this occurs if the additional information causes the discard kept all rate to drop such that it overcomes any increases in kept all since the last computation. The overall estimated discards usually tend to increase over time because the multiplier (kept all) is always increasing through time. Figure 1 shows an example of the estimation over time of the 35 day moving average and the cumulative method in comparison to the true discards for a single iteration. The cumulative methods can be started with the first observed trip. The combined ratio and stratified by quarter method were done as a comparison to what the stock assessments used in the groundfish assessments.

For the moving average estimators if an observed trip occurred, then the actual observed discards were used for the trip and not the estimated discards using the estimator. Amendment 16 explicitly states that observed discards will be directly counted as part of the catch on observed trips (NEFMC 2009). However, for the cumulative method the results were the same whether this is or is not explicitly accounted for. The working paper entitled “Methods to Determine Discards from Observed Trips” describes the functional details required in the data structure to perform the discard monitoring calculations (Wigley 2010).

Seven different temporal discard scenarios using large mesh trawl were developed and tested in the initial MS Excel simulation. Scenarios were developed from Gulf of Maine cod and Georges Bank haddock large mesh trawl fisheries. Georges Bank haddock was

used to test possible trends in discarding that could occur associated with a large year class (GARM III, NEFSC 2008). The seven scenarios were Gulf of Maine Cod, Gulf of Maine Cod with the trips randomly reordered to test a possible influence of autocorrelation, Georges Bank haddock with high discards associated with a strong year class at the beginning, middle, and end of the year. The last two scenarios tested an artificial extreme trend in the discards through a descending and ascending sort of the Georges Bank haddock discard rates. Results of the MS Excel simulation structured as seven different scenarios with 5 different coverage rates and 5000 random draws resulted in 175,000 iterations and are summarized in figures 2 through 15. An additional run was done to test the influence of accounting for discards on observed trips for the moving average estimators (Figure 16 and 17).

In general, the moving average window estimators tend to be biased high. This bias is likely influenced by high discard trips which can be reused depending on the size of the window. The reuse of an outlier trip in the moving average could amplify the estimated discards. The moving average window estimator will produce biased low estimates if discards have an increasing trend over time. This is probably the result of high discard trips not being utilized by the moving window at the end of the year. The simulation work reveals that the amount of bias will change depending on the temporal trends in the Discard/kept all ratio over time. The moving window estimators do better with higher coverage rates since a higher proportion of the discards are taken directly from the observed trips and are not estimated (Figure 16 and 17). The cumulative to date estimator seems to have the best relative performance overall. In many cases the cumulative estimator performed just as good if not better than the combined ratio and stratified by quarter estimators. In general, the combined ratio and the stratified by quarter estimators had slightly less variability when a temporal trend exists in the discards. A run comparing the maximum cumulative discard estimate on any day of the year to the true discards at the end of the year produced only a slight shift in the distribution in comparison to the distribution at the end of the year (Figure 18). This suggests that overshooting the end of the year estimates during the year is not a big concern.

After the November 18th working group meeting the MS Excel simulation was reconfigured to accept collected observer trip data by date. Judging from additional runs done with the reconfigured MS Excel simulation there appears to be little influence of the one trip per day assumption in the original MS Excel simulations. Example calendar year runs for 2004 and 2008 for Gulf of Maine Cod are in figures 19 and 20. In addition, the cumulative separate ratio estimators had similar performance in the SAS simulation work suggesting that the one trip per day assumption had little impact.

Four runs using large mesh trawl Gulf of Maine cod were done to test the influence of trimming outlier trips in the estimation (Figures 21 to 25). Run 1 omitted the 3 highest trips (greater than 3000 lbs discarded per trip) in the estimation. Run 2 omitted the eight highest trips (greater than 2000 lbs discarded per trip) in the estimation. Run 3 omitted all trips with zero discards and run 4 omitted both the zero discard trips and the 3 highest discard trips from the estimation. The four data trimming runs suggest that outlier

omission results in highly biased estimates for all of the estimators. The results are very sensitive to the trimming of outliers suggesting that data trimming should not be done when monitoring discards.

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Cales, D. and S. Wang. 2004. Methodology for US/Canada shared resources monitoring. Unpublished manuscript.

Cochran, W.L. 1963. Sampling Techniques. J. Wiley and Sons. New York.

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Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884.

Palmer, M.C. 2010. Estimating in-season discards from the Northeast United States groundfish fishery: an investigation of the separate ratio method (Part II). Working Paper #3. Discard Estimation Methodology Review.

Wigley SE, Rago PJ, Sosebee KA, Palka DL. 2007. The Analytic Component to the Standardized Bycatch Reporting Methodology Omnibus Amendment: Sampling Design, and Estimation of Precision and Accuracy (2nd edition). US Dep. Commer., *Northeast Fish. Sci. Cent. Ref. Doc.* 07-09.

Wigley SE. 2010. Methods to determine discards from observed trips. Working Paper #1. Discard Estimation Methodology Review.

Gulf of Maine Cod 40% Coverage Rate

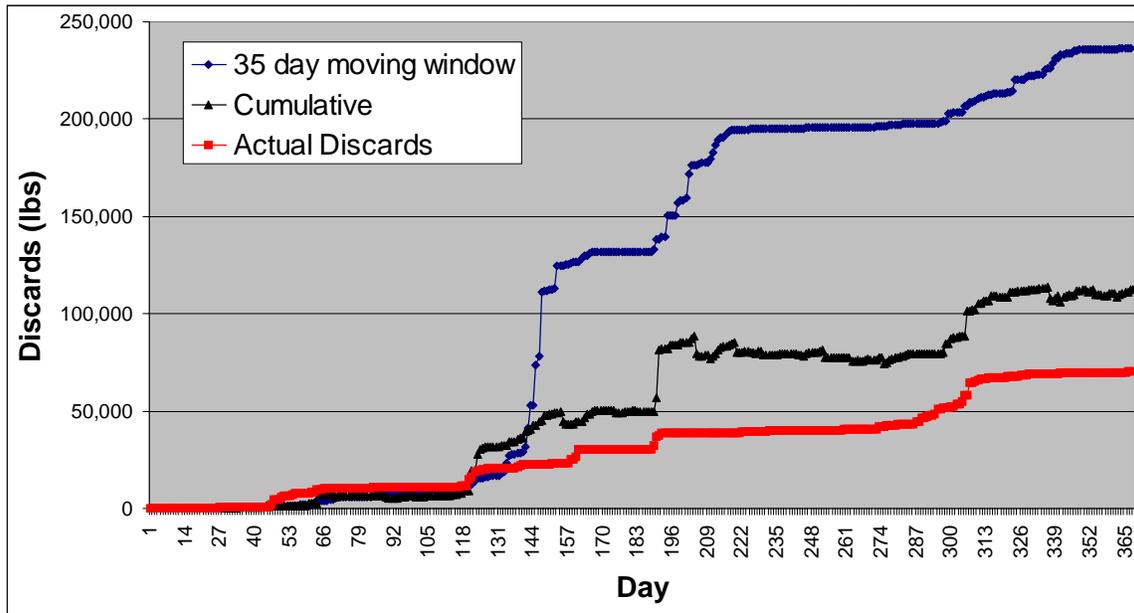


Figure 1. An example of a single iteration of the estimated discards over time for the 35 day moving average and the cumulative method in comparison to the true discards.

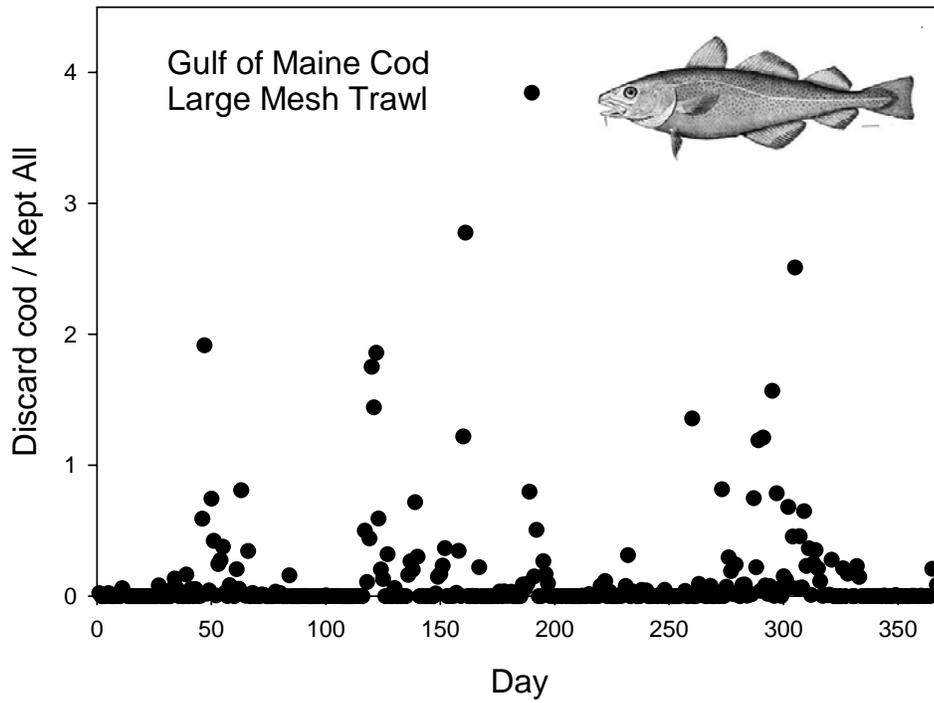


Figure 2. Discard to kept all ratios over time for the Gulf of Maine cod large mesh trawl scenario.

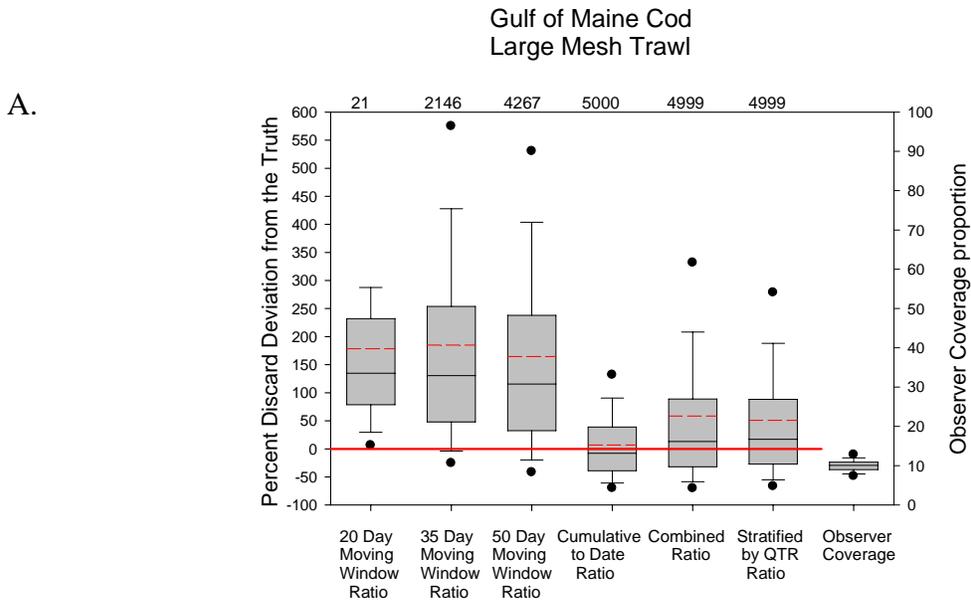


Figure 3. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Gulf of Maine cod scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentile. Note the range on the left hand y-axis does rescale comparing plots A through E.

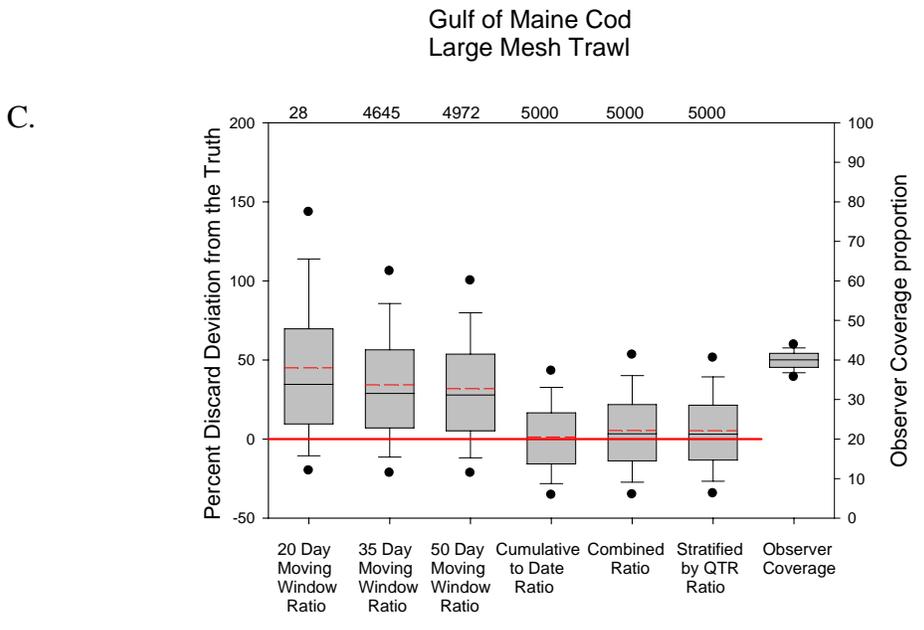
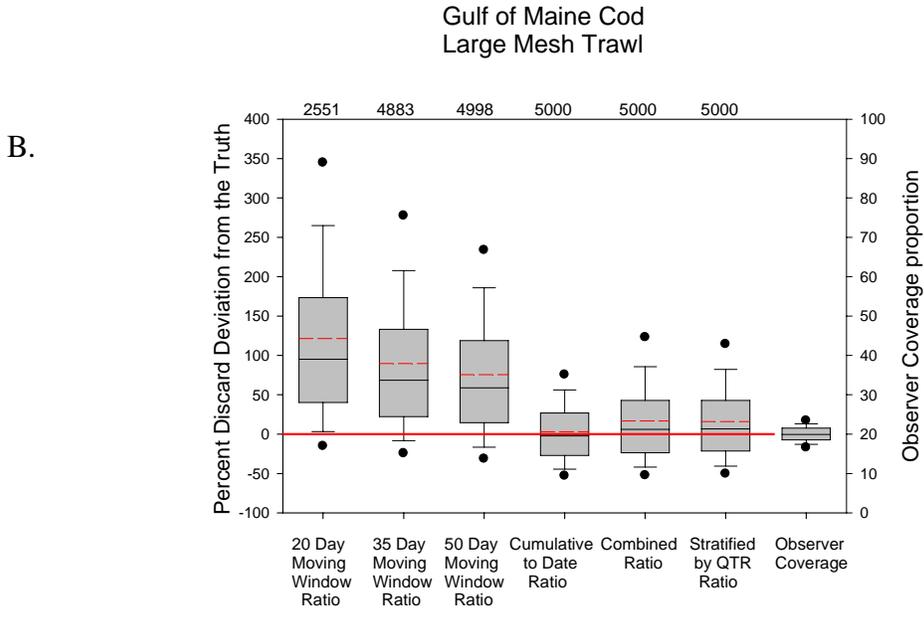
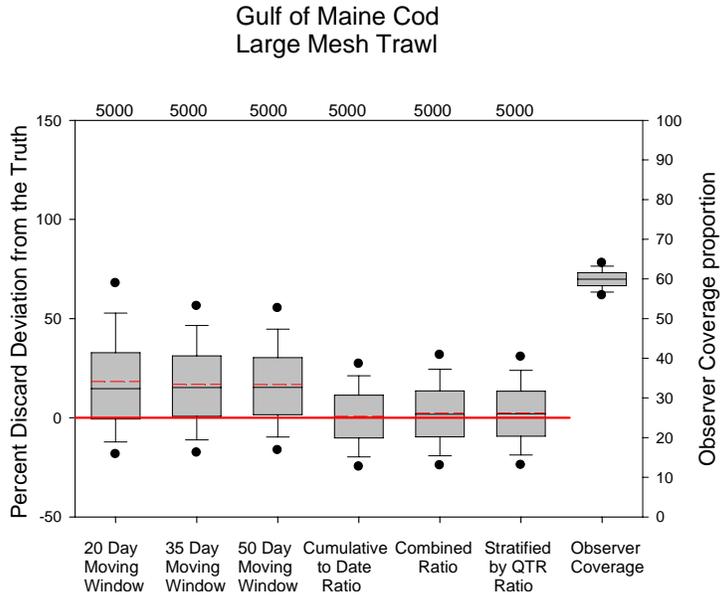


Figure 3. cont.

