Analysis of Landings/Discards-Proportional Cost-Effective 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 is a relative standard deviation precision measure, targeted to deploy observers at an almost equal rate across groundfish sectors, gear types, and broad fishing areas on a trip basis regardless of variations in landings or discards demonstrated by various sized vessels and trip length.

Based on the NMFS Groundfish Data Matching and Imputation System (DMIS) dataset during fishing year (FY) 2010 and FY 2011, the current allocation scheme resulted in relatively more observers being allocated to trips with low landings and discards. Also, relatively more seadays were observed per pound of groundfish catch on those trips. That is to say, the current allocation of observers is disproportionate to the total discards of each vessel category (size and gear). As a result the ASM resources were not equitably allocated to observe the majority of the catch and discards and therefore lowering the degree of accuracy for the overall catch estimates.

Given that ASM funding is limited to support the billable observer, the purpose of this analysis is to identify whether the groundfish sector ASM observer seadays were cost-effectively assigned across various vessel categories (size and gear). Furthermore, by estimating a Seemingly Unrelated Regression system model of the discards, weighted by the utilization rate of each stock in each trip, the appropriateness of using the vessel category as a predictor of discards for each stock is verified. In other words, the vessel category and trip length (in seadays) significantly influenced the volume of weighted discards. Based on these findings, an alternative discard-proportional allocation scheme for ASM observer coverage by vessel category is proposed that ensures an accurate accounting of landings and discards and more cost-effective monitoring coverage across the groundfish fleet.

By reallocating observers based on this approach, observer seadays could have been reduced by 1,691 days, resulting in what would have been a $1.5 million total cost savings for FY 2011, while still observing the same amount of weighted discards as under the current monitoring standards. Ultimately this proposed approach could improve the overall accuracy and efficiency of the ASM program and provide some relief to smaller vessels faced with disproportionately looming ASM costs.

1. Background and Motivation

For many fishermen in New England groundfish sectors, shouldering the costs of At-Sea Monitoring (ASM) could signal financial ruin for their fishing businesses. In fishing year (FY) 2011, the total expected ASM cost to be paid by the industry would has been $4.7 million; this is equivalent to more than 5% of the $90 million groundfish landings value. While Framework Adjustment 48 (FW 48) deferred industry funding of ASM in FY2013, there is no guarantee that the NMFS budget will be able to cover this level of monitoring in FY2014, although the fishery will still be required to meet Amendment 16 standards for monitoring (i.e, 30% coefficient of variation (CV) as determined by the Standardized Bycatch Reporting Methodology [SBRM]).

The stated objective for the 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." Under the assumption that the calculated discards by stock assigned to each sector are proportional to landings by fishing area and gear type on a trip basis, the current monitoring coverage rate is calculated based on the 30% CV precision standard to allocate observers across the combination of three basic dimensions (or strata) of sector, gear type, and broad fishing area on a trip basis, regardless the magnitude of landings or discards in each trip, operating vessel size, or the number of billable seadays in each trip.

The New England Fishery Management Council (NEFMC) revised certain elements of the groundfish monitoring program through FW 48 to the Northeast Multispecies Fishery Management Plan. These measures were voted on during the December 2012 meeting, and were implemented by the National Marine Fisheries Service (NMFS) in FY2013. Through their vote, NEFMC revised the goals and objectives for the ASM program; clarified the 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.

This analysis attempts to identify the distribution of monitoring effort by estimating the average historical landings and discards that were observed on each observer seaday among different vessel category (size and gear) configurations, in order to determine whether these categories could serve as an appropriate combination of strata for developing an alternative cost-effective allocation scheme for ASM observer coverage that could be included with the current sector/gear/area-fished strata. In this case, the broad stock area information and vessel category prior to embarkation could help ASM vendors 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 across vessel category, although the alternative analysis was not considered in time for further consideration in FW48, primarily due to the delay of being able to access the landings dataset before the September 2012 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.

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[1] For more information about the MWG, visit: www.gmri.org/monitoring

[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.

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 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.

Rossman (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 Rossman (2007) proposed for protecting marine mammals in the Northeast and Mid Atlantic bottom trawl and gillnet fisheries by identifying the priority of observer coverage scheme.

