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River Herring Discard Estimation, Precision and Sample Size Analysis

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Executive Summary

A total of 106,455 pounds (149% CV) of river herring was discarded during the 12-month period from July 2007 through June 2008. The river herring discards occurred primarily in the New England small mesh otter trawl fleet, and to a lesser extent in the New England shrimp trawl, New England large mesh trawl and Mid-Atlantic small mesh otter trawl fleets.

The total number of sea days (9,002 days) needed to achieve a 30% CV for river herring discard estimates is 40% less than those needed for the 15 Standardized Bycatch Reporting Methodology (SBRM) species groups (15,125 days). On a fleet by fleet basis, the number of sea days needed to achieve a 30% CV for river herring discard estimates was either the same or less than for the 15 SBRM species groups with the exception of one fleet: New England large mesh otter trawl where the river herring species group needed 2,827 more sea days than the 15 SBRM species groups.

The low number of observed trips in the Mid-Atlantic gillnet fleets and the limitations of observing all discards associated with the fishing practices of the high-volume fisheries are two sources of uncertainty in the discard estimation and sample size analysis.

Introduction

Concerns have been expressed by governmental and non-governmental groups regarding the discarding of river herring by commercial fishing fleets operating off the northeastern coast of the United States. River herring is a species group comprising two individual species: alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*. This document provides estimates of river herring discards, with associated precision, and the number of sea days needed to achieve discard estimates over a range of precision levels. This document then compares the number of sea days needed for river herring with sea days needed for the 15 Standardized Bycatch Reporting Methodology (SBRM) species groups for the same time period derived in the 2009 SBRM analysis[1]. The SBRM is an omnibus amendment to the 13 fishery management plans in the Northeast region that establish review and reporting requirements for bycatch monitoring and observer coverage as well as a process for prioritizing observer coverage when there is a shortfall in funding (NMFS 2007).

River herring is managed by the Atlantic States Marine Fisheries Commission (ASMFC). Background information on river herring is available on the ASMFC web site: http://www.asmfc.org/

Methods

Discard Estimation

The 2009 SBRM analysis data set was expanded to include the river herring species group. This data set includes data from the Northeast Fisheries Observer Program (NEFOP), the Vessel Trip Report (VTR, including logbooks from the surfclam and ocean quahog fishery) database, the Northeast Fisheries Science Center (NEFSC) commercial landings database, and the NOAA Fisheries Marine Recreational Information Program (MRIP) recreational landings from July 2007 through June 2008.

This analysis used the discard estimation methods described in the SBRM analysis (Wigley et al. 2007). Total discards of river herring from July 2007 through June 2008 were estimated using a combined d/k ratio estimator (Cochran 1963), where d = discarded pounds of river herring and k = the kept pounds of all species. Total discards (in weight) of river herring, were derived by multiplying the estimated discard rate of each fleet by the corresponding fleet landings in the VTR database, and then summing over fleets. In this report, the term coefficient of variation (CV) is defined as the ratio of the standard error of the total discards divided by the total discards. Appendix 1 presents the equations used in the analysis. We assumed 100% mortality for all discarded fish.

In the analysis, the sampling unit was a fishing trip. The same broad stratification scheme used in the SBRM was employed, where trips were partitioned into fleets using

[1] 2009 SBRM Prioritization documents are available on-line at http://www.nefsc.noaa.gov/femad/fishsamp/fsb/ (under DATA/REPORTS, click on ‘SBRM Annual Discard Report’).

six classification variables: calendar quarter, geographic region, gear type, mesh, access area, and trip category. Calendar quarter was based on landed date and used to capture seasonal variations in fishing activity and discard rates. Two broad geographical regions were defined: New England (NE) and Mid-Atlantic (MA) based on port of departure[2]; ports located from Maine to Rhode Island constituted the NE region and ports located in states from Connecticut southward constituted the MA region. Gear type was based on Northeast gear codes (*negear)*. Some gear codes were combined: sink, anchored and drift gillnets, and single and paired mid-water trawls, (Table 1), and trips for which gear was unknown were excluded. Mesh size groups were formed for otter trawl and gillnet gear types. For otter trawls, two mesh groups were formed: small (mesh less than 5.5 inches) and large (5.5 inch mesh and greater). For gillnets: three mesh groups were formed: small (mesh less than 5.5 inches); large (mesh between 5.5 and 7.99 inches) and extra large (mesh 8 inches and greater). Two access area categories were formed: access area (AA) and open (OPEN). Trips participating in the US/Canada access area, 'B-day' category and other quota monitoring programs could not be identified in the VTR database, and hence these trips were grouped by the other stratification variables and therefore not partitioned separately. The sea scallop fishery was divided into General (GEN) and Limited (LIM) category trips. All other fisheries were combined into a category called 'all'.

Of the 44 fleets examined in the analysis, 22 fleets had little or no observer data (all quarterly cells were missing for a fleet, or sparse observer coverage existed across all quarters for a fleet). No discard estimation was performed for these fleets, and all 22 fleets were designated as in need of pilot coverage (Table 1). Pilot coverage is defined as a minimum level of observer coverage to acquire bycatch information with which to calculate variance estimates that in turn can be used to further define the level of sampling needed (NMFS 2004). For each of the remaining 22 fleets, estimates of river herring discards were derived. Eight fleets had limited observer data (*i.e.,* one or no observed trips in a calendar quarter), and an imputation approach was used to 'fill in' the missing (or incomplete) information using data from an adjoining stratum. In this imputation procedure, only the temporal stratification (*i.e.,* calendar quarter) was relaxed to half year or entire year, recognizing that seasonal variations may occur that will thus not be accounted for. For 14 fleets, sufficient observer data existed to estimate discards without imputation (Table 1).

