New England Fishery Management Council
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Revised 6/6/18
Corrects a typo and includes Attachment #3

MEMORANDUM

DATE: May 29, 2018

TO: Groundfish Committee

FROM: Groundfish Plan Development Team

SUBJECT: **Additional Analyses for Amendment 23/Groundfish Monitoring**

The Groundfish Plan Development Team (PDT) met on May 22, 2018, in Falmouth, MA to 1) discuss the draft alternatives for Amendment 23 (A23)/Groundfish Monitoring; and 2) review additional PDT analyses for the action.

This memorandum summarizes revisions to the draft Amendment 23 alternatives, following input from the Groundfish Advisory Panel and the Groundfish Committee at their meetings on May 8 and May 9, respectively. This memorandum is also a follow-up to our previous memorandum to the Groundfish Committee (dated May 3, 2018) which described the scope of the current monitoring program in the commercial Northeast Multispecies (groundfish) fishery and provided a preliminary analysis of uncertainties in the program.

1. Draft Alternatives

The PDT revised the draft alternatives incorporating input from the following Committee consensus statement and motion:

Consensus Statement:

> *In the draft alternatives in Section 4.1.1.1 (Sector Reporting Requirements), the Plan Development Team should refine Option 2 (Streamline Sector Reporting Requirements) to grant the Regional Administrator the authority to modify specific sector reporting requirements for the June 1 Groundfish Committee meeting.*

The PDT revised this section of the alternatives to reflect the Committee's intent to grant the Regional Administrator authority to streamline sector reporting requirements.

Motion:

> *To move Section 4.1.1.3.2 (Option 2: Additional Options for Industry Funded Cost of Monitoring) to considered but rejected.* Carried 5/4/2.

The PDT revised this section of the alternatives by moving Section 4.1.1.3.2 (Option 2: Additional Options for Industry Funded Cost of Monitoring) to considered and rejected.

2. Additional PDT Analyses

The PDT completed additional analyses related to uncertainties in the current monitoring program for the commercial groundfish fishery, provided as attachments to this memorandum:

- **Attachment #1 – Analysis of Discards of Legal-Sized Gulf of Maine Cod**
- **Attachment #2 – Sector Monitoring CV Analysis**
- **Attachment #3 – Observer Bias Analysis*** (*To be provided at the meeting*)

*Note: this analysis addresses an uncertainty identified in an earlier memorandum to the Groundfish Committee (dated May 3, 2018) – *Uncertainty #5: Fishermen behave differently when observers are on-board.*

The PDT addressed a Committee motion related to Amendment 23 analyses:

> **Motion:**
>
> *The Groundfish Committee requests the Plan Development Team under their analysis of quantifying accuracy through observer bias, review behavior of fishing vessels during fishing years 2010 to 2012 when monitoring and annual catch limits were higher in comparison to recent years.* Carried 4/3/4.

The observer bias analysis (Attachment #3) includes this request.

Preliminary PDT Discussion

In working through the analysis on Sector Monitoring CV (Attachment #2), the PDT raised several concerns with the present at-sea monitoring system.

1. Large observer effects concerns will likely make the use of CVs to predict monitoring coverage invalid.
2. The present system has become complicated with the use of both CV moving averages by stock and stock status determination under trends of increasing stratification in the fishery over time. The present monitoring system could also require future higher coverage rates based on higher variation seen in a stock which has a poor stock status determination over several years.
3. There are stratification issues with the combining the NEFOP and ASM sampling frames. PTNS 2.0 separates the two sampling frames but this has not been implemented yet. If the present monitoring system does not change, when this does get implemented, then there could be undesirable inequities among sectors for the required ASM coverage costs.
4. At present the very high CVs at the stratification used to monitor the fishery suggests high uncertainty with the discard estimates at the sector level. It may be more justified to base ASM monitoring requirements on the stratification used to monitor the fishery rather than basing it on the discard estimate for the stock as a whole.

Additional Analysis

The PDT also addressed a request from the Committee to report on missing catch and retrospective patterns in stock assessments:

Motion:

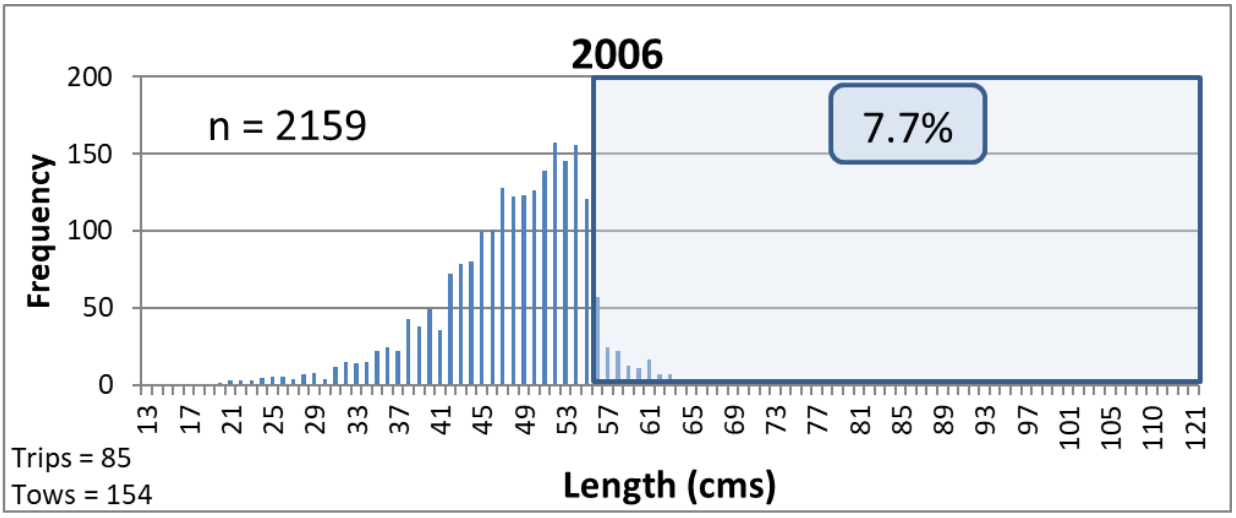
The Groundfish Committee requests the Plan Development Team report the scale of missing catch (in pounds and percentages) necessary to account for the retrospective pattern on a stock by stock basis, using available documents. Carried 9/0/2.

As discussed at the Committee meeting, determining the amount of missing catch necessary to account for the retrospective pattern in a stock assessment is beyond the role of the PDT. Upon review of the available assessment documents, the PDT feels the answer to the Committee's question it is not as straightforward as it might appear. It would be more well-suited in a stock assessment model environment where multiple sources of mortality can be examined through simulations.

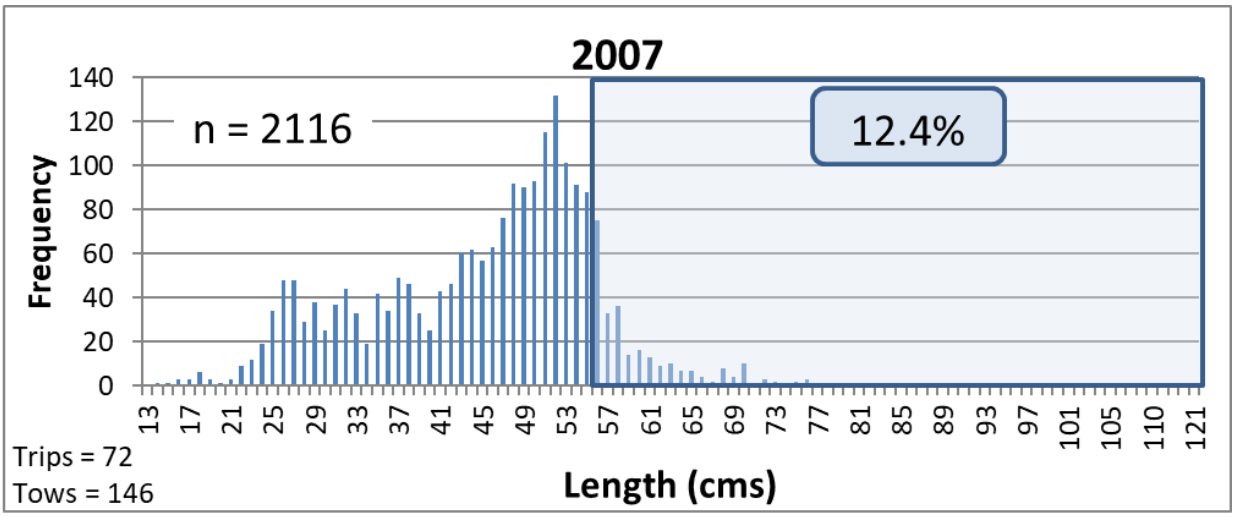
Preliminary Analysis of Discards of Legal-Sized Gulf of Maine Cod

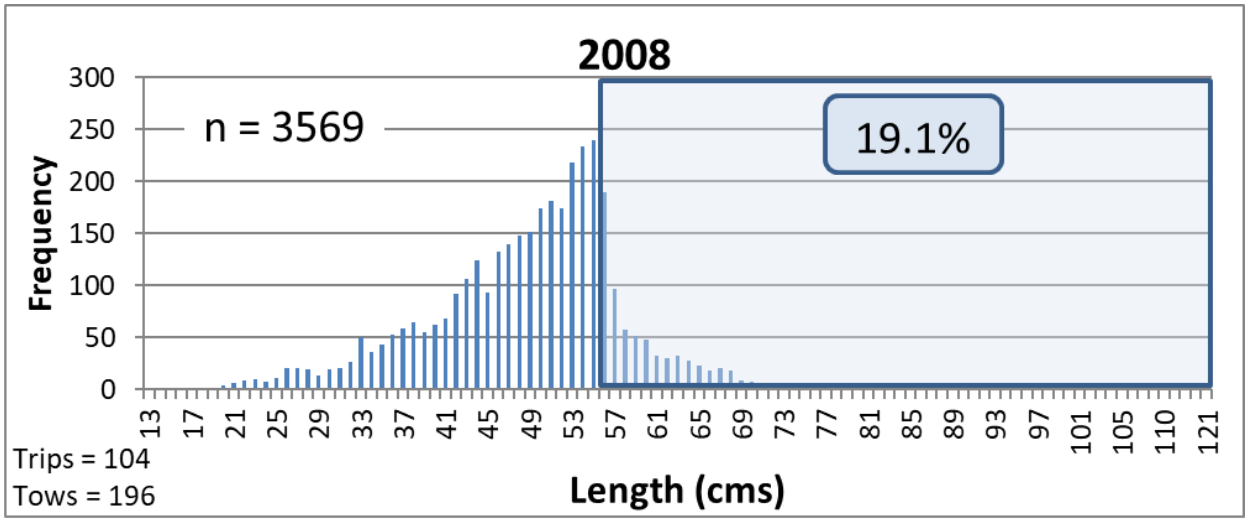
The PDT examined observer data on the discarding of legal-sized Gulf of Maine (GOM) cod, following reports received at the April Council meeting on this topic. The data included observed trips, both NEFOP and ASM, displayed by year from CY 2006 - 2017. The PDT determined the length frequency distribution of discarded GOM cod, only for those lengths recorded as discarded (Catch Disposition Code = 0). For the preliminary analysis, the PDT summarized samples from large-mesh bottom otter trawl (Gear Code = 050). The data include lengths of GOM cod discarded under all fish disposition codes.

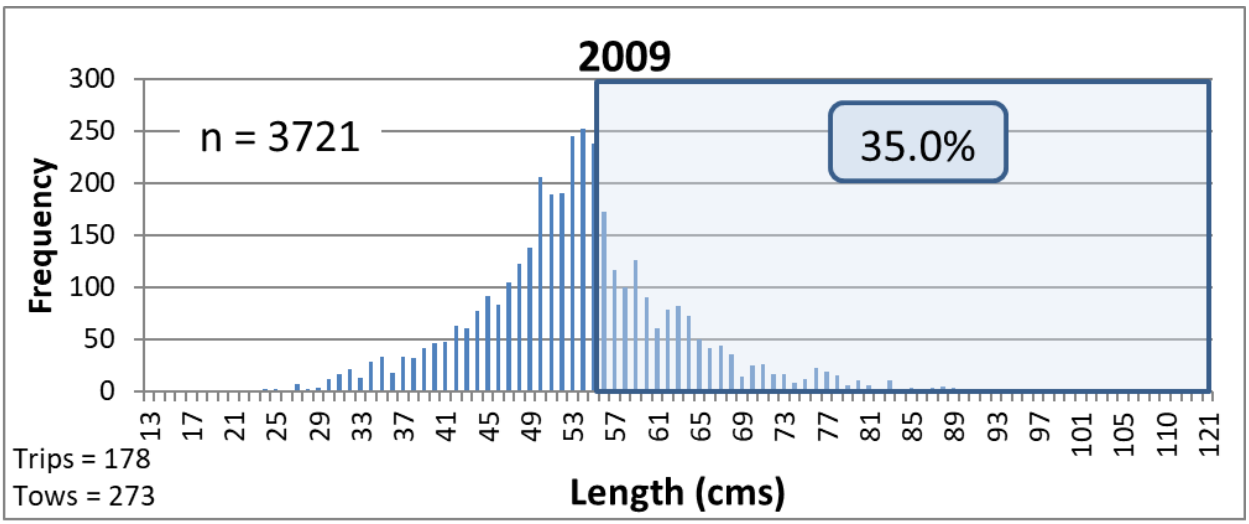
The following figures summarize the length frequency distributions by year. "n" is the total number of GOM cod in the length frequency samples. Number of trips and number of tows are also displayed. The shaded area is the proportion of fish discarded that are over the minimum size limit. Note the minimum fish size change for GOM cod as of July 1, 2013 from 22in (55.9cm) to 19in (48.3cm). Also of note, FY2014 had an emergency action for GOM cod which required additional discarding, and so a higher proportion of legal-sized cod discards is expected for CYs 2014 - 2015.

