Appendix VII

Developing River Herring Catch Cap Options in the Directed Atlantic Herring Fishery

Prepared for the Atlantic Herring PDT

by

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Background

At its September 2010 meeting, the New England Fishery Management Council (NEFMC) passed a motion for the Herring Oversight Committee (OC) to develop catch cap options for river herring (alewife, *Alosa pseudoharengus*, and blueback herring, Alosa *aestivalis*) in Amendment 5 (A5) to the Atlantic Herring Fishery Management Plan (FMP). Since that meeting, the Plan Development Team (PDT) has analyzed river herring removals for the OC to consider when developing river herring catch cap options for the directed Atlantic herring, *Clupea harengus*, fishery. The following is a summary of analysis developed by the PDT.

Previous Estimations of River Herring Removals

Two recent studies estimated river herring removals by New England and Mid-Atlantic fisheries. Table 1 summarizes the general findings from these studies. Cieri et al. (2008) found that river herring bycatch (kept and discarded) in the directed herring fishery was highest in late fall and winter. Overall, the highest bycatch was for single and paired mid-water trawl gears. They noted that Atlantic herring, Atlantic mackerel (*Scomber scombrus*), and river herring mix as they migrate around Cape Cod to their overwintering grounds south of Block Island. Wigley et al. (2009) concluded that river herring discards were greatest in the New England small mesh otter trawl fleet and to a lesser extent in New England shrimp trawl, New England large mesh trawl and Mid-Atlantic small mesh otter trawl fleets. They noted that the number of observed gillnet trips was low and difficulty estimating discards in high volume fisheries likely impacted the results.

Year	Fishery	Estimation	Removals of River Herring (lbs)	Coefficient of Variation	Authors
2005	Directed Atlantic Herring	Kept + Discards	285,833	60%	Cieri et al. 2008
2006	Directed Atlantic Herring	Kept + Discards	171,973	60%	Cieri et al. 2008
2007	Directed Atlantic Herring	Kept + Discards	1,686,617	50%	Cieri et al. 2008
June 2008-July 2009	All fisheries with river herring discards	Discards	106,455	149%	Wigley et al. 2009

Table 1: Comparison of recent studies to estimate river herring removals at sea.

Catch Cap Relative to Catch History

In the absence of an assessment for river herring, one alternative is to set a catch cap relative to recent river herring catches in the directed Atlantic herring fishery. The first step in this process is to obtain the best possible estimate of river herring removals, both kept and discarded, by the directed Atlantic herring fishery. Here, directed Atlantic herring trips were defined as those which kept or landed in excess of 2,000 lbs of Atlantic herring.

Methods

Data Selection. Northeast Fishery Observer Program (NEFOP) data and Vessel Trip Reports (VTRs) from 2005-2009 directed Atlantic Herring trips were selected for this analysis, similar to the data selected for the river herring hotspot analysis. Although other data sources were considered (e.g., dealer data, portside sampling), these alternatives were subject to shortcomings that would likely lead to biased and imprecise estimates of river herring bycatch, which made them less favorable to the use of NEFOP and VTR data. Alewife and blueback herring are combined in the analysis because species identification is difficult and the portside project did not distinguish between species until 2006. Furthermore, 2009 data was robust when compared with other sampling years because of improvements in the pelagic fisheries observing programs and higher coverage rates by gear type.

Stratification. For this analysis, trip data from the NEFOP and VTRs were grouped into year, half-year (Jan-June and July-Dec), area, and gear type. Three broad gear categories were used that included bottom trawls, mid-water trawls (single and paired), and purse seines. Areas were defined as Gulf of Maine (GOM), Cape Cod (CC), and Southern New England (SNE). These areas represent the major locations where the directed Atlantic herring fishery occurs and loosely follow the Fishery Management Plan area boundaries for Atlantic herring (Figure 1). Groupings with less than three observer trips were omitted from the analysis (Table 2).

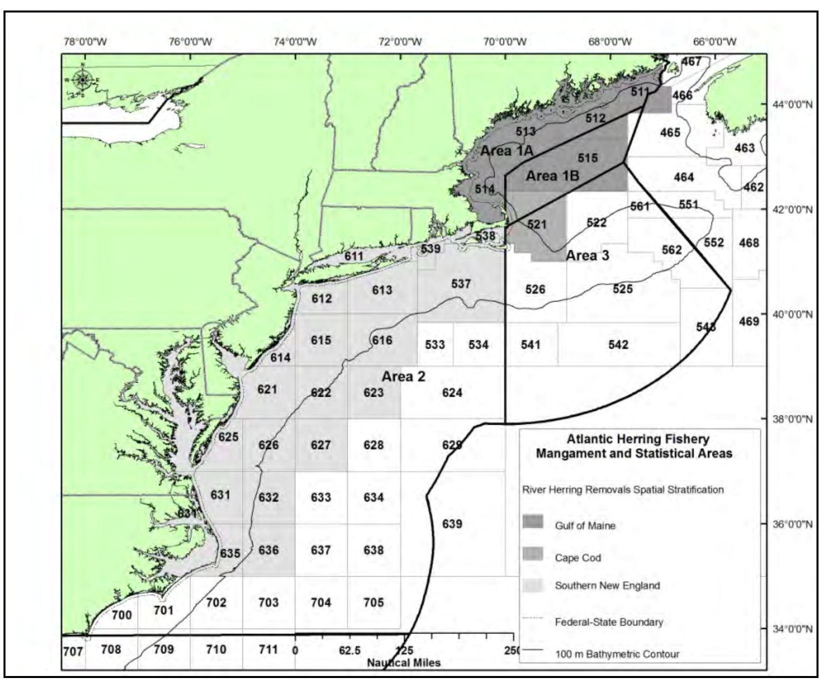

Figure 1: Atlantic Herring Fishery Management Plan management areas and statistical areas. River herring removals spatial stratification areas were defined as Gulf of Maine (GOM), Cape Cod (CC), and Southern New England (SNE).

Count of sampled trips		Year 2005	Half	2006		2007		2008		2009		Grand Total
Area	Gear	1	2	1	2	1	2	1	2	1	2	
CC	BT				2							2
	MWT		20		3	4	4	4	8	1	10	54
	PS											
GOM	BT		4		3		3		2		2	14
	MWT	30	65	3	12	5	3	7	9	9	28	171
	PS	4	35				10	10	16	13	21	109
SNE	BT			5		7	2	2		7	2	25
	MWT	21	4	23		5	1	21	3	28	1	107
	PS											
Grand Total		56	130	32	22	22	25	45	40	59	66	482

Count of landing trips		2005		2006		2007		2008		2009		Grand Total
		1	2	1	2	1	2	1	2	1	2	
CC	BT		1		4		1		1	1		8
	MWT	4	48	20	77	27	43	11	29	1	15	275
	PS			2								2
GOM	BT	1	27		36		227		29		57	377
	MWT	140	339	143	270	79	37	17	69	13	94	1201
	PS	25	174	25	147	52	311	53	193	53	168	1201
SNE	BT	22	25	71	38	154	31	62	16	104	37	560
	MWT	139	11	174	18	164	10	126	15	172	4	833
	PS											
Grand Total		331	625	435	590	476	660	269	352	344	375	4457

		2005		2006		2007		2008		2009	
Percent coverage		1	2	1	2	1	2	1	2	1	2
CC	BT		0.00				0.00		0.00	0.00	
	MWT	0.00	0.42	0.00	0.04	0.15	0.09	0.36	0.28		0.67
	PS			0.00							
GOM	BT	0.00	0.15		0.08		0.01				
	MWT	0.21	0.19	0.02	0.04	0.06	0.08	0.41	0.13	0.69	0.30
	PS	0.16	0.20	0.00	0.00	0.00	0.03	0.19	0.08	0.25	0.13
SNE	BT	0.00	0.00	0.07	0.00	0.05			0.00	0.07	
	MWT	0.15	0.36	0.13	0.00	0.03		0.17	0.20	0.16	
	PS										

Not sampled
less then 3 samples
No samples or landings

Table 2: Sampling coverage by year, gear type and area. Top panel: count of sampled trips. Middle panel: count of trips landing Atlantic herring. Bottom panel: percent coverage. Cells with less than 3 observed trips were not used in estimation. CC is Cape Cod, GOM is Gulf of Maine, SNE is Southern New England, BT is bottom trawl, MWT is paired and single midwater trawl, and PS is Purse Seine.

Challenges Linking Fishery Datasets

Trips observed at-sea (NEFOP) were linked to the VTR database by the VTR serial number as recorded by the at-sea observer. This poses difficulties when a vessel fishes in more than one statistical reporting area on a single trip because recording protocols differ between at-sea observer reports and VTRs. According to regulations, the vessel's captain is required to fill out a separate VTR log when crossing statistical area boundaries during a trip. However, at-sea observers do not fill out a separate trip report to coincide with the new VTR log. Instead, at-sea observers link records using the VTR serial number from the 1st VTR log.

A comparison of Atlantic herring catches as reported by observer reports and VTRs suggest that substantial differences occur between the two reporting systems (Appendices A and B). Some of the differences between observer reports and VTRs in this dataset could be explained by these reporting requirements if vessels fished in more than 1 statistical area on a trip. The direction of the bias would lower captain's hail weight for Atlantic herring compared to observer record for a given trip. Other differences can be attributed to the handling of pair-trawls, especially in the early years of the time-series. Further analysis can be found in Appendix A and B.

Calculations. Two methods were used to examine and estimate river herring removals from the directed Atlantic herring fishery. Both methods are based on the Standard Bycatch Reporting Methodology (SBRM) amendment (2007). In general, Method 1 uses the ratio of river herring to Atlantic herring for the expansion, while Method 2 extrapolates to the trip level by using the mean discard level per trip.

Method 1. Following Lohr (1999) and Cieri et al (2007), the ratio estimate (R) for each grouping was calculated using the form:

$$\hat{R}_g = \frac{\sum_i r_{g,i}}{\sum_i A_{g,i}}$$

where $r_{g,i}$ is the observed river herring bycatch (pounds) from trip *i* in grouping g and $A_{g,i}$ is the Atlantic herring landings (pounds) for trip *i* in grouping g.

Its variance is estimated by:

$$\operatorname{var}(\hat{R}_g) = \frac{1}{n_g \bar{A}_g^2} \frac{\sum_i (r_{g,i} - \hat{R}_g A_{g,i})^2}{n-1}$$

where n_S is the number of observer observations and A_g bar is the mean of Atlantic herring observer landings for grouping g.

Total river herring bycatch (D) for each grouping was calculated as:

$$\hat{D}_g = \hat{R}_g \cdot K_g$$

where K_g is the total Atlantic herring catch/landings from grouping *g* (year, quarter, area, and gear type).

The variance $Var(D_{g)}$ was estimated by:

$$Var(D_g) = \operatorname{var}(\hat{R}_g) \cdot L_g$$

Because estimates across gear types were desired within the groupings, estimates by gear type were combined by strata, defined as area, half year, and year.