Sample Size Analysis

A sample size analysis was conducted to estimate the number of baseline trips and sea days needed to monitor river herring discards in each fleet. As described in the SBRM analysis (and given in Appendix 1), the number of trips and sea days needed to achieve a given precision level was based on the variance of the total river herring discard estimates. Sample size (trips and sea days) associated with the SBRM precision standard for discard estimates (30% CV) were derived along with 5 other precision levels: 10%, 20%, 40%, 50% and 60% CV. The sample size analysis was performed using trips as the sampling unit of the analysis, and then converting the number of trips to

[2] Wigley et al. (2007) found that the majority (over 93%) of 2004 observed trips both originated and fished in the same region and exhibited the same general pattern as in the VTR data.

sea days by multiplying by the weighted mean trip length (Table 2) - where the weighting factor was the quarterly number of VTR trips.

When total discards could not be estimated due to little or no observer coverage (no data) or when total discards were zero (no variance), the sample size (number of trips) was determined using a pilot coverage level set to 2% of the quarterly VTR trips for a fleet, with a minimum of 3 trips per quarter (12 trips per year) and a maximum of 100 trips per quarter (400 trips per year). The 2% pilot coverage level is the same as used in the 2009 SBRM analysis. The quarterly trips were then multiplied by the quarterly mean VTR trip length to derive quarterly sea days. The quarterly trips and quarterly sea days were then summed for annual number of trips and sea days. The pilot coverage may result in too much coverage in cases where little or no observer coverage may actually be needed.

Importance filters were used in SBRM to provide a standardized protocol to further refine the number of baseline sea days based on (a) the importance of the discarded species relative to the total amount of discards by a fleet, and (b) the total fishing mortality due to the discards. Three filters (*i.e.,* unlikely cell filter; fraction of discard filter; and fraction of mortality due to discards filter) are applied simultaneously. The unlikely cell filter eliminates sea days associated with fleets where species and gear combinations are unlikely or infeasible. The unlikely cell filter can act as an 'override' mechanism in situations where pilot coverage is evoked due to no variance (observer coverage indicates zero discards). A detailed description of the SBRM importance filters is given in Wigley et al. (2007). As in the 2009 SBRM analysis, the baseline sea days for river herring were filtered using a 95% cut-point in the discard mortality filter, and a 98% cut-point for the total mortality filter due to discards. The unlikely cell filter was not updated to include the river herring species groups as all fleets were considered 'likely' to discard river herring.

Results and Discussion

Discard Estimation

River herring discards were estimated for 22 of the 44 fleets (Table 2). Of the 22 fleets with discard estimates, 6 fleets had discard estimates greater than zero and 16 fleets had discard estimates equal to zero. A total of 106,455 pounds of river herring was discarded during the 12-month period from July 2007 through June 2008. By fleet, discards of river herring ranged between 0 and 95,744 pounds, with largest amount occurring in the New England small mesh otter trawl fleet. The coefficient of variation of the total river herring discard estimate was 149%. For the six fleets where estimated river herring discards were greater than zero, the coefficient of variation ranged between 31% and 166% (Table 2).

Sample Size Analysis

Sample size coverage levels (baseline trips and sea days) to assess river herring discards are presented in Table 2. To achieve a 30% CV on river herring discards, a total of 6,923 baseline trips and 15,395 baseline sea days would be needed (Table 2). In six fleets, sample sizes (5,317 trips and 12,107 days) were based on the variance of total discards, while sample sizes for 38 fleets (1,606 trips and 3,288 days) were based on pilot coverage. The sample size based on pilot coverage (due to no data or no variance) contributed 23% and 21% to the total baseline trips and sea days, respectively. By fleet, the total number of baseline trips ranged between 6 and 1,662 trips while the total number of baseline sea days ranged between 10 and 4,060 days (Table 2).

For the six fleets where estimated river herring discards were greater than zero, the number of baseline trips and sea days needed to estimate discards over a range of precision levels are presented in Tables 3a and 3b and Figure 1. The sample sizes reported in Tables 3a and 3b are subtotals associated with the six fleets. To obtain a grand total, the subtotal must be added to the pilot coverage subtotal given in the text above. For example, to achieve a 20% CV based on river herring discards, a total of 11,423 baseline trips [9,817 trips (Table 3a) + 1,606 trips based on pilot coverage] and 25,454 days [22,166 days (Table 3b) + 3,288 days based on pilot coverage] would be needed.

The importance filter eliminated the sea days associated with the 16 fleets with zero discards of river herring. As well, three other fleets (MA large mesh otter trawl, MA small mesh otter trawl, and New England mid-water trawl) were eliminated from coverage because these fleets contributed to less than 5% of total discards and less than 2% of the total mortality due to discards. The total number of filtered sea days needed to achieve a 30% CV is 9,002 days (Table 2). By fleet, the number of filtered sea days needed to achieve a 30% CV for the total discards of river herring ranged between 0 and 4,060 days (Table 2).

The total number of filtered sea days needed for river herring may be an overestimate due to the inclusion of sea days associated with fleets that would have been eliminated had the unlikely cell filter been updated for river herring. The sea days associated with the clam dredge fleets, handline fleets, and the fish, conch, lobster, and crab pot fleets would most likely have been eliminated as these gear types rarely capture river herring. The total number of filtered sea days needed for river herring will be improved when observer data are available for all the fleets (no sea day estimates based on pilot coverage) and the unlikely cell filter is updated for this species group. In 2011, a three-year evaluation of the SBRM will occur and, at that time, bycatch information and estimation methods will be evaluated including an evaluation of the unlikely cell filter for all species.