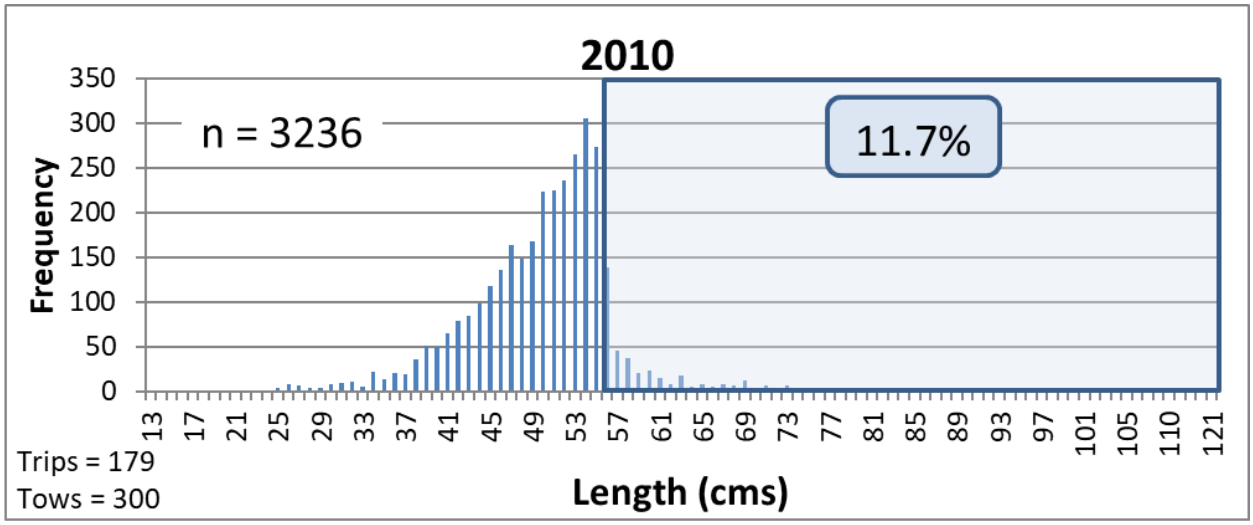


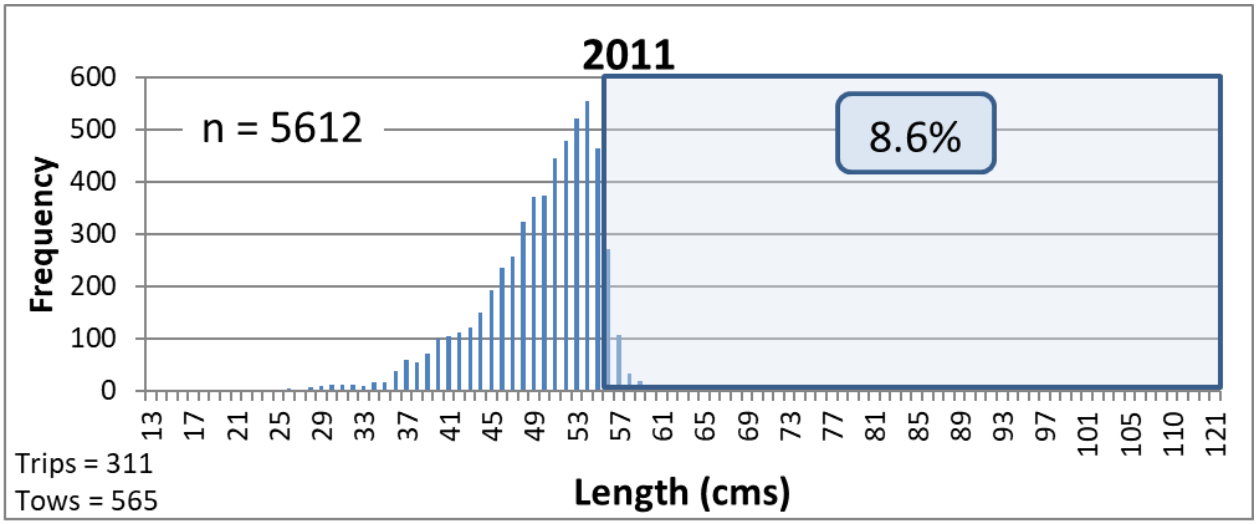
Attachment #1

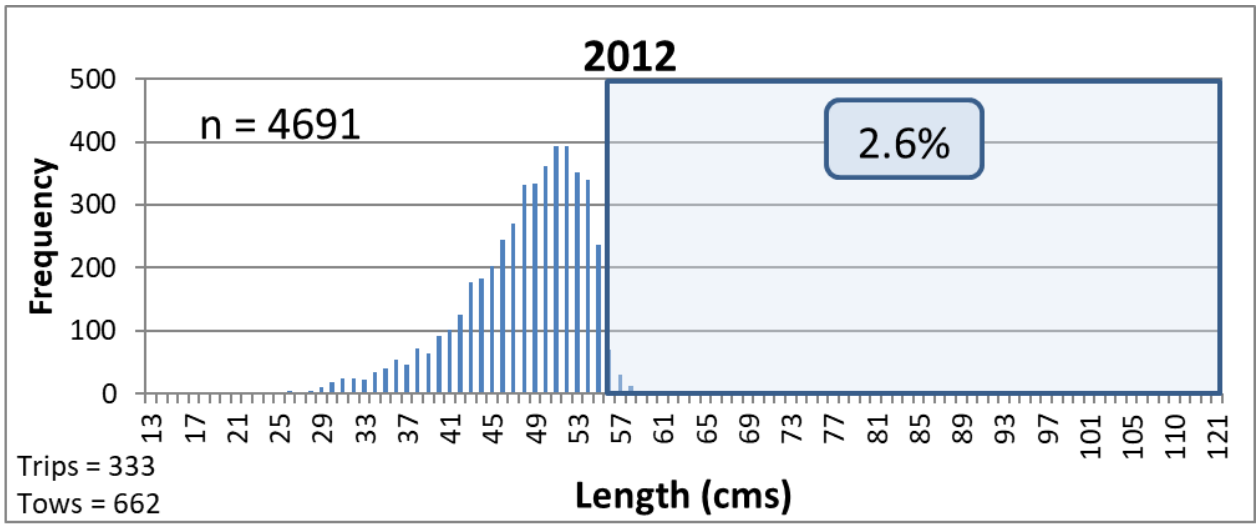


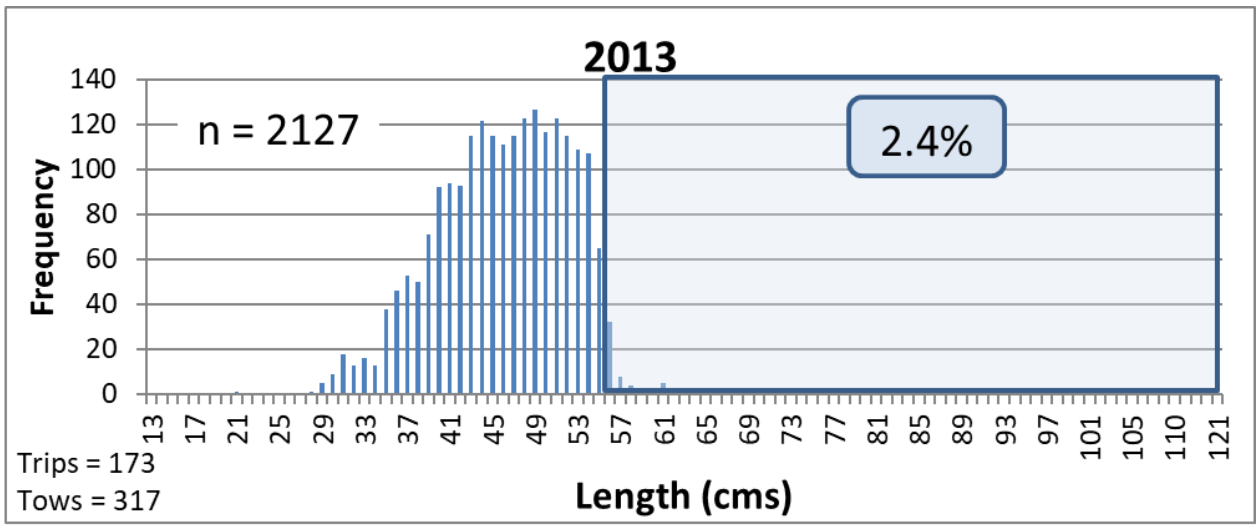


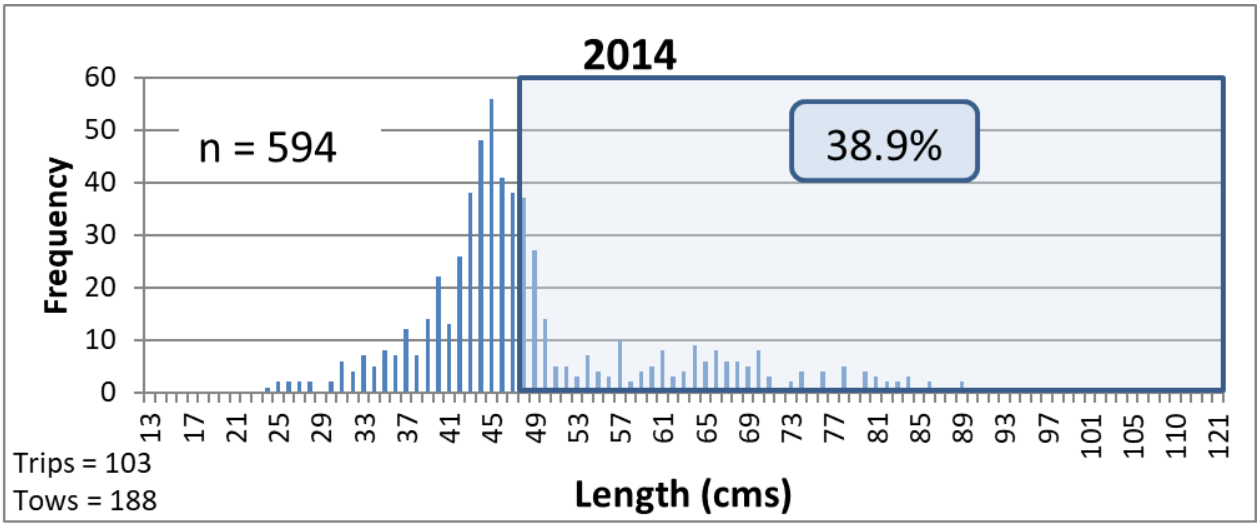


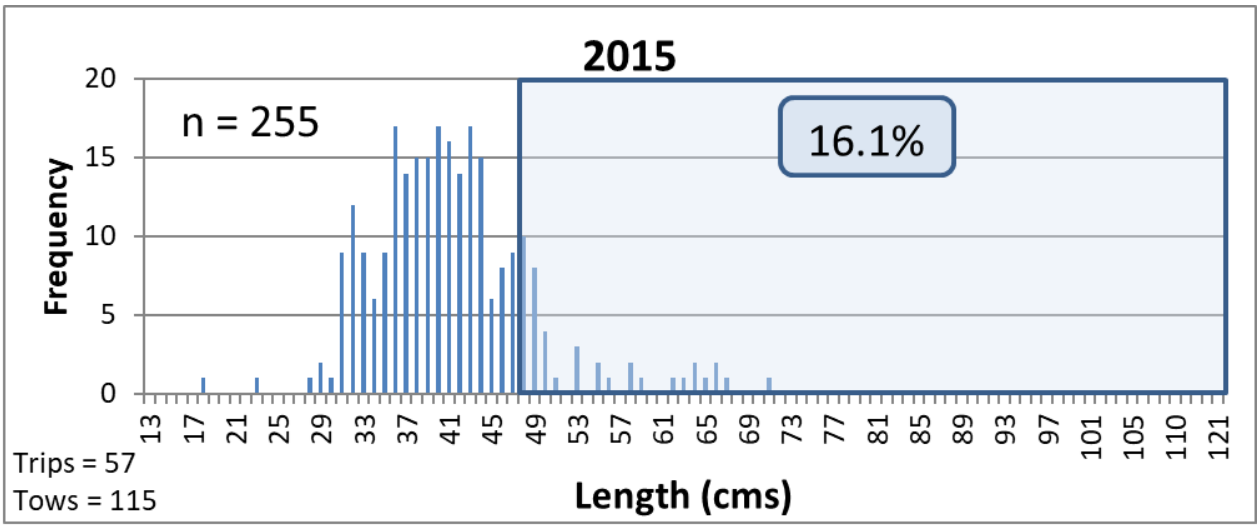

2010
n = 3236
11.7%
Frequency
Length (cms)
Trips = 179
Tows = 300

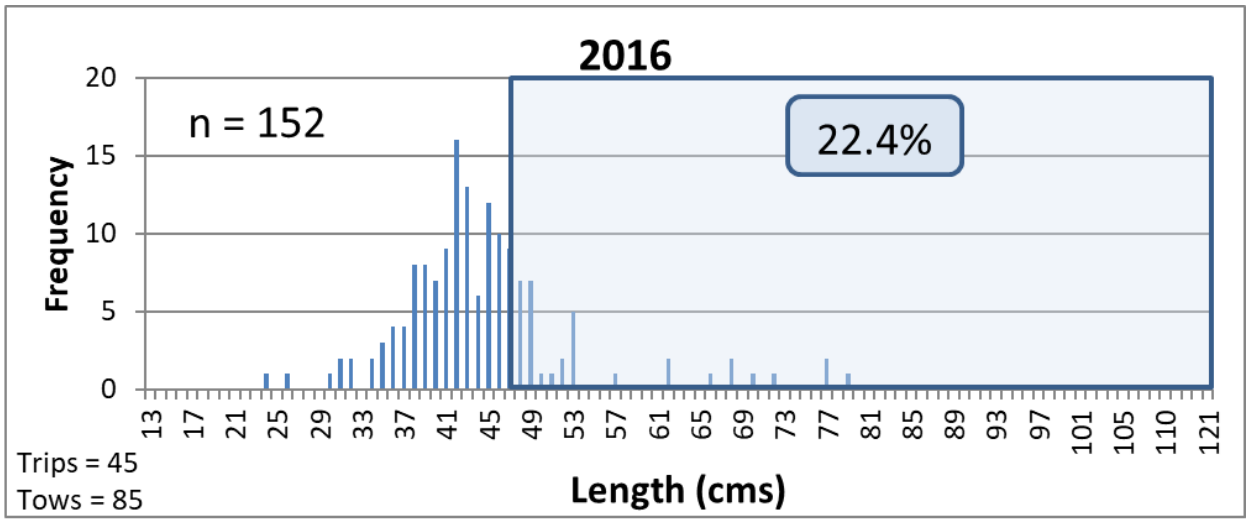

2011
n = 5612
8.6%
Frequency
Length (cms)
Trips = 311
Tows = 565

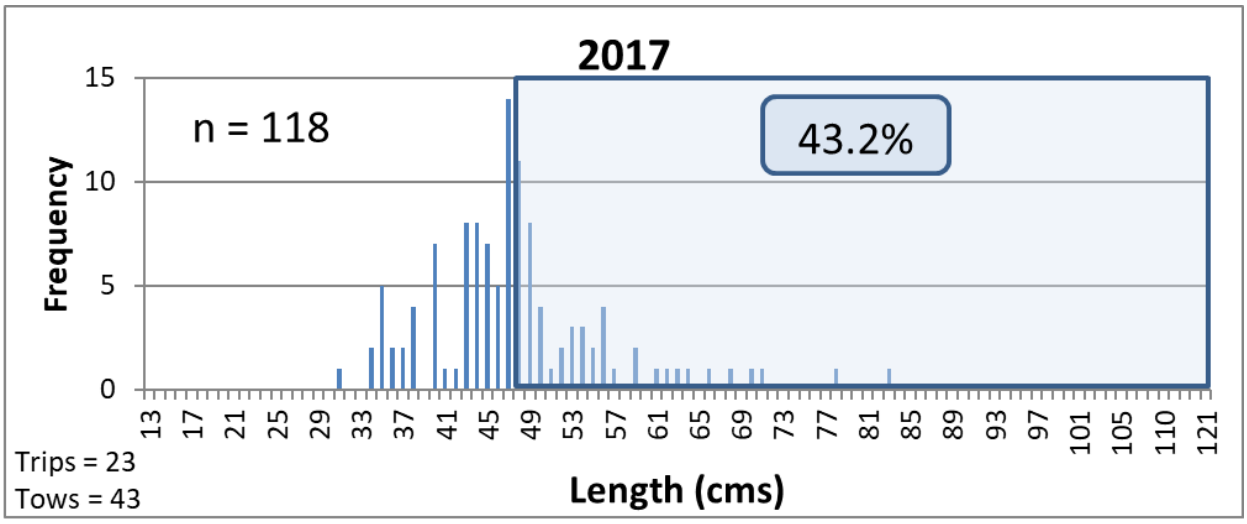

2012
n = 4691
2.6%
Frequency
Length (cms)
Trips = 333
Tows = 662


2013
n = 2127
2.4%
Frequency
Length (cms)
Trips = 173
Tows = 317

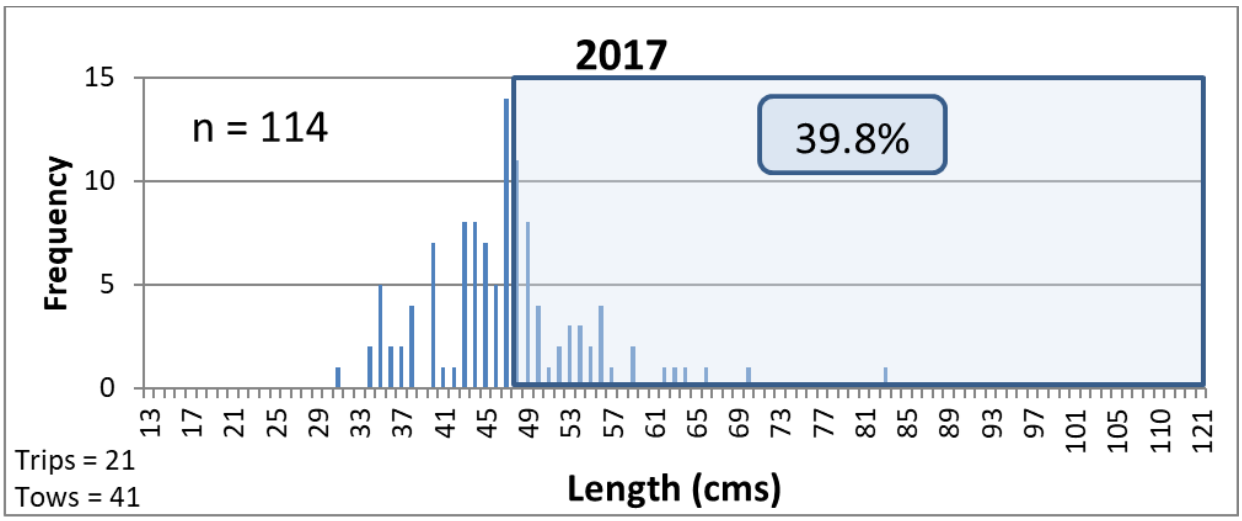

2014
n = 594
38.9%
Frequency
Length (cms)
Trips = 103
Tows = 188


2015
n = 255
16.1%
Frequency
Length (cms)
Trips = 57
Tows = 115


2016
n = 152
22.4%
Frequency
20
15
10
5
0
13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105 110 121
Length (cms)
Trips = 45
Tows = 85


2017
n = 118
43.2%
Frequency
15
10
5
0
13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105 110 121
Length (cms)
Trips = 23
Tows = 43

The preliminary analysis included all NEFOP and ASM trips, including both sector trips and common pool trips. The PDT explored removing common pool trips from the data, as these would be expected to have some legal-sized discards due to trips limits. The figure below displays length frequency distribution of discarded cod for CY 2017 with common pool trips removed, which resulted in four fish being removed from the data.



