INTRODUCTION

The Standardized Bycatch Reporting Methodology (SBRM) Omnibus Amendment (NEFMC 2007; NMFS 2008) was vacated by the US District Court of the District of Columbia on 15 September 2011 because of a deficiency associated with the prioritization process, an element of the amendment. The regulations implementing the SBRM were removed by the National Marine Fisheries Service (NMFS) on 29 December 2011 (NMFS 2011). A revised SBRM Omnibus Amendment was approved on 13 March 2015 and the final rule became effective 30 July 2015 (NEFMC 2015). This report provides some of the information required by the annual discard report specified in the SBRM amendment.

The SBRM discard estimation methods described in Wigley et al. 2007 are still applicable. The analyses conducted for 2017 are similar to those conducted in 2016 (Wigley et al. 2016) in which the sample size analyses are based on the assumption that the pattern of fishing activity observed in the prior year will be similar to that in the upcoming year.

This document presents the estimated discards and associated precision as well as the number of sea days needed to obtain a 30% coefficient of variation (CV) on the discard estimates for the 14 species groups associated with federal fishery management plans (FMPs) in northeastern US fleets[1]. Additionally, discard reasons associated with the discarded species are summarized. This document differs from SBRM documents prior to 2012 in that this document does not include a sea day prioritization[2] and does not contain information about sea turtles.

METHODS

Data Sources

The data sets used include July 2015 through June 2016 data from the Northeast Fisheries Observer Program[3] (NEFOP) database, the Vessel Trip Report (VTR; including logbooks from the surfclam [*Spisula solidissima*] and ocean quahog [*Arctica islandica*] fishery) database, the Northeast Fisheries Science Center (NEFSC) commercial landings database, and the National Oceanic and Atmospheric Administration Marine Recreational Information Program (MRIP) database.

The NEFOP is a comprehensive, multipurpose program that collects a broad range of data including information on all species, by disposition (retained and discarded), that are

[1] "Fleet" is synonymous with "fishing mode."

[2] The observer sea day allocation documents are available online.

[3] There were 880 At-Sea Monitoring Program (ASM) trips associated with New England hand line, longline, otter trawl, Ruhle trawl, and gillnet fleets in the July 2015 through June 2016 data. A comparison of discard rates derived from observer and at-sea monitor data in 2015 and 2016 revealed there were generally similar discard rates between the 2 data collection programs for the 18 fish species and 5 gear types (longline, large mesh otter trawl, large mesh Ruhle trawl, large mesh gillnet, and extra large mesh gillnet) where at-sea monitor data exist; hence NEFOP and ASM data were pooled. See Northeast Fisheries Observer Program (2013, 2016a, 2016b) for more information on ASM. The Atlantic States Marine Fisheries Commission (ASMFC) funded 81 otter trawl trips (84 trips when stratified by gear type and mesh size) in the July 2015 through June 2016 data. A comparison of discard rates derived from NEFOP-allocated and ASMFC-allocated trips revealed there were generally similar discard rates for the 3 fleets where ASMFC-allocated trips exist (Mid-Atlantic small mesh otter trawl fleet [62 trips], Mid-Atlantic large mesh otter trawl fleet [1 trip], and New England small mesh otter trawl fleet [19 trips]); hence, these data have been pooled.

encountered during a fishing trip as well as gear characteristics data, economic information, and biological samples (NEFOP 2013, 2016a, 2016b). The NEFOP employs trained sea-going observers and monitors to collect these data. Fish and invertebrate species are recorded by weight. Conversion factors were applied to convert any dressed weight data to live[4] weight equivalents.

For this analysis, only observed hauls from NEFOP trips with a "complete" sampling protocol were used. A "complete" sampling protocol includes obtaining species weights for both kept and discarded portions of all species in the catch. NEFOP training trips have been included in the analysis. Aborted trips and "set only" trips were excluded from the analysis along with trips fishing in statistical areas associated with the Southeast Region (statistical area ≥ "700"), trips landing outside the Greater Atlantic Region (e.g., trips landing in Canada), and "carrier" trips (*fleet_type* = "050"; no fishing effort occurred on these trips). Hauls with no catch reported, species weight with discard reason "039" ("previously discarded"), and catch of nonliving matter (such as debris, shells, etc.; these items would not be kept and sold) were also excluded for the analysis. Additionally, there were 2 observed New England (NE) small mesh haddock separator trawl trips, 2 observed NE tuna purse seine trips, and 2 observed NE scallop beam trawl trips for which there were no corresponding VTR trips for the gear; consequently these 6 observed trips were removed from the analysis. The 5 observed lobster pot trips associated with non-random vessel selection (program code 103) and 15 observed lobster pot trips without VTR reporting requirements during the January-March 2016 time period (trips outside the sampling frame) were excluded from the analysis.

