

**Analysis of Landings/Discards-Proportional Allocation Scheme for the At-Sea
Monitoring Program of the Groundfish Fishery in New England**



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Abstract

The New England groundfish At-Sea Monitoring (ASM) observer program's 30% coefficient of variation (CV) standard deploys observers at an almost equal rate across various groundfish vessel sizes, gear types, and in terms of broad stock area. This results in too many observers being allocated to trips with low landings and discards, lowering the degree of accuracy for overall catch estimates. Continued use of the 30% CV fixed target as a measure of relative standard deviation precision will result in similar coverage levels across vessel categories (size and gear).

Given that funding is limited to support the billable seadays taken by observers in all trips, the purpose of this analysis is to identify whether the groundfish sector ASM observer seadays were equitably assigned across all appropriate strata in fishing year (FY) 2010 and in FY2011. Furthermore, this study focuses on how many billable seadays were taken by observers by trip type and vessel size. The appropriateness of these additional strata as predictors of discards for each stock is examined using a Seemingly Unrelated Regression model. The results of the model are then used to present an alternate monitoring approach for FY2014 and beyond.

Based on the Data Matching and Imputation System (DMIS) dataset for FY2010 and FY2011, more seadays were observed per pound of groundfish catch on smaller vessels, especially gillnetters, than on larger vessels, especially those fishing with otter trawl gear. That is to say, more ASM resources were expended to observe less catch in the former category. Allocation of the observer seadays based on discard volume is proposed as a cost-effective method to ensure an accurate accounting of landings and discards for each sector.

1. Background and Motivation

The current, stated objective for the At-Sea Monitoring (ASM) program in Amendment 16 to the Northeast Multispecies Fishery Management Plan is to “verify area fished, catch, and discards by species, by gear type.” The calculated discards by stock assigned to each sector are assumed to be proportional to landings by fishing area and gear type. However, the current monitoring coverage rate is calculated based on the number of trips in each strata and is not distinguished by the magnitude of landings or discards in each strata, operating vessel size, or the number of billable seadays per trip.

The New England Fishery Management Council (NEFMC) revised certain elements of the groundfish monitoring program through Framework Adjustment 48 (FW 48) to the Northeast Multispecies Fishery Management Plan. These measures were voted on during their December 2012 meeting, and were implemented by the National Marine Fisheries Service (NMFS) for FY2013. Through their vote, NEFMC revised the goals and objectives for the ASM program; clarified the coefficient of variation (CV) standard; removed the requirement for industry-funded ASM in FY2013 (i.e., fund ASM for sectors at the level NMFS can afford); limited the responsibility of the industry to pay for the salary of an at-sea monitor; lowered coverage rates for sector trips on a monkfish day-at-sea (DAS) in the Southern New England Broad Stock Area using extra-large mesh gillnet gear; and eliminated the dockside monitoring program. While the Groundfish Oversight Committee requested that the Plan Development Team (PDT) develop monitoring standards that address both accuracy and precision, ultimately these revisions did not address accuracy or give the industry much flexibility in using various tools to meet the monitoring goals and standards. Further, while FW 48 deferred industry funding of ASM in FY2013, there is no guarantee the NMFS budget will be able to cover this level of monitoring in FY2014, yet the fishery will still be required to meet Amendment 16 standards for monitoring (i.e., 30% CV as determined by the Standardized Bycatch Reporting Methodology [SBRM]).

This analysis attempts to identify the distribution of monitoring effort by estimating the average historical landings and discards that were observed in each seaday among different vessel sizes and fishing gear configurations, in order to see if these categories should serve as appropriate strata to adjust coverage levels. This approach could still include sector/area-fished

strata as ASM vendors have broad stock area information, vessel size and gear type prior to embarkation to help them determine the appropriate coverage rate under each category.

During the early developmental stages of FW 48, the Gulf of Maine Research Institute (GMRI) convened a Monitoring Working Group (MWG) with members from industry, NMFS, NEFMC staff, and other non-profit organizations.¹ The purpose of the MWG was to increase industry participation in the development of the revised monitoring standards, and to develop multiple monitoring alternatives for sectors to propose in their operations plans, which were required to meet the new monitoring goals and objectives in FW 48. A MWG meeting on April 19, 2012 identified the need for analysis of alternative monitoring allocations in order to give sectors the necessary time to thoughtfully adapt their monitoring programs to the new goals and standards and negotiate contracts with monitoring providers prior to FY 2013.²

As part of this process, the MWG developed several alternatives that each sector could review with their manager and board of directors to determine the ideal option for their operations. Throughout summer and fall of 2012, the PDT vetted setting the coverage rate proportional to discards, although the analysis was not completed in time for further consideration in FW48, primarily due to the lack of available data for the 2011 fishing year. Therefore, having missed the September deadline for sectors to propose any of these alternatives for FY2013, this analysis is now aimed toward FY2014 and beyond, although implementation of this approach may require regulatory changes outside of those included in sector operations plans.

Literature Review

ASM coverage distribution within a fleet is not a topic that is abundant in literature. Most studies were found to focus mainly on the total observer coverage rate, rather than across vessel sizes and gear types. Zollett et al. (2011) gives an extensive overview of effective monitoring programs. In terms of setting the level of observer coverage, guiding principles included a formal threat assessment and/or a cost-benefit analysis, and consideration for the needs of industry. In

¹ For more information about the MWG, visit: www.gmri.org/monitoringworkinggroup

² Ultimately NMFS announced funding 100% of the ASM program in FY 2013, and as such, the ASM program continued to be operated by NMFS, and sectors did not propose alternate ASM programs.

terms of program costs, guiding principles included shifting the burden of responsibility to the industry and an aim to implement a program that can fund its own resource. Moving observer program costs to industry is intended to incentivize vessel operators to fish “cleaner”.

Furlong and Patrick (2001) focus on the optimal level of observer coverage in a fishery through which maximum net benefits are realized. The benefits come in the form of reduced illegal and underreported fishing and are measured against the costs of observer coverage. While this paper does not employ a cost-benefit analysis framework to find the optimal overall rate of coverage, multiple scenarios are presented so as to present several possibilities. The tradeoffs here include discards observed (more equals more reliable data) vs. observer costs.

Rossmann (2007) highlights the importance of looking at observer coverage and relative bycatch rates for each stratum with respect to marine mammals in the Northeast and Mid-Atlantic bottom trawl and gillnet fisheries. Those vessels responsible for higher marine mammal mortality were deemed a priority in receiving observer coverage. Similarly, those vessels responsible for mortalities of mammal populations in particularly poor shape were also given priority observer coverage.

This analysis expands on these previous studies in showing that while there may be an optimal level of observer coverage within a fishery, there is also an optimal way to disperse those observers among fleet members. Put another way, a certain level of ASM coverage is required to effectively enforce quota controls but that ASM coverage can come in different forms.

Currently, the 30% CV standard applied to GF trips will result in about 30% of trips observed and around 30% of landings and discards observed. However, by targeting those vessels that land and discard the most, fewer trips can carry an observer while observing the same volume of landings and discards. If the goal were to observe the most landings of highly utilized GF species, then using a weighted GF stock utilization rate would be necessary. This model is similar to what Rossmann (2007) proposed for protecting marine mammals in the Northeast and Mid Atlantic bottom trawl and gillnet fisheries.

Overview of Groundfish Activity by Trip Type, Vessel Size, and Fishing Gear

The data in this analysis was compiled from the individual trip level DMIS dataset, which was acquired by GMRI through a data access agreement for a project evaluating the viability of sectors as businesses. The sector viability project is funded in part by the Social Sciences Branch of the Northeast Fisheries Science Center, which restricts access of these confidential data to the GMRI staff directly working on the project, except in aggregated form. Since ASM costs are closely associated with sector viability, GMRI was given permission to use the DMIS dataset for this monitoring analysis; however, no funding from the sector viability project was used for this study.

Table 1 shows relevant data for FY2010 and FY2011, including number of trips, number of seadays, landings volume, and discards volume for all groundfish (GF). We considered GF trips to be any trip identified in the DMIS dataset performing groundfish fishing activities. The trips were then categorized by vessel size and gear type. This method yielded a total of 13,982 GF trips in 2010 and 16,609 GF trips in FY2011. These figures are slightly higher than those indicated in Table 1, as trips taken on vessels less than 30 feet in length are not included in the table. Both figures are also slightly higher than those reported in the 2011 NMFS groundfish fishery performance report (Murphy et al., 2012). This discrepancy is due to double counting for a small number of trips in which more than one type of fishing gear was used.³

For vessel size, four classes were chosen: class 1 vessels, less than 30 feet in length; class 2 vessels, measuring 30 to 50 feet; class 3 vessels, measuring 50 to 75 feet; and class 4 vessels, those longer than 75 feet. The DMIS dataset indicates that only two trips made on class 1 vessels (landing less than 1% of total GF landings in FY2011) had ASM coverage in for FY2011;⁴ thus they are not indicated individually in the tables, but are included in the totals. Those vessels that made less than 30 trips in hand line, longline or Ruhl trawl categories are also not indicated individually in the tables but are included in the totals. In both the 2010 and 2011 fishing years, the majority of trips on class 2 vessels used gillnets, and the majority of trips on larger, class 3 and 4 vessels fished with otter trawl gear. Overall, the majority of GF trips were made by class 2

³ No deletion was made, but could count only the gear type that landed the most fish if needed.

⁴ We understand that smaller vessels, many of which are handgear A or category C vessels, are subject to the default NEFOP rate of 8%, but are not required to call into PTNS and therefore may not be subject to additional ASM coverage.

vessels using gillnets, however the majority of seadays were made by class 3 and class 4 boats using otter trawl gear, as shown in Columns A and B in Table 1.

The number of seadays was calculated in accordance with the definition provided in a request for northeast observer contractors (NMFS, 2011). That is, the first calendar day the vessel leaves port is counted as one seaday regardless of when the vessel leaves or returns, the day the vessel lands is prorated from the beginning of the day to the time landed (unless the vessel lands on the same day it sails), and any interim days are counted as one seaday.⁵ The number of observed trips and observed seadays were summed in each sub-category, with all observer data coming from the Northeast Fisheries Observer Program (NEFOP) or the ASM program.

The current ASM observer program defines the coverage rate based on number of trips without considering how the scale of landings and discards vary substantially based on the size of the vessel and the length of the trip. Since the majority of GF seadays were made by class 3 and 4 multiday-trip boats with otter trawls, and their average seadays per trip is about 3 to 7 days, their landings and discards per trip are expected to be much higher than that of the class 2 day-trip boats. This study proposes to evaluate the distribution of observed seadays, GF landings, and GF discards, such as shown in the following section, in order to find a fair and equitable way to allocate the observer on various types of trips.