Therefore the sum of the river herring removals were:

$$\hat{D}_s = \sum \hat{D}_{Gg}$$

Where $D(hat)_S$ is the total river herring removed within a half year, year, area stratum and $D(hat)_{Gg}$ is the river herring removals by gear type within a grouping.

As such the combined variance was calculated as:

$$Var(D_S) = \sum Var(D_{Gg})$$

Landings and catch data were generated by querying the NMFS VTR database for targeted trips (landed more than 2,000 lbs of Atlantic herring). This database gives location, date, time, and gear type used. Generally catch and landings are interchangeable for Atlantic herring as the reports of discards in the VTRs are small.

Method 2. Because of concerns about the previous method, a second method was used to examine and estimate river herring removals from the directed Atlantic herring fishery (Appendices A and B). Here the NEFOP and VTR data were grouped as before, where groupings consisted of gear, half years, years, and areas. To estimate river herring removals the Simple Expansion Method was used (SBRM 5.4.2.3. Simple Expansion Method: mean discard per trip, pp 143)

As such, river herring removals by groupings were calculated as:

$$\hat{D}_g = \sum_i N_g \left(\frac{\sum_i d_{ig}}{n_g} \right)$$

Where D_g is the removals of river herring in a grouping (half year, year, area and gear) N_g is the total trips from the VTR for that grouping, d_{ig} is the observed removals of river herring on trip i in grouping g and n is the total observed trips in that grouping.

Because estimates across gear types were desired within the groupings estimates by gear type were combined within a strata, defined as area, half year, and year.

As before the sum of the river herring removals were:

$$\hat{D}_s = \sum \hat{D}_{Gg}$$

Where D(hat)$_S$ is the total river herring removed within a half year, year, area stratum and D(hat)$_{Gg}$ is the river herring removals by gear type within a strata.

Variance was calculated using a derivation of the SBRM equation 19 to produce a variance estimate for each half year, year, and area stratum:

$$\operatorname{var}\left(\hat{D}_s\right) = \sum N_g^2 \left(\frac{N_g - n_g}{N_g}\right)\left(\frac{\sum d_{ig}^2 - \frac{\left(\sum d_{ig}\right)^2}{n_g}}{n_g\left(n_g - 1\right)}\right)$$

Where N_g is the number of VTR trips in a grouping d_{ig} is the observed removals of river herring in trip i by gear type, area, half year, and year, and n_g is the observed trips in the grouping.

After consideration of percentage coverage by grouping (see Table 2), it was decided to collapse the half year estimates to the full year estimates, allowing for the use of observed trip by area, gear and year across both half years. This produced fewer dropped strata and more robust sample sizes (Table 2). As such, both methods outlined above were repeated with gear, area, and year groupings and subsequent area, year strata. For convenience error is expressed as CV of the stratum as calculated by:

$$CV_s = \frac{\sqrt{Var\left(\hat{D}_s\right)}}{\hat{D}_s}$$

Results from Method 1 and Method 2 are given in Tables 3 and 4 and Figure 2 for full years and Tables 5 and 6 and Figure 3 for half years.

Estimates of River Herring Removals

As can be seen by the tables and figures, in general the Cape Cod (CC) area and the Gulf of Maine (GOM) had lower removals of river herring when compared to Southern New England (SNE). Also both CC and GOM had similar removal levels of river herring by the directed herring fleet (Tables 3-6 and Figures 2-3).

The variability, both between methods and among years, makes comparison of historical removals by area less meaningful then other fisheries. For example, using Method 2, median removals in CC were approximately 15% of the SNE removals. However, the yearly removals for CC (2005-2009) ranged from 0 to 1.5 million lbs while the range for SNE was from 170 to 730 thousand lbs using Method 1. Likewise in 2006 for SNE, Method 1 and Method 2 differ by almost 150,000 lbs or 50%. A statistical comparison of the results from Method 1 and Method 2 can be found in Appendix C.

Year	2005	2006	2007	2008	2009
CC	137.8 (-30.3 to 305.9)	0.0 (No River herring)	1,282.2 (-948.8 to 3513.2)	81.4 (-48.8 to 211.6)	0.2 (-0.3 to 0.7)
GOM	80.8 (-37.2 to 198.8)	38.7 (-31.7 to 109.1)	15.9 (-1.6 to 33.4)	254.5 (-198.5 to 707.6)	173.9 (17.4 to 330.4)
SNE	142.9 (-14.3 to 300.2)	178.7 (-50.0 to 407.3)	1256.5 (653.4 to 1859.6)	575.6 (-69.1 to 1220.2)	422.1 (118.2 to 726.0)

Table 3: Estimates of river herring catch in 000's lb (± 2 Standard errors) by year and area. Estimates made using Method 1 with gear, area and year as strata. CC is Cape Cod, GOM is Gulf of Maine, and SNE is Southern New England

Year	2005	2006	2007	2008	2009
CC	94.6 (9.5 to 179.8)	0.0 (No River herring)	1,159.7 (-510.5 to 2829.7)	93.4 (-44.8 to 231.6)	0.2 (0.0 to 0.4)
GOM	92.4 (-27.7 to 212.6)	66.2 (-66.2 to 194.6)	19.6 (-1.2 to 40.4)	294.0 (-170.5 to 758.5)	163.4 (45.7 to 281.0)
SNE	171.6 (51.5 to 291.7)	303.1 (84.9 to 521.43)	729.5 (160.5 to 1298.5)	585.0 (-11.7 to 1181.7)	603.3 (253.4 to 953.2)

Table 4: Estimates of river herring catch in 000's lb (± 2 Standard errors) by year and area. Estimates made using Method 2 with gear, area and year as strata. CC is Cape Cod, GOM is Gulf of Maine, and SNE is Southern New England

Year		2005		2006		2007		2008		2009	
half year		1	2	1	2	1	2	1	2	1	2
CC	Total catch	No samples	132.7	No samples	0.0	594.2	188.0	1.6	90.8	No samples	0.0
	-2SE		-29.2			-570.4	-191.8	-0.9	-43.6		
	+2SE		294.6			1758.8	567.8	4.1	225.2		
GOM	Total catch	0.2	84.1	0.0	34.7	11.7	5.3	0.0	345.1	1.9	191.8
	-2SE	-0.1	-38.7	0.0	-27.1	-10.3	1.2		-276.1	-1.7	15.3
	+2SE	0.5	206.9	0.0	96.5	33.7	9.4		966.3	5.5	368.3
SNE	Total catch	130.9	11.1	154.8	No samples	1263.4	No samples	690.0	5.0	338.6	No samples
	-2SE	-20.9	-13.5	-49.5		783.3		-27.6	-3.6	67.7	
	+2SE	282.7	35.7	359.1		1743.5		1407.6	13.6	609.5	

Table 5: Estimates of river herring catch in 000's lb (X ± 2 Standard errors) by half year (Jan-June and July-Dec) and area. Estimates made using Method 1 with gear, area and half year as strata. Cells with estimates= 0 and blank SE indicate that river herring were not found any sampled catch. CC is Cape Cod, GOM is Gulf of Maine, and SNE is Southern New England.

Year		2005		2006		2007		2008		2009	
half year		1	2	1	2	1	2	1	2	1	2
CC	Total catch	No samples	87.3	No samples	0.0	803.6	145.0	2.0	99.0	No Samples	0.0
	-2SE		12.2			-433.9	-34.8	0.2	-53.5		
	+2SE		162.4			2041.1	324.8	3.8	251.5		
GOM	Total catch	0.2	95.3	0.0	54.3	14.2	5.7	0.0	418.9	1.4	187.1
	-2SE	0.0	-30.5		-50.0	-6.5	-3.6	0.0	-259.7	1.2	44.9
	+2SE	0.4	221.1		158.6	34.9	15.0	0.0	1097.5	1.6	329.3
SNE	Total catch	177.8	4.8	234.8	No Samples	691.7	No samples	588.4	7.5	551.0	No samples
	-2SE	-7.1	-2.9	28.2		138.3		-11.8	-5.3	198.4	
	+2SE	362.7	12.5	441.4		1245.1		1188.6	20.3	903.6	

Table 6: Estimates of river herring catch in 000's lb (X ± 2 Standard errors) by half year (Jan-June and July-Dec) and area. Estimates made using Method 2 with gear, area and half year as strata. Cells with estimates= 0 and blank SE indicate that river herring were not found any sampled catch. CC is Cape Cod, GOM is Gulf of Maine, and SNE is Southern New England.

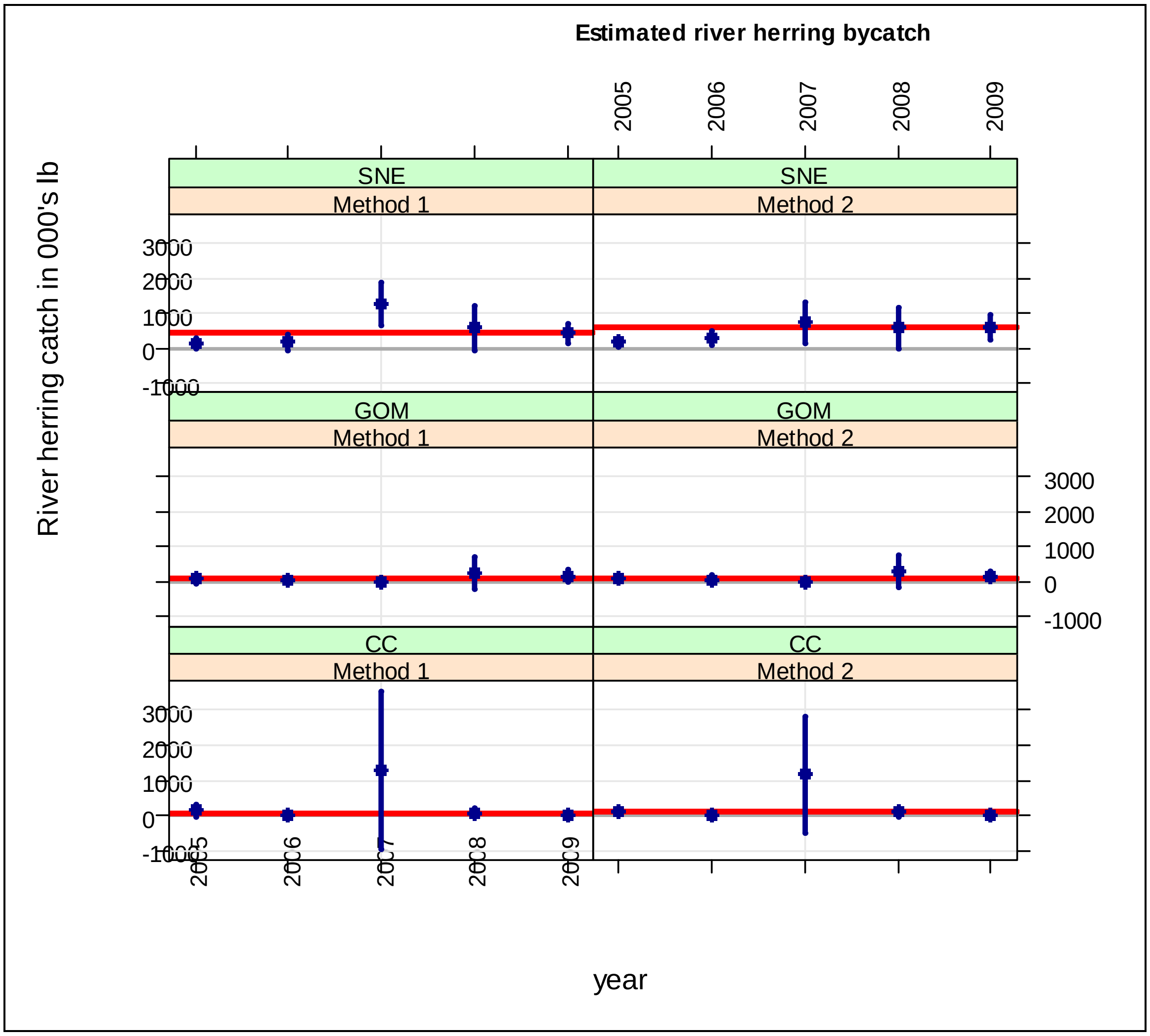

Figure 2: Estimates of river herring catch (000's lb) by method, area and year. Error bars are total catch ± 2 standard errors. Red line is the median of estimates within a panel. Gray line = 0. Both methods used gear, area and year as strata. CC is Cape Cod, GOM is Gulf of Maine, SNE is Southern New England.