The same broad stratification scheme used in previous SBRM analyses was employed in this analysis, in which trips were partitioned into nonoverlapping fleets by using 5 classification variables: geographic region, gear type, mesh, access area, and trip category. Calendar quarter was used in the analyses and was based on landed date 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[5]; ports in states from Maine to Rhode Island constituted the NE region, and ports in states from Connecticut to northern North Carolina (35^{o} N) 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. Trips for which gear was unknown were excluded. Mesh size groups were formed for otter trawl and gillnet gear types. For otter trawls, 2 mesh groups were formed: small (mesh less than 5.50 in) and large (mesh 5.50 in and greater). For gillnets, 3 mesh groups were formed: small (mesh less than 5.50 in), large (mesh from 5.50 to 7.99 in), and extra large (mesh 8.00 in and greater). Two access area categories were formed: access area (AA) and open (OPEN). The sea scallop fishery was divided into general (GEN) and limited (LIM) category trips. All other fisheries were combined into a category called "all." In the data set analyzed, there were also trips associated with 1 exempted fishery where 100% monitoring coverage was required for trips. The exempted trips using a mid-water trawl fishing in the groundfish access area have been grouped together to form the NE AA mid-water trawl fleet (Row 40).

[4] In this document, "live" is equivalent to "round" grade (i.e., includes the weight of the shell for shellfish).

[5] 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. An updated analysis using July 2007 through June 2011 data found similar results (Wigley et al. 2012a).

Stratification abbreviations used are given below.

Abbreviation	Definition
NE	New England ports (RI and northward)
MA	Mid-Atlantic ports (CT and southward)
Sm	Small mesh (less than 5.50 in)
Lg	Large mesh (from 5.50 to 7.99 in for gillnet; 5.50 in and greater for otter trawl)
Xlg	Extra large mesh (8.00 in and greater for gillnet)
AA	Access area
OPEN	Nonaccess area
GEN	General category
LIM	Limited access category

The VTR data are used as a basis for defining the sampling frame, since all federally permitted vessels are required to file a VTR for each fishing trip except those vessels that hold only a federal commercial lobster permit (See NOAA Fisheries Greater Atlantic Regional Fisheries Office Vessel Trip Report Instructions for guidance). These self-reported data[6] constitute the basis of the fishing activity of the commercial fleets. While dealer data are the preferred data to use because of more accurate weights, VTR data are used as a surrogate because dealer data do not contain mesh size and area fished information. The VTR data were thus used to expand the NEFOP discard ratios to total discards. For this analysis, the commercial federal VTR trips were used. Conversion factors were applied to convert various units of measure to pounds and all weight to live weight. VTR trip data were grouped into fleets as defined above. Trips participating in the US/Canada access area and other special access programs could not be identified in the VTR data. These trips were grouped by the other stratification variables and were not partitioned separately.

The VTR trips associated with the MA shrimp trawl fleet (Row 19) were partitioned into 2 groups: trips fishing in Pamlico Sound and trips fishing in ocean waters. Partitioning was needed because the Southeast Region has mandatory observer coverage of the southeastern shrimp fishery and allocates observer coverage to trips fishing in Pamlico Sound (Scott-Denton 2012). MA shrimp trawl trips fishing in Pamlico Sound have been removed from these analyses, while trips fishing in ocean waters have been retained.

The clam fishery has a logbook system separate from the VTR logbook. The commercial clam logbook data were used to augment the VTR data for the clam dredge fishery. The commercial and recreational landings (in live weight) for the federally managed species were used only in sample size analysis.

A list of the 14 federally managed fish and invertebrate species groups analyzed and the individual species that compose each species groups is given in Table 1. Summaries of the data used, in terms of number of trips and number of sea days, by fleet, calendar quarter, and data source (NEFOP and VTR), are given in Tables 2 and 3, respectively.