Estimates of Observer Coverage Rates and Distribution of Seadays, Landings, and Discards

Observer coverage rates in the j^{th} category of trips (based on vessel size and gear type) were calculated as follows: a dummy variable was assigned to each trip, where i indexes the GF trips in the j^{th} sub-category.

$$Observer_{ij} = \begin{cases} 1, & \text{when trip } i \text{ was observed} \\ 0, & \text{otherwise} \end{cases}$$

To find the coverage rate by trip, we simply used the mean of the $Observer_{ij}$ dummy. Note that this is equivalent to dividing the number of observed trips by the total number of trips.

⁵ Starting in FY12, NMFS' contracts with ASM providers are transitioning to a new billing structure of quarter-day (i.e., 6-hr) seadays; however this does not affect our historical analysis of FY 2010 and FY 2011 (<http://www.nefsc.noaa.gov/fsb/asm/ASM%202012%20Contract%20Information/AIS.Signed.Redacted.Contract-TOs-2.2012.pdf>).

The estimated coverage rate weighted by GF landings was then calculated, with the variable L_{ij} being the round weight of all GF landed on the i^{th} trip of the j^{th} sub-category.

$$P_j^L = \frac{\sum_{i=1}^N \text{Observer}_{ij} \cdot L_{ij}}{\sum_{i=1}^N L_{ij}}$$

The coverage rate by trips and by seadays, so as weighted by GF landings and discards, were calculated in a similar manner and defined in Table 2 for each category of vessel size and fishing gear in Columns A-D of Table 2 for FY2010 and FY2011 as the percentage of trips that carried an observer on board (A); the percentage of seadays fished with an observer on board (B); the percentage of total GF landings that were observed (C); and the percentage of total GF discards that were observed (D).

The percentage of trips that carry observers (coverage rate by trip) is the category that the current monitoring system is most concerned with. The result of this method of ASM is similar values for the percentage of trips observed vs. the percentage of total landings or discards observed. However, this does not necessarily indicate equitable distribution of monitoring resources. In 2010, class 3 and 4 otter trawl trips accounted for a total of 73.2% (27.3% and 45.9%, respectively, in Table 2 Column F) of total GF landings and 74.8% (31.3% and 43.5%, respectively, in Table 2 Column G) of total GF discards, but only 55.4% (25.1% and 30.3%, respectively, in Table 2 Column E) of total observed seadays were used to monitor them.

A disparity between monitoring effort and GF landings and discards is generally present for all gear types under various vessel sizes, though it is most pronounced for the large vessels fishing with otter trawl gear and the small vessels using gillnets. These two vessel categories made the majority of GF trips, shown in Table 1 Column A, though their total landings and discards differed greatly.

Table 2 shows the GF landings by class 4 vessels using otter trawls were 3.9 times (45.9% vs. 11.7% in Column F) the GF landings by class 2 vessels using gillnets with large mesh. Large otter trawls also discarded 4.5 times (43.5% vs. 9.6% in Column G) more than the small gillnetters, in FY2010. This is a large discrepancy considering the ASM observed seadays were only 1.5 (30.3% vs. 20.6%) times higher for large otter trawlers than small gillnetters in FY2011, as shown in Column E. A similar disparity between catch/discards and monitoring effort appeared for these vessel categories for FY2011 indicated in Table 2.

Large vessels fishing with otter trawls produce more discards per trip than most of the other fishing activity categories. In addition, by comparing the discards by seadays (shown in Table 3 Column G), what was discarded by an average class 4 otter trawler in one seaday in 2010 would take a class 2 extra-large mesh gillnet vessel an average of 13.03 seadays to discard an equivalent amount of fish (Table 3 Column H). Clearly this is a large discrepancy that is not being accounted for when evaluating the tradeoffs of assigning one observer seaday in various vessel size classes in order to observe the majority of the discards.

This mismatch is caused by the 30% CV precision standard by trip, which is a normalized formal equality measure of dispersion required for all ASM of groundfish sector trips. The 30% CV criteria is a precision measurement by using the ratio of the sample standard deviation(s) to the sample mean (\bar{x}). As shown in the coverage rate on seadays indicated in Table 2 Column B, the coverage rate by trip, seaday, landings, and discards for small gillnet and larger otter trawl are all around 30%. Neither the magnitude of the average landings and discards per seaday nor the distribution of total discards across vessel size and gear type category is taken into account in deciding how high of the CV is needed for various fishing activities.

This mismatch suggests two avenues for improvement: first, allocate coverage effectively (and its associated costs) to better reflect the magnitude of GF landings and discards by vessel categories, and increase the amount of both landings and discards that can be monitored; second, achieve the same industry-wide observed magnitude of GF landings and discards with less monitoring effort and at a reduced cost. The first avenue could be approached by adding vessel size as strata under the current ASM program when deciding coverage rates, the second by making coverage rates proportional to the landings or discards produced per seaday within the industry-wide stratified categories. If observing most of the discards is preferable, the higher the discard the higher the coverage rate that would be assigned, i.e. discard-proportional monitoring approach.

CVs measure precision of discard rates in the trip base, which is to say how much they vary around an average of the trip no matter the trip length. However, while the discard rates may be precise in fulfilling the 30% CV requirement, they likely are not accurate across all trip lengths and vessel size categories. In addition, how precise a discard rate is needed depends on how meaningful it is for monitoring Annual Catch Entitlement (ACE). By comparing the relative

costs for paying each observer seaday with the outcomes (discards observed), it is not as cost-effective to assign observers on trips that experience so little landings and discards per seaday than those trips discarding at a higher rate.

From a limited monitoring funding point of view, there is a need to reallocate the observers in a more cost-effective way to observe most of the discards and to monitor the majority of the ACE under the quota management objective. Allard and Chouinard (2011), show the importance of a cost-efficient strategy in enforcing regulations against discarding. Therefore, the approach proposed in this paper primarily addresses how to identify whether observed trips are distributed efficiently and equitably and how should the relative magnitude of the landings and discards across vessel size and gear be considered in the monitoring program. There is a compelling and time-sensitive need to have a comprehensive evaluation of the requirement to set the strata to assigning observers with the transition to an industry-funded ASM program on the horizon. If the majority of observers are assigned to observe the majority of the landings and discards, then it would more accurately ensure that a sector does not exceed their ACE.

Utilization Rate of Groundfish Stocks

The PDT report from July 25, 2012 suggests that there may be differences in monitoring coverage levels by various vessel size, fishing gear, and broad stock area for three stocks (GOM cod, GB haddock, and pollock). In order to be comprehensive, all 22 GF stocks are considered in this paper to explore a system multivariate regression model to identify if adding trip type and vessel size as an additional strata to sector, fishing gear, and broad stock area as a significant factor in determining the discard level by stock.

The collective members' landings and discards are counted against a sector's ACE for each GF stock. To maximize the value of catch, sector members wish to catch or utilize a large percentage of the ACE for various species. Table 4 shows that there is great variability in the utilization rate of GF stocks. Stocks such as Georges Bank haddock and redfish were not heavily utilized in FY2011, while others, such as white hake and Georges Bank yellowtail flounder, had almost their entire ACE utilized. To combat this variability, a weighting scheme was introduced for the discards in this analysis in order to put more weight to allocate more observer seadays to observe those stocks that are highly utilized. By using pollock as the equivalent-based stock in

standardizing the discard rates for all stocks relative to their utilization rate, GB cod East and GB cod West were assigned with 2.838 and 1.634 times the discards for each pound of discards than the discards of pollock, as shown in Table 4. A weighted discard model will also be specified in the discard system equation model in addition to the discard level by stock.

Correlations of Landings and Discards vs. Trip Length and Vessel Size

As discards are calculated based on the amount of landings for each trip, it is reasonable to believe that landings and discards should have a strong, positive correlation with trip length and vessel size. Indeed, such a correlation appears in FY2011, as shown in Figure 1. A positive correlation also exists between trip duration and discards, shown in Figure 2. Note that for trips shorter than 5 days, discards per trip are strongly concentrated below 1,000 pounds, while trips 5 days or longer do not follow this trend. The relationships between landings, trip duration, and discards are not surprising, nor are they especially useful from a management perspective, as landings and trip duration cannot be known prior to a given trip.

There are, however, variables that can be determined prior to a fishing trip that are strongly correlated with landings and trip duration. Larger vessels have a greater hold capacity, and it is logical to believe that these vessels will have higher landings per trip. Figure 3 shows that in FY2011 there was in fact a strong, positive correlation between vessel length and discards. Also, while the exact length of a multiday trip generally depends on several factors that occur during the trip, it is generally known in advance when a vessel intends to return on the same day it leaves. So while trip duration may be unknown prior to departure, it is reasonable to categorize trips as day trips or multiday trips before they leave port. Therefore, vessel length and trip type (day vs. multiday) serve as proxies for landings and trip duration, which are expected to be strong predictors of discards.

There is also considerable variability in the distribution of landings and discards by vessel size and gear type among different GF stocks. Therefore, allocating ASM observer coverage based on the overall total discards by various vessels and gear types may result in better monitoring coverage for some stocks over others. Figures 4 and 5, which show the distribution of GF landings and discards by stock among different gear types in FY2010 and FY2011, illustrate this variability. By utilizing the preceding simulation model, the overall discard coverage will be

improved for stocks having a discard distribution similar to the combined stock distribution in Figure 1 (the rightmost value on the horizontal axis). However, this same model may result in lesser coverage for those stocks with distributions that differ greatly from the total discard distribution. Most notably, GOM cod, GOM pollock, and GBE haddock have lower discard percentages by class 3 otter trawlers compared to other fishing gears and vessel sizes for FY2010.

2. Specification Discard Regression Model

Regression analysis is utilized to show the explanatory power of vessel size and trip length variables in relation to discards, with the best fit being a double-log Seemingly Unrelated Regression (SUR) model. This method accounts for the high correlation of the error terms in the species models resulting from the species being landed together in a multispecies fishery. The SUR model utilizes an aggregate regression to estimate discards for all groundfish stocks combined, and also runs separate regressions for each stock. The data used in this model was compiled from the individual trip level DMIS dataset for FY2011 and contains 14,946 observations. Discards in this dataset have been inputted using the weighted average of the discard rate assigned to each vessel by NOAA using gear type, broad stock area, and sector strata.