D.



E.

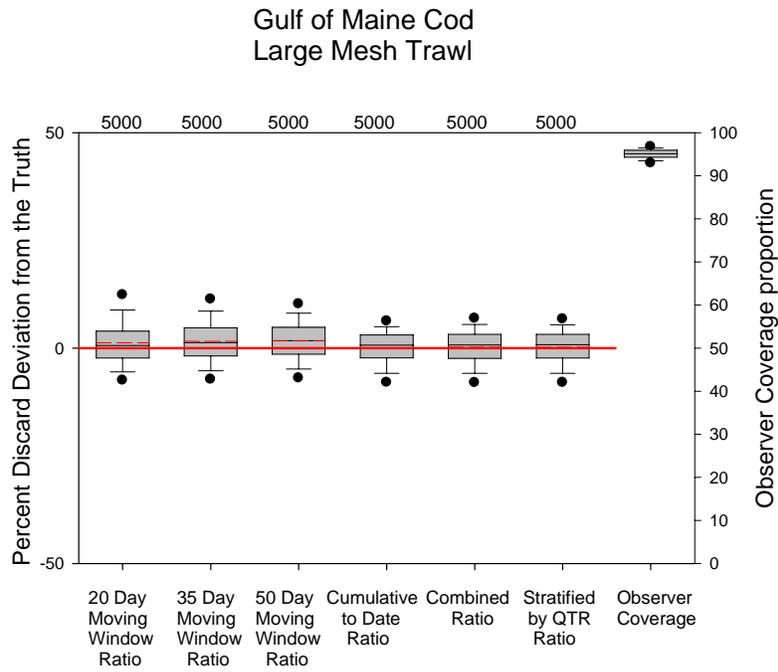


Figure 3. cont.

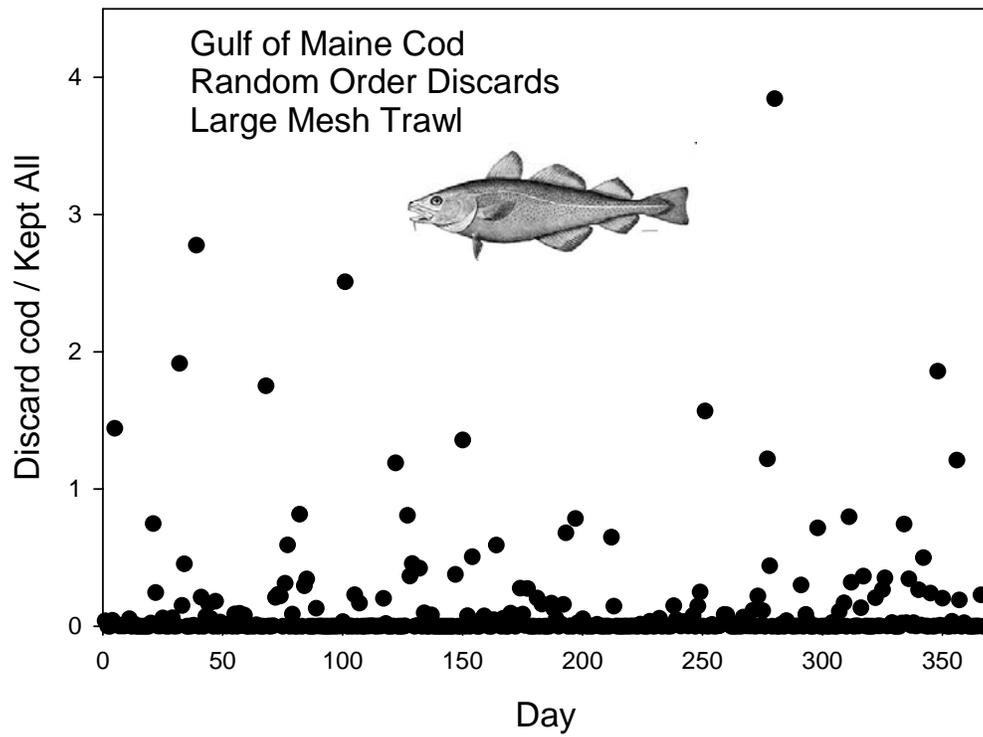


Figure 4. Discard to kept all ratios over time for the Gulf of Maine cod large mesh trawl scenario which randomly reordered the days to test for possible autocorrelation effects.

Gulf of Maine Cod
 Random Order Discards
 Large Mesh Trawl

A.

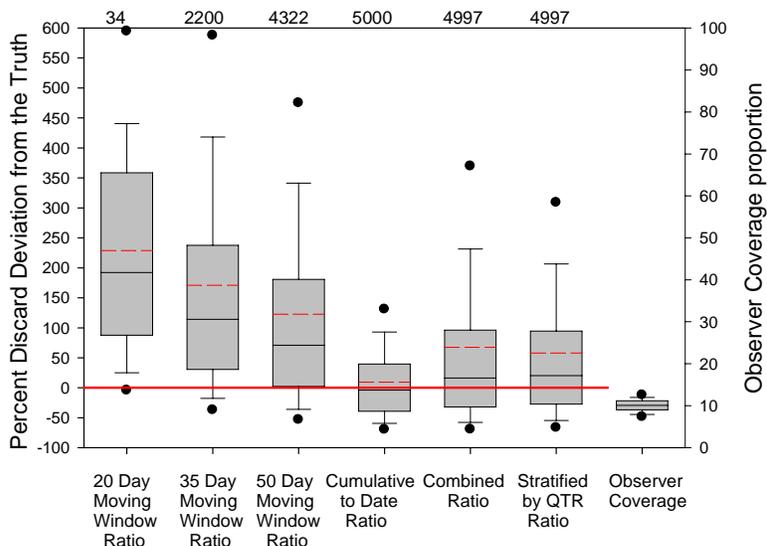


Figure 5. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Gulf of Maine cod with random reorder of the discard ratios scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentile. Note the range on the left hand y-axis does rescale comparing plots A through E.

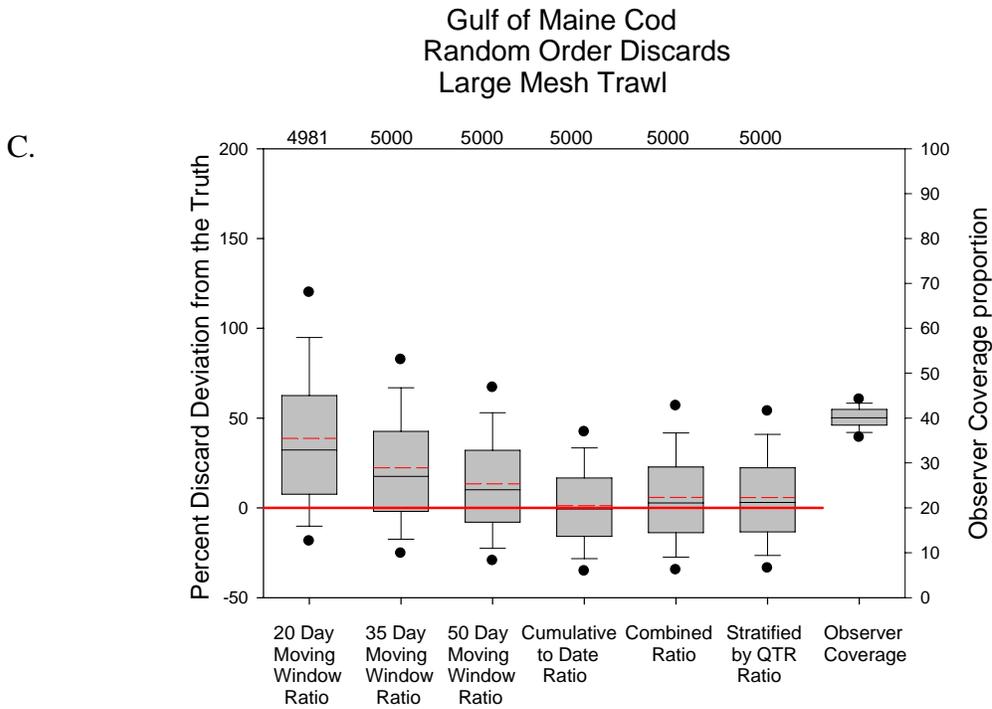
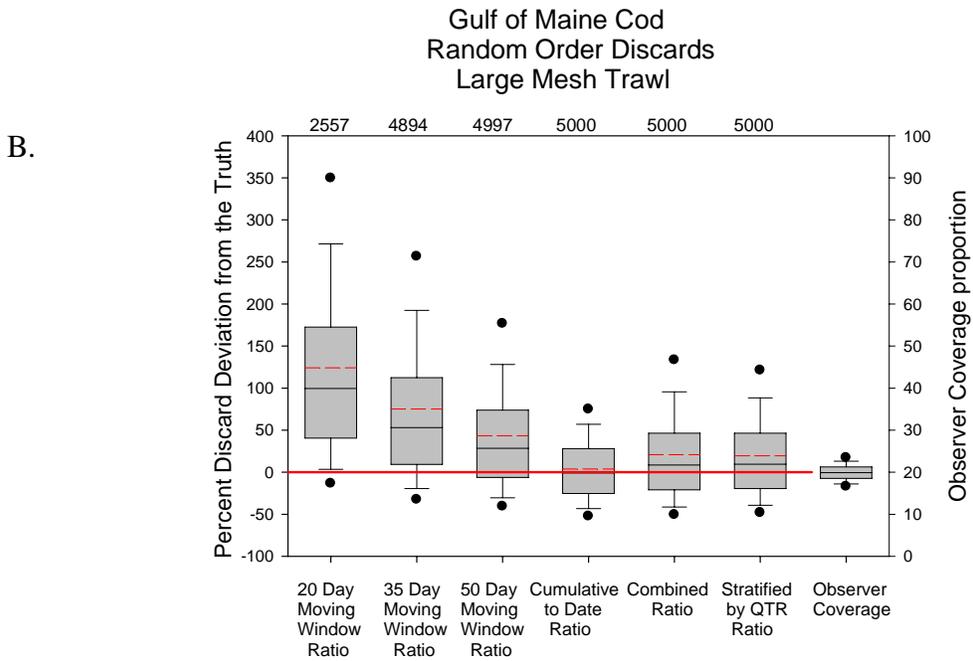
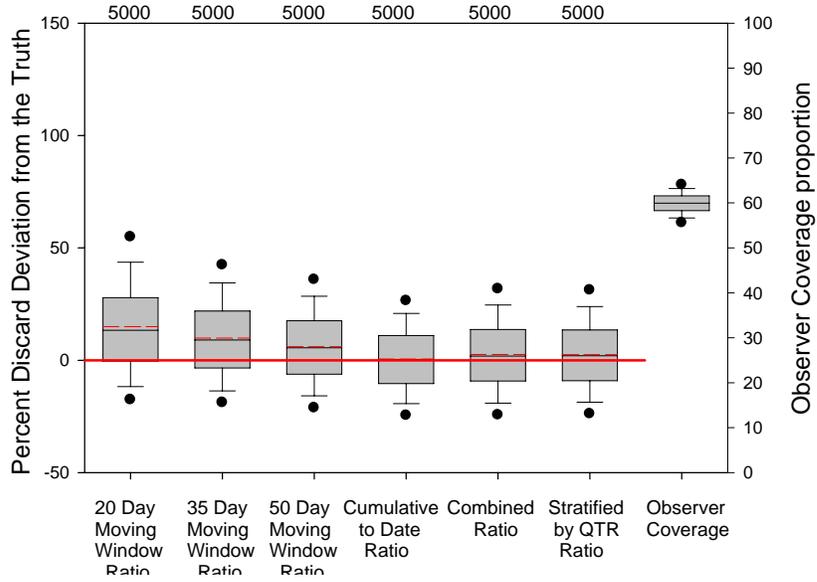


Figure 5. cont.

Gulf of Maine Cod
Random Order Discards
Large Mesh Trawl

D.



Gulf of Maine Cod
Random Order Discards
Large Mesh Trawl

E.

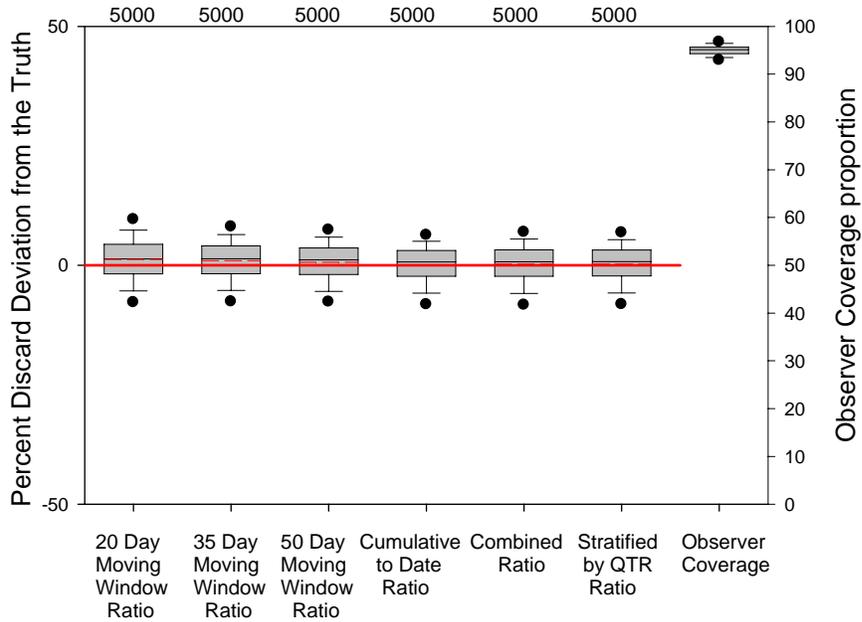


Figure 5. cont.

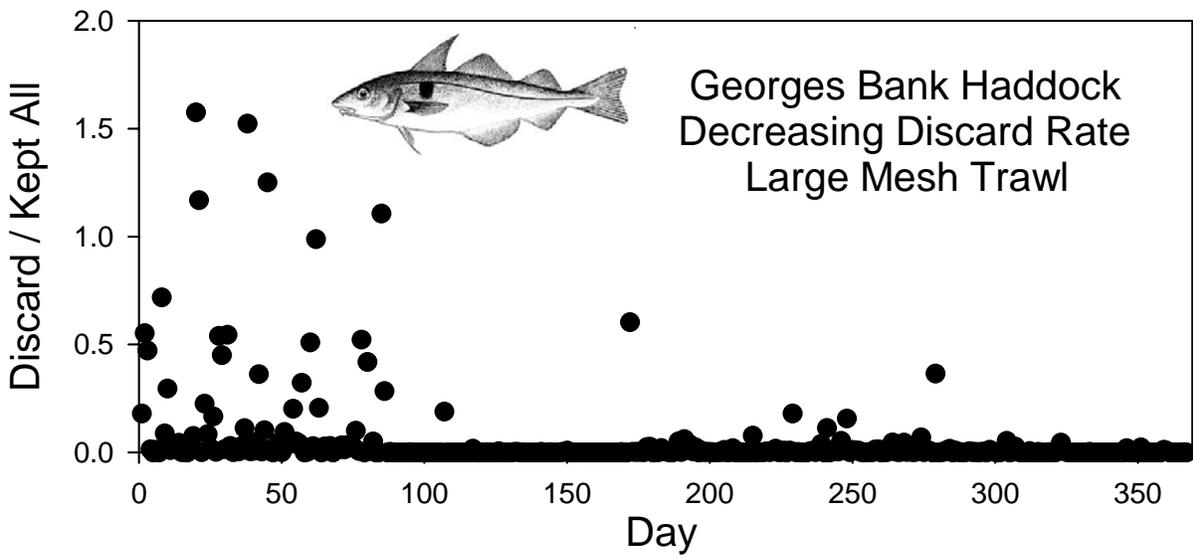


Figure 6. Discard to kept all ratios over time for the Georges Bank haddock large mesh trawl scenario using high discards associated with a large year class at the beginning of the year.