The spatial and temporal patterns of observer coverage within a fleet were evaluated. Rather than using number of trips (a trip-based metric), the kept weight of all species reported in the VTR was used. The "kept weight with observer coverage" was derived as the kept weight of all species reported in the VTR summed by fleet, statistical area, and quarter, where at least 1

[6] See Wigley et al. 2007 for more details on self-reported VTR data.

observed trip occurred in the fleet-quarter-statistical area cell and at least 3 observed trips[7] occurred in the fleet-quarter stratum. The "kept weight" was derived as the kept weight of all species reported in the VTR summed over all statistical areas and quarters within a fleet. The percentages of "kept weight with observer coverage" were calculated by dividing the "kept weight with observer coverage" by the "kept weight." These percentages were derived for the individual fleets, confidential fleets combined into "Confidential fleets," "Other minor fleets," and all fleets combined. Additionally, as a relative measure of fleet activity among all fleets, the percentage of "kept weight" was derived by dividing the "kept weight" by the sum of the "kept weight" across all fleets.

Discard Estimation

Total discards of each of the 14 federally managed species groups were estimated for the July 2015 through June 2016 time period by using a combined discard/kept (d/k) ratio estimator (Cochran 1963), where d = discarded pounds of a given species group, and k = the kept pounds of all species (i.e., any species retained during the trip). Total discards (in weight) 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 analysis, no survival ratios were applied to discard estimates.

Simple imputation methods were used to fill quarterly cells for which there were fewer than 3 observed trips. Data from adjoining strata were pooled to impute estimates for cells with 0, 1, or 2 trips. In this imputation only the temporal stratification (calendar quarter) was relaxed to an annual aggregation even though seasonal variation can occur for some species. This simple imputation could not be applied to fleets where observer coverage was low or missing throughout the year (i.e., too few data to support the simple imputation approach). In these cases, imputed values were not used, and the fleet was designated as a fleet in need of pilot coverage[8]. If some data were available, then discard estimates were derived, but these results were not used in sample size analyses.

The variances and standard errors (SE) of the discard estimates were also derived. In this document, CV is defined as the ratio of the standard error of the total discards divided by the total discards. The appendix presents the equations used in the analysis.

For each species/species group and fleet, the landings from the VTR and clam logbook are presented to provide perspective for the discard estimates.

Discard Reasons

For each species group and fleet, the fish dispositions associated with discarding (as reported by the at-sea observer) have been grouped into the following 6 discard reason categories: no market, regulation (size), regulation (quota), regulation (other), poor quality, and other. The discard reason categories and the associated fish dispositions are summarized in Appendix Table 2. The discard reasons "No Market" and "Poor Quality" are considered economic discards and not regulatory discards.

[7] The 3 trips for fleet-quarter correspond with a minimum threshold for allocating observer coverage.

[8] Pilot coverage is defined as a minimum level of observer coverage necessary to acquire bycatch information with which to calculate variance estimates that can then be used to further define the level of sampling needed (NMFS 2004).

The observed (nonextrapolated) discards associated with each of the 6 discard reason categories were summed for each species group/species for the fleets where discards could be estimated. For individual fleets, the percentage of observed discards by discard reason category was derived by dividing the sum of the observed discards for each discard reason category by the sum of the total observed discards for each species group/species and fleet. The discard reason category percentages were taken from the observed discard reason category percentages. For each fleet that composes the "Other fleets filtered out" (an aggregated fleet that represents fleets where the variance of the discard estimate was not used in the annual sample size analysis), the observed discard reason category percentages were then multiplied by the total estimated (extrapolated) discards for each species group/species to derive the estimated discards by discard reason category. The total estimated discards by discard reason category were summed over the fleets that compose the fleet aggregation for each species group/species. The estimated discard reason category percentage was derived by dividing the estimated discards for each discard reason category by the sum of the total estimated discards for each species group/species and fleet. In other words, the "Other fleets filtered out" represents the weighted percentage where the weighting factor was the fleet extrapolated discards.