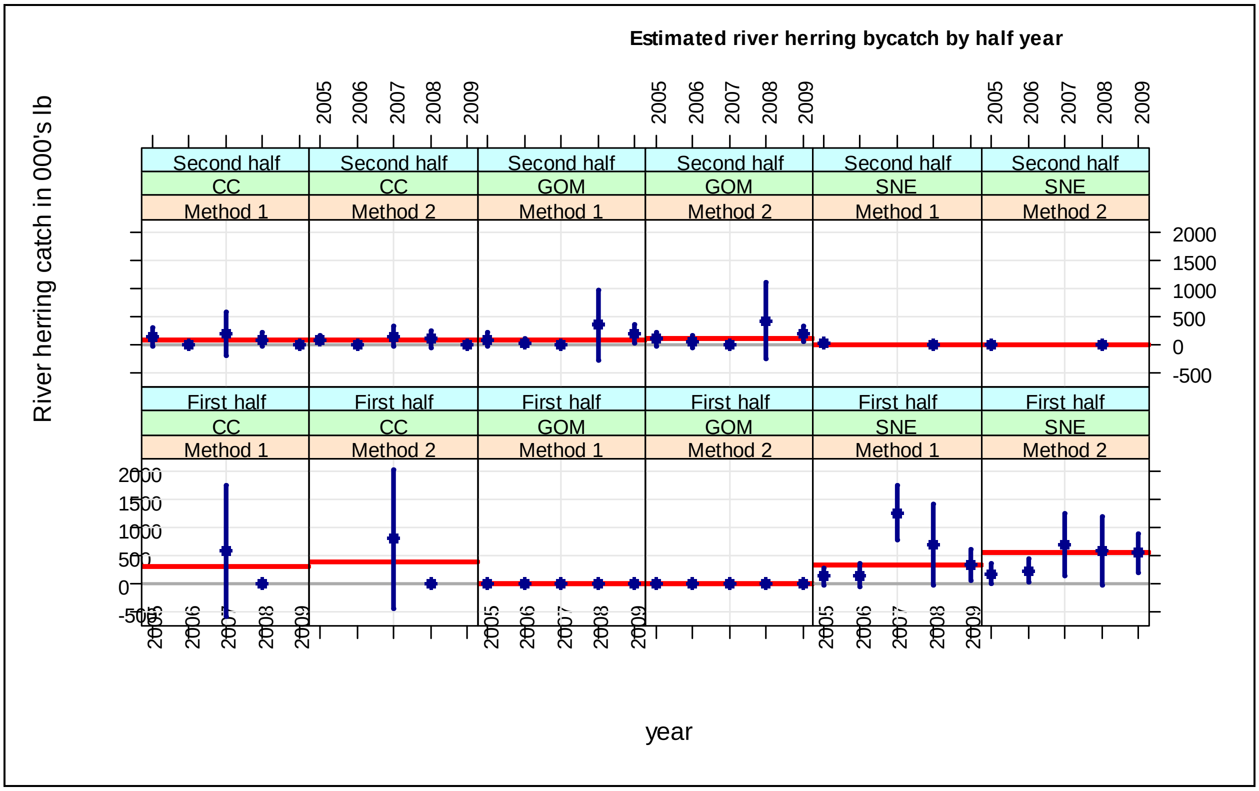

Figure 3: Estimates of River herring catch by method and area and year using half years as strata. Error bars are total catch ± 2 standard errors. Red line is the median of estimates within a panel. Both methods used gear, area and year as strata. CC is Cape Cod, GOM is Gulf of Maine, SNE is Southern New England.

Comparison of Mid-Water and Bottom-Trawl River Herring Removals

The directed Atlantic herring bottom-trawl fleet removes a relatively large amount of river herring given their low Atlantic herring landings; far higher than the mid-water trawl fishery per pound of Atlantic herring landed. Combined across years, the directed bottom-trawl fishery has removed an estimated 1.2 million lbs or approximately 48% of the total estimated removals by the total directed Atlantic herring fishery in the SNE area from 2005-2009 (Figure 4). In some years, removals can exceed those of the directed mid-water trawl fleet in this area by almost 4 fold. This level of removals of river herring is relatively large given that the directed bottom-trawl fishery for Atlantic herring only accounts for approximately 16% of the total catch of Atlantic herring in this management area. Despite this high removal rate, at-sea sampling of this fishery is particularly low when compared to other gears fishery wide.

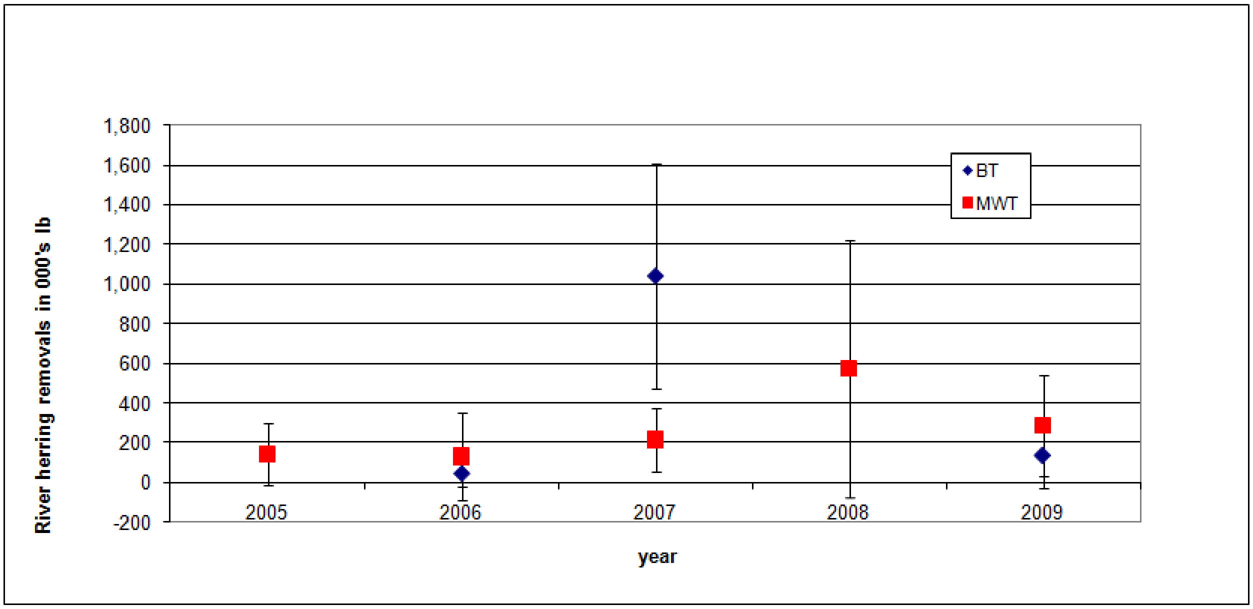

Figure 4: Comparison of river herring removals in 000's lb by bottom-trawl (BT) and mid-water trawl (MWT) gears in Southern New England. Error bars represent two standard deviations.

Conclusion

Our estimates of river herring removals have high uncertainty. Sampling by year, gear and area is not complete and missing strata exist in the dataset across years. The distribution of river herring catch has high variability and strata sample sizes are generally low. Finally, our estimate of uncertainty is likely to be underestimated because within trip variation of river herring catch is not propagated into the variation of the total catch estimate. Separating the strata into seasonal-area groups exacerbates the missing strata problems.

The non-sampling component of inter-annual variation for river herring catch can also include population dynamics such as year-class strength and population size, oceanographic conditions, and distribution of Atlantic herring fishing effort. The time series is currently too short to investigate whether these factors impact river herring catch in the Atlantic herring fishery. River herring do not currently have a stock assessment, thus the removal cap cannot be related to the river herring population. The cap only functions to prevent future river herring catch from exceeding recent catches. If river herring populations decline, then the cap may be too high for the river herring population. If a strong year-class is produced, then the cap may be set too low relative to the river herring population size, prematurely closing the Atlantic herring fishery.

The PDT has high confidence in describing times and locations where river herring bycatch has occurred in the directed Atlantic herring fishery. This information can be used to develop management plans to reduce the river herring interactions with the Atlantic herring fishery, without the need for defining a cap or estimating river herring bycatch within season.

In addition for reference, possible approaches to setting a catch cap and how a catch cap might interaction with other measures in A5 are explored in Appendix D and E, respectively.

PDT Consensus Statement

Given the variability, uncertainty, and challenges associated with sampling the Atlantic herring fishery, the Herring PDT cannot generate a precise enough estimate of river herring catch on which to base a cap. There may be some utility in applying a river herring catch estimate to trigger increased monitoring or other management approaches. However, the Herring PDT does not recommend developing quota-based approaches to river herring bycatch management in Amendment 5. Expected improvements to the catch monitoring program in Amendment 5 and completion of the forthcoming river herring stock assessment by ASMFC may create the necessary link between the cap and some measure of river herring stock status or reference point, as well as the mechanisms to monitor a cap. Other management approaches under consideration in this amendment (catch monitoring and hotspot alternatives) are more appropriate to consider at this time to address bycatch to the extent practicable.

Literature Cited

Cieri, M., G. Nelson, and M. A. Armstrong. 2008. *Estimates of river herring bycatch in the directed Atlantic herring fishery*. Report prepared for the Atlantic States Marine Fisheries Commission, Washington, DC. September 23, 2008.