2. 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 13,845 GF trips in 2010 and 16,326 GF trips in FY2011. These figures are slightly less than 3% different than those reported in the 2011 NMFS groundfish fishery performance report (Murphy et al., 2012). The discrepancy is due to a small number of trips in which more than one type of fishing gear was used in a single trip will cause double counting those trips and so as trips taken on vessels less than 30 feet in length are only subject to the random NEFOP 8%, i.e., and they are not included in the current analysis, since 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[3].

For vessel size, three classes were chosen: 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. thus they are not indicated individually in the tables, but are included in the totals. Those vessels that made

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[3] 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 (Pre-Trip Notification System) and therefore may not be subject to additional ASM coverage.

less than 30 trips in hand line, longline or Ruhle 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 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.[4] 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.

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[4] 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).

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

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. 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.

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

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 criteria that the current 30% CV monitoring system is most concerned with. The result of this method of ASM is shown in Table 2 column A through D and shows almost similar equal coverage rate of all trips regardless of the magnitude of the landings and discards across vessel category and shows a disproportional to the distribution of total discards.

Furthermore, this does not necessarily indicate equitable distribution of monitoring resources. In 2010, class 3 and 4 otter trawl activities 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 disproportional disparity between catch/discards and monitoring effort appeared for these vessel categories for FY2011 is also noted in the lower part of the 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), the average discard that could be observed in in one observer seaday in 2010 on an class 4 otter trawler would take an average of 13.03 observer seadays deployed on a class 2 extra-large mesh gillnet vessel to observe an equivalent amount of discard (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 to the sample mean. 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 gillnetter and larger otter trawl are all around 30%.

The equal coverage of all trips regardless of the magnitude of the landings and discards of various activities shows a disproportional to the distribution of total discards. The 30% CV is neither cost-effective nor equitable for trips with low landings and discards, largely dayboat gillnetters less than 50 feet in length, and lowers the degree of accuracy for overall catch estimates of highly utilized groundfish stocks.

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, weighted by the utilization rate by stock, 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 allocating observers proportional to the weighted landings or discards based on vessel category under the current ASM program when deciding coverage rates, the second by further limiting observers to observe the same amount of weighted discards as under the current monitoring standards 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.

3. Discard Regression Model

A double-log Seemingly Unrelated Regression (SUR) system model is utilized to show the explanatory power of vessel size and trip length variables in relation to discards per trip. This method accounts for the high correlation of the error terms in each of the discards by species models resulting from the 22 groudfish stocks being landed together in a multispecies groundfish fishery. An estimate of both the total unweighted and weighted discards for all groundfish stocks combined is also included in the regression system model that including the discards of each stock per trip. The data used in this model was compiled from the individual trip level DMIS dataset for FY2011 and contains 14,946 observations. Discards in the DMIS 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. And the definition of weighted discards is defined in the following section.

Definition of Weighted Discards Based on the Utilization Rate by 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 the discard model to explore a system multivariate regression model to identify if vessel category could serve as a better strata to sector, than 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.

Specification of Discard Regression Model

The regression dependent variable is discards per trip measured in pounds. The key explanatory variables for this analysis are listed in Table 5. 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, such as an average of 226.62 pounds of groundfish per trip was discarded in FY2011 with the average trip duration was 1.39 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, which is defined as the base in the fishing gear group of variables.

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.

4. Cost-Effective Discards-Proportional Approach across Vessel 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.

Allocation Based on Unweighted Discards across Vessel Categories

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 29.2% (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 reduction of overall observed seadays is achieved by increasing monitoring for trawl (Otter and Ruhle) class 3 vessels by 31 (19 and 12 days, respectively) seadays and class 4 vessels by 377 seadays, and reducing the seadays of all other gears by 1,885, are thereby reduced the overall observed seadays by 1,477 seadays from 7,726 to 6,249, shown in Column E.

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 Discards across Vessel 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 2 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 29.2% 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, which is estimated at 29%, while reducing the total observed seadays. The results of this simulation are shown in Columns E through H in Table 8. The reduction of overall observed seadays is achieved by increasing monitoring for trawl (Otter and Ruhle) class 3 vessels by 45 seadays (31 and 14 days, respectively) and class 4 vessels by 333 seadays, so the seadays of all other gears could be reduced by 1,908 and thereby the overall observed seadays reduced by 1,530 seadays from 7,726 to 6,196, shown in Column E.