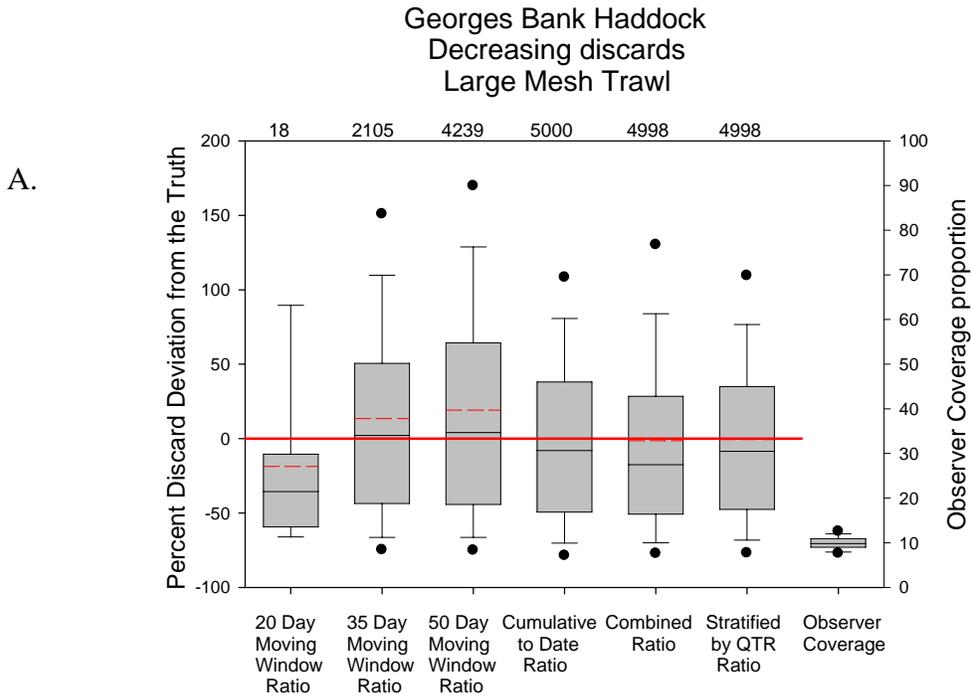


Figure 7. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Georges Bank Haddock with decreasing discard trend scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentile. Note the range on the left hand y-axis does rescale comparing plots A through E.

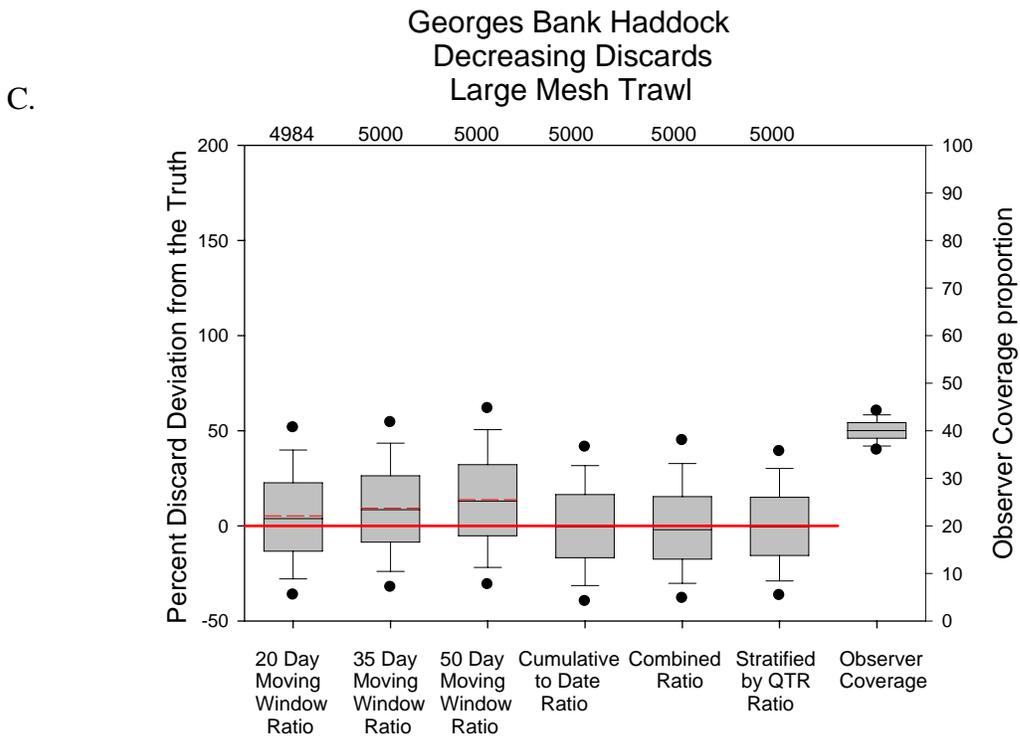
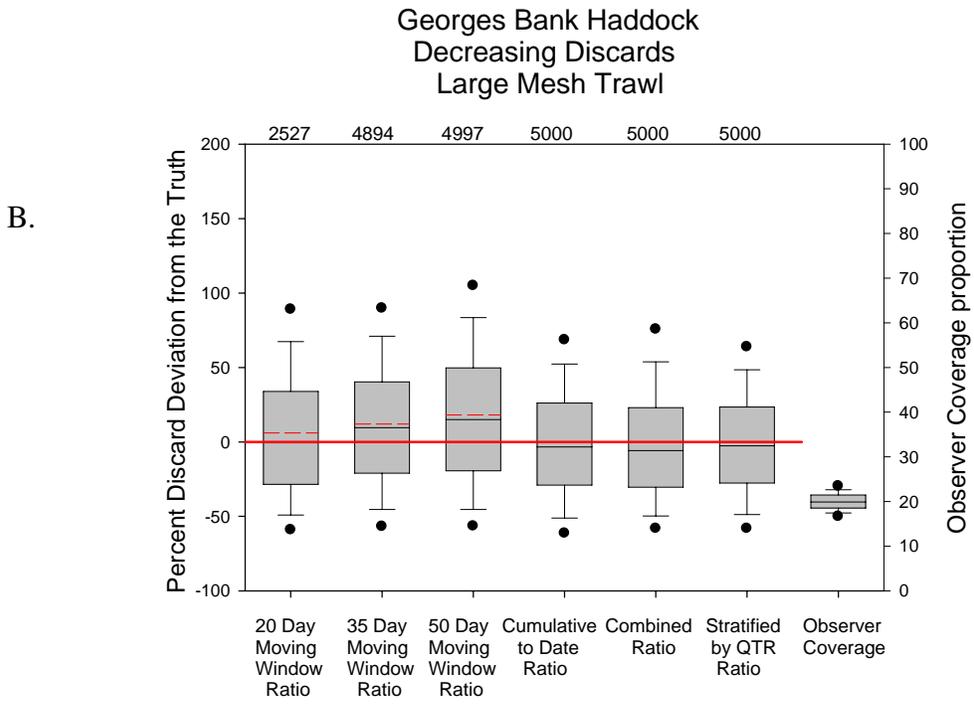


Figure 7. cont.

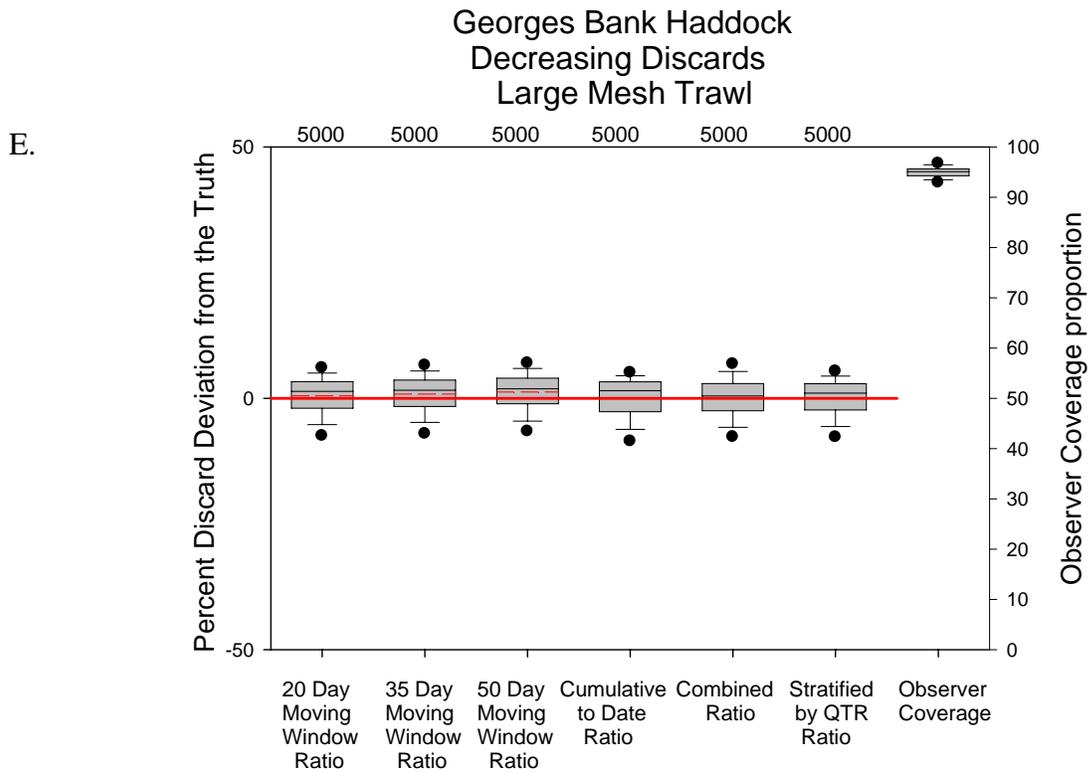
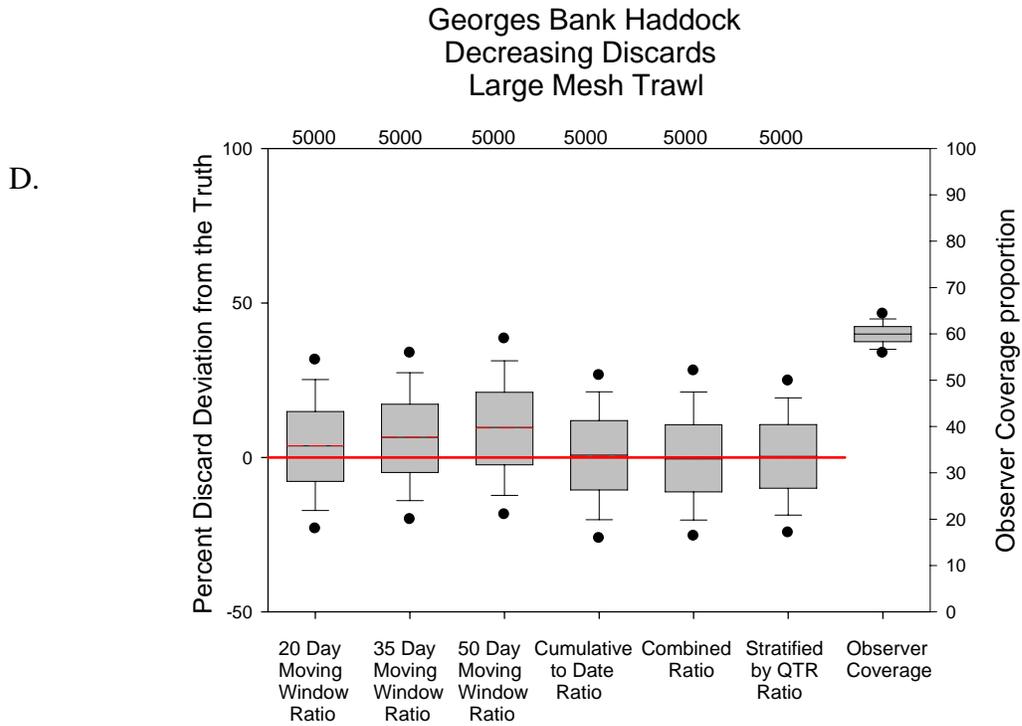


Figure 7. cont.

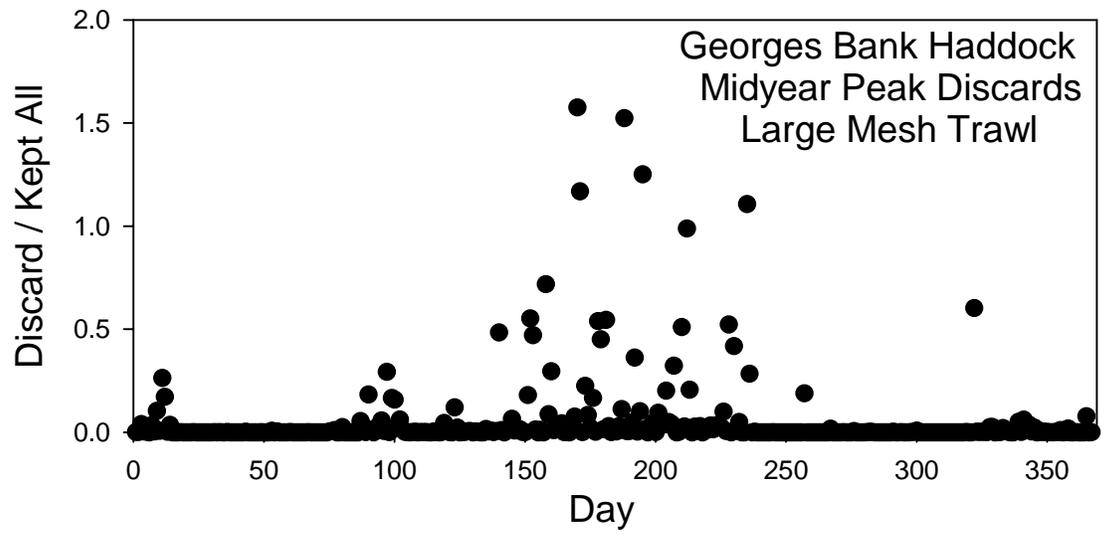


Figure 8. Discard to kept all ratios over time for the Georges Bank haddock large mesh trawl scenario using high discards associated with a large year class in the middle of the year.

Georges Bank Haddock
 Midyear Peak Discards
 Large Mesh Trawl

A.

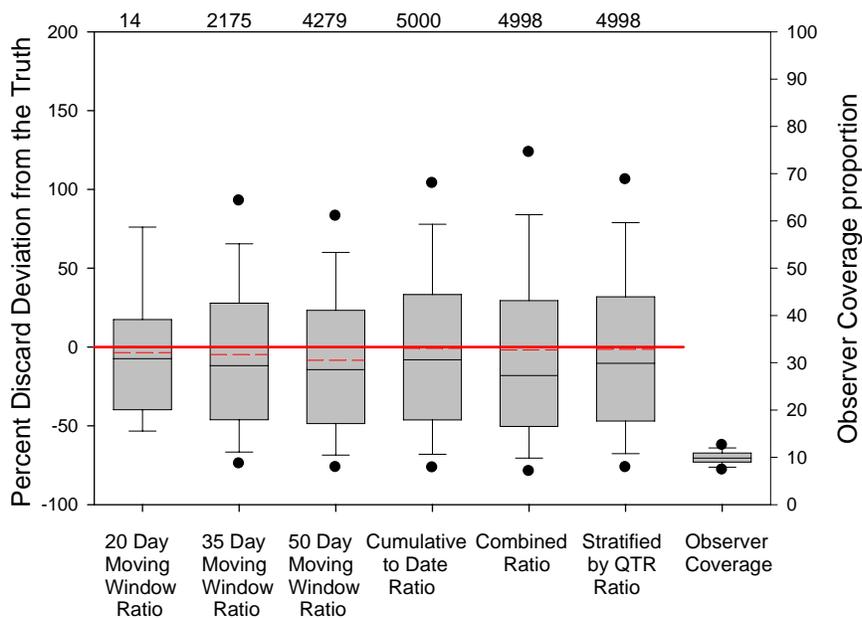
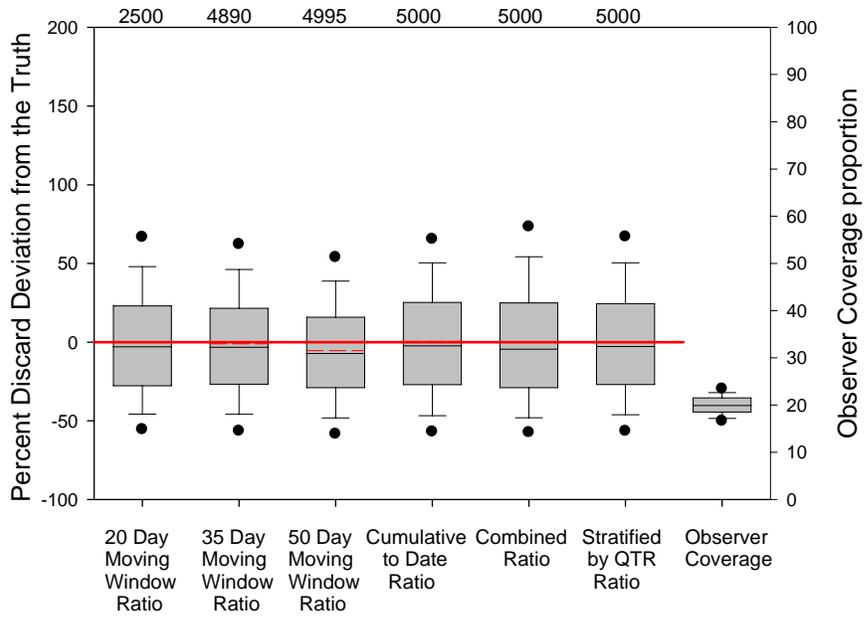


Figure 9. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Georges Bank Haddock with high discards midyear scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentile. Note the range on the left hand y-axis does rescale comparing plots A through E.