Sample Size Analysis

A sample size analysis (also referred to as sea day analysis) was conducted to estimate the number of baseline trips and sea days needed to monitor the 14 federally managed species groups in each fleet. As described in Wigley et al. 2007 (and given in the appendix), the number of trips and sea days needed to achieve a given precision level was based on the variance of the total discard estimate for a species group, with the assumption that the pattern of fishing activity observed in the prior year would be similar to that in the upcoming year. Sample sizes (trips and sea days) associated with the precision standard for discard estimates (30% CV) were derived. The sample size analysis was performed by using trips as the sampling unit and then converting the number of trips to sea days by multiplying by the weighted mean VTR trip length, where the weighting factor was the quarterly number of VTR trips that occurred during July 2015 through June 2016 time period. The percentage of trips was derived by dividing the number of trips needed by the number of VTR trips that occurred in the fleet. When total discards could not be estimated because of little or no observer coverage (no data), or when total discards were zero (no variance), the sample size (number of trips) was determined by using a pilot coverage level set to 2% of the quarterly VTR trips that occurred in 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 was the same as was used in previous sea day analyses. In this analysis, to avoid assigning more coverage than could be attained, a refinement was made to pilot coverage: if less than 3 VTR trips occurred in a fleet and quarter, then pilot coverage was set to zero. 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 the annual number of trips and sea days. It is recognized that pilot coverage may still result in too much coverage in cases where little or no observer coverage may actually be needed, when effort changes sharply between years, or when the fleet comprises a low number of trips on an annual basis.

Some fleet/species combinations contribute very little to the total fishing mortality or discard of the species but may require significant resources to characterize the precision of the estimate. For example, a high variance estimate for a rare event within a fleet would require high levels of sampling, even though the total discard in that fleet was unimportant with respect to

either the total discard or total fishing mortality of the resource. To address this, importance filters were used 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 discards.

The 2017 baseline sea days were filtered by using a 95% cut-point in the discard filter and a 98% cut-point for the total mortality filter due to discards. In other words, estimates of sea day coverage for a given species or species group were derived for those fleets where discards constituted 95% of the discard mortality and catch constituted 98% of the total fishing mortality.

To determine the number of sea days (referred to as the "2017 sea days needed") and trips needed to achieve a 30% CV on the estimates of discards for each of the 14 species groups within a fleet, the maximum number of sea days for the 14 species groups (i.e., the maximum number of sea days in a row) was used. This approach ensures that all species groups will have a 30% CV or less. In the event that sea days for each species group within a fleet were filtered out, the number of sea days for the fleet was based on minimum pilot days to maintain monitoring coverage for that fleet. Minimum pilot coverage represents a minimum threshold for the allocation of sea days and is defined as 3 trips per quarter for each quarter where industry activity was 3 trips or greater. The quarterly number of trips is multiplied by the quarterly mean VTR trip length and then summed over quarters to derive the annual minimum pilot days for the fleet. If the fleet was designated as a pilot fleet, then pilot sea days were used. These fleets are indicated with a "P." The fleets with sufficient data to estimate sample size are referred to as nonpilot fleets.

RESULTS

There were 56 fleets uniquely identified in the July 2015 through June 2016 data (Tables 2 and 3; Appendix Table 1). Based upon the industry activity during this time period, no new fleets were added to the collection of fleets analyzed. The NE small mesh haddock separator trawl fleet (an exempted fishery fleet) was not active in the time period analyzed. The other minor fleets not uniquely identified in this analysis were aggregated into a single fleet labeled "Other minor fleets." Because of confidentiality rules, the landings and discards associated with 4 unique fleets (MA AA LIM scallop trawl [Row 10], MA large mesh Ruhle trawl [Row 15], MA floating trap [Row 21], and MA mid-water trawl [Row 41]) in Tables 2 and 3 were aggregated into a single fleet labeled "Confidential fleets" for reporting purposes in Tables 4 and 5. Hence, the fleet row numbers within Tables 2, 3, and 6 are sequential, while the fleet row numbers in Tables 4, 5, and 7 are ordered but there are gaps in the row numbers.

Of the 56 fleets examined, 22 fleets had little or no observer data: 5 fleets had sparse observer data across all quarters, while 17 fleets were missing observer data in all quarterly cells. The fleets with no observer coverage include trawl, purse seine, pot, and trap fleets, several of which have little industry activity. No discard estimation was performed for the 17 fleets with no observer coverage, and they were designated as fleets in need of pilot coverage (Tables 2 and 3; Appendix Table 1). The 5 fleets with sparse observer coverage were also designated as fleets in need of pilot coverage for the sample size analysis; however, discard estimation was performed with the sparse observer data. For the 34 remaining fleets (designated as nonpilot fleets; Rows 1, 2, 4-9, 11, 18, 23-25, 27, 28, 30-38, 40, 42-46, 48, 49, 55, and 56), estimates of discards and their associated variance were derived and used to determine the sample sizes needed for a 30% CV.

Of the 34 fleets, there were 16 fleets (Rows 1, 2, 4, 9, 11, 30-32, 37, 40, 42-45, 48, and 55) where the simple imputation was applied (Tables 2 and 3).