For FY2011 the overall percentage of weighted GF discards observed could be increased from 30%, what has been observed in FY2010, to 47% (Column G in Table 8) while using the same number of observed seadays in Table 1 Column D, or observer effort could be reduced by 1,691 seadays (shown in Column I in Table 8), and the same volume of weighted discards could be observed as the status quo.

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 cost[5] 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*1,477) in FY2010 and $1,483,407 ($917.95*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, $1,404,464 ($917.95*1,530 seadays) could be

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[5] 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).

saved by allocating ASM more efficiently under scenario 3 in 2010 and $1,552,253 ($917.95*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 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.

5. 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.[6]

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 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

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[6] 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.

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 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.

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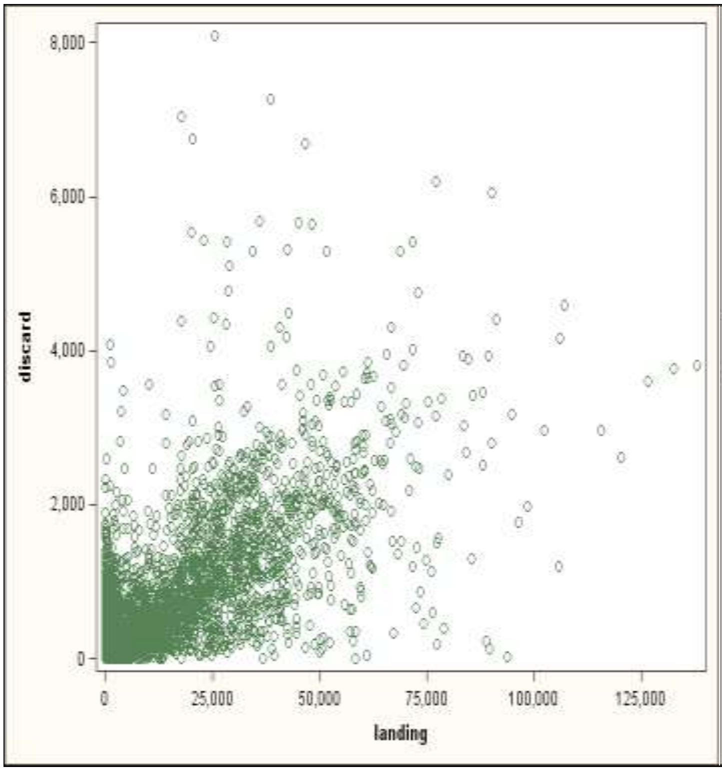