The regression dependent variable is discards per trip measured in pounds. The key explanatory variables for this analysis are trip type and vessel size. Vessel size is divided into four classes. Class 1 vessels are dropped because they do not carry observers, and class 2 is used as the base size. The regression therefore indicates how the larger vessels compare to the class 2 category. A positive value on the class 3 or class 4 coefficient would indicate that larger vessels are associated with higher discards. For trip length, a binary variable, *dday*, is used, which takes a value of 1 if the trip is shorter than 24 hours and a value of 0 if the trip is longer than 24 hours. A negative value for this variable would indicate that day trips are associated with lower discards. Dummy variables are also included for the strata currently used by the ASM program: sector, gear type, and broad stock area. All sectors are specified that take the value 0 or 1 as dummy variables to sort data into mutually exclusive categories to indicate the absence or presence of the sector effect that may be expected to shift the discards, which represents

differential intercept coefficients in the discard model. For gear type, the base of comparison is the otter trawl, and the broad stock area base group is Southern New England (SNE). The explanatory variables and their definitions appear in Table 5.

The regression results are based on all groundfish trips in FY2011 and are summarized in Table 5. A total of 3,625,779 pounds of groundfish were discarded in FY2011, an average of 226.6 pounds per trip. The average trip duration was 1.4 days. For the dummy variables, the mean value can be interpreted as the percent of trips that belong to that category. For example the variable *dFixedgear* has a mean of 0.18, meaning that 18% of groundfish trips in FY2011 were taken by vessels in the Fixed Gear Sector. Similarly the mean of *dGillnetExtraLargeMesh* is 0.38 indicating that extra-large mesh gillnets were used on 38% of the trips in FY2011. The sum of the mean from various gear type dummy variables shows 61.32% trips were taken by all of the gear type indicated in Table 5 and indicates the rest of the 38.68% trips are taken by otter trawls as the base category.

Regression Results

The log dependent variable SUR results for all stocks combined are displayed in Table 6 and the regression results for all 22 individual stocks is also available upon request from the author. The binary variable *dday* is negative (-1.872) and statistically significant. For specifications with a logged dependent variable and dummy independent variables, the following formula is used to estimate the percentage change associated with the dummy variable category over the base group with exponential of coefficient minus one.

Therefore, the interpretation of the *dday* coefficient is that trips lasting fewer than 24 hours are associated with an 85% ($e^{-1.875} - 1$) decrease in discards compared to multiday trips. The coefficients for the vessel size class variables were both positive, but only the coefficient for *dclass4* was statistically significant. The value for *dclass4* can be interpreted as follows: a trip on a vessel greater than 75 feet long is associated with discards 106% higher than trips on vessels shorter than 50 feet.

The R^2 value for the aggregated stock model was 0.401; the model explained about 40% of the variation in discards. However, once the information from the individual stock models was incorporated using the SUR method, the system R^2 value increased to 0.834.

A joint test for significance was conducted on all of the vessel class and trip type variables in the model. The test returned an F statistic value of 66.79 with 69 degrees of freedom in the numerator and 343,114 degrees of freedom in the denominator. The null hypothesis was therefore rejected and we conclude that vessel class and trip type are highly statistically significant in explaining discards.

3. Allocation Proportional to Relative Volume of Discards across Vessel/Gear Categories

The following simulation is based on the premise that the optimal allocation of observed seaday resources should be proportional to the amount of discards recorded in each category for the GF fishery. For reference, Table 2 Column G shows the actual distribution of GF discards for these various categories of GF trips in FY2010 and FY2011. As observed seadays determine most of the cost of the monitoring program, it is identified as the basic unit of observing effort in this simulation.

Two scenarios of the simulated ideal allocation of observed seadays for groundfish trips in FY2010 and FY2011 are shown in Table 7. Scenario 1 re-allocates the actual 7,726 observed seadays in FY2010, shown in Table 1 Column D. Without increasing the monitoring effort, the percentage of weighted discards observed increases to 36% (Column D in Table 7) from the actual average observed GF discard of 29% (Column D in Table 2) in FY2010.

Scenario 2 shows how to achieve the same volume of discards observed in FY2010 (869,044 in Table 1 Column H) while reducing the total observed seadays. The results of this simulation are shown in Columns E through I in Table 7. The overall observed seadays are thereby reduced by 1,477 seadays from 7,726 to 6,249, shown in Column E. The reduction is achieved by increasing monitoring for trawl class 3 vessels by 31 seadays and class 4 vessels by 377 seadays, and reducing the seadays of all other gears by 1,885.

For FY2011 the percentage of GF discards observed could be increased from 30% to 37% while using the same number of observed seadays in Column A under scenario 1, or observer effort could be reduced by 1,616 seadays under scenario 2, shown in Column I, and the same total volume of discards could be observed as the status quo shown in Table 1 Column H under 2011.

Allocation Based on Weighted Volume of Discards across Vessel/Gear Categories

As with the allocation scheme based on total discards, the weighted discard simulation is presented in Table 8 with scenarios 3 and 4 as the corresponding scenarios to scenarios 1 and 2 in Tables 7, respectively, relative to the status quo. Scenario 1 re-allocates the actual 7,726 observed seadays in FY2010, shown in Table 1 Column D. Without increasing the monitoring effort, in scenario 3 the percentage of weighted discards observed increases to 57% in FY2010 (Column D in Table 8) from the average weighted observed GF discard of 29% in FY2010. Such an increase would be of great assistance to fishery managers and scientists in evaluating the impact of discards on GF stocks and fisheries.

Scenario 4 shows how to achieve the same percentage of weighted discards observed in FY2010 (29%) while reducing the total observed seadays. The results of this simulation are shown in Columns E through H in Table 8. The overall observed seadays is thereby reduced by 1,530 seadays from 7,726 to 6,196, shown in Column E. The reduction is achieved by increasing monitoring for trawl (Otter and Ruhle) class 3 vessels by 45 seadays and class 4 vessels by 333 seadays, so the seadays of all other gears could be reduced by 1,908.

For FY2011 the percentage of weighted GF discards observed could be increased from 30% to 47% while using the same number of observed seadays in Table 1 Column D, or observer effort could be reduced by 1,691 seadays and the same volume of weighted discards could be observed as the status quo, shown in Column G.

Costs of Monitoring

While similar to the sector ASM program, the existing NEFOP, which currently provides 8% coverage, will not be replaced by the industry-funded ASM program. Based on FY2010, the

overall cost⁶ of an ASM seaday is \$917.95. The cost for an at-sea monitor can be separated into two components: at-sea and infrastructure. In this case, the industry (or NOAA) could have saved \$1,355,812 ($\$917.95 \times 1,477$) in FY2010 and \$1,483,407 ($\$917.95 \times 1,616$) in FY2011 by allocating ASM based on the volume of discards across vessel categories (size and gear), as shown in Table 7 under scenario 2.

If ASM were allocated proportional to weighted discard volume of various sizes of vessels, at a cost of \$917.95 per ASM seaday, \$1,483,407 ($\$917.95 \times 1,530$ seadays) could be saved by allocating ASM more efficiently under scenario 3 in 2010 and \$1,552,253 ($\$917.95 \times 1,691$ seadays) could have been saved in FY2011, as shown in Table 8 under scenario 4. Once again, shifting observer seadays away from small gillnetters to class 4 otter trawlers is where most of the savings occur.

If the goal was to reach the FY2011 level of observed discards using the least amount of coverage possible, significant monetary resources could be saved by allocating ASM based on volume of discards by vessel size and trip length.

One potential method to distribute the monitoring burden equitably in scenarios where vessels with higher discards are covered at higher rates could be for individual sectors to develop a transfer scheme. Vessels with lower coverage rates could help compensate the vessels that have higher coverage rates so they could collectively reduce the number of observed seadays but would still be able to effectively monitor the ACE. For example, as shown by the ratio in Column H of Table 3 in FY2010, a sector could increase observed seadays for otter trawl class 4 vessels (accounting for 43.5% of all GF discards), by 1 seaday in order to reduce coverage assigned to class 2 extra-large mesh gillnet vessels (accounting for 1.6% of all GF discards), by 13 seadays.

This compensation scheme would be possible since the overall observed seadays are less than the current status quo for most of the vessels. Nearly all vessels, except class 4 otter trawlers, would be saving substantially with less coverage than the status quo. This savings would be more than enough to compensate the cost to the large otter trawlers. How a sector

⁶ An average seaday in FY2010 cost \$630.44 + \$32.28 in travel + \$37.46 in training for a subtotal of \$700.19. In addition, there were \$217.76 in NEFOP infrastructure and overhead costs for administration of the program, for a combined total of \$917.95 (Van Atten, 2001a *as cited in* Northern Economics, Inc. A Review of Observer and Monitoring Programs in the Northeast, the West Coast, and Alaska, prepared for Environmental Defense Fund, September 2011).

would establish their compensation scheme would be at their discretion, and this is merely one possible scenario of many that a sector could develop. Importantly, when all types of vessels and gears are combined in a sector, the percentage of discards observed would not be less than the actual FY2011 percentage.

Monitoring costs will be one of the major factors affecting groundfish sector viability moving forward, especially with decreased federal assistance. Based on “Developing Effective Monitoring for the Northeast Multispecies Fishery: Methods and Considerations,” draft white paper for NEFMC on April 12, 2012, sectors are required to monitor their members to ensure compliance with self-regulating measures designed to prevent a sector allocation overage. Currently all sectors employ a sector manager, who typically oversees reporting requirements and implements an ASM program, amongst other duties.

Currently, coverage rates must meet a minimum requirement to get at the precision goal, unless NEFMC removes the 30% CV language following NMFS’ 3-year review of the discard rate methodology, or the language is otherwise modified in Amendment 16. Therefore, this approach may need to be used as one component of a monitoring program, and allow precision to be covered by NEFOP or another approach unless these regulations are revised.

However, how to interpret what’s fair and equitable at the sector level, and not the vessel level, might also need to be further investigated. CVs measure precision of discard rates, which is to say how much they vary around an average. However, as indicated by a PDT member, while the discard rates may be precise, they do not vary a lot around their central value, and therefore they may not be accurate - their central value may be far from the true discard rate.

Therefore, the approach proposed in this paper primarily addresses the accuracy of the monitoring program (*which was not addressed in FW 48 and will not be addressed in FW 51 either*), and not the precision. In addition, the current flat CV of 30% applies no matter what the distribution of ACE or discards is geographically, temporally, or by vessel size and gear type. This is not the most cost effective method, and doesn’t help identify whether observed trips are distributed efficiently and equitably. There is a compelling need to have a comprehensive evaluation of the requirement to set the strata to assigning observers. If more observers were assigned to observe trips with high rates of landings and discards, then the monitoring program

could more effectively ensure that a sector does not exceed their ACE, and more accurate data could be integrated into stock assessments and other analyses that utilize catch and discards.