Lohr, S. L. 1999. *Sampling: Design and Analysis*. Brooks/Cole Publishing Company: Pacific Grove, California.

New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council and National Marine Fisheries Service. 2007. *Northeast Region Standardized Bycatch Reporting Methodology: An Omnibus Amendment to the Fishery Management Plans of the New England and Mid-Atlantic Fishery Management Councils*. June 2007. 642p

Wigley, S. E. , J. Blaylock, P. J. Rago. 2009. River herring discard estimation, precision and sample size analysis. *Northeast Fish Science Center Reference Document* 09-20. US Department of Commerce.

Appendix A

Comparison of observer estimates and VTR estimates for river herring and Atlantic herring catches for 2006-2009

Prepared for the Herring PDT

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December 15, 2010

The Atlantic Herring PDT asked whether the amount of river herring catch was correlated with Atlantic herring catch.

Data

Dataset consists of 158 trips that had both observer estimates and VTR estimates of herring catch (Table A1). Data were provided by Matthew Cieri in excel spreadsheet OBD_HER_VTR_link2.xls dated 11.18.2010. Trips were selected as having 2,000 lb or more of kept Atlantic herring and were sea sampled by the NEFOP. Two trips were deleted that had observer data but no herring landings reported in the VTR. Trips were selected as having 2,000 lb or more of Atlantic herring and were sea sampled by the NEFOP.

Trips observed at-sea were linked to the Vessel Trip Report (VTR) database by the VTR serial number as recorded by the at-sea observer. According to regulations, the vessel's captain is required to fill out a separate VTR log when crossing statistical area boundaries during a trip. However, at-sea observers do not fill out a separate trip report to coincide with the new VTR log. Instead, at-sea observers link records using the VTR serial number from the 1st VTR log. Some of the differences between observer and VTR report in this dataset could be explained by differences in reporting requirements if vessels fished in more than 1 statistical area on a trip. The direction of the bias would lower captain's hail weight for Atlantic herring compared to observer record for a given trip.

Another issue occurs in matching records for paired trawls. In some cases observers are on one or both vessels, particularly early in the time series. In addition, vessels often pair with multiple vessels within a trip. This can contribute to discordance between observer and VTR records.

Relationship between Atlantic herring catch and river herring catch

Plots of river herring catch against observer reported and VTR reported Atlantic herring catch by trip are shown in Figures A1-A2. Data pairs with no reported river herring were excluded from the dataset because the zero river herring could represent a time-area combination when river herring are not available to the gear.

The magnitude of river herring catch appears to be independent of the magnitude of the Atlantic herring catch (measured by either observer reports or VTR) over much of the bivariate distribution (Figures A3-A4). Catches appear related at the lowest quantiles (0.05-0.10) of Atlantic herring and river herring bivariate distribution, but the bulk of the distribution shows no relationship between amount of river herring and Atlantic herring.

I tested for correlation using Pearson product moment correlation coefficient and Kendal's Tau on the arithmetic and log10 transformed data. Correlation between river herring and Atlantic herring was not significant on the arithmetic scale for either the VTR or observer estimates. Pearson product-moment correlation coefficients were low but statistically significant on the log transformed data (Table A2). These correlations are highly influenced by the linear relationship near the low end of the distributions ($< 10^{th}$ quantiles). Correlations were not significant based on Kendal rank correlation method.

Conclusions

The correlation between river herring and Atlantic herring are weak, and the magnitude of catches is unrelated over most of the bivariate distribution using either VTR or observer estimates of Atlantic herring. The PDT should consider alternative estimation methods such as estimating catch per trip and expanding catch within strata by number of trips rather than expanding by Atlantic herring catch.

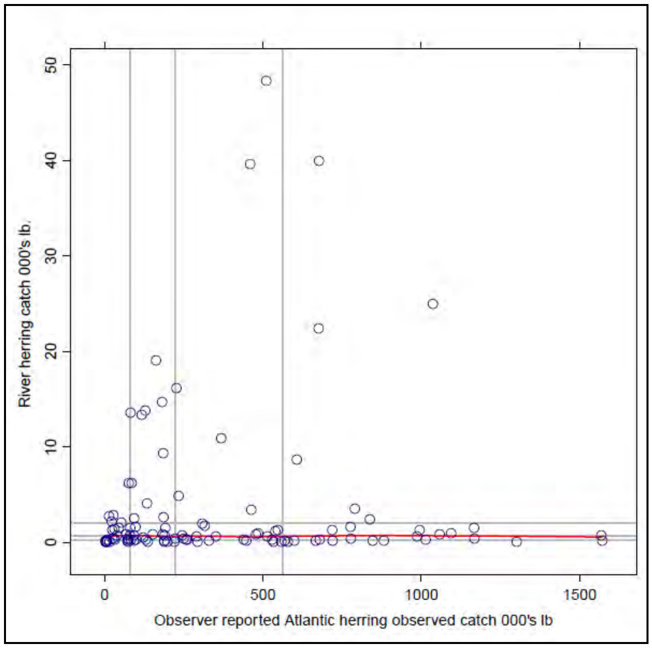
Area	Bottom trawl 2006	2007	2008	2009	Total	Purse seine 2006	2007	2008	2009	Total
511							0	0	0	0
512							0	0	0	0
513	0	1		1	2			0	5	5
514		0	2	1	3					
515										
521	0				0					
522										
537		3		3	6					
539	5	4	1	3	13					
611										
612										
613				1	1					
615										
616										
total	5	8	3	9	25		0	0	5	5

Area	Midwater trawl 2006	2007	2008	2009	Total	Paired midwater trawl 2006	2007	2008	2009	Total
511		0			0		1			1
512										0
513	0		0	2	2	0		3	9	12
514	1		1	0	2	0	3	1	7	11
515		0	0	1	1			0	1	1
521		3	2	0	5		2	3	1	6
522			1	0	1	0	0	0	0	0
537		1	1		2	0		4	2	6
539	0		1		1			1		1
611	1				1	4		1	3	8
612	1			1	2	0		1	2	3
613			0	0	0			3	2	5
615			0	1	1				4	4
616								1		1
total	3	4	6	5	18	4	6	18	31	59

Table A1. Number of trips by gear type, year and statistical reporting area for trips with observed river herring catch. Empty cells indicate that statistical reporting area not sampled, zero's indicate that sampling occurred but river herring was not observed any sampled trip.

	Kendall's coefficient of rank correlation		Pearson product-moment correlation coefficient	
Source for Atlantic herring catch	Tau	P-value	r (95% CI)	P-value
Observer	0.06	0.37	0.24 (0.04-0.41)	< 0.05
VTR	0.08	0.22	0.30 (0.11-0.46)	<0.01

Table A2. Summary statistics for test of correlation between amount of River herring in trip (log10 lb) and the amount of Atlantic herring (log10 lb) in trip as reported by observer or VTR. All gear types and years combined. Number of pairs is 105.



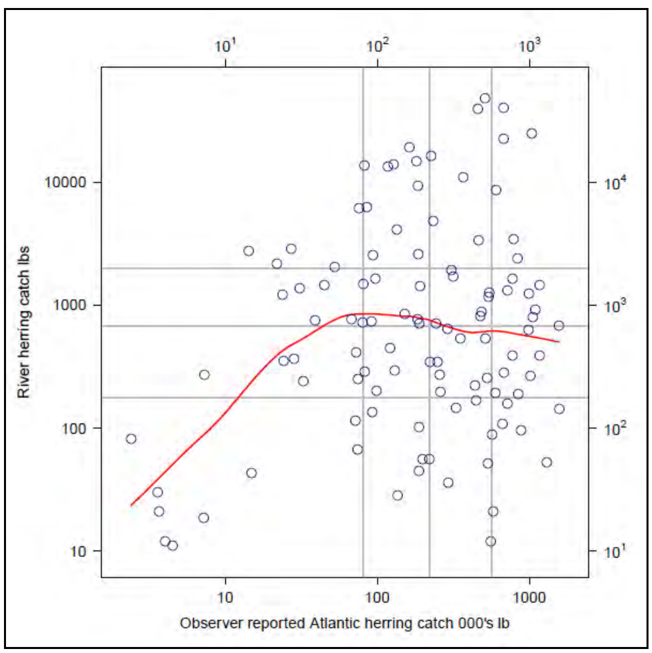
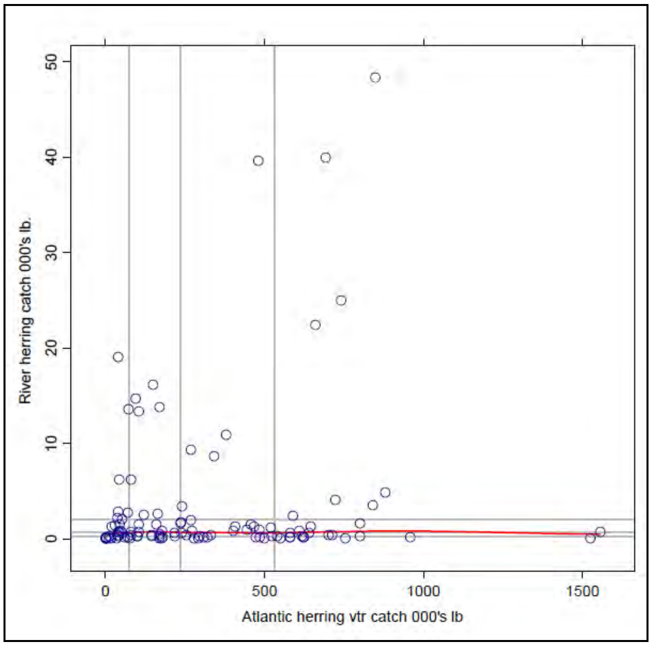


Figure A1. Scatterplot of river herring catch on Atlantic herring catch as reported by at sea observers. Top plot: arithmetic scales, bottom plot: logarithmic scales. Gray lines are 25th, 50th and 75th quantiles. Red line is loess fit with span=0.6 and degree=1.



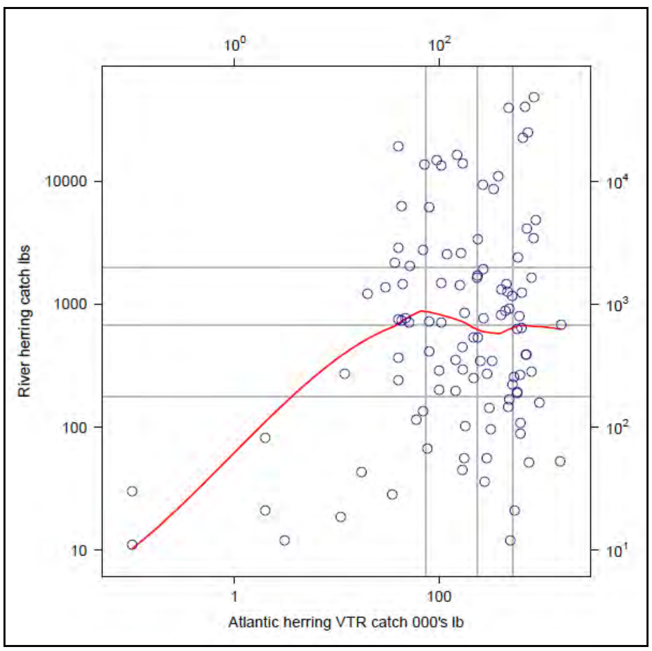


Figure A2. Scatterplot of river herring catch on Atlantic herring catch as reported in VTR. Top plot: arithmetic scales, bottom plot: logarithmic scales. Gray lines are 25th, 50th and 75th quantiles. Red line is loess fit with span=0.6 and degree=1.