This analysis used the SBRM Omnibus Amendment cut-points of 95% and 98% to eliminate sea days associated with fleets that contribute the smallest amount to total discards and total mortality due discards for river herring, respectively. Table 4 reveals that had another cut-point been used for the total discard filter, for example 93% instead of 95%, eliminating fleets contributing to the lower 7% of total discards instead of the lower 5% of total discards, then the 4,060 days associated with the NE large mesh otter fleet would have been filtered out and the total number of filtered sea days for river herring would have been 4,942 days instead of 9,002 days.

River herring is not a species group included the SBRM analysis[3], thus the number of sea days needed to monitor the river herring species group can be compared

[3] SBRM only considers federally managed species and turtles.

with the 15 SBRM species groups. A comparison of the filtered sea days for river herring and the 15 SBRM species groups (Table 2) reveals fewer total sea days would be needed to monitor only river herring (Table 2). However, on a fleet basis, only the NE large mesh otter trawl fleet needed more sea days for river herring than for the 15 SBRM species groups. As noted above, if the SBRM cut-point for total discards was relaxed to 93% and eliminated the sea days associated with the lower 7% of the total river herring discards, then the sea days from the NE large mesh otter trawl would be filtered out and the total number of sea days needed to monitor the 15 SBRM species groups would be greater than the sea days needed to monitor river herring for all fleets.

The total number of sea days needed for the 15 SBRM species groups (15,125 days) and for river herring (9,002 days) exceed the total number of sea days that the Northeast Fisheries Science Center (NEFSC) has funding to support. The NEFSC has funds to support a total of 6,283 days [4,283 days (Table 2) plus 1,940 US/Canada Quota-Monitoring sea days and 60 Discovery days; NEFSC 2009b]. When a funding shortfall exists, the SBRM Sea Day Prioritization Process (NEFMC 2007; NMFS 2007; NEFSC 2009b) is invoked; the resulting 2009 sea days, by fleet, are given in Table 2.

Misreporting of gear code in the VTR database is evident for the NE shrimp trawl fleet. The seasonal nature (December to April) of the northern shrimp fishery contributes to the inadvertent misreporting of gear code (OTS = otter trawl, shrimp and OTF = otter trawl fish) by fisherman who switch between these two fisheries. Thus caution is warranted when interpreting results regarding the NE shrimp trawl fleet. There is a need for improved data auditing and the identification of Special Access Program trips within the VTR database. Additionally, the low number of observed trips in Mid-Atlantic gillnet fleets contribute to uncertainty in the river herring discard estimates. Increased observer coverage will confirm the extent to which these fleets encounter river herring.

From 2005 onwards, the NEFOP has informally collected information to characterize unique fishing practices (fish pumping, use of sorting grates at the pump entrance and on deck, and net release) of high-volume fisheries like the paired and single mid-water trawl fleets. In 2010, the NEFOP manual describing data collection will be formally expanded to include sampling protocols designed to systematically characterize the fishing practices of high-volume fisheries. It is important to emphasize that only information systematically collected has been used in the current discard estimation analysis. Thus, discards associated with underwater net release or those associated with sorting grate at the pump entrance have not been included. Therefore, the discard estimates presented here may underestimate river herring discards associated with the high-volume fisheries. In the future, discard estimation methods may be able to incorporate the expanded data collection information and summarize the frequency of underwater net releases.

River herring is a non-targeted species group captured in various commercial trawl fleets. The 2009 SBRM Annual Discard Report[4] (NEFSC 2009a) summarizes where and when (statistical area and calendar quarter) observers have recorded the disposition of catch (kept or discarded) and the weight (pounds) of alewife and blueback herring among the commercial fleets (NEFSC 2009a, Section II, Tables 4c and 5c). Some trawl fleets that encounter river herring are retaining these species while other

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[4] SBRM Annual Discard Report is a data summary of the information collected by NEFOP observers, no extrapolation of observations (discard estimation) is performed in this summary.

fleets are discarding them. Generally, the mid-water trawl fleets are retaining river herring, while the otter trawl fleets are not.

Nominal catch (landings only) estimates of river herring during 2005 to 2007 have been derived by Cieri et al. (2008). In their study, a ratio estimator of observed river herring bycatch (kept) to Atlantic herring landings was developed based upon NEFOP observer data, Maine Department of Marine Resource portside sampling data, and VTR data. A stratification scheme was also used that included: year, calendar quarter, area, and gear type. Estimates of the annual nominal catch of river herring during 2005-2007 were 285,833, 171,973 and 1,686,617 pounds, respectively. It is important to note that the Cieri et al. (2008) estimates are for *nominal catch* of river herring as a non-targeted (hence their use of the term '*bycatch*') species in four commercial fishing fleets. In this context, the 'bycatch' estimates are not equivalent to the discard estimates derived in the present analysis. In the present analysis, discards represent the component of total catch that are not retained; total catch = landings (target and non-target) + discards.

Conclusions

This analysis indicates that during the July 2007 through June 2008 time period, river herring were primarily discarded in the NE small mesh otter trawl fleet, and to a lesser extent in the NE shrimp trawl, NE large mesh trawl and MA small mesh otter trawl fleets.