4. Conclusion and Discussion

According to the “Sector Operations Plan, Contract, and Environmental Assessment Requirements for FY 2013,” the regulations stated in 50 CFR 648.87(b)(1)(v)(B)(3), contain the following objectives for an ASM program:

- Objective 1: It must provide coverage that is fair and equitable.
- Objective 2: It must be distributed in a statistically random manner among all trips.
- Objective 3: Coverage must be representative of fishing activities and operations by all vessels within the sector throughout the entire FY.

The stated goal of ASM is: “To verify area fished and catch (landings and discards), by species and gear type, for the purposes of monitoring sector ACE utilization.”

We offer two methods of allocating observer coverage that will be an improvement over the status quo. The first is to assign coverage to vessels based on discard volume; the second is to assign coverage based on discards per seaday. Both distribute costs to those who produce the most discards, and result in collection of data that is more reflective of actual fishing activity. These proposed options are tiered allocation schemes, so observers could still be assigned randomly within each tier. These approaches also incentivize vessels to reduce discards and meet other proposed goals for a monitoring program. While the precision standard is not specifically addressed, it may either be used in conjunction with the current 30% CV, or an alternate precision standard could be developed and implemented to meet the overarching goals of monitoring.⁷

Assigning ASM coverage proportionally to discards meets the FW 48 (78 FR 53363; August 29, 2013) monitoring Goal 1, *improve documentation of catch*, because it increases accuracy (*i.e., the true discard estimates instead of a relative ratio without taking into account*

⁷ While the NEFMC clarified how the 30% CV standard is applied in FW48, we understand that this does not represent a change to current practices, and only clarifies the intent in the regulations.

the scale for various GF fishing activity per seaday) over the existing program. The proposed allocation methods therefore meet the objective to determine total catch and effort of target species. The objective to achieve coverage levels sufficient to minimize effects of potential observer bias was analyzed by the PDT, which ultimately concluded that they could not determine how observer bias related to discards on unobserved trips.

The proposed ASM schemes fully meets monitoring Goal 2, *reduce the cost of monitoring*, in that the monitoring costs and coverage levels do not conform to the one-size-fits all approach, which equates to similar costs whether you are landing higher volumes (and getting more of a return per trip) with a large vessel or smaller volumes with a smaller boat. This alternative distributes the costs of monitoring commensurate to the pounds caught, and avoids high coverage rates on small boats that have lower than proportional volume landings/discards than large boats on a daily basis. The proposed ASM schemes support monitoring Goal 3, *incentivize reducing discards*, as vessels that have a lower relative volume of discards (or volume per seaday) would be assigned lower coverage levels. Coverage levels will be assigned to specified vessel categories within a sector, and the status quo, which does not reward individual vessels with low discards, will be improved upon.

The proposed ASM schemes would not provide additional data streams for stock assessments (Goal 4), beyond the data already collected under the existing program. While there could be alterations to accommodate this goal, they could directly contradict Goal 2, unless the government could fund these data streams. The proposed schemes do, however, provide more accurate data streams for stock assessments.

Vessel size would serve as an appropriate strata and would help to determine more suitable coverage rates that would cut costs for the industry and incentivize reducing discards while achieving monitoring goals and providing accounting of ACE for the fishery.

References

- Allard J, Chouinard GA. A strategy to detect fish discarding by combining onboard and onshore sampling. *Canadian Journal of Fisheries and Aquatic Sciences*, 1997, 54(12); 2955-2963.
- Furlong W, Martin PM. Observer deployment in the fishery and regulatory self-enforcement. In: IIFET Proceedings. Corvallis, OR: International Institute of Fisheries and Trade; 2000.
- Murphy T, Kitts A, Records D, Demarest C, McPherson M, Walden J, Caless D, Bing-Sawyer E, Steneck S, Olson J. 2011 Final Report on the Performance of the Northeast Multispecies (Groundfish) Fishery (May 2011-April 2012). U.S. Department of Commerce, Northeast Fisheries Science Center. Ref. Doc. 12-30; 2012.
- NMFS. Request for Proposal for Observer Provider Contractor in Northeastern USA. Solicitation Number: NFFM7210-11-03209. Section B.3; 2011.
- Rossmann MC. Allocating observer sea days to bottom trawl and gillnet fisheries in the Northeast and Mid-Atlantic regions to monitor and estimate incidental bycatch of marine mammals. U.S. Department of Commerce, Northeast Fisheries Science Center. Ref Doc. 07-19; 2007.
- Sun J. Evolution of groundfish sector business model (in progress). U.S. Department of Commerce, Northeast Fisheries Science Center Social Sciences Branch; 2013.
- Zollett E, Americas, M. R. A. G., Trumble R, Swasey J, Bonzon K, et al. Guiding Principles for Development of Effective Monitoring Programs. In: Report prepared for Environmental Defense Fund. Essex, MA: MRAG Americas; 2011.