Georges Bank Haddock
Midyear Peak Discards
Large Mesh Trawl

B.



Georges Bank Haddock
Midyear Peak Discards
Large Mesh Trawl

C.

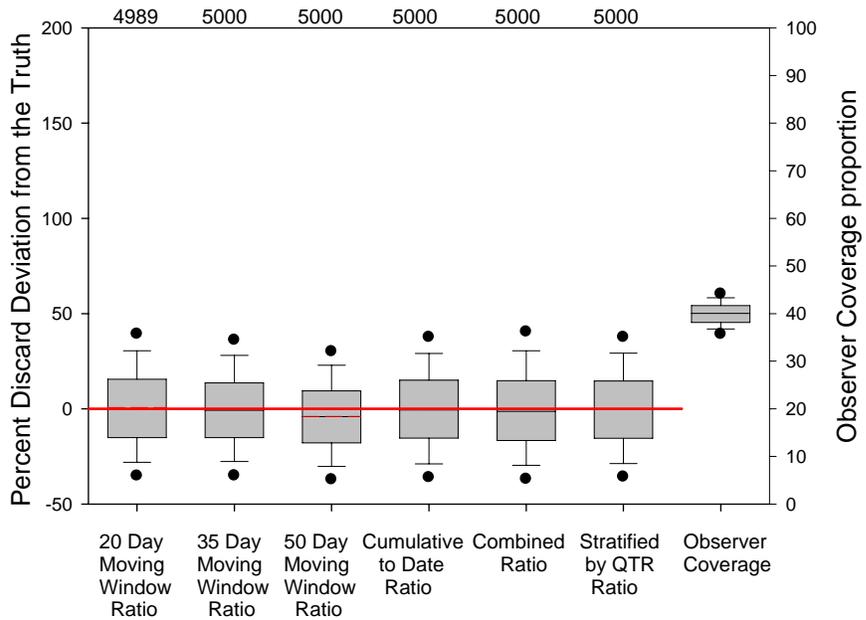
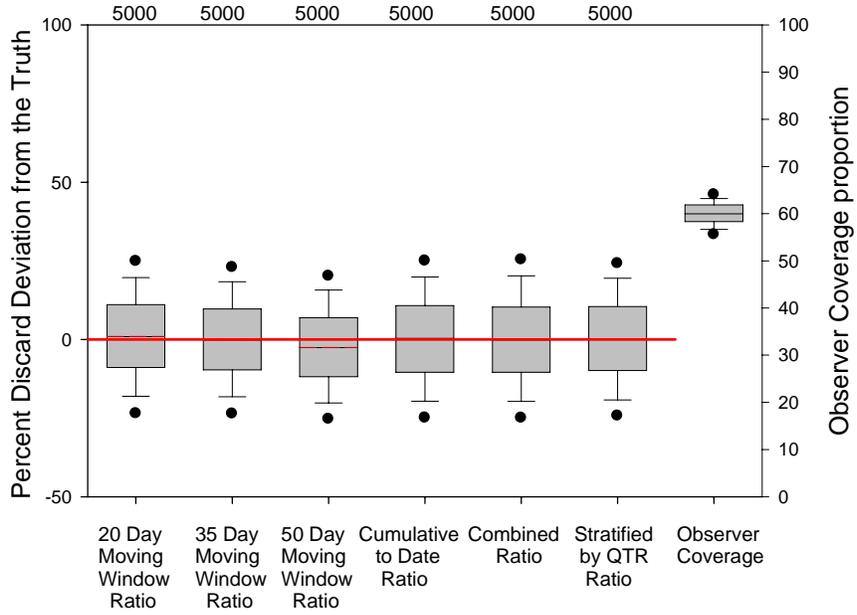


Figure 9. cont.

Georges Bank Haddock
Midyear Peak Discards
Large Mesh Trawl

D.



Georges Bank Haddock
Midyear Peak Discards
Large Mesh Trawl

E.

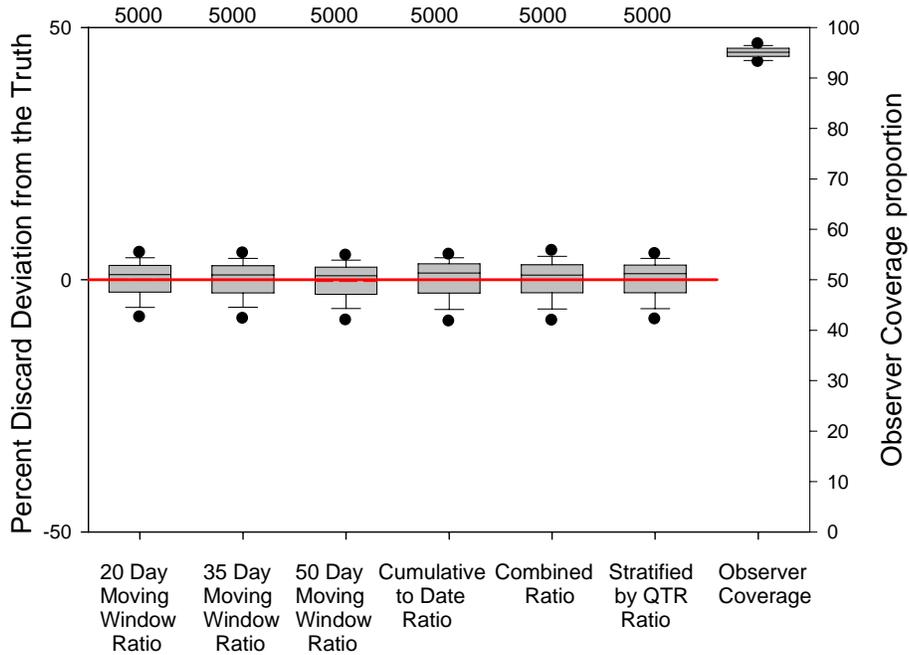


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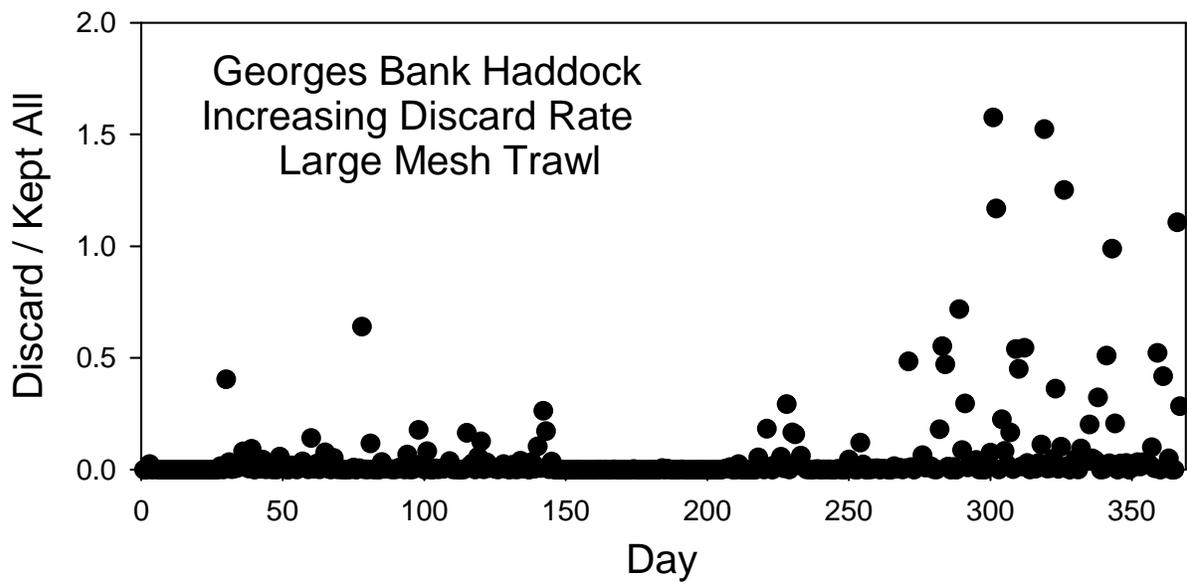


Figure 10. Discard to kept all ratios over time for the Georges Bank haddock large mesh trawl scenario using high discards associated with a large year class at the end of the year.

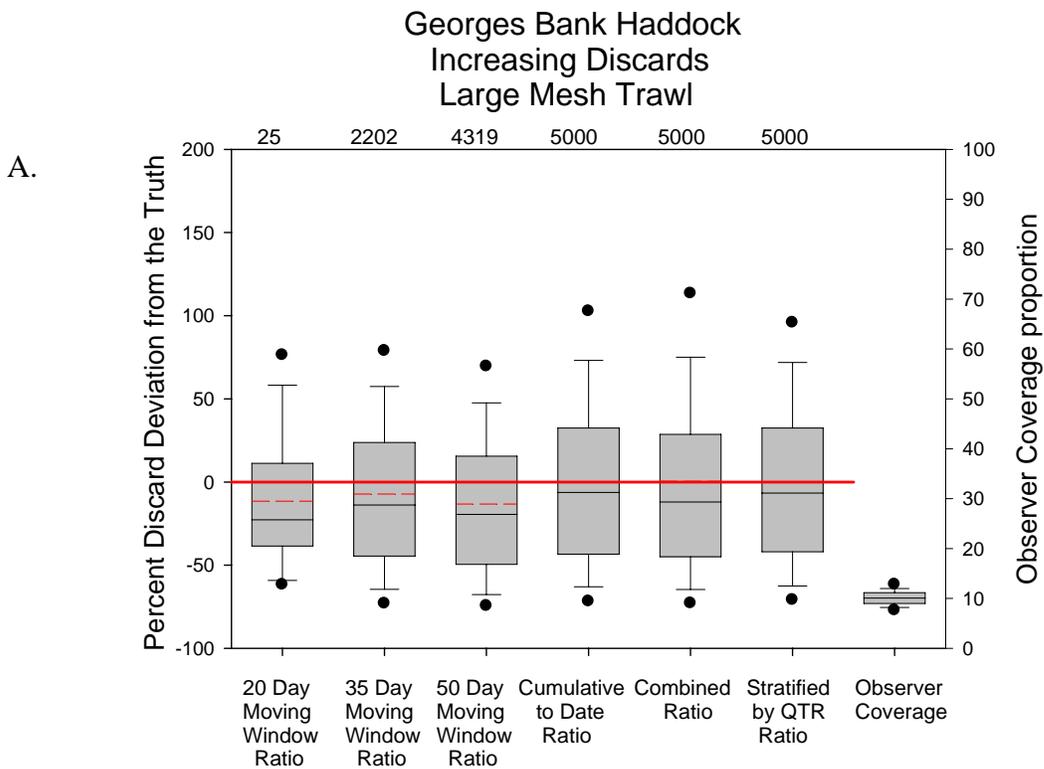


Figure 11. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Georges Bank Haddock with increasing discard trend scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentiles. Note the range on the left hand y-axis does rescale comparing plots A through E.

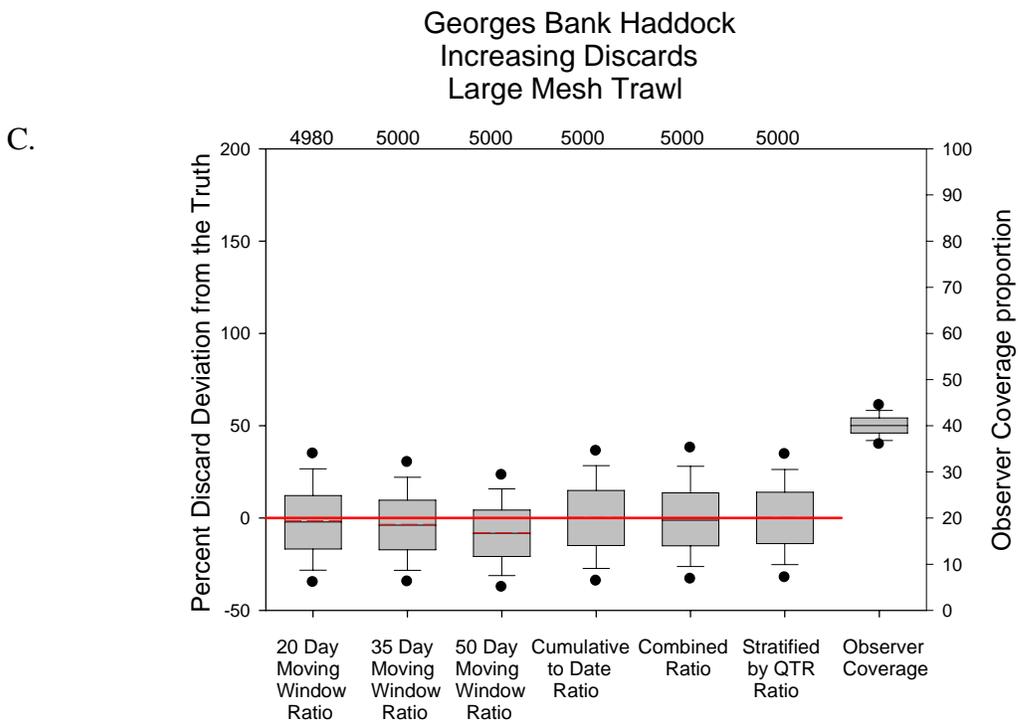
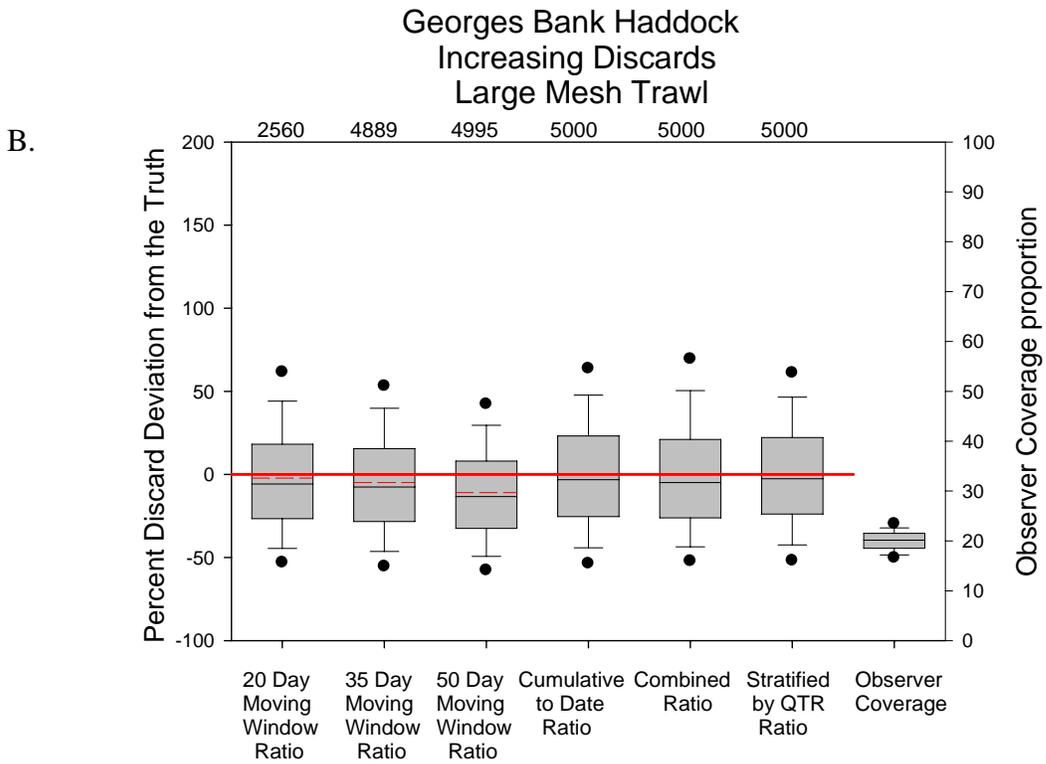


Figure 11. cont.