The PDT also examined the fish disposition codes for all discarded GOM cod included in the analysis. The table below displays the proportion of cod discards by disposition code. The majority of fish are recorded under Disposition Code = 012 – Regulations Prohibit Retention, Too Small. Other disposition codes in the data of notable proportions include 014 – Regulations Prohibit Retention, Quota Filled; 015 – Regulations Prohibit Retention, No Quota In Area; 063 – Retaining Only Certain Size Better Price Trip Quota in Effect; and 099 – Discarded, Other. Of note is that for CY 2017, 89.83% of discarded cod were recorded as Disposition Code = 012, while 43.2% of these fish were over the minimum size limit.

Proportion of Cod Discards by Disposition Code

Sum of NUMI	Column												
Row Label	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Grand Total
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.66%	0.00%	0.00%
2	0.00%	0.00%	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.66%	0.00%	0.01%
7	0.00%	0.00%	0.03%	0.03%	0.09%	0.02%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
11	0.00%	0.00%	0.00%	0.00%	0.15%	0.00%	0.00%	0.00%	0.00%	2.35%	0.00%	0.00%	0.04%
12	90.32%	90.45%	68.20%	57.16%	93.85%	99.36%	99.98%	100.00%	74.41%	90.59%	93.42%	89.83%	87.39%
14	6.86%	2.27%	14.82%	30.21%	2.53%	0.62%	0.00%	0.00%	25.59%	4.71%	3.29%	0.85%	7.53%
15	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.78%	0.03%
63	2.83%	5.20%	16.90%	6.75%	3.28%	0.00%	0.00%	0.00%	0.00%	2.35%	0.00%	2.54%	4.02%
99	0.00%	2.08%	0.00%	5.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.97%	0.00%	0.93%
39	0.00%	0.00%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

001 NO MARKET, REASON NOT SPECIFIED
002 NO MARKET, TOO SMALL
007 NO MARKET, BUT RETAINED FOR OBSERVER FOR SCIENTIFIC PURPOSES
011 REGULATIONS PROHIBIT RETENTION, REASON NOT SPECIFIED
012 REGULATIONS PROHIBIT RETENTION, TOO SMALL
014 REGULATIONS PROHIBIT RETENTION, QUOTA FILLED
015 REGULATIONS PROHIBIT RETENTION, NO QUOTA IN AREA
063 RETAINING ONLY CERTAIN SIZE BETTER PRICE TRIP QUOTA IN EFFECT
099 DISCARDED, OTHER
039 POOR QUALITY, PREVIOUSLY DISCARDED

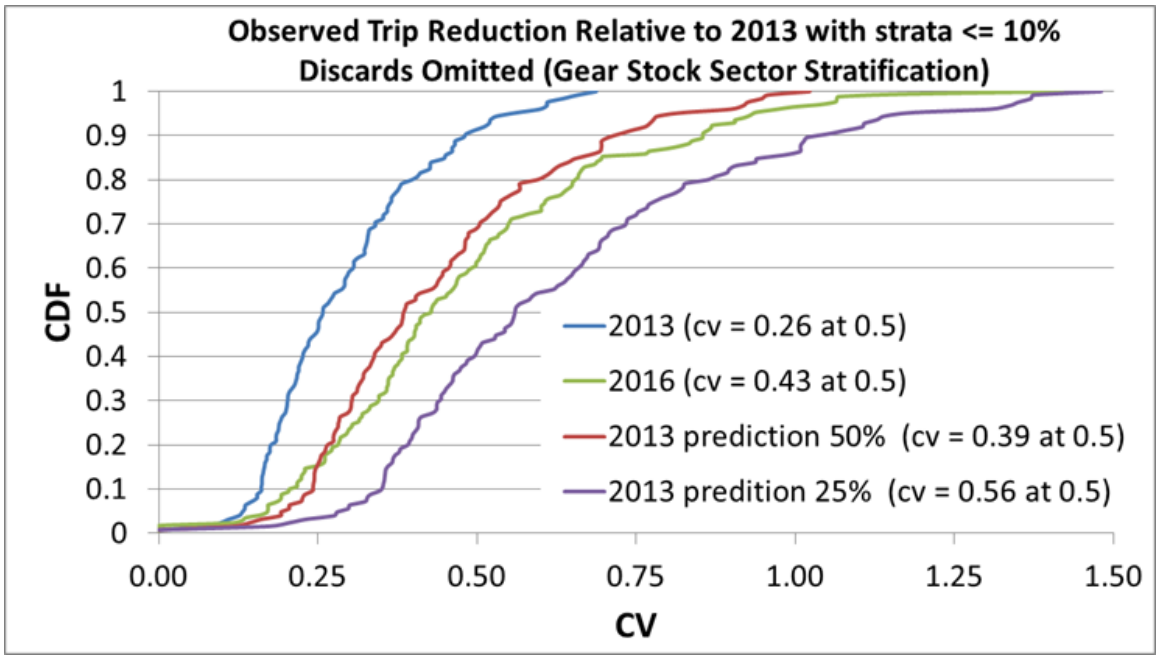
This preliminary analysis of observer data to explore potential discarding of legal-sized cod revealed evidence that suggests non-compliance may be occurring, but limitations in these data related to sample size require further investigation. Sample size for GOM cod length frequencies decreased substantially over the time period, which is expected given a decline in both observer coverage and GOM cod ACLs over time.

The PDT plans to further explore the trips for which discards of legal-sized cod have been recorded, although notes from an initial look that this does not appear to be isolated to specific vessels or observers. Further analysis is also planned to examine whether discarding of legal-sized cod has been recorded on fixed gear trips (gillnet and longline). Additionally, further analysis may include additional stocks and species to examine whether discarding of legal-sized fish may be occurring with other groundfish stocks, particularly other constraining stocks.

Attachment #2

Sector Monitoring CV Exploration

An exploration with estimated sector-gear-stock (monitoring stratification) CVs was done to determine if the CVs increased as sampling theory would predict under the lower coverage rates in 2016. From 2013 to 2016 the realized coverage rates were roughly cut in half. Sampling theory would suggest that the variation should increase with lower coverage rates. The PDT made predictions on sector-gear-stock CVs increase under lower coverage rates during the development of framework 55. In general the overall CDF (cumulative distribution function) of realized CVs appears to correspond to the predictions made in framework 55 (green line and red line are relatively close to each other). The median CV (strata less than 10% discards were filter out of the CDF) increased from 0.26 to 0.43 from 2013 to 2016.



There are some complicating factors with this analysis. The stratification has increased in 2016 (exemption strata were added). This may complicate the comparison due to a fundamental change in the underline stratification. The 2014 emergency action year was also not used due to potential effects of forced discarding under trip limits for Gulf of Maine cod. Management changes like changes in minimum sizes over time could also degrade the predictive power of using CVs to estimate monitoring coverages.

Overall, this analysis did not seem to detect an observer bias effect in the estimated CVs between 2013 and 2016. However this analysis is also likely not proof that a potential issue does not exist. A potential observer biases may be related to discarding of legal sized fish on unobserved trips which may not be detected in this sub-legal CV discard estimates on observed trips.

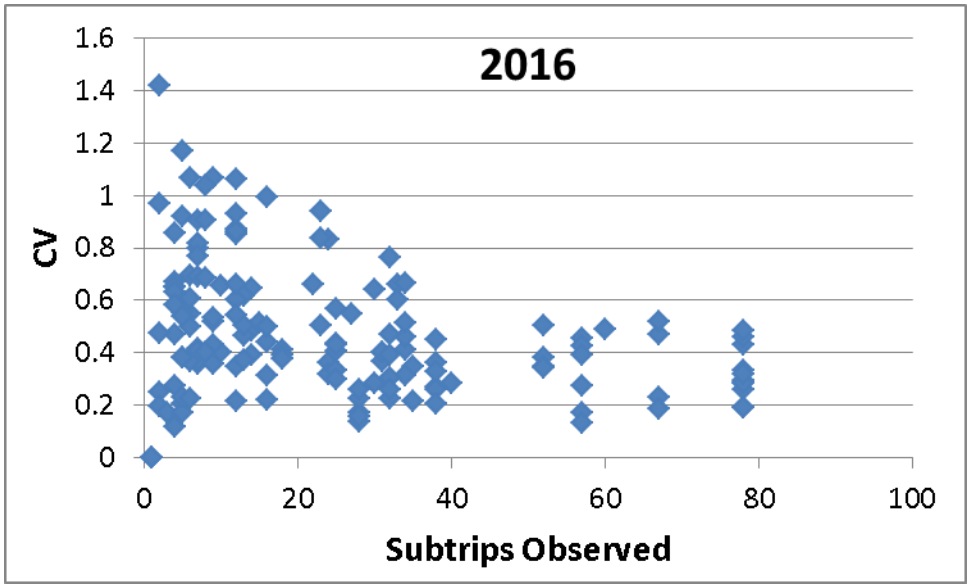
Observer bias was not detected in this analysis but this work suggests there are other concerns and questions with the present CV method for determination of coverage rates.

1) At the present 2016 coverage rates the CVs are very high on the stratification used for monitoring the fishery. This is not surprising since it was predicted in the framework 55 analysis but now this result raises real questions with our ability to monitor the fishery with the present stratification regardless of other concerns on the observer effect? From a statistical sense the present stratification does not seem to be justified. If there was an actual large change in discarding on specific stock sector gear basis for an important stratum then we would likely not be ability to detect this change with the present observed uncertainty on these estimates.

2) The uncertainty in the relationship between the realized CVs and the amount of observed trips brings up questions with the ability predict CVs under different coverage rates for a particular stock. The overall increase in the CVs across sectors was predicted but there is also error associated with the ability to predicted coverage rates that should result in the desired CVs.

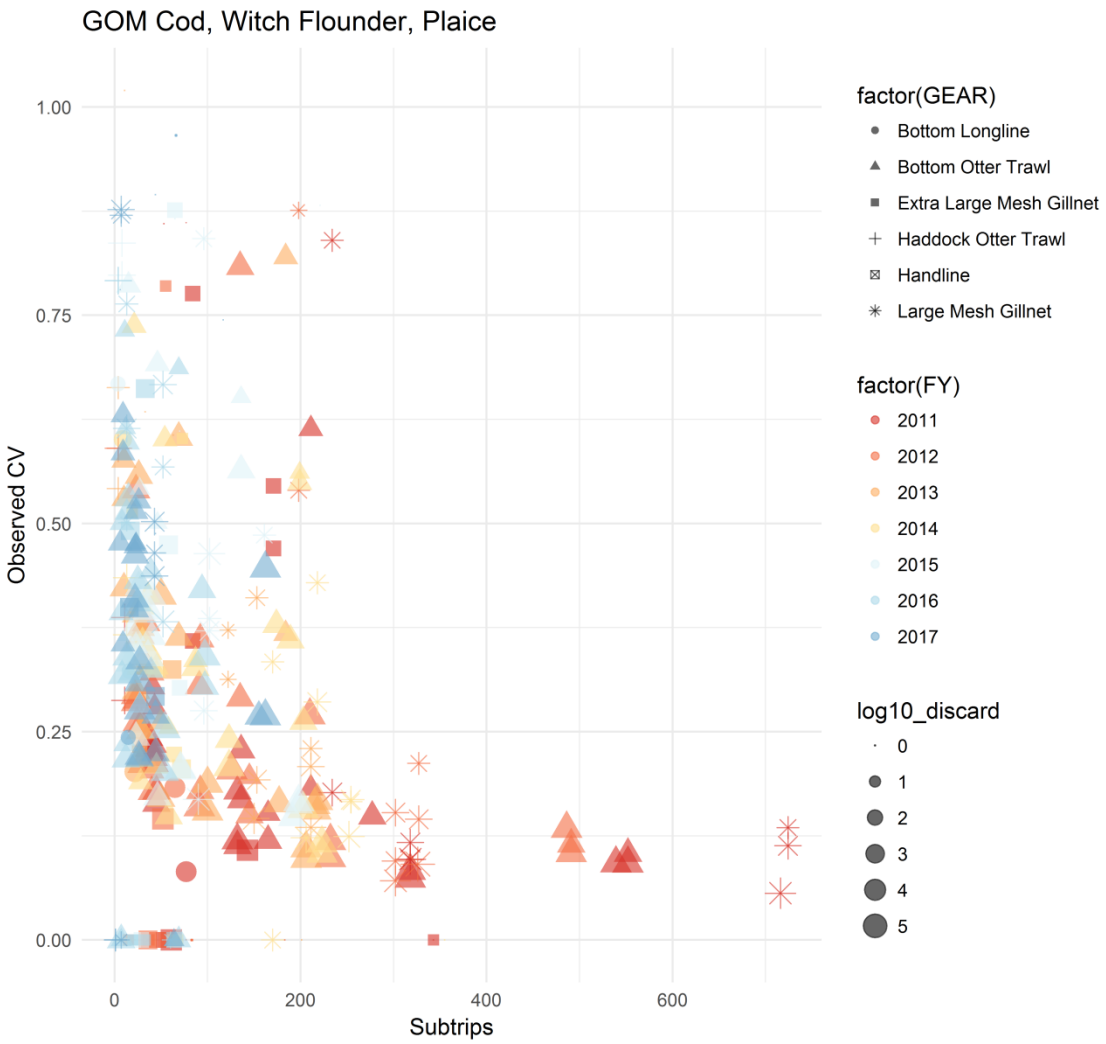
Below are the observed CVs across all strata (Sector-stock-gear) and years.

The plot below is limited to 2016 with the bottom 10% of discards filtered out by stock to help prevent insignificant strata from having too much of an influence on the results. Note under the present high CVs it may be more difficult to determine if some strata that truly are insignificant.



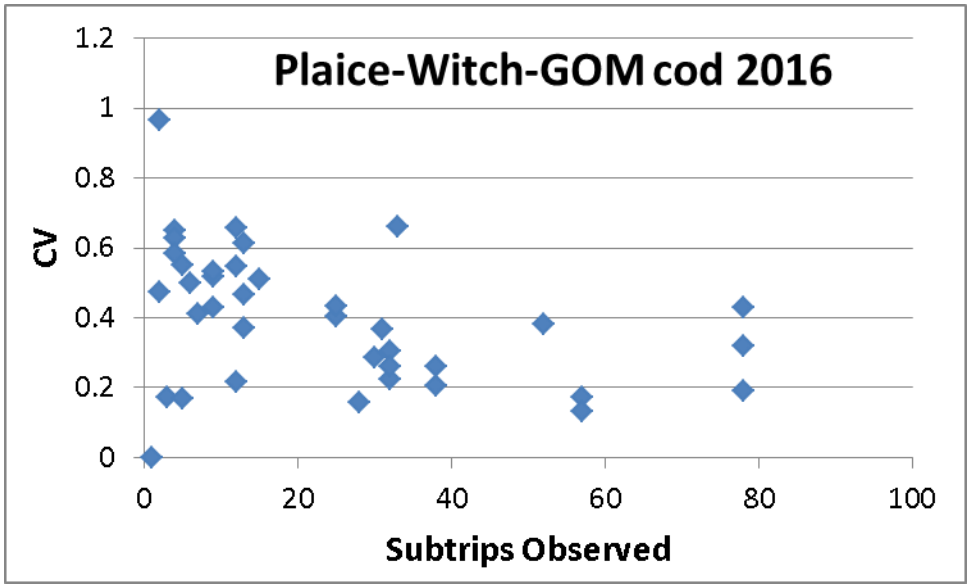
The plot below was limited to the more constraining stocks of American plaice, witch flounder and GOM cod which did not show a different pattern relative to the variation of CVs with observer trip coverage.

Attachment #2



The plot below is limited to 2016 with the bottom 10% of discards filtered out for the three constraining stocks (American plaice, witch flounder, GOM cod) to help prevent insignificant strata from having too much of an influence on the results.