Thus, for the discard estimation and precision analysis, 17 fleets had no discard estimation, and 39 fleets had discards estimated. For the sample size analysis, 34 fleets had sample sizes derived from the discard variances, and 22 fleets had sample sizes based upon pilot coverage.

A total of 3,802 trips (10,500 days) was observed during the July 2015 through June 2016 period. When these trips were stratified, some trips were partitioned between strata, resulting in 4,202 trips (11,401 days; Tables 2 and 3) in the NEFOP data set.

In terms of number of trips, the percentages of observed trips varied by fleet and calendar quarter. On an annual basis, for the 39 fleets with some observer coverage, the percentage of observed trips by fleet ranged between 0.1% (MA Hand Line, Row 3; Table 2) to 88% (NE AA mid-water trawl fleet, Row 40; Table 2). It is unexpected to have coverage percentages at or near 100%; however, this fleet is composed of the exempt fisheries trips for which 100% monitoring was required[9]. All trips within this fleet did have an observer aboard; however, 1 trip had all hauls classified as unobserved, and unobserved hauls are not used in the analysis. For the 34 nonpilot fleets (excluding the exempted fleet [Row 40]), the percentage of observed trips ranged between 0.8% (NE lobster pot, Row 49) and 17.6% (NE large mesh gillnet fleet, Row 27). Over all fleets, the percentage of observed trips was 5.0% (Table 2). The percentage of observer days (Table 3) was generally similar to the percentage of observed trips.

In terms of kept weight of all species, the percentage of observer coverage over all fleets was 72% (Table 4). For the 34 nonpilot fleets, the percentage of observer coverage ranged between 3% and 99% with an average of 75% (Table 4). Twenty-six of the 34 fleets had a percentage greater than or equal to 61% with an average of 86%. This finding indicates that the majority of kept weight within the fleet was associated with statistical areas and quarters with observer coverage. Additionally, these 26 fleets composed 86% of the total kept weight across all fleets. The kept weight of all species was considered a surrogate for fishing effort; hence, observer coverage occurred spatially and temporally where the majority of fishing effort occurred at the statistical area and quarter year scales.

The landings associated with the combined fleet "Other minor fleets" contributed 0.1% of the total landings across all fleets (Table 4); thus, the 56 uniquely identified fleets account for almost all of the total VTR landings.

Annual VTR landings for all fleets and estimated discards (live weight, in pounds) with associated precision (CV and SE) for 39 individual fleets (Rows 1-9, 11, 13, 14, 16, 18, 19, 23-25, 27, 28, 30-38, 40, 42-46, 48, 49, 55, and 56) and 2 combined fleets ("Confidential fleets" and "Other minor fleets" [with landings only]) are summarized for each of the 14 species groups, the individual species that composed those species groups, and the 14 species groups combined (Tables 5A, 5B, and 5C; Figures 1A and 1B). There were 13 fleets (Rows 12, 17, 20, 22, 26, 29, 39, 47, and 50-54) as well as the "Other minor fleets" that have no discard estimation because of the lack of NEFOP coverage. Fleets with no discard estimation have dark shade in Tables 5A and 5B. In Table 5A, the CVs associated with the cells (species group and fleet) that were not used in the sample size analysis (i.e., cells filtered out via the importance filter) are indicated in light shading. Precision of discards of individual species (Table 5B) and 14 species group combined (Table 5C) were not used in the sample size analysis.

[9] For further information see the Federal Register RIN 0648-AY47.

Based upon this analysis, 69,691 mt (153,643,333 lb; live weight) of discards for the 14 species groups occurred during the July 2015 through June 2016 period (Table 5C). The majority (70%) of the discards comprises 2 species groups: skates (Rajidae; 55%) and sea scallop (*Placopecten magellanicus*; 15%); the remaining SBRM species groups each accounted for less than or equal to 8% (Table 5A).

