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EXECUTIVE SUMMARY

Since 2010, the Northeast Fisheries Observer Program (NEFOP) and the At-sea Monitoring Program (ASM) have provided onboard observers to the groundfish fishery. Until recently, both programs allocated observers to trips in the groundfish fishery based on fixed coverage rates to meet required total combined coverage targets, established annually, prior to each fishing year. Beginning in fishing year (FY) 2019, the National Marine Fisheries Service (NMFS) will use a more sophisticated method for selecting groundfish fishing trips for NEFOP observation. This method will still implement the combined coverage target rate for the groundfish fishery, but will use the Standardized Bycatch Reporting Methodology (SBRM) fleet-based stratification to allocate NEFOP coverage rather than a flat rate across sectors. ASM coverage, assigned through Pre-trip Notification System (PTNS), will be used in conjunction with NEFOP to ensure that sectors achieve their total required combined coverage. Because each sector differs in its SBRM fleet type composition, some sectors will be provided higher levels of NEFOP coverage comparatively to others. Because NEFOP coverage is paid for by NMFS and the ASM program is intended to be industry-funded, this change in selection method may cause cost disparities across sectors in future fishing years.[1]

Though it is impossible to predict exactly how the fleet-based NEFOP selection method will affect each sector's ASM coverage in 2019, this paper aims to estimate the magnitude of these cost disparities by using fishing data from 3 previous years. We conduct a retrospective Monte Carlo analysis that simulates the potential distribution of NEFOP and ASM observers from April 1st 2015 to March 31st 2017 according to the revised FY19 sampling method (i.e., SBRM stratification). To better understand the cost discrepancies across sectors, we also compare these results to cost estimations generated under an alternative flat rate.[2] The simulation results suggest that 3–year average ASM sector costs range from $4.9k to $244.2k—contributing 31-64% of the total cost of combined coverage. We find modest variation in NEFOP coverage across sectors under the SBRM stratification. Though NEFOP coverage appears to be, more or less, uniformly distributed across sectors, some sectors are consistently sampled above, and others below, the median annual NEFOP coverage rate, resulting in cost disparities. Simulation results suggest that, if NEFOP observers were stratified under SBRM, as opposed to distributed equally under a flat rate (modeled as 9%, 6%, and 8% for SBRM years 2015, 2016, and 2017, respectively), aggregate costs would increase for some sectors (1-60%) and decrease for others (1-41%).

INTRODUCTION

In the Northeast US groundfish fishery, observers are deployed on fishing vessels under 2 programs: the Northeast Fishery Observer Program (NEFOP) and the At-sea Monitoring Program (ASM). Though both are managed by the Northeast Fishery Science Center's Fisheries Sampling Branch (NEFSC FSB), there are fundamental differences between the 2 programs. NEFOP is designed to meet Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSA) requirements for estimating discards of all species and fisheries, while ASM

[1] NOAA Fisheries will reimburse 100 percent of industry's at-sea monitoring costs for FY 19 with Congressional appropriations.

[2] The alternative flat rate is set to the median NEFOP sampling rate derived from the SBRM simulations— 9%, 6%, and 8% for SBRM years 2015, 2016, and 2017, respectively. Note these rates are not equivalent to the true combined coverage targets set for these years (Table 1).

satisfies a groundfish fishery requirement to accurately estimate regulated groundfish discards and to ensure annual catch limits are not exceeded.[3] NEFOP observers collect extensive data on all aspects of bycatch in each federally managed fishery, including biological sampling data, weights and lengths of fish, and detailed descriptions and sampling of protected species encounters. ASM observers focus on weights and lengths of retained and discarded fish, with an emphasis on groundfish species, less biological sampling, and overall, fewer additional sampling requirements.

Since 2010, the groundfish fishery has employed a system where a single combined NEFOP and ASM coverage target rate is calculated for sectors prior to each fishing year based on observed variation in the estimation of groundfish discards. This target rate is apportioned between the NEFOP and ASM programs, dictated primarily by the number of sea days required by NEFOP to achieve the SBRM requirements for each fleet type.[4, 5] The residual coverage needed to achieve the combined target is provided under the ASM program (see Table 1). For example, in fishing year 2015, the combined groundfish coverage rate was 24%, where 4% of groundfish trips were predicted to be contributed by NEFOP and the other 20% was expected to be covered by ASM. The target coverage levels for NEFOP were intended to be met or exceeded in each groundfishing sector. Targets were also intended to be more or less equally distributed, such that the percentage of ASM coverage was also somewhat equally distributed across sectors. In many cases, however, the target and realized coverage rates differ greatly, adding complexity to this combined coverage system.

The percentage of coverage provided by NEFOP is derived from SBRM sea day requirements. SBRM coverage requirements are met by using a stratification scheme based on region, trip category, access area, mesh category, and gear type. SBRM fleets are then allocated a quantity of sea days to be observed under the NEFOP program. Because of the disconnect between the SBRM sea day calculations, the ASM coverage rate calculations, and how they intersect on a sector level, some groundfish-related SBRM strata risk insufficient sampling under this combined coverage system. This risk has become more prevalent as ASM coverage levels within the groundfish fishery have declined.

To better achieve SBRM coverage targets, the NEFSC released an upgraded Pre-Trip Notification System (PTNS2) in May 2018. PTNS2 can support multiple sampling programs with differing stratification schemes including, but not limited to, those required for assigning NEFOP and ASM observers (e.g., NEFOP: SBRM-defined landing port region, trip category, access area, gear, and mesh category; ASM: sector, gear, mesh category, and broad stock area). This capability allows the SBRM sampling design to be fully supported in the groundfish fishery, allocating NEFOP observers by SBRM fleet type instead of a flat rate, as was previous practice. Ultimately, this change ensures that the NEFOP coverage requirements supporting SBRM are met within groundfish-related SBRM fleet types. Though this sampling change increases efficiency in achieving the SBRM sea day requirements, it diverges from the flat rate method and creates a

[3] ASM requirements were added under Amendment 16 to the Northeast Multispecies Fishery Management Plan (FMP).