Attachment #2



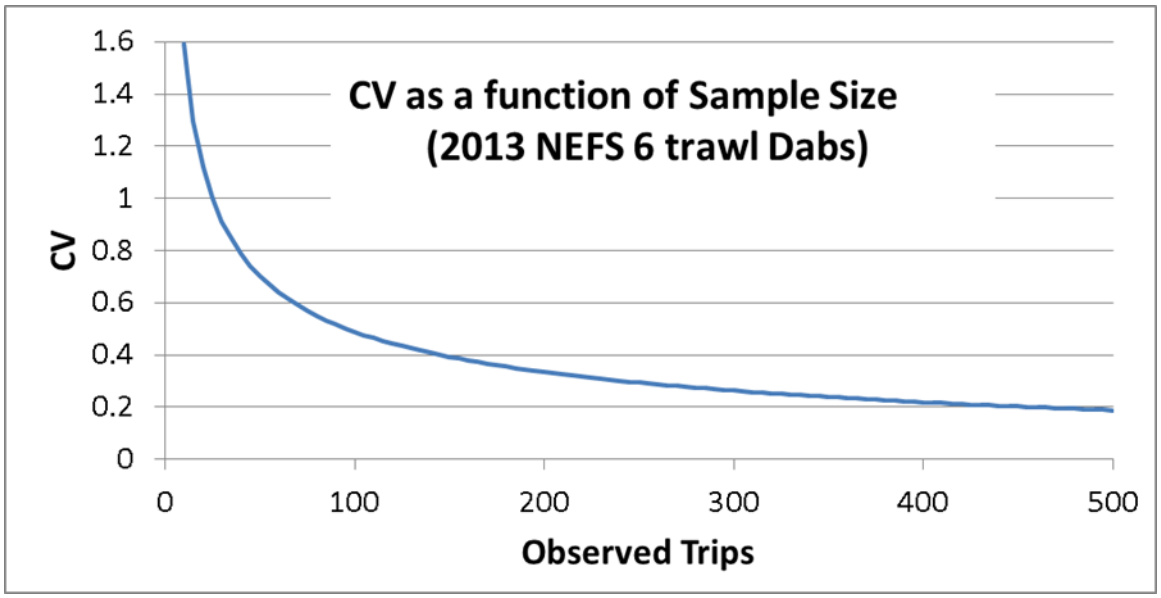
Below is the equation from SBRM for predicting CVs given a sample size.

The number of trips necessary to achieve a 30% CV based on the variance of the composite annual total discards for species group j in fleet h is defined as:

$$(11)\quad \hat{TD}_{30\,j,h} = \frac{\sum_{q=1}^{Q}\left(\frac{K_{q,h}^2}{\bar{k}_{q,h}^2}\hat{S}_{j,q,h}^2\frac{1}{\delta_{q,h}}\right)}{(0.09)\hat{D}_{j,h}{}^2 + \frac{\sum_{q=1}^{Q}\frac{K_{q,h}^2}{\bar{k}_{q,h}^2}\hat{S}_{j,q,h}^2}{N_h}}$$

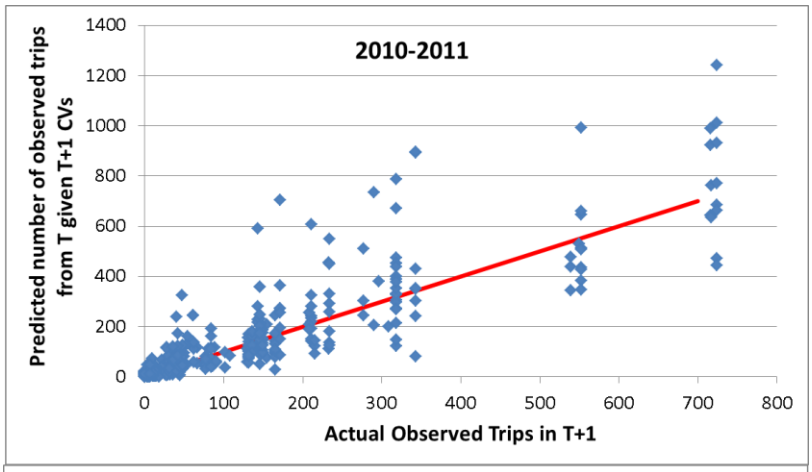
where $0.09 = 0.30^2$, the square of the 30% CV, the given precision level.

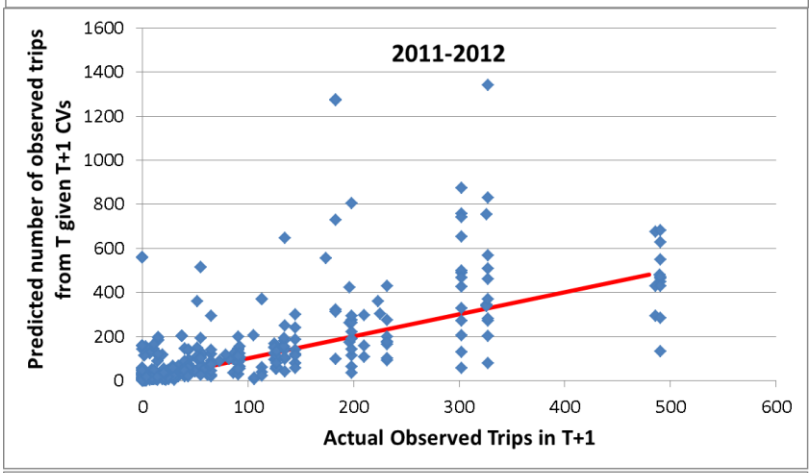
Using this equation one can make predictions on the needed sample size to achieve a particular CV. The plot below is an example of predicted CVs for a single stratum (2013 NEFS 6 trawl Dabs) under different observer trips using the equation above. The tradeoffs between sample size and CVs is evident in the curve. It is not a linear one to one relationship.

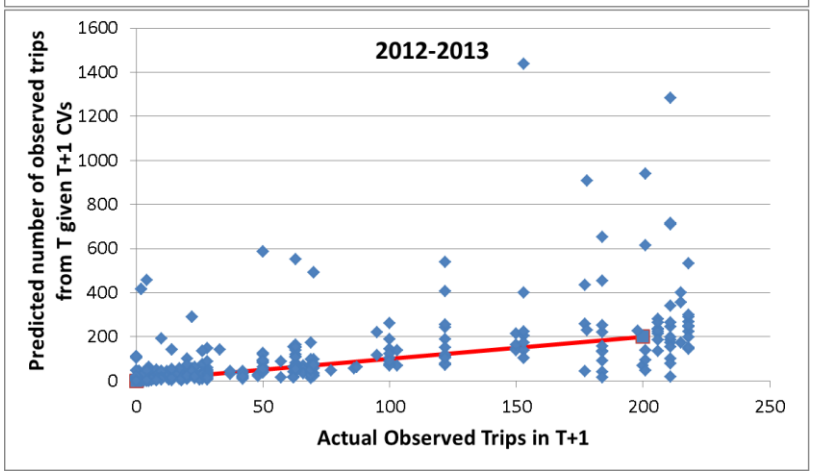


With the equation above we can test how well the predicted number of trips in time t given the realized CVs in time T+1 (y-axis) corresponds to the actual observed trips in year T+1 (x-axis).

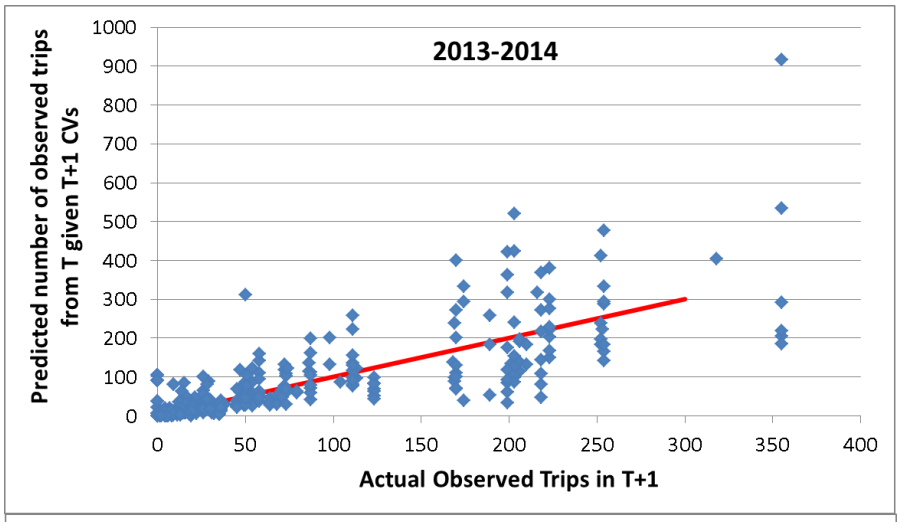
Attachment #2

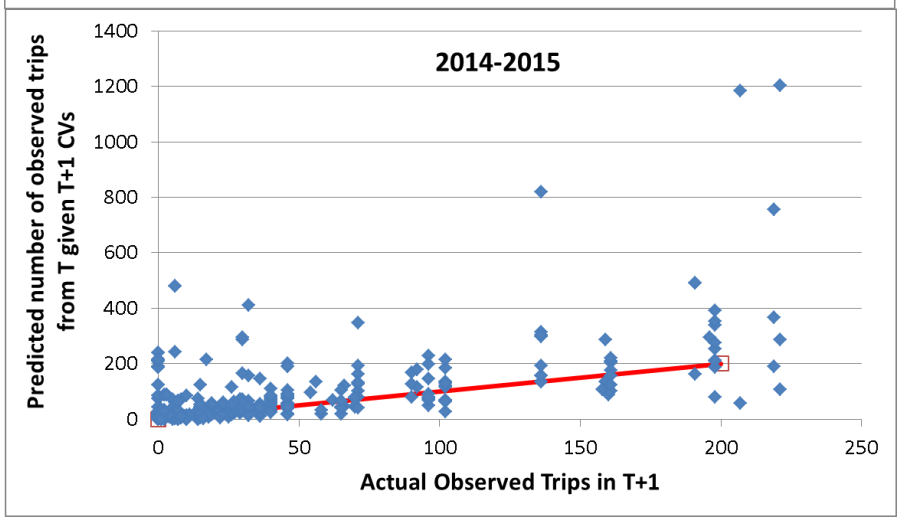






Attachment #2

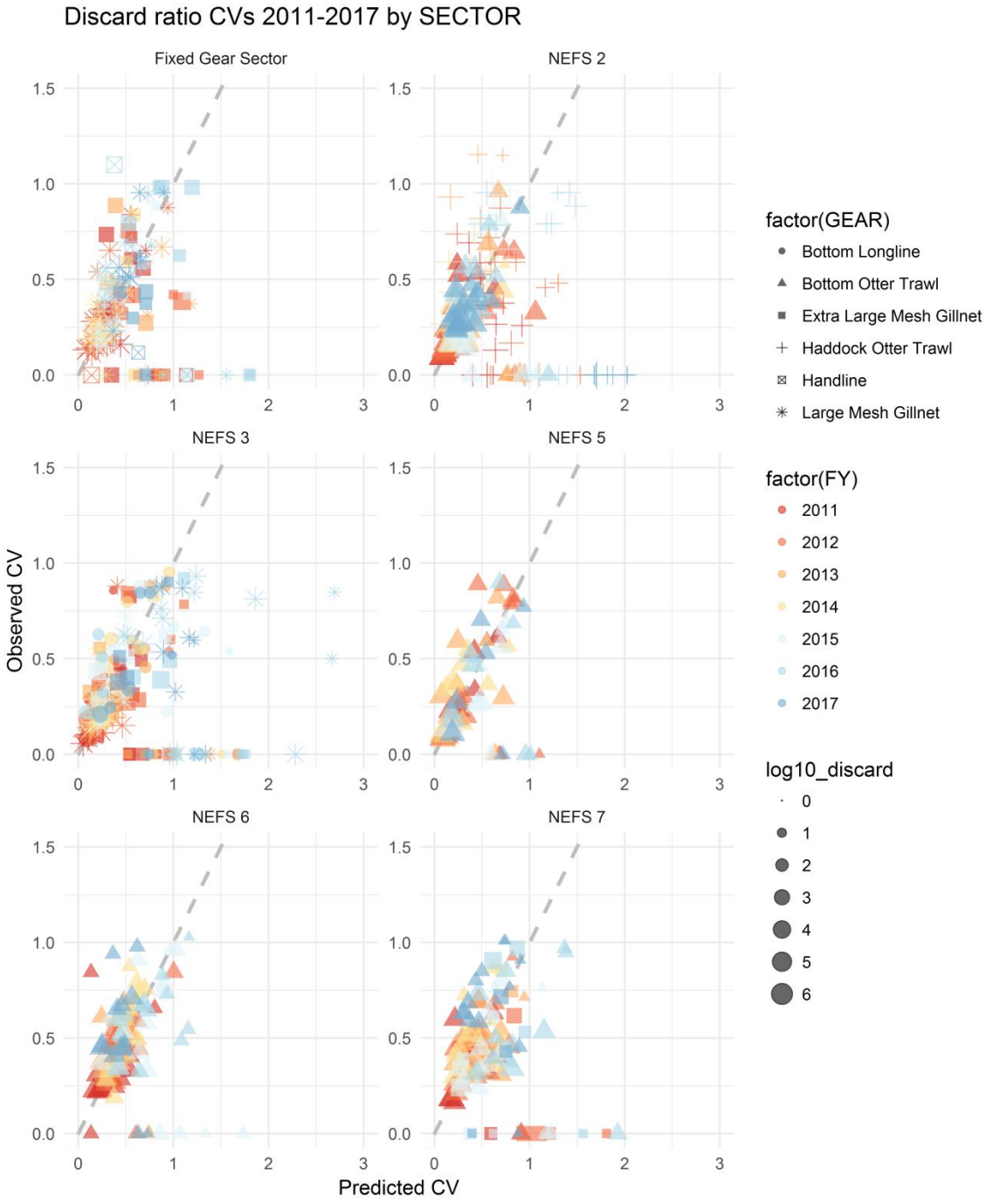




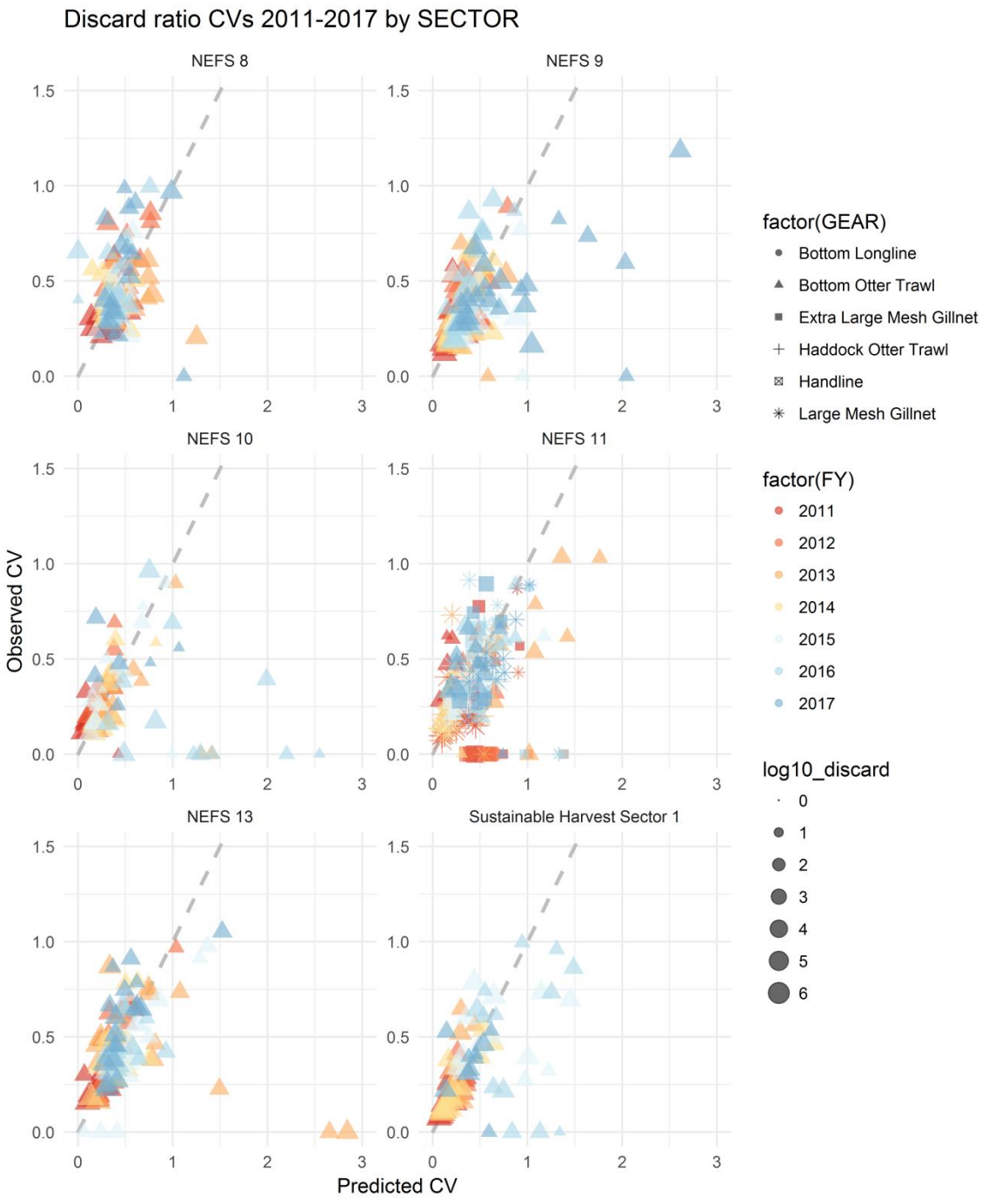
A better depiction is to use the above equation to solve of CVs so that one can compare the predicted CVs relative to the observed CVs under the monitoring stratification. The one to one line is also shown to signify a perfect relationship. Overall there did not seem to be an obvious bias in the predictions over time or among strata. It appears the variance can be used to make predictions on future observed trips needed to acquire a desired CV but perhaps not surprising there is also error associated with these predictions. In other words, there is error in using the error in year t to predict the require sample size to achieve a particular CV in year t+1.