The percentage of discards to total catch varied among the 14 species groups (Table 5A; Figure 1A) and individual species (Table 5B; Figure 1B). One species group (SAL) had zero discards (this species group is not presented in Figure 1A and Appendix 3A); 2 species groups (SCOQ, and HERR) where discards were less than 1% of total catch; 5 species groups (TIL, BLUE, SCAL, RCRAB, and SBM) where percentages of discards ranged between 1% and 10% of total catch; 3 species groups (GFL, GFS, and FSB) where discards ranged between 11% and 25% of total catch; and 3 species groups (MONK, DOG, and SKATE) where discards were greater than 26% of total catch. The species groups with the highest percentage of total discards relative to total catch were: skates (73%), spiny dogfish (*Squalus acanthias;* 42%), and monkfish (*Lophius americanus*; 29%; Figure 1A). For individual species (Table 5B; Figure 1B), most notable are the high percentages of discards to total catch for Atlantic wolffish *(Anarhichas lupus*; >99%), ocean pout (*Zoarces americanus*; >99%), and windowpane flounder (*Scophthalmus aquosus*; >99%) because of the no possession regulations for these 3 individual species, and for Atlantic halibut (*Hippoglossus hippoglossus*; 76%) because of a 1 fish per trip regulation. Offshore hake (*Merluccius albidus*; 86%) and red hake (*Urophycis chuss*; 71%) had a high percentage of discards to total catch because of economic reasons (no market). The NE large mesh otter trawl fleet (Row 8) had the highest estimated discards of SBRM species (Table 5C).

The reasons for discarding varied among the 14 species groups (Appendix Table 3A) and individual species (Appendix Table 3B). Overall, for the 14 species groups, the majority (81%) of discards were attributed to "No Market." "Regulation" (size, quota, and other), "Poor Quality," and "Other" contributed 15%, 2%, and 2%, respectively (Appendix Table 3A).

The percentages of discards to total catch by fleet were also summarized for the 34 nonpilot fleets (Figure 2). Discards of 1 or more of the 14 species groups that were filtered out via the importance filter have been aggregated into a species group labeled "Other SBRM." Discards of nonfederally managed species have been aggregated into a species group labeled "Non-SBRM." The percentages of discards to total catch varied by fleet (Figure 2). There were 3 fleets (Rows 30, 40, and 42) where discards were less than 1% of the total catch in the fleet; 6 fleets (Rows 4, 23, 24, 32, 55, and 56) where the percentages of discards ranged between 1% and 10%; 10 fleets (Rows 1, 2, 7, 25, 28, 31, 33, 34, 38, and 45) where the percentages of discards ranged between 11% and 25% of total catch; 11 fleets (Rows 5, 8, 18, 27, 35-37, 43, 44, 48, and 49) where the percentages of discards ranged between 26% and 50% of the total catch; and 4 fleets (Rows 6, 9, 11, and 46) where discards were greater than 50% of the total catch (Figure 2).

The number of species groups discarded within a fleet also varied among fleets. The majority of fleets (23 of the 34 fleets) comprised 2 or 3 discarded species groups. For 9 of these fleets (Rows 1, 4, 9, 11, 31, 32, 43, 44, and 55), the "Other SBRM" species group comprised the majority of the discards. This finding indicates that the majority of discards for those 9 fleets were filtered out via the importance filter. There were 9 fleets (Rows 23, 30, 40, 42, 45, 46, 48, 49, and 56) for which the "Non-SBRM" species group comprised the majority of the discards. There were another 5 fleets where 2 of the 3 discarded species groups were "Other SBRM" and "Non-SBRM," and the third represented the majority of the discards: Row 25 (skate; 77%), Row

18 (GFL; 64%) and Rows 2, 24, and 27 (spiny dogfish; 71%, 55%, and 72% respectively; Figure 2). The remaining fleets (11 of the 34 fleets) had between 4 and 9 discarded species groups. The skate species group comprised the plurality of the discards in 5 of these fleets (Rows 5, 6, 8, 28, and 35) while the "Non-SBRM" group comprised the plurality of the discards in 4 fleets (Rows 7, and 36-38), and there were 2 fleets (Rows 33 and 34) for which SCAL comprised the plurality of discards. The dominant "Non-SBRM" species in the scallop dredge fleets (Rows 31-38) were sand dollar (Clypeasteroida), starfish (Asteroidea), and sponge (Porifera). "Fish, not known" was the dominant "Non-SBRM" species in the NE purse seine fleet and the NE mid-water trawl fleets (Rows 30, 40, and 42, respectively). American lobster (*Homarus americanus*) and Jonah crab were the dominant "Non-SBRM" species in the MA and NE lobster pot fleets (Rows 48 and 49, respectively; Figure 2).