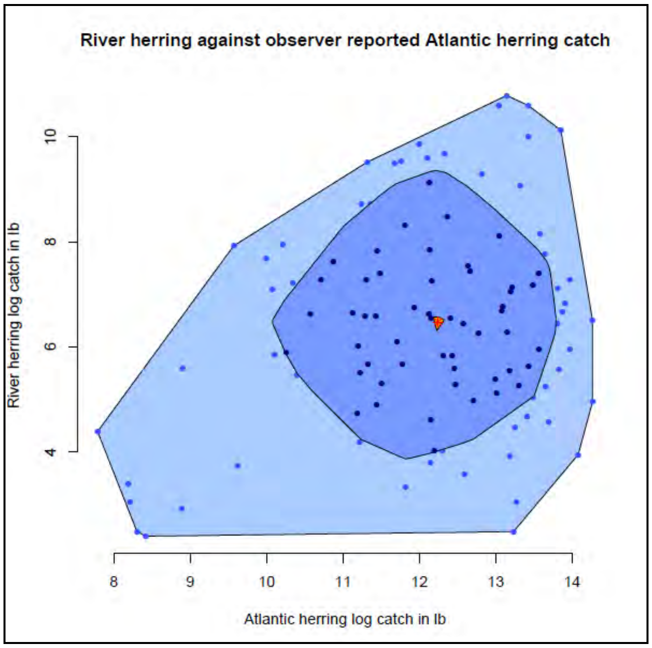


Figure A3. Bagplot of Log10 observed River herring catch against log10 Observer reported Atlantic herring catch. Red asterisk is location of bivariate median. Inner dark circle is middle 50% bivariate data with the greatest depth. The outer bag is 3X expansion of inner bag.

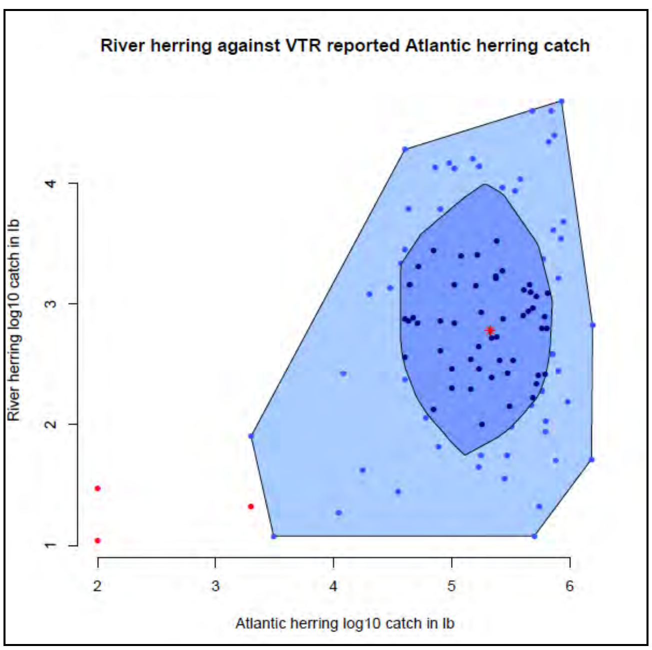


Figure A4. Bagplot of Log10 observed River herring catch against log10 VTR reported Atlantic herring catch. Red asterisk is location of bivariate median. Inner dark circle is middle 50% bivariate data with the greatest depth. The outer bag is 3X expansion of inner bag. Red points are considered "outside" values.

Appendix B

Comparison of observer estimates and VTR estimates for Atlantic herring for 2006-2009

Prepared for the Herring PDT

By

Steven J. Correia

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December 15, 2010

The Atlantic Herring PDT is tasked with developing a river herring catch cap. This may require estimating river herring catch in recent years in order to provide a benchmark for setting a river herring cap. Raising the estimate of river herring catch at various strata (gear, area, and season) to the total will likely require the use of either observer reported or VTR reported catch. I provide some summary statistics on the difference between observer reported and VTR herring catch by gear, year and statistical reporting area. Summary statistics are also provided for the ratio of observer to VTR reported catch.

Data

Dataset consists of 158 trips that had both observer estimates and VTR estimates of herring catch (Table B1). Data were provided by Matthew Cieri in an Excel spreadsheet OBD_HER_VTR_link2.xls dated 11.18.2010. Trips were selected as having 2,000 lb or more of kept Atlantic herring and were sea sampled by the NEFOP. Two trips were deleted that had observer data but no herring landings reported in the VTR

Trips observed at-sea were linked to the Vessel Trip Report (VTR) data base by the VTR serial number as recorded by the at-sea observer. According to regulations, the vessel's captain is required to fill out a separate VTR log when crossing statistical area boundaries during a trip. However, at-sea observers do not fill out a separate trip report to coincide with the new VTR log. Instead, at-sea observers link records using the VTR serial number from the 1st VTR log. Some of the differences between observer and VTR reported catch in this dataset could explained by these reporting requirements if vessels fished in more than 1 statistical area on a trip. The direction of the bias would lower captain's hail weight for Atlantic herring compared to observer record for a given trip.

The number of trips by gear type, statistical reporting area and year is shown in Table B1. In general, few observations are available in paired area-year cells for bottom trawl and mid-water trawls. Sampling by year and area for paired-mid-water trawl occurred in 2008 and 2009. Purse seine samples are restricted to areas 511, 512, and 513, but sampling did not occur in 2006. Number of trips is summarized by gear and statistical reporting area in Table B2 and by gear type and year in Table B3.

As a result of small sample sizes, year, gear, and statistical area strata will likely be collapsed into larger units for estimation of river herring catch.

Differences between observer catch and VTR reported catch

A summary of differences between observer catch estimates and VTR by year for all gears combined is shown in Table B4 and by gear for all years combined in Table B5. Differences are highly variable within and among gear types. The distributions of differences by gear appear leptokurtic. Boxplots of the differences by year and gear type are presented in Figure B1. Differences appear to be biased for paired mid-water trawls in 2006 and 2007. I tested whether the median differences from significantly different from zero for each gear type using the Wilcoxon's signed-rank test (Table B8). A significant difference was found for paired mid-water trawl ($p<0.001$, pseudo-median difference=38,470 with 95% confidence interval of 18,436 to 66,880). Differences were not significant from zero for bottom trawls, mid-water trawls and purse seines. Boxplots of differences by gear type and area for all years combined are shown in Figure B2.

Bland-Altman plots of the differences by gear type (all years pooled) are presented in Figure B4. Variance in differences appears to increase with the mean of the paired estimates but bias is not related to the mean, with the possible exception of mid-water trawls. Paucity of sampling suggests that separating year, gear and area effects will not be possible.

Boxplots of differences by gear type, year and whether river herring were present in the catch are shown in Figure B3. The amount of bias does not appear related to the presence or absence of river herring.

Ratio of observer reports to VTR reports

The relationship between the variance and mean indicated in the Bland-Altman plot suggests that log transformation may be useful. Summary statistics for distribution of ratio by year (all gears pooled) and by gear (all years pooled) are shown in Tables B6 and B7. Boxplots of the log ratio (observer/VTR) by year are shown in Figure B5. The log transformation shortened the tails, and removed the relationship between the variance and mean. The distributions remained leptokurtic.

Conclusions

In-season estimation of river herring catch will require use of observer reported Atlantic herring catch by strata (statistical area, gear type, and season). Trip level differences and the ratio between observer and VTR estimates of kept Atlantic herring are highly variable and will contribute to uncertainty in the estimation of river herring catch.

	Bottom trawl					Purse seine				
Area	2006	2007	2008	2009	Total	2006	2007	2008	2009	Total
511					0		4	2	4	10
512					0		5	15	4	24
513	1	1		1	3			6	23	29
514		1	2	1	4					
515					0					
521	2				2					
522					0					
537		3		3	6					
539	5	5	2	5	17					
611					0					
612					0					
613				1	1					
615					0					
616					0					
total	8	10	4	11	33	0	9	23	31	63

	Midwater trawl					Paired midwater trawl				
Area	2006	2007	2008	2009	Total	2006	2007	2008	2009	Total
511		2			2		1			1
512					0	1				1
513	3		1	2	6	6		6	16	28
514	1		1	1	3		3	3	10	16
515		1	2	1	4			4	7	11
521		4	3	1	8	2	2	8	11	23
522			1	3	4	1	1	7	25	34
537		1	1		2			4	2	6
539	1		1		2	8		1		9
611	1				1	4		2	4	10
612	1			1	2			2	4	6
613			1	2	3			3	5	8
615			1	1	2				4	4
616								1		1
total	7	8	12	12	39	22	7	41	88	158

Table B1: Number of trips by gear type, year and statistical reporting area.

Statistical area	Gear type: Bottom trawl	Purse seine	Paired mid-water trawl	Mid-water trawl	Total	Number of gear types
511		10	1	2	**13**	**3**
512		24	1		**25**	**2**
513	3	29	28	6	**66**	**3**
514	4		16	3	**23**	**3**
515			11	4	**15**	**1**
521	2		23	8	**33**	**2**
522			34	4	**38**	**1**
537	6		6	2	**14**	**2**
539	17		9	2	**28**	**2**
611			10	1	**11**	**1**
612			6	2	**8**	**1**
613	1		8	3	**12**	**2**
615			4	2	**6**	**1**
616			1		**1**	**1**
total	**33**	**63**	**158**	**39**	**293**	

Table B2: Number of observed trips by gear type and statistical area for 2006-2009. Four trips were excluded from the analysis because either the observer or VTR reported no Atlantic herring catch.

Year	Bottom trawl	Purse seine	Paired mid-water trawl	Mid-water trawl	Total
2006	8		22	7	**37**
2007	10	9	7	8	**34**
2008	4	23	41	12	**80**
2009	11	31	88	12	**142**
Total	**33**	**63**	**158**	**39**	**293**

Table B3: Number of observed trips by gear type and year. Four trips were excluded from analysis because observer or VTR reported no Atlantic herring catch.

Year	min	12.5th	25th	median	mean	75th	87.5th	max	IQR	Inter-octile range
2006	-120.7	-26.3	0.0	86.4	155.3	248.4	330.5	959.3	248.4	356.8
2007	-944.2	-38.9	-3.8	8.1	40.4	39.5	164.1	1262.0	43.3	203.0
2008	-380.8	-87.8	-21.5	9.7	57.6	59.9	282.1	1240.0	81.4	369.9
2009	-645.9	-106.6	-37.6	-0.6	-7.4	29.9	79.2	448.1	67.4	185.8

Table B4: Summary statistics for differences between observer and VTR estimates for all gear types combined.