Attachment #2

The next two plots are a closer look of the predicted vs observed CVs by sector.

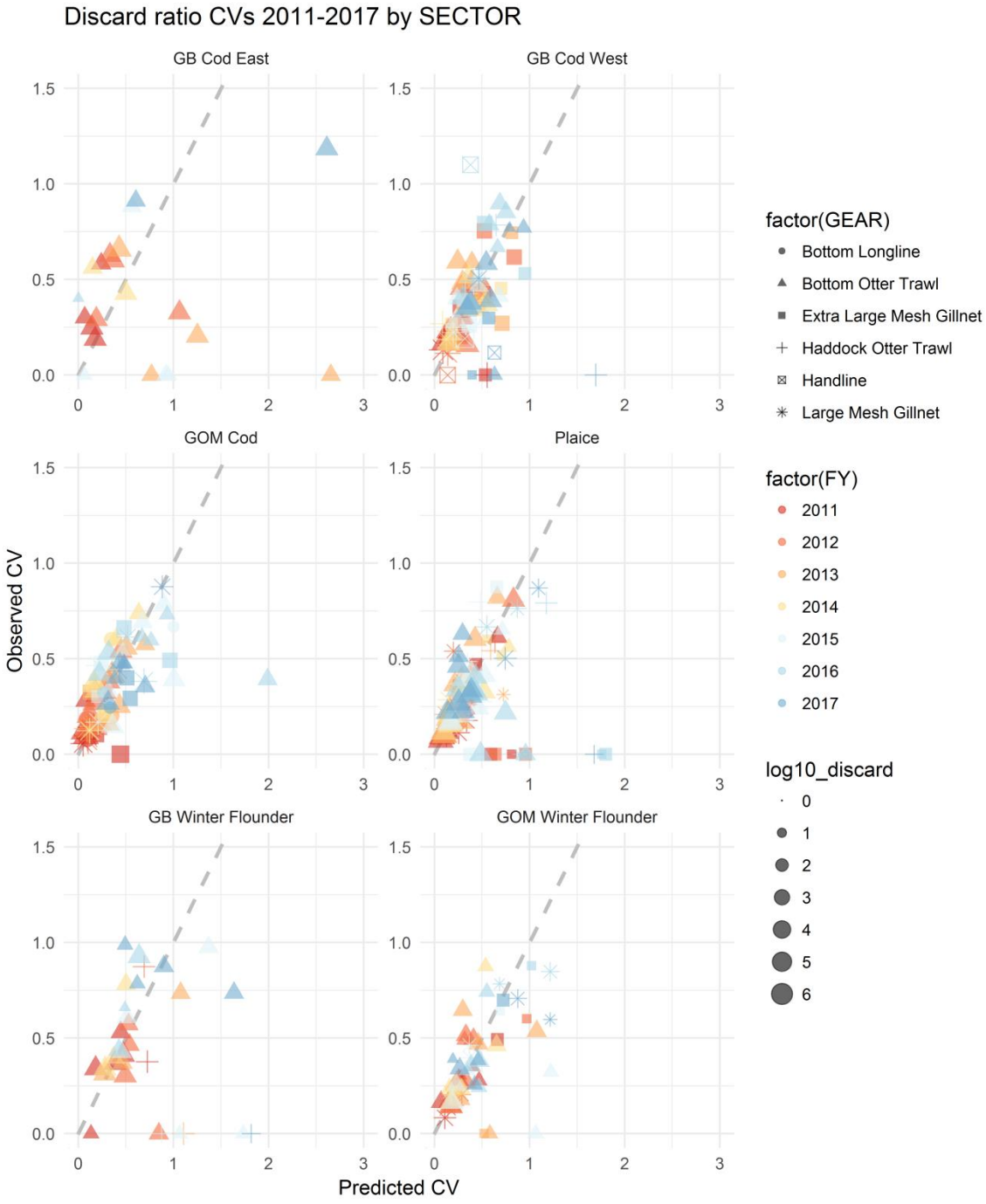


Attachment #2

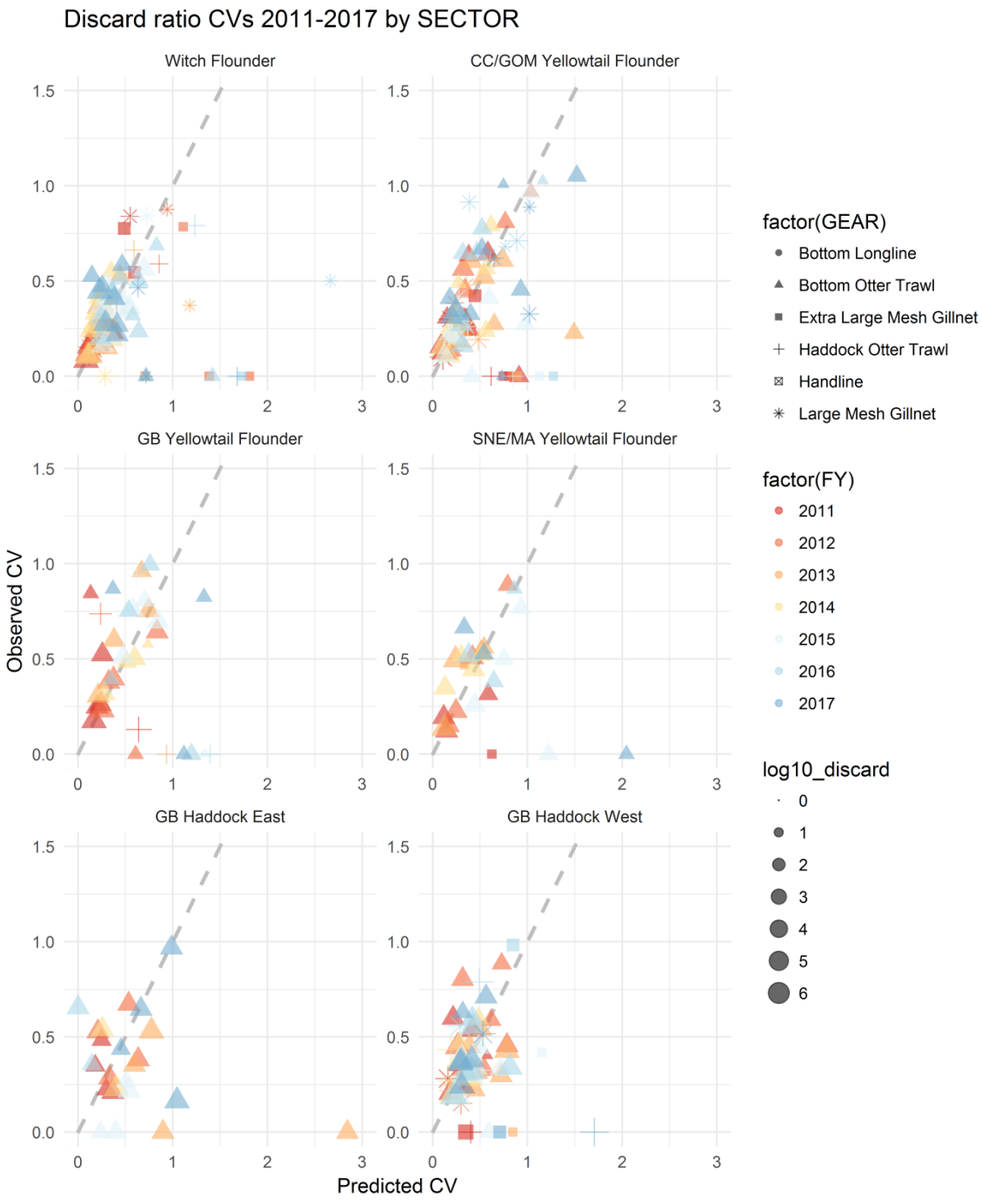


Attachment #2

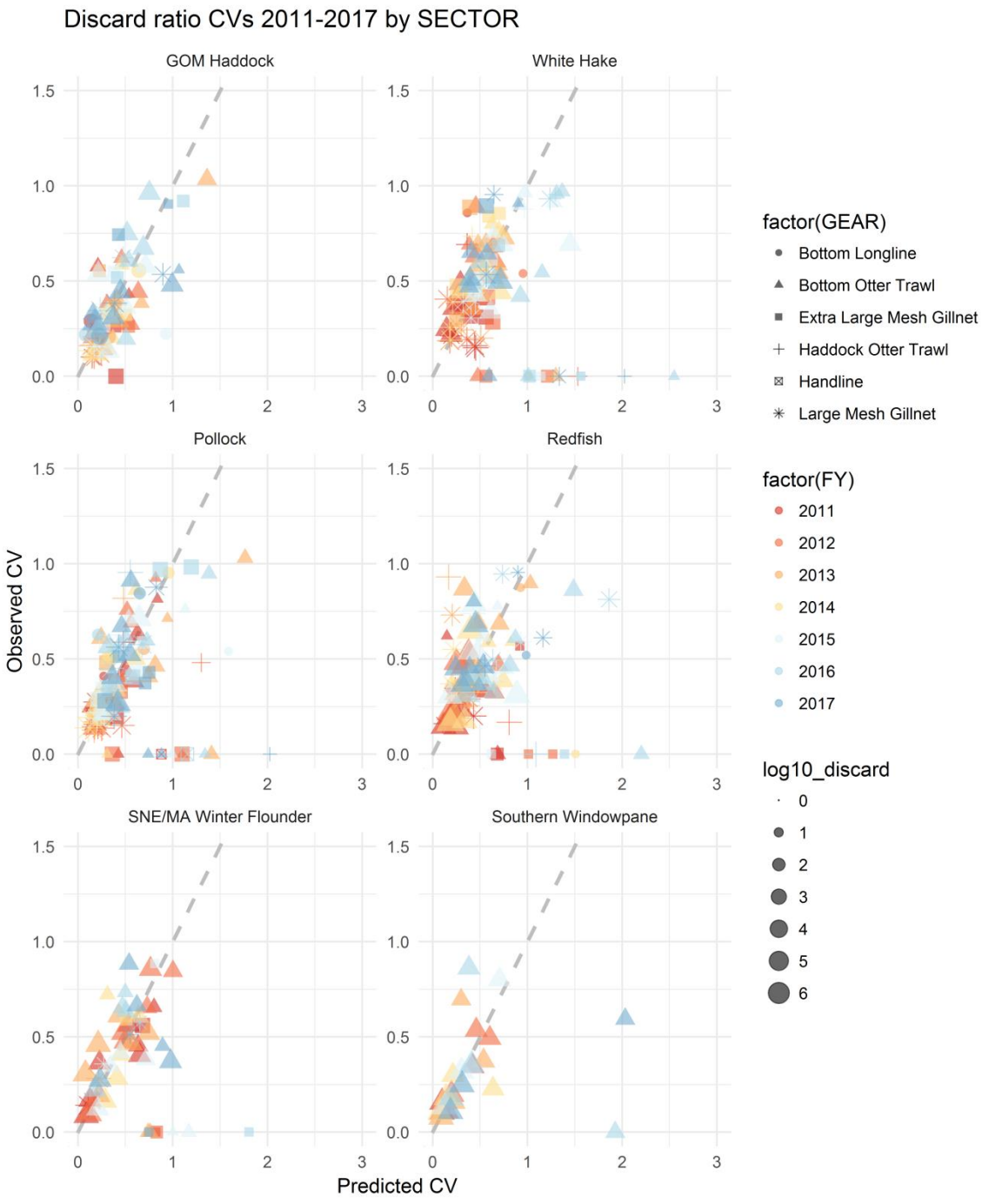
The next four plots below are for predicted vs observed CVs by stock.



Attachment #2



Attachment #2



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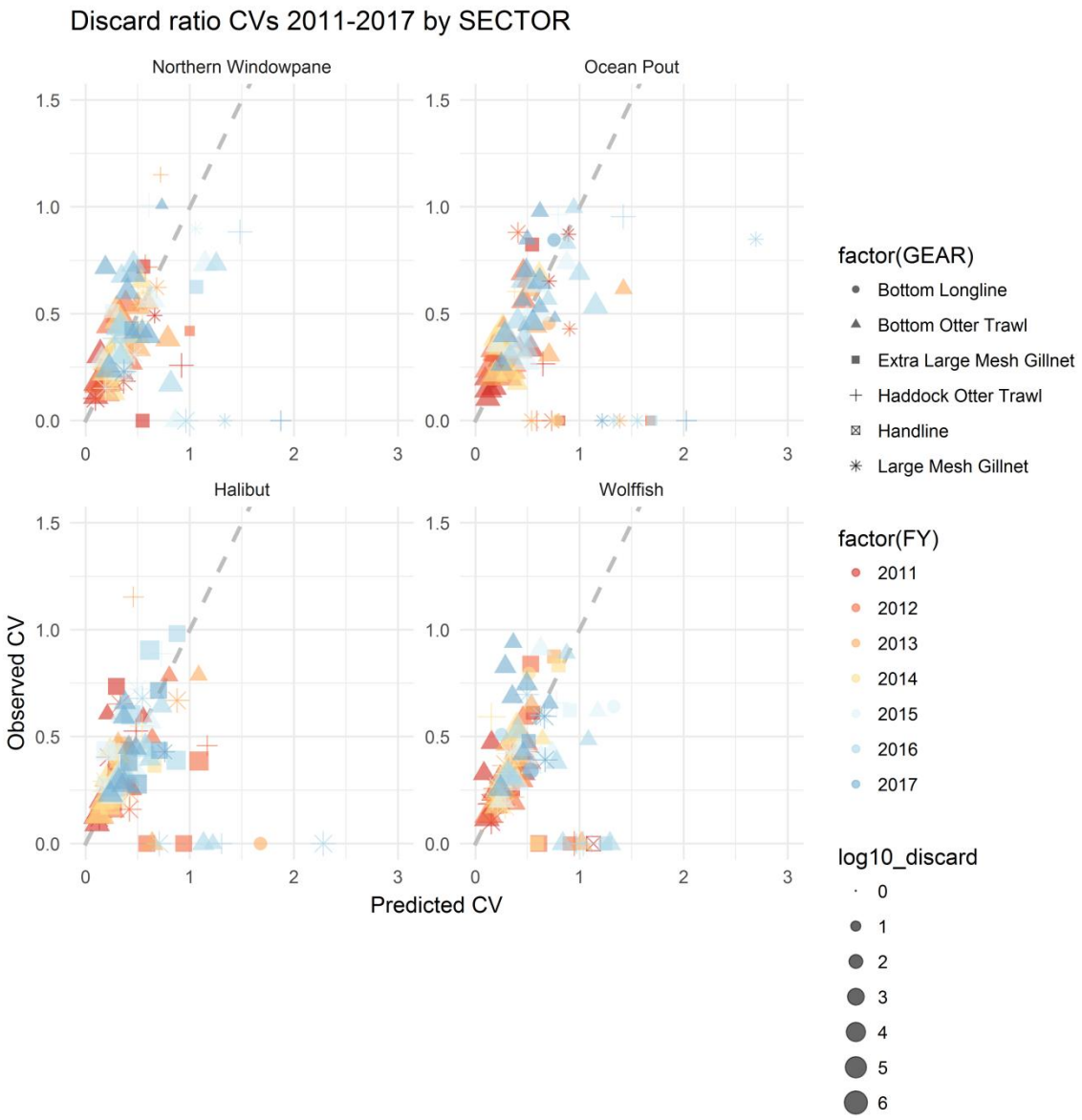

Attachment #3

Evaluating the Observer Effect for the Northeast U.S. Groundfish Fishery

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May 31, 2018

Groundfish Plan Development Team - White Paper

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– DRAFT –

Introduction

The commercial component of the Northeast U.S. Multispecies fishery comprises 20 individual fish stocks and 2 management units[1]. Of these, commercial fisherman are allocated quota for 15 stocks, leaving 5 for which retention is prohibited. Fishing quota is allocated to approximately 1,000 permits and actively fished by around 200 participating commercial vessels (NEFMC 2017). The majority of the commercial fishery for groundfish (~98% of landings) is managed under the Sector system whereby individual vessel owners pool stock-level quota into 21 sectors, each operating as a collective, pooling the quota and allocating it to individual member fisherman. Observers are deployed on participating vessels to estimate discarded catch for each of the 22 fish stocks on each trip. Observer coverage levels vary across stocks but in general observers have been onboard trips accounting for between 15-40% of all trips taken in any given fishing year. Actual discards are calculated by dividing the sum of stock-level discards observed for observed tows by the total amount of retained catch on these trips. For trips with no observer coverage, discards are estimated by stratifying the population of fishing trips by broad stock area, sector and fishing gear and applying the annualized real time observed discard rate for each sector's strata. Estimates are applied to the corresponding strata's unobserved trips. Discards count against a sector's quota after adjusting for gear and stock-specific discard mortality rates. Vessels are assessed estimated discards on unobserved trips based on their strata, regardless of whether or not an individual species was reported on that trip. Sectors must have adequate quota reserves for all species in a given stock area prior to any member vessels fishing in that area.