[4] The SBRM required sea days are converted into a target percentage of groundfish trips to be covered by NEFOP observers.

[5] The Northeast Fisheries Science Center's Standardized Bycatch Reporting Methodology (SBRM) is used to stratify NEFOP observer coverage for all fisheries, based on a trip's gear type, region, access area, trip category, and mesh size—collectively referred to as an SBRM "fleet type." Because these fleet types do not include Fishery Management Plan (FMP) in their stratification, they overlap with, but do not correspond directly to, the sector-based criteria for allocating observers under the groundfish FMP.

sampling regime dictated by the types of trips taken within each sector, causing some sectors to be allocated more NEFOP observers than others. This allocation can then create disproportional ASM coverage when compared across sectors.

Differing NEFOP and ASM coverage levels across sectors may have cost implications, given the funding source of each program. NEFOP is fully funded by the National Oceanic and Atmospheric Administration (NOAA) (i.e., shoreside and at-sea costs[6]) while ASM is only partially funded by NOAA—covering shoreside costs while industry is intended to absorb the costs of at-sea monitoring.[7] However, it should be noted that since 2010, ASM at-sea costs have either been paid for or reimbursed by NOAA Fisheries to varying extents. When the NEFOP and ASM combined coverage rate was distributed evenly across sectors, all sectors should have, in theory, incurred proportional ASM at-sea costs. Meeting the combined groundfish target rate under the SBRM stratification, however, could lead to cost inequalities among sectors, given that sectors will receive disproportionate levels of NEFOP and ASM coverage. In order to investigate the magnitude of these cost inequalities, we estimate sector-level ASM at-sea costs by simulating observer allocation as if the trip selection method for fishing year 2019 (FY 19) had been implemented in previous fishing years.

METHODS

In this study, we estimate how commercial groundfish fishing trips *would* have been selected for observation in years 2015-2017 under the SBRM sampling method by using a Monte Carlo simulation.[8,9] Each trip in the database has information on its respective SBRM fleet type and number of sea days (i.e., billable observer time). The simulation randomly selects trips within each SBRM fleet type for hypothetical NEFOP selection until each fleet type's allocated sea day requirement for the SBRM year is met.[10] SBRM fleet types associated with the groundfish fleet are described in Table 2. Simulations are run for each SBRM year, providing a year-specific distribution of hypothetical NEFOP selected trips.[11] From these selected trips, we identified which trips were "groundfish fishing" according to the ASM criteria. To obtain the number of trips needed to meet the coverage target, we use the annual combined coverage rate (Table 1) minus the proportion of groundfish trips selected for NEFOP observation, allocating the remaining percentage of each sector to the ASM program. This percentage is multiplied by the total number of groundfish trips accomplished by each sector to get the number of trips which would require ASM monitoring according to the SBRM selection method. The number of trips that require ASM coverage in the simulation is then multiplied by the average number of sea days per sector-trip to

[6] Shoreside costs relate to administering and monitoring the programs, as well as ensuring data quality (e.g., training/certification and debriefing of observers/monitors, processing and quality assurance of observer/monitor data), while at-sea costs relate to the costs and services corresponding with observer/monitor deployment (GARFO/NEFSC 2015).

[7] This is a requirement under Amendment 16 to the NE Multispecies FMP.

[8] The SBRM fishing year runs from April 1st through March 31st of each year.

[9] A Monte Carlo Simulation is a statistical technique used for predicting potential outcomes through the use of repeated random sampling.

[10] Allocated SBRM sea days and fleet types were incorporated from the Standardized Bycatch Reporting Methodology Annual Discard Report with Observer Sea Day Allocation Reports for SBRM years 2015, 2016, and 2017 (*see NEFSC/GARFO 2015, 2016, 2017*).

[11] For these models, 100 simulations were run for each fishing year.

obtain total sea days required for ASM observation. Total costs are estimated by multiplying total ASM sea days by $612, an estimate for ASM at-sea costs per observed sea day.[12] This calculation provides an estimate of sector-level costs for the additional ASM trips required to meet the combined coverage target rate which mimics the trip selection method to be used in FY 19. To understand how ASM costs change under the SBRM sampling regime, we estimate ASM costs in 2 ways: (1) using the SBRM stratification simulation of NEFOP observers (i.e., the method described above) and (2) using a fixed flat rate to delegate equal NEFOP/ASM coverage across sectors. The fixed flat rates are equal to the median percentage of NEFOP coverage from each of the annual SBRM stratification simulation. This allows for a comparison of ASM costs incurred under the SBRM sampling method to ASM costs under a flat rate sampling method similar to that used in previous years.

DATA

To simulate the sampling selection process, we recreated SBRM stratification by using Vessel Trip Report (VTR) data for all trips taken during SBRM years 2015 to 2017.[13] For each trip, we retain the gear type and mesh size used to land the highest quantity (pounds) of fish on that trip. To define an ASM eligible trip, a trip must have been: (1) taken by a vessel enrolled in a groundfish sector; (2) associated with the declaration code specifying a groundfish or a specific monkfish trip; and (3) not excluded under the Extra-Large Mesh Gillnet option, as described by Framework Adjustment 55 to the Northeast Multispecies Fishery Management Plan (FMP). Sector affiliation by groundfish fishing year was taken from the Moratorium Qualification Review System Participant tables. A full list of the active groundfish sectors and their abbreviations is presented in Table 3, including lease-only sectors and sectors with no ASM eligible groundfish fishing trips. Sectors that are lease-only or sectors that did not take ASM eligible trips are omitted from the Monte Carlo simulations, as they do not take trips requiring ASM observation. For this reason, only 16 sectors are included in the analysis.

We use the Data Matching and Imputation System (DMIS) of the Greater Atlantic Regional Fisheries Office (GARFO) to apply the ASM eligibility criteria. The DMIS fishery group variable is merged into the VTR trips data set via the VTR trip ID, noting that 2.4% of DMIS groundfish trips failed to merge into the final trips data set.[14] Again, from DMIS, we use mesh sizes, gear, and statistical areas to identify the Extra-Large Mesh Gillnet trips excluded from ASM as described in Framework 55 to the Northeast Multispecies FMP. Merging back to the base VTR data by using trip ID resulted in the loss of an additional 2.1% of trips. Using these data, we simulate NEFOP trip selection on all trips, identify which of the selected NEFOP trips were “groundfish fishing” (e.g., ASM eligible), and derive the number of additional groundfish trips per sector that would require ASM coverage to meet the total combined target.