The precision of the discard estimates varied by species group and fleet (Table 5A). Of the 14 species groups, 12 species groups (BLUE, FSB, HERR, GFL, MONK, RCRAB, SCAL, SKATE, GFS, DOG, SBM, and TIL) had an overall CV that was less than 30%, and 1 species group (SCOQ) had an overall CV that was greater than 30% and 1 species group (SAL) had zero discards and consequently no CV. The discards of 4 species groups (BLUE, HERR, SCOQ, and TILE) were filtered out in all fleets; this finding indicates that the discards of these species groups were a minor component of the total catch of these species (Table 5A; Figure 1A). The precision of the discard estimates for individual species are given in Table 5B; these precision estimates were not used in the sample size analysis.

The number of sea days needed for each species group and fleet, as well as the number of pilot coverage days, minimum pilot coverage days, and the sea days needed for the fleet (referred to as "2017 Sea Days Needed"), are summarized in Table 6. A total of 12,278 days are needed for the 56 fleets. As mentioned previously, 22 fleets had insufficient observer information to estimate discards, and the sea days for these fleets were based on pilot coverage. The number of sea days needed for fleets with the pilot coverage designation was 641 days (5% of 12,278 days; Table 6). Of these 22 fleets, there were 2 fleets (Rows 10 and 26) where industry activity was so low that pilot coverage was zero (Tables 2 and 6). There are 16 fleets for which the sea days for all species groups were filtered out via the importance filter, and minimum pilot coverage days were used to maintain some coverage (Rows 1, 4, 11, 23, 30-32, 40, 42-46, 48, 55, and 56; Table 6). A total of 368 sea days was associated with the fleets with minimum pilot coverage (3% of 12,278 days; Table 6). The sea days needed for the remaining 18 fleets (11,269 days, representing 92% of the total sea days needed) were derived by using the variance of the discard estimate (Tables 6). Of the 11,269 days, 5,256 days (47%) were associated with 1 fleet (NE large mesh otter trawl [Row 8]; Table 6).

The sample size (in terms of number of sea days, number of trips, and percentage of trips based on the July 2015 through June 2016 VTR trips) needed to achieve a 30% CV of the discard estimate in 18 fleets is given in Table 7. The relationship between sample size and precision, over a range of sample sizes, is shown in Figure 3 for species groups and fleets.

DISCUSSION

A broad stratification was used to support the deployment of observers on commercial fishing trips among various fleets by using attributes known prior to the trip departure. As discussed in previous discard estimation analyses (Wigley et al. 2007, 2011), species-specific stock assessment discard estimation may differ from this report because of differences in

stratification and data used (calendar year versus 12-month [July through June] time period; area fished versus region [port of departure]; gear groupings; discard mortality assumptions; and VTR landings versus dealer landings). Region, based on port of departure, was used for the deployment of observers. It is recognized that area fished would provide a better stratification for discard estimation. It is expected, however, that, when uncertainty in the estimates is taken into account, estimates would be in the same order of magnitude. The discard estimates presented here are not definitive estimates but rather are indicative of where discarding occurred among the commercial fleets for the 14 federally managed species groups.

No survival ratios were applied to the discard estimates; we do not account for potential survival of organisms returned to the water. When comparing discard estimates from this study with those from stock assessments, it is useful to note that survival ratios are applied in stock assessments for Georges Bank and Gulf of Maine stocks of Atlantic cod (*Gadus morhua*), Atlantic sea scallop (*Placopecten magellanicus*), skates, spiny dogfish, fluke (*Paralichthys dentatus*), southern New England/Mid-Atlantic and Gulf of Maine stocks of winter flounder (*Pseudopleuronectes americanus*), and southern New England/Mid-Atlantic yellowtail flounder (*Limanda ferruginea*).

These analyses have used VTR data. Dealer (*CFDERSyyyy*) data do not contain mesh or area fished information until the trip-based allocation is performed (Wigley et al. 2008). The trip-based allocation of dealer (*CFDETT/SyyyyAA*) data is conducted annually and was not available when this analysis was initiated. Given that the VTR landings estimates are usually less (VTR reports the captain's hail weight) than the dealer records for a given fleet, the corresponding estimates of discards will also be underestimated. The magnitude of the underestimation will vary by fleet and year.

It is important to note the discard estimates provided in this analysis appropriately reflect the underlying data used (e.g., the VTR data used to raise the discard ratios to total discards and the observed trips used to derive the discard ratios were from the same VTR-based sampling frame). It is inappropriate to extrapolate beyond the sampling frame used unless it can be shown that the trips with no VTR reporting requirements have the same landings and discard characteristics as the trips with VTR reporting requirements.