As observer coverage represents only a fraction of the total fishing activity in the sector component of the commercial groundfish fishery, obvious questions arise: Does data generated on observed fishing trips reflect the activities of the whole fleet? Are estimates generated from these data unbiased? Bias may be induced by either a deployment effect, where the assignment of observers to vessels is non-random, or an observer effect, where the fishing activities on observed trips vary in detectable ways from those on unobserved trips (Benoit and Allard 2009). These two effects, deployment and observer, may act separately and in combination to render data collected by on board observers biased. This paper focuses specifically on one component of the the latter effect: do individual vessels alter their behavior in response to the presence of an observer?

Fisherman may alter their fishing behavior when carrying an observer for any one of at least five reasons: (1) people may act differently as a repsonse to simply being watched, an established phenomena referred to as the Hawthorne Effect (McCambridge et al. 2018); (2) fisherman may not want to impart their individual discarding preferences on the other members of their sector, an effect driven primarily by within-strata target

[1]George's Bank is divided into a "west" component for which haddock and cod stocks are assessed exclusively by NOAA fisheries, and an "east" component for which these stocks together with yellowtail flounder are jointly assessed with the Canadian Department of Fisheries and Oceans under a trans-boundary management agreement.

species and fishing practice heterogeneity; (3) observers incur costs associated with slower fish processing and handling times, carrying extra food, and general inconvenience, all of which may incentivize fisherman to make shorter trips when observers are on board; (4) catch of undersized fish varies across space and fishing in areas and at times where undersized fish are relatively less abundant may minimize discard rates, though presumably at a cost in terms of reduced total trip revenues; and (5) binding quota constraints impart strong economic incentives to discard legal-sized fish when an observer is not on board and to avoid these stocks in the presence of an observer, again presumably at a cost in terms of reduced total trip revenues.

This paper employs an exact matching method to determine if vessel performance along several metrics vary in a detectable way when an observer is on board, and when one is not.

Methods

Following a procedure laid out by Benoit and Allard, same-vessel trip sequences are analyzed to test for differences among various metrics. These trip sequences take the form of either: (1) three unobserved trips in a row (UUU), or (2) one observed trip between unobserved trips (UOU). To attenuate the possibility of interpreting seasonal effects as behavioral effects, only trips occurring within 45 days of each other are included. Trips are not repeated in multiple sequences. Vessels with less than two sequences are excluded from the analysis.

Triplet sequences are winnowed to pairs by taking the difference of either the leading or lagging trip with respect to the middle trip. The variable U in equation (1) and U^1 in equation (2), below, are selected randomly as either the leading or trailing trip in the triplet sequence, while the middle trip in the sequence is always the reference trip (O or U^1, below). To mitigate against regulatory changes affecting fishing behavior within trip sequences while maximizing particularly the number of OU pairs for analysis, sequences overlapping the start of a new fishing year change (May 1 of each year) select only the lead or lag pair occurring in the same FY as the reference trip.

Differences are calculated as

$$\Delta O_{yfv} = \left(O - U/U'\right)_{yfv} * 100$$

(Equation 1)

$$\Delta U_{yfv} = \left(U^1 - U^2/U'\right)_{yfv} * 100$$

(Equation 2)

where y is a fishing year, f is fishing vessel and v is any one of the metrics evaluated. U' is the mean unobserved value for each year, vessel and metric combination.

Metrics evaluated, v, are:

1. Trip duration
2. Kept catch
3. Total revenue
4. Kept groundfish
5. Kept non-groundfish
6. Groundfish average price
7. Non-groundfish average price
8. Number of market categories included in kept catch

The difference between the median values for ΔU's and O's is calculated as

$$(M_{\Delta U-\Delta O})_{yfv} = median(\Delta U)_{yfv} - median(\Delta O)_{yfv}$$

.

(Equation 3)

Differences between observed and unobserved trips are tested in three ways: (1) location differences[2] are observed in $M_{\Delta U-\Delta O}$, with 95% confidence intervals estimated using bootstrap sampling (1,000 replicates) from the U_{yfv} and O_{yfv} values, where a lack of overlap with zero implies a 95% probability that the true median values for each population are significantly different; (2) the Kolmogorov-Smirnov statistic is used to test for general differences in shape of the U_{yfv} and O_{yfv} distributions; and (3) the Kuiper statistic is used to test for differences in the extremities of the distributions.

Multiple hypothesis tests are performed with the Kolmogorov-Smirnov (KSA) and Kuiper (KA) statistics. For these, a p-value of 0.005 is considered to be significant. Statistical significance should be considered in light of the data and research question. All p-values are reported.

Data

Vessel Trip Report (VTR) and Commercial Fishery Dealer (CFDBS) data are combined to construct trip-level data using the Data Matching and Imputation System (DMIS) database [cite needed]. Trips with an Allocation Management System (AMS) declaration code of "NMS" are included in the initial dataset. Only vessels fishing with trawl or gillnet gears are retained. Observer trips are matched by a step-wise algorithm, focusing on permit number, VTR serial number, days-at-sea (DAS) identification number, date and time sailed. For the post-Sector years, both Northeast Fishery Observer Program (NEFOP) and at-sea monitoring (ASM) data are matched.

UUU and UOU triplets are extracted from these data, and annual fishing year data sets are built (May 1 – April 30) with same-vessel two-trip sequences constructed from the UUU and UOU triplets.

Trips in the United States-Canada Resource Sharing Agreement Area (USCA area) are removed from the pre-sector (FY 2007-2009) dataset, as these trips were subject to observer coverage at higher rates than trips outside the area. All trips fishing with extra large mesh (ELM) under the conditions of the 2015 ELM exemption are excluded for all years, as are all trips by vessels enrolled in the Common Pool from 2010-2017. All excluded trips and their corresponding triplets are retained and, to better understand the potential drivers of observer effects, may be analyzed separately in the future.

Results

Results are reported based on two levels of aggregation:

- regulatory regime, as
  - pre-Sector years (FY's 2007-2009),
  - initial Sector years (FY's 2010-2012),
  - intermediate Sector years (FY's 2013-2015),
  - contemporary Sector years (FY's 2016-2017); and
- gear type, distinguishing between trawl and gillnet gears[3].

[2] "Location" refers to the central tendency of the data, in this case the median values, and has no geographic connotation here.

[3] Trawl gears include the Vessel Trip Report (VTR) codes 'OHS','OTB','OTC','OTF','OTM','OTO','OTR','OTS', and 'OTT'. Gillnet gears include the codes 'GNR','GNS', and 'GNT'.

Preliminarily, results at the fishing year (FY) level, dis-aggregated by gillnet and trawl, are included for context. Separate analyses have also been completed for single-day and multi-day trips, as well as a stock-level analysis of kept catch, number of market categories and average price for 15 individual groundfish stocks. The results are still being analyzed and will be integrated in the future.

Tests for differences in central tendency

Equations (1) and (2) are scaled by each vessel's mean annual values and median value differences are represented as percentages. For example, a median value of -0.042 for the kept catch variable implies that vessels catch roughly 4.2% less fish on an observed trip, relative to a neighboring unobserved trip by that same vessel, as measured across all vessels in the dataset. If the bootstrapped 95% confidence intervals fail to overlap with zero, the value is interpreted as significant using the confidence interval test.

Trawl vessels catch less fish when an observer is onboard. In the stanzas after 2009, they fish for less time and land less groundfish in particular. Statistical significance is obtained for kept catch in all four stanzas, and for trip duration, groundfish kept catch and total revenues in the three post-2009 stanzas. Groundfish average prices are statically higher for three of the four stanzas, the exception being the period from 2010-2012, indicating that composition of groundfish catch on observed and unobserved trips is different. Based on the reductions in catch and fishing time on observed trips after 2009, the changes in response to observer presense appear to be related to incentives embedded in catch accountability and the sector management system.

Gillnet vessels consistently made shorter trips, generate less revenue and appear to retain slightly less catch overall in the presence of an observer, but the results are more variable relative to trawl vessels. There is a trend in later stanzas toward more groundfish and less non-groundfish on observed trips for these vessels, indicating a difference in the mix of species landed in response to an observer. The increase in the number of groundfish market categories in the last stanza may indicate differential groundfish targeting, or perhaps high-grading of specific species. Statistically different behavior in response to an observer is equally prevalent for gillnet vessels and trawl vessels, but the magnitude of the effect appears to be slightly smaller for gillnet vessels. This may reflect a truly smaller behavioral response, or it may be due to a smaller number of paired trips, particularly in the later stanzas, or some combination of both. There is a less clear distinction in response before and after the implementation of sectors, where gillnet vessels demonstrated a significant response before sectors and trawl vessels, for the most part, did not.

Tests for differences in distribution shape

TBC

Discussion

Fishing vessels alter their behavior in response to observers. Estimated median paired trip differences are zero for only a handful of the metrics evaluated across stanzas or fishing years. Generally, the most pronounced effects are seen across trip duration, kept catch, kept groundfish and trip revenue. Observer presence has the smallest affect on the number of groundfish market categories and non-groundfish average prices, but even here we see differences.

Incentives to alter fishing behavior have varied across time. Prior to sector implementation discards had no direct cost to fisherman and trip limits required discarding certain species. These factors may have reduced the incentive to alter fishing practices in response to an observer, noting that gillnet vessels did demonstrate a significant behavioral response prior to sectors. After full sector implementation, the accountability of discards and the application of sector/gear specific discard rates to unobserved trips, together with the potential catch of constraining stocks, increased the incentive to change behavior in response to an observer.

There may be off-setting incentives due to quota allocations, fishing preferences or other factors. One vessel may attempt to minimize observed discarding of flatfish at the expense of cod, while another vessel may take the exact opposite approach. Such offsetting behavior could change the central tendency of the distribution of $M_{\Delta U - \Delta O}$ very little, but may affect the shape of the distribution, particularly at the tails. This is where the Kuiper and Kolmogorov-Smirnov (K-S) tests become valuable. The K-S evaluates changes in the overall shape of the distribution, while the Kuiper tests for changes in the the tails.

These analyses point toward a consistent pattern of different fishing behaviors when an observer is on board. The Benoit and Allard method isolates vessel effects by focusing on the differences in behavior in response to an observer *for the same vessel*. The data show a clear trend for three key metrics–in almost all circumstances vessels appear to retain less fish, fish for less time and obtain lower revenues when an observer is on board. Persistent differences such as higher average groundfish prices with an observer on board (trawl vessels) and emerging differences like a greater number of market categories retained with an observer (gillnet vessels) indicate that the composition of catch on observed trips is different. This suggests that data collected by observers are not merely a compressed representation of unobserved fishing practices but, rather, they may be non-representative along critical dimensions such as proportions and quantities of fish discarded and retained.

Tables and figures

Table 1: Stanza 1, 2007-2009

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish		-1.4 %	-0.4 %	0.3 %	21,734	750
Trawl	Number groundfish market categories		0 %	0 %	0 %	21,734	750
Trawl	Groundfish avg price	*	0.9 %	1.4 %	1.9 %	21,734	750
Trawl	Kept catch	*	-4.6 %	-3.5 %	-2.4 %	21,734	750
Trawl	Kept non-groundfish		0 %	0 %	0 %	21,734	750
Trawl	Non-groundfish avg price		0 %	0 %	0 %	21,734	750
Trawl	Total revenue		-1 %	0.2 %	1.4 %	21,734	750
Trawl	Trip duration		-0.1 %	0.4 %	1.2 %	21,734	750
Gillnet	Kept groundfish	*	-2.6 %	-1.9 %	-1.2 %	21,530	532
Gillnet	Number groundfish market categories	*	-3.5 %	-2.1 %	-1 %	21,530	532
Gillnet	Groundfish avg price	*	1 %	1.5 %	2 %	21,530	532
Gillnet	Kept catch	*	-2.7 %	-1.9 %	-1.1 %	21,530	532
Gillnet	Kept non-groundfish	*	-1 %	-0.7 %	-0.4 %	21,530	532
Gillnet	Non-groundfish avg price		-0.3 %	0 %	0 %	21,530	532
Gillnet	Total revenue	*	-4.4 %	-3.5 %	-2.6 %	21,530	532
Gillnet	Trip duration	*	-4.9 %	-4.3 %	-3.9 %	21,530	532

Table 2: Stanza 2, 2010-2012

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-11.7 %	-9.2 %	-6.8 %	5,756	1,616
Trawl	Number groundfish market categories		-0.9 %	0 %	0 %	5,756	1,616
Trawl	Groundfish avg price		-1.3 %	-0.3 %	0.6 %	5,756	1,616
Trawl	Kept catch	*	-11 %	-8.5 %	-6.2 %	5,756	1,616
Trawl	Kept non-groundfish		-3.6 %	-1.6 %	0 %	5,756	1,616
Trawl	Non-groundfish avg price		-0.2 %	0.5 %	1.8 %	5,756	1,616
Trawl	Total revenue	*	-8.9 %	-6.7 %	-4.4 %	5,756	1,616
Trawl	Trip duration	*	-4.3 %	-3 %	-1.7 %	5,756	1,616
Gillnet	Kept groundfish		-3.3 %	-1 %	1.3 %	5,234	1,365
Gillnet	Number groundfish market categories		0 %	0.8 %	2.9 %	5,234	1,365
Gillnet	Groundfish avg price	*	0.3 %	1.2 %	2 %	5,234	1,365
Gillnet	Kept catch		-3.6 %	-1.6 %	0.5 %	5,234	1,365
Gillnet	Kept non-groundfish		-0.8 %	-0.2 %	0.2 %	5,234	1,365
Gillnet	Non-groundfish avg price		-1 %	-0.1 %	0.5 %	5,234	1,365
Gillnet	Total revenue		-4.3 %	-2.1 %	0 %	5,234	1,365
Gillnet	Trip duration	*	-4 %	-3.2 %	-2.5 %	5,234	1,365

Table 3: Stanza 3, 2013-2015

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-10.2 %	-7.9 %	-5.4 %	5,944	1,026
Trawl	Number groundfish market categories		0 %	0 %	0 %	5,944	1,026
Trawl	Groundfish avg price	*	0.9 %	1.9 %	3 %	5,944	1,026
Trawl	Kept catch	*	-10.7 %	-8.6 %	-6.1 %	5,944	1,026
Trawl	Kept non-groundfish		-5.1 %	-2.4 %	0.1 %	5,944	1,026
Trawl	Non-groundfish avg price		-1.9 %	-0.3 %	0.9 %	5,944	1,026
Trawl	Total revenue	*	-7.2 %	-5 %	-2.8 %	5,944	1,026
Trawl	Trip duration	*	-4.6 %	-3.3 %	-2.1 %	5,944	1,026
Gillnet	Kept groundfish		-2.2 %	0.8 %	4 %	3,287	447
Gillnet	Number groundfish market categories		0 %	0 %	1.6 %	3,287	447
Gillnet	Groundfish avg price		-0.8 %	0.3 %	1.6 %	3,287	447
Gillnet	Kept catch		-2.1 %	0.7 %	3.3 %	3,287	447
Gillnet	Kept non-groundfish		-3.9 %	-2 %	0.2 %	3,287	447
Gillnet	Non-groundfish avg price	*	0.3 %	2.1 %	4.2 %	3,287	447
Gillnet	Total revenue		-0.1 %	2.7 %	5.3 %	3,287	447
Gillnet	Trip duration	*	-4.4 %	-3.3 %	-2.4 %	3,287	447