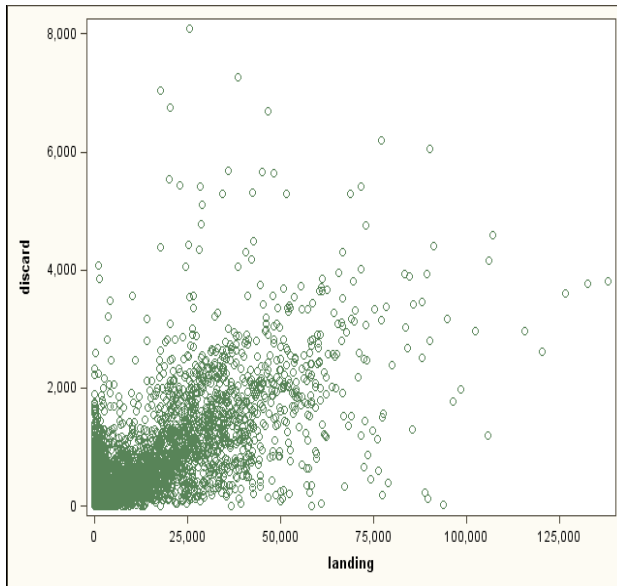


Figure 1 Landings vs. Discards per Trip in FY2011

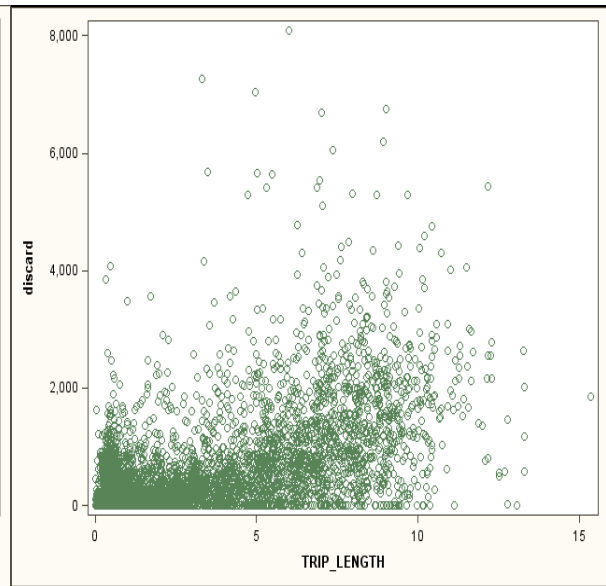


Figure 2 Trip Length (Seadays) vs. Discards per Trip in FY2011

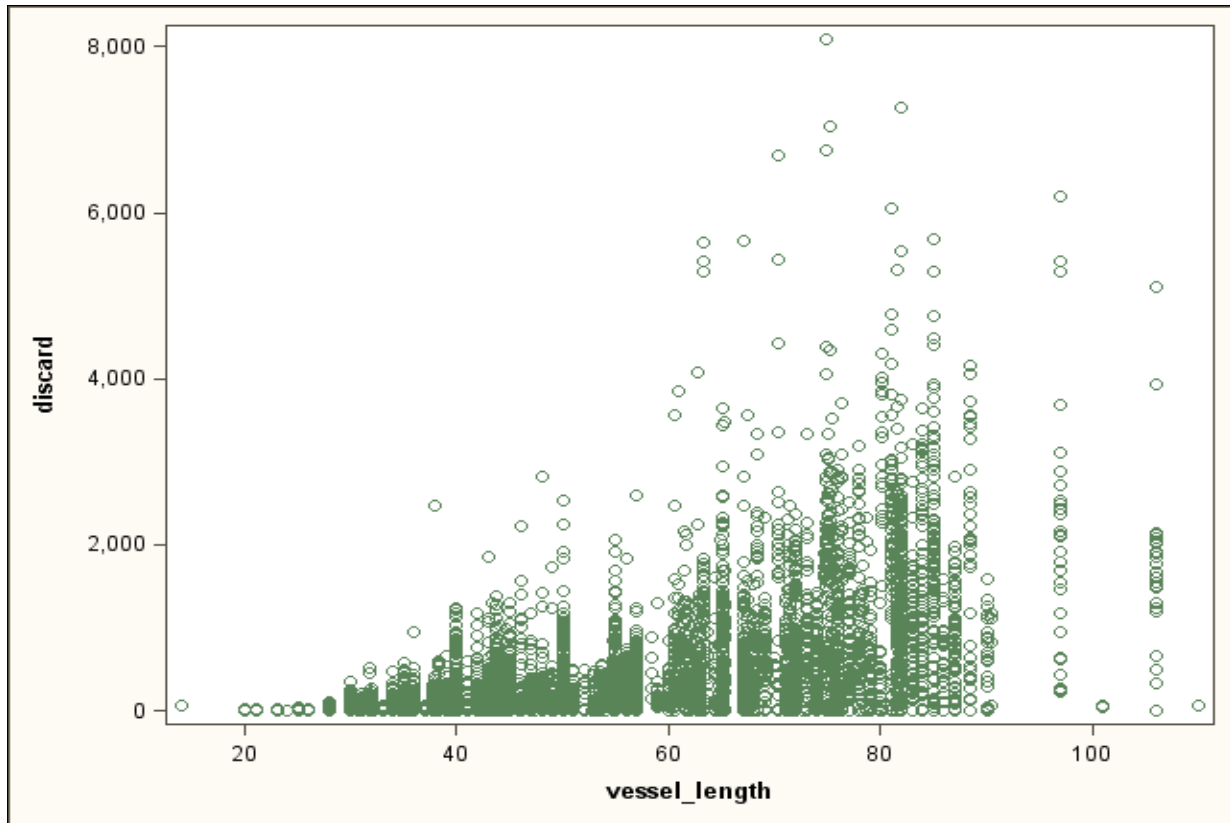


Figure 3 Vessel Length vs. Discards per Trip in FY2011

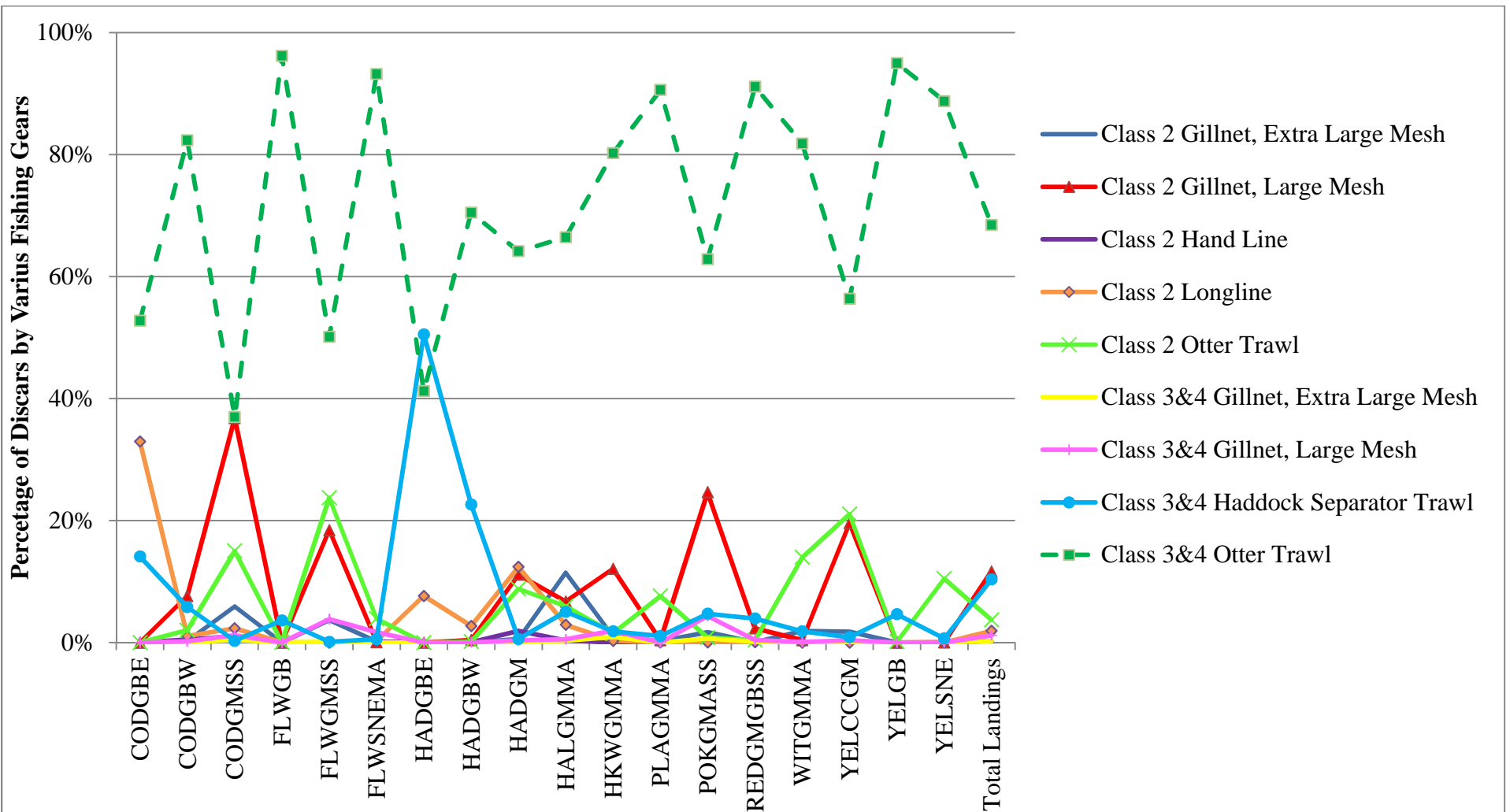
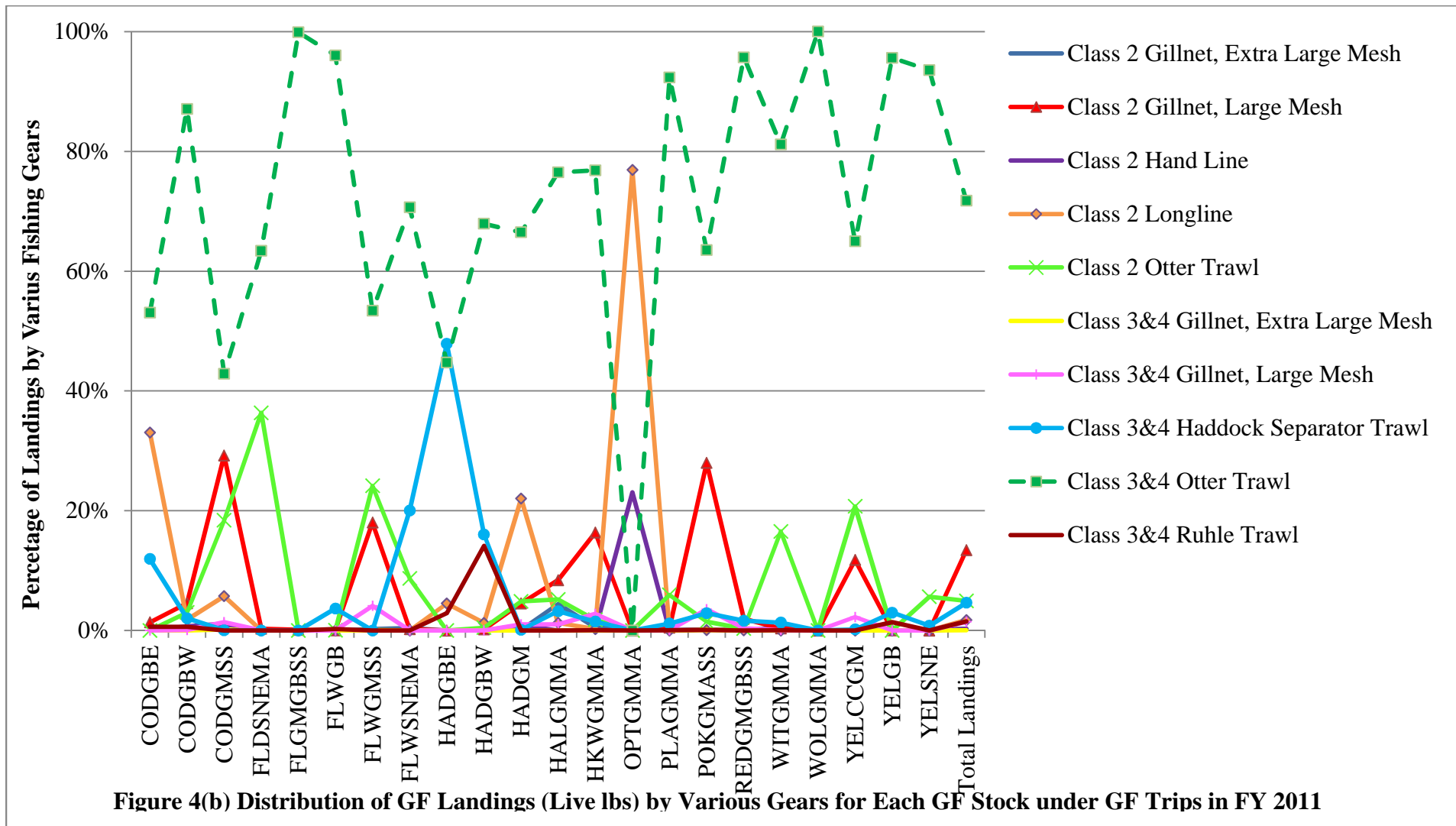


Figure 4(a) Distribution of GF Landings (Live lbs) by Various Gears for Each GF Stock under GF Trips in FY 2010

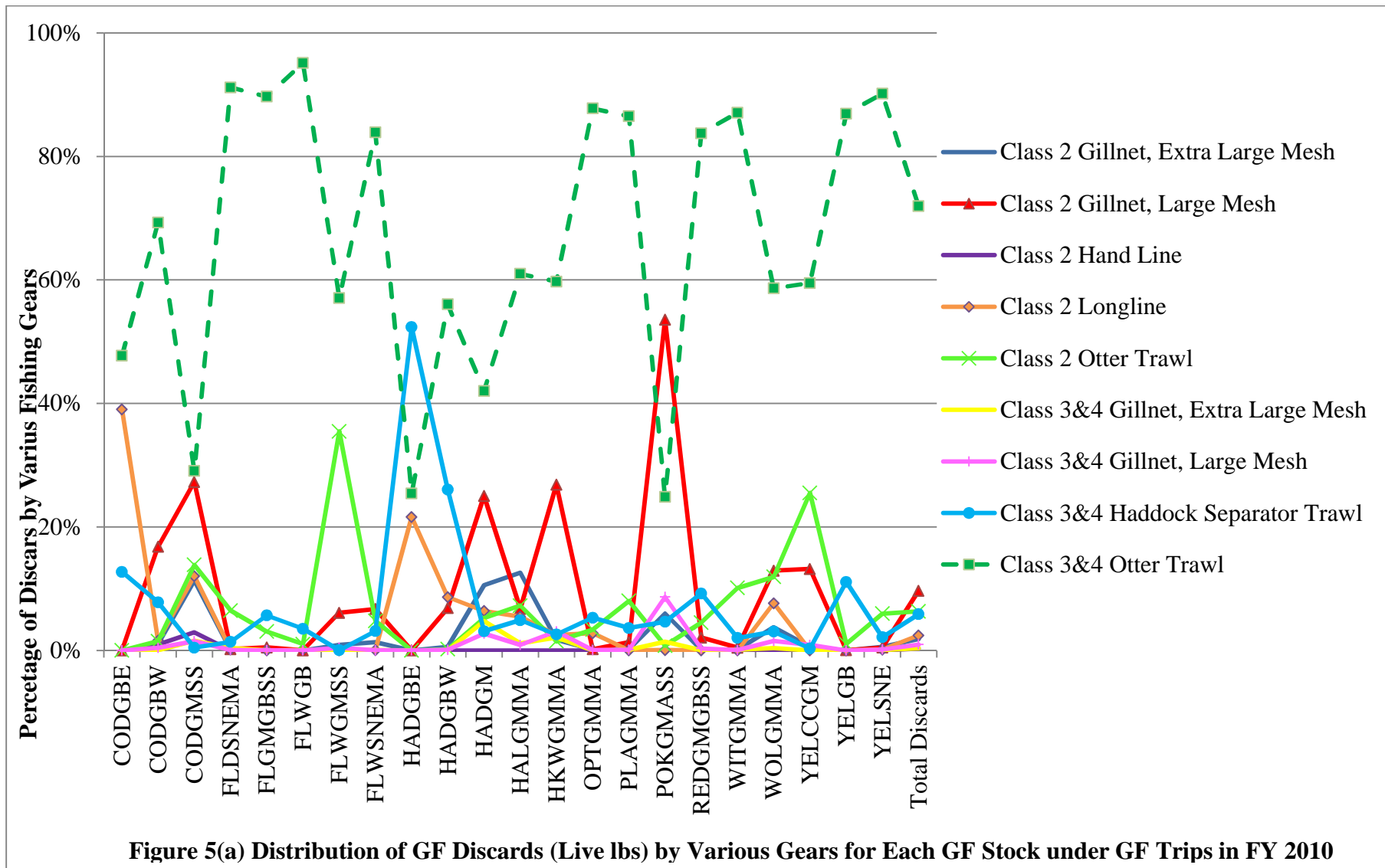
Note: Abbreviation of Groundfish stock are defined as follows and those stocks with an “*” indicated are zero possession prohibited species under landing/possession limits.