The baseline sea days needed to attain a 30% CV for discard estimates of river herring are slightly higher than the total filtered sea days needed to monitor 15 SBRM species groups. When the importance filter is applied to the river herring species group, the sea days associated with 19 of the 22 fleets with estimated discard were eliminated, indicating that the discarding of river herring is a minor component of total discards and total catch of river herring in the majority of fleets. The total number of filtered sea days needed to monitor river herring is 40% less than those needed to monitor the 15 SBRM species groups. On a fleet by fleet basis, the number of filtered sea days needed to monitor river herring was either the same (due to pilot coverage) or less than for the 15 SBRM species groups with the exception of one fleet: NE large mesh otter trawl where the river herring species group needed 2,827 more sea days than the 15 SBRM species groups.

The low number of observed trips in the Mid-Atlantic gillnet fleets and the limitations of observing all discards associated with the fishing practices of the high-volume fisheries are two sources of uncertainty in this analysis. More observer coverage, particularly in the Mid-Atlantic region, is needed to derive discard estimates and sample sizes. Direct discard estimation will reduce the dependency on pilot coverage for sample sizes estimates.

The discard estimation used a broad stratification approach designed to encompass all species groups considered in the SBRM analysis. The discard estimates reported here may not necessarily correspond directly with the discard estimates derived specifically for river herring due to differences in stratification. It is expected, however, that estimates would be in the same order of magnitude.

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Table 1. Number of Vessel Trip Report (VTR) and Northeast Fisheries Observer Program (NEFOP) trips, by fleet and calendar quarter (Q) for the July 2007 to June 2008 time period. Remarks indicate where discard estimation was possible, where imputed data were used for discard estimation, and where fleets were designated as in need of pilot coverage (no discard estimation) in this analysis and the 2009 SBRM analysis. See text for abbreviations.

						Number of VTR trips					Number of NEFOP trips					
Row	Gear Type	Access Area	Trip Category (general-limited)	Region	Mesh Group	Q3	Q4	Q1	Q2	TOTAL	Q3	Q4	Q1	Q2	TOTAL	**Remarks**
1	Longline	OPEN	all	MA	all	28	37	36	31	**132**	1	1	.	1	**3**	Pilot
2	Longline	OPEN	all	NE	all	140	226	577	133	**1,076**	10	56	10	16	**92**	Estimate
3	Hand Line	OPEN	all	MA	all	1,625	894	181	884	**3,584**	.	.	.	.	**.**	Pilot
4	Hand Line	OPEN	all	NE	all	1,267	276	197	354	**2,094**	.	.	.	3	**3**	Pilot
5	Otter Trawl	OPEN	all	MA	lg	1,988	1,065	1,187	1,850	**6,090**	78	31	17	42	**168**	Estimate
6	Otter Trawl	OPEN	all	MA	sm	1,082	1,307	666	1,096	**4,151**	76	41	33	37	**187**	Estimate
7	Otter Trawl	OPEN	all	NE	lg	3,202	2,706	2,984	2,500	**11,392**	165	164	170	173	**672**	Estimate
8	Otter Trawl	OPEN	all	NE	sm	1,193	801	671	991	**3,656**	33	12	8	14	**67**	Estimate
9	Scallop Trawl	AA	GEN	MA	all	40	17	26	10	**93**	.	.	2	3	**5**	Pilot
10	Scallop Trawl	AA	LIM	MA	all	.	1	6	7	**14**	.	.	1	1	**2**	Pilot
11	Scallop Trawl	OPEN	GEN	MA	all	380	60	53	311	**804**	.	.	.	10	**10**	Pilot
12	Scallop Trawl	OPEN	LIM	MA	all	35	36	6	7	**84**	.	.	.	.	**.**	Pilot
13	Shrimp Trawl	OPEN	all	MA	all	293	346	37	186	**862**	.	.	.	.	**.**	Pilot
14	Shrimp Trawl	OPEN	all	NE	all	19	363	2,252	72	**2,706**	.	.	16	.	**16**	Imputed
15	Sink,Anchor,Drift Gillnet	OPEN	all	MA	lg	158	322	135	224	**839**	3	7	.	2	**12**	Imputed
16	Sink,Anchor,Drift Gillnet	OPEN	all	MA	sm	786	478	275	421	**1,960**	11	3	.	1	**15**	Imputed
17	Sink,Anchor,Drift Gillnet	OPEN	all	MA	xlg	148	1,088	516	1,154	**2,906**	.	10	12	11	**33**	Imputed
18	Sink,Anchor,Drift Gillnet	OPEN	all	NE	lg	2,756	2,115	1,770	1,506	**8,147**	47	44	23	36	**150**	Estimate
19	Sink,Anchor,Drift Gillnet	OPEN	all	NE	sm	68	4	3	5	**80**	.	.	.	3	**3**	Pilot
20	Sink,Anchor,Drift Gillnet	OPEN	all	NE	xlg	1,249	927	385	1,118	**3,679**	86	48	11	28	**173**	Estimate
21	Purse Seine	OPEN	all	MA	all	144	32	.	51	**227**	.	1	.	.	**1**	Pilot
22	Purse Seine	OPEN	all	NE	all	231	62	.	50	**343**	8	2	.	10	**20**	Estimate
23	Scallop Dredge	AA	GEN	MA	all	86	40	330	460	**916**	2	3	68	79	**152**	Estimate
24	Scallop Dredge	AA	GEN	NE	all	120	5	2	63	**190**	29	.	.	46	**75**	Imputed
25	Scallop Dredge	AA	LIM	MA	all	77	70	93	169	**409**	18	7	16	29	**70**	Estimate
26	Scallop Dredge	AA	LIM	NE	all	117	51	49	96	**313**	34	26	27	40	**127**	Estimate
27	Scallop Dredge	OPEN	GEN	MA	all	2,887	1,477	1,667	2,648	**8,679**	9	7	2	7	**25**	Estimate
28	Scallop Dredge	OPEN	GEN	NE	all	1,400	584	559	1,012	**3,555**	6	1	2	1	**10**	Imputed
29	Scallop Dredge	OPEN	LIM	MA	all	344	266	281	452	**1,343**	13	11	6	19	**49**	Estimate
30	Scallop Dredge	OPEN	LIM	NE	all	570	345	291	431	**1,637**	23	11	19	24	**77**	Estimate
31	Mid-water paired/single Trawl	OPEN	all	MA	all	.	.	41	3	**44**	.	.	1	.	**1**	Pilot
32	Mid-water paired/single Trawl	OPEN	all	NE	all	2	105	133	62	**302**	.	9	23	14	**46**	Imputed
33	Fish pots/Traps Fish	OPEN	all	MA	all	429	419	74	361	**1,283**	.	.	.	2	**2**	Pilot
34	Fish pots/Traps Fish	OPEN	all	NE	all	515	179	.	154	**848**	.	.	.	1	**1**	Pilot
35	Fish pots/Traps Conch	OPEN	all	MA	all	89	287	129	136	**641**	.	.	.	.	**.**	Pilot
36	Fish pots/Traps Conch	OPEN	all	NE	all	272	238	.	169	**679**	.	.	.	.	**.**	Pilot
37	Fish pots/Traps Hagfish	OPEN	all	MA	all	9	.	5	9	**23**	1	.	1	1	**3**	Pilot
38	Fish pots/Traps Hagfish	OPEN	all	NE	all	66	36	19	36	**157**	.	.	2	5	**7**	Imputed
39	Lobster Pots	OPEN	all	MA	all	1,327	535	232	715	**2,809**	.	.	.	.	**.**	Pilot
40	Lobster Pots	OPEN	all	NE	all	13,437	9,344	2,298	4,135	**29,214**	.	.	.	.	**.**	Pilot
41	Crab Pots	OPEN	all	MA	all	64	34	17	11	**126**	.	.	.	1	**1**	Pilot
42	Crab Pots	OPEN	all	NE	all	51	18	5	32	**106**	.	.	.	.	**.**	Pilot
43	Clam/Quahog Dredge	OPEN	all	MA	all	1,040	850	844	991	**3,725**	.	.	.	.	**.**	Pilot
44	Clam/Quahog Dredge	OPEN	all	NE	all	920	514	472	838	**2,744**	.	.	.	.	**.**	Pilot
	Total					40,654	28,560	19,504	25,944	114,662	653	495	470	660	2,278	