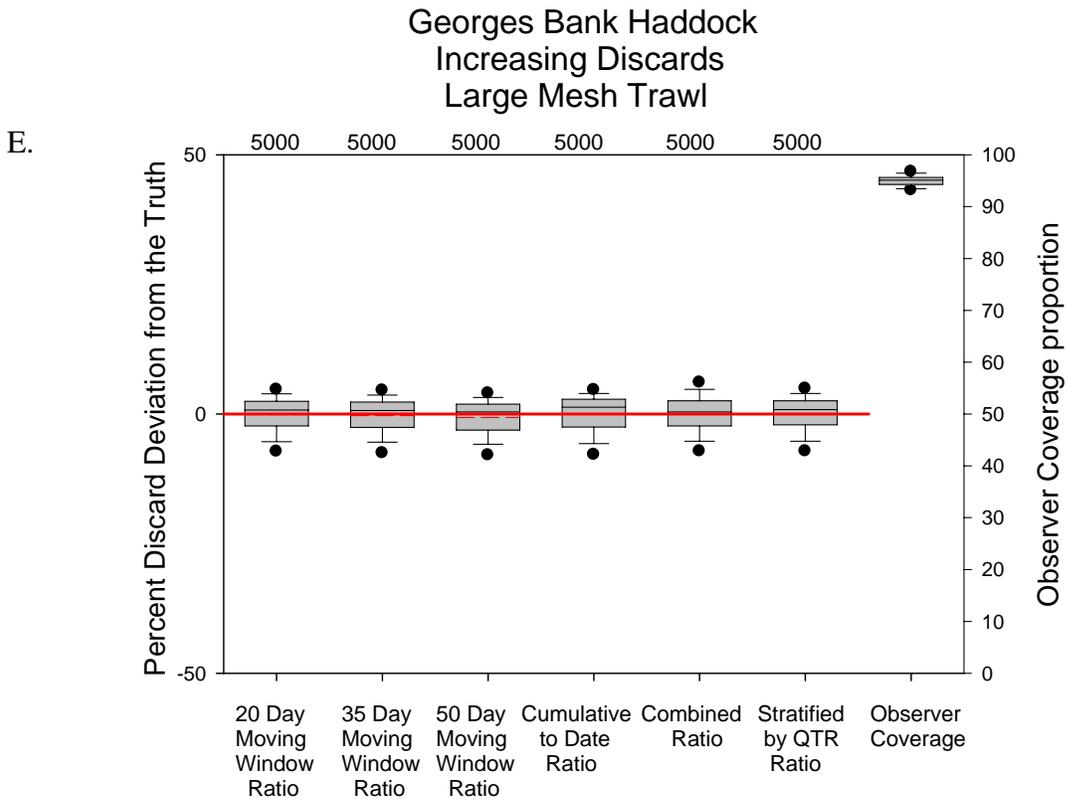
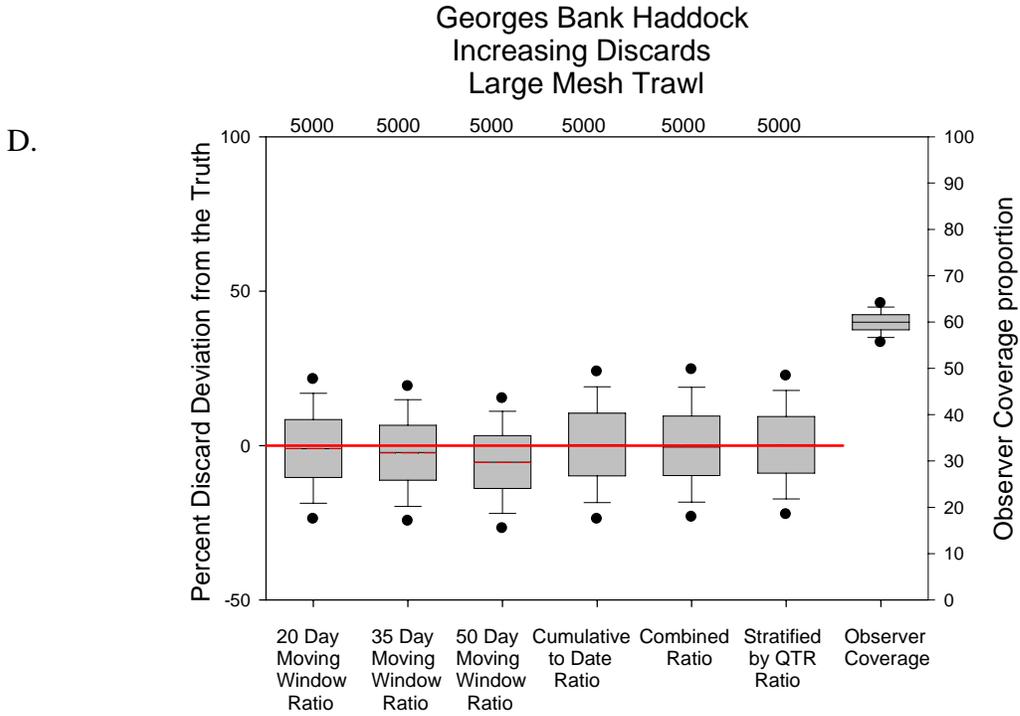


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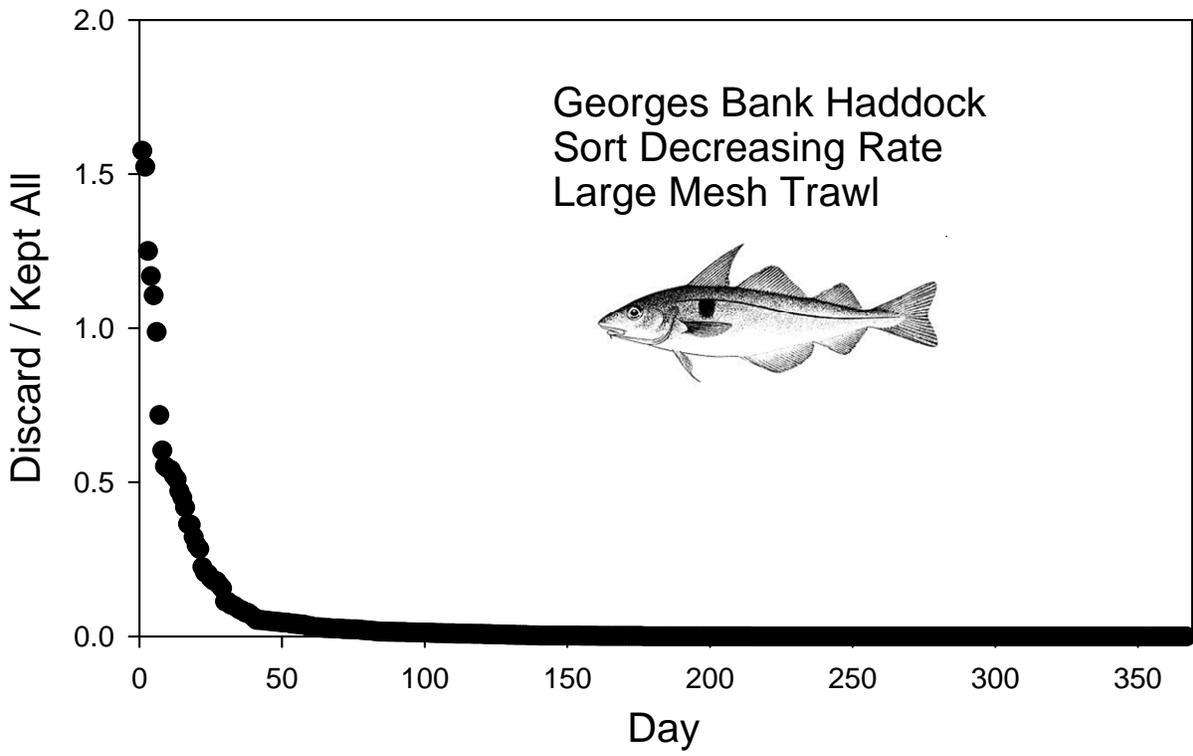


Figure 12. Discard to kept all ratios over time for the Georges Bank haddock large mesh trawl scenario using a decreasing sort of the discards rates.

Georges Bank Haddock
Sort Decreasing Discard Rate
Large Mesh Trawl

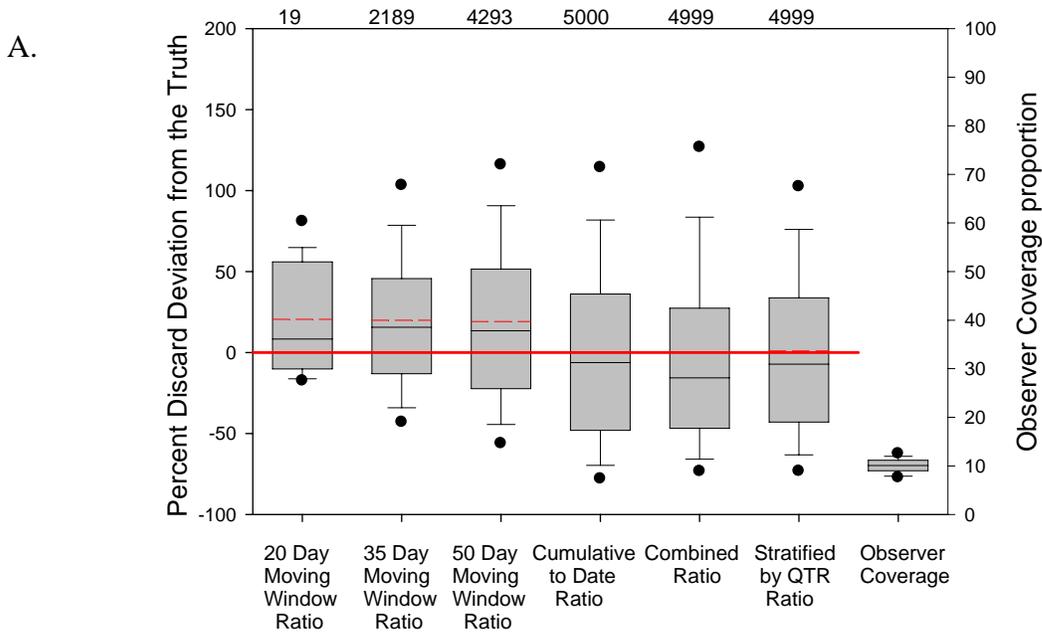
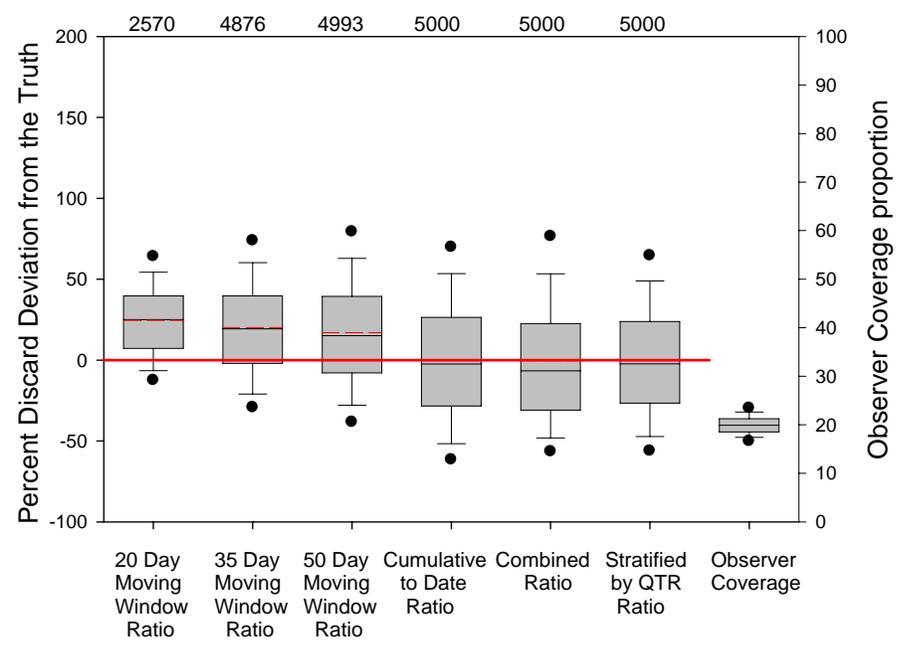


Figure 13. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Georges Bank Haddock with a decrease sort in the discard ratios scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentile. Note the range on the left hand y-axis does rescale comparing plots A through E.

Georges Bank Haddock
Sort Decrease Discard Rate
Large Mesh Trawl

B.



Georges Bank Haddock
Sort Decreasing Discard Rate
Large Mesh Trawl

C.

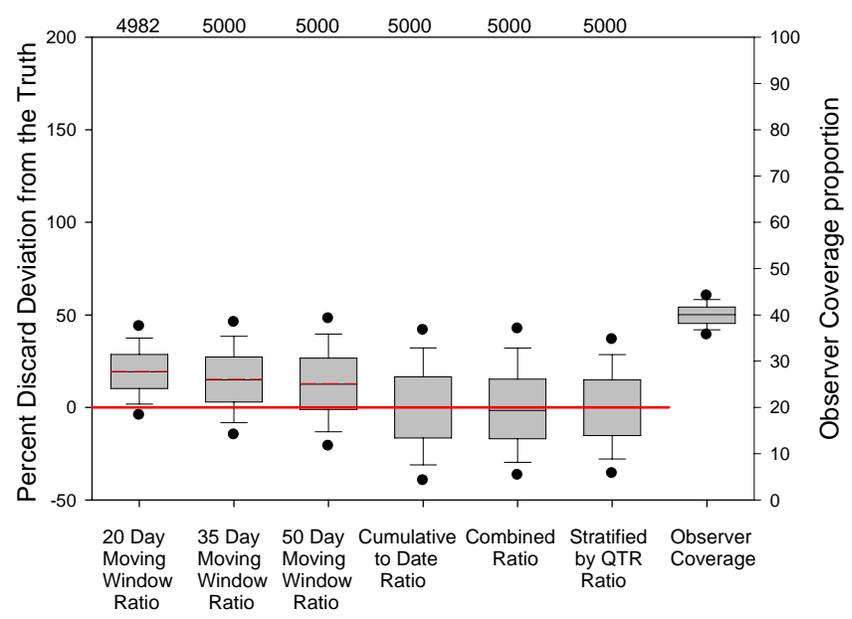


Figure 13. cont.