There are some key differences between how the simulations presented in this paper are conducted and how observers are *actually* deployed on groundfish fishing trips. First, the combined coverage realized rate is achieved based on the effort of the current fishing year while

[12] Rates are reported in 2017 constant US dollars from Ardini et al. 2018, which describes the average annual ASM sea day rate resulting from private negotiations of service provision contracts between sectors and providers (FY16-FY18), which will continue in FY19.

[13] SBRM fleet types, specific to the groundfish fleet, were assigned to each trip according to the trip’s gear type, landing port region, and mesh size, as reported in the VTR.

[14] Within the DMIS database, the document identifier (DOCID) is equivalent to the VTR trip ID.

the allocated coverage rate is based on a prediction from the previous fishing year. This disparity creates differences in the allocated and realized coverages and, consequently, the combined coverage in the groundfish fleet. Further, the selection of NEFOP and ASM trips via PTNS occurs simultaneously and in real time while, for simplicity, our analysis is conducted in 2 distinct steps. Several ASM-exempted Experimental Fishing Permit programs are not mentioned here, as these exemptions are expected to have minimal impacts on the results. Here, selection was modeled according to SBRM years, which run from April to March of each calendar year, as that is when the fleet types and NEFOP observer sea days are reallocated. Groundfish fishing years span from May 1st to April 30th of each calendar year. This incongruence in timing should be noted when interpreting the results. Lastly, the flat rate NEFOP targets presented in Table 1, were often exceeded because of SBRM sea day requirements, thus the intersector cost disparities discussed in this paper have existed, to varying degrees, since the implementation of ASM.

RESULTS

The results of the Monte Carlo simulations are presented in Tables 4-6 for SBRM years 2015, 2016, and 2017, respectively. Using SBRM year 2015 (Table 4) as an example, the simulation results for each year are interpreted as follows. The simulated average number of trips selected for NEFOP observation by SBRM fleet for each sector is reported in the first 12 rows of Table 4. Note that the number of trips for any given sector/SBRM fleet may not be a whole number because it is the average of the 100 Monte Carlo simulations. For example, for Fixed Gear Sector (FGS), the simulated NEFOP coverage averaged 0.1 trips for New England (NE) longline, 1.2 trips for NE hand line, 7.9 trips for NE large-mesh otter trawl, 31.6 trips for NE large-mesh gillnet, and 95.3 trips for NE extra-large mesh gillnet for a total of 136 NEFOP trips (Table 4, row 1) covered during SBRM year 2015. FGS took a total of 1,483 ASM eligible trips (Table 4, row 2), meaning 9% (Table 4, row 3) of the 24% combined coverage requirement would have been accomplished under the SBRM NEFOP coverage, leaving 15% (Table 4, row 4) of the 1,483 trips taken by FGS which require coverage from ASM. The cost of the resulting ASM requirement is the product of the number of ASM trips (222, Table 4, row 5), the estimated average sea days per trip for FGS (1, Table 4, row 6), and the cost per sea day ($612), which results in a total ASM cost of $135,864 in SBRM year 2015. The ASM costs for all other sectors are estimated in a manner similar to that described for FGS.

At the 24% combined NEFOP/ASM target coverage rate set for SBRM year 2015, ASM costs range from a minimum of $1.2k (Northeast Coastal Communities Sector [NCCS]) to a maximum of $329.9k (Sustainable Harvest Sector [SHS] 3) with an average cost of $94.0k (median $56.3k), implying that ASM costs generate anywhere from 31-64% of the total cost of combined coverage for each sector in this year (i.e., 31-64% of costs are contributed by ASM and 69-36% of costs contributed by NEFOP, respectively). The large range of ASM costs is driven by 2 sector-specific characteristics: (1) the total number of ASM eligible trips and (2) the average number of sea days per sector-trip. For example, Northeast Fishery Sector (NEFS) 10 and SHS 3 had a similar number of trips which required ASM coverage (72 and 77 trips, respectively). However, the average length of a trip taken by SHS 3 was 7 times that of NEFS 10; hence, SHS 3 had 7 times the ASM costs of NEFS 10 (SHS 3 with $329.9k and NESF 10 with $44.1k). The coverage provided by NEFOP was somewhat uniformly distributed across sectors in this simulation (11% on average, ranging from 7-14%) which caused little variation in the percentage of ASM coverage when assessed across sectors. Because of these marginal differences, the number

of trips which would require ASM sampling is primarily a function of the total number of ASM eligible trips taken within each sector.

For 2016 and 2017, the combined NEFOP/ASM coverage targets were 14% and 16%, respectively. At these coverage rates, again, nearly all sectors required ASM coverage to achieve their combined coverage targets when NEFOP coverage is simulated under the SBRM stratification (Tables 5 and 6).[15,16] Sector costs were lower in these years relative to 2015, with costs ranging from $2.5k to $108.3k in 2016 and $1.8k to $174.4k in 2017. Across sectors, the average costs were 32.4k and 46.0k for 2016 and 2017, respectively. The differences in costs from 2015 to 2017 are unsurprising, as the target NEFOP coverage in 2015 is 10 and 8 percentage points higher than in 2016 and 2017, respectively. Similar to 2015, the NEFOP coverage in SBRM years 2016 and 2017 was somewhat equally distributed across sectors with coverage average rates of 7% for both years (ranging from 0-14% in 2016 and 1-10% in 2017). Here, again, ASM costs are primarily a function of the number of ASM eligible trips and the average trip lengths within each sector. Considering the results across all 3 SBRM years (Table 7), we find that all sectors would have to pay for ASM coverage in every year simulated, with the exception of NCCS and SHS 3 in SBRM year 2016.