Table 4: Stanza 4, 2016-2017

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-9.5 %	-6.8 %	-4.1 %	3,559	571
Trawl	Number groundfish market categories		0 %	0 %	0 %	3,559	571
Trawl	Groundfish avg price	*	0.9 %	2 %	3.3 %	3,559	571
Trawl	Kept catch	*	-7 %	-4.4 %	-1.5 %	3,559	571
Trawl	Kept non-groundfish		-3.1 %	-0.2 %	2.4 %	3,559	571
Trawl	Non-groundfish avg price		-2.4 %	-0.6 %	1 %	3,559	571
Trawl	Total revenue	*	-5.4 %	-2.8 %	-0.1 %	3,559	571
Trawl	Trip duration	*	-4.3 %	-2.8 %	-1.3 %	3,559	571
Gillnet	Kept groundfish		-1.4 %	4.1 %	10.1 %	996	197
Gillnet	Number groundfish market categories		0 %	5.4 %	9.5 %	996	197
Gillnet	Groundfish avg price		-0.5 %	2.4 %	5.5 %	996	197
Gillnet	Kept catch		-8.1 %	-3.8 %	0.8 %	996	197
Gillnet	Kept non-groundfish	*	-13 %	-8.1 %	-4 %	996	197
Gillnet	Non-groundfish avg price		-1.7 %	0.9 %	3.6 %	996	197
Gillnet	Total revenue		-7.3 %	-3.1 %	1 %	996	197
Gillnet	Trip duration	*	-4.7 %	-3.2 %	-1.3 %	996	197

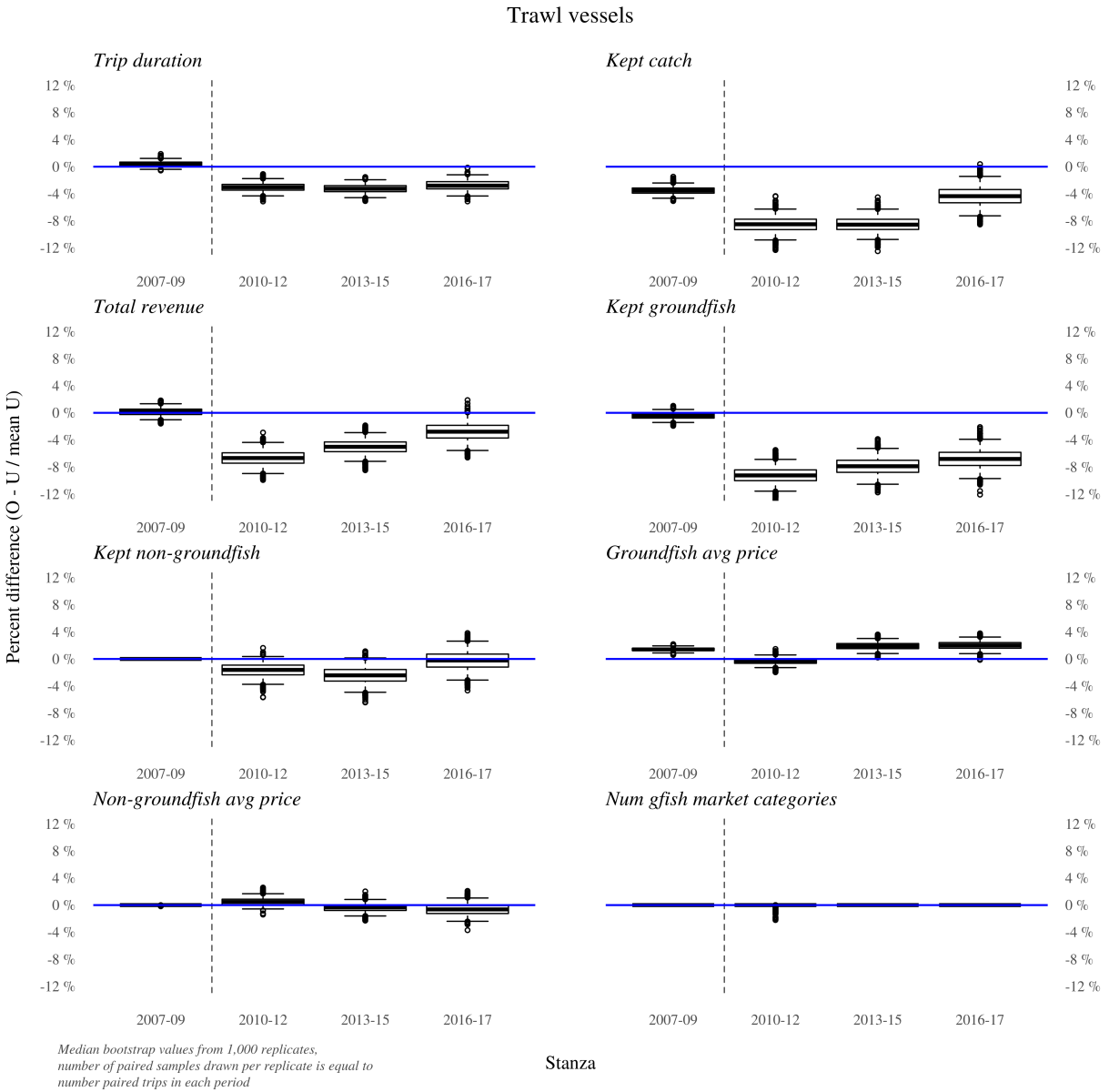

Figure 1: Results of bootstrap analysis, observed and unobserved same-vessel paired trips by stanza

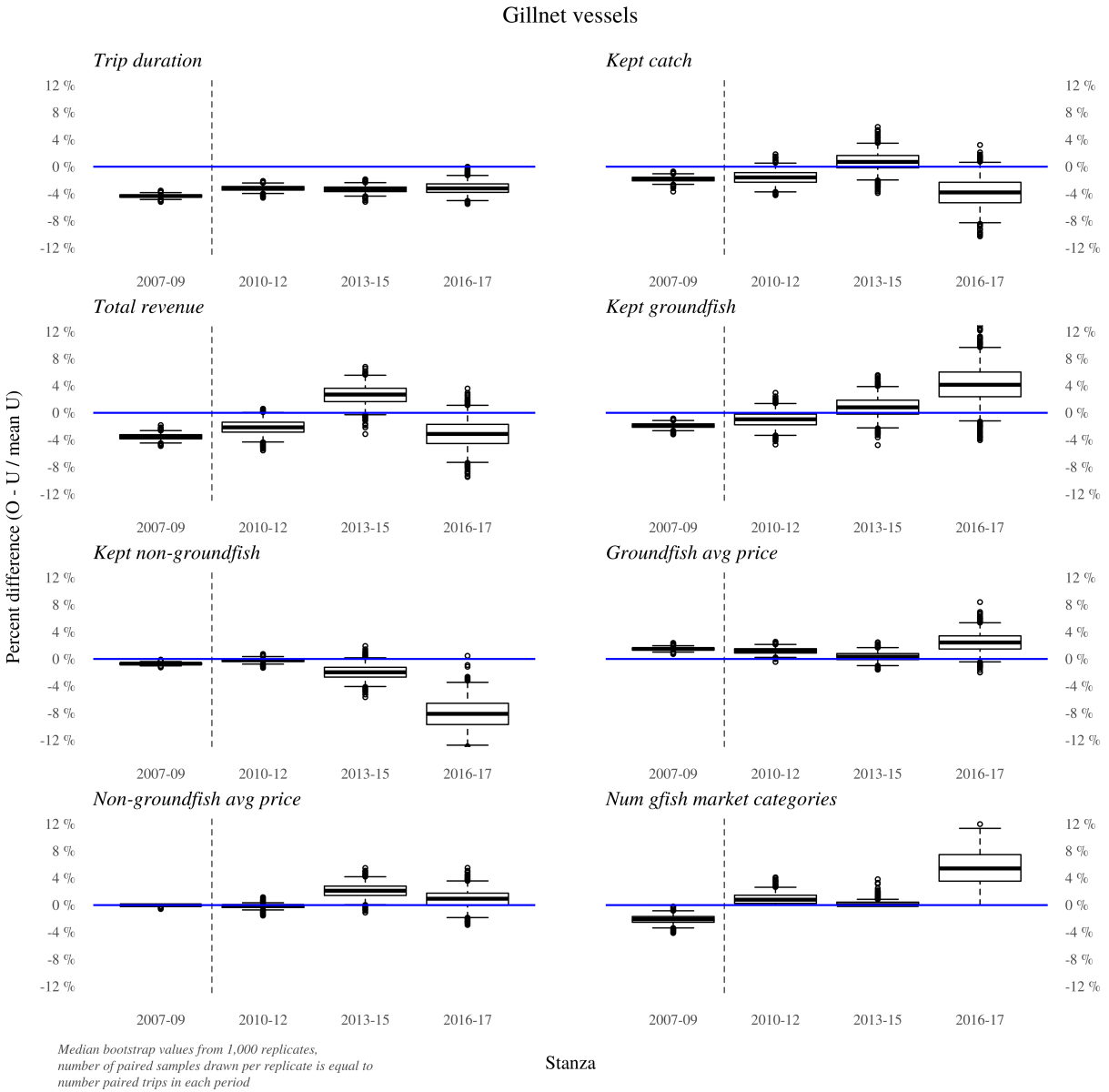

Figure 2: Results of bootstrap analysis, observed and unobserved same-vessel paired trips by stanza

Table 5: Fishing Year 2007

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-4.7 %	-2.8 %	-0.9 %	8,076	247
Trawl	Number groundfish market categories		0 %	0 %	0 %	8,076	247
Trawl	Groundfish avg price	*	0.3 %	1 %	1.7 %	8,076	247
Trawl	Kept catch	*	-8.1 %	-6.2 %	-4.4 %	8,076	247
Trawl	Kept non-groundfish		-3.8 %	-1.8 %	0 %	8,076	247
Trawl	Non-groundfish avg price		0 %	0 %	0.1 %	8,076	247
Trawl	Total revenue		-3.2 %	-1.4 %	0.6 %	8,076	247
Trawl	Trip duration		-2.1 %	-0.9 %	0 %	8,076	247
Gillnet	Kept groundfish	*	-4.7 %	-2.9 %	-1.3 %	6,172	154
Gillnet	Number groundfish market categories	*	-6.7 %	-4.2 %	-1.9 %	6,172	154
Gillnet	Groundfish avg price		-0.3 %	0.5 %	1.3 %	6,172	154
Gillnet	Kept catch		-1.5 %	0 %	1.5 %	6,172	154
Gillnet	Kept non-groundfish		-0.6 %	0 %	0 %	6,172	154
Gillnet	Non-groundfish avg price		0 %	0 %	0 %	6,172	154
Gillnet	Total revenue	*	-4.1 %	-2.5 %	-0.9 %	6,172	154
Gillnet	Trip duration	*	-4.2 %	-3.2 %	-2.3 %	6,172	154

Table 6: Fishing Year 2008

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish		-3.1 %	-1.2 %	0.5 %	7,348	303
Trawl	Number groundfish market categories		0 %	0 %	0 %	7,348	303
Trawl	Groundfish avg price	*	1.2 %	2.2 %	3.2 %	7,348	303
Trawl	Kept catch	*	-7.6 %	-5.7 %	-3.6 %	7,348	303
Trawl	Kept non-groundfish		0 %	0 %	0 %	7,348	303
Trawl	Non-groundfish avg price		-0.6 %	0 %	0 %	7,348	303
Trawl	Total revenue	*	-5.7 %	-3.4 %	-1.3 %	7,348	303
Trawl	Trip duration		-2.1 %	-0.8 %	0.3 %	7,348	303
Gillnet	Kept groundfish	*	-6.4 %	-4.8 %	-3.3 %	6,903	180
Gillnet	Number groundfish market categories		-2 %	-0.2 %	0 %	6,903	180
Gillnet	Groundfish avg price	*	2.5 %	3.4 %	4.3 %	6,903	180
Gillnet	Kept catch	*	-6.3 %	-4.9 %	-3.5 %	6,903	180
Gillnet	Kept non-groundfish	*	-2.4 %	-1.9 %	-1.3 %	6,903	180
Gillnet	Non-groundfish avg price	*	-2.4 %	-1.3 %	-0.5 %	6,903	180
Gillnet	Total revenue	*	-5.4 %	-3.7 %	-2.1 %	6,903	180
Gillnet	Trip duration	*	-4.4 %	-3.6 %	-2.7 %	6,903	180

Table 7: Fishing Year 2009

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	0.6 %	1.7 %	3 %	6,310	200
Trawl	Number groundfish market categories		0 %	0 %	2.1 %	6,310	200
Trawl	Groundfish avg price	*	0.1 %	0.9 %	1.9 %	6,310	200
Trawl	Kept catch		0 %	1.8 %	3.5 %	6,310	200
Trawl	Kept non-groundfish	*	0.6 %	2 %	3.7 %	6,310	200
Trawl	Non-groundfish avg price		-0.3 %	0 %	0 %	6,310	200
Trawl	Total revenue	*	5.1 %	7.1 %	9.1 %	6,310	200
Trawl	Trip duration	*	3.5 %	5 %	6.6 %	6,310	200
Gillnet	Kept groundfish		-0.4 %	0 %	0.5 %	8,455	198
Gillnet	Number groundfish market categories	*	-5.4 %	-2.5 %	-0.1 %	8,455	198
Gillnet	Groundfish avg price		-0.2 %	0.5 %	1.4 %	8,455	198
Gillnet	Kept catch		-1.7 %	-0.5 %	0.3 %	8,455	198
Gillnet	Kept non-groundfish		-0.7 %	-0.4 %	0 %	8,455	198
Gillnet	Non-groundfish avg price		-0.1 %	0 %	0 %	8,455	198
Gillnet	Total revenue	*	-5.5 %	-4.2 %	-2.7 %	8,455	198
Gillnet	Trip duration	*	-6.9 %	-6 %	-5.2 %	8,455	198

Table 8: Fishing Year 2010

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-19.1 %	-14.2 %	-8.8 %	1,226	456
Trawl	Number groundfish market categories		-5.2 %	-1.2 %	0 %	1,226	456
Trawl	Groundfish avg price		-2.2 %	0.1 %	2 %	1,226	456
Trawl	Kept catch	*	-15.2 %	-10.4 %	-5.5 %	1,226	456
Trawl	Kept non-groundfish	*	-10.4 %	-5.5 %	-0.7 %	1,226	456
Trawl	Non-groundfish avg price		-0.6 %	1 %	3.6 %	1,226	456
Trawl	Total revenue	*	-15.2 %	-10.5 %	-5.4 %	1,226	456
Trawl	Trip duration	*	-9.4 %	-6.1 %	-2.4 %	1,226	456
Gillnet	Kept groundfish	*	-12.2 %	-7.5 %	-2.6 %	1,385	460
Gillnet	Number groundfish market categories		0 %	0.7 %	6.3 %	1,385	460
Gillnet	Groundfish avg price	*	0.3 %	2 %	3.6 %	1,385	460
Gillnet	Kept catch		-6.7 %	-2.1 %	2.2 %	1,385	460
Gillnet	Kept non-groundfish		-0.6 %	0 %	0.4 %	1,385	460
Gillnet	Non-groundfish avg price		-2.4 %	-0.1 %	0.9 %	1,385	460
Gillnet	Total revenue		-6.7 %	-2.4 %	2.4 %	1,385	460
Gillnet	Trip duration	*	-6 %	-4.5 %	-2.7 %	1,385	460

Table 9: Fishing Year 2011

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-11 %	-6.6 %	-1.9 %	1,826	606
Trawl	Number groundfish market categories		-1.1 %	0 %	0 %	1,826	606
Trawl	Groundfish avg price		-1.8 %	-0.1 %	1.4 %	1,826	606
Trawl	Kept catch	*	-9.6 %	-5.8 %	-1.8 %	1,826	606
Trawl	Kept non-groundfish		-5 %	-1.4 %	1.3 %	1,826	606
Trawl	Non-groundfish avg price		-0.5 %	1.1 %	3.4 %	1,826	606
Trawl	Total revenue		-7.3 %	-3.3 %	0.8 %	1,826	606
Trawl	Trip duration	*	-5.4 %	-3.3 %	-1.2 %	1,826	606
Gillnet	Kept groundfish	*	1.6 %	4.9 %	8.4 %	1,775	545
Gillnet	Number groundfish market categories	*	0.4 %	3 %	6.6 %	1,775	545
Gillnet	Groundfish avg price		-0.4 %	0.8 %	2 %	1,775	545
Gillnet	Kept catch		-2.6 %	0.7 %	4 %	1,775	545
Gillnet	Kept non-groundfish		-1.8 %	-0.8 %	0 %	1,775	545
Gillnet	Non-groundfish avg price		-2.2 %	-0.3 %	1.1 %	1,775	545
Gillnet	Total revenue		-3.1 %	0.2 %	3.5 %	1,775	545
Gillnet	Trip duration	*	-2.7 %	-1.6 %	-0.2 %	1,775	545