CODGBE: GB Cod East;	FLWGB*: GB Winter Flounder;	HADGM: GOM Haddock;	POKGMASS: Pollock;	YELCCGM: CC/GOM Yellowtail Flounder;
CODGBW: GB Cod West;	FLWGMSS: GOM Winter Flounder;	HALGMMA: Halibut;	REDGMGBSS: Redfish;	YELGB: GB Yellowtail Flounder;
CODGMSS: GOM Cod;	FLWSNEMA*: SNE Winter Flounder;	HKWGMMA: White Hake;	WITGMMA: Witch Flounder;	YELSNE: SNE Yellowtail Flounder.
FLDSNEMA*: Southern Windowpane;	HADGBE: GB Haddock East;	OPTGMMA*: Ocean Pout;	WOLGMMA*: Wolffish;	
FLGMGBSS*: Northern Windowpane;	HADGBW: GB Haddock West;	PLAGMMA: American Plaice;		



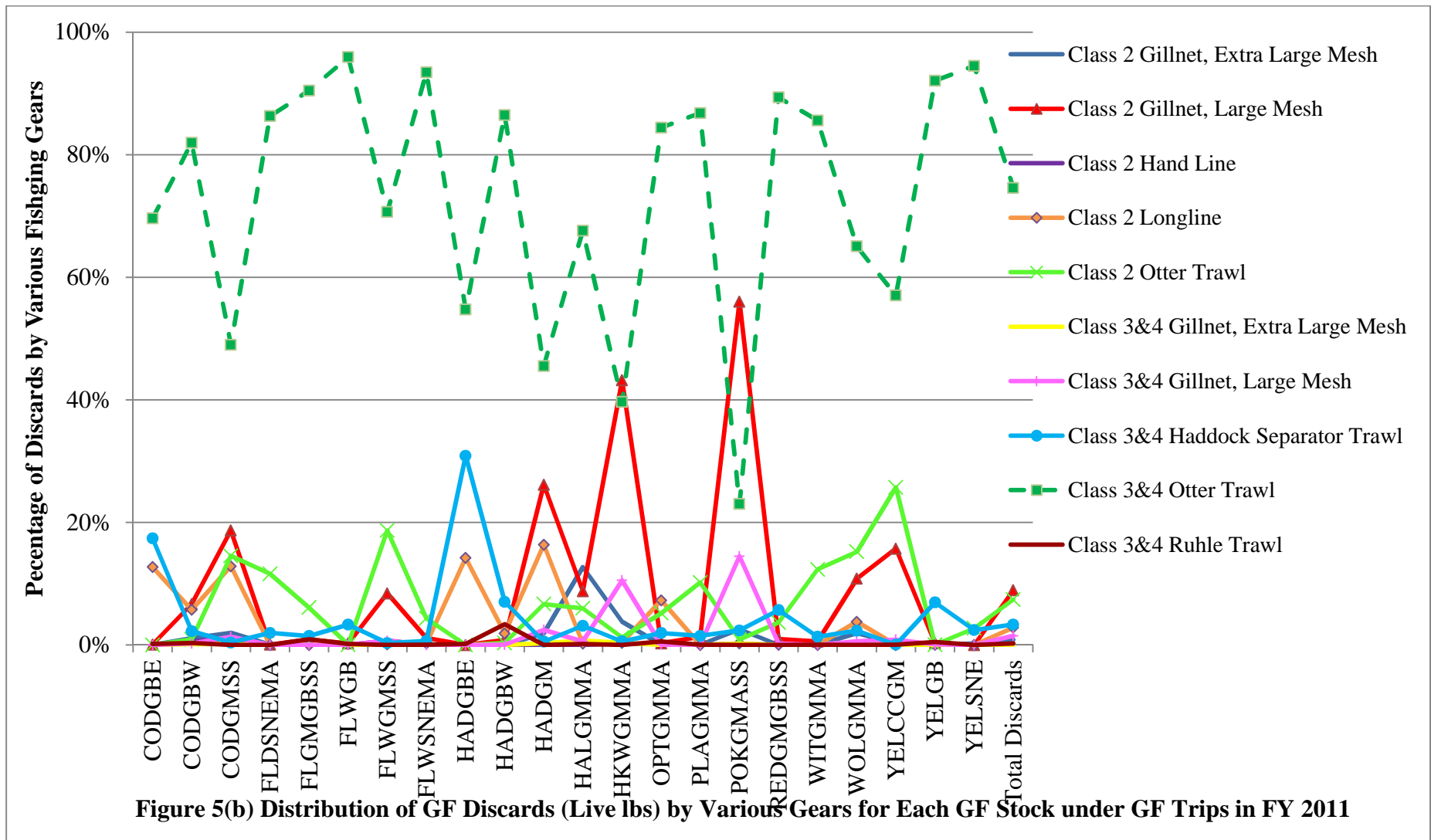
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CODGMSS: GOM Cod;	FLWSNEMA*: SNE Winter Flounder;	HKWGMMA: White Hake;	WITGMMA: Witch Flounder;	YELSNE: SNE Yellowtail Flounder.
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FLGMGBSS*: Northern Windowpane;	HADGBW: GB Haddock West;	PLAGMMA: American Plaice;		

Table 1 Number of Trips, Seadays, Landings, and Discards for GF Trips in FY 2010

Size Class	Gear Type	Trips (A)	Seadays (B)	Observed Trips (C)	Observed Seadays (D)	GF Landings (E)	Non-GF Landings (F)	GF Discards (G)	Observed GF Discards (H)
FY 2010									
2 (0'-50')	Gillnet, XL Mesh	2,955	3,585	564	656	814,477	12,451,412	47,020	9,209
	Gillnet, L Mesh	4,524	5,185	1,367	1,594	7,609,899	5,259,914	286,156	89,358
	Hand Line	271	297	40	43	99,625	158,660	12,556	3844
	Longline	547	745	185	242	1,249,132	386,952	72,371	18,827
	Otter Trawl	1,328	1,643	399	488	2,328,292	687,035	195,397	67,399
3 (50'-75')	Gillnet, XL Mesh	271	502	38	79	170,105	1,018,179	9,605	2130
	Gillnet, L Mesh	172	413	58	120	768,548	291,740	27,978	10,915
	Haddock Sep. Trawl	15	46	4	11	187,285	10,359	5,135	1,157
	Otter Trawl	2,438	6,657	745	1,936	17,783,821	9,350,367	930,740	269,042
	Ruhle Trawl	8	50	0	0	115,547	44,944	5,822	0
4 (75'+)	Haddock Separator Trawl	81	547	24	182	3,318,470	121,026	77,768	25,558
	Otter Trawl	1,214	7,571	361	2,339	29,900,139	6,441,003	1,293,505	369,709
	Ruhle Trawl	17	117	6	36	727,338	26,576	11,461	1,896
Total*		13,845	27,362	3,791	7,726	65,073,596	36,249,551	2,975,574	869,044
FY 2011									
2 (30'-50')	Gillnet, XL Mesh	2,854	3,573	379	486	174,417	14,466,542	23,316	4,177
	Gillnet, L Mesh	5,485	6,511	1,520	1,745	9,209,041	7,534,108	324,231	90,349
	Hand Line	444	459	29	29	157,499	109,995	7,982	826
	Longline	745	865	137	154	1,201,593	466,010	105,039	16,974
	Otter Trawl	2,022	2,349	503	601	3,326,165	1,030,607	273,134	76,775
3 (50'-75')	Gillnet, XL Mesh	291	472	29	49	28,114	1,440,591	2,302	639
	Gillnet, L Mesh	269	595	107	240	987,089	457,267	52,890	18,594
	Haddock Sep. Trawl	18	26	4	4	16,289	3,751	6,870	1,653
	Longline	1	1	1	1	13	3,010	0	0
	Otter Trawl	2,903	7,983	794	2,424	20,032,274	11,697,859	1,301,553	424,915
	Ruhle Trawl	4	30	0	0	56,882	14,972	1,679	0
4 (75'+)	Haddock Sep. Trawl	37	263	17	115	1,247,060	79,098	29,178	13,286
	Hand Line	5	7	0	0	739	5,168	279	0
	Otter Trawl	1,196	8,225	400	2,845	30,666,386	9,062,349	1,468,505	427,654
	Ruhle Trawl	49	368	19	139	1,390,287	172,761	28,729	13,500
Total*		16,326	31,732	3,939	8,831	68,500,349	46,545,612	3,625,779	1,089,342

Table 2 Observer Coverage Rates and Proportion of Observed Seadays, Landings, and Discards during GF Trips in FY 2010