Gear	min	12.5th	25th	median	mean	75th	87.5th	max	IQR	Inter-octile range
Bottom trawl	-55.7	-12.9	0.4	-2.6	1.2	248.4	4.4	42.5	8.6	17.3
Midwater trawl	-944.2	-205.0	-4.9	-52.9	21.4	39.5	58.1	465.2	107.1	263.1
Paired Midwater trawl	-645.9	-93.8	23.5	78.2	128.1	59.9	309.0	1262.0	152.7	402.9
Purse seine	-380.8	-69.8	4.0	7.5	28.4	29.9	77.2	383.5	46.9	147.0

Table B5: Summary statistics for differences between observer and VTR estimates by gear types for all years combined.

Year	min	12.5th	25th	median	mean	75th	87.5th	max	IQR	Inter-octile range
2006	0.17	0.77	1.00	1.40	2.49	2.42	2.03	30.61	1.03	1.72
2007	0.19	0.64	0.90	1.12	2.13	1.32	1.51	5.09	0.61	1.49
2008	0.29	0.77	0.91	1.05	2.19	2.29	1.34	45.04	0.44	1.42
2009	0.27	0.73	0.86	1.00	1.34	1.08	1.12	4.32	0.26	0.61

Table B6: Summary statistics for the ratio of observer:VTR estimates for all gear types combined.

Gear	min	12.5th	25th	median	mean	75th	87.5th	max	IQR	Inter-octile range
Bottom trawl	0.20	0.68	0.83	1.01	3.41	1.20	1.54	45.04	0.37	0.87
Midwater trawl	0.19	0.57	0.72	0.86	1.08	1.17	1.43	3.88	0.45	0.86
Paired Midwater trawl	0.17	0.85	0.95	1.07	1.52	1.45	2.01	30.61	0.50	1.16
Purse seine	0.29	0.78	0.91	1.02	1.19	1.19	1.43	5.67	0.28	0.65

Table B7: Summary statistics for the ratio of observer:VTR estimates by gear types for all years combined.

Gear	Wilcoxon Statistic	P-value	Lower limit	Upper limit	Pseudo- median
Paired mid-water trawl	8539	<0.001	18,436	66,880	38,470
Mid-water trawl	285	0.146	-63,660	5,687	-20,432
Bottom trawl	237	0.447	-5,380	898	-1,397
Purse seine	1132	0.398	-7,099	16,201	6,950

Table B8: Summary of Wilcoxon signed rank test for differences between paired observer and reported VTR Atlantic herring estimates by gear type (all years pooled).

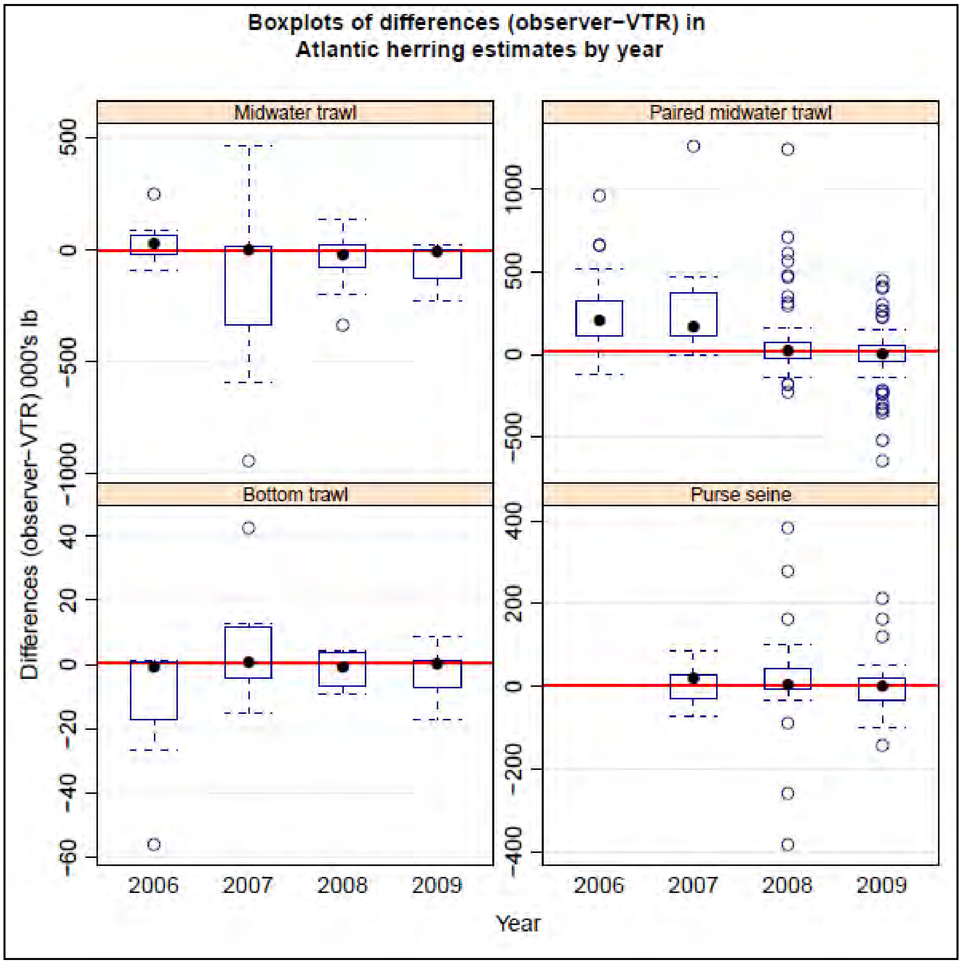

Figure B1: Boxplots of differences (Observer-VTR) in 000's lb by gear type for all years combined. Note that the y-scale differs by panel.

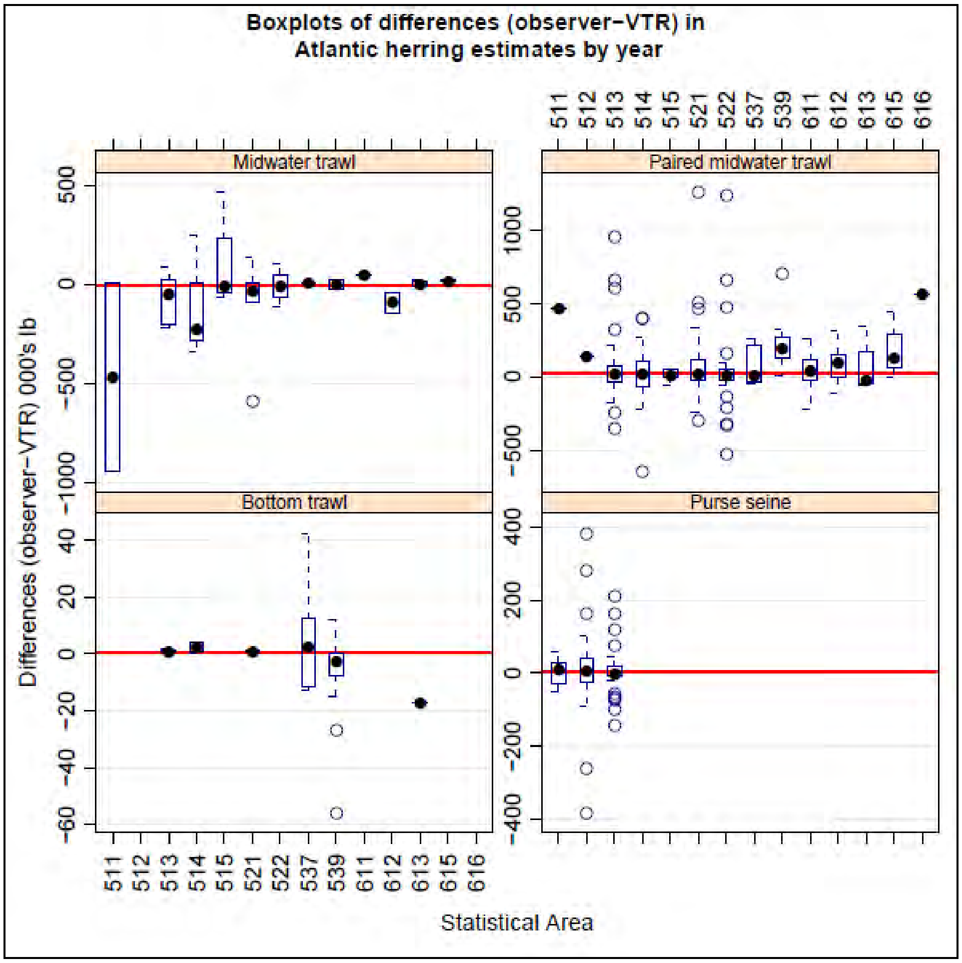

Figure B2: Boxplots of differences (Observer-VTR) by gear for all years combined. Note that y-scale differs by panel.

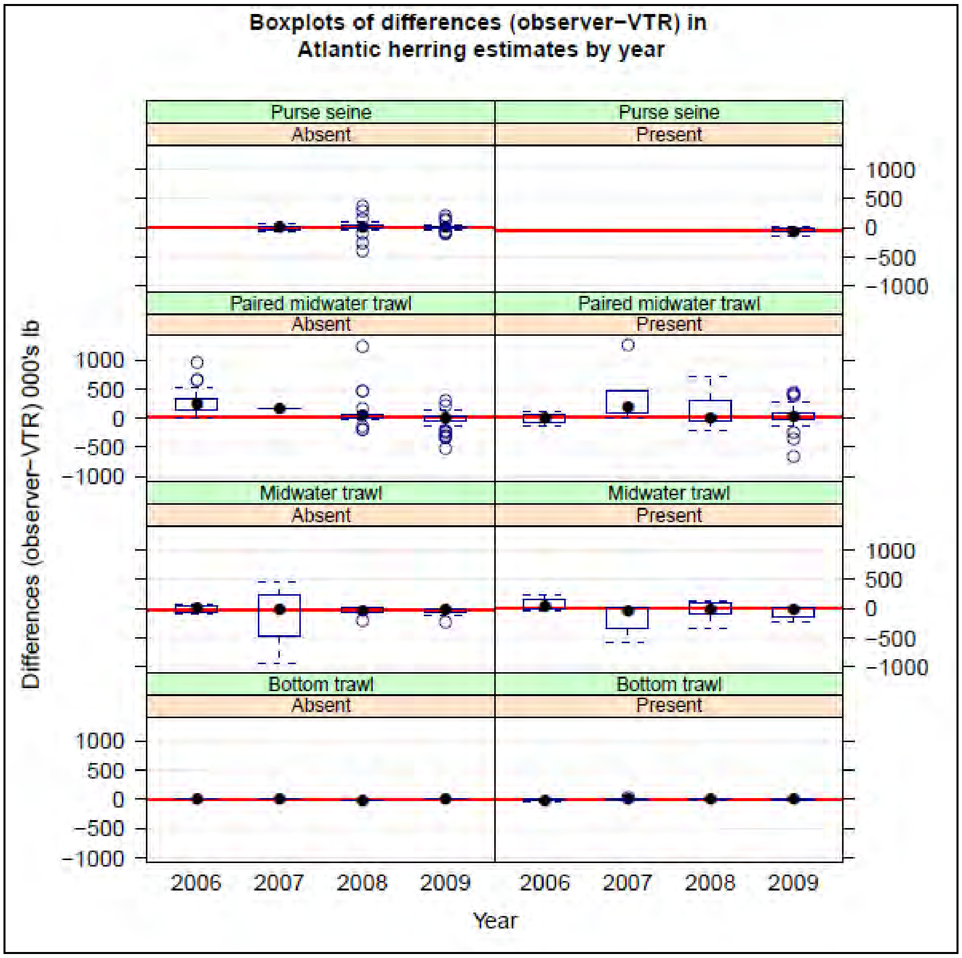

Figure B3: Boxplots of differences between observer estimates and VTR estimates by year, gear type and presence/absence of river herring. Redline is the median for all years combined.