Table 10: Fishing Year 2012

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-12 %	-8.1 %	-4.6 %	2,704	554
Trawl	Number groundfish market categories		-1.4 %	0 %	0 %	2,704	554
Trawl	Groundfish avg price		-2.7 %	-1.1 %	0.4 %	2,704	554
Trawl	Kept catch	*	-13.9 %	-10.5 %	-6.9 %	2,704	554
Trawl	Kept non-groundfish		-2 %	0.6 %	4 %	2,704	554
Trawl	Non-groundfish avg price		-3 %	-0.5 %	1.5 %	2,704	554
Trawl	Total revenue	*	-11.2 %	-7.8 %	-4.3 %	2,704	554
Trawl	Trip duration		-2.9 %	-1 %	0.6 %	2,704	554
Gillnet	Kept groundfish		-5.2 %	-1.4 %	2.1 %	2,074	360
Gillnet	Number groundfish market categories		0 %	0 %	0.1 %	2,074	360
Gillnet	Groundfish avg price		-1.1 %	0.4 %	2 %	2,074	360
Gillnet	Kept catch		-6 %	-2.9 %	0.4 %	2,074	360
Gillnet	Kept non-groundfish		-1.7 %	0.2 %	2.1 %	2,074	360
Gillnet	Non-groundfish avg price		-1.7 %	0 %	1.6 %	2,074	360
Gillnet	Total revenue	*	-8.8 %	-5.2 %	-2 %	2,074	360
Gillnet	Trip duration	*	-5.5 %	-4.5 %	-3.2 %	2,074	360

Table 11: Fishing Year 2013

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-16.7 %	-12.8 %	-8.9 %	2,294	320
Trawl	Number groundfish market categories		0 %	0 %	0.8 %	2,294	320
Trawl	Groundfish avg price	*	1.1 %	2.9 %	4.9 %	2,294	320
Trawl	Kept catch	*	-13.9 %	-10.2 %	-6.6 %	2,294	320
Trawl	Kept non-groundfish		-1.6 %	2.7 %	7.2 %	2,294	320
Trawl	Non-groundfish avg price		-3.2 %	-1.3 %	0.4 %	2,294	320
Trawl	Total revenue	*	-7.4 %	-3.8 %	-0.5 %	2,294	320
Trawl	Trip duration	*	-5.6 %	-3.5 %	-1.5 %	2,294	320
Gillnet	Kept groundfish		-3 %	1.4 %	6.1 %	1,521	167
Gillnet	Number groundfish market categories		-3.1 %	-0.3 %	0 %	1,521	167
Gillnet	Groundfish avg price		-1.6 %	0.2 %	1.8 %	1,521	167
Gillnet	Kept catch		-3.7 %	0.7 %	5.2 %	1,521	167
Gillnet	Kept non-groundfish		-3.3 %	-0.2 %	2.6 %	1,521	167
Gillnet	Non-groundfish avg price		-3.2 %	-0.6 %	1.7 %	1,521	167
Gillnet	Total revenue		-2.4 %	1.8 %	6.4 %	1,521	167
Gillnet	Trip duration	*	-6.5 %	-5.1 %	-3.8 %	1,521	167

Table 12: Fishing Year 2014

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish		-7.4 %	-3.3 %	0.6 %	1,683	342
Trawl	Number groundfish market categories		0 %	0 %	1.5 %	1,683	342
Trawl	Groundfish avg price		-0.2 %	1.7 %	4 %	1,683	342
Trawl	Kept catch	*	-12.5 %	-8.2 %	-3.8 %	1,683	342
Trawl	Kept non-groundfish	*	-9.7 %	-5.1 %	-0.3 %	1,683	342
Trawl	Non-groundfish avg price		-2.3 %	0.3 %	3.2 %	1,683	342
Trawl	Total revenue	*	-9.9 %	-6.2 %	-2.2 %	1,683	342
Trawl	Trip duration	*	-7.1 %	-4.8 %	-2.4 %	1,683	342
Gillnet	Kept groundfish		-4.2 %	1.1 %	7.4 %	1,119	176
Gillnet	Number groundfish market categories		0 %	2.4 %	7.4 %	1,119	176
Gillnet	Groundfish avg price		-2 %	0.1 %	2.1 %	1,119	176
Gillnet	Kept catch		-0.2 %	4 %	8.4 %	1,119	176
Gillnet	Kept non-groundfish		-5 %	-1.1 %	2.6 %	1,119	176
Gillnet	Non-groundfish avg price		-0.9 %	3 %	7.2 %	1,119	176
Gillnet	Total revenue	*	2.4 %	6.7 %	11.1 %	1,119	176
Gillnet	Trip duration		-2 %	0 %	1.6 %	1,119	176

Table 13: Fishing Year 2015

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-11.4 %	-7 %	-2.8 %	1,967	364
Trawl	Number groundfish market categories		-1.8 %	0 %	0 %	1,967	364
Trawl	Groundfish avg price		-0.3 %	1.3 %	2.9 %	1,967	364
Trawl	Kept catch	*	-11.1 %	-7 %	-3.2 %	1,967	364
Trawl	Kept non-groundfish	*	-8.6 %	-4.1 %	-0.3 %	1,967	364
Trawl	Non-groundfish avg price		-2.1 %	0.1 %	2.7 %	1,967	364
Trawl	Total revenue	*	-8.7 %	-5.2 %	-1.6 %	1,967	364
Trawl	Trip duration		-3.9 %	-1.9 %	0.1 %	1,967	364
Gillnet	Kept groundfish		-6.7 %	-0.4 %	6.9 %	647	104
Gillnet	Number groundfish market categories		0 %	0.3 %	7.3 %	647	104
Gillnet	Groundfish avg price		-2.3 %	1.3 %	4.6 %	647	104
Gillnet	Kept catch		-9.5 %	-4.8 %	0.4 %	647	104
Gillnet	Kept non-groundfish	*	-10.6 %	-5.7 %	-1.6 %	647	104
Gillnet	Non-groundfish avg price	*	2.4 %	6.5 %	11.3 %	647	104
Gillnet	Total revenue		-7.6 %	-2.3 %	2.7 %	647	104
Gillnet	Trip duration	*	-7.8 %	-5.5 %	-3.6 %	647	104

Table 14: Fishing Year 2016

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish		-8.3 %	-4.1 %	0 %	1,951	280
Trawl	Number groundfish market categories		0 %	0 %	0 %	1,951	280
Trawl	Groundfish avg price		-0.6 %	0.8 %	2.4 %	1,951	280
Trawl	Kept catch	*	-10.1 %	-6.5 %	-2.8 %	1,951	280
Trawl	Kept non-groundfish		-5.6 %	-1.4 %	2.6 %	1,951	280
Trawl	Non-groundfish avg price		-1.4 %	0.9 %	3.3 %	1,951	280
Trawl	Total revenue		-6.6 %	-2.9 %	0.9 %	1,951	280
Trawl	Trip duration	*	-5.2 %	-3 %	-0.9 %	1,951	280
Gillnet	Kept groundfish		-6.6 %	1.4 %	10 %	494	112
Gillnet	Number groundfish market categories		0 %	3.8 %	9.7 %	494	112
Gillnet	Groundfish avg price		-0.4 %	3.4 %	6.7 %	494	112
Gillnet	Kept catch		-11 %	-3.6 %	2.7 %	494	112
Gillnet	Kept non-groundfish	*	-14.2 %	-7.6 %	-0.8 %	494	112
Gillnet	Non-groundfish avg price		-3.6 %	0.3 %	4.5 %	494	112
Gillnet	Total revenue		-8.4 %	-2.3 %	3.4 %	494	112
Gillnet	Trip duration	*	-6.9 %	-4.4 %	-2.2 %	494	112

Table 15: Fishing Year 2017

Gear	Variable	CIs <> 0	95% CI, low	Median	95% CI, high	n Unobserved	n Observed
Trawl	Kept groundfish	*	-13.2 %	-8.9 %	-5.2 %	1,608	291
Trawl	Number groundfish market categories		0 %	0 %	0 %	1,608	291
Trawl	Groundfish avg price	*	1.5 %	3.3 %	5.1 %	1,608	291
Trawl	Kept catch		-6.3 %	-2.1 %	1.9 %	1,608	291
Trawl	Kept non-groundfish		-2.9 %	1.3 %	5.3 %	1,608	291
Trawl	Non-groundfish avg price		-4.7 %	-2.2 %	0.2 %	1,608	291
Trawl	Total revenue		-6.9 %	-2.9 %	0.7 %	1,608	291
Trawl	Trip duration	*	-4.5 %	-2.4 %	-0.2 %	1,608	291
Gillnet	Kept groundfish	*	0.8 %	8.3 %	15.7 %	502	85
Gillnet	Number groundfish market categories		0 %	8 %	13.6 %	502	85
Gillnet	Groundfish avg price		-3.7 %	1.5 %	6.2 %	502	85
Gillnet	Kept catch		-9.4 %	-3.3 %	2.1 %	502	85
Gillnet	Kept non-groundfish	*	-15 %	-8.8 %	-2.6 %	502	85
Gillnet	Non-groundfish avg price		-1.6 %	1.7 %	5.2 %	502	85
Gillnet	Total revenue		-9.5 %	-3.8 %	1.5 %	502	85
Gillnet	Trip duration		-3.8 %	-1.5 %	1.1 %	502	85

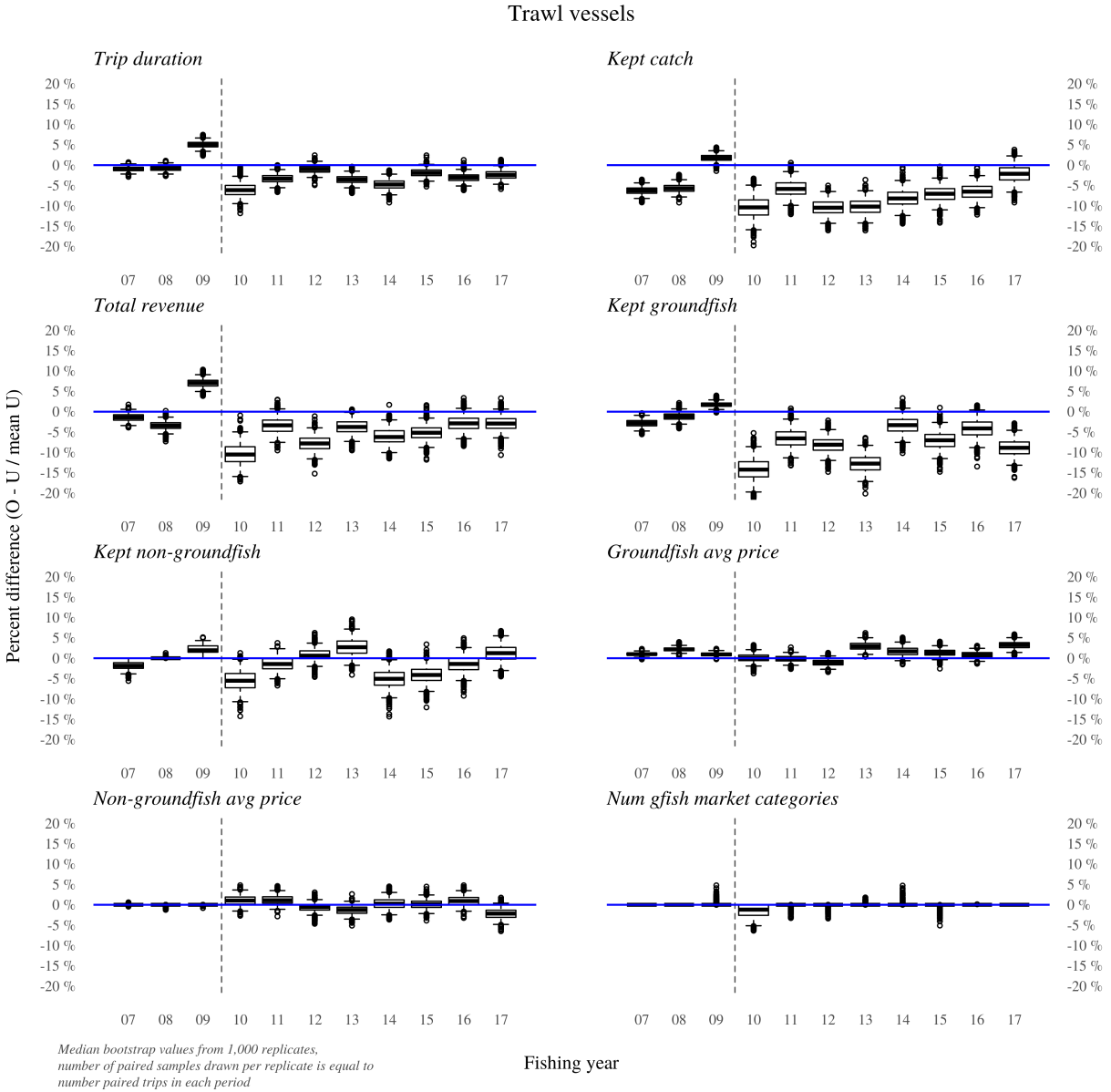

Figure 3: Results of bootstrap analysis, observed and unobserved same-vessel paired trips by fishing year

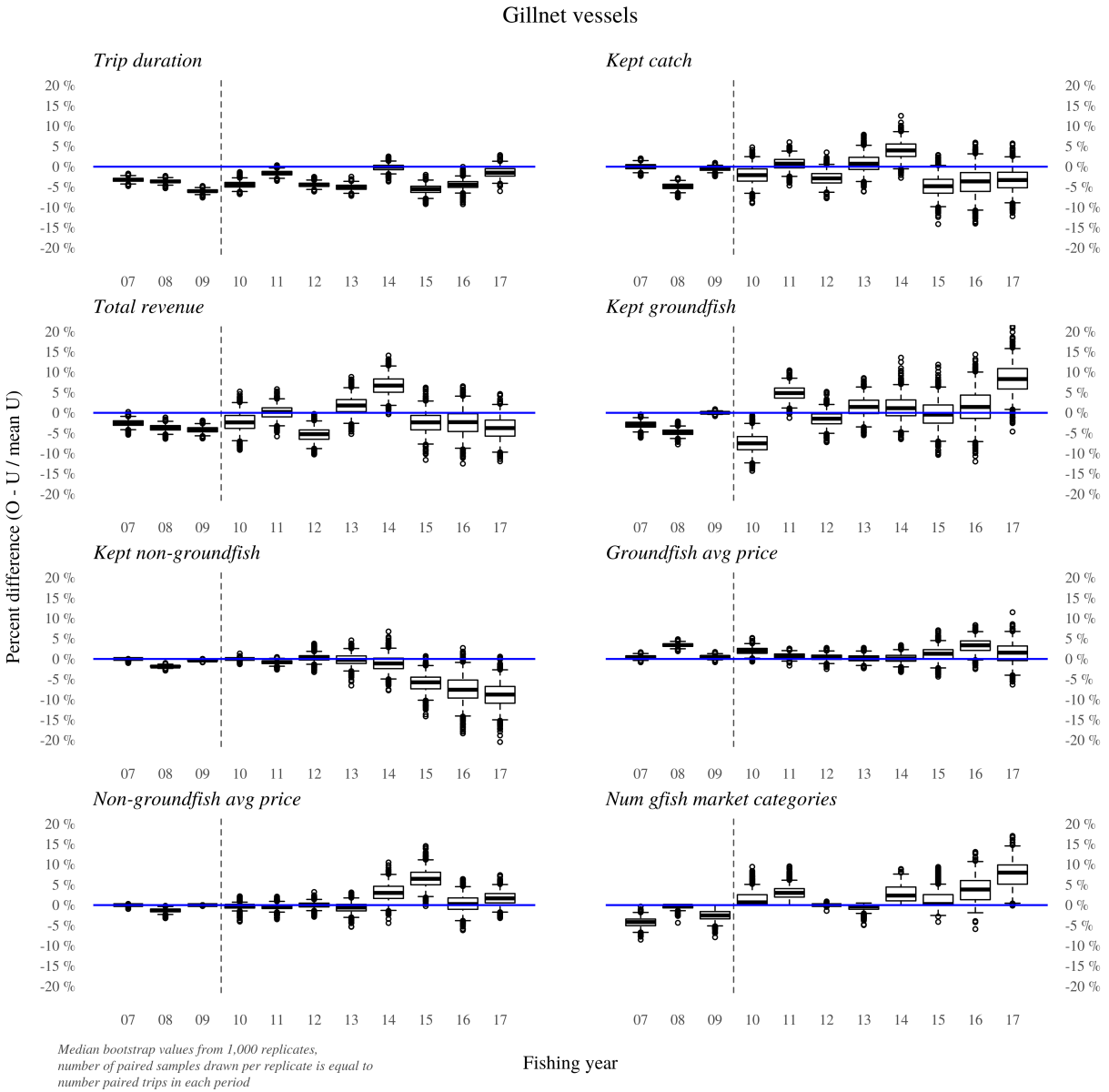

Figure 4: Results of bootstrap analysis, observed and unobserved same-vessel paired trips by fishing year

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