Fig. 1 Landings vs. Discards per Trip in FY2011

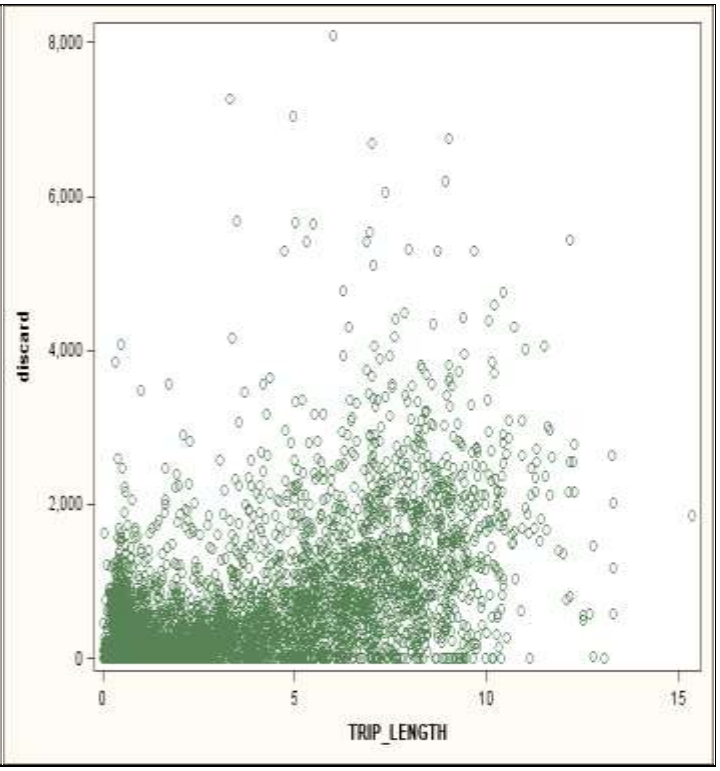

Fig. 2 Trip Length (Seadays) vs. Discards per Trip in FY2011

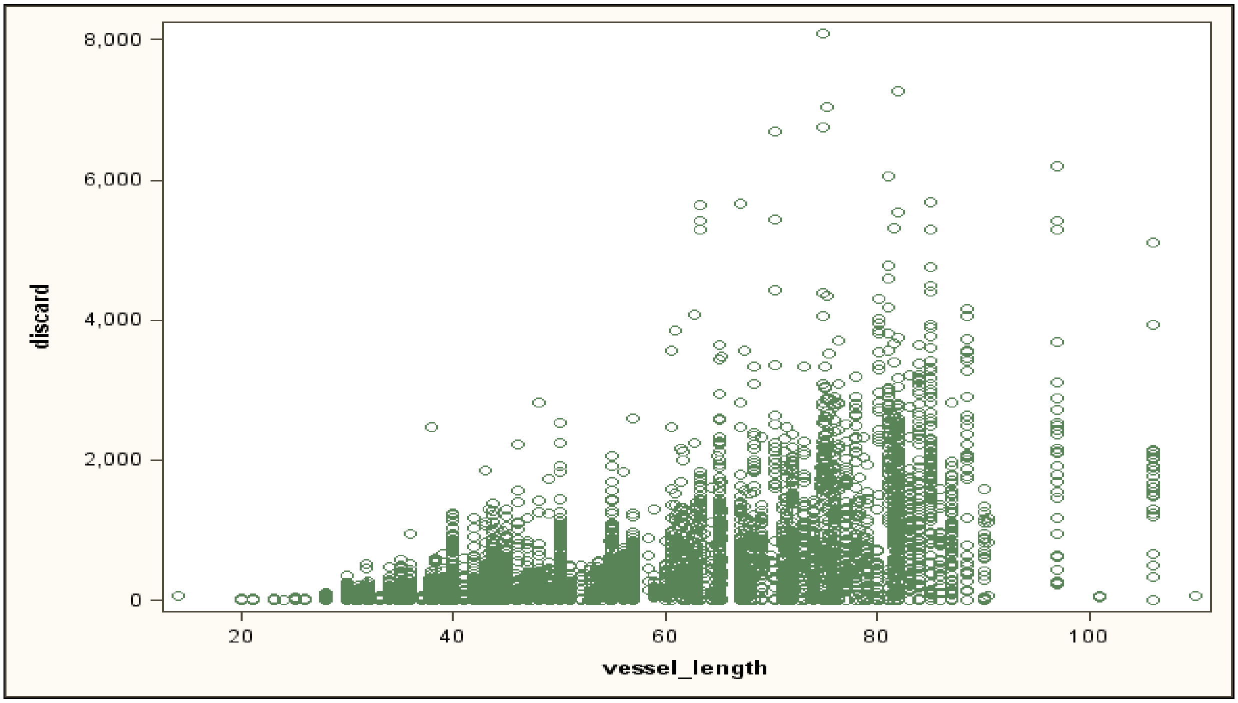