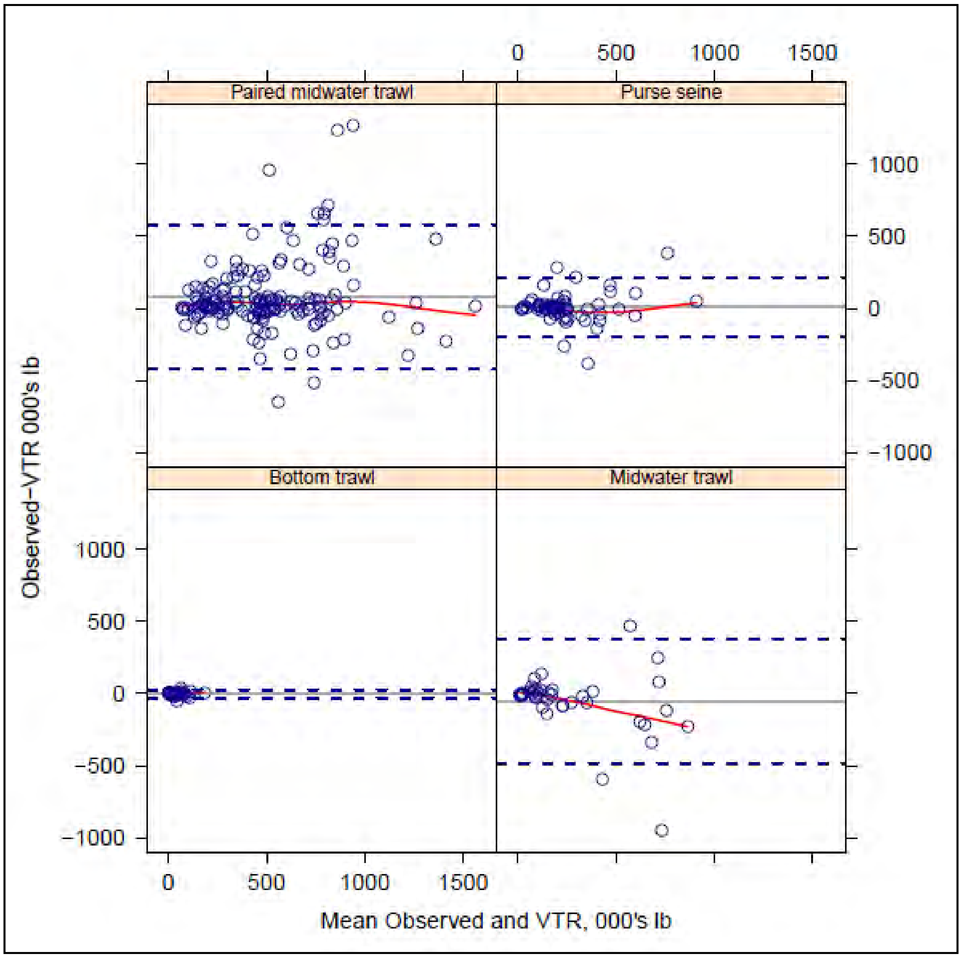

Figure B4: Differences (observer-vtr) against mean (observer and VTR) by gear type. Excludes observations where observer estimates=0. Gray line is the mean difference. Dashed blue lines are the mean +/- 2 standard deviations of the differences.

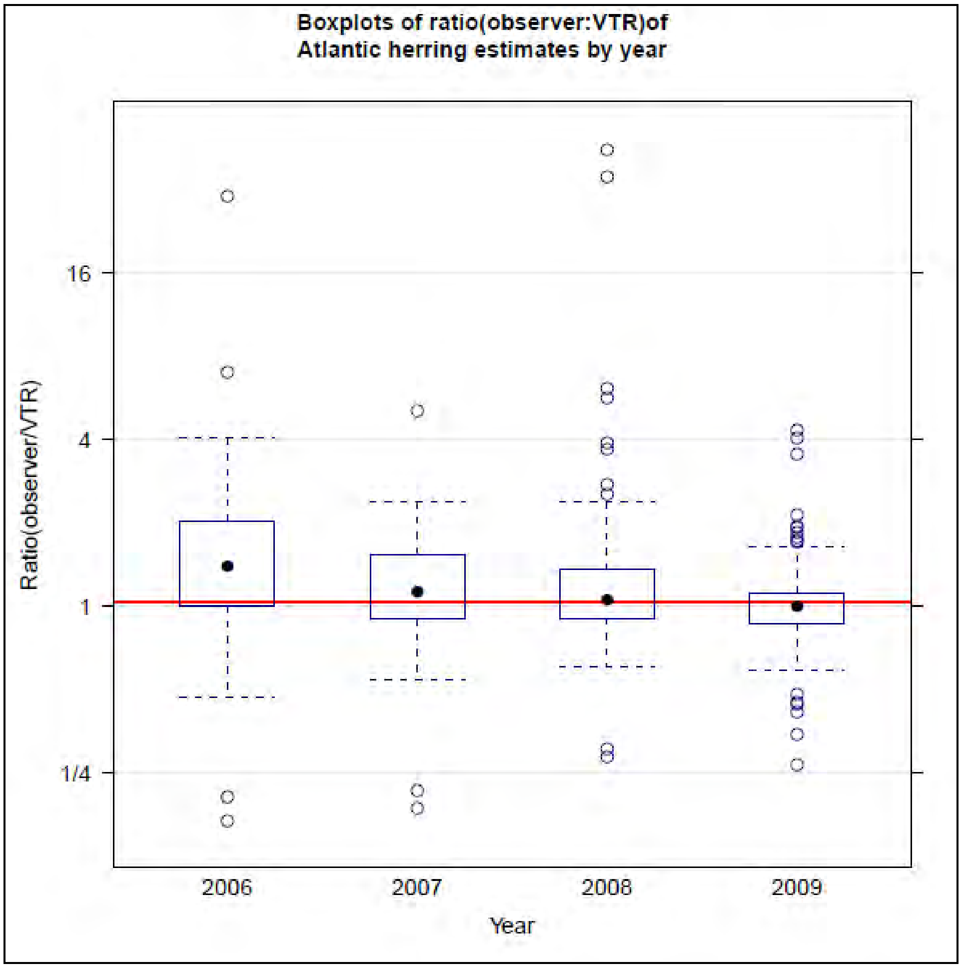

Figure B5: Boxplots of ratio (observer estimate: VTR estimate by year. Observations with observer estimate= 0 are excluded. Redline is the median for all years. Note y-scale is logarithmic.

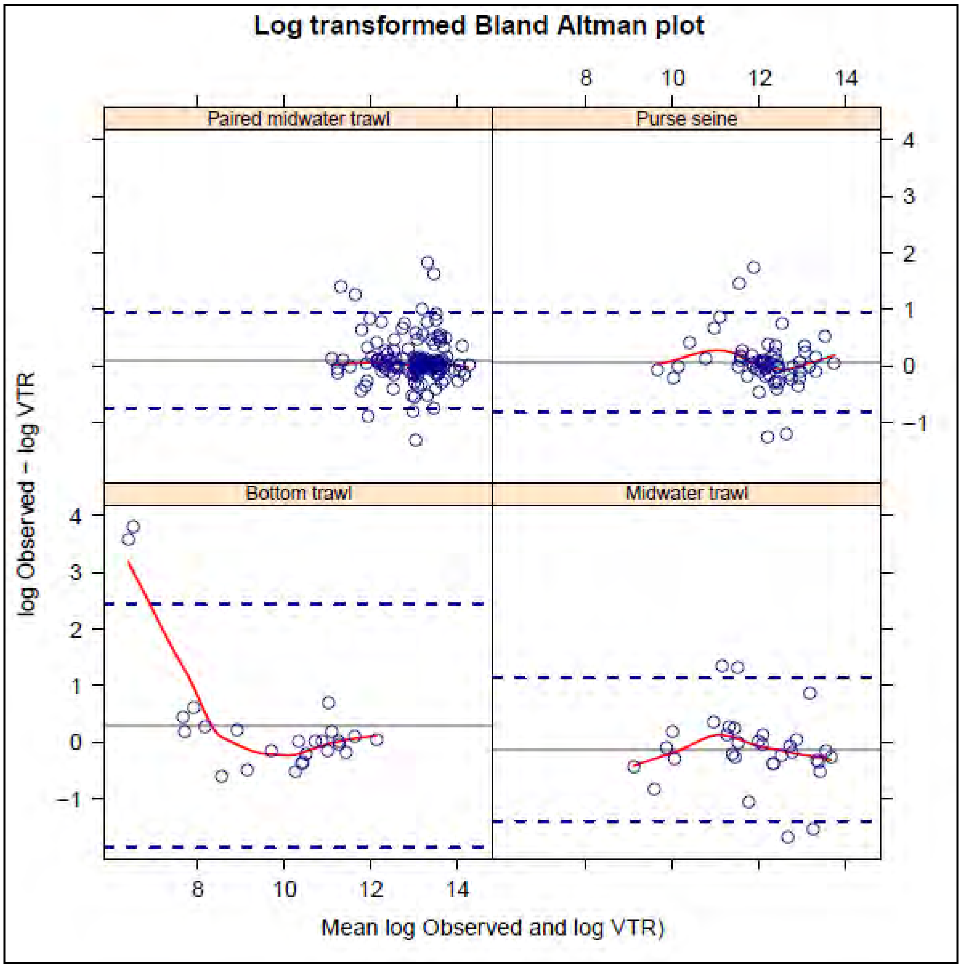

Figure B6: Log (observer/vtr) against mean log observer plus VTR. Excludes 2006 and observations where observer estimates=0. Gray line is the mean difference. Dashed blue lines are the mean +/- 2 standard deviations of the log (observer/VTR).