In 2014, the northern shrimp fishery was closed and remained closed through 2016. As in years past, the VTR trips associated with NE shrimp trawl fleet (Row 20; Tables 2 and 3) were investigated. These trips used 2 in mesh, and most trips reported catching small mesh groundfish and/or herring while a few trips reported catching squid. The northern shrimp fishery requires a finfish excluder device (FED); however, other small mesh exempted fisheries do not require a FED. Currently, there is no data element within the VTR database that indicates whether or not a FED or other bycatch reduction device was used. Based upon previous investigations, the captains of the vessels participating in the small mesh exempted fisheries indicated that a FED was not used. An additional data element within the VTR database is needed to distinguish trips using a FED from those that are not.

The analysis conducted for the spatial and temporal observer coverage used live weight. As a result, fleets using scallop dredge and clam dredge targeting species with shells have higher kept weight percentage than other fleets because of the use of "live" weight rather than "landed meat" weight. However, the use of live weight does not distort the observed percentage (spatial or temporal pattern) within a fleet. It is important to remember that percent observer coverage is an indicator of where observed kept weight (or trips) occurred relative to unobserved kept weight (or trips). The percentage observed should not be confused with the precision of the discard

estimate, which is the metric used to describe discard variability and to determine the sample size needed for monitoring purposes.

The refinement to pilot coverage made in the 2016 analysis (pilot coverage was applied only when there were at least 3 VTR trips in a fleet and calendar quarter; Wigley et al. 2016) reduced the pilot coverage in 8 of the 22 pilot fleets (Rows 10, 17, 19, 21, 26, 39, 41, and 50; Table 2) where there were 1 or 2 VTR trips within a fleet and calendar quarter and prevented pilot coverage from exceeding industry activity. The refinement also resulted in no coverage for fleets with low overall trip activity: MA AA LIM scallop trawl fleet (Row 10; 1 VTR trip) and NE small mesh gillnet fleet (Row 26; 4 VTR trips; Tables 2 and 6).

There is 1 fleet with high sea day requirements (>2,000 sea days). The high monitoring coverage for NE large mesh otter trawl fleet (Row 8; Table 6) was because of high variability of red deepsea crab discards. In this analysis, as well as in previous analyses (NEFSC 2011a, 2011b; Wigley et al. 2011, 2012b, 2013, 2014, 2015, 2016), the high variability arose from observing some trips that were fishing in deep-water portions of statistical areas as well as observing the same trips or other trips that were fishing in shallower portions of the same statistical areas. Red deepsea crabs were encountered during trips fishing in deep water. Although the discard reason reported for this fleet was "No Market" (Appendix Table 3A), these vessels do not generally have permits to land red deepsea crabs, thus the red deepsea crabs must be discarded. Currently, the analysis does not stratify fleets further to account for depth because statistical area is the finest spatial resolution that defines a subtrip within the VTR (a subtrip within the VTR is a unique gear, mesh, and statistical area).

Regulatory red deepsea crab discards (e.g., non-retention of female crabs) are known to occur in the NE and MA crab pot fleets (Rows 50 and 51, respectively). However, with no observed trips in the timeframe of the analysis, the magnitude of these discards, relative to those in observed fleets, is unknown. Discards from unobserved fleets are not incorporated into the importance filter. If the penultimate (next largest) value of sea days is used in the NE large mesh otter trawl fleet (i.e., 796 days rather than 5,256 days for Row 8; Table 6), then the total number of sea days needed across the 56 fleets would be 7,818 days (a 36% decrease from the 12,278 days). When the penultimate value is used, the expected achieved precision of red deepsea crab discards in Row 8 would be about 91% CV (Figure 3).

Fish may be discarded for economic reasons (e.g., "No Market" or "Poor Quality") or for regulatory reasons (size, quota, or other). When considering mechanisms to reduce discards, it may be useful to know why discarding is occurring.

It is important to note that large discard percentages may be associated with a small quantity of discards. Additionally, it is important to note that for many species, the discards are associated with fleets that have been filtered out by the importance filter. Observers classify the discards by fish disposition based upon the NEFOP protocol (NEFOP 2013, 2016a, 2016b) in which the observer asks the captain/crew why species are being discarded. Thus, these data should be considered a form of self-reported data, and as such, these data are difficult to verify and should be interpreted cautiously.

This analysis does not address the coverage needed for individual sectors or multiple stock components of a species. The analytical basis for the allocation of future sea day coverage in this analysis is a specified level of precision (i.e., 30% CV), and an expectation that the pattern of fishing activity observed in the prior year will be similar to that in the upcoming year.

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