Fig. 3 Vessel Length vs. Discards per Trip in FY2011

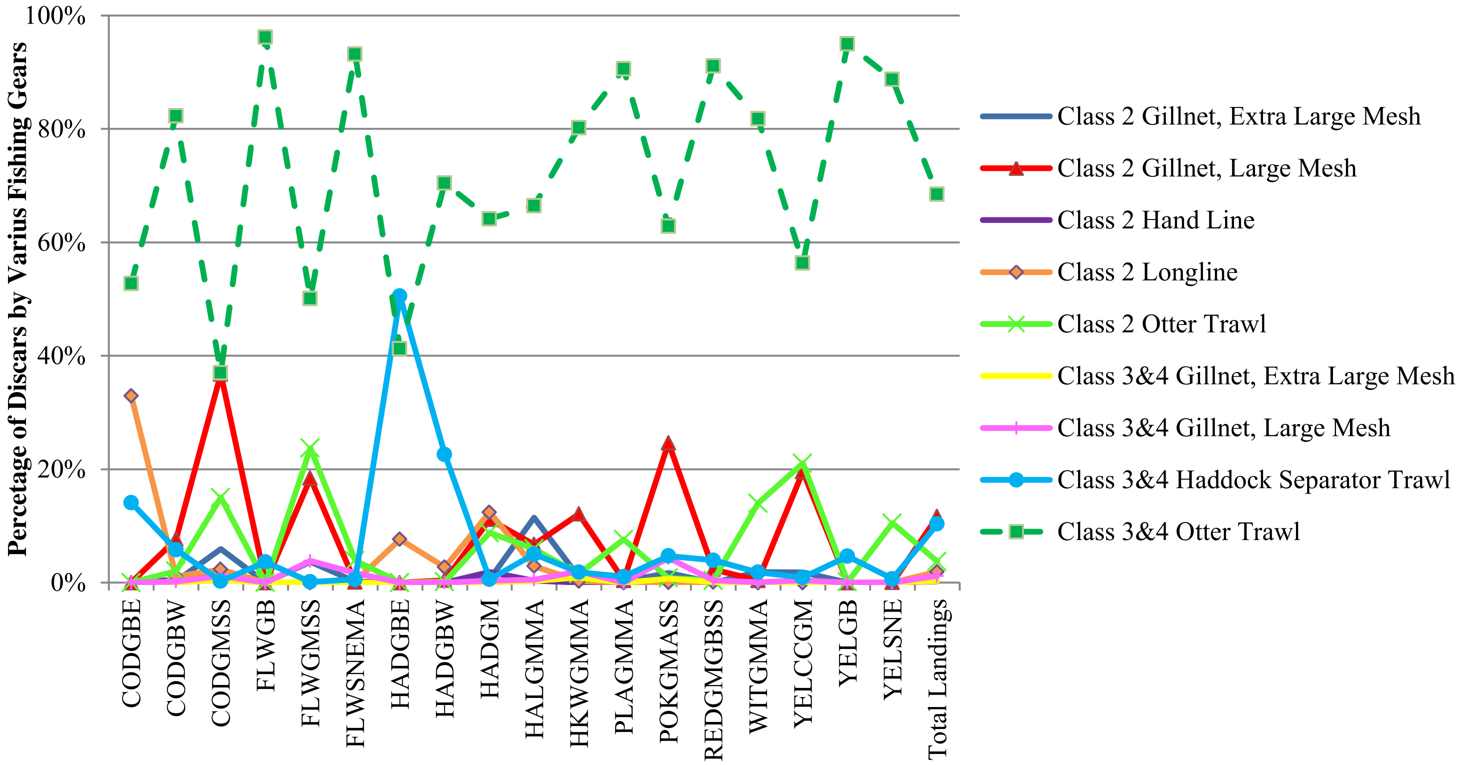

Fig. 4(a) Distribution of GF Landings (Live lbs) by Various Gears for Each GF Stock under GF Trips in FY 2010