Appendix C

Comparison of river herring catches and CV's from Method 1 and Method 2

Prepared for the Herring PDT

By

Steven J. Correia

Massachusetts Division of Marine Fisheries

December 15, 2010

We compared the paired estimates of total river herring catches and CV's derived from Method 1 and Method 2 for both strata sets (whole year and half year). Pairs where no river herring=0 were dropped from the analysis. We tested for differences using the Wilcoxon signed rank test and the paired t-test on log-transformed data. All tests were two-sided.

Exploratory analysis suggests that the relationship between River herring catch estimates by method are likely multiplicative rather than additive (Figures C1-C4). The median paired difference (pseudo-median= -7,050 lb with approximate 95% CI -33,200 to 15,600 lb) was not significantly different from 0 (P=0.26). A paired T-test on the log-transformed pairs was not significant (P=0.36). The back transformed mean ratio was 0.95 with 95% CI of 0.86 to 1.06. This suggests that the differences in estimates by Method 1 and Method 2 are not consistent.

We conducted a similar analysis for the coefficients of variation. The median paired difference (pseudo-median=0.10 with approximate 95% CI 0.05 to 0.17) was significantly different ($p<0.001$). A paired T-test on the log-transformed pairs was significant (P=0.36). The back transformed mean ratio was 0.81 with 95% CI of 0.67 to 0.98. These results suggest that Method 2 provides a lower coefficient of variation than Method 1. That Method 1 provides higher CV's than Method 2 is not surprising given that the variance estimate in the ratio method is inflated by the lack of relationship between river herring catch and Atlantic herring catch.

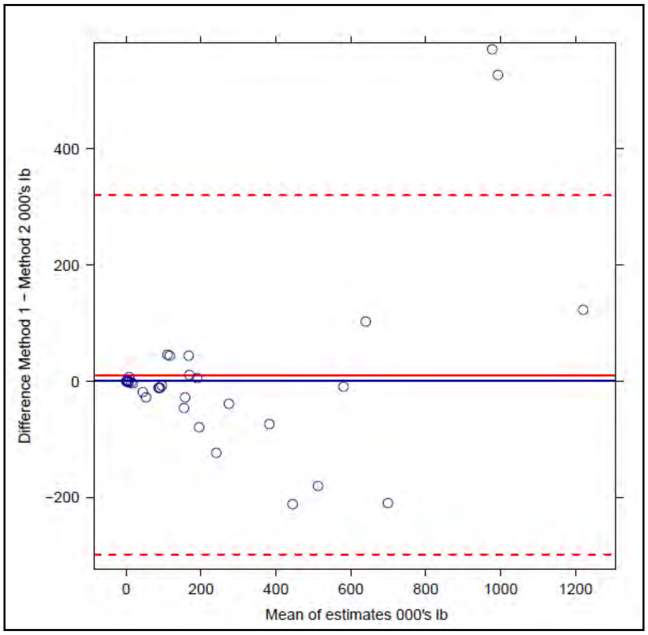

Figure C1: Comparison of river herring estimates using Method 1 and Method 2. Solid red line is mean difference (Method 1-Method 2). Dashed lines are mean difference ± 2 standard deviations.

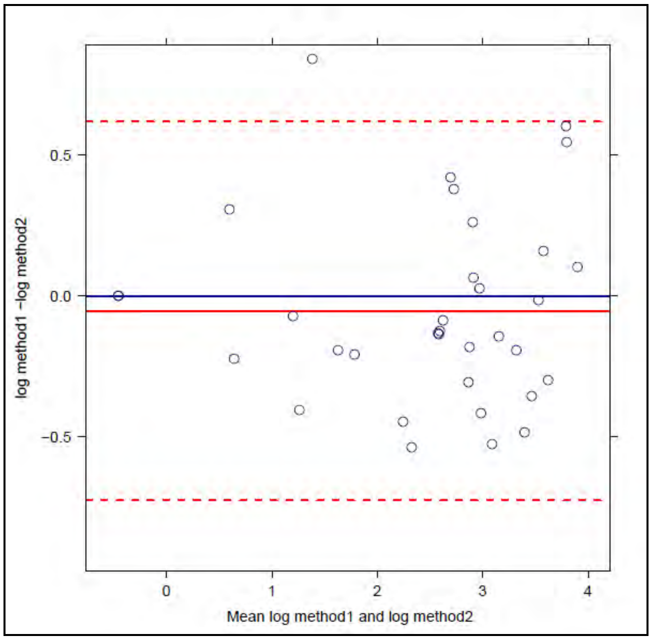

Figure C2: Comparison of river herring estimates using Method 1 and Method 2 on log transformed scale. Solid red line is mean difference (Method 1-Method 2). Dashed lines are mean difference ± 2 standard deviations.

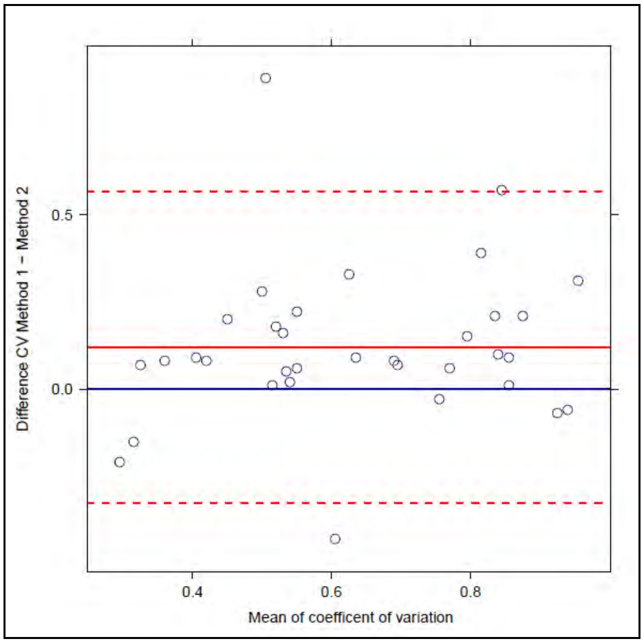

Figure C3: Comparison of river herring CV estimates using Method 1 and Method 2. Solid red line is mean difference (Method 1-Method 2). Dashed lines are mean difference ± 2 standard deviations.

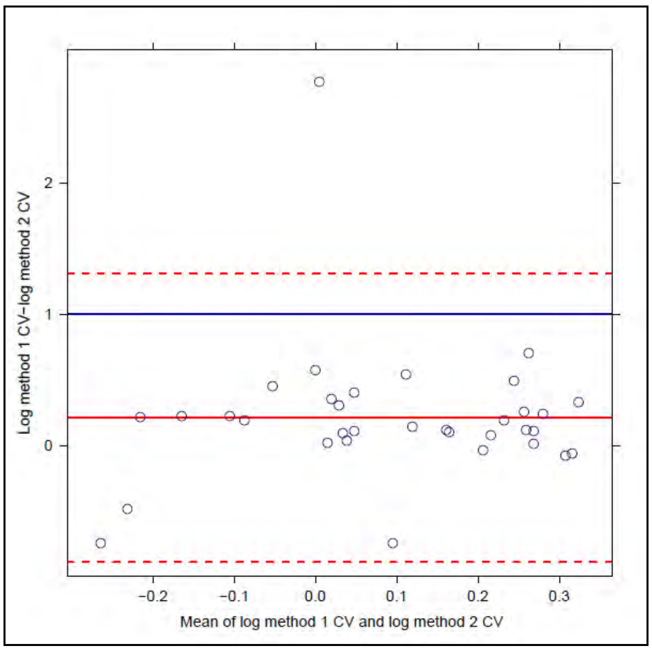

Figure C4: Comparison of river herring CV using Method 1 and Method 2 on log transformed scale. Solid red line is mean difference (Method 1-Method 2). Dashed lines are mean difference ± 2 standard deviations.

Appendix D

Possible Approaches to Setting a Catch Cap

The PDT did not agree on an approach to setting a catch cap at this time, but did discuss possible alternatives. Some of the options rely on the use of the catch history estimates described above, while others do not. The options include:

- Ceiling: Set a ceiling catch cap based on an average of recent river herring removals.
- Percentage: Set a ceiling catch cap as some percentage of the average of recent river herring removals. These can be set by area and half or full years.
- Stock Assessment: Allow the fishery to operate under the status quo option until a stock assessment is complete for river herring by ASMFC (2012) and therefore set catch caps relative to some measure of river herring stock status or reference point (e.g., Bmsy). Catch caps based on historical removals cannot account for changes in river herring abundance or availability. As such, river herring abundance may increase, while the catch caps would remain the same.
- Trips: Limit the number of hauls/sets or trips within Atlantic herring management areas (1A, 1B, 2, and 3) with river herring removals based on a threshold level of river herring removals per haul/set or trip. In other words, set a cap on the number of river herring encounters versus the amount of river herring catch.

Appendix E

Interactions with Other Measures in Amendment 5

The PDT discussed mechanisms to link the river herring hotspot analysis and spatial management measures with the river herring catch cap analysis. Linkages between a river herring catch cap and river herring spatial management measures could include:

- River herring catch cap applied in hotspot areas/times only. In which case the overall removals are not capped, as bycatch and further removals of river herring would likely occur outside of the defined hotspots. The more constrained the hotspots temporally and spatially the more likely this is to occur.
- River herring catch cap could be used as a catch trigger, i.e., a soft TAC that does not close the fishery when reached, but triggers a management action.
- River herring catch cap allocated by Atlantic herring management areas or by defined strata areas (specified above). The allocation would be determined using the hotspot analysis to weigh times/areas.

The PDT also discussed challenges for a catch cap approach given the current monitoring system.

- IVRs and VTRs are very difficult for "real time" use.
- VTRs have statistical area but not management area or groundfish closed area. Statistical area has been proven to be of very low data quality. VTRs give exact location for the starting tow or set. So you do know the management area and groundfish closed area, but not in real time as the vessel fishes in other locations within a statistical area.
- IVRs are not by the trip, but do identify Atlantic herring management area.
- The pre-trip notification system for the observer program asks if they are going into Closed Area 1, but does not distinguish other trips. The questions asked during the call cannot be changed in process without going through the regulatory and Paperwork Reduction Act process.
- There is variability associated with sampling a time, area and associated expansion. River herring removals could be over the cap but because of the variability associated with sample, would not appear so
- There might be data confidentiality limitations with making the river herring hot spot catches public - or being able to share catch information among the fleet in real time.
- A centralized reporting system for vessels to access while at sea should be supported.
- There are uneven and often low coverage rates in various areas.
    - Coverage has not been even in all areas that the fishery operates. For example during 2010, the NEFOP had to target 100% coverage if a vessel thought they may go into Closed Area I, while other areas are expected to meet or exceed 20%.
    - This is no spatial or temporal definition for coverage (and whether this is trips, seadays, or landings of herring).
    - Continued uneven coverage levels pose significant challenges in monitoring the cap during the fishing year.

Many of these challenges may be addressed under Amendment 5, which provides for options to improve the current catch monitoring program.