Size Class	Gear Type	Observer Coverage rate (%) by Category				Distribution % across Category		
		Trips (A)	Seadays (B)	GF Landings (C)	GF Discards (D)	Observed Seadays (E)	GF Landings (F)	GF Discards (G)
FY 2010								
2 (30'-50')	Gillnet, XL Mesh	19.1%	18.3%	24.2%	19.6%	8.5%	1.3%	1.6%
	Gillnet, L Mesh	30.2%	30.7%	35.1%	31.2%	20.6%	11.7%	9.6%
	Hand Line	14.8%	14.5%	34.1%	30.6%	0.6%	0.2%	0.4%
	Longline	33.8%	32.5%	28.8%	26.0%	3.1%	1.9%	2.4%
	Otter Trawl	30.0%	29.7%	30.1%	34.5%	6.3%	3.6%	6.6%
3 (50'-70')	Gillnet, XL Mesh	14.0%	15.7%	28.8%	22.2%	1.0%	0.3%	0.3%
	Gillnet, L Mesh	33.7%	29.1%	28.7%	39.0%	1.6%	1.2%	0.9%
	Haddock Separator Trawl	26.7%	23.9%	34.6%	22.5%	0.1%	0.3%	0.2%
	Otter Trawl	30.6%	29.1%	30.2%	28.9%	25.1%	27.3%	31.3%
	Ruhle Trawl	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
4 (75'+)	Haddock Separator Trawl	29.6%	33.3%	39.6%	32.9%	2.4%	5.1%	2.6%
	Otter Trawl	29.7%	30.9%	30.5%	28.6%	30.3%	45.9%	43.5%
	Ruhle Trawl (Class 3&4)	35.3%	30.8%	27.2%	16.5%	0.5%	1.1%	0.4%
Average/Total*		27.4%	28.2%	31.1%	29.2%	100.0%	100.0%	100.0%
FY 2011								
2 (30'-50')	Gillnet, XL Mesh	13.3%	13.6%	21.0%	17.9%	5.5%	0.3%	0.6%
	Gillnet, L Mesh	27.7%	26.8%	26.1%	27.9%	19.8%	13.4%	8.9%
	Hand Line	6.5%	6.3%	7.4%	10.3%	0.3%	0.2%	0.2%
	Longline	18.4%	17.8%	13.2%	16.2%	1.7%	1.8%	2.9%
	Otter Trawl	24.9%	25.6%	26.1%	28.1%	6.8%	4.9%	7.5%
3 (50'-75')	Gillnet, XL Mesh	10.0%	10.4%	47.6%	27.8%	0.6%	0.0%	0.1%
	Gillnet, L Mesh	39.8%	40.3%	41.2%	35.2%	2.7%	1.4%	1.5%
	Haddock Sep. Trawl	22.2%	15.4%	20.8%	24.1%	0.0%	0.0%	0.2%
	Longline	100.0%	100.0%	100.0%	-	0.0%	0.0%	0.0%
	Otter Trawl	27.4%	30.4%	31.7%	32.6%	27.4%	29.2%	35.9%
	Ruhle Trawl	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
4 (75'+)	Haddock Separator Trawl	45.9%	43.7%	60.8%	45.5%	1.3%	1.8%	0.8%
	Hand Line	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Otter Trawl	33.4%	34.6%	33.7%	29.1%	32.2%	44.8%	40.5%
	Ruhle Trawl	38.8%	37.8%	34.2%	47.0%	1.6%	2.0%	0.8%
Total*		24.1%	27.8%	31.8%	30.0%	100.0%	100.0%	100.0%

Table 3 Landings and Discards per Trip and per Seaday for GF Trips in FY 2010

Size Class	Gear Type	GF Landings per Trip	Non-GF Landings per Trip	GF as % of Total Landings	GF Discards per Trip	GF Landings per seaday	Non-GF Landings per seaday	GF Discards per seaday	Relative Seaday Ratio** (H)= [Max(G)/(G)]
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	
FY 2010									
2 (30'-50')	Gillnet, XL Mesh	276	4,214	6.14%	16	227	3,473	13	13.03
	Gillnet, L Mesh	1,682	1,163	59.13%	63	1,468	1,014	55	3.10
	Hand Line	368	585	38.57%	46	335	534	42	4.04
	Longline	2,284	707	76.35%	132	1,677	519	97	1.76
	Otter Trawl	1,753	517	77.22%	147	1,417	418	119	1.44
3 (50'-75')	Gillnet, XL Mesh	628	3,757	14.32%	35	339	2,028	19	8.93
	Gillnet, L Mesh	4,468	1,696	72.48%	163	1,861	706	68	2.52
	Haddock Sep. Trawl	12,486	691	94.76%	342	4,071	225	112	1.53
	Otter Trawl	7,294	3,835	65.54%	382	2,671	1,405	140	1.22
	Ruhle Trawl	14,443	5,618	72.00%	728	2,311	899	116	1.47
4 (75'+)	Haddock Sep. Trawl	40,969	1,494	96.48%	960	6,067	221	142	1.20
	Otter Trawl	24,629	5,306	82.28%	1065	3,949	851	171	1.00
	Ruhle Trawl	42,785	1,563	96.47%	674	6,217	227	98	1.74
Total*		4,700	2,618	64.22%	215	2,378	1,325	109	1.57
FY 2011									
2 (30'-50')	Gillnet, XL Mesh	61	5,069	1.19%	8	49	4,049	7	40.49
	Gillnet, L Mesh	1,679	1,374	55.00%	59	1,414	1,157	50	5.31
	Hand Line	355	248	58.88%	18	343	240	17	15.19
	Longline	1,613	626	72.06%	141	1,389	539	121	2.18
	Otter Trawl	1,645	510	76.34%	135	1,416	439	116	2.27
	Ruhle Trawl	6,466	930	87.43%	62	2,155	310	21	12.79
3 (50'-75')	Gillnet, XL Mesh	97	4,950	1.91%	8	60	3,052	5	54.18
	Gillnet, L Mesh	3,669	1,700	68.34%	197	1,659	769	89	2.97
	Haddock Sep. Trawl	905	208	81.28%	382	627	144	264	1.00
	Longline	13	3,010	0.43%	0	13	3,010	0	-
	Otter Trawl	6,901	4,030	63.13%	448	2,509	1,465	163	1.62
	Ruhle Trawl	14,221	3,743	79.16%	420	1,896	499	56	4.72
4 (75'+)	Haddock Sep. Trawl	33,704	2,138	94.04%	789	4,742	301	111	2.38
	Hand Line	148	1,034	12.51%	56	106	738	40	6.63
	Otter Trawl	25,641	7,577	77.19%	1,228	3,728	1,102	179	1.48
	Ruhle Trawl	28,373	3,526	88.95%	586	3,778	469	78	3.38
Total*		4,196	2,851	59.54%	222	2,159	1,467	114	2.31

Table 4 Annual Catch Entitlement of Groundfish to Groundfish Sector, Catches, and the Utilization Rate by Species/Stocks

Groundfish Species/stocks	2010 ACE (lb)	2010 Catch (Landings + Discards) (lb)	2011 ACE (lb)	2011 Catch (Landings + Discards)(lb)	Predicted Utilization Rate for 2011 (E=B/C)	Actual Utilization Rate for 2011 (F=D/C)	Standardized Ratio based on Pollock (G)
	(A)	(B)	(C)	(D)	(E=B/C)	(F=D/C)	(G)
CC/GOM Yel. Fl.	1,608,084	1,234,074	2,169,519	1,752,995	56.88%	80.80%	1.614
GB Cod East	717,441	558,835	431,357	357,959	100.00%	83.00%	2.838
GB Cod West	6,563,099	5,494,540	9,544,297	6,730,519	57.57%	70.50%	1.634
GB Haddock East	26,262,695	4,019,295	21,122,576	2,337,362	19.03%	11.10%	0.540
GB Haddock West	62,331,182	14,164,402	54,741,830	6,103,776	25.87%	11.20%	0.734
GB Winter Fl.	4,018,496	3,047,725	4,796,109	4,242,164	63.55%	88.50%	1.803
GB Yellowtail Fl.	1,770,451	1,629,253	2,474,662	2,178,073	65.84%	88.00%	1.868
GOM Cod	9,540,389	7,974,284	11,357,677	9,629,834	70.21%	84.80%	1.992
GOM Haddock	1,761,206	816,869	1,871,943	1,066,284	43.64%	57.00%	1.238
GOM Winter Fl.	293,736	177,934	716,989	348,756	24.82%	48.60%	0.704
Plaice	6,058,149	3,315,063	7,302,377	3,597,139	45.40%	49.30%	1.288
Pollock	35,666,741	12,014,768	34,096,310	16,629,760	35.24%	48.80%	1.000
Redfish	14,894,618	4,725,257	18,034,606	5,959,501	26.20%	33.00%	0.744
SNE/MA Yel. Fl.	517,372	336,125	941,762	802,444	35.69%	85.20%	1.013
White Hake	5,522,677	4,884,630	7,038,744	6,645,585	69.40%	94.40%	1.969
Witch Fl.	1,824,125	1,533,027	2,847,251	2,189,017	53.84%	76.90%	1.528
Grand Total	179,350,461	65,926,081	179,488,008	70,762,673	36.73%	39.40%	-