Table 2. River herring discards (in pounds) and coefficient of variation (CV), the number of baseline trips, baseline sea days, and filtered sea days needed to achieve a 30% CV for river herring, number of filtered sea days needed to achieve a 30% CV for the 15 SBRM species groups, and the number of sea days accepted via the 2009 SBRM Prioritization process, by fleet for the July 2007 to June 2008 time period. Note: where estimated river herring discards equal zero (no CV), the baseline trips and sea days are based on pilot coverage. See text for abbreviation; IF = industry funded sea days.

							River Herring					15 SBRM species groups		
Row	Gear Type	Access Area	Trip Category (general-limited)	Region	Mesh Group	Weighted Mean Trip Length (days)	Discards (lbs)	CV	**Baseline Trips**	**Baseline Sea Days**	**Filtered Sea Days**	**Filtered Sea Days**	2009 SBRM Re-Prioritization Sea Days	Basis for SBRM Recommended Coverage
1	Longline	OPEN	all	MA	all	9.023			12	108	108	108	0	Pilot
2	Longline	OPEN	all	NE	all	1.401	0		22	31	0	456	104	
3	Hand Line	OPEN	all	MA	all	1.110			72	80	80	80	0	Pilot
4	Hand Line	OPEN	all	NE	all	1.059			42	44	44	44	0	Pilot
5	Otter Trawl	OPEN	all	MA	lg	1.893	883	0.917	1,400	2,651	0	1,459	655	
6	Otter Trawl	OPEN	all	MA	sm	2.135	2,128	0.579	636	1,358	0	1,495	347	
7	Otter Trawl	OPEN	all	NE	lg	2.443	3,178	0.492	1,662	4,060	4,060	1,233	1,233	
8	Otter Trawl	OPEN	all	NE	sm	2.353	95,744	1.661	1,441	3,390	3,390	4,027	1,019	
9	Scallop Trawl	AA	GEN	MA	all	2.215			12	27	27	27	0	Pilot
10	Scallop Trawl	AA	LIM	MA	all	5.571			9	46	46	46	0	Pilot
11	Scallop Trawl	OPEN	GEN	MA	all	1.947			20	39	39	39	0	Pilot
12	Scallop Trawl	OPEN	LIM	MA	all	7.345			12	97	97	97	0	Pilot
13	Shrimp Trawl	OPEN	all	MA	all	4.225			20	80	80	80	0	Pilot
14	Shrimp Trawl	OPEN	all	NE	all	1.032	3,692	0.314	23	23	23	61	16	
15	Sink,Anchor,Drift Gillnet	OPEN	all	MA	lg	1.054	0		17	18	0	139	0	
16	Sink,Anchor,Drift Gillnet	OPEN	all	MA	sm	1.036	0		39	41	0	1,155	0	
17	Sink,Anchor,Drift Gillnet	OPEN	all	MA	xlg	1.358	0		58	79	0	1,273	55	
18	Sink,Anchor,Drift Gillnet	OPEN	all	NE	lg	1.144	0		163	186	0	187	225	
19	Sink,Anchor,Drift Gillnet	OPEN	all	NE	sm	1.000			12	12	12	12	0	Pilot
20	Sink,Anchor,Drift Gillnet	OPEN	all	NE	xlg	1.492	0		74	110	0	171	34	
21	Purse Seine	OPEN	all	MA	all	1.110			9	10	10	10	44	Pilot
22	Purse Seine	OPEN	all	NE	all	2.213	0		11	24	0	24	71	
23	Scallop Dredge	AA	GEN	MA	all	1.641	0		22	36	0	36	IF	
24	Scallop Dredge	AA	GEN	NE	all	1.732	0		12	26	0	26	IF	
25	Scallop Dredge	AA	LIM	MA	all	7.900	0		12	98	0	271	IF	
26	Scallop Dredge	AA	LIM	NE	all	8.236	0		12	102	0	233	IF	
27	Scallop Dredge	OPEN	GEN	MA	all	1.556	0		174	270	0	167	29	
28	Scallop Dredge	OPEN	GEN	NE	all	1.607	0		71	114	0	43	6	
29	Scallop Dredge	OPEN	LIM	MA	all	8.712	0		27	234	0	398	IF	
30	Scallop Dredge	OPEN	LIM	NE	all	10.244	0		33	335	0	254	IF	
31	Mid-water paired/single Trawl	OPEN	all	MA	all	5.136			6	41	41	41	12	Pilot
32	Mid-water paired/single Trawl	OPEN	all	NE	all	4.036	830	0.611	155	625	0	433	433	
33	Fish pots/Traps Fish	OPEN	all	MA	all	1.029			27	28	28	28	0	Pilot
34	Fish pots/Traps Fish	OPEN	all	NE	all	1.026			17	17	17	17	0	Pilot
35	Fish pots/Traps Conch	OPEN	all	MA	all	1.022			15	15	15	15	0	Pilot