Despite the marginal differences in sector NEFOP coverage within time periods, trends across time periods suggest that some sectors are consistently sampled by NEFOP at higher rates than others, as shown in Figure 1. Here, NEFS 11, NEFS 5, and SHS 3 are consistently sampled above the median NEFOP coverage percentage while the FGS, Maine Coast Community Sector (MCCS), NEFS 8, NEFS 12, NEFS 13, and NEFS 6 are consistently sampled at or below the median NEFOP percentage coverage level. These results suggest that there may be consistency in each sector's SBRM fleet-type composition, resulting in patterns of NEFOP allocation across sectors over time. To further explore the cost implications of disproportional NEFOP/ASM coverage, ASM costs were also estimated under a fixed NEFOP sampling rate (9%, 6%, and 8% for SBRM years 2015, 2016, and 2017, respectively).[17] Simulation results, shown in Table 8, suggest that if NEFOP coverage were allocated through SBRM stratification, as opposed to fixed and distributed equally across sectors, the total aggregate ASM costs from 2015-2017 would:

- increase for 7 sectors (FGS, SHS, MCCS, NEFS 8, NEFS 2 NEFS 6, and NCCS) by $1.8k-$14.7k (1-60%);
- decrease for 7 sectors (NEFS 7, NEFS 11, NEFS 3, NEFS 10, NEFS 9, NEFS 5, SHS 3) by $1.0k-$335.4k (1-41%); and,
- stay the same for 2 sectors (NEFS 12 and NEFS 13).

[15] The one exception is SHS 3 in SBRM year 2016 which met its combined coverage with NEFOP alone.

[16] Note that NCCS would have required ASM coverage according to the 2016 simulation; however, the low number of ASM eligible trips taken by the sector generated an absence of additional ASM covered trips.

[17] The NEFOP flat rates chosen for this comparison are not equal to the true combined coverage rates previously set for each year (Table 1). The true NEFOP target rates are 4%, 4%, and 8% for 2015, 2016, and 2017, respectively, where we use 9%, 6%, and 8% for SBRM years 2015, 2016, and 2017. The flat rates were set at the median, rather than the true targets, because this allows for the identification of sectors which have consistently higher NEFOP coverage rates comparatively to other sectors according to the SBRM stratification simulation.

DISCUSSION

Simulation results suggest that, under the SBRM stratification, the combined coverage target rate was rarely met by NEFOP coverage alone and ASM costs were incurred by practically every sector in each of the 3 years modeled. Under SBRM stratification, we find that NEFOP coverage is spread relatively uniformly across sectors within each of the 3 simulated years, such that ASM coverage costs are almost directly related to average trip durations and the number of ASM eligible trips taken within each sector. ASM sector costs range from $4.9k to $244.2k. under the SBRM sampling regime.

Assessing trends in the NEFOP coverage levels over time reveals that, under SBRM stratification, some sectors are consistently covered above, and others below, the median annual NEFOP coverage rate. Simulation results suggest that ASM costs from the SBRM stratification of NEFOP observers, when compared to ASM costs estimated under equally distributed NEFOP coverage levels, would create changes in total costs ranging from -41% to +60% (-$335.4k to +$14.7k), depending on the sector. Under the SBRM stratification simulation, some sectors were delegated higher proportions of NEFOP coverage, comparatively to ASM coverage, because of sector composition (i.e., gear types) and prioritization of certain SBRM fleet types under the SBRM sampling regime. These results suggest that some sectors will benefit, while others will be at a disadvantage, under SBRM stratification comparatively to a flat rate sampling method if ASM costs are to fall on industry. Lastly, because the flat rates set for 2015-2017 were always influenced by SBRM sea day allocations, the cost disparities revealed in this study may have been present, in part or in whole, since ASM implementation in 2010.

The data used for this analysis included trips that were actually taken during the three-year period of analysis. These trips were deployed under the conditions during those years, and these results are based on a “business-as-usual” model that does not attempt to incorporate any behavioral changes that may occur under different observer deployment conditions (e.g., the participation in trips or sector membership).

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Table 1. Combined Northeast Fishery Observer Program (NEFOP) and At-sea Monitoring Program (ASM) groundfish coverage rates for fishing years 2010-2017.

Fishing Year	NEFOP Target Coverage Level	ASM Target Coverage Level	Total Target Coverage Level
2010	8%	30%	38%
2011	8%	30%	38%
2012	8%	17%	25%
2013	8%	14%	22%
2014	8%	18%	26%
2015	4%	20%	24%
2016	4%	10%	14%
2017	8%	8%	16%

Note: The predicted combined groundfish coverage rates for NEFOP and ASM follow groundfish years (May – April). Percentages were retrieved from the Greater Atlantic Regional Fisheries Office Summary of Analyses Conducted to Determine At-sea Monitoring Requirements for Multispecies Sectors FY 2018 (GARFO 2017).

Table 2. Groundfish fishing relevant Standardized Bycatch Reporting Methodology (SBRM) fleet type descriptions (SBRM Years 2015-2017).

SBRM Fleet Type 2015	Fleet Gear Type	Region	Mesh Group
2	Longline	NE	All
4	Hand Line	NE	All
5	Otter Trawl	MA	Small
6	Otter Trawl	MA	Large
7	Otter Trawl	NE	Small
8	Otter Trawl	NE	Large
18	Otter Trawl, Haddock Separator	NE	Large
23	Sink, Anchor, Drift Gillnet	MA	Small
24	Sink, Anchor, Drift Gillnet	MA	Large
25	Sink, Anchor, Drift Gillnet	MA	Extra-Large
27	Sink, Anchor, Drift Gillnet	NE	Large
28	Sink, Anchor, Drift Gillnet	NE	Extra-Large
SBRM Fleet Type 2016			
2	Longline	NE	All
4	Hand Line	NE	All
6	Otter Trawl	MA	Large
7	Otter Trawl	NE	Small
8	Otter Trawl	NE	Large
13	Otter Trawl, Twin	MA	All
17	Otter Trawl, Ruhle	NE	Large
19	Otter Trawl, Haddock Separator	NE	Large
24	Sink, Anchor, Drift Gillnet	MA	Small
26	Sink, Anchor, Drift Gillnet	MA	Extra-Large
27	Sink, Anchor, Drift Gillnet	NE	Small
28	Sink, Anchor, Drift Gillnet	NE	Large
29	Sink, Anchor, Drift Gillnet	NE	Extra-Large
SBRM Fleet Type 2017			
2	Longline	NE	All
4	Hand Line	NE	All
5	Otter Trawl	MA	Small
6	Otter Trawl	MA	Large
7	Otter Trawl	NE	Small
8	Otter Trawl	NE	Large
13	Otter Trawl, Twin	MA	All
17	Otter Trawl, Ruhle	NE	Large
18	Otter Trawl, Haddock Separator	NE	Large
27	Sink, Anchor, Drift Gillnet	NE	Large
28	Sink, Anchor, Drift Gillnet	NE	Extra-Large
53	Beam Trawl	NE	All