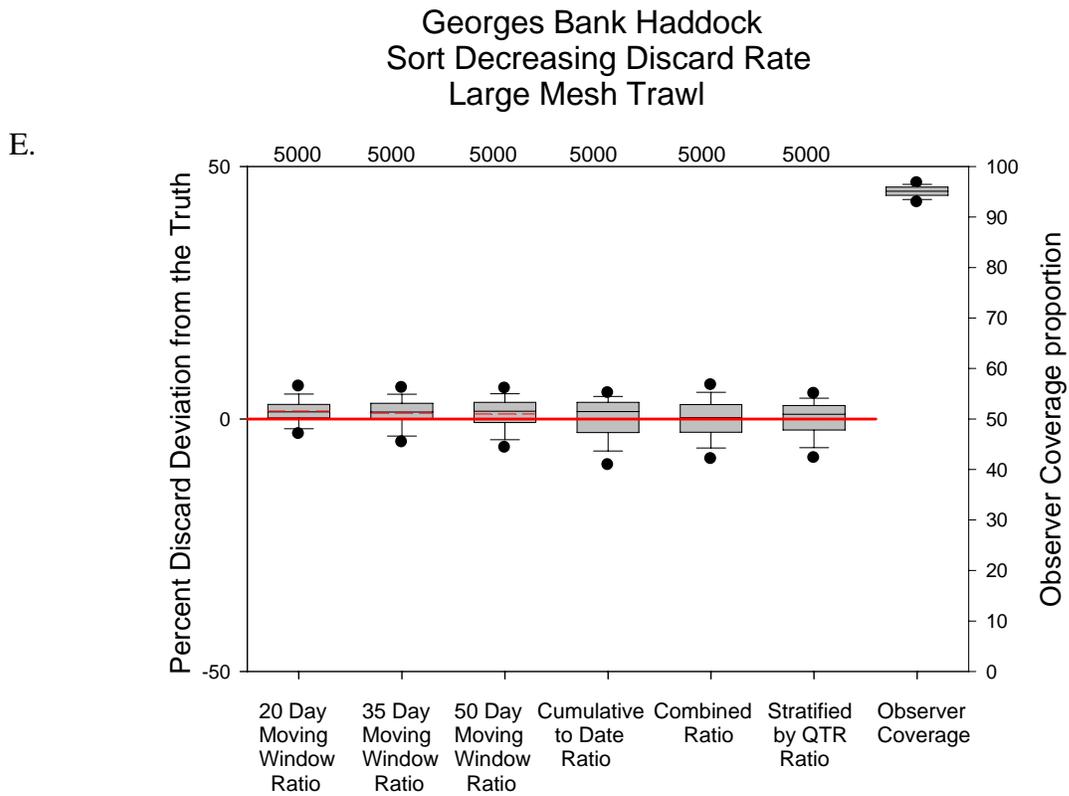
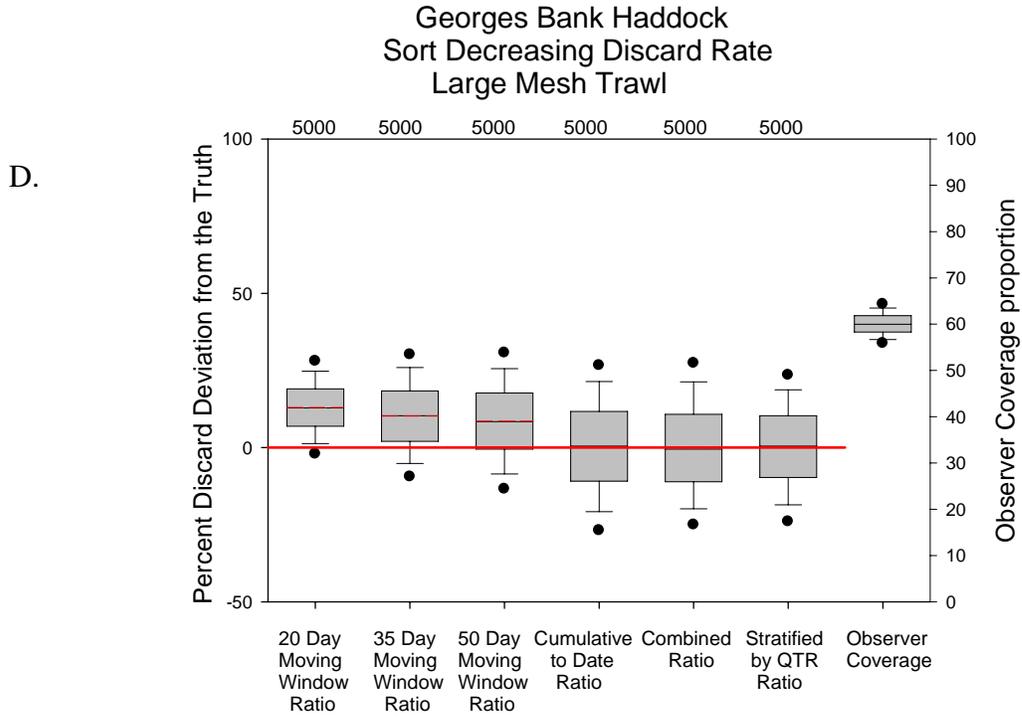


Figure 13.

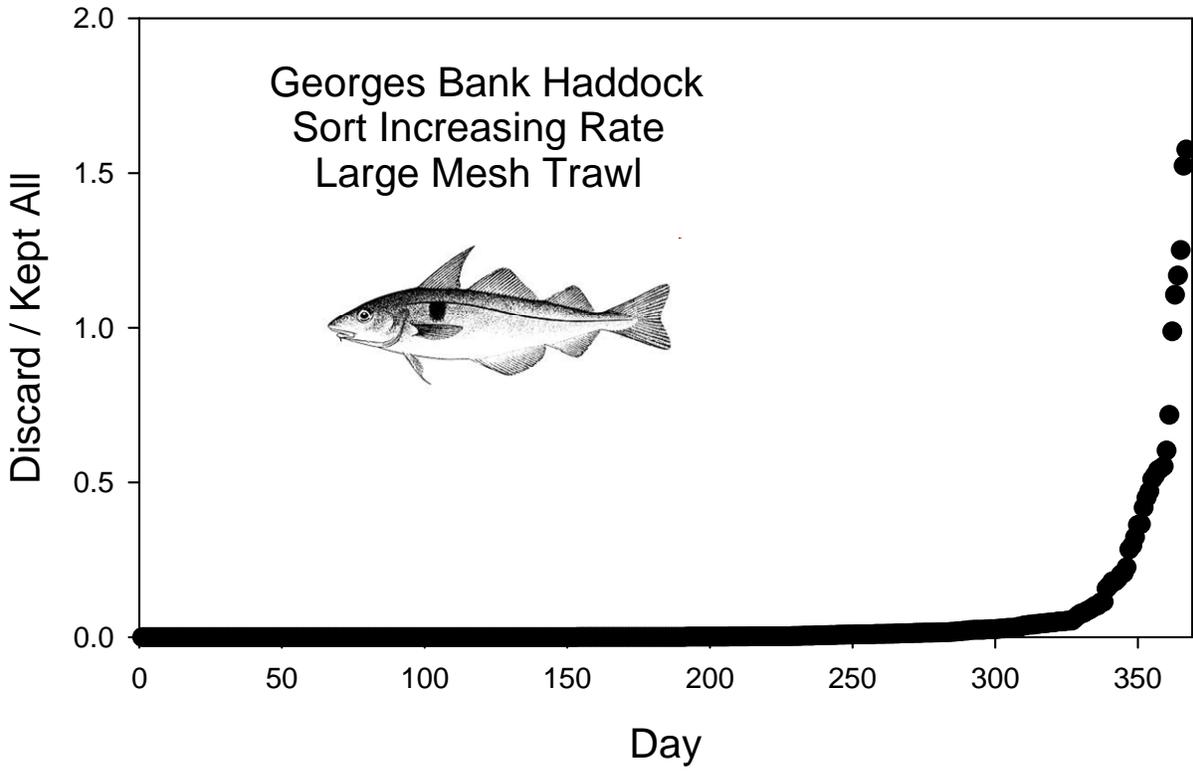


Figure 14. Discard to kept all ratios over time for the Georges Bank haddock large mesh trawl scenario using an increasing sort of the discards rates.

Georges Bank Haddock
Sort Increasing Discard Rate
Large Mesh Trawl

A.

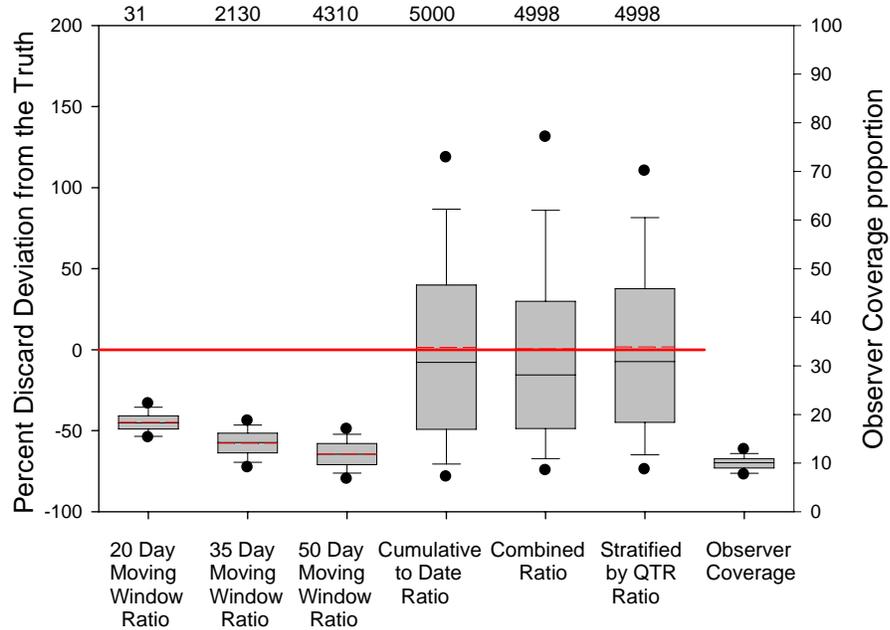
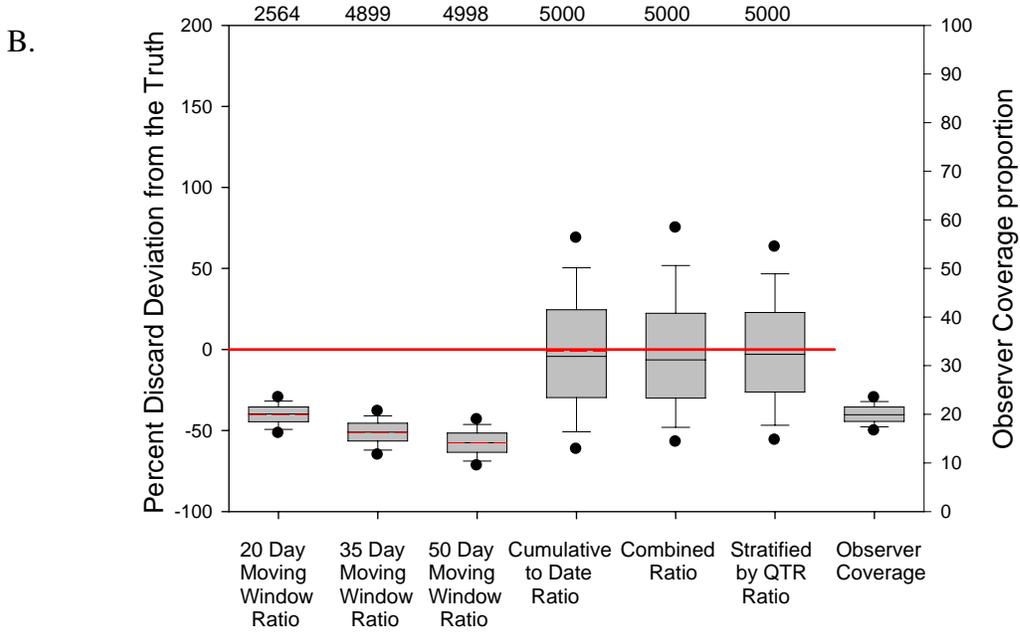


Figure 15. Comparison of six different boxplot distributions relative to the truth (zero line) from 5000 random draws of the Georges Bank Haddock with an increase in the discard ratios scenario using 5 different target sampling coverage rates (A through E). The resulting coverage rate distribution is given on the right y-axis. The number of random draws with sufficient data for each estimator is given on top. The dashed red line represents the mean. The box is the interquartile range with median line. The whiskers are the 10th and 90th percentiles and the dots are the 5th and 95th percentiles. Note the range on the left hand y-axis does rescale comparing plots A through E.

Georges Bank Haddock
Sort Increase Discard Rate
Large Mesh Trawl



Georges Bank Haddock
Sort Increasing Discard Rate
Large Mesh Trawl

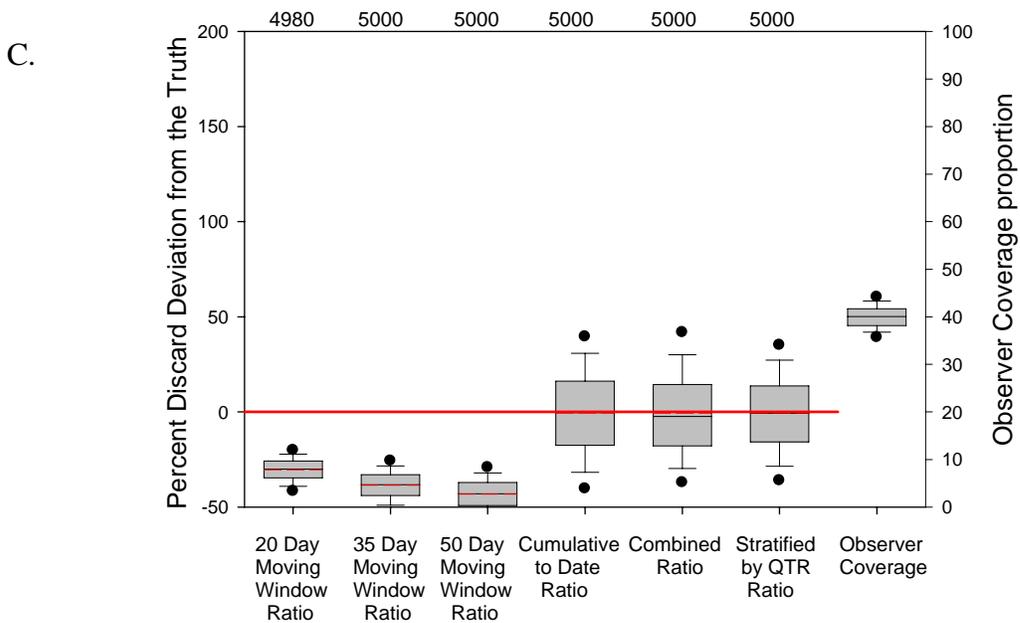
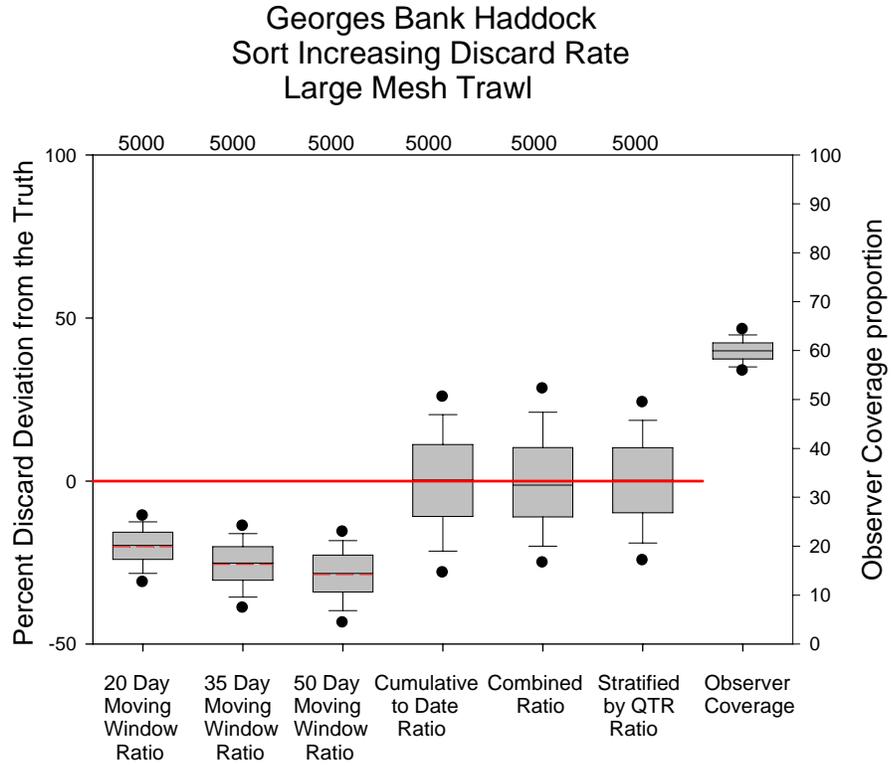


Figure 15. cont.

D.



E.