36	Fish pots/Traps Conch	OPEN	all	NE	all	1.022			14	14	14	14	0	Pilot
37	Fish pots/Traps Hagfish	OPEN	all	MA	all	11.348			9	106	106	106	0	Pilot
38	Fish pots/Traps Hagfish	OPEN	all	NE	all	4.140	0		12	55	0	55	0	
39	Lobster Pots	OPEN	all	MA	all	1.226			56	69	69	69	0	Pilot
40	Lobster Pots	OPEN	all	NE	all	1.259			329	430	430	430	0	Pilot
41	Crab Pots	OPEN	all	MA	all	1.833			12	28	28	28	0	Pilot
42	Crab Pots	OPEN	all	NE	all	3.745			12	70	70	70	0	Pilot
43	Clam/Quahog Dredge	OPEN	all	MA	all	1.643			75	122	122	122	0	Pilot
44	Clam/Quahog Dredge	OPEN	all	NE	all	0.845			55	46	46	46	0	Pilot
	Total						106,455	1.494	6,923	15,395	9,002	15,125	4,283	

Table 3a. Number of baseline trips needed to achieve discard estimates for river herring over a range of precision levels, for the six fleets where estimated river herring discards are greater than zero. To obtain the total number of baseline trips needed across 44 fleets, add 1,606 trips to the six fleet subtotals.

Row	Gear Type	Access Area	Trip Category (general-limited)	Region	Mesh Group	Coefficient of variation (CV) 10%	20%	30%	40%	50%	60%
5	Otter Trawl	OPEN	all	MA	lg	6,403	2,736	1,400	831	546	385
6	Otter Trawl	OPEN	all	MA	sm	2,949	1,248	636	377	248	174
7	Otter Trawl	OPEN	all	NE	lg	7,372	3,221	1,662	990	652	460
8	Otter Trawl	OPEN	all	NE	sm	3,740	2,340	1,441	937	646	469
14	Shrimp Trawl	OPEN	all	NE	all	195	51	23	13	8	6
32	Mid-water paired/single Trawl	OPEN	all	NE	all	298	221	155	109	79	59
	Six fleet subtotal					20,957	9,817	5,317	3,257	2,179	1,553

Table 3b. Number of baseline sea days needed to achieve discard estimates for river herring over a range of precision levels, for the six fleets where estimated river herring discards are greater than zero. To obtain the total number of baseline sea days needed across 44 fleets, add 3,288 sea days to the six fleet subtotals.

Row	Gear Type	Access Area	Trip Category (general-limited)	Region	Mesh Group	Coefficient of variation (CV) 10%	20%	30%	40%	50%	60%
5	Otter Trawl	OPEN	all	MA	lg	12,123	5,181	2,651	1,574	1,034	729
6	Otter Trawl	OPEN	all	MA	sm	6,297	2,664	1,358	805	529	372
7	Otter Trawl	OPEN	all	NE	lg	18,014	7,871	4,060	2,420	1,593	1,123
8	Otter Trawl	OPEN	all	NE	sm	8,800	5,505	3,390	2,204	1,521	1,103
14	Shrimp Trawl	OPEN	all	NE	all	201	52	23	13	8	6
32	Mid-water paired/single Trawl	OPEN	all	NE	all	1,201	893	625	440	319	239
	Six fleet subtotal					46,636	22,166	12,107	7,457	5,004	3,572

Table 4. River herring discards (in pounds), fraction of total discards, cumulative fraction of total discards, fraction of total discard filter, discard mortality ratio, fraction of total mortality due to discards, cumulative fraction of total mortality due to discards, fraction of total mortality due to discards filter[5], unlikely cell filter, and importance filter, by fleet for 22 fleets with no discards estimated, 16 fleets with discard equal to zero, and six fleets with discard estimates greater than zero. A 95% cut-point has been used in the discard filter and a 98% cut-point for the total mortality due to discards filter; filter value of 1 indicates the sea days associated with the fleet are kept and 0 indicates the sea days associated with the fleet are eliminated.