Note: The listed fleet types are typical of At-sea Monitoring eligible groundfish fishing trips. For the listed fleet types, all access areas are open and all trip categories are eligible. Region indicates the landing port, either New England (NE) or Mid-Atlantic (MA). Mesh sizes are <5.50, 5.50-7.99 (5.50 or greater for otter trawl), and >8.00 for gillnet when describing small, large, and extra-large mesh groups, respectively.

Table 3. Identification codes, names, and abbreviations of active groundfish sectors during fishing years 2015-2017.

Sector ID	Sector Name	Sector
3	Georges Bank Cod Fixed Gear Sector	FGS
5	Sustainable Harvest Sector 1	SHS 1
6	Maine Coast Community Sector	MCCS
7	Northeast Fishery Sector 7	NEFS 7
8	***Northeast Fishery Sector 4***	***NEFS 4***
9	Northeast Fishery Sector 8	NEFS 8
10	Northeast Fishery Sector 11	NEFS 11
11	Northeast Fishery Sector 12	NEFS 12
12	Northeast Fishery Sector 2	NEFS 2
13	Northeast Fishery Sector 3	NEFS 3
14	***Northeast Fishery Sector 1***	***NEFS 1***
15	Northeast Fishery Sector 10	NEFS 10
16	Northeast Fishery Sector 13	NEFS 13
17	Northeast Fishery Sector 9	NEFS 9
18	Northeast Fishery Sector 5	NEFS 5
20	Northeast Fishery Sector 6	NEFS 6
21	Northeast Coastal Communities Sector	NCCS
22	Sustainable Harvest Sector 3	SHS 3
26	***Sustainable Harvest Sector 2***	***SHS 2***

Note: Bolded sectors are either lease-only or did not take any At-sea Monitoring eligible trips in Standardized Bycatch Reporting Methodology years 2015-2017 and, therefore, are inherently omitted from the simulation and analysis.

Table 4. Monte Carlo simulation results: Northeast Observer Program (NEFOP) trip selection of At-sea Monitoring (ASM) eligible trips in Standardized Bycatch Reporting Methodology (SBRM) year 2015 with 24% combined coverage.

SBRM FLEET TYPE 2015			Sector ID															
Fleet Gear Type	**Region**	**Mesh Group**	**FGS**	**SHS 1**	**MCCS**	**NEFS 7**	**NEFS 8**	**NEFS 11**	**NEFS 12**	**NEFS 2**	**NEFS 3**	**NEFS 10**	**NEFS 13**	**NEFS 9**	**NEFS 5**	**NEFS 6**	**NCCS**	**SHS 3**
Longline	NE	All	0.1	0	0	0	0	0	--	0	1.0	0	0	0	0	0	0	0
Hand Line	NE	All	1.2	0	1.1	1.0	0	0	--	0	0	0	0	0	0	0	0	0
Otter Trawl	MA	Small	0	0	0	0	0	0	--	0	0	0	0	0	0	0.2	0	0
Otter Trawl	MA	Large	0	0	0	2.4	0	0	--	0	0	0	2.9	6.1	13.6	0.4	0	0
Otter Trawl	NE	Small	0	0	0	0	0	0	--	0	0	0	0	0	0.3	0	0	0.1
Otter Trawl	NE	Large	7.9	13.3	1.9	8.7	6.2	6.4	--	55.2	3.0	19.9	21.1	29.3	47.3	10.8	0	43.5
Otter Trawl, Haddock Separator	NE	Large	0	0	0	0	0	0	--	6.9	0	0	0	1.4	0	0	0	21.8
Sink, Anchor, Drift Gillnet	MA	Small	0	0	0	0	0	0	--	0	1.0	0	0	0	0	0	0	0
Sink, Anchor, Drift Gillnet	MA	Large	0	0	0	0	0	1.0	--	0	1.0	0	0	0	0	0	0	0
Sink, Anchor, Drift Gillnet	MA	Extra-Large	0	0	0	0	0	9.1	--	0	26.6	0	0	0	1.2	0	0	0
Sink, Anchor, Drift Gillnet	NE	Large	31.6	0	8.2	5.4	0	20.1	--	0	24.0	16.6	0	0	0	0	0	6.3
Sink, Anchor, Drift Gillnet	NE	Extra-Large	95.3	0	1.1	13.9	0	2.8	--	0	12.2	8.1	0	0	0.9	0	1.3	1.8

Note: The Northeast Fishery Sector 12 did not take any trips that fit the criteria of ASM eligible in SBRM Year 2015, however, does take ASM eligible trips in subsequent years. NE = New England, MA = Mid-Atlantic. See Table 3 for sector name abbreviations.

Table 4, continued. Monte Carlo simulation results Northeast Observer Program (NEFOP) trip selection of At-sea Monitoring (ASM) eligible trips in Standardized Bycatch Reporting Methodology (SBRM) year 2015 with 24% combined coverage.