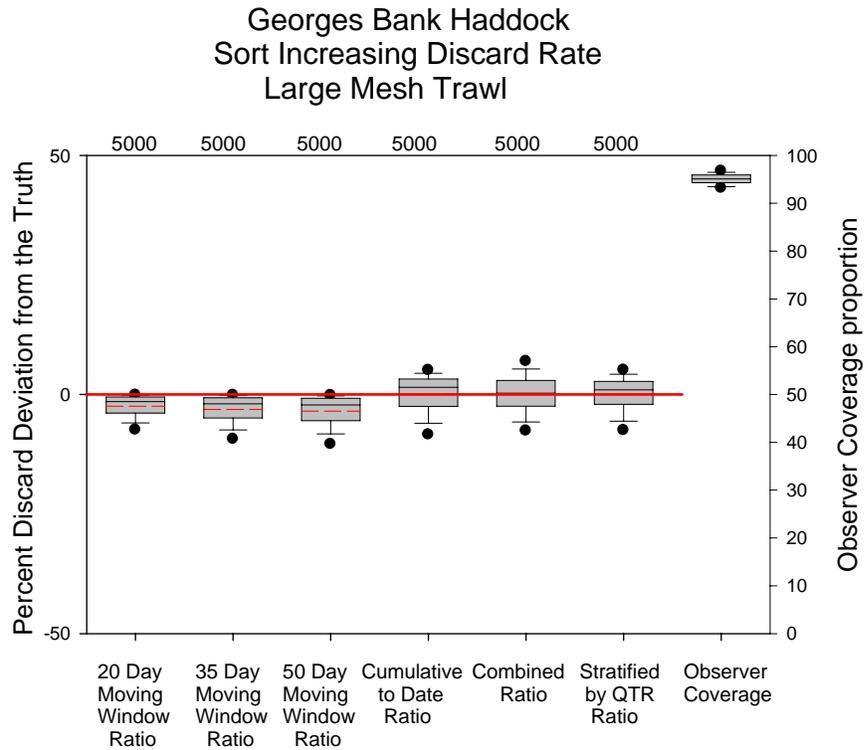
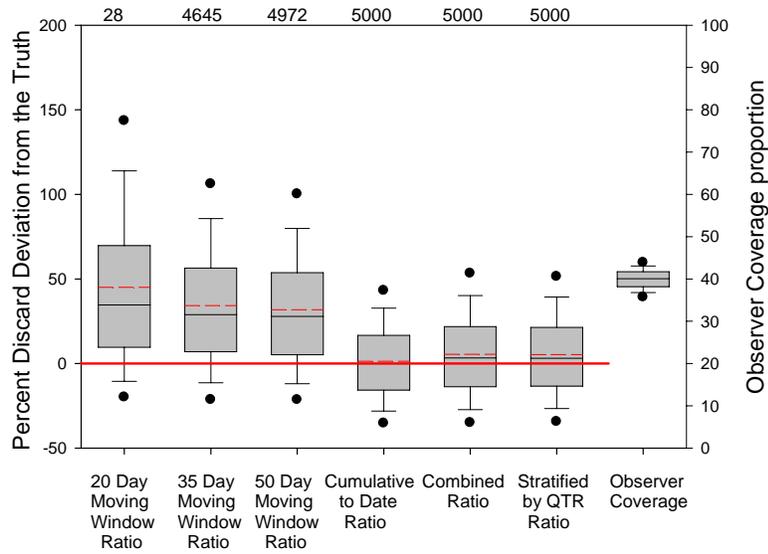


Figure 15. cont.

Gulf of Maine Cod
Large Mesh Trawl



Gulf of Maine Cod
Use estimator for all Trips
Large Mesh Trawl

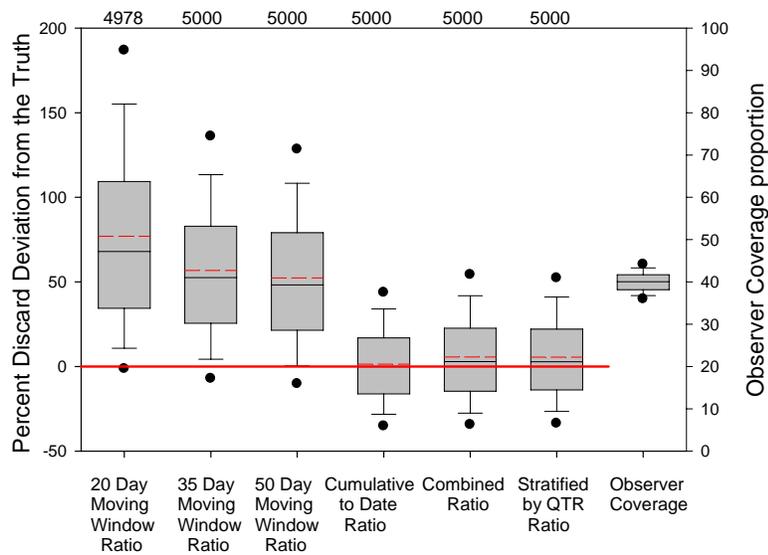


Figure 16. Top plot used the observed discards for trips which were observed with a 40% coverage rate while the bottom plot estimated all of the discards using the moving average estimator.

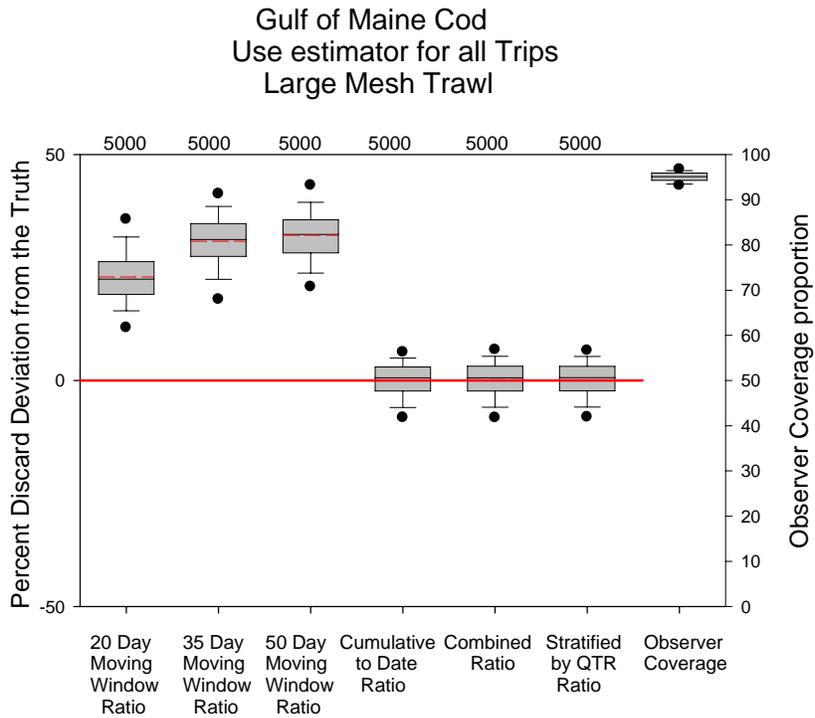
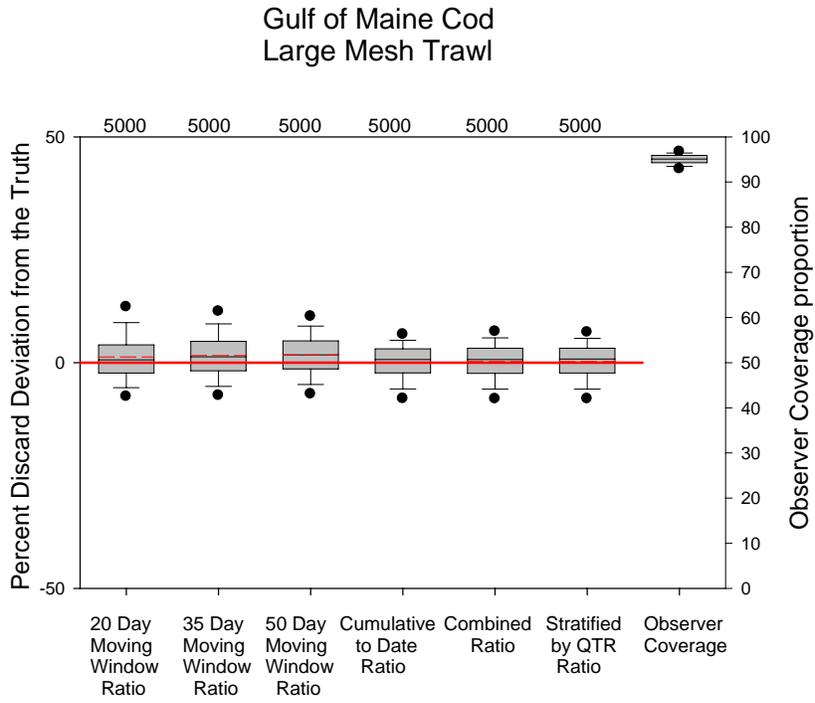


Figure 17. Top plot used the observed discards for trips which were observed with a 95% coverage rate while the bottom plot estimated all of the discards using the moving average estimator.

Gulf of Maine Cod Cumulative Maximum Large Mesh Trawl

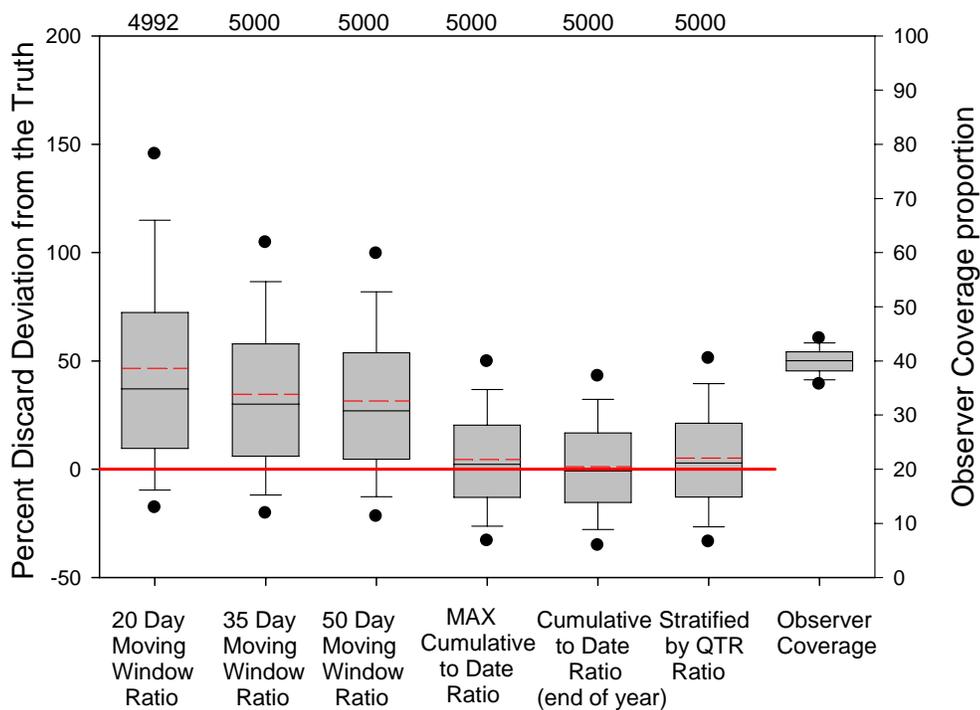
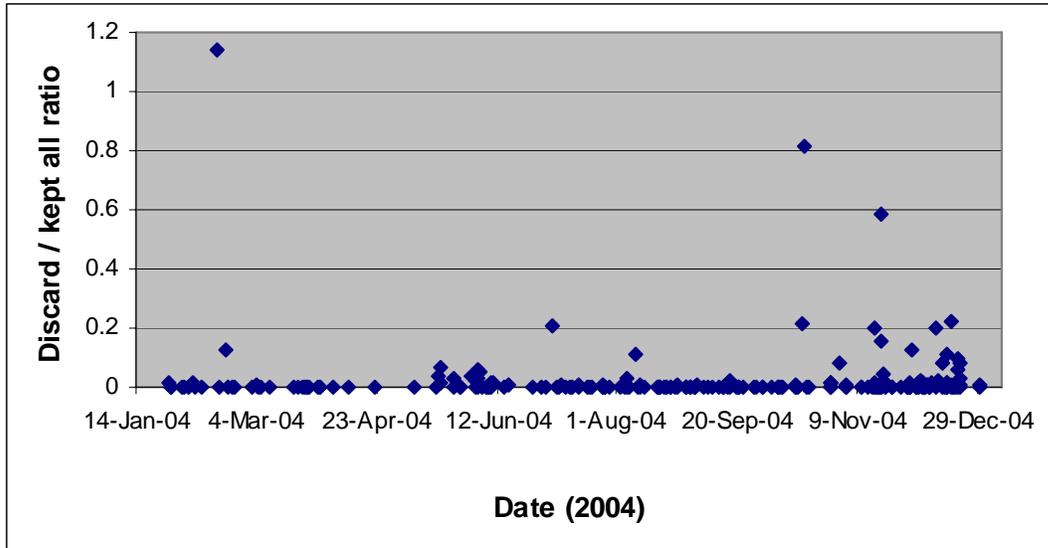


Figure 18. A slight shift can be seen when comparing the maximum of the cumulative method on any day of the year with the distribution at the end of the year.



Gulf of Maine Cod
Calendar year 2004
Large Mesh Trawl

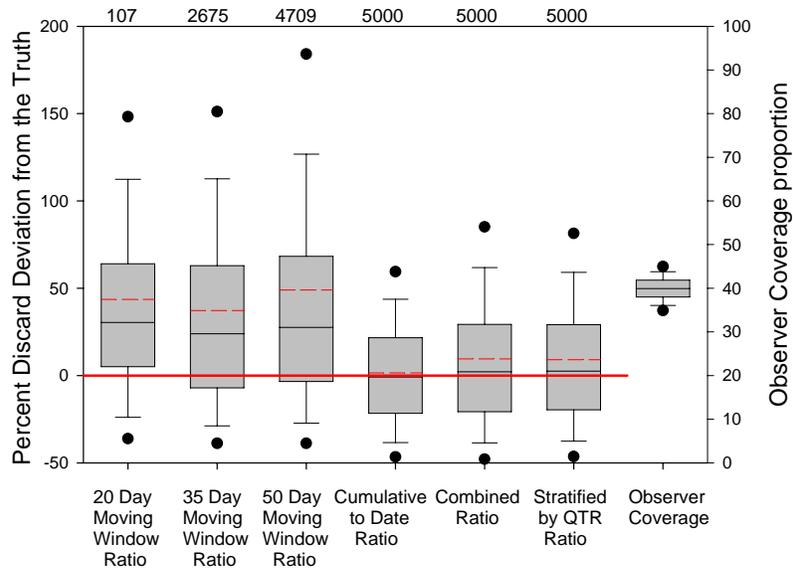
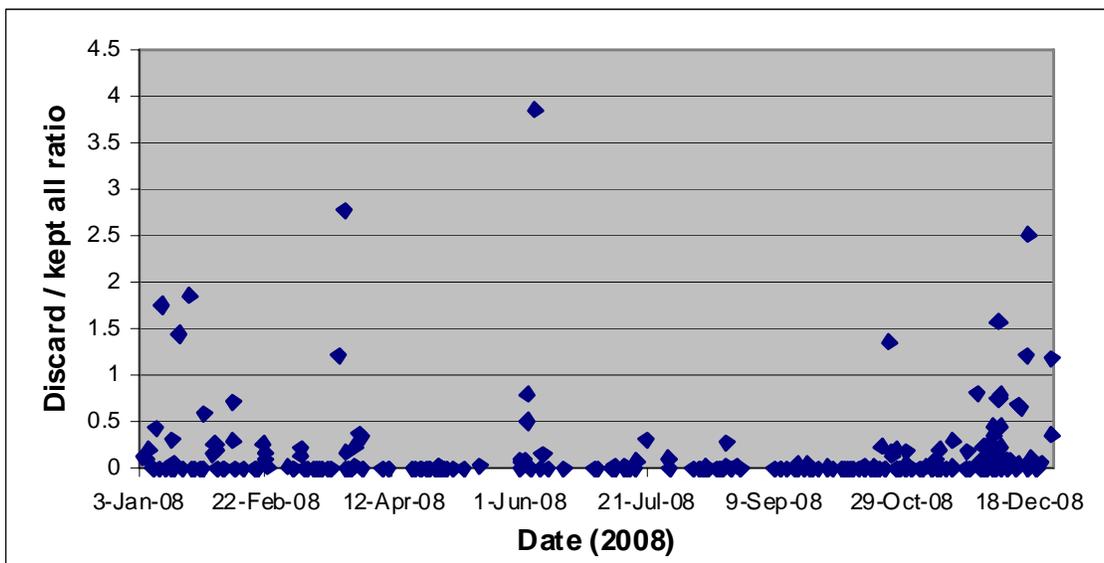


Figure 19. Comparison of estimators (bottom) using calendar year 2004 data (top) for Gulf of Maine Cod large mesh trawl.