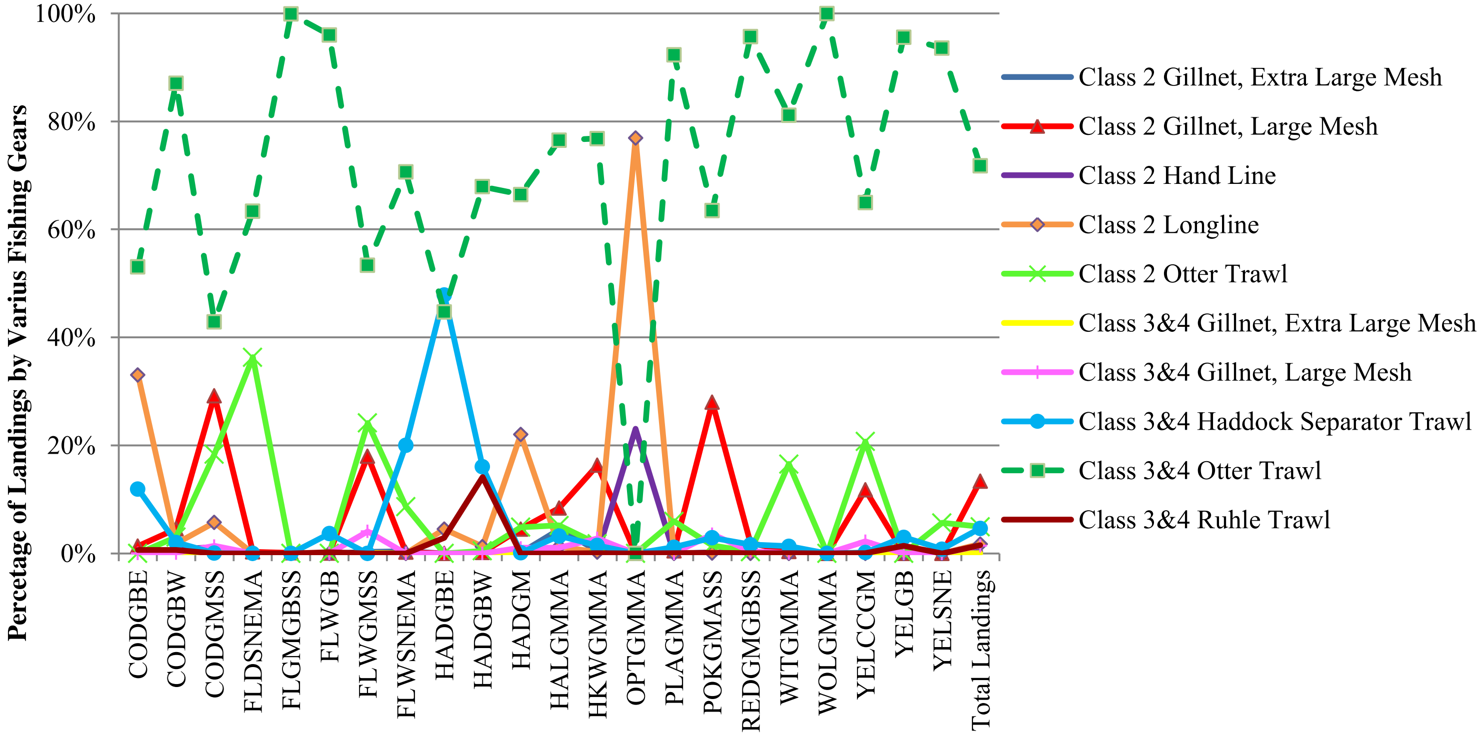

Fig. 4(b) Distribution of GF Landings (Live lbs) by Various Gears for Each GF Stock under GF Trips in FY 2011