						Total Discard				Total Mortality due to Discard					
Row	Gear Type	Access Area	Trip Category (general-limited)	Region	Mesh Group	Discard (lbs)	Fraction	Cumulative Fraction	Filter	Discard Mortality Ratio	Fraction	Cumulative Fraction	Filter	Unlikely Filter	Importance Filter
	22 fleets with no discards													1	1
	16 fleets with discards = 0					0	0.00%	0.00%	0	0	0.00%	0.00%	0	1	0
32	Mid-water paired/single Trawl	OPEN	all	NE	all	830	0.78%	0.78%	0	0.003	0.32%	0.32%	0	1	0
5	Otter Trawl	OPEN	all	MA	lg	883	0.83%	1.61%	0	0.003	0.34%	0.66%	0	1	0
6	Otter Trawl	OPEN	all	MA	sm	2,128	2.00%	3.61%	0	0.008	0.82%	1.48%	0	1	0
7	Otter Trawl	OPEN	all	NE	lg	3,178	2.98%	6.59%	1	0.012	1.22%	2.70%	1	1	1
14	Shrimp Trawl	OPEN	all	NE	all	3,692	3.47%	10.06%	1	0.014	1.42%	4.12%	1	1	1
8	Otter Trawl	OPEN	all	NE	sm	95,744	89.94%	100.00%	1	0.368	36.81%	40.92%	1	1	1
						106,454				0.409					

[5] Fraction of total mortality due to discards is defined as the ratio of discards of species group *j* in fleet *h* (D_{jh}) to the sum of commercial landings (L_{jh}), recreational landings (R_{jh}), and discards (D_{jh}) summed of h; river herring commercial landings equaled 136,908 pounds and recreational landings equaled 16,765 pounds from July 2007 through June 2008.

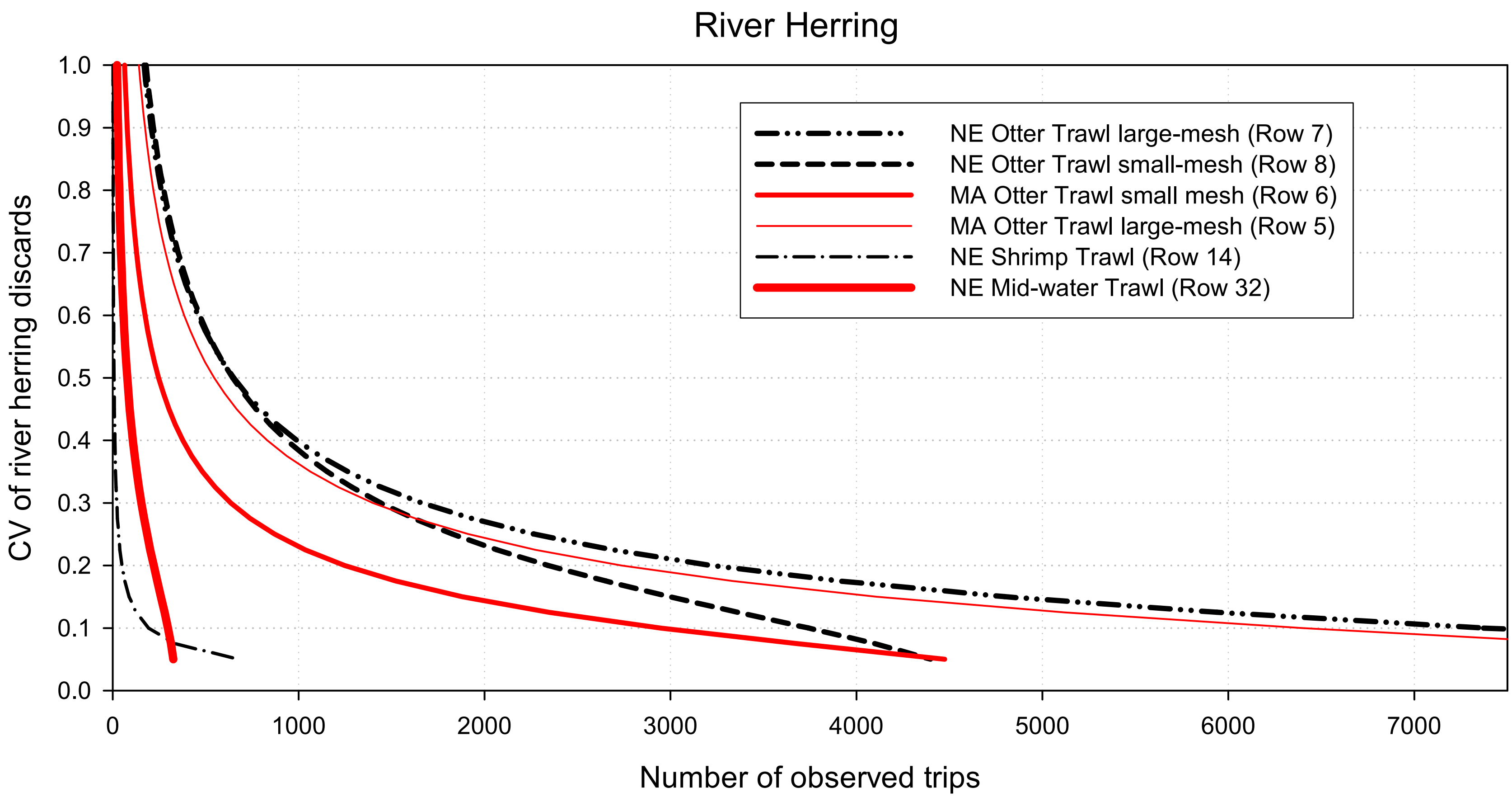

Figure 1. Relationship between sample size (number of observed trips) and precision (coefficient of variation, CV) of river herring discards for six fleets where estimated river herring discards are greater than zero. The solid (red) curves represent fleets that are eliminated through the importance filter process; patterned (black) curves represent fleets that are not eliminated.