	Sector ID															
	FGS	SHS 1	MCCS	NEFS 7	NEFS 8	NEFS 11	NEFS 12	NEFS 2	NEFS 3	NEFS 10	NEFS 13	NEFS 9	NEFS 5	NEFS 6	NCCS	SHS 3
Total Average ASM Eligible Trips Selected for NEFOP Observation	136	13	12	31	6	39	--	62	69	45	24	37	63	11	1	74
Total Eligible ASM Trips within Each Sector (SBRM 2015)	1483	154	179	323	74	357	--	655	482	480	256	366	619	126	8	642
Percent of ASM Eligible Trips Covered by NEFOP (within Sectors)	9%	8%	7%	10%	8%	11%	--	9%	14%	9%	9%	10%	10%	9%	13%	12%
Percent of ASM Trips Needed To Meet Total Target Coverage Requirement	15%	16%	17%	14%	16%	13%	--	15%	10%	15%	15%	14%	14%	15%	11%	12%
Trips Needed To Meet the Total Target Coverage Requirement Using ASM	222	25	30	45	12	46	--	98	48	72	38	51	87	19	1	77
Average Sea Day / Trip by Sector	1	2	2	4	6	2	--	3	1	1	3	7	1	6	2	7
Sea Day Standard Deviation by Sector	1	1	2	3	3	2	--	3	1	1	3	3	1	4	1	3
Average Cost / Sector for Additional ASM Coverage To Meet Total Target Coverage Rate	$135,864	$30,600	$36,720	$110,160	$44,064	$56,304	--	$179,928	$29,376		$69,768	$218,484	$53,244	$69,768	$1,224	$329,868

Note: The Northeast Fishery Sector 12 did not take any trips that fit the criteria of ASM eligible in SBRM Year 2015, however, does take ASM eligible trips in subsequent years. NE = New England, MA = Mid-Atlantic. See Table 3 for sector name abbreviations.

Table 5. Monte Carlo simulation results: Northeast Observer Program (NEFOP) trip selection of At-sea Monitoring (ASM) eligible trips in Standardized Bycatch Reporting Methodology (SBRM) year 2016 with 14% combined coverage.

SBRM FLEET TYPE 2016			Sector ID															
Gear Type	**Region**	**Mesh Group**	**FGS**	**SHS 1**	**MCCS**	**NEFS 7**	**NEFS 8**	**NEFS 11**	**NEFS 12**	**NEFS 2**	**NEFS 3**	**NEFS 10**	**NEFS 13**	**NEFS 9**	**NEFS 5**	**NEFS 6**	**NCCS**	**SHS 3**
Longline	NE	All	0.1	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	1.0
Hand Line	NE	All	0.2	1.0	1.0	0	0	0	0	0	0.2	0	0	0	0	0	0	0
Otter Trawl	MA	Large	0	0	0	0	0	0	0	0	0	0	0.5	6.3	24.1	0.4	0	0
Otter Trawl	NE	Small	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0
Otter Trawl	NE	Large	3.2	5.2	2.5	2.8	5.6	5.3	8.6	38.4	2.1	2.3	12.7	17.2	26.1	4.5	0	31.1
Otter Trawl, Twin	MA	All	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0
Otter Trawl, Ruhle	NE	Large	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0
Otter Trawl, Haddock Separator	NE	Large	0	0	0	0	0	0	0	6.6	0	0	2.0	1.9	0	0	0	58.2
Sink, Anchor, Drift Gillnet	MA	Small	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0
Sink, Anchor, Drift Gillnet	MA	Extra-Large	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0	0
Sink, Anchor, Drift Gillnet	NE	Small	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sink, Anchor, Drift Gillnet	NE	Large	12.5	2.7	5.6	1.0	0	19.8	11.0	10.2	4.1	1.6	0	0	0	0	0	3.6
Sink, Anchor, Drift Gillnet	NE	Extra-Large	1.7	0	0	0.6	0	1.1	1.5	1.8	4.3	0	0	0	0	0	0.2	0.5

Note: NE = New England, MA = Mid-Atlantic. See Table 3 for sector name abbreviations.

Table 5, continued. Monte Carlo simulation results: Northeast Observer Program (NEFOP) trip selection of At-sea Monitoring (ASM) eligible trips in Standardized Bycatch Reporting Methodology (SBRM) year 2016 with 14% combined coverage.

	Sector ID															
	FGS	SHS 1	MCCS	NEFS 7	NEFS 8	NEFS 11	NEFS 12	NEFS 2	NEFS 3	NEFS 10	NEFS 13	NEFS 9	NEFS 5	NEFS 6	NCCS	SHS 3
Total Average ASM Eligible Trips Selected for NEFOP Observation	19	9	9	4	6	26	21	57	16	4	15	25	52	5	0	96
Total Eligible ASM Trips within Each Sector (SBRM 2016)	335	130	146	68	99	397	340	847	290	60	237	339	617	80	3	679
Percent of ASM Eligible Trips Covered by NEFOP (within Sectors)	6%	7%	6%	6%	6%	7%	6%	7%	6%	7%	6%	7%	8%	6%	0%	14%
Percent of ASM Trips Needed To Meet Combined Coverage Requirement	8%	7%	8%	8%	8%	7%	8%	7%	8%	7%	8%	7%	6%	8%	14%	0%
Trips Needed To Meet the Combined Coverage Requirement Using ASM	27	9	12	5	8	28	27	59	23	4	19	24	37	6	0	0
Average Sea Day / Trip by Sector	1	4	2	4	6	2	1	3	1	1	4	6	1	7	2	6
Sea Day Standard Deviation by Sector	1	3	2	2	2	2	0	2	1	0	3	3	0	3	1	3
Average Cost / Sector for Additional ASM Coverage To Meet Combined Coverage Rate	$16,524	$22,032	$14,688	$12,240	$29,376	$34,272	$16,524	$108,324	$14,076	$2,448	$46,512	$88,128	$22,644	$25,704	--	--

Note: NE = New England, MA = Mid-Atlantic. See Table 3 for sector name abbreviations.

Table 6. Monte Carlo simulation results Northeast Observer Program (NEFOP) trip selection of At-sea Monitoring (ASM) eligible trips in Standardized Bycatch Reporting Methodology (SBRM) year 2017 with 16% combined coverage.

SBRM Fleet Type 2017			Sector ID															
Fleet Gear Type	**Region**	**Mesh Group**	**FGS**	**SHS 1**	**MCCS**	**NEFS 7**	**NEFS 8**	**NEFS 11**	**NEFS 12**	**NEFS 2**	**NEFS 3**	**NEFS 10**	**NEFS 13**	**NEFS 9**	**NEFS 5**	**NEFS 6**	**NCCS**	**SHS 3**
Longline	NE	All	1.1	0	1.8	0	0	0	1.1	0	4.3	1.1	0	0	0	0	0	0
Hand Line	NE	All	0.4	0.8	1.0	0	0	0	0	0	0.1	0	0	0	0	0	0.6	0
Otter Trawl	MA	Small	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
Otter Trawl	MA	Large	0	0	0	0.4	1.0	0	0	0	0	0	6.2	1.3	43.3	0.5	0	0
Otter Trawl	NE	Small	0	0	0	0	0	0	0	0.2	0	0	0.3	0	0	0	0	0.2
Otter Trawl	NE	Large	4.3	8.3	3.2	2.5	7.5	7.3	10.9	55.8	1.8	1.7	12.9	11.1	32.9	7.3	0	30.8
Otter Trawl, Twin	MA	All	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0
Otter Trawl, Ruhle	NE	Large	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0
Otter Trawl, Haddock Separator	NE	Large	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.9
Sink, Anchor, Drift Gillnet	NE	Large	7.1	2.1	10.2	1.0	0	18.8	13.6	3.4	1.3	0	0	0	0	0	0	4.7
Sink, Anchor, Drift Gillnet	NE	Extra-Large	0	0	7.5	3.3	0	11.4	5.6	14.5	10.6	0	0	0	0	0	0	0.2
Beam Trawl	NE	All	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0

Note: NE = New England, MA = Mid-Atlantic. See Table 3 for sector name abbreviations.

Table 6, continued. Monte Carlo simulation results Northeast Observer Program (NEFOP) trip selection of At-sea Monitoring (ASM) eligible trips in Standardized Bycatch Reporting Methodology (SBRM) year 2017 with 16% combined coverage.

	Sector ID															
	FGS	**SHS 1**	**MCCS**	**NEFS 7**	**NEFS 8**	**NEFS 11**	**NEFS 12**	**NEFS 2**	**NEFS 3**	**NEFS 10**	**NEFS 13**	**NEFS 9**	**NEFS 5**	**NEFS 6**	**NCCS**	**SHS 3**
Total Average ASM Eligible Trips Selected for NEFOP Observation	13	11	24	7	8	37	31	75	19	3	19	12	78	8	1	60
Total Eligible ASM Trips within Each Sector (SBRM 2017)	232	200	288	69	125	425	386	1060	225	36	236	179	762	120	94	622
Percent of ASM Eligible Trips Covered by NEFOP (within Sectors)	6%	6%	8%	10%	6%	9%	8%	7%	8%	8%	8%	7%	10%	7%	1%	10%
Percent of ASM Trips Needed To Meet Combined Coverage Requirement	10%	10%	8%	6%	10%	7%	8%	9%	8%	8%	8%	9%	6%	9%	15%	6%
Trips Needed To Meet the Combined Coverage Requirement Using ASM	23	20	23	4	13	30	31	95	18	3	19	16	46	11	14	37
Average Sea Day / Trip by Sector	1	2	2	4	6	2	1	3	1	1	5	7	1	7	1	7
Sea Day Standard Deviation by Sector	1	1	2	1	2	2	0	3	0	0	3	2	0	2	0	3
Average Cost / Sector for Additional ASM Coverage To Meet Combined Coverage Rate	$14,076	$24,480	$28,152	$9,792	$47,736	$36,720	$18,972	$174,420	$11,016	$1,836	$58,140	$68,544	$28,152	$47,124	$8,568	$158,508

Note: NE = New England, MA = Mid-Atlantic. See Table 3 for sector name abbreviations.

Table 7. Monte Carlo retrospective analysis average and total At-sea Monitoring (ASM) costs by sector for Standardized Bycatch Reporting Methodology (SBRM) years 2015-2017.

	Sector ID															
	FGS	**SHS 1**	**MCCS**	**NEFS 7**	**NEFS 8**	**NEFS 11**	**NEFS 12**	**NEFS 2**	**NEFS 3**	**NEFS 10**	**NEFS 13**	**NEFS 9**	**NEFS 5**	**NEFS 6**	**NCCS**	**SHS 3**
SBRM Year 2015	$135,864	$30,600	$36,720	$110,160	$44,064	$56,304	--	$179,928	$29,376	$44,064	$69,768	$218,484	$53,244	$69,768	$1,224	$329,868
SBRM Year 2016	$16,524	$22,032	$14,688	$12,240	$29,376	$34,272	$16,524	$108,324	$14,076	$2,448	$46,512	$88,128	$22,644	$25,704	--	--
SBRM Year 2017	$14,076	$24,480	$28,152	$9,792	$47,736	$36,720	$18,972	$174,420	$11,016	$1,836	$58,140	$68,544	$28,152	$47,124	$8,568	$158,508
Total ASM Coverage Cost (3 Years)	$166,464	$77,112	$79,560	$132,192	$121,176	$127,296	$35,496	$462,672	$54,468	$48,348	$174,420	$375,156	$104,040	$142,596	$9,792	$488,376
Average ASM Coverage Cost / SBRM Year	$55,488	$25,704	$26,520	$44,064	$40,392	$42,432	$17,748	$154,224	$18,156	$16,116	$58,140	$125,052	$34,680	$47,532	$4,896	$244,188
Average Sea Days / Trip (SBRM Years 2015-2017)	1	2	2	4	6	2	1	3	1	1	4	7	1	7	2	6
Average ASM Eligible Trips (SBRM Years 2015-2017)	683	161	204	153	99	393	363	854	332	192	243	295	666	109	35	648

Note: See Table 3 for sector name abbreviations.

Table 8. Total At-sea Monitoring (ASM) cost estimations by sector (SBRM Years 2015-2017): Comparing ASM costs from a simulated Standardized Bycatch Reporting Methodology (SBRM) stratification of NEFOP Observers to ASM costs simulated under a flat rate assignment of Northeast Fisheries Observer Program (NEFOP) Observers.

	Sector ID															
	FGS	**SHS 1**	**MCCS**	**NEFS 7**	**NEFS 8**	**NEFS 11**	**NEFS 12**	**NEFS 2**	**NEFS 3**	**NEFS 10**	**NEFS 13**	**NEFS 9**	**NEFS 5**	**NEFS 6**	**NCCS**	**SHS 3**
Total ASM Costs (SBRM Stratified NEFOP Coverage)	$166,464	$77,112	$79,560	$132,192	$121,176	$127,296	$35,496	$462,672	$54,468	$48,348	$174,420	$375,156	$104,040	$142,596	$9,792	$488,376
Total ASM Costs (Flat Rate Median NEFOP Coverage)	$164,016	$72,216	$75,888	$144,432	$106,488	$146,880	$35,496	$460,836	$69,156	$48,960	$174,420	$394,740	$124,236	$138,312	$6,120	$823,752
Difference in Total ASM Costs (SBRM Stratified NEFOP Coverage Minus the Flat Rate Median NEFOP Coverage)	$2,448	$4,896	$3,672	-$12,240	$14,688	-$19,584	$0	$1,836	-$14,688	-$612	$0	-$19,584	-$20,196	$4,284	$3,672	-$335,376

Note: See Table 3 for sector name abbreviations.

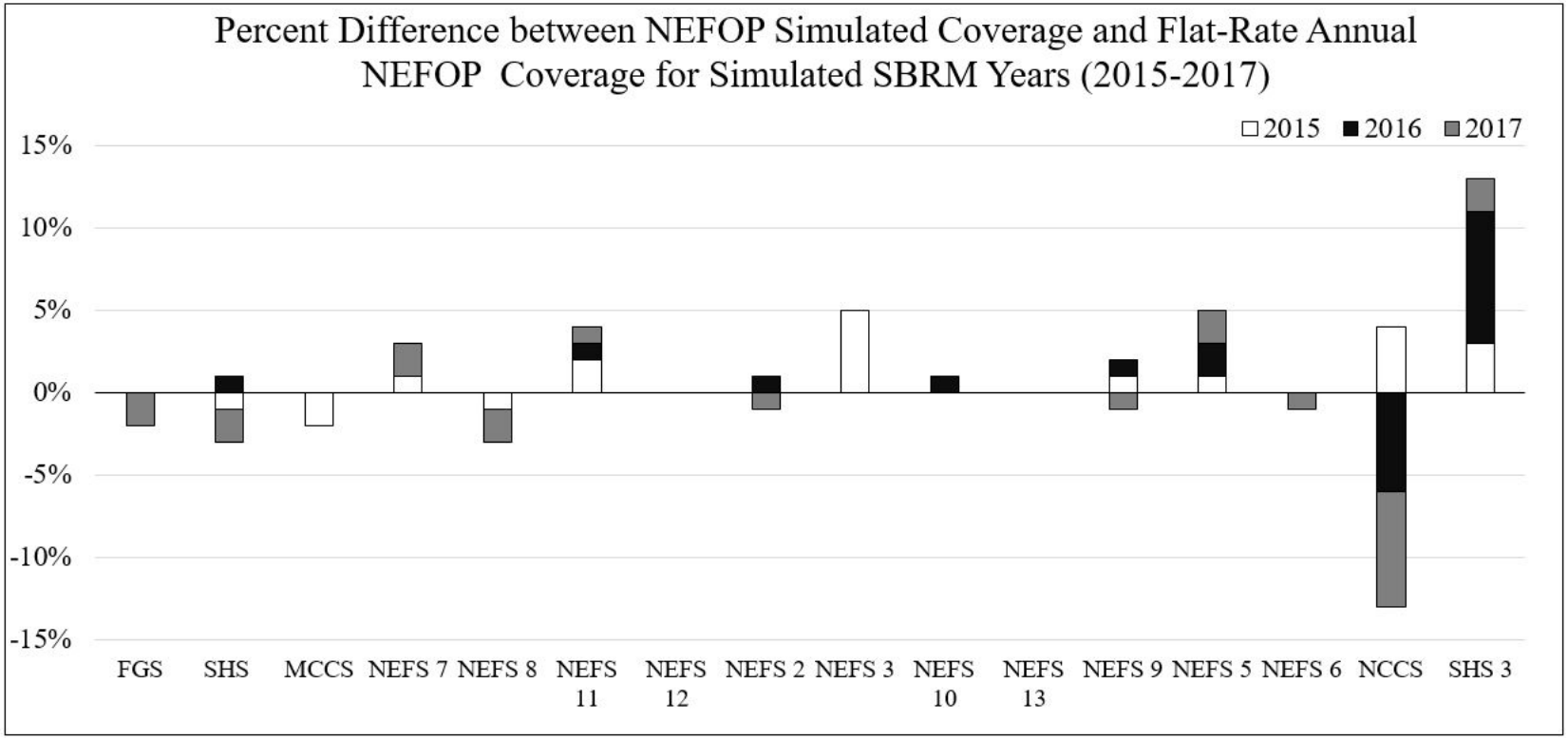

Figure 1. Calculation of the percentage difference between the Monte Carlo simulation of Northeast Fisheries Observer Program (NEFOP) Standardized Bycatch Reporting Methodology (SBRM)stratified coverage (At-sea Monitoring eligible trips only), compared to the flat rate median annual NEFOP coverage from the Monte Carlo simulations for SBRM years 2015-2017. The Monte Carlo simulation stratifies NEFOP observers on SBRM fleet types for biological data needs, causing variation in coverage across sectors. The median percentage coverages from the simulations are 9%, 6%, and 8% for SBRM years 2015, 2016, and 2017, respectively, and were fixed for each sector. The difference between the simulated and flat rate percentage coverages demonstrates trends in the NEFOP coverage when dictated by SBRM and tracks the magnitude of this difference over the 3-year simulation period. Sectors with percentages above 0% experience NEFOP coverage above the median flat rate, below 0% experience coverage below the median, and those equal to 0% were sampled at the median in every year of the simulation. See Table 3 for sector name abbreviations.

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