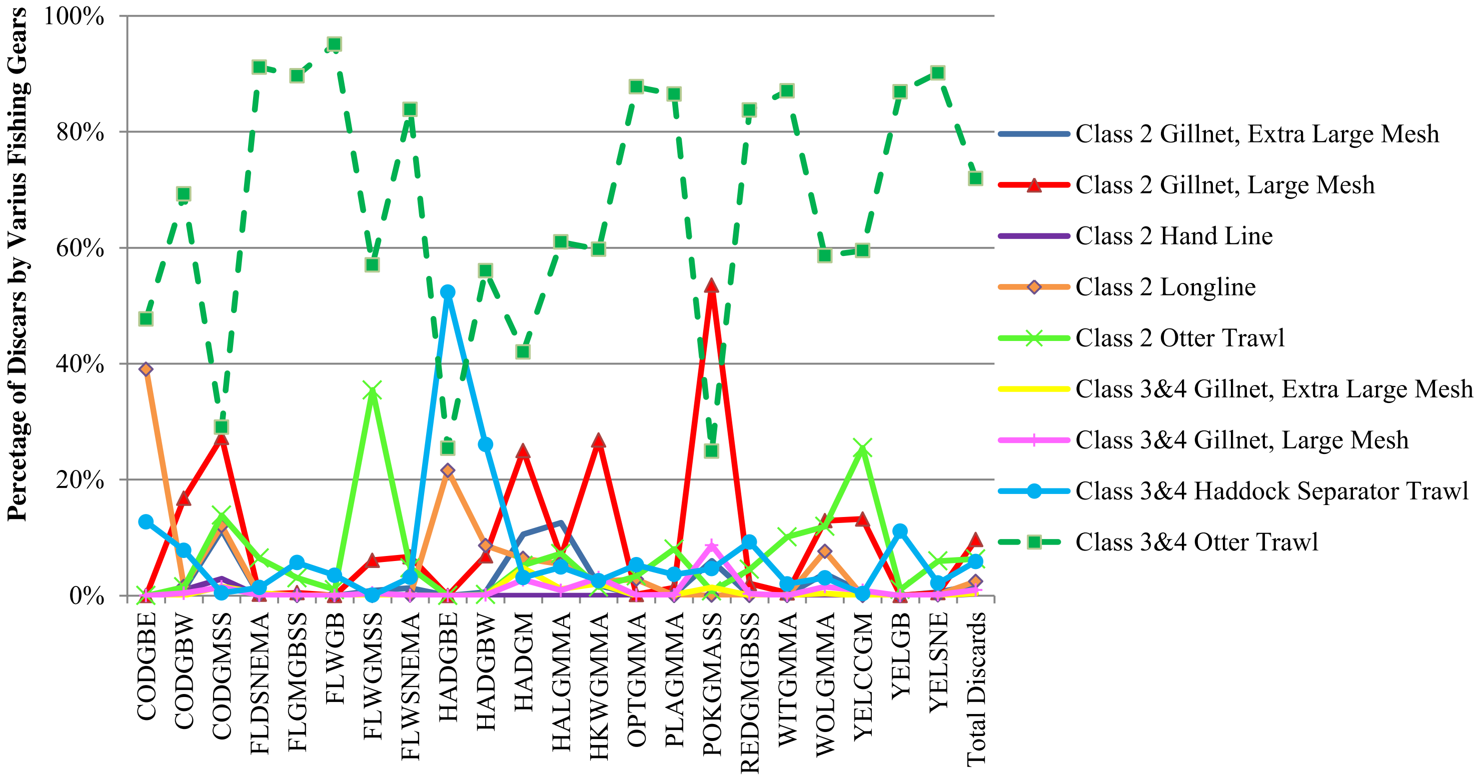

Fig. 5(a) Distribution of GF Discards (Live lbs) by Various Gears for Each GF Stock under GF Trips in FY 2010