Table 5 Variable definitions and descriptive statistics

Variable	Definition	Mean	Std. Dev.
Discards	Discards per trip (Lbs)	226.62	529.25
Landings	Landings per trip (Lbs)	4,482.43	10,561.93
trip_length	Length of the trip by number of seadays	1.39	2.25
Dday	=1 if trip less than 24 hours, and =0 otherwise	0.76	0.43
• Size class (omitted if vessel size is less than 30')			
class2 (base)	= 0 if vessel size is 30' to <50'		
dclass3	=1 if vessel size is 50' to <75'	0.21	0.41
dclass4	=1 if vessel size is >75'	0.09	0.29
• Sectors (NEFS4 and the common pool are omitted)			
dFixedgear	=1 if vessel belongs to that sector, and = 0 if otherwise	0.18	0.38
dSHS	=1 if vessel belongs to that sector, and = 0 if otherwise	0.08	0.26
dPortclyde	=1 if vessel belongs to that sector, and = 0 if otherwise	0.05	0.22
dNEFS7	=1 if vessel belongs to that sector, and = 0 if otherwise	0.02	0.15
dNEFS8	=1 if vessel belongs to that sector, and = 0 if otherwise	0.01	0.09
dNEFS11	=1 if vessel belongs to that sector, and = 0 if otherwise	0.11	0.32
dNEFS12	=1 if vessel belongs to that sector, and = 0 if otherwise	0.02	0.13
dNEFS2	=1 if vessel belongs to that sector, and = 0 if otherwise	0.14	0.35
dNEFS3	=1 if vessel belongs to that sector, and = 0 if otherwise	0.20	0.40
dNEFS10	=1 if vessel belongs to that sector, and = 0 if otherwise	0.07	0.26
dNEFS13	=1 if vessel belongs to that sector, and = 0 if otherwise	0.03	0.17
dNEFS9	=1 if vessel belongs to that sector, and = 0 if otherwise	0.03	0.17
dNEFS5	=1 if vessel belongs to that sector, and = 0 if otherwise	0.04	0.20
dTristate	=1 if vessel belongs to that sector, and = 0 if otherwise	0.00	0.06
dNEFS6	=1 if vessel belongs to that sector, and = 0 if otherwise	0.01	0.09
dNCCS	=1 if vessel belongs to that sector, and = 0 if otherwise	0.00	0.06
• Gear			
dLongline	= 1 if Longline gear was used to land catch	0.05	0.21
dHandline	= 1 if Hand Line gear was used to land catch	0.01	0.10
dGillnetLargeMesh	= 1 if Large Mesh Gillnet was used to land catch	0.38	0.48
dGillnetExtraLargeMesh	= 1 if Extra Large Gillnet was used to land catch	0.16	0.37
dRuhleTrawl	= 1 if Ruhle Trawl was used to land catch	0.00	0.06
dHaddockSeparatorTrawl	= 1 if Haddock Separator Trawl was used to land catch	0.01	0.10
• Broad Stock Areas			
dGOM	=1 if landings occurred in the Gulf of Maine (515)	0.61	0.49
dGBW	=1 if landings occurred in the George's Bank West (521)	0.20	0.40
dGBE	=1 if landings occurred in the George's Bank East (525)	0.00	0.07

Table 6 Double Log SUR Regression Results

Models Variables	Unweighted Discards Model		Weighted Discards Model	
	Parameter Estimate	t statistic	Parameter Estimate	t statistic
dday	-1.872	-15.820	-1.658	-17.190
dclass3	0.072	0.560	0.104	0.990
dclass4	0.723	3.620	0.720	4.430
dFixedgear	3.827	15.740	4.543	22.940
dSHS	4.844	22.910	5.298	30.770
dPortclyde	4.978	19.530	5.506	26.520
dNEFS7	4.746	17.290	5.318	23.800
dNEFS8	4.160	10.020	5.051	14.940
dNEFS11	5.290	22.060	5.652	28.940
dNEFS12	3.814	12.450	4.619	18.520
dNEFS2	4.867	23.580	5.361	31.890
dNEFS3	5.117	21.440	5.657	29.100
dNEFS10	4.783	19.430	5.442	27.140
dNEFS13	5.580	21.240	6.135	28.670
dNEFS9	1.675	6.480	2.977	14.150
dNEFS5	6.242	26.870	6.789	35.890
dTristate	4.979	8.450	5.702	11.890
dNEFS6	4.834	11.840	5.377	16.170
dNCCS	5.060	7.400	5.791	10.400
dLongline	0.007	0.030	0.126	0.680
dHandline	-3.315	-8.810	-2.947	-9.610
dGillnetLargeMesh	-1.726	-11.420	-1.605	-13.040
dGillnetExtraLargeMesh	-3.708	-20.850	-3.308	-22.850
dRuhleTrawl	-2.134	-3.550	-2.169	-4.430
dHaddockSeparatorTrawl	-0.804	-2.300	-0.831	-2.920
dGOM	0.928	5.730	0.729	5.530
dGBW	0.726	4.810	0.587	4.780
dGBE	1.872	3.650	1.578	3.780
Number of Observation	14,946		14,946	
Discard model R-squared	0.401		0.571	
System weighted R-squared	0.834		0.842	

Table 7 Simulation of Possible Allocation of Observed Seadays for GF Trips in FY 2010 and FY2011

Size Class	Gear Type	Scenario 1: Reallocation of Observed Seadays				Scenario 2: Reduce Observed Seadays by 19%				
		Observed Seadays	Observed Seadays %	Observed Discards	Observed Discards %	Observed Seadays	Observed Seadays %	Observed Discards	Observed Discards %	Change in Observed Seadays
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
FY 2010										
2 (30' - 50')	Gillnet, XL Mesh	122	3%	1,601	3%	99	3%	1,295	3%	-557
	Gillnet, L Mesh	743	14%	41,005	14%	601	12%	33,164	12%	-993
	Haddock S.Trawl	0	8%	5	8%	0	7%	4	7%	-
	Hand Line	33	11%	1,378	11%	26	9%	1,115	9%	-17
	Longline	188	25%	18,254	25%	152	20%	14,764	20%	-90
	Otter Trawl	507	31%	60,337	31%	410	25%	48,799	25%	-78
3 (50' - 75')	Gillnet, XL Mesh	25	5%	477	5%	20	4%	386	4%	-59
	Gillnet, L Mesh	73	18%	4,921	18%	59	14%	3,980	14%	-61
	Haddock S. Trawl	13	29%	1,488	29%	11	23%	1,203	23%	0
	Otter Trawl	2,417	36%	337,880	36%	1,955	29%	273,267	29%	19
	Ruhle Trawl	15	30%	1,760	30%	12	24%	1,424	24%	12
4 (75' +)	Haddock S. Trawl	202	37%	28,708	37%	163	30%	23,218	30%	-19
	Otter Trawl	3,359	44%	573,808	44%	2,716	36%	464,080	36%	377
	Ruhle Trawl	30	25%	2,915	25%	24	21%	2,358	21%	-12
Total*		7,726	28%	1,074,523	36%	6,249	23%	869,044	29%	-1,477
FY 2011										
2 (30' - 50')	Gillnet, XL Mesh	57	2%	371	2%	46	1%	303	1%	-440
	Gillnet, L Mesh	790	12%	39,325	12%	645	10%	32,129	10%	-1,100
	Hand Line	19	4%	338	4%	16	3%	276	3%	-13
	Longline	256	30%	31,067	30%	209	24%	25,382	24%	55
	Otter Trawl	665	28%	77,353	28%	544	23%	63,199	23%	-57
	Ruhle Trawl	0	5%	3	5%	0	4%	2	4%	0
3 (50' - 75')	Gillnet, XL Mesh	6	1%	27	1%	5	1%	22	1%	-44
	Gillnet, L Mesh	129	22%	11,451	22%	105	18%	9,356	18%	-135
	Haddock S.Trawl	17	64%	4,421	64%	14	53%	3,612	53%	10
	Longline	0	0%	0	-	0	0%	0	-	-1
	Otter Trawl	3,170	40%	516,852	40%	2,590	32%	422,275	32%	166
	Ruhle Trawl	4	14%	229	14%	3	11%	187	11%	3
4 (75' +)	Haddock S.Trawl	71	27%	7,884	27%	58	22%	6,441	22%	-57
	Otter Trawl	3,577	43%	638,592	43%	2,922	36%	521,738	36%	77
	Ruhle Trawl	70	19%	5,463	19%	57	16%	4,463	16%	-82
Total*		8,831	28%	1,333,321	37%	7,215	23%	1,089,341	30%	-1,616

Table 8 Weighted Discard Simulation of Observed Seadays for GF Trips in FY 2010

Size Class	Gear Type	Scenario 3: Reallocation of Observed Seadays				Scenario 4: Reduce Observed Seadays by 20%				
		Observed Seadays	Observed Seadays %	Observed Weighted Discards	Observed Discards %	Observed Seadays	Observed Seadays %	Observed Weighted Discards	Observed Discards %	Change in Observed Seadays
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(G)	(I)
2010										
2 (30'-50')	Gillnet, XL Mesh	135	4%	3,054	6%	108	3%	2,449	5%	-548
	Gillnet, L Mesh	708	14%	58,448	20%	568	11%	46,871	16%	-1,026
	Haddock S. Trawl	0	10%	11	18%	0	8%	9	14%	0
	Hand Line	39	13%	3,036	24%	31	10%	2,435	19%	-12
	Longline	224	30%	40,835	56%	180	24%	32,747	45%	-62
	Otter Trawl	518	32%	98,829	51%	416	25%	79,255	41%	-72
3 (50'-75')	Gillnet, XL Mesh	26	5%	817	9%	21	4%	655	7%	-58
	Gillnet, L Mesh	61	15%	5,428	19%	49	12%	4,353	16%	-71
	Haddock S. Trawl	12	25%	1,788	35%	9	20%	1,434	28%	-2
	Otter Trawl	2,453	37%	546,256	59%	1,967	30%	438,065	47%	31
	Ruhle Trawl	18	36%	3,931	68%	14	29%	3,152	54%	14
4 (75'+)	Haddock S. Trawl	167	31%	30,941	40%	134	25%	24,813	32%	-48
	Otter Trawl	3,332	44%	886,101	69%	2,672	35%	710,600	55%	333
	Ruhle Trawl	32	27%	5,248	46%	26	22%	4,208	37%	-10
Total*		7,726	28%	1,684,723	57%	6,196	23%	1,351,047	45%	-1,530
2011										
2 (30'-50')	Gillnet, XL Mesh	63	2%	715	3%	51	1%	578	2%	-435
	Gillnet, L Mesh	740	11%	54,093	17%	598	9%	43,734	13%	-1,147
	Hand Line	22	5%	682	9%	18	4%	551	7%	-11
	Longline	292	34%	63,584	61%	236	27%	51,408	49%	82
	Otter Trawl	717	31%	140,734	52%	580	25%	113,783	42%	-21
	Ruhle Trawl	0	6%	8	13%	0	5%	6	10%	0
3 (50'-75')	Gillnet, XL Mesh	6	1%	50	2%	5	1%	41	2%	-44
	Gillnet, L Mesh	105	18%	11,895	22%	85	14%	9,617	18%	-155
	Haddock S. Trawl	20	76%	9,514	138%	16	61%	7,692	112%	12
	Longline	0	0%	0	-	0	0%	0	-	-1
	Otter Trawl	3,281	41%	866,945	67%	2,653	33%	700,925	54%	229
	Ruhle Trawl	5	16%	470	28%	4	13%	380	23%	4
4 (75'+)	Haddock S. Trawl	62	23%	9,305	32%	50	19%	7,523	26%	-65
	Hand Line	1	10%	44	16%	1	8%	36	13%	1
	Otter Trawl	3,442	42%	926,051	63%	2,783	34%	748,712	51%	-62
	Ruhle Trawl	76	21%	9,963	35%	61	17%	8,055	28%	-78
Total*		8,831	28%	2,094,054	58%	7,140	23%	1,693,043	47%	-1,691