Appendix 1. Equations used in discard estimation and sample size analysis

Total discarded pounds for species *j* is defined as:

(1) $$\hat{D}_j = \sum_{h=1}^{Q} K_h r_{c,j}$$

where

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

where $\hat{D}_j$ is total discarded pounds for species *j*; K_h is VTR total kept pounds in stratum *h*; $r_{c,j}$ is the combined ratio of species *j*; d_{jih} is discards of species *j* from trip *i* in stratum *h*; k_{ih} is kept pounds of all species on trip i in stratum h; N_h is the number of VTR trips in stratum *h*; n_h is the number of observed trips in stratum h. In Eq 2 the summation over strata *h* = 1 to Q is over calendar quarters and the other strata values are held constant. Equation 3 (below) requires a more explicit definition of the stratum designation since the summation over quarter relies on an annual average ratio defined in Eq 2.

Variance of $\hat{D}_j$ for species j is defined as:

(3) $$V(\hat{D}_j) = \sum_{q=1}^{4} K_{qh}^2 \left(\frac{N_{qh} - n_{qh}}{n_{qh} N_{qh}} \right) \frac{1}{\left(\frac{\sum_{i=1}^{n_h} k_{iqh}}{n_{qh}} \right)^2} \left[\frac{\sum_{i=1}^{n_{qh}} \left(d_{jiqh}^2 + (r_{c,j})^2 k_{iqh}^2 - 2 r_{c,j}\, d_{jiqh} k_{iqh} \right)}{n_{qh} - 1} \right]$$

where $\hat{D}_j$ is total discarded pounds for species *j*; K_{qh} is VTR total kept pounds in quarter q and stratum h; $r_{c,j}$ is the combined ratio of species *j*; d_{jiqh} is discards of species *j* from trip *i* in quarter q and stratum *h*; k_{iqh} is kept pounds of all species on trip *i* in quarter *q* and stratum *h*; N_{qh} is the number of VTR trips in quarter *q* and stratum *h*; n_{qh} is the number of observed trips in quarter *q* and stratum *h*.

Coefficient of variation (CV) of $\hat{D}_j$ is defined as:

$$(4) \quad CV(\hat{D}_j) = \frac{\sqrt{V(\hat{D}_j)}}{\hat{D}_j}$$

The number of sea days and trips needed to achieve a 30% CV are derived based on the variance of the total discards using the combined ratio method and the d/k discard ratio (Eq 3).

From Eq 3, let

$$(5) \quad \hat{S}^2_{jqh} = \left[\frac{\sum_{i=1}^{n_{qh}} \left(d^2_{jiqh} + (r_{c,jh})^2 k^2_{iqh} - 2r_{c,j}\ d_{jiqh} k_{iqh} \right)}{n_{qh} - 1} \right] \qquad \text{and}$$

$$(6) \quad \delta_{qh} = \frac{n_{qh}}{\sum_{q=1}^{4} n_{qh}}$$

where δ_{qh} is the fraction of the trips in quarter *q* in stratum *h*; $r_{c,jh}$ is the combined annual ratio of species *j* in stratum *h*; d_{jiqh} is discards of species *j* from trip *i* in stratum *h* in quarter *q*; k_{iqh} is kept pounds of all species on trip *i* in stratum *h* in quarter *q*; and n_{qh} is the number of observed trips in stratum *h* in quarter *q*. The $r_{c,jh}$ in Eq. 5 is defined in Eq. 2 where the summation is over quarters within a given strata defined by gear, region, access area, trip type and so forth.

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 stratum h is defined as

$$(7) \quad \hat{T}D_{30jh} = \frac{\sum_{q=1}^{4} \left(\frac{K^2_{qh}}{\bar{k}^2_{qh}} \hat{S}^2_{jqh} \frac{1}{\delta_{qh}} \right)}{(0.09) D_{jh}{}^2 + \frac{\sum_{q=1}^{4} \frac{K^2_{qh}}{\bar{k}^2_{qh}} \hat{S}^2_{jqh}}{N_h}}$$

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

The number of sea days necessary to achieve a 30% CV based on the variance of the composite annual total discards for species group *j* in stratum h is defined as

$$(8) \quad \hat{S}D_{30jh} = \hat{T}D_{30jh} * \overline{DA_h}$$

where $\overline{DA_h}$ is the weighted average trip length of VTR trips in stratum h (weighted by the number of VTR trips in each quarter) .

When total discards could not be estimated due to little or no observer coverage (no data) or when total discards are zero (no variance), sample size was determined by pilot cover, where 2% of the quarterly VTR trips for a fleet were multiplied by the quarterly mean VTR trip length.

(9) $\hat{S}_{30,jhq} = \hat{T}_{hq} * \overline{DA_{hq}}$

where $\hat{T}_{hq}$ is 2% of the VTR trips in stratum *h* and quarter *q*, and 3 <= $\hat{T}_{hq}$ <= 100 trips; $\overline{DA_{hq}}$ is the average trip length of VTR trips in stratum *h* and quarter *q*.

The quarterly trips and sea days were then summed for annual number of trips and sea days.

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