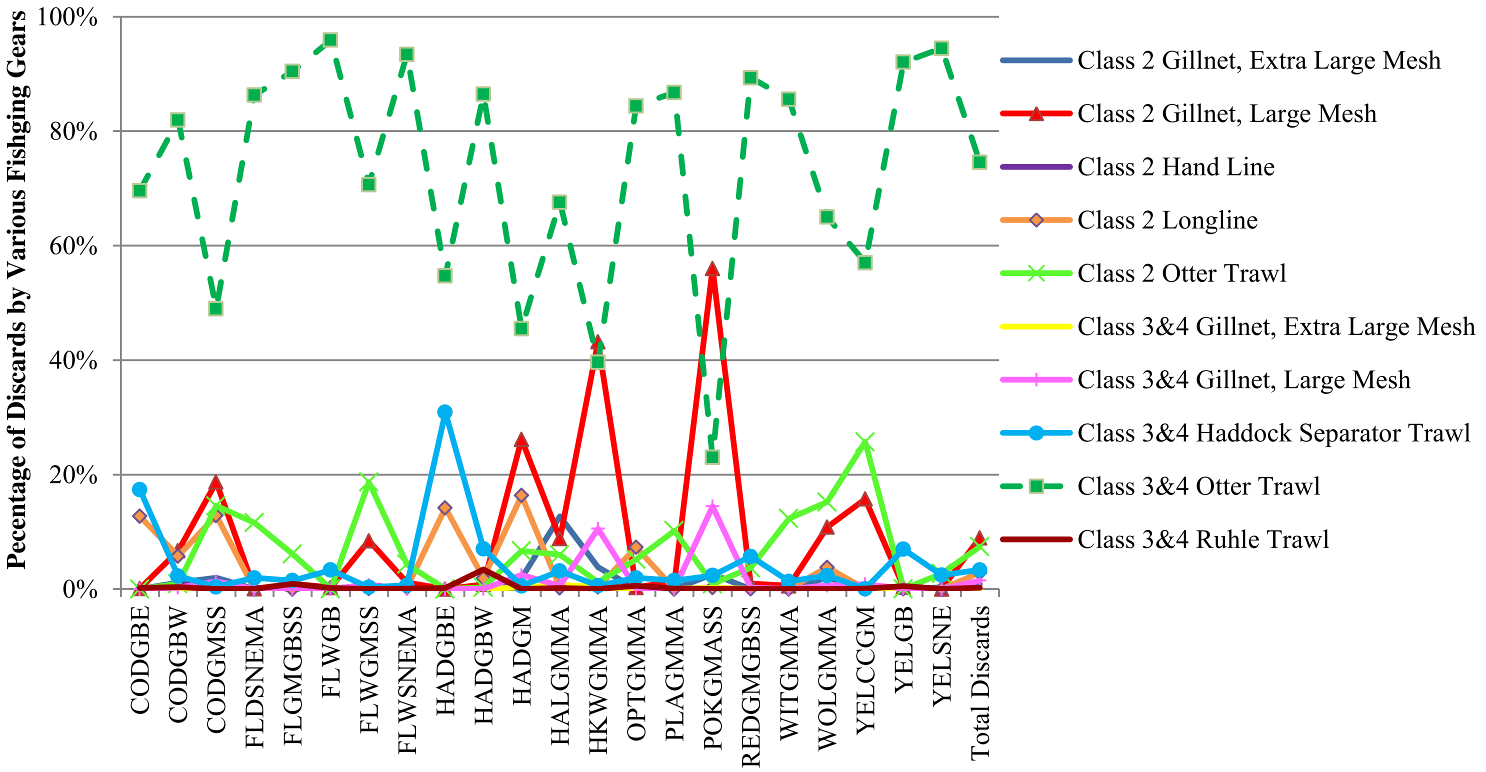

Fig. 5(b) Distribution of GF Discards (Live lbs) by Various Gears for Each GF Stock under GF Trips in FY 2011

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

1	CODGBE	GB Cod East;
2	FLWGB*	GB Winter Flounder;
3	HADGM	GOM Haddock;
4	POKGMASS	Pollock;
5	YELCCGM	CC/GOM Yellowtail Flounder;
6	CODGBW	GB Cod West;
7	FLWGMSS	GOM Winter Flounder;
8	HALGMMA	Halibut;
9	REDGMGBSS	Redfish;
10	YELGB	GB Yellowtail Flounder;
11	CODGMSS	GOM Cod;
12	FLWSNEMA*	SNE Winter Flounder;
13	HKWGMMA	White Hake;
14	WITGMMA	Witch Flounder;
15	YELSNE	SNE Yellowtail Flounder.
16	FLDSNEMA*	Southern Windowpane;
17	HADGBE	GB Haddock East;
18	OPTGMMA*	Ocean Pout;
19	WOLGMMA*	Wolffish;
20	FLGMGBSS*	Northern Windowpane;
21	HADGBW	GB Haddock West;
22	PLAGMMA	American Plaice;

Table 1 Number of Trips, Seadays, Landings, and Discards for GF Trips in FY 2010 and 2011

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 (30'-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 Sep. 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 and 2011

		Observer Coverage rate (%) by Category				**Distribution % across Category**		
Size Class	**Gear Type**	**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 Sep. 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 Sep. 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%
	/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 Sep. 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 (A)	Non-GF Landings per Trip (B)	GF as % of Total Landings (C)	GF Discards per Trip (D)	GF Landings per seaday (E)	Non-GF Landings per seaday (F)	GF Discards per seaday (G)	Relative Seaday Ratio** (H)= [Max(G) /(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 (Landings + Discards), and the Utilization Rate (UR) by Species/Stocks

Groundfish Species/stocks	2010 ACE (lb) (A)	2010 Catch (lb) (B)	2011 ACE (lb) (C)	2011 Catch (lb) (D)	Predicted UR in 2011 (E=B/C)	Actual UR in 2011 (F=D/C)	Standardized Ratio based on Predicted UR of Pollock in (E) (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	= Landingss 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 Discards Models Regression Results for both Unweighted and Weighted Discards by Utilization Rate across all Groundfish Stocks

Models Variables	Unweighted Discards Model (A)		Weighted Discards Model (B)	
	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

		Scenario 1: Reallocation of Observed Seadays				Scenario 2: Reduce Observed Seadays by 19%				
Size Class	**Gear Type**	**Observed Seadays (A)**	**Observed Seadays % (B)**	**Observed Discards (C)**	**Observed Discards % (D)**	**Observed Seadays (E)**	**Observed Seadays % (F)**	**Observed Discards (G)**	**Observed Discards % (H)**	**Change in Observed Seadays (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 (A)	**Observed Seadays % (B)**	**Observed Weighted Discards (C)**	**Observed Discards % (D)**	**Observed Seadays (E)**	**Observed Seadays % (F)**	**Observed Weighted Discards (G)**	**Observed Discards % (G)**	**Change in Observed Seadays (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
	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**