Gulf of Maine Cod
 Calendar year 2008
 Large Mesh Trawl

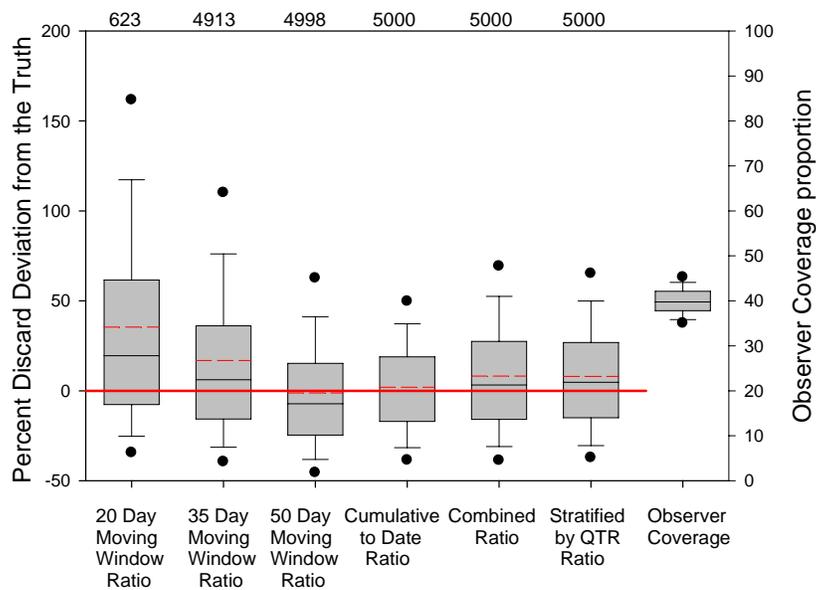


Figure 19. Comparison of estimators (bottom) using calendar year 2008 data (top) for Gulf of Maine Cod large mesh trawl.

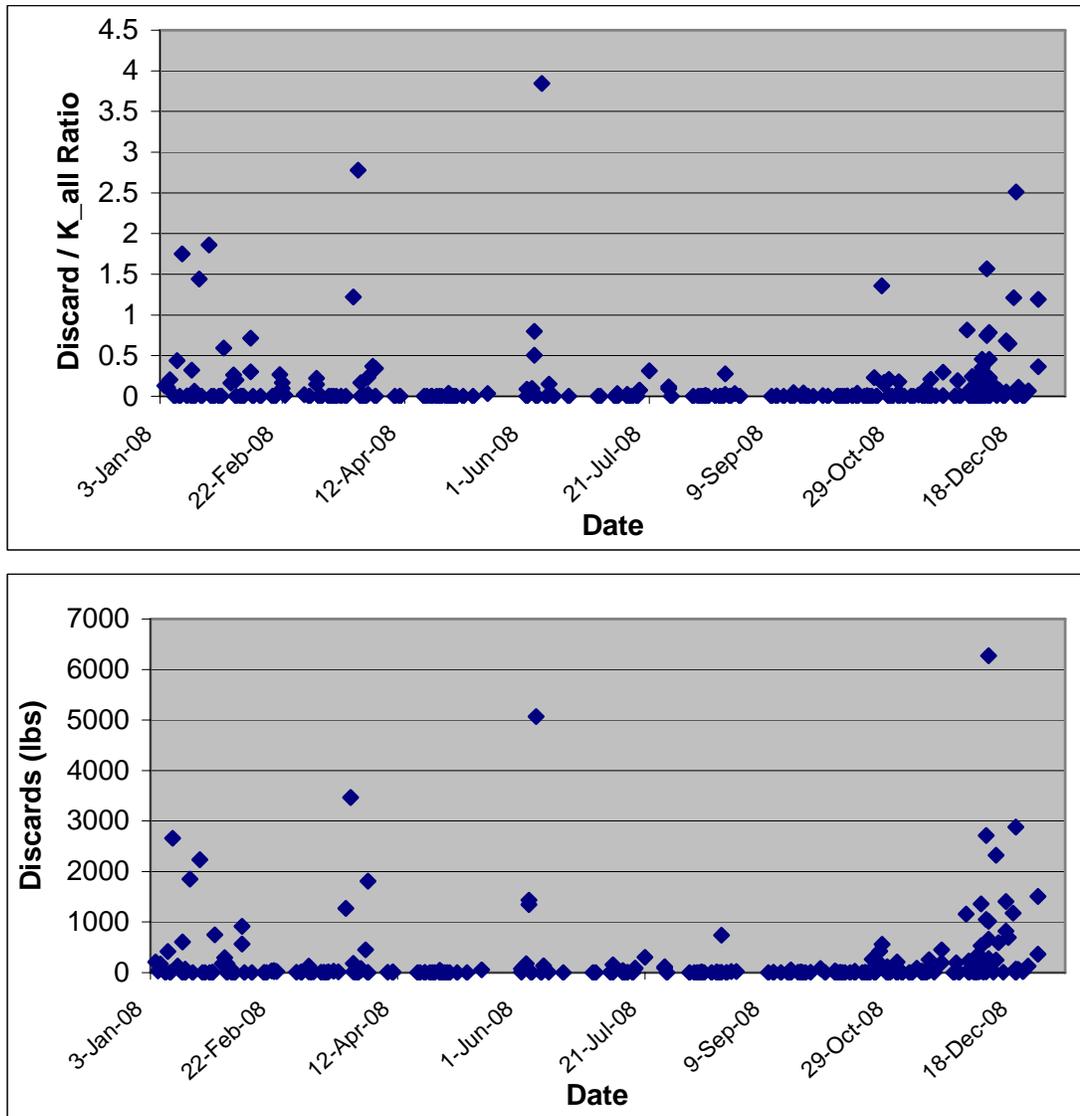


Figure 20. Calendar year 2008 discard to kept all ratios (top) and total discards (bottom) for the Gulf of Marine cod scenario used for test data trimming effects.

Omit 3 Highest trips in the Estimation
(Omit trips with greater than 3000 lbs of discards)
Calendar year 2008, Gulf of Maine Cod
Large Mesh Trawl, 5000 iterations

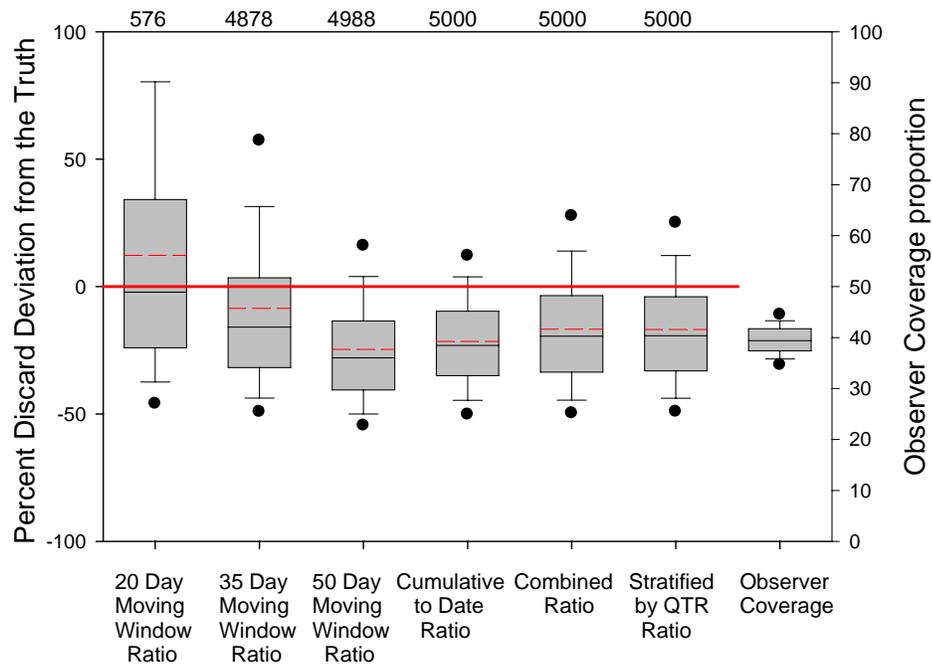


Figure 21. Comparison of estimator results relative to the truth for run 1 which omitted the 3 highest trips (greater than 3000 lbs discarded per trip) in calendar year 2008 Gulf of Marine cod large mesh trawl scenario.

Omit 8 Highest trips in the Estimation
(Omit trips with greater than 2000 lbs of discards)
Calendar year 2008, Gulf of Maine Cod
Large Mesh Trawl, 5000 iterations

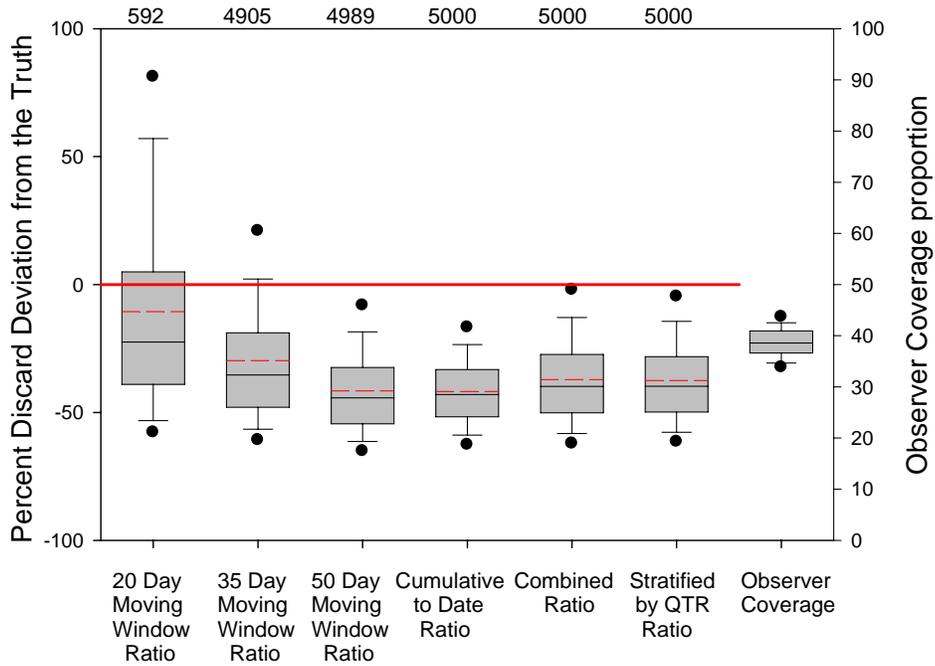


Figure 22. Comparison of estimator results relative to the truth for run 2 which omitted the eight highest trips (greater than 2000 lbs discarded per trip) in calendar year 2008 Gulf of Marine cod large mesh trawl scenario.

Omit Zero Discard trips in the Estimation
 Calendar year 2008, Gulf of Maine Cod
 Large Mesh Trawl, 5000 iterations

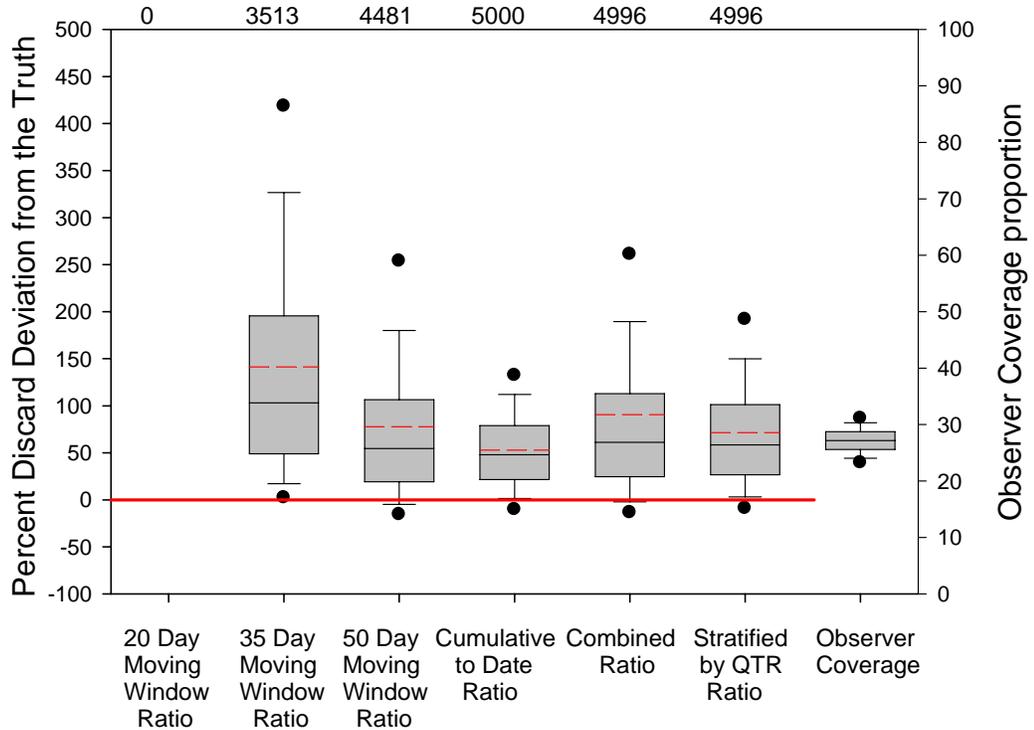


Figure 23. Comparison of estimator results relative to the truth for run 3 which omitted all trips with zero discards trips in calendar year 2008 Gulf of Marine cod large mesh trawl scenario.

Omit 3 Highest and Zero Discard Trips in the Estimation
 Calendar year 2008, Gulf of Maine Cod
 Large Mesh Trawl, 5000 iterations

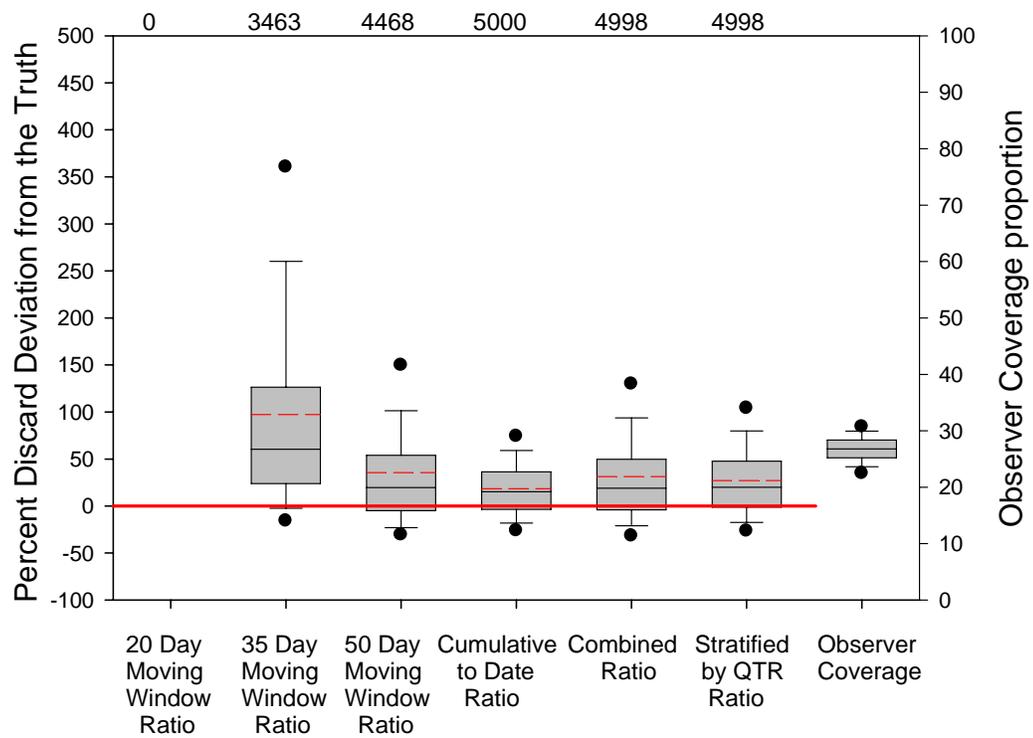


Figure 24. Comparison of estimator results relative to the truth for run 4 which omitted both the zero discard trips and the 3 highest discard trips in calendar year 2008 Gulf of Marine cod large mesh